Migratory shorebirds in the Guerrero Negro Saltworks, Baja California Sur, Mexico

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This study describes the species composition, seasonal abundance, and migration chronology of shorebirds at the Guerrero Negro Saltworks, an artificial habitat located at the mid point of the Baja California Peninsula, Mexico. Censuses of shorebirds were carried out once a month from December 1995 to December 1996. We recorded 26 shorebird species. Taking the highest monthly record for each species, the estimated minimum abundance in the study period was 110,500 birds. Red-necked Phalaropes *Phalaropus lobatus* and Western Sandpipers *Calidris mauri* were the most abundant. Seasonally abundance varied between winter (December to February, mean = 31,600 birds/month), spring migration (March to April, mean = 15,800 birds/month), summer (May to June, mean = 1,900 birds/month), and fall migration (July to November, mean = 44,300 birds/month). This pattern is similar to that observed in La Paz Bay in the south of the peninsula, but contrasts with that observed on the eastern coast of the Gulf of California, where greater numbers of shorebirds occur during spring migration. Our results indicate that the Guerrero Negro saltworks is one of the most important habitats for migratory shorebirds along the Baja California Peninsula, surpassed only by the Ojo de Liebre and San Ignacio coastal lagoons.

INTRODUCTION

Shorebirds breeding in the Arctic and interior regions of the United States and Canada migrate to their wintering grounds using several flyways. The Pacific Flyway runs along the western side of America and includes the Baja California Peninsula, where major shorebird wintering grounds have recently been identified (Massey & Palacios 1994, Morrison *et al.* 1994, Page *et al.* 1997). However, most studies have focused on the north and south parts of the peninsula and data are limited in seasonality, area surveyed, and species covered (Palacios *et al.* 1991, Carmona 1995, Mellink *et al.* 1997, Fernández *et al.* 1998).

This study describes the species composition and seasonal abundance patterns of shorebirds at the Guerrero Negro saltworks (also known as "salinas"), a man-made habitat in the middle of the west coast of the Baja California Peninsula. This research, the first to be carried out for the whole of one complete year in this part of Baja California, increases our understanding of shorebird movements along the peninsula during northward and southward migration. It also allows a first evaluation of the importance of this artificial habitat as a stopover for migratory shorebirds.

STUDY AREA AND METHODS

The Guerrero Negro saltworks are located next to the Ojo de Liebre (Scammon's) Lagoon, south of Guerrero Negro, a small industrial town in the northwest of the state of Baja California Sur, Mexico (Fig. 1).

Salt production involves pumping seawater from the lagoon through a system of concentration ponds, where it evaporates through the action of the sun and wind. These ponds cover 27,773 ha, and include islands, sand bars, mud flats, and shallow water areas used by shorebirds to roost and feed. Water levels and salinity are kept fairly stable at all times, as a requirement of the industrial process. The first ponds of the system (S1-A and 1 in Fig. 1) receive water pumped from Ojo de Liebre Lagoon and their salinities are similar to that of the lagoon at around 33 ppt (López Cortés 1991). Shorebirds make use of even the most saline ponds in the system, where salinity reaches 250 ppt. The ponds are separated by dikes, which are mostly drivable.

The area, which is part of the "El Vizcaíno" Biosphere Reserve, is concessioned to Exportadora de Sal (ESSA), a joint venture of the Mexican government and a foreign corporation. All access to the area is restricted.

