Salton Sea Management Project
Evaluation of Salinity and Elevation Management Alternatives

Prepared for

The Salton Sea Authority
333 E. Barioni Drive
Imperial, CA 92251

Prepared by

Ogden Environmental and Energy Services Co., Inc.
5510 Morehouse Drive
San Diego, California 92121
(619) 458-9044

June 1996
Project No. 313561000

EXECUTIVE SUMMARY

BACKGROUND AND PROJECT SETTING

In 1993, the counties of Riverside and Imperial, the Imperial Irrigation District (IID), and the Coachella Valley Water District (CVWD) entered into a Joint Powers Agreement, creating a public agency known as the Salton Sea Authority. The Salton Sea Authority directs and coordinates actions relating to improvement of water quality, stabilization of water elevation, enhancement of recreational and economic development potential of the Salton Sea, and other beneficial uses, recognizing the importance of the Salton Sea to the dynamic agricultural economy in Imperial and Riverside counties. In 1994, the Salton Sea Authority received a grant from the U.S. Environmental Protection Agency's (USEPA) Clean Lakes Program to conduct environmental and economic analyses of salinity and elevation management options for the Salton Sea. The general goal or purpose of the management project is to stabilize the salinity and elevation of the Salton Sea at levels that maximize the economic, environmental, social, and cultural attributes of the region. This document, the Final Report for the Clean Lakes Grant, summarizes management alternatives proposed to date, screens these proposed alternatives against criteria established by the Salton Sea Authority, and presents environmental scoping issues raised during the public review period.

The Salton Sea is the largest lake in California and is a regionally important feature from both environmental and economic standpoints. It is located in the southeastern corner of the state within the geologic feature known as the Salton Basin, a natural basin located approximately 278 feet below mean Sea level (-278 feet msl). The Salton Sea receives drainage from approximately 8,000 square miles of Riverside, Imperial, and San Diego counties and the Republic of Mexico. It is a closed basin; water only leaves the Sea via evaporation. Inflow to the Salton Sea consists of agricultural drainage, storm water, and wastewater and is generally in hydrologic balance with evaporative losses. The closed nature of the system has resulted in changes in the salinity and water surface elevation of the Salton Sea over time. The salinity of the Sea is currently 44 parts per thousand (ppt) and is expected to continue to rise. The increasing salinity is due mainly to high evaporation rates, low rainfall, and the discharge of saline agricultural wastewaters into the lake. Elevation of the Sea varies as a result of changes in inflows and weather conditions that alter its hydrologic balance.

The Salton Sea and surrounding area provides important habitat for many wildlife species. The Salton Sea is characterized by both terrestrial and freshwater wetland vegetation communities. Typical vegetation communities occurring in the Salton Sea area include Sonoran creosote bush scrub, desert saltbush scrub, desert sink scrub, stabilized and partially stabilized desert dunes, tamarisk scrub, freshwater marsh, cismontane alkali marsh, Sonoran cottonwood-willow riparian forest/nonnative tamarisk scrub intermediate, open water, mud flats, ruderal, and agricultural lands. Sensitive habitats are those which are considered rare within the region or that support sensitive plants or animals. Sensitive habitats found in the Sea area include wetlands and non-vegetated aquatic habitats ("waters of the U.S."), which include freshwater marsh, cismontane alkali marsh, Sonoran cottonwood-willow riparian forest/nonnative tamarisk scrub intermediate, open water, and mud flat habitats.

There are numerous invertebrates, amphibians, reptiles, fish, birds, and mammals that are found in aquatic and terrestrial habitats adjacent to the Sea and in the surrounding Imperial and Coachella valleys. The Sea and adjacent wetlands, river systems, natural habitats, and agricultural fields provide foraging and roosting opportunities for large numbers of migrant and resident birds. There are also important fishery resources present in canals, irrigation ditches, rivers, and the Sea itself. The Salton Sea is currently reported to support eight species of fish, including the federally endangered desert pupfish (*Cyprinodon macularius*) and four important sport fishes, tilapia (*Oreochromis mossambiqus*), bairdiella (*Bairdiella icistia*), sargo (*Anisotremus davidsoni*), and orangemouth corvina (*Cynoscion xanthulus*). There are also several sensitive fish, reptile, bird, and mammal species found at the Sea and adjacent areas.

The Regional Water Quality Control Board, Colorado River Region has designated a number of beneficial uses for the Salton Sea. These include aquaculture; water contact recreation; non-contact water recreation; warm freshwater habitat; wildlife habitat; and preservation of rare, threatened, or endangered species. Industrial service supply is designated as a potential beneficial use.

The continued rise in salinity and variable elevation threaten the region's environmental, recreational, and economic values associated with the Salton Sea. The Sea currently serves many important functions such as serving as a drainage basin for agricultural run-off of Coachella and Imperial valleys; providing important habitat for both resident and migratory wildlife species as well as several endangered species; providing recreational values such

as fishing, hunting, boating, camping, nature study, bird-watching, and sightseeing; providing for growth of commercial resources and residential developments; and providing flood control measures by serving as a repository for stormwater run-off. The Salton Sea Authority is evaluating alternatives that have the ability to manage salinity and elevation of the Sea in order to protect the beneficial uses of the Sea.

In order to evaluate the efficacy of various potential management alternatives, salinity and elevation management goals or targets were established. Three quantitative criteria for screening potential management alternatives include, a target salinity range of 35 to 40 ppt, a target elevation range of -230 to -235 feet msl, and operation and maintenance cost that does not exceed $10,000,000 per year. Additionally, the Salton Sea Authority decided that the alternatives must make use of currently available, proven technologies. Any alternative that does not meet these criteria will be eliminated from consideration in further environmental reviews.

PROPOSED MANAGEMENT ALTERNATIVES

A wide variety of alternatives have been proposed over the years to manage the salinity and surface elevation of the Salton Sea. The various management alternatives have been grouped into six general categories: 1) diked impoundments within the Salton Sea; 2) pump-out of Salton Sea water to another area (e.g., dry lake beds, onshore evaporation ponds, the Gulf of California, or the Pacific Ocean); 3) a combination of alternatives consisting of diked impoundments, onshore evaporation ponds, and a pipeline/canal system to transport concentrated brine to Laguna Salada/Gulf of California, among others; 4) removal of salts from inflowing water before it enters the Sea (e.g., desalination plant, biological filters, or special pre-treatment reservoirs); 5) use of imported water to dilute the Sea; and 6) other proposed alternatives that do not specifically address the problem of stabilizing salinity or surface elevation.

Diked Impoundments

Managing salinity with diked impoundments is based on removing salts from the Sea and decreasing the volume of the lake, which results in greater dilution of the remaining Salton Sea water by inflowing fresh water. The diked impoundment acts as an evaporation basin, isolating and concentrating the brine by evaporating Salton Sea water within the impoundment (USDOI and RAC 1969, 1974; Aerospace Corporation 1971; CVWD pers.

comm. 1995). Although the effective volume of the lake would be reduced by the volume of the impoundment, which would result in a rising lake level given the same fresh water inflow, a volume of Salton Sea water equal to the freshwater inflow can be let into the impoundment to evaporate away, thereby controlling lake elevation. Eventually, the impoundment would fill with salts, and salt disposal would be necessary.

