THE AVIFAUNA OF THE SALTON SEA: A SYNTHESIS

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EXECUTIVE SUMMARY

The Salton Sea, as an integral part of the Río Colorado Delta region, supports large numbers and a great variety of avian species, and is arguably one of the most important wetlands to birds in North America. The Salton Sea hosts hundreds of thousands, and at times low millions, of migratory, wintering, and breeding birds and is the destination for many post-breeding birds moving north from Mexico. Populations in the Salton Sea area of a number of species – Eared Grebe, American White Pelican, White-faced Ibis, Ruddy Duck, Mountain Plover, Black Tern, and Burrowing Owl – are of regional, continental, or worldwide importance. Colonial breeding species with significant populations at the Sea include the Double-crested Cormorant, Cattle Egret, Gull-billed Tern, Caspian Tern, and Black Skimmer. The Sea also supports notable populations of a number of additional taxa of conservation concern, such as the Fulvous Whistling-Duck, Least Bittern, Wood Stork, Yuma Clapper Rail, Black Rail, Snowy Plover, and Large-billed Savannah Sparrow.

Great concern recently has been expressed about the fate of the Salton Sea ecosystem because of increasing salinity, contamination from agricultural and urban sources, disease outbreaks, and large die-offs of waterbirds. Concern is heightened because connections with other important ecosystems in western North America link the the health of populations of many species of waterbirds to that of the Salton Sea. Birds at the Sea particularly hard hit by mortality during the 1990s include the Eared Grebe (150,000 in 1992, unknown causes); American White Pelican (9,000 in 1996, botulism); Brown Pelican (1,200 in 1996, botulism); and waterfowl, shorebirds, and waders (>11,000 in 1998, avian cholera).

Although this report summarizes the important data available on species with large populations, species of conservation concern, and factors that have or may heighten mortality of birds using the Salton Sea and adjacent habitats, there are large gaps in the knowledge needed to effectively identify solutions to the problems facing the Sea. Some of this information remains unavailable from unpublished studies, but most such knowledge still needs to be gathered. Future research should continue to focus on diseases and contaminants; the reproductive success, ecology, diet, and habitat use of key species; and life history needs of species that move between the Sea and adacent agricultural habitats or to and from distant wetlands. Ongoing research and monitoring is needed to understand seasonal and long-term population dynamics and to assess the effectiveness of any large scale projects implemented to resolve the Sea's ecological problems.

INTRODUCTION

The Salton Sea, as an integral part of the Río Colorado Delta region, supports large numbers and a great variety of avian species, and arguably is one of the most important wetlands to birds in North America. A number of bird species have populations in the Salton Sea area that are of regional or continental importance in size or are highly vulnerable. Additionally, the Salton Sea serves as a vital migratory stopover and wintering area for species that breed elsewhere in western North America. Because of this connectivity, the health of populations of many species of waterbirds is linked to that of the Salton Sea. Great concern recently has been expressed about the fate of the Salton Sea ecosystem because of increasing salinity, contamination from agricultural and urban sources, disease outbreaks, and large die-offs of waterbirds (e.g., USFWS 1997a). Various proposals to deal with these problems are hampered by limited data available on the distribution, abundance, and other aspects of the ecology of birds using the Salton Sea and its surrounding habitats. In synthesizing knowledge of the avifauna of the Salton Sea, we have emphasized species with very large populations at the Sea, species with declining populations for which the Sea provides important habitat, and factors there that have or may heighten mortaily of birds. This information, along with identification of gaps in our knowledge, should aid those making management decisions or proposing further research and monitoring.

IMPORTANCE OF THE SALTON SEA TO BIRDS

The Salton Sea is an important part of the Río Colorado Delta region, including the northern Gulf of California, and contains some of the highest biological diversity in the southwestern United States (Anderson 1999, Patten 1999). This is especially true for birds. To date, 402 native and 5 non-native bird species have been recorded in the Salton Sea area, including about 100 breeding species (Appendix; see also for scientific names).

Beyond diversity of birds, the sheer number of birds using the Salton Sea at various times of the year is noteworthy, establishing it as an important component of the Pacific Flyway. In a recent 5 year period (1993-1997), the total number of birds recorded on the Salton Sea (south) and Salton Sea (north) Christmas Bird Counts (count areas described in American Birds 26:521, 1972) averaged 150,372 individuals (± 26,139 SD). While these numbers are impressive, they underestimate birds present at the Salton Sea because they cover only a part of the area. Numbers of wintering Eared Grebes alone have reached 3.5 million birds at the Salton Sea (R. McKernan pers. comm. in Jehl 1988), which in some years they may bypass (Jehl 1988). Mid-winter counts of waterfowl in the Coachella and Imperial valleys from 1978 to 1987 averaged >75,000 individuals (Heitmeyer et al. 1989). Shorebird populations at the Salton Sea from 1989 to 1995 averaged 24,000 in December, 90,000 in April, and about 85,000 individuals in August. Recent peak counts of American White Pelicans at the Salton Sea have ranged from 26,500 to 33,000 individuals (Setmire et al. 1990, McCaskie 1999), and counts of Ring-billed Gulls often exceed 20,000 (Christmas Bird Counts, eg. 1994, 1995, 1996, 1997). Counts at the Finney Lake heronry in 1992 included 12 pairs of Great Blue Herons, 140 pairs of Great Egrets, 150 pairs of Snowy Egrets, 370 pairs of White-faced Ibis, 1,300

pairs of Black-crowned Night-Herons, and 25,000+ pairs of Cattle Egrets (McCaskie 1992). Collectively these data suggest that bird populations at and immediately around the Salton Sea on almost any given day number at least in the low hundreds of thousands and at times reach the low millions of birds. Total numbers of birds that use the Salton Sea through the year are unknown because of a lack of regular comprehensive counts of all birds.

OVERVIEW OF AVIFAUNA

COLONIAL NESTING WATERBIRDS

The Salton Sea supports a diverse suite of colonial breeding waterbirds. Fourteen species, representing five families, currently breed (or have bred historically) at the Salton Sea and in adjacent habitats. These include the American White Pelican, Brown Pelican, Double-crested Cormorant, Great Blue Heron, Great Egret, Snowy Egret, Little Blue Heron, Tricolored Heron, Cattle Egret, Black-crowned Night-Heron, White-faced Ibis, Laughing Gull, California Gull, Gull-billed Tern, Caspian Tern, Forster's Tern , and Black Skimmer. Of these, the American White Pelican is extirpated as a breeder and the Little Blue and Tricolored herons are known to have bred only once.

Populations of several species of colonial breeders at the Salton Sea are of regional significance. The larger of only two *vanrossemi* Gull-billed Tern colonies in the western U. S. is well established at the Salton Sea (Parnell et al. 1995). Reviews of recent literature concerning the status of California's colonial breeding waterbirds (Carter et al. 1992, Shuford 1998) indicate that the nesting populations of Double-crested Cormorants and Caspian Terns now form some of the largest nesting aggregations of these species in the state. Additionally, in some years nearly 40% of California's breeding Black Skimmers occur at the Sea (Collins and Garrett 1996).

History of Waterbird Colonization

American White Pelicans, Double-crested Cormorants, and Great Blue Herons were among the earliest waterbird species to colonize the Salton Sea, doing so almost immediately after its formation in 1906-07 (Grinnell 1908, Dawson 1923). Documentation of nesting Gull-billed and Caspian terns (Pemberton 1927) and Laughing Gulls (Miller and van Rossem 1929) followed in the late 1920s and early 1930s. These species continued to nest regularly, although in declining numbers, until the late 1950s (Remsen 1978). After the cessation of nesting by pelicans, Caspian Terns, and Laughing Gulls on sandy islets along the southwestern shore, only Gull-billed Terns continued to nest sporadically around the south end of the Sea. Loss of nesting habitat from erosion, as a result of increasing surface elevation, was thought responsible for the cessation of nesting (Remsen 1978). The first nesting of Forster's Terns occurred in 1970 (McCaskie 1970a); subsequently, at least a few pairs have attempted to nest nearly annually along the southeast shore (K. Molina unpubl. data).

Early ornithologists documented breeding by Great Blue Herons and Great Egrets, but not by Snowy Egrets, Black-crowned Night-Herons, White-faced Ibis, and Cattle Egrets (Grinnell and Miller 1944). Cattle Egrets did not colonize the Sea until 1970 (McCaskie 1970a, Garrett and Dunn 1981). The earliest egg sets of Great and Snowy egrets in the Western Foundation of Vertebrate Zoology collection date from 1961 and 1978, respectively (M. Marin pers. comm.). By the early 1980s, Garrett and Dunn (1981) considered Great Egrets to be common breeders, whereas Snowy Egrets were thought to be declining because of competition from the rapidly expanding Cattle Egret populations. The earliest recorded nesting by Black-crowned Night-Herons occurred in 1986 (N. Hogg written comm. in Setmire et al. 1993, Salton Sea National Wildlife Refuge [SSNWR] files), although it is not clear what effort was spent looking for nesting herons in earlier years. White-faced Ibis have nested sporadically at the Salton Sea since the late 1950s; by 1978 a few pairs were nesting at both the north and south ends (Garrett and Dunn 1981). Nests of the Black Skimmer were first discovered at the Salton Sea in 1973 (McCaskie et al. 1974). Caspian Terns are now regular and abundant breeders since their recolonization of the Sea beginning in 1992 (McCaskie 1992, K. Molina unpubl. data). Most recently Brown Pelicans colonized the Salton Sea along the Alamo River delta in 1996 (McCaskie 1996) and California Gulls at the south end in 1997 (K. Molina unpubl. data).

Although not considered to represent colonization, a single pair of Little Blue Herons nested successfully near Seeley in 1979 (McCaskie 1980) as did a Tricolored Heron pair at Ramer Lake in 1994 (McCaskie 1994).

Colony Sizes and Population Trends

Figure 1 illustrates the most recent population estimates of colonial breeding birds at the Salton Sea. Species with the largest nesting populations during the last several seasons include the Cattle Egret (maximum estimate of 30,000 pairs in 1992) and Double-crested Cormorant and Caspian Tern (each with up to 2,000-3,000 pairs, SSNWR files and K. Molina unpubl. data). The latter two species have shown explosive population growth over the last three years: the cormorant after about 20 years with only sporadic evidence of nesting (Garrett and Dunn 1981) and the tern since its recolonization of the Sea in 1992 (McCaskie 1992).

Several pairs of Brown Pelicans have attempted to breed at the Sea annually since the successful nesting of up to a half dozen pairs in 1996 (McCaskie 1996, SSNWR files). The successful California Gull population established at the south end of the Sea in 1997 had nearly doubled in size, to 40 pairs, the following year. Black Skimmer colonies in excess of 300 pairs form at the north and south ends of the Sea in most years (Molina 1996), and Gull-billed Terns continue to form significant nesting populations of up to 160 pairs annually (K. Molina unpubl. data). Little information other than documentation of first nesting appears to be available for the Forster's Tern. Garrett and Dunn (1981) reported a breeding colony of Forster's Terns existing at the south end of the Salton Sea since 1970 and 200 pairs at the north end of the Salton Sea in 1978. In recent years, populations of Gull-billed Terns and Black Skimmers have been consolidated into fewer nesting sites (only 2 in 1998 vs. 5 in 1994). This trend may

reflect increased competition from the larger, more gregarious ground-nesting species, such as the Double-crested Cormorant, California Gull, and Caspian Tern.

Since at least 1986, locations of ardeid nesting colonies appear to be fluid with sometimes widely fluctuating population sizes (SSNWR files, N. Hogg unpubl. data). Snowy Egrets and Black-crowned Night-Herons showed population peaks of 1,900 and 1,500 pairs, respectively, during the 1992 and 1993 nesting seasons. Great Egrets exhibited peaks of 900 pairs in 1996, whereas Great Blue Herons reached a maximum of 360 pairs in 1998. Cattle Egret colonies consistently number in the thousands of pairs.

Nesting Habitats

The majority of nesting colonies are concentrated near the deltas of the Whitewater River at the north end of the Salton Sea and in the vicinity of the New and Alamo rivers at the south end. A large heron and egret rookery previously had formed at Finney Lake, but more recently shifted to Ramer Lake soon after the latter was rehabilitated and filled in the mid-1990s. Both lakes are units of the Imperial Wildlife Area (WA) about 10 km southeast of the Salton Sea NWR. Nesting colonies of gulls, terns, and skimmers occur on earthen levee remnants, low-lying boulder and barnacle bars and, in the case of Forster's Terns, on elevated clumps of vegetation; all are isolated by water. Herons, egrets, and ibis nest predominantly over water on stands of salt cedar and mesquite snags. Cormorants nest mostly on rock ledges, such as those on Mullet Island, but also may nest in egret and heron colonies. Like cormorants, pelicans may nest on rocky ledges or on accumulations of dead vegetation along river deltas. The Salton Sea NWR currently manages an impoundment with five small earthen islets at its headquarters, the only such protected habitat for colonial ground nesters at the Salton Sea. All other sites, except for the Finney-Ramer lakes colony, occur on private lands.