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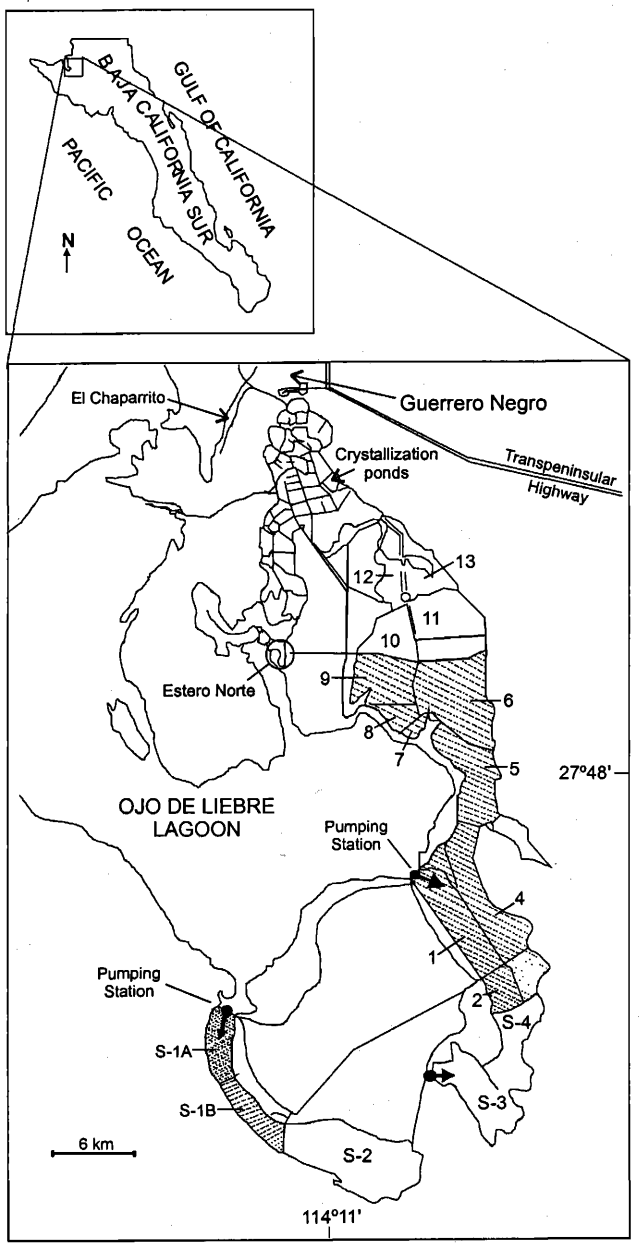

Fig. 1. The Guerrero Negro Saltworks and Ojo de Liebre Lagoon, Baja California Sur, Mexico. The concentration ponds surveyed from December 1995 to November 1996 are shaded. They are also numbered according to a scheme used by the managers of the saltworks (S-1A, S-1B, and 1 to 9).

The saltworks were surveyed using a vehicle provided by ESSA, which travelled along established routes. There were two limitations: (1) it was not possible to visit areas serviced by roads and dikes in bad condition, and (2) it was not possible to visit the saltwork shores located south and east of the concentration ponds, as there are no roads in those areas.

Shorebird censuses were carried out once a month from December 1995 to December 1996, except for October 1996 when no count was made. Owing to the large size of the study area, two days were required to complete each census. Flocks smaller than 300 individuals were counted directly, while the size of larger flocks was estimated using the method described by Page *et al.* (1979), following the suggestions made by Kasprzyk & Harrington (1989) to standardize estimations. Observations were made using binoculars (8× and 10×) and spotting scopes (15–60×). We calculated the abundance of a species in any given month as the sum of our counts and estimates for all parts of the study area. Scientific names of all species mentioned are given in Table 1.

In planning our censuses, we did not take into account tide levels in the nearby Ojo de Liebre Lagoon. As a consequence, our shorebird counts show fluctuations that may not be wholly the product of migratory patterns, and may include variation arising from daily movements between the saltworks and the lagoon. To identify migratory patterns, we divided the year into four seasons: winter (December–February), spring/northward migration (March–April), summer (May–June), and fall/southward migration (July–November). To each period we assigned the highest number recorded for each species in any of the monthly censuses. Then, we rated each period with an A for abundances >90% of the year's highest record for the species (peak abundance), B for abundances from 50 to 90% of the year's highest record (high abundance), C for abundances from 10 to 50% of the year's highest record (low abundance), and D for abundances <10% of the year's highest record (marginal occurrence). This allowed us to compare relative abundances per season through the year.

