Prepared for the California State Water Resources Control Board and Bureau of Reclamation

Salton Sea Ecosystem Monitoring Project

Open File Report 2009–1276

U.S. Department of the Interior
U.S. Geological Survey

Cover: A flock of Wilson's Phalaropes create a reflection while flying over constructed saline habitat ponds (SHP), Salton Sea, California. Numerous species of waterbirds rapidly inhabited the SHP after completion in March 2006, and continue to use the SHP for foraging, roosting, and nesting activities. (Photograph courtesy of Tom Anderson, U.S. Geological Survey, Salton Sea Science Office.)

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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

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Conversion Factors

SI to US System

Multiply	By	To obtain
centimeter (cm)	0.3937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
hectare (ha)	0.003861	square mile (mi^2)
microgram (µg)	3.527e-08	ounce (oz)
milligram (mg)	3.527e-05	ounce (oz)
gram (g)	0.03527	ounce (oz)
milliliters (mL)	0.03382	ounce, fluid (fl. oz)
liter (L)	33.82	ounce, fluid (fl. oz)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32.

Datum

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD83).

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1. Executive Summary

The Salton Sea is critically important for wintering and breeding waterbirds, but faces an uncertain future due to water delivery reductions imposed by the Interstate and Federal Quantification Settlement Agreement of 2003. The current preferred alternative for wetland restoration at the Salton Sea is saline habitat impoundments created to mitigate the anticipated loss of wetland habitat.

In 2006, a 50-hectare experimental complex that consisted of four inter-connected, shallow water saline habitat ponds (SHP) was constructed at the southeastern shoreline of the Salton Sea and flooded with blended waters from the Alamo River and Salton Sea. The present study evaluated ecological risks and benefits of the SHP concept prior to widespread restoration actions.

This study was designed to evaluate (1) baseline chemical, nutrient, and contaminant measures from physical and biological constituents, (2) aquatic invertebrate community structure and colonization patterns, and (3) productivity of and contaminant risks to nesting waterbirds at the SHP. These factors were evaluated and compared with those of nearby waterbird habitat, that is, reference sites.

A summary of findings include:

- Water salinity at the SHP was variable over time, averaging between 4–24 milliliters per liter (mL/L) in Pond 1, 9–30 mL/L in Pond 2, and 30–70 mL/L in Pond 3. Pond 4 was characterized by hypersaline conditions that averaged around 150 and 175 mL/L from fall 2006 to fall 2007, and then more than 335 mL/L after spring 2008. With the exception of salinity and chlorophyll in Pond 4, discrete measures of other water quality, chemistry (non-contaminant), or nutrient parameters were within acceptable limits for biological colonization, recruitment, and survival characteristic of variable salinity salt pond systems.

- Invertebrate community structure and diversity was most strongly coupled with water and sediment salinity. Invertebrate composition in Ponds 1 and 2 was characterized by variable abundance of Capitellidae, Amphipoda, and Corixidae. Conditions in Ponds 3 and 4 were most conducive to Corixidae (most ubiquitous invertebrate at Salton Sea wetlands) or Ephydridae, whereas conditions at most reference sites favored Chironomidae, Clitellata, Capitellidae, Amphipoda, Gastropoda, and Ephemeroptera.

- Selenium was the most notable inorganic contaminants of concern. Selenium was statistically higher in sediment (1.8 micrograms per gram [µg/g], dry weight [dw]) and Corixidae (4.2 µg/g, dw) at the SHP than in sediment (1.0 µg/g dw) or Corixidae (2.2 µg/g dw) from reference sites. Selenium concentrations in water did not differ between the SHP (2.3 micrograms per liter [µg/L]) and reference sites (2.2 µg/L); however, the Alamo River had the highest average water selenium concentrations (5.6 µg/L) but the one of the lowest average sediment selenium concentrations (0.5 µg/g) of any site. Those reference sites sustained directly by Colorado River water (U.S. Fish and Wildlife Service Refuge's D-Pond and Hazard Complex) consistently had the lowest selenium among all sites. When accounting for inter-pond variation, selenium concentrations decreased over time in water and Corixidae across all SHP ponds. In contrast, selenium concentrations in sediments increased in Ponds 1 and 2 and decreased in Pond 4.

- Of the water samples taken from most sites (SHP Ponds 2 and 3 and reference D-Pond were the exceptions), 64–100 percent exceeded the 2.0 µg/L selenium toxicity threshold, whereas no sediment samples collected exceeded the 4.0 µg/g toxicity threshold. In Corixidae, 67–80 percent of samples from SHP Ponds 1, 2, and 3 exceeded the 4.0 µg/g toxicity threshold compared to less than or equal to 7 percent from SHP Pond 4 and reference sites.

- Corixidae significantly bioconcentrated selenium from water and sediment at both the SHP and reference sites. However, Corixidae bioconcentrated selenium from water at a steeper rate at the SHP. Selenium concentrations in Corixidae and Chironomidae were correlated at fresh- to- brackish water reference sites, but not at SHP Ponds 1 and 2.

- Distinct physical and biological patterns characterized differences in elements between SHP and reference sites. Boron and molybdenum concentrations in sediment and water samples and iron, aluminum, chromium, copper, and zinc concentrations in water and Corixidae were higher in SHP samples than those sampled at reference sites.

- Organochlorine compounds were rarely detected with the exception of *p,p*' DDE. Concentrations of *p,p*' DDE in water samples were consistently less than two times the limit of detection at all sites. Sediment *p,p*' DDE concentrations were statistically lower at the SHP than those at reference sites. Within sites, concentrations of sediment *p,p*' DDE were lowest in Ponds 1, 2, and 4 (≤0.02 µg/g) and highest at the Freshwater Marsh (0.10 µg/g) and Alamo River (0.06 µg/g). Concentrations of *p,p*' DDE were highest in Corixidae from Freshwater Marsh (0.34 µg/g dw, 0.06 µg/g wet weight [ww]) and Pond 2 (0.16 µg/g dw; 0.03 µg/g ww). The reference D-Pond site consistently had the lowest sediment and Corixidae *p,p*' DDE concentrations. Concentrations of *p,p*' DDE did not exceed predicted threshold effects levels in any sediment or Corixidae sample.

- Selenium concentrations in fresh Black-necked Stilt (*Himantopus mexicanus*; hereafter stilt) eggs varied over time between groups. Concentrations of selenium in stilt eggs collected from the SHP were significantly higher than reference site eggs in 2006 and 2008 but did not differ between sites in 2007.

- A large percentage of fresh stilt eggs collected from the SHP (47 percent) and reference sites Freshwater Marsh and Morton Bay (39 percent) exceeded the predicted 6.0 µg/g egg selenium toxicity threshold during the study. In contrast, no eggs collected from reference site D-Pond or Hazard exceeded the toxicity threshold. Selenium apparently did not affect embryo malpositioning that in turn affects hatchability.

- In contrast to patterns observed for water, sediment, and Corixidae, no distinct patterns in elemental composition or concentrations in stilt eggs occurred among sites, which suggested non-localized foraging prior to egg formation.

- Concentrations of *p,p*' DDE were significantly higher in stilt eggs collected from the SHP than those from reference sites in 2007 and 2008, but not in 2006. The percentage of stilt eggs exceeding the maximum fresh wet weight concentration reported from a previous south Salton Sea study ranged from 21 percent at D-Pond and Hazard reference sites to 44 percent at the SHP.

- Spatial use of the SHP by post-hatch stilt chicks was characterized by a low frequency of inter-pond movements, rapid dispersal out of the SHP within 3 days post-hatch, and large, non-random dispersal movements into surrounding freshwater habitats. In contrast, chicks hatched at freshwater reference sites moved shorter distances and were less likely to emigrate. These differences indicated that salinity or cryptic cover were important factors influencing chick-movements during the pre-fledgling life stage.

- Stilt chick survival to 21 days post-hatch was significantly higher for chicks hatched at reference sites (56 – 69 percent) than those hatched at the SHP (30 – 41 percent). Stilt chicks hatched at the SHP were about 2.5 times more likely to suffer mortality than chicks hatched at reference sites. Selenium concentrations determined from sibling eggs probably had no effect on survival. However, failure to emigrate from the SHP increased the probability of death by a factor of 9.

- Predictive modeling indicated slightly elevated risk of selenium toxicity for stilts nesting at the SHP compared to reference sites.

2. Problem Statement

The Salton Sea is an inland terminal water body created in its present form during the early 1900s. The Salton Sea is one of the most important wetlands in the Western United States, supporting more than 400 species of wintering or breeding waterbirds (Shuford and others, 2002). However, recent water transfer agreements defined in the Quantification Settlement Agreement will reduce agricultural drainwater inflows into the Sea by an estimated 30% by 2018 (California Department of Water Resources, 2007). Human-health and ecological hazards are predicted as inflow is reduced and the Salton Sea recedes. These hazards include reduced air quality from alkaline dust storms that result as the seabed dries, harmful or toxic salinity levels, and the loss of shoreline wetlands. The Salton Sea is listed as an impaired water body due to elements leached and concentrated by agricultural irrigation, a legacy of organochlorine pesticides, and nutrient-rich drainwater. Selenium, which is the most problematic of the elements, is essential for metabolic function but toxic at elevated doses (Ohlendorf, 1998). Current restoration planning alternatives for the Salton Sea are predicated on mitigating predicted hazards.

The construction of wetland impoundments was proposed as a promising restoration alternative to offset the detrimental effects of reduced inflow (California Department of Water Resources, 2007). Wetland creation using direct deliveries of 'clean' Colorado River water is not a likely option for large-scale restoration given the conditions imposed by the Quantification Settlement Agreement. Using agricultural drainwater from irrigated alkaline soils poses known selenium risks in California, exemplified most profoundly by the ecological disaster at Kesterson National Wildlife Refuge in the 1980s (Skorupa, 1998; Ohlendorf, 2002). Thus, a mix of water from the Salton Sea and drainwater was proposed as the best alternative for adequate water supply and to mitigate contaminant risks associated with using only fresh, agricultural drainwater. The elevated salinity of the blended water was expected to inhibit colonization of plants that may bioaccumulate selenium and to control mosquitoes.

The Bureau of Reclamation in cooperation with the U.S. Geological Survey created four inter-connected shallow water saline habitat ponds (SHP) at the southeastern shoreline of the Salton Sea. Fresh (albeit agricultural-runoff) water from the Alamo River was mixed with saline water (approximately 44 parts per thousand or milliliters per liter [mL/L]) from the Salton Sea to inundate the ponds. Blended water entered Pond 1 at a target salinity of 20 mL/L and flowed to each subsequent Ponds 2, 3, and 4 with increasing salinity due to evaporation. The small scale of the SHP provided an ideal setting to evaluate the feasibility of created wetlands under the prescribed water conditions. Physical and biological parameters were measured at the SHP in order to identify ecological risks or benefits that resource managers could evaluate prior to implementation of larger scale wetland restoration complexes. We used migratory waterbirds, in particular the common Black-necked Stilt (*Himantopus mexicanus*; hereafter stilt), as the focal endpoint for ecological assessment.

3. Project Goals and Objectives

We conducted an ecological assessment of the SHP and corresponding reference sites following completion of construction and initial flood-up in spring 2006. Sampling was timed to evaluate conditions for waterbirds during pre-breeding, breeding, and early wintering seasons. Our objectives were to determine:

1. Chemical, nutrient, and contaminant patterns in water and sediment.
2. Community structure and contaminants in avian prey, that is, common macroinvertebrates.
3. Contaminant concentration in stilt eggs and post-hatch spatial use and survival of stilt chicks.
4. Ecological risk assessment of adverse affects on avian populations inhabiting the SHP.

4. Project Description

4.1 Study Area

The SHP is located at the southeastern shoreline of the Salton Sea, near the Davis and Shrimpf Road intersection, Imperial County, California (fig. 1). The approximate 50-ha complex is comprised of four, near equal-sized ponds separated by earthen levees. Intake pumps at the Garst and Shrimpf Road intersection drew water of about 30 mL/L salinity from the Salton Sea and ≤ 2 mL/L salinity from the Alamo River. The blended water was pumped about 2.5 km via an underground pipe into SHP Pond 1 where it then flowed to the remaining ponds through a series of gravity flow control gates. Flooding of Ponds 1 and 2 was initiated in March 2006 and all four ponds were flooded by September 2006 to average depths ranging from 0.2 to 0.4 m.

Reference sites were established at the Alamo River, Salton Sea, Freshwater Marsh, and the D-Pond or Hazard complexes (Sonny Bono National Wildlife Refuge, U.S. Fish and Wildlife Service) to assess biological communities and contaminant risks characteristic of adjacent habitats (fig. 1). The Alamo River and Salton Sea sites represented habitats that provided source waters to the SHP. The Freshwater Marsh represented an expansive vegetated open wetland sustained by flow-through agricultural drainwater. The National Wildlife Refuge complexes are impounded wetlands sustained by water directly from the Colorado River that represented an assumed lowest contaminant risk. We initially investigated the D-Pond complex (hereafter D-Pond); however, it was drained prior to the end of the study and we substituted it with the Hazard complex (hereafter Hazard).

4.2. Methods

4.2.1. Water, Sediment, and Invertebrate Sampling

4.2.1.1 Sampling Locations and Frequency

We selected three random sampling points within each of the four SHP sites, and three sampling points at each of the four reference sites (table 1, fig. 1). At each sampling point, three subsamples were taken approximately 20–30 m apart and then composited as one sample per sampling point. Alamo River points were located at the SHP river intake pump, bridge at Sinclair Road, and Alamo River spit. The Salton Sea points were located near the intake pump, mudflat adjacent to the Alamo River spit, and Morton Bay, which had variable water intake from the Salton Sea or drainwater inflows. Points in Freshwater Marsh were near the terminus of a drainwater canal (the O Drain), the western end of Pound Road, and the marsh interior. Points in D-Pond were located in the northwestern, northeastern, and southeastern corners.

Each sampling point was spatially fixed using a Global Positioning System (GPS) (UTM Zone 11S, NAD83). Sediment samples were collected in March 2006 prior to flooding in order to obtain baseline contaminant and chemistry data. Water, sediment, and invertebrates were sampled on a bi-annual basis (spring = April, fall = October) beginning fall 2006 and ending fall 2008. All sample matrices were collected at all SHP points during the study. Fewer reference site points (n = 8) were sampled initially (fall 2006) but 12 reference points (3 per site) were sampled in spring 2007 through the remainder of the study.

4.2.1.2. Water Nutrients and Quality

Surficial (top 10 cm) water was collected at each sampling point to determine levels of nutrients and primary productivity. Water was collected in clean, 250 mL Nalgene® bottles, placed on ice, frozen within 8 hrs, and then sent within 1 week to the UC Davis Agricultural and Natural Resources (ANR) Laboratory for nutrient analysis. Samples were analyzed for nitrate (NO_3), ammonium (NH_4), phosphorous (soluble P), total dissolved solids (TDS). Concentrations of NO_3 and NH_4 were determined by flow injection analysis (ANR Method 847), soluble P by inductively coupled plasma atomic emission spectrometry (ICP-AES) (ANR Method 835), and TDS by oven drying and gravimetric analysis (ANR Method 870). Specific analytical details are provided at *http://groups.ucanr.org/danranlab/Water_and_Waste_Water/*. Total dissolved solids were quantified beginning spring 2007. To estimate primary productivity, water was collected at each sampling point in clean, acid (nitric) rinsed, 500 mL non photo-reactive Nalgene® bottles and immediately placed on ice. These samples were then express shipped to the UC Davis Limnology Lab for analysis of chlorophyll-a (Chl-a) within 24 hrs of collection. Water was filtered and the resulting extract analyzed for Chl-a using mass spectrometry. High salinity samples (for example, > 100 mL/L) were diluted prior to analysis.

Surficial water was further measured for salinity, conductivity, pH, dissolved oxygen, oxidative-reduction potential, and temperature *in situ* with a Hydrolab® Water Quality Analyzer. High salinity (>75 mL/L) samples were diluted with deionized water and salinity measured with a hand-held refractometer, and then back-calculated to the *in situ* concentration. All measuring devices were thoroughly rinsed with deionized water between points.

4.2.1.3. Water Inorganic and Organic Contaminants

Surficial water was analyzed for inorganic and organic contaminants at each sampling point within each site. Samples were collected in 1,000-mL Trace Clean® HDPE bottles for inorganic contaminants and in 1,000-mL Trace Clean® glass bottles for organic contaminants. Both sample types were placed on ice and then express shipped within 8 hours of collection to Battelle Marine Sciences Laboratory (BMSL) for inorganics and to Mississippi State Chemical Lab (MSCL) for organic contaminants.

Inorganic samples were acidified upon arrival at BMSL and analyzed for a maximum of 23 elements (listed in table 8) typically by inductively coupled plasma optical emissions spectroscopy (ICP-OES) or inductively coupled plasma-mass spectrometry (ICP-MS) depending on salinity interference and Quality Assurance/Quality Control (QA/QC) guidelines (appendix 1). Selenium (Se) was analyzed by either ICP-MS or hydride generation atomic absorption-flow injection atomic spectroscopy (HGAA-FIAS). Mercury (Hg) was analyzed by cold vapor atomic fluorescence (CVAF); Hg was determined only for samples collected in fall 2006 when all SHP ponds were flooded because of low or non-detectable levels. Limits of detection (LOD; appendix 2) varied according to dilutions required to analyze high salinity samples (appendix 3). Percent recoveries for certified reference materials (1640 or CASS-4) and matrix spikes averaged 102% (standard deviation [SD] = 5%) and 102% (SD = 10%), respectively. Relative percent difference for duplicate samples averaged 7% (SD = 11%). All elemental concentrations in water are reported as micrograms per liter (or parts per billion, μg/L]).

Organic samples were analyzed for a maximum of 22 organochlorine compounds (listed in table 15) by dual column gas chromatography – electron capture device (GC-ECD) (EPA Method 507 and 508). All organochlorine concentrations in water are reported as milligrams per liter (or parts per million, [mg/L]). The LOD was <0.0001 mg/L for chlorinated pesticides, <0.0005 mg/L for total PCBs, and <0.001 mg/L for toxaphene (appendix 4).

4.2.1.4. Sediment Chemistry and Composition

Sediment samples were analyzed for alkalinity (pH), salinity (carbonate (CO_3), bicarbonate (HCO_3), calcium (Ca^+), chloride (Cl^-), magnesium (Mg^+), sodium (Na^+), estimated soluble salts (EC), and composition (percent organic matter, percent organic carbon, and percent sand, clay, and silt). At each sampling point within sites, the top 5 cm of sediment from five subpoints spaced approximately 3 m apart was collected with a garden trowel, placed in a 3.8-L Ziploc® freezer bag, immediately placed on ice, refrigerated within 8 hrs of collection, and sent to the ANR Laboratory for analysis within 1 week of collection. Sampling instruments were thoroughly rinsed and cleaned between points. Using saturated paste extracts, sediment pH was determined with a pH meter (ANR Method 205), CO_3 and HCO_3 by acid titration (ANR Method 220), Cl^- by flow injection analysis (ANR Method 227), Ca^+, Mg^+ by ICP-AES (ANR Method 235), Na^+ by emission spectrometry (ANR Method 235), and EC with a conductivity meter (ANR Method 215). Percent organic matter and carbon were determined by potassium dichromate reduction and spectrophotometric measurement (ANR Method 410), and percent sand, clay, silt by hydrometric measurement of suspended particles (ANR Method 470). Specific analytical details of ANR methods can be found at http://groups.ucanr.org/danranlab/Soil_Analysis/index.htm.

4.2.1.5. Sediment Inorganic and Organic Contaminants

At each sampling point within sites, cores from the top 5 cm of sediment from five subpoints spaced approximately 3 m apart were collected with a 2.5-cm PVC pipe for analysis of inorganic and organic contaminants. Samples were placed in 250-mL Trace Clean® HDPE jars for inorganic analyses and 250-mL Trace Clean® glass jars for organic analyses, immediately placed over ice, and frozen within 8 hrs of collection. Sampling instruments were thoroughly rinsed and cleaned between points.

Sediment samples were sent to BMSL for analysis of a maximum of 22 elements typically using ICP-OES or ICP-MS depending on salinity interference and QA/QC guidelines (appendix 5). All samples were analyzed for selenium by HGAA-FIAS except those from spring 2006 originally analyzed by ICP-OES. The spring 2006 samples were biased by an interfering wavelength ostensibly due to high salt content in most samples. Selenium concentrations in these samples were conservatively back-calculated using the upper 95% confidence limits from the regression of selenium determined from ICP-OES against selenium determined from HGAA-FIAS (adjusted selenium = exp -0.51+ $0.66^{\text{Se ICP-OES}}$, $r^2 = 0.68$). Mercury was analyzed by cold vapor atomic fluorescence (CVAF) and determined only for those samples collected in spring 2006 due to low or non-detectable levels. Limits of detection are provided in appendix 5. Percent recoveries for certified reference materials (NIST 2702 and 2704) averaged 94% (SD = 13%) and matrix spikes averaged 100% (SD = 8%). Relative percent difference for duplicate samples averaged 6% (SD = 11%). All elemental concentrations are reported as micrograms per gram (parts per million), dry weight.

Sediment samples sent to MSCL were analyzed for 22 organochlorines using GC-ECD. Dry weight LODs were 0.002 µg/g for chlorinated pesticides, 0.01 µg/g for total PCBs, and 0.05 µg/g for toxaphene (appendix 6). Only DDT compounds (*p,p'* -DDD, -DDT, DDE; *o,p'*-DDD, -DDT, -DDE) were quantified in spring 2008. All organochlorine concentrations in sediment are reported as micrograms per gram, dry weight.

4.2.1.6. Invertebrate Community Structure

To estimate community structure of littoral macroinvertebrates, we collected benthic samples from three subpoints spaced approximately 3 m apart with a standard Ekman dredge, and each pelagic sample consisted of five figure-8 sweeping motions with a D-ring net through the water column. Samples were washed through a 1.0-mm sieve, placed in plastic cups, preserved in 70% EtOH dyed with rose-bengal, and sorted by USGS Davis Field Station laboratory personnel using dissecting scopes. Invertebrates were identified typically to taxonomic Family or the next best identifiable taxonomic classification and enumerated. We estimated taxonomic richness by tallying the total number of families that had at least 10 individuals per sample.

Zooplankton were sampled by pulling a hand-held net (150-µm mesh size) through the water for 20 seconds at a constant speed at each sampling point. Using 70% EtOH, netted particulates were rinsed into a 250 mL Nalgene® bottle, fixed with 4–5 drops of Lugol's solution, and stored in a dark place. Zooplankton samples were composited by site for each sampling period and sent to Dr. MaryAnn Tiffany (University of California, Riverside) for identification and quantification. A 3 mL subsample was rinsed with DI water to remove fixative using a 55-µm mesh cup. The sample was placed on a 3 mL counting slide to enumerate zooplankton. A larger subsample was taken and enumerated if few zooplankton were encountered. Equipment was washed and a new pipette used between samples to avoid cross contamination.

4.2.1.7. Invertebrate Inorganic and Organic Contaminants

We collected Corixidae (Family - water boatmen) for analysis of inorganic and organic contaminants. Corixidae were available in sufficient biomass (≥6 g, blotted wet weight) at most sites due to their wide range of salinity tolerance (Menke, 1979). Only Ephydridae (Family - brine fly larvae) were present in the hyper-saline SHP Pond 4, and the Alamo River sites contained insufficient invertebrate biomass of any taxa probably due to fast water flow and high turbidity. We also collected epibenthic Chironomidae (Family - midge larvae) for selenium analysis from sites where present in spring and fall 2008 for comparison to the more vagile Corixidae. Invertebrates, collected at each point within sites using a D-ring net, were placed in 500-mL Trace Clean® glass jars filled with site water for at least 24 hrs to allow their guts to purge. These samples were then sorted, rinsed in deionized water, blotted, and frozen in 60-mL Trace Clean® jars.

Invertebrates were analyzed for a maximum of 21 elements by BMSL using ICP-OES or ICP-MS depending on salinity interference and adherence to QA/QC guidelines (appendix 7). All selenium samples were analyzed by ICP-MS or HGAA-FIAS. Limits of detection are provided in appendix 7. Percent recoveries for certified reference materials (NIST 1566-b) averaged 103% (SD = 39%) and matrix spikes averaged 103% (SD = 8%). Relative percent difference for duplicate samples averaged 7% (SD = 16%). All elemental concentrations are reported as micrograms per gram, dry weight.

Invertebrate samples were analyzed for 22 organochlorines by MSCL using GC-ECD. Wet weight LOD was 0.002 µg/g for chlorinated pesticides, 0.01 µg/g for total PCBs, and 0.05 µg/g for toxaphene (appendix 8). Only DDT compounds were quantified in spring 2008 because no other organochlorine compounds were detected during previous sampling periods. All organochlorine concentrations are reported as micrograms per gram on a wet or dry weight basis as indicated.

All invertebrate collections were authorized by scientific collecting permits (SC-4849) issued by the California Department of Fish and Game.

4.2.2. Avian Contaminants and Ecology

4.2.2.1. Inorganic and Organic Contaminants in Black-Necked Stilt Eggs

Black-necked Stilts (*Himantopus mexicanus,* hereafter stilts) rapidly colonized Ponds 1 and 2 at the SHP after initial flood-up in spring 2006 and were the most ubiquitous and abundant nesting waterbird throughout the study (Anderson, 2009). Stilts have been extensively studied as avian indicators of selenium toxicity (Ohlendorf, 2003; Skorupa, 1998), and we used stilt eggs as a representative endpoint of contaminant risk.

We collected viable eggs from stilt nests at the SHP during the nesting season (May–July) of 2006, 2007, and 2008 (fig. 2). Nest success at the SHP was determined in a related study (Anderson, 2009). We collected eggs along the shoreline or on islands in Ponds 1 and 2 (the only flooded ponds spring 2006) and at all four ponds in 2007 and 2008. Stilt eggs were collected at reference sites in proximity to established sampling points when possible but nest placement dictated where eggs were actually collected. Nests with eggs were found at D-Pond in 2006 and 2007, Morton Bay in 2007, Hazard in 2007 and 2008, and Freshwater Marsh in all years. All nests were marked, geo-referenced with GPS, and then the eggs floated in a container of fresh water to estimate laying date (Westerskov, 1950). We then selected one egg at random from a nest, ideally at 7–12 days of incubation when possible. The total number collected annually from each site was governed by the scientific collection permits. We attempted to spread the number of nests targeted for egg collection evenly among sites and across the nesting season. Eggs were refrigerated within 2 hrs of collection.

Whole egg mass was measured on a digital scale to the nearest 0.1 g, and length and breadth measured with digital calipers to the nearest 0.01 cm. The blunt end of each egg was then opened with clean recurved surgical scissors and the contents emptied into Trace Clean® 60-mL jars and frozen until analyses. To evaluate embryonic abnormalities that are often indicative of selenium toxicity (Ohlendorf, 1998), eggs containing later stage embryos (≥18 days old) were examined for mal-positionings that deter hatchability, and all embryos 12 days old were examined for teratogenic defects (for example, missing or poorly developed eyes and appendages). Malposition classes were: head between thighs (MP-I), head in small end of egg (MP-II), head under left wing (MP-III), beak not directed toward air cell (MP-IV), feet over head (MP-V), and beak over right wing (MP-VI); malposition classes MP-I, III, and V generally are considered most fatal (Hutt, 1929; Wilson and others, 2003).

Egg samples were shipped to MSCL, homogenized, and an aliquot analyzed for 22 organochlorines using GC-ECD. The LOD was 0.002 µg/g for chlorinated pesticides, 0.01 µg/g for total PCBs, and 0.05 µg/L for toxaphene (appendix 9). Egg organochlorine concentrations are reported as micrograms per gram, wet or fresh wet weight. We used the following formula to convert wet weight to fresh wet weight (FWW):

FWW = wet weight concentration* [(original whole egg mass/(0.000467*((egg length*egg width2)*1.1)] (Hoyt, 1979; Evers and others, 2003; C.A. Eagles-Smith, unpublished USGS data, October 2009).

An aliquot of homogenate from each egg sample was shipped from MSCL to BMSL, where it was freeze-dried and analyzed for a maximum of 21 elements typically using ICP-OES or ICP-MS depending on QA/QC guidelines (appendix 10). All selenium samples were analyzed using ICP-MS or HGAA-FIAS. The LOD is provided in appendix 10. Percent recoveries for certified reference materials (NIST 1566-b) averaged 97% (SD = 12%) and matrix spikes averaged 105% (SD = 5%). Relative percent difference for duplicate samples averaged 12% (SD = 17%). Egg elemental concentrations are reported as micrograms per gram, dry weight.

Egg collections were authorized by scientific collection permits issued by the U.S. Fish and Wildlife Service's Region 1 Migratory Bird Office (MB-121218) and the California Department of Fish and Game (SC-4849).

4.2.2.2. Post-Hatch Movement and Survival

Chick Radio-Marking and\Tracking

We evaluated spatial use and survival patterns of post-hatch stilt chicks as an additional measure of ecological risks and benefits of the SHP relative to reference sites. Chicks were marked in Ponds 1 and 2 in 2006 (Ponds 3 and 4 were dry) and at all SHP ponds in the 2007 and 2008 nesting seasons. Chicks were found and marked only at Hazard in 2007 and 2008, and Freshwater Marsh in 2008 probably due to high rates of nest predation outside of the SHP (protected by an electric fence).

We visited nests near their hatch date that was estimated through nest monitoring and marked one chick less than 24 hours post-hatch per brood. In 2007 and 2008, we targeted nests where an egg was collected so that we could correlate egg contaminant concentrations to the marked chick. The selected chick was weighed to the nearest 0.5 g with a hanging Pensola® scale, and then the length of wing chord, tarsus, and culmen measured to the nearest 0.1 cm with digital calipers. Chick age was estimated based on weight and the presence of an egg tooth. A 0.8-g radio transmitter (model BD-2T, Holohil Systems Ltd., Ontario, Canada) was then attached between the chick's scapulars using subcutaneous dissolvable sutures. The chick was assessed for mobility and condition and then returned to its nest. To minimize stress, no chick was processed once the air temperature reached 35^{o} C. Radios transmitted for an average of 18 days, had a maximum audible range of 1 km, and were equipped with mortality sensors that transmitted a low pulse rate when chick body temperatures decreased below normal levels. Radio marking was authorized under USGS Bird Banding Lab Permit Number 22911.

Marked chicks were located during morning (0500–1200) and evening (1900–2200) hours using a hand-held telemetry receiver attached to a 3-element Yagi antennae. Most locations (ca. >85%) were obtained by direct visual observation or circling within less than 50 m of the chick, and recorded with GPS. We used Locate 3.18 (Pacer Computing, Tatamagouche, NS, Canada) to estimate the remaining locations from triangulated bearings. We monitored radio signal pulse rates within an hour of sunrise when ambient temperatures were lowest to assess survival on days when locations were not obtained. Thus, no more than 48 hrs elapsed between searches for radio signals. All dead radio-marked chicks were recovered, labeled, and the cause of death determined if possible, and frozen.

Spatial Use Estimation

We used fixed kernel estimators with bandwidths calculated from least-squares cross validation to calculate 95% (home range) and 50% utilization distributions (core area) using the Animal Movement Extension for ArcView 3.2 (Hooge and Eichenlaub, 1997). The utilization distributions represented the probability that chicks occurred in a given area during a specified time, and were calculated separately for the marked populations of chicks hatched in the SHP, Hazard, and Freshwater Marsh for each year.

For each chick, we calculated an index of dispersal: the distance and direction from nest site to the location farthest from nest site that the chick was detected as alive. We also calculated an index of site tenacity: average distance traveled between successive locations among sites. To specifically measure space use within the SHP, we calculated the proportion of locations that occurred within a chick’s natal pond, and the proportion of chicks that moved between ponds for chicks hatched during 2007 and 2008. We defined emigration as permanent chick movement out of the SHP ponds or when chicks from reference sites crossed a major obstacle (for example, a steep-sided canal). Three days was the median number of days to emigration at all sites, thus we assumed that all chicks that survived at least 3 days post-hatch were capable of emigrating in this analysis.

Survival Estimation

Maximum survival estimations for stilt chicks corresponded with the maximum life of the radios, that is, 21 days post-hatch. We excluded any chicks that died within 1 day of hatching and showed no obvious signs of trauma from all survival analyses in order to minimize capture effects bias. We estimated survival and chick fates under two scenarios due to a high incidence of chicks that disappeared before 21 days. Under scenario 1, chicks that survived more than 18 days (average transmitter life) or whose signals were failing (that is, signal pulse rate doubled or audible distance range decreased to less than 100 m) were right censored, that is, it was assumed that the transmitter failed but that the chick survived (Lawless, 2003). We also right censored chicks whose transmitters were recovered in questionable locations (for example, canal bottoms) within 4 days post hatch. Under scenario 2, chicks that disappeared in less than 18 days with no prior warning signal or transmitters that were recovered under questionable circumstances were assumed dead. This provided liberal (scenario 1) and conservative (scenario 2) survival estimates due to uncertainty in assigning known fates for all marked chicks.

Survival rates for populations of marked chicks at the SHP and reference sites were estimated with the Kaplan-Meier method (Pollack and others, 1989) using PROC LIFETEST in SAS (v8.12 statistical software, SAS Institute, Cary, NC). We used SAS PROC PHREG to estimate hazard or risk ratios (that is, the odds of an animal dying at a particular time).

Habitat Measurements

We measured water salinity and macroinvertebrate abundance as additional variables that might explain variation in chick spatial use and survival. Sampling occurred at a minimum of three locations and two time intervals in each SHP pond and reference site per year. Salinity was measured with a hand-held refractometer. Pelagic invertebrate samples were collected, preserved, and enumerated as described in section 4.2.1.6. We report the average number of Corixidae per site as an index of food availability.

In 2008, we measured vertical and horizontal hiding cover at the SHP and reference sites as an additional habitat component. Vertical cover (which included relief such as rocks and slope) was estimated with a modified 2-m tall Robel pole (Griffith and Youtie, 1988), horizontal cover was measured in a 1-m^2 plot using Daubenmire coverage classes. Twenty-three transects (about 300 m in length) were randomly placed within sites and cover was estimated every 10 m.

4.2.3. Statistical Analyses

4.2.3.1. Contaminant Concentrations

For water, sediment, or invertebrate sample matrices, we used mixed-effects nested analysis of variance (ANOVA) to test for differences in selenium and *p,p'* DDE concentrations between groups (SHP, reference), sites (nested within groups), and time. Because fewer reference sites were sampled for sediments prior to fall 2006 or water prior to spring 2007, statistical comparisons of these sample types were made from these time intervals forward to maintain model balance in the number of sites between the SHP and reference groups. We conducted a mixed-effect ANOVA to test for differences among SHP ponds over time for all sampling periods to further elucidate spatial and temporal patterns within the SHP. Reported results were for main effects models unless interactions were significant. We report *t*-statistics for time parameter coefficients to infer positive or negative relationships. Models were constructed using SAS PROC Mixed, whereby the sampling point was treated as a random effect. Differences between least-square means were compared with Tukey Kramer adjusted multiple comparison tests. Contaminant concentrations were $\log_e$ transformed prior to all statistical analyses. Organochlorine concentrations in invertebrates were tested on a dry weight basis.

We examined differences between groups in potential uptake of selenium from water and sediment by Corixidae and Chironomidae using mixed effects analysis of covariance (ANCOVA). Sites were treated as a random variable and sampling point treated as a random repeated effect to control for time. Only data from spring 2007 onward were included in the analysis to maintain model balance. Relationships between selenium concentrations in Corixidae and Chironomidae from paired sampling points were tested with mixed effects ANCOVA using the same random effects. These data represented samples from fresh to brackish water sites where Chironomidae were present during spring and fall 2008.

We used nested ANOVA to test for differences in elemental (dry weight) and organochlorine (fresh wet weight) concentrations in stilt eggs between groups and sites. Separate models were run for each year (2006, 2007, and 2008) because not all sites were sampled each year.

To determine selenium effects on egg hatchability, we used logistic regression (SAS PROC Logistic) to model the effect of egg selenium concentrations (dry weight) on the likelihood of total embryo malpositions and fatal embryo malpositions. Site effects were controlled by creating a dummy variable for the SHP and pooled Freshwater Marsh/Morton Bay sites. No egg from D-Pond/Hazard contained a malpositioned embryo ≥18 days old. Eggs from all years were pooled because too few eggs from particular sites contained malpositions within each year. The pooled Freshwater Marsh/Morton Bay sites represented habitats sustained by agricultural drainwater variably mixed with Salton Sea water.

We used principal components analysis using PC-ORD (McCune and Mefford, 2006) to reduce elemental data to highly correlated sets to elucidate spatial and temporal patterns for each sample matrix. All concentrations were $\log_e$ transformed prior to all statistical analyses. Elements that occurred with an overall detection frequency of <50% for a particular sample matrix and outliers (SD ≥ 2.0) were excluded from the ordination to minimize the influence of rarely detected elements. The final number of axes to retain was determined by a combination of axis eigenvalues (>1.0 to retain), comparisons to broken-stick values (eigenvalue > broken-stick), and randomization tests ($P < 0.05$) (McCune and Grace, 2002). We used joint plots and correlation coefficients ($r^2 > 0.3$) to identify gradients of elemental concentrations driving axis loadings, and to determine associations with relativized water and sediment physical measurements (for example, water quality and sediment composition).

4.2.3.2. Invertebrate Community Structure

We used non-metric multidimensional scaling (NMS) (Kruskal, 1964) using PC-ORD (McCune and Mefford, 2006) to identify patterns of macroinvertebrate community structure among groups, sites, and time. We grouped common taxa by taxonomic Family, which included Capitellidae, Chironomidae, Corixidae, Daphniidae, Ephydridae, and Nereidae. Uncommon (that is <5% of all samples at a specific time interval) taxa were grouped into higher taxonomic classifications of Order, Class, or Phylum. These groups included: Amphipoda (Corophiidae, Gammaridae), Arachnida (Hydracarina, unknown Arachnida), Clitellata (Tubificidae, Naididae, unknown Haplotaxida, unknown Oligochaeta), Coleoptera (Carabidae, Curculionidae, Dytiscidae, Elmidae, Hydrophilidae, Staphylinidae), other Diptera (Culicidae, Ceratopogonidae, Dolichopodidae, Empididae, Muscidae, Tipulidae, unknown Diptera), Ephemeroptera (Baetidae, Caenidae, unknown Ephemeroptera), Gastropoda (Assimineidae, Physidae, Rissoidae, unknown Gastropoda), other Hemiptera (Aphididae, Cicadellidae, Lygaeidae, Notonectidae unknown Hempiptera), Maxillopoda (unknown Cirripedia, unknown Copepoda), Nematoda (unknown Nematoda), Ostracoda (Cytherideidae, Sarsiellidae, unknown Ostracoda), and Polychaeta (unknown Polychaeta). Rare (<5% of all samples collected during the study) taxa were excluded from the analysis to minimize the effect of rare taxa on the ordination (McCune and Grace, 2002). We applied Beals smoothing, which creates a favorability index of each sample for each taxa, to relieve the ‘zero truncation problem’ common among community data sets, and selected the Sorensen proportion coefficient as the distance measure (McCune and Grace, 2002). Goodness of fit of the final NMS model was achieved when stress criterion fell below 15%. We used joint plots and correlation coefficients to identify gradients of taxa composition driving axis loadings, and to determine associations with relativized water quality, water nutrient, sediment composition, and sediment salinity measurements.

Stilt Spatial Use

We used ANCOVA to test for differences in maximum distance traveled from nest site and average distance traveled between successive locations among hatch groups and years. Julian hatch date was included as a covariate because of asynchrony in hatching across sites. Response variables were strongly right-skewed and therefore square root transformed to meet normality assumptions. Within groups and years, we used Rayleigh's *Z* to determine if angles of movement for maximum distance traveled from nests were random (Zar, 1996). All statistical tests for movement were restricted to chicks capable of emigrating.

Stilt Survival

Statistical tests of survival were conducted for chicks hatched in 2007 and 2008 (few chicks hatched at the SHP in 2006 when flooding initiated). Differences between the shapes of survivorship curves between groups (SHP vs. Reference) and years were tested with the log rank test (Allison, 1995). We used three sets of Cox-proportional hazard models to test covariate effects on estimated hazard ratios, that is, the odds of mortality occurring at a given point in time (Allison, 1995). The Cox model assumes that covariates multiply hazard or increase the chance of mortality. For Set 1, we first constructed time dependent covariates for group and year to test for violations of the proportional hazards assumption. If proportionality was met, Set 1 covariates included Julian hatch date, morphometrically adjusted body size at hatching (heretofore body size), year, and group for all chicks. Set 2 included the egg selenium concentration as an additional covariate for the subset of chicks where a sibling egg was collected. Set 3 only included chicks capable of emigrating ≥3 days post-hatch) to determine if chick emigration influenced the hazard ratio. For Sets 2 and 3, group and year were not of direct interest and were treated as strata variables to control for possible spatial and temporal effects. Low sample size precluded testing differences in survival within groups (SHP or reference) but patterns are qualitatively described.

4.2.4 Predictive Ecological Risk Assessment (PERA)

The PERA is a process of comparing measured concentrations of toxic chemicals with contaminant-specific toxicity data to derive levels that are protective of biota. The result of this process is a hazard quotient (HQ) that is generated for each species of concern. More detail about this assessment is provided in appendix 11. For the Salton Sea Ecosystem Monitoring Project, the PERA is used to evaluate the potential risk of selenium on stilts. The stilt was selected as the assessment endpoint because it is an upper-trophic-level species susceptible to bioaccumulation or biomagnification and was directly tied to the structure and function of the ecosystem at risk, that is, the SHP Ponds. Baseline risk assessment of this indicator species provides measurable guidance for the degree of recovery necessary to reduce risk, and is a means of determining the rate of recovery as mitigation actions are enacted.

As secondary consumers, stilts represent exposure routes involving potential bioaccumulation of contaminants and food-web transfer. Thus, ingestion of contaminated aquatic invertebrates is the primary route of exposure with incidental ingestion of sediments. The exposure model for ingestion is

$Di_{BNST} = \{[(C_i \times R_d \times F_i) + (EC_s \times R_d \times F_s)] \div BW_{BNST}\} \times T_{f,}$

Where

Di_{BNST}	=	daily dosage from ingestion
C_i	=	concentrations of potentially toxic chemicals in invertebrates
R_d	=	intake rate for Black-necked Stilt
F_i	=	fraction of invertebrates in Black-necked Stilt diet
EC_s	=	concentrations of potentially toxic chemicals in sediment
F_s	=	fraction of soil in Black-necked Stilt diet
BW_{BNST}	=	mean body weight of Black-necked Stilt
T_f	=	fractional intake, or fraction of time spent in contact with contaminated sediments

A hazard Quotient (HQ) is the ratio of the estimated exposure to the toxicity reference values (TRV, U.S. Environmental Protection Agency, 2009; Heinz and others, 1989):

$$HQ = \frac{\text{Estimated Exposure}}{\text{TRV}}.$$

The implicit assumption in characterizing risk is that, based on the estimated potential effects on individuals, inferences or extrapolations can be made to assessment endpoints or population-level effects. Low HQs are derived using no observable adverse effects levels (NOAEL) and High HQs are derived using low observable adverse effects levels (LOAEL). Chronic low HQs that exceed 1.0 suggest that adverse effects are possible to sensitive individuals, while chronic high HQs that exceed 1.0 suggest that adverse effects to most individuals are likely.

4.3. Results and Discussion

4.3.1. Water Quality and Nutrients

Average water-quality measurements of the SHP and reference sites are provided in table 2. Salinity was the most notable of the parameters that varied spatially and temporally in the SHP. Average salinity concentrations in SHP Ponds 1, 2, and 3, were lower in the fall seasons of 2006 and 2007 than in the subsequent spring seasons of 2007 and 2008 (fig. 3). By fall 2008, the pattern of salinity concentrations was more similar to the previous spring 2008 in the SHP. Salinity concentrations were expectedly lower in Ponds 1 (intake) and 2 than in Ponds 3 and 4 (terminal pond). Measures of Pond 4 in spring 2007 indicated hypersalinity that increased from 174 to 398 mL/L by fall 2008. Salinity in the Salton Sea ranged from 23 to 40 mL/L prior to spring 2008, but then decreased to greater than 8.4 mL/L thereafter during the study. Salinity in the Alamo River, Freshwater Marsh, and D-Pond reference sites was relatively constant (≤6 mL/L). Conductivity also varied spatially and temporally, but was highly correlated to salinity.

Concentrations of Chl-a, an estimate of primary productivity, varied spatially and temporally (fig. 4). Average Chl-a concentrations were consistently highest (>350 µg/L) at Pond 4 and lowest (<25 µg/L) at the Alamo River. At the SHP, average Chl-a concentrations at Pond 1 were highest (136 µg/L) in fall 2006 and then <59 µg/L thereafter. Chl-a concentrations in pond 2 were <66 µg/L across all intervals until fall 2008 (158 µg/L). At the reference sites, average concentrations were consistently high at the Salton Sea and D-Pond sites (≥90 µg/L). Notably D-Pond was dry in fall 2008, and the subsequent sample collected at the Hazard complex was substantially lower than any measures for D-Pond. With some temporal exceptions, concentrations of Chl-a in Ponds 1, 2, 3, and Freshwater Marsh were mostly similar to those reported for productive salt ponds in the north San Francisco Bay (about 25–52 µg/L) (Takekawa and others, 2006). In contrast, Chl-a concentrations at Pond 4, Salton Sea, and D-Pond exhibited reflected higher primary productivity relative to north San Francisco Bay.

Water nutrient measurements were characteristically low or within normal concentrations at most sites over time (table 3). Average ammonium concentrations were ≤2 mg/L at all sites except for Pond 4 and the Salton Sea sites in fall 2006. Average concentrations of nitrate and phosphorous at most SHP and reference sites were ≤3.5 mg/L. The notable exception was the Alamo River sites where nitrate concentrations ranged from 4.2 to 6.9 mg/L. With the possible exception of the Alamo River, nutrient concentrations at the SHP and reference sites were well below the 10 mg/L threshold associated with anaerobic waterbodies (Peng and others, 2008). Total dissolved solids in Pond 4 (170,730–266,970 mg/L) were 3–200 times higher than concentrations measured at all other sites.

4.3.2. Sediment Chemistry and Composition

Sediment salinity and composition measurements are summarized in tables 4 and 5, respectively. Sediments in the closed SHP pond system expectedly had higher concentrations of magnesium, sodium, calcium, chloride and estimated soluble salts than detected at most (Salton Sea was the exception) reference sites. Low concentrations of these salts at most reference sites were indicative of fresh to brackish open or flow through systems. Organic carbon concentrations were low to moderate at all SHP and reference ponds (0.3–2.0%). Increased organic carbon content in sediments is often associated with reduced invertebrate abundances as it accompanies low dissolved oxygen and elevated sulfide, ammonia, and contaminant concentrations (Thompson and Lowe, 2004).

4.3.3. Invertebrate Community Structure

Abundance of macroinvertebrate taxa varied spatially and temporally (table 6, fig. 5). Chironomidae, Corophiidae, Capitellidae, and Ostracoda were absent or infrequent in Pond 1 in fall 2006 and then fluctuated as much as 20-fold during subsequent sampling intervals. Corixidae generally were most abundant (>1,500 individuals/sample) at Pond 3 and the Salton Sea, but were detected in Pond 4 only in fall 2006. At reference sites, Corixidae were most abundant (>4,000 individuals/sample) at the Salton Sea in spring and fall 2008. Tubificidae were most common at the Freshwater Marsh and D-Pond in spring 2008, and were detected only in Pond 2 at the SHP. Capitellidae generally were most abundant at Pond 2, and were detected only at abundances ≥200 individuals at Pond 3 in spring 2008 and Salton Sea in fall 2006. Corophiidae were not detected at any reference site. Ostracoda were most frequently detected at Ponds 1 and 2, and the Salton Sea.

Family richness in Ponds 1 and 2 more than doubled from fall 2006 to spring 2008 before decreasing to values near baseline richness (that is, fall 2006 richness values) in fall 2008 (fig. 6). Ponds 3 and 4 generally had the lowest Family richness ($n \leq 3$) during the study, with the exception of Pond 3 ($n = 5$) during spring 2008. Family richness at the reference sites varied over time, with the highest richness at Freshwater Marsh in spring 2008 ($n = 11$) and the lowest richness at the Alamo River ($n = 2$) in fall 2006 and fall 2007.

Ninety-one percent of the cumulative variation in macroinvertebrate community structure was explained by a two-dimensional NMS solution (fig. 7). Axis 1 (72%) was most negatively correlated ($r^2 \geq 0.57$) with Corixidae and Ephydridae ($r^2 \geq 0.53$), and most positively correlated with Chironomidae and Clitellata ($r^2 = 0.69$). Axis 2 (19%) was most negatively correlated with Capitellidae and Amphipoda ($r^2 \geq 0.52$) and most positively correlated with Gastropoda and Ephemeroptera ($r^2 \geq 0.49$). Samples clearly separated by group and site to a lesser degree in the ordination space. Samples from Ponds 3 and 4 were associated with high favorability for Corixidae and Ephydridae on the left side of Axis 1, whereas samples from most reference sites were associated high favorability for Chironomidae and Clitellata on the right-hand side of Axis 1 (fig. 7). The Freshwater Marsh, D-Pond/Hazard, and (to a lesser degree) Salton Sea samples located in the upper right-hand quadrant of the ordination space were associated the most diverse taxonomic assemblage of invertebrates. Samples from Ponds 1 and 2, and some Alamo River sites were associated with high favorability of Capitellidae and Amphipoda along the lower end of Axis 2. Although absolute invertebrate abundance was variable over time (table 6, fig. 5), relative favorability changed little over time as evidenced by the consistent separation of groups and sites in the ordination space. A gradient of water salinity, sediment salinity, and total dissolved solids was best associated with invertebrate community structure along Axis 1 ($r^2 \geq 0.36$), indicating that increasing salinity and turbidity increased favorability for Corixidae and Ephydridae, and decreased favorability for the remaining salt intolerant taxa (fig. 7). All other water and sediment measurements were weakly correlated with Axis 1 ($r^2 \leq 0.19$) and Axis 2 ($r^2 \leq 0.09$).

We identified 12 different taxonomic groups of zooplankton, most at the level of Class and Order. Copepoda was the most abundant and diverse Class with four Orders identified. Three different Classes of zooplankton were identified in the SHP ponds and seven different Classes were identified in the reference ponds. The relative abundance of zooplankton between seasons and ponds is presented in table 7.

