Chapter 5. Biological Resource Issues

Introduction

The Salton Sea and adjacent land and wetlands provide habitat resources to a wide range of fish and wildlife species. For example, 400+ bird species have been recorded from the area. The abundance and diversity of avifauna using the Sea illustrates the area's ability to provide resources and its value to such a wide range of species. Various studies have indicated that the Salton Sea has both regional (e.g., Pacific Flyway) and national importance to several avian species (Shuford et al., 2002). This importance, coupled with the diversity of bird species using the Sea and surrounding areas during all seasons, provide a focus for impact assessment of proposed management actions. Birds are, therefore, used in this assessment to reflect anticipated changes in the ability of the Sea and surrounding landscapes to provide habitat resources.

The Salton Sea and surrounding landscapes function—in terms of bird use—as a very large and a very complex system. Although this system has been extensively studied, a great deal of uncertainty remains as to how the Sea functions to provide bird habitat resources and, more importantly, how natural and human-induced future alterations may affect these functions. It would be nearly impossible to predict how anticipated future changes in the Sea would individually affect the 400+ bird species that have been identified in the study area. Therefore, the species of interest are those birds that are directly linked to the landscape features that would change in the future. Basically, these features include those associated with the Sea (shoreline, open water, islands and snags, and constructed wetland complexes); the three rivers, major drains, and sites managed for wildlife (marsh, riparian); and some agricultural fields (alfalfa, grasslands) that receive heavy bird use.

An assessment focus on landscape features linked to the Sea—and the species that use them—is still a complex undertaking. Further refinement is necessary. For example, some of these features and the resources provided by them would not be affected by future management of the Sea. For example, wetlands managed for wildlife habitat such as those on Federal (e.g., Salton Sea National Wildlife Refuge), State (e.g., Wister Wildlife Management Area), and some private duck clubs use Colorado River water in their management activities. This practice is assumed to continue into the future, and these areas would not be subjected to concerns over reduced water supply, increasing salinity, or the uncertainties that surround selenium. In addition, future agricultural cropping practices would likely depend on the availability and cost of irrigation water rather than management activities focusing on the Sea. The future abundance and/or availability of resources provided by irrigated alfalfa and grasslands would therefore be outside the scope of this assessment. Finally, it is assumed that the security function for roosting, loafing, and nesting sites currently provided by islands and snags will be designed into, and maintained in, future features constructed to provide habitat resources. The landscape features remaining—the Sea (shoreline, open water, and constructed wetland complexes**)** and sites supporting unmanaged wetlands (marsh, riparian)—still support large numbers of birds.

Issues Overview

Habitat is a concept that requires an operational definition. Habitat provides resources for specific species, and, in the case of the Salton Sea, abundant habitat resources have supported abundant and diverse wildlife. For example, the abundance and diversity of avifauna (400+ bird species recorded with about 270 species observed on a regular basis [Cooper, 2004]) using the Sea and associated landscapes illustrates the area's ability to provide resources and its value to such a wide range of species. This ability to provide resources to a diverse assemblage of birds, coupled with their high visibility, render birds an ideal assessment tool for evaluating potential changes in future resource abundance. Birds are, therefore, used in this assessment to define the landscape features or habitat types providing resources at risk, and as indicators of how successful future restoration strategies may be in providing habitat resources to area wildlife.

Not all habitat types currently providing resources would be affected by future reductions in water inflow to the Sea and associated changes in water quality.

Essentially, habitat types of interest include components of the Sea (shoreline, open water, islands, and constructed wetland complexes), and associated unmanaged wetlands (associated with the three rivers, major drains, and ephemeral pools that may develop in the exposed Seabed). Other types, such as freshwater marshes managed by wildlife agencies or agricultural fields providing food for numerous species, would not be directly affected by future changes in water management (DWR, 2006). These habitat types and the birds that use them are not addressed in this assessment.

Birds that use the habitat types that would be most affected by reduced water inflow and changes in water quality are generally known as semi-aquatic water birds, and can be grouped into several functional groups, such as fish-eating divers, shorebirds, long-legged waders, etc. (Shuford et al., 2000). The principal resources provided by habitat types at risk are food and cover (secure sites used for roosting, loafing, and or nesting). Principal food resources are fish and invertebrates; snags and small islands provide security (DWR, 2006). The habitat types of interest in this assessment and the bird groups that use them are identified in **Table 5.1**.

Table 5.1 Avifauna functional groupings associated with various landscape features (habitat types) present within and/or adjacent to the Salton Sea

Avifauna Functional Groups[1]	Shoreline[2]	Open Water[3]	Islands and Snags[4]	Wetlands[5]
Fish-eating divers	x	x	x	x
Gulls, terns, and skimmers	x	x	x	x
Invertebrate-eating divers	x	x		x
Diving ducks	x	x		x
Shorebirds	x			x
Long-legged waders	x		x	x
Rails, bitterns, and moorhens				x
Dabbling ducks				x

[1] Groupings generally follow the descriptions provided by Shuford et al. (2000). The groupings imply that representatives generally occur in or use the indicated habitat types. Comparisons are best for fish-eating and invertebrate-eating birds (top seven groups), and become mixed with birds employing mixed foraging strategies. For example, cattle egrets (long-legged waders) can be found along the shoreline, but are more commonly observed feeding in agricultural fields and roosting away from the Sea. In addition, the distinction between shoreline and wetlands becomes less clear in certain delta sites.

[2] Shoreline is operationally defined as the wetted surface area (acres) of the Sea from the edge of water to a depth of 6 feet.

[3] Open water is operationally defined as the wetted surface area (acres) of the Sea from a depth of 6 feet to the maximum depth.

[4] Islands and snags are used by some avian groups for nesting sites and/or roosting sites. These features are currently located at the north and south ends of the Sea.

[5] These wetlands occur along canals, drains, creeks, and other locations, and are not managed as habitat. Principal vegetation includes cattail-bulrush marshes and/or varying densities of salt cedar (tamarisk).

Both features that provide security, and sites that provide food, can be developed and operated to provide habitat resources for wildlife using the Salton Sea area. Food is the major issue confronting resource agencies and the relevant questions involve "how much" and of "what quality." Current approaches generally look at bird use of existing habitat types to provide insight into future area requirements for habitat restoration features. For example, the shoreline habitat type is generally recognized as providing abundant food resources as defined by high bird use (Shuford et al., 2000; DWR, 2006). Recent estimates of the areal coverage of "shoreline," based on depth, range from about 6,000 acres (0-3 feet deep, DWR, 2006) to about 12,000 acres (0 to 6 feet deep, Reclamation, unpublished data). The area producing abundant food resources—again defined by bird use—increases to about 38,000 acres when a "nearshore" habitat type (water's edge to 1 kilometer offshore) is considered (DWR, 2006). One could infer that the area—or "how much"—needed to provide or replace this food resource ranges between 6,000 and 38,000 acres depending upon management objectives. Potential restoration strategies evaluated in this report address the question of "how much" through different sized marine lakes, or different sized SHC, or different combinations of the two food-producing concepts.

Addressing the question of "how much" food also requires an evaluation of "what quality." The question of food quality is important when addressing Salton Sea issues because of the presence of Se in agricultural waste water that would be used in restoration efforts. Se effects associated with avian reproductive impairment have been widely studied and extensively documented. In aquatic birds that feed on fish and/or invertebrates, accumulated Se can impair reproduction by affecting egg viability and/or producing deformities in developing embryos. Bioaccumulation is a concern because some species at the Salton Sea currently exhibit Se egg concentrations associated with reduced egg viability in other locations (Setmire et al., 1993; Bennett, 1998). Consequences of these elevated Se concentrations have not been determined, but it is assumed that any increase in Se levels in area food chains would increase the risk of additional Se bioaccumulation for breeding birds. Because Se-induced reproductive impairment is dose responsive (Skorupa, 1998), an increased risk of Se bioaccumulation—to birds that may be currently on the threshold of experiencing reduced egg viability—should be avoided.

Objectives

Reclamation's principal objective in this study is to attempt to identify a restoration approach that retains the Salton Sea's historic habitat function of providing quality habitat resources:

- To an abundant and diverse assemblage of fish and wildlife species.
- At a level sustainable within the constraints of future water availability and water quality.

This assessment of restoration alternatives evaluates the acreages of habitat type developed—with a focus on shoreline and open water—and then attempts to characterize, to the extent possible, the risk of increased Se bioaccumulation in both fish-eating and invertebrate-eating birds that may be associated with features of each alternative management plan.

Landscape Features/Habitat Types

Three landscape features were selected—shoreline, open water, and wetlands (both non-managed and constructed) for evaluation in this report. These features are operationally defined as:

- *Shoreline*: The surface area of the Sea from water's edge to a depth of about 6 feet in areas with selenium in sediments less than or equal to 2.5 mg/kg and salinity less than or equal to 250 g/L. This feature provides food resources for breeding, migrant, and some wintering shorebirds, dabbling ducks, and diving ducks (e.g., ruddy ducks). A depth of 6 feet was selected to represent the photosynthetic zone (Holdren and Montano, 2002).

- *Open water*: The surface area from depths of about 6 feet to the deepest portions (about 51 feet) of the Sea with salinity values less than or equal to 60 g/L. During the months of November through about May, this feature supports oxygen throughout the water column and can be quite productive depending on salinity concentrations (Holdren and Montano, 2002). June through October, approximately the top 6 feet of this type receives both light and oxygen, while deeper water becomes anoxic. Seasonally, this type provides food resources for invertebrate-eating diving birds such as eared grebes, and if fish are present, fish-eating diving birds such as brown pelicans.

- Wetlands (both non-managed and constructed)

    1. *Non-managed wetlands*: Often develop along rivers and in association with irrigation waste water drains emptying into the Sea. While cattail-bulrush marshes also occur in constructed wetlands in Federal, State, and private sites, the focus here is marshes that are not managed as wildlife habitat. The second type of wetland of interest supports salt cedar (tamarisk) and commonly occurs along the Alamo, New, and Whitewater Rivers and along some drains. This feature is also non-managed.

    2. *Constructed wetlands*: Also known as “saline habitat complexes” do not currently exist at the Sea. These features would be constructed to mimic shoreline and some deeper water sites that currently produce habitat resources, but would be lost in the future. Some shoreline areas—such as the deltas of the three rivers—are believed to be the most productive landscape features because of the high bird use they receive.

Bird Groups

Landscape features discussed above provide resources for large numbers of birds. The value of these resources is best understood by understanding how various functional groupings of birds use landscape features to obtain resources. Birds that use these resources can be grouped as follows:

- *Fish-eating divers*. These are large fish-eating birds such as brown pelicans (federally endangered), double-crested cormorants, and American white pelicans (although these birds generally do not dive). American white pelicans and cormorants are most numerous in winter, and brown pelicans and cormorants are present during the breeding season (Shuford et al., 2000). Bird numbers within this group are declining as fish disappear. Pelicans and cormorants roost in the deltas of the New and Alamo Rivers.

- *Gulls, terns, and skimmers*. Eighteen species of gulls and terns have been recorded at the Sea, with the largest numbers found during the winter months (Shuford et al., 2000). Common species include California, herring, and ring-billed gulls. These birds are also mainly dependent on fish as food, although some, such as ringed-billed gulls, forage in agricultural fields in winter for invertebrate food. All species reach peak numbers in summer or fall.

- *Invertebrate-eating divers*. Eared grebes are the most abundant species in this group. The Salton Sea is an important area for eared grebes, with an estimated 90 percent of North America's population passing through the Salton Sea in some years (Shuford et al., 2002). Some eared grebes can be found year-round, but the largest numbers are found at the Sea during winter. Western and Clark's grebes reach peak numbers in summer.

- *Shorebirds*. Shorebirds use the Sea's resources during the breeding season, as migrants, and during winter. For example, breeding shorebirds include black-necked stilts, snowy plovers, American avocets, and others. These birds nest on shoreline sites adjacent to the Sea and feed on invertebrates. Examples of migrant shorebirds include numerous species, such as the western sandpipers that pass through the area in spring and fall. The shoreline is used for feeding and loafing and some feeding in agricultural fields occurs depending on species. Common species include western sandpiper, American avocet, dowitchers, phalaropes, black-necked stilts, snowy plovers, and others (Shuford et al., 2000). Finally, examples of wintering shorebirds include willet, marbled godwit, snowy plovers, and least sandpipers. As with migrant shorebirds, wintering shorebirds use the shoreline for feeding and loafing, and some feeding in agricultural fields occurs depending on species.