We estimated total numbers through the year and by season by considering only the highest monthly count for each species. In this way, we avoided multiple counts of birds staying in the area more than one month. The result is a conservative estimate, as it does not take into account either turnover or tide-related movements between the saltworks and Ojo de Liebre Lagoon.

RESULTS AND DISCUSSION

Shorebird abundance

During the year, we recorded 26 shorebird species using the saltworks with a minimum estimate of 110,500 individuals (Table 1).

Shorebird surveys carried out during the winters of 1992, 1993 and 1994 at the Ojo de Liebre-Guerrero Negro Lagoon complex (Morrison *et al.* 1992, Page *et al.* 1997) estimated populations of 267,983, 128,710, and 275,391 birds, respectively. Our highest winter numbers at the saltworks indicate a minimum population of 34,200 shorebirds, or 12.4 to 26.6% of the totals estimated for the entire lagoon complex during the winters of 1992–1994.

Red-necked Phalaropes and Western Sandpipers were the most abundant species, followed by Dunlins, dowitchers, and Marbled Godwits. Except for the high numbers of phalaropes, the relative abundances of shorebirds were comparable to other areas in northwest Mexico (Morrison *et al.* 1992, Mellink *et al.* 1997, Page *et al.* 1997, Engilis *et al.* 1998).

Species accounts

Red-necked Phalarope

On the basis of its seasonal occurrence in the study area (peak abundance in fall and only marginal occurrence for the rest of the year (Table 2, Fig. 2), we consider this species as a fall migrant. During fall, it is found in higher numbers in Guerrero Negro than anywhere else in coastal California (Page *et al.* 1979) or the Baja California Peninsula (Morrison *et al.* 1992, Page *et al.* 1997). Although it takes advantage

Table 1. Maximum counts of shorebird species at the Guerrero Negro Saltworks during December 1995 to November 1996. The minimum shorebird abundance for the year is calculated by summing the maximum counts for all species.

Species	Maximum count	Species	Maximum count
Red-necked Phalarope *Phalaropus lobatus*	58,000	Black Turnstone *Arenaria melanocephala*	60
Western Sandpiper *Calidris mauri*	18,200	Sanderling *Calidris alba*	60
Dunlin *Calidris alpina*	13,000	Long-billed Curlew *Numenius americanus*	40
Dowitchers *Limnodromus* spp.	12,000	Whimbrel *Numenius phaeopus*	32
Marbled Godwit *Limosa fedoa*	5,400	Snowy Plover *Charadrius alexandrinus*	19
American Avocet *Recurvirostra americana*	1,100	Red Knot *Calidris canutus*	10
Willet *Catoptrophorus semipalmatus*	1,000	Semipalmated Plover *Charadrius semipalmatus*	9
Ruddy Turnstone *Arenaria interpres*	400	American Oystercatcher *Haematopus palliatus*	6
Black-necked Stilt *Himantopus mexicanos*	340	Wilson's Plover *Charadrius wilsonia*	6
Greater Yellowlegs *Tringa melanoleuca*	220	Wilson's Phalarope *Phalaropus tricolor*	5
Black-bellied Plover *Pluvialis squatarola*	220	Least Sandpiper *Calidris minutilla*	2
Lesser Yellowlegs *Tringa flavipes*	200	Wandering Tattler *Heterocelus incanus*	1
Red Phalarope *Phalaropus fulicaria*	170	Black Oystercatcher *Haematopus bachmani*	1
		Minimum shorebird abundance for 1996 = 110,500	

of the hypersaline condition of the saltworks during fall, its spring migration routes are probably offshore (Paulson 1993). Bearing in mind the well-known halophylic habits of the phalaropes (Jehl 1988), our findings suggest that this location could be the most important stopover for the species on the Mexican Pacific coast.

Sandpipers

Five sandpiper species were recorded at the saltworks: Western Sandpiper, Dunlin, Sanderling, Red Knot, and Least Sandpiper. Of these, Western Sandpipers and Dunlins were the most abundant, while Sanderlings, Red Knots and Least Sandpipers generally numbered less than 100 individuals (Table 1).