4.3.4. Inorganic and Organochlorine Contaminants

4.3.4.1. Water Contaminants

Selenium

Selenium was detected in all water samples (table 8). Concentrations of selenium in water did not differ significantly between groups (lsmeans: SHP = 2.34 µg/L, reference = 2.15 µg/L; $F = 2.3$, $P = 0.2$), and did not increase over time beginning in spring 2007 across both groups ($F = 0.3$, $P = 0.6$). However, sites nested within groups differed significantly ($F = 45.5$, $P < 0.0001$). Selenium concentrations were highest in the Alamo River, lowest in D-Pond/Hazard (followed by Ponds 2 and 3), and did not differ among Pond 4, Freshwater Marsh, Salton Sea, or Pond 1 (fig. 8). After accounting for inter-pond variation, water selenium concentrations in SHP ponds as a whole decreased linearly over time ($t_{[60]} = -2.2$, $P = 0.02$).

The suggested toxicity threshold for selenium in water is 2.0 µg/L (U.S. Department of the Interior, 1998; Hamilton, 2004). Selenium concentrations greater than 1–2 µg/L are considered elevated above typical background concentrations. All water samples from Pond 4 and the Alamo River, and 64–67% of samples from Pond 1, Salton Sea, and Freshwater Marsh across all time periods exceeded the toxicity threshold (fig. 9). No samples from D-Pond exceed the toxicity threshold whereas 27% of these samples exceeded background concentrations. Notably, Pond 2 had a low percentage of samples exceeding the toxicity threshold (20%) and background concentration (33%). The percentage of samples in Pond 3 was intermediate, with 33% exceeding the toxicity threshold and 67% exceeding the background concentration. In contrast, 100% of samples from the Alamo River exceeded the U.S. Environmental Protection Agency's (1987) water-quality criteria of 5.0 µg/L for the protection of aquatic life.

Elemental Concentrations and Compositional Patterns

Elemental concentrations in water are provided in table 8. Arsenic concentrations in water averaged from less than the limit of detection (LOD) – 229.7 µg/L during the study. However, the highly elevated concentrations of arsenic in Pond 4 and Salton Sea samples in fall 2006 and 2007 were suspected as sampling or laboratory artifacts because these concentrations were not observed at other sampling intervals or locations. Excluding these samples, all average arsenic concentrations were less than the 48 µg/L no effect and 190 µg/L toxicity thresholds (U.S. Department of the Interior,1998). Average concentrations of boron, consistently exceeded the 13,000 µg/L toxicity threshold for exposure to aquatic invertebrates (U.S. Department of the Interior, 1998) in Ponds 3 and 4, and approached or exceeded the 6,000 µg/L level of concern (U.S. Department of the Interior, 1998) in Ponds 1 and 2. In contrast, average boron concentrations were consistently below the level of concern in the Freshwater Marsh and D-Pond/Hazard. Average concentrations of zinc exceeded the 30 µg/L level of concern (U.S. Department of the Interior,1998) in all SHP Ponds during at least one sampling event, exceeded the 110 µg/L toxicity threshold in Pond 4 during fall 2007 and spring 2008, and were below the level of concern in all reference sites except Salton Sea during spring 2008. However, the toxicity of waterborne zinc is water quality dependent, and the hard water characteristics of the study area probably reduced its toxicity (U.S. Department of the Interior, 1998). Total mercury concentrations were ≤0.02 µg/L when measured fall 2006, therefore it was not analyzed at subsequent sampling intervals because this and other studies (for example, Riedel and others, 2002) indicated low potential risk at the Salton Sea.

Sixty-two percent of the cumulative variation in elemental concentrations in surface water was explained by two principal components (fig. 10). Axis 1 (41%, eigenvalue 7.0) was negatively correlated ($r^2 \geq 0.57$, eigenvalue 3.5) with boron, beryllium, cadmium, and cobalt, and positively correlated with barium ($r^2 = 0.30$). Axis 2 (21%) was positively correlated ($r^2 \geq 0.59$) with aluminum, iron, and vanadium. Water samples clearly separated in the ordination space by group as well as by site. Water samples from the SHP were associated with higher concentrations of elements loaded on Axis 1 (left hand side of fig. 10), beginning with Pond 4 and ending with Pond 1. In contrast, samples from all reference sites were associated with low concentrations along Axis 1 (right-hand side). The Alamo River and most Pond 4 samples were associated with high concentrations of elements loaded on Axis 2 (upper end), although most Pond 3 samples were associated with low concentrations along Axis 2 (lower end). All other samples did not strongly position along Axis 2. Total dissolved solids and soluble phosphorous were associated with Axis 1 ($r^2 \geq 0.50$), indicating that high concentrations of these nutrient measurements were correlated with high concentrations of elements loaded on Axis 1. Nitrate was positively yet weakly associated ($r^2 = 0.21$) with higher concentrations of elements loaded on Axis 2.

Organochlorines

No organochlorine compounds were detected in water in fall 2006 when all SHP ponds were inundated (table 9). The DDT compound *p,p'* DDE was the only organochlorine detected in water samples (fall 2008); mean *p,p'* DDE concentrations in these samples were less than 2 times the detection limit and detected only in samples from Pond 1, Alamo River, and Freshwater Marsh. Concentrations of, *p,p'* DDE did not exceed 0.02 mg/L in any water sample.

4.3.4.2. Sediment Contaminants

Selenium

Selenium is an element of ecological concern and was detected in all sediment samples (table 10). Selenium concentrations were significantly higher ($F = 53.7$, $P < 0.0001$) in sediments from the SHP group (lsmean = 1.81 µg/g) compared to the reference group (0.99 µg/g), and marginally decreased from fall 2006 to the end of the study across both groups ($t = -1.8$, $P = 0.07$). Sediment selenium concentrations also differed among sites nested within groups ($F = 24.7$, $P < 0.0001$); these were lowest in sediments from the Alamo River and D-Pond than all other sites (fig. 11). When only SHP ponds were examined from spring 2006 onward, the effect of time was not consistent across all ponds (Pond*time interaction: $F = 6.1$, $P = 0.001$). Sediment selenium concentrations increased over time in Ponds 1–2 ($t \geq 2.7$, $P \leq 0.008$) relative to a slight decrease at Pond 4 ($t = -1.8$, $P = 0.08$).

A selenium concentration >4.0 µg/g is a suggested toxicity threshold in sediments, and concentrations from 1 to 4 µg/g are considered elevated above background concentrations (U.S. Department of the Interior, 1998, Hamilton, 2004). No sediment samples taken during the study exceeded the toxicity threshold. However, 83–100% of the samples from SHP, Salton Sea, and Freshwater Marsh sites were above background concentrations whereas none from the Alamo River or D-Pond exceeded 1 µg/g.

Elemental Concentrations and Compositional Patterns

Elemental concentrations in sediment are provided in table 10. Average concentrations of arsenic did not exceed the toxicity threshold of 70 µg/g (dw) (Long and others, 1995; U.S. Department of the Interior,1998) at any site across all sampling periods, but approached or slightly exceeded the 8.2 µg/g level of concern (Long and others, 1995; U.S. Department of the Interior, 1998) in Ponds 1and 2, and Freshwater Marsh during most sampling periods. Average concentrations of cadmium, chromium, copper, nickel, and silver never exceeded their respective levels of concern (effects range-low, Long and others, 1995) of 1.2, 81, 34, 20.9, and 1.0 µg/g at any site across all sampling periods. Average concentrations of lead slightly exceeded (by about 3.0 µg/g) the 48.9 µg/g level of concern (Long and others, 1995) in Pond 2 during spring 2007 and fall 2008, and were below this level at all other sites across all sampling periods. Average concentrations of zinc approached or exceeded the 150 µg/g level of concern (Long and others, 1995) in Ponds 1 and 2 across all sampling periods, exceeded the 410 toxicity threshold (effects range-median, Long and others, 1995) by 9 µg/g in Pond 2 during fall 2008, and were below the level of concern in Ponds 3 and 4 and all reference sites across all sampling periods. Sediment total mercury concentrations were ≤0.06 µg/g in fall 2006, which is a value at least two times lower than the 0.15 µg/g level of concern (Long and others, 1995). Thus, mercury was not subsequently analyzed due to low potential risk.

Seventy-eight percent of the cumulative variation in elemental concentrations in sediments was explained by three principal components (fig. 12). Axis 1 (38%, eigenvalue = 5.8) was negatively correlated with cobalt, chromium, copper, nickel, and vanadium ($r^2 \geq 0.51$), Axis 2 (23%, eigenvalue = 3.4) was positively correlated with zinc, and lead ($r^2 \geq 0.49$), and Axis 3 (17%, eigenvalue = 2.5) was negatively correlated with boron, molybdenum, and selenium ($r^2 \geq 0.57$). Patterns of elemental differences among sites occurred in the ordination space. Although clear separation among sites was difficult to distinguish among sites along Axis 1, most samples from Ponds 1 and 2 were positively correlated with elements loaded on Axis 2. Notably, most samples from all SHP ponds followed a gradient of high boron, molybdenum, and selenium along Axis 3. Sediment salinity and composition measurements were mostly unrelated to Axes 1 and 2 ($r^2 \leq 0.29$). In contrast, organic matter and water conductivity exhibited a slight correlation with Axis 3 ($r^2 \geq 0.34$), which indicated a positive correlation with high concentrations of elements loaded on Axis 3.

Organochlorines

Organochlorines were not detected in sediments during any time except DDT compounds (table 11). Concentrations of *p,p'* DDE were detected in 98% of all samples but *p,p'* DDD, DDT, and *o,p'* DDE were detected only in samples from spring 2008 or fall 2008 at the reference sites or Pond 2, and were less than 3 times the detection limit.

Sediment *p,p'* DDE concentrations were significantly higher ($F = 20.3$, $P = 0.0001$) at the reference group (lsmean = 0.02 µg/g) than at the SHP group (0.01 µg/g), and did not change over time ($t = -1.8$, $P = 0.07$). The 0.01 µg/g overall difference between groups was likely not biologically significant. Sites nested within groups differed ($F = 25.4$, $P < 0.0001$), where *p,p'* DDE was highest in sediments from the Freshwater Marsh, and then the Alamo River, SHP Pond 3, and Salton Sea (fig. 13).

Sediment *p,p'* DDE concentrations were lower in D-Pond (reference) than SHP Ponds 4, 2, and 1. When examining only SHP ponds, the effect of time was not consistent across all ponds (Pond*time interaction: $F = 5.7$, $P = 0.002$). Sediment *p,p'* DDE concentrations decreased linearly over time in Pond 4 ($t = -4.0$, $P = 0.002$), but not in Ponds 1, 2, or 3 ($t \leq 1.5$, $P > 0.15$). No sediment sampled during the study exceeded the suggested toxicity threshold of >2.5 µg/g for *p,p'* DDE (U.S. Department of the Interior, 1998).

4.3.4.3. Invertebrate Contaminants

Selenium

Selenium was detected in all invertebrate samples (table 12). Selenium concentrations in Corixidae were significantly higher ($F = 59.2$, $P < 0.0001$) at the SHP (lsmean = 4.4 µg/g) than at the reference (2.2 µg/g) group, and did not change over time across both groups ($t = 1.0$, $P = 0.3$). Selenium concentrations in Corixidae also differed among sites nested within groups ($F = 5.3$, $P = 0.0008$), and were highest in SHP Ponds 1, 2, and 3, and lower in D-Pond, then Freshwater Marsh and Salton Sea (fig. 14). At the SHP, selenium concentrations in Corixidae did not differ among Ponds 1, 2, or 3 ($F = 0.05$, $P = 0.9$), but decreased linearly over time ($t = -3.2$, $P = 0.003$). Corixidae were abundant in Pond 4 only in fall 2006 when initially flooded, and Chironomidae were common only in SHP Pond 1 and the Salton Sea, Freshwater Marsh, and D Pond/Hazard reference sites.

Most suggested dietary (that is, invertebrate as avian prey) toxicity thresholds for selenium concentrations range between 3–4 µg/g dry weight (Hamilton, 2004). Therefore, we examined the percentage of invertebrate samples exceeding 4.0 µg/g as a measure of selenium risk to higher trophic levels. The average percentage of Corixidae samples that exceeded the threshold was highest at SHP Ponds 1, 2, and 3 (67–80%) and lowest at D-Pond, Salton Sea, and Freshwater Marsh (0–7%); confidence intervals did not overlap between the high and low groups during the study (fig. 15). In contrast, the percentage of Chironomidae samples that exceeded the threshold was 100% at Salton Sea, 83% at Freshwater Marsh, 33% at Pond 1 and D-Pond, and 0% at Pond 2. However, confidence intervals overlapped for all sites possibly because of small sample size (≤ 6 composite samples per site) therefore Chironomidae risk estimates were not as robust as those for Corixidae. No Ephydridae sampled in Pond 4 exceeded the suggested dietary toxicity threshold for selenium.

Selenium Bioconcentration and Interspecies Relations

Selenium concentrations in Corixidae were positively related with those in sediment ($t = 3.1$, $P = 0.03$) and water ($t = 14.0$, $P < 0.0001$), and Corixidae from the SHP had significantly higher average concentrations than those from the reference group when accounting for variation in selenium in sediment ($F = 25.3$, $P = 0.03$) and water ($F = 43.2$, $P = 0.006$; fig. 16). Corixidae selenium was more highly correlated with water selenium for both the SHP and reference groups than Corixidae selenium and sediment selenium but the predictability was weak in all cases with the possible exception of Corixidae and water in the reference group (fig. 16). In contrast, there was no correlation of Chironomidae selenium concentrations with sediment ($t = 1.3$, $P = 0.2$) or water selenium concentrations ($t = 1.9$, P 0.09) but sample size was less than that for Corixidae.

Corixidae selenium concentrations (geomean = 5.3 µg/g) were higher than those in Chironomidae (3.6 µg/g) at SHP Ponds 1 and 2, whereas Chironomidae selenium concentrations (4.5 µg/g) were higher than those in Corixidae (2.2 µg/g) at the reference group (fig. 17). Selenium concentrations in Chironomidae and Corixidae were not related ($t = 1.6$, $P = 0.2$) and did not differ between sites ($F = 7.8$, $P = 0.07$). However, the relationship of selenium concentrations in Chironomidae and Corixidae was significant ($F = 9.9$, $P = 0.03$) when a single site outlier was removed, which indicated that selenium in Corixidae and Chironomidae was highly correlated in the reference group but not the SHP group (fig. 18).

Elemental Concentrations and Compositional Patterns

Elemental concentrations in Corixidae and Ephydridae are provided in table 12. Concentrations of boron at SHP Ponds 3 and 4, barium at Freshwater Marsh, copper at SHP Ponds 1, 2, and 3, iron at all sites, manganese at all sites but more notably at the SHP, and zinc at all sites exceeded suggested background concentrations for estuarine invertebrates (Miles and Tome, 1997) during at least one sampling interval. Other than selenium (discussed above), dietary levels of boron (>30 µg/g) was the only element in SHP Ponds 3 and 4 that may have a subtle but non-toxic effect on developing avian embryos (Smith and Anders, 1989). Mercury was not analyzed in invertebrates because of low or non-detectable concentrations in water and sediments.

Sixty-three percent of the cumulative variation in elemental concentrations in Corixidae was explained by two principal components (fig. 19). Axis 1 (39%, eigenvalue = 6.6) was positively correlated with aluminum, cobalt, chromium, iron, and nickel ($r^2 \geq 0.51$), and Axis 2 (24%, eigenvalue = 4.1) was positively correlated with silver, copper, selenium, and zinc ($r^2 \geq 0.53$). Subtle separation occurred along Axis 1, where Corixidae from Salton Sea sites were associated with lower concentrations of elements loaded on Axis 1 compared to Corixidae from Pond 2. However, Corixidae clearly separated in the ordination space by group along Axis 2, where samples from the SHP group were associated with higher concentrations of elements loaded on Axis 2 (upper end) compared to the reference group (lower end).

Organochlorines

Similar to pattern observed for sediments, DDT compounds were the only organochlorines detected in invertebrates during the study (table 13). With the exception of one sample, *p,p'* DDE comprised all detected DDT compounds and was detected in 89% of all samples. Corixidae *p,p'* DDE concentrations did not differ significantly between groups (lsmeans: SHP = 0.11 µg/g dw, reference = 0.12 µg/g dw; $F = 0.1$, $P = 0.9$), and did not change over time across both groups ($F = 3.2$, $P = 0.8$). Although concentrations were variable within sites, significant differences occurred among sites ($F = 6.9$, $P < 0.0001$), with the highest least squares mean concentrations in Freshwater Marsh (0.34 µg/g dw) and Pond 2 (0.16 µg/g dw), and lowest in D-Pond (0.06 µg/g dw) and SHP Pond 3 (0.04 µg/g dw) (fig. 20). When only SHP ponds were examined, *p,p'* DDE did not differ among ponds ($F = 2.0$, $P = 0.14$), and marginally increased over time ($t = 1.9$, $P = 0.07$). No invertebrate sampled during the study exceeded the level of concern (> 10 µg/g, dry weight) for insectivorous waterfowl (U.S. Department of the Interior, 1998).

4.3.4.4. Contaminants in Stilt Eggs

Selenium

Selenium was detected in all fresh and salvaged (that is, abandoned or failed to hatch) stilt eggs (table 14). In 2006, selenium concentrations were significantly higher (F = 9.9, P = 0.006) in fresh eggs collected at the SHP (lsmean = 8.0 µg/g dw) than those from all reference sites (4.9 µg/g). Concentrations were lowest in eggs from D-Pond (3.5 µg/g) than eggs from Freshwater Marsh (6.9 µg/g), Pond 1 (7.4 µg/g), and Pond 2 (8.5 µg/g) (F = 5.4, P = 0.02) (fig. 21). In 2007, egg selenium concentrations did not differ between groups (SHP = 5.6 µg/g, reference = 5.3 µg/g; F = 0.01, P = 0.9 or among sites (F = 1.5, P = 0.2). In 2008, selenium concentrations were significantly higher (F = 9.4, P = 0.004) in eggs from the SHP (5.7 µg/g) than those from reference sites (4.8 µg/g). Among sites, concentrations were highest in eggs from Pond 3 and lowest in eggs from Hazard and FW Marsh (F = 3.1, P = 0.03). Notably, egg selenium concentrations were lower (and similar) at the SHP in 2007 and 2008 than 2006, and similar at the reference sites all years. Initial flooding of the SHP in 2006 probably influenced the spike observed, and selenium seemed to decline to equilibrium in eggs thereafter.

Egg selenium greater than 6.0 µg/g (dry weight) is a conservative measure of toxicity risk that is suggested to cause reproductive impairment (Hamilton, 2004; U.S. Department of the Interior, 1998) but a higher selenium toxicity threshold of 16 µg/g has been proposed by Fairbrother and others (2000). During this study, 47% of the stilt eggs collected from the SHP and 39% from the Freshwater Marsh/Morton Bay exceeded 6.0 µg/g (fig. 22). Overlapping confidence intervals indicated percentages did not differ significantly between SHP and Freshwater Marsh/Morton Bay eggs during any year. In 2006, 70% of the eggs collected from the SHP and 83% of those from the Freshwater Marsh /Morton Bay exceeded 6.0 µg/g. The percentage of eggs > 6.0 µg/g decreased subsequently at the SHP but confidence intervals overlapped for all years, whereas it was significantly lower in 2008 than 2006 at Freshwater Marsh/Morton Bay. Spatially explicit egg selenium concentrations illustrated substantial variation among sites and years, with isolated hot spots (> 8.0 µg/g) in SHP Ponds 1, 2, and 3 and the interior of the Freshwater Marsh (figs. 23A – 23C). During the study, no eggs collected from D-Pond or Hazard exceeded 6.0 µg/g nor did any egg collected exceed the proposed higher toxicity threshold of 16 µg/g selenium.

For all fresh eggs collected at an incubation age of ≥18 days, 8 of 24 (33%) had malpositioned embryos; only 2 of these were malpositions typically considered fatal. The percentages of eggs with malpositioned embryos were identical at the SHP (33%) and Freshwater Marsh (33%) (fig. 24). Malpositioned embryos did not occur in eggs collected from D-Pond, Hazard, or Morton Bay. After controlling for group effects, egg selenium concentrations significantly influenced the likelihood of malpositions (χ^2 = 0.30, P = 0.58, odds ratio = 1.2, 95% CI = 0.7 – 1.9) or fatal malpositions (χ^2 = 0.04, P = 0.83, odds ratio = 1.0, 95% CI = 0.5 – 2.4). Two eggs contained potentially deformed embryos, one exhibited underdeveloped skull and legs (5.3 µg/g selenium), the other exhibited a curved billed and enlarged eyes (11.5 µ/g).

Elemental Concentrations and Compositional Patterns

Elemental concentrations in stilt eggs are provided in table 14. Average concentrations of arsenic in eggs ranged from 0.70 to 1.5 µg/g among sites in 2006 and 2007 and arsenic was not detected in eggs from 2008 (table 14). Average arsenic concentrations in eggs from Pond 1 during 2006 slightly exceeded the 1.3 µg/g level of concern (U.S. Department of the Interior, 1998), but average concentrations were well below the 2.8 toxicity threshold (U.S. Department of the Interior, 1998) across all sites and years. Average boron concentrations were similarly low, ranging from 0.18 to 1.82 µg/g in eggs collected during the study, and were at least 7 times lower than 13.0 µg/g level of concern (U.S. Department of the Interior, 1998). Average concentrations of zinc ranged from 46.3 to 64.3 µg/g, which generally exceeded the 50 µg/g level of concern but were well below the 2,100 µg/g toxicity threshold (U.S. Department of the Interior, 1998). Most remaining elements were detected in less than 50% of all egg samples, which indicated relatively low exposure.

Unlike patterns observed for elements in water, sediments, and invertebrates, only 32% of the cumulative variation in elemental concentrations in fresh eggs was explained by two principal components. Axis 1 (19%, eigenvalue = 2.7) was positively correlated with boron, iron, and zinc ($r^2 > 0.38$), and Axis 2 (12%, eigenvalue = 1.7) was negatively correlated with chromium and nickel. Eggs did not clearly separate in the ordination space by group or site (fig. 25*A*), but eggs collected in 2008 were associated with lower concentrations of elements loaded on Axis 1 (fig. 25*B*).

Organochlorines

The compound *p,p'* DDE comprised 93% of the organochlorines detected and was found in all fresh stilt egg samples; concentrations in eggs by site averaged 1.0–6.4 µg/g wet weight (table 15). Total PCBs comprised 5% of organochlorines and was detected only in 2008 at average concentrations of ≤0.29 µg/g. Only trace concentrations (generally less than 5 times the LOD) of the remaining suite of organochlorines comprised the remaining 2% of the total concentration.

On a fresh wet weight basis, concentrations of *p,p'* DDE in stilt eggs from 2006 did not differ among groups ($F = 0.2$, $P = 0.7$). However, *p,p'* DDE in eggs from the SHP were significantly higher in 2007 (lsmean: SHP = 1.73 µg/g, reference = 0.89 µg/g; $F = 4.9$, $P = 0.03$) and 2008 (SHP = 1.56 µg/g, reference 1.08 µg/g; $F = 3.9$, $P = 0.05$) than in those from the reference sites (fig. 26). Concentrations of *p,p'* DDE did not differ among nested sites in any year ($F \leq 1.9$, $P \geq 0.13$).

Eggshell thinning is a universally accepted indicator of *p,p'* DDE effects, and (wet weight) concentrations >3.0 µg/g (Blus, 1996) to >4.0 µg/g (Henny and Herron, 1989) have been suggested as detrimental to aquatic birds based on empirical studies. Henny and others (2008) did not find eggshell thinning in stilt eggs at 1.7 µg/g *p,p'* DDE (fresh wet weight) at south Salton Sea wetlands; thus, we used this concentration along with the 4.0 µg/g wet weight threshold as conservative indicators of *p,p'* DDE risk. Of the stilt eggs collected during the study, 44% (95% CI: 33–56%) at the SHP, 29% (95% CI: 13–45%) at Freshwater Marsh/Morton Bay, and 21% (95% CI: 0–43%) at D-Pond/Hazard exceeded 1.7 µg/g *p,p'* DDE (fresh wet weight). On a wet weight basis, however, only 18% (95% CI: 9–27%) of the SHP eggs, 3% (95% CI: 0–6%) of the Freshwater Marsh/Morton Bay eggs, and 7% (95% CI: 0–7%) of the D-Pond/Hazard eggs exceeded 4.0 µg/g *p,p'* DDE.

4.3.5. Post-Hatch Spatial Use

We radio-marked 132 stilt chicks within 1 day-post hatch; 18 were marked in 2006, 54 in 2007, and 60 in 2008. We obtained 253 locations in 2006, 471 in 2007, and 450 in 2008 (figs. 27*A* – 27*C*). Spatial utilization distribution estimates are provided in table 16. Home range estimates for populations of chicks hatched at the SHP ranged from 143 to 212 ha across all years. In contrast, estimates for populations of chicks hatched at Hazard were about one-half the size of the SHP home ranges, and the estimate for chicks hatched at the Freshwater Marsh was only 5 ha.

Home ranges or core areas of chicks hatched in specific areas did not overlap with other areas during the study (figs. 28*A* – 28*C*). In 2006 and 2007, home ranges for chicks hatched at the SHP encompassed the entire SHP, portions of the Freshwater Marsh to the north, Morton Bay to the south, and the Salton Sea mudflat to the west. In 2008, these home ranges encompassed a larger portion of Morton Bay as well as a privately owned waterfowl hunting club to the south, but did not extend as deeply into Freshwater Marsh as in 2006 and 2007. In addition, portions of the Salton Sea mudflat and Freshwater Marsh adjacent to the SHP became newly vegetated with *Carex* sp. and *Rumex* sp. during spring 2008. These may be reasons for less extensive chick movements into the Marsh interior during 2008. The SHP core area generally was associated with centers of activity that included the area of high nest density and the Freshwater Marsh. The Hazard home range encompassed the interior portions of the complex and extended farther eastward to the Alamo River in 2007. In contrast, the Hazard home range extended into the southern Hazard ponds and southeastern portion of Red Hill Bay in the Salton Sea in 2008. The Hazard core areas were comprised of multiple centers of activity that encompassed portions of the entire complex in both years. The small home range for chicks hatched at the Freshwater Marsh essentially comprised the nesting area along Alcott Road.

Chicks hatched at the SHP exhibited relatively little inter-pond movement, particularly during 2007 (table 17, fig. 29). For example, 84% of all locations occurred in the same ponds where chicks were hatched, and only 30% of individual chicks actually moved to a non-hatch pond. The percentage of all locations occurring in the same ponds where chicks were hatched decreased to 59% during 2008, which was mostly driven by the three chicks hatched in Pond 2 displaying all inter-pond movements into Pond 1. A similar pattern was observed during 2006 where all chicks from Pond 2 exhibited movement into Pond 1. Movements into the dry Ponds 3 and 4 occurred during emigration in 2006.

Maximum distances traveled from nest sites were greater for chicks hatched at the SHP than those at reference sites ($F = 3.8$, $P = 0.05$), and for chicks hatched in 2007 than 2008 ($F = 6.4$, $P = 0.01$) (table 18, figs. 30*A* – 30*C*). Similarly, average distance traveled between successive locations were greater for chicks hatched at the SHP than those at reference sites ($F = 6.1$, $P = 0.05$), and for chicks hatched in 2007 than 2008 ($F = 7.1$, $P = 0.009$). Neither response variable was influenced by Julian hatch date ($F \leq -1.1$, $P \geq 0.29$). Mean maximum distances from nest sites for chicks hatched at individual SHP ponds ranged from 205 m at Pond 2 in 2008 to 1,212 m at Pond 1 in 2006. In contrast, mean maximum distances from nest sites for chicks hatched at reference sites ranged from 52 m at Freshwater Marsh in 2008 to 584 m at Hazard in 2007 (table 18).

Chicks tended to disperse from hatch sites within the SHP in a northwesterly direction towards the Freshwater Marsh during the study (table 18, figs. 30*A* – 30*C*). Vectors for maximum distances from nest sites within the SHP were non-random for chicks hatched in 2006 and 2007 ($Z \geq 6.0$, $P < 0.002$), but not 2008 ($Z = 1.9$, $P = 0.15$). The random movement in 2008 was likely due to chicks that emigrated southward from the SHP, which was not observed in 2006 or 2007 (fig. 30*C*). Chicks hatched at Hazard dispersed in a similarly non-random direction in 2007 and 2008 ($Z \geq 4.9$ $P < 0.004$), but in an east to southeasterly direction. In contrast, dispersal vectors for chicks hatched at the Freshwater Marsh in 2008 were random ($Z = 2.4$, $P = 0.08$).

Three days was the median time to emigration across all sites and years for chicks that survived at least 3 days post-hatch (table 18). Chicks generally emigrated from the SHP within 2 days post-hatch with the exception of chicks in Pond 1 in 2007 (median = 6.0 days). Among years, 59%, 85%, and 68% of chicks that survived at least 3 days post-hatch permanently left the SHP in 2006, 2007, and 2008, respectively. Moreover, 65% to 85% of the chicks presumably died that did not leave the SHP, depending on the scenario assumed for chicks that disappeared (see section, "Factors Influencing Survival"). In contrast, chicks emigrated less frequently from reference sites, ranging from 5% in 2008 to 60% in 2007 at Hazard. Notably, the median time to emigration for chicks hatched in Hazard during 2007 was 5.5 days.

Factors Influencing Movements

Water salinity greater than 32 mL/L has been associated with physiological stress that may decrease chick survival (Hannam and others, 2003), and the SHP Ponds approached or exceeded this level during at least one year of the study (fig. 31*A*). Salinity in Pond 4 was exceptionally high, ranging from an average of 178 to 314 mL/L in 2007 and 2008, whereas Pond 1 was relatively fresh (ca. 15 mL/L) those years. Chick emigrated from the SHP towards areas with lower water salinity across all years (figs 32*A*–32*C*). Notably, the increased frequency of southward movements from the SHP in 2008 corresponded with a substantial decrease in salinity at Morton Bay compared to other years. Westward movements from the SHP were not observed in 2006 when salinity of the Salton Sea mudflat was higher compared to previous years. Only one chick that hatched at Hazard moved towards the high salinity waters of the Salton Sea.

The availability of cryptic cover or food also may have influenced movements. Structural cover measured in 2008 indicated ample vertical cover (and horizontal cover to a lesser extent) at the low salinity Freshwater Marsh and Hazard sites versus essentially non-existent cover at the SHP and Morton Bay (fig. 31*B*). Although not directly measured every year, the relative structural differences at these sites changed little during the study (authors, *personal observation*). Availability of Corixidae was similarly high (>1,000 individuals/sweep) at SHP Ponds 1 and 2 and Morton Bay in 2006 and 2007, and SHP Pond 3 and Freshwater Marsh in 2007 (fig. 31*C*). In contrast, food availability was relatively low in Freshwater Marsh and Salton Sea mudflat in 2006, and SHP Pond 4 and Hazard in 2007. Chicks exhibited little movement from the SHP to Morton Bay even though food availability was similar among sites, and instead moved towards sites with equal or lower food availability at Freshwater Marsh or the Salton Sea mudflats. In addition, low average movements corresponded to relatively low food availability for chicks at Hazard. Collectively, these patterns indicated that salinity and available cryptic cover might be more important factors influencing chick movements than food availability.

4.3.6. Post-Hatch Survival

4.3.6.1 Survival Rates

Yearly estimates of survival to 21 days post-hatch are provided in table 19. In 2006 (pilot year), survival rates were 71% and 49% under censored scenarios 1 and 2, respectively. In 2007 and 2008, survival rates for chicks hatched at the SHP were 45% and 37% compared to 40% and 19% under scenarios 1 and 2, respectively. Survival within SHP ponds seemed to vary differently in 2007 and 2008. For example in 2007 under scenario 2, survival was 52% for chicks hatched in Ponds 1 and 2 compared to 27% for chicks hatched in Ponds 3 and 4, whereas in 2008, survival for chicks hatched in Ponds 1 and 2 was 8% compared to 28% for chicks hatched in Ponds 3 and 4 under the same scenario. In contrast, survival at reference hatch sites tended be high under scenario 2, ranging from a high of 83% for chicks hatched in Hazard in 2007 to a low of 45% for chicks hatched at the Freshwater Marsh in 2008.

Survivorship curves did not differ significantly by year ($\chi^2 = 1.3$, $P = 0.26$) under scenario 1, but under scenario 2 decreased at a significantly steeper rate ($\chi^2 = 5.4$, $P = 0.02$) for chicks hatched in 2008 compared to 2007. Notably, survivorship curves decreased at a significantly steeper rate ($\chi^2 \geq 6.1$, $P \leq 0.01$) for chicks hatched in the SHP compared to the reference group under both scenarios when chicks hatched in 2007 and 2008 were pooled (fig. 33). Survival to 21 days post-hatch for chicks hatched at the SHP was 41% and 30% compared to 69% and 56% for chicks hatched at the reference group under scenarios 1 and 2, respectively.

Factors Influencing Survival

Three sets of Cox-proportional hazard models were used to test covariate effects on estimated hazard ratios. For Set 1 covariates, the proportional hazards assumption was met as insignificant interactions for site * days post hatch ($\chi^2 \leq 0.7$, $P \geq 0.79$), and year * days post-hatch ($\chi^2 < 2.8$, $P > 0.09$) occurred under both censored scenarios. Therefore, non-time dependent site and year effects were included as covariates. The odds of mortality for chicks hatched at the SHP were 2.7 ($\chi^2 = 6.9$, $P = 0.009$) and 2.5 ($\chi^2 = 8.0$, $P = 0.005$) times higher than chicks hatched at the reference group under scenarios 1 and 2, respectively. Year did not influence hazard ratios under scenario 1 $\chi^2 = 2.7$, $P = 0.10$), but the odds of mortality for chicks hatched during 2008 were 2.2 ($\chi^2 = 7.6$, $P = 0.006$) times higher than chicks hatched in 2007. After accounting for group and year effects, hazard ratios were not significantly influenced by Julian hatch date ($\chi^2 \leq 0.08$, $P \geq 0.78$) or body mass ($\chi^2 \leq 0.9$, $P \geq 0.33$) under either scenario.

For Set 2 covariates, selenium concentrations in sibling eggs did significantly increase the odds of mortality in radio-marked chicks under either scenario ($\chi^2 = 0.15$, $P > 0.70$). After accounting for any selenium effects and controlling for group and year, hazard ratios were not significantly influenced by Julian hatch date ($\chi^2 \leq 0.2$, $P \geq 0.65$) or body mass ($\chi^2 \leq 0.8$, $P \geq 0.35$) under either censored scenario.

For Set 3 covariates, chicks that did not emigrate incurred significantly higher risks of mortality under both censored scenarios (fig. 34). Hazard ratios were 8.7 ($\chi^2 = 13.7$, $P = 0.0002$) and 7.3 ($\chi^2 = 14.6$, $P = 0.0001$) times higher under scenarios 1 and 2, respectively, for chicks from both groups. After accounting for emigration effects, hazard ratios were not significantly influenced by Julian hatch date ($\chi^2 \leq 3.2$, $P \geq 0.07$) or body mass ($\chi^2 \leq 0.2$, $P \geq 0.6$) under either scenario. Similar patterns occurred when only chicks hatched at the SHP were considered, whereby the odds of mortality for chicks that failed to emigrate were 8.9 ($\chi^2 = 11.3$, $P = 0.0008$) and 10.9 ($\chi^2 = 14.4$, $P = 0.0001$) times higher under scenarios 1 and 2, respectively. Furthermore, the odds of mortality significantly decreased by 3.9% (hazard ratio = 0.96, $\chi^2 = 4.8$, $P = 0.03$) with each daily increase in Julian hatch date under scenario 2. Julian hatch date did not significantly influence hazard ratios under scenario 1 ($\chi^2 = 2.2$, $P = 0.14$), nor did body mass influence hazard ratios under either scenario ($\chi^2 \leq 0.005$, $P \geq 0.94$).

Causes of Mortality

The most frequent cause of mortality across all groups and years was avian depredation, followed by unknown deaths, canals, and crack entrapment under censored scenario 1 (table 20, fig. 35). The relative importance of unknown predators and canals increased under censored scenario 2. Increased death rates by unknown predators under scenario 2 are plausible because the entire chick (including transmitter) can be consumed and signal no longer heard. In fact, the transmitter from one chick missing from the SHP was fortuitously found in a coyote scat 3 km to the southeast of the SHP 1 week later, with an audible radius of only about 50 m. Furthermore, chicks that could not escape steep sided canals bordering the SHP to the north and south were likely depredated by aquatic predators (for example, largemouth bass, catfish, or large bullfrogs) because faint mortality signals emitting from underwater were heard moving upstream. Death from avian predators notably increased in 2008, which coincided with the new establishment of nesting gull-billed tern (*Sterna nilotica*) and California gull (*Larus californicus*) colonies at the SHP. Eleven deaths were associated with these predators, and five chicks hatched at the SHP were actually brought to the gull-billed tern colony (including one chick from Freshwater Marsh approximately 2 km to the north). Peregrine falcons were known but infrequent avian predators ($n = 2$). Death due to entrapment was most frequent during 2006; chicks emigrating from Ponds 1 and 2 fell into deep (about 0.5 m) cracks in the dry beds of Ponds 3 and 4 prior to flooding in fall 2006. Crack-entrapment (off site) became less frequent in subsequent years.

4.3.7. Ecological Risk Assessment

The daily dosage of selenium was calculated for stilts using average sediment and Corixidae selenium concentrations at the SHP ponds and reference sites. The exposure values used to calculate the daily dosage from ingestion (Di_{BNST}) are provided in table 21. The daily dosage ranged from 0.30 to 0.44 µg/g at the SHP as a whole and 0.14–0.26 µg/g at the reference group. The low HQ (1.82) for the SHP ponds exceeded 1.0 but not the high HQ (0.45). For reference sites, the low (0.88) and high HQ (0.22) were less than 1.0. SHP pond specific daily doses (0.31–0.44) and hazard quotients (low HQ: 1.33–1.90, high HQ 0.33–0.47) were similar to those estimated for the entire SHP. Within the reference group, however, low HQs approached or exceeded 1.0 for Salton Sea and Freshwater Marsh sites, whereas high HQs were <0.28 at these sites. Conversely, the low HQ at D-Pond/Hazard (0.62) was <1.0.

Our assessment assumed nominal movements between sites for breeding stilts. Movement of pre-breeding stilts typically decreases rapidly with the onset of nest-initiation (Demers and others, 2008), and egg selenium primarily represents dietary exposure within 2 weeks prior to follicle formation (Latshaw and Osman, 1975; DeVink and others, 2008). Given the spatial scale and juxtaposition of sites within our study area, a greater proportion of selenium exposure in nesting stilts was site specific. However, a lesser yet unknown proportion of selenium exposure may have been derived from areas in close proximity to nesting sites.

5. Conclusions

Our discrete measures of water quality, chemistry, and nutrients at SHP Ponds 1, 2, and 3 and reference sites were within acceptable limits for biological colonization, recruitment, and survival characteristic of salt pond systems with variable salinity (for example, Takekawa and others, 2006). Aquatic invertebrates rapidly colonized the SHP, where taxonomic richness and composition followed typical patterns governed largely by salinity gradients. Pond 4 was a notable exception where hypersaline conditions approached or exceeded levels harmful to most aquatic biota and waterborne inorganic contaminants concentrated. These conditions were expected in Pond 4, as this was a terminal pond designed to mimic conditions anticipated in brine sinks that will result as the Salton Sea recedes.

Selenium was the primary contaminant of concern, as concentrations frequently exceeded levels of concern or toxicity thresholds in all sample matrices at several reference and SHP sites, and bioconcentrated from water and to a lesser degree sediments to invertebrates. The low concentrations of selenium detected in all sample media from the D-Pond and Hazard reference sites indicated that the selenium risk was reduced at wetland habitats sustained by direct deliveries of Colorado River water; however, such ‘clean’ water is not considered a viable option for restoration. Alternatively, the blended water approach used for the SHP successfully diluted the high selenium concentrations detected in the Alamo River. Results from the predictive ecological risk assessment indicated slightly elevated risk of selenium toxicity for stilts nesting at the SHP but patterns of selenium in water, sediment, and invertebrates were relatively similar between the SHP and reference sites. Furthermore, we did not detect any relationship between selenium and embryonic malpositioning or post-hatch survival of stilt chicks, or a high frequency of embryonic deformities associated with selenium toxicity. Therefore, although a selenium risk was indicated at the SHP, it was not manifested by a reduction in the productivity parameters measured in the stilt avian endpoint. Our study demonstrated that the SHP model is a viable alternative for restoration of wetlands at the Salton Sea, but that resource managers will have to consider the potential risk of selenium.

Widespread exposure to organochlorine pesticides was not evident. Only *p,p*' DDE was consistently detected in upper trophic organisms (Corixidae and stilts). Concentrations of *p,p'* DDE in water were either below or < 2 times the limit of detection, and concentrations in sediment were below levels of concern. These patterns for water and sediment indicated that exposure to *p,p'* DDE in Corixidae likely stemmed from its persistence from legacy use in the Imperial Valley and were below potentially harmful levels. Concentrations of *p,p'* DDE in stilt eggs may have reflected local as well as distant source exposure as well as longer term exposure due to its lipophillic nature. An unknown proportion of stilts nesting at the Salton Sea may over-winter in Baja California and the eastern coast of the Sea of Cortez (Robinson and others, 1999). Although some evidence suggests a lack of transboundary contaminant exposure between the southwestern United States and Latin America (Mora, 1997), elevated concentrations of *p,p'* DDE have been detected in sediments and biota of the Colorado River delta (García-Hernández and others, 2001), and recent exposure to organochlorine contaminants during migration to Mexico has been reported in osprey (Elliott and others, 2008).

Black-necked Stilts rapidly colonized the SHP during the first breeding season post-flood and maintained high numbers thereafter, although nest success was relatively low (about 53%) during 2006 and 2007 (Anderson 2009). Survival of newly hatched chicks during the rearing life stage prior to fledging is an important measure of avian productivity. Post hatch chick survival was significantly higher at reference sites than at the SHP. Emigration from the SHP had a dramatic positive effect on post-hatch chick survival, whereby chicks that did not emigrate from the SHP were at least 9 times more likely to die than chicks that remained in the SHP. Chicks typically emigrated to adjacent habitats characterized by ample vegetative cover or water salinity less than 20 milliliters per liter. Although the SHP provided suitable habitat for nesting, adequate juxtaposition of low salinity habitats with an element of cryptic cover is a likely key element for maintaining productivity of stilts and similar waterbirds with precocial young. However, our results indicated that the SHP is a relatively dynamic ecosystem. For example, avian predators (that is, gull-billed terns and California gulls) did not occur frequently at the SHP during 2006 and 2007 but substantially contributed to chick mortality during 2008. Mammalian depredation of nests and chicks occurred despite the presence of an electric fence surrounding the SHP in 2007 (Anderson 2009). Movements of chicks hatched at the SHP were markedly lower during 2008 compared to previous years, which was may have been due to the freshening of Morton Bay and Salton Sea adjacent to the SHP, and increased vegetative cover at the southern end of the Freshwater Marsh. Lastly, a high frequency of chicks perished after becoming entrapped in the cracked dry ponds of SHP Ponds 3 and 4 during 2006. This cause of death was ameliorated after all pond cells were flooded in subsequent years, but future drying of the mudflats in the Salton Sea may present additional mortality hazards.

6. Project Evaluation and Effectiveness

This study demonstrated that the design and logistics of the SHP was an ecologically viable solution to offset the anticipated problems of a receding Salton Sea. Although the duration of the study was brief, a fully functional ecological community established at the SHP. However, the long-term sustainability of that community is unknown. The experimental, shallow water saline habitat ponds were sufficient to support and sustain colonization and recruitment of invertebrates and birds as well as avian breeding and nesting at least in the short-term. Most biological and physical parameters measured were within acceptable ranges for sustaining viable avian centric communities based on our knowledge of the function of salt ponds. Although this study did not evaluate logistical or mechanical requirements necessary to sustain the ponds, observed problems of water delivery and flow into and between ponds undoubtedly contributed to within seasonal variation in physical and biological parameters measured at the ponds. However, these variations were not extraordinary or disruptive of aquatic biological cycles within the SHP during the course of the study.

7. Suggestions for Future Study

The duration of this study (chronologically 2.5 years but effectively only several months of total observations during this period) was insufficient to predict long-term benefits or problems that may be associated with ecosystem creation such as the SHP. For this reason, we recommend continued monitoring of ecological communities within the SHP, and also specific contaminants, that is, selenium and DDE and also possibly boron that may affect birds or their eggs and prey. Concurrently, we suggest expanding to a multi-guild approach to include higher trophic level avian consumers that include obligate piscivorous and omnivores. We suggest that it is necessary to identify spatially explicit sources of contaminant exposure in these endpoint consumers by study of stable isotopes (^{34}S, ^{15}N, ^{13}C) and telemetric monitoring of both local and long distance foraging and site use behavior of pre-breeding in birds. Importantly, the potential impacts of nest predation on avian productivity as a function of habitat composition and juxtaposition, nest density, and predator movement patterns needs to be determined. This includes the relationship between avian predators and structural within-pond cover on food web dynamics inclusive of fish, key invertebrates, and chicks at the SHP as well as the potential impacts of mammalian predators on all birds that utilize re-created sites, such as the SHP.

8. Acknowledgments

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10. Figures

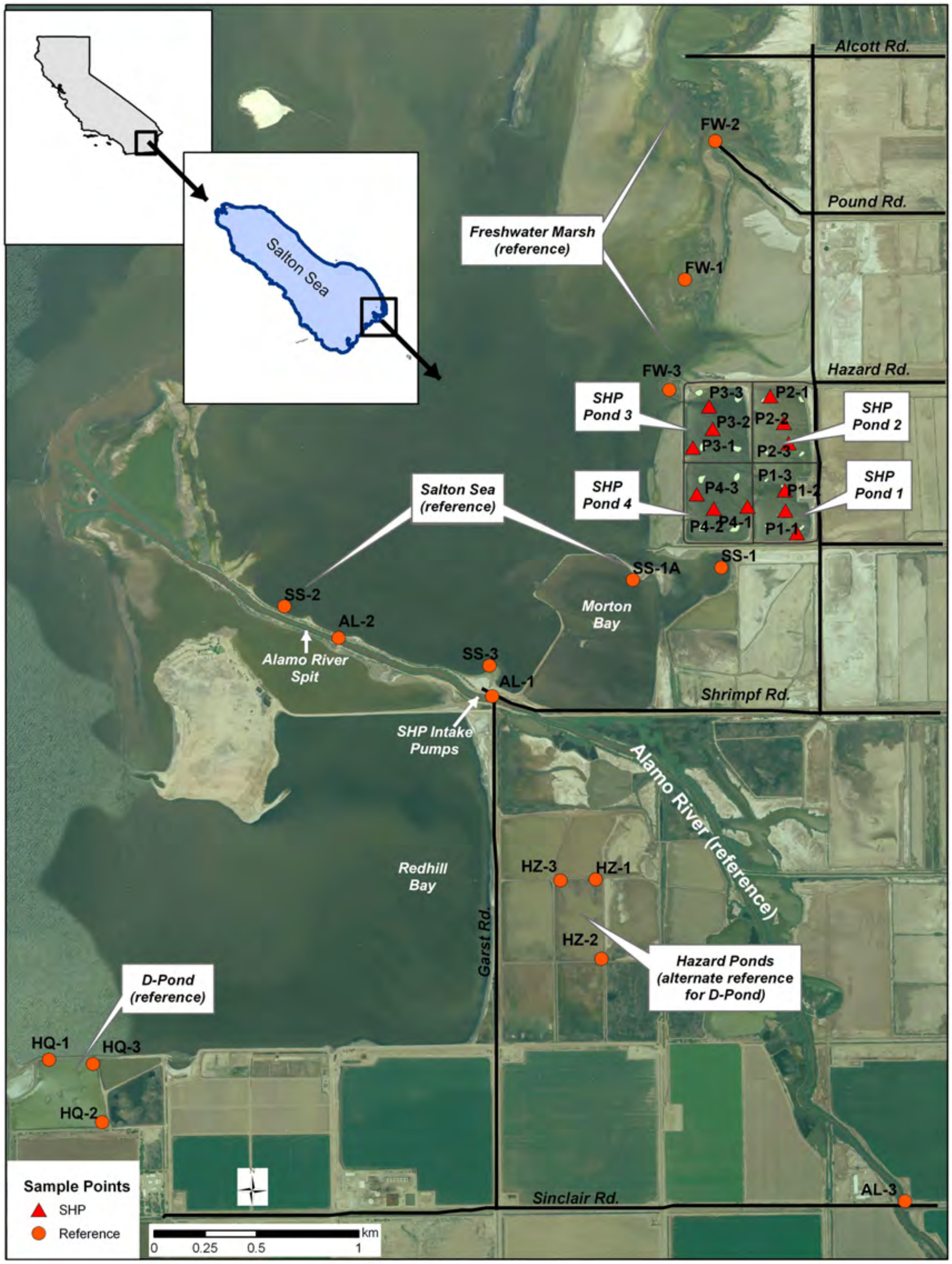
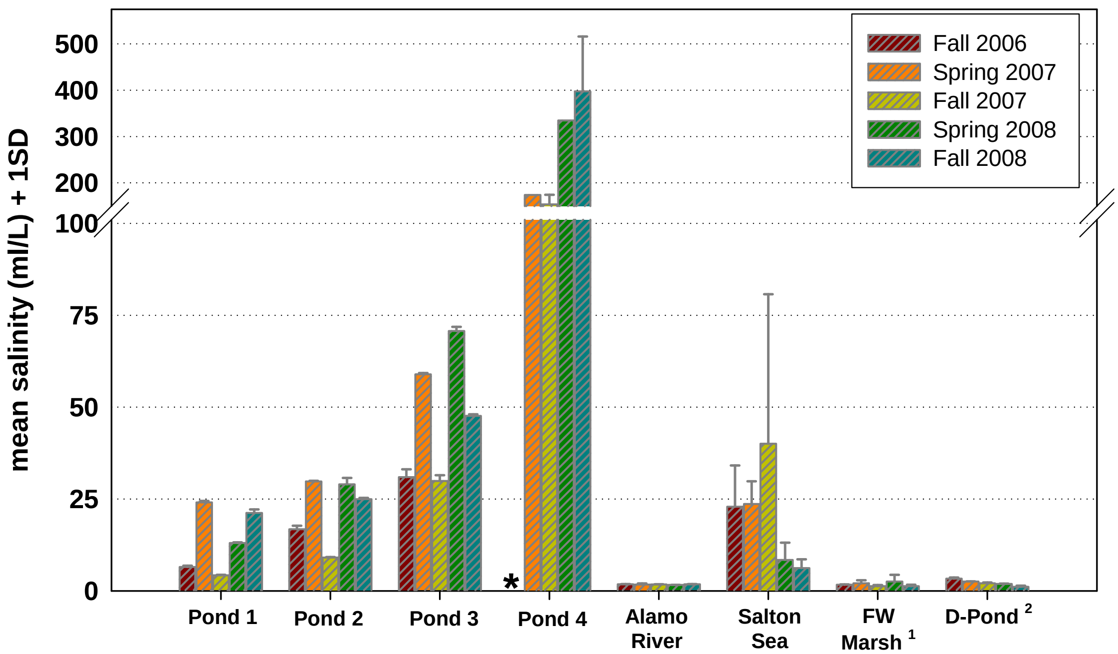


Figure 1. Sampling points, Ecosystem Monitoring Project, Salton Sea, California, 2006–08. SHP, saline habitat ponds.