- *Diving ducks*. The principal representative of this group (89 percent) is the ruddy duck that uses the Sea for feeding on invertebrates and some submerged vegetation. Some divers also nest in adjacent marshes. Winter surveys indicated that diving ducks make up about 11 percent of all waterfowl using the Sea and adjacent areas (Shuford et al., 2000).

- *Long-legged waders*. This is a mixed group of egrets and herons. Some individuals, such as the great blue heron, feed on animal prey from adjacent brackish and/or freshwater marshes, while some (e.g., cattle egrets) feed in agricultural fields and roost away from the Sea (Shuford et al., 2000). Their link to the Sea lies in its support of adjacent wetlands and trees/snags for roosting/nesting.

- *Dabbling ducks*. Largest numbers of dabbling ducks occur in winter, and only five species are known to nest at the Salton Sea (Shuford et al., 2002). Dabbling ducks comprise about 48 percent of all waterfowl in winter surveys (Shuford et al., 2000). This group uses managed and non-managed marshes adjacent to the Sea. Common species include mallards and northern shovelers.

- *Rails, bitterns, and moorhens*. This group consists of birds that are generally year-round residents. Species include the federally endangered Yuma clapper rail, black rails, American coot, least bittern, common moorhen, and others. These birds are generally limited to managed and non-managed cattail-bulrush marshes common at the south end of the Sea.

- *Geese*. This group consists almost exclusively of snow and Ross's geese. Geese make up about 41 percent of all waterfowl in winter surveys (Shuford et al., 2000). Geese use the south end of the Sea and are found almost exclusively found in managed marshes such as the Salton Sea National Wildlife Refuge, Wister Unit, and duck clubs.

Of these nine groups of birds, geese would likely be least affected by future trends in water supply, salinity, and selenium concerns. This observation is based on their almost exclusive use of managed wetlands at the south end of the Sea that receive water from the Colorado River. Habitat resources are likely secure at these sites for the foreseeable future. For this reason, geese have been removed from further treatment in this assessment. **Table 5.1** combines the concepts of landscape features providing habitat resources and the functional groups of birds using these features.

Assessment Methods

Habitat is a concept that requires an operational definition to facilitate the communication of impacts during the assessment process. Habitat provides resources for species, or in this assessment, landscape features provide resources for functional groups of water birds using the Salton Sea. **Table 5.1** provides the operational definition of habitat for this assessment. The principal resources provided by landscape features—now "habitat types"—is food. Principal food resources are fish and invertebrates.

Two issues are associated with food. First, the assessment is concerned with food abundance for the various avifauna groups listed in **Table 5.1**. Two parameters are used in this assessment to characterize food abundance: acres of the habitat type, and salinity. Different habitat types will change in coverage and salinity as water supply is reduced in the future. For example, the Salton Sea will change from a "marine sea" with a certain size and salinity to a "brine basin" with a smaller size and higher salinity in the future. These changes will be accompanied by changes in food available to area birds. (These changes are discussed later under No-Project conditions.)

As presented in Chapter 4, the Sea will become smaller and more saline in the future. These changes will affect the surface area available (e.g., shoreline and open water) to produce food and also the ability (e.g., increasing salinity) of the reduced surface area to produce food. Although multiple variables are likely associated with the production of food (fish and invertebrates) and its use by birds, a simple approach of comparing habitat type (shoreline, open water, and wetlands) area, as modified by salinity and possibly Se risk, was used to evaluate effects on avian groups using the Salton Sea.

Both Reclamation's analysis and DWR's Salton Sea Ecosystem Restoration Program draft PEIR analysis focus on acres of available habitat types now and in the future. Both approaches recognize bird use numbers as an indicator of habitat quality. Area (acres) is one of the two generally accepted components defining habitat quality. The second component—resource abundance as supported by the physical attributes of the area—was treated qualitatively by Reclamation using modifiers such as salinity, eutrophication, and potential for selenium bioaccumulation. The PEIR approach treats resource abundance through weighted bird density values for a select group of species using the Sea. Because bird- use numbers are highest at shallow shoreline sites, alternatives that include large areas of facilities mimicking shallow shoreline were considered in both approaches through incorporation of Saline Habitat Complex features.

Any bird-density approach should be carefully evaluated to determine how numbers of individual birds would affect management goals. For example, DWR's PEIR habitat capacity ranking approach currently relies on data for 14 species. The brown pelican and Yuma clapper rail—species of Federal concern—are not included. Of the included species, annual use of the Salton Sea ranges from a few hundred individuals to more than one million, and seasonal use ranges from one or two seasons to year-around. The species were selected based on density-data availability and illustrate how such information can be used. No species specific management goals currently exist for Salton Sea resources.

It is recognized that some individuals may have a preference for one habitat type over another. Depending on species considered, some habitat types may have higher values. Reclamation treated all habitat types uniformly relative to bird values in general. However, it is recognized that more birds at the Salton Sea tend to use the shallow water areas in and around the Sea. This study emphasizes the importance of shallow saline habitat areas through incorporation of Saline Habitat

Complex features. Regardless of whether you evaluate habitat values in terms of densities acquired by past observations or by landscape feature values, both approaches incorporate inherent subjectivity. Neither approach tries to give weight to one habitat type over another.

Both of the above approaches attempt to deal with the uncertainties of a complex system that will continue to change throughout the life of the proposed project to 2078. Reclamation believes that a bird-density approach to defining habitat quality may be a valuable tool once additional studies identify the capability of constructed facilities to provide safe and abundant food, and nesting and loafing sites; and specific management goals are developed that address and prioritize individual species needs by season within the constraints of water availability and water quality. A progressive and adaptive approach to habitat development would provide the framework for further exploration of these issues.

Area Determinations

The area of shoreline and open water habitats were determined for the marine lakes, residual Sea (brine basin), and SHC proposed for each alternative, including the No-Project Alternative. Different features would be developed at different times and, thus, would provide varying amounts of habitat resources. The actual future timing of events, including feature development associated with the alternatives, is unknown. However, for the purposes of analysis, four time periods were evaluated. Changes in acres of marine lakes, brine basins, and SHC were estimated for each period, and descriptions of conditions at the end of each period were developed. The following periods were evaluated:

- 1999–2006 (i.e., current conditions) (2006)
- 2007–2023 (2023)
- 2024–2040 (2040)
- 2041–2078 (i.e., the conclusion of the study period) (2078)

It was assumed that because of the time needed to complete analyses, obtain the necessary permits, secure funding, and complete design and construction, the various features of the alternatives would not become functional until 2024. Therefore, conditions under the first period (1996–2006) and second period (2007–2023) would be the same under all alternatives, including No-Project. Following a rapid reduction in inflow after year 2018, the Sea would begin a rapid reduction in surface area and increase in salinity.

It was assumed that during the third and fourth periods (2024–2040 and 2041–2078), the various features of the alternatives would be in place and functional. All alternatives would approach environmental equilibrium by year 2040. The residual Sea would continue its decline during these periods. During the third period (2024–2040), salinity concentrations within the brine basin would likely reach levels favoring brine flies and brine shrimp and would mark a significant change in the character of residual food chains.

Salinity concentrations, important in defining the type and relative abundance of food present for bird use, were estimated for each habitat type and time period. Nutrient levels are also important in determining food item abundance. The Sea is currently in a hypereutrophic condition and is expected to remain that way for some time. In this analysis of bird habitat resources abundance, nutrients were assumed to be non-limiting.

Salinity Concentrations in Habitat Types

Salinity concentrations are estimated for each habitat type and time period as described above. Salinity concentrations (as described below) are important in defining the type and relative abundance of food present for bird functional groups.

Nutrient levels are also important in determining food item abundance. The Sea is currently in a hypereutrophic condition and is expected to remain that way for some time. In this analysis of bird habitat resource abundance, nutrients are assumed to be non-limiting, although the reader is encouraged to explore the sections in this document on nutrient cycling and eutrophication.

Selenium Concerns

Brine fly larvae.

Dilution is likely a significant process in reducing initial inflow Se concentrations (5-10 micrograms per liter [µg/L]) to observed Sea concentrations (1-2 µg/L). The Sea currently contains about 7.2 million acre-feet of water with an annual inflow of about 1.23 million acre-feet. When a large volume of water (the Sea) with a low concentration of some constituent receives a smaller flow of water with a higher concentration of that constituent, dilution occurs. Setmire et al. (1993) described the dilution process for sample sites at the mouth of the Alamo River. At these sites, total Se concentration in river water went from 6.35 µg/L to less than 2.4 µg/L in the interface mixing zone between the river and the Sea. Se species composition went from about 60 percent selenate to predominantly selenite.

Selenium exhibits a complex chemistry in natural systems (**Figure 5.1)**. Dilution alone cannot explain current Se concentrations in Sea water. Indeed, Schroeder

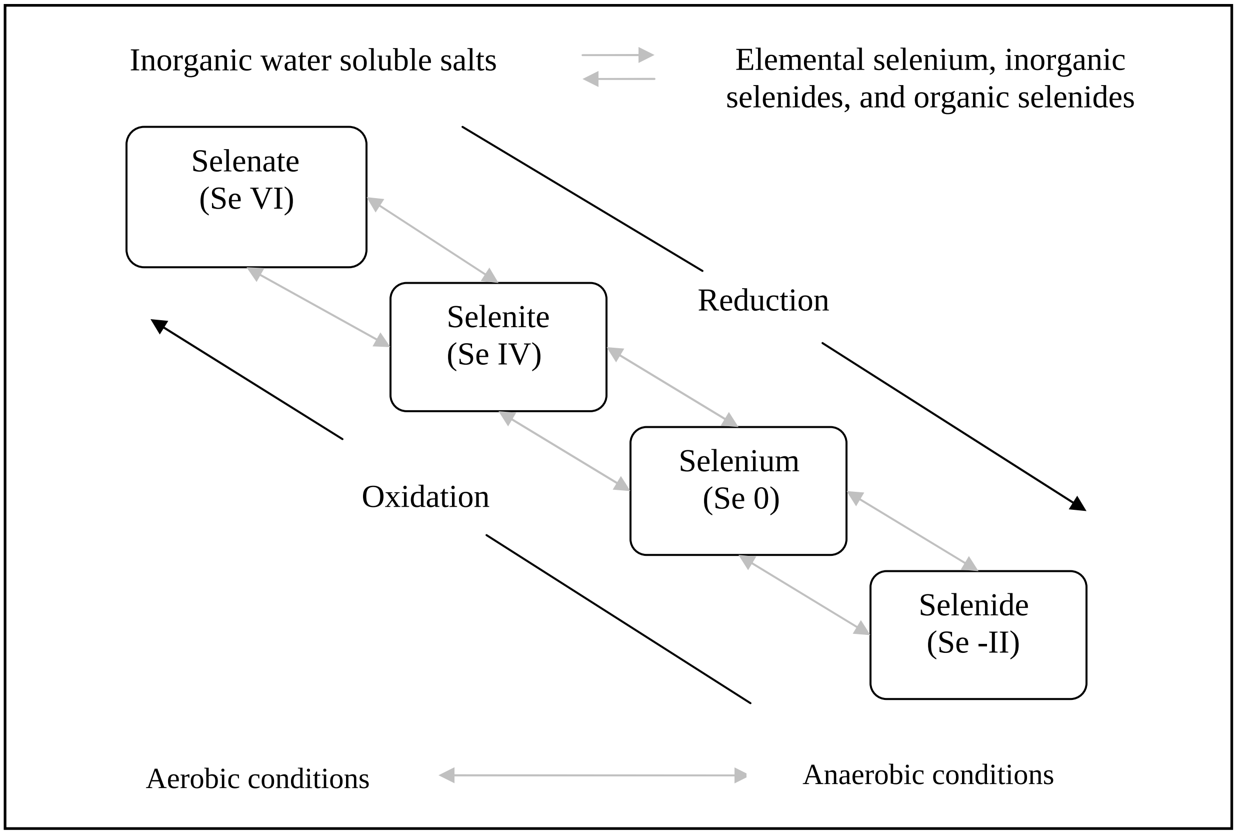

Figure 5.1 Selenium exhibits a complex chemistry in natural systems. The above schematic depicts the general relationships between the four valence forms or oxidation states of selenium. As implied, forms can be converted to other forms under the proper chemical and/or biological conditions.

