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DISTRIBUTION PATTERNS OF WATERBIRDS AT THE SALTON SEA, CALIFORNIA, IN 1999

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Abstract. As part of a multi-disciplinary reconnaissance survey, we used a variety of survey methods to describe the distribution patterns of waterbirds at and around the Salton Sea in 1999. Waterbirds were not equally distributed around the Sea. Our studies documented the great importance to a variety of birds of habitats along the northern, southwestern, southern, and southeastern shorelines of the Salton Sea. These areas hosted large numbers of birds, important nesting, roosting, and foraging sites, and habitats for various species of conservation concern. Inshore waters within a kilometer of the entire shoreline were also important to a variety of diving waterbirds. Certain wading birds and shorebirds were much more numerous in agricultural fields of the Imperial Valley than in wetland habitats at the Salton Sea. Projects to restore the ecosystem's health by reducing salinity and limiting bird mortalities should be carefully assessed to ensure they do not have unintended impacts and are not placed where breeding, roosting, or foraging birds concentrate.

Key Words: conservation concerns; Imperial Valley; migratory stopover; nesting colonies; wintering area.

PATRONES DE DISTRIBUCIÓN DE AVES ACUÁTICAS EN EL MAR SALTON, CALIFORNIA, EN 1999

Resumen. Como parte de un muestreo de reconocimiento multidisciplinario, usamos una variedad de métodos de muestreo para describir los patrones de distribución de aves acuáticas en y alrededor del Mar Salton en 1999. Las aves acuáticas no estuvieron distribuidas igualmente alrededor del Mar Salton. Nuestro estudio documentó la gran importancia de hábitats a lo largo de las costas norte, suroeste, sur y sureste del Mar Salton para una variedad de aves. Estas áreas albergaron un gran número de aves, sitios importantes de anidamiento, sitios de descanso y sitios de alimentación, y hábitats para varias especies de interés para la conservación. Aguas dentro de la costa incluidas dentro de un kilómetro de la línea de costa fueron también importantes para una variedad de aves acuáticas zambullidoras. Ciertas aves vadeadoras y aves playeras fueron mucho más numerosas en campos agrícolas del Valle Imperial que en hábitats de humedales en el Mar Salton. Los proyectos para restaurar la salud del ecosistema, por medio de la reducción de la salinidad y limitando la mortalidad de aves, deberían ser cautelosamente evaluados para asegurar que no provoquen impactos no intencionales y que no sean llevados a cabo donde se concentran aves en reproducción, en sitios de descanso o en sitios de alimentación.

Palabras claves: área de invernada; colonias de anidamiento; interés en conservación; sitios de parada durante la migración; Valle Imperial.

The Salton Sea and its surrounding area has long been recognized as a strategic breeding, migratory stopover, and wintering location for waterbirds (e.g., Grinnell 1908, McCaskie 1970b, Heitmeyer et al. 1989, Patten et al. 2003). This site supports populations of many species of waterbirds that are of conservation concern either because they have small overall populations or the proportion of their populations at the Sea are of regional, national, or continental stature (Shuford et al. 2002b). Yet, no comprehensive data have been published on the distribution patterns and concentration areas of all waterbirds at the Salton Sea. Spawned by concern over high salinity, large bird mortalities, disease outbreaks, and risks of contaminants (Tetra Tech 2000), current efforts to restore the health of the Salton Sea's ecosystem need such information to design restoration projects that will benefit the Sea's bird populations. Efforts to increase recreation and revitalize commerce at the Sea also might impact breeding or non-breeding birds if human activities encroach on areas where birds concentrate.

As part of a year-long reconnaissance survey, we gathered data on the abundance, distribution, seasonal phenology, and broadscale habitat associations of birds at the Salton Sea and adjacent habitats. Here we report the patterns of distribution of the key groups and species of waterbirds at the Salton Sea in 1999 and identify areas of the Sea where particularly large bird concentrations or sensitive species occur. We also identify a list of needed research on the distribution of waterbirds at the Salton Sea.

STUDY AREA AND METHODS

We used a suite of survey methods to document the distribution of waterbirds at the Salton Sea, adjacent wetland habitats, and irrigated agricultural fields of the Imperial Valley. As our primary method of documenting the distributions of most waterbirds, we conducted

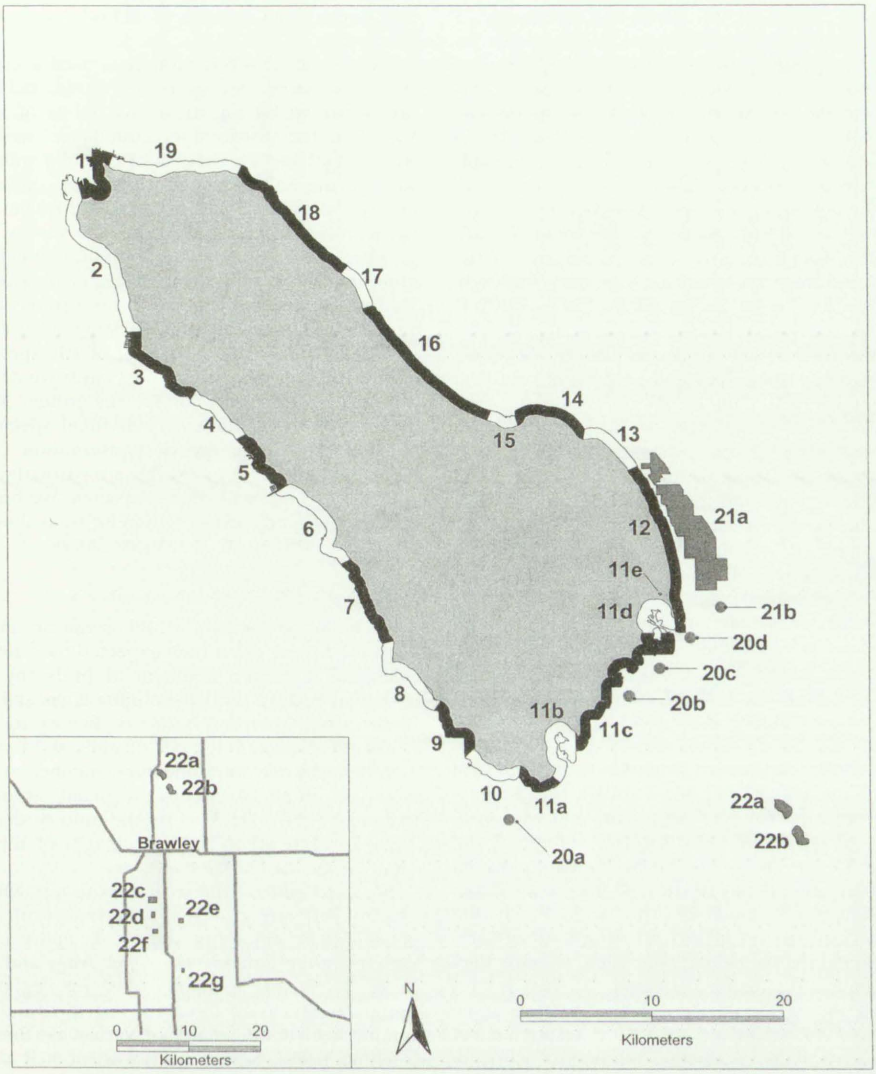

FIGURE 1. Shoreline segments of the Salton Sea, California, and adjacent wetlands used in the 1999 study.