Figure 2. Black-necked Stilt egg collection locations, 2006, 2007, 2008, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

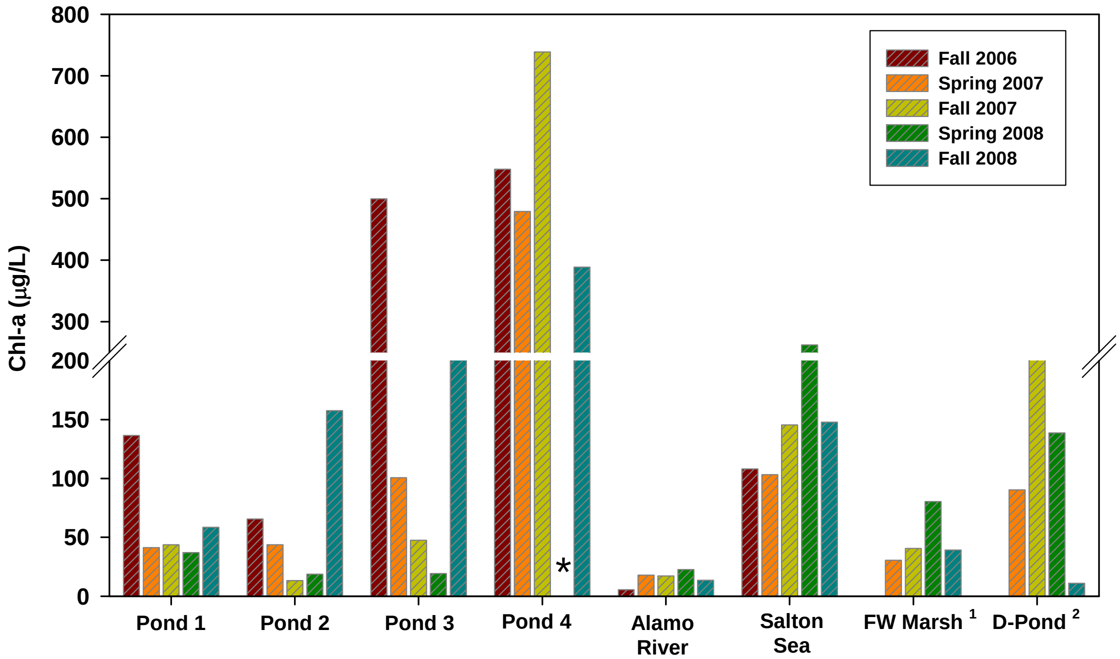


* Pond 4 salinity exceeded the instrument capability at that time.

[1] FW Marsh = Freshwater Marsh.

[2] Hazard Pond sampled due to lack of water in D-pond during fall 2003

Figure 3. Average (+1 standard deviation) for salinity concentrations in water samples collected from the saline habitat ponds (1-4) and reference sites[1], Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

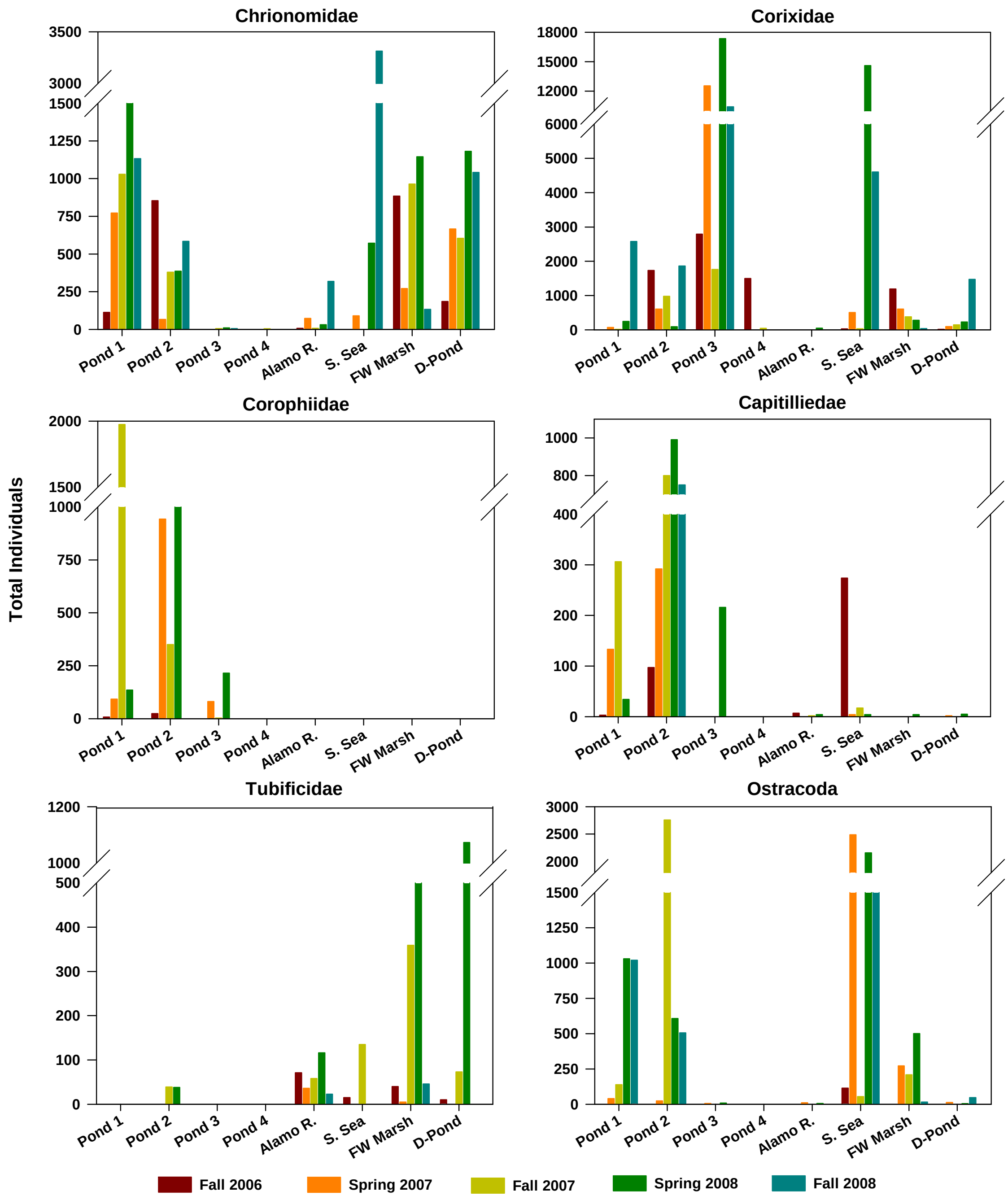


* Pond 4 salinity exceeded the instrument capability at that time.

[1] FW Marsh = Freshwater Marsh.

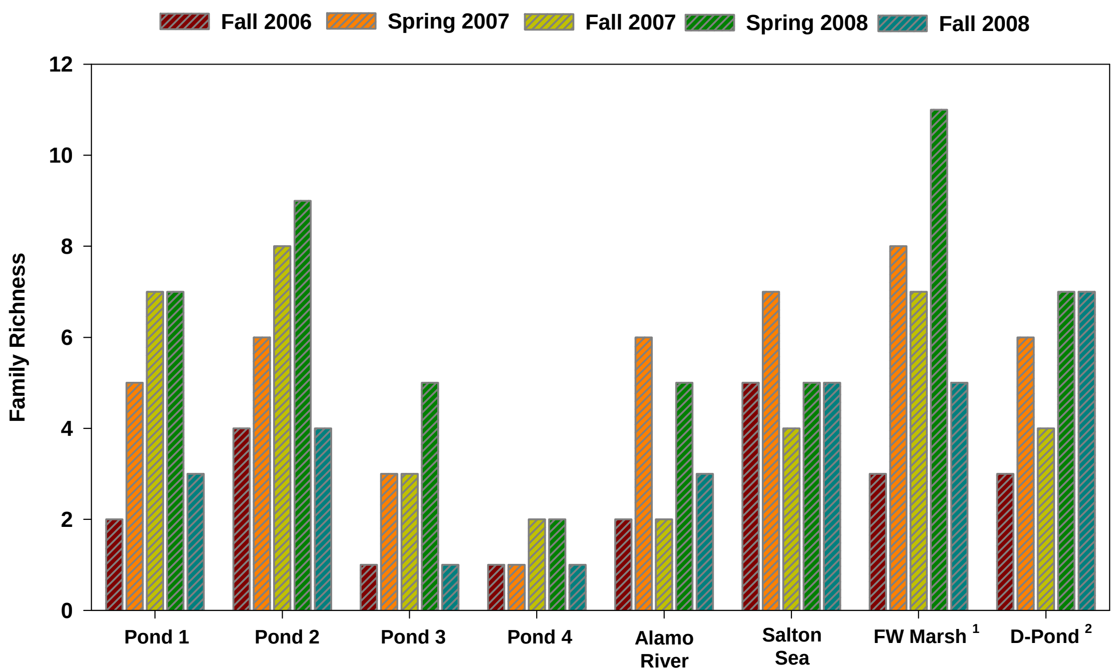
[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008.

Figure 4. Average chlorophyll-a concentrations in surface-water samples collected from the saline habitat ponds (1 – 4) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.



[1] FW Marsh = Freshwater Marsh; Hazard Pond sampled due to lack of water in D-pond during fall 2008.

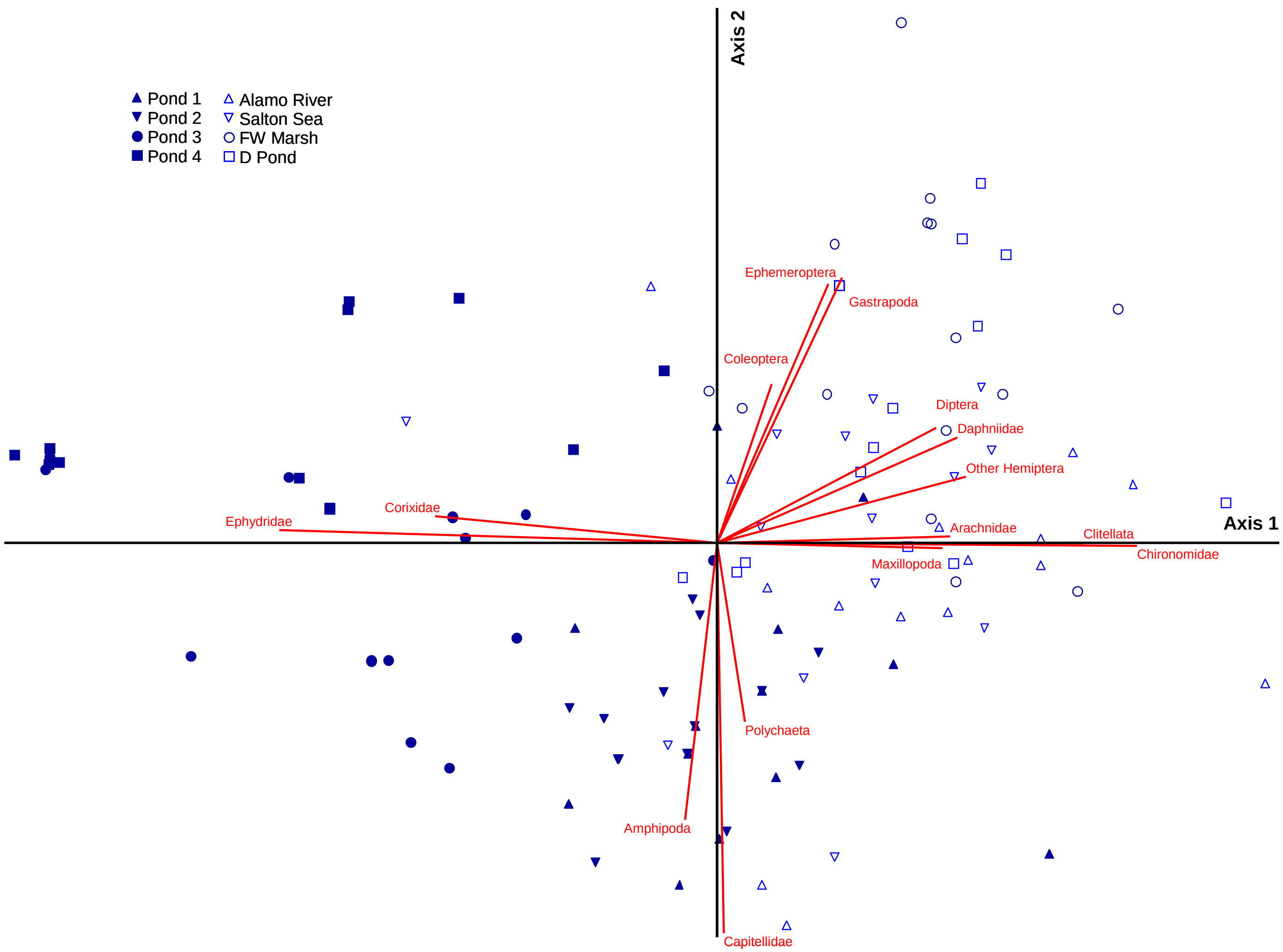
Figure 5. Abundance of macro invertebrate taxa most frequently encountered at the saline habitat ponds (1–4) and reference sites[1], Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.



[1] FW Marsh = Fresh Water Marsh.

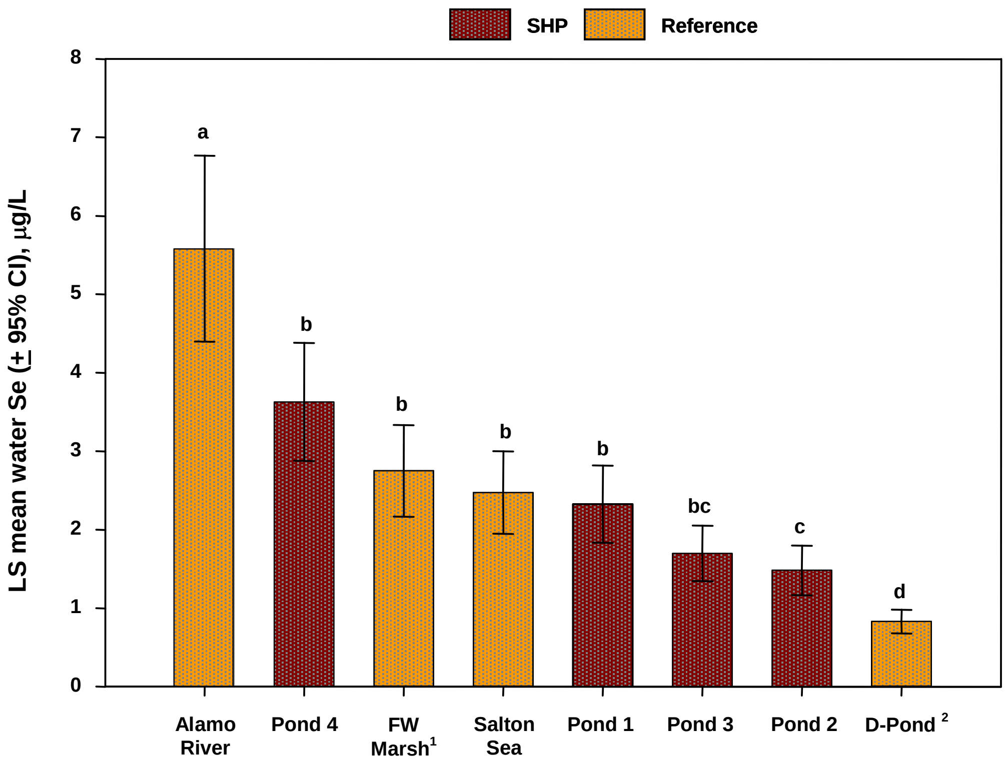
[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008

Figure 6. Taxonomic family richness for macro invertebrates sampled at the saline habitat ponds (1 – 4) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Families include those with equal to or greater than 10 individuals enumerated at any site or time.



[1] FW Marsh = Freshwater Marsh, Hazard Pond sampled due to lack of water in D-pond during fall 2008.

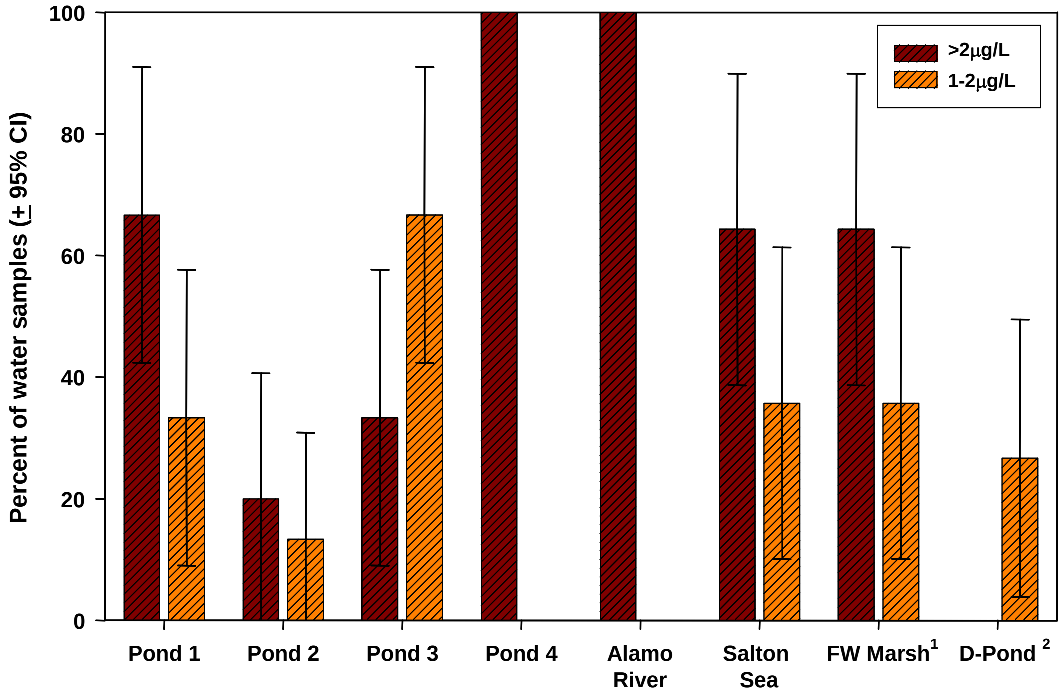
Figure 7. Non-metric multidimensional scaling ordination of macro invertebrate community structure at the saline habitat ponds (1–4, closed symbols) and reference sites (open symbols)[1], Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Vectors (red lines) represent strength (R^2 ≥0.30) and direction of species' loading in the ordination space.



[1] FW Marsh = Freshwater Marsh.

[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008.

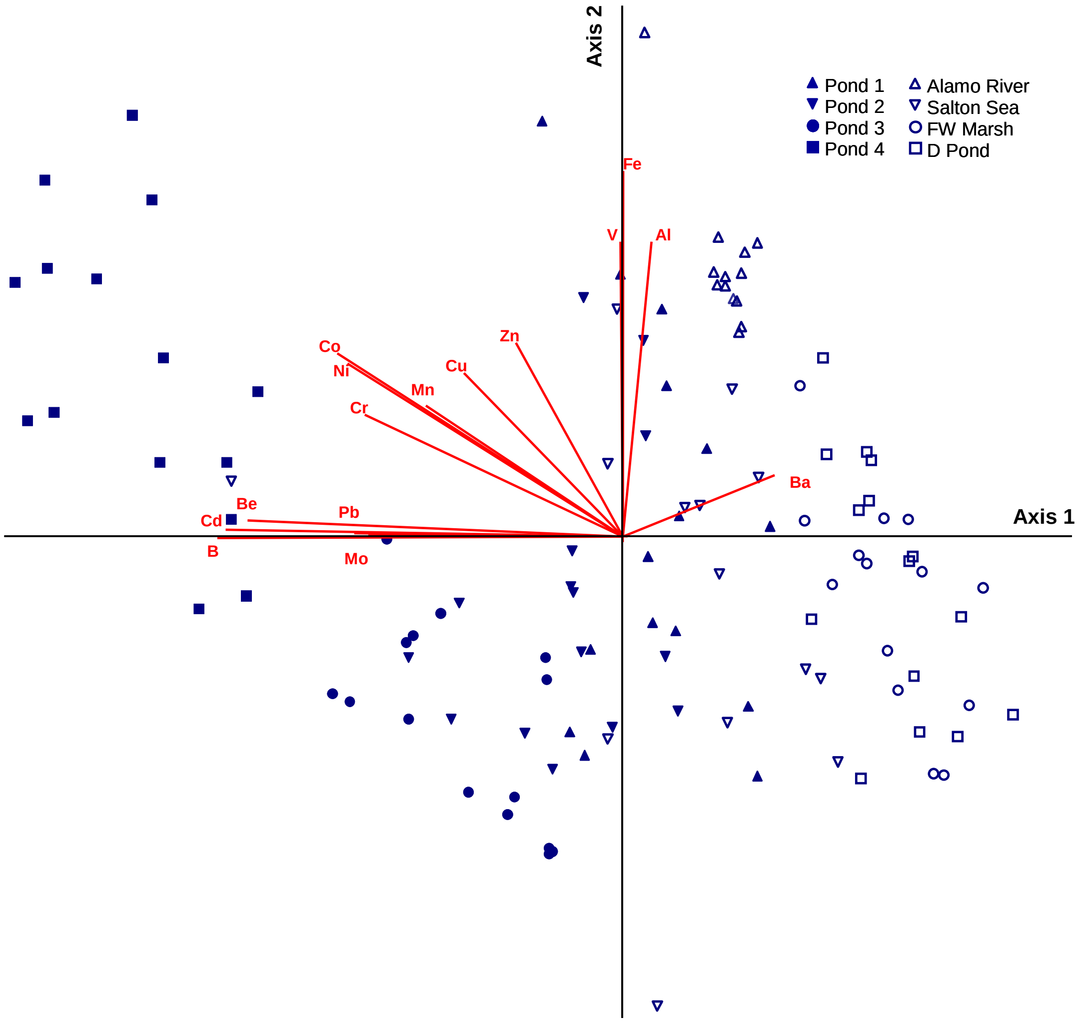
Figure 8. Least-squares means (and 95-percent confidence intervals) for selenium concentrations in surface-water samples collected from the saline habitat ponds (1–4, red bars) and reference sites (orange bars), Ecosystem Monitoring Project, Salton Sea, California, spring 2007–fall 2008. Means are ordered from high to low; means sharing the same letter do not differ significantly.



[1] FW Marsh = Freshwater Marsh.

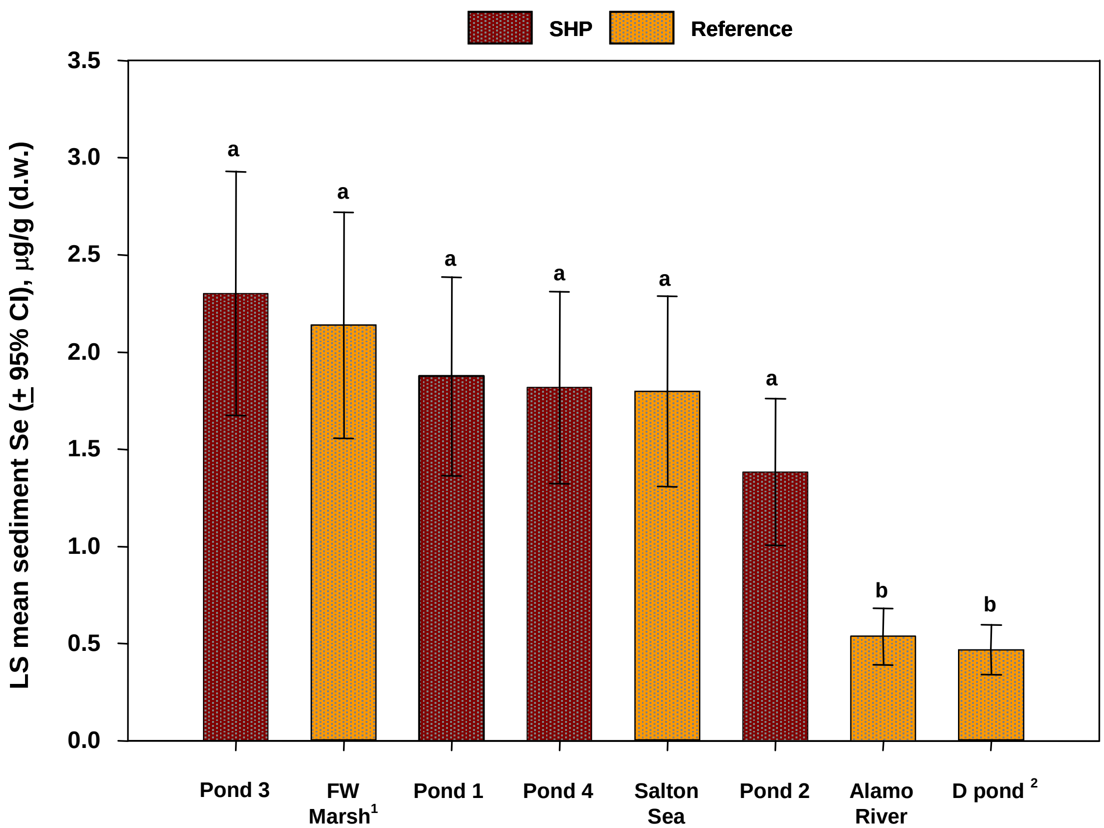
[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008.

Figure 9. Average percentages (and 95-percent confidence intervals) for water samples collected from the saline habitat ponds (1–4) and reference sites exceeding selenium toxicity threshold (red bars) and background concentrations (orange bars), Ecosystem Monitoring Project, Salton Sea, California, spring 2007–fall 2008.



[1] FW Marsh = Freshwater Marsh, Hazard Pond sampled due to lack of water in D-pond during fall 2008.

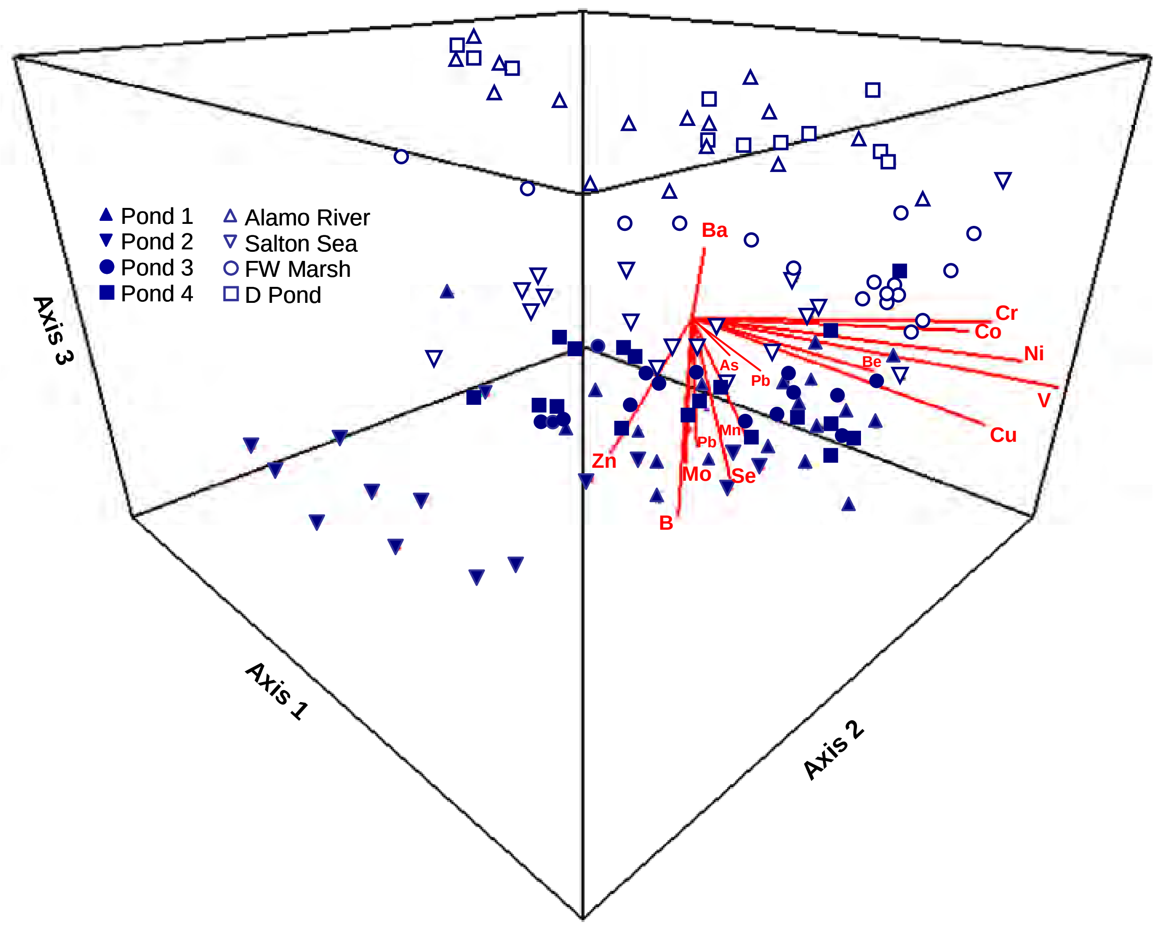
Figure 10. Principal components analysis ordination of elemental concentrations in surface water at the saline habitat ponds (1–4, closed symbols) and reference sites[1] (open symbols), Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Vectors (red lines) represent strength ($R^2 \geq 0.30$) and direction of elemental loadings in the ordination space.



[1] FW Marsh = Freshwater Marsh.

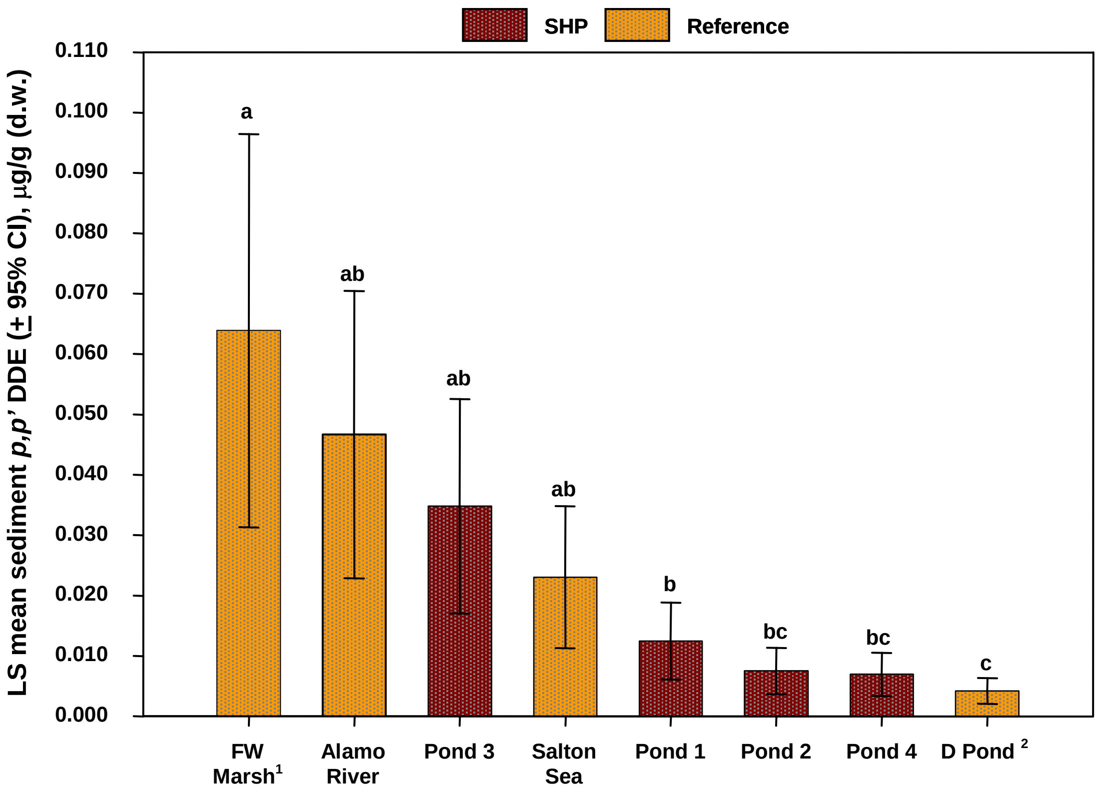
[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008.

Figure 11. Least-squares means (and 95-percent confidence intervals) for selenium concentrations in sediment samples collected from the saline habitat ponds and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Means are ordered from high to low; means sharing the same letter do not differ significantly.



[1] FW Marsh = Freshwater Marsh, Hazard Pond sampled due to lack of water in D-pond during fall 2008.

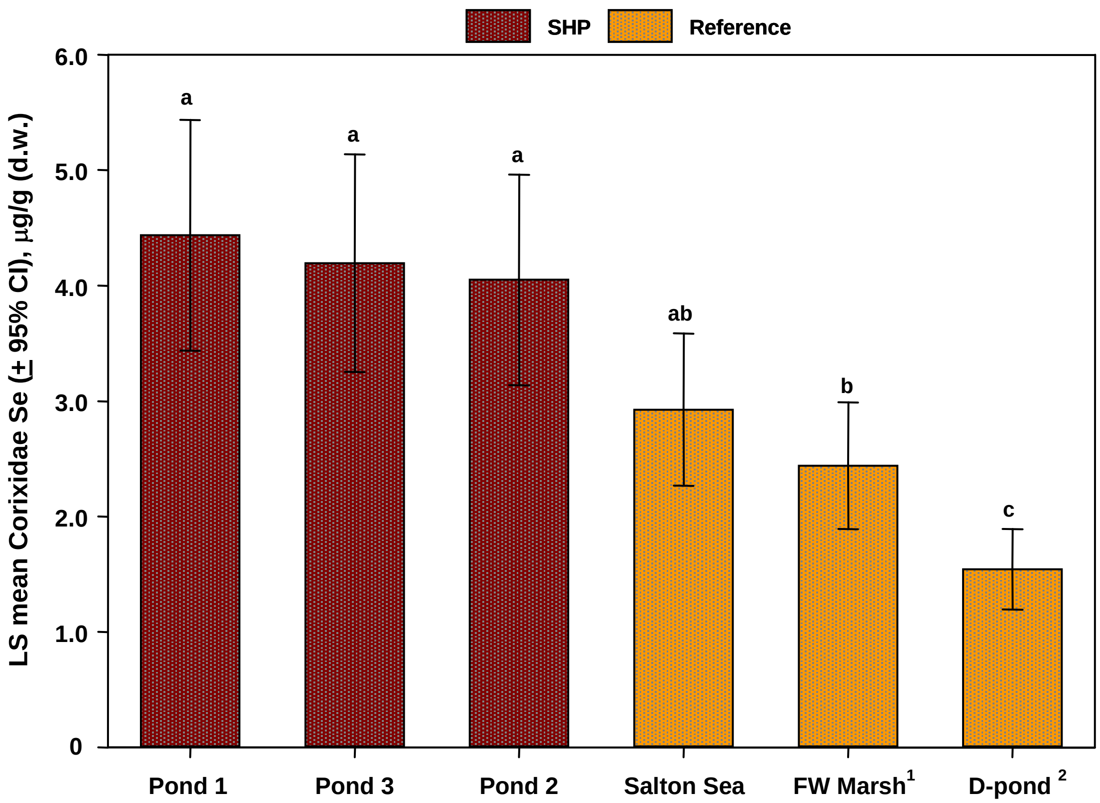
Figure 12. Three dimensional principal components analyses ordination of elemental concentrations in sediments at the saline habitat ponds (1–4) and reference sites[1], Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Vectors (red lines) represent strength ($R^2 \geq 0.30$) and direction of elemental loadings in the ordination space.



[1] FW Marsh = Freshwater Marsh.

[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008

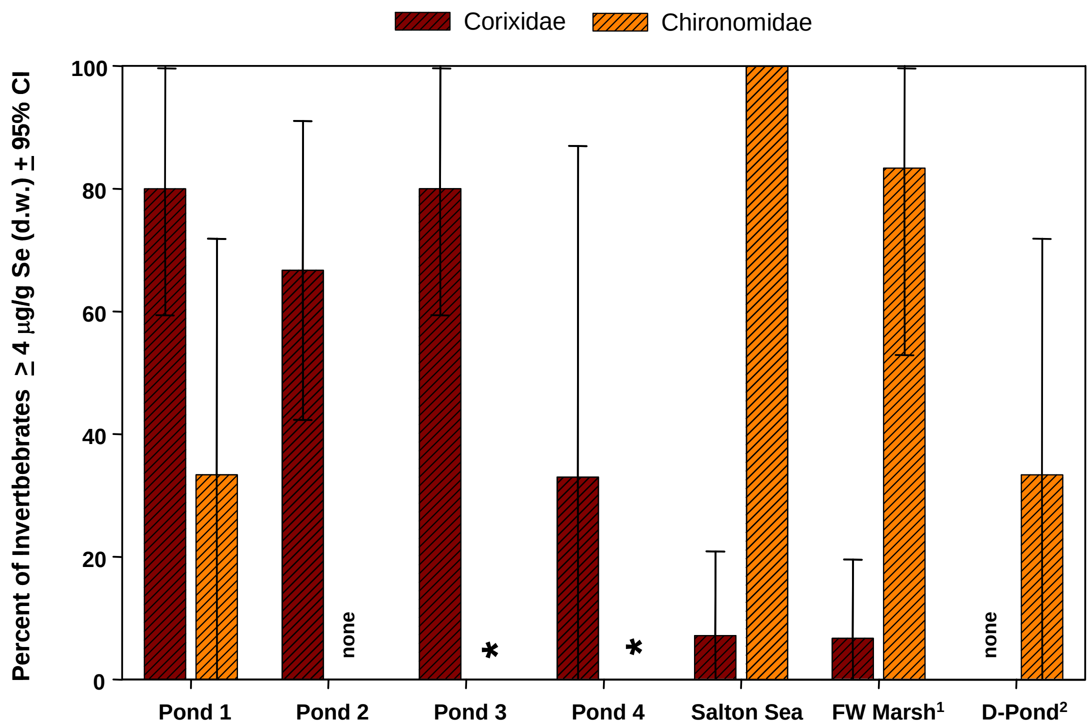
Figure 13. Least-squares means (and 95-percent confidence intervals) for *p,p'* DDE concentrations in sediment samples collected from the saline habitat ponds (1–4, red bars) and reference sites (orange bars), Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Means are ordered from high to low; means sharing the same letter do not differ significantly.



[1] FW Marsh = Freshwater Marsh.

[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008.

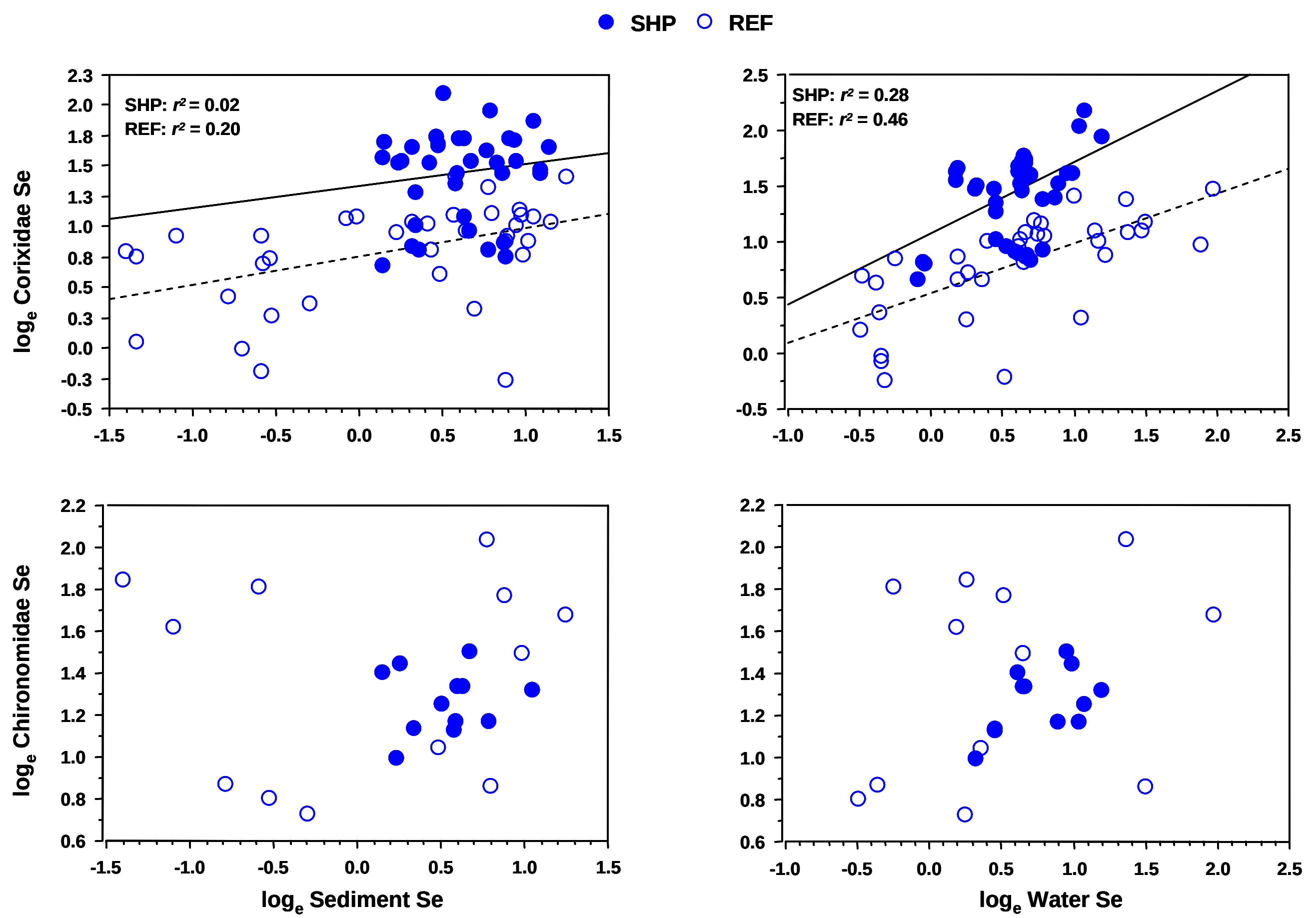
Figure 14. Least-squares means (and 95-percent confidence intervals) for selenium concentrations in Corixidae samples collected from the saline habitat ponds (1–4, red bars) and reference sites (orange bars), Ecosystem Monitoring Project, Salton Sea, California, fall 2006–all 2008. Means are ordered from high to low; means sharing the same letter do not significantly differ. Pond 4 was omitted because it only contained Corixidae samples in fall 2006.



[1] FW Marsh = Freshwater Marsh.

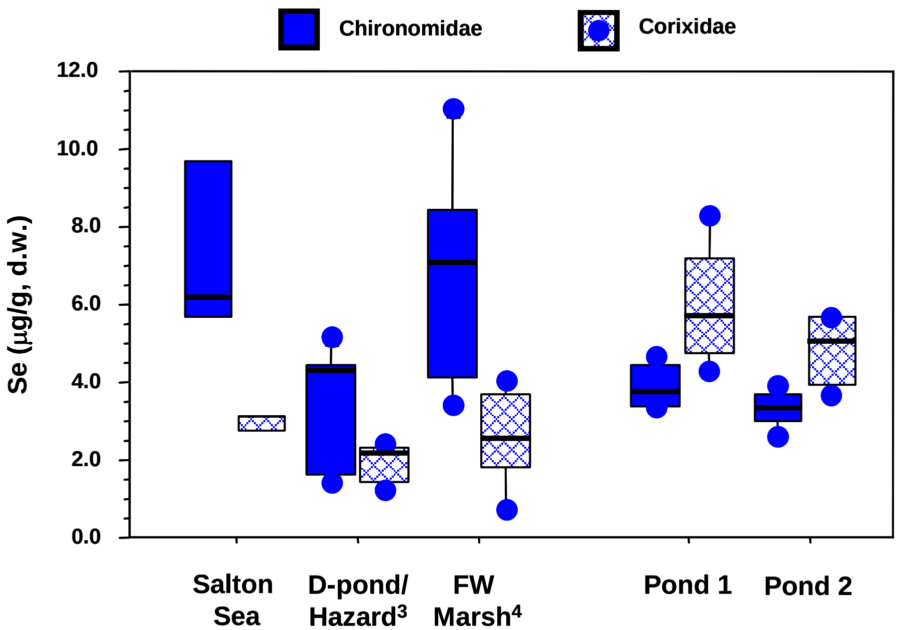
[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008.

Figure 15. Average percentages (and 95-percent confidence intervals) for Corixidae (red bars) and Chironomidae (orange bars) samples collected from the saline habitat ponds (1–4) and reference sites exceeding selenium toxicity threshold concentrations, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Asterisks indicate taxa were not present, 'none' indicates no samples exceeded the toxicity threshold. Pond 4 was omitted because it only contained Corixidae samples in fall 2006.



[1] FW Marsh = Freshwater Marsh, Hazard Pond sampled due to lack of water in D-pond during fall 2008.

Figure 16. Relationships between natural log transformed selenium concentrations (µg/g, dw) in Corixidae and Chironomidae (y-axis), and water and sediment (x-axis) samples from the saline habitat ponds (SHP, closed symbols) and reference sites (REF, open symbols)[1], Ecosystem Monitoring Project, Salton Sea, California, spring 2008–fall 2008. Concentrations are adjusted for modeled random effects of site and sampling point. Regression lines are only plotted for significant (P < 0.05) relationships.



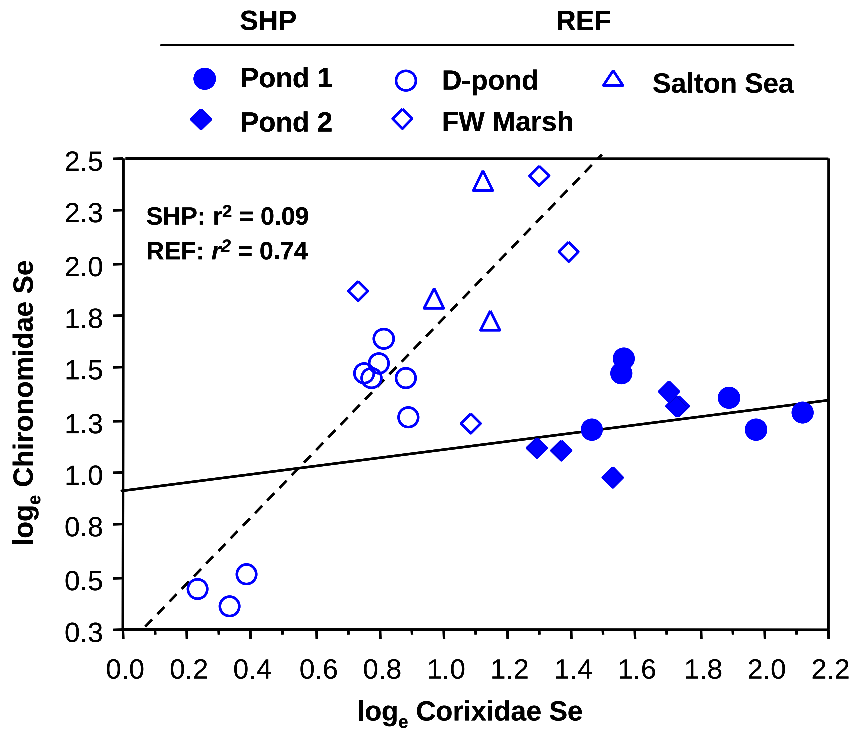
[1] Bold lines within boxes represent median concentration; boxes represent concentrations at the 25th (lower bound) and 75% (upper bound) percentiles; dots extending from lines below and above boxes represent concentrations at the 10th and 90th percentiles, respectively.

[2] Chironomidae were only present in the Salton Sea during fall 2008, only concentrations from fall 2008 are shown for both taxa at this site. Only the 25th and 75th percentiles (box ends) are displayed because *n* = 3 per taxa.

[3] Samples from both taxa in D-Pond and Hazard Pond collected during spring 2008–fall 2008.

