Assessment of Natural Resource Injuries to Birds at Searles Lake

1998 to 2001

San Bernardino County, CA

Prepared by:

Steve Hampton, Ph.D.,
Julie Yamamoto, Ph.D.,
California Department of Fish and Game - Office of Spill Prevention and Response
Denyse Racine
California Department of Fish and Game – Eastern Sierra and Inland Deserts Region

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A. INTRODUCTION AND SCOPE OF THIS ASSESSMENT

At Searles Lake in San Bernardino County, California, IMC Chemicals (IMCC) conducts mining of the brine solution that constitutes the groundwater under the lake bed. As part of the mining process, IMCC discharges approximately 20 million gallons of this water per day, some of it mixed with other constituents, onto the surface of the lake bed. The resulting ponds cover over 1,000 acres, or approximately two square miles. These hypersaline waters measure over 110 degrees Fahrenheit in places, and contain over 600 parts per thousand (ppt) salt. For comparison, sea water contains 35.5 ppt sodium, and Mono Lake (California) contains 78 ppt salt. Since the California Department of Fish and Game (DFG) began investigating in January of 2000, we have become aware of on-going mortality to grebes, ducks, and other birds that are attracted to the open water bodies. Since that time, over 600 dead and dying birds, representing at least 35 different species, have been collected. Analysis of the dead birds suggests that some of the causes of death have been salt toxicosis, salt encrustation, and oiling. Based on analyses of water samples taken by CDFG from IMCC ponds, potential contaminants of concern include nonylphenol, petroleum hydrocarbons (e.g., lube oil, kerosene, diesel, PAHs), arsenic, and sodium. Formaldehyde is also believed to be a potential component of the effluent from mining operations.

This report details an assessment of the natural resource injuries that have occurred at Searles Lake in the years 1998, 1999, 2000, and 2001, as well as those injuries that are presumed to occur through the end of 2001. This report focuses only on the injuries to birds and the habitat value of Searles Lake to birds.

B. NATURAL RESOURCE INJURIES

On maps and in most geographical references, Searles Lake is referred to as a dry lake. Because the lake bed has been used for mining purposes for over 100 years, its surface has been significantly altered through the construction of ponds and levees. This has resulted in permanent ponds of substantial size. The Percolation Pond covers approximately 1,000 acres, while the Dredge Pond occupies over 200 acres. Other ponds are more ephemeral and depend upon both climatic conditions and industrial operations.

1. Bird usage and natural mortality

The ponds at Searles Lake are seemingly attractive to birds in migration. Intensive bird surveys by Eremico Biological Services were conducted from September 2000 through September 2001 (LaBerteaux, 2001b). The surveys were conducted twice a week in migration and once a week during other times of the year. The surveyed area included all of the main ponds and many of the side ponds. The aim of each survey was to count every bird possible. The results provide a good understanding of bird use at Searles Lake through the year.

The birds that visit Searles Lake may be divided into two categories: at-risk migrants and

resident or low-risk species. Loons, grebes, cormorants, and waterfowl migrate through the area and represent nearly all of the dead birds; these are the at-risk species. Shorebirds (including nesting Snowy Plovers and American Avocets, as well a various other species in migration) are seemingly at low risk. These birds tend to congregate at relatively clean water outflows and have not experienced the high mortality rates of the other species. Ravens are also common at the ponds throughout the year, scavenging on the dead birds.

The Eremico surveys provide an estimate of the number of birds by species for each day. We have taken the birds/per day estimates for each day that surveys were conducted and extrapolated that estimate to the rest of the month. We have then evaluated the monthly usage by species. Focusing on the at-risk species, the surveys suggest that over 2,000 waterbirds use the ponds each year. Table 1 below summarizes the data.

Table 1: Estimated Number of Birds Using Searles Lake Each Month

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Eared Grebe	0	0	0	117	12	15	0	0	0	357	8	0	**507**
Blue-winged & Cinnamon Teal	0	0	0	3	58	20	19	175	132	0	45	39	**491**
Mallard	0	0	0	3	0	30	74	14	60	20	30	0	**231**
Am. Wigeon	0	0	0	0	12	0	0	0	60	58	0	0	**130**
Gadwall	0	0	0	0	0	10	0	0	8	97	8	0	**122**
Canvasback	0	0	0	3	0	0	0	48	49	0	15	0	**115**
Duck, sp./other	0	42	0	33	23	15	43	62	49	167	179	15	**632**
TOTAL	**0**	**42**	**0**	**160**	**105**	**90**	**136**	**299**	**358**	**699**	**285**	**54**	**2229**

These surveys show that a wide variety of species frequent the lake, primarily in spring and fall migration. Eared Grebes dominate among the spring migrants, while ducks in post-breeding dispersal and fall migration account for most of the rest of the birds.