Western Sandpipers were most abundant in winter; their second highest abundance was recorded in fall (southward migration) and lowest abundance in spring (northward migration) (Table 2, Fig. 2). This pattern is similar to that found in La Paz Bay, on the southeast coast of the peninsula (Fernández *et al.* 1998), but differs from that found in California, USA (Page *et al.* 1979), where the species shows a peak abundance during spring.

Dunlins were most abundant in spring (Table 2, Fig. 2). This peak may relate to northward passage of birds wintering further south along the peninsula. Dunlins wintering in Baja California are from the *pacifica* race, that has a restricted winter range from the west coast of Canada to the Baja California Peninsula (Warnock & Gill 1996).

Marbled Godwit

This species was present year round, with peak abundance during winter (Table 2). More than 90% of the Marbled Godwits observed in the saltworks were roosting; they probably fed on the nearby mudflats of the Ojo de Liebre Lagoon (Morrison *et al.*1992, Page *et al.* 1997).

Dowitchers

These species were most abundant during fall (southward migration), with lower numbers in winter (Table 2). Dowitchers have been reported in La Paz Bay in much smaller numbers (<200, Carmona 1995). There, migratory fluctuations were not as great as those recorded at the saltworks.

American Avocet and Black-necked Stilt

American Avocets were more abundant than the Black-necked Stilts in all seasons. Avocets were present year round, with the highest number in winter, while stilts were predominantly winter residents and were absent in summer (Table 1). Both species are more common on the east coast of the Gulf of California than on the peninsula (Morrison *et al.* 1992, Engilis *et al.* 1998).

Willets

Present year round, with highest numbers in winter (Table 2). The winter population at the saltworks averaged around 300, and was comparable in size to that of La Paz Bay (Carmona 1995), while the east coast of the Gulf of California has a winter population of 5,000–8,000, mainly in the Colorado River delta (Mellink *et al.* 1997, Morrison *et al.* 1992).

Yellowlegs

Greater Yellowlegs were slightly more abundant than Lesser Yellowlegs (1.1:1). Both species showed fall migration peaks of 220 and 200 birds respectively (Table 2). Southward migratory flocks of these species in La Paz Bay usually do not exceed 30 individuals (Carmona 1995).

Turnstones

The occurrence of these species in the saltworks was sporadic. When present, Ruddy Turnstones were generally more abundant than Black Turnstones (Table 1). The same pattern was found in La Paz Bay (Carmona 1995).

Plovers

Four species of plovers were recorded: Black-bellied Plover (= Grey Plover), Snowy Plover (= Kentish Plover), Semipalmated Plover, and Wilson's Plover (Table 1). Black-bellied Plovers were most abundant during spring migration, but were also present during fall and summer (Table 2). Snowy Plovers breed in the saltworks (Danemann & Carmona 2000). We found two nests (each one with one egg) on a sand flat beside Area 1, and three chicks on another sand

