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Personal Perspective of Salton Sea Science Needs[1]

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INTRODUCTION

The agenda indicates that I am to address various science subject areas associated with the Salton Sea. My assumptions are that you know quite a bit about the Salton Sea and use that information to formulate opinions and take positions regarding this subject area. I also assume that those opinions and positions are subject to modification as additional information is obtained. I share those characteristics with you. Therefore, one of my purposes for being here today is to enhance my knowledge and understanding by what I learn from others. I hope you will openly share the basis for differences you may have with the scientific perspective I present regarding the Salton Sea so that I can consider those perspectives in my evaluations. Without dialogue science stagnates and limits rather than advances accomplishment.

BACKGROUND

The information gathering that influences the perspectives I hold regarding the Salton Sea began decades before my first involvement with the Sea. By training and experience I am an individual who has spent many years investigating and trying to understand the ecology of diseases affecting free-ranging wildlife. The motivation for this strange behavior has not been

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[1] Salton Sea Restoration Environmental Community Workshop, Tiburon, California, November 2, 1998.

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because of specific interest in microbes and other disease agent, but instead because of my interest in the conservation and well-being of wildlife populations and species. The following excerpts from scientific literature on conservation biology, wildlife management, and human disease are offered to place my orientation towards disease ecology in an appropriate perspective:

1.	Robert May
2.	Dobson and May
3 and 4.	CDC (two quotes)
5 and 6.	Role of Agriculture (two quotes)
7.	Human Health and Ecology
8 and 9.	Joseph Lederberg (two quotes)

The point of all this is that disease is an outcome, not a cause. A sound understanding of the ecology of disease is required to be successful in mitigating against and preventing major impacts from most diseases affecting free-ranging wildlife. This is much more important and more challenging an undertaking for wildlife than for humans and captive populations and species of animals. Perhaps the complexity of the challenge is an underlying basis for my personal motivation. A poor appreciation of the role of environmental quality as it relates to disease in free-ranging wildlife, and perhaps the complexity associated with considerations for addressing many types of disease in "nature," are reasons why natural resource agencies and NGOs have placed so little emphasis on addressing disease. Those efforts that are undertaken are grossly disproportionate in their focus relative to the significance of diseases addressed vs. those that are not. Thus, we maintain a major infrastructure and annually spend many millions of dollars on environmental contaminants (low end of the direct mortality significance spectrum) and spend almost nothing to address such disease as avian botulism, the single most important cause of waterbird mortality within the United States and worldwide.

How then does this relate to the Salton Sea? The two major points of relevance are that first, avian botulism is the most important disease problem at the Sea and second, that to adequately understand and address this and other diseases at the Sea, we need to focus on gaining a better understanding of functional relations within the ecosystem as a whole, not just focus on avian botulism as an outcome. That is precisely what is being pursued and is a point I will come back to in a few moments.

I return now to the information gathering that influences my perspectives towards the Salton Sea. In addition to personal perspectives about disease, chance has resulted in my having the opportunity to view the Salton Sea from three different perspectives. The Salton Sea first appeared on my "radar screen" during the early 1990s. At that time, I was Director of the National Wildlife Health Center which was a research component within the U.S. Fish and Wildlife Service (FWS). That Center is responsible for responding to wildlife health issues across the Nation that involve species under U.S. Department of the Interior stewardship. At that time our focus was almost entirely on FWS areas of responsibility. The proliferation of disease events at the Sea resulted in investigations by Center scientists. Our findings suggested that the Salton Sea was an ecosystem with significant health problems and that intervention was necessary to minimize further losses from disease. We discharged our mission in a very pragmatic manner by providing diagnostic evaluations for determining the disease agents responsible for various die-offs and by recommending disease control activities for the management component of our agency to carry out. These reactive actions were accompanied by recommendations for research to be conducted to enhance our understanding of disease ecology at the Sea as a means for improving management capability to address disease. FWS management components carried out the disease response activities but other research priorities within the FWS prevented any support for our Center to conduct disease research at the Salton Sea.