Species of Concern

In this and in subsequent sections below on Species of Concern, we conditionally treat all state and federally Threatened or Endangered species, all Bird Species of Special Concern in California (CDFG 1992), and all Migratory Nongame Birds of Management Concern in the U.S. (USFWS 1995) only if the Salton Sea or immediately adjacent habitats support these taxa for the season(s) at which they are considered at risk. For example, we do not treat taxa of concern if they occur at the Salton Sea only as stragglers away from their normal range (e.g., Black Storm-Petrel) or ones that occur principally as widespread migrants if concern has been expressed primarily for breeding populations elsewhere in the taxa's range (e.g., Yellow Warbler).

Brown Pelican. This pelican is listed as state and federally Endangered. See comments above regarding history of its breeding populations at the Salton Sea.

Double-crested Cormorant. The Double-crested Cormorant is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992). See comments above on the history of its breeding populations at the Salton Sea and those below on contaminants.

White-faced Ibis. The White-faced Ibis is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992) and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). See comments above on the history of its breeding

populations at the Salton Sea and below for its winter status and habitat use in the Imperial Valley.

Laughing Gull. The Laughing Gull is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992). See comments above on the history of its breeding populations at the Salton Sea.

California Gull. The California Gull is considered a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992), primairly for reason of perceived threats at the state's premier breeding colony at Mono Lake. See comments above on its recent breeding colonization of the Salton Sea.

Gull-billed Tern. This tern is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992). See comments above on the history and size of its breeding colonies at the Salton Sea.

Black Skimmer. The Black Skimmer is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992). See comments above on the history and size of its breeding populations at the Salton Sea.

WATERFOWL

Thirty-six species of ducks, geese, and swans have been recorded at the Salton Sea (Appendix). Most species occur primarily as winter visitors, and only five species have been confirmed breeding. The Coachella and Imperial valleys are second in importance, after the Central Valley, to wintering waterfowl in California (Heitmeyer et al. 1989). McCaskie (1970c) listed the following peak numbers of waterfowl at the Salton Sea NWR between December 1969 and March 1970: 3,290 Canada Geese, 19,000 Snow Geese, 50 Ross's Geese, 325 Mallards, 84,000 Northern Pintails, 23,300 Green-winged Teal, 1,465 Cinnamon Teal, 45,500 American Wigeon, 11,990 Northern Shovelers, 260 Canvasbacks, and 29,000 Ruddy Ducks. The total number of ducks and geese in the Coachella and Imperial valleys averaged about 77,000 individuals of 16 taxa on U.S. Fish and Wildlife Service mid-winter inventories from 1978 to 1987 (Heitmeyer et al. 1989). Average population sizes of key taxa were about 16,800 Snow and Ross's geese, 16,300 Ruddy Ducks, 14,100 Northern Pintail, 12,700 Northern Shovelers, 5,600 American Wigeon, 3,100 Green-winged Teal, 3,300 Canada Geese, 1,800 scaup spp., and 1,700 Canvasback.

No analysis has been conducted of population trends of waterfowl at the Salton Sea, though the data may be unsuitable for this purpose as indicated by substantial shifts in population estimates when observers conducting the counts have changed (K. Sturm pers. comm.). Similarly, estimates of open water, diving ducks may be low, as aerial survey routes cover only impounded wetlands and the shoreline and immediate inshore zone of the Sea (K. Sturm pers. comm.).

Nothing appears to have been published on the distribution and habitat use of waterfowl around the Salton Sea and Imperial and Coachella valleys, although there are unpublished data collected on U.S. Fish and Wildlife Service aerial flights summarized by sites within this region. For example on a 6 January 1998 aerial survey, 40.0% of all waterfowl were along the Imperial County shoreline of the Sea, 17.4% on Unit 1 of

Salton Sea NWR, 10.7% on the Riverside County shoreline of the Sea, 9.0% on the Wister Unit of Imperial WA, 6.7% on Unit 2 of Salton Sea NWR, 6.5% on south shore duck clubs, 6.4% on duck clubs south of Brawley in the Imperial Valley, 2.5% in Coachella Valley duck clubs, and 0.7% on Finney and Ramer lakes of Imperial WA (SSNWR unpubl. data).

Species of Concern

Fulvous Whistling-Duck. The Fulvous Whistling-Duck is considered a Bird Species of Special Concern (Remsen 1978, CDFG 1992) because of substantial range contraction and population decline in its California breeding range, particularly on the coastal slope and in the San Joaquin Valley. By the 1970s the species was considered to breed in California only in the Imperial Valley (Remsen 1978). Its historical status in the Salton Sea area appears to be imperfectly known. Grinnell and Miller (1944) formerly considered it a common transient in the Imperial Valley, where apparently it had "only recently begun to breed." Remsen (1978) noted an apparent decline in the Imperial Valley population since the 1950s based on more frequent observations of broods in that period than in the 1970s, when there appeared to be great year-to-year variation in breeding numbers and a lack of breeding in some years. Remsen's citation of Pyle (1951) appears to be one of few that include quantitative information for that period – an observation of 28 whistling-ducks near Calipatria on 25 June 1951. Garrett and Dunn (1981) considered the species a "fairly common" (but declining) summer resident" at the south end of the Salton Sea and also noted year-to-year variation in summer numbers. During the 1990s, probably fewer than five pairs of whistling-ducks have bred in the Imperial Valley, principally around Finney and Ramer lakes and other nearby sites at the south end of the Salton Sea (M. A. Patten in litt.).

VARIOUS OTHER WATERBIRDS

The Salton Sea supports a wide variety of waterbirds (Appendix) in addition to the colonial waterbirds treated above. As detailed below, populations of a number of species at the Sea or in the adjoining Imperial Valley are of continental or worldwide importance. Particularly notable in this regard are the Eared Grebe, American White Pelican, Black Tern, and White-faced Ibis.

Despite being landlocked, the Salton Sea has hosted 8 species of seabirds of the order procellariiformes (Appendix, Patten and Minnich 1997). The occurrence of these tubenoses at the Salton Sea relates to annual southerly monsoon flows through the Gulf of California and increased sea surface temperatures off southwestern Mexico (Patten and Minnich 1997). While numbers of these species are insignificant, they further demonstrate that waterbird use of this inland water body is intricately linked to the Gulf of California (McCaskie 1970a, Jehl 1988, Patten and Minnich 1997, Patten 1999).

Species of Concern

Eared Grebe. The Salton Sea serves as one of the most important migratory stopover and wintering areas for Eared Grebes in North America and the World (Jehl 1988). In fact, 90% or more of the entire North American population may pass through the Salton Sea in some years (Jehl in litt.). Limited band recovery data suggest that grebes from breeding grounds throughout western North America stage at key areas such as Mono Lake, California, and Great Salt Lake, Utah, enroute to the species' main North American wintering areas at the Salton Sea and the Gulf of California (Jehl and Yochem 1986, Jehl 1988). Some published estimates of the total number of Eared Grebes at the Salton Sea are 1 to 1.75 million in January 1988 and 3.5 million in March 1988 (Jehl 1988).

American White Pelican. The American White Pelican is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992). Recent high counts of white pelicans at the Salton Sea have been 33,000 in winter 1987 (Setmire et al. 1990) and 26,500 in March 1998 (McCaskie 1999). The Sea also appears to be an important migratory stopover site for white pelicans in the fall (September through November), especially for birds that breed in the western Great Basin (Fuller et al. 1998). Fifty-four percent of 161 banded pelicans found dead during the 1996 botulism die-off at the Salton Sea had been banded at Pyramid Lake (Yates in press). Based on pelicans with satellite platforms, the pelicans appear to use the Salton Sea for a few weeks to a few months before continuing down to the west coast of Mexico (Yates in press). At least some pelicans from breeding grounds at Clear Lake NWR in northern California have been detected at the Salton Sea during their southward migration (D. Anderson pers. comm.)

Wood Stork. The Wood Stork is a Bird Species of Special Concern in California (CDFG 1992). Garrett and Dunn (1981) considered the Wood Stork to be a "common post-breeding visitant" to the south end of the Salton Sea. Although noting year-to-year variability in numbers, they considered numbers there always high and cited high counts of 1,000 individuals on 18 September 1964 and 650 in late July 1977. Small (1994) reported counts exceeding 1,500 storks at the south end of the Salton Sea in the 1950s, but considered normal summer numbers there to be 200 to 500. He noted a steady decline in stork numbers such that in recent years fewer than 100 were recorded in summer.

Sandhill Crane. Sandhill Cranes winter regularly in agricultural fields of the Imperial Valley. Counts in the 1990s, taken primarily at nighttime roosts, have ranged from about 200 to 350 individuals (SSNWR files). Apparently both Lesser *(G. c. canadensis)* and Greater *(G. c. tabida)* Sandhill Cranes occur in the area, but the status of the two forms is imperfectly known (Garrett and Dunn 1981, SSNWR files). The Greater Sandhill Crane is listed as Threatened in California.

Black Tern. The Black Tern is a Bird Species of Special Concern in California (CDFG 1992) and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). Concern is warranted because of continent-wide population declines (Peterjohn and Sauer 1997, Shuford in press). The Salton Sea-Imperial Valley vicinity is one of only a few crucial fall staging areas in western North America (Shuford in press). Small (1994) reported that "tens of thousands" of Black Terns occur at the Salton Sea in fall, but there appear to have been no studies of population size or habitat use in this area.

Largest numbers are seen foraging over irrigated agricultural fields in the Imperial Valley (K. Sturm pers comm.).

White-faced Ibis. The White-faced Ibis is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992) and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). The Imperial Valley supports a major wintering population and a small breeding population of White-faced Ibis. Statewide surveys in winter 1994-95 found about 16,000 ibis in the Imperial Valley, which represented 57% of the total California wintering population (Shuford et al. 1996). Counts were taken at nighttime roost sites at Ramer Lake and four duck clubs in the Imperial Valley, but ibis were foraging primarily in irrigated agricultural fields. Recent estimates of the breeding ibis population in the Salton Sea area were 320 pairs at Finney Lake in both 1992 and 1993 (K. Sturm in Earnst et al. 1998). Liver and fat samples of ibis had some of the highest DDE concentrations found in birds in the Imperial Valley, apparently because the ibis feed on terrestrial invertebrates that are in direct contact with DDE-contaminated soils (Setmire et al. 1993). The DDE concentrations in Imperial Valley ibis were similar to concentrations in ibis eggs collected at Carson Lake, Nevada, where ibis reproduction was impaired (Henny and Herron 1989). Band recovery data indicate that many ibis from western Nevada winter in the Imperial Valley (E. Kelchlin in Shuford et al. 1996), suggesting that the Imperial Valley may be the source of DDE-contamination in the Carson Lake ibis.

SHOREBIRDS

Forty-four species of shorebirds have been recorded at the Salton Sea (Appendix). Most species occur as migrants or winter visitors, and 5 species have bred (4 regularly). Large numbers of spring migrants pass through the Salton Sea, apparently after moving up the west coast of Mexico and concentrating in the Gulf of California (McCaskie 1970a). Although little is known of the origin of migrant shorebirds in this area, Western Sandpipers banded in Panama have been detected at the Salton Sea during migration (Butler et al. 1996). McCaskie (1970a) summarized anecdotal information on shorebird use of the Salton Sea via brief accounts on the seasonal status and abundance of thirty-five species.

Data from comprehensive shorebird surveys from 1989 to 1995, as part of the Pacific Flyway Project, document that the Salton Sea is one of the most important sites in the interior of North America for migratory and wintering shorebirds and that its populations are of international importance (Page et al. 1992, PRBO and R. McKernan unpubl. data.). The Salton Sea is one of eight sites in the interior of the West that holds over 10,000 shorebirds in fall and five such sites in spring. In terms of overall shorebird numbers, the Salton Sea was the most important area in the Intermountain and Desert region of the West in spring and the second most important, after Great Salt Lake, in fall. Shorebird populations at the Salton Sea averaged about 85,000 individuals in August (n = 4 censuses), 24,000 in December (n = 2), and 90,000 in April (n = 4). Eleven taxa had populations that averaged over 1,000 individuals in at least one season (Table 1).

Table 1 Numbers of shorebirds at the Salton Sea for species with populations averaging over 1000 individuals in any season (PRBO unpubl. data).