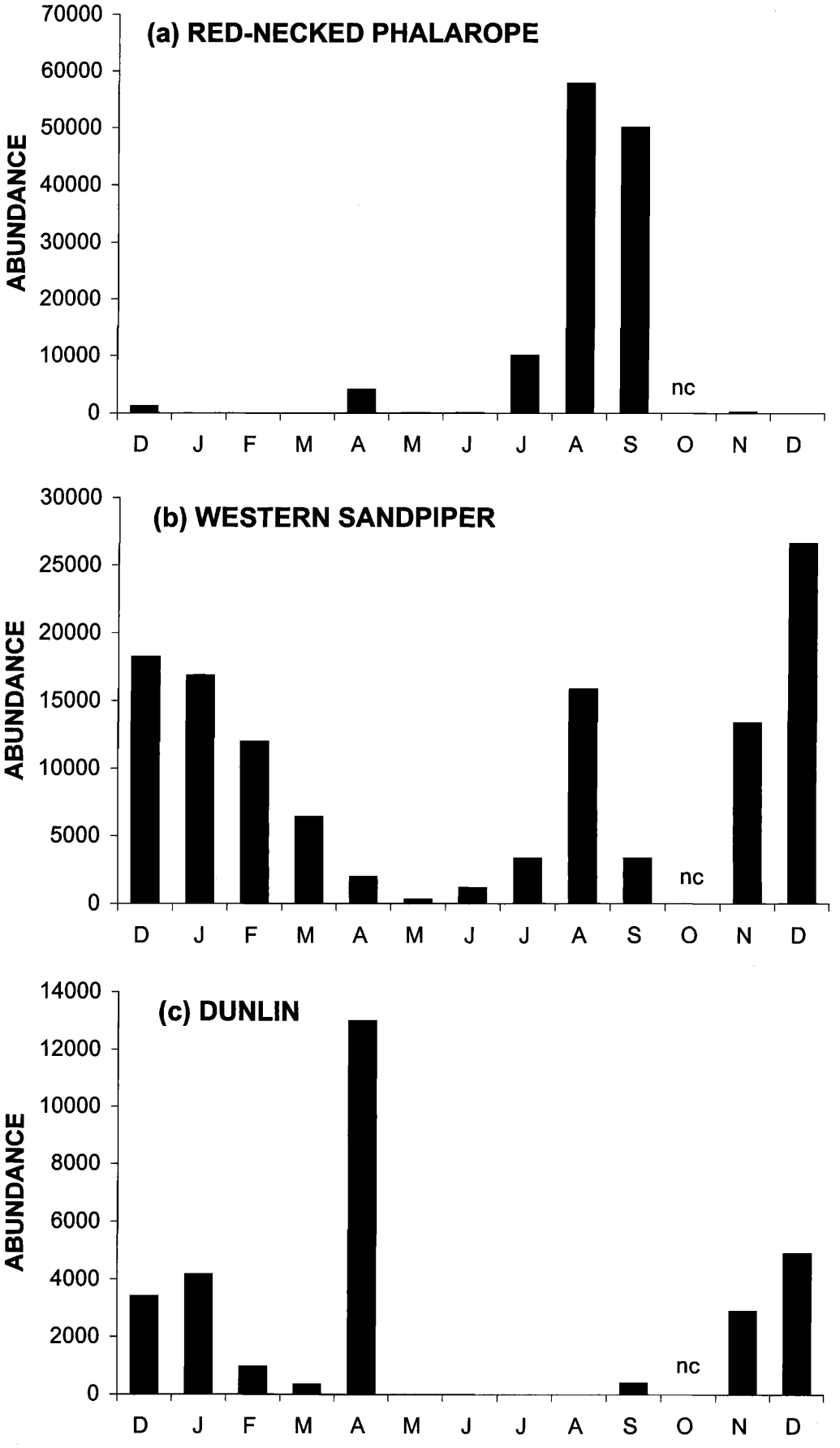

Fig. 2. Monthly counts of (**a**) Red-necked Phalaropes, (**b**) Western Sandpipers and (**c**) Dunlins (the three most abundant species) at the Guerrero Negro Saltworks during December 1995 to December 1996 (nc = no count was made in October).

flat, beside Area 8 (Fig. 1). This species was most numerous in summer and was not observed in winter. Only small numbers of Semipalmated and Wilson's plovers were recorded, never more than 15 of either species.

Long-billed Curlew

Maximum numbers occurred during fall migration (40 individuals), a smaller population remained in winter and the species was also present in spring. Similar patterns of occurrence have been reported for the Colorado River Delta (Mellink *et al.* 1997) and La Paz Bay (Carmona 1995). At the latter site, flocks of up to 200 have been seen.

Whimbrel

Present during fall migration, but more abundant during winter, when we observed 32 individuals.

Oystercatchers

American Oystercatchers were not abundant, but present during winter and summer, when we recorded three breeding pairs (Danemann & Carmona, 2000). Black Oystercatchers were rare and only observed during winter.

Wandering Tattler

We observed only one individual, during the winter.