The separation of our Center from the FWS that occurred when we were incorporated into the newly formed National Biological Survey and then became part of the Biological Resources Division (BRD) of the U.S. Geological Survey (USGS) provided a second viewpoint towards the Salton Sea. Research perspectives within these new science organizations were primarily focused at the ecosystem level to provide basic information and understanding that might be applicable to a wide variety of circumstances and thereby provide a greater return on dollars invested. Disease occurrence at the Salton Sea was continuing to intensify and it was evident that migratory bird losses at the Sea were a significant intrusion relative to the well-being of the Sea's avifauna rather than being an incidental or random "blip" of avian mortality on my "radar screen" for viewing wildlife disease events. Our assessment was that the Salton Sea represented an ecosystem health problem and needed to be addressed from that perspective. This viewpoint was an appropriate expanded focus for our Center in our newly formed science agency.

This assessment was in part based on the frequency of disease event occurring, the multiplicity of causes involved, and the magnitude of losses occurring. Placed in context with the diminished habitat base in the Pacific Flyway, the major increase in disease within migratory bird populations, and the importance of environmental quality relative to health and disease, my perspectives towards the Salton Sea shifted from the Sea being a local disease issue to one of far greater importance. The Sea was now viewed as an important regional wetland. Further, the Sea was seen as a wetland that had become a major focal point for migratory bird losses from disease. This viewpoint had regional and international implications for the migratory bird resource. This expanded, but still limited focus on the Sea as seen from a distance of 1,500 miles from the Sea, was translated into attempts to elevate the Salton Sea for ecosystem funding support within my agency and also to obtain emergency funds for disease investigations. These efforts were not rewarding. Decision makers receiving these requests were an additional 1,500

miles removed from the Sea and were not hearing voices other than mine, such as the State of California or NGOs urging a need for action. As a result, competing interests for agency attention and funding prevailed. However, continued bird mortality at the Sea provided additional opportunity.

The disastrous 1996 pelican die-off at the Sea accelerated visibility of the ecological problems of the Sea and helped to gain support for a workshop sponsored by and held at the NWHC during October 1996. The purpose of that workshop was to develop an issue paper that could be used to support a budget initiative to address ecosystem health at the Sea. Representatives from six agencies participated in the October 22-23 workshop and developed a Salton Sea ecosystem initiative that contained recommendations for addressing the ongoing pelican die-off and long-term management needs as well. Immediate research needs identified focused on understanding the relations between avian botulism in pelicans and tilapia. The long-term goals focused on developing:

(1) a better understanding of the ecology of the Salton Sea;

(2) methodology for managing the Salton Sea ecosystem for maximum sustainability of economic and biological resources; and

(3) a long-term fiscal and personnel support base for addressing ecosystem health at the Salton Sea.

The ecology goal contained components involving the evaluation and synthesis of existing data, development of a conceptual model of the ecology of the Sea, and inventory and monitoring needs. The management goal contained components that considered socio-economic evaluations relative to biological outcomes, strategies for mitigation, and the development of an interagency coalition for information exchange and resolution of biological problems at the Sea. The fiscal

goal sought Congressional support through agency initiatives, agency commitments to apply discretionary funds to resolving issues at the Sea, and collaborative initiatives by the coalition being developed. The issue paper resulting from the NWHC workshop was widely distributed in an attempt to gain support for funding a coordinated and collaborative science effort to address ecosystem health at the Sea.

Initial follow-up to the NWHC workshop occurred during August, 1997. Effort by the U.S. Fish and Wildlife Service resulted in more than 100 scientists, managers, and others convening in Palm Springs, California to develop an in-depth research needs assessment. That effort resulted in a document titled, "Saving the Salton Sea," which was released in October 1997. A total of 39 study proposals accompanied by a larger number of recommendations are contained within that document. Budgets were developed for 34 of those proposals, and totaled more than $36 million, or approximately $12 million per year for 3 years.