and Orem (2000) have estimated that if Se were to have continued to accumulate within the water column, as have other constituents such as chloride, its concentration would have risen to about 400 µg/L. It is currently believed that anaerobic bacteria play a significant role in the removal of Se from the water column (Setmire et al., 1993). Schroeder et al. (2002) found no selenate in Sea water—even in the oxygenated surface water. Selenite composed about 33 percent of total Se in the upper 4 m, but no selenite was detected in deeper water. The bulk of Se entering the Sea is sequestered in bottom sediments in the elemental form and as non-volatile organic selenides. Any change in future conditions that would alter the dilution functions and/or affect the anaerobic bacterial Se processing mechanisms currently in place should be carefully evaluated for increased Se concentrations. For this study, the potential for increased risk of Se bioaccumulation in future food chains was evaluated qualitatively. The evaluation was based on the predicted depth, salinity, Se levels, and other factors of the alternative features. Five risk categories were identified:

- ***Low Risk***: Problems are evident but do not require mitigation measures
- ***Moderate Risk***: Problems are evident and may require mitigation
- ***Serious Risk***: Problems create significant threats—mitigation required
- ***High Risk***: Problems require extreme measures that may result in additional unforeseen problems and risks
- ***Fatal***: No solution for problems currently exists

Potential Changes in Selenium Risk

The other issue associated with food involves the quality of food. Different future management scenarios, including no project, will face the challenge of increasing selenium levels in the drainwater entering the Sea and/or used in future management activities. A great deal of uncertainty is associated with predictions of how selenium will respond in future systems. Selenium concerns for the Salton Sea focus on the uncertainties associated with the interactions of the physical, chemical, and biological components that would characterize the future no project system, and/or future systems that would result from the various management alternatives. The future Salton Sea system may support selenium cycling similar to the current situation, or a different system—with a different selenium risk to local food chains—may be supported.

Selenium is a consideration in Salton Sea studies because of the potential for bioaccumulation in aquatic food chains supporting abundant and diverse bird use of the area. Bioaccumulation can occur when selenium is acquired from one level of a food chain and passed on to the next higher level. For example, selenium can be accumulated from water and/or sediments by bacteria and algae and passed on to macro-invertebrates that feed on them. Birds that feed on the macro-invertebrates would then accumulate larger amounts of selenium. Under certain conditions, selenium can accumulate to toxic levels in food chains (e.g., in birds).

Selenium can bioaccumulate in aquatic food chains until it reaches levels that can adversely affect fish-eating and invertebrate-eating birds. Because a great many variables interact on and within the food chain, it is difficult to predict a response based only on various selenium concentrations in water, sediments, primary and secondary producer, etc. Because of these uncertainties, egg concentrations have become an important assessment standard for selenium risk in birds. The embryo is the most selenium-sensitive stage in a bird's life cycle, and egg concentrations avoid the uncertainties mentioned above for various environment concentrations, and permit the identification of a reproductive toxicity threshold.

The reproductive toxicity threshold for bird eggs has been identified at about 10 micrograms per gram (µg/g) dry weight (Heinz, 1996). At these concentrations, the most sensitive indicator of reproductive toxicity—reduced egg viability (hatchability)—begins to appear and can be measured. The 10 µg/g is a general value for all birds with some species exhibiting reduced egg viability at lower concentrations, and some at higher concentrations. It is important to note that under the proper conditions, these levels of selenium in eggs can develop from much lower concentrations in food. **Table 5.2** identifies selenium levels in various media and their importance.

Table 5.2 Selenium effect levels (U.S. Department of the Interior 1998). Several authors have published similar guidance with minor variations in values. All indicate a small range of values between "no effect" and "toxicity threshold" levels

Medium	No Effect	Level of Concern	Toxicity Threshold
Water (parts per billion [ppb], total recoverable)	<1	1-2	>2
Sediment (parts per million [ppm], dry weight)	<1	1-4	>4
Dietary (ppm, dry weight)	<2	2-3	>3
Waterbird eggs (ppm, dry weight)	<3	3-6	>6
Warmwater fish (ppm, whole body dry weight)	<3	3-4	>4
Coldwater fish (ppm, whole body dry weight)	<2	2-4	>4

This assessment attempts to characterize, to the extent possible, the risk of increased bioaccumulation of selenium in both fish-eating and invertebrate-eating birds associated with various features that would be parts of the proposed management scenarios, and aspects of no action conditions. The negative impacts of interest from increased bioaccumulation of selenium deal with egg viability (hatchability). Reduced hatchability reduces potential recruitment into local and regional populations.

Alternative Assessment

The current suite of six alternatives is evaluated below. To reduce redundancy, the discussion makes frequent reference to material presented in the previous sections, especially no project conditions. Again, for the purposes of analysis, it has been assumed that all management alternatives would become functional in the period 2024–2040. As previously discussed, it is assumed that conditions for all alternatives would be similar to the No-Project conditions until about 2024. For this reason, No-Project conditions are presented through the first two periods without reference to other alternatives. Changes in area coverage of habitat types and changes in salinity, and the effect of these changes on biota are first discussed followed by a discussion of selenium issues resulting from these changes.

Alternative No. 6: No-Project

The No-Project Alternative is discussed in four time periods as follows.

1999–2006 Conditions

As recently as 1999, the Salton Sea supported one of the world's most productive fisheries (Cohen, 2000). The fish and other aquatic organisms associated with it supported abundant year-round avifauna use. More than 400 bird species have been recorded at the Sea, and more than one-half million water birds were surveyed in 1999 (Shuford et al., 2002). Nutrient-rich, highly productive waters support short food chains that provided abundant forage for birds during migration, the winter months, and during the breeding season. Food chains are of two basic types. The first food-chain begins with pileworms, bacteria, and amphipods that live in the bottom sediments and recycle detritus (Setmire et al., 1993). There are currently about 20 macro-invertebrate species in Sea, including rotifers, copepods, amphipod, pileworms, and barnacles. Several species of fish (e.g., croaker and sargo) historically fed on theses prey items and were in turn fed on by other fish (corvina) and/or fish-eating birds (pelicans and cormorants). The second food-chain involves phytoplankton, zooplankton, macro-invertebrates, and invertebrate-eating birds.

Since 1999, the salinity concentration of the Sea has increased, and several large fish-kills have occurred. Tilapia, a species that feeds on plankton, is the only major fish species remaining over large portions of the Sea. Tilapia have also experienced large die-offs during recent years. The reduction in fish abundance has resulted in a reduction of fish-eating birds during this period.

Area and Salinity Considerations. Physical conditions at the end of this period (2006) can be summarized as elevation ranging from -230 to -232 feet msl, salinity ranging from 49 to 54 grams per liter (g/L), and surface area ranging from 225,000 to 229,000 acres. Reductions in acreages of landscape features providing habitat resources would continue during this period. Shoreline would occupy about 13,803 acres, and open water would occupy 213,132 acres.

Selenium Considerations. The Salton Sea currently supports a salinity regime that generally dictates the fate of chemical constituents entering the Sea via drainwater. For example, a significant proportion of total selenium concentrations in the New and Alamo Rivers is in the selenite (+4 oxidation state) and selenate (+6 oxidation state) oxidation states. These states are water soluble, but are generally less available (particularly selenate) for higher organisms to use (**Figure 5.1**).

For example, organic selenides are the most bioavailable forms (i.e., can enter metabolic pathways with minimum or no alteration) while selenates are among the least bioavailable forms (i.e., require reduction for metabolic processing). However, selenate and selenide are readily taken up by plants and microorganisms and transformed into various organic selenides (Fan et al., 2002). Elemental selenium and inorganic and organic selenides are relatively water insoluble, but can absorb to particulates within the water column.

A potential increase in bioaccumulation is important because aquatic birds using the Salton Sea may be on the threshold of reproductive toxicity from area selenium levels. Bird eggs from the Salton Sea had selenium concentrations of 1.6–35 µg/g (Setmire et al., 1993), and black-necked stilts—a species moderately sensitive to selenium—experienced an estimated 5-percent reduction in egg viability linked to selenium in 1993 (Bennet, 1998; Skorupa, 1998). Currently, selenium levels in bird eggs vary with functional group, with fish-eating birds and invertebrate eating birds exhibiting the highest values.

2006–2023 Conditions

Major changes would occur during this period.

Area and Salinity Considerations. Physical conditions at the end of this period (2023) can be summarized as elevation ranging from -243 to -249 feet msl, salinity ranging from 93 to 123 g/L, and surface area ranging from 169,000 to 190,400 acres. Although the area of shoreline is predicted to increase somewhat during this period (estimated at 18,691 acres), open water would continue to decline in area coverage (estimated at 0 acres due to salinity exceeding 60 g/L). As discussed below, increasing salinity levels would alter food chains during this period. Islands and snags used by numerous species (**Table 5.1**) would be connected to land by receding water levels.

This period would witness a combination of gradual adverse effects to biological resources (2006–2017), and then an acceleration of adverse effects as inflows into the Sea are reduced after 2017. Major system changes would likely occur during this period:

- Tilapia would functionally disappear as the Sea reaches a salinity of about 64–65 g/L, meaning there would be no major food source for fish-eating birds While some fish would persist in the river deltas and drains, the prey biomass necessary to sustain current numbers of fish-eating birds would disappear.

- Mullet Island and other islands used for roosting and nesting by a variety of birds will no longer be islands. The connection of these sites to shore would likely expose them to terrestrial predation. Birds currently using these sites may abandon them.

- The reduction in Sea surface elevation would expose and thus eliminate from use most existing barnacle substrate. Barnacles would all but disappear in the 2017–2019 period as hard substrates are exposed to air and salinities exceed 70–80 g/L tolerances (Cohen and Nyun, 2006).

- Pileworms would disappear during this period; salinity of about 75 g/L is the limit for these organisms. Some may persist in estuaries (New and Alamo Rivers inflow areas), but reduced suitable substrate would also limit pileworms.

- Copepods would persist until salinity exceeds 90–100 g/L (about 2022–2023).

- Water boatmen would increase as fish disappear and would feed on phytoplankton, brine shrimp, and brine fly larvae. Boatman can tolerate salinities of 110 g/L and have been observed in situations with salinities of 126 g/L.

- Brine fly larvae and brine shrimp would be dominant macro-invertebrates within 20 years as salinity levels eliminate copepods and water boatmen. As predators disappear, brine flies would explode. Brine fly larvae can tolerate salinities as high as 330 g/L. Brine shrimp can persist at salinities of 295–346 g/L. Both species would, however, decline significantly at levels above 250 g/L.

In summary, rising salinity levels during this period would cause a transition in food-chain structure from detritus to pileworms/copepods to fish to birds to structure of phytoplankton to brine flies and brine shrimp (with an intermediate period of water boatmen to birds). There may be reduced levels of invertebrate forage during this transition period, and invertebrate-feeding birds such as diving ducks and invertebrate-feeding divers would likely seek alternative feeding locations.

Fish-eating birds would be affected as soon as tilapia populations decline during this period. Fish-eating divers (pelicans and cormorants) may supplement their diets with sailfin mollies and pupfish that use the Sea, but sufficient biomass would not exist to support current use levels. In addition, nesting and roosting sites would be connected to land during this period and thus loose their security value. With the loss of habitat resources during this period, these birds may abandon the Sea.

Fish-eating gulls and terns may persist on pupfish and mollies for the next 15–17 years. Although some food base would remain, breeding sites—small areas surrounded by water—would likely disappear, and this group would likely abandon the Sea.

Selenium Considerations. Three events will occur during this period that may affect selenium concentrations in the residual Sea. These events include:

- Selenium concentrations in drainwater may increase as irrigation operations move to reduce tailwater. Mitigation water would also end during this period. Collectively, higher concentrations of selenium would likely be discharged into the Sea in remaining drainwater.

- Wetlands associated with the three rivers and drains carrying increased concentrations of selenium in drainwater would be at increased risk of selenium bioaccumulation in wetland food chains. The bird groups at risk are listed in **Table 5.1** and include the endangered Yuma clapper rail.

- The Sea would be shallower and more prone to mixing. Increased mixing may re-suspend bottom sediments containing sequestered selenium. Increased mixing may increase the internal loading of selenium within the Sea.