four comprehensive surveys of waterbirds at the Salton Sea and nearby wetlands and marshes. We conducted these surveys primarily from the ground, but used aerial surveys to gather information on certain species (see below). Survey periods were during mid-winter (22 January–5 February), spring migration (17–18 April), fall migration (13–16 August), and early winter (11–15 November). To obtain data on the patterns of waterbird distribution in particular, observers tallied birds separately within 19 shoreline segments (with adjacent open water zone) and three complexes of freshwater marshes and impoundments (Fig. 1). See Shuford et al. (2000) for a comprehensive list of the species surveyed and for further descriptions of areas and areas boundaries.

We also conducted aerial surveys for various waterbirds using the inshore (<1 km from shore) and offshore waters (>1 km) of the Salton Sea. We sampled the latter area with two north-south transects (each transect 45–50 km long), 6–10 km in from the east–west shorelines (see Shuford et al. 2000 for more details). Species surveyed on aerial transects included the Eared Grebe (*Podiceps nigricollis*), Western (*Aechmophorus occidentalis*) and Clark's (*A. clarkii*) grebe (lumped as *Aechmophorus* spp.), American White Pelican (*Pelecanus erythrorhynchos*), Brown Pelican (*P. occidentalis*), Double-crested Cormorant (*Phalacrocorax auritus*), and Ruddy Duck (*Oxyura jamaicensis*). We assessed spatial distribution patterns by tallying all birds within the 19 shoreline and inshore segments, and for Eared Grebes, *Aechmophorus* grebes, and Ruddy Ducks, also within the two offshore transects. Aerial survey dates were: 28 January, 12 February, 5 March, 19 March, 28 March, 16 April, 28 May, 16 August, 29 November, and 17 December. On the 16 August survey, we also counted all Black Terns (*Chlidonias niger*) seen within the 19 shoreline and inshore segments and along six parallel transects about 25–30 km long and spaced 5 km apart over irrigated agricultural fields in the Imperial Valley.

For geese and ducks, we report distribution data collected by the Sonny Bono Salton Sea National Wildlife Refuge (SSNWR) biologists on aerial surveys of the Salton Sea and Imperial Valley on 8 January, 9 March, 3 April, 27 May, and 18 November 1999. SSNWR biologists tallied waterfowl numbers separately for two areas of the Salton Sea (Imperial County shoreline, Riverside County shoreline) and seven impoundment complexes (SSNWR Unit 1, SSNWR Unit 2, south shore duck clubs, Wister Unit of Imperial Wildlife Area (Wister Unit), Finney and Ramer lakes, duck clubs and reservoirs south of Brawley, and northshore/ Coachella duck clubs and fish farms).

We documented the distribution patterns of breeding rails in a variety of marsh habitats around the periphery of the Salton Sea. The Yuma Clapper Rail (*Rallus longirostris yumanensis*), and the Black Rail (*Laterallus jamaicensis*) were targeted and surveyed through their response to taped play backs of their breeding calls following established protocol (USFWS 1983, Evens et al. 1991). We focused survey efforts at previously known Clapper Rail areas, particularly the Wister Unit and SSNWR, but also covered four areas not traditionally covered in previous years. Surveys within both the Wister Unit and SSNWR followed established transects from previous years and were conducted by personnel of the respective refuges. Point Reyes Bird Observatory (PRBO) biologists conducted surveys at all new off-refuge sites. Biologists surveyed all transects twice between 24 April and 15 May. On each transect, observers picked listening stations within appropriate marsh habitat. At each station, they played a tape for two min, stopped to listen for responses for two min, and then played the tape again for two min. Observers recorded birds responding to the tapes as well as incidental sightings of rails. In general, stations along a transect were 70 to 100 m apart depending on the habitat. Observers conducted all rail surveys between 0500–0900 except for one Black Rail survey done at Finney Lake between 1800–1930.

We counted various wading birds (herons, egrets, ibis, cranes) that came to nighttime roosts at up to six wetlands in the Imperial Valley on 27 January, 13 February, 13 March, 14 August, 15 September, 21 October, 11 November, and 16 December. Although these counts mainly provided data on the population sizes and annual phenology patterns of these species, they also documented the importance of agricultural areas and alternative wetland habitats as roost sites for certain species in the Imperial Valley.

To sample the distribution of birds in agricultural fields near the Salton Sea, we conducted monthly surveys along five 8.05-km long roadside transects located in the northern Imperial Valley just south of the Salton Sea. Because these transects covered only a small portion of the Imperial Valley, they provided only limited data on patterns of bird distribution in this area.

PRBO and SSNWR biologists used a combination of airboat, aerial photographic, ground, and kayak surveys (varying by logistical constraints or species) to document the distribution, abundance, nesting chronology, and nesting success of colonial waterbird colonies at the Salton Sea in 1999. We conducted most surveys between 22 January and 16 July but continued some through 8 September. On each survey, observers recorded the number of active nests, the general stage of nesting, and the location of each active colony. See Shuford et al. (2000) for brief descriptions of the colony sites surveyed and their nesting substrates.

Although we recorded a total of 107 species of waterbirds on our surveys, in most cases we describe distribution patterns only for species groups. We discuss patterns of distribution of individual species or taxa mainly when these are of conservation concern or when the patterns they exhibit are particularly striking compared to those of related species. We briefly touch on distribution patterns of shorebirds, as these data are presented in Shuford et al. (*this volume*).

ANALYSES

To better understand which areas around the Sea were used more often than expected by waterbirds, we calculated expected numbers of birds (by waterbird group) in each of the 19 shoreline areas and compared these to our observed numbers. For example, to calculate the expected number of gulls and terns in Area 1 in January we multiplied the number of gulls and terns seen in all 19 shoreline segments around the Sea in January ($N = 41,327$) by the ratio of the length of Area 1 (5476 m) to the total length of the shoreline around the Sea (270,006 m).

We used general linear models to test whether densities of different groups of waterbirds (gulls and terns, pelican and cormorants, shorebirds, and wading birds) varied among counts (Jan, Apr, Aug, and Nov) and areas (1–19). We examined data for departures from normality and used Levene's test to examine the assumption of homogeneity of variances (Snedecor and Cochran 1989). Significance was set at $P \leq 0.05$, and statistical analyses were performed using STATA (STATA Corp. 1999).