My current viewpoints towards the Sea have been modified further as a result of an additional act of chance that has placed me in my current position and removed me from my previous role as Director of NWHC. In my new role, I still view the Salton Sea as an ecosystem under stress. It is an ecosystem that requires remedial actions to prevent further deterioration and enhance environmental quality for the benefit of fauna and humans alike. However, in my current role, the expanded information I have gained through on-site experience and interactions with others on a continuos basis regarding "restoration" of the Sea has provided a wealth of additional information to consider. My new role requires that I consider the entire spectrum of scientific information and concern, not just disease. Salinity control has now appeared on my "radar screen" as a critical factor for achievement of a Salton Sea that serves migratory bird and other needs. I will also return to this subject shortly.

The purposes for my identification of salinity at this point are to acknowledge that this was not a factor of concern when my initial focus on the Sea involved responsibility for providing assistance in the form of reactive actions of disease diagnosis and control of outbreaks that occurred. That limited area of activity and focus would not have led to a consideration of salinity in the near term except as a factor in bird deaths as we have dealt with elsewhere. Similarly, salinity control was not a focus for ecosystem considerations developed by NWHC scientists. Had we been funded to pursue our ecosystem studies, salinity would have surfaced as an ecosystem health need to be addressed as we gained a better understanding of the Sea and the forces that were negatively impacting on the health of this ecosystem.

There are four major points associated with all of the background information just provided. These are offered as a foundation for the remainder of this presentation. The primary point is that disease outcomes have an ecological basis that is generally heavily vested in environmental quality. Therefore, the primary means for addressing disease is to "doctor the environment, not the animal" (Leopold 1933). To do this, one must understand the ecological relations that result in disease. A second point is that despite the occurrence of numerous and continuous wildlife die-offs at the Salton Sea and vigorous efforts to obtain funding support for research to address this problem, funding has not been forthcoming for such needs. A third point is that from a wildlife conservation viewpoint, the Salton Sea is an important component of the migratory bird habitat base within the Pacific Flyway. Even if disease were not an issue, the maintenance of the Sea as a resting, nesting, and feeding area is important because of the magnitude of habitat loss that has occurred within the Flyway. The fourth and final point is that salinity control is a critical factor regarding a level of environmental quality required to sustain this water body in a manner that will provide for the migratory birds that now use it. The remainder of this presentation will focus on how these different needs are being served by the current Salton Sea project.

THE SALTON SEA PROJECT - THEN AND NOW

The first important points are to recognize that a Salton Sea project existed long before the Sonny Bono Memorial Legislation, that the project was limited to considerations of salinity and water elevation control, and that it was nearing a decision stage for action within the fiscal constraints of the local agencies to fund and maintain a project. Next, there should be full realization that nothing associated with Congressional actions or the expanded involvement of stakeholders in the current projects directs that control of salinity and water elevation be set aside in favor of other activities. Instead, these remain as areas for focus. Also, it is important to understand what the 18 month time line that has been imposed means relative to scientific investigations. In reality, it meant very little. This is another point I will return to.

There are three significant points regarding the current Salton Sea project that serve to mesh the four factors identified at the start of my presentation. First, during December 1997, Interior Secretary Bruce Babbitt expanded the role of the Federal government in Salton Sea issues by forging a consensus with officials from other governmental agencies and the Torres Martinez Indian Tribe that called for the initiation of two actions which are the foundation for the current project. These actions are:

(1) Initiation of an open environmental review process under the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA) to identify and evaluate specific options for addressing the issues of the Salton Sea; and

(2) Establishment of a joint governmental coordinating mechanism to help coordinate and focus the efforts of the many governmental agencies who are involved in funding important research activities related to the Salton Sea.

The action by Secretary Babbitt provided for the first major integration of science with management of the Salton Sea. Despite his action, a major detraction associated with the Salton Sea project has been continued statements by members of Congress, local officials, and members of the general public that the Salton Sea has been studied to death and additional studies are not needed. There have in fact been many investigations conducted at the Salton Sea. However, for the most part, these investigations have been narrowly focused and do not provide for the type of integrated database that allows the Sea to be evaluated in a manner that provides the information needed to adequately guide decisions within the current NEPA/CEQA process. A task for the Science Subcommittee is to identify the critical science needs that exist and to obtain the information needed.