- Ephemeral and/or semi-permanent pools would likely form in the exposed sediments of the Sea floor as the Sea recedes. Residual pools may receive periodic or sustained water supply from limited local precipitation, seeps, and/or discharge from drains that have historically emptied directly into the Sea. Dust control efforts may also contribute water to such sites. Depending upon where they form, how long they persist, and the level of evapo-concentration that occurs, residual pools could support very high selenium concentrations.

These events could individually or collectively lead to increased selenium concentrations at some sites or for the entire Sea. The uncertainty lies within the interactions among the physical, chemical, and biological components of the changing future system. The potential exists for both an increase in selenium from drainwater entering the Sea and for an increase in selenium as it is released from mixed and/or exposed sediments. Selenium in natural systems can be a complex issue (**Figure 5.1**).

Individual nesting pairs or localized colonies may be at increased risk if they are in feeding proximity to ephemeral pools.

2024–2040 Conditions

Major changes in the invertebrate community would occur during this period, with a subsequent response from invertebrate eating birds.

Area and Salinity Considerations. Physical conditions at the end of this period (2040) can be summarized as elevation ranging from -254 to -265 feet msl, surface area ranging from 117,800 to 154,600 acres, and salinity ranging from about 123 g/L to 250 g/L. Reductions in acreages of habitat types and habitat resources would continue during this period. Although a large surface area of saline water would be present, salinities would be assumed to exceed 250 g/L during this period. At this level, it would be assumed that brine flies and brine shrimp that reached maximum abundance during the previous period would be functionally eliminated during this period. The differentiation between shoreline and open water would become meaningless. Salt-tolerant green algae and salt-tolerant bacteria would likely dominate the Sea, with high levels of viruses (Cohen and Hyun, 2006). It is assumed that in this condition, the residual Sea would provide no habitat resources for area avifauna.

Adjustments to habitat resource abundance (i.e., food) begun during the last time period would continue during this period. Fish-eating birds, whose numbers would have been substantially reduced during the last period as tilapia disappeared, would likely abandon the Sea. Some fish would be found in drains and the rivers, but not at a level to maintain numbers of fish-eating divers and gulls, terns, and skimmers.

Selenium Considerations. Selenium concerns would likely be reduced during this period with the removal of macro-invertebrates from the residual Sea. Bird use of the Sea would likely be a small fraction of the numbers and diversity present during the 1999–2006 period.

As discussed above, selenium concentrations in residual pools formed in exposed Sea-bed sediments may be high due to alternate wetting and drying cycles. Depending upon where they form, how long they persist, and the level of evapo-concentration that occurs, residual pools could support very high selenium concentrations. However, because of the lack of food resources in the adjacent residual Sea, the attractiveness of these sites may be reduced. Reduced use by area birds—especially shorebirds—would reduce the selenium risk.

2041–2078 Conditions

Conditions would be very similar to the previous period.

Area and Salinity Considerations. Physical conditions at the end of this period (2078) can be summarized as elevation ranging from -255 to -265 feet msl, surface area ranging from 116,400 to 151,200 acres, and salinity ranging from about 189 g/L to 250 g/L. Although a large surface area of saline water would be present, high salinities would prevent survival of most organisms. Salt tolerant green algae and salt-tolerant bacteria would likely dominate the Sea, with high levels of viruses (Cohen and Hyunm, 2006). It is assumed that in this condition, the residual Sea would provide no habitat resources for area avifauna.

Selenium Considerations. Conditions would likely be very similar to those described for the previous period. Although areas of high selenium concentrations (e.g., residual pools in exposed sediments) may exist, the overall unattractiveness of the area (no food) may limit use of these sites.

Summary of No-Project Conditions

Salinity and acreages for four habitat types providing resources to birds using the Salton Sea are illustrated in **Table 5.3**.

Table 5.3 Salinity values and acres for four habitat types during four time periods under the No-Project Alternative

	Shoreline	Open Water	Islands and Snags	Resources Present
2006				
Salinity (g/L)	49 to 54	49 to 54	Present	Invertebrate food Fish Islands and Snags
Acres	13,803	213,132		
2023				
Salinity (g/L)	93 to 123	93 to 123	Absent	Invertebrate Food
Acres	18,691	0		
2040				
Salinity (g/L)	123 to 250	123 to 250	Absent	No Resources
Acres	[1]	[1]		
2074				
Salinity (g/L)	189 to 250	189 to 250	Absent	No Resources
Acres	[1]	[1]		

[1] The differentiation between shoreline and open water would become meaningless at salinity levels near or above 250 g/L.

As recently as 1999, the Salton Sea provided abundant food and secure nesting, roosting, and resting sites for large numbers of birds. Several functional groups—primarily fish-eating and invertebrate-eating birds—used the habitat resources provided by the Sea’s shoreline, open water, islands and snags, and associated wetlands (**Table 5.1**). Rising salinity levels, along with water quality issues, reduced the already declining fish populations further between 1999 and 2006.

In the period 2006 to 2023, significant changes would occur in biota supported by the Sea and bird populations using the Sea and its habitat resources. An accelerated reduction in the Sea’s elevation after the termination of mitigation water in 2017, with an accompanying increase in salinity, would change the structure of food chains historically supported by the Sea. Fish, pileworms, and most other macro-invertebrates that now populate the Sea’s food chains and support the fish-eating and invertebrate-eating bird groups listed in **Table 5.1** would disappear. In addition, secure sites (islands and snags) would be connected to land by receding water levels and loose their habitat value. Fish-eating divers and gulls, terns and skimmers—represented by pelicans, cormorants, terns, and others—would loose their food supply and nesting/roosting sites (**Table 5.1**).

Other groups, such as invertebrate-eating divers (e.g., eared grebes), shorebirds (e.g., snowy plovers), and diving ducks (ruddy ducks) would loose their traditional food items and be forced to use brine flies and brine shrimp or else abandon the Sea. Some fish and some invertebrate communities would persist in the mixing zones and fresh water lenses at the mouths of the three rivers. However, the food biomass needed to support the abundance and diversity of avifauna historically supported by the Sea would not be present. Abundance and diversity of birds using the Sea would decline during this period.

The periods 2024–2040 and 2041–2078 would be very similar with salinity levels in the residual Sea rising above the 250 g/L value in the former period and continuing to rise in the latter period. Most fish and macro-invertebrates would have disappeared at much lower salinity levels during the previous period (2006–2023). This salinity value (250 g/L) is significant because it is the level assumed to impact brine flies and brine shrimp. Above this salinity level, the Sea would be functionally devoid of macro-invertebrates. But before reaching this level, salinity would rise during the 2023–2040 period through levels that would provide optimum conditions for these two macro-invertebrates, and densities should reach maximum levels. Certain species within the functional groups identified in Table 5.1 (e.g., eared grebes, ruddy ducks, and some shorebirds) may exploit this abundant food supply. Numbers of these birds using the Salton Sea during this period may be high. However, as salinity values exceed optimum levels for brine flies and brine shrimp, bird numbers would likely decline until both prey and the birds using them will reach low numbers. The period 2041–2078 would be characterized by low resource abundance and low numbers of birds using the Salton Sea.

It is generally believed that selenium concentration within drainwater entering the Sea will increase in the future as other demands are placed on dilution water. Increases in selenium concentrations in drainwater would likely increase selenium within associated wetland food chains and the birds that feed in such sites. A limited fishery would likely persist in the rivers and surface drains that carry water. Currently, surface drains support desert pupfish, tilapia, sailfin mollies, mosquitofish, carp, longjaw mudsucker, and redfin shiners (Setmire et al., 1993). Some fish samples taken from drains exceed the dietary threshold levels of concern for selenium (**Table 5.2**). These fish are fed upon by long-legged waders such as great blue herons, great egrets, green-backed herons, snowy egrets, and others. However, because of the increased concentrations of selenium carried by these water bodies, selenium concentrations in fish would increase and would pose additional risk to fish-eating birds using these sites for foraging. The same concerns exist for birds with a more omnivorous diet, such as rails, bitterns, and moorhens. The level of increased risk is unknown.

Uncertainty also is associated with the residual Sea that will rapidly develop into a hypersaline-brine basin. Biota currently occupying Sea water would disappear as described above and be replaced by a low-diversity, but potentially high-biomass community of brine shrimp, brine fly larva, and a few other salt-tolerant species. Although bacterial and chemical selenium removal mechanisms would function under increasingly saline conditions (Setmire, pers. comm.), selenium levels would increase through evaporation. Increased selenium levels may be passed on to the brine fly-brine shrimp prey base. Invertebrate-feeding aquatic birds would be attracted to biota within the brine basin, and they may be at increased risk of bioaccumulation in these shortened food chains. This risk would continue until salinity removed macro invertebrates from the residual sea. Again, the level of risk—while present—is unknown.

Finally, there may be a localized increase of selenium availability from residual pools that develop in the exposed Seabed as the Sea recedes. This potential risk would be localized and would exist only during the period the residual Sea would support macro-invertebrates (i.e., salinity < 250 g/L). Once the attractiveness of the Sea as a food provider passes, the potential risk would likely be reduced because of the low number of birds using the area.

Alternative No. 1: Mid-Sea Dam with North Marine Lake (Salton Sea Authority Alternative)

The discussion of conditions under the Salton Sea Authority Alternative begins at the second time period (2024–2040). It is assumed that conditions from 1999 through 2023 would be the same as under the No-Project Alternative.

2024–2040 Conditions

Major features designed to provide habitat resources under this alternative include a north marine lake, an outer pool located at the southern end of the current Sea, a brine basin, and both saline and freshwater constructed wetlands.

Area and Salinity Considerations. Physical conditions at the end of this period (2040) for the north marine lake can be summarized as elevation ranging from -234 to -247 feet msl, surface area ranging from 73,800 to 101,500 acres, and salinity ranging from about 37 g/L to 90 g/L. For purposes of analysis, it is assumed that salinity in the north marine lake would preclude the establishment of a viable fishery. Macro-invertebrate communities similar to those described under No-Project conditions would occupy the Sea.

The residual brine basin would occupy about 12,500 acres during this period. Although a large body of saline water would be present, salinities are assumed to exceed 250 g/L in the brine basin during this period. At this level, it is assumed that brine flies and brine shrimp would be functionally eliminated during this period. However, between the last time period (see No-Project 2006–2023) and the time salinities reach 250 g/L, optimum salinity levels for brine flies and brine shrimp would exist. These two species should reach maximum densities and provide abundant food for a select number of bird species as described under No-Project conditions. Once a salinity of about 250 g/L is reached and passed, salt-tolerant green algae and salt-tolerant bacteria would likely dominate the Sea, with high levels of viruses (Cohen and Hyun, 2006). It is assumed that in this condition, the residual Sea would provide no habitat resources for area avifauna.

Two types of constructed wetlands are a part of this proposed management scenario. About 4,000 acres of constructed wetlands are proposed for development along the New and Alamo Rivers for the assumed purpose of water treatment. Saline habitat complexes also are proposed for the Whitewater River delta (1,250 acres), and another 17,000 acres at the southern end of the Sea. It is assumed that salinities within both wetland types would support both fish and invertebrates and the birds that would feed on them.

Adjustments to habitat resource abundance (i.e., food) begun during the last time period (described under No-Project) would continue during this period. Fish-eating birds, whose numbers would have been substantially reduced during the last period as tilapia disappeared, would likely abandon the Sea. Some fish would be found in drains and the rivers, but not at a level to maintain numbers of fish-eating divers and gulls, terns, and skimmers.

Selenium Considerations. It is assumed that the north marine lake would function as the current Sea functions in terms of selenium cycling. Selenium concentrations may increase somewhat but should not pose an increased selenium risk for invertebrate-eating birds. There would be no selenium risk to fish-eating birds if projected salinity levels fail to support a fishery.

The brine basin may support increased selenium levels if anticipated increased selenium levels in drainwater reach the basin. It appears that water would be routed through freshwater wetland and/or saline habitat complexes, an outer ring lake, and the north marine lake before reaching the brine basin. If this routing holds, then most selenium would be removed by food chains in other facilities. It is unclear what selenium levels would be present in water and invertebrates supported by the brine basin at salinities < 250 g/L. Above salinities of 250 g/L, any potential selenium risk from the brine basin would decrease with a decrease in macro-invertebrates.