RESULTS

Linear models indicated that densities of all groups of waterbirds varied significantly by area. For shorebirds, however, Levene's test indicated significant heterogeneity even after transformations (Table 1). While test scores are highly significant for shorebirds for the overall model and the effect of area (Table 1), results should be interpreted as suggestive rather than definitive, and further studies on these effects on shorebirds are warranted. Densities of gull, pelican, and wader groups varied significantly by count period, but we failed to detect a significant difference in densities of shorebirds among counts (Table 1). However, no comprehensive surveys were conducted in May and June when

TABLE 1. RESULTS OF GENERAL LINEAR MODEL (ANOVA) TESTING DENSITIES (ARC-SIN TRANSFORMED) OF WATERBIRDS AT THE SALTON SEA, CALIFORNIA, IN 1999, BY AREA OF THE SEA AND COUNT PERIOD

		Gulls[a] (N = 73 counts)		Pelicans[b] (N = 76 counts)		Shorebirds[c] (N = 76 counts)		Waders[d] (N = 73 counts)	
	df	F	P	F	P	F	P	F	P
Model	21	6.0	<0.001	4.03	<0.001	7.59	<0.001	3.76	<0.001
Area	18	3.19	<0.001	2.00	0.026	8.65	<0.001	3.27	<0.001
Count	3	21.64	<0.001	16.23	<0.001	1.21	0.316	7.41	<0.001

[a] Gulls includes gulls, terns, and skimmers.
[b] Pelicans includes pelicans and cormorants.
[c] Levene's test indicated significant heterogeneity even after transformations.
[d] Waders include herons, egrets, ibis, and cranes.

most shorebirds depart the area (Shuford et al. *this volume*).

GREBES

Over four surveys, an average of 88.9% (SE = 4.3, min–max = 78–99%) of all Eared Grebes occurred in the inshore zone of the Sea within 1 km of land. In spring and winter, inshore areas of shoreline segments 6 and 7 held a high proportion of the small grebes that were observed (Table 2). Eared Grebes generally were widely distributed on offshore transects, especially in the late March survey. In general, few Eared Grebes were counted along the northeastern shoreline of the Sea. Over the four aerial surveys, an average of 78.5% (SE = 6.3, min–max = 64–92%) of all Western and Clark's grebes occurred in the inshore zone within 1 km of land. Overall, *Aechmophorus* grebes were widely distributed within the inshore zone, except for a tendency for reduced numbers along the western and southwestern shorelines in March and the southeastern and northwestern shorelines in November (Table 2). Ground observations for the inshore zone indicated a fairly even split between Western and Clark's grebes in April (379 Western Grebes, 340 Clark's Grebes) and August (363 Western Grebes, 371 Clark's Grebes), and a roughly 3:1 ratio in November (714 Western Grebes, 222 Clark's Grebes). In November and December, about 85% of *Aechmophorus* grebes in the offshore zone were at the northern end of transect 3 in the northeastern section of the Sea.

PELICANS AND CORMORANTS

For pelicans and cormorants, areas 9, 12, and 17 were particularly important in August, January, and November, respectively (Table 3). Densities of pelicans and cormorants were highest at the south end in January and among the lowest there in November, when many areas showed high densities (Fig. 2).

WADERS

For wading birds (primarily herons, egrets, and night-herons), highest densities were at the north and south ends of the Sea (Fig. 3). Ob-

TABLE 2. PROPORTION OF TOTAL NUMBER OF GREBES AND RUDDY DUCKS COUNTED DURING AERIAL SURVEYS OF INSHORE AND OFFSHORE AREAS OF THE SALTON SEA, CALIFORNIA, IN 1999

	Eared Grebe				*Aechmophorus* Grebes[a]				Ruddy Ducks			
Area[b]	19 Mar	28 Mar	29 Nov	17 Dec	19 Mar	28 Mar	29 Nov	17 Dec	19 Mar	28 Mar	29 Nov	17 Dec
Inshore												
1–2	**0.15**	0.10	0.05	0.04	0.09	0.09	0.04	0.02	**0.24**	**0.25**	0.11	0.08
3–5	**0.20**	0.14	0.07	0.14	0.14	**0.28**	**0.15**	0.12	**0.21**	**0.17**	0.09	0.08
6–7	**0.23**	**0.19**	**0.25**	**0.18**	0.00	0.01	0.07	0.03	0.05	0.07	0.09	0.09
8–10	0.12	0.07	0.10	0.13	0.03	0.05	**0.18**	**0.15**	**0.18**	0.03	0.06	0.08
11	0.08	0.04	**0.18**	0.10	0.00	0.00	0.04	0.06	0.11	0.02	**0.15**	0.12
12–15	0.13	**0.16**	0.14	**0.17**	**0.28**	**0.17**	0.02	0.02	0.02	0.01	**0.19**	**0.16**
16–17	0.06	0.06	0.04	0.06	0.14	**0.17**	**0.18**	**0.15**	0.00	0.00	0.08	0.07
18–19	0.02	0.02	0.05	0.07	**0.17**	0.14	0.03	0.09	0.00	0.00	**0.21**	**0.23**
Offshore	0.01	**0.22**	0.11	0.11	0.14	0.08	**0.28**	**0.36**	**0.18**	**0.46**	0.01	0.09
Total	47,561	58,412	172,550	321,575	8620	7123	1508	3830	5120	3924	26,584	32,680

Notes: Data for areas accounting for ≥15% of birds in a particular group or species on a particular date are denoted in bold.
[a] *Aechmophorus* grebes = Clark's and Western grebes.
[b] The inshore zone is <1 km of the shore and the offshore zone is 1 km (see Shuford et al. 2000 for more details).

TABLE 3. RATIO OF OBSERVED TO EXPECTED NUMBERS OF BIRDS (BY WATERBIRD GROUP) IN EACH OF 19 AREAS AROUND THE SALTON SEA, CALIFORNIA IN 1999

	Gulls and terns				Pelicans and cormorants				Shorebirds				Waders			
Area	Jan	Apr	Aug	Nov	Jan	Apr	Aug	Nov	Jan	Apr	Aug	Nov	Jan	Apr	Aug	Nov
1													2.42	**3.17**	**3.43**	
2		**3.78**		**4.46**									2.14	2.56		
3																
4			2.34					2.69								
5																
6									2.51	2.73						
7			**3.16**													
8	2.83		2.39					2.05								
9							**6.76**									
10																
11						2.37										
12			**3.96**		**4.99**				**5.80**	**7.00**	**9.39**	**9.76**			2.45	
13	**3.61**	**3.21**		2.42				2.49								
14																
15	**4.27**							2.31								
16																
17								**6.84**								
18																
19		2.75														**4.36**

Notes: Expected number of birds per segment per count calculated by multiplying the total number of birds per count by the ratio of the segment length to the entire shoreline length (see Methods). Data only reported for segments with at least twice the expected number of birds. Segments with three times or more the expected numbers of birds are denoted in bold.

served numbers were more than double than expected numbers in areas 1, 2, 12, and 19 (Table 3). Two species of wading birds were much more numerous in agricultural areas of the Imperial Valley than suggested by our comprehensive surveys of the Sea. Peak counts of Cattle Egrets (*Bubulcus ibis*) and White-faced Ibis (*Plegadis chihi*) coming to night-time roosts in the Imperial Valley were 33 and 45 times greater, respectively, than peak counts at the Salton Sea and adjacent wetlands (see also Shuford et al. 2002b).