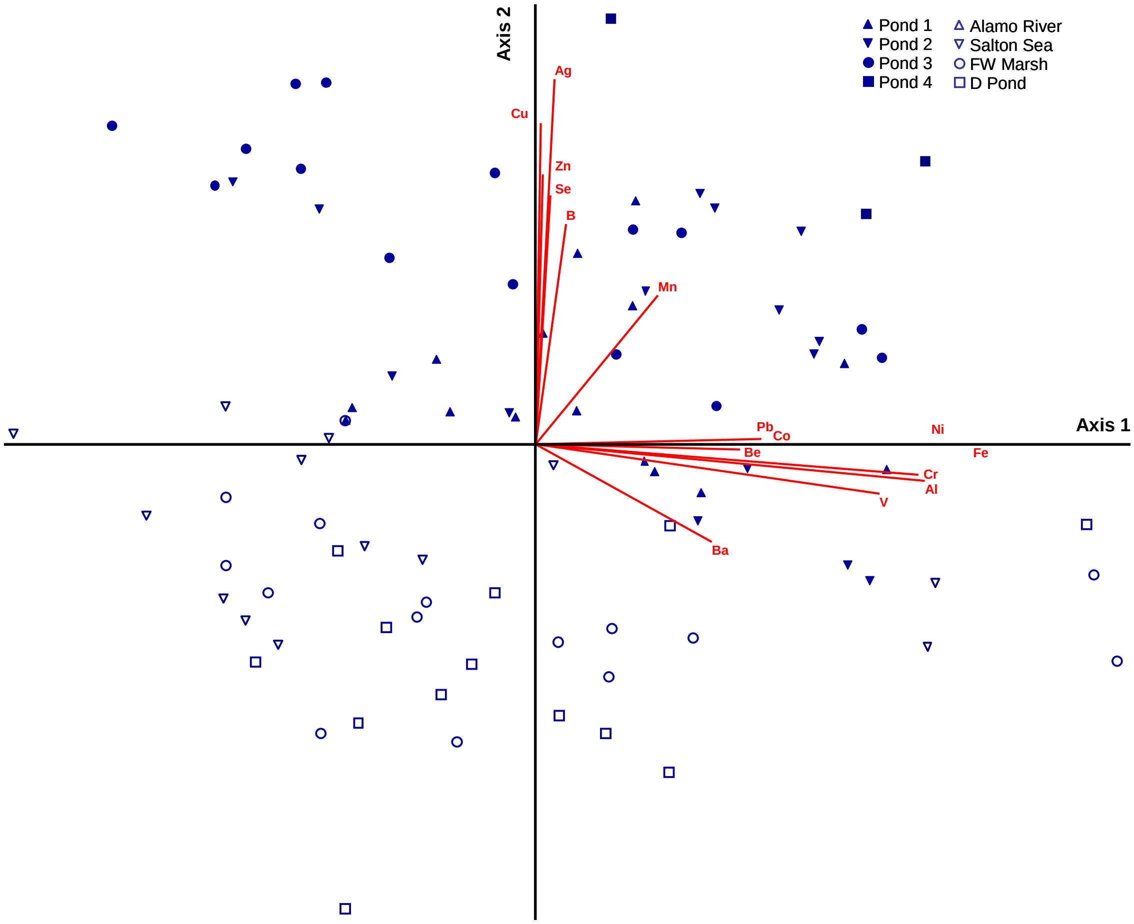
[4] FW Marsh = Freshwater Marsh.

Figure 17. Box plots[1] for selenium concentrations in Corixidae and Chironomidae samples from the saline habitat ponds and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2008–fall 2008.



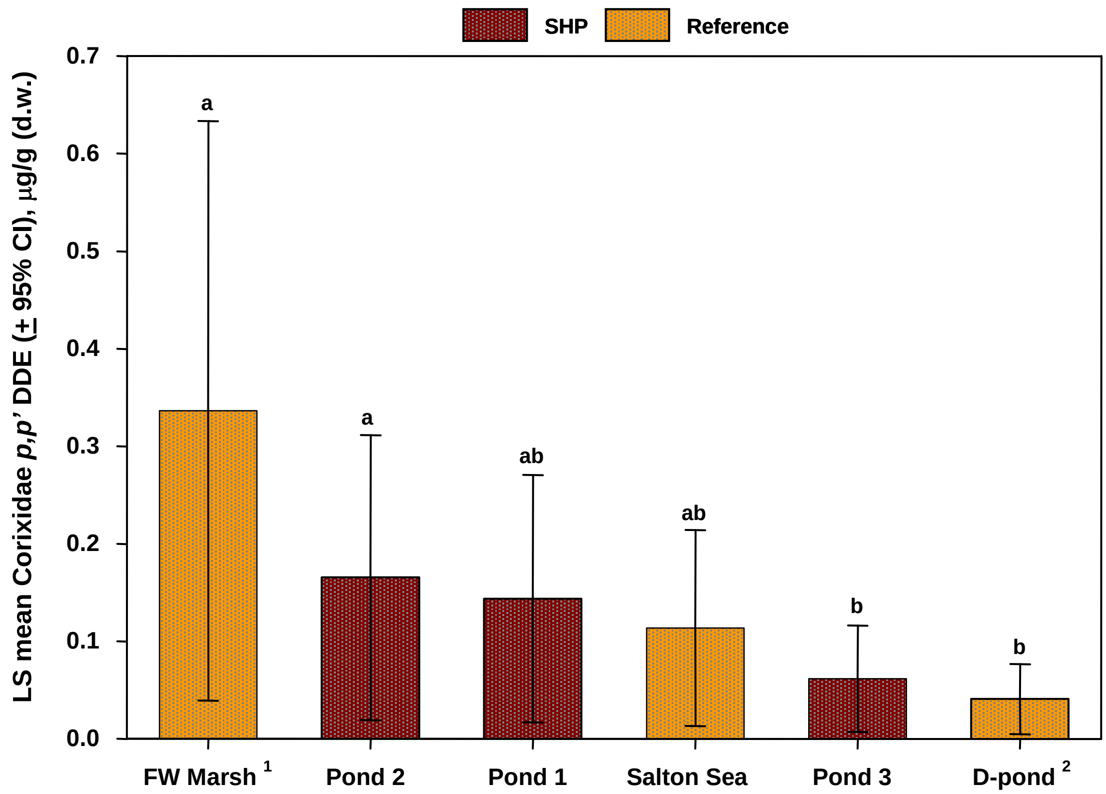
[1] FW Marsh = Freshwater Marsh, Hazard Pond sampled due to lack of water in D-pond during fall 2008.

Figure 18. Relationships between natural log transformed selenium concentrations (µg/g, dw) in Corixidae and Chironomidae samples from the saline habitat ponds 1 and 2 (SHP, closed symbols) and reference sites (REF, open symbols)[1], Ecosystem Monitoring Project, Salton Sea, California, spring 2008–fall 2008.



[1] FW Marsh = Freshwater Marsh, Hazard Pond sampled due to lack of water in D-pond during fall 2008.

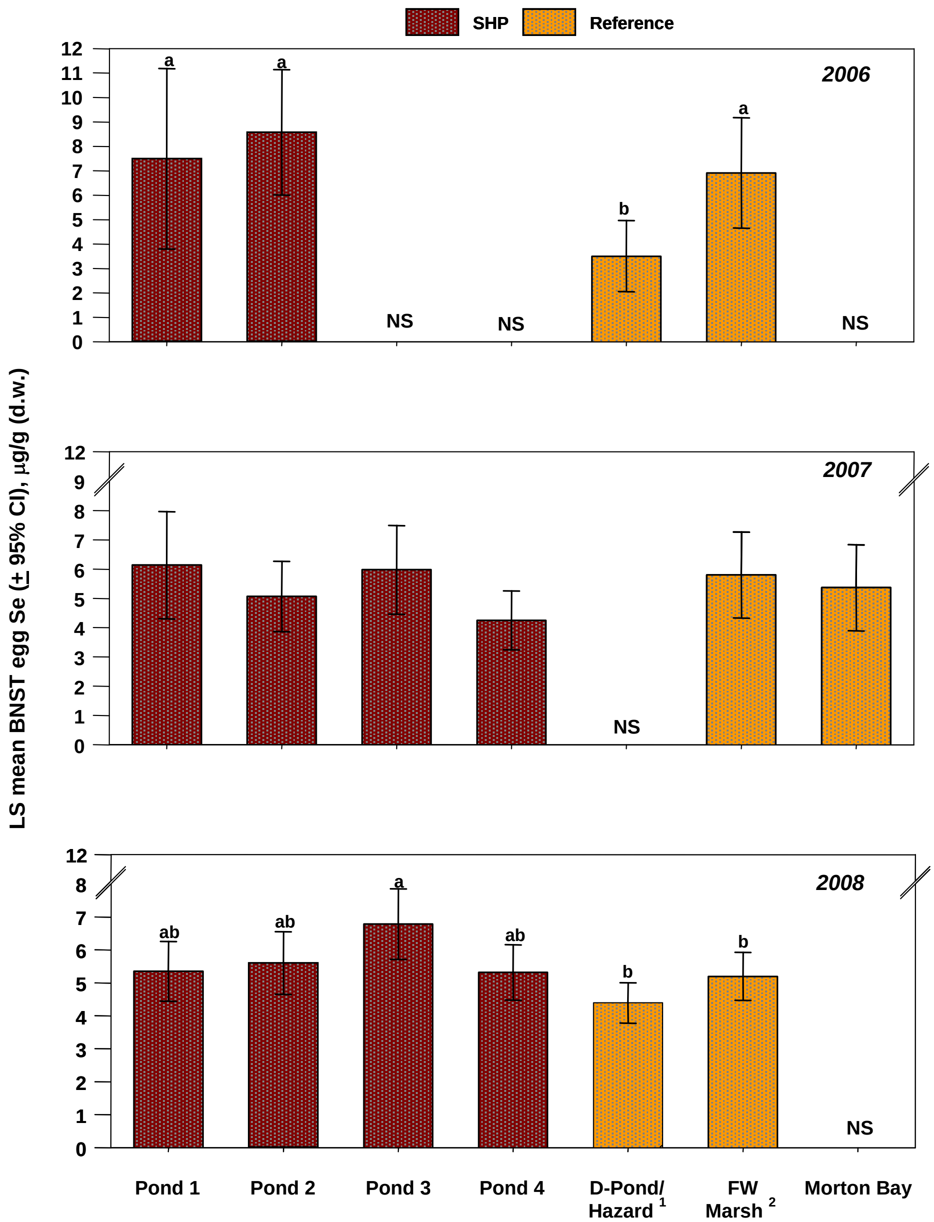
Figure 19. Principal component analysis ordination of elemental concentrations in Corixidae at the saline habitat ponds (1–4, closed symbols) and reference sites (open symbols)[1], Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Vectors (red lines) represent strength ($R^2 \geq 0.30$) and direction of elemental loadings in the ordination space.



[1] FW Marsh = Freshwater Marsh.

[2] Hazard Pond sampled due to lack of water in D-pond during fall 2008.

Figure 20. Least-squares means (and 95-percent confidence intervals) for *p,p*' DDE concentrations in Corixidae samples collected from the saline habitat ponds (1–3, red bars) and reference sites (orange bars), Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008. Means are ordered from high to low; means sharing the same letter do not differ significantly.



[1] D-Pond sampled during 2006, Hazard sampled during 2008.

[2] FW Marsh = Freshwater Marsh.

Figure 21. Least-squares means (and 95-percent confidence intervals) for selenium concentrations in fresh Black-necked Stilt eggs collected from the saline habitat ponds (1–4, red bars) and reference sites (orange bars) for the Ecosystem Monitoring Project, Salton Sea, California, 2006 (A), 2007 (B), 2008 (C). Means sharing the same letter or means with no letters do not significantly differ. NS denotes 'none sampled'.

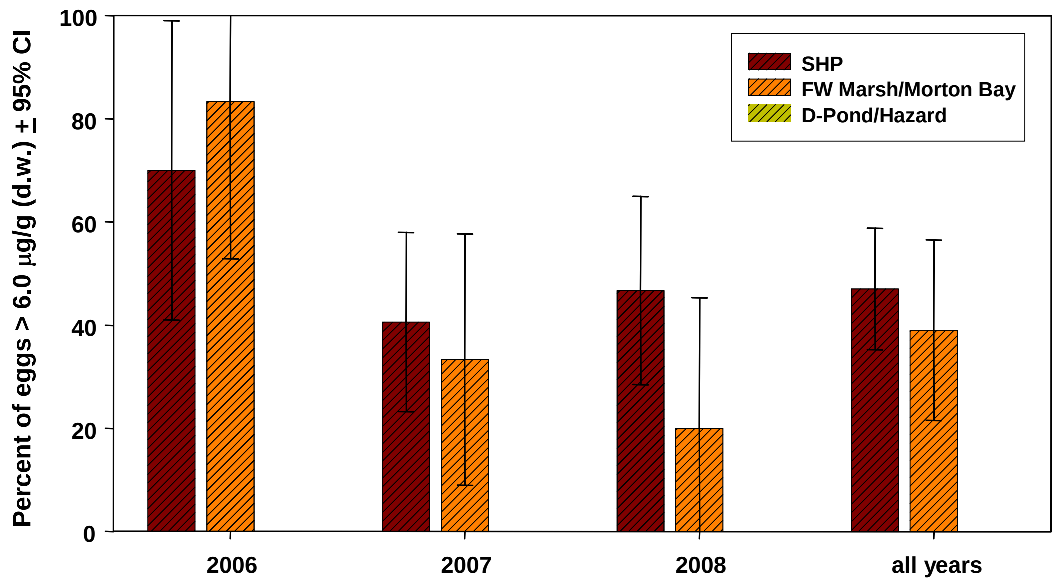


Figure 22. Average percentages (95-percent confidence intervals) of fresh Black-necked Stilt eggs collected from the saline habitat ponds (SHP) and reference sites (Freshwater Marsh/Morton Bay and D-Pond/Hazard) with selenium concentrations exceeding a toxicity threshold of 6.0µg/g (dry weight), Ecosystem Monitoring Project, Salton Sea, California, 2006–08. No egg sampled from D-Pond or Hazard ponds exceeded the toxicity threshold. FW Marsh = Fresh Water Marsh.

Figure 23A. Spatially explicit selenium concentrations (µg/g, dry weight) in fresh Black-necked Stilt eggs collected during the 2006 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

Figure 23B. Spatially explicit selenium concentrations (µg/g, dry weight) in fresh Black-necked Stilt eggs collected during the 2007 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

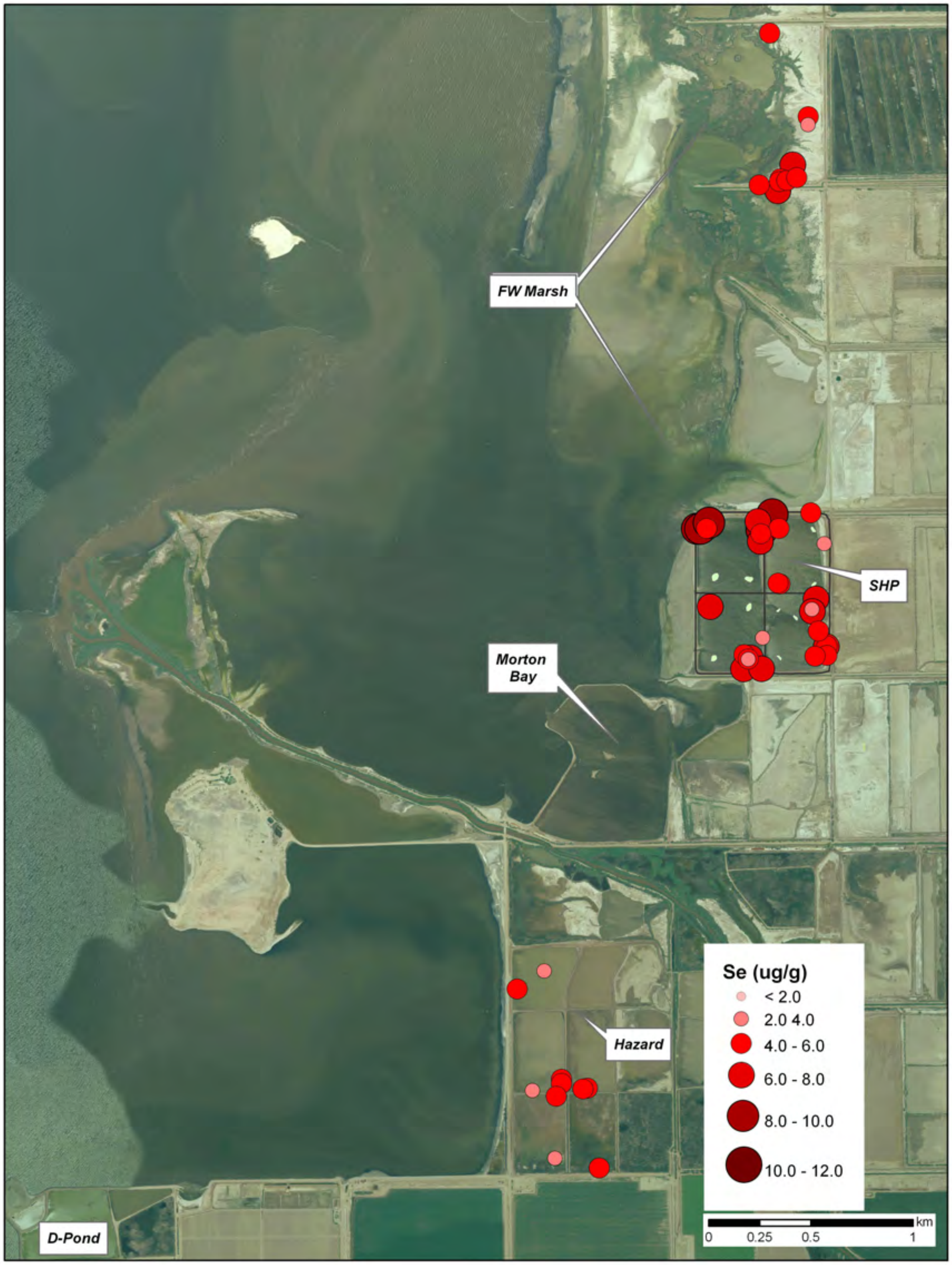


Figure 23C. Spatially explicit selenium concentrations (µg/g, dry weight) in fresh black-necked stilt eggs collected during the 2008 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP = Saline Habitat Ponds, FW Marsh = Freshwater Marsh.

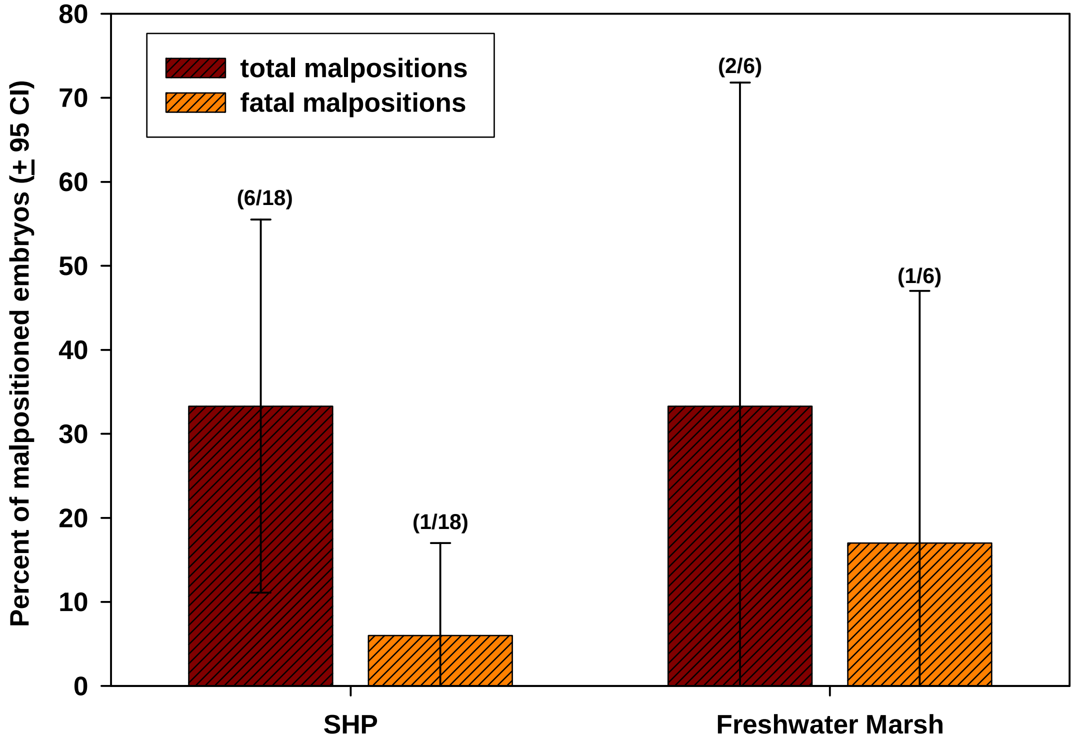


Figure 24. Average percentages (and 95% confidence intervals) of fresh black-necked stilt eggs collected from the saline habitat ponds (SHP) and reference sites (Freshwater Marsh) containing an embryo malposition (red bars) or a fatal embryo malposition (orange bars), Ecosystem Monitoring Project, Salton Sea, CA, 2006–08. Numbers in parentheses above bars indicate number of eggs containing a malpositioned embryo divided by the total number of eggs containing an embryo greater than or equal to 18 days old.

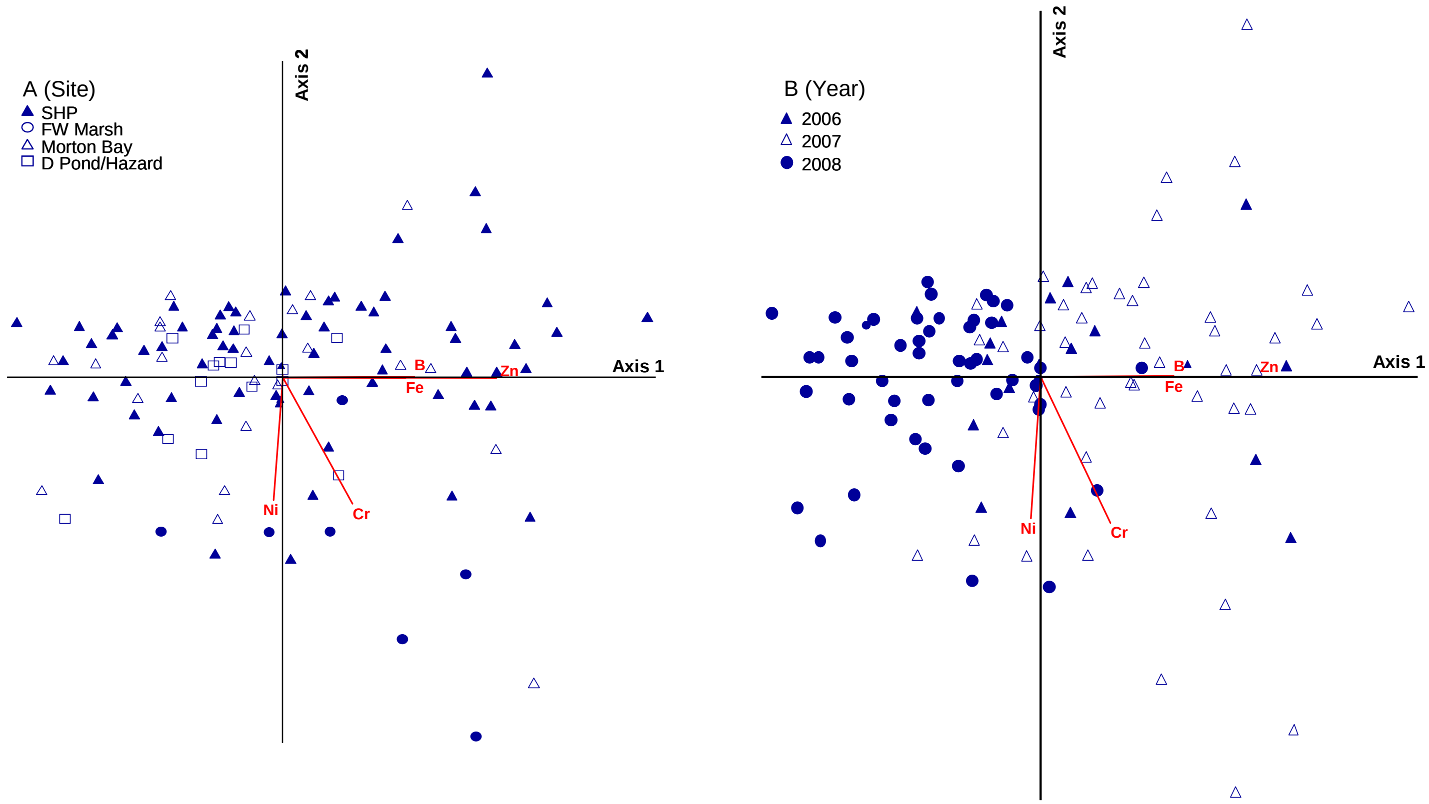


Figure 25. Principal component analysis ordination of elemental concentrations (µg/g, dry weight) in fresh Black-necked Stilt eggs collected at the saline habitat ponds (SHP) and reference sites by site (A) and year (B), Ecosystem Monitoring Project, Salton Sea, California, 2006–08. Vectors (red lines) represent strength ($R^2 \geq 0.30$) and direction of elemental loadings in the ordination space. FW Marsh, Freshwater Marsh.

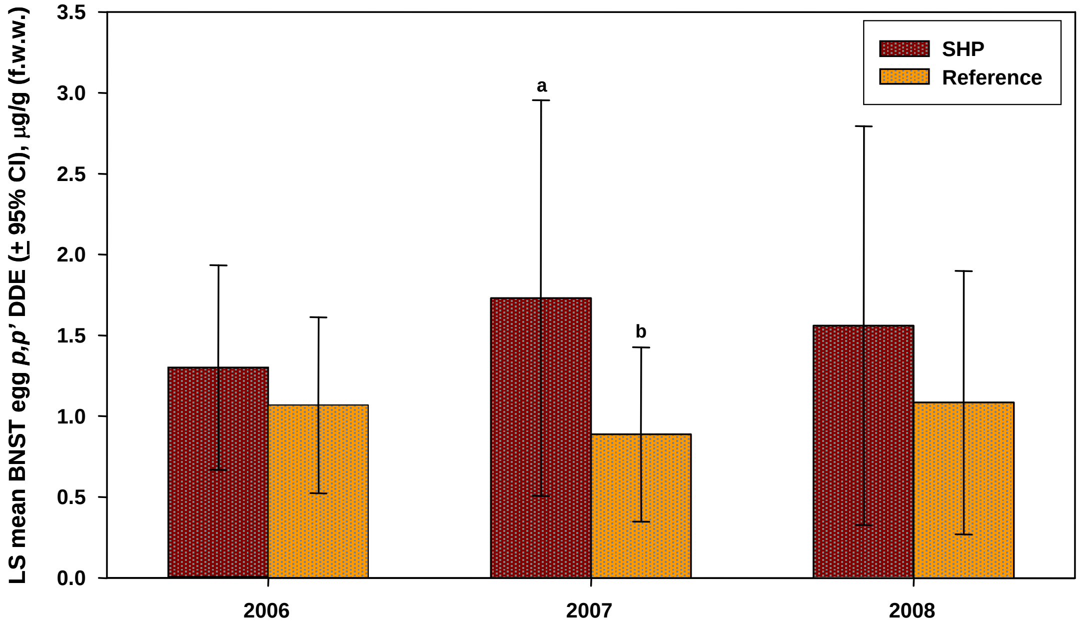


Figure 26. Least-squares means (and 95-percent confidence intervals) for *p,p'* DDE concentrations in fresh Black-necked Stilt eggs collected from the saline habitat ponds (SHP, red bars) and reference sites (orange bars), Ecosystem Monitoring Project, Salton Sea, California, 2006–08. Means sharing the same letter or means with no letters do not differ significantly.

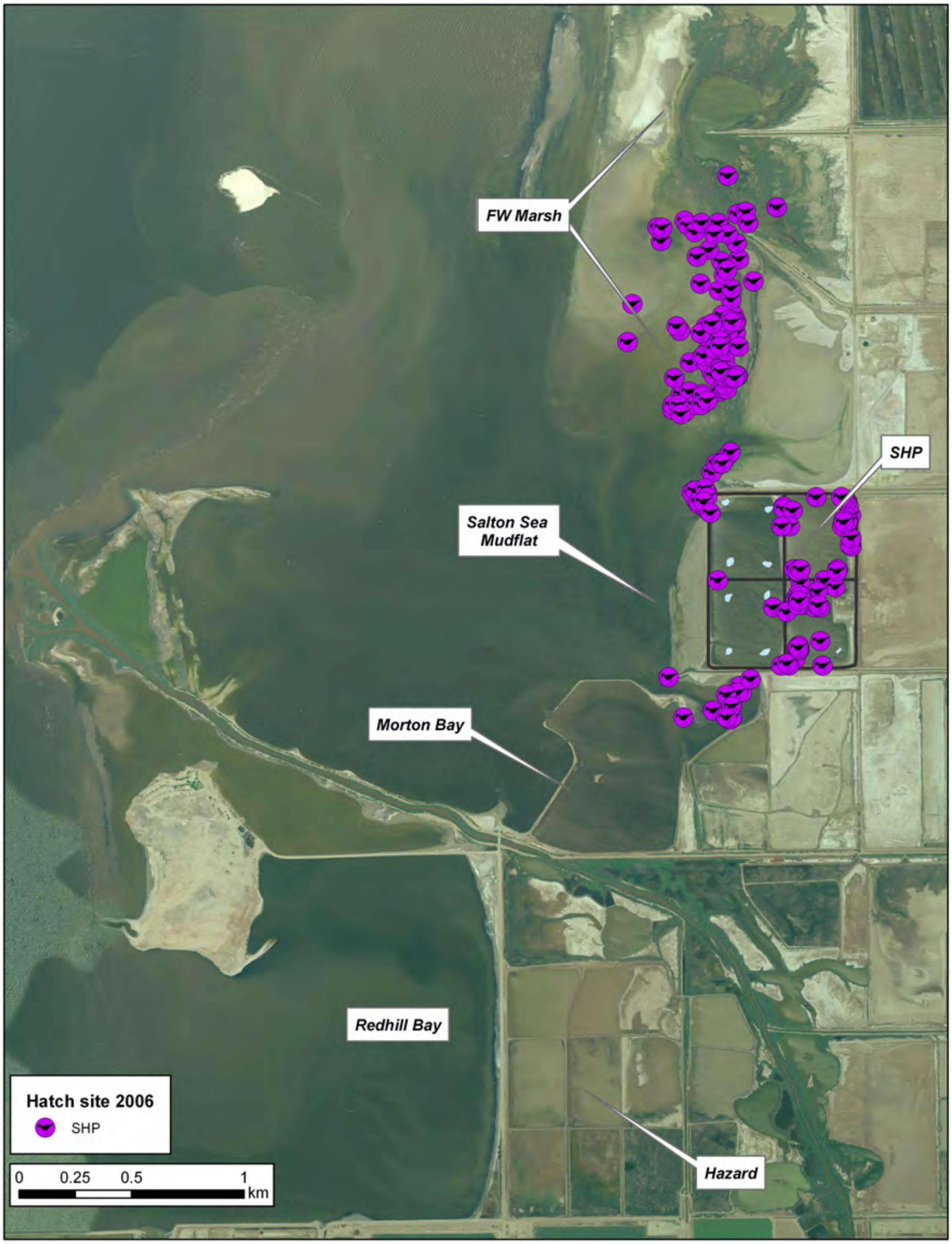


Figure 27A. Locations for radio-marked Black-necked Stilt chicks hatched at the saline habitat ponds (SHP) detected alive during the 2006 nesting season, Ecosystem Monitoring Project, Salton Sea, California. FW Marsh, Freshwater Marsh.

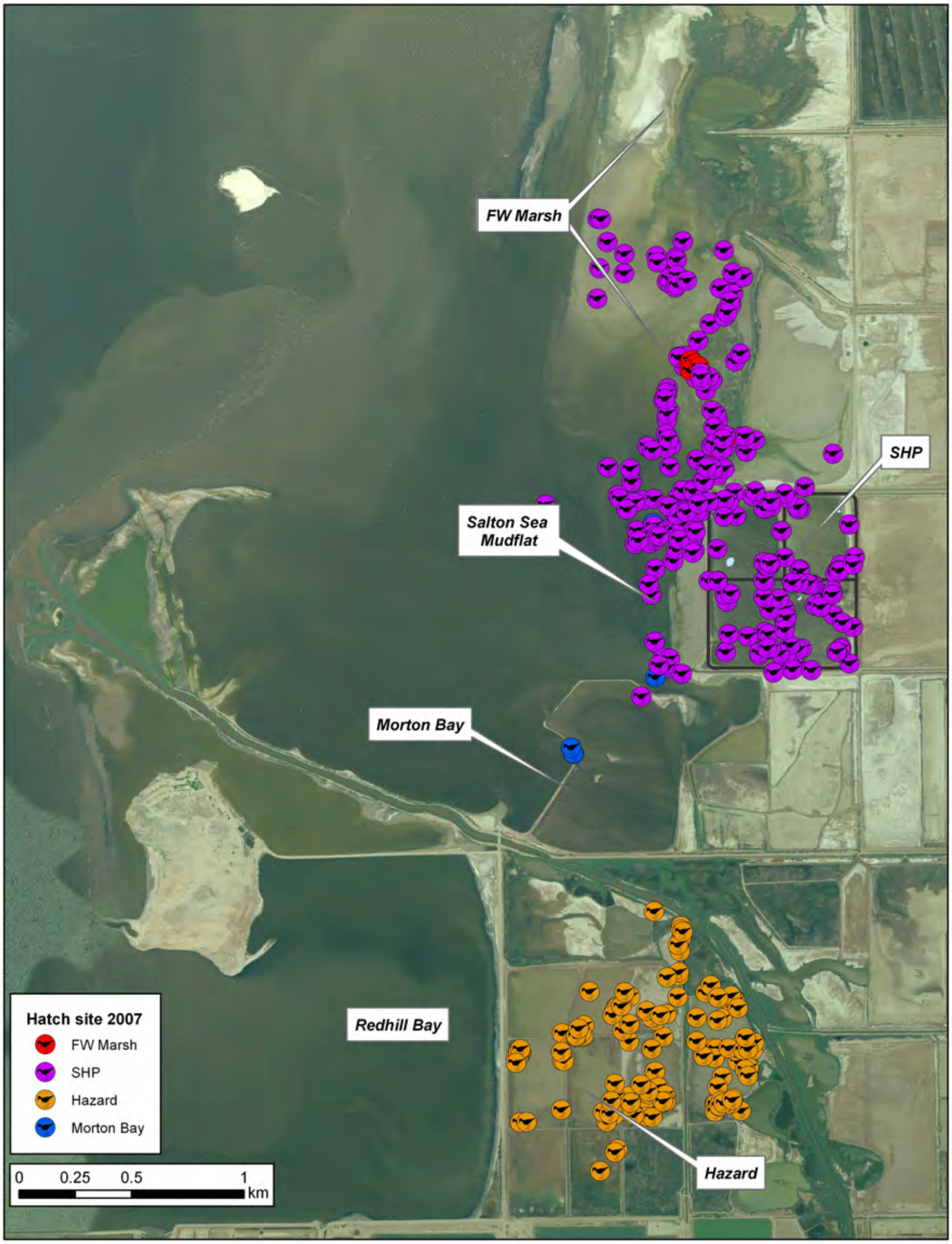


Figure 27B. Locations for radio-marked Black-necked Stilt chicks detected alive during the 2007 nesting season, Ecosystem Monitoring Project, Salton Sea, California. Locations for chicks hatched at different sites are color coded. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

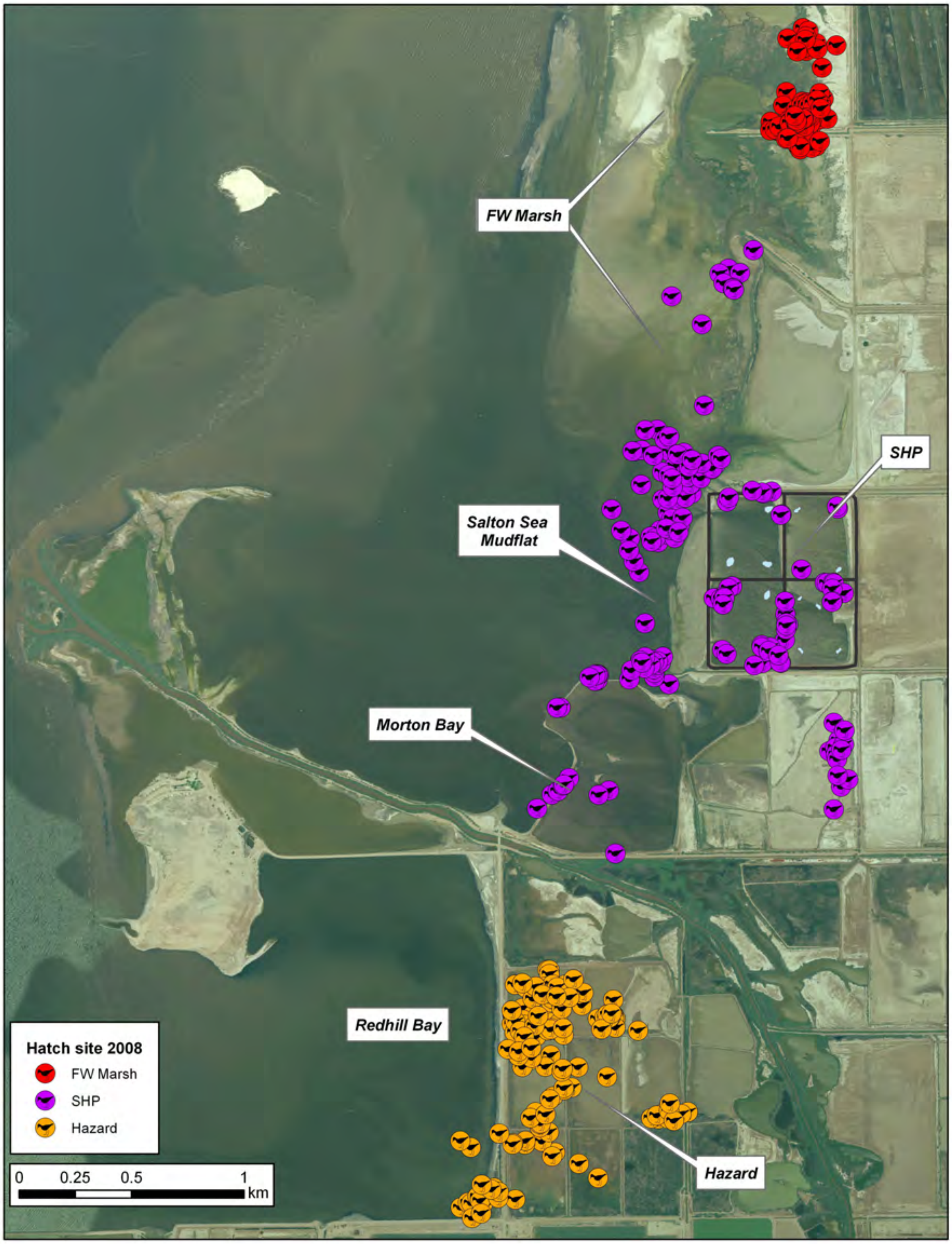


Figure 27C. Locations for radio-marked black-necked stilt chicks detected alive during the 2008 nesting season, Ecosystem Monitoring Project, Salton Sea, California. Locations for chicks hatched at different sites are color coded. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

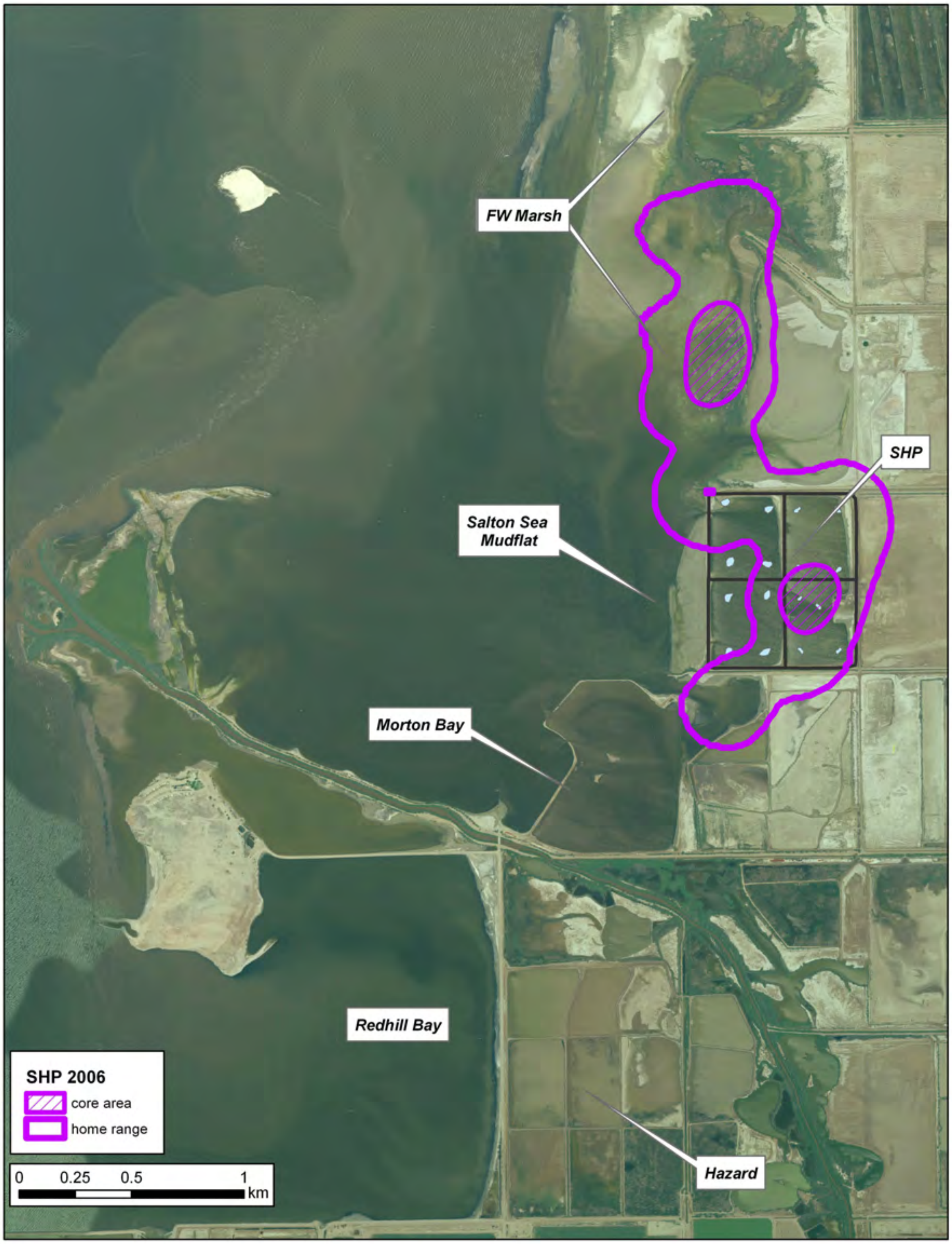


Figure 28A. Estimated 95% (home range) and 50% (core area) utilization distributions for populations of radio-marked Black-necked Stilt chicks during the 2006 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

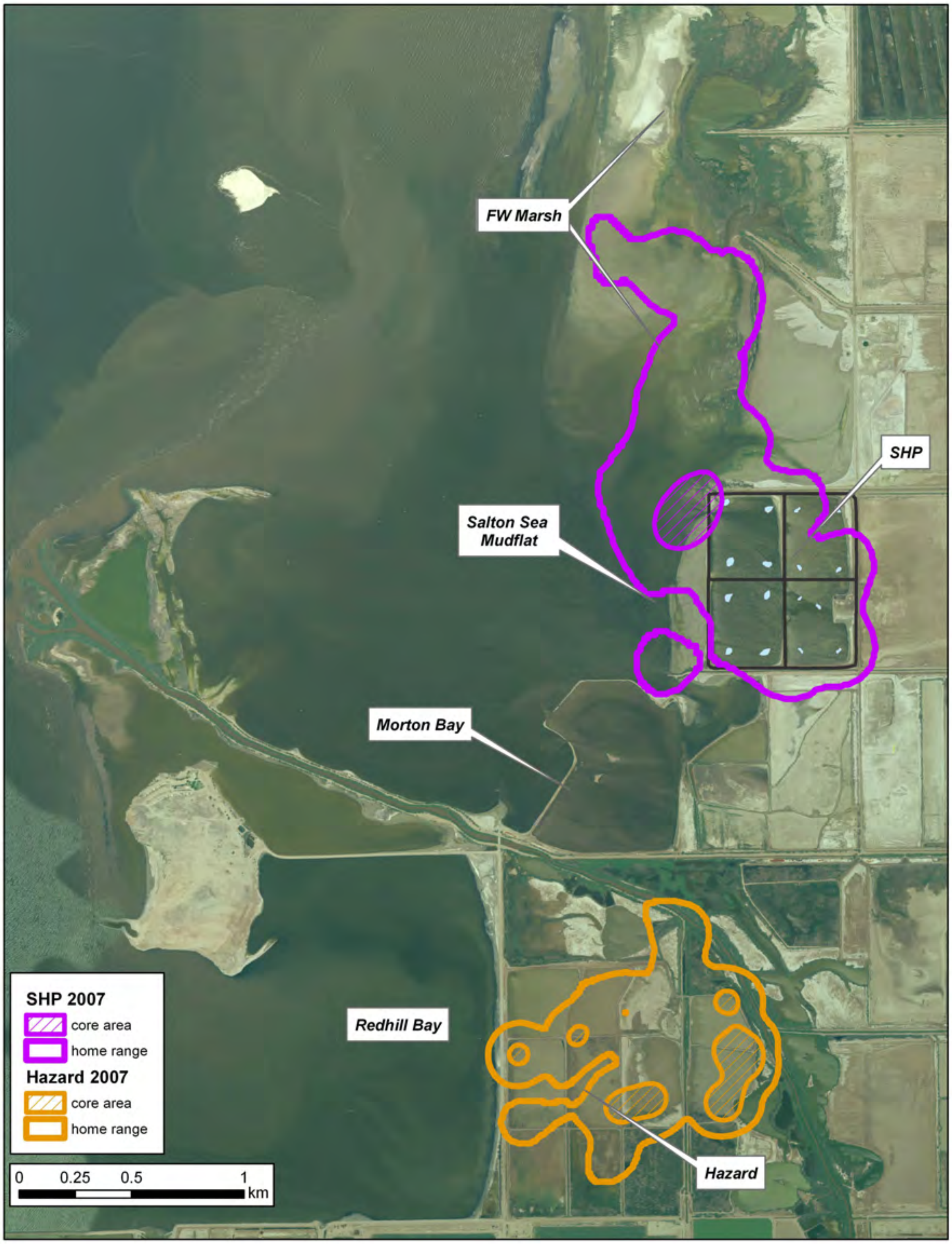


Figure 28B. Estimated 95% (home range) and 50% (core area) utilization distributions for populations of radio-marked Black-necked Stilt chicks during the 2007 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

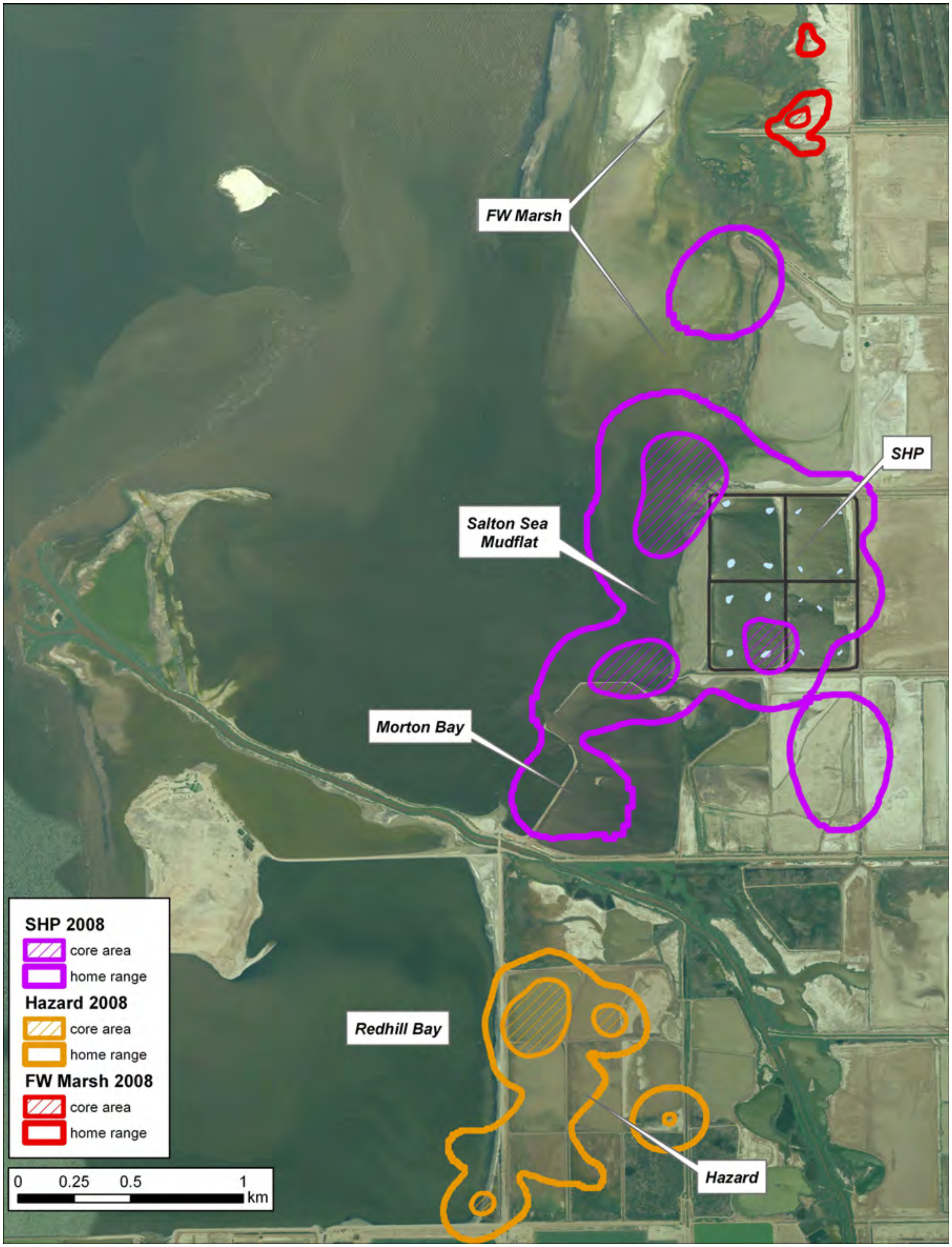


Figure 28C. Estimated 95% (home range) and 50% (core area) utilization distributions for populations of radio-marked Black-necked Stilt chicks during the 2008 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

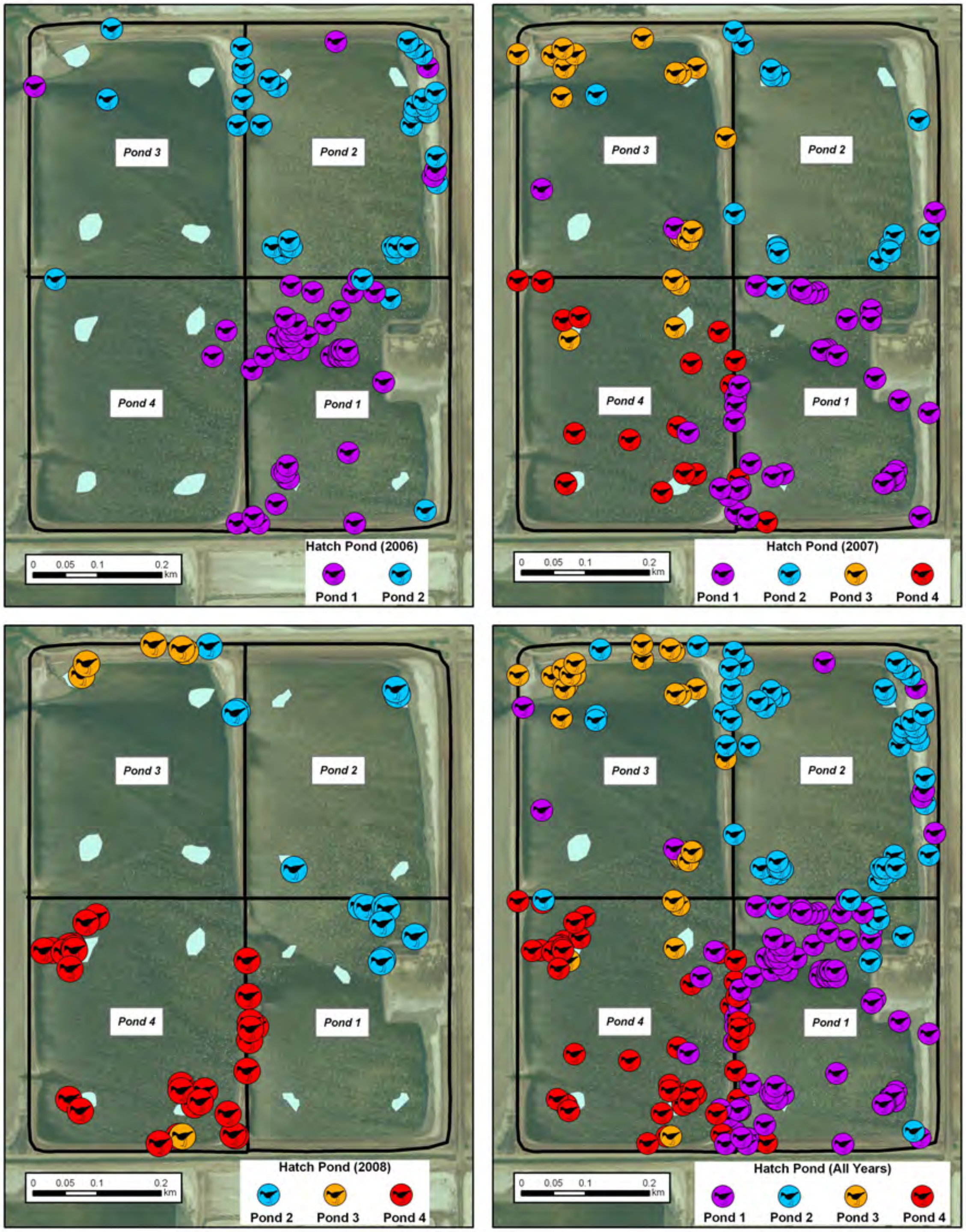


Figure 29. Inter-pond movements for radio-marked black-necked stilt chicks hatched at the saline habitat ponds (SHP) during the 2006–08 nesting seasons, Ecosystem Monitoring Project, Salton Sea, California. Locations for chicks hatched within particular SHP ponds are color coded.