Numerous diked impoundment alternatives have been proposed over time. The major differences in these options include size of the impoundment, location of the impoundment, and the type of dike structure and design. Nine locations were first studied, with impoundment sizes ranging from 20 to 50 square miles. Since then, CVWD has updated the descriptions of various diked impoundment options and evaluated their efficacy in managing the Sea's salinity. Selected alternative configurations included in this discussion are: 1) a 50-square-mile diked impoundment at the southern end of the lake, 2) a 40-square-mile diked impoundment at the southern end of the lake, 3) two impoundments, one at the southwestern and on at the southeastern end of the lake, totaling 50 square miles, 4) diking off the northern third of the lake, 5) diking off the northern half of the lake, 6) parallel dikes forming 47-square miles of impoundment, and 7) a phased zoning concept. In general, the smaller diked impoundments have been placed in the southern portion of the Sea because the slope of the Sea's bottom and average depth of water is less in the southern end than the northern end. Larger impoundments that dike off one third to one half of the Sea would be located at the northern end of the Sea because the majority of fresher water inflows (New and Alamo rivers) are located in the southern end of the Sea. In addition to these configurations, many other sizes and locations are possible. In general, proposed sizes of the impoundment have ranged from approximately 8 to 50 percent of the surface area of the Salton Sea, and proposed impoundment locations have included all sectors of the lake.

The initial proposal for dike construction proposed an earthen dike be constructed with a conventional excavate and dredge, haul, and dump method. Since the time of this initial proposal, new technologies have made alternative dike structures feasible. A value engineering team formed by the U.S. Bureau of Reclamation (USBR) and the Salton Sea Authority Technical Advisory Committee (TAC) was formed to evaluate these alternative structures (USBR and Salton Sea Authority TAC 1994). The alternative structures evaluated included a plastic curtain, sheetpile, concrete wall, geotextile bags, pile and dredge, and dump and dredge. The value engineering team concluded that the excavation, haul, and dump dike was the most flexible, reliable, and cost effective separation structure

and recommended this type of construction for the diked impoundments within the Salton Sea (USBR and Salton Sea Authority TAC 1994). This option does not include dredging of Salton Sea sediments, which eliminates the danger of resuspending large quantities of potential contaminants in Salton Sea sediments.

Pump-out Alternatives

The pump-out alternatives are based on the concept of removing Salton Sea water (and its associated salts) from the lake. This would provide, in effect, an outflow from the lake and change the system from a closed terminal lake to an open flowing system. Salts would be exported with the outflow rather than being retained in the lake when water evaporates. In addition to salts being exported from the Sea with a pump-out alternative, the lake's total volume is reduced as a result of pump-out (inflow no longer equal to outflow), which would result in a salinity decline from dilution with inflowing fresher water and a drop in the Sea's elevation. Surface elevation can only be maintained by importing water back to the Salton Sea. For example, water from the Gulf of California or the Colorado River could be used, in concept, to replace an amount of Salton Sea water that is pumped-out.

All of the pump-out alternatives are based on exporting saline water out of the Salton Sea. The major differences between different pump-out alternatives are the amount of water removed each year, the location to which Salton Sea water would be pumped, and whether water is pumped back to the Salton Sea to control elevation. The pump-out rate will be dependent upon the salinity of the Sea when initiation of pumping begins, the desired target salinity, the desired time to reach that target salinity, and cost considerations. The alternative pump-out locations proposed to date include pump-out to a dry lake bed (Palen Dry Lake will be used as an example, but other dry lakes such as Clark and Ford are considered options), evaporation ponds, Laguna Salada, the Gulf of California, the Pacific Ocean, or onshore treatment/filtration units.

The pump-out to onshore evaporation alternative involves pumping Salton Sea water into evaporation ponds located on the lake's shore, where the water evaporates leaving behind saline residue. Saline water would be removed from the lake at a predetermined rate until the desired salinity was reached. At this point, pump-out would continue at a rate such that salts removed by pump-out each year would equal the annual inflow of salts to the lake. Eventually, the evaporation ponds would fill with salts, and disposal would be necessary.

Areas on the southeastern shore, between Bombay Beach and Red Hill, have been suggested as a potential location for onshore evaporation ponds).

Most evaluations of evaporation ponds have concluded that evaporation ponds on land are not economical because of the high costs of acquiring sufficient land around the lake (USDOI and RAC 1969). However, developments in solar pond technology, such as an enhanced evaporation system (EES) (Ormat 1989), where salt water is pumped through an elevated spray system, producing increased evaporation rates, appear to require less land than standard evaporation ponds. The original volume of removed water is reduced by 90 percent with the enhanced evaporation system. The remaining saline water is pumped to conventional evaporation ponds for further evaporation. With the use of enhanced evaporation, Ormat anticipated the need for only 10 percent of the land area necessary for conventional evaporation ponds (Ormat 1989). The need for salt disposal still exists because the evaporation ponds would eventually fill with salt. Furthermore, there is more energy needed for the pumping and spray system associated with enhanced evaporation.

Evaporation ponds could be used for other purposes, such as using the saline residue in a solar plant for generation of electricity or using Sea water for aquaculture by first pumping the water to a series of aquaculture ponds and then to a series of evaporation ponds. In both cases, the principles for salt removal are essentially the same as described above for onshore evaporation ponds. These additional options represent a potential means to generate monies to offset construction, or operation and maintenance costs.

The pump-out of saline Salton Sea water to the Gulf of California alternative would transport Salton Sea water via a series of canals and pipelines to Laguna Salada and then to the Gulf of California. Canals would be used when transporting water downgradient, and pipelines would be used when pumping water uphill or for outfalls. Another option would be to carry water only to Laguna Salada and allow water to evaporate and the salts to remain. However, the consent of the Mexican government would be required for this option.

An additional option is to construct a return canal/pipeline to transport less saline Gulf of California water to the Salton Sea. Water from the Gulf of California would be pumped over the mountains to Laguna Salada and then gravity-fed to the Salton Sea. The amount of Gulf water pumped to the Sea would equal the amount pumped from the Sea to the Gulf, stabilizing the Sea's elevation.

Construction of an inland seaport at Laguna Salada has been discussed by both the Mexican and United States governments (Salton Sea Authority pers. comm. 1995). A canal would be constructed to carry sea water from the Gulf of California to Laguna Salada, which would replenish the dry lake. This canal would be large enough for both freight and pleasure ships to navigate. This proposal could benefit the Salton Sea area by providing for an outlet from the lake. If approval from the Mexican government were obtained, Salton Sea water could be pumped from the Salton Sea to the inland seaport. This alternative is essentially the same as a pump-out alternative to Laguna Salada or the Gulf of California, but the canal/pipe system would extend only to the northern terminus of the navigable waterway. It has also been suggested that a navigable waterway with a lock system could be constructed from Laguna Salada into the United States, providing for economic growth to both the United States and Mexico.