The freshwater wetlands proposed for development along the New and Alamo Rivers are a concern for increased selenium concentration in wetland food chains. It is assumed that these wetlands would be receiving drainwater with increased concentrations of selenium. It is anticipated that birds feeding in these wetlands would be at increased risk from selenium bioaccumulation. Similar concerns exist for constructed saline habitat complexes. These features would receive drainwater with increased concentrations of selenium that may be incorporated into supported food chains. As with freshwater wetlands, both fish and invertebrate eating birds may be at increased risk from selenium bioaccumulation. However, the level of accumulation is unknown.

Finally, there may be a localized increase of selenium availability from residual pools that develop in the exposed Seabed as the Sea recedes, as previously described under No-Project. This potential risk would be localized; however, rather than decrease because of reduced attractiveness of the brine basin after it loose its macro-invertebrates, the potential risk would persist as long as features within this alternative provide invertebrate food.

2041–2078 Conditions

Conditions would be very similar to the previous period.

Area and Salinity Considerations. Physical conditions at the end of this period (2078) for the north marine lake can be summarized as elevation ranging from -235 to -247 feet msl, surface area ranging from 72,900 to 101,000 acres, and salinity ranging from about 34 g/L to 85 g/L. For purposes of analysis, it is assumed that salinity in the north marine lake would preclude the establishment of a viable fishery. Macro-invertebrate communities similar to those described under No-Project conditions would occupy the sea.

Area and salinity concentrations for other features would be similar to those described for the 2024–2040 period. The exception would be the brine basin (about 11,498 acres) where salinity levels would continue to increase.

Selenium Considerations. Conditions would likely be very similar to those described for the previous period. The features of concern during this time period would be the freshwater wetlands and saline habitat complexes.

Summary of Alternative No. 1 Conditions

Salinity and acreages for habitat types providing resources to birds using the Salton Sea and adjacent areas are illustrated in **Table 5.4**. As described previously, time periods 1999–2006 and 2007–2023 are identical to No-Project conditions.

Area and Salinity Considerations. Features within this alternative are designed to maintain elevation and salinity. The north marine lake, south outer pool, and wetlands would maintain their size over the life of the project. Therefore, the 2024–2040 and 2041–2078 periods would support very similar conditions. It is assumed that the north marine lake would support abundant invertebrate food resources for area birds, but because of salinity levels, would not support a functional fishery. The outer pool, freshwater wetlands, and saline habitat complexes are assumed to support both fish and invertebrates.

Table 5.4 Salinity values and acres for four habitat types during four time periods under Alternative No. 1: Mid-Sea Dam with North Marine Lake (Salton Sea Authority Alternative). Shaded cells indicate conditions identical to No-Project conditions

Time Period	Residual Sea or Brine Basin		Marine Lake		Saline Habitat Complexes		Other Wetlands	Resources Supported
	Shoreline	Open Water	Shoreline	Open Water	Shoreline	Open Water		
2006								
Salinity (g/L)	49 to 54	49 to 54	Same as residual Sea	Same as residual Sea	0	0	0	Invertebrates Fish Secure Substrates
Acres	13,803	213,132			0	0	0	
2023								
Salinity (g/L)	93 to 123	93 to 123	Same as residual Sea	Same as residual Sea	0	0	0	Invertebrates
Acres	18,691	0			0	0	0	
2040								
Salinity (g/L)	>250	>250	37 to 90	37 to 90	20 to 150	20 to 150	Fresh	Invertebrates Fish
Acres	[1]	[1]	13,788	103,664	12,800	3,200	4,000	
2074								
Salinity (g/L)	>250	>250	34 to 85	34 to 85	20 to 150	20 to 150	Fresh	Invertebrates Fish
Acres	[1]	[1]	14,111	102,510	12,800	3,200	4,000	

[1] The differentiation between shoreline and open water would become meaningless at salinity levels near or above 250 g/L.

Selenium Considerations. The various features of this alternative would support different levels of selenium risk for bioaccumulation. For example, the north marine lake may support somewhat higher selenium concentrations, but would likely function similarly to the current Sea and remove much of the selenium from the water column.

The remaining features may have an increased risk of selenium bioaccumulation. For example, the brine basin may support higher selenium level within brine flies and brine shrimp as long as they survive. These species—early in period 2024–2040—would likely provide an abundant and, therefore, attractive food supply for birds that can utilize the resources. During this period of abundance, some birds may preferentially use the brine basin for feeding, rather than the lake and/or saline habitat complexes. Problems could arise if brine flies and brine shrimp accumulate and pass on higher concentrations of selenium to birds feeding on them.

The constructed wetlands are also a concern—especially the freshwater wetlands that would be used for water treatment. These wetlands would likely accumulate selenium from drainwater into the food chains they will support. The level of accumulation is unknown but any increase in potential bioaccumulation is a concern because of potential use of these sites by sensitive species such as the Yuma clapper rail.

Alternative No. 2: Mid-Sea Barrier with South Marine Lake

The discussion of conditions under the Mid-Sea Barrier with South Marine Lake Alternative (South Marine Lake) begins at the second time period (2024–2040). It is assumed that conditions from 1999 through 2023 would be the same as the No-Project Alternative.

2024–2040 Conditions

Major features designed to provide habitat resources within this alternative include a south marine lake and a constructed saline habitat complex wetland. A northern brine basin representing the residual Sea would also provide some resources for a portion of this period.

Area and Salinity Considerations. Physical conditions at the end of this period (2040) for the south marine lake can be summarized as elevation ranging from -254 to -269 feet msl, surface area ranging from 36,000 to 78,100 acres, and salinity ranging from about 10 g/L to 48 g/L. For purposes of analysis, it is assumed that salinity in the south marine lake would preclude the establishment of a viable fishery. Estimated mean area of shoreline is 17,353 acres, and mean area in open water is 44,648 acres. However, because of the high end of the projected salinity range, it is assumed that a functional fishery would not exist in the south marine lake. Macro-invertebrate communities similar to those described under No-Project conditions would occupy the sea.

The residual brine basin would occupy about 66,000 acres during this period. Although a large body of saline water would be present, salinities are assumed to exceed 250 g/L in the brine basin during this period. At this level, it is assumed that brine flies and brine shrimp would be functionally eliminated during this period. However, between the last time period (see No-Project 2006–2023) and the time salinities reach 250 g/L, optimum salinity levels for brine flies and brine shrimp would exist. These two species should reach maximum densities and provide abundant food for a select number of birds as described under No-Project conditions. Once a salinity of about 250 g/L is reached and passed, salt-tolerant green algae and salt-tolerant bacteria would likely dominate the Sea, with high levels of viruses (Cohen and Hyun, 2006). It is assumed that in this condition, the residual Sea would provide no habitat resources for area avifauna.

Four sediment detention basins would be developed to treat water on the three rivers.

Two saline habitat complexes would be developed during this period along the southeast corner of the residual Sea and near the mouth of the Whitewater River. The proposed complexes would encompass about 16,700 acres the southern end of the Sea and 5000 acres at the north end. It is assumed that salinities within the complex would support both fish and invertebrates, and the birds that would feed on them.

Adjustments to habitat resource abundance (i.e., food) begun during the last time period (described under No-Project) would continue during this period. Fish-eating birds, whose numbers would have been substantially reduced during the last period as tilapia disappeared, would likely abandon the Sea. Some fish would be found in drains and the rivers, but not at a level to maintain numbers of fish-eating divers and gulls, terns, and skimmers (**Table 5.1**). The south marine lake shoreline would be several miles from the historic mixing zone in the delta of the New and Alamo Rivers.

Selenium Considerations. It is assumed that the south marine lake would function as the current Sea functions in terms of selenium cycling. Selenium concentrations may increase somewhat but should not pose an increased selenium risk for invertebrate-eating birds. There would be no selenium risk to fish-eating birds if projected salinity levels fail to support a fishery.

The brine basin may support increased selenium levels if anticipated increased selenium levels in drainwater reach the basin. It appears that water would be routed through the saline habitat complexes before reaching the brine basin. If this routing holds, then most selenium would be removed by food chains within the sediment detention basins and the first habitat cells receiving drainwater (below). It is unclear what selenium levels would be present in water and invertebrates supported by the brine basin at salinities < 250 g/L. Above salinities of 250 g/L, any potential selenium risk from the brine basin would decrease with a decrease in macro-invertebrates.

The sediment detention basins proposed for development along the New, Alamo, and Whitewater Rivers are a concern for increased selenium concentration in wetland food chains. These facilities would function as constructed wetlands and provide habitat resources for area birds. These wetlands would be receiving drainwater with increased concentrations of selenium. It is anticipated that birds feeding in these wetlands would be at increased risk from selenium bioaccumulation. Similar concerns exist for constructed saline habitat complexes. These features would receive drainwater with increased concentrations of selenium that may be incorporated into supported food chains. This situation would be particularly true for the first cells receiving water from the sediment detention basins. As with freshwater wetlands, both fish- and invertebrate-eating birds may be at increased risk from selenium bioaccumulation within the saline habitat complexes—especially those with lower salinities. However, the level of potential accumulation is unknown.

Finally, there may be a localized increase of selenium availability from residual pools that develop in the exposed Seabed as the Sea recedes, as previously described under No-Project. This potential risk would be localized; however, rather than decrease because of reduced attractiveness of the brine basin after it loses its macro-invertebrates, the potential risk would persist as long as features within this alternative provide invertebrate food.

2041–2078 Conditions

Conditions would be very similar to the previous period.

Area and Salinity Considerations. Physical conditions at the end of this period (2078) for the south marine lake can be summarized as elevation ranging from -256 to -270 feet msl, surface area ranging from 32,500 to 73,100 acres, and salinity ranging from about 8 g/L to 45 g/L. For purposes of analysis, it is assumed that salinity in the south marine lake would preclude the establishment of a viable fishery. Macro-invertebrate communities similar to those described under No-Project conditions would occupy the sea.

Area and salinity concentrations for other features would be similar to those described for the 2024–2040 period. The exception would be the brine basin (about 65,600 acres) where salinity levels would continue to increase.

Selenium Considerations. Conditions would likely be very similar to those described for the previous period. The features of concern during this time period would be the freshwater wetlands (sediment detention basins) and certain cells of saline habitat complexes.

Finally, there may be a localized increase of selenium availability from residual pools that develop in the exposed Seabed as the Sea recedes, as previously described under No-Project. This potential risk would be localized; however, rather than decrease because of reduced attractiveness of the brine basin after it loose its macro-invertebrates, the potential risk would persist as long as features within this alternative provide invertebrate food.

Summary of South Marine Lake Alternative Conditions

Salinity and acreages for habitat types providing resources to birds using the Salton Sea and adjacent areas are illustrated in **Table 5.5.** As described previously, time periods 1999–2006 and 2007–2023 are identical to No-Project conditions.

Table 5.5 Salinity values and acres for habitat types present during four time periods under Alternative No. 2: Mid-Sea Barrier with South Marine Lake. Shaded cells indicate conditions identical to No-Project conditions

Time Period	Residual Sea or Brine Basin		Marine Lake		Saline Habitat Complexes		Other Wetlands	Resources Supported
	Shoreline	Open Water	Shoreline	Open Water	Shoreline	Open water		
2006								
Salinity (g/L)	49 to 54	49 to 54	Same as residual Sea	Same as residual Sea	0	0	0	Invertebrates Fish Secure Substrates
Acres	13,803	213,132			0	0	0	
2023								
Salinity (g/L)	93 to 123	93 to 123	Same as residual Sea	Same as residual Sea	0	0	0	Invertebrates
Acres	18,691	0			0	0	0	
2040								
Salinity (g/L)	>250	>250	10 to 48	10 to 48	20 to 150	20 to 150	Fresh	Invertebrates Fish
Acres	[1]	[1]	17,353	44,648	17,360	4,340	4,000	
2074								
Salinity (g/L)	>250	>250	8 to 45	8 to 45	20 to 150	20 to 150	Fresh	Invertebrates Fish
Acres	[1]	[1]	20,953	35,565	17,360	4,340	4,000	

[1] The differentiation between shoreline and open water would become meaningless at salinity levels near or above 250 g/L.

Area and Salinity Considerations. It is assumed that the south marine lake would support abundant invertebrate food resources for area birds, but because of salinity levels, would not support a functional fishery. Fish may occasionally occupy portions of the lake for short periods, but would not persist as a viable food source for fish-eating birds.