WATERFOWL

Distribution patterns of waterfowl varied among regions of the study area. As is typical, Snow (*Chen caerulescens*) and Ross's (*C. rossii*) geese in 1999 were found exclusively at the south end of the Sea in or around SSNWR, the Wister Unit, and nearby duck clubs. Diving ducks predominated on the inshore waters of the Sea at all seasons (Fig. 4). By contrast, dabbling ducks predominated on freshwater impoundments adjacent to and primarily at the south end of the Sea. Diving ducks numbers also exceeded or equaled those for dabbling ducks in the Imperial Valley because Ruddy Ducks also concentrate there in modest numbers on reservoirs. Over four aerial surveys, an average of 81.6% (SE = 9.8, min–max = 54–99%) of all Ruddy Ducks occurred in the inshore zone, especially during fall periods when higher numbers were on the Sea. In November and December, they appeared primarily in the inshore zone with highest concentrations along the eastern inshore shoreline (Table 2). Of the 2899 Ruddy Ducks in the offshore zone in December, 96% were in the northeastern section of the Sea. Ruddy Ducks concentrated near the northern and western shorelines and offshore zone in March.

RAILS

Observers detected a total of 279 Clapper Rails in the Salton Sea area in 1999, 271 in marshes immediately around the Salton Sea, three at Lower Finney Lake, and five at Holtville Main Drain in the central Imperial Valley (Table 4). Highest concentrations were in the Wister Unit and Unit 2 of SSNWR. Smaller numbers were in Unit 1 of SSNWR and a few small marshes along the east side of the Sea. No birds were detected at the north end or along the west side of the Sea. The northern third of Wister Unit (section A) supported the highest numbers of Clapper Rails on both the April and mid-May surveys (Table 4), but there appeared to be movement of birds from sections B and C into A between these surveys. We did not detect any Black Rails on our surveys in 1999.

SHOREBIRDS

In all seasons, Area 12, the Wister Unit shoreline, held the highest densities of shorebirds (Fig. 5, Table 3; Shuford et al. 2000). During

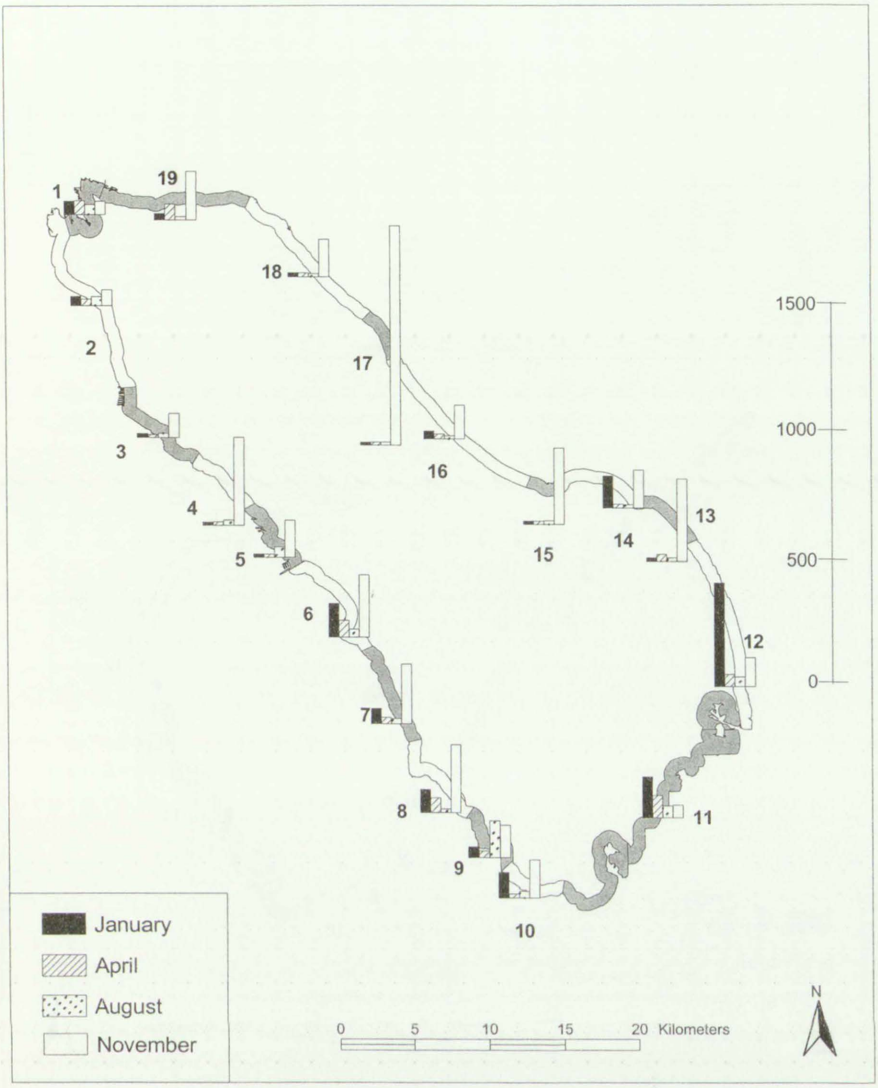

FIGURE 2. Comparison of the density (individuals/km) of all pelicans and cormorants within 19 shoreline segments for four comprehensive surveys of the Salton Sea, California, in 1999.

January and April comprehensive surveys, Area 6, the shoreline around Iberia Wash on the west side of the Sea, attracted higher shorebird numbers than expected (Table 3). In all seasons, Snowy Plovers (*Charadrius alexandrinus*) concentrated primarily on sandy beaches and sand or alkali flats along the western and southeastern shorelines of the Sea.

GULLS AND TERNS

Certain areas attracted more gulls and terns than expected, including areas 12, 13, and 15 on the southeast side of the Sea, area 7 and 8 on the southwest side of the Sea, and areas 2 and 19 on the north side of the Sea (Fig. 6, Table 3; Shuford et al. 2000). During the comprehensive August survey along the shoreline of the Sea, of Black Terns counted (N = 4011), 45% occurred in Area 12, and 34% in areas 7 and 8 (Shuford et al. 2000). Totals of 31 and 539 Black Terns were recorded during agricultural field transects in the northern Imperial Valley on 16 May and 11 August, respectively. In contrast, we did not see any Black Terns on a 16 August aerial survey of agricultural fields further south in the Imperial Valley.