The pump-out to the Pacific Ocean alternative is similar to the pipeline/canal to the Gulf of California alternative, except a link between the Salton Sea and the Pacific Ocean would be established (Salton Sea Authority Public Comments 1995). The exact route has not yet been selected but would be dependent upon cost and engineering considerations. Ocean water would be carried to the Salton Sea, and Salton Sea water would be transported to the Pacific Ocean via the shortest and least expensive route. The distance between the two is estimated at about 100 miles. This exchange of water between the ocean and the Sea would eventually stabilize the salinity and elevation.

A number of proposed alternatives rely on treating or filtering Salton Sea water. Water would most likely be pumped to a filtering unit or plant to remove salts and other constituents. Many of these alternatives rely on developing or unproven and therefore could not be considered viable management alternatives.

Combinations of Impoundment and Pump-out Alternatives

The combination of alternatives use various combinations of the previously described alternatives and some enhancement options not yet mentioned (Salton Sea Authority Public Comments 1995; Dangermond and Associates, Inc. 1994). They may include all or some of the following options: diked impoundments, onshore evaporation ponds, shoreline enhancement areas, constructed wetlands, stabilizing dikes, solar pond and power

generation plant, canal/pipeline with or without storage facilities. Some of the combined alternatives proposed thus far include:

- an in-Sea diked impoundment, on-shore evaporation ponds, and a pipeline to the Gulf of California;
- an in-Sea diked impoundment and a pipeline to the Gulf of California;
- on-shore evaporation ponds and a pipeline to the Gulf of California;
- a stabilizing dike, solar pond power generation, and constructed wetlands;
- a stabilizing dike, solar pond power generation, constructed wetlands, and pumped storage facility to the Gulf of California; and
- a joint USA/Mexico solar power generation and pumped storage to Laguna Salada.

These alternatives combine various options already discussed. A diked impoundment adjacent to the shoreline would serve to control elevation, allowing water in and out of the impoundment as needed, as well as manage the salinity. An onshore evaporation pond would serve to manage salinity and could potentially be used for solar pond power generation. A pipeline could be used to transport concentrated brine to another area (e.g., Laguna Salada, the Gulf of California, or the Yuma desalting plant discharge canal). The combined alternative offers the advantage of optimum control of salinity and elevation while also solving the problem of salt disposal. Any combination, such as a diked impoundment and pipeline; evaporation ponds and a pipeline; or a diked impoundment, evaporation ponds, and a pipeline, could be used to manage salinity and elevation.

Other options that could be coupled with these three options described above include, constructed wetlands and shoreline enhancement projects. This would serve to improve water quality and could potentially help to filter out contaminants as they enter the Sea. A stabilizing dike could be used to decrease the overall volume of the Sea and help to control elevation. This differs from the diked impoundment in that there is no enclosure and evaporation of water. Instead a dike is constructed at the southern end of the Sea to reduce the overall volume of the lake, helping to stabilize the surface elevation. A pumped storage

facility could be constructed at the highest point of the canal/pipeline. This would allow for more control of the transportation of water, allowing pumping at night when electricity rates are the lowest.

Water Imports

Another proposed solution is to import fresh water to the Sea, diluting the Sea water to a desired salinity. It is unlikely sufficient fresh water is available to dilute the Sea to the desired salinity, nor does this solution address elevational control. However, many of the management alternatives discussed above, especially pump-out alternatives, call for the removal of Salton Sea water, which will lower the lake's elevation. The only way to stabilize surface elevation would be to add an equal amount of water to the lake to replace that which is removed. This would also help to decrease the Sea's salinity if the replacement water has low salinity relative to the Sea's water.

Identified sources of replacement water include Colorado River water and the Gulf of California water. Colorado River water could be delivered through existing canals or expanded canal systems only in years when surplus water is available. Gulf of California water could be delivered through constructed pipeline/canal systems. The latter option is more expensive, but potentially more reliable.

Other Proposed Options

Other proposed alternatives do not specifically address the problem of stabilizing salinity or surface elevation. Since these alternatives do not meet the purpose and need of the project, these alternatives can not be considered viable management alternatives.

ALTERNATIVES EVALUATION AND SCREENING

The primary objective of the management project is to stabilize the salinity and elevation of the Salton Sea at levels that maximize the economic, environmental, social, and cultural attributes of the region. To focus future studies and environmental analyses on those alternatives that are most likely to meet the objectives of the project, the Salton Sea Authority set management targets that were used to screen potential alternatives. These targets included the ability to maintain salinity in a range of 35 to 40 ppt, maintain surface elevation in range of -230 to -235 feet msl, have an annual O&M cost less than

$10,000,000, and rely on proven technologies. The ability of proposed management alternatives to meet these criteria are summarized below.

A number of alternatives, such as research or enhancement projects, did not address the problem of stabilizing salinity or surface elevation, and were not considered further as management alternatives. Alternatives that did not meet the established screening criteria include alternatives that propose to remove salts before water enters the Salton Sea. While many of the specifics of these alternatives were not available, it is unlikely that the various proposed alternatives could remove the 4,000,000 tons of salt that enter the Salton Sea each year, except at enormous cost, most likely exceeding the established annual O&M cost target. In addition, these alternatives do not manage surface elevation.

Alternatives that import water also do not appear to be an effective method to manage salinity of the Salton Sea. Sufficient volumes of water from the Colorado River do not appear to be available at a frequency to allow management of the Sea's salinity. Gulf of California water could be used to replenish water removed as part of a pump-out alternative, but pipeline/canal systems to the Gulf of California have been estimated to exceed the established annual O&M cost target.

Pump-out options, which do not incorporate water imports, do not manage surface elevation. Pump-out options which do incorporate water imports have the capability of managing salinity, elevation, and solve the problem of salt disposal. However, pipeline/canal alternatives are relatively expensive to operate and maintain, and are generally estimated to exceed the O&M target. In addition, the majority of pump-out options involve siting project components in Mexico, which would result in a loss of control over the project and greater uncertainty in the environmental process for the Salton Sea Authority. Similarly, combinations of alternatives that rely on pump-out or transport of Salton Sea water from the Salton Basin have the same problems as the pump-out alternatives; although the specifics of many of these combinations of alternatives are presently not available. Many of the remaining pump-out options rely on unproven technology or lack sufficient information to adequately evaluate their ability to meet screening targets. However, since the specifics of some of the pump-out and combinations of alternatives are not available, some of these alternatives were not eliminated by the screening process.

