SALTON SEA ECOSYSTEM RESTORATION PLAN

Food Webs and Selenium Pathways

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FOOD WEBS AND SELENIUM PATHWAYS

INTRODUCTION AND PURPOSE

An evaluation of the ecological risks associated with selenium in the Salton Sea ecosystem requires an understanding of the potential food-chain transfer pathways that selenium may follow. Various habitats that provide important functions for fish and birds in the Salton Sea ecosystem have been identified (CH2M HILL, 2005). This memorandum focuses on those aquatic habitats that are most relevant to potential selenium exposures under different restoration alternatives. The purpose of this memorandum is to document the representative species and associated food-chain relationships that will be used to quantitatively evaluate ecological risks from selenium under current conditions in the Salton Sea and for modeling selenium transfer to evaluate potential selenium risks under the different restoration alternatives.

Earlier studies (Setmire et al., 1993) described the generalized food-chain relationships of the Salton Sea and the upgradient agricultural areas at the time of those studies (late 1980s and early 1990s). Changing conditions in the Salton Sea since that time include rising salinity and nutrient levels. The changes have likely brought about significant changes in the abundance and composition of fish and wildlife communities within the Salton Sea under current conditions. The most obvious changes are the virtual collapse of introduced sport fisheries in the Salton Sea that included orangemouth corvina, sargo, and bairdiella, as reflected in ongoing, periodic fish population surveys that have been conducted by the California Department of Fish and Game (2003, 2004). The food-chain relationships described in this memorandum are intended to reflect current and expected future conditions for aquatic habitats within and near the Salton Sea.

HABITATS AND ASSOCIATED REPRESENTATIVE SPECIES

Fish and wildlife that depend on the Salton Sea require a diversity of aquatic and terrestrial habitats for completion of their life cycles. Another report (CH2M HILL, 2005) provides broad characterizations of habitats and typical plant and animal species associated with the Salton Sea. This memorandum provides a brief summary of characteristic species for the aquatic habitats within or near the Salton Sea and identifies representative avian receptors for evaluation of selenium-related risks of adverse effects at different trophic levels.

Birds are among the most abundant and diverse forms of wildlife that use the Salton Sea and adjacent habitats, and they have been identified as the most sensitive forms of wildlife for selenium-induced effects. Bird species are often selective in the types of habitat they utilize, and the diversity of habitats associated with the Salton Sea ecosystem is reflected in the diversity of birds found there. Representative bird species were chosen for various habitats and trophic levels based on their likely occurrence within the habitats in the Salton Sea area. Other considerations for the choice of the representative species included the relative sensitivity to selenium and availability of information concerning the effects of selenium on that species. The selected representative bird species are listed in Table 1. A comparison of the different habitat classifications used for the Salton Sea is provided in Table 2.

Open Water Habitat

Open water is defined for this project as those portions of the Salton Sea that are greater than 6 inches (0.15 meters) in depth (CH2M HILL, 2005). Open water includes deep open water (deeper than 6.6 feet [2 meters]) and inshore water within 0.6 mile [1 kilometer] of the shoreline (depth range of 6 inches to 6.6 feet [0.15 to 2 meters]). Most shorebirds and wading birds utilize the shallower areas (< 6 inches [<0.15 meters]) while other guilds of birds and fishes utilize waters deeper than 6 inches. Bird species using the open water habitats are similar, but much of the use is in the inshore areas. Open water also includes valuable habitat features such as islands, and is the predominant habitat associated with the Salton Sea.

Table 1
Representative Bird Species for Various Salton Sea Habitats

Habitats	Representative Species													
	Eared Grebe	Double-crested Cormorant	Black-crowned Night-Heron	White-faced Ibis	Mallard	Northern Shoveler	Ruddy Duck	Yuma Clapper Rail	American Coot	Snowy Plover	Black-necked Stilt	Black Skimmer	Gull-billed Tern	Burrowing Owl
Open Water > 0.5 ft (0.15 m)	●	●				●	●					●		
Shoreline and Shallow Water < 0.5 ft (0.15 m)			●		●	●				●	●	●		
Managed Marshes			●		●			●	●		●		●	
Estuaries (Deltas and Drains)			●		●				●		●	●	●	
Agricultural Land				●										●