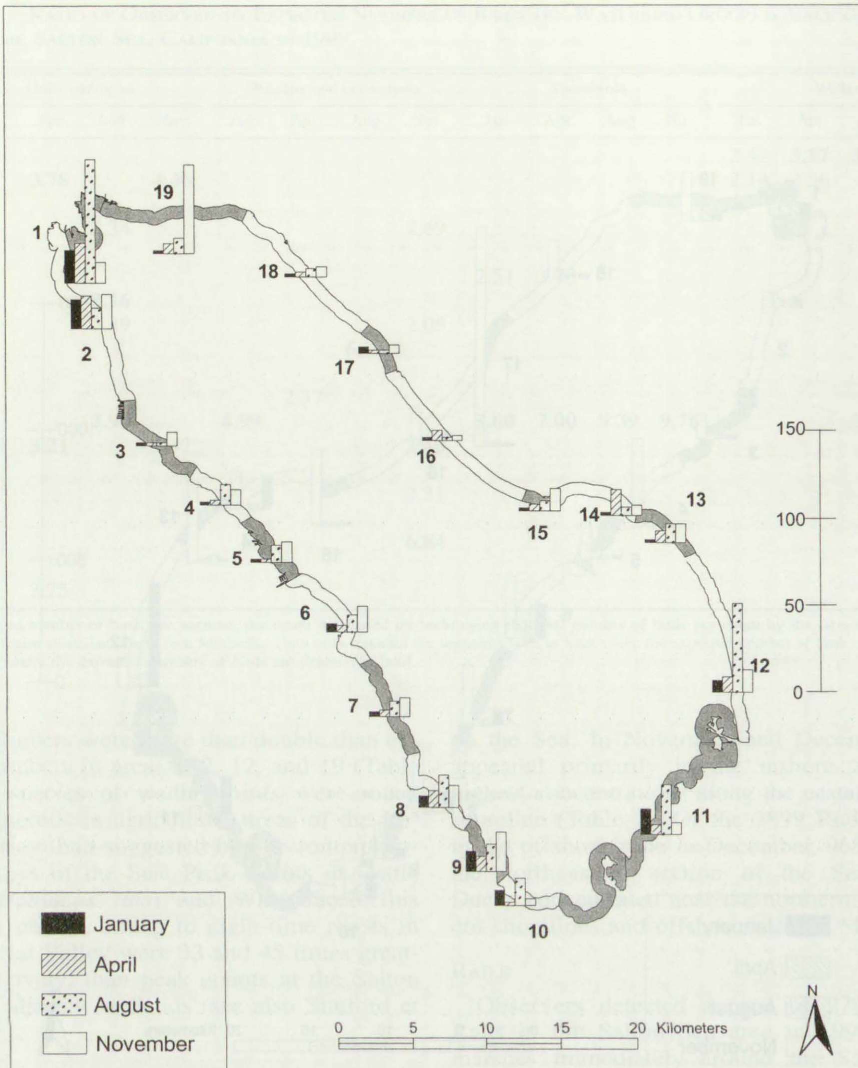

FIGURE 3. Comparison of the density (individuals/km) of all waders (herons, egrets, ibis, storks) within 19 shoreline segments for four comprehensive surveys of the Salton Sea, California, in 1999. * = survey data lacking for January.

COLONIAL BREEDERS

The 14,000 pairs of colonial breeders in 1999 bred at 21 sites on or near the shoreline of the Salton Sea, at Ramer Lake, and near Westmorland in the Imperial Valley (Fig. 7; Shuford et al. 2000). Of the 23 sites, 21 provided substrate suitable for arboreal nesters, whereas only five offered suitable habitat for obligate ground nesters. Most nesting sites and concentrations were near the Whitewater River mouth at the north end of the Sea or between, and including, the New and Alamo river deltas along the southeastern shoreline. Great Blue Heron (*Ardea herodias*), Double-crested Cormorant, and Great Egret (*A. alba*) nested at 18, eight, and six sites, respectively, whereas all other species nested at one to four sites. Species richness was highest at Johnson Street, where seven of the 11 species nested. Species richness of ardeids also was high at the Alamo River and 76th Avenue, where four species bred at each site. Species richness of larids was highest at Rock Hill on the Salton Sea NWR, where four species bred in an area managed specifically for terns and skimmers. Large

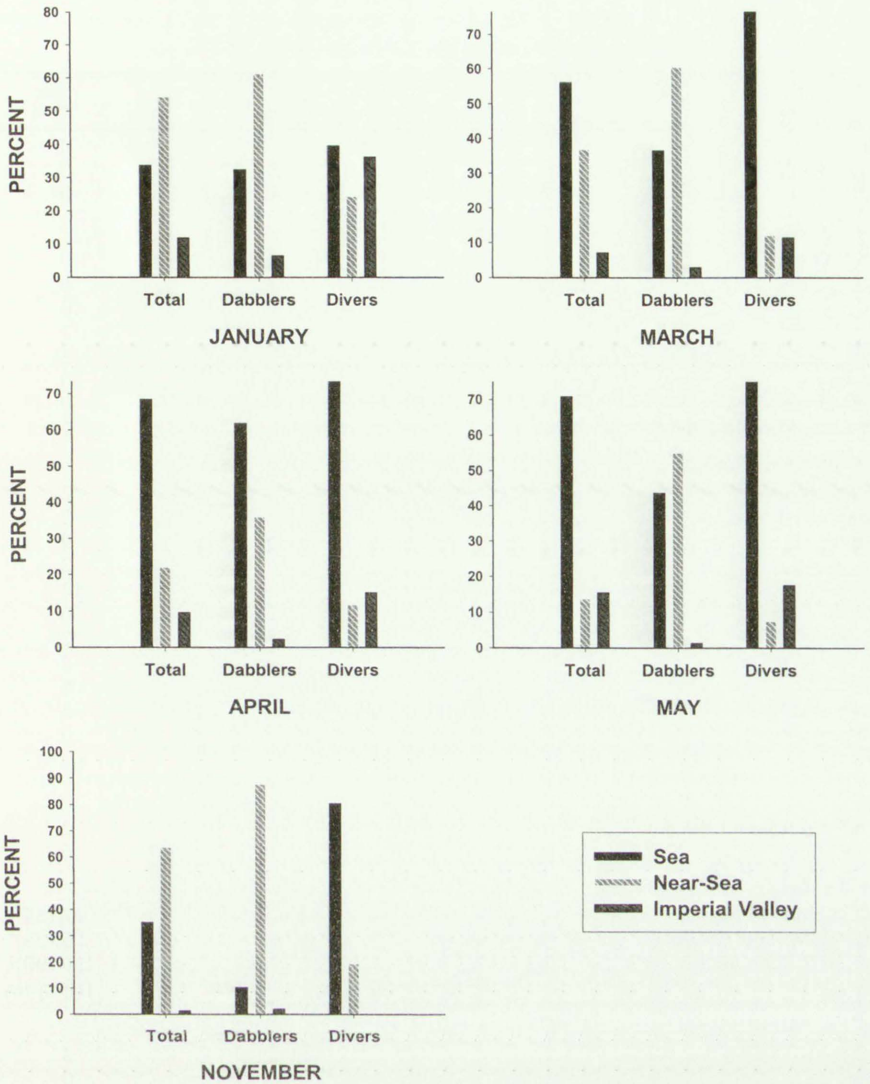

FIGURE 4. Percent of total numbers of all ducks, dabbling ducks, and diving ducks on the inshore waters of the Salton Sea, California, near-Sea freshwater impoundments, and Imperial Valley duck clubs and reservoirs from aerial surveys in 1999. Data courtesy of Sonny Bono Salton Sea National Wildlife Refuge.

colonies dominated primarily by cormorants and Cattle Egrets formed at Mullet Island and the Westmorland eucalyptus grove, respectively.