Diked impoundments appear to have the greatest potential for meeting the project objectives while satisfying the established Salton Sea Authority's screening criteria. In general, diked

impoundments have the ability to manage both salinity and surface elevation and are relatively inexpensive to operate and maintain. However, the diked impoundment alternatives store the salts within the impoundment and salt disposal will be necessary at some point within the life of the project. A value engineering evaluation of alternative dike structures (USBR and Salton Sea Authority TAC 1994) concluded that excavation, haul, and dump dike construction is the most flexible, reliable, and cost-effective method. Combinations of alternatives that make use of diked impoundments and certain pump-out alternatives also appear to meet established screening criteria, except O&M costs of these alternatives have not been estimated. Based on the projected O&M costs for pipeline/canal systems, combinations of alternatives that utilize both diked impoundments and pipeline/canal systems are unlikely to meet the established O&M target; however, the O&M costs of many of these systems are uncertain at this time.

A number of environmental scoping issues, raised during the public review process, were identified for the project. All of the proposed alternatives will have potential environmental consequences that have not been addressed in this report. Potential impacts include construction or operational impacts to sensitive resources (e.g., wetlands, endangered species, and migratory birds); the potential for creating or exacerbating problems with toxic substances; and potential impacts to Mexican resources. Other issues include the need for and cost of land acquisition, right-of-way requirements, and environmental permitting requirements. Comments were also received regarding the need for refinement of the project's purpose and need, how management targets were established, the need for comprehensive water quality analyses, and making use of long-term inflow data and inflow variability (wet and dry cycles) for environmental analyses.

1.0 INTRODUCTION

The overall objectives of this report are to summarize the salinity and surface elevation management alternatives that have been proposed for the Salton Sea and to conduct a preliminary screening of these alternatives based on their ability to achieve identified salinity and surface elevation management targets, and operation and maintenance (O&M) costs. In addition, only those alternatives that are technologically feasible will be considered further in subsequent environmental analyses. This report is not intended to provide an analysis of environmental impacts but to narrow the list of potential management alternatives to those that meet the screening criteria discussed in Section 3.0.

This report represents the final product of the 1994 Clean Lakes Grant, and includes information presented in two previous submittals for this Clean Lakes Grant: Summary of Salinity and Elevation Management Alternatives (Ogden 1995a), and Economic Profile Study and a Discussion of Methodology for Economic Impact Analysis (Ogden 1995b, Appendix A).

1.1 BACKGROUND

This Salton Sea is the largest lake in California and is a regionally important feature from both environmental and economic standpoints. It is located in the southeastern corner of the state (Figure 1-1) within the geologic feature known as the Salton Basin (also Salton Sink or Trough), a natural basin located approximately 278 feet below mean sea level (-278 feet msl). The Salton Sea receives drainage from approximately 8,000 square miles of Riverside, Imperial, and San Diego counties and the Republic of Mexico. It is a closed basin; water only leaves the Sea via evaporation. Inflow to the Salton Sea consists of agricultural drainage, storm water, and wastewater and is generally in hydrologic balance with evaporative losses. The closed nature of the system has resulted in changes in the salinity and water surface elevation of the Salton Sea over time. The salinity of the Sea is currently 44 parts per thousand (ppt) and is expected to continue to rise. Elevation of the Sea varies as a result of changes in inflows and weather conditions that alter its hydrologic balance.

The continued rise in salinity and variable elevation threaten the region's environmental, recreational, and economic values associated with the Salton Sea. The Salton Sea supports many recreational activities, including a renowned sport fishery, and is an important habitat

for over two million migratory birds and several endangered species. The continued rise in salinity threatens the viability of populations of fish and fish-eating birds occurring at the Sea, as well as associated recreational activities. Lands surrounding the Salton Sea have been developed, creating an economy beneficial to Riverside and Imperial counties, the state, and the nation. Local agriculture is dependent on the Sea as a repository for agricultural drainage. Unstable Sea levels have adverse implications for the regional economy when events such as inundation of property and loss of tourism occur.

Over the years, a number of salinity and elevation management strategies have been proposed by various agencies. In 1993, the counties of Riverside and Imperial, the Imperial Irrigation District (IID), and the Coachella Valley Water District (CVWD) entered into a Joint Powers Agreement, creating a public agency known as the Salton Sea Authority. The Salton Sea Authority directs and coordinates actions relating to improvement of water quality, stabilization of water elevation, enhancement of recreational and economic development potential of the Salton Sea, and other beneficial uses, recognizing the importance of the Salton Sea to the dynamic agricultural economy in Imperial and Riverside counties. In 1994, the Salton Sea Authority received a grant from the U.S. Environmental Protection Agency's (USEPA) Clean Lakes Program to conduct environmental and economic analyses of salinity and elevation management options for the Salton Sea.

The purpose of this report, the final product of the 1994 Phase I Clean Lakes Grant, is to describe the environmental setting of the Salton Sea, the purpose and need for the project, the salinity and surface elevation management targets, the various salinity and elevation management alternatives under consideration by the Salton Sea Authority, and a preliminary screening of the management alternatives under consideration. It should be noted that the models used to evaluate changes in salinity and elevation under diked impoundment and pump-out alternatives have not been evaluated with respect to their sensitivity to model assumptions. Therefore, the quantitative predictions of these models should be interpreted with caution.

2.0 PROJECT SETTING

A description of the Salton Sea and surrounding areas is provided in this section. It is intended to provide a general overview of existing conditions and to identify sources of information for future environmental analyses.

2.1 HISTORY OF THE SALTON SEA

To understand how the Salton Sea was formed, a brief history is presented here. This is largely based on William Blake's expedition to the area in the 1850s and de Stanley's account of the history of the Salton Sea (Blake 1858; de Stanley 1966).

2.1.1 Lake Cahuilla

The Colorado River has historically flowed alternately into the Gulf of California and into the Salton Basin. During periodic, extreme flood stages, the river would flow north across the Colorado River delta and into the Salton Basin forming a large, temporary lake. Eventually, the Colorado River would return to its old course, south to the Gulf of California and, deprived of its water supply, the lake would ultimately dry up. The last in the series of these ancient lakes was Lake Cahuilla.

In the 1850s, William Blake, a geologist who was with an early exploration party searching for possible railroad routes in the southeastern desert area of California, studied the Colorado Desert region and found evidence of a historic lake that occupied much of the Imperial and Coachella valleys. Blake first identified the ancient lake in 1853 and named it Lake Cahuilla, after the Cahuilla Valley and the Cahuilla Indians who inhabited the area. He described the lake as 100 miles long and about 35 miles at its widest point. He speculated that the lake had been formed by the Colorado River flowing into the Salton Basin during flood stages. The influx of river water into the basin also deposited rich alluvial sediments, creating the rich agricultural environment of the Coachella and Imperial valleys. Buildup of sediments within the Colorado River Delta eventually blocked the river's flow into the Salton Basin and diverted it back to the Gulf of California. With the loss of the water supply, Lake Cahuilla dried up by evaporation, leaving behind the lacustrine (related to lakes) clay and alluvial surface of the Coachella and Imperial valleys. In 1853, Blake noted that if irrigation were possible, the valley would be capable of supporting luxuriant vegetation growth (Blake 1858).