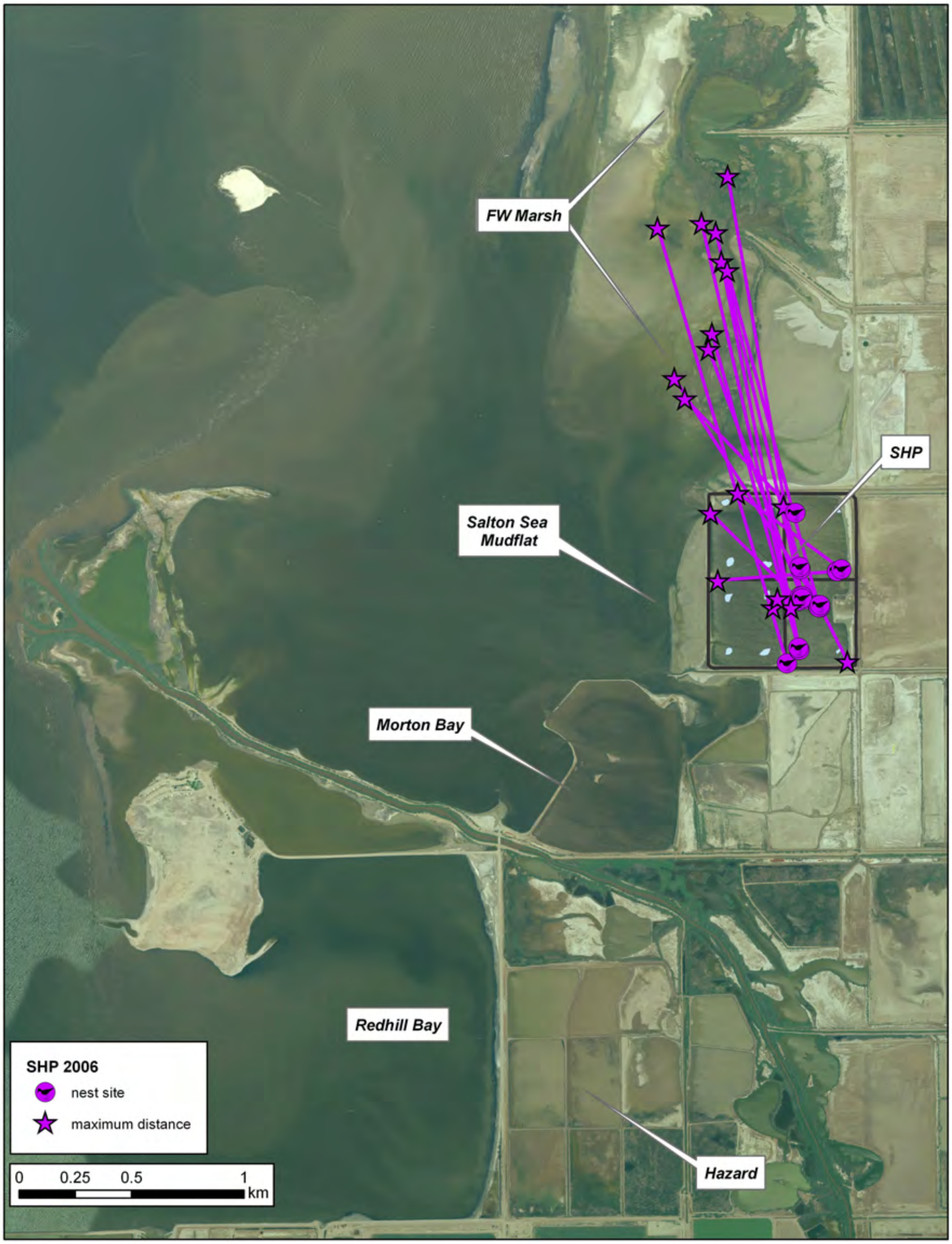


Figure 30A. Maximum distance and direction traveled from nest sites for Black-necked Stilt chicks radio-marked during the 2006 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

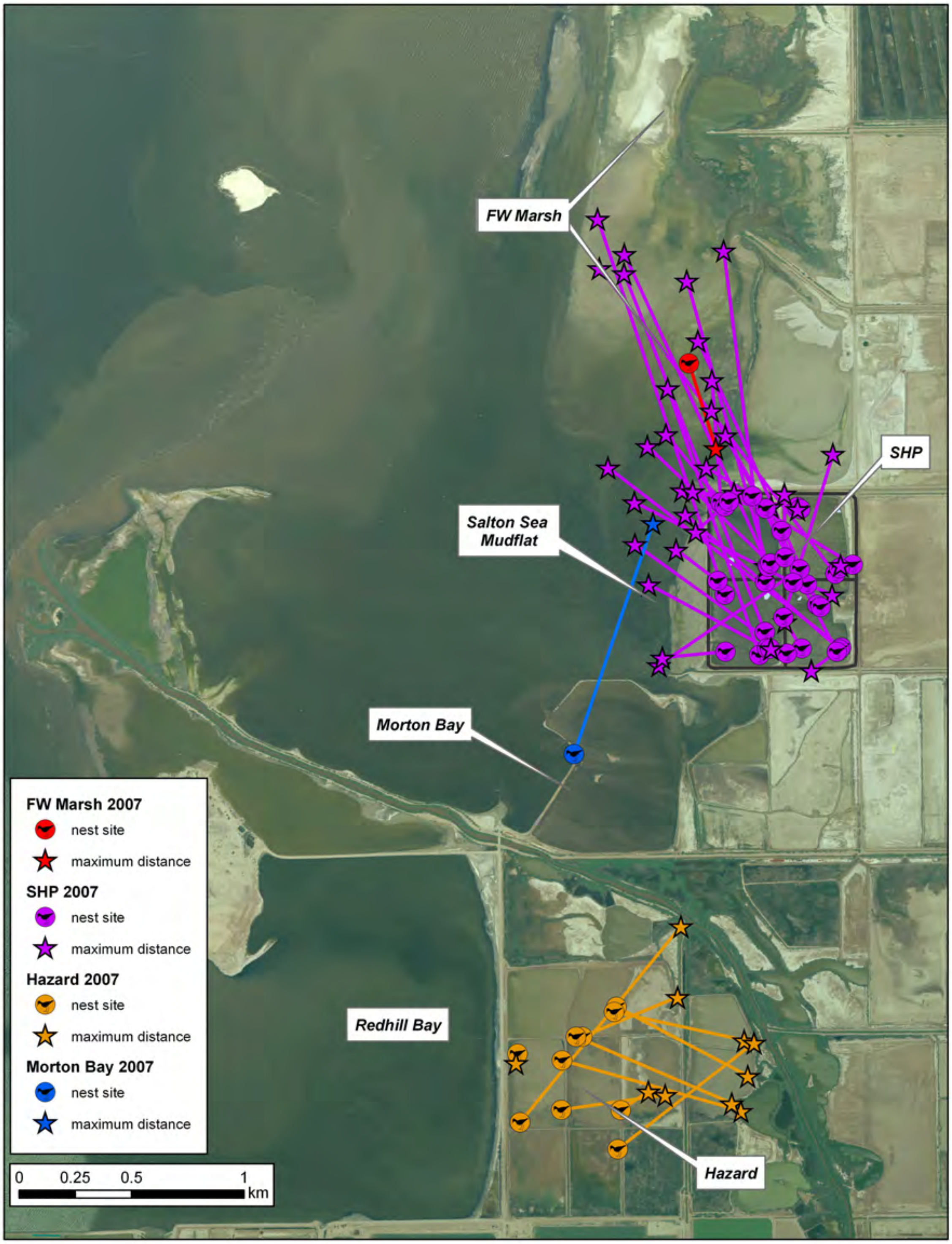


Figure 30B. Maximum distance and direction traveled from nest sites for Black-necked Stilt chicks radio-marked during the 2007 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

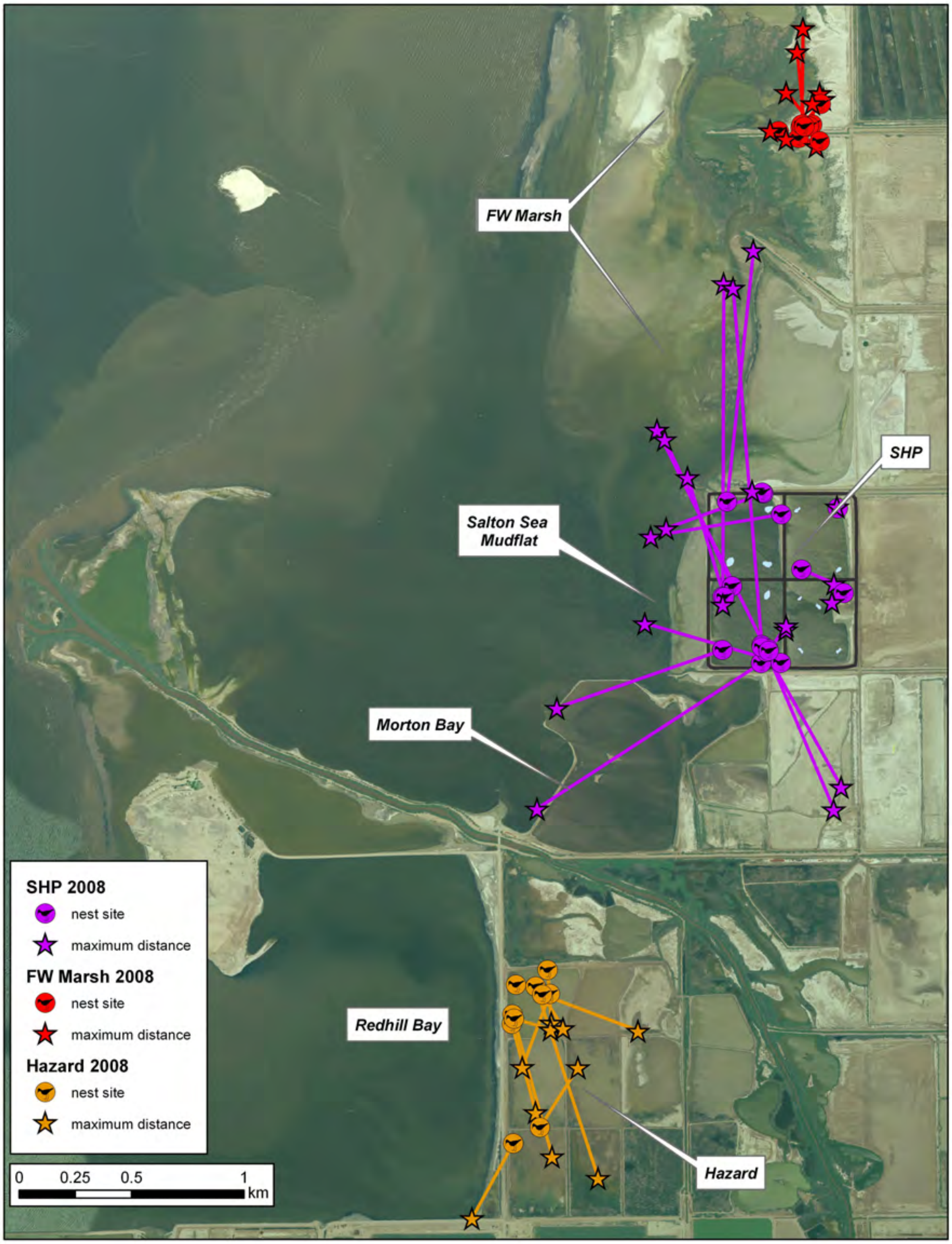
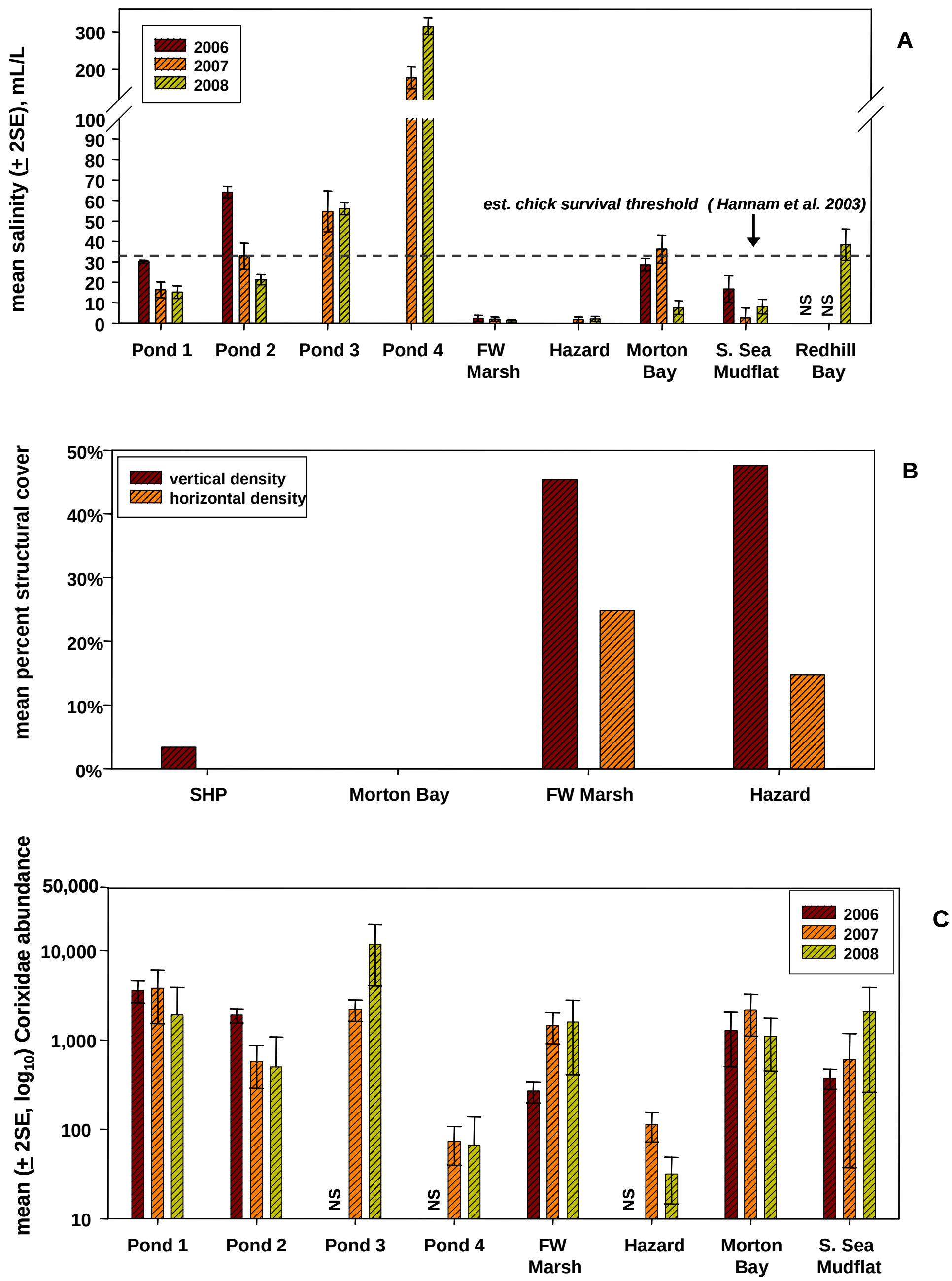


Figure 30C. Maximum distance and direction traveled from nest sites for Black-necked Stilt chicks radio-marked during the 2008 nesting season, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.



[1]Enumeration of Corixidae abundance from 2008 is ongoing at the time of this report

Figure 31. Measurements for water salinity (A), structural cover (B), and prey (Corixidae) abundance[1] (C) in habitats occupied by radio-marked black-necked stilt chicks during the 2006, 2007, or 2008 nesting seasons, Ecosystem Monitoring Project, Salton Sea, California. Structural cover was only measured during 2008, prey abundance is reported for 2006–07. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

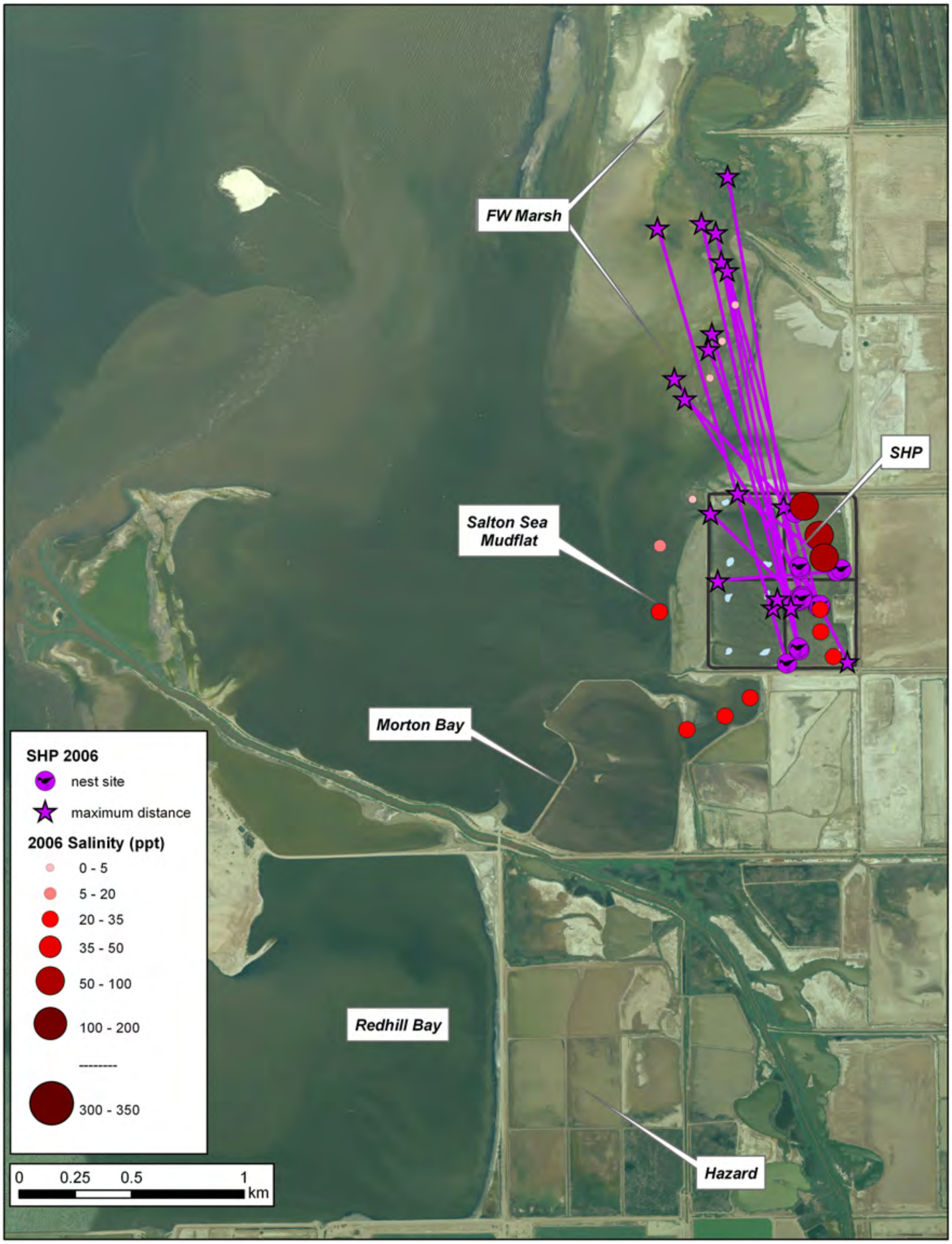


Figure 32A. Maximum distance and direction traveled from nest sites for Black-necked Stilt chicks radio-marked during the 2006 nesting season relative to average water salinity, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

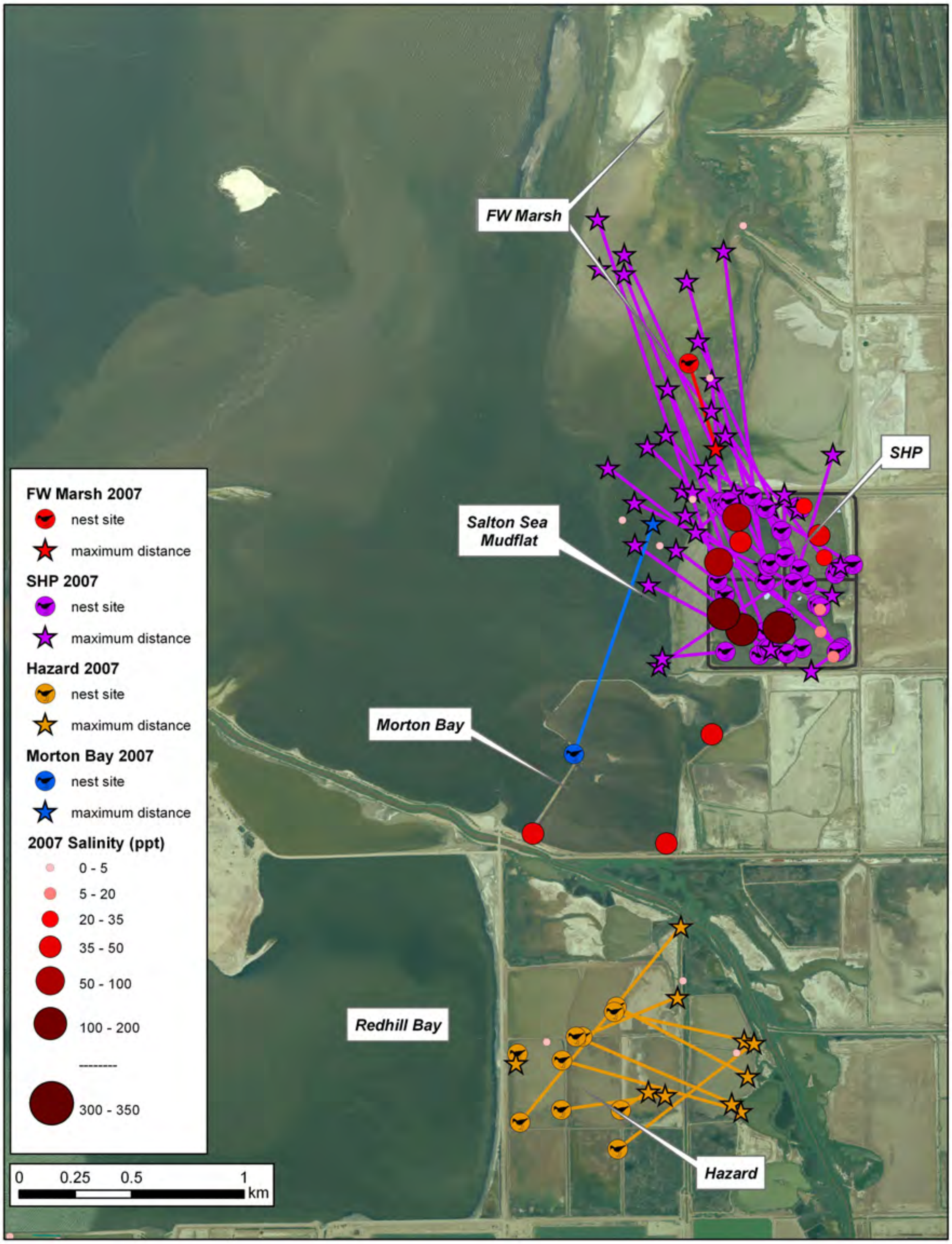


Figure 32B. Maximum distance and direction traveled from nest sites for Black-necked Stilt chicks radio-marked during the 2007 nesting season relative to average water salinity, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

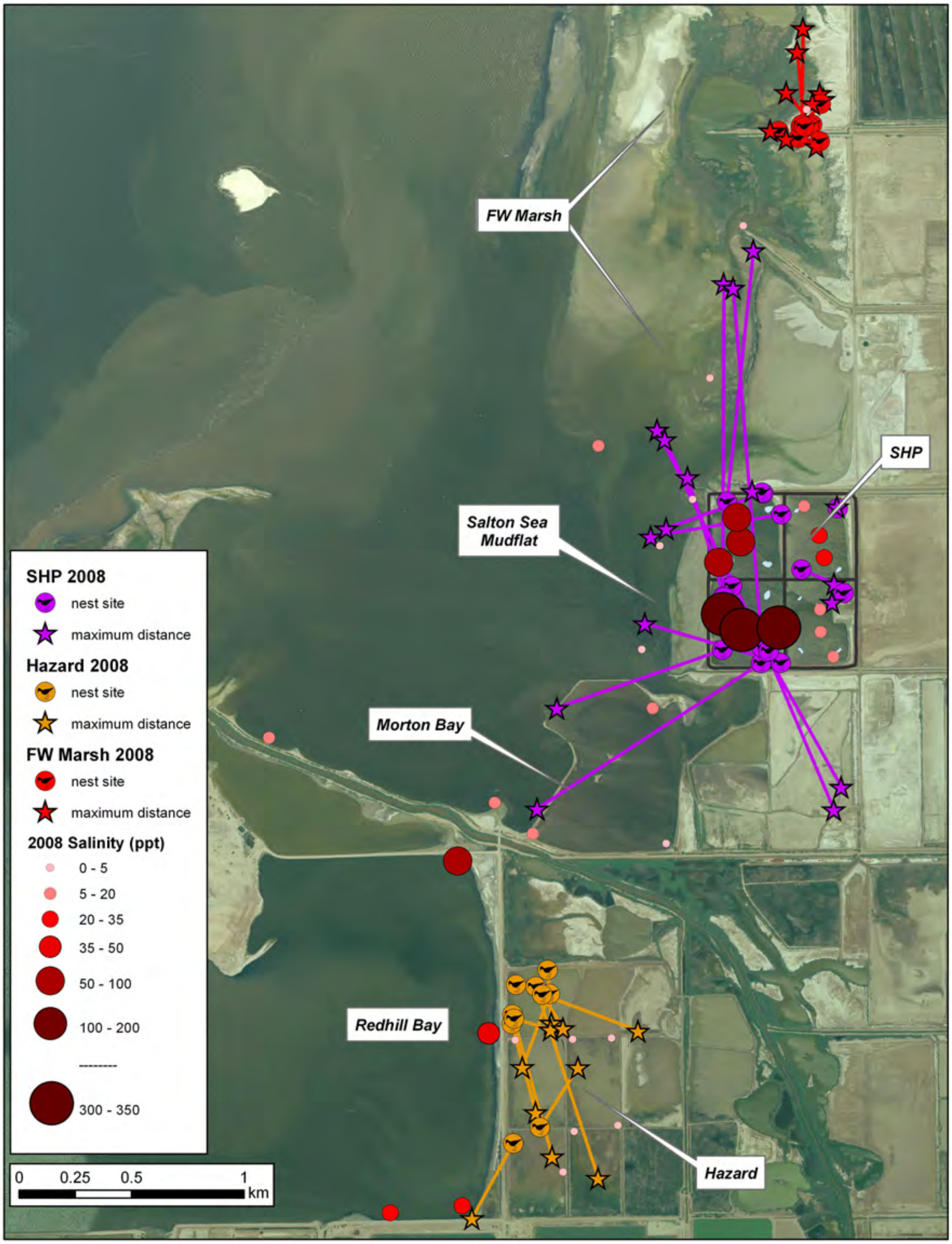


Figure 32C. Maximum distance and direction traveled from nest sites for Black-necked Stilt chicks radio-marked during the 2008 nesting season relative to average water salinity, Ecosystem Monitoring Project, Salton Sea, California. SHP, saline habitat ponds; FW Marsh, Freshwater Marsh.

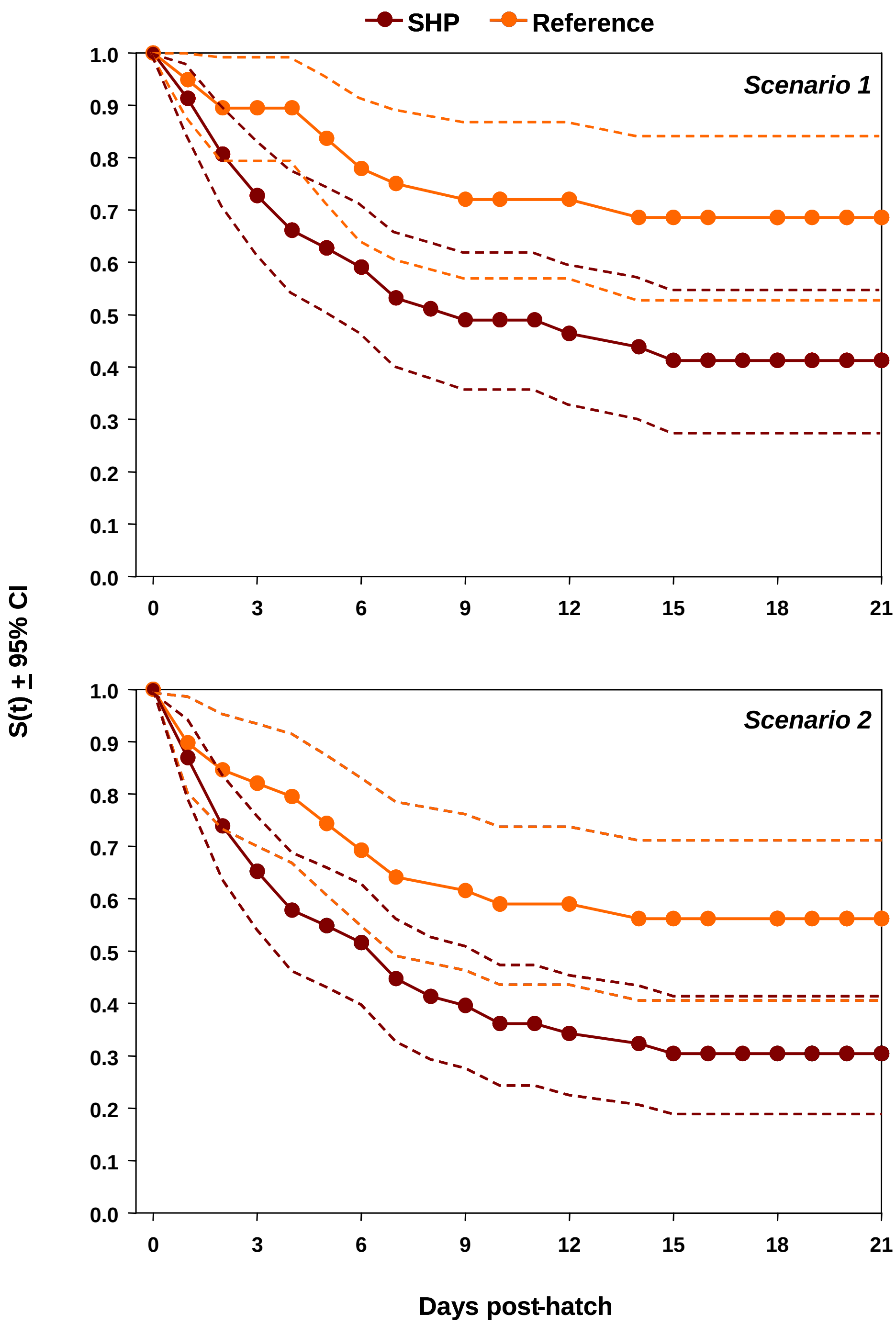


Figure 33. Kaplan Meier survivorship functions (S(t), solid lines) and 95% confidence intervals (dotted lines) to 21 days post-hatch for Black-necked Stilt chicks hatched at the saline habitat ponds (SHP) and reference sites during the 2007–08 breeding seasons, Ecosystem Monitoring Project, Salton Sea, California. Circles represent a mortality or censoring event. See text methods section 4.2.2.2—survival estimation for definitions of scenarios and survival rate estimation.

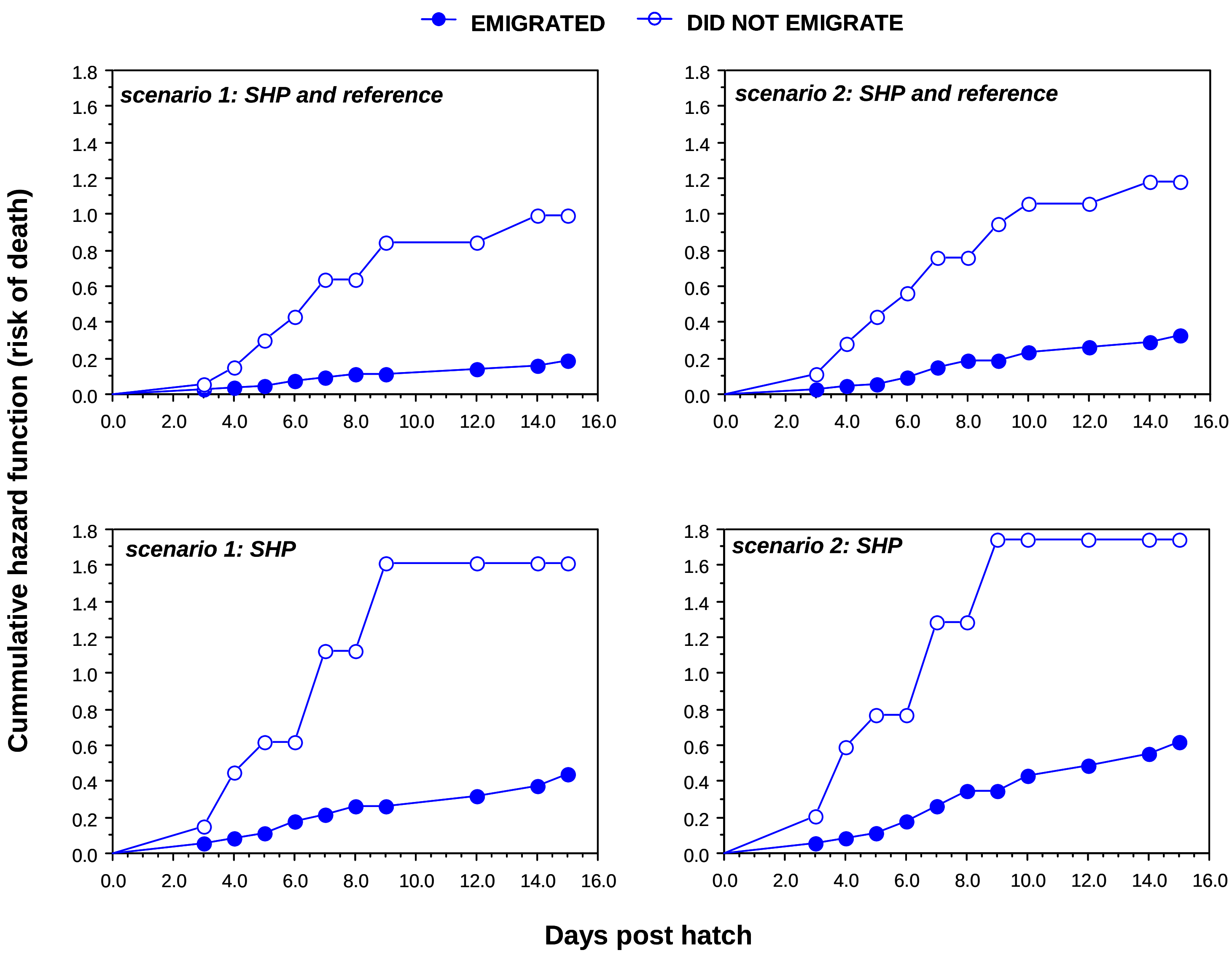


Figure 34. Effect of emigration from hatch site on hazard functions for Black-necked Stilt chicks hatched at the saline habitat ponds (SHP) and reference sites during the 2007–08 breeding seasons, Ecosystem Monitoring Project, Salton Sea, California. Circles represent a mortality or censoring event, only chicks capable of emigrating (≥3 days post-hatch) are in included in the analysis; see text methods section 4.2.2.2 — survival estimation for definitions of scenarios and survival rate estimation.

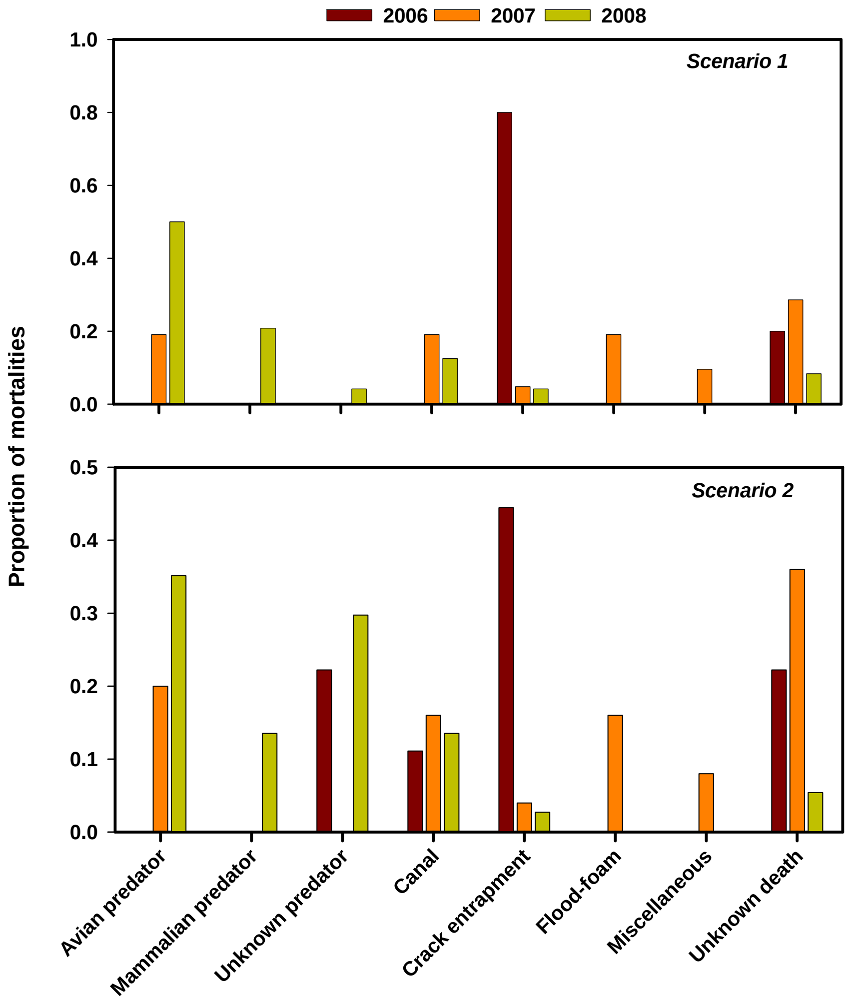


Figure 35. Relative frequencies for probable causes of mortality for all radio-marked post hatch Black-necked Stilt chicks, Ecosystem Monitoring Project, Salton Sea, California, 2006–08. Note y axis varies according to scenario, see text methods section 4.2.2.2 — survival estimation for definitions of scenarios.

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11. Tables

Table 1. Geographical coordinates (decimal degrees, NAD83) for fixed water, sediment, and invertebrate sampling points, Ecosystem Monitoring Project, Salton Sea, California, 2006–08.

[SHP, saline habitat ponds. NAD83, North American Datum of 1983]

Group	Site	Water source	Point	Latitude (N)	Longitude (W)
SHP	Pond 1	Salton Sea and Alamo River	P1-1	33.206348	115.581044
			P1-2	33.207346	115.581629
			P1-3	33.208249	115.581647
	Pond 2	Pond 1	P2-1	33.212405	115.582341
			P2-2	33.211225	115.581641
			P2-3	33.21032	115.58142
	Pond 3	Pond 2	P3-1	33.210197	115.586443
			P3-2	33.210997	115.58539
			P3-3	33.211991	115.585556
	Pond 4	Pond 2	P4-1	33.207549	115.58361
			P4-2	33.207479	115.585382
			P4-3	33.208121	115.586262
Reference	Alamo River	Agricultural runoff	AL-1	33.199315	115.597153
			AL-2	33.201985	115.605167
			AL-3	33.176778	115.575858
	Salton Sea	Salton Sea and Alamo River	SS-1	33.20486	115.585038
			SS-1A[1]	33.204369	115.589696
			SS-2	33.203405	115.607987
			SS-3	33.200669	115.597271
	Freshwater Marsh	Agricultural runoff	FW-1	33.217596	115.586743
			FW-2	33.223692	115.585057
			FW-3	33.212736	115.587647
	D-pond	Colorado River	HQ-1	33.183524	115.620658
			HQ-2	33.18074	115.617913
			HQ-3	33.183314	115.618345
	Hazard[2]	Colorado River	HZ-1	33.191165	115.591855
			HZ-2	33.187663	115.5916
			HZ-3	33.191141	115.593711

[1]SS-1 point moved due to consistent lack of water after fall 2006.

[2]Site added during spring 2008 due to draining of D-Pond in fall 2008.

Table 2. Arithmetic mean values for water-quality measurements from surface-water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for Salton Sea reference samples in fall 2006 where n = 2. cm, centimeters; mL/L, milliliters per liter; mS/cm, millisiemens per centimeter; %, percent; mV, millivolts; °C, degrees Celsius]

			Sampling period				
Measurement	Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Salinity (mL/L)	SHP	Pond 1	6.5	24.1	4.2	13.0	21.2
		Pond 2	16.8	29.8	9.1	29.0	24.9
		Pond 3	30.9	58.9	29.9	70.7	47.6
		Pond 4	([1])	174.0	153.3	335.0	398.0
	Reference	Salton Sea	22.9	23.6	40.0	8.4	6.2
		Alamo River	1.8	1.7	1.8	1.6	1.8
		Freshwater Marsh	1.6	2.1	1.3	2.6	1.3
		D-pond[2]	3.3	2.6	2.1	1.9	1.1
Conductivity (mS/cm)	SHP	Pond 1	11.8	37.9	7.6	21.8	33.7
		Pond 2	27.3	45.9	15.6	35.2	39.1
		Pond 3	47.4	85.0	45.6	82.5	69.7
		Pond 4	([1])	([1])	([1])	([1])	([1])
	Reference	Salton Sea	35.9	37.0	51.7	14.3	10.8
		Alamo River	3.3	3.2	3.3	3.0	3.3
		Freshwater Marsh	3.0	3.8	2.4	4.4	2.4
		D-pond	6.0	4.7	3.8	3.5	2.1
pH (units)	SHP	Pond 1	8.32	7.52	7.91	7.53	8.32
		Pond 2	8.38	7.79	8.23	7.43	8.61
		Pond 3	8.96	8.39	8.37	7.99	8.85
		Pond 4	8.1	7.57	7.82	7.45	7.71
	Reference	Salton Sea	8.48	8.43	8.71	8.25	8.55
		Alamo River	7.87	7.83	7.66	7.21	7.61
		Freshwater Marsh	8.27	8.07	8.22	7.33	7.14
		D-pond	8.66	8.6	8.53	7.5	7.02
Depth (cm)	SHP	Pond 1	37.7	38.7	32.0	28.3	34.3
		Pond 2	23.0	20.0	12.3	15.7	22.7
		Pond 3	21.3	35.0	22.0	23.3	21.7
		Pond 4	29.0	11.3	15.0	15.0	20.7
	Reference	Salton Sea	13.5	29	6.67	9.67	14.33
		Alamo River	70.0	39.7	35.0	26.0	21.7
		Freshwater Marsh	9.7	12.0	23.3	20.0	25.3
		D-pond	24.7	21.3	27.3	20.7	25.3

Table 2. Arithmetic mean values for water-quality measurements from surface-water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued.

[n = 3 for all sites and sampling periods, except for Salton Sea reference samples in fall 2006 where n = 2. cm, centimeters; mL/L, milliliters per liter; mS/cm, millisiemens per centimeter; %, percent; mV, millivolts; ^{o}C, degrees Celsius]

Measurement	Group	Site	Sampling period: Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
DO (%)	SHP	Pond 1	76.0	44.1	92.7	88.1	107.6
		Pond 2	60.3	91.9	105.5	93.2	166.5
		Pond 3	139.1	124.3	76.4	119.5	71.6
		Pond 4	135.4	140.6	222.7	372.0	98.4
	Reference	Salton Sea	75.1	127.3	119.0	199.8	149.4
		Alamo River	79.7	48.0	84.8	84.5	92.6
		Freshwater Marsh	115.9	108.7	162.4	157.5	78.4
		D-pond	58.3	95.1	76.7	89.2	52.8
ORP (mV)	SHP	Pond 1	281	490	424	282	374
		Pond 2	368	472	313	361	370
		Pond 3	293	418	260	264	284
		Pond 4	167	465	343	328	321
	Reference	Salton Sea	19	178	347	223	346
		Alamo River	273	334	530	309	385
		Freshwater Marsh	271	372	274	475	500
		D-pond	280	267	422	457	481
Temperature (^{o}C)	SHP	Pond 1	21.6	20.1	23.6	20.8	25.2
		Pond 2	19.4	21.8	24.8	14.8	25.3
		Pond 3	23.0	24.3	17.8	18.9	19.3
		Pond 4	20.5	26.4	22.5	24.8	24.0
	Reference	Salton Sea	27.5	32.2	20.9	30.8	28.6
		Alamo River	22.6	22.2	20.9	20.9	21.5
		Freshwater Marsh	27.1	22.5	25.0	21.9	18.8
		D-pond	21.1	27.9	19.0	19.4	17.0

[1]Value exceeded measuring device capacity (salinity = 70 mL/L, conductivity = 100 mS/cm).

[2]D-pond was dry in fall 2008, thus Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

Table 3. Arithmetic mean values for water nutrient measurements from surface water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for all fall 2006 sites where n = 2. ND, all concentrations below limit of detection (nitrate = 0.05–0.10 mg/L, phosphorous = 0.2–2.0 mg/L; varied according to salinity). NQ, analyte not quantified. mg/L, milligrams per liter]

Analyte	Group	Site	Sampling period Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ammonium (mg/L)	SHP	Pond 1	0.40	0.89	0.21	0.44	1.16
		Pond 2	0.26	0.24	0.19	0.30	0.15
		Pond 3	0.60	0.09	0.27	0.42	0.25
		Pond 4	6.23	1.58	0.57	0.55	0.51
	Reference	Alamo River	0.45	0.86	0.33	1.56	0.26
		Salton Sea	14.63	0.70	2.19	1.59	0.93
		Freshwater Marsh	0.19	0.34	0.05	0.04	0.14
		D-pond[1]	0.24	0.85	0.13	0.87	0.12
Nitrate (mg/L)	SHP	Pond 1	0.98	0.05	0.31	0.48	0.10
		Pond 2	ND	0.04	0.11	0.19	ND
		Pond 3	ND	ND	ND	0.18	ND
		Pond 4	0.03	ND	ND	0.28	ND
	Reference	Alamo River	5.87	6.88	6.14	4.20	6.45
		Salton Sea	0.07	0.08	ND	0.30	0.57
		Freshwater Marsh	0.16	3.55	0.17	0.39	0.37
		D-pond	ND	0.04	ND	0.07	ND
Phosphorous (mg/L)[2]	SHP	Pond 1	0.13	0.13	ND	0.07	0.23
		Pond 2	0.17	0.20	ND	ND	0.12
		Pond 3	0.43	0.20	ND	0.13	0.20
		Pond 4	1.33	2.40	ND	3.20	2.07
	Reference	Alamo River	0.50	0.40	0.50	0.43	0.27
		Salton Sea	1.03	0.23	0.83	0.07	0.33
		Freshwater Marsh	0.08	0.35	ND	0.15	0.07
		D-pond	0.10	ND	ND	ND	ND
Total dissolved solids (mg/L)	SHP	Pond 1	NQ	23,757	3,040	12,477	23,410
		Pond 2	NQ	28,837	10,757	23,937	28,673
		Pond 3	NQ	58,587	33,300	63,133	54,843
		Pond 4	NQ	181,223	170,730	304,007	266,970
	Reference	Alamo River	NQ	1,953	2,147	1,817	2,253
		Salton Sea	NQ	24,007	45,147	8,900	7,167
		Freshwater Marsh	NQ	2,000	1,640	2,307	1,513
		D-pond	NQ	2,460	2,343	2,143	1,293

[1]D-pond was dry in fall 2008, thus Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

[2]Quantified as total P in unfiltered sample in fall 2006, quantified as soluble P by ICP in all other sampling periods.