These surveys imply that approximately 2,229 birds (i.e. loons, grebes, ducks) pass through Searles Lake each year. Note that these are bird user-days. However, given that the surveys are conducted three to seven days apart, it is likely that very few of these birds were counted twice.

This information allows us to estimate the potential rate of natural mortality at Searles Lake. For most of these species, the life expectancy of birds in their first or even second year is around 2.5 years. Conservatively, assume that life expectancy is 2 years. [1] If birds have an equal probability of dying on any given day, some would die tomorrow and some would die in 4 years,

[1] In reality, a Leslie matrix using demographic parameters for a Mallard suggest that life expectancy is 1.95 years for juveniles and 2.50 years for adults.

with the average life expectancy being death in 2 years. There are 1,460 days in four years. This implies that the odds of dying on any one day is 1 in 1,460.

We must then assess the number of days a migrating bird would spend at Searles Lake. Given the lack of food resources for waterfowl, as well as the toxic condition of the water, it is unlikely that a bird would stay longer than two days. With 2,229 birds passing through the area each year, and each staying 2 days, there would be 4,458 bird-days of visits. If the odds of a bird dying under normal natural probabilities is 1 in 1,460, then we would expect 3 birds per year to die of natural causes while they are passing through Searles Lake.

Given the fact that these birds are migrating over the desert, it is reasonable to assume that natural mortality would be higher than average. Even assuming a natural mortality rate five times greater than average, only 15 birds per year would die of natural causes at Searles Lake. This represents a very small number relative to the total number of dead birds collected at the lake.

Comparison of bird mortalities at other more natural saline desert lakes suggest that mortality at Searles Lake is highly elevated. For example, at Badwater in Death Valley, only one dead salt encrusted duck has ever been found.

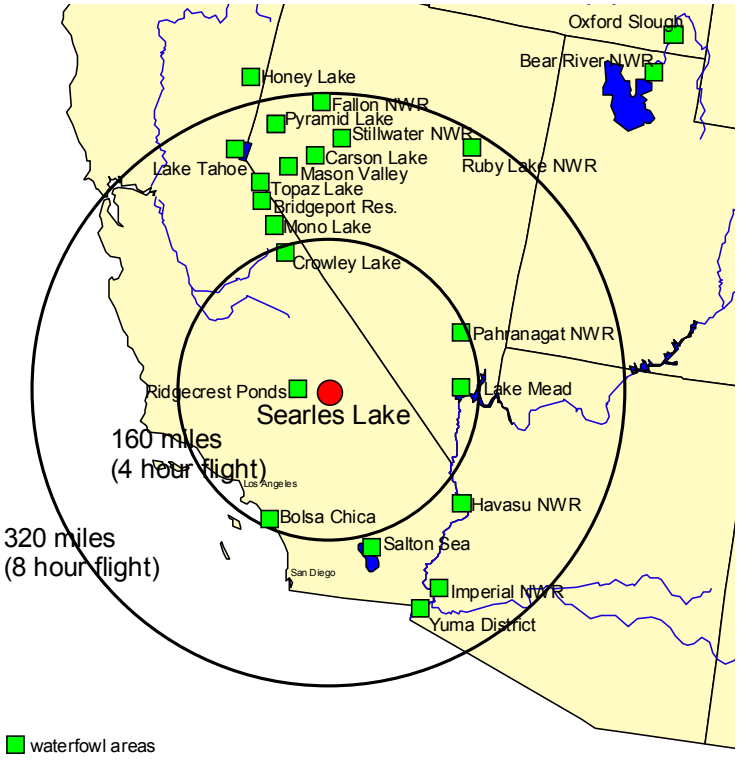
2. Observed impacts to birds

Response crews began collecting birds on January 18, 2000. During the course of the year, search effort for birds increased, resulting in the discovery of many dead and dying birds. Simultaneously, IMCC began implementing hazing and bird rehabilitation, which prevented some bird deaths. From January 18, 2000 through September 30, 2001, 642 birds (alive and dead) were collected from the ponds and adjacent areas. 505 of those were alive or are assumed to have been relatively fresh at the time of collection. The remaining 137 are assumed to have been old carcasses that may pre-date the response period and are thus not useful for estimating annual mortality. Of the 505 fresh birds collected, 254 were found dead and 251 were collected alive and transferred to rehabilitation. Of the 251 birds collected alive, at least 100 of those died later. This amounts to a total of 354 fresh dead birds over the period. Appendix A lists all the birds by species along with the number collected alive and dead.