This history of Lake Cahuilla is documented by the dating of shoreline features and also by local Indian folklore. About 40,000 years ago, early stages of the lake were at an elevation of 160 feet msl. More recently, about 15,000 years ago, the lake's elevation was about 40 feet msl. According to both Indian legends and carbon dating, the lake disappeared

about 300 years ago (Littlefield 1966). The historic Lake Cahuilla shoreline can be seen today along the base of the Santa Rosa Mountains to the west and northwest of the Sea. and in the sand dunes on the southeast side near Niland (Setmire et al. 1990).

2.1.2 Salton Sea

Periodically during years of heavy rainfall, large river discharges would spread over the Colorado River Delta and drain into the Salton Basin. Floodwaters were reported in the Salton Basin in 1828, 1840, 1849, 1852, 1859, 1862, 1867, and 1891 (Littlefield 1966). The idea of constructing a canal from the Colorado River to the Salton Basin to reclaim the desert was first conceived in 1849. The canal would carry Colorado River water to the Imperial Valley for the purpose of agricultural development. It was not until 1901, however, that the main canal (Imperial Canal) was completed, and much of this canal was located in Mexico. By 1904, more than 12,000 people had moved to the area buying land at auctions for agricultural purposes.

The area prospered and towns such as Brawley, Holtville, Heber, and Calexico grew. Two important problems of the area had been ignored, however. These were the regular history of flooding in the area, and the tons of silt that were carried along with Colorado River water by the Imperial Canal. By 1904, the Imperial Canal was blocked by sediment. and the Imperial Valley was without water (de Stanley 1966).

To remedy this problem, a temporary diversion of the Colorado River on the Mexican side of the United States-Mexico border was constructed. On October 11, 1905, the temporary diversion failed during flood conditions, and the entire flow of the Colorado River rushed into the Salton Basin. It was not until February 1907, 16 months later, that the break in the dike was repaired, and the river was diverted back to its old course to the Gulf of California (de Stanley 1966).

At the time the break in the dike was repaired, the Salton Sea was -195 feet msl with a surface area of 520 square miles. By 1925, however, the lake's elevation had dropped to -250 feet msl due to evaporation and the low volume of agricultural wastewater draining to the Sea (Setmire et al. 1990). Since 1925, diversion of Colorado River water into the Imperial and Coachella valleys has raised the elevation of the lake to about -227 feet msl with a surface area of about 380 square miles (Ferrari and Weghorst 1995).

2.1.3 Agriculture

The California Development Company delivered water to the Imperial Valley in 1901. There were several mutual water companies that operated distribution canals for about 77,000 acres of land by 1904. The California Development Company, however, went bankrupt because of damage suits from the floods of 1905-1907. The Southern Pacific Company acquired its assets (United States Department of the Interior and the Resources Agency of California (USDOI and RAC) 1969).

The IID was officially formed in 1911 and by 1923 had acquired the California Development Company assets and the distribution canals from the mutual water companies. By 1928, irrigated land had expanded to 409,943 acres. Problems with silt buildup and potential flooding were still present, however. Congress passed the Boulder Canyon Project Act in 1928 authorizing the USBR to build the Hoover Dam, Imperial Dam, and the All-American Canal system. These facilities were completed in 1940, alleviating threats of flooding and silt buildup. The All-American Canal system included the construction of the Coachella Canal and its distribution system in 1954. This added 78,500 acres of irrigated land in the Coachella Valley. Today there are over 500,000 acres of irrigated land in the two valleys, approximately 460,000 acres in Imperial Valley, and 60,000 acres in Coachella Valley (Colorado River Board of California 1992). One of the major functions of the Sea is to serve as a sump for agricultural run-off for the Coachella and Imperial valleys. Executive Order of Withdrawal (Public Water Reserve No. 114, California No. 26), signed in 1928, designated lands within the Salton Sea below elevation -220 feet msl as storage for wastes and seepage water from irrigated lands in the Imperial Valley (RWQCB 1994).

2.1.4 Beneficial Uses

Water quality objectives for water bodies in California are established to protect or support the particular "beneficial uses" of the water body. Section 13050(f) of Division 7 of the California Water Code (Porter-Cologne Water Quality Control Act) describes beneficial uses as follows:

> "Beneficial uses of the waters of the State that may be protected against quality degradation include, but are not necessarily limited to, domestic, municipal, agricultural, and industrial supply; power generation; recreation; aesthetic

enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves."

As described in Section 2.1.4, the primary purpose of the Salton Sea, as designated by Executive Order, is to store agricultural wastewater. Federal regulations, however, specify that waste transport or assimilation cannot be designated as a beneficial use for waters of the United States, per Clean Water Act, 40 CFR, Section 131.10(a) (RWQCB 1994). Beneficial uses that have been designated for the Salton Sea (RWQCB 1994) include:

- Aquaculture
- Contact Water Recreation
- Noncontact Water Recreation
- Warm Freshwater Habitat
- Wildlife Habitat
- Preservation of Rare, Threatened, or Endangered Species

Industrial Service Supply has been designated as a potential beneficial use.

The RWQCB, Colorado River Basin Region, considers some beneficial uses of the Salton Sea to be impaired due to low water quality (RWQCB 1996). Impaired beneficial uses are described below (from RWQCB 1996).

- Aquatic habitat is impaired by the currently elevated salinity level, the high level of nutrients, and the amount of selenium entering the food chain of the Sea. Lesser impairments are caused by pesticides and possibly boron.

- Wildlife are impaired by the rising salinity level and by selenium entering the food chain. Impacts from boron and nutrients are uncertain.

- Recreation is impaired by impacts to the Sea's fishery which are caused primarily by the salinity level. Selenium impairs recreation because there is a health advisory on eating Salton Sea fish. Fish kills and odor problems associated with the death of over abundant algae are caused by excessive nutrients and impair the aesthetic recreational use of the Sea. Elevated levels of bacteria in localized areas of the Sea (i.e., the extreme southern end) are of concern at times.

Impacts to endangered species are uncertain but may be similar to the impacts to wildlife noted above.