Table 4. Arithmetic mean values for sediment salinity measurements from sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for spring 2006 Freshwater Marsh (n = 2), Alamo River (n = 1) and D-pond (n = 1). ND, all concentrations below limit of detection. meq/L, milliequivalents per liter; dS/m, deciSiemens per meter]

			Sampling period					
Analyte	Group	Site	Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
pH	SHP	Pond 1	7.8	8.0	8.0	7.9	7.9	8.0
		Pond 2	7.4	8.1	8.1	8.1	8.1	8.1
		Pond 3	7.8	8.0	8.1	8.2	8.1	8.1
		Pond 4	8.1	8.2	8.2	7.9	7.7	7.3
	Reference	Alamo River	7.9	7.9	8.1	8.0	8.0	7.8
		Salton Sea	8.2	8.3	8.3	8.1	8.0	7.9
		Freshwater Marsh	7.8	7.8	8.0	7.8	7.5	7.5
		D-pond[1]	8.1	8.0	8.0	8.0	7.9	7.9
Carbonate (CO_3, meq/L)	SHP	Pond 1	0.5	ND	ND	ND	ND	ND
		Pond 2	0.6	ND	ND	ND	ND	ND
		Pond 3	0.1	ND	ND	0.1	0.2	0.4
		Pond 4	ND	0.3	0.4	0.7	ND	2.7
	Reference	Alamo River	ND	ND	ND	ND	0.4	ND
		Salton Sea	0.4	0.4	ND	ND	0.2	ND
		Freshwater Marsh	ND	ND	ND	ND	ND	ND
		D-pond	ND	ND	ND	ND	ND	ND
Bicarbonate (HCO_3, meq/L)	SHP	Pond 1	1.8	3.5	2.6	5.9	4.4	2.8
		Pond 2	1.5	2.7	2.1	4.2	4.2	2.6
		Pond 3	1.7	4.5	1.8	3.8	3.7	3.5
		Pond 4	1.7	4.4	1.9	4.4	4.7	2.0
	Reference	Alamo River	3.0	4.0	2.5	3.9	4.8	2.7
		Salton Sea	4.5	5.6	3.6	5.5	4.9	4.0
		Freshwater Marsh	2.5	4.6	3.0	5.5	5.5	3.5
		D-pond	2.3	3.6	3.0	4.5	5.5	2.4
Estimated soluble salts (EC, dS/m)	SHP	Pond 1	262.2	19.5	34.5	12.2	28.1	39.7
		Pond 2	390.8	49.2	41.9	28.8	41.7	46.9
		Pond 3	182.9	58.7	76.2	94.5	109.7	101.7
		Pond 4	165.7	105.5	156.9	274.3	320.9	442.4
	Reference	Alamo River	6.9	4.1	5.2	4.4	6.2	5.5
		Salton Sea	57.2	149.4	39.0	80.3	38.0	22.9
		Freshwater Marsh	11.0	7.7	7.6	6.7	8.8	10.6
		D-pond	29.8	9.9	7.0	8.8	6.5	9.9

Table 4. Arithmetic mean values for sediment salinity measurements from sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for spring 2006 Freshwater Marsh (n = 2), Alamo River (n = 1) and D-pond (n = 1). ND, all concentrations below limit of detection. meq/L, milliequivalents per liter; dS/m, deciSiemens per meter]

Analyte	Group	Site	Sampling period: Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Calcium (Ca, meq/L)	SHP	Pond 1	93.9	37.0	39.0	27.2	36.7	44.0
		Pond 2	152.4	49.7	44.3	36.9	39.8	42.0
		Pond 3	109.8	49.5	54.1	41.2	44.1	42.0
		Pond 4	61.6	61.2	59.8	23.0	24.5	16.2
	Reference	Alamo River	20.1	13.4	13.7	14.2	19.1	18.4
		Salton Sea	39.2	39.0	37.2	32.2	30.2	29.3
		Freshwater Marsh	28.3	22.3	19.3	20.4	24.7	25.8
		D-pond	37.1	20.3	15.8	16.6	12.8	26.5
Chloride (Cl, meq/L)	SHP	Pond 1	2,094.2	128.1	280.6	68.1	214.5	342.3
		Pond 2	3,346.5	358.6	346.5	234.1	324.6	408.8
		Pond 3	1,557.6	440.9	1,318.7	848.5	996.4	927.6
		Pond 4	1,306.4	869.7	2,934.0	2,739.0	3,018.4	4,554.5
	Reference	Alamo River	27.6	16.2	30.6	21.0	29.8	27.2
		Salton Sea	836.3	1,135.6	330.9	756.1	298.3	161.7
		Freshwater Marsh	57.9	27.9	37.5	30.7	41.9	57.3
		D-pond	214.6	100.8	36.7	52.8	33.9	69.1
Magnesium (Mg, meq/L)	SHP	Pond 1	536.3	44.9	53.8	34.1	53.6	75.9
		Pond 2	800.6	90.1	62.3	60.0	71.3	77.7
		Pond 3	356.0	101.9	117.2	161.8	187.2	170.1
		Pond 4	304.3	224.0	256.6	510.2	547.0	857.3
	Reference	Alamo River	15.7	10.4	12.3	11.9	19.8	14.7
		Salton Sea	175.1	232.8	70.2	141.5	67.8	53.5
		Freshwater Marsh	34.2	27.5	21.0	24.5	31.4	35.1
		D-pond	74.5	34.6	18.9	25.8	17.8	26.3
Sodium (Na, meq/L)	SHP	Pond 1	1,899.6	146.2	296.0	124.9	225.1	301.0
		Pond 2	2,826.0	372.8	342.1	249.9	328.7	380.0
		Pond 3	1,353.8	452.2	611.5	898.9	1,019.2	894.6
		Pond 4	1,328.2	800.3	1,325.3	2,837.4	3,153.0	3,914.3
	Reference	Alamo River	36.6	21.1	30.6	22.9	35.3	29.2
		Salton Sea	964.7	1,311.9	370.1	781.8	321.2	181.9
		Freshwater Marsh	70.5	39.7	44.4	38.1	51.6	60.3
		D-pond	250.0	58.3	44.7	62.0	42.0	58.8

[1]D-pond was dry in fall 2008, Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

Table 5. Arithmetic mean values for sediment composition measurements from sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for spring 2006 Freshwater Marsh (n = 2), Alamo River (n = 1) and D-pond (n = 1). NQ, analyte not quantified. %, percent]

Analyte	Group	Site	Sampling period: Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Organic carbon (%)	SHP	Pond 1	1.0	1.2	1.2	1.2	0.9	0.9
		Pond 2	0.7	0.4	0.5	0.6	0.5	0.7
		Pond 3	1.8	2.0	2.0	1.7	1.7	1.6
		Pond 4	1.8	1.3	1.5	1.5	1.5	1.4
	Reference	Alamo River	0.6	0.5	0.5	0.5	0.4	0.5
		Salton Sea	1.7	1.5	1.9	1.2	1.6	1.2
		Freshwater Marsh	1.5	1.6	1.5	1.6	1.6	1.7
		D-pond[1]	0.3	1.0	0.6	0.8	1.0	0.6
Organic matter (%)	SHP	Pond 1	1.8	2.1	2.0	2.0	1.5	1.5
		Pond 2	1.2	0.8	0.9	1.1	0.9	1.2
		Pond 3	3.0	3.5	3.4	2.9	2.9	2.8
		Pond 4	3.1	2.3	2.6	2.7	2.6	2.3
	Reference	Alamo River	1.0	0.9	0.9	0.8	0.7	0.9
		Salton Sea	2.9	2.6	3.2	2.1	2.8	2.0
		Freshwater Marsh	2.5	2.7	2.5	2.7	2.8	3.0
		D-pond	0.5	1.6	1.1	1.5	1.6	1.1
Sand (%)	SHP	Pond 1	27.3	12.7	22.3	20.0	NQ	33.3
		Pond 2	42.3	40.7	39.0	38.7	NQ	32.7
		Pond 3	18.0	11.0	12.3	22.3	NQ	25.7
		Pond 4	13.0	16.3	17.0	23.7	NQ	19.3
	Reference	Alamo River	48.0	32.7	36.7	25.3	NQ	47.7
		Salton Sea	25.7	20.0	22.7	32.7	NQ	43.3
		Freshwater Marsh	11.5	18.3	23.7	24.3	NQ	22.7
		D-pond	70.0	11.3	37.7	21.7	NQ	9.3
Silt (%)	SHP	Pond 1	51.0	46.7	40.0	40.7	NQ	32.3
		Pond 2	44.7	53.7	38.7	45.0	NQ	53.0
		Pond 3	61.7	54.7	53.3	64.0	NQ	57.0
		Pond 4	51.0	51.3	62.3	58.3	NQ	47.3
	Reference	Alamo River	30.0	41.0	36.7	47.7	NQ	30.7
		Salton Sea	40.3	50.3	40.7	35.7	NQ	30.7
		Freshwater Marsh	50.0	50.7	45.0	44.7	NQ	42.3
		D-pond	19.0	58.7	39.7	51.0	NQ	43.0
Clay (%)	SHP	Pond 1	21.7	40.7	37.7	39.3	NQ	34.3
		Pond 2	13.0	5.7	22.3	16.3	NQ	14.3
		Pond 3	20.3	34.3	34.3	13.7	NQ	17.3
		Pond 4	36.0	32.3	20.7	18.0	NQ	33.3
	Reference	Alamo River	22.0	26.3	26.7	27.0	NQ	21.7
		Salton Sea	34.0	29.7	36.7	31.7	NQ	26.0
		Freshwater Marsh	38.5	31.0	31.3	31.0	NQ	35.0
		D-pond	11.0	30.0	22.7	27.3	NQ	47.7

[1]D-pond was dry in fall 2008, thus Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

Table 6. Percent relative abundance of macroinvertebrates collected from saline habitat ponds (SHP) and references sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[Totals represent 9 Ekman benthic grab and 3 D-ring sweep samples at each site, enumerated to the nearest taxonomic class, order, and/or family. Relative abundance for taxa with less than 10 individuals at any sampling period and site are not listed. Pond 4, hypersaline intolerant taxa (that is, non-Ephydridae) encountered in Pond 4 after fall 2006 typically were dead at time of collection. Wind and/or water flow through the SHP was the probable reason for their occurrence in Pond 4. --, sites with no invertebrates]

			Fall 2006							
			SHP				Reference			
Class	Order	Family	Pond 1	Pond 2	Pond 3	Pond 4[2]	Alamo River	Salton Sea	Freshwater Marsh	D-pond
Polychaeta	Capitellida	Capitellidae	1.3	3.6	--	--	7.0	57.0	--	--
	Aciculata	Nereidae	0.4	0.0	--	--	5.0	--	--	--
Insecta	Ephemeroptera	Baetidae	--	--	--	--	--	--	--	--
	Diptera	Ceratopogonidae	--	--	--	--	--	--	--	--
		Chironomidae	47.3	31.5	--	--	7.0	--	41.4	85.6
		Ephydridae	--	--	0.1	0.5	--	--	--	--
		Other Diptera	0.4	--	--	0.1	--	10.0	0.0	1.9
	Hemiptera	Corixidae	--	63.9	99.9	99.3	10.0	6.2	56.0	7.4
		Notonectidae	--	--	--	--	--	--	--	--
		Aphididae	--	--	--	--	--	--	--	--
		Other Hemiptera	--	--	--	--	--	--	--	--
	Coleoptera	Dytiscidae	--	--	--	--	--	--	--	--
		Hydrophilidae	--	--	--	--	--	--	--	--
Clitellata	Haplotaxida	Naididae	--	--	--	--	--	--	--	--
		Tubificidae	--	--	--	--	71.0	3.1	1.9	4.6
		Other Oligocheata[1]	--	--	--	--	--	--	--	--
Malacostraca	Amphipoda	Corophiidae	3.3	0.9	--	--	--	--	--	--
		Gammaridae	--	--	--	--	--	--	--	0.5
Ostracoda	Podocopa	Cytherideidae	1.3	0.1	--	0.1	--	23.7	0.05	--
	Ostracoda	Other Ostracoda	--	--	--	--	--	--	--	--
Branchiopoda	Cladocera	Daphniidae	--	--	--	--	--	--	--	--
Maxillopoda	Copepoda	Other Copepoda	--	--	--	--	--	--	--	--
Nematoda[1]	Nematoda	Other Nematoda	46.0	--	--	--	--	--	0.2	--
Gastropoda	Basommatophora	Physidae	--	--	--	--	--	--	--	--
		Other Gastropoda	--	--	--	--	--	--	0.4	--

Table 6. Percent relative abundance of macro invertebrates collected from saline habitat ponds (SHP) and references sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued.

[Totals represent 9 Ekman benthic grab and 3 D-ring sweep samples at each site, enumerated to the nearest taxonomic class, order, and/or family. Relative abundance for taxa with less than 10 individuals at any sampling period and site are not listed. Pond 4, hypersaline intolerant taxa (that is, non-Ephydridae) encountered in Pond 4 after fall 2006 typically were dead at time of collection. Wind and/or water flow through the SHP was the probable reason for their occurrence in Pond 4. --, sites with no invertebrates]

			Spring 2007							
			SHP				Reference			
Class	Order	Family	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	D-pond
Polychaeta	Capitellida	Capitellidae	11.9	14.3	--	--	0.3	0.1	--	0.01
	Aciculata	Nereidae	--	--	--	--	0.3	0.5	--	--
Insecta	Ephemeroptera	Baetidae	--	--	--	--	--	--	--	--
	Diptera	Ceratopogonidae	--	--	--	--	--	--	0.2	--
		Chironomidae	69.2	3.2	--	1.1	23.5	2.7	14.4	2.9
		Ephydridae	0.1	--	0.1	92.0	--	--	--	--
		Other Diptera	0.2	--	--	1.1	6.5	0.7	1.4	0.02
	Hemiptera	Corixidae	6.5	29.8	99.1	4.0	0.7	15.4	32.4	0.4
		Notonectidae	--	--	--	--	--	--	--	--
		Aphididae	--	--	--	--	--	--	--	--
		Other Hemiptera	--	--	--	--	0.3	0.03	--	--
	Coleoptera	Dytiscidae	--	--	--	--	--	--	0.05	--
		Hydrophilidae	--	--	--	--	--	0.03	--	--
Clitellata	Haplotaxida	Naididae	--	--	--	--	--	--	--	--
		Tubificidae	--	--	--	--	11.8	--	0.3	--
		Other Oligocheata[1]	--	--	--	--	16.7	--	3.1	1.5
Malacostraca	Amphipoda	Corophiidae	8.3	46.3	0.6	--	--	--	--	--
		Gammaridae	--	--	--	--	--	--	0.05	0.03
Ostracoda	Podocopa	Cytherideidae	3.6	1.2	0.0	1.7	3.3	75.8	14.4	0.1
	Ostracoda	Other Ostracoda	--	--	--	--	--	--	--	--
Branchiopoda	Cladocera	Daphniidae	--	--	--	--	2.3	1.5	27.6	94.8
Maxillopoda	Copepoda	Other Copepoda	--	--	--	--	32.7	3.0	2.9	0.02
Nematoda[1]	Nematoda	Other Nematoda	0.3	5.2	0.04	--	1.6	0.2	3.2	0.2
Gastropoda	Basommatophora	Physidae	--	--	--	--	--	--	--	--
		Other Gastropoda	--	--	--	--	--	--	--	0.01

Table 6. Percent relative abundance of macro invertebrates collected from saline habitat ponds (SHP) and references sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued.

[Totals represent 9 Ekman benthic grab and 3 D-ring sweep samples at each site, enumerated to the nearest taxonomic class, order, and/or family. Relative abundance for taxa with less than 10 individuals at any sampling period and site are not listed. Pond 4, hypersaline intolerant taxa (that is, non-Ephydridae) encountered in Pond 4 after fall 2006 typically were dead at time of collection. Wind and/or water flow through the SHP was the probable reason for their occurrence in Pond 4. --, sites with no invertebrates]

			Fall 2007							
			SHP				Reference			
Class	Order	Family	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	D-pond
Polychaeta	Capitellida	Capitellidae	8.6	13.5	0.1	--	2.2	6.9	--	--
	Aciculata	Nereidae	--	--	--	--	15.6	--	--	--
Insecta	Ephemeroptera	Baetidae	--	--	--	--	--	--	--	--
	Diptera	Ceratopogonidae	--	--	--	--	--	--	--	--
		Chironomidae	28.8	6.4	0.3	0.9	7.8	0.4	48.7	69.0
		Ephydridae	--	1.3	7.3	88.3	3.3	0.8	0.5	--
		Other Diptera	--	--	--	--	--	--	--	--
	Hemiptera	Corixidae	0.4	16.4	91.6	10.1	4.4	13.4	19.2	16.5
		Notonectidae	--	--	--	--	--	--	--	--
		Aphididae	--	--	--	--	--	--	--	--
		Other Hemiptera	--	--	--	--	--	--	--	--
	Coleoptera	Dytiscidae	--	--	--	--	--	--	--	--
		Hydrophilidae	0.0	--	0.2	--	2.2	--	0.1	--
Clitellata	Haplotaxida	Naididae	--	--	--	--	--	--	--	--
		Tubificidae	0.0	0.7	--	--	64.4	54.7	18.1	8.3
		Other Oligocheata[1]	--	--	--	--	--	2.0	1.9	--
Malacostraca	Amphipoda	Corophiidae	55.3	5.9	0.2	--	--	--	--	--
		Gammaridae	--	0.03	--	--	--	--	--	--
Ostracoda	Podocopa	Cytherideidae	3.9	46.4	--	0.7	--	21.9	10.2	--
	Ostracoda	Other Ostracoda	--	--	--	--	--	--	--	--
Branchiopoda	Cladocera	Daphniidae	--	--	--	--	--	--	--	--
Maxillopoda	Copepoda	Other Copepoda	1.4	9.4	0.5	--	--	--	--	5.7
Nematoda[1]	Nematoda	Other Nematoda	1.5	--	--	--	--	--	0.8	--
Gastropoda	Basommatophora	Physidae	--	--	--	--	--	--	0.6	0.5
		Other Gastropoda	--	--	--	--	--	--	--	--

Table 6. Percent relative abundance of macro invertebrates collected from saline habitat ponds (SHP) and references sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued.

[Totals represent 9 Ekman benthic grab and 3 D-ring sweep samples at each site, enumerated to the nearest taxonomic class, order, and/or family. Relative abundance for taxa with less than 10 individuals at any sampling period and site are not listed. Pond 4, hypersaline intolerant taxa (that is, non-Ephydridae) encountered in Pond 4 after fall 2006 typically were dead at time of collection. Wind and/or water flow through the SHP was the probable reason for their occurrence in Pond 4. --, sites with no invertebrates]

			Spring 2008								
			SHP				Reference				
Class	Order	Family	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	D-pond	Hazard
Polychaeta	Capitellida	Capitellidae	0.9	30.3	1.2	--	1.6	0.02	0.1	--	0.2
	Aciculata	Nereidae	--	--	--	--	0.8	--	--	--	--
Insecta	Ephemeroptera	Baetidae	--	--	--	--	--	--	--	--	--
	Diptera	Ceratopogonidae	--	--	--	--	--	--	0.3	0.03	--
		Chironomidae	45.0	11.8	0.1	0.0	12.4	3.0	34.6	30.4	37.1
		Ephydridae	--	--	0.1	68.9	--	0.05	0.03	--	0.03
		Other Diptera	--	--	0.0	1.6	1.6	--	0.1	0.0	0.03
	Hemiptera	Corixidae	6.6	2.8	97.4	21.3	18.9	77.2	8.5	5.9	18.5
		Notonectidae	--	--	--	--	--	--	0.03	--	0.03
		Aphididae	--	0.03	--	--	1.2	0.03	1.2	0.03	--
		Other Hemiptera	--	--	--	--	--	--	0.5	--	--
	Coleoptera	Dytiscidae	--	--	--	--	--	--	--	--	--
		Hydrophilidae	--	--	--	--	--	--	--	--	0.1
Clitellata	Haplotaxida	Naididae	--	--	--	--	0.8	--	0.1	0.0	0.7
		Tubificidae	0.03	1.2	--	--	46.6	--	21.4	27.6	1.6
		Other Oligocheata[1]	0.1	0.6	--	--	1.2	--	0.6	--	2.0
Malacostraca	Amphipoda	Corophiidae	3.6	31.4	1.2	--	--	--	0.03	--	--
		Gammaridae	--	--	--	--	--	--	--	0.4	--
Ostracoda	Podocopa	Cytherideidae	14.2	18.6	0.04	--	2.0	11.4	0.03	0.1	2.1
	Ostracoda	Other Ostracoda	13.4	--	--	--	--	--	15.1	--	0.2
Branchiopoda	Cladocera	Daphniidae	--	--	0.03	8.2	6.4	2.9	15.3	32.7	18.7
Maxillopoda	Copepoda	Other Copepoda	16.1	3.1	--	--	6.0	5.3	1.7	1.3	17.6
Nematoda[1]	Nematoda	Other Nematoda	--	0.3	--	--	0.4	--	0.2	1.4	0.5

Table 6. Percent relative abundance of macro invertebrates collected from saline habitat ponds (SHP) and references sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued.

[Totals represent 9 Ekman benthic grab and 3 D-ring sweep samples at each site, enumerated to the nearest taxonomic class, order, and/or family. Relative abundance for taxa with less than 10 individuals at any sampling period and site are not listed. Pond 4, hypersaline intolerant taxa (that is, non-Ephydridae) encountered in Pond 4 after fall 2006 typically were dead at time of collection. Wind and/or water flow through the SHP was the probable reason for their occurrence in Pond 4. --, sites with no invertebrates]

			Fall 2008							
			SHP				Reference			
Class	Order	Family	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	Hazard
Polychaeta	Capitellida	Capitellidae	--	20.3	0.01	--	0.3	--	--	--
	Aciculata	Nereidae	--	--	--	--	0.3	--	--	--
Insecta	Ephemeroptera	Baetidae	--	--	--	--	--	--	--	4.7
	Diptera	Ceratopogonidae	--	--	--	--	--	--	0.4	--
		Chironomidae	23.9	15.8	0.05	--	85.7	34.9	52.6	23.8
		Ephydridae	0.1	--	0.1	94.2	--	--	--	--
		Other Diptera	0.02	--	--	--	0.5	0.03	--	0.05
	Hemiptera	Corixidae	54.3	50.3	99.9	5.8	4.0	48.5	14.2	33.8
		Notonectidae	--	--	--	--	--	0.5	--	0.02
		Aphididae	--	--	--	--	0.3	--	0.4	--
		Other Hemiptera	--	--	--	--	--	--	1.2	--
	Coleoptera	Dytiscidae	--	--	--	--	--	--	--	0.5
		Hydrophilidae	0.02	0.03	--	--	--	0.03	--	1.5
Clitellata	Haplotaxida	Naididae	--	--	--	--	--	--	5.5	--
		Tubificidae	--	--	--	--	6.2	--	18.2	--
		Other Oligocheata[1]	--	--	--	--	--	--	0.4	--
Malacostraca	Amphipoda	Corophiidae	--	--	--	--	--	--	--	--
		Gammaridae	--	--	--	--	--	--	--	--
Ostracoda	Podocopa	Cytherideidae	--	--	--	--	--	--	--	--
	Ostracoda	Other Ostracoda	21.5	13.7	--	--	--	15.9	5.9	1.1
ranchiopoda	Cladocera	Daphniidae	0.1	--	--	--	1.3	--	--	34.5
Maxillopoda	Copepoda	Other Copepoda	0.1	--	--	--	1.3	0.1	--	--
Nematoda[1]	Nematoda	Other Nematoda	--	--	--	--	--	--	--	0.1
Gastropoda	Basommatophora	Physidae	--	--	--	--	--	--	1.2	0.02
		Other Gastropoda	--	--	--	--	--	--	--	--

[1]Phylum.

Table 7. Percent relative abundance of zooplankton collected by taxonomic class and location, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[Reported results are averages for sample sizes greater than one. SHP, saline habitat ponds. 0, less than 1 percent]

		Fall 2006							
		SHP				Reference			
Class	Order	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	D-pond
Insecta	Hemiptera	0	5	6	15	0	0	0	0
Copepoda	Cyclopoida	59	42	57	55	0	32	0	10
	Calanoida	0	0	0	0	0	0	0	8
	Harpacticoida	2	17	32	13	0	39	0	2
	Nauplii	10	18	3	0	0	28	0	0
Oligochaeta		0	0	0	0	0	0	0	1
Ostracoda		0	0	2	8	94	1	100	66
Amphipoda		0	0	0	0	0	0	0	0
Branchiopoda	Cladocera	0	0	0	0	0	0	0	2
Monogononta	Ploima	27	17	1	5	6	1	0	11
Insecta[1]	larvae	0	0	0	3	0	0	0	0
Nematoda[1,2]		0	0	0	3	0	0	0	0

		Spring 2007							
		SHP				Reference			
Class	Order	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	D-pond
Insecta	Hemiptera	1	([3])	56	13	0	1	1	([4])
Copepoda	Cyclopoida	5	([3])	6	0	85	2	12	([4])
	Calanoida	71	([3])	0	0	0	7	3	([4])
	Harpacticoida	23	([3])	39	40	0	45	39	([4])
	Nauplii	0	([3])	0	0	0	1	0	([4])
Oligochaeta		0	([3])	0	0	6	0	1	([4])
Ostracoda		1	([3])	0	33	9	6	30	([4])
Amphipoda		0	([3])	0	0	0	0	0	([4])
Branchiopoda	Cladocera	0	([3])	0	0	0	0	8	([4])
Monogononta	Ploima	0	([3])	0	0	0	36	0	([4])
Insecta[1]	larvae	0	([3])	0	13	0	1	0	([4])
Nematoda[1,2]		0	([3])	0	0	0	1	6	([4])

Table 7. Percent relative abundance of zooplankton collected by taxonomic class and location, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[Reported results are averages for sample sizes greater than one. SHP, saline habitat ponds. 0, less than 1 percent]

		Fall 2007							
		SHP				Reference			
Class	Order	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	D-pond
Insecta	Hemiptera	0	1	0	0	0	0	0	0
Copepoda	Cyclopoida	6	64	46	0	0	8	42	52
	Calanoida	0	0	0	0	0	0	0	0
	Harpacticoida	7	31	52	50	0	43	1	0
	Nauplii	0	0	1	0	0	0	0	0
Oligochaeta		2	0	0	0	0	0	0	0
Ostracoda		82	5	1	0	0	49	53	37
Amphipoda		0	0	0	0	0	0	0	0
Branchiopoda	Cladocera	0	0	0	0	0	0	2	5
Monogononta	Ploima	0	0	0	0	0	0	2	6
Insecta[1]	larvae	2	0	0	50	0	0	0	0
Nematoda[1,2]		0	0	0	0	0	0	0	0

		Spring 2008							
		SHP				Reference			
Class	Order	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	D-pond
Insecta	Hemiptera	0	0	3	0	0	3	1	0
Copepoda	Cyclopoida	78	92	2	0	56	44	34	7
	Calanoida	0	0	0	0	0	0	0	0
	Harpacticoida	3	7	91	0	21	45	16	0
	Nauplii	0	0	0	0	0	0	0	0
Oligochaeta		0	0	0	0	0	0	3	1
Ostracoda		18	0	4	0	15	4	21	49
Amphipoda		0	0	0	0	0	0	0	0
Branchiopoda	Cladocera	0	0	0	0	0	0	9	42
Monogononta	Ploima	0	0	0	0	3	1	1	1
Insecta[1]	larvae	0	0	0	0	5	1	4	0
Nematoda[1,2]		0	0	0	100	0	2	9	0

Table 7. Percent relative abundance of zooplankton collected by taxonomic class and location, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[Reported results are averages for sample sizes greater than one. SHP, saline habitat ponds. 0, less than 1 percent]

		Fall 2008							
		SHP				Reference			
Class	Order	Pond 1	Pond 2	Pond 3	Pond 4	Alamo River	Salton Sea	Freshwater Marsh	Hazard
Insecta	Hemiptera	1	4	44	82	0	3	0	4
Copepoda	Cyclopoida	85	81	47	18	67	76	7	20
	Calanoida	0	0	0	0	0	2	4	0
	Harpacticoida	10	4	3	0	0	2	2	0
	Nauplii	1	0	0	0	0	0	0	0
Oligochaeta		0	0	0	0	0	0	0	0
Ostracoda		2	12	6	0	0	13	87	0
Amphipoda		0	0	0	0	0	0	0	0
Branchiopoda	Cladocera	0	0	0	0	0	0	0	76
Monogononta	Ploima	0	0	0	0	33	3	0	0
Insecta[1]	larvae	1	0	0	0	0	1	0	0
Nematoda[1,2]		0	0	0	0	0	0	0	0

[1]Benthic animals that may have been brought into the water column during sampling.

[2]Phylum.

[3]Sample lost in transit.

[4]Insufficient water in pond to sample.

Table 8. Arithmetic mean values for concentrations of trace elements (µg/L) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for fall 2006 Alamo River (n = 1), Freshwater Marsh (n = 2), and Salton Sea (n = 2). ND, all concentrations below limit of detection (LOD), which are provided in appendix 3. NQ, element not quantified]

Element	Group	Site	Sampling period: Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ag (Silver)	SHP	Pond 1	1.51	1.25	ND	ND	1.22
		Pond 2	2.81	1.29	ND	1.91	ND
		Pond 3	5.05	3.53	ND	4.82	ND
		Pond 4	12.34	ND	ND	17.81	ND
	Reference	Alamo River	0.79	ND	ND	ND	0.18
		Salton Sea	3.02	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	0.16
		D-pond[1]	0.92	ND	ND	0.16	ND
Al (Aluminum)	SHP	Pond 1	674	5,147	2,562	1,774	464
		Pond 2	373	4,538	1,187	1,597	245
		Pond 3	640	758	308	804	ND
		Pond 4	449	768	3,765	3,465	571
	Reference	Alamo River	4,720	4,246	6,614	4,549	4,580
		Salton Sea	254	2,038	1,715	2,146	1,485
		Freshwater Marsh	1,667	1,030	1,079	647	2,160
		D-pond	729	2,186	2,448	2,748	721
As (Arsenic)	SHP	Pond 1	ND	6.5	7.7	2.1	7.3
		Pond 2	ND	3.1	9.2	1.0	13.3
		Pond 3	ND	6.8	28.9	2.2	7.8
		Pond 4	229.7	6.6	153.0	13.4	12.9
	Reference	Alamo River	ND	6.1	7.0	5.7	5.7
		Salton Sea	57.4	3.4	55.8	3.0	3.0
		Freshwater Marsh	ND	9.7	3.9	3.9	4.9
		D-pond	5.1	2.5	4.8	1.7	6.4
B (Boron)	SHP	Pond 1	2617	10,170	2,237	5,152	8,563
		Pond 2	6,947	12,664	5,081	10,152	12,367
		Pond 3	15,534	53,457	18,338	34,139	24,800
		Pond 4	42,737	61,767	40,916	123,760	122,333
	Reference	Alamo River	543	548	626	551	680
		Salton Sea	9,337	6,708	9,492	3,336	2,890
		Freshwater Marsh	528	1,027	591	1,488	894
		D-pond	1,206	826	763	725	422
Ba (Barium)	SHP	Pond 1	74.9	217.2	150.7	114.9	89.8
		Pond 2	70.7	152.6	102.7	102.9	89.9
		Pond 3	90.4	46.8	71.3	52.5	104.7
		Pond 4	69.1	34.1	83.5	39.9	116.3
	Reference	Alamo River	161.5	150.0	176.3	136.7	130.3
		Salton Sea	100.0	124.0	127.3	115.4	101.3
		Freshwater Marsh	141.8	102.2	117.7	91.2	127.7
		D-pond	177.3	166.2	190.0	182.6	82.4

Table 8. Arithmetic mean values for concentrations of trace elements (µg/L) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Alamo River (n = 1), Freshwater Marsh (n = 2), and Salton Sea (n = 2). ND, all concentrations below limit of detection (LOD), which are provided in appendix 3. NQ, element not quantified]

			Sampling period				
Element	Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Be (Beryllium)	SHP	Pond 1	ND	3.3	1.4	4.3	4.9
		Pond 2	ND	3.7	3.5	8.8	10.1
		Pond 3	2.2	10.1	7.0	19.5	21.4
		Pond 4	6.7	18.1	45.4	71.5	86.8
	Reference	Alamo River	ND	0.8	1.0	1.1	1.1
		Salton Sea	1.5	2.8	12.6	2.7	2.0
		Freshwater Marsh	ND	0.7	0.6	0.8	1.0
		D-pond	ND	0.8	0.8	0.9	0.8
Cd (Cadmium)	SHP	Pond 1	1.0	0.5	0.3	1.7	ND
		Pond 2	2.3	0.6	1.4	1.3	2.3
		Pond 3	2.3	2.0	ND	3.6	3.3
		Pond 4	ND	ND	ND	ND	ND
	Reference	Alamo River	0.7	0.3	0.5	0.5	0.4
		Salton Sea	1.0	ND	3.3	ND	0.4
		Freshwater Marsh	0.5	0.3	0.2	0.3	0.3
		D-pond	0.2	ND	0.2	0.3	0.2
Co (Cobalt)	SHP	Pond 1	0.6	2.7	1.3	ND	ND
		Pond 2	0.9	ND	1.0	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	ND	ND	ND	ND
	Reference	Alamo River	2.6	1.8	3.0	2.5	2.1
		Salton Sea	ND	1.4	5.1	1.2	0.7
		Freshwater Marsh	1.1	0.7	0.6	0.6	0.9
		D-pond	0.7	0.6	1.4	1.4	0.5
Cr (Chromium)	SHP	Pond 1	0.6	2.6	3.6	4.6	2.5
		Pond 2	ND	1.4	5.7	7.1	3.9
		Pond 3	3.4	ND	6.8	14.4	6.9
		Pond 4	8.5	ND	48.5	58.3	30.4
	Reference	Alamo River	4.6	3.8	6.8	4.7	4.5
		Salton Sea	1.8	0.8	15.7	3.3	2.0
		Freshwater Marsh	1.5	0.5	1.7	1.2	2.4
		D-pond	0.7	1.6	2.8	2.9	0.8
Cu (Copper)	SHP	Pond 1	2.2	16.4	7.3	1.3	8.1
		Pond 2	ND	12.7	ND	ND	10.2
		Pond 3	ND	25.8	ND	ND	14.9
		Pond 4	ND	23.8	13.7	ND	ND
	Reference	Alamo River	8.2	8.5	10.8	13.6	8.4
		Salton Sea	ND	5.4	5.8	3.7	4.3
		Freshwater Marsh	0.5	0.9	0.3	3.8	4.3
		D-pond	ND	2.6	2.2	5.7	2.9

Table 8. Arithmetic mean values for concentrations of trace elements (µg/L) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Alamo River (n = 1), Freshwater Marsh (n = 2), and Salton Sea (n = 2). ND, all concentrations below limit of detection (LOD), which are provided in appendix 3. NQ, element not quantified]

Element	Group	Site	Sampling period: Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Fe (Iron)	SHP	Pond 1	752	8,653	3,425	1,665	788
		Pond 2	540	6,138	1,664	1,314	844
		Pond 3	957	3,353	242	521	1,492
		Pond 4	1,758	5,091	6,150	4,040	1,156
	Reference	Alamo River	5,121	5,227	6,952	4,630	4,467
		Salton Sea	331	2,499	1,741	2,242	1,327
		Freshwater Marsh	1,750	1,447	1,110	803	2,620
		D-pond	669	2,367	2,530	2,725	669
Hg (Mercury)	SHP	Pond 1	0.00	NQ	NQ	NQ	NQ
		Pond 2	0.00	NQ	NQ	NQ	NQ
		Pond 3	0.01	NQ	NQ	NQ	NQ
		Pond 4	0.02	NQ	NQ	NQ	NQ
	Reference	Alamo River	0.01	NQ	NQ	NQ	NQ
		Salton Sea	0.01	NQ	NQ	NQ	NQ
		Freshwater Marsh	0.00	NQ	NQ	NQ	NQ
		D-pond	0.00	NQ	NQ	NQ	NQ
Mn (Manganese)	SHP	Pond 1	77	714	245	115	295
		Pond 2	173	493	275	113	728
		Pond 3	189	473	76	9	591
		Pond 4	805	123	1,450	1,250	2,006
	Reference	Alamo River	205	226	233	217	178
		Salton Sea	42	179	141	116	122
		Freshwater Marsh	52	94	41	72	102
		D-pond	29	86	91	99	91
Mo (Molybdenum)	SHP	Pond 1	19.3	16.0	19.5	16.7	23.2
		Pond 2	24.6	33.4	22.1	27.7	16.5
		Pond 3	36.5	29.6	35.4	17.7	ND
		Pond 4	106.0	67.5	43.2	ND	ND
	Reference	Alamo River	14.8	14.0	16.2	12.7	14.5
		Salton Sea	15.6	29.8	27.2	17.7	21.8
		Freshwater Marsh	8.3	11.6	12.1	9.2	9.9
		D-pond	24.9	11.9	16.8	10.3	12.3
Ni (Nickel)	SHP	Pond 1	3.5	10.0	4.4	5.5	2.0
		Pond 2	7.6	7.8	4.2	7.1	3.3
		Pond 3	ND	15.0	6.8	10.2	ND
		Pond 4	ND	15.1	33.3	31.9	ND
	Reference	Alamo River	6.8	7.3	8.4	6.3	5.7
		Salton Sea	4.2	4.0	10.5	3.7	2.4
		Freshwater Marsh	4.1	2.9	2.7	2.4	3.3
		D-pond	2.6	4.4	4.0	4.1	1.6

Table 8. Arithmetic mean values for concentrations of trace elements (µg/L) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Alamo River (n = 1), Freshwater Marsh (n = 2), and Salton Sea (n = 2). ND, all concentrations below limit of detection (LOD), which are provided in appendix 3. NQ, element not quantified]

Element	Group	Site	Sampling period				
			Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Pb (Lead)	SHP	Pond 1	17.4	24.4	5.3	ND	19.4
		Pond 2	42.7	8.2	2.7	ND	43.0
		Pond 3	45.1	44.3	0.9	50.6	62.2
		Pond 4	198.4	60.4	6.5	ND	319.7
	Reference	Alamo River	10.3	7.1	6.0	4.4	5.1
		Salton Sea	54.3	ND	2.3	4.2	6.8
		Freshwater Marsh	6.8	ND	0.9	ND	4.4
		D-pond	7.9	2.9	2.4	2.8	3.0
Sb (Antimony)	SHP	Pond 1	ND	1.0	1.2	1.3	NQ
		Pond 2	ND	0.9	0.6	0.9	NQ
		Pond 3	40.4	1.2	1.5	1.2	NQ
		Pond 4	ND	1.3	2.8	2.9	NQ
	Reference	Alamo River	9.6	0.4	0.4	0.5	NQ
		Salton Sea	29.5	1.5	4.0	1.5	NQ
		Freshwater Marsh	ND	0.6	0.4	0.6	NQ
		D-pond	5.5	0.5	0.5	0.6	NQ
Se (Selenium)	SHP	Pond 1	3.9	1.9	2.0	3.0	2.6
		Pond 2	2.4	1.9	0.9	1.9	1.5
		Pond 3	2.7	2.7	1.2	1.6	1.7
		Pond 4	3.8	3.0	3.4	5.7	3.2
	Reference	Alamo River	7.0	5.2	5.9	5.4	5.9
		Salton Sea	2.1	3.1	1.9	3.2	2.0
		Freshwater Marsh	2.5	4.1	2.0	4.2	2.6
		D-pond	0.9	0.7	0.8	0.9	1.1
Sn (Tin)	SHP	Pond 1	ND	0.16	ND	NQ	NQ
		Pond 2	0.17	0.15	ND	NQ	NQ
		Pond 3	0.19	0.14	ND	NQ	NQ
		Pond 4	0.42	0.12	ND	NQ	NQ
	Reference	Alamo River	ND	ND	ND	NQ	NQ
		Salton Sea	0.12	0.04	ND	NQ	NQ
		Freshwater Marsh	0.08	0.05	ND	NQ	NQ
		D-pond	ND	ND	ND	NQ	NQ
Tl (Thallium)	SHP	Pond 1	ND	39.60	1.78	ND	ND
		Pond 2	ND	24.84	13.35	ND	ND
		Pond 3	ND	125.7	18.1	ND	ND
		Pond 4	ND	152.8	ND	ND	ND
	Reference	Alamo River	12.6	4.8	3.1	1.9	1.8
		Salton Sea	ND	20.1	44.8	5.3	ND
		Freshwater Marsh	ND	3.1	2.2	2.2	ND
		D-pond	ND	3.5	ND	2.1	ND

Table 8. Arithmetic mean values for concentrations of trace elements (µg/L) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Alamo River (n = 1), Freshwater Marsh (n = 2), and Salton Sea (n = 2). ND, all concentrations below limit of detection (LOD), which are provided in appendix 3. NQ, element not quantified]

			Sampling period				
Element	Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
V (Vanadium)	SHP	Pond 1	2.9	11.3	5.5	2.3	ND
		Pond 2	2.2	7.2	1.1	ND	ND
		Pond 3	2.2	ND	ND	ND	ND
		Pond 4	9.4	ND	ND	ND	ND
	Reference	Alamo River	16.1	14.2	17.8	14.5	13.7
		Salton Sea	2.3	9.9	9.5	6.5	3.0
		Freshwater Marsh	7.1	8.0	4.3	4.4	6.9
		D-pond	7.9	5.6	6.2	6.0	3.7
Zn (Zinc)	SHP	Pond 1	11.9	73.0	31.2	23.2	24.4
		Pond 2	14.1	81.1	17.4	30.7	43.7
		Pond 3	11.5	5.6	ND	52.1	63.5
		Pond 4	ND	20.2	164.7	137.5	85.2
	Reference	Alamo River	25.6	20.3	28.7	22.4	27.2
		Salton Sea	ND	4.6	57.6	19.8	19.5
		Freshwater Marsh	6.0	2.6	6.1	3.3	17.2
		D-pond	3.9	7.6	11.3	13.1	13.1

[1]D-pond was dry in fall 2008, Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

[2]A value of ½ the LOD was substituted when calculating averages for sites with partial analyte detection.