DISCUSSION

NON-BREEDING BIRDS

The non-random distribution of non-breeding birds around the Salton Sea is likely influenced by a variety of factors. In almost all months, the north end of the Sea, including areas 1, 2, and 19, were particularly important to wading birds and gulls, collectively. Undoubtedly, for these fish eaters, part of this distribution pattern is influenced by access to fish prey. Whether these sites have a greater abundance of fish is unknown, but the concentration of fish farms near the Sea in this area may also influence this pattern. For waders in particular, the presence of snags in the north end of the Sea that are suitable for nesting and roosting are presumably a major influence on their distribution.

Twenty-nine percent of all the birds counted at the Salton Sea during comprehensive surveys were found in Area 12, the Wister Unit shore-

TABLE 4. YUMA CLAPPER RAIL TOTALS AT WETLANDS AROUND THE SALTON SEA, CALIFORNIA, FROM BREEDING RAIL SURVEYS CONDUCTED IN APRIL AND MAY 1999 (EACH SITE SURVEYED TWICE)

Area	1990–1998[a] (mean ± SD)	1999 Total
Johnson St.	NC	0
King's Road Marsh	NC	0
81st Drain	NC	0
SSNWR—Unit 1		
Trifolium 1 Drain		0
A-1 Pond		6
B-1 Pond		10
Reidman 3		2
Reidman 4		3
Bruchard Bay		0
New River Delta		0
Lack and Grumble (off refuge)		2
SSNWR—Unit 2 and Hazard		
Barnacle Bar Marsh		2
Headquarter 'B' Pond		2
Union Pond		9
McKindry Pond		2
Hazard 6		12
Hazard 7		6
Hazard 8 (east)		2
Hazard 9 and Ditch		2
Hazard 10		6
Alamo River (east)		3
Alamo River (west)		0
SSNWR (total)	62 ± 33	67
Off Refuge		
Walt's Club (McDonald Rd.)		2
"T" Drain Marsh		6
Wister Wildlife Area		
Section C (S and T units)[b]		27 (35)[c]
Section B (U, W, and Y units)[b]		25 (54)[c]
Section A (100, 300–500 units)[b]		139 (90)[c]
Wister (total)	248 ± 77	191 (179)
North of Wister Wildlife Area		
Bombay Marsh		3
Salt Creek	1 ± 2	0
Barnacle Beach (total)[d]	16 ± 10	13
Imperial Valley sites		
Lower Finney Lake[e]	NC	3
Holtville Main Drain	7 ± 5	5

[a] Averages of Yuma Clapper Rail Survey results from 1990–1998; NC = not counted in that period; means calculated from data supplied by Yuma Clapper Rail Recovery Team, USFWS, Phoenix, AZ.
[b] Units numbered according to Imperial Wildlife Area designation.
[c] Number of rails from 12 May count, numbers in parentheses are from 26 Apr count.
[d] Barnacle Beach total = Lack and Grumble + Walt's Club (McDonald Rd.) + 'T' Drain Marsh + Bombay Marsh.
[e] Clapper Rails detected during Black Rail survey.

line, which accounts for only 6% of the total Salton Sea shoreline. Shorebirds were particularly clumped in areas 12 and 11, which respectively held 53% and 25% of total shorebird numbers. A combination of shallow waters, soft substrate, river deltas, islands for foraging and roosting, and nearby access to fresh water sources for bathing and drinking appeared to be especially important to the distribution of nonbreeding waterbirds in these areas. Shoreline segments that were little used by waterbirds around the Salton Sea in 1999, such as 3, 4, 10, 16, and 18, tended to be ones with narrow beaches and lacked shallow water and close ac-