2.2 PHYSICAL DESCRIPTION

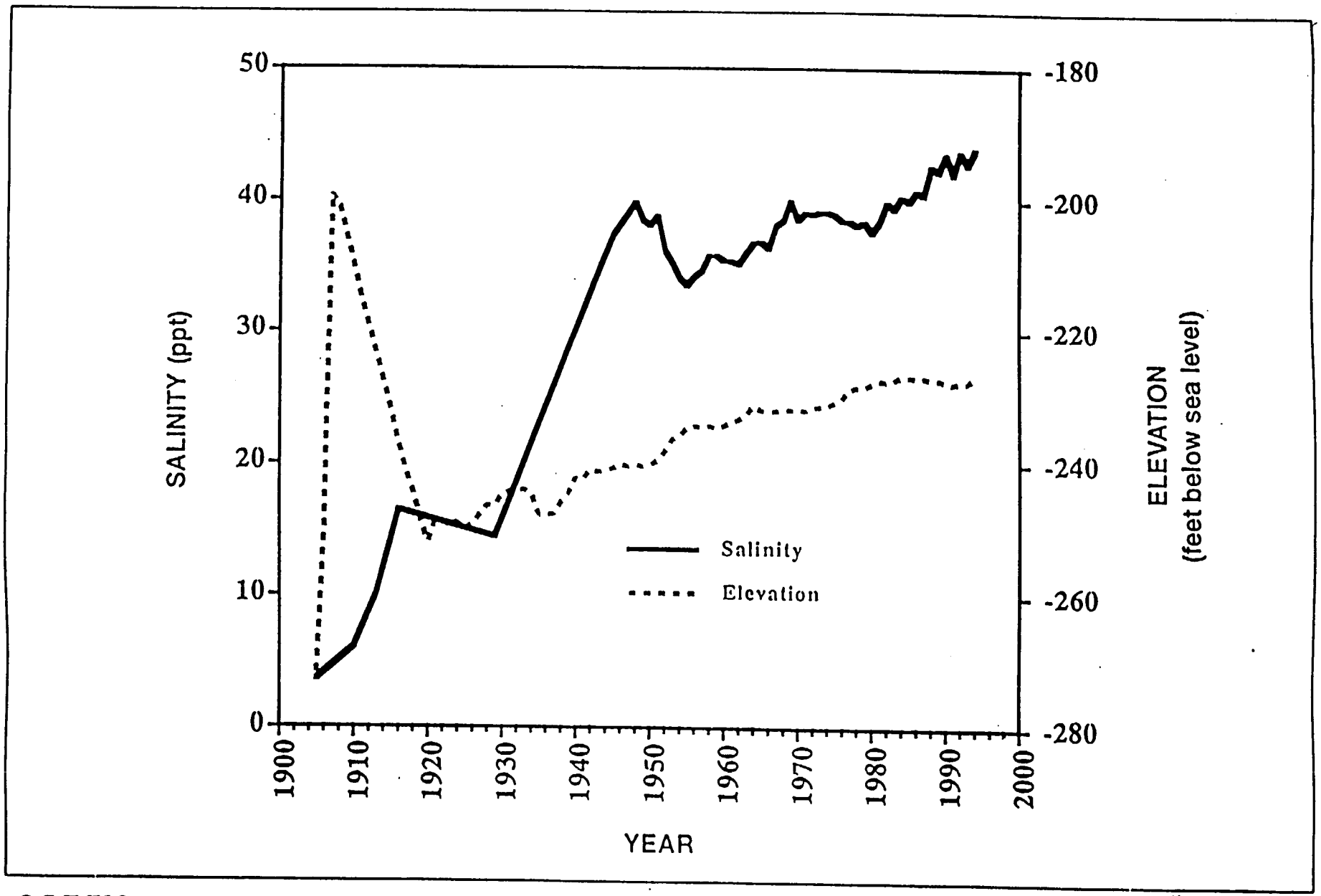
2.2.1 Geologic Setting

The Salton Sea is located in the northern part of the Salton Basin. The basin is at the north end of the actively spreading rift valley that runs along the bottom of the Gulf of California. In the geologic past, the Salton Basin was part of the Gulf of California. The Colorado River deposited its silt load at the mouth of the river, and eventually the Colorado River delta gradually extended to the southwest. Eventually, the Colorado River Delta separated the Salton Basin from the Gulf of California.

The Salton Basin (Figure 2-1) is bordered on the northwest by the San Gorgonio pass, on the west by the San Jacinto and Santa Rosa mountains, on the east by the Little San Bernadino and Chocolate mountains, and is contiguous with the Mexicali Valley in Mexico to the south (Setmire et al. 1990). The Salton Basin is 130 miles long and is 70 miles at its widest point.

2.2.2 Physical Characteristics

The Salton Sea currently has a surface elevation of about -227 to -228 feet msl with an estimated surface area of 242,049 acres (378 square miles) and 239,125 acres (374 square miles), respectively, at these surface elevations (Ferrari and Weghorst 1995). The lake is about 35 miles long and 15 miles wide at its widest point (Ferrari and Weghorst 1995). Recent data obtained by the USBR (Ferrari and Weghorst 1995) show that the Sea has a maximum depth of 51 feet with a volume of 7,654,585 acre-feet at surface elevation -227 feet msl and 7,413,997 acre-feet at elevation -228 feet msl. The inflow into the Sea is approximately 1,300,000 acre-feet per year, which carries about 4,000,000 tons of salt per year (California Regional Water Quality Control Board 1993).



OGDEN

Historical Salinity and Elevation Through Time

FIGURE

2-2

pastoris), five-hook bassia (*Bassia hyssopifolia*), saltbush, tamarisk, bindweed (*Convolvulus arvensis*), Russian thistle (*Salsola tragus*), bermuda grass (*Cynodon dactylon*), Mexican sprangletop (*Leptochloa* sp.), as well as other common weedy species.

Agricultural Land

Agricultural land is found extensively throughout the Imperial and Coachella valleys and consists of actively cultivated, irrigated, and drained land. This habitat generally offers poor habitat for wildlife except as foraging areas for agricultural pest species and raptors, such as burrowing owls and red tailed hawks, which feed on insects and rodents attracted to crops. Flooded fields also offer foraging areas for wading birds and waterfowl, such as egrets and geese, particularly during winter.

2.5.2 Wildlife

It is probable that during the breakthrough of the Colorado River many organisms living in the river were introduced into the newly formed lake (Evermann 1916). With the increase in salinity, however, there have been major changes in the biotic community within the Sea. The following sections summarize the wildlife expected to occur in the Sea and in the surrounding desert habitats. This information is based on existing literature and databases as referenced.

Bacteria

The abundance and significance of bacteria in alkaline saline lakes are not well understood or studied in general. Bacteria probably have a dual functional role, acting as both primary producers and decomposers. As with most saline lakes, the Salton Sea bacterial assemblage is virtually unstudied. There are purple and green sulphur bacteria present, but there have been no real attempts to study the pelagic or benthic bacteria qualitatively or quantitatively. Elevated levels of bacteria are periodically present at the south end of the Salton Sea as a result of elevated bacterial levels in river discharge (RWQCB 1996).

Phytoplankton and Phytobenthos

The dominant primary producers in the lake are phytoplankton and phytobenthos. Phytoplankton and phytobenthos are microscopic plants that are found in the water column

and benthic (bottom) habitats, respectively. The plant life in the Salton Sea is predominantly single-celled algae. Carpelan (1961) studied the lake between 1954 and 1956. The major groups of algae present were found to be diatoms (Chrysophyta), dinoflagellates (Pyrrophyta), and green algae (Chlorophyta). At this time, blue-green algae (Cyanophyta) was also found on the bottom of the lake in shallow water, and on buoys and pilings in the lake. In 1970, the USDOI reported that the major species present in the Salton Sea included diatoms (*Cyclotella caspia, Nitzchia longissima, Nitzschia sp., Pleurosigma sp., Thalassionema nitzschoides*), dinoflagellates (*Gyrodinium resplendens, Peridinium sp., Cachonina niei, Exuviella sp.*), Euglenophyta (*Eutreptia sp.*), (*Westella botryoides*), and blue-green algae (*Oscillatoria sp., Phomidium sp.*). Though no recent, in-depth studies of the current phytoplankton assemblage of the Sea have been conducted, samples collected by Gonzalez in 1991, indicated that many of these species are still present (Gonzalez, pers. comm. 1995). Dominant species in these collections included diatoms (*Cyclotella caspia, Nitzchia longissima, Nitzschia* sp., *Pleurosigma* sp., *Thalassionema nitzschoides*), dinoflagellates (*Oxyrrhis marina, Exuviella* sp., *Cachonina neii, Gymnodinium* sp., *Peridinium throchoideum*), and blue-green algae (*Oscillatoria* sp., *Phormidium* sp., *Spirulina* sp., *Calothrix* sp.).