Table 2
Crosswalk Table of Habitats and Habitat Features Used in this Document and Their Link to Habitat Types Recommended by DFG, Audubon California, and the Salton Sea Restoration Biology Panel

Habitat Designations Used in Defining Preliminary Habitat Design Criteria	Habitats Listed in the DFG Vision Document	Habitats Listed in the Audubon California Comment Letter	Salton Sea Restoration: Final Preferred Project Report (Biology Panel)
Open Water (Deep ≥ 6.6 ft [2 m]) (Inshore 0.5 -6.6 ft [0.15-2 m]) (Includes islands)	Deep salt water	Water maintained at a depth of 30 feet	
Shoreline and Shallow Water (0.5 ft of water to 3.0 ft above water line [0.15 m of water to 0.9 m above water line])	Shallow salt water Shoreline pools Mudflats Barnacle bars Unvegetated beaches	Shallow water less than 15 inches deep Mudflats (vegetative and non-vegetative) Entire shoreline (especially the southern shoreline) Brackish water	Mudflats Shallow water habitat
Managed Marshes	Cattail marsh Saltwater marsh	Freshwater marsh	Typha marshes

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Estuaries and Deltas (including drains)	River estuaries Irrigation drains	River deltas Drains	Estuarine habitat Drain influenced lagoons and lagoon overwash
Agricultural Land	Agricultural lands	Permanently or frequently flooded lands Dry crops Canals, seeps and riparian zones	Flooded agricultural field

Source: CH2M HILL 2005

Species that depend on the open water habitat include a large number of birds, fishes, and food web organisms (Patten et al., 2003; Shuford et al., 2000). Open water is particularly valuable to eared grebes, double-crested cormorants, pelicans, gulls, terns, and black skimmers. Wintering and migrating eared grebes can number in the millions, particularly from January through March, and most are found within 1,640 feet (0.5 kilometer) of the shore. White pelicans are especially attracted to large expanses of shallow open water where fish are present as a forage base. Snags protruding from the water are used by cormorants, herons, and egrets for nesting and perching. Waters within 0.6 mile (1 km) of the shoreline are valuable to a diversity of diving waterbirds.

Piscivorous (fish-eating) birds to be evaluated include the double-crested cormorant and the gull-billed tern, which nest at the Salton Sea (Figure 1). Tilapia, although their numbers are declining, are the staple prey item for piscivorous birds. Omnivorous waterfowl using the open water habitat and selected as representative species include the ruddy duck and northern shoveler. Both of those are primarily winter resident species, but they may be numerous in the open-water habitat and feed by diving (ruddy duck) or at the surface (shoveler). Eared grebes feed primarily on invertebrates such as pileworms, waterboatmen, and amphipods.

Shoreline and Associated Shallow Water Habitat

The shoreline is the area immediately adjacent to the Salton Sea, within 150 feet (46 meters) of the high-water line (or 3 feet [0.9 meters] above it). From the high-water line to the permanently flooded level is an area that is periodically flooded and exposed as the surface level of the Sea changes on a seasonal basis. This area contains unvegetated mud flat habitat. The adjacent shallow water extends from the water line to a depth of 6 inches (0.15 meter). Pools along the shoreline formed by sand or barnacle-shell bars parallel to shore and connected to the sea and/or drains are included in this habitat type. These pools vary in size over time due to changes in Sea level and evaporation.