Species	August	December	April
Black-necked Stilt	10,200	3100	4500
American Avocet	15,700	4600	7600
Willet	900	1700	200
Whimbrel	30	0	7000
Long-billed Curlew	2100	250	50
Marbled Godwit	1700	1300	1200
Western Sandpiper	33,600	4000	50,000
Least Sandpiper	2300	2300	1800
Dowitcher spp.	10,400	4500	15,800
Wilson's Phalarope	3000	0	250
Red-necked Phalarope	4500	0	700
TOTAL SHOREBIRDS	85,400	24,100	89,900

Key taxa in fall were Western Sandpiper, American Avocet, dowitcher spp., Black-necked Stilt, Red-necked Phalarope, and Wilson's Phalarope. Species using the Sea primarily as a wintering area are Willet, Marbled Godwit, and Least Sandpiper. Although not numerically dominant, the Stilt Sandpiper population (135+) at the Salton Sea is still the only substantial wintering population of that species in North America (G. McCaskie pers. comm.). Important taxa numerically in April are Western Sandpiper, dowitcher spp., American Avocet, Whimbrel, and Black-necked Stilt. Agricultural fields of the Imperial Valley appear to be one of the most important areas in the West to spring migrant Whimbrels (PRBO unpubl. data) and wintering Mountain Plovers (Anonymous 1999).

Unlike many interior sites that hold their largest numbers of shorebirds in fall – particularly saline lakes where large numbers of American Avocets and Wilson's Phalaropes stage – the Salton Sea holds comparable numbers in both spring and fall. Although its wintering shorebird numbers are not nearly as large, the Salton Sea is only one of two sites in the interior of the West, along with California's Central Valley, that hold tens of thousands of shorebirds in winter (PRBO unpubl. data). Pacific Flyway Project unpublished shorebird data suggest that a number of species, such as Snowy Plover, Willet, Marbled Godwit, and Stilt Sandpiper, are differentially distributed around the Salton Sea, but these data have not yet been analyzed.

Comparisons of winter shorebird populations at the Salton Sea with those of the Central Valley and Río Colorado Delta, the nearest marine shorebird habitat, shows that the Salton Sea has a somewhat greater affinity with the Río Colorado Delta (Table 2). The Salton Sea and Río Colorado Delta share relatively high numbers of wintering American Avocets, Willets, and Marbled Godwits and relatively low numbers of Dunlin. The Salton Sea holds small numbers (100) of Sanderling in winter as does the Río Colorado Delta (230). The occurrence at the Salton Sea of moderate numbers of Red

Knot (maximum 500), Sanderling (265), and Ruddy Turnstone (45) in spring also shows its connection with the Gulf of California, as these species are rare elsewhere in the interior of California and much of the rest of the West. Unlike the Río Colorado Delta, and more like the Central Valley, the Salton Sea holds relatively large numbers of wintering Black-necked Stilts and Long-billed Dowitchers.

Table 2 Comparison of peak winter shorebird populations at the Salton Sea (PRBO/R. Mckernan unpubl. data), Río Colorado Delta (Morrison et al. 1992, Mellink et al. 1997), and Central Valley (Shuford et al. 1998).

Species	Salton Sea	Río Colorado Delta	Central Valley
Black-bellied Plover	1000	4600	10,200
Black-necked Stilt	4300	380	13,400
American Avocet	5800	9400	4000
Willet	1800	8000	110
Marbled Godwit	1400	9100	140
Western Sandpiper	4700	75,000	8400
Dunlin	600	100	176,000
Dowitcher spp.	9500	2900	118,000
TOTAL SHOREBIRDS	28,000	164,000	374,000

Species of Concern

Snowy Plover. The interior population of the Snowy Plover is a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992) and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). The Salton Sea supports the largest population of wintering Snowy Plovers in the interior of western North America (Shuford et al. 1995) and one of a handful of key breeding populations in the interior of California (Page et al. 1991). Total numbers of wintering plovers at the Salton Sea were 285 and 214 in 1993 and 1994, respectively, whereas breeding numbers were 226 and 198 in 1978 and 1988, respectively. Plovers at both seasons were concentrated primarily on sandy beaches or alkali flats along the western and southeastern shorelines of the Sea.

Mountain Plover. The Mountain Plover is a Bird Species of Special Concern in California (CDFG 1992) and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995) that currently is under consideration for listing as federally Threatened (Anonymous 1999). The primary wintering areas for the species are California's Central and Imperial valleys (Knopf and Rupert 1995). Plovers in the Imperial Valley primarily use agricultural fields. The 2,072 and 755 Mountain Plovers recorded in Imperial County represented, respectively, 61% and 35% of the totals of 3,390 and 2,179 individuals found in 1994 and 1998 on comprehensive statewide surveys of the species' wintering population (B. Barnes in litt., CDFG unpubl. data, K. Hunting in litt.). Counts of Mountain Plovers on the Salton Sea (south) Christmas Bird Count from 1980 to 1997 have ranged from 1-1,003 birds (median = 151 birds; data from K. Hunting/CDFG in litt.). The diet of wintering plovers in the Imperial Valley is

dominated by coloepterans and orthopterans, and the species appears to be an opportunistic forager on the wintering grounds (Knopf 1998). Contaminants have not been found to affect the biology of the species (F. Knopf et al. unpubl. data cited in Knopf 1998).

Long-billed Curlew. The Long-billed Curlew is a Bird Species of Special Concern in California (CDFG 1992), presumably because of concern for breeding populations in the northeastern part of the state, and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). The breeding grounds of migrant and wintering populations at the Salton Sea appear to be unknown. The highest count on a Pacific Flyway Project shorebird survey of the Salton Sea was about 7,500 in August 1995, but coverage of agricultural fields in the Imperial Valley, where curlews concentrate, was limited on all surveys in all seasons.

GULLS

Eighteen species of gulls (family Laridae) have been recorded at the Salton Sea (Appendix), including the two breeding species treated above. Largest populations of gulls occur at the Salton Sea in winter. McCaskie (1998) estimated that in an average winter roughly tens of thousands of Ring-billed and California gulls and 1000 to 2000 Herring Gulls are present, along with a sprinkling of other rarer species. He further estimated that during an unprecedented influx of gulls to the Sea in winter 1997-98 that 10,000 to 15,000 Herring Gulls were present. Although the accuracy of these estimates is unknown, they suggest the size of wintering gull populations at the Salton Sea probably are among the largest, if not the largest, at any inland site in North America. In addition to the gulls at the Salton Sea itself, tens of thousands of Ring-billed Gulls also forage in agricultural fields in the Imperial Valley (K. Molina, D. Shuford pers. obs.).

SECRETIVE MARSHBIRDS

Six species of rails, moorhens, and coots (Family Rallidae) have been sighted at or near the Salton Sea, of which four, or possibly five, breed there (Appendix). In addition, the Least Bittern is known to breed and the American Bittern is suspected to breed around the Sea.

Population Sizes

With the exception of the Black Rail and the Clapper Rail, very little is known about the population sizes of rallids at the Salton Sea. In southeastern California, Black Rails are patchily distributed in low numbers (Laymon et al. 1990, Evens et al. 1991). The species is a rare breeder at and around the Salton Sea (Laymon et al. 1990, Evens et al. 1991, Appendix). A total of 23 birds was recorded in 1989 on the only systematic survey for Black Rails at the Salton Sea. Thirteen rails were located at the mouth of the New River, 8 in seep marshes along the Coachella Canal, 1 at Finney Lake (although up to 7 birds have been reported there in the past, Garrett and Dunn 1981), and 1 at the

mouth of Salt Creek (Laymon et al. 1990). Black Rail occurrence around the Sea is expected to be sporadic, reflecting frequent and extensive marshland modifications in the area (Evens et al. 1991).

Since 1990, an average of 365 (± 106 SD, $n = 8$ years) Yuma Clapper Rails have been counted around the Salton Sea (Fig. 2). These numbers account for approximately 40% (± 12 SD, $n = 8$ years) of all Yuma Clapper Rails counted in the United States. The majority of birds at the Salton Sea are counted in the Wister Unit of the Imperial WA, but other important areas include the B-1 Pond (Unit 1, SSNWR), Union Pond (Unit 2, SSNWR), Hazard 6 and 7 (Unit 2, SSNWR), "T" Drain Marsh, Holtville Main, and Barnacle Beach Marsh (R. McKinstry pers. comm., SSNWR files).

Fleischer et al. (1995) used DNA fingerprinting techniques to examine the genetic structure of Clapper Rails in southern California, and their sampling included DNA from 9 birds captured at the Wister Unit. Individuals of *yumanensis* showed significant genetic variation from various southern California coastal populations of *R. l. levipes*, and the estimated effective population size of *yumanensis* was calculated to be 824 individuals (min.-max.: 507-1140 individuals, Fleischer et al. 1995).

The American Bittern is considered an uncommon winter visitor and an extremely rare suspected breeder around the Salton Sea (Appendix). Its population size there is unknown. The Least Bittern breeding population around the Salton Sea has been estimated to be 550 individuals (Setmire et al. 1993), but how this number was derived is unclear.

Nesting Habitats

Breeding rails use a variety of freshwater and brackish marshes at and near the Salton Sea. Black Rails found in the Salton Trough have been associated with seeps and springs along the All-American and Coachella canals in wet, marshy areas with a mosaic of cattail, willow, tamarisk, *Salicornia* and *Phragmites* (Evens et al. 1991). At the Salton Sea, Black Rails appeared to be associated with river mouths; areas with Three-edged Bulrush were especially important (Laymon et al. 1990, Evens et al. 1991). The Yuma Clapper Rail is a bird of the cattail-bulrush marsh edge, preferring mature stands of cattail-bulrush in shallow water near high ground (USFWS 1983).

The Common Moorhen is a fairly common breeder at the Salton Sea, whereas the American Coot is a common breeder (Appendix). Their breeding habitat at the Sea has not been described. The Sora is suspected of breeding at the Salton Sea (Appendix). All three of these species nest in cattail-bulrush marshes and probably breed in areas similar to those where the Clapper Rail is found. Both bittern species are partial to dense marshes of cattail and rushes (Garrett and Dunn 1981). The Least Bittern roosts in dense salt cedar stands (Imperial Irrigation District 1994)

Species of Concern

Yuma Clapper Rail (Rallus longirostris yumanensis). This subspecies of the Clapper Rail is listed as state Threatened and federally Endangered. See comments above on natural history and population sizes at the Salton Sea.

Black Rail. The Black Rail is listed as state Threatened and is considered a Nongame Bird of Management Concern in the U.S. (USFWS 1995). See comments above on natural history and population sizes at the Salton Sea.

American Bittern. The American Bittern is a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). See comments above on natural history and population sizes at the Salton Sea.

Least Bittern. This bittern is a Bird Species of Special Concern in California (CDFG 1992) and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). See comments above on natural history and population sizes at the Salton Sea.

RAPTORS

Although 20 species of raptors have been sighted around the Salton Sea (Appendix), with the exception of the Burrowing Owl, little work has been done there on this group of birds. White-tailed Kites, Red-tailed Hawks, American Kestrels, Western Screech-Owls, Great Horned Owls, and Burrowing Owls breed around the Sea (Appendix). The Harris's Hawk formerly bred in the area (Bancroft 1920) and was occasionally found in large numbers within the Imperial Valley (Chambers 1921, 1924). The Harris's Hawk is now listed as an extirpated breeder (Appendix).

Species of Concern

Burrowing Owl. The Burrowing Owl, a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995) and a Bird Species of Special Concern in California (Remsen 1978, CDFG 1992), has been the focus of several studies. Around the Salton Sea, Burrowing Owls are classified as common breeding residents (Appendix), and some of the highest densities of these birds in California are found in this area (D. Rosenberg pers. comm.). The Institute of Bird Populations' estimate of 6,429 pairs of Burrowing Owls in the Imperial Valley represents 69% of their estimate of the entire California population of 9,266 pairs (E. Ruhlen pers. comm.). In the Imperial Valley, the owls are found on irrigated farm lands, especially along irrigation drain canals (Coulombe 1971, Hurlbert 1997, Rosenberg et al. 1998). The Burrowing Owl was the most common bird species observed at the Elder and Rice agricultural drains and the second most abundant species at the P agricultural drain in the Imperial Valley (Hurlbert 1997). While some of the owls around the Sea are migratory, 20-25% of the breeding population remains in the valley (Coulombe 1971). In a California-wide survey (exclusive of the Great Basin and desert areas), the presence of ground squirrels was the single highest predictor of site fidelity to breeding sites from one year to the next (E. Ruhlen pers. comm.).

Other species of concern. Osprey, Bald Eagle, Northern Harrier, Sharp-shinned Hawk, Cooper's Hawk, Swainson's Hawk, Ferruginous Hawk, Peregrine Falcon, and Prairie Falcon. Most species of concern occur at the Salton Sea primarily in non-wetland habitats or in limited numbers as non-breeders.

PASSERINES

One hundred seventy-six native passerines have been recorded around the Salton Sea (Appendix), of which 15 are California Bird Species of Special Concern (Remsen 1978, CDFG 1992). However, few quantitative data exist on the importance of the Salton Sea area to passerines. During semi-monthly mist-netting efforts in 1993 and 1994, 44 species of passerines were found in terrestrial habitats at the Salton Sea NWR headquarters. Wilson's, Yellow-rumped, Orange-crowned, and Yellow warblers were prominent during spring and fall migration periods along with White-crowned Sparrows, Willow Flycatchers, and Ruby-crowned Kinglets (K. Molina unpubl. data). In nearby agricultural drains of the Imperial Valley, Savannah Sparrows, Northern Rough-winged Swallows, Yellow-rumped Warblers, and Red-winged Blackbirds were some of the most numerous passerines (Hurlbert 1997). Garrett and Dunn (1981) currently is the best single published source on the status of passerines at the Salton Sea.