These birds are primarily ducks and grebes. The most common species impacted, in order of the number recovered, are Mallard, American Coot, Blue-winged and Cinnamon Teal (combined), Redhead, Lesser Scaup, Western and Pied-billed Grebe (tied), and Eared Grebe. It is supposed that these birds were attempting to use Searles Lake as a migratory resting stop. These birds likely come from various wetland complexes in the Great Basin region, as well as from points farther north. They likely winter at the Salton Sea, along the southern California coast, and in Mexico. Figure 1 shows the location of Searles Lake relative to important wetland areas for waterfowl. The concentric circles highlight the distance that a duck or grebe, flying at 40 mph, could fly in four hours and eight hours. Most of the areas to the north are breeding grounds for waterfowl, while most of the areas to the south are used primarily as wintering grounds. Thus,

Searles Lake is well within the normal migration corridor for species utilizing these wetlands.

Figure 1: Searles Lake Location Relative to Wetlands in the Migration Corridor



3. Total impacts to birds

The Trustees believe that many of the birds that die at Searles Lake are never discovered by response crews. Many factors play a role in this: 1) coyotes and ravens are common in the area and scavenge the birds before crews can find them;[2] 2) birds that are not scavenged may hide in the rocks or die in remote areas and thus be missed by searchers; 3) salt encrusted birds may sink and not be discovered.

The Trustees have estimated the actual mortality as a function of the number of birds found by response crews. This use of a multiplier is commonly employed in estimating wildlife mortality due to pollution events (see Page et al. 1990). For the sake of this injury assessment, we assume that the multiplier is 2.86; that is, that the true number of dead birds is 2.86 times the number of dead birds found at the site, plus the number of birds that die in rehab.[3] Note that the multiplier

2. Note also that Eared Grebes, while they visit the ponds in the largest numbers, are collected rather infrequently. This is likely due to their rather small size, which makes them difficult to see once beach and, more importantly, possible for a raven to carry to another location.

3. This multiplier was derived based on the following assumptions: 80% of the birds that die arrive at Searles Lake at night, while 20% of those that die

is not applied to the birds collected alive and released to unknown fates. This implies an assumption that 100% of live birds on the water are found by bird rescue crews. The calculation of total bird mortality can be expressed as:

Total bird mortality = (# of birds found dead x 2.86) + # of birds that die in rehab.

Inserting the actual numbers of birds, we have:

826 = (254 x 2.86) + 100.

These numbers reflect the period January 18, 2000 to September 30, 2001, a period of 621 days. The next step is to put this mortality estimate into annual terms. Adjusted to one year, this results in a total mortality of 486 birds per year. Appendix A lists the estimated annual kill by species.

IMCC has taken several steps to reduce bird mortality. Some passive bird hazing devices (e.g., noise-making devices) have been set up around the ponds. Also, in an effort to lure birds away from the pond and to provide them with water for rehydration, IMCC has constructed a "rinse pond" using brackish water. This pond, however, is only one acre in size, and is thus not as attractive from the air as the 1000-acre Percolation Pond. The data suggest that approximately 8% of the at-risk waterbirds do find the Rinse Pond and use it. As a whole, annual mortality did decline slightly as a result of these measures. However, the decline was relatively small and may simply be a function of natural variation. Given that there are only two years of data to compare, it is not clear that these measures have been successful.

4. Toxicological Investigations

Previous toxicological analyses

In June, 2000, CDFG submitted carcasses of ducks collected from IMCC ponds to the USGS National Wildlife Health Center (Madison, Wisconsin) for pathological analyses. The brains of six ducks were analyzed for sodium concentrations, all of which were found to contain elevated sodium concentrations consistent with toxicity and lethality. Normal concentrations of sodium in the brain are cited in the National Wildlife Health Center report as ranging from 1,200-1,400 parts per million (ppm). The sodium concentrations in the six duck brains ranged from 1,850 to 2,940 ppm. These ducks represented samples from three sites at IMCC: the Dredge Pond,

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arrive in the day. This assumption is driven by our knowledge that these birds are primarily nocturnal migrants attempting to use Searles Lake as a migratory resting spot. Of the birds that arrive at night and die at the lake, 25% of them are discovered by response crews. Of the birds that arrive in the day, 75% are found by response crews. This assumption is based on our knowledge of the site characteristics, our experience in other contexts, the time it takes birds to die, and anecdotal observations of search efficiency by response crews. These assumptions, taken together, imply a multiplier of 2.86.