Invertebrates

There are currently five phyla of invertebrates represented within the Salton Sea: Protozoa, Rotifera, Nematoda, Annelida (segmented worms), and Arthropoda (crustaceans and insects). Some of the common invertebrates found in the Sea include ciliate protozoans, *Brachionus plicatilis* (rotifer), *Apocyclops dengizicus* and *Cletocamptus dietersi* (copepods), *Balanus amphitrite* (barnacle), *Neanthes succinea* (pileworm), *Gammarus mucronatus* (amphipod), and *Trichocorixa reticulata* (corixid or water boatman). The major zooplankters (microscopic animals) in the Salton Sea include *Brachionus*, the two copepods, the egg and larval stages of the pile worm, and the nauplia and cypris of the barnacle. The remaining organisms and life history stages are considered to be primarily benthic. Most habitats in the lake are soft bottomed sand or silt, with only a few rocky areas present. This means all sessile organisms that need to attach to a hard substrate are limited to rocky areas, docks, discarded debris, or inundated brush along the shore.

Fish

Fishery resources in the Salton Sea area are present in canals, irrigation ditches, rivers, and the Sea itself. A list of fish present in the these water bodies is provided in Table 2-4. A brief history of fish introductions into the Sea is provided below.

History of Fish Introductions

Since the first introduction of fish to the Salton Sea in the early 1900s, the Sea has been characterized by changing fish communities. Initially freshwater species were introduced to the Salton Sea from the Colorado River during the Sea's initial formation. Though no published records exist, the fish were noted to be abundant in both numbers and numbers of species (Evermann 1961). As both the salinity and water level increased over time, however, the original freshwater fish fauna disappeared.

In 1929, a biological survey conducted by Coleman (1929) recommended the introduction of sportfish into the Salton Sea. Between 1929 and 1956, the California Department of Fish and Game (CDFG) made numerous transplants of both fish and invertebrates to develop a sport fishery in the Sea. Of the numerous species intentionally transplanted, only the pileworm (*Neathes*, introduced as fish forage), mudsucker, and three sportfish (orangemouth corvina, sargo, and bairdiella) survived. Two fish, threadfin shad (*Dorosoma petenense*) and tilapia, were accidentally introduced to the Salton Sea through tributary drainages. The threadfin shad was introduced into the Colorado River in 1954, entering the Salton Sea via irrigation canals in 1955 (Walker et al. 1961). This fish cannot reproduce in the Sea (Meyer Resources, Inc. 1988), and is probably only present in the tributaries. Both *Oreochromis mossambicus* and *Tilapia zilli* were seen in tributaries near the lake in 1964. The accounts vary as to which species exist in the lake, but is most likely *Oreochromis mossambicus* or some hybrid (Meyer Resources Inc. 1988; Black 1981).

The Salton Sea is currently reported to support eight species of fish, including desert pupfish (*Cyprinodon macularius*), sailfin molly (*Poecilia latipinna*), porthole livebearer (*Poeciliopsis gracilis*), longjaw mudsucker (*Gillichthys mirabilis*), tilapia, bairdiella (*Bairdiella icistia*), sargo (*Anisotremus davidsoni*), and orangemouth corvina (*Cynoscion xanthulus*). Bairdiella, sargo, and corvina are marine species, while the remaining species are estuarine or freshwater fish with extreme salinity tolerances. Each of these species is briefly described below.

Table 2-4

FISH SPECIES OCCURRING AT THE SALTON SEA

Scientific Name*	Common Name
Family Centrachidae	
Lepomis cyanellus	Green Sunfish
Micropterus salmoides	Largemouth Bass
Family Cichlidae	
Oreochromis mossambicus	Tilapia
Tilapia zilli	Tilapia
Family Cottidae	
Dorosoma petenense	Threadfin Shad
Family Cyprinidae	
Cyprinus carpio	Carp
Notropis lutrensis	Red Shiner
Pimephales promelas	Fathead Minnow
Family Cyprindontidae	
Cyprinodon macularius	Desert Pupfish
Fundulus parvipinnis	California Killifish
Family Gobiidae	
Gillichthys mirabilis	Longjaw Mudsucker
Family Haemulidae	
Anisotremus davidsoni	Sargo
Family Ictaluridae	
Ictalurus catus	White Catfish
Ictalurus natalis	Yellow Bullhead
Ictalurus punctatus	Channel Catfish

Table 2-4 (Continued)

FISH SPECIES OCCURRING AT THE SALTON SEA

Scientific Name*	Common Name
Family Poeciliidae	
Gambusia affinis	Mosquitofish
Poeciliopsis gracilis	Porthole Livebearer
Poecilia latipinna	Sailfin Molly
Poecilia mexicana	Shortfin Molly
Xiphophorus variatus	Variable Platyfish
Family Sciaenidae	
Cynoscion xanthulus	Orangemouth Corvina
Bairdiella icistia	Gulf Croaker (Bairdiella)

* Marine fish nomenclature follows Miller and Lea (1972), freshwater fish follows AFS (1991)

Desert Pupfish

Desert pupfish is the only native species in the Salton Sea. Historically, it was found in portions of Arizona, southeastern California, and northern Mexico (Lau and Boehm 1991). It is both a California endangered and a federally endangered species (Federal Register 51(61):10842-51). Desert pupfish is a small and chubby fish, with a thick body that measures up to 1.8 inches (in) in length. The females are pale with brownish blotches. The males are brightly colored during the spring and summer with blue backs and golden bellies, which may be important for visual stimulation during courtship (Liu 1969).

Desert pupfish have a high tolerance for extreme environmental conditions, including temperature, dissolved oxygen, and salinity (Barlow 1958). Barlow (1958) reported that the desert pupfish survived salinity as high as 90 ppt in the laboratory and reported finding them in pools near the Salton Sea with salinities of up to 65 ppt.

Desert pupfish are opportunistic feeders; their diet varies seasonally with food availability (Naiman 1979). Their diet consists of algae, minute organisms associated with detritus, insects, fish eggs, and small crustaceans (Cox 1972; Naiman 1979). They are not considered important food for wading birds and other fish because of their low numbers (Walker et al. 1961; Barlow 1961).