California Partners in Flight's riparian bird conservation plan targets 14 bird species based on conservation need and their dependency on riparian habitat throughout the state. Nine of these species are known to breed or have bred historically in Riverside and Imperial counties (Grinnell and Miller 1944, Garrett and Dunn 1981), including the federally Endangered Least Bell's Vireo (but not known to occur at the Salton Sea). Four breed in the Salton Sea area: Song Sparrow, Common Yellowthroat, Yellow-breasted Chat, and Blue Grosbeak (Grinnell and Miller 1944, Garrett and Dunn 1981). Garrett and Dunn (1981) reported that the subspecies of Song Sparrow (*M. m. saltonis*) breeding in the Salton Sea area appears to be declining, although this should be confirmed with systematic surveys.

Species of Concern

Loggerhead Shrike. The Loggerhead Shrike is a Bird Species of Special Concern in California (CDFG 1992) and a Migratory Nongame Bird of Management Concern in the U.S. (USFWS 1995). At the Salton Sea it is a fairly common resident and breeder in open upland habitats (Appendix).

Crissal Thrasher. This Bird Species of Special Concern in California (CDFG 1992) is an uncommon resident and breeder in riparian and mesquite associations around the Salton Sea (Appendix, Garrett and Dunn 1981).

LeConte's Thrasher. The LeConte's Thrasher is a Bird Species of Special Concern in California (CDFG 1992). It is a rare resident and breeder at the Salton Sea (Appendix), where it inhabits inhabit very sparse desert scrub and avoids irrigated areas (Garrett and Dunn 1981).

Yellow-breasted Chat. The chat is a Bird Species of Special Concern in California (CDFG 1992) and a rare summer resident and breeder at the Salton Sea (Appendix). In southern California, it nests in dense riparian thickets generally near lowland watercourses (Garrett and Dunn 1981).

Large-billed Savannah Sparrow (A. s. rostratus). This subspecies is a California Bird Species of Special Concern (CDFG 1992). It is a rare to uncommon post-breeding and winter visitor to the Salton Sea, where it is usually found in salt cedar and *Allenrolfea* scrub along the immediate shoreline and around duck club ponds (Garrett and Dunn

1981; P. Unitt in litt.; K. Molina, D. Shuford pers. obs.). The decline of this subspecies is attributed in part to loss of marshes in its breeding areas at the Río Colorado Delta, from which Salton Sea winterers are thought to originate (Garrett and Dunn 1981).

SALTON SEA AVIAN MORTALITY

DISEASE

Historically, birds at the Salton Sea have experienced mortality attributed to a variety of diseases – including botulism, Newcastle disease, avian cholera, and salmonellosis – and possibly to toxins produced by algae (Fig. 3).

Information summarized here for bird mortality at the Salton Sea originated from the Salton Sea NWR files and from information posted by various federal agencies on the Internet. Because only tallies of the absolute numbers for the species affected are reported for each pickup date, and because information about the intensity of pickup effort (number of airboats, shoreline parties, etc.) or spatial coverage is lacking, only the most general interpretation of these data are warranted. Large gaps in the reporting of disease events occurred during the 1940s, 1950s, and 1970s. Lack of data in these years could reflect inconsistencies in reporting or differences in effort and coverage (SSNWR 1998a).

Coverage of the Salton Sea for avian mortality has increased since about 1992, but particularly, beginning with the outbreak of botulism in pelicans in 1996. Prior to this period, coverage was probably confined to refuge lands and adjacent areas (SSNWR 1974). Refuge personnel likely were unaware of mortality events that originated away from the wildlife refuge units (e.g., areas at the north end of the Sea) until alerted by reports from state recreation areas, duck club proprietors, shoreline residents, and visitors. To more closely monitor conditions throughout the year, Salton Sea NWR personnel currently conduct periodic surveys of the Salton Sea via a fleet of airboats, which greatly enhances surveillance ability and carcass collection effort. Mortality events associated with particular diseases are discussed below.

Botulism

Since 1939, significant mortality events attributed to botulism (affecting $\geq$ 2,000 birds; Fig. 3) appear to have occurred throughout the Salton Sea NWR and adjacent areas. Botulism type C is the form that commonly affects waterfowl and shorebirds in the western United States (Rocke 1996). The large-scale botulism event of 1996 was unusual in the number of birds and in the species that were predominately affected (also type C; NWHC 1997b). Except for the death of 86 American White Pelicans and 19 Brown Pelicans in 1994, bird mortality attributed to botulism at the Salton Sea had been confined largely to waterfowl and various shorebirds. During the period August through November 1996, nearly 9,000 White and 1,200 Brown pelicans (57% and 8% of total carcasses, respectively) succumbed to botulism. Herons, egrets, and gulls also were heavily affected, bringing the total number of collected carcasses to just over 14,000. The total estimate of mortality for this period was 20,000 (SSNWR 1998a). This pelican

mortality appeared to be associated with large-scale die-offs of tilapia, which in turn have been attributed to several bacterial pathogens of the family Vibrionaceae (Winton 1997). It is hypothesized that under the anaerobic conditions present in the gut of dead and dying tilapia, botulism toxin may then become available to birds that ingest infected fish. These conditions represent a novel transmission link between botulism and piscivorous birds (SSNWR files).

The number of dead birds collected during the period March through November 1997, and attributed to botulism, decreased from that of 1996 to just under 5,000. Total deaths were estimated at 8,000. Unlike the previous year, White and Brown pelicans each accounted for $\leq 6\%$ of the total carcasses collected (SSNWR 1998a). Additionally, several hundred each of both pelican species were transferred to rehabilitation facilities. Eared Grebes and Double-crested Cormorants, respectively, accounted for 36% and 28% of the total mortality in 1997 and are discussed in more detail later.

The severity of botulism, particularly for pelicans, appeared to lessen in 1998, when about 100 carcasses of each species were collected during the period December 1997 through October 1998 (SSNWR 1998a). The increasing incidence of avian botulism is of national concern as single outbreaks, killing in excess of 10,000 waterbirds, now occur widely throughout the western and north-central prairie states and Canada (Rocke 1996).

Newcastle Disease

Newcastle disease was unknown in Double-crested Cormorants west of the Rockies until 1997 (NWHC 1997b). This disease was believed to be the likely cause of death of 1,600 Double-crested Cormorants, mostly nestlings, on Mullet Island, at the south end of the Salton Sea in 1997 (USFWS 1997b), although chicks and eggs were not submitted for analysis that year (Campbell 1998). Reports describing the complete failure/abandonment of the mixed cormorant and Caspian Tern colony on Mullet Island during this period (USFWS 1997b, SSNWR 1998b, various news media reports) conflict with observations indicating that creches of apparently unaffected pre-fledged Caspian Terns swam away from the island during the initial visit on 12 May (Molina 1997). Since the large Mullet Island cormorant colony had, by that time, been active for well over four months (SSNWR 1997a, SSNWR 1998c), little evidence exists to confirm that the early breeding efforts were not successful. The suspected Newcastle diagnosis was based on field observations of weakness and paralysis of head, neck, and extremities (SSNWR 1997a) and on laboratory analyses of both presumed adults and of non-nestling birds of unknown age (Campbell 1998). This diagnosis was later confirmed by state and federal labs (NWHC 1997b). Determining the age of Double-crested Cormorants in the field is complex, as they exhibit great variation in plumage within age classes. Because of this difficulty in aging cormorants, much of the mortality observed and attributed to "juveniles" or hatch-year birds (SSNWR 1997a; 1998a, b) actually could have involved immature birds of up to two years of age (Palmer 1962, Johnsgard 1993). Whether these birds originated from the Mullet Island colony would be impossible to ascertain.

Newcastle disease was also confirmed from two other Double-crested Cormorant colonies in the western U.S. in 1997. The degree of mortality exhibited by these colonies, ranging from low levels to none, contrasts greatly with that at Mullet Island

(NWHC 1997b). The susceptibility of cormorant nestlings, as altricial young, to heat stress at the Salton Sea is high (Bartholomew and Dawson 1954). Chicks and eggs exposed to direct solar radiation, for even brief periods, may be subject to lethal temperature extremes (Grant 1982) as adults are flushed from their nests during visits to the colony. Therefore, the effects of human disturbance to the Mullet Island colony may have played a role in the heavy mortality of nestlings (Campbell 1998). Other, smaller cormorant colonies near Mullet Island nested successfully in 1997 and 1998, despite the presence of symptomatic birds in these colonies (SSNWR 1998b).

Double-crested Cormorants began nesting again on Mullet Island, now under frequent surveillance, in December 1997 and birds near fledging age were apparent by March (SSNWR 1998c). Newcastle disease was suspected later in the 1998 nesting season when the failed nests of an estimated 3,000 pairs of cormorants were discovered in late April (USFWS 1998, SSNWR 1998b). Confirmation of Newcastle disease requires isolation and identification of the virus (NWHC 1998a). Although microscopic brain and spinal cord lesions found in Salton Sea adult and nestling specimens in 1998 were believed to be consistent with those of a confirmed Newcastle outbreak in Great Lakes Double-crested Cormorants in the early 1990s, isolation and identification of the virus from Salton Sea cormorants during the 1998 event has yet to be achieved (Campbell 1998, Dein 1998, Meteyer 1998).

Newcastle disease has not been implicated in the mortality of other species at the Salton Sea, although antibodies were present in a White Pelican in 1998 (SSNWR 1998d).

Avian Cholera

According to Salton Sea NWR records, avian cholera was not known as a cause of avian mortality until 1979, when a large-scale waterfowl die-off involving 9,000 birds was attributed to this disease (Fig. 3). Lower levels of mortality attributed to cholera continued to affect ducks, grebes, and shorebirds through the 1980s. Large cholera die-offs (> 2,000) occurred again in 1991-1992 and in 1996. In 1998, the death of >11,000 waterfowl, shorebirds, and waders was attributed to cholera.

Salmonellosis

The incidence of salmonellosis appears to be rare at the Salton Sea. However, a mortality event of some 4,000 cattle egrets in 1989 (Fig. 3), followed by a much smaller event in a dozen Great Blue Herons in 1998, was attributed to this disease (NWHC 1998b).

Unknown Causes

Large-scale die-offs involving an estimated 150,000 and 20,000 Eared Grebes (including some Ruddy Ducks) occurred in 1992 and 1994, respectively (Fig. 3). In 1998, a mortality event involved 4,000 grebes. Despite analysis efforts, the cause of these large-scale grebe die-offs remains uncertain in all years. Working hypotheses

include potential neurological poisoning by toxin production associated with seasonal algal blooms (Jehl 1996).

CONTAMINANTS

Early studies by Koranda et al. (1979), Mora (1984), Ohlendorf and Miller 1984, White et al. (1987), and others documented elevated levels of contaminants in waterbirds at the Salton Sea and nearby areas. Contaminant levels generally have been found to be higher than in other regions of California (Ohlendorf and Miller 1984, Mora et al. 1987, Setmire et al. 1993). Results of bird contaminant studies at the Salton Sea have been reviewed by Setmire et al. (1990, 1993) and by the Imperial Irrigation District (1994). These reviews should be read in conjunction with this synthesis. Setmire et al. (1993) concluded from a study of agricultural-related contaminants at the Salton Sea that selenium, boron, and DDE posed the most significant threats to birds.

Selenium

Setmire et al. (1993) found concentrations of selenium exceeding 30 μg/g, levels at which the risk of reproductive problems is thought to be high, in four species of birds: Double-crested Cormorant (33% of samples), Eared Grebe (60% of samples), Ruddy Duck (2% of samples), and Northern Shoveler (10% of samples). Five percent of the Black-necked Stilt eggs collected at the Salton Sea had at least a 10% probability of embryotoxicity, compared to 60% at Kesterson NWR – an area of high selenium contamination (Setmire et al. 1993). In the one endangered species tested, one individual of the Yuma Clapper Rail, levels of selenium were found to be high enough to potentially cause reproductive failure (Setmire et al. 1993). The mean selenium concentration of Black-crowned Night-Herons eggs from the Sea (1.10 μg/g) was significantly higher than that of eggs from locations in the San Joaquin Valley. Additionally, the mean selenium concentration of night-heron eggs was significantly higher than that of Great Egret eggs. Ohlendorf and Marois (1990) concluded that elevated levels of selenium in Black-crowned Night-Heron eggs from the Sea may not have affected reproductive success.