Percolation Pond, and Outflow Area. Other diagnostic tests included cholinesterase analyses, infectious diseases (botulism type C, avian cholera), and parasites; none of these were identified as being possible contributing factors to mortality.

During approximately the same period (August, 2000), ten waterfowl (representing 7 species) collected at IMCC were also examined by a CDFG veterinary pathologist (M.A. Chechowitz, DVM; Marine Wildlife Veterinary Care and Research Center). Seven of the ten birds appeared visibly oiled (i.e., having tarry substances on feathers or wetted, slimy feathers), and four of these were later confirmed to have petroleum hydrocarbons on feathers or in bile or stomach contents (test results for the remaining three visibly oiled birds are pending). Gross and microscopic findings were consistent with salt toxicosis as described by Meteyer et al. (1997). However, sodium concentrations in the brain were not measured in these specimens. Gross and histological examination did not suggest presence of infectious or chronic diseases in any specimen; this was consistent with the finding that all ten birds were in excellent nutritional condition with relatively high fat stores. Direct toxicity of salt, with petroleum as a contributing factor (e.g., causing birds to be trapped in the hypersaline water), as well as direct toxicity of petroleum, were suggested as being potential causes of mortality in these birds.

Finally, a recent study by the CDFG (Gordus et al. 2002) documented salt toxicosis in Ruddy Ducks wintering on agricultural evaporation ponds. These ponds exhibit hypersaline conditions (>70,000 umhos/cm; up to 39,000 ppm sodium in water) less extreme than those observed at Searles Lake. Ruddy Ducks found dead in these ponds during the winter were found to have 1,890 to 3,670 ppm sodium in their brains (n = 7), whereas control Ruddy Ducks collected from a freshwater wetland in California had brain concentrations of 988 to 1,150 ppm (n=5). The latter finding suggests that free-living ducks utilizing normal salinity freshwater wetlands can exhibit lower normal brain sodium concentrations than indicated in the National Wildlife Health Center report to CDFG. Gross and microscopic findings in Ruddy Ducks with high brain sodium concentrations included conjunctivitis, lens opacity with cataract formation, vascular congestion in various organs, and myocardial and skeletal muscle degeneration. Controls did not exhibit these lesions.

IMCC-CDFG Avian Analyses, 2001-2002

Beginning in the summer of 2001, CDFG and IMCC began cooperative analyses of birds that were found dead at the IMCC plant or that died/were euthanized during rehabilitation attempts. Assessment included veterinary pathology and contaminant analyses (feather and gastrointestinal tissues analyzed for petroleum hydrocarbons, liver and serum samples analyzed for inorganic compounds). To date, most of these analyses have been completed for 28 birds, although contaminant analyses have been completed for fewer birds (15 birds have been analyzed for petroleum hydrocarbons and nonylphenol, and 19 birds have been analyzed for inorganics).

Regarding veterinary assessment of submitted birds, veterinarians with the California Animal Health and Food Safety Laboratory (CAHFS; UC Davis, CA) conducted gross and microscopic

necropsy, bacteriological cultures, and brain sodium analyses for each bird and submitted individual necropsy reports. As a standard practice, CAHFS uses a threshold of 2000 ppm sodium in the brain to diagnose sodium toxicosis in submitted birds. Discussions between CDFG Senior Toxicologist Julie Yamamoto and CAHFS veterinary staff indicate that this threshold is "somewhat arbitrary" and based on a small amount of data, primarily from captive domestic poultry. Given these uncertainties, CDFG used relevant studies from the literature to inform interpretations of brain sodium concentrations (Meteyer et al 1997; Gordus et al. 2002). Another source of uncertainty results from the fact that some submitted birds (found alive) were treated with supportive fluids by bird rescue staff prior to dying or being euthanized; according to CAHFS veterinarians, such treatment is likely to confound the use of brain sodium as a diagnostic tool.