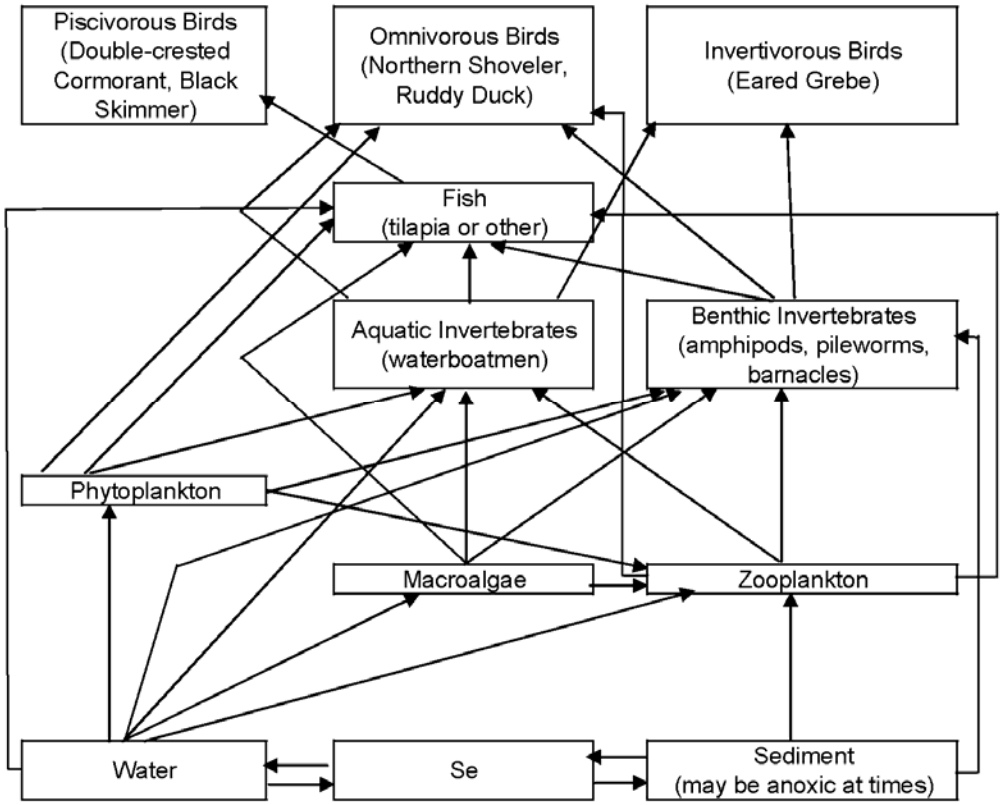

Figure 1
Exposure Pathways and Food Web Relationships for Open Water Habitat (>0.5 ft [0.15 m] depth)

Shorebirds (e.g., snowy plover and black-necked stilt), piscivorous birds (e.g., terns, herons, and egrets), and waterfowl use the shoreline and adjacent shallow waters for resting and foraging. Rocky, inshore substrates in this habitat have a high invertebrate (pileworm and amphipod) production rate through summer (Detwiler et al., 2000). These invertebrates as well as smaller fish in shallow waters provide a food resource for various species (Salton Sea Authority, 2000), as shown in Figure 2. Species selected for evaluation include the black-crowned night-heron, gull-billed tern, snowy plover, black-necked stilt, mallard, and northern shoveler, because they represent the range of diets and foraging methods as well as other considerations mentioned above.

Managed Marshes

Managed marshes are defined as the existing wildlife refuge and duck club marshes located adjacent to and near the Salton Sea. Managed wetlands can also be found at aquaculture ponds along the southern shore and near the mouth of the Whitewater River to the north. The refuges include adjacent uplands that are managed primarily to provide forage for birds, but also to provide habitat for other wildlife species. The marshes range from freshwater to salt marshes and are actively managed for one or more marsh habitat functions and values as described elsewhere (CH2M HILL, 2005). Additional managed marsh habitat may be created if treatment wetlands are used for nutrient and selenium removal.