Boron

Setmire et al. (1993) measured boron levels in 7 species of birds at the Salton Sea. Highest concentrations were found in migratory waterfowl, reflecting their propensity for feeding on vegetation with high boron concentrations (Setmire et al. 1993). Samples of Ruddy Ducks collected in different winter months indicated that boron was being accumulated at the Sea, primarily through the ingestion of pileworms (Setmire et al. 1993). Highest geometric mean concentration of boron was found in Northern Shovelers (3.9 μg/g) that fed on filamentous algae with high concentrations of boron (geometric mean = 170 μg/g, Setmire et al. 1993). The only resident bird to be closely examined was the Black-necked Stilt. Boron concentrations in stilt eggs were as much as double the threshold levels associated with reduced weight gain in ducklings (Setmire et al. 1993). Growth rates of stilts measured at the Salton Sea were also lower than growth

rates of stilts on the coast in an area not affected by agricultural wastewater. The boron level in a single Clapper Rail from the Wister Unit was 14.0 µg/g dry weight, and the effect of this concentration was unknown (Setmire et al. 1993). Setmire et al. (1993) speculated that fish-eating birds at the Salton Sea may accumulate boron concentrations high enough to cause reproductive effects.

Just south of the Salton Sea, in the Mexicali Valley, boron levels were found to be high enough to be of concern in Morning Doves, but not in Double-crested Cormorants, Cattle Egrets, Red-winged Blackbirds, and Great-tailed Grackles (Mora and Anderson 1995).

Organochlorines

The Imperial Valley, including the Salton Sea, has the highest recorded concentrations of DDE in California (Setmire et al. 1993). Fish-eating birds foraging at the Salton Sea probably were especially vulnerable to elevated DDT/DDE levels in the 1970s and 1980s, as the highest total DDT levels in fish anywhere in California were recorded there in 1981 (La Caro et al. 1982). Ohlendorf and Marois (1990) found concentrations of DDE in Black-crowned Night-Herons (geometric mean 8.62µg/g wet wt.) and Great Egrets (24.0 µg/g) collected from Salton Sea in 1985 that were high enough to potentially negatively affect reproductive success. DDE contamination of eggs of Black-crowned Night-Herons from nests at Ruby Lake, Nevada, was attributed to bioaccumulation by adult birds on wintering grounds in the southwestern United States, including the Imperial Valley (Henny and Blus 1986). Similarly, elevated organochlorine levels in eggs of White-faced Ibis breeding at Carson Lake, Nevada, were attributed to bioaccumulation on wintering grounds in Mexico, including the Mexicali Valley just to the south of the Imperial Valley (Henny and Herron 1989).

Mora et al. (1987) sampled a variety of ducks from a number of locations in Mexico and California, including the Salton Sea, and failed to find organochlorine levels high enough to cause adverse effects on reproduction or survival. However, DDE levels were higher in Northern Pintails collected at the Salton Sea NWR during winter than from any other area, and highest DDT levels were found at the Salton Sea. Higher levels of DDE and DDT at the Salton Sea (and San Quintin, Mexico) were explained by a past history of heavy use of these persistent pesticides, potential illegal use of these pesticides, and the presence of other sources of DDE (Mora et al. 1987). Hexachlorobenzene residues were found more frequently in ducks collected at the Salton Sea than in those from other areas.

Setmire et al. (1993) sampled over 10 species of birds collected around the Salton Sea for organochlorines. Migratory ducks using the river and drains around the Salton Sea had higher concentrations of DDE than waterfowl just using the Sea (Setmire et al. 1993). Levels of DDE being ingested by waterfowl were high enough to cause reproductive problems. Some of the highest DDE concentrations were found in White-faced Ibis (geometric mean in liver = 5.93 µg/g wet weight, Setmire et al. 1993). Highest levels of DDE were found in resident birds around the Salton Sea. DDE concentrations in Double-crested Cormorants (geometric mean = 1.13 µg/g wet weight) at the Salton Sea were found to be comparable to levels found in the heavily contaminated Houston Shipping Channel in Texas (Setmire et al. 1993). High DDE concentrations in Black-

necked Stilt eggs were thought to cause significant eggshell thinning, which also was found in at least five species of local colonial nesters (Setmire et al. 1993). Setmire et al. (1993) concluded that resident birds of prey and fish eating birds were at the highest risk of DDE contamination in the Imperial Valley.

SALINITY

Concern has been expressed regarding the effects of increasing salinity on the Salton Sea ecosystem. Salinities at the Sea have increased from about 3% when it formed to about 40% to 43% in the 1990s, and the current salinities approach the upper tolerance levels for important invertebrates and some fish (Jehl 1994). If salinities continue to increase, within a decade large-scale changes could effect the entire ecosystem and its bird life, particularly fish-eating colonial species. High salinity levels also may affect breeding waterbirds. For example, increased intake of salt water by ducklings decreases their growth rates and increases their mortality (reviewed in Rubega and Robinson 1997). High salinity water also may increase feather wetting in young of precocial birds, thereby exposing them to excessive heat loss (Rubega and Robinson 1997).

ADDITIONAL SOURCES OF DATA

Although we have attempted to synthesize all the important data pertaining to birds at the Salton Sea, the short time frame available to us precluded an exhaustive search of potential sources of data, especially unpublished material. There is a significant amount of research done on birds in the Salton Sea area that currently remains unpublished. Below we identify the most important potential sources of such information known to us.

FIELD NOTES AND CHRISTMAS BIRD COUNTS

In this synthesis, we touched only briefly upon information published *in Field Notes* (and its predecessors *American Birds*, etc.). Christmas Bird Counts at two parts of the Salton Sea were initiated in 1972 and offer significant data on bird occurrence and numbers, although these data are often difficult to interpret. We summarized some of the data collected in the past five years. Seasonal reports from the Southern Pacific Coast region of *Field Notes* go back even further and also offer useful data, especially on peak numbers of some birds, historical trends, and noteworthy events concerning birds at the Salton Sea. Most of this information is currently being compiled by Michael Patten (see below).

UNPUBLISHED STUDIES

Daniel W. Anderson, Wildlife, Fisheries and Conservation Biology, University of California, Davis, has worked at the Salton Sea at various times in recent years and possesses information on a number of waterbirds. He has partial counts of Eared Grebes at different areas within the Sea and also has closely monitored Brown Pelican populations there, especially since 1996. Dan Anderson and Miguel Mora (Texas A&M) have nearly completed a bibliography of contaminant studies done in the Río Colorado Delta area.

David DeSante and his co-workers at the Institute of Bird Populations have unpublished data on the ecology and population size of the Burrowing Owl in the Imperial Valley.

Robert McKernan, San Bernardino County Museum, has gathered extensive long-term data on population sizes, distribution, and seasonal use of a variety of waterbirds at the Salton Sea. Among the more important focal species were the Eared Grebe, American White Pelican, and Ruddy Duck. He also has collected samples of various bird species for diet studies. Collectively, these data comprise the single most important set of unpublished (and unavailable) material on key species of waterbirds using the Salton Sea.

Barbara Massey and Richard Zembal, USFWS, are currently working on a book on the birds of the Salton Sea. Over the last year they have collected survey data on the distribution, abundance, and habitat use of birds at 14 areas around the Sea.

Kathy Molina, Natural History Museum of Los Angeles County, has monitored and banded nesting larids at the Salton Sea from 1991 to the present. She has unpublished information on various aspects of the breeding biology of California Gulls, Gull-billed and Caspian terns, and Black Skimmers. Additional she and Kimball Garrett have collected information on the post-breeding dispersal of terns and skimmers from the Salton Sea to the Río Colorado Delta.

Michael A. Patten, Department of Biology, University of Riverside, is currently writing a book on the birds of the Salton Sea. Part of his data were used in this synthesis (Appendix). He has collected extensive information on the birds of the Salton Sea from a variety of sources.

Stacy Peterson, Loma Linda University, is currently examining the winter distribution of the Large-billed Savannah Sparrow *(A. s. rostratus)* at the Salton Sea.

Point Reyes Bird Observatory has unpublished data on the differential distribution and habitat use of shorebirds around the Salton Sea and currently is gathering extensive baseline data on the population sizes, distribution, and habitat needs of a large variety of other types of birds as part of the broader Salton Sea Reconnaissance Project.

Philip Unitt and his staff at the San Diego Natural History Museum recently have made significant additional specimen collections from the Salton Sea region.

RESEARCH NEEDS

Although this report summarizes information on the important bird groups and mortality factors at the Salton Sea, there are large gaps in the knowledge needed to

effectively identify solutions to the problems facing the Sea. Some of this information remains unavailable from unpublished studies, but most such knowledge still needs to be gathered. Here we identifiy areas of bird research that seem to be lacking or need substantial additional work:

(1) Habitat use – little quantitative information is available on the within-Sea distribution and habitat needs of most species of waterbirds, data that will be crucial to ensure that any large scale projects designed to solve problems, such as increasing salinity, will not harm important species or habitats. Time series studies are needed to see how birds use the Sea at different water elevations both on a seasonal and long-term basis.

(2) Diseases – ongoing work is needed to identify the causes of large scale die-offs, mechanisms of disease transmission, and factors that trigger these events before solutions can be implemented to reduce their effects.

(3) Contaminants – additional studies are needed to understand the sources, mechanisms of uptake, and effect of contaminants on survival and reproduction of birds.

(4) Dietary studies – crucial to both disease and contaminant work will be more research on the diet of key species of birds, an area of study that has been particularly poorly represented in the past. Especially needed are collaborative projects between bird researchers and fish and invertebrate researchers.

(5) Long-term studies are needed of the reproductive success and demographics of colonial nesting waterbirds, which may be linked to disease, contaminant, and dietary research.

(6) Connectivity and dispersal – research is needed on the daily and seasonal use patterns and movements of birds between agricultural fields in the Imperial and Coachella valleys and the Sea and movements among various portions of the Sea. On a larger scale, research is needed on the dispersal patterns and migratory movements of birds between the Salton Sea and various other wetlands, such as the Río Colorado Delta and the Gulf of California. Banding and, particularly, radio-telemetry work is best suited for answering such questions.

(7) Monitoring – ongoing research and monitoring is needed to understand seasonal and long-term population dynamics and to assess the effectiveness of any large scale projects implemented to resolve the Sea's ecological problems.

(8) Passereines – there is a need to add to the very limited quantitative data on the importance of the Salton Sea area to migratory, wintering, and breeding landbirds.

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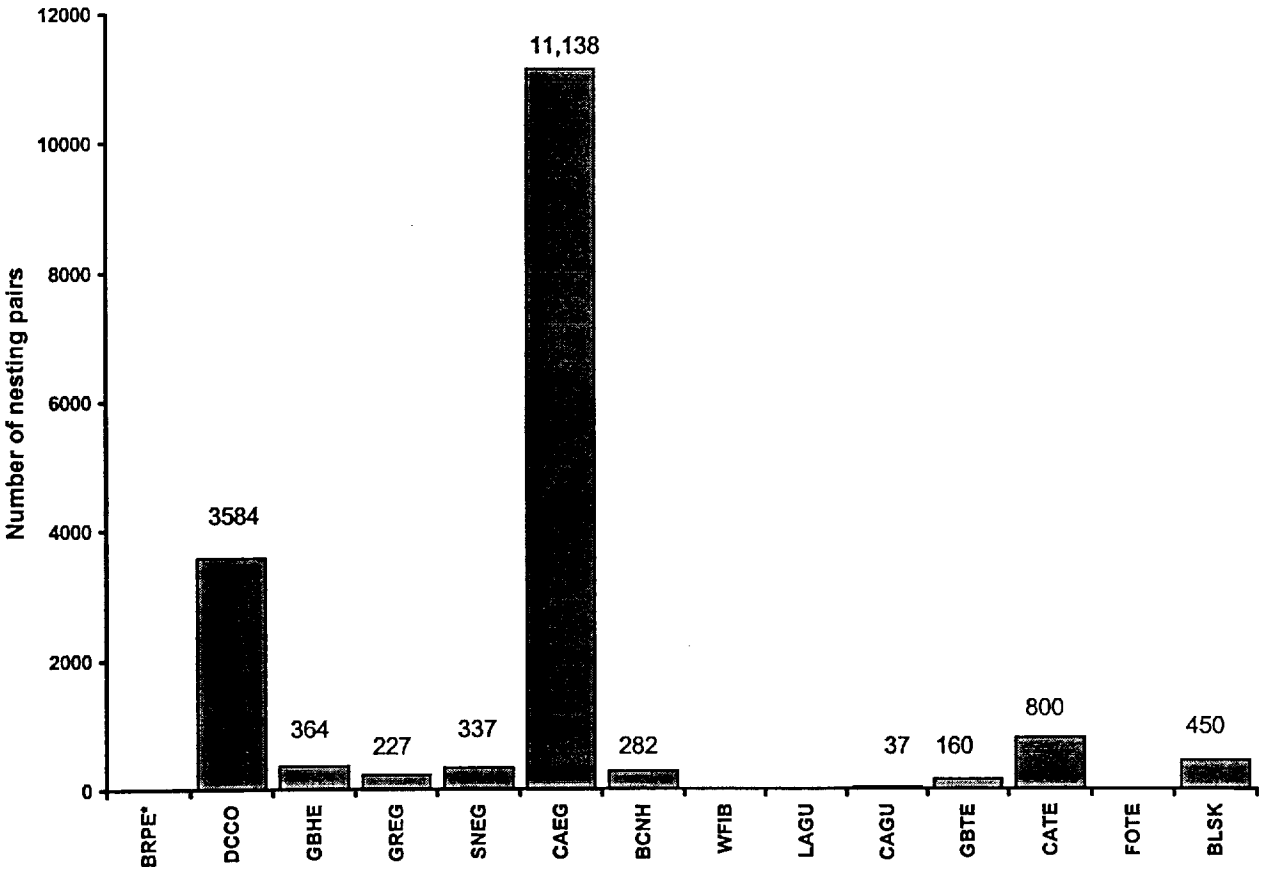

Figure 1. Estimates of the number of pairs of colonial nesting birds for 1998. Brown Pelican* (BRPE) attempts only, Double-crested Cormorant (DCCO), Great Blue Heron (GBHE), Great Egret (GREG), Snowy Egret (SNEG), Cattle Egret (CAEG), Black-crowned Night-Heron (BCNH), White-faced Ibis (WFIB), California Gull (CAGU), Laughing Gull (LAGU), Gull-billed Tern (GBTE), Caspian Tern (CATE), Forster's Tern (FOTE), Black Skimmer (BLSK). WFIB, LAGU, and FOTE were not known to nest in 1998. Sources are Salton Sea NWR files and K. Molina unpubl. data.