Table 9. Arithmetic mean values for concentrations of *p,p*' DDE (mg/L) in surface-water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for fall 2006 Freshwater Marsh (n = 2), Alamo River (n = 1), and Salton Sea (n = 2). Sampling period: Spring 2008 was not sampled. ND, all concentrations are below limit of detection (LOD), which are provided in appendix 4]

		Sampling period			
Group	Site	Fall 2006	Spring 2007	Fall 2007	Fall 2008
SHP	Pond 1	ND	ND	ND	0.00001
	Pond 2	ND	ND	ND	ND
	Pond 3	ND	ND	ND	ND
	Pond 4	ND	ND	ND	ND
Reference	Alamo River	ND	ND	ND	0.00002
	Salton Sea	ND	ND	ND	ND
	Freshwater Marsh	ND	ND	ND	0.00001
	D-pond[1]	ND	ND	ND	ND

[1]D-pond was dry in fall 2008, Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

Table 10. Arithmetic mean values for concentrations of trace elements (µg/g, dry weight) in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for spring 2006 Salton Sea (n = 2), Alamo River, Freshwater Marsh, and D-Pond (n = 1). Element definitions are given in table 8. ND, all concentrations below limit of detection (LOD), which are provided in appendix 5. NQ, element not quantified]

Element	Group	Site	Sampling period: Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ag	SHP	Pond 1	0.757	0.029	0.084	0.291	0.144	0.197
		Pond 2	0.965	0.109	0.091	0.331	0.086	0.406
		Pond 3	0.683	ND	ND	0.141	ND	0.079
		Pond 4	0.668	ND	ND	0.143	ND	0.015
	Reference	Alamo River	0.747	ND	ND	0.104	ND	ND
		Salton Sea	0.740	ND	ND	0.104	ND	0.052
		Freshwater Marsh	0.687	ND	ND	0.150	ND	0.048
		D-pond[1]	0.428	ND	ND	0.089	ND	ND
Al	SHP	Pond 1	41,208	56,307	48,877	52,133	46,780	50,084
		Pond 2	33,126	37,575	41,277	38,561	40,616	46,703
		Pond 3	41,342	50,419	46,398	38,016	38,823	35,507
		Pond 4	39,915	51,888	46,987	38,639	35,991	34,220
	Reference	Alamo River	44,043	51,022	50,590	49,795	43,119	49,036
		Salton Sea	44,148	39,440	45,308	40,279	47,419	53,922
		Freshwater Marsh	50,363	48,642	48,095	51,102	50,056	54,068
		D-pond	34,268	53,994	48,242	49,209	49,123	69,172
As	SHP	Pond 1	4.55	6.25	10.84	7.71	11.64	12.84
		Pond 2	7.55	7.22	10.65	7.53	10.08	14.07
		Pond 3	3.82	3.78	6.95	2.17	5.48	4.92
		Pond 4	3.19	2.81	5.86	3.63	5.03	5.43
	Reference	Alamo River	2.36	3.24	3.94	4.83	3.05	5.39
		Salton Sea	4.02	2.81	5.43	3.49	4.06	6.37
		Freshwater Marsh	10.44	4.69	8.18	6.41	8.08	13.50
		D-pond	ND	3.99	4.89	5.82	4.75	8.37
B	SHP	Pond 1	128	61.2	63.6	42.3	53.0	51.4
		Pond 2	133	65.9	77.9	56.3	79.5	86.0
		Pond 3	130	64.0	87.1	75.5	113.5	110.3
		Pond 4	120	95.6	117.92	125	181	196
	Reference	Alamo River	30.8	13.2	19.4	14.3	22.1	15.1
		Salton Sea	86.5	72.6	68.9	34.7	54.0	35.3
		Freshwater Marsh	53.2	20.8	29.5	21.9	28.3	30.7
		D-pond	21.3	19.0	20.1	16.2	17.9	24.9
Ba	SHP	Pond 1	535	692	696	711	763	816
		Pond 2	536	599	647	527	599	685
		Pond 3	338	398	385	311	321	283
		Pond 4	346	437	382	311	295	264
	Reference	Alamo River	525	529	542	530	540	539
		Salton Sea	421	334	439	419	453	486
		Freshwater Marsh	447	458	482	481	489	465
		D-pond	499	512	645	547	549	519

Table 10. Arithmetic mean values for concentrations of trace elements (µg/g, dry weight) in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for spring 2006 Salton Sea (n = 2), Alamo River, Freshwater Marsh, and D-Pond (n = 1). Element definitions are given in table 8. ND, all concentrations below limit of detection (LOD), which are provided in appendix 5. NQ, element not quantified]

Element	Group	Site	Sampling period: Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Be	SHP	Pond 1	1.28	1.60	1.12	1.46	1.36	1.33
		Pond 2	1.07	1.27	1.01	1.16	1.26	1.36
		Pond 3	1.24	1.50	1.02	1.11	1.16	0.99
		Pond 4	1.20	1.53	1.07	1.11	1.08	0.95
	Reference	Alamo River	1.17	1.32	0.83	1.32	1.08	1.19
		Salton Sea	1.26	1.22	0.95	1.11	1.27	1.32
		Freshwater Marsh	1.49	1.39	0.904	1.45	1.36	1.40
		D-pond	0.809	1.49	0.812	1.30	1.27	1.73
Cd	SHP	Pond 1	0.34	0.38	0.41	0.75	0.63	0.49
		Pond 2	0.29	0.55	0.37	0.78	0.66	0.71
		Pond 3	0.39	0.36	0.21	0.32	0.30	0.26
		Pond 4	0.36	0.31	0.25	0.31	0.24	0.25
	Reference	Alamo River	0.29	0.30	0.32	0.37	0.29	0.34
		Salton Sea	0.29	0.31	0.20	0.31	0.36	0.39
		Freshwater Marsh	0.44	0.29	0.21	0.43	0.39	0.44
		D-pond	0.06	0.26	0.17	0.29	0.26	0.38
Co	SHP	Pond 1	6.11	6.45	7.07	6.62	5.70	5.60
		Pond 2	4.62	4.68	5.52	4.88	4.78	5.21
		Pond 3	6.57	6.67	6.99	5.04	4.91	4.62
		Pond 4	6.32	6.87	7.16	5.33	4.58	4.36
	Reference	Alamo River	6.40	5.96	6.76	6.41	4.81	5.61
		Salton Sea	6.73	5.33	6.40	4.92	5.38	6.39
		Freshwater Marsh	7.85	6.18	6.52	6.84	5.92	6.77
		D-pond	3.70	6.86	6.31	6.03	5.75	8.52
Cr	SHP	Pond 1	30.1	38.4	35.9	37.3	32.0	30.7
		Pond 2	22.4	24.8	29.7	26.1	27.1	29.6
		Pond 3	32.8	37.5	36.8	29.6	29.6	25.4
		Pond 4	31.4	37.8	36.3	28.9	27.2	23.8
	Reference	Alamo River	32.2	34.9	37.3	35.1	28.3	30.2
		Salton Sea	34.0	29.5	34.8	25.3	32.9	36.1
		Freshwater Marsh	39.4	33.1	36.5	37.7	35.6	36.9
		D-pond	20.7	38.4	33.4	35.4	33.7	47.0
Cu	SHP	Pond 1	18.4	20.3	22.8	22.4	19.4	17.5
		Pond 2	18.3	19.8	23.4	18.1	22.6	22.8
		Pond 3	22.0	24.9	25.3	19.6	19.7	17.3
		Pond 4	21.4	24.8	23.6	18.0	17.4	16.3
	Reference	Alamo River	19.2	17.7	19.6	18.9	13.7	15.1
		Salton Sea	19.6	16.3	20.8	13.2	18.3	19.7
		Freshwater Marsh	25.4	19.4	20.5	22.8	22.4	24.3
		D-pond	9.1	19.4	16.7	17.6	15.9	23.3

Table 10. Arithmetic mean values for concentrations of trace elements (µg/g, dry weight) in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for spring 2006 Salton Sea (n = 2), Alamo River, Freshwater Marsh, and D-Pond (n = 1). Element definitions are given in table 8. ND, all concentrations below limit of detection (LOD), which are provided in appendix 5. NQ, element not quantified]

			Sampling period					
Element	Group	Site	Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Fe	SHP	Pond 1	21,589	26,883	25,022	25,405	24,062	23,668
		Pond 2	19,220	21,630	25,103	21,878	24,316	25,323
		Pond 3	20,757	24,697	23,142	18,767	19,751	17,058
		Pond 4	18,987	25,648	22,716	17,724	17,719	15,868
	Reference	Alamo River	17,055	19,823	20,249	18,322	16,060	18,060
		Salton Sea	19,636	17,180	20,271	14,431	20,315	22,275
		Freshwater Marsh	24,340	21,622	21,355	22,135	22,538	24,862
		D-pond	10,716	22,012	19,005	18,503	19,340	28,613
Hg	SHP	Pond 1	0.03	NQ	NQ	NQ	NQ	NQ
		Pond 2	0.02	NQ	NQ	NQ	NQ	NQ
		Pond 3	0.04	NQ	NQ	NQ	NQ	NQ
		Pond 4	0.06	NQ	NQ	NQ	NQ	NQ
	Reference	Alamo River	0.02	NQ	NQ	NQ	NQ	NQ
		Salton Sea	0.04	NQ	NQ	NQ	NQ	NQ
		Freshwater Marsh	0.04	NQ	NQ	NQ	NQ	NQ
		D-pond	0.01	NQ	NQ	NQ	NQ	NQ
Mn	SHP	Pond 1	809	986	1,119	850	1,079	870
		Pond 2	695	843	1,066	870	1,127	1,065
		Pond 3	419	589	516	478	506	492
		Pond 4	397	617	474	378	382	357
	Reference	Alamo River	396	458	493	459	396	423
		Salton Sea	408	379	472	370	485	462
		Freshwater Marsh	457	428	436	439	444	514
		D-pond	242	502	439	442	443	510
Mo	SHP	Pond 1	1.90	1.11	1.24	1.92	1.09	1.02
		Pond 2	1.48	0.86	0.82	1.04	0.96	0.62
		Pond 3	1.43	1.54	3.10	2.56	1.46	1.73
		Pond 4	1.87	1.66	2.96	2.21	1.23	1.00
	Reference	Alamo River	0.71	0.43	0.40	0.77	0.33	0.26
		Salton Sea	1.73	1.16	1.76	1.81	1.40	0.73
		Freshwater Marsh	0.913	0.807	0.602	1.03	0.380	0.204
		D-pond	0.468	0.428	0.498	0.680	0.421	0.023
Ni	SHP	Pond 1	12.0	15.9	14.7	16.0	13.8	14.4
		Pond 2	8.8	10.3	11.4	11.1	11.9	13.7
		Pond 3	13.1	16.3	15.0	12.9	13.2	11.8
		Pond 4	12.7	16.2	15.2	12.5	12.0	10.9
	Reference	Alamo River	11.6	12.9	14.1	13.3	10.9	12.9
		Salton Sea	13.2	11.5	13.4	10.2	13.9	15.4
		Freshwater Marsh	15.8	13.5	13.7	15.7	15.0	17.2
		D-pond	6.3	15.7	12.2	14.2	14.1	22.0

Table 10. Arithmetic mean values for concentrations of trace elements (µg/g, dry weight) in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for spring 2006 Salton Sea (n = 2), Alamo River, Freshwater Marsh, and D-Pond (n = 1). Element definitions are given in table 8. ND, all concentrations below limit of detection (LOD), which are provided in appendix 5. NQ, element not quantified]

			Sampling period					
Element	Group	Site	Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Pb	SHP	Pond 1	28.4	33.5	34.8	34.5	38.0	39.2
		Pond 2	37.2	44.9	48.9	33.9	41.9	49.1
		Pond 3	15.0	15.2	14.7	8.9	12.4	10.0
		Pond 4	14.4	15.1	14.7	9.3	11.5	9.4
	Reference	Alamo River	14.8	11.4	13.3	11.6	13.5	12.5
		Salton Sea	17.6	8.9	14.4	8.5	16.4	17.3
		Freshwater Marsh	17.2	12.1	14.1	11.3	13.7	16.1
		D-pond	13.5	15.1	14.8	12.5	16.1	23.5
Sb	SHP	Pond 1	ND	1.51	0.464	1.88	NQ	NQ
		Pond 2	1.09	2.29	0.645	1.74	NQ	NQ
		Pond 3	ND	0.819	ND	0.615	NQ	NQ
		Pond 4	ND	0.873	ND	0.601	NQ	NQ
	Reference	Alamo River	ND	0.693	ND	0.634	NQ	NQ
		Salton Sea	ND	0.673	ND	0.697	NQ	NQ
		Freshwater Marsh	ND	0.720	ND	0.753	NQ	NQ
		D-pond	ND	0.750	ND	0.707	NQ	NQ
Se[2]	SHP	Pond 1	1.03	1.38	2.15	2.32	2.22	1.68
		Pond 2	0.94	1.25	1.37	1.31	1.61	1.48
		Pond 3	1.83	2.99	3.00	2.06	2.12	1.73
		Pond 4	1.67	2.44	2.35	1.97	1.92	1.37
	Reference	Alamo River	0.614	0.523	0.640	0.597	0.540	0.476
		Salton Sea	1.42	1.66	2.31	1.45	2.42	1.67
		Freshwater Marsh	1.73	2.03	2.27	1.97	2.67	2.16
		D-pond	0.61	0.61	0.43	0.47	0.59	0.38
Sn	SHP	Pond 1	1.12	1.68	0.94	1.66	ND	ND
		Pond 2	0.81	1.13	0.71	1.11	ND	ND
		Pond 3	1.30	1.69	1.12	1.33	ND	ND
		Pond 4	1.25	1.76	1.07	1.30	ND	ND
	Reference	Alamo River	1.07	1.41	0.85	1.41	ND	ND
		Salton Sea	1.22	1.28	0.90	1.20	ND	ND
		Freshwater Marsh	1.54	1.56	0.94	1.63	ND	ND
		D-pond	0.60	1.57	0.77	1.39	ND	ND
Tl	SHP	Pond 1	1.13	1.22	1.76	1.79	ND	ND
		Pond 2	1.44	2.58	2.34	2.62	ND	ND
		Pond 3	ND	0.592	0.595	0.464	ND	ND
		Pond 4	0.327	0.563	0.555	0.448	ND	ND
	Reference	Alamo River	1.24	0.512	0.556	0.485	ND	ND
		Salton Sea	0.61	0.473	0.577	0.459	ND	ND
		Freshwater Marsh	ND	0.525	0.539	0.542	ND	ND
		D-pond	ND	0.547	0.534	0.498	ND	ND

Table 10. Arithmetic mean values for concentrations of trace elements (µg/g, dry weight) in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for spring 2006 Salton Sea (n = 2), Alamo River, Freshwater Marsh, and D-Pond (n = 1). Element definitions are given in table 8. ND, all concentrations below limit of detection (LOD), which are provided in appendix 5. NQ, element not quantified]

Element	Group	Site	Sampling period: Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
V	SHP	Pond 1	58.2	73.3	67.6	71.5	62.5	61.0
		Pond 2	44.6	48.9	55.4	51.1	54.9	58.6
		Pond 3	60.9	71.9	67.3	55.2	55.5	47.9
		Pond 4	58.0	71.7	67.5	55.4	53.5	45.8
	Reference	Alamo River	51.0	56.7	59.3	58.3	47.6	52.3
		Salton Sea	60.7	51.4	64.0	45.5	62.5	66.4
		Freshwater Marsh	70.6	60.4	60.6	68.4	66.1	69.0
		D-pond	31.5	66.3	55.6	58.8	58.1	89.4
Zn	SHP	Pond 1	146	212	234	201	246	226
		Pond 2	277	423	431	363	347	419
		Pond 3	64.3	89.3	70.5	61.6	65.7	54.3
		Pond 4	61.0	87.3	68.3	57.2	53.4	51.8
	Reference	Alamo River	52.5	60.4	61.9	60.1	48.4	57.2
		Salton Sea	60.9	55.1	64.2	53.7	69.2	73.2
		Freshwater Marsh	72.5	61.3	63.7	70.5	66.6	73.5
		D-pond	29.9	66.0	56.3	59.1	56.8	86.1

[1] D-pond was dry in fall 2008, Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

[2]Spring 2006 values are conservative estimates using the upper 95% confidence limits from the corrective equation derived from the regression of Se determined from ICP-OES against Se determined from HGAA-FIAS (adjusted Se = exp -0.51+ $0.66^{\text{Se ICP-OES}}$); r^2 = 0.68)

Table 11. Arithmetic mean values for concentrations of DDT compounds (µg/g, dry weight) in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for spring 2006 Alamo River (n = 1), Freshwater Marsh (n = 2), and Salton Sea (n = 2). Sampling period: Fall 2006 was not sampled. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 6]

			Sampling period				
Compound	Group	Site	Spring 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
p,p' DDD	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	ND	ND	ND	ND
	Reference	Alamo River	ND	ND	ND	ND	ND
		Salton Sea	ND	ND	ND	ND	0.002
		Freshwater Marsh	ND	ND	ND	ND	0.001
		D-pond[1]	ND	ND	ND	ND	ND
p,p' DDE	SHP	Pond 1	0.008	0.008	0.024	0.012	0.012
		Pond 2	0.005	0.007	0.011	0.009	0.009
		Pond 3	0.021	0.048	0.041	0.026	0.030
		Pond 4	0.016	0.009	0.013	0.007	0.004
	Reference	Alamo River	0.047	0.054	0.041	0.056	0.045
		Salton Sea	0.022	0.031	0.028	0.015	0.041
		Freshwater Marsh	0.060	0.062	0.098	0.090	0.095
		D-pond	0.002	0.006	0.004	0.005	0.004
p,p' DDT	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	ND	ND	ND	ND
	Reference	Alamo River	ND	ND	ND	ND	0.002
		Salton Sea	ND	ND	ND	ND	0.002
		Freshwater Marsh	ND	ND	ND	ND	0.003
		D-pond	ND	ND	ND	ND	ND
o,p' DDD	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	ND	ND	ND	ND
	Reference	Alamo River	ND	ND	ND	ND	ND
		Salton Sea	ND	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond	ND	ND	ND	ND	ND
o,p' DDE	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	0.001
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	ND	ND	ND	ND
	Reference	Alamo River	ND	ND	ND	ND	0.002
		Salton Sea	ND	ND	ND	ND	0.004
		Freshwater Marsh	ND	ND	ND	0.006	0.005
		D-pond	ND	ND	ND	ND	ND

Table 11. Arithmetic mean values for concentrations of DDT compounds (µg/g, dry weight) in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for spring 2006 Alamo River (n = 1), Freshwater Marsh (n = 2), and Salton Sea (n = 2). Sampling period: Fall 2006 was not sampled. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 6]

			Sampling period				
Compound	Group	Site	Spring 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
o,p' DDT	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	ND	ND	ND	ND
	Reference	Alamo River	ND	ND	ND	ND	ND
		Salton Sea	ND	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond	ND	ND	ND	ND	ND

[1]D-pond was dry in fall 2008, Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

Table 12. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in invertebrate samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for fall 2006 Salton Sea (n = 2). Element definitions are given in table 8. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 7. NQ, element not quantified]

			Sampling period				
Element	Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ag	SHP	Pond 1	0.427	0.180	0.290	0.356	0.226
		Pond 2	0.574	0.245	0.222	0.415	0.269
		Pond 3	0.457	0.451	0.329	0.708	0.593
		Pond 4[1]	2.15	*0.597*	*0.479*	*0.287*	*0.097*
	Reference	Salton Sea	0.113	0.098	0.129	0.075	0.190
		Freshwater Marsh	0.099	0.087	0.117	0.125	0.184
		D-pond[2]	0.073	0.075	0.128	0.107	0.330
Al	SHP	Pond 1	412	535	820	668	381
		Pond 2	570	1,243	1,458	325	438
		Pond 3	385	1,152	580	134	60
		Pond 4	615	*590*	*901*	*1,380*	*321*
	Reference	Salton Sea	51.4	899	85	323	783
		Freshwater Marsh	192	707	2,654	296	252
		D-pond	605	441	341	347	3,701
As	SHP	Pond 1	ND	ND	1.18	ND	2.54
		Pond 2	ND	ND	1.35	ND	2.23
		Pond 3	ND	ND	1.11	ND	4.23
		Pond 4	ND	*ND*	*0.856*	*ND*	*16.0*
	Reference	Salton Sea	ND	ND	0.893	ND	1.34
		Freshwater Marsh	ND	ND	1.60	ND	ND
		D-pond	ND	ND	0.394	ND	3.03
B	SHP	Pond 1	6.12	22.2	5.91	4.13	19.2
		Pond 2	18.3	32.9	13.6	17.9	27.1
		Pond 3	29.0	98.0	42.1	43.8	62.8
		Pond 4	77.0	*72.5*	*68.5*	*245*	*213*
	Reference	Salton Sea	8.96	18.5	14.5	3.35	5.85
		Freshwater Marsh	2.80	3.40	4.94	2.92	2.07
		D-pond	5.12	1.98	1.65	0.37	5.09
Ba	SHP	Pond 1	5.71	7.41	9.84	12.7	8.29
		Pond 2	6.12	12.1	14.9	5.35	11.1
		Pond 3	4.08	10.0	9.60	2.1	6.32
		Pond 4	7.22	*7.88*	*60.3*	*19.0*	*118*
	Reference	Salton Sea	1.45	8.40	5.02	5.86	10.4
		Freshwater Marsh	46.6	16.2	35.1	8.25	11.6
		D-pond	16.8	6.60	7.80	4.50	32.5
Be	SHP	Pond 1	0.022	0.037	0.071	0.008	0.025
		Pond 2	0.026	0.059	0.105	0.007	0.034
		Pond 3	0.021	0.060	0.065	0.004	0.026
		Pond 4	0.036	*0.046*	*0.106*	*0.101*	*0.038*
	Reference	Salton Sea	0.004	0.050	0.036	0.004	0.044
		Freshwater Marsh	0.009	0.037	0.143	ND	0.021
		D-pond	0.029	0.029	0.043	ND	0.147

Table 12. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in invertebrate samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Salton Sea (n = 2). Element definitions are given in table 8. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 7. NQ, element not quantified]

			Sampling period				
Element	Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Cd	SHP	Pond 1	0.147	0.118	0.179	0.107	0.091
		Pond 2	0.131	0.130	0.074	0.126	0.052
		Pond 3	0.386	0.551	0.220	0.227	0.380
		Pond 4	0.721	*0.551*	*0.260*	*0.373*	*0.116*
	Reference	Salton Sea	0.106	0.168	0.187	0.125	0.209
		Freshwater Marsh	0.116	0.155	0.195	0.201	0.244
		D-pond	0.083	0.101	0.109	0.116	0.977
Co	SHP	Pond 1	0.778	0.308	0.268	0.271	0.416
		Pond 2	0.471	0.433	0.402	0.217	0.291
		Pond 3	0.455	0.462	0.298	0.178	0.315
		Pond 4	1.666	*0.527*	*0.193*	*0.535*	*0.114*
	Reference	Salton Sea	0.196	0.386	0.259	0.286	0.340
		Freshwater Marsh	0.270	0.408	0.692	0.215	0.191
		D-pond	0.551	0.486	0.346	0.307	1.022
Cr	SHP	Pond 1	0.759	0.784	0.906	0.964	0.507
		Pond 2	0.824	1.34	1.36	0.469	0.495
		Pond 3	0.644	1.23	0.727	0.384	0.166
		Pond 4	0.914	*1.27*	*1.25*	*1.13*	*ND*
	Reference	Salton Sea	0.357	1.10	0.306	0.501	1.08
		Freshwater Marsh	0.459	1.03	2.63	0.522	0.379
		D-pond	0.925	0.603	0.549	0.509	3.15
Cu	SHP	Pond 1	43.93	21.57	23.10	52.33	13.63
		Pond 2	35.90	36.63	13.43	43.69	12.97
		Pond 3	31.17	33.06	26.03	53.49	40.73
		Pond 4	31.40	*9.23*	*9.21*	*11.35*	*9.78*
	Reference	Salton Sea	15.04	14.07	13.90	11.75	18.93
		Freshwater Marsh	11.10	13.09	15.17	23.00	18.60
		D-pond	8.15	11.13	17.97	13.78	29.20
Fe	SHP	Pond 1	468	518	698	731	506
		Pond 2	674	936	1,390	414	665
		Pond 3	463	968	513	246	202
		Pond 4	777	*1,936*	*846*	*1,499*	*286*
	Reference	Salton Sea	129	636	184	333	604
		Freshwater Marsh	238	573	1,938	371	262
		D-pond	482	357	311	314	2,102
Mn	SHP	Pond 1	31.0	46.0	71.5	42.2	37.3
		Pond 2	112	74.9	120	40.9	155
		Pond 3	65.5	85.4	51.0	17.0	444
		Pond 4	127	*1,246*	*2,101*	*1,986*	*2,603*
	Reference	Salton Sea	9.03	25.1	30.84	16.5	25.3
		Freshwater Marsh	11.2	19.2	46.3	14.0	10.9
		D-pond	17.4	18.2	18.7	16.6	76.5

Table 12. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in invertebrate samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Salton Sea (n = 2). Element definitions are given in table 8. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 7. NQ, element not quantified]

Element	Group	Site	Sampling period				
			Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Mo	SHP	Pond 1	0.756	0.663	0.735	0.710	0.799
		Pond 2	0.884	0.802	0.653	0.695	0.626
		Pond 3	0.642	0.755	0.615	0.502	0.564
		Pond 4	0.862	*0.506*	*ND*	*0.266*	*ND*
	Reference	Salton Sea	0.603	0.657	0.504	0.677	0.981
		Freshwater Marsh	0.760	0.737	0.763	0.825	0.739
		D-pond	0.687	0.716	0.825	0.605	0.908
Ni	SHP	Pond 1	0.574	0.416	0.782	0.691	0.472
		Pond 2	1.064	0.698	0.846	0.351	0.586
		Pond 3	0.567	0.817	0.575	0.278	0.451
		Pond 4	0.610	*0.382*	*0.586*	*0.940*	*0.254*
	Reference	Salton Sea	0.261	0.578	0.310	0.350	0.924
		Freshwater Marsh	0.369	0.592	1.630	0.347	0.351
		D-pond	0.613	0.397	0.292	0.298	1.99
Pb	SHP	Pond 1	1.62	1.11	0.916	1.95	0.947
		Pond 2	1.42	1.36	1.24	0.869	0.900
		Pond 3	0.648	0.938	0.410	0.273	0.327
		Pond 4	1.41	*1.46*	*0.664*	*3.78*	*0.738*
	Reference	Salton Sea	0.222	0.731	0.454	2.45	0.342
		Freshwater Marsh	0.320	0.730	1.09	0.321	0.231
		D-pond	0.473	0.729	0.273	0.86	2.28
Sb	SHP	Pond 1	0.193	ND	ND	ND	ND
		Pond 2	0.321	0.119	ND	ND	ND
		Pond 3	0.116	ND	ND	ND	ND
		Pond 4	0.114	*ND*	*ND*	*0.11*	*ND*
	Reference	Salton Sea	ND	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond	ND	0.135	ND	ND	ND
Se	SHP	Pond 1	6.69	5.10	2.28	7.36	4.59
		Pond 2	8.50	5.32	2.22	5.63	4.09
		Pond 3	6.76	4.58	5.34	4.61	2.77
		Pond 4	3.51	*2.56*	*2.30*	*2.16*	*2.84*
	Reference	Salton Sea	2.51	2.37	3.03	3.64	2.97
		Freshwater Marsh	2.05	2.60	2.74	2.83	2.30
		D-pond	1.42	0.916	1.98	1.37	2.31
Sn	SHP	Pond 1	0.421	0.533	0.236	NQ	NQ
		Pond 2	0.829	0.287	0.181	NQ	NQ
		Pond 3	0.245	0.590	0.272	NQ	NQ
		Pond 4	0.400	*0.116*	*0.295*	*NQ*	*NQ*
	Reference	Salton Sea	0.492	0.178	0.349	NQ	NQ
		Freshwater Marsh	0.209	0.297	0.634	NQ	NQ
		D-pond	0.770	0.231	0.195	NQ	NQ

Table 12. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in invertebrate samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Salton Sea (n = 2). Element definitions are given in table 8. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 7. NQ, element not quantified]

			Sampling period				
Element	Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Tl	SHP	Pond 1	ND	ND	0.025	ND	ND
		Pond 2	ND	ND	0.131	ND	ND
		Pond 3	ND	ND	0.009	ND	ND
		Pond 4	ND	*ND*	*0.019*	*ND*	*ND*
	Reference	Salton Sea	ND	0.203	0.017	ND	ND
		Freshwater Marsh	ND	ND	0.043	ND	ND
		D-pond	ND	0.154	0.007	ND	ND
V	SHP	Pond 1	0.855	0.958	1.47	1.31	0.816
		Pond 2	1.16	2.03	2.83	0.608	0.759
		Pond 3	0.77	1.98	1.03	0.191	ND
		Pond 4	1.54	*1.86*	*1.38*	*3.30*	*0.201*
	Reference	Salton Sea	0.082	1.50	0.224	0.625	1.44
		Freshwater Marsh	0.372	1.53	5.28	0.756	0.50
		D-pond	1.17	0.755	0.62	0.595	7.10
Zn	SHP	Pond 1	401	152	207	204	192
		Pond 2	345	315	167	312	186
		Pond 3	227	141	186	233	204
		Pond 4	302	*46.0*	*44.8*	*59.9*	*33.5*
	Reference	Salton Sea	118	127	181	184	132
		Freshwater Marsh	114	163	173	195	150
		D-pond	70	127	162	130	119
% dry weight	SHP	Pond 1	17.9	19.9	12.9	17.7	18.6
		Pond 2	14.4	20.8	13.1	19.3	16.3
		Pond 3	18.2	18.7	12.1	23.3	16.0
		Pond 4	17.0	*14.6*	*19.2*	*18.9*	*29.2*
	Reference	Salton Sea	24.7	16.3	19.9	16.1	16.9
		Freshwater Marsh	17.0	13.2	11.9	19.1	20.0
		D-pond	32.8	14.8	15.4	17.2	19.7

[1]Ephydra sp. (brine fly larvae) from Pond 4 after fall 2006 (highlighted by italics), Corixidae (water boatmen) from all other sites and sampling periods.

[2]D-pond was dry in fall 2008, Salton Sea National Wildlife Refuge Hazard Pond sampled in its place. No invertebrates were available from Alamo River sites throughout the study.

Table 13. Arithmetic mean concentrations of DDT compounds (µg/g, wet weight) in invertebrate samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[n = 3 for all sites and sampling periods, except for fall 2006 Salton Sea (n = 2). No invertebrates were available from Alamo River sites throughout the study. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 8. %, percent]

Compound	Group	Site	Sampling period: Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
p,p' DDD	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4[1]	ND	*ND*	*ND*	*ND*	*ND*
	Reference	Salton Sea	ND	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond[2]	ND	ND	ND	ND	ND
p,p' DDE	SHP	Pond 1	0.010	0.015	0.009	0.051	0.010
		Pond 2	0.008	0.018	0.013	0.083	0.007
		Pond 3	0.012	0.008	0.008	0.081	ND
		Pond 4	0.005	*0.016*	*0.012*	*0.034*	*ND*
	Reference	Salton Sea	0.013	0.013	0.010	0.044	0.019
		Freshwater Marsh	0.033	0.043	0.030	0.150	0.026
		D-pond	0.012	0.007	0.002	0.004	0.021
p,p' DDT	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	*ND*	*ND*	*ND*	*ND*
	Reference	Salton Sea	ND	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond	ND	ND	ND	ND	ND
o,p' DDD	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	*ND*	*ND*	*ND*	*ND*
	Reference	Salton Sea	ND	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond	ND	ND	ND	ND	ND
o,p' DDE	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	*ND*	*ND*	*ND*	*ND*
	Reference	Salton Sea	ND	ND	0.001	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond	ND	ND	ND	ND	ND

Table 13. Arithmetic mean concentrations of DDT compounds (µg/g, wet weight) in invertebrate samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.—Continued

[n = 3 for all sites and sampling periods, except for fall 2006 Salton Sea (n = 2). No invertebrates were available from Alamo River sites throughout the study. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 8. %, percent]

Compound	Group	Site	Sampling period: Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
o,p' DDT	SHP	Pond 1	ND	ND	ND	ND	ND
		Pond 2	ND	ND	ND	ND	ND
		Pond 3	ND	ND	ND	ND	ND
		Pond 4	ND	*ND*	*ND*	*ND*	*ND*
	Reference	Salton Sea	ND	ND	ND	ND	ND
		Freshwater Marsh	ND	ND	ND	ND	ND
		D-pond	ND	ND	ND	ND	ND
% Lipid	SHP	Pond 1	0.33	0.88	0.68	1.41	0.52
		Pond 2	0.30	0.62	1.04	1.95	0.36
		Pond 3	0.38	0.46	0.75	1.74	0.35
		Pond 4	0.42	*1.17*	*1.41*	*2.73*	*0.50*
	Reference	Salton Sea	1.13	0.68	0.99	1.28	0.51
		Freshwater Marsh	0.80	0.91	0.96	1.92	0.74
		D-pond	0.92	0.67	0.69	1.53	1.56
% Moisture	SHP	Pond 1	82.8	80.5	89.5	93.2	88.4
		Pond 2	83.5	78.5	86.0	88.4	94.5
		Pond 3	81.5	82.4	88.3	84.3	88.9
		Pond 4	82.1	*89.7*	*82.0*	*86.9*	*82.1*
	Reference	Salton Sea	77.5	86.5	80.5	91.5	87.2
		Freshwater Marsh	84.7	85.0	87.0	87.9	85.1
		D-pond	82.0	87.3	84.4	88.3	87.4

[1]Ephydra sp. (brine fly larvae) from Pond 4 after fall 2006 (highlighted by italics), Corixidae (water boatmen) from all other sites and sampling periods.

[2]D-pond was dry in fall 2008, Salton Sea National Wildlife Refuge Hazard Pond sampled in its place.

Table 14. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.

[Sample sizes for 2006: Pond 1 (n = 3), Pond 2 (n = 7), Freshwater Marsh (n = 6), D-Pond (n = 4). Sample sizes for 2007: Pond 1 (n = 6), Pond 2 (n = 9), Pond 3 (n= 8), Pond 4 (n = 9), Morton Bay (n = 7) Freshwater Marsh (n = 6), D-Pond (n = 1). Sample sizes for 2008: Pond 1 (n = 7), Pond 2 (n = 7), Pond 3 (n = 8), Pond 4 (n = 8), Freshwater Marsh (n = 10), Hazard (n = 10). Element definitions are given in table 8; ND, all concentrations were below limit of detection (LOD), which are provided in appendix 9. NQ, element not quantified. --, sites with no eggs collected]

			Sampling period		
Element	Group	Site	2006	2007	2008
Ag	SHP	Pond 1	0.044	0.042	ND
		Pond 2	0.027	0.043	ND
		Pond 3	--	0.035	0.025
		Pond 4	--	0.051	ND
	Reference	Morton Bay	--	0.024	--
		Freshwater Marsh	0.052	0.037	0.030
		D-Pond/Hazard	0.030	0.048	ND
Al	SHP	Pond 1	1.43	0.608	ND
		Pond 2	0.882	0.478	ND
		Pond 3	--	0.704	0.231
		Pond 4	--	0.835	0.230
	Reference	Morton Bay	--	1.93	--
		Freshwater Marsh	0.722	0.489	0.259
		D-Pond/Hazard	0.715	ND	0.235
As	SHP	Pond 1	1.52	0.695	ND
		Pond 2	1.06	0.885	ND
		Pond 3	--	0.843	ND
		Pond 4	--	0.951	ND
	Reference	Morton Bay	--	0.925	--
		Freshwater Marsh	1.04	1.06	ND
		D-Pond/Hazard	1.05	0.859	ND
B	SHP	Pond 1	0.929	1.28	0.472
		Pond 2	1.82	1.34	0.510
		Pond 3	--	1.50	0.709
		Pond 4	--	1.90	0.314
	Reference	Morton Bay	--	1.37	--
		Freshwater Marsh	0.332	0.739	0.537
		D-Pond/Hazard	1.12	0.692	0.183
Ba	SHP	Pond 1	1.13	1.45	0.868
		Pond 2	1.59	1.48	1.09
		Pond 3	--	1.58	1.45
		Pond 4	--	1.58	1.51
	Reference	Morton Bay	--	1.17	--
		Freshwater Marsh	2.01	1.91	2.43
		D-Pond/Hazard	0.820	1.51	2.10

Table 14. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes for 2006: Pond 1 (n = 3), Pond 2 (n = 7), Freshwater Marsh (n = 6), D-Pond (n = 4). Sample sizes for 2007: Pond 1 (n = 6), Pond 2 (n = 9), Pond 3 (n= 8), Pond 4 (n = 9), Morton Bay (n = 7) Freshwater Marsh (n = 6), D-Pond (n = 1). Sample sizes for 2008: Pond 1 (n = 7), Pond 2 (n = 7), Pond 3 (n = 8), Pond 4 (n = 8), Freshwater Marsh (n = 10), Hazard (n = 10). Element definitions are given in table 8; ND, all concentrations were below limit of detection (LOD), which are provided in appendix 9. NQ, element not quantified. --, sites with no eggs collected]

Element	Group	Site	Sampling period 2006	Sampling period 2007	Sampling period 2008
Be	SHP	Pond 1	0.016	0.024	0.020
		Pond 2	0.010	0.027	0.021
		Pond 3	--	0.024	0.016
		Pond 4	--	0.031	0.020
	Reference	Morton Bay	--	0.015	--
		Freshwater Marsh	0.018	0.021	0.017
		D-Pond/Hazard	0.023	0.016	0.020
Cd	SHP	Pond 1	0.013	0.008	ND
		Pond 2	0.008	0.021	ND
		Pond 3	--	0.014	ND
		Pond 4	--	0.019	ND
	Reference	Morton Bay	--	0.008	--
		Freshwater Marsh	0.011	0.017	ND
		D-Pond/Hazard	ND	ND	ND
Co	SHP	Pond 1	0.034	0.047	0.016
		Pond 2	0.039	0.052	0.039
		Pond 3	--	0.029	0.026
		Pond 4	--	0.050	0.014
	Reference	Morton Bay	--	0.017	--
		Freshwater Marsh	0.037	0.044	0.026
		D-Pond/Hazard	0.053	0.064	0.025
Cr	SHP	Pond 1	0.191	0.188	0.172
		Pond 2	0.275	0.177	0.197
		Pond 3	--	0.180	0.153
		Pond 4	--	0.205	0.172
	Reference	Morton Bay	--	0.474	--
		Freshwater Marsh	0.252	0.223	0.156
		D-Pond/Hazard	0.178	0.145	0.187
Cu	SHP	Pond 1	3.61	3.85	3.40
		Pond 2	3.40	8.41	3.63
		Pond 3	--	3.75	3.47
		Pond 4	--	3.86	3.67
	Reference	Morton Bay	--	3.65	--
		Freshwater Marsh	3.48	3.64	3.57
		D-Pond/Hazard	3.49	3.40	3.62

Table 14. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes for 2006: Pond 1 (n = 3), Pond 2 (n = 7), Freshwater Marsh (n = 6), D-Pond (n = 4). Sample sizes for 2007: Pond 1 (n = 6), Pond 2 (n = 9), Pond 3 (n= 8), Pond 4 (n = 9), Morton Bay (n = 7) Freshwater Marsh (n = 6), D-Pond (n = 1). Sample sizes for 2008: Pond 1 (n = 7), Pond 2 (n = 7), Pond 3 (n = 8), Pond 4 (n = 8), Freshwater Marsh (n = 10), Hazard (n = 10). Element definitions are given in table 8; ND, all concentrations were below limit of detection (LOD), which are provided in appendix 9. NQ, element not quantified. --, sites with no eggs collected]

Element	Group	Site	Sampling period		
			2006	2007	2008
Fe	SHP	Pond 1	87.7	120	98.1
		Pond 2	95.9	111	96.4
		Pond 3	--	125	108
		Pond 4	--	118	110
	Reference	Morton Bay	--	107	--
		Freshwater Marsh	118	120	98.0
		D-Pond/Hazard	110	114	112
Mn	SHP	Pond 1	1.73	1.43	1.28
		Pond 2	1.88	1.48	1.37
		Pond 3	--	1.55	1.14
		Pond 4	--	1.69	1.37
	Reference	Morton Bay	--	1.52	--
		Freshwater Marsh	1.36	1.39	1.26
		D-Pond/Hazard	1.22	0.815	1.43
Mo	SHP	Pond 1	0.155	0.173	0.149
		Pond 2	0.063	0.129	0.150
		Pond 3	--	0.131	0.138
		Pond 4	--	0.103	0.123
	Reference	Morton Bay	--	0.249	--
		Freshwater Marsh	0.113	0.156	0.339
		D-Pond/Hazard	0.125	0.070	0.137
Ni	SHP	Pond 1	0.035	0.024	0.038
		Pond 2	0.047	0.019	0.075
		Pond 3	--	0.022	0.039
		Pond 4	--	0.039	0.150
	Reference	Morton Bay	--	0.075	--
		Freshwater Marsh	0.017	0.061	0.035
		D-Pond/Hazard	0.021	ND	0.084
Pb	SHP	Pond 1	ND	ND	ND
		Pond 2	0.105	0.093	ND
		Pond 3	--	0.089	ND
		Pond 4	--	0.078	ND
	Reference	Morton Bay	--	0.090	--
		Freshwater Marsh	0.089	0.098	ND
		D-Pond/Hazard	0.117	ND	ND

Table 14. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes for 2006: Pond 1 (n = 3), Pond 2 (n = 7), Freshwater Marsh (n = 6), D-Pond (n = 4). Sample sizes for 2007: Pond 1 (n = 6), Pond 2 (n = 9), Pond 3 (n= 8), Pond 4 (n = 9), Morton Bay (n = 7) Freshwater Marsh (n = 6), D-Pond (n = 1). Sample sizes for 2008: Pond 1 (n = 7), Pond 2 (n = 7), Pond 3 (n = 8), Pond 4 (n = 8), Freshwater Marsh (n = 10), Hazard (n = 10). Element definitions are given in table 8; ND, all concentrations were below limit of detection (LOD), which are provided in appendix 9. NQ, element not quantified. --, sites with no eggs collected]

Element	Group	Site	Sampling period 2006	Sampling period 2007	Sampling period 2008
Sb	SHP	Pond 1	2.32	ND	ND
		Pond 2	1.73	ND	ND
		Pond 3	--	ND	ND
		Pond 4	--	ND	0.329
	Reference	Morton Bay	--	ND	--
		Freshwater Marsh	1.10	ND	0.150
		D-Pond/Hazard	1.11	ND	0.143
Se	SHP	Pond 1	7.85	6.18	5.45
		Pond 2	9.09	5.45	5.73
		Pond 3	--	6.06	6.99
		Pond 4	--	4.52	5.46
	Reference	Morton Bay	--	5.41	--
		Freshwater Marsh	7.05	6.11	5.26
		D-Pond/Hazard	3.62	2.18	4.42
Sn	SHP	Pond 1	0.132	ND	NQ
		Pond 2	0.139	0.006	NQ
		Pond 3	--	ND	NQ
		Pond 4	--	ND	NQ
	Reference	Morton Bay	--	0.009	--
		Freshwater Marsh	0.125	0.012	NQ
		D-Pond/Hazard	0.088	ND	NQ
Tl	SHP	Pond 1	0.217	0.147	ND
		Pond 2	0.221	0.137	ND
		Pond 3	--	0.144	ND
		Pond 4	--	0.155	ND
	Reference	Morton Bay	--	ND	--
		Freshwater Marsh	0.161	ND	ND
		D-Pond/Hazard	0.147	ND	ND
V	SHP	Pond 1	ND	ND	ND
		Pond 2	ND	ND	ND
		Pond 3	--	ND	ND
		Pond 4	--	ND	ND
	Reference	Morton Bay	--	ND	--
		Freshwater Marsh	ND	ND	ND
		D-Pond/Hazard	ND	ND	ND

Table 14. Arithmetic mean concentrations of trace elements (µg/g, dry weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes for 2006: Pond 1 (n = 3), Pond 2 (n = 7), Freshwater Marsh (n = 6), D-Pond (n = 4). Sample sizes for 2007: Pond 1 (n = 6), Pond 2 (n = 9), Pond 3 (n= 8), Pond 4 (n = 9), Morton Bay (n = 7) Freshwater Marsh (n = 6), D-Pond (n = 1). Sample sizes for 2008: Pond 1 (n = 7), Pond 2 (n = 7), Pond 3 (n = 8), Pond 4 (n = 8), Freshwater Marsh (n = 10), Hazard (n = 10). Element definitions are given in table 8; ND, all concentrations were below limit of detection (LOD), which are provided in appendix 9. NQ, element not quantified. --, sites with no eggs collected]

			Sampling period		
Element	Group	Site	2006	2007	2008
Zn	SHP	Pond 1	49.4	57.8	46.5
		Pond 2	51.6	61.7	47.9
		Pond 3	--	58.5	49.3
		Pond 4	--	64.3	51.8
	Reference	Morton Bay	--	55.9	--
		Freshwater Marsh	50.8	55.5	47.0
		D-Pond/Hazard	46.7	46.3	52.0
% dry weight	SHP	Pond 1	28.7	27.2	31.5
		Pond 2	25.9	29.1	30.8
		Pond 3	--	28.3	31.0
		Pond 4	--	27.9	29.0
	Reference	Morton Bay	--	27.7	--
		Freshwater Marsh	25.1	26.4	30.7
		D-Pond/Hazard	27.0	29.5	29.0

Table 15. Arithmetic mean concentrations of organochlorine compounds (µg/g, wet weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.

[Sample sizes are given in table 14. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 10. NQ, element not quantified. --, sites with no eggs collected]

Organochlorine group	Compound	Group	Site	Sampling period 2006	2007	2008
DDT	*p,p′* DDD	SHP	Pond 1	0.002	0.002	ND
			Pond 2	0.002	0.001	0.004
			Pond 3	--	0.006	ND
			Pond 4	--	0.002	ND
		Reference	Morton Bay	--	0.003	--
			Freshwater Marsh	ND	0.001	0.003
			D-Pond/Hazard	0.005	ND	ND
	p,p′ DDE	SHP	Pond 1	1.137	1.223	1.917
			Pond 2	3.413	2.954	1.983
			Pond 3	--	3.358	2.363
			Pond 4	--	6.351	1.898
		Reference	Morton Bay	--	1.624	--
			Freshwater Marsh	1.315	1.029	1.951
			D-Pond/Hazard	2.100	1.300	1.096
	p,p′ DDT	SHP	Pond 1	ND	0.008	0.008
			Pond 2	0.005	0.007	0.013
			Pond 3	--	0.008	0.006
			Pond 4	--	0.008	0.005
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	0.001	0.010
			D-Pond/Hazard	ND	ND	0.004
	o,p′ DDD	SHP	Pond 1	ND	ND	0.002
			Pond 2	ND	ND	0.004
			Pond 3	--	0.002	0.003
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	0.002
			D-Pond/Hazard	ND	ND	ND
	o,p′ DDE	SHP	Pond 1	ND	ND	0.008
			Pond 2	ND	ND	0.012
			Pond 3	--	ND	0.003
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	ND
	o,p′ DDT	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	0.002
			Pond 3	--	ND	ND
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	ND

Table 15. Arithmetic mean concentrations of organochlorine compounds (µg/g, wet weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes are given in table 14. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 10. NQ, element not quantified. --, sites with no eggs collected]

Organochlorine group	Compound	Group	Site	Sampling period		
				2006	2007	2008
Chlordane	alpha chlordane	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	0.002
			Pond 3	--	ND	ND
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	ND
	gamma chlordane	SHP	Pond 1	ND	ND	0.004
			Pond 2	ND	ND	0.005
			Pond 3	--	ND	0.008
			Pond 4	--	ND	0.004
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	0.003
			D-Pond/Hazard	ND	ND	0.003
	oxychlordane	SHP	Pond 1	0.002	0.006	0.004
			Pond 2	0.002	0.006	0.006
			Pond 3	--	0.006	0.006
			Pond 4	--	0.008	0.004
		Reference	Morton Bay	--	0.003	--
			Freshwater Marsh	0.003	0.004	0.003
			D-Pond/Hazard	0.003	0.004	ND
	cis-nonachlor	SHP	Pond 1	ND	ND	0.002
			Pond 2	ND	ND	ND
			Pond 3	--	ND	0.002
			Pond 4	--	ND	0.002
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	0.002
			D-Pond/Hazard	ND	ND	ND
	trans-nonachlor	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	0.004
			Pond 3	--	ND	0.002
			Pond 4	--	ND	0.002
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	0.001	ND	ND
			D-Pond/Hazard	0.003	ND	0.002
	heptachlor epoxide	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	0.003
			Pond 3	--	ND	0.002
			Pond 4	--	0.001	0.002
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	0.001

Table 15. Arithmetic mean concentrations of organochlorine compounds (µg/g, wet weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes are given in table 14. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 10. NQ, element not quantified. --, sites with no eggs collected]

Organochlorine group	Compound	Group	Site	Sampling period 2006	2007	2008
Hexachloro-cyclohexane	alpha BHC	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	0.002
			Pond 3	--	ND	ND
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	ND
	beta BHC	SHP	Pond 1	ND	0.003	0.010
			Pond 2	ND	0.008	0.006
			Pond 3	--	0.006	0.007
			Pond 4	--	0.005	ND
		Reference	Morton Bay	--	0.003	--
			Freshwater Marsh	ND	0.001	0.004
			D-Pond/Hazard	ND	ND	0.002
	delta BHC	Study Ponds	Pond 1	ND	NQ	NQ
			Pond 2	ND	NQ	NQ
			Pond 3	--	NQ	NQ
			Pond 4	--	NQ	NQ
		Reference	Morton Bay	--	NQ	NQ
			Freshwater Marsh	ND	NQ	NQ
			D-Pond/Hazard	ND	NQ	NQ
	gamma BHC	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	0.003
			Pond 3	--	ND	ND
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	0.002
			D-Pond/Hazard	ND	ND	ND

Table 15. Arithmetic mean concentrations of organochlorine compounds (µg/g, wet weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes are given in table 14. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 10. NQ, element not quantified. --, sites with no eggs collected]

Organochlorine group	Compound	Group	Site	Sampling Period 2006	Sampling Period 2007	Sampling Period 2008
Drin	dieldrin	SHP	Pond 1	ND	0.011	0.012
			Pond 2	ND	0.009	0.010
			Pond 3	--	0.008	0.020
			Pond 4	--	0.028	0.013
		Reference	Morton Bay	--	0.011	--
			Freshwater Marsh	ND	0.005	0.009
			D-Pond/Hazard	ND	ND	0.014
	endrin	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	ND
			Pond 3	--	ND	0.002
			Pond 4	--	ND	0.002
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	ND
PCB	Total PCBs	SHP	Pond 1	ND	ND	0.254
			Pond 2	ND	ND	0.247
			Pond 3	--	ND	0.288
			Pond 4	--	ND	0.210
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	0.218
			D-Pond/Hazard	ND	ND	0.178
Chlorobenzene	HCB	SHP	Pond 1	0.001	0.005	0.003
			Pond 2	0.002	0.004	0.008
			Pond 3	--	0.006	0.004
			Pond 4	--	0.006	0.003
		Reference	Morton Bay	--	0.003	--
			Freshwater Marsh	0.002	0.002	0.002
			D-Pond/Hazard	0.003	ND	0.001

Table 15. Arithmetic mean concentrations of organochlorine compounds (µg/g, wet weight) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.—Continued

[Sample sizes are given in table 14. ND, all concentrations were below limit of detection (LOD), which are provided in appendix 10. NQ, element not quantified. --, sites with no eggs collected]

Organochlorine group	Compound	Group	Site	Sampling period		
				2006	2007	2008
Other	mirex	SHP	Pond 1	ND	ND	0.278
			Pond 2	ND	ND	0.003
			Pond 3	--	ND	ND
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	0.002
	toxaphene	SHP	Pond 1	ND	ND	ND
			Pond 2	ND	ND	ND
			Pond 3	--	ND	ND
			Pond 4	--	ND	ND
		Reference	Morton Bay	--	ND	--
			Freshwater Marsh	ND	ND	ND
			D-Pond/Hazard	ND	ND	ND
	% Lipid	SHP	Pond 1	12.6	11.2	13.6
			Pond 2	12.1	12.0	14.5
			Pond 3	--	12.0	12.5
			Pond 4	--	10.0	14.9
		Reference	Morton Bay	--	12.6	--
			Freshwater Marsh	10.6	11.6	14.0
			D-Pond/Hazard	13.7	13.6	12.9
	% Moisture	SHP	Pond 1	71.4	75.5	78.4
			Pond 2	73.1	73.3	75.8
			Pond 3	--	75.2	76.1
			Pond 4	--	72.9	80.4
		Reference	Morton Bay	--	75.1	--
			Freshwater Marsh	75.3	73.8	81.5
			D-Pond/Hazard	75.7	63.6	78.0

Table 16. Estimates for 95% (home range) and 50% (core area) utilization distributions for radio marked Black-necked Stilt chicks during the 2006–08 breeding seasons, Ecosystem Monitoring Project, Salton Sea, California.

[SHP, saline habitat ponds. Number: Number of locations and chicks used to calculate population spatial use estimates. UD, utilization distributions. ha, hectares; %, percent]

Year	Group	Hatch site	Number		Area (ha)	
			locations	chicks	95% UD	50% UD
2006	SHP	All ponds	253	18	143	16
2007	SHP	All ponds	310	39	148	7
		Hazard	134	15	85	12
2008	SHP	All ponds	180	20	212	28
	Reference	Hazard	143	10	66	10
		Freshwater Marsh	127	9	5	1

Table 17. Proportion of Black-necked Stilt chick locations occurring within a hatch pond and proportion of stilt chicks with more than one location in a non-hatch pond during the 2006–08 breeding seasons at the saline habitat ponds (SHP), Ecosystem Monitoring Project, Salton Sea, California.

[Hatch pond: Based on pond where chicks hatched. Ponds 3 and 4 were dry with no nesting during 2006]

Year	Hatch pond	Total number of locations	Percentage of locations in hatch pond	Total number of chicks	Percentage of chicks with movement in non-hatch pond
2006	Pond 1	55	84	13	46
	Pond 2	42	67	5	100
	All SHP Ponds	97	76	18	61
2007	Pond 1	45	87	9	44
	Pond 2	19	84	8	25
	Pond 3	26	85	11	33
	Pond 4	22	77	8	14
	All SHP Ponds	112	84	36	30
2008	Pond 1	--	--	--	--
	Pond 2	11	36	3	[1]67
	Pond 3	2	100	4	0
	Pond 4	21	67	13	23
	All SHP Ponds	34	59	20	30

[1]All Pond 2 non-hatch pond locations during 2008 occurred in Pond 1.

Table 18. Descriptive statistics for movements by post-hatch Black-necked Stilt chicks during the 2006–08 breeding seasons, Ecosystem Monitoring Project, Salton Sea, California.

[SHP, saline habitat ponds. m, meters; %, percent; --, no marked chicks]

			Hatch site							
			SHP ponds					Reference		
Year	Variable	Parameter	Pond 1	Pond 2	Pond 3	Pond 4	All SHP	Hazard	Freshwater Marsh	All reference
2006	Max distance from nest (m)	mean	1,212	515	--	--	1,018	--	--	--
		range	124–2,023	290–709	--	--	124 – 1,764	--	--	--
					--	--		--	--	--
	Angle of max distance from nest (degrees)	mean	331°	300°			322°			
					--	--		--	--	--
	Distance between locations (m)	mean	160	171	--	--	163	--	--	--
		range	95–233	60–282			95 - 282			
	Number of days to emigration	median	3.0	1.0	--	--	2.5	--	--	--
		range	1–5	1–1	--	--	1 - 5	--	--	--
	Percentage of chicks emigrating[1]	%	69%	33%	--	--	59%	--	--	--
2007	Max distance from nest (m)	mean	758	589	667	964	730	584	--	546
		range	121–1,310	12–1,717	4–1,531	231–1,766	4–1,766	40–1,128	--	40–1,128
	Angle of max distance from nest (degrees)	mean	317°	286°	314°	324°	311°	88°	--	88°
	Distance between locations (m)	mean	182	185	173	210	186	124	--	124
		range	4–1,139	2–755	1 – 1,531	0 - 832	0 – 1,531	1–1,073	--	1–1,073
	Number of days to emigration	median	6.0	2.0	2.0	2.0	2.5	5.5	--	5.5
		range	2 - 17	1–4	1–5	1–5	1–17	5–7	--	5–7
	Percentage of chicks emigrating[1]	%	78%	83%	82%	100%	85%	60%	--	60%
2008	Max distance from nest (m)	mean	--	205	543	749	609	416	175	302
		range	--	8–589	45–1,125	33–1,604	8–1,604	169– 895	37 - 429	37–895
	Angle of max distance from nest (degrees)	mean		259°	294°	325°	304°	154°	337°	149°
	Distance between locations (m)	--	--	75	155	165	155	106	52	81
		range	--	1–320	6–854	3–889	1–889	1–562	0 - 413	0–562
	Number of days to emigration	median	--	3.0	1.5	2.0	2.0	3.0	--	3.0
		range	--	--	1–2	1–5	1–5	--	--	--
	Percentage of chicks emigrating[1]	%	--	25%	100%	77%	68%	10%	0%	5%

[1]Conservative estimate only that includes chicks surviving more than 3 days post hatch; see text for rationale.

Table 19. Survival rate estimates (S(t)) to 21 days post hatch for black-necked stilt chicks during the 2006–08 breeding seasons, Ecosystem Monitoring Project, Salton Sea, California.