Selenium Considerations. The various features of this alternative would support different levels of selenium risk for bioaccumulation. For example, the south marine lake may support somewhat higher selenium concentrations, but would likely function similarly to the current Sea and remove much of the selenium from the water column.

The remaining features may have an increased risk of selenium bioaccumulation. For example, the brine basin may support higher selenium level within brine flies and brine shrimp as long as they survive. These species—early in period 2024–

2040—would likely provide an abundant and, therefore, attractive food supply for birds that can use the resources. During this period of abundance, some birds may preferentially use the brine basin for feeding, rather than the lake and/or saline habitat complexes. Problems could arise if brine flies and brine shrimp accumulate and pass on higher concentrations of selenium to birds feeding on them.

The constructed wetlands are also a concern—especially the freshwater wetlands that would be used for sediment detention. These wetlands would likely accumulate selenium from drainwater into the food chains they will support. The level of accumulation is unknown but any increase in potential bioaccumulation is a concern because of potential use of these sites by sensitive species such as the Yuma clapper rail.

Alternative No. 3: Concentric Lakes Dikes Alternative

The discussion of conditions under the Concentric Lakes Dikes Alternative begins at the second time period (2024–2040). It is assumed that conditions from 1999 through 2023 would be the same as the No-Project Alternative.

2024–2040 Conditions

Major features designed to provide habitat resources within this alternative include three concentric lakes around the perimeter of the current Sea, with a central brine basin. No additional wetlands are proposed at this time.

Area and Salinity Considerations. Physical conditions at the end of this period (2040) for the three proposed ring lakes include are summarized in **Table 5.6**.

Table 5.6   Area and salinity estimates for Alternative No. 3: Concentric Lakes Alternative

Ring No.	Elevation	Area		Total Area	Salinity Target (g/L)
		Shoreline	Open Water		
1	-230	6,117	188	6,305	20
2	-240	21,976	346	22,322	35
3	-255	18,692	283	18,975	45

It is assumed that ring lake Nos. 1-3 would support both fish and invertebrates. Macro-invertebrate communities similar to those described under No-Project conditions would occupy the residual Sea.

The residual brine basin would occupy the center of the ring lake configuration. It is assumed that it would occupy a relatively small area and support salt crusts.

For purposes of analysis, it is assumed that the brine basin would not provide any habitat resources because of very high salinities soon after project construction.

Selenium Considerations. Because there is no current plan for water treatment, it must be assumed that the first (highest) ring lake would receive drainwater directly from the three rivers and existing drains. With selenium concentrations expected to increase in drainwater, this lake would likely experience a greater risk of selenium bioaccumulation than under No-Project conditions. The remaining ring lakes would support reduced risk of bioaccumulation because the first ring would likely incorporate much of the selenium in drainwater into the food chains it supports. Area birds using this ring lake would be at increased risk of bioaccumulation of selenium.

Finally, there may be a localized increase of selenium availability from residual pools that develop in any exposed Seabed between ring lake No. 1 and ring lake No. 2. This potential risk would be localized; however, rather than decrease because of reduced attractiveness as described for the brine basin under No-Project conditions, the potential risk would persist as long as features within this alternative provide invertebrate food.

2041–2078 Conditions

Conditions would be very similar to the previous period.

Area and Salinity Considerations. Physical conditions at the end of this period (2078) are assumed to be identical to those presented in **Table 5.6**.

Selenium Considerations. Conditions would likely be very similar to those described for the previous period. The features of concern during this time period would be ring lake No.1 and any seep areas that may support residual pools between ring lake No. 1 dike and ring lake No. 2.

Summary of Concentric Lakes Dikes Alternative Conditions

Salinity and acreages for the three proposed ring lakes are presented in **Table 5.6**. Time periods 1999–2006 and 2007–2023 are identical to No-Project conditions.

The features of concern during this time period would be ring lake No. 1 and any seep areas that may support residual pools between ring lake No. 1 dike and ring lake No. 2.

Alternative No. 4: North-Sea Dam with North Marine Lake

The discussion of conditions under the North Sea Dam with North Marine Lake Alternative (North Marine Lake) begins at the second time period (2024–2040). It is assumed that conditions from 1999 through 2023 would be the same as the No-Project Alternative.

2024–2040 Conditions

Major features designed to provide habitat resources within this alternative include a north marine lake and a constructed saline habitat complex wetland. A central brine basin representing the residual Sea, would also provide some resources for a portion of this period.

Area and Salinity Considerations. Physical conditions at the end of this period (2040) for the north marine lake can be summarized as elevation ranging from -226 to -227 feet msl, surface area ranging from 19,000 to 19,600 acres, and salinity ranging from about 19 g/L to 30 g/L. A functional fishery should be possible under these conditions. Macro-invertebrate communities similar to those described under No-Project conditions would occupy the sea.

The residual brine basin would occupy about 94,800 acres during this period. Although a large body of saline water would be present, salinities are assumed to exceed 250 g/L in the brine basin during this period. At this level, it is assumed that brine flies and brine shrimp would be functionally eliminated during this period. However, between the last time period (see No-Project 2006–2023) and the time salinities reach 250 g/L, optimum salinity levels for brine flies and brine shrimp would exist. These two species should reach maximum densities and provide abundant food for a select number of birds as described under No-Project conditions. Once a salinity of about 250 g/L is reached and passed, salt-tolerant green algae and salt-tolerant bacteria would likely dominate the Sea, with high levels of viruses (Cohen and Hyun, 2006). It is assumed that in this condition, the residual Sea would provide no habitat resources for area avifauna.

Three sediment detention basins would be developed to treat water on the three rivers.

Three saline habitat complexes would be developed during this period at the south end of the Sea. The proposed complexes would encompass about 37,200 acres the southern end of the Sea. It is assumed that salinities within the complex would support both fish and invertebrates, and the birds that would feed on them.

Selenium Considerations. It is assumed that the north marine lake would function as the current Sea functions in terms of selenium cycling. Selenium concentrations may increase somewhat but should not pose an increased selenium risk for invertebrate-eating birds. There would be no selenium risk to fish-eating birds if projected salinity levels fail to support a fishery.

The brine basin may support increased selenium levels if anticipated increased selenium levels in drainwater reach the basin. It appears that water would be routed through the saline habitat complexes before reaching the brine basin. If this routing holds, then most selenium would be removed by food chains within the sediment detention basins and the first habitat cells receiving drainwater (see below). It is unclear what selenium levels would be present in water and invertebrates supported by the brine basin at salinities < 250 g/L. Above salinities of 250 g/L, any potential selenium risk from the brine basin would decrease with a decrease in macro-invertebrates.

The sediment detention basins proposed for development along the New and Alamo Rivers are a concern for increased selenium concentration in wetland food chains. These facilities would function as constructed wetlands and provide habitat resources for area birds. These wetlands would be receiving drainwater with increased concentrations of selenium. It is anticipated that birds feeding in these wetlands would be at increased risk from selenium bioaccumulation. Similar concerns exist for constructed saline habitat complexes. These features would receive drainwater with increased concentrations of selenium that may be incorporated into supported food chains. This situation would be particularly true for the first cells receiving water from the sediment detention basins. As with freshwater wetlands, both fish and invertebrate eating birds may be at increased risk from selenium bioaccumulation within the Saline habitat complexes—especially those with lower salinities. However, the level of potential accumulation is unknown.

Finally, there may be a localized increase of selenium availability from residual pools that develop in the exposed sea-bed as the Sea recedes, as previously described under No-Project. This potential risk would be localized; however, rather than decrease because of reduced attractiveness of the brine basin after it loose its macro-invertebrates, the potential risk would persist as long as features within this alternative provide invertebrate food.

2041–2078 Conditions

Conditions would be very similar to the previous period.

Area and Salinity Considerations. Physical conditions at the end of this period (2078) for the north marine lake can be summarized as elevation ranging from -228 to -229 feet msl, surface area ranging from 18,100 to 18,600 acres, and salinity ranging from about 5 g/L to 34 g/L. This range in salinity would support both a fishery and an invertebrate community. Macro-invertebrate communities similar to those described under No-Project conditions would occupy the Sea. Area and salinity concentrations for other features would be similar to those described for the 2024–2040 period. The exception would be the brine basin (about 90,500 acres) where salinity levels would continue to increase.

Selenium Considerations. Conditions would likely be very similar to those described for the previous period. The features of concern during this time period would be the freshwater wetlands (sediment detention basins) and certain cells of saline habitat complexes.

Finally, there may be a localized increase of selenium availability from residual pools that develop in the exposed Seabed as the Sea recedes, as previously described under No-Project. This potential risk would be localized; however, rather than decrease because of reduced attractiveness of the brine basin after it loose its macro-invertebrates, the potential risk would persist as long as features within this alternative provide invertebrate food.

Summary of North Marine Lake Alternative Conditions

Salinity and acreages for habitat types providing resources to birds using the Salton Sea and adjacent areas are illustrated in **Table 5.7**. As described previously, time periods 1999–2006 and 2007–2023 are identical to No-Project conditions.

Table 5.7   Salinity values and acres for habitat types present during four time periods under Alternative No. 4: North dam with North Marine Lake. Shaded cells indicate conditions identical to No-Project conditions

Time Period	Residual Sea or Brine Basin		Marine Lake		Saline Habitat Complexes		Other Wetlands	Resources Supported
	Shoreline	Open Water	Shoreline	Open Water	Shoreline	Open water		
2006								
Salinity (g/L)	49 to 54	49 to 54	Same as residual Sea	Same as residual Sea	0	0	0	Invertebrates Fish Secure Substrates
Acres	13,803	213,132			0	0	0	
2023								
Salinity (g/L)	93 to 123	93 to 123	Same as residual Sea	Same as residual Sea	0	0	0	Invertebrates
Acres	18,691	0			0	0	0	
2040								
Salinity (g/L)	>250	>250	19 to 30	19 to 30	20 to 150	20 to 150	Fresh	Invertebrates Fish
Acres	[1]	[1]	3,123	16,327	29,760	7,440	4,000	
2074								
Salinity (g/L)	>250	>250	5 to 34	5 to 34	20 to 150	20 to 150	Fresh	
Acres	[1]	[1]	3,143	15,215	29,760	7,440	4,000	Invertebrates Fish

[1] The differentiation between shoreline and open water would become meaningless at salinity levels near or above 250 g/L.

Area and Salinity Considerations. It is assumed that the north marine lake would support a viable fishery and abundant invertebrate food resources for area birds.

Selenium Considerations. The various features of this alternative would support different levels of selenium risk for bioaccumulation. For example, the north marine lake may support somewhat higher selenium concentrations, but would likely function similarly to the current Sea and remove much of the selenium from the water column.

The remaining features may have an increased risk of selenium bioaccumulation. For example, the brine basin may support higher selenium level within brine flies and brine shrimp as long as they survive. These species—early in period 2024–2040—would likely provide an abundant and, therefore, attractive food supply for birds that can use the resources. During this period of abundance, some birds may preferentially use the brine basin for feeding, rather than the lake and/or saline habitat complexes. Problems could arise if brine flies and brine shrimp accumulate and pass on higher concentrations of selenium to birds feeding on them.

The constructed wetlands are also a concern—especially the freshwater wetlands that would be used for sediment detention. These wetlands would likely accumulate selenium from drainwater into the food chains they will support. The level of accumulation is unknown but any increase in potential bioaccumulation is a concern because of potential use of these sites by sensitive species such as the Yuma clapper rail.

Alternative No. 5: Habitat Enhancement Without Marine Lake

The discussion of conditions under the Habitat Enhancement without Marine Lake Alternative (Habitat Enhancement) begins at the second time period (2024–2040). It is assumed that conditions from 1999 through 2023 would be the same as the No-Project Alternative.

2024–2040 Conditions

Major features designed to provide habitat resources within this alternative include five constructed saline habitat complexes. A central brine basin, representing the residual Sea, also would provide some resources for a portion of this period. Five constructed wetlands, serving as sediment detention basins, would also provide habitat resources to local avifauna. No marine lake feature is proposed under this alternative.