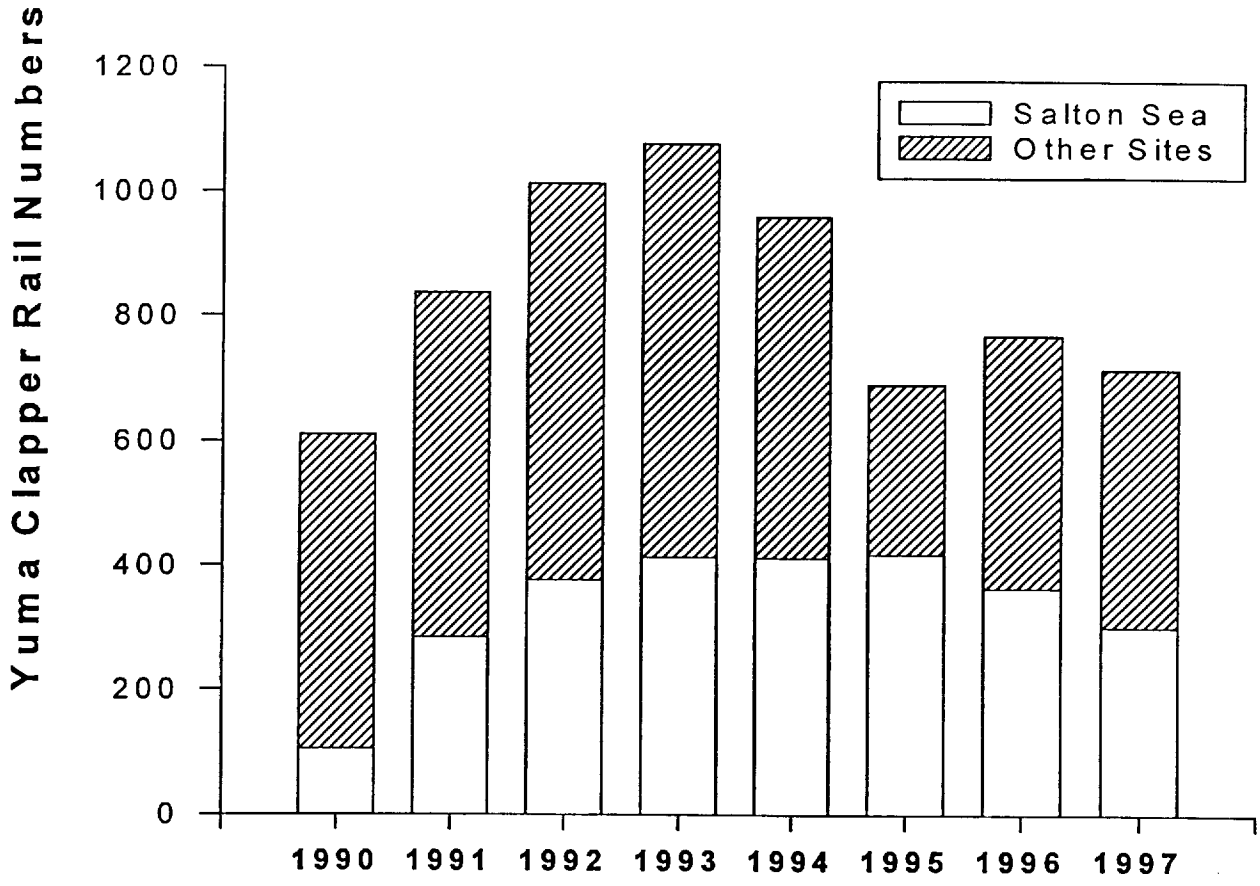

Figure 2. Yuma Clapper Rail census results: 1990 – 1997. Salton Sea numbers include breeding season counts from the Wister Unit, SSNWR, Salton Sea shoreline – Barnacle Beach, Salt Creek, and Holtville Drain. Other sites include all other known breeding areas of Yuma Clapper Rail. Data provided by Ron McKinstry of the Yuma Clapper Rail Recovery Team.

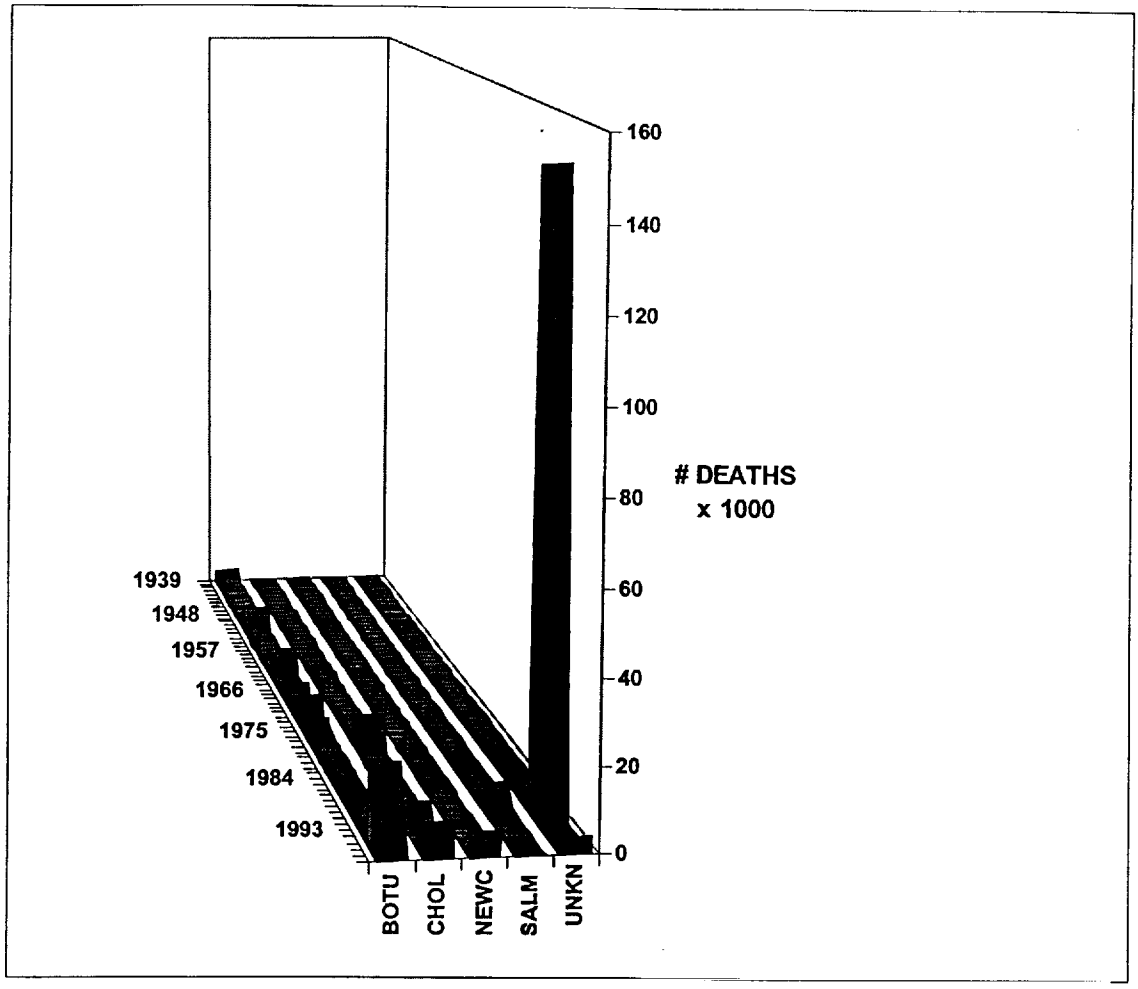

Fig. 3. Salton Sea avian mortality, 1939-1998. BOTU = botulism, CHOL = avian cholera, NEWC = Newcastle disease, SALM = salmonellosis, UNKN = cause unknown (SSNWR 1998a).

APPENDIX

CHECKLIST OF THE BIRDS OF THE SALTON SEA
(Compiled 17-18 December 1998)
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The Salton Sea is a large, saline lake in southeastern California. Although it was created in 1905 by accidental flooding by water diverted from the Colorado River, it lies entirely within a portion of historical Lake Cahuilla, a vastly larger ephemeral lake that was last filled in the mid-1600s. In this regard the Salton Sea can be viewed as a natural part of the Sonoran Desert ecosystem. The Sea is situated in a sub-sea level depression bordered on the west, north, and east by mountains, but to the south by the Imperial and Mexicali valleys, substantial portions of which also lie below sea level. From a biogeographic perspective, the Salton Sea and its adjacent valleys behave as a northern extension of the Gulf of California. Even a cursory examination of the list of seabirds and waterbirds that use the Salton Sea make its connection with the Gulf readily apparent. The Sea is also one of the most important locales in the Pacific Flyway for migratory shorebirds and wintering waterfowl. Lastly, it acts as a natural funnel for migratory landbirds, and is a unique westward extension of landbird avifauna associated with the Lower Colorado River Valley and points eastward.

Perhaps it is not surprising then, given this unique biogeographic setting, that nearly 400 species of birds have been recorded in the Salton Sea region, including about 100 species that breed. What follows is a complete list of all of those species, with status codes annotated for each. The region covered includes everything below the sea level line from the extreme southern Coachella Valley south to the Mexican border. Status codes are modified versions of those used by DeSante and Pyle (1986, Distributional Checklist of North American Birds, Artemisia Press, Lee Vining, Calif.). Assignment of status codes was largely a qualitative exercise. In general, the season during which the species is most common is listed first.

Status codes:

- c common (occurs in large numbers and/or is widespread in the region)
- f fairly common (occurs in modest numbers)
- u uncommon (occurs in small numbers)
- r rare (occurs infrequently, but regularly; a few records per year)
- x extremely rare (few records for the region; unexpected)
- l local (occurs regularly but in < 10% of region)
- e extirpated/former status
- i irruptive/irregular (peak commonness status is listed)

Seasonal codes:

S	summer visitor
T	transient (if unmodified [see below] then both spring and fall)
W	winter visitor
R	resident
P	perennial visitor (invididuals migrate but species present all year)

Modifiers:

*	breeding confirmed
+	breeding suspected
a	autumn records only (for transients)
s	spring records only (for transients)
as	autumn records predominate (for transients)
sa	spring records predominate (for transients)
p	post-breeding visitor (for transients)

GAVIIFORMES	
Gaviidae	
Red-throated Loon *Gavia stellata*	xW
Pacific Loon *Gavia pacifica*	xT
Common Loon *Gavia immer*	rT, xW
PODICIPEDIFORMES	
Podicipedidae	
Least Grebe *Tachybaptus dominicus*	xTa
Pied-billed Grebe *Podilymbus podiceps*	cR*
Horned Grebe *Podiceps auritus*	rT, xW, xS
Eared Grebe *Podiceps nigricollis*	cW
Western Grebe *Aecmophorus occidentalis*	uS*, fW
Clark's Grebe *Aechmophorus clarkii*	fR*
PROCELLARIIFORMES	
Diomedidae	
Laysan Albatross *Phoebastria immutabilis*	xTs
Procellariidae	
Cook's Petrel *Pterodroma cookii*	xS
Wedge-tailed Shearwater *Puffinus pacificus*	xS
Buller's Shearwater *Puffinus bulleri*	xTa
Sooty Shearwater *Puffinus griseus*	xS