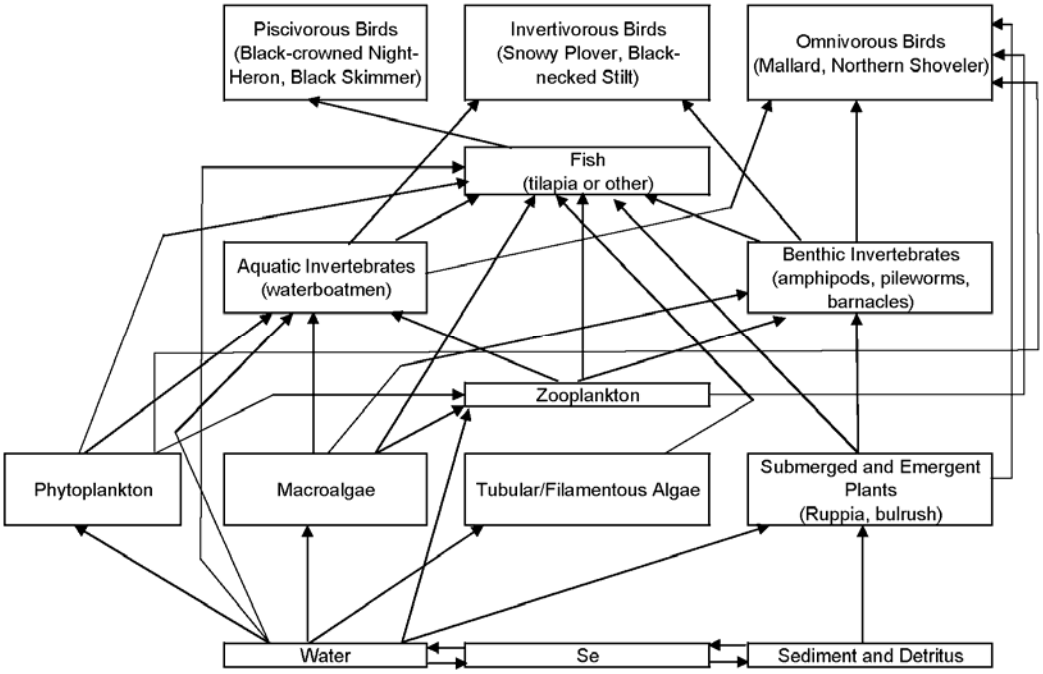

Figure 2
Exposure Pathways and Food Web Relationships for Shoreline and Shallow Water Habitat (<0.5 ft [0.15 m] depth)

The managed marshes are designed and managed primarily for waterfowl uses and, while the managed marshes support large numbers of waterfowl, specific units within the marshes are also managed to support a variety of sensitive species, particularly Yuma clapper rail and black rail. Other species that feed and nest in these marshes include pied-billed grebe, American coot, common moorhen, Yuma clapper rail, herons and egrets, terns, marsh wrens, and other similar species. Representative species selected for evaluation of selenium exposure include black-crowned night-heron, gull-billed tern, black-necked stilt, Yuma clapper rail, American coot, and mallard (Figure 3).

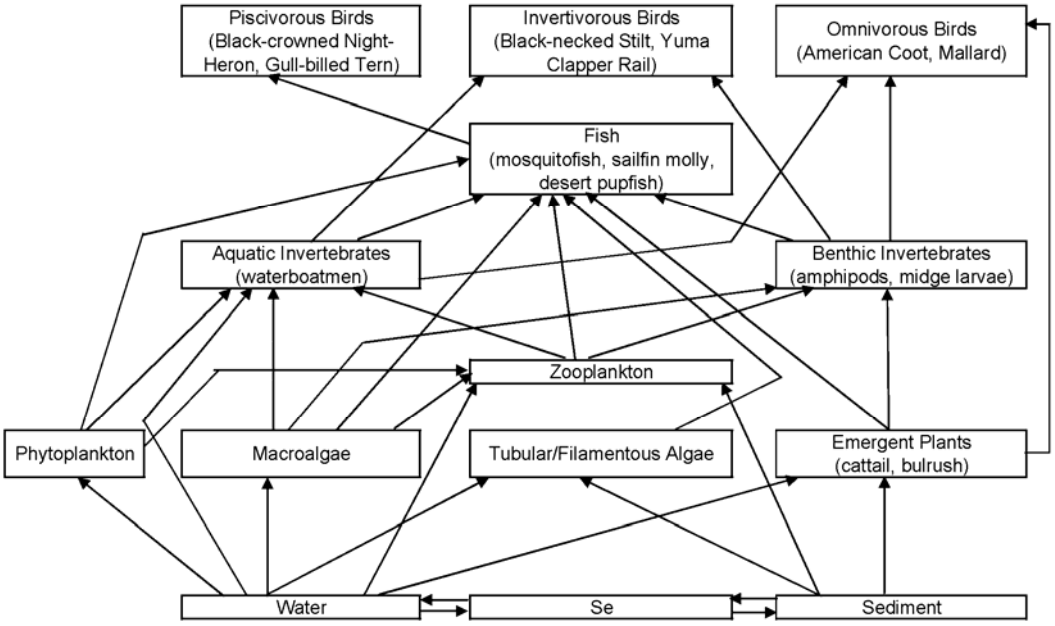

Figure 3
Exposure Pathways and Food Web Relationships for Managed Marsh Habitat

Estuaries (Deltas and Drains)

