Shorebird Use of Estero Santa Cruz, Sonora, México: Abundance, Diversity and Conservation Implications

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Abstract.—Ground-based censuses of shorebirds were conducted during the winters of 2000-2008 (even years only) and the springs of 2002-2004 and 2008 at Estero Santa Cruz, Sonora, México, a 3,622 ha coastal wetland at the Gulf of California between the Colorado River Delta and Bahía Santa Maria and Ensenada Pabellones, Sinaloa. We documented 21 shorebird species using Estero Santa Cruz. Winter species richness averaged 13 (SD = 2, range 11-16 species, N = 8) while the spring species richness averaged eleven (SD = 2, range 8-16 species, N = 15). In all censuses, *Calidris* spp.—primarily Western Sandpiper (*C. mauri*)—was the most abundant species group, accounting for up to 92% of daily abundance—varying between 60-91% in winter and 34-92% in spring. The highest winter daily count of calidrids was 3,485 while the spring high count was 7,095. The two highest single day counts were the latest dates censused (10 April 2004, 9 April 2008) suggesting that the peak of spring migration comes later, and thus that peak shorebird abundance in the estero is higher than our censuses have recorded. Estero Santa Cruz and other estuaries geographically intermediate between larger shorebird staging areas and migratory bottlenecks represent important migratory stopover sites. Such sites allow for flexibility in migratory pathways, and thus deserve conservation attention and management. *Received 17 February 2008, accepted 20 August 2008.*

Key words.—shorebirds, Gulf of California, coastal wetlands, migratory stopover sites, Western Sandpiper, *Calidris*, conservation.

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Little has been published describing the seasonal use and importance of estuarine habitats along the eastern shore of the Gulf of California for wintering and migrating shorebirds. Shorebird inventory and monitoring efforts in northwest México have focused on the Pacific Coast of Baja California (López-Uriate *et al.* 1997; Page *et al.* 1997; Ruiz-Campos *et al.* 2005; Zárate-Ovando *et al.* 2006) and the southeastern tip of the Baja California peninsula, near the mouth of the Gulf of California (Guzmán *et al.* 1994; Fernández *et al.* 1998). Surveys in the Colorado River Delta ("the Delta") have documented seasonal use and abundance of waterbirds in the extreme northern Gulf of California (Mellink *et al.* 1997; Hinojosa-Huerta *et al.* 2004), while Ensenada Pabellones and Bahía Santa Maria, Sinaloa, approximately 1,000 km south of the Delta, have been identified as crucial shorebird habitat (Engilis *et al.* 1998). The vast stretch of mainland coastline between the Sinaloan sites and the Delta is dotted with smaller coastal wetlands (Glenn *et al.* 2006) but has received little attention from shorebird biologists. Two brief aerial surveys conducted in 1992 (Morrison *et al.* 1992; Harrington 1993) and a preliminary survey of a single site near the Yaqui River Delta (Cervantes Abrego and Muratalla Contreras 1996) provided the only published surveys of shorebird abundance at these smaller, geographically intermediate estuaries.

Since 1998 we have monitored winter and spring shorebird populations at one of the largest of these geographically intermediate estuaries, Estero Santa Cruz, near Bahía Kino, Sonora (Fig. 1). Our primary objective was to contribute to an understanding of shorebird populations in this region by conducting ground-based surveys in Estero Santa Cruz, where we documented the species richness and relative abundance of wintering and migrating shorebirds. Like many coastal wetlands in northwestern México, Estero Santa Cruz is increasingly at risk from anthropogenic disturbances such as shrimp aquaculture facilities,

Figure 1. Four study sites in Estero Santa Cruz, Sonora, México: Levee ("LV"), Middle Mud ("MM"), Heron Island ("HI"), and Montecristo ("MC"). Insert: arrow indicates position of Estero Santa Cruz on the Sonoran coast of the Gulf of California, México; stars indicate positions of shorebird habitats at Bahía Santa Maria and Ensenada Pabellones, Sinaloa (northern and southern stars, respectively).

increased tourism and resort development (Brusca *et al.* 2005; Páez-Osuna and Ruiz-Fernández 2005; Glenn *et al.* 2006; Brusca 2007; Lluch-Cota *et al.* 2007). The eastern perimeter of Estero Santa Cruz has been converted to aquaculture since 1998, resulting in effluent discharge and a loss of foraging and roosting habitat for shorebirds. Because stopover and wintering sites are critically important to migratory bird populations (Rappole 1995; Pettit 2000), such wetland conversions can have both regional and hemispheric impacts on shorebird populations.

METHODS

Study Area

Estero Santa Cruz (28°48'N 111°54'W) is located along the Gulf of California's eastern shore, approximately 400 km south of the Colorado River Delta (Fig. 1, insert), and is one of the northernmost mangrove estuaries in the Gulf (Fleischner and Riegner 1993; Glenn *et al.* 2006). The 3,622 ha estuary is characterized by extensive mudflats and intermittent sandbars with an assortment of broad channels draining into Bahía Kino. Like most wetlands along this part of the Gulf of California coast, Estero Santa Cruz is a "negative estuary" (Brusca 1980; = "antiestuarine wetland" of Ruiz-Campos *et al.* 2005). Due to high evaporation rates and minimal surface water input in such esteros (Brusca et al. 2005), salinity increases as one moves inland, creating increasingly hypersaline mudflats The eastern (interior) portions of Estero Santa Cruz consist of these hypersaline flats, bordered by halophytes, predominately *Allenrolfea occidentalis*. The western portions of the estero, closer to the sea, are bordered by dense stands of Black Mangrove (*Avicennia germinans*) with isolated patches of Red Mangrove (*Rhizophora mangle*).

Monitoring

In 1998 we established four census sites for monitoring shorebirds in Estero Santa Cruz, including three sites along the northwestern peninsula that separates the estero from the Gulf of California ("peninsular sites") and one in the estero's north-central portion ("Montecristo"; Fig. 1). These sites were selected because they regularly supported shorebird populations and consistent access from the ground was possible. These four sites allow examination of approximately one-third of the estero's area, including the more biologically productive outer reaches of the estero, rather than its relatively depauperate hypersaline eastern portions. Other portions of the estero could not be easily surveyed from ground or water due to difficulty of access (subsequent limited survey of these areas, as described below, revealed no large concentrations of shorebirds).

During 2000-2008, we censused wintering and migrating shorebirds in Estero Santa Cruz, supervising 10-12 observers each year. "Winter" surveys occurred in January, while "spring" surveys took place March-April. We surveyed all four census sites simultaneously ("simultaneous census") during the winters of 2000, 2002, 2004, 2006 and 2008, and in the spring of 2003. In addition, we sequentially surveyed ("sequential census") two or three (usually three) sites twice in winter 2004, three times in spring 2002, eight times in spring 2004 and three times in 2008. At each site, one to three observers identified and counted all shorebirds during a 30-minute census period. Observation effort at the four sites varied from 23 surveys at the most frequently visited site to nine at the least visited and were made during falling mid-level tides. Because accurate tide charts are lacking for this region, it was impossible to precisely quantify tide levels. Under poor observation conditions, when reliably identifying individuals to species was difficult, certain species were recorded in taxonomic groups (e.g., "dowitchers," "yellowlegs" and "*Calidris* spp.").

In January 2000 during high tide, a boat survey was conducted while the three peninsular sites were being simultaneously censused. The boat observers were able to view all four ground-based census sites (and thus could compare counts with ground-based observers), as well as other sandbars and channels, which are inaccessible from any of the normal census sites. The boat survey allowed census of an additional ~20% of the estero.

All common and scientific names conform to the American Ornithologists' Union Checklist of North American Birds, 7th edition (AOU 1998) and its 47th Supplement (Banks *et al.* 2006). Species richness calculations include species that were observed during site visits but not during formal census.

RESULTS

We documented 21 species of shorebirds utilizing Estero Santa Cruz. *Calidris* spp. (primarily Western Sandpiper, *C. mauri*) was the most abundant species group in both winter and spring, accounting for up to 91% of daily abundance in winter (Table 1) and 92% of daily abundance in spring (Table 2; varying between 60-91% in winter and 34-92% in spring). The highest winter daily count of calidrids totaled 3,485 individuals (28 January 2006; Table 1) while the spring high count documented 7,095 calidrids (9 April 2008, Table 2). Dowitchers (*Limnodromus* spp.) was the second most abundant species group in the winter, followed by Willet (*Tringa semipalmata*) and Marbled Godwit (*Limosa fedoa*). The highest winter count (30 January 2000) of Dowitchers was 474 while the spring high count (142 on 2 March 2004) was considerably lower. American Avocet (*Recurvirostra americana*) and Willet were the second and third most abundant species in spring (on 9 April 2008, 1,258 "large shorebirds" - a combination of Willet, Whimbrel (*Numenius phaeopus*), and Marbled Godwit—were observed). Due to distance, these individuals were lumped together. Killdeer (*Charadrius vociferous*) was absent during spring but all other species were seen during both seasons. Species richness averaged 13 in winter (SD = 2, range 11-16 species, N = 8) and eleven in spring (SD = 2, range 8-16 species, N = 15). In 2004, the year with most consistent coverage between seasons, we documented seasonal changes in abundance of shorebird species from winter to spring (Fig. 2). Total shorebird abundance increased four-fold from 4 January to 10 April, while calidrid abundance increased five-fold, and Black-bellied Plover (*Pluvialis squatarola*) abundance increased fifteenfold.

DISCUSSION

Our counts confirm the regional importance of Estero Santa Cruz to shorebirds that winter in and migrate through northwestern México. Our census numbers more than double the aerial census of Morrison *et al.* (1992), who observed 1,695 shorebirds (including 1,160 "small") in Estero Santa Cruz in late January 1992. Harrington (1994, pers. comm.) has aerial survey data from mid-January 1994 for Estero Santa Cruz of 12,907 shorebirds (including 10,500 peeps)—a higher count than anything we documented. The higher count in the past could reflect one or more of the following: a) daily variation; b) differences between aerial and ground-based censusing (the former allowing more comprehensive observation of the estero); or c) a notable decline in shorebird use of the estero during the 1990s, the period when shrimp aquaculture facilities were constructed in the eastern portion of the estero.

Given that we only surveyed part of Estero Santa Cruz, our counts are minimum estimates of the numbers of birds using the region, especially for migratory periods. Moreover, the fact that our highest single day counts were the latest dates censused (10 April 2004, 9 April 2008; Table 2) suggests that the peak of spring migration comes later, and thus that the estero's greatest shorebird abundance remains unsurveyed. During migratory periods, even small sites may be used by many more birds than single day counts indicate when one factors in turnover of birds at the site. Western Sandpipers - the most abundant shorebird in the study area and along the entire Pacific Coast of North America (Wilson 1994; Butler *et al.* 1996), turn over rapidly during migration, often stopping only for a few days (Iverson *et al.* 1996; Warnock and Bishop 1998) as they migrate in short hops along the Pacific Coast. These patterns have also been observed in other species of shorebirds that migrate through Estero Santa Cruz (e.g., Dunlin [*Calidris alpina*], dowitchers; Warnock *et al.* 2004).

Our January 2000 boat survey reinforced confidence in our four ground-based census

Table 1. Relative abundance and species richness of shorebirds at Estero Santa Cruz, Sonora, México, during winter censuses (2000-2008). Effort: * = simultaneous census; all 3 peninsular sites and Montecristo; + = simultaneous census; boat and peninsular sites; ^ = sequential census; peninsular sites (≥2 peninsular sites); # = sequential census; one peninsular site and Montecristo.

		2000		2002		2004		2006	2008
Common name	Scientific name	29-Jan	30-Jan	25-Jan	3-Jan	4-Jan	23-Jan	28-Jan	21-Jan
Black-bellied Plover	*Pluvialis squatarola*	17	85	0	2	3	22	22	29
Snowy Plover	*Charadrius alexandrinus*	69	0	1	0	0	0	21	0
Wilson's Plover	*C. wilsonia*	6	1	11	2	5	0	47	7
Semipalmated Plover	*C. semipalmatus*	4	11	9	1	2	3	50	11
Killdeer	*C. vociferous*	0	0	0	0	0	0	1	0
Plover sp.	*Pluvialis* or *Charadrius* spp.	0	0	16	0	0	1	8	3
American Oystercatcher	*Haematopus palliates*	2	7	0	1	1	0	0	2
Black-necked Stilt	*Himantopus mexicanus*	7	14	4	13	7	12	0	0
American Avocet	*Recurvirostra americana*	38	51	45	0	0	0	12	2
Spotted Sandpiper	*Actitis macularius*	0	1	0	1	0	0	0	0
Greater Yellowlegs	*Tringa melanoleuca*	0	0	24	0	0	0	2	8
Willet	*T. semipalmata*	94	160	40	83	75	111	109	163
Lesser Yellowlegs	*T. flavipes*	11	0	0	0	0	0	0	0
Yellowlegs	*T. melanoleuca* and/or *flavipes*	6	18	0	6	7	9	3	2
Whimbrel	*Numenius phaeopus*	8	14	5	5	3	8	5	17
Long-billed Curlew	*N. americanus*	19	35	9	5	10	8	17	13
Marbled Godwit	*Limosa fedoa*	73	224	108	14	24	48	53	179
Ruddy Turnstone	*Arenaria interpres*	1	4	0	0	0	0	0	0
Calidris spp. (Western and Least Sandpiper, Dunlin)	*C. mauri, minutilla,* and/or *alpina*	1971	1720	871	1064	887	1561	3485	1558
Dowitcher spp.	*Limnodromus griseus* and/or *scolopaceus*	283	474	320	44	94	113	0	0
	Effort	*	+	*	^	^	*	*	*
	Total	2609	2819	1463	1241	1118	1896	3835	1999
	Species Richness	16	16	12	12	12	11	13	12
	Percent Calidrids	76%	61%	60%	86%	79%	82%	91%	78%

Table 2. Relative abundance and species richness of shorebirds at Estero Santa Cruz, Sonora, México, during spring censuses (2002-2008). Effort: * = simultaneous census; all 3 peninsular sites and Montecristo; $