Of the 28 birds submitted for analyses, brain sodium concentrations were measured for 26. Of the 26, 16 exhibited brain sodium concentrations (range 1,780-5,310) consistent with salt toxicosis, based on previous studies of wild birds (Meteyer et al 1997; Gordus et al. 2002). Ten of these were found with salt-encrusted feathers, and three were visibly oiled (i.e., having a black substance adhering to feathers or having feathers that were wetted and coated with a film). In addition, two of these were passerines (dove species), suggesting a sodium exposure pathway for terrestrial, as well as aquatic, birds at the IMCC facility.

Of the remaining ten birds, five had elevated brain sodium concentrations, based on those reported for control captive ducks given fresh drinking water (1,305 and 1,413 ppm; Meteyer et al. 1997). All of these birds had been found alive and treated with fluids prior to euthanasia, such that it is possible that brain sodium in these birds was higher prior to fluid treatment. As indicated above, this treatment while the birds were alive renders post-mortem measurements of brain sodium difficult to interpret with respect to sodium toxicity. One of the five was assigned a presumptive cause of mortality (renal gout) by the CAHFS veterinarian, whereas the other four had inconclusive diagnoses. Three of these five birds were found with salt-encrusted feathers.

The remaining five birds had brain sodium concentrations exceeding those measured in wild ducks collected from a freshwater wetland in California (1,150 ppm; Gordus et al. 2002). All five birds had also been treated prior to euthanasia, and none were found to exhibit pathological signs indicative of a cause of mortality. Two of these five birds were visibly oiled.

In summary, CAHFS analyses suggest that the majority of birds submitted had abnormally high levels of brain sodium that likely contributed to morbidity and mortality of these birds. This finding is supported by previous veterinary diagnoses (National Wildlife Health Center and CDFG Wildlife Veterinary Care and Research Center) of birds collected at IMCC. Given the extreme hypersaline conditions at IMCC ponds, and the relatively rapid onset of sodium toxicosis and accumulation in the brain of birds exposed to these types of conditions (Meteyer et al. 1997), it is reasonable to conclude that salt toxicosis observed in birds collected on IMCC ponds results from the direct exposure to high levels of sodium in pond waters.

Regarding contaminant analyses of a subset of submitted birds, CDFG's final assessment of their contribution to bird injury, if any, will be addressed elsewhere. Based on preliminary review of the data, CDFG does not believe at this time that concentrations of organic or inorganic compounds, other than sodium, measured in tissues of submitted birds reflect lethal concentrations. This finding may change, pending further assessment of the analytical data by CDFG.

The visible oiling of five of 26 submitted birds indicates that oil exposure of birds may still be occurring at IMCC. On October 1, 2001, an oiled and moribund Sabine's Gull was observed at the ponds by CDFG staff (S. Hampton), and a visibly oiled grebe was collected by IBRRC as recently as December 4, 2001. Since the oiling of birds was identified as a potentially significant problem in 2000, IMCC has taken steps to reduce the amount of oil discharged in the ponds. These steps have included the use of booms and skimmers to collect oil, complete netting of the discharge channels on the north side of the Dredge Pond where many of the oiled birds had been collected, and measures at the plants to reduce discharges of oil. As a result, the number of oiled birds has fallen.

E. HABITAT VALUE OF SEARLES LAKE

1. Migrating loons, grebes, and waterfowl

Alkali lakes and playas in the Great Basin Desert support dense concentrations of waterbirds. These species are accustomed to migrating long distances, often over arid regions. Saline lakes provide stopovers for hundreds of thousands of phalaropes and Eared Grebes. Walker Lake (Nevada) supports one of the largest concentrations of migrating Common Loons during spring in western North America with peaks of more than 1000 birds. Up to one million Eared Grebes congregate at Mono Lake in winter and fall to molt. Searles Lake is centrally located within the flyway and would be a logical stopover point for any of these birds. In overland migration, Eared Grebes rely on stopover sites such as lakes and rivers to rest and rehydrate. Eared Grebes often take advantage of artificial environments such as settling ponds and landfill ponds. Eared Grebes are also attracted to ground lights. During a severe snowstorm in Nevada, thousands of migrating Eared Grebes landed one night, likely drawn by the lights of town, and were unable to take off again. Waterfowl are more likely to utilize saline areas during nonbreeding periods because adults have salt glands which allow them to excrete salt. These salt glands are not developed in young waterfowl. Stopover locations can change over time with changing water conditions. Areas can be abandoned by waterfowl during droughts and re-occupied when water returns.

