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Shorebird abundance and species diversity in natural intertidal and non-tidal anthropogenic wetlands of the Colorado River Delta, Mexico

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ABSTRACT

Shorebirds constitute the highest abundance group of birds that use the Upper Gulf of California and Colorado River Delta (CRD) wetlands for nesting, spring stopover and overwintering sites. From August 2005 to December 2008 ground surveys were conducted on three natural intertidal wetlands (Golfo de Santa Clara, Isla Montague and Bahia Adair) and three brackish anthropogenic wetlands (Cienega de Santa Clara, Cerro Prieto and Mesa de Andrade) in the Upper Gulf and CRD. The goal was to determine the overall importance of the CRD in supporting shorebirds, and in particular the role of the anthropogenic wetlands, which face uncertain futures. Species richness varied from 15 to 26 species among sites and 29 species were detected across sites. The most abundant species was *Calidris mauri*, which was most abundant in Isla Montague and Golfo de Santa Clara in winter and spring, while it was most abundant in the Cienega de Santa Clara and Mesa de Andrade wetland in spring and fall. Cienega de Santa Clara and Golfo de Santa Clara had the highest bird density with 168 and 105 individuals/ha in the peak migration month. Birds tended to use the intertidal wetlands during the winter and spring migration period while the inland wetlands were most used during spring and fall. The Cerro Prieto geothermal power plant wetlands were most used by Phalaropes species during fall migration. Bahia Adair, an extensive intertidal wetland system south of the CRD, had a low density of shorebirds (10 individuals/ha) compared to CRD sites, but it had higher species diversity and the highest proportion of large size shorebirds. This study shows the importance of both intertidal and anthropogenic wetlands in supporting shorebirds along the Pacific Flyway. Management decisions that might impact these wetlands should consider their habitat value for migratory shorebirds as documented here.

1. Introduction

The Colorado River Delta (CRD) and the Upper Gulf of California support 37,890 ha of intertidal and non-tidal brackish wetlands (Glenn et al., 1996). Much of this area is protected by Mexican Law as a Biosphere Reserve and is designated as a Ramsar Site, an Important Bird Conservation Area (AICA), and a component of the Western Hemispheric Shorebird Reserve Network (WHSRN). Even though biotic and abiotic characteristics of this delta region have been modified by the reduction in water flow due to upstream water diversion (Glenn et al., 1996, 2006) the CRD and Upper Gulf area still have high productivity wetlands that support resident and migratory waterbird communities (Hinojosa-Huerta et al., 2004a).

Documented waterbird habitat uses for Upper Gulf and CRD region include reproduction sites for several species, and stopover and wintering sites for migratory species along the Pacific Flyway (Hinojosa-Huerta et al., 2004b; Mellink et al., 1997; Morrison, 1992). Shorebirds (families: *Charadriidae*, *Recurvirostridae*, *Haematopodidae* and *Scolopacidae*) are the group with the highest abundance (Mellink et al., 1997; Hinojosa-Huerta et al., 2004b). An earlier aerial survey estimated 163,744 wintering shorebirds in the CRD (Morrison, 1992), whereas subsequent ground survey estimates ranged from 88,000 (Román-Rodríguez, 2004) to 148,285 (Mellink et al., 1997). These studies indicated that the CRD region is equal to the Salton Sea and other high-density shorebird sites on the Pacific Flyway (Shuford et al., 2002). Shorebirds use the CRD wetlands mostly as a wintering site, with the mudflats and saltflats located near the mouth of the river being the most used areas (Mellink et al., 1997). According to Mellink et al. (1997) there is a possibility that individuals that use the Salton Sea could be the same individuals that use CRD wetlands since both

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sites are reported to be on the flyway for birds moving southward to the Pacific coastal areas during their migrations (Shuford et al., 2002).

The intertidal wetlands are extensive due to the shallow slope of the seabed and the high amplitude (up to 5 m) of the mixed diurnal tides (two tide cycles per day) in the CRD. However, the Colorado River no longer carries seasonal fresh water flows due to upstream dams and water diversions, and as a consequence the salinity regime of the estuary has been altered from seasonally miohaline to consistently euryhaline, which has induced changes in the flora and fauna (e.g., Avila-Serrano et al., 2006). On the other hand, a series of non-tidal, anthropogenic brackish wetlands have been created in the delta from the disposal of agricultural drainage water and other management activities. Our research question was, what is the relative contribution of the now-euryhaline intertidal wetlands and the brackish anthropogenic wetlands in supporting shorebird abundance and diversity? The answer to this question has management implications, because these anthropogenic wetlands were all inadvertently created by water management decisions in the U.S. and Mexico, and as a result they could be altered or eliminated by future management activities.

2. Methods

2.1. Study sites

Studies sites are shown in Fig. 1 and their size and main features are described in Table 1. The intertidal zone (Fig. 1) includes the coastline located at El Golfo de Santa Clara village, Isla Montague, San Felipe and Bahia Adair. The first three localities are part of the CRD estuary, which is dissected by three channels bordering the Montague-Gore and Pelicano Islands inside the core zone of the Biosphere Reserve. The coastline consists of extensive mudflats that decrease in silt and clay with increasing distance from the river mouth. The vegetation includes patches of the endemic saltgrass *Distichlis palmerii* on the Isla Montague and adjacent coastline areas and other halophytic species at other locations in the intertidal zone (Yensen et al., 1983; Felger, 2000).