Among past and current investigations are more than two decades of engineering evaluations of how to address salinity, a variety of water related monitoring studies and contaminant investigations carried out by the U.S. Geological Survey and others, university studies on various aspects of the Sea, disease investigations by government agencies and universities, and economic evaluations of the social values associated with various aspects of the Sea. In addition, several conceptual and issue focused models addressing various aspects of the Sea have been developed. The quality of these investigations varies widely, much of the data are historic rather than current, and there are few hypothesis testing studies among the work that has been completed. An opportunity now exists to bring these various interests together through the Salton Sea project and develop a coordinated science effort for addressing the environmental issues of the Salton Sea ecosystem. However, as in the past this opportunity will bear little fruit without funding to support such efforts.

The second significant point is that for the first time, there is funding for scientific investigations for ecological investigations at the Salton Sea. This funding results form an EPA grant to the Salton Sea Authority who in turn has made that funding available for science needs identified by the Science Subcommittee under the coordination mechanism agreed to among the stakeholder agencies.

The third significant point is that project objectives have been established that identify the commitments by the stakeholder agencies. These objectives are an important "yardstick" for environmental assessments regarding actions to be taken. Such actions should not negatively impact on achievement of those objectives even if they do not directly benefit those objectives. Therefore, the current project provides a means to gather a broad spectrum of ecological information about the Sea and utilize that information in decision processes to address salinity while needed scientific efforts are being carried out to better understand the "State of the Sea. This knowledge is essential for guiding the development of means for addressing the long-term project objectives.

STATE OF THE SEA

There can be no argument that the Salton Sea is an ecosystem in poor environmental health. This is reflected by the frequency and magnitude of fish and bird kills that are occurring. The contribution of environmental factors to disease events are seen in the following graphic. All disease have three common factors: an agent that causes damages to the host in a manner that diminishes the health of the host; susceptible individuals and populations that are damaged by contact with the disease agents; and environmental factors that precipitate or facilitate

interactions between the host and the agent in a manner that results in disease. The context for the term disease is an absence of health. Thus, disease is an outcome not a cause and can result from a broad spectrum of agents including those that are infectious and non-infectious, or are of a biological or physical nature. The same agents can act in different ways to cause impairment of the host. An example is salt. Physical salt loading destroys the integrity of feather structure and results in bird deaths due to several types of impairments; cataract formation is another impact from the physical contact with salt. Salt is also toxic for birds if levels ingested are greater than those various species can tolerate. The levels of salt tolerance are negatively impacted by factors that impair salt regulation, such as organophosphate and carbamate pesticides.

A wide variety of disease agents have been responsible for bird mortality at the Salton Sea. The following overview should provide an enhanced perspective of the "cancerous" conditions of the Sea that results in these disease outbreaks. The key point is that disease is the symptom not the cause and we need to treat the cause, not the symptom.

AVIAN DISEASES

Avian Botulism

A. Status / Importance

1. Most significant, if not addressed, of the avian diseases occurring at the Sea relative to probable impacts on the variety of waterbirds that use the Sea.
2. Has occurred at the Sea since at least the 1930s.
3. Expanded geographical distribution worldwide since the 1960s-1970s.
4. Responsible for major pelican losses in 1996 that focused national attention on the Sea.

B. Agent

1. Clostridium botulinum type C.
2. Potent toxins produced during the growth stages of the bacteria are the cause of disease.
3. Different toxins, identified by the letters A to G are the causes of disease in different species and countries.

    a. Wild birds are almost exclusively victimized by type C.
    b. Type E occasionally occurs in fish-eating birds in the Great Lakes and at a few other locations.

C. Host

1. All species of birds that use the Sea are susceptible to type C toxin.
2. These same species are also susceptible to type E.

D. Ecology

1. Avian botulism is truly an environmental disease.

    a. Like tetanus, the organism exists in nature (soils, sediments) in an inactive spore form.
    b. The spores germinate and produce vegetative cells, which are the source of toxin, when exposed to appropriate environmental conditions.
    c. The ecology of avian botulism is further complicated by toxin production being mediated by bacteriophage infections of the bacteria which encode the bacterial cell to produce toxin.