Dabbling ducks (mallards, teal) and other species typically migrate at night. High altitude (1000'-5000') migration is common. These traits, as well as other physiological traits, allow birds to migrate long distances under arid conditions. Several migration corridors cross the Great Basin and Mojave Deserts. Concentrations of water birds are found at other sites located in arid regions such as at the Salton Sea, Owens Lake, Mono Lake, Walker Lake, and Great Salt

Lake.

Throughout the Great Basin and northern Mojave Desert, dry lakebeds become seasonally flooded when precipitation is high. Water typically runs off adjacent mountain ranges and collects in these alkali playas. Seeds, spores, eggs, estivating adult invertebrates, phytoplankton, and algae can remain dormant under the playa surface for as long as 15 years, awaiting adequate moisture. When these sites receive adequate flooding, these typically dry playa lakes can become attractive to migrating waterfowl and shorebirds. As the temporary lake dries, the water becomes saltier and saltier and the playa community retreats into the mud to wait for the next storm. Often when playa lakes stay dry for many years, the salts, which were brought to the surface as the lake evaporated, are blown away. If the surface remains dry for a long enough period of time to allow most of the salts to erode away, it will begin again as a fresh or brackish water lake when it is again flooded.

It is likely that Searles Lake functioned as many other alkali playas within the Great Basin and Mojave Deserts prior to commencement of the existing mining operation. Due to the scarcity of freshwater sources around the margins of the lake, it is probable that the playa remained dry in most years. However, during years of heavy rainfall, or during severe storms, it is likely that water did collect on the surface of Searles Lake, for short periods of time. This pattern is seen today at other nearby playa lakes such as Panamint Lake, and in Death Valley. When water collects on these lakes, they become attractive to waterfowl and migratory shorebirds looking for a stopover point. At these other locations, the invertebrate and plankton communities may still become active when the playa is flooded under the proper circumstances. It is likely that with the years of manipulation at Searles Lake, the invertebrate and planktonic community that likely did exist at some point in the past is no longer present. However, the presence of surface brine at Searles Lake does present an attractive nuisance to waterfowl, who likely perceive it as a suitable stopover point. It is probable that in historic times, when the Searles Lake playa was dry, waterfowl passed it by during their migrations, just as they pass by Panamint Lake and other desert playa lakes today when no water is present. Today, surface brine is present year round at Searles Lake. Additionally, the fluid that is present on the surface of Searles Lake is a highly concentrated brine which would not be found on the surface under natural circumstances

2. Breeding and migrating shorebirds

Playa lakes are important breeding areas for the inland population of Snowy Plover, a migratory shorebird species. Owens Lake, Mono Lake, and Great Salt Lake all have high concentrations of nesting Snowy Plovers. Smaller numbers of breeding Snowy Plovers are typically found at other playa lakes throughout the region, such as at Deep Springs Lake, and Saline Valley. Extensive surveys for Snowy Plovers conducted during the 2001 breeding season concluded that 14 breeding adults were present at Searles Lake (LaBerteaux, 2001a). Surveys this year (2002) have determined the presence of nests and broods of Snowy Plovers at Searles Lake (Joyce Schlachter, BLM, personal communication). This species depends on the presence of brine flies found at brackish water locations on alkali playas. This species breeds both along the coast and

at inland locations, where it depends on its cryptic coloration to hide from predators. It nests on bare substrate, with little to no vegetation, and lays its well-camouflaged eggs in a scrape in the sand or alkali playa surface. Other breeding shorebird species found at Searles Lake are also typically found at other alkali playas in the Great Basin and Mojave Deserts. American Avocets also nest on bare substrate, and often nest on dikes and roads adjacent to wetland sites. The presence of brine flies at the brackish water outflows at Searles Lake is necessary for the successful breeding of avocets, plovers, and other nesting shorebirds.

F. CONCLUSIONS

The wastewater ponds at Searles Lake pose a serious risk to migrating loons, grebes, and waterfowl, as well as other water-dependent species that migrate through the area. These ponds, occupying over 1,000 acres, are attractive to these birds. It is estimated that over 2,000 individuals of these species stop at the ponds each year. The water in the ponds is hypersaline and contains various potentially harmful chemicals including oil. We estimate that approximately 25% of the birds (close to 500 birds) die each year as a result of the water quality in the ponds. The most impacted species are dabbling ducks and grebes.

The ponds also include a few brackish water outflows. These areas provide foraging habitat for migrating and nesting shorebirds, including the Snowy Plover. The shorebirds seemingly avoid the more toxic wastewater ponds and do not appear to experience the mortality levels of other species.

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