Area and Salinity Considerations. The residual brine basin would be the most visible feature of this alternative. The basin would occupy between 74,900 and 135,200 acres during this period at an elevation between -260 and -271 feet. Although a large body of saline water would be present, salinities are assumed to exceed 250 g/L in the brine basin during this period. At this level, it is assumed that brine flies and brine shrimp would be functionally eliminated during this period. However, between the last time period (see No-Project 2006–2023) and the time salinities reach 250 g/L, optimum salinity levels for brine flies and brine shrimp would exist. These two species should reach maximum densities and provide abundant food for a select number of birds as described under No-Project conditions. Once a salinity of about 250 g/L is reached and passed, salt-tolerant green algae and salt-tolerant bacteria would likely dominate the Sea, with high levels of viruses (Cohen and Hyun, 2006). It is assumed that in this condition, the residual Sea would provide no habitat resources for area avifauna.

Five saline habitat complexes would be developed during this period at both the north (two complexes) and south ends (three complexes) of the Sea. The proposed complexes would encompass about 42,200 acres of the Seabed. It is assumed that salinities within the complex would support both fish and invertebrates and the birds that would feed on them.

Five sediment detention basins would be developed to treat water on the three rivers. Although not intended to provide habitat resources, vegetation would be difficult to control and marsh-like conditions would likely develop. These conditions would provide some habitat resources for area avifauna.

Selenium Considerations. The brine basin may support increased selenium levels if anticipated increased selenium levels in drainwater reach the basin. It appears that water would be routed through the sediment detention basins and then the saline habitat complexes before reaching the brine basin. If this routing holds, then most selenium would be removed by food chains within the sediment detention basins and the first habitat cells receiving drainwater (see below). It is unclear what selenium levels would be present in water and invertebrates supported by the brine basin at salinities < 250 g/L, but levels may be near present conditions within the existing Sea if selenium is removed by the constructed wetlands. Above salinities of 250 g/L, any potential selenium risk from the brine basin would decrease with a decrease in macro-invertebrates.

The sediment detention basins proposed for development along the New, Alamo, and Whitewater Rivers are a concern for increased selenium concentration in wetland food chains. These facilities would function as constructed wetlands and provide habitat resources for area birds. These wetlands would be receiving drainwater with increased concentrations of selenium. It is anticipated that birds feeding in these wetlands would be at increased risk from selenium bioaccumulation. Similar concerns exist for constructed saline habitat complexes. These features would receive drainwater with increased concentrations of selenium that may be incorporated into supported food chains. This situation would be particularly true for the first cells receiving water from the sediment detention basins. As with freshwater wetlands, both fish- and invertebrate-eating birds may be at increased risk from selenium bioaccumulation within the saline habitat complexes—especially those with lower salinities. However, the level of potential accumulation is unknown.

Finally, there may be a localized increase of selenium availability from residual pools that develop in the exposed Seabed as the Sea recedes, as previously described under No-Project. This potential risk would be localized; however, rather than decrease because of reduced attractiveness of the brine basin after it loose its macro-invertebrates, the potential risk would persist as long as features such as Saline habitat complexes provide invertebrate food.

2041–2078 Conditions

Conditions would be very similar to the previous period.

Area and Salinity Considerations. The residual brine basin would occupy between 66,700 and 135,200 acres during this period at an elevation between -260 and -271 feet. Salinity levels continue to increase during this period. Salt-tolerant green algae and salt-tolerant bacteria would likely dominate the Sea, with high levels of viruses (Cohen and Hyun, 2006). It is assumed that in this condition, the residual Sea would provide no habitat resources for area avifauna.

Area and salinity concentrations for other features would be similar to those described for the 2024–2040 period.

Selenium Considerations. Conditions would likely be very similar to those described for the previous period. The features of concern during this time period would be the freshwater wetlands (sediment detention basins), certain cells of saline habitat complexes, and residual pools that develop in the exposed sea-bed.

Summary of Habitat Enhancement Alternative Conditions

Salinity and acreages for habitat types providing resources to birds using the Salton Sea and adjacent areas are illustrated in **Table 5.8**. As described previously, time periods 1999–2006 and 2007–2023 are identical to No-Project conditions.

Area and Salinity Considerations. It is assumed that the saline habitat complexes would support a viable fishery and abundant invertebrate food resources for area birds.

Selenium Considerations. The various features of this alternative would support different levels of selenium risk for bioaccumulation. For example, selenium levels in the residual Sea/brine basin would likely be near current levels. Brine flies and brine shrimp would provide an abundant and, therefore, attractive food supply during portions of the 2024–2040 period. During this period of abundance, some birds may preferentially use the brine basin for feeding, rather than the saline habitat complexes.

Table 5.8 Salinity values and acres for habitat types present during four time periods under Alternative No. 5: Habitat Enhancement without Marine Lake. Shaded cells indicate conditions identical to No-Project conditions

Time Period	Residual Sea or Brine Basin		Saline Habitat Complexes		Constructed Wetlands	Resources Supported
	Shoreline	Open Water	Shoreline	Open Water		
2006						
Salinity (g/L)	49 to 54	49 to 54	0	0	0	Invertebrates Fish Secure Substrates
Acres	13,803	213,132	0	0	0	
2023						
Salinity (g/L)	93 to 123	93 to 123	0	0	0	Invertebrates
Acres	18,691	0	0	0	0	
2040						
Salinity (g/L)	>250	>250	20 to 150	20 to 150	Fresh	Invertebrates Fish
Acres	[1]	[1]	33,760	8,440	4,000	
2074						
Salinity (g/L)	>250	>250	20 to 150	20 to 150	Fresh	Invertebrates Fish
Acres	[1]	[1]	33,760	8,440	4,000	

[1] The differentiation between shoreline and open water would become meaningless at salinity levels near or above 250 g/L.

The constructed wetlands are a concern—especially the freshwater wetlands that would be used for sediment detention. These wetlands would likely accumulate selenium from drainwater into the food chains that will develop. The level of accumulation is unknown but any increase in potential bioaccumulation is a concern because of potential use of these sites by sensitive species such as the Yuma clapper rail. Vegetation should be managed to reduce the attractiveness of these sites for sensitive species.

Summary of Conditions Under No-Project Alternative

As recently as 1999, the Salton Sea provided abundant food and secure nesting, roosting, and resting sites for large numbers of birds (Shuford et al, 2000). Several functional groups—primarily fish-eating and invertebrate-eating birds—used the habitat resources provided by the Sea's shoreline, open water, and islands and snags (**Table 5.1**). Rising salinity levels, along with water quality issues, further reduced the already declining fish populations between 1999 and 2006.

The description of the period 2006 to 2023, while presented here for the No-Project Alternative, would generally describe conditions under all alternatives.

Therefore, during this period—under all alternatives—significant changes would occur in biota supported by the Sea and bird populations using the Sea and its habitat resources (Cohen and Hyum, 2006). An accelerated reduction in the Sea's elevation after the termination of mitigation water in 2017, with an accompanying accelerated increase in salinity, would change the structure of food chains historically supported by the Sea. Tilapia, pileworms, and most other macro-invertebrates that now populate the Sea's food chains and support the fish-eating and invertebrate-eating bird groups would decrease. In addition, secure sites (islands and snags) would be connected to land as water levels decrease and lose their habitat value. Currently, there are no known significant elevated land masses that would be exposed to create replacement habitat as the Sea recedes. Fish-eating divers and gulls, terns and skimmers—represented by pelicans, cormorants, terns, and others—would lose their food supply and nesting/roosting sites. Other groups, such as invertebrate-eating divers (e.g., eared grebes), shorebirds (e.g., snowy plovers), and diving ducks (ruddy ducks) would lose their traditional food items during this period and be forced to use brine flies and brine shrimp, or abandon the Sea. Some fish and some invertebrate communities would persist in the mixing zones and fresh water lenses at the mouths of the three rivers. However, the food biomass needed to support the abundance and diversity of avifauna historically supported by the Sea would not survive this period because of increasing salinity levels. Without a diverse prey base, the abundance and diversity of birds using the Sea would decline during this period.

Biological change in response to chemical and physical changes in the residual Sea would continue during the 2024–2040 period. For example, by the end of this period, salinity would exceed 250 g/L, which is the level expected to impact brine flies and brine shrimp. Above this salinity, the Sea would be functionally devoid of macro-invertebrates. However, there is the potential for areas at the interface of the rivers and the Salton Sea that may support macro-invertebrates and possibly even fish. But before reaching this level of 250 g/L, salinity would rise during the 2023–2040 period through levels that would provide optimum conditions for these two macro-invertebrates, and densities should reach maximum levels. Certain species within the functional groups identified in **Table 5.1** (e.g., eared grebes, ruddy ducks, and some shorebirds) may exploit this abundant food supply. Numbers of these birds using the Salton Sea during this period may be high. However, as salinity values exceed optimum levels for brine flies and brine shrimp, bird numbers would likely decline until both prey and the birds using them would reach low numbers.

Salt encrustation on the feathers of birds using the residual Sea/brine basin may be a concern as salinity levels continue to increase in the future. Under certain conditions—reported from saline wetlands, salt ponds, and evaporation ponds—encrustation can adversely affect birds' abilities to swim, dive, fly, and, in some cases, can cause mortality (Wobeser and Howard, 1987; Euliss et al., 1989; Gordus et al., 2002). Birds are generally attracted to saline waters by abundant food such as brine shrimp and brine fly larvae. Ruddy ducks, eared grebes, and some shorebirds that use saline impoundments with high brine shrimp/brine fly productivity may be at specific risk from salt encrustation, but several other affected bird species have also been documented in the above references.

Salt encrustation appears to be associated—at least in saline impoundments smaller than the Sea—with high salt concentrations (conductivity ≥77,000-90,000 micromhos per centimeter [≥ about 54-63 g/L]), and low air and water temperatures approaching freezing (≤ 4º C) (Wobeser and Howard, 1987, Gordus *et al*., 2002). Future conditions that may facilitate salt encrustation, e.g., high salinities, high food productivity (brine shrimp/brine flies), and cold temperatures, are likely at both the residual Sea/brine basin and saline habitat complexes. However, the potential for salt encrustation on birds using the residual Sea/brine basin and/or saline habitat complexes has received little study to date.

Future Se levels in the residual Sea are a concern. If current anaerobic reduction mechanisms continue to function, then Se levels may remain similar to current levels. However, it is possible that Se concentrations in the residual Sea could increase for the following reasons:

- The residual Sea would be shallower than under current conditions and may be more prone to wind mixing. Mixing may re-suspend Se bearing sediments. Re-suspension may facilitate changes in Se speciation that result in increased concentrations within the water column.

- If additional mixing occurs, it may result in a more oxygenated system. More oxygen may reduce the effectiveness of anaerobic bacteria in removing Se from the water column.

- Sediments would be exposed as the Sea is reduced in size. Alternate wetting and drying of exposed sediments via drains, seepage, and/or dust mitigation may facilitate the formation of ephemeral pools with high Se levels.

- Agricultural drainage concentrations entering the Sea would increase as drainage volumes decrease. Concentrations of Se in the New and Alamo Rivers could increase to as high as 8 to 18 µg/L in the future with future conservation actions (Setmire, 2005).

Any increases in Se levels in the residual Sea, coupled with the assumed abundance of brine fly larva and brine shrimp during this period, create uncertainty regarding increased risk of Se bioaccumulation.

Finally, the period 2041–2078 would be marked by low resource abundance and low numbers of birds using the Salton Sea.

Summary of Conditions Under Restoration Alternatives

An assessment of how best to replace habitat resources that would be lost in the future is actually an evaluation of concepts. In the present study, the principal concepts involve (1) large saline ("marine") lakes, (2) large SHC, and (3) combinations of marine lake and various sized saline complexes. The alternatives resulting from these concepts are assumed to provide varying quantities of food—represented here by acreage estimates for both shoreline and open water habitats—for marine lakes and/or SHC. Most alternatives also contain additional features (e.g., brine basins, sediment retention basins, conveyance channels) with primary functions other than providing habitat resources, but that would also provide invertebrate and/or fish prey items for area birds. Food produced by alternative features must, therefore, also be subject to a quality modification by salinity and/or potential Se levels that may be associated with alternative features in the future.