[See text methods section 4.2.2.2—Survival estimation for definitions of scenarios and methods for estimating survival. Both scenarios exclude mortalities associated with capture (2007: n = 2; 2008: n =4). SHP, saline habitat ponds. %, percent]

Year	Censor scenario	Group	Hatch site	Number marked	Number died	Number censored	S(t)	95% CI[1]
2006	Scenario 1	SHP	SHP Ponds 1&2	18	5	13	0.71	0.49 - 0.92
	Scenario 2	SHP	SHP Ponds 1&2	18	9	9	0.49	0.25 - 0.72
2007	Scenario 1	SHP	SHP Ponds 1&2	17	8	9	0.52	0.28 - 0.76
			SHP Ponds 3&4	21	11	10	0.35	0.10 - 0.60
			All SHP	38	19	19	0.45	0.27 - 0.62
		Reference	Hazard	10	1	9	0.83	0.68 - 1.0
			All Reference	14	2	12	0.83	0.62 - 1.0
	Scenario 2	SHP	SHP Ponds 1&2	17	8	9	0.52	0.28 - 0.76
			SHP Ponds 3&4	21	13	8	0.27	0.06 - 0.49
			All SHP	38	21	17	0.40	0.23 - 0.56
		Reference	Hazard	10	1	9	0.83	0.68 - 1.0
			All Reference	14	4	10	0.71	0.46 - 0.95
2008	Scenario 1	SHP	SHP Ponds 1&2	12	6	6	0.38	0.05 - 0.70
			SHP Ponds 3&4	19	9	10	0.43	0.16 - 0.70
			All SHP	31	15	16	0.37	0.14 - 0.60
		Reference	Hazard	14	3	11	0.76	0.52 - 1.00
			Freshwater Marsh	11	6	5	0.45	0.16 - 0.75
			All Reference	25	9	16	0.60	0.40 - 080
	Scenario 2	SHP	SHP Ponds 1&2	12	11	1	0.08	0.00 - 0.24
			SHP Ponds 3&4	19	13	6	0.28	0.07 - 0.50
			All SHP	31	24	7	0.19	0.04 - 0.34
		Reference	Hazard	14	7	7	0.50	0.24 - 0.76
			Freshwater Marsh	11	6	5	0.45	0.16 - 0.75
			All Reference	25	13	12	0.48	0.28 - 0.68

[1]Values truncated between 0 and 1.

Table 20. Probable causes of death for radio-marked post hatch black-necked stilt chicks during the 2006–08 breeding seasons, Ecosystem Monitoring project, Salton Sea, California.

[Cause of death by scenario: Numbers outside parentheses for Scenario 1, numbers inside parentheses for Scenario 2. See text for scenario definitions. SHP, saline habitat ponds]

			Cause of death by scenario								
Year	Group	Hatch Site	Avian predator	Mammalian predator	Unknown predator	Canal	Crack entrapment	Flood-foam	Misc	Unknown death	Total deaths
2006	SHP	Pond 1	0 (0)	0 (0)	0 (2)	0 (0)	3 (3)	0 (0)	0 (0)	0 (0)	3 (5)
		Pond 2	0 (0)	0 (0)	0 (0)	0 (1)	1 (1)	0 (0)	0 (0)	1 (2)	2 (4)
		All SHP	0 (0)	0 (0)	0 (2)	0 (1)	4 (4)	0 (0)	0 (0)	1 (2)	5 (9)
2007	SHP	Pond 1	0 (0)	0 (0)	0 (0)	1 (1)	0 (0)	0 (0)	1 (1)	1 (1)	3 (3)
		Pond 2	2 (2)	0 (0)	0 (0)	3 (3)	0 (0)	0 (0)	0 (0)	0 (0)	5 (5)
		Pond 3	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	1 (1)	1 (1)	3 (4)	6 (7)
		Pond 4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (3)	0 (0)	2 (3)	5 (6)
		All SHP	2 (2)	0 (0)	0 (0)	4 (4)	1 (1)	4 (4)	2 (2)	6 (8)	19 (21)
	Reference	D Pond / Morton Bay	1 (2)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	1 (3)
		Freshwater Marsh	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
		Hazard	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
		All Reference	2 (3)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	2 (4)
		All sites	4 (5)	0 (0)	0 (0)	4 (4)	1 (1)	4 (4)	2 (2)	6 (9)	21 (25)
2008	SHP	Pond 1	1 (1)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	3 (3)
		Pond 2	3 (4)	0 (0)	0 (3)	0 (1)	0 (0)	0 (0)	0 (0)	0 (0)	3 (8)
		Pond 3	2 (2)	1 (1)	0 (1)	0 (1)	1 (1)	0 (0)	0 (0)	0 (0)	4 (6)
		Pond 4	3 (3)	0 (0)	0 (2)	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)	5 (7)
		All SHP	9 (10)	1 (1)	1 (7)	2 (4)	1 (1)	0 (0)	0 (0)	1 (1)	15 (24)
	Reference	Freshwater Marsh	2 (2)	3 (3)	0 (0)	1 (1)	0 (0)	0 (0)	0 (0)	0 (0)	6 (6)
		Hazard	1 (1)	1 (1)	0 (4)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	3 (7)
		All Reference	3 (3)	4 (4)	0 (4)	1 (1)	0 (0)	0 (0)	0 (0)	1 (1)	9 (13)
		All sites	12 (13)	5 (5)	1 (11)	3 (5)	1 (1)	0 (0)	0 (0)	2 (2)	24 (37)
All Years		All sites	16 (18)	5 (5)	1 (13)	7 (10)	6 (6)	4 (4)	2 (2)	9 (12)	50 (70)

Table 21. Values used to estimate ingested daily doses of selenium by Black-necked Stilts (DIBNST) and hazard quotients (HQ) for predictive ecological risk assessment; Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[Exposure values: Ci, average dry weight selenium concentration in Corixidae from each site; Rd, daily dietary intake rate for stilts (mg/d, dw); Fi, fraction of invertebrates in stilt diet; ECs, average dry weight selenium concentration in sediments from each site; Fs, fraction of sediment in stilt diet; BWBNS, average stilt body weight; Tf, fraction of time spent at site. See appendix 11 for rationale behind selected exposure values]

		Exposure values									
Group	Site	Ci	Rd	Fi	ECs	Fs	BWBNST	Tf	DIBNST	HQ(low)	HQ (high)
SHP	Pond 1	5.20	14.219	0.949	1.80	0.16	169.6	1.0	0.44	1.90	0.47
	Pond 2	5.15	14.219	0.949	1.33	0.16	169.6	1.0	0.43	1.86	0.46
	Pond 3	4.81	14.219	0.949	2.29	0.16	169.6	1.0	0.41	1.80	0.44
	Pond 4	3.51	14.219	0.949	1.95	0.16	169.6	1.0	0.31	1.33	0.33
	All SHP	4.96	14.219	0.949	1.84	0.16	169.6	1.0	0.42	1.82	0.45
Reference	Salton Sea	2.93	14.219	0.949	1.82	0.16	169.6	1.0	0.26	1.12	0.28
	D-Pond/Hazard	1.70	14.219	0.949	0.49	0.16	169.6	1.0	0.14	0.62	0.15
	Freshwater Marsh	2.50	14.219	0.949	2.16	0.16	169.6	1.0	0.23	0.99	0.25
	All Reference	2.32	14.219	0.949	1.26	0.16	169.6	1.0	0.20	0.88	0.22

12. Appendixes

Appendix 1. EPA methods used by Battelle Marine Sciences Laboratory to analyze concentrations of trace elements (µg/L) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[NQ, element not quantified]

	Sampling period				
Element	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ag (Silver)	200.7[1]	200.7	200.7	200.7	200.7
Al (Aluminum)	200.7	200.7	200.7	200.7	200.7
As (Arsenic)	200.7	7742	200.8	7742	7742
B (Boron)	200.7	200.7	200.7	200.7	200.7
Ba (Barium)	200.7	200.7	200.7	200.7	200.7
Be (Beryllium)	200.7	200.7	200.7	200.7	200.7
Cd (Cadmium)	200.7	200.7	200.7	200.7	200.7
Co (Cobalt)	200.7	200.7	200.7	200.7	200.7
Cr (Chromium)	200.7	200.7	200.7	200.7	200.7
Cu (Copper)	200.7	200.7	200.7	200.7	200.7
Fe (Iron)	200.7	200.7	200.7	200.7	200.7
Hg (Mercury)	245.5	NQ	NQ	NQ	NQ
Mn (Manganese)	200.7	200.7	200.7	200.7	200.7
Mo (Molybdenum)	200.7	200.7	200.7	200.7	200.7
Ni (Nickel)	200.7	200.7	200.7	200.7	200.7
Pb (Lead)	200.7	200.7	200.8	200.7	200.7
Sb (Antimony)	200.7	7742	200.8	7742	NQ
Se (Selenium)	200.7	7742	7742	7742	7742
Sn (Tin)	200.8	200.8	200.8	NQ	NQ
Tl (Thallium)	200.7	200.7	200.7	200.7	200.7
V (Vanadium)	200.7	200.7	200.7	200.7	200.7
Zn (Zinc)	200.7	200.7	200.7	200.7	200.7

[1] 200.7 = inductively coupled plasma optical emissions spectrometry (ICP-OES); 200.8 = inductively coupled plasma-mass spectrometry (ICP-MS); 7742 = hydride generation atomic absorption - flow injection atomic spectroscopy (HGAA-FIAS); 245.5 = cold vapor atomic fluorescence (CVAF).

Appendix 2. Dilution factors used analyzing concentrations of trace elements by ICP-OES (EPA 200.7) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

		Sampling period				
Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
SHP	Pond 1	5x	5x	1x	5.7x	5.75x
	Pond 2	10x	5x	4x	11.4x	11.5x
	Pond 3	10x	10x	10x	25x	28.75x
	Pond 4	40x	40.0	50 - 100x	114x	115x
Reference	Alamo River	2x	2x	1x	1x	1.15x
	Salton Sea	10x	2x	5 - 100x	2.5 - 5.7x	1.15 - 2.30x
	Freshwater Marsh	2x	2x	1x	1x	1.15x
	D-Pond[1]	2x	5x	1x	1x	1.15x

[1]D-pond was dry in fall 2008, SSNWR Hazard Pond sampled in its place.

Appendix 3. Analytical limits of detection for concentrations of trace elements (µg/L) in water samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[Limit of detection increased accordingly with dilution used due to salinity (see appendix 2) and modified EPA method (see appendix 1). NQ, element not quantified]

			Sampling period				
Element	Group	Site	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ag (Silver)	SHP	Pond 1	2.0	0.9	0.2	1.0	1.0
		Pond 2	3.9	0.9	0.7	2.0	2.0
		Pond 3	3.9	3.4	1.7	5.5	4.9
		Pond 4	15.7	5.2	14.3	19.6	19.8
	Reference	Alamo River	0.8	0.3	0.2	0.2	0.2
		Salton Sea	3.9	0.9	6.3	0.6	0.3
		Freshwater Marsh	0.8	0.3	0.2	0.2	0.2
		D-pond[1]	0.8	0.3	0.2	0.2	0.2
Al (Aluminum)	SHP	Pond 1	20.4	12.7	2.5	16.4	16.6
		Pond 2	40.7	12.7	10.2	32.8	33.3
		Pond 3	40.7	50.8	25.4	92.2	82.8
		Pond 4	162.8	76.2	211.7	328.3	331.2
	Reference	Alamo River	8.1	5.1	2.5	2.9	3.3
		Salton Sea	40.7	12.7	93.1	9.8	5.5
		Freshwater Marsh	8.1	5.1	2.5	2.9	3.3
		D-pond	8.1	5.1	2.5	2.9	3.3
As (Arsenic)	SHP	Pond 1	17.5	0.0	0.0	0.0	0.0
		Pond 2	34.9	0.02	0.02	0.02	0.04
		Pond 3	34.9	0.08	0.02	0.02	0.11
		Pond 4	139.6	0.14	0.02	0.02	0.21
	Reference	Alamo River	7.0	0.02	0.02	0.02	0.03
		Salton Sea	34.9	0.02	0.02	0.02	0.02
		Freshwater Marsh	7.0	0.07	0.02	0.02	0.02
		D-pond	7.0	0.0	0.0	0.0	0.0
B (Boron)	SHP	Pond 1	800.0	213.5	42.7	9.4	11.6
		Pond 2	1,600.0	213.5	171.0	18.8	23.4
		Pond 3	1,600.0	854.0	427.0	47.0	58.1
		Pond 4		1,281.0	3,558.3	188.0	232.3
	Reference	Alamo River	320.0	85.4	43.0	1.9	2.3
		Salton Sea	1,600.0	213.5	1,566.0	5.6	3.9
		Freshwater Marsh	320.0	85.4	43.0	1.9	2.3
		D-pond	320.0	85.4	43.0	1.9	2.3
Ba (Barium)	SHP	Pond 1	0.6	0.7	0.1	0.8	0.8
		Pond 2	1.2	0.7	0.6	1.6	1.6
		Pond 3	1.2	2.8	1.4	4.4	4.0
		Pond 4	4.8	4.2	11.6	15.8	16.0
	Reference	Alamo River	0.2	0.3	0.1	0.1	0.2
		Salton Sea	1.2	0.7	5.1	0.5	0.3
		Freshwater Marsh	0.2	0.3	0.1	0.1	0.2
		D-pond	0.2	0.3	0.1	0.1	0.2

Appendix 3.—Continued

Element	Group	Site	Sampling period Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Be (Beryllium)	SHP	Pond 1	0.4	0.3	0.1	0.3	0.3
		Pond 2	0.8	0.3	0.2	0.6	0.6
		Pond 3	0.8	1.1	0.5	1.7	1.6
		Pond 4	3.3	1.6	4.6	6.2	6.3
	Reference	Alamo River	0.2	0.1	0.1	0.1	0.1
		Salton Sea	0.8	0.3	2.0	0.2	0.1
		Freshwater Marsh	0.2	0.1	0.1	0.1	0.1
		D-pond	0.2	0.1	0.1	0.1	0.1
Cd (Cadmium)	SHP	Pond 1	0.5	0.8	0.2	0.9	0.9
		Pond 2	1.1	0.8	0.6	1.8	1.8
		Pond 3	1.1	3.2	1.6	5.1	4.5
		Pond 4	4.2	4.7	13.2	18.0	18.2
	Reference	Alamo River	0.2	0.3	0.2	0.2	0.2
		Salton Sea	1.1	0.8	5.8	0.5	0.3
		Freshwater Marsh	0.2	0.3	0.2	0.2	0.2
		D-pond	0.2	0.3	0.2	0.2	0.2
Co (Cobalt)	SHP	Pond 1	0.5	1.3	0.3	1.5	1.5
		Pond 2	1.0	1.3	1.0	2.9	3.0
		Pond 3	1.0	5.1	2.6	8.2	7.4
		Pond 4	4.2	7.7	21.3	29.2	29.4
	Reference	Alamo River	0.2	0.5	0.3	0.3	0.3
		Salton Sea	1.0	1.3	9.4	0.9	0.5
		Freshwater Marsh	0.2	0.5	0.3	0.3	0.3
		D-pond	0.2	0.5	0.3	0.3	0.3
Cr (Chromium)	SHP	Pond 1	0.7	1.0	0.2	1.2	1.2
		Pond 2	1.4	1.0	0.8	2.3	2.3
		Pond 3	1.4	4.1	2.0	6.5	5.8
		Pond 4	5.4	6.1	16.9	23.1	23.3
	Reference	Alamo River	0.3	0.4	0.2	0.2	0.2
		Salton Sea	1.4	1.0	7.4	0.7	0.4
		Freshwater Marsh	0.3	0.4	0.2	0.2	0.2
		D-pond	0.3	0.4	0.2	0.2	0.2
Cu (Copper)	SHP	Pond 1	1.6	1.2	0.2	1.3	1.3
		Pond 2	3.2	1.2	0.9	2.7	2.7
		Pond 3	3.2	4.7	2.3	7.5	6.7
		Pond 4	12.7	7.0	19.4	26.6	26.8
	Reference	Alamo River	0.6	0.5	0.2	0.2	0.3
		Salton Sea	3.2	1.2	8.5	0.8	0.4
		Freshwater Marsh	0.6	0.5	0.2	0.2	0.3
		D-pond	0.6	0.5	0.2	0.2	0.3

Appendix 3.—Continued

Element	Group	Sit	Sampling period Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Fe (Iron)	SHP	Pond 1	5.0	5.9	1.2	5.9	6.8
		Pond 2	10.0	5.9	4.7	13.5	13.6
		Pond 3	10.0	23.6	11.8	37.8	33.9
		Pond 4	40.0	35.4	98.3	134.5	135.7
	Reference	Alamo River	2.0	2.4	1.2	1.2	1.4
		Salton Sea	10.0	5.9	43.3	3.8	2.3
		Freshwater Marsh	2.0	2.4	1.2	1.2	1.4
		D-pond	2.0	2.4	1.2	1.2	1.4
Hg (Mercury)	SHP	Pond 1	0.0001	NQ	NQ	NQ	NQ
		Pond 2	0.0001	NQ	NQ	NQ	NQ
		Pond 3	0.0001	NQ	NQ	NQ	NQ
		Pond 4	0.0001	NQ	NQ	NQ	NQ
	Reference	Alamo River	0.0001	NQ	NQ	NQ	NQ
		Salton Sea	0.0001	NQ	NQ	NQ	NQ
		Freshwater Marsh	0.0001	NQ	NQ	NQ	NQ
		D-pond	0.0001	NQ	NQ	NQ	NQ
Mn (Manganese)	SHP	Pond 1	0.42	0.18	0.04	0.20	0.21
		Pond 2	0.84	0.18	0.14	0.41	0.41
		Pond 3	0.84	0.72	0.36	1.15	1.03
		Pond 4	3.36	1.07	2.98	4.08	4.12
	Reference	Alamo River	0.17	0.07	0.04	0.04	0.04
		Salton Sea	0.84	0.18	1.31	0.12	0.07
		Freshwater Marsh	0.17	0.07	0.04	0.04	0.04
		D-pond	0.17	0.07	0.04	0.04	0.04
Mo (Molybdenum)	SHP	Pond 1	1.6	4.2	0.8	4.6	4.7
		Pond 2	3.3	4.2	3.3	9.3	9.4
		Pond 3	3.3	16.6	8.3	26.1	23.4
		Pond 4	13.1	24.9	69.3	92.9	93.7
	Reference	Alamo River	0.7	1.7	0.8	0.8	0.9
		Salton Sea	3.3	4.2	30.5	2.8	1.6
		Freshwater Marsh	0.7	1.7	0.8	0.8	0.9
		D-pond	0.7	1.7	0.8	0.8	0.9
Ni (Nickel)	SHP	Pond 1	2.0	2.1	0.4	2.4	2.4
		Pond 2	3.9	2.1	1.7	4.7	4.8
		Pond 3	3.9	8.3	4.1	13.2	11.9
		Pond 4	15.6	12.4	34.5	47.2	47.6
	Reference	Alamo River	0.78	0.83	0.41	0.41	0.48
		Salton Sea	3.91	2.07	15.18	1.42	0.79
		Freshwater Marsh	0.78	0.83	0.41	0.41	0.48
		D-pond	0.78	0.83	0.41	0.41	0.48

Appendix 3.—Continued

Element	Group	Site	Sampling period Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Pb (Lead)	SHP	Pond 1	9.9	7.7	0.0	11.4	11.5
		Pond 2	19.7	7.7	0.0	22.8	23.1
		Pond 3	19.7	30.6	0.0	64.0	57.5
		Pond 4	78.8	45.9	0.0	228.0	230.0
	Reference	Alamo River	3.9	3.1	0.0	2.0	2.3
		Salton Sea	19.7	7.7	0.0	6.8	3.8
		Freshwater Marsh	3.9	3.1	0.0	2.0	2.3
		D-pond	3.9	3.1	0.0	2.0	2.3
Sb (Antimony)	SHP	Pond 1	18.2	0.1	0.0	0.1	NQ
		Pond 2	36.3	0.1	0.0	0.1	NQ
		Pond 3	36.3	0.2	0.0	0.1	NQ
		Pond 4	145.0	0.4	0.0	0.1	NQ
	Reference	Alamo River	7.3	0.1	0.0	0.1	NQ
		Salton Sea	36.3	0.1	0.0	0.1	NQ
		Freshwater Marsh	7.3	0.1	0.0	0.1	NQ
		D-pond	7.3	0.1	0.0	0.1	NQ
Se (Selenium)	SHP	Pond 1	0.08	0.08	0.08	0.07	0.07
		Pond 2	0.08	0.08	0.30	0.07	0.13
		Pond 3	0.08	0.18	0.76	0.07	0.34
		Pond 4	0.08	0.28	3.90	0.07	0.67
	Reference	Alamo River	0.08	0.08	0.08	0.07	0.09
		Salton Sea	0.08	0.08	1.57	0.07	0.07
		Freshwater Marsh	0.08	0.08	0.08	0.07	0.07
		D-pond	0.08	0.08	0.08	0.07	0.07
Sn (Tin)	SHP	Pond 1	0.10	0.06	0.10	NQ	NQ
		Pond 2	0.10	0.06	0.10	NQ	NQ
		Pond 3	0.10	0.06	0.10	NQ	NQ
		Pond 4	0.10	0.06	0.10	NQ	NQ
	Reference	Alamo River	0.10	0.06	0.10	NQ	NQ
		Salton Sea	0.10	0.06	0.10	NQ	NQ
		Freshwater Marsh	0.10	0.06	0.10	NQ	NQ
		D-pond	0.10	0.06	0.10	NQ	NQ
Tl (Thallium)	SHP	Pond 1	25.0	11.1	2.2	12.7	12.8
		Pond 2	50.0	11.1	8.9	25.3	25.7
		Pond 3	50.0	44.4	22.2	71.0	63.8
		Pond 4	200.0	66.6	185.0	253.1	255.3
	Reference	Alamo River	10.0	4.4	2.2	2.2	2.6
		Salton Sea	50.0	11.1	81.4	7.6	4.3
		Freshwater Marsh	10.0	4.4	2.2	2.2	2.6
		D-pond	10.0	4.4	2.2	2.2	2.6
V (Vanadium)	SHP	Pond 1	1.1	1.4	0.3	1.6	1.6
		Pond 2	2.1	1.4	1.1	3.1	3.2
		Pond 3	2.1	5.5	2.8	8.8	7.9
		Pond 4	8.4	8.3	23.0	31.5	31.7

Appendix 3.—Continued

Element	Group	Site	Sampling period Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
V (Vanadium)	Reference	Alamo River	0.4	0.6	0.3	0.3	0.3
		Salton Sea	2.1	1.4	10.1	0.9	0.5
		Freshwater Marsh	0.4	0.6	0.3	0.3	0.3
		D-pond	0.4	0.6	0.3	0.3	0.3
Zn (Zinc)	SHP	Pond 1	17.4	0.6	0.1	0.7	0.7
		Pond 2	42.7	0.6	0.5	1.3	1.4
		Pond 3	45.1	2.3	1.2	3.7	3.4
		Pond 4	198.3	3.5	9.8	13.3	13.5
	Reference	Alamo River	10.3	0.2	0.1	0.1	0.1
		Salton Sea	54.3	0.6	4.3	0.4	0.2
		Freshwater Marsh	6.8	0.2	0.1	0.1	0.1
		D-pond	7.9	0.2	0.1	0.1	0.1

[1]D-pond was dry in fall 2008, Hazard Pond sampled in its place.

Appendix 4. Limits of detection (mg/L) for organochlorine compounds in surface-water samples, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[Sampling period: Spring 2008 was not sampled. NQ, analyte not quantified]

Organochlorine group	Compound	Sampling period: Fall 2006	Spring 2007	Fall 2007	Fall 2008
DDT	*p,p'* DDD	0.00010	0.00010	0.00005	0.00001
	p,p' DDE	0.00010	0.00010	0.00005	0.00001
	p,p' DDT	0.00010	0.00010	0.00005	0.00001
	o,p' DDD	0.00010	0.00010	0.00005	0.00001
	o,p' DDE	0.00010	0.00010	0.00005	0.00001
	o,p' DDT	0.00010	0.00010	0.00005	0.00001
Chlordane	alpha chlordane	0.00010	0.00010	0.00005	0.00001
	gamma chlordane	0.00010	0.00010	0.00005	0.00001
	oxychlordane	0.00010	0.00010	0.00005	0.00001
	cis-nonachlor	0.00010	0.00010	0.00005	0.00001
	trans-nonachlor	0.00010	0.00010	0.00005	0.00001
	heptachlor epoxide	0.00010	0.00010	0.00005	0.00001
Hexachloro-cyclohexane	alpha BHC	0.00010	0.00010	0.00005	0.00001
	beta BHC	0.00010	0.00010	0.00005	0.00001
	delta BHC	0.00010	0.00010	NQ	NQ
	gamma BHC	0.00010	0.00010	0.00005	0.00001
Drin	dieldrin	0.00010	0.00010	0.00005	0.00001
	endrin	0.00010	0.00010	0.00005	0.00001
PCB	PCB-TOTAL	0.00010	0.00050	0.00025	0.00005
Chlorobenzenes	HCB	0.00010	0.00010	0.00005	0.00001
Other	mirex	0.00010	0.00010	0.00005	0.00001
	toxaphene	0.00010	0.00250	0.00100	0.00025

Appendix 5. Analytical limits of detection (µg/g, dry weight) and modified EPA methods used by Battelle Marine Sciences Laboratory (in parentheses) for concentrations of trace elements in sediment samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.

[NQ, element not quantified]

Element	Sampling period					
	Spring 2006	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ag (Silver)	0.22 (200.7)[1]	0.026 (200.7)	0.0327 (200.7)	0.006 (200.8)	0.0134 (200.7)	0.0134 (200.7)
Al (Aluminum)	2.28 (200.7)	2.03 (200.7)	2.03 (200.7)	2.03 (200.7)	2.66 (200.7)	0.87 (200.7)
As (Arsenic)	1.95 (200.7)	0.282 (200.7)	0.02 (200.8)	0.564 (200.7)	0.218 (200.7)	0.218 (200.7)
B (Boron)	0.551 (200.8)	3.62 (200.8)	3.62 (200.8)	3.62 (200.8)	0.212 (200.7)	0.212 (200.7)
Ba (Barium)	0.067 (200.7)	0.111 (200.7)	0.111 (200.7)	0.111 (200.7)	0.0614 (200.7)	0.0614 (200.7)
Be (Beryllium)	0.046 (200.7)	0.021 (200.7)	0.021 (200.7)	0.0437 (200.7)	0.0378 (200.7)	0.0378 (200.7)
Cd (Cadmium)	0.0594 (200.7)	0.004 (200.8)	0.0295 (200.7)	0.0542 (200.7)	0.0139 (200.7)	0.0139 (200.7)
Co (Cobalt)	0.019 (200.8)	0.0023 (200.8)	0.0023 (200.8)	0.2 (200.7)	0.0203 (200.7)	0.0203 (200.7)
Cr (Chromium)	0.076 (200.7)	0.162 (200.7)	0.162 (200.7)	0.162 (200.7)	0.137 (200.7)	0.137 (200.7)
Cu (Copper)	0.178 (200.7)	0.186 (200.7)	0.186 (200.7)	0.186 (200.7)	0.0577 (200.7)	0.0577 (200.7)
Fe (Iron)	0.385 (200.7)	0.944 (200.7)	0.944 (200.7)	0.944 (200.7)	0.638 (200.7)	0.638 (200.7)
Hg (Mercury)	0.003 (245.5)	NQ	NQ	NQ	NQ	NQ
Mn (Manganese)	0.047 (200.7)	0.0286 (200.7)	0.0286 (200.7)	0.0286 (200.7)	0.0165 (200.7)	0.022 (200.7)
Mo (Molybdenum)	0.0602 (200.7)	0.06 (200.7)	0.052 (200.7)	0.12 (200.7)	0.0253 (200.7)	0.0253 (200.7)
Ni (Nickel)	0.219 (200.7)	0.331 (200.7)	0.331 (200.7)	0.331 (200.7)	0.14 (200.7)	0.14 (200.7)
Pb (Lead)	1.1 (200.7)	1.22 (200.7)	1.22 (200.7)	1.22 (200.7)	0.759 (200.7)	0.759 (200.7)
Sb (Antimony)	0.668 (200.7)	0.1 (200.8)	0.405 (200.7)	0.018 (200.8)	NQ	NQ
Se (Selenium)	1.04 (200.7)	0.00838 (7742)	0.00838 (7742)	0.00838 (7742)	0.0232 (7742)	0.005 (7742)
Sn (Tin)	0.049 (200.8)	0.1 (200.8)	0.009 (200.8)	0.1 (200.8)	NQ	NQ
Tl (Thallium)	0.362 (200.7)	0.0027 (200.8)	0.0027 (200.8)	0.0027 (200.8)	NQ	NQ
V (Vanadium)	0.117 (200.7)	0.221 (200.7)	0.221 (200.7)	0.221 (200.7)	0.258 (200.7)	0.202 (200.7)
Zn (Zinc)	0.108 (200.7)	0.0936 (200.7)	0.0936 (200.7)	0.0936 (200.7)	0.0558 (200.7)	0.0558 (200.7)

[1]200.7 = inductively coupled plasma optical emissions spectrometry (ICP-OES); 200.8 = inductively coupled plasma-mass spectrometry (ICP-MS); 7742 = hydride generation atomic absorption - flow injection atomic spectroscopy (HGAA-FIAS); 245.5= cold vapor atomic fluorescence (CVAF).

Appendix 6. Limits of detection (µg/g, dry weight) for organochlorine compounds in sediment samples, Ecosystem Monitoring Project, Salton Sea, California, spring 2006–fall 2008.

[Sampling period: Spring 2008 samples were not analyzed for non-DDT compounds. NQ, compound not quantified]

Organochlorine group	Compound	Sampling period: Spring 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
DDT	*p,p'* DDD	0.002	0.002	0.002	0.002	0.002
	p,p' DDE	0.002	0.002	0.002	0.002	0.002
	p,p' DDT	0.002	0.002	0.002	0.002	0.002
	o,p' DDD	0.002	0.002	0.002	0.002	0.002
	o,p' DDE	0.002	0.002	0.002	0.002	0.002
	o,p' DDT	0.002	0.002	0.002	0.002	0.002
Chlordane	alpha chlordane	0.002	0.002	0.002	NQ	0.002
	gamma chlordane	0.002	0.002	0.002	NQ	0.002
	oxychlordane	0.002	0.002	0.002	NQ	0.002
	cis-nonachlor	0.002	0.002	0.002	NQ	0.002
	trans-nonachlor	0.002	0.002	0.002	NQ	0.002
	heptachlor epoxide	0.002	0.002	0.002	NQ	0.002
Hexachloro-cyclohexane	alpha BHC	0.002	0.002	0.002	NQ	0.002
	beta BHC	0.002	0.002	0.002	NQ	0.002
	delta BHC	0.002	0.002	0.002	NQ	NQ
	gamma BHC	0.002	0.002	0.002	NQ	0.002
Drin	dieldrin	0.002	0.002	0.002	NQ	0.002
	endrin	0.002	0.002	0.002	NQ	0.002
PCB	Total PCBs	0.010	0.010	0.010	NQ	0.010
Chlorobenzene	HCB	0.002	0.002	0.002	NQ	0.002
Other	mirex	0.002	0.002	0.002	NQ	0.002
	toxaphene	0.050	0.050	0.050	NQ	0.050

Appendix 7. Analytical limits of detection (µg/g, dry weight) and modified EPA methods used by Battelle Marine Sciences Laboratory (parentheses) for concentrations of trace elements (µg/g) in invertebrate samples collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[NQ, element not quantified]

	Sampling period				
	Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
Ag (Silver)	0.0387 (200.7)[1]	0.0387 (200.7)	0.0387 (200.7)	0.0377 (200.7)	0.0377 (200.7)
Al (Aluminum)	0.248 (200.7)	0.248 (200.7)	0.248 (200.7)	0.325 (200.7)	0.325 (200.7)
As (Arsenic)	0.189 (200.7)	0.189 (200.7)	0.1 (200.8)	1.28 (200.7)	1.28 (200.7)
B (Boron)	0.551 (200.8)	0.551 (200.8)	0.551 (200.8)	0.126 (200.7)	0.126 (200.7)
Ba (Barium)	0.013 (200.7)	0.013 (200.7)	0.013 (200.7)	0.0192 (200.7)	0.0192 (200.7)
Be (Beryllium)	0.0034 (200.7)	0.0034 (200.7)	0.0034 (200.7)	0.0046 (200.7)	0.0046 (200.7)
Cd (Cadmium)	0.0077 (200.7)	0.0077 (200.7)	0.008 (200.7)	0.0403 (200.7)	0.0403 (200.7)
Co (Cobalt)	0.0178 (200.7)	0.0178 (200.7)	0.0178 (200.7)	0.0207 (200.7)	0.0207 (200.7)
Cr (Chromium)	0.042 (200.7)	0.042 (200.7)	0.042 (200.7)	0.0362 (200.7)	0.0362 (200.7)
Cu (Copper)	0.050 (200.7)	0.050 (200.7)	0.050 (200.7)	0.0334 (200.7)	0.0334 (200.7)
Fe (Iron)	1.53 (200.7)	1.53 (200.7)	1.53 (200.7)	0.297 (200.7)	0.297 (200.7)
Mn (Manganese)	0.0115 (200.7)	0.0115 (200.7)	0.0115 (200.7)	0.0088 (200.7)	0.0088 (200.7)
Mo (Molybdenum)	0.0403 (200.7)	0.0403 (200.7)	0.0403 (200.7)	0.0662 (200.7)	0.0662 (200.7)
Ni (Nickel)	0.0217 (200.7)	0.0227 (200.7)	0.0217 (200.7)	0.0617 (200.7)	0.0617 (200.7)
Pb (Lead)	0.138 (200.7)	0.138 (200.7)	0.138 (200.7)	0.273 (200.7)	0.273 (200.7)
Sb (Antimony)	0.165 (200.7)	0.165 (200.7)	0.0123 (200.8)	0.165 (200.7)	0.256 (200.7)
Se (Selenium)	0.194 (200.8)	0.194 (200.8)	0.194 (200.8)	0.0124 (7,742)	0.0082 (7,472)
Sn (Tin)	0.0491 (200.8)	0.0491 (200.8)	0.0491 (200.8)	NQ	NQ
Tl (Thallium)	0.200 (200.7)	0.200 (200.7)	0.0015 (200.8)	0.244 (200.7)	0.244 (200.7)
V (Vanadium)	0.034 (200.7)	0.034 (200.7)	0.034 (200.7)	0.0411 (200.7)	0.0411 (200.7)
Zn (Zinc)	0.110 (200.7)	0.110 (200.7)	0.110 (200.7)	0.063 (200.7)	0.063 (200.7)

[1]200.7 = inductively coupled plasma optical emissions spectrometry (ICP-OES); 200.8 = inductively coupled plasma-mass spectrometry (ICP-MS); 7742 = hydride generation atomic absorption - flow injection atomic spectroscopy (HGAA-FIAS).

Appendix 8. Limits of detection (µg/g, wet weight) for organochlorine compounds in invertebrate samples, Ecosystem Monitoring Project, Salton Sea, California, fall 2006–fall 2008.

[NQ, compound not quantified]

Organochlorine group	Compound	Sampling period				
		Fall 2006	Spring 2007	Fall 2007	Spring 2008	Fall 2008
DDT	*p,p'* DDD	0.002	0.002	0.002	0.002	0.002
	p,p' DDE	0.002	0.002	0.002	0.002	0.002
	p,p' DDT	0.002	0.002	0.002	0.002	0.002
	o,p' DDD	0.002	0.002	0.002	0.002	0.002
	o,p' DDE	0.002	0.002	0.002	0.002	0.002
	o,p' DDT	0.002	0.002	0.002	0.002	0.002
Chlordane	alpha chlordane	0.002	0.002	0.002	NQ	0.002
	gamma chlordane	0.002	0.002	0.002	NQ	0.002
	oxychlordane	0.002	0.002	0.002	NQ	0.002
	cis-nonachlor	0.002	0.002	0.002	NQ	0.002
	trans-nonachlor	0.002	0.002	0.002	NQ	0.002
	heptachlor epoxide	0.002	0.002	0.002	NQ	0.002
Hexachloro-cyclohexane	alpha BHC	0.002	0.002	0.002	NQ	0.002
	beta BHC	0.002	0.002	0.002	NQ	0.002
	delta BHC	0.002	0.002	0.002	NQ	NQ
	gamma BHC	0.002	0.002	0.002	NQ	0.002
Drin	dieldrin	0.002	0.002	0.002	NQ	0.002
	endrin	0.002	0.002	0.002	NQ	0.002
PCB	Total PCBs	0.010	0.010	0.010	NQ	0.010
Chlorobenzene	HCB	0.002	0.002	0.002	NQ	0.002
Other	mirex	0.002	0.002	0.002	NQ	0.002
	toxaphene	0.050	0.050	0.050	NQ	0.050

Appendix 9. Analytical limits of detection (µg/g, dry weight) and modified EPA methods used by Battelle Marine Sciences Laboratory (values in parentheses) for concentrations of trace elements (mg/g) in fresh Black-necked Stilt eggs collected from saline habitat ponds (SHP) and reference sites, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.

[NQ, element not quantified]

Element	Sampling period		
	2006	2007	2008
Ag (Silver)	0.0387 (200.7)[1]	0.0387 (200.7)	0.0377 (200.7)
Al (Aluminum)	0.248 (200.7)	0.248 (200.7)	0.325 (200.7)
As (Arsenic)	0.189 (200.7)	0.189 (200.7)	1.28 (200.7)
B (Boron)	0.551 (200.8)	0.33 (200.8)	0.126 (200.7)
Ba (Barium)	0.013 (200.7)	0.013 (200.7)	0.0192 (200.7)
Be (Beryllium)	0.0034 (200.7)	0.0034 (200.7)	0.0046 (200.7)
Cd (Cadmium)	0.0077 (200.7)	0.0077 (200.7)	0.0403 (200.7)
Co (Cobalt)	0.0178 (200.7)	0.0178 (200.7)	0.0207 (200.7)
Cr (Chromium)	0.042 (200.7)	0.042 (200.7)	0.0362 (200.7)
Cu (Copper)	0.050 (200.7)	0.050 (200.7)	0.0334 (200.7)
Fe (Iron)	1.53 (200.7)	1.53 (200.7)	0.297 (200.7)
Mn (Manganese)	0.0115 (200.7)	0.0115 (200.7)	0.0088 (200.7)
Mo (Molybdenum)	0.0403 (200.7)	0.0403 (200.7)	0.0662 (200.7)
Ni (Nickel)	0.0217 (200.7)	0.0227 (200.7)	0.0617 (200.7)
Pb (Lead)	0.138 (200.7)	0.138 (200.7)	0.273 (200.7)
Sb (Antimony)	0.165 (200.7)	0.0123 (200.8)	0.256 (200.7)
Se (Selenium)	0.194 (200.8)	0.194 (200.8)	0.0082 (7742)
Sn (Tin)	0.0491 (200.8)	0.010 (200.8)	NQ
Tl (Thallium)	0.200 (200.7)	0.200 (200.7)	0.244 (200.7)
V (Vanadium)	0.034 (200.7)	0.034 (200.7)	0.0411 (200.7)
Zn (Zinc)	0.110 (200.7)	0.110 (200.7)	0.063 (200.7)

[1]200.7 = inductively coupled plasma optical emissions spectrometry (ICP-OES); 200.8 = inductively coupled plasma-mass spectrometry (ICP-MS); 7742 = hydride generation atomic absorption - flow injection atomic spectroscopy (HGAA-FIAS).

Appendix 10. Limits of detection (µg/g, wet weight) for organochlorine compounds in fresh Black-necked Stilt eggs, Ecosystem Monitoring Project, Salton Sea, California, May–July 2006–08.

		Sampling period		
Organochlorine group	Compound	2006	2007	2008
DDT	*p,p*' DDD	0.002	0.002	0.002
	p,p' DDE	0.002	0.002	0.002
	p,p' DDT	0.002	0.002	0.002
	o,p' DDD	0.002	0.002	0.002
	o,p' DDE	0.002	0.002	0.002
	o,p' DDT	0.002	0.002	0.002
Chlordane	alpha chlordane	0.002	0.002	0.002
	gamma chlordane	0.002	0.002	0.002
	oxychlordane	0.002	0.002	0.002
	cis-nonachlor	0.002	0.002	0.002
	trans-nonachlor	0.002	0.002	0.002
	heptachlor epoxide	0.002	0.002	0.002
Hexachloro-cyclohexane	alpha BHC	0.002	0.002	0.002
	beta BHC	0.002	0.002	0.002
	delta BHC	0.002	0.002	0.002
	gamma BHC	0.002	0.002	0.002
Drin	dieldrin	0.002	0.002	0.002
	endrin	0.002	0.002	0.002
PCB	Total PCBs	0.010	0.010	0.010
Chlorobenzene	HCB	0.002	0.002	0.002
Other	mirex	0.002	0.002	0.002
	toxaphene	0.050	0.050	0.050

Appendix 11. Predictive Ecological Risk Assessment (PERA)

The PERA is a process of comparing measured concentrations of toxic chemicals with contaminant-specific toxicity data to derive levels that are protective of biota. The result of this process is a hazard quotient (HQ) and/or hazard index (HI) that is generated for each species of concern. For the Salton Sea Ecosystem Monitoring project, the PERA is used to evaluate the potential risk of selenium to aquatic invertebrate-consuming shorebirds. For the purposes of the PERA, exposure pathways are defined as having the following elements

a. A source and mechanism for the release of contaminant(s)
b. Affected medium (or media) that retains or transports contaminants and is accessible to biota
c. Biological receptor(s) present
d. Feasible route of exposure

The PERA is based on the following assumptions and constraints

a. Current chemical concentrations are present at a steady state and will not change over time.
b. The media of primary ecological concern are sediments within 5 cm of the ground surface, surface water shallower than 1-meter, and also, biological prey.
c. Chemicals not detected are not present, assuming appropriate detection limits.
d. The toxicological information used represents information currently available from literature and database searches.
e. Aquatic organisms are exposed to contaminants via ingestion or direct contact with surface water or sediment.

ASSESSMENT ENDPOINTS

Ecological Relevance

The Black-necked Stilt (*Himantopus mexicanus*) was selected as the assessment endpoint because it is directly tied to the structure and function of the ecosystem at risk. The structure and function of the ecosystem at risk influence the degree and rate of its recovery. Ecologically relevant criteria include

a. Upper-trophic-level species
b. Important prey species
c. Species important to ecosystem structure and function
d. Species with high potential for exposure
e. Species susceptible to bioaccumulation or biomagnification

Toxicological Relevance

The black-necked stilt was selected to determine risks to receptors or habitat from contaminants that were measured using existing data. Assessment endpoints are designed to protect populations of vertebrate wildlife, particularly wide-ranging species and their prey, and the important habitat of Salton Sea, including lower trophic terrestrial and aquatic plants and invertebrates from acute (that is, mortality) or chronic (for example, reproductive, growth, or behavioral impairment).

Measurement of Endpoints

For the Salton Sea Ecosystem Monitoring project PERA, measurement endpoints include evidence of chronic effects such as reproductive, morphological, or physiological impairment in black-necked stilts. Literature-derived no-observable-adverse-effect levels or NOAELs were used to measure the potential for these adverse chronic effects to occur from direct and secondary exposure to site-related selenium. Field observations and measurements provided a weight-of-evidence approach to qualitatively assess measurement endpoints during this risk assessment.

QUANTITATIVE RISK ASSESSMENT FOR BIOTA

Functional groupings and representative species at the Salton Sea

The black-necked stilt (aquatic invertebrate consuming shorebird) was selected for the PERA's toxicity evaluations. The criteria for this selection included:

- Species considered essential to or indicative of healthy functioning ecosystems
- Species vital to the structure and function of the food web (for example, principal prey or top-trophic-level predators)
- Species that are representative of entire guilds
- Species for which toxicological data are available in the literature
- Species for which completed exposure pathways can be developed
- Species considered sensitive or of special status by federal or state regulatory agencies or that can be considered surrogates for these species

Exposure pathways

An exposure pathway is the means by which a representative species comes into contact with and ingests, inhales, or absorbs contaminants of ecological concern (COECs). A complete exposure pathway must include the four elements listed in section 1.2. If any of the four elements are determined to be absent, the pathway is considered incomplete. The only exception is that a transport mechanism may be absent, and the pathway is still considered complete if the ecological receptor is in direct contact with the release point of the COEC. Exposure of ecological receptors to COECs may be direct (that is, primary pathway) or indirect (that is, secondary pathway, for example, exposure through prey).

Ingestion is the primary route of exposure that will be evaluated for stilts. Inhalation and dermal routes of exposure are assumed to be negligible for aquatic birds and will not be assessed. Pathways of exposure that estimate the quantities of chemicals in contact with stilts include:

Food Webs

COECs may be transferred through ingestion of affected prey. Receptors, with the exception of primary producers, may be exposed to COECs through the consumption of contaminated food items. Black-necked stilts may be exposed to chemicals accumulated by prey species (for example, aquatic invertebrates). Receptors may also ingest sediment suspended in the water column while drinking surface waters, but this pathway is considered minimal because of the duration of exposure. Lower-trophic-level aquatic receptors may be directly exposed to sediment-associated contaminants by physical contact or ingestion, and by osmotic exchange, respiration, or ventilation of sediments in the water column or in pore water

SELECTION AND USE OF TOXICITY DATA

Ecological assessment of toxicity effects

Reference concentrations (RfCs) refer to concentrations of chemicals in media (for example, sediment, invertebrates, or water) where there are established no-observable-effect levels (NOELs) or NOAELs. Reference doses (RfDs) refer to concentrations of chemicals in media that when ingested or dermally applied are associated with no adverse effect.

Uncertainty factors will be used to adjust various available toxicity criteria to produce no-observed-effect toxicity criteria. Research on different species of birds exposed to 37 pesticides found that LC50s for the different species were approximately the same. Therefore, an uncertainty factor of 1 was the most appropriate between all classes of birds (Mineau and others, 1996). Based on guidance from DTSC (1996), the following uncertainty factors were used:

- Test species within the same taxonomic genus $UF_1 = 1$
- Test genera within the same taxonomic family $UF_1 = 1$
- Test families within the same taxonomic order $UF_1 = 5$
- Test order within the same taxonomic class $UF_1 = 10$

An effects level uncertainty factor (UF_2) is used to adjust toxicity criteria representing various effects levels to the equivalent of a NOAEL so that they could be used as RfDs or RfCs. *UF2* values (DTSC 1996) are recommended for lethal doses or concentrations (LD_{50}, LC_{50}), lowest-observable-effect levels (LOEL), or lowest-observed-adverse-effect level (LOAEL) as follows:

Lethality (LD_{50}, LC_{50}) to $NOAEL_{chronic}$	UF_2	= 500
Nonlethal but toxic effects (e.g., $LOAEL_{acute}$ or EC_{50} to $NOAEL_{chronic}$)	UF_2	= 10
$LOAEL_{chronic}$ or LOEL to $NOAEL_{chronic}$	UF_2	= 5

CALCULATION OF ESTIMATES OF EXPOSURE

Daily Dosage for Aquatic-Associated Shorebird (Invertebrate Consumer)

The black-necked stilt was selected as the representative species—a shorebird that utilizes both terrestrial and aquatic-associated habitats. As secondary consumers, stilts represent exposure routes involving potential bioaccumulation of contaminants and food-web transfer. Ingestion of contaminated aquatic invertebrates is the primary route of exposure with incidental ingestion of sediments. The exposure model for ingestion is

$$Di_{BNS} = \{[(C_i \times R_d \times Fi) + (EC_s \times R_d \times F_s)] \div BW_{BNS}\} \times T_f$$

Where

Di_{BNS}	=	daily dosage from ingestion
C_i	=	concentrations of potentially toxic chemicals in invertebrates
R_d	=	intake rate for black-necked stilt
F_i	=	fraction of invertebrates in black-necked stilt diet
C_p	=	concentrations of potentially toxic chemicals in plants
F_p	=	fraction of plant in black-necked stilt diet
EC_s	=	concentrations of potentially toxic chemicals in sediment
F_s	=	fraction of soil in black-necked stilt diet
BW_{BNS}	=	mean body weight of black-necked stilt
T_f	=	fractional intake, or fraction of time spent in contact with contaminated sediments

Black-necked stilts both winter (September–February) and breed (May–August) at the Salton Sea. As it is not known whether breeding birds are yearlong residents, fractional intake is estimated conservatively at 1.0 for permanent aquatic habitat. However, concentrations of selenium in eggs generally represent recent (for example, < 1 month) dietary exposure. The exposure factors for the black-necked stilt are presented below.

Parameter	Value	Reference
General		
Body Weight (kg)	0.1696[a]	Robinson and Oring, 1996
Foraging Area (ha)	no information	Rigney, 2001 • assume site use factor of 1.0
Soil and Food Ingestion		
Dietary Intake [mg/day(dry wt)]	1.4219 × 104	Derived from U.S. Environmental Protection Agency, 1993[b]
Soil Diet Proportion	0.160	Derived from Hui and Beyer, 1998 • assume ingestion is incidental based on feeding behaviors (for example, probing, pecking)
Plant Diet Proportion	0.011	Robinson and Oring, 1996
Animal Diet Proportion	0.949	Derived from Robinson and others, 1992
Water Intake (L/day)	0	Hamilton (1975)

[a] = Mean value

[b] = Dietary Intake (DI) calculated using equation [3-5]: DI (g/day) = 0.301 Wt0.751 (g)

Hazard Quotients for Aquatic-Associated Shorebird (Invertebrate Consumer)

A hazard Quotient (HQ) is the ratio of the estimated exposure to the toxicity reference values (TRV, U.S. Geological Survey, 2001b):

$$HQ = \frac{\text{Estimated Exposure}}{\text{TRV}}$$

The implicit assumption in characterizing risk is that, based on the estimated potential effects on individuals, inferences or extrapolations can be made to assessment endpoints or population-level effects. Chronic NOAEL-based HQs that exceed one suggest that adverse effects are possible to sensitive individuals, while chronic LOAEL-based HQs that exceed one suggest that adverse effects to most individuals are likely.

UNCERTAINTY EVALUATION

Uncertainties, which may lead to either overstatements or understatements of risk, are possible with any risk assessment methodology. Consistently conservative approaches in selecting literature values were used, and descriptions of the limitations of using any values chosen were provided.

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