2. Studies by scientists from the NWHC have clearly demonstrated that the interstitial water level is where toxin production takes place in wetlands.

3. These same studies have identified the water quality parameters that are important for toxin production and the range of values where this occurs.

   a. These relations are not linear.
   b. These relations are interactive rather than independent.

4. Water quality is only one component of the ecology of this disease.

   a. Cl. botulinum is a strict anaerobe, therefore, bacterial multiplication must take place in an environment that is without any oxygen.
   b. Cl. botulinum is also essentially a "meat lover" - it needs a source of protein for nourishment. This is usually an invertebrate or vertebrate carcass.
   c. Avian botulism is basically a food poisoning requiring the ingestion of the toxin in food items.

5. Typically, avian botulism involves toxin production taking place in the gut of a decaying vertebrate carcass (usually a bird).

   a. The spores are present in the intestines of animals that have fed in environments seeded with this bacteria.
   b. Decomposition of the carcass during warmer months of the year provides appropriate environmental conditions for spore germination and multiplication of the bacteria.

6. When these carcasses become flyblown, the ensuing maggots consume the toxin along with the flesh and other carcass tissues.

   a. Invertebrates are not susceptible to botulinum toxin due to having a different nervous system than vertebrates.
   b. The maggots concentrate the toxin in their bodies.

7. Birds that consume as few as two toxic maggots are quickly killed and become additional incubators for toxin production, produce additional toxic maggots, and perpetuate the classic maggot cycle.

8. Fish-eating birds are rarely victimized by type C botulism because their food habits do not result in feeding on maggots.

9. Pelican mortality from this disease at the Salton Sea appears to be a different type of botulism cycle.

   a. Preliminary investigations suggest that bacterial multiplication and toxin production are taking place in the intestines of live tilapia.
   b. These investigations indicate that tilapia are highly susceptible to the toxin being produced within their intestinal tissues.

10. Pelicans appear to be become exposed to the toxin by feeding on sick tilapia which are dying from their intestinal infections of Cl. botulinum.

11. Therefore, there are two distinct types of avian botulism cycles occurring at the Sea.

   a. The pelican cycle can contribute to the maggot cycle, but the reverse does not occur.
   b. The pelican cycle is unique, as is the presence of two types of botulism cycles.

Avian Cholera

A. Status / Importance

1. Most significant infectious disease currently known to be occurring at the Sea relative to magnitude of losses this disease is capable of causing.

2. Most common cause of multiple bird death events reported for the Sea.
3. Like avian botulism, an increasing problem within North America since 1970.

B. Agent

1. Pasteurella multocida
2. Infectious and contagious bacterial disease that first occurred in wild birds in the United States in 1944.

C. Hosts

1. All species of birds that use the Sea are susceptible.
2. More than 100 species of wild birds documented to have died from infections (not at the Sea).

D. Ecology

1. Disease carriers are thought to be the source of outbreaks that occur.

2. Water quality has been shown to be an important factor regarding the survival time for bacteria shed into the environment from infected birds and from contamination associated with scavenging of carcasses.

3. Disease transmission occurs through direct contact with infected birds, ingestion of contaminated food or water, and bacterial laden aerosols of water droplets associated with the disturbance of water surfaces by the activities of birds.

4. Gulls and other scavenger species have extended incubation periods between exposure and clinical disease, thereby, serving to extend die-offs by also serving as new sources of contamination of the environment and as a vehicle for disease spread through their movement patterns.

Salmonellosis

A. Status / Importance

1. Occasional occurrence in nesting colonies at the deltas and surrounding areas.
2. Capable of infecting large-scale losses, especially in young birds.

B. Agent

1. Salmonella typhimurium primarily.
2. Infectious and contagious bacterial disease that is an emerging disease of wild birds.

C. Host

1. All species of birds that use the Sea are susceptible to infection.

    a. Disease has essentially been confined to colonial waterbirds.
    b. Most events have involved young of the year in rookeries.

2. Humans are susceptible.

D. Ecology

1. Carriers among the bird population are one potential source of infection.

    a. Rodents are a common source for infection
    b. Other species can also be sources for infection.