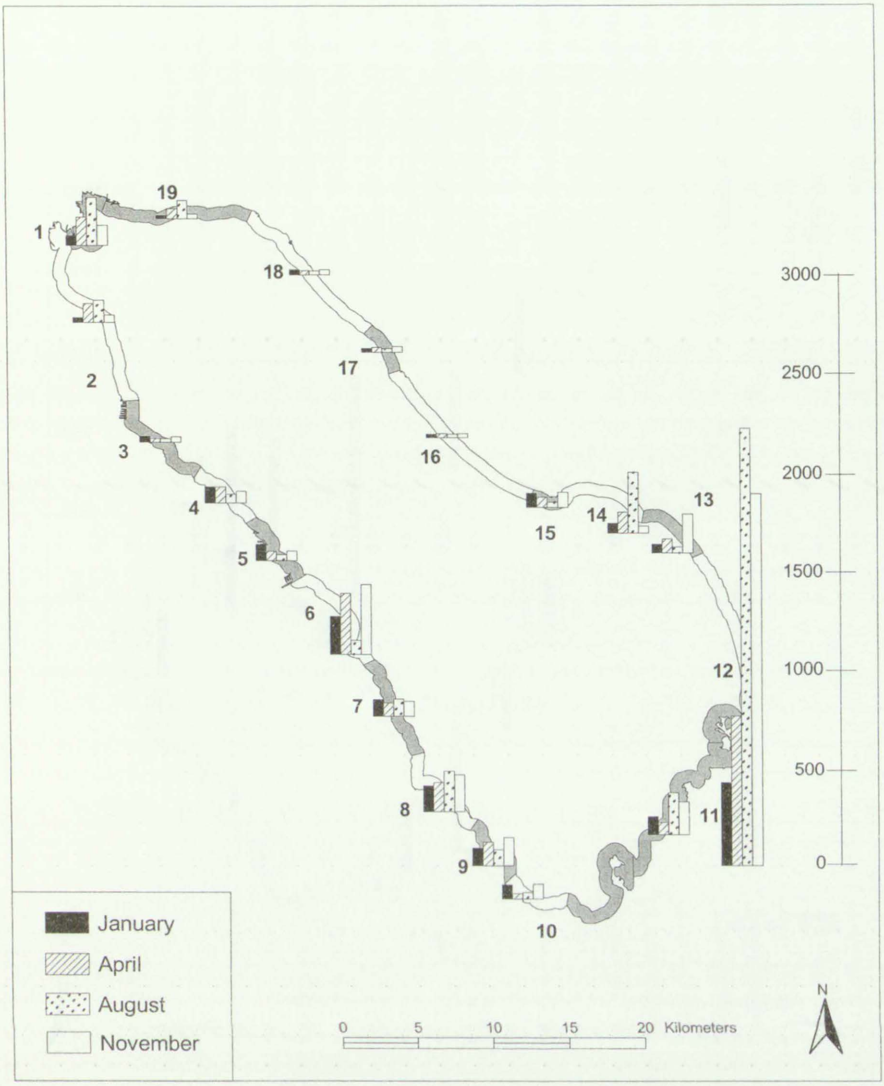

FIGURE 5. Comparison of the density (individuals/km) of all shorebirds within 19 shoreline segments for four comprehensive surveys of the Salton Sea, California, in 1999.

cess to freshwater sources such as rivers, irrigation outflows, or nearby ponds.

Within the Sea itself, distribution of waterbirds was also non-random, although explanations of patterns are less obvious. In general, largest numbers of these waterbirds occurred within 1 km of the shore. Except for the Pied-billed Grebe (*Podilymbus podiceps*), which mainly occurred on freshwater impoundments, other grebes primarily used the open waters of the Salton Sea, as did pelicans, cormorants, and Ruddy Ducks. Pelicans on the water were widely distributed around the Sea, especially during November, but large numbers of roosting pelicans and cormorants were found at the far reaches of the New and Alamo river deltas, particularly in January (Fig. 8a, b). Overall, small and large grebes were widely distributed within the inshore zone of the Sea. At Mono Lake, the distribution of Eared Grebes on the water was influenced by population size, age and molt condition of individual birds, availability of prey, season, and time of day (Jehl 1988). The pattern for grebes at Mono Lake was for birds to feed close to shore and move offshore when molting or when particular prey declined. How these variables influence grebes and other waterbirds at the Salton Sea is presently unknown. Eared

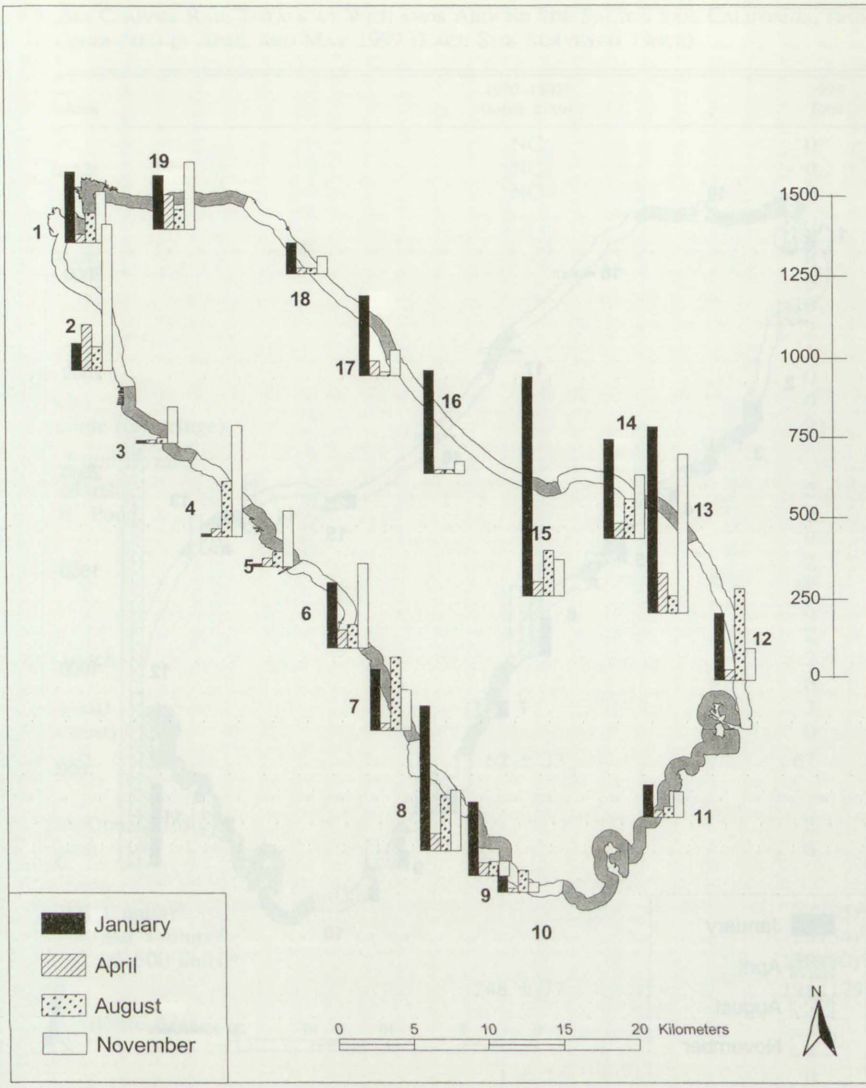

FIGURE 6. Comparison of the density (individuals/km) of all gulls and terns within 19 shoreline segments for four comprehensive surveys of the Salton Sea, California, in 1999. * = no survey data for January.

Grebes tended to be the main species on offshore transects.

Many waterbirds at the Salton Sea also used adjacent habitats, particularly agricultural fields in the Imperial Valley. Throughout California, Mountain Plovers (*Charadrius montanus*) use heavily grazed and burned fields and cultivated landscapes (Knopf and Rupert 1995). The Mountain Plover, Whimbrel (*Numenius phaeopus*), and Long-billed Curlew (*N. americanus*) all were much more numerous in agricultural fields in the Imperial Valley than along shoreline or other wetland habitats at or near the Salton Sea (Shuford et al. *this volume*). Some shorebirds may switch between using the shores of the Salton Sea and agricultural lands, but the extent of this is unknown. Shorebirds switching between coastal bodies of water and adjacent agricultural fields has been documented at a variety of sites around the world (Townshend 1981, Colwell and Dodd 1995, Warnock et al. 1995). For some egrets and gulls, their use of habitats adjacent to the Sea was also striking (Shuford et al. 2002b). During monthly agricultural field surveys in areas adjacent to the Sea in 1999, 66% of the over 38,000 birds detected consisted of Ring-billed Gulls (*Larus delawarensis*), Cattle Egrets, and White-faced Ibis (PRBO, unpubl.