Hydrobatidae	
Leach's Storm-Petrel *Oceanodroma leucorhoa*	xT
Black Storm-Petrel *Oceanodroma melania*	xTa
Least Storm-Petrel *Oceanodroma microsoma*	xTa, xS
PELECANIFORMES	
Sulidae	
Blue-footed Booby *Sula nebouxii*	irTp
Brown Booby *Sula leucogaster*	rTp
Pelecanidae	
American White Pelican *Pelecanus erythrorhynchos*	fW, uS, euS*
Brown Pelican *Pelecanus occidentalis*	fS, rS*
Phalacrocoracidae	
Neotropic Cormorant *Phalacrocorax brasilianus*	xT, xS, xS*
Double-crested Cormorant *Phalacrocorax auritus*	cP*
Brandt's Cormorant *Phalacrocorax penicillatus*	xTs
Fregatidae	
Magnificent Frigatebird *Fregata magnificens*	rTp, xW
CICONIIFORMES	
Ardeidae	
American Bittern *Botaurus lentiginosus*	uW, xS+
Least Bittern *Ixobrychus exilis*	fS*, rW
Great Blue Heron *Ardea herodias*	cP*
Great Egret *Ardea alba*	cP*
Snowy Egret *Egretta thula*	cP*
Little Blue Heron *Egretta caerulea*	rTsa, xS*
Tricolored Heron *Egretta tricolor*	xP, xS+
Reddish Egret *Egretta rufescens*	xS, xW
Cattle Egret *Bubulcus ibis*	cR*
Green Heron *Butorides virescens*	fP*
Black-crowned Night-Heron *Nycticorax nycticorax*	cP*
Yellow-crowned Night-Heron *Nyctanassa violacea*	xTs
Threskiornithidae	
White Ibis *Eudocimus albus*	xS
White-faced Ibis *Plegadis chihi*	fS*, cW
Roseate Spoonbill *Ajaia ajaja*	xS
Ciconiidae	
Wood Stork *Mycteria americana*	ecTp, lrTp

Cathartidae	
Turkey Vulture *Cathartes aura*	cT, uW
ANSERIFORMES	
Anatidae	
Fulvous Whistling-Duck *Dendrocygna bicolor*	lrS*, xT
Black-bellied Whistling-Duck *Dendrocygna autumnalis*	xS, xT
Greater White-fronted Goose *Anser albifrons*	uT, rW
Snow Goose *Chen caerulescens*	cW, xS
Ross's Goose *Chen rossii*	cW, xS
Canada Goose *Branta canadensis*	cW, xS
Brant *Branta bernicla*	uTs, rS, rTa
Tundra Swan *Cygnus columbianus*	xW
Wood Duck *Aix sponsa*	xW
Gadwall *Anas strepera*	fW, rS
Eurasian Wigeon *Anas penelope*	rW
American Wigeon *Anas americana*	cW, rS
Mallard *Anas platyrhynchos*	cW, uS*
Blue-winged Teal *Anas discors*	rT, xW, xS
Cinnamon Teal *Anas cyanoptera*	cW, fS*
Northern Shoveler *Anas clypeata*	cW, rS
Northern Pintail *Anas acuta*	cW, rS
Baikal Teal *Anas formosa*	xW
Green-winged Teal *Anas crecca*	cW, rS
Redhead *Aythya americana*	cP*
Canvasback *Aythya valisineria*	uW, xS
Ring-necked Duck *Aythya collaris*	uW, xS
Tufted Duck *Aythya fuligula*	xW
Greater Scaup *Aythya marila*	rW, xS
Lesser Scaup *Aythya affinis*	uW, rS
Oldsquaw *Clangula hyemalis*	xT, xW
White-winged Scoter *Melanitta fusca*	rTsa, rS, xW
Surf Scoter *Melanitta perspicillata*	rTsa, rS, xW
Black Scoter *Melanitta nigra*	xP
Bufflehead *Bucephala albeola*	cW, rS
Common Goldeneye *Bucephala clangula*	uW
Barrow's Goldeneye *Bucephala islandica*	xW
Hooded Merganser *Lophodytes cuculatus*	rW
Common Merganser *Mergus merganser*	rW
Red-breasted Merganser *Mergus serrator*	uW, xS
Ruddy Duck Oxyura jamaicensis	cP*
FALCONIFORMES	
Accipitridae	
Osprey *Pandion haliaetus*	uP+
White-tailed Kite *Elanus leucurus*	rP*

Accipitridae (continued)	
Bald Eagle *Haliaeetus leucocephalus*	rW
Northern Harrier *Circus cyaneus*	cW, rS
Sharp-shinned Hawk *Accipiter striatus*	uW
Cooper's Hawk *Accipiter cooperi*	uW
Common Black-Hawk *Buteogallus anthracinus*	xTs
Harris's Hawk *Parabuteo unicinctus*	efR*, xW, xS
Red-shouldered Hawk *Buteo lineatus*	rP
Broad-winged Hawk *Buteo platypterus*	xW
Swainson's Hawk *Buteo swainsoni*	rTsa, xW
Zone-tailed Hawk *Buteo albonotatus*	xW
Red-tailed Hawk *Buteo jamaicensis*	cP*
Ferruginous Hawk *Buteo regalis*	uW
Rough-legged Hawk *Buteo lagopus*	rW
Golden Eagle *Aquila chrysaetos*	xT, xW
Falconidae	
American Kestrel *Falco sparverius*	cR*
Merlin *Falco columbiarus*	rW
Peregrine Falcon *Falco peregrinus*	uS, rW
Prairie Falcon *Falco mexicanus*	rP
GALLIFORMES	
Odontophoridae	
Gambel's Quail *Callipepla gambelii*	cR*
GRUIFORMES	
Rallidae	
Black Rail *Laterallus jamaicensis*	rS*
Clapper Rail *Rallus longirostris*	uR*
Virginia Rail *Rallus limicola*	uW
Sora *Porzana carolinensis*	fW, xS+
Common Moorhen *Gallinula chloropus*	fR*
American Coot *Fulica americana*	cR*
Gruidae	
Sandhill Crane *Grus canadensis*	luW
CHARADRIIFORMES	
Charadriidae	
Black-bellied Plover *Pluvialus squatarola*	cT, fW, uS
American Golden-Plover *Pluvialus dominica*	xT
Pacific Golden-Plover *Pluvialus fulva*	xT, xW
Snowy Plover *Charadrius alexandrinus*	cS*, uW
Wilson's Plover *Charadrius wilsonia*	xS*
Semipalmated Plover *Charadrius semipalmatus*	cT, uW, rS

Charadriidae (continued)	
Killdeer *Charadrius vociferus*	cR*
Mountain Plover *Charadrius montanus*	lfW
Haematopidae	
American Oystercatcher *Haematopus palliatus*	xTa
Recurvirostridae	
Black-necked Stilt *Himantopus mexicanus*	cR*
American Avocet *Recurvirostra americana*	cR*
Scolopacidae	
Greater Yellowlegs *Tringa melanoleuca*	cT, uW, uS
Lesser Yellowlegs *Tringa flavipes*	fT, rW
Spotted Redshank *Tringa erythropus*	xTs
Solitary Sandpiper *Tringa solitaria*	rT, xW
Willet *Catoptrophorus semipalmatus*	fP
Wandering Tattler *Heteroscelus incanus*	xT
Spotted Sandpiper *Actitis macularia*	fW
Whimbrel *Numenius phaeopus*	cT, rS, xW
Long-billed Curlew *Numenius americana*	cW, luS
Hudsonian Godwit *Limosa haemastica*	xTs
Marbled Godwit *Limosa fedoa*	fW, uS
Ruddy Turnstone *Arenaria interpes*	uTs, rTa, xW, xS
Black Turnstone *Arenaria melanocephala*	rTs, xTa, xW, xS
Surfbird *Aphriza virgata*	rTs
Red Knot *Calidris canutus*	fTs, rTa
Sanderling *Calidris alba*	uT, rW
Semipalmated Sandpiper *Calidris pusilla*	rT
Western Sandpiper *Calidris mauri*	cT, fW, rS
Little Stint *Calidris minuta*	xTs
Least Sandpiper *Calidris minutilla*	cW, rS
White-rumped Sandpiper *Calidris fuscicollis*	xTs
Baird's Sandpiper *Calidris bairdii*	rTa, xTs
Pectoral Sandpiper *Calidris melanotos*	xTas, xW
Dunlin *Calidris alpina*	uW
Curlew Sandpiper *Calidris ferruginea*	xT
Stilt Sandpiper *Calidris himantopus*	lcTs, luW
Ruff *Philomachus pugnax*	xTa, xW
Short-billed Dowitcher *Limnodromus griseus*	cT
Long-billed Dowitcher *Limnodromus scolopaceus*	cW, rS
Common Snipe *Gallinago gallinago*	uW
Wilson's Phalarope *Phalaropus tricolor*	cT, xW
Red-necked Phalarope *Phalaropus lobatus*	cT
Red Phalarope Phalaropus fulicaria	rT

Stercorariidae	
Pomarine Jaeger *Stercorarius pomarinus*	xS, xT
Parasitic Jaeger *Stercorarius parasiticus*	rTa, xTs
Long-tailed Jaeger *Stercorarius longicaudus*	xT
Laridae	
Laughing Gull *Larus atricilla*	fTp, xW, xS*
Franklin's Gull *Larus pipixcan*	uTs, rTa, xS, xW
Little Gull *Larus minutus*	xW, xT
Bonaparte's Gull *Larus philadelphia*	uW, rS
Heermann's Gull *Larus heermanni*	xTp, xW
Mew Gull *Larus canus*	rW
Ring-billed Gull *Larus delawarensis*	cW, uS
California Gull *Larus californicus*	cW, uS, lrS*
Herring Gull *Larus argentatus*	fW
Iceland (Thayer's) Gull *Larus glaucoides*	rW
Lesser Black-backed Gull *Larus fuscus*	xW, xTa
Slaty-backed Gull *Larus schistisagus*	xW
Yellow-footed Gull *Larus livens*	cS, rW
Western Gull *Larus occidentalis*	rP
Glaucous-winged Gull *Larus glaucescens*	rW, xS
Glaucous Gull *Larus hyperboreus*	xP
Black-legged Kittiwake *Rissa tridactyla*	xW, xS, xTa
Sabine's Gull *Xema sabini*	rTa, xS, xTs
Gull-billed Tern *Sterna nilotica*	fS*
Caspian Tern *Sterna caspia*	fS*, rW
Royal Tern *Sterna maxima*	xS
Elegant Tern *Sterna elegans*	xS
Common Tern *Sterna hirundo*	cTa, rTs
Arctic Tern *Sterna paradisaea*	xTsa, xS
Forster's Tern *Sterna forsteri*	fS*, uW
Least Tern *Sterna antillarum*	rTs, xS
Black Tern *Chlidonias niger*	fT, uS
Black Skimmer *Rynchops niger*	fS*, xW
Alcidae	
Ancient Murrelet *Synthliboramphus antiquus*	xTs
COLUMBIFORMES	
Columbidae	
Band-tailed Pigeon *Columba fasciata*	xT, xW
White-winged Dove *Zenaida asiatica*	cS*
Mourning Dove *Zenaida macroura*	cR*
Inca Dove *Columbina inca*	uR+
Common Ground-Dove *Columbina passerina*	cR*

CUCULIFORMES	
Cuculidae	
Yellow-billed Cuckoo *Coccyzus americanus*	euS*, xS
Greater Roadrunner *Geococcyx californianus*	fR*
Groove-billed Ani *Crotophaga sulcirostris*	xTa
STRIGIFORMES	
Tytonidae	
Barn Owl *Tyto alba*	uR*
Strigidae	
Flammulated Owl *Otus flammeolus*	xTa
Western Screech-Owl *Otus kennicottii*	lrR*
Great Horned Owl *Bubo virginianus*	uR*
Elf Owl *Micrathene whitneyi*	xTa
Burrowing Owl *Athene cunnicularia*	cR*
Long-eared Owl *Asio otus*	rW
Short-eared Owl *Asio flammeus*	rW
Northern Saw-whet Owl *Aegolius acadicus*	xW
CAPRIMULGIFORMES	
Caprimulgidae	
Lesser Nighthawk *Chordeiles acutipennis*	cS*, xW
Common Poorwill *Phalaenoptilus nuttallii*	xTa
Whip-poor-will *Camprimulgus vociferus*	xTa
APODIFORMES	
Apodidae	
Black Swift *Cypseloides niger*	xTsa
Chimney Swift *Chaetura pelagica*	xT
Vaux's Swift *Chaetura vauxi*	cTs, uTa
White-throated Swift *Aeronautes saxatalis*	uW
Trochilidae	
Black-chinned Hummingbird *Archilochus alexandri*	fS*
Anna's Hummingbird *Calypte anna*	fR*
Costa's Hummingbird *Calypte costae*	fR*
Calliope Hummingbird *Stellula calliope*	rTs
Rufous Hummingbird *Selasphorus rufus*	uT
Allen's Hummingbird *Selasphorus sasin*	xTa
CORACIFORMES	
Alcedinidae	
Belted Kingfisher *Ceryle alcyon*	uW