2. Ingestion of contaminated food and water is the usual route for infection by this bacteria.

3. Environmental conditions are a significant factor influencing the survival time for salmonella in the environment.

4. Feces from infected sources are the usual source of environmental contamination.

Newcastle Disease

A. Status / Importance

1. Cause of total loss of production in cormorant colonies on Mullet Island.
2. Disease eradicated from poultry in Canada and the United States by early 1970s.
3. Appearance at Salton Sea first time reported in wild birds west of the Rocky Mountains.

B. Agent

1. Newcastle Disease Virus
2. Highly pathogenic and virulent strain of the Newcastle Disease virus.

C. Host

1. Only cormorants have been found to be infected at the Sea.
2. White pelicans and gulls also found infected in Canadian outbreaks.
3. Chickens moderately susceptible to strain isolated.
4. Disease has been conferred to younger age classes and has been especially lethal in nestlings.
5. Humans can contract a mild respiratory and conjunctivitis from exposure to concentrated amounts of this virus.

D. Ecology

1. Only the ground nesting colony has been found to be infected.
2. Fecal contamination is an important means for virus transmission and results in different virus exposure potentials for ground nesting vs. tree nesting birds.
3. Recent occurrence of NDV in cormorants within Canada, the Midwestern United States, and now the Salton Sea is a matter of growing concern.

Algal Toxins

A. Status / Importance

1. Algal blooms are an increasing problem worldwide.
2. Algal blooms are increasing at the Sea but their importance as a source of toxins contributing to bird kills remains unknown.

B. Agent

1. Two primary types of algae of concern regarding toxins

   a. blue-green algae (cyanobacteria)

      (1) Hepatotoxins (i.e., caused by microcystins such as Microcystis aeroginosa)
      (2) Neurotoxins (i.e., such as anatoxins, saxitoxin, and neosaxitoxin.

   b. dinoflagellates.

C. Hosts

1. We suspect algal blooms are resulting in production of toxin responsible for the large grebe kill of 1992 and continue to be a source of grebe mortality.

2. Too little is known to assess potential impacts on other species.

D. Ecology

1. The clinical signs and pathological effects of algal toxins are poorly to not described for most birds.
2. Technology to diagnose algal toxicity remains largely inadequate.
3. Significance of finding algal toxins in the tissues of sick and dead animals is yet to be determined.

Other Toxins

A. Status / Impacts

1. There is no evidence of any significant problems from pesticides and other toxins regarding direct effects.

2. There have been a few small scale bird die-offs on on-farm locations following pesticide application - mortality associated with exposure to pesticide within the Sea has not been documented.

B. Agent

1. Lead poisoning from spent lead shot has been documented at the Sea (State Waterfowl Area).

2. Organophosphate and carbamates have caused minor on-farm losses and one moderate sized on-farm loss.

C. Host

All species present (birds) are susceptible.

D. Ecology

1. Sublethal effects may be occurring but have not been documented.
2. Interactions between salt gland function and modern pesticides should be evaluated.

SCIENCE AND THE SCIENCE SUBCOMMITTEE

To "close the loop" that connect the Salton Sea project components of construction engineering, NEPA/CEQA, and science, I return to the action by Secretary Babbitt in forging an agreement for project coordination. The coordinating mechanism put in place was the formation of a Research Management Committee of high-level representatives of the four governments involved in the Salton Sea recovery effort. That Committee was directed to appoint a Science Subcommittee consisting of stakehold agency representatives to assist the Committee. A key point is that the science effort provided for by this action is directly supportive of the NEPA/CEQA process. Therefore, the scientific exploration associated with this process is very pragmatic and highly focused on providing biological evaluations addressing potential environmental impacts, positive and negative, associated with project management alternatives being considered. However, in meeting these needs basic information needed to address all project objectives is being obtained.