Several cautionary notes are in order when evaluating these alternatives. First, the current Sea supports a unique combination of physical, chemical, and biological components that provide both food for birds and deal with Se input by sequestering it in sediments. Although the eggs of some birds nesting at the Salton Sea exhibit Se levels associated with reduced egg viability in other studies, no major reproductive impairment issues have been identified in area birds to date. Note however, that all proposed alternatives—including No-Project—would alter the current combination of physical, chemical, and biological components in features by increasing or decreasing salinity levels and generally increasing Se concentrations. Major features and their associated concerns are as follows:

- Marine Lake—As discussed in other sections of this report, most marine lakes would likely experience salinity and/or nutrient problems. Salinity may be difficult to reduce to levels that would support a viable fishery in some lakes, and/or eutrophication issues may result in frequent fish kills. Food for fish-eating birds using such lakes may be limited. Invertebrates produced by marine lakes are assumed to contain Se levels similar or somewhat higher than current levels—if Se sequestering mechanisms in future marine lakes function as efficiently as in the current Sea.

- Residual Sea/Brine Pool—The residual Sea would be the dominant feature of all alternatives until about 2024. Existing food chains would disappear as salinity increases and be replaced for a time by brine fly larvae and brine shrimp. Although the residual Sea/brine basin would likely not produce food by the end of the third time period (2024–2040) because of salinity levels greater than 250 g/L. Optimum conditions for brine flies and brine shrimp would occur at some time during the period. This food resource may be so abundant for a time after 2024 that some birds may use the residual Sea rather than facilities constructed for their use. A proactive plan is needed that would address the potential for Se accumulation within this future food source supported by the residual Sea.

- SHC—These features are large constructed wetlands with varying salinities. The majority of these shallow wetland habitats would be less than 3 feet deep. SHC are described in more detail in Chapter 3. These constructed wetlands would use a mix of river, marine lake (or brine pool) water to mimic shallow shoreline with dispersed deep pools of open water for fish. As Se levels rise in the rivers, and water within the complexes is concentrated to increase salinities, Se concentrations would also increase. Unless some mechanism is used to reduce or eliminate Se in water used in the complexes, food chains that develop would experience increased Se levels.

- Sediment Retention Basins—These constructed freshwater wetlands receiving drain water could pose a risk for Se bioaccumulation in the food chains they would support (Setmire, 2005). The assumed shallow water and relatively low salinities would support vegetation that would rapidly develop into "marsh-like" conditions. These conditions would be attractive to several bird groups, including the federally listed Yuma clapper rail. Unless some mechanism is used to reduce or eliminate Se in water used in the basins, food chains that develop would experience increased Se levels.

- Other Wetlands—Other wetlands would develop in response to a receding Sea shoreline and/or in association with various alternative features. For example, ponded water on exposed Sea-floor sediments would present an opportunity for increased Se concentrations. Alternate wetting and drying—which would occur during dust mitigation actions—could result in high Se concentrations. Increased Se concentrations would then be available for incorporation into local food chains.

All of the proposed alternatives would provide some level of food for fish- and invertebrate-eating birds. Food abundance would vary, but all alternatives would include operational uncertainties and, therefore, would present some level of increased risk for Se bioaccumulation at levels higher than currently exhibited by area birds. These uncertainties are discussed below and summarized in **Table 5.9**. Note that **Table 5.9** addresses alternatives as fully operational and near equilibrium in the year 2040. Although **Table 5.9** lists salinity values for the residual Sea/brine pool as greater than 250 g/L, this level would not likely be reached until the latter part of the 2024–2040 period. Before reaching this salinity level, the residual Sea would provide optimum conditions for brine fly larvae and brine shrimp. If Se concentrations increase, this abundant food supply could result in increased Se bioaccumulation in birds using this resource.

Table 5.9 Summary comparison of shoreline habitat, open water habitat, and food provided under restoration alternatives and No-Project Alternative in the year 2040

	Alternative No. 1: Mid-Sea Dam with North Marine Lake			Alternative No. 2: Mid-Sea Barrier with South Marine Lake			Alternative No. 3: Concentric Lakes Dikes			Alternative No. 4: North-Sea Dam with Marine Lake			Alternative No. 5: Habitat Enhancement Without Marine Lake			Alternative No. 6: No-Project		
	Marine lake																	
	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided	Shoreline habitat[1]	Open water habitat[2]	Food provided
Acres	13,800	103,700	Inverts Fish	17,300	44,700	Inverts Fish	46,800	817	Inverts Fish	3,100	16,400	Inverts Fish	No lake	No lake	No lake	No lake	No lake	No lake
Salinity (g/L)[3]	[4]58	[4]58	[4]58	34	34	34	20 to 45	20 to 45	20 to 45	26	26	26	No lake	No lake	No lake	No lake	No lake	No lake
Selenium	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	Increase possible	No lake	No lake	No lake	No lake	No lake	No lake
	Brine pool																	
Acres	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food	No shoreline habitat (Salinity > 250)	No open water habitat (Salinity > 60)	No food
Salinity (g/L)[3]	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250	>250
Selenium	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food	No food
	Saline habitat complex																	
Acres	16,000	0	Inverts	17,400	4,300	Inverts Fish	No complex	No complex	No complex	29,800	7,400	Inverts Fish	33,800	8,400	Inverts Fish	No complex	No complex	No complex
Salinity (g/L)[3]	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	No complex	No complex	No complex	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	20 to 150	No complex	No complex	No complex
Selenium	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	No complex	No complex	No complex	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	Increase probable	No complex	No complex	No complex

[1] Shoreline habitat is defined as habitat with depths of water between 0 and 6 feet with selenium in sediments less than or equal to 2.5 milligrams per kilogram (mg/kg) and salinity <= 250,000 mg/L.

[2] Open water habitat is defined as habitat with depths of water greater than 6 feet and salinity less than or equal to 60,000 mg/L.

[3] Salinities are for mean possible future conditions as described in Chapter 4.

[4] Salinities for the Alternative No. 1 will exceed 60,000 mg/L under all possible inflow conditions less than mean possible future inflows (as described in Chapter 4) unless the marine lake is operated at elevations below than -238 feet.

Following is a discussion of potential benefits and uncertainties relative to each restoration alternative.

Alternative No. 1: Mid-Sea Dam with North Marine Lake

Potential Benefits

This alternative would provide about 13,800 acres of the shoreline habitat type in the marine lake component and another 12,800 acres of shoreline habitat within SHC (**Table 5.9**). About 103,700 acres of open water would be available within the marine lake and 3,200 acres within SHC. The total surface area the SHC in this alternative is 16,000 acres.

Uncertainties

Model simulations indicate that the marine lake may not reach salinities that would support a viable fishery until late (after 2038) in the study period. The risk to fish-eating birds of increased Se bioaccumulation is assumed moderate—if Se sequestering mechanisms continue to efficiently function in the marine lake. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 2: Mid-Sea Barrier with South Marine Lake

Potential Benefits

This alternative would provide about 17,300 acres of the shoreline habitat type in the marine lake component and another 17,400 acres of shoreline habitat within SHC (**Table 5.9**). About 44,700 acres of open water habitat type suitable for fish would be provided by the marine lake, and an additional 4,300 acres of open water habitat would be provided by saline complexes.

Uncertainties

The risk to fish-eating birds of increased Se bioaccumulation is assumed moderate—if Se sequestering mechanisms continue to efficiently function in the marine lake. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 3: Concentric Lakes

Potential Benefits

No “SHC” are proposed for this alternative. However, the concentric lakes would likely function as “linear complexes” under this alternative, with similar habitat areas to those created in SHC. The concentric lakes would provide about 46,800 acres of the shoreline habitat type and about 817 acres of open water habitat (**Table 5.9**).

Uncertainties

This alternative would use river water (with increased future Se levels) and then concentrate it to reach desired salinity levels in the various lakes. Uncertainties surrounding the ring lakes, water management, and residual Sea/brine basin previously discussed, indicate the risk of increased Se bioaccumulation to both fish- and invertebrate-eating birds is assumed serious.

Alternative No. 4: North-Sea Dam with Marine Lake

Potential Benefits

This alternative would provide about 3,100 acres of the shoreline habitat type in the marine lake component and another 29,800 acres of shoreline habitat within SHC (**Table 5.9**). About 16,400 acres of open water suitable for fish would be provided by the marine lake, and an additional 7,400 acres of open water habitat would be provided by saline complexes.

Uncertainties

The risk to fish-eating birds of increased Se bioaccumulation is assumed moderate—if Se sequestering mechanisms continue to efficiently function in the marine lake. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 5: Habitat Enhancement Without Marine Lake

Potential Benefits

This alternative does not include a marine lake component, but would provide about 33,800 acres of the shoreline habitat type, and an additional 8,400 acres of open water habitat via constructed SHC (**Table 5.9**).

Uncertainties

The risk of increased Se bioaccumulation to fish-eating birds is assumed moderate. Uncertainties surrounding the SHC, residual Sea/brine basin, sediment retention basins, and other constructed wetlands previously discussed, indicate the risk of increased Se bioaccumulation to invertebrate-eating birds is assumed serious.

Alternative No. 6: No-Project

The conditions that would likely exist into the future for the residual Sea/brine basin have been previously described. As noted earlier, **Table 5.9** indicates that no food would be produced after salinity levels exceed about 250 g/L. Because most fish except tilapia have disappeared, and tilapia will likely functionally disappear soon, the risk of increased Se bioaccumulation to fish-eating birds is assumed to be low under this alternative. However, before the residual Sea/brine basin loses its ability to support macro-invertebrates (salinity > 250 m/L), it would support an abundant prey base of brine fly larvae and brine shrimp. Because of the uncertainties involved with future Se cycling in the residual Sea, the risk to invertebrate-eating birds of increased Se bioaccumulation is assumed serious.

Alternative Assessment

All of the proposed alternatives would provide some level of food resources for future bird populations using the Salton Sea area. In terms of the shoreline habitat type, Alternative No. 3, Concentric Lakes, would provide the largest area, with Alternative No. 2, Alternative No. 5, and Alternative No. 4 providing similar acreages, and Alternative No. 1 providing the smallest acreage (**Table 5.9**). Alternative No. 1, Mid-Sea Dam with North Marine Lake, would provide the largest open water area, followed by Alternative No. 2 and Alternative No. 4. Alternative Nos. 3 and 5 would provide limited open water when compared to the other alternatives (**Table 5.9**).

Although Alternative No. 3 would provide the largest area of the shoreline habitat type, and Alternative No. 1 would provide the largest area of open water, there are concerns for both of these approaches. Specifically, there are questions of salinity levels under Alternative No. 1 and the ability of this approach to provide a marine lake that would support a viable fishery within the study period. In addition, Alternative No. 3 would concentrate river water within the various ring lakes and thus increase the risk of Se exposure to birds (Setmire, 2005). The remaining alternatives—Alternative Nos. 2, 4, and 5—have potential of providing shoreline and open water resources if Se levels can be managed at safe levels. The uncertainties surrounding the risk for increased Se bioaccumulation at this stage of planning requires caution, and, thus, ratings for all alternatives range from moderate to serious.

There appear to be many unanswered questions concerning how best to provide adequate food resources for area wildlife, and how to ensure that food produced would not increase the risk of Se bioaccumulation in area food chains. These unanswered questions should be addressed before a large and irretrievable commitment of resources is dedicated to a long-term approach to restoration. For example, the U.S. Geological Survey is currently collecting data on a 100-acre experimental saline pool near the Alamo River Delta. This experimental pool is yielding valuable information on construction techniques, salinity levels, bird use, etc. An expanded version of this approach—in 200-to-500-acre-sized pools—should perhaps be considered for future implementation. Benefits may include a better understanding of:

- Water depths and salinities that maximize food production and bird use.
- Construction techniques that are efficient and cost effective in producing water depths that maximize food production and bird use.
- Mechanisms to safely deal with Se in water used for food production.

Such an approach would provide some habitat resources while improving our understanding of how future systems may operate. Such an approach would also maintain needed flexibility until a consensus approach can be developed. Further study and experimentation appears warranted.

Finally, the residual Sea would be the only source of substantial habitat resources (not considering early start projects) until about 2024, when proposed plan features would become operational. Sometime during the 2006–2023 period, increasing salinity levels would eliminate existing food chains, and brine flies and brine shrimp would become the dominant food items in the Sea. Although these species may reach an impressive abundance, they will not support the numbers and diversity of avifauna found at the Sea in recent years. An experimental SHC approach would not only provide important information but may also provide needed habitat resources as resource agencies determine how best to address the questions of “how much” and of “what quality” resources are needed in the long term.