PICIFORMES

Picidae

Lewis' Woodpecker *Melanerpes lewis*	rW
Red-headed Woodpecker *Melanerpes erythrocephalus*	xS
Acorn Woodpecker *Melanerpes formicivorus*	xTa, xW
Gila Woodpecker *Melanerpes uropygialis*	uR*
Yellow-bellied Sapsucker *Sphyrapicus varius*	xW
Red-naped Sapsucker *Sphyrapicus nuchalis*	rW
Red-breasted Sapsucker *Sphyrapicus ruber*	xW
Ladder-backed Woodpecker *Picoides scalaris*	fR*
Nuttall's Woodpecker *Picoides nuttallii*	xTa
Downy Woodpecker *Picoides pubescens*	xTs
White-headed Woodpecker *Picoides albolarvatus*	xTa
Northern Flicker *Colaptes auratus*	fW
Gilded Flicker *Colaptes chrysoides*	xW

PASSERIFORMES

Tyrannidae

Olive-sided Flycatcher *Contopus cooperi*	uT
Greater Pewee *Contopus pertinax*	xTa
Western Wood-Pewee *Contopus sordidulus*	cT
Alder Flycatcher *Empidonax alnorum*	xTa
Willow Flycatcher *Empidonax traillii*	cT, xS
Least Flycatcher *Empidonax minimus*	xW
Hammond's Flycatcher *Empidonax hammondii*	fT
Dusky Flycatcher *Empidonax oberholseri*	rT
Gray Flycatcher *Empidonax wrightii*	uT, rW
Pacific-slope Flycatcher *Empidonax difficilis*	fT
Black Phoebe *Sayornis nigricans*	cW, uS*
Eastern Phoebe *Sayornis phoebe*	xTa, rW
Say's Phoebe *Sayornis saya*	cW, uS*
Vermilion Flycatcher *Pyrocephalus rubinus*	leuS*, rW, xS+
Dusky-capped Flycatcher *Myiarchus tuberculifer*	xW
Ash-throated Flycatcher *Myiarchus cinerascens*	uT, rW
Brown-crested Flycatcher *Myiarchus tyrannulus*	lxS*
Tropical Kingbird *Tyrannus melanocolichus*	xTa, xW
Cassin's Kingbird *Tyrannus vociferans*	xTas, xW
Western Kingbird *Tyrannus verticalis*	cS*
Eastern Kingbird *Tyrannus tyrannus*	xT, xS
Scissor-tailed Flycatcher *Tyrannus forficatus*	xTa

Laniidae

Northern Shrike *Lanius excubitor*	xW
Loggerhead Shrike *Lanius ludovicianus*	fR*

Vireonidae	
Bell's Vireo *Vireo bellii*	rS, xW
Gray Vireo *Vireo vicinior*	xTs
Cassin's Vireo *Vireo cassinii*	uT
Plumbeous Vireo *Vireo plumbeus*	rT, rW
Warbling Vireo *Vireo gilvus*	cT
Red-eyed Vireo *Vireo olivaceus*	xTa
Corvidae	
Western Scrub-Jay *Aphelocoma californica*	xTa, xW
Pinyon Jay *Gymnorhinus cyanocephalus*	xW
Clark's Nutcracker *Nucifraga columbiana*	xTa
American Crow *Corvus brachyrhynchos*	xW
Common Raven *Corvus corax*	fR*
Alaudidae	
Horned Lark *Eremophila alpestris*	cP*
Hirundinidae	
Purple Martin *Progne subis*	xT, xS
Tree Swallow *Tachycineta bicolor*	cT, fW
Violet-green Swallow *Tachycineta thalassina*	fT, xW
Northern Rough-winged Swallow *Stelgidopteryx serripennis*	cT, uW
Bank Swallow *Riparia riparia*	fT, xW
Cave Swallow *Petrochelidon fulva*	xT
Cliff Swallow *Petrochelidon pyrrhonota*	cT, fS*, xW
Barn Swallow *Hirundo rustica*	cT, lrS*, xW
Paridae	
Mountain Chickadee *Peocile gambelii*	xW, xTa
Oak Titmouse *Baelophus inornatus*	xW
Remizidae	
Verdin *Auriparus flaviceps*	cR*
Aegithalidae	
Bushtit *Psaltriparus minimus*	xW
Sittidae	
Red-breasted Nuthatch *Sitta canadensis*	rW
White-breasted Nuthatch *Sitta carolinensis*	xTa
Certhidae	
Brown Creeper *Certhia americana*	rW

Troglodytidae	
Cactus Wren *Campylorhynchus brunneicapillus*	fR*
Rock Wren *Salpinctes obsoletus*	rW
Canyon Wren *Catherpes mexicanus*	xW
Bewick's Wren *Thryomanes bewickii*	uW, rS+
House Wren *Troglodytes aedon*	fW
Winter Wren *Troglodytes troglodytes*	xW
Marsh Wren *Cistothorus palustris*	cR*
Regulidae	
Golden-crowned Kinglet *Regulus satrapa*	rW
Ruby-crowned Kinglet *Regulus calendula*	cW
Sylviidae	
Blue-gray Gnatcatcher *Polioptila caerulea*	cW
Black-tailed Gnatcatcher *Polioptila melanura*	cR*
Turdidae	
Western Bluebird *Sialia mexicana*	rW
Mountain Bluebird *Sialia currucoides*	ifW
Townsend's Solitaire *Myadestes townsendii*	rW, rTa
Swainson's Thrush *Catharus ustulatus*	fTs, rTa
Hermit Thrush *Catharus guttatus*	uW
American Robin *Turdus migratorius*	ifW, rS*
Varied Thrush *Ixoreus naevius*	xTa, xW
Mimidae	
Northern Mockingbird *Mimus polyglottos*	cR*
Sage Thrasher *Oreoscoptes montanus*	rW
Brown Thrasher *Toxostoma rufum*	xTa, xW
Bendire's Thrasher *Toxostoma bendirei*	xW
Curve-billed Thrasher *Toxostoma curvirostre*	xT, xW
Crissal Thrasher *Toxostoma crissale*	uR*
Le Conte's Thrasher *Toxostoma lecontei*	rR*
Motacillidae	
American Pipit *Anthus rubescens*	cW
Sprague's Pipit *Anthus spragueii*	xW, xTa
Bombycillidae	
Cedar Waxwing *Bombycilla cedorum*	iuW
Ptilogonatidae	
Phainopepla *Phainopepla nitens*	fW, rS*

Parulidae	
Blue-winged Warbler *Vermivora pinus*	xTa
Tennessee Warbler *Vermivora chrysoptera*	xTa, xW
Orange-crowned Warbler *Vermivora celata*	cW
Nashville Warbler *Vermivora ruficapilla*	cT, xW
Virginia's Warbler *Vermivora virginiae*	xTa, xW
Lucy's Warbler *Vermivora luciae*	leuS*, xS
Northern Parula *Parula americana*	xT, xW
Yellow Warbler *Dendroica petechia*	cT, rW
Chestnut-sided Warbler *Dendroica pensylvanica*	xW, xTa
Magnolia Warbler *Dendroica magnolia*	xTa
Cape May Warbler *Dendroica tigrina*	xW, xTa
Black-throated Blue Warbler *Dendroica caerulescens*	xT
Yellow-rumped Warbler *Dendroica coronata*	cW
Black-throated Gray Warbler *Dendroica nigrescens*	fT, xW
Townsend's Warbler *Dendroica townsendi*	fT, xW
Hermit Warbler *Dendroica occidentalis*	rTs
Black-throated Green Warbler *Dendroica virens*	xW
Blackburnian Warbler *Dendroica fusca*	xTa
Yellow-throated Warbler *Dendroica dominica*	xW
Pine Warbler *Dendroica pinus*	xTa, xW
Prairie Warbler *Dendroica discolor*	xTa
Palm Warbler *Dendroica palmarum*	xW, xTa
Bay-breasted Warbler *Dendroica castanea*	xTs
Blackpoll Warbler *Dendroica striata*	xTa
Cerulean Warbler *Dendroica cerulea*	xTa
Black-and-white Warbler *Mniotilta varia*	xT, xW
American Redstart *Setophaga ruticilla*	rW, rT
Prothonotary Warbler *Protonotaria citrea*	xTa
Ovenbird *Seiurus aurocapillus*	xT, xW
Northern Waterthrush *Seiurus noveboracensis*	xTa, xW
Louisiana Waterthrush *Seiurus motacilla*	xTa
MacGillivray's Warbler *Oporornis tolmiei*	uT
Common Yellowthroat *Geothylpis trichas*	cP*
Wilson's Warbler *Wilsonia pusilla*	cT, xW
Painted Redstart *Myioborus pictus*	xW, xT
Yellow-breasted Chat *Icteria virens*	rS*
Thraupidae	
Summer Tanager *Piranga rubra*	xW, xT
Western Tanager *Piranga ludoviciana*	fT
Emberizidae	
Green-tailed Towhee *Pipilo chlorurus*	rW, rT
Spotted Towhee *Pipilo maculatus*	rW
Abert's Towhee *Pipilo aberti*	cR*

Emberizidae (continued)	
Cassin's Sparrow *Aimophila cassinii*	xTs
American Tree Sparrow *Spizella aborea*	xW
Chipping Sparrow *Spizella passerina*	uW
Clay-colored Sparrow *Spizella pallida*	xTs, xW
Brewer's Sparrow *Spizella breweri*	cW
Black-chinned Sparrow *Spizella atrogularis*	xT
Vesper Sparrow *Pooecetes gramineus*	uW
Lark Sparrow *Chondestes grammacus*	uT, rS*
Black-throated Sparrow *Amphispiza bilineata*	rR*
Sage Sparrow *Amphispiza belli*	fW
Lark Bunting *Calamospiza melanocorys*	rT, xW
Savannah Sparrow *Passerculus sandwichensis*	cW
Grasshopper Sparrow *Ammodramus savannarum*	xT, xW
Fox Sparrow *Passerella iliaca*	rW
Song Sparrow *Melospiza melodia*	cR*
Lincoln's Sparrow *Melospiza lincolnii*	fW
Swamp Sparrow *Melospiza georgiana*	rW
Harris's Sparrow *Zonotrichia querula*	xW
Golden-crowned Sparrow *Zonotrichia atricapilla*	rW
White-throated Sparrow *Zonotrichia albicollis*	xW
White-crowned Sparrow *Zonotrichia leucophrys*	cW
Dark-eyed Junco *Junco hyemalis*	uW
McCown's Longspur *Calcarius mccownii*	xTa, xW
Lapland Longspur *Calcarius lapponicus*	xW
Chestnut-collared Longspur *Calcarius ornatus*	xW
Cardinalidae	
Pyrrhuloxia *Cardinalus sinuatus*	xP
Rose-breasted Grosbeak *Pheucticus ludovicianus*	xT, xW
Black-headed Grosbeak *Pheucticus melanocephalus*	cT
Blue Grosbeak *Guiraca caerulea*	fS*
Lazuli Bunting *Passerina amoena*	fT
Indigo Bunting *Passerina cyanea*	xT, xW
Dickcissel *Spiza americana*	xTa
Icteridae	
Bobolink *Dolichonyx oryzivorus*	xS
Red-winged Blackbird *Agelaius phoeniceus*	cR*
Tricolored Blackbird *Agelaius tricolor*	xTs
Western Meadowlark *Sturnella neglecta*	cR*
Yellow-headed Blackbird *Xanthocephalus xanthocephalus*	fS*, uW
Brewer's Blackbird *Euphagus cyanocephalus*	cW, luS*
Great-tailed Grackle *Quiscalus mexicanus*	cR*
Bronzed Cowbird *Molothrus aeneus*	lrS*
Brown-headed Cowbird *Molothrus ater*	cP*

Icteridae (continued)	
Orchard Oriole *Icterus spurius*	xT, xW
Hooded Oriole *Icterus cuculatus*	uS*, xW
Bullock's Oriole *Icterus bullockii*	cS*, xW
Baltimore Oriole *Icterus galbula*	xT
Scott's Oriole *Icterus parisorum*	xTa, xW
Fringillidae	
Purple Finch *Carpodacus purpureus*	rW
Cassin's Finch *Carpodacus cassinii*	xW
House Finch *Carpodacus mexicanus*	cR*
Red Crossbill *Loxia curvirostra*	irW
Pine Siskin *Carduelis pinus*	iuW
Lesser Goldfinch *Carduelis psaltria*	uR*
Lawrence's Goldfinch *Carduelis lawrencei*	rW
American Goldfinch *Carduelis tristis*	uW
Evening Grosbeak *Coccothraustes verpertinus*	xTa
Non-Native Species	
Ring-necked Pheasant *Phasianus colchicus*	luR*
Feral Pigeon *Columba "livia"*	cR*
Spotted Dove *Streptopelia chinensis*	lrR+, xS
European Starling *Sturnus vulgaris*	cR
House Sparrow *Passer domesticus*	cR