The Salton Sea Science Subcommittee is a coordination and advisory body and does not carry out scientific activities beyond data synthesis and evaluations. No funding is vested in or controlled by the Subcommittee and neither its members, persons, or organizational units supervised by its members can profit from recommendations made by the Subcommittee. This

arrangement is designed to maintain focus on the pragmatic task before us and to facilitate objectivity in our deliberations and actions. Further, we are by design a terminal Subcommittee whose task will have ended by January 2000 when recommendations for actions to be taken under the current Salton Sea project are transmitted to Congress by Interior Secretary Babbitt. However, science needs associated with the Salton Sea are long-term and will not have ended with the disbanding of the current Subcommittee. Therefore, in addition to addressing immediate science needs, we are also considering long-term science needs.

As just noted, the immediate needs are directly associated with the NEPA/CEQA process. Our first Request for Proposals (RFP) was issued late in June. Selection of those we are recommending for funding was made last week. Studies to be conducted under these proposals will provide important reconnaissance level information about the Sea regarding:

1. Biological and physical limnology
2. Fish communities
3. Avian communities
4. Sediment contaminants
5. Microbial pathogens

Vegetative mapping is being provided through other means. All of these activities will be carried out in a coordinated manner and provide time sensitive information for evaluations within the NEPA/CEQA process. In addition, information synthesis is being undertaken to provide a better understanding of what is known and what yet needs to be determined. The University of Redlands serves as our database and source of technical assistance in this effort. The University is funded for this purpose by separate appropriations.

Additional RFPs issued by the Subcommittee will build upon these initial studies and enhance our basic understanding of the ecology of the Sea and provide a sound understanding of the ecological factors contributing to disease events in fish and birds. Modeling will be an important component of this effort and is something we are now turning our attention to along with basic ecological studies that will help to better define the functional relations between various components of the Salton Sea ecosystem. All of this information is fundamental for the development of baselines against which a monitoring program can be designed. The purpose for monitoring related to the current project is to evaluate whether or not management actions taken serve the project objectives in a positive manner, or if adjustments are needed.

The establishment of sound baselines and an ecologically sensitive monitoring program are fundamental building blocks for a long-term coordinated science effort that addresses the problems of the Sea in addition to those being dealt with by the current focus on salinity and water level control. Both of these aspects along with in-depth scientific studies required to resolve those problems are the focus for Subcommittee development of a strategic science plan for achieving and sustaining an enhanced state of ecosystem health at the Salton Sea that serves all current project objectives. A series of subject specific expert workshops will be developed to help gather information to assist with our efforts. This strategic plan will be the culmination of our Subcommittee efforts and will likely also contain recommendations for some type of interagency body to coordinate science efforts at the Sea for the next decade.

CONCLUSION

The following closing comments are offered for your consideration. The current Salton Sea project is the first phase of what must be a multi-phased effort to improve the environmental quality of the Sea. Therefore, this project is a beginning not an endpoint. Science is the foundation of information needed to guide management actions throughout the entire effort. Therefore, the current scientific effort is also a beginning rather than an endpoint. There are many competing interests regarding the direction these scientific efforts should take, all of which have validity. The validity of those viewpoints exists regardless of whether one has a vested interest in a particular viewpoint or is a detached objective observer. How then do we select among those viewpoints?

I respond to that question by noting that science provides a foundation for management, but is not the determinant of management actions since scientific findings are only one factor in the equation leading to problem resolution. Management of the Salton Sea is an ecosystem management issue, and as noted by Robert Lackey:

> "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)

In this context, it is important to examine the divergent viewpoints about the Sea and objectively evaluate which of those viewpoints are responsive to the desires of society that must pay the bills and live with the outcomes, and which are simply responsive to our specific interests of scientific pursuit and personal values. When we favor the latter, rather than the former, as the contributions we offer to the task at hand then we are a "destabilizing force in public policy" (Taubes 1998).

I have attempted to illustrate how Science Subcommittee activities are associated with, and are relevant to, the desired social benefits defined by society for this project. In closing, I borrow an 1860 quotation of Thomas Huxley that I believe provides a good perspective for viewing the needs at the Salton Sea.

> "Science...warns me to be careful how I adopt a view which jumps with my preconceptions, and to require stronger evidence for such belief than for one to which I was previously hostile. My business is to teach my aspiration to conform themselves to fact, not to try and make facts harmonize with my aspirations."
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> (Huxley 1860)