Migratory chronology

The seasonal presence of shorebirds in the Guerrero Negro saltworks follows the general migratory pattern shown by nearctic shorebirds (Myers *et al.* 1987, Paulson 1993). This comprises a wintering period (December to February), with a minimum count of 34,200 (calculated from the sum of the highest numbers recorded for each species during winter), spring (northward) migration (March to April), with a minimum count of 27,800, summer (May to June), with a minimum count of 3,000, and fall (southward) migration (July to November), with a minimum count of 91,800. This pattern is comparable to that observed in La Paz Bay (Carmona 1995, Fernandez *et al.* 1998), but is different from that reported for the eastern coast of the Gulf of California (Mellink *et al.* 1997) and California, USA (Page *et al.* 1979), where the greater concentrations of shorebirds occur during spring (northward) migration. However, all areas show that the southward migration is more protracted in time than the northward migration (Helmers 1992, Paulson 1993).

A feature of shorebird migration at Guerrero Negro is the difference in the numbers recorded between the fall (southward) and spring (northward) migrations. It appears that in the fall high numbers of shorebirds migrate southward along the Baja California Peninsula before stopping or crossing to the mainland, while most of them migrate northward along the Sonora–Sinaloa (mainland) coast in spring. This might particularly be the case for Western Sandpiper, which in spring occurs in relatively low numbers at Guerrero Negro, but in high numbers in the Colorado River Delta (Sonora) and in Santa María Bay (Sinaloa) (Mellink *et al.* 1997, Engilis *et al.* 1998).

The over-summering population in Guerrero Negro of Marbled Godwits was 22% of that found during winter (based on the highest count for each season). For American Avocets this number was 19%, for Willets 16%, and for Western Sandpipers 6%. Hockey *et al.* (1998) suggest that larger shorebird species may require more than a year to mature, and subadults may remain in wintering areas. Therefore, a greater percentage over-summering might be expected in larger than smaller species. This is what we observed in the saltworks and suggests that the area may be particularly important for young birds, enabling them to survive and improve their foraging efficiency during summer.

Table 2. Relative abundance of shorebirds in the Guerrero Negro Saltworks by season. A = peak abundance (>90% of year's highest count), B = high abundance (50–90% of the year's highest count), C = low abundance (10–50% of the year's highest count), D = marginal occurrence (<10% of the year's highest count).

Species	Winter	Spring	Summer	Fall
Red-necked Phalarope	D	D	D	A
Western Sandpiper	A	C	D	B
Dunlin	C	A	D	C
Dowitchers	C	D	D	A
Marbled Godwit	A	C	C	C
American Avocet	A	C	C	C
Willet	A	B	C	C
Ruddy Turnstone	A	C	D	D
Black-necked Stilt	A	B	D	C
Greater Yellowlegs	C	D	D	A
Black-bellied Plover	D	A	C	C
Lesser Yellowlegs	D	C	D	A

Importance of the Guerrero Negro saltworks as a habitat for shorebirds

The salt production process at Guerrero Negro generates an artificial habitat with relatively stable food availability through time and protection from human disturbance (Carmona & Danemann 1998). The ponds provide food for small shorebirds like Red-necked Phalarope, Western Sandpiper and Dunlin (i.e. brine fly *Ephydra* spp., brine shrimp *Artemia* spp., polychaete worms as *Platynereis* and *Palola*, and amphipods, isopods and alpheid crustaceans), and roosting areas for larger species, like Marbled Godwit. These characteristics make the Guerrero Negro saltworks one of the most important habitats for shorebirds on the Baja California Peninsula, only surpassed in terms of shorebird abundance by the Ojo de Liebre and San Ignacio lagoons (Massey & Palacios 1994, Morrison *et al.* 1992, Page *et al.* 1997), and possibly by the Magdalena Bay lagoon complex, the largest wetland of the peninsula, which has still not been thoroughly studied. In 2000, in recognition of their significance, the Guerrero Negro Saltworks were declared a "Site of International Importance" by the Western Hemisphere Shorebird Reserve Network (B. Harrington, Manomet Center for Conservation Sciences, Massachusetts, USA, pers. comm.).

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