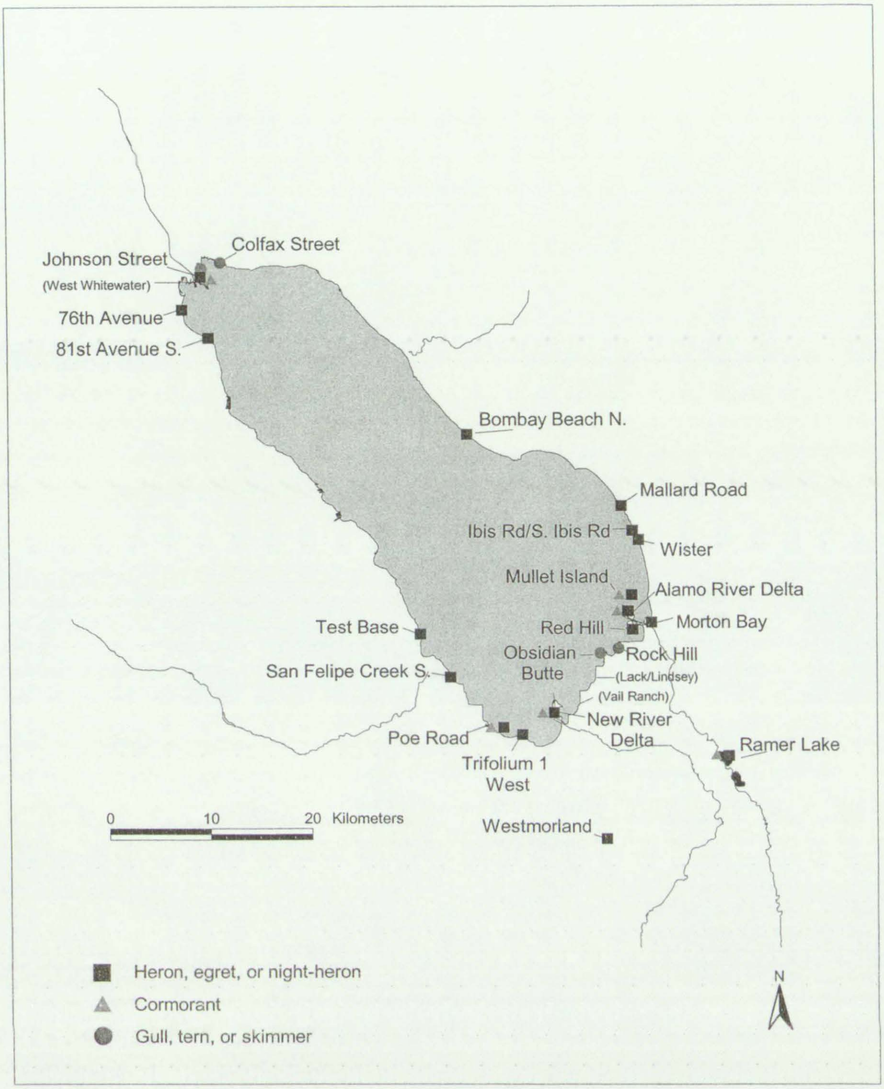

FIGURE 7. Location of nesting colonies of cormorants, ardeids (herons, egrets, and night-herons), and larids (gulls, terns, and skimmers), at the Salton Sea, California, in 1999. Arboreal sites previously used but unoccupied in 1999 are listed in parentheses. New River Delta includes three sites associated with that area (see Shuford et al. 2000).

data). For Black Terns, nearby agricultural fields also appear to be important foraging areas, although the Sea also attracts thousand of these birds (Small 1994, Shuford et al. 2002b, this study).

Breeding Birds

Although nesting colonies often shift locations at the Salton Sea, our 1999 survey results concur with prior data (SSNWR files), indicating that the areas around the Whitewater, New, and Alamo rivers continue to be important focal points for colonial nesting waterbirds. During the 1990s, these birds have regularly nested at about 22 sites around the Salton Sea perimeter. In recent years, cormorants and ardeids have not established colonies at the extant sites of Lack/Lindsey and Vail Ranch, and larids have not reestablished nesting on the islets of Morton Bay or at Ramer Lake (Molina *this volume*). Cormorants bred at fewer colony sites in 1999 than in 1998, and Great Blue Herons, after deserting the New River Delta, dispersed to colonize snag stands offering marginal nesting substrate, and

FIGURE 8. Upper panel: aerial overview of the New River mouth, an important roosting area and shallow-water foraging area for waterbirds, looking northwesterly over the Salton Sea to the Santa Rosa Mountains. Lower panel: aerial view of the west side of the New River mouth showing large concentrations of American White Pelicans and Double-crested Cormorants (Photos by W. D. Shuford, 12 February 1999).

to artificial structures not previously used (SSNWR files). In 1999, Great Egrets, Cattle Egrets, and Black-crowned Night-Herons (*Nycticorax nycticorax*) nested at fewer sites than in 1998, whereas Snowy Egrets (*Egretta thula*) nested at the same number of sites. Colonial ground nesters requiring bare earthen islets, such as terns and skimmers, have experienced a net loss of suitable nesting habitat from the complete erosion or vegetative overgrowth of several previously used sites. Gull-billed Terns (*Sterna nilotica*), Caspian Terns (*S. caspia*), and Black Skimmers (*Rynchops niger*) all have undergone recent contractions in nest site occupancy (Molina *this volume*). The California Gull (*Larus californicus*), a recent but now annual breeder at the Salton Sea, continues to nest at a single site, although recent observations indicate that they may be attempting to expand to Rock Hill (Molina 2000a). The Salton Sea NWR currently manages a few impoundments with small earthen islets, 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.

With minor exceptions, our Clapper Rail surveys documented a distribution pattern similar to that observed from 1990 to 1998 (unpublished data, Yuma Clapper Rail Recovery Team, USFWS, Phoenix, Arizona). 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), and major concentrations of the Yuma Clapper Rail around the Salton Sea reflected the distribution and extent of this marsh habitat.

Study Implications

Projects to restore the health of the Salton Sea's ecosystem should be carefully assessed to ensure they do not have unintended impacts. Those projects with potentially negative impacts should not be placed where large numbers of breeding, roosting, or foraging birds currently concentrate. However, caution must be used in interpreting the results of a one-year study. Even within a year, our results indicate a variable and dynamic distribution of birds around the Salton Sea, which will complicate efforts to mitigate the effects of its changing hydrology (e.g., Tetra Tech 2000).

Our study on the distribution of waterbirds around the Salton Sea suggests avenues of future research. While our 1999 study revealed gross patterns of waterbird distributions, finer scale studies on the mechanisms influencing bird distributions would be beneficial and facilitate mitigation efforts. Fruitful topics of research would be studies of how the distribution and abundance of prey, substrate, water depth, and salinity affect waterbird distributions. Additional information is needed on the daily and seasonal use patterns and movements of birds between agricultural fields and wetlands in the Imperial, Coachella, and Mexicali valleys and the Salton Sea proper. Finally, a better picture of how human disturbance may impact waterbird distribution at the Salton Sea is needed to effectively understand and plan for future changes there, especially as related to recreational and commercial activities.

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