Estuaries are the mixing zones where agricultural drains, creeks (San Felipe and Salt), and rivers (Whitewater, New, and Alamo) enter the Salton Sea. The size of these estuaries varies on a daily to seasonal basis in relation to the volume of water discharging to the Salton Sea at each location. Estuarine waters ranging from 10 to 30 ppt extend about 1,600 to 3,300 feet (488 to 1,006 meters) offshore (Costa-Pierce, no date), with the greater distance during summer when irrigation runoff is high. Estuaries, particularly in the southern part of the Salton Sea, provide an area of reduced salinity and higher dissolved oxygen. Higher abundances of fish in this area during the summer may be due to the higher dissolved oxygen (Riedel et al., 2002). Many of the same species that use the open water and shallow water near the shoreline also use these areas. In low-salinity or freshwater areas, tilapia, mollies, longjaw mudsucker, and other freshwater species are present.

The food web in the estuaries is similar to that described for open water. The abundance of fish in this area during summer may provide an enhanced feeding area for top predators such as orangemouth corvina and birds. Piscivorous birds selected for evaluation include black-crowned night-heron and gull-billed tern, invertivores include black-necked stilts and Yuma clapper rail, and the mallard is selected as an omnivore (Figure 4).

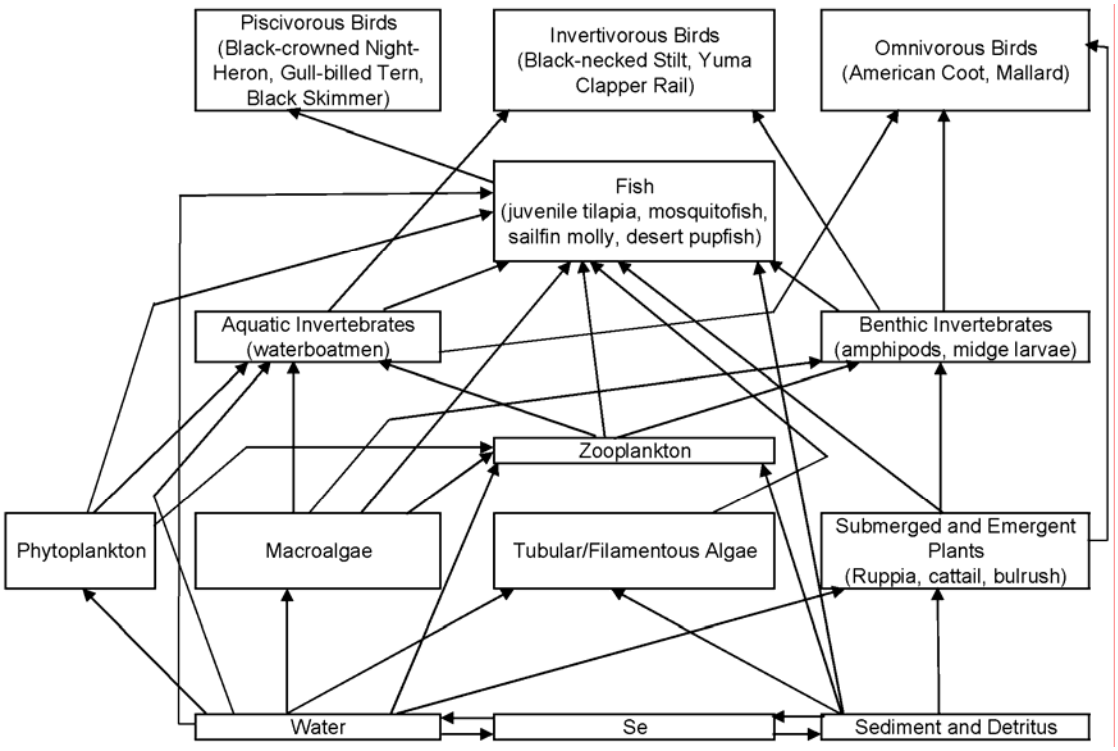

Figure 4
Exposure Pathways and Food Web Relationships for Estuaries (Deltas and Drains) Habitat