Historically, desert pupfish were abundant along the shore of the Salton Sea through the 1950s (Barlow 1961). During the 1960s, the numbers declined and by 1978, they were noted as scarce and sporadic (Black 1980). The decline in abundance is due primarily to the introduction of exotic species and habitat alteration (Lau and Boehm 1991). Surveys conducted by the U.S. Fish and Wildlife Service (USFWS) to determine their distribution around the Salton Sea indicated that desert pupfish were present in a majority of the drains and shoreline pools around the Salton Sea, at the mouth of Salt Creek, and in lower San Felipe Creek with varying densities (Lau and Boehm 1991).

Sailfin Molly

Sailfin molly has a native range along the east coast of North America from North Carolina to the Yucatan Peninsula. The population in the Salton Sea is believed to have stemmed from escapees/releases from tropical fish farms in the 1960s (St. Amant 1966). Sailfin

mollies inhabit saltwater marshes, ponds, and ditches, as well as freshwater pools, ponds, and ditches (Herbert et al. 1987). They are an oblong fish, reaching over 4.7 inches in length. They differ from most other freshwater species in that they are livebearers, the females carry the developing eggs until they hatch internally, and the young emerge from the female alive (Eddy and Underhill 1978). They feed on plants, small organisms associated with detritus, and opportunistically on insects and their larvae (Eddy and Underhill 1978; Herbert et al. 1987). They are extremely tolerant of wide ranges of salinity (Herbert et al. 1987) and adults are reported to withstand salinities greater than 80 ppt (Nordlie et al. 1992; Herre 1929).

Porthole Livebearer

Porthole livebearer native range includes Central America and southern Mexico (Lee et al. 1980). It was also probably introduced through escapes/releases from tropical fish farms in the 1960s (Mearns 1975).

Longjaw Mudsucker

Longjaw mudsucker has a native range from central California to the Gulf of California. The Salton Sea population stems from 500 fish planted in 1930 by CDFG (Walker et al. 1961). They are found mostly inshore around cover and quiet water (Walker et al. 1961). The longjaw mudsucker reaches a length of 5.5 in. They have a long upper jaw reaching to the posterior part of the head. They are able to withstand high salinities and have been collected in the field with salinities of 83 ppt (Barlow 1963).

Their diet consists of harpacticoid copepods, larvae, and nematodes for juveniles and *Neanthes*, barnacles, and juvenile pupfish, mudsuckers, and tilapia for the adults. They have value as baitfish for corvina and historically were numerous enough to support a small bait fishery. During certain seasons they may be an important food item for corvina (Walker et al. 1961).

Tilapia

Tilapia is an introduced cichlid from Africa used in mosquito control, weed control, and as an aquarium fish. They are a robust fish reaching up to 3.53 pounds (lbs) in weight and a length of 15.8 in. The males are larger than the females, which may be related to the fact

that they are mouthbreeders (females carry the eggs and young fry in their mouths). Tilapia is a warm freshwater species that is also able to withstand high salinities. Spawning may occur 5 to 8 times per year. They are limited by high water temperatures and low dissolved oxygen concentrations in the spring and summer and by low winter water temperatures in the Sea which can cause large die offs (Meyer Resources Inc. 1988: USFWS 1996a).

Tilapia are omnivorous feeding on plankton, insects, larvae, crustaceans, and plant material. They are currently the major food source for corvina, and are also an important sportfish (Black 1981; Meyer Resources Inc. 1988). Their salinity range is thought not to exceed 70 ppt, and their reproductive capabilities may be lost at 60 ppt (Pullin et al. 1982). Popper and Lichatowich (1975) reported reproduction at salinities as high as 49 ppt.

Bairdiella

Bairdiella is native to the Gulf of California. They are common in shallow and moderate depths. The Salton Sea population stems from 67 fish introduced in 1950 to 1951 by CDFG (Walker et al. 1961). By 1952, sampling in the Sea indicated a sizable population (Walker et al. 1961). Bairdiella are small silvery fish, and average about 5.6 ounces in weight and 9.8 inches in length.

The diet of the young of the year consists of copepods and their larvae, barnacle larvae, fish eggs, and smaller larvae of their own. The adults feed primarily on pileworms (Quast 1961) and probably other invertebrates. Bairdiella are an important source of food for corvina. Salinity and temperature effects on bairdiella reproduction studied by May (1975, 1976) indicate diminished reproductive success at 40 ppt and above. Ichthyoplankton field data collected between 1987 and 1989, with salinities ranging from 38 to 44 ppt respectively, showed a significant increase in the number of late larval stages but a decrease in the number of eggs and early larvae with each progressive year (Matsui et al. 1991a).

Sargo

Sargo have a native range from Point Conception, California to southern Baja California and the upper Gulf of California. The population in the lake stems from the 65 fish planted in 1951. Initially, they did not show an explosive increase. Evidence of spawning occurred in 1957 and by 1960 a large population existed, supporting a sportfishery (Walker et al. 1961).

Sargo has been reported to exceed a length of 17 in. In the Salton Sea they have been reported to reach 2.2 lbs in weight and 13.8 inches in length. They have a deep body, a strong spinous first dorsal fin, and have three strong spines in the anal fin. A black bar extends below the 5th and 7th dorsal spine. With their increase in numbers, the sargo became an important gamefish and forage fish in the Sea (Walker et al. 1961; Meyer Resources Inc. 1988). Their numbers, however, have greatly declined and their present status is unclear. Results of laboratory salinity tolerance tests indicated that although sargo acclimated to treatment salinities of 45 ppt, significant larval mortality occurred in salinities above 40 ppt (Matsui et al. 1991b). Field data collected between 1987 and 1989 with salinities of 38 and 44 ppt, respectively, showed a decrease in both the number of late egg and early larval stages for sargo (Matsui et al. 1991a).

Orangemouth Corvina

Orangemouth corvina has a native range within the Gulf of California. They were planted in the Salton Sea at various times between 1950 and 1955. They increased substantially to form the sportfishery in the Salton Sea (Walker et al. 1961), and are considered the chief gamefish in the Sea. They are a long fish with a tan back and silvery sides that reach over 26.5 lbs in weight and 42.5 inches in length. They have two almost separated dorsal fins and two anal spines. It was introduced at the same time as short fin corvina, which showed initial signs of acclimation, but was not able to spawn in the Sea.

The diet of young of the year corvina consists of barnacle nauplii and other plankters. When they are 1.2 to 2.4 inches, they feed primarily on pileworms or other invertebrates. The adults feed on the fry and young of the year of tilapia, bairdiella, and other fish of appropriate size. Corvina were acclimated to laboratory test salinities up to 55 ppt, but oocytes failed to mature in salinities greater than 50 ppt (Matsui et al. 1991c). Natural spawning occurred in test salinities of 35 and 40 ppt, but no spawning occurred in test salinities of 45 or 50 ppt (Matsui et al. 1991c). Field data collected between 1987 and 1989 with salinities of 38 and 44 ppt respectively, showed a decrease in number of ichthyoplankton (larval fish) as a result of significant decline in both the late egg and early larval stages for corvina (Matsui et al. 1991a).