The shoreline sites selected for sampling in the CRD consists of silty-clay (limo-arcilloso) sediments, with high benthic species richness (46), high density of benthic organisms (98.6 individuals/m^2) and high values for biomass (58.07 mg/m^2) (Villarreal and Carmona, 1999). Sampling was also conducted in Bahia Adair, an extensive estuary of tidal channels, mudflats and saltflats southeast of the CRD on the Sonoran shoreline (Felger, 2000). Sediments in that estuary sit on cemented seashell formations called coquinas, interrupted by tidal ponds and sandy areas. Halophytic species from Bahia Adair include *Allenrolfea occidentalis*, *Batis maritima*, *Salicornia bigelovii*, *S. subterminalis*, *S. virginica*, *Suaeda esteroa*, *S. puertopenascoa*, *Atriplex linearis*, *Atriplex barclayana*, *Cressa truxillensis*, *Frankenia salina*, *Distichlis palmeri*, *Monanthochloë littoralis* (Felger, 2000).

The first anthropogenic wetland complex selected for sampling was Cienega de Santa Clara (Fig. 1), a 4200 ha brackish wetland maintained by mildly saline (2–3 ppt) water releases from the Wellton-Mohawk Irrigation District in the U.S. (Glenn et al., 1992, 2001). It is an emergent marsh dominated by cattail (*Typha domingensis*), with about 15% open water areas, and patches of *Phragmites australis*, *Juncus*, *Distichlis spicata*, *D. palmeri*, *Scirpus* spp., *Tamarix chinensis* and *Allenrolfea occidentals* within the marsh or along the sides of the marsh (Abarca et al., 1993). The Cienega also supports large quantities of submerged aquatics such as *Najas marina* and *Ruppia maritima* (Glenn et al., 1992), important food sources for some waterfowl. South of the Cienega is an extensive evaporation basin that receives effluent from the Cienega and occasional tidal flooding. The Cienega is within the core and buffer zone of the Biosphere Reserve.

The second anthropogenic wetland complex is the Cerro Prieto geothermal field (Fig. 1). It consists of approximately 4000 ha of evaporation ponds, mud volcanos (0.05–2 m high), hot springs, vents, salt pans and fault scarps (Mercado and Fernández, 1998). Water sources include ground water fed by the Cucapa Mountain Range alluvial fans and the Colorado River (Mercado and Fernández, 1998). The wetlands are salty and shallow with an important microcrustacean community and other benthic species (Varela-Romero et al., 1998). *A. occidentalis* is the dominant plant species. The main shorebird habitats are in a series of evaporation ponds where effluent water from the geothermal electric generating facility is discharged. These shallow ponds contain islands of dredged material, which provide protection from predators for nesting birds. The ponds also provide food in the form of submerged aquatic vegetation, fish and invertebrates growing in the brackish ponds. According to Hinojosa-Huerta et al. (2004a) the Cerro Prieto wetlands are a nesting site link for shorebirds, between the Lower Colorado River (Isla Montague) and Salton Sea nesting sites.

The third set of anthropogenic wetlands are the Mesa de Andrade wetlands (Fig. 1), extending over an area of 6200 ha. These wetlands are formed by water seeping from the formerly unlined All American Canal in the United States. Seepage flows under the dune field comprising the San Andrade Mesa and surfaces along the foot of the dune field at its southern extent in Mexico, forming small, isolated wetlands separated by dunes. The wetlands consist of emergent marshes, playas and vegetated dunes, where the water table is within the reach of phreatophytic vegetation. Representative plant species in the marshes are *Distichlis spicata* and *T. domingensis*, while the dunes support *Larreta tridentata*, *Prosopis glandulosa*, *P. pubescens* and *Atriplex* spp. and other halophytes (Hinojosa-Huerta et al., 2002). With the lining of the All American Canal in 2008, seepage is not expected to continue and the future of these wetlands is in doubt.

2.2. Survey methods

The methods were based on the protocol of the Western Shorebird Survey (Bart et al., 2005). Surveys at each site were conducted at times of year previously identified as critical migration, wintering or nesting periods. Counts started at around 0800 h and continued throughout the day. At each site transects were set along the coastline or edge of the wetland and consisted of five or more point counts 400 m apart unless noted otherwise below. Each survey point had a radius of 250 m and an area of 12.5 ha. Surveyors used 10× binoculars and a 20× spotting scope to observe birds. In cases in which species identification was not possible, only the genus of the bird was recorded. In cases when larger concentrations than could be counted were encountered, numbers of shorebirds were determined by flock estimation following Kasprzyk and Harrington (1989) recommendations. Relative abundance (% composition) was calculated for each species.

At the intertidal zone habitats, the sampling dates corresponded to the lowest neap tide day for each month. At the non-tidal sites sampling dates were selected by chance keeping a similar time frame among surveys on each site. Surveys started in August 2005 in all the sites and in November for Bahia Adair and Isla Montague.

For the period from August 2005 to December 2006 six sampling zones were selected in Golfo de Santa Clara, Isla Montague and Bahia Adair for the intertidal zone and Cienega de Santa Clara, Cerro Prieto and Mesa de Andrade for the anthropogenic sites. At El Golfo de Santa Clara five points each were set along the shoreline from northwest to southeast.