Agricultural Land

Agriculture land includes irrigated crops at the north and south ends of the Salton Sea. In the northern part of the Salton Sea, agricultural lands considered to be important to birds that also use the Salton Sea have been identified by DFG along the Whitewater River, extending from the sea to Highway 195 (66th Avenue) on the north and west and Highway 111 on the east. In the southern part of the Salton Sea, agricultural lands are between and along the New and Alamo rivers within about 10 miles (16 kilometers) of the sea. While exposure pathways and food web diagrams are presented here (Figure 5), it should be noted that the proposed Salton Sea Restoration Alternatives are not expected to directly affect selenium pathways in these habitats.

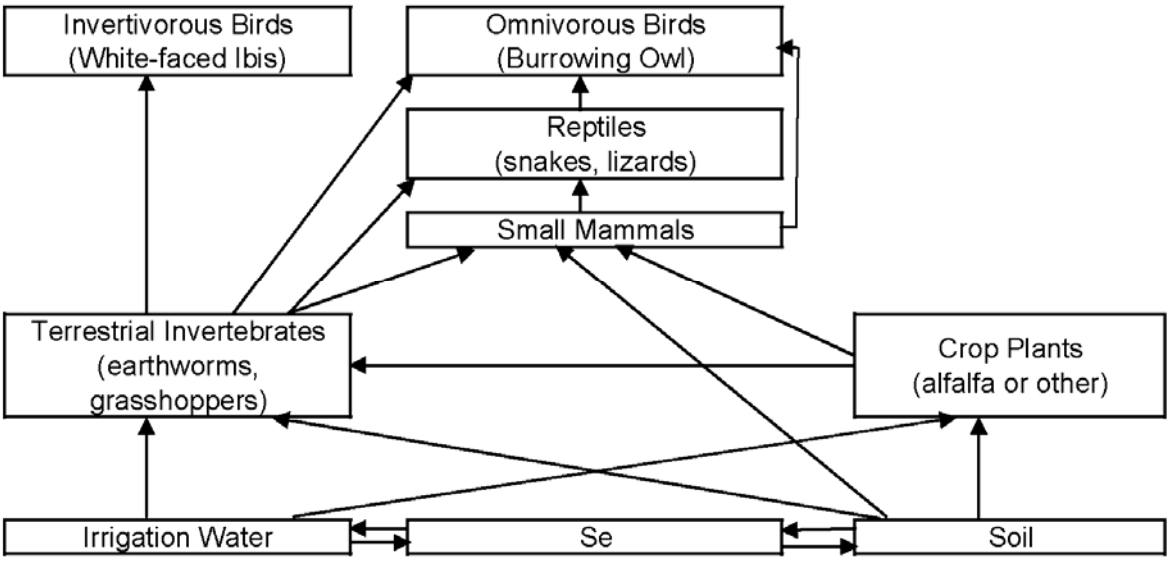

Figure 5
Exposure Pathways and Food Web Relationships for Agricultural Land

Agricultural lands are used by a variety of wildlife including invertebrates, reptiles, birds, and mammals. A number of bird species associated with the Salton Sea use flooded agricultural fields. Species include great blue herons, green-backed herons, great egrets, cattle egrets, rough-winged swallows, white-faced ibis, ring-billed gulls, and shorebirds (Patten et al., 2003). Geese also forage on crops in non-flooded fields. Burned asparagus and other crop fields are important wintering habitat for mountain plovers, horned larks, and American pipits in Imperial Valley. Orchards are used by ground doves and lark sparrows. American kestrels, loggerhead shrikes, and northern harriers are also associated with agriculture. Fields fallowed during crop rotation support foraging northern harriers, short-eared owls, western meadowlarks, and sparrows. Burrowing owls forage over open fields, with a preference for those with dried, weedy vegetation. Burrowing owls are common in Imperial Valley but uncommon in Coachella Valley. Nesting occurs in burrows, usually modified ground squirrel burrows, in the sides of earthen irrigation ditches from late March to June. Abundance is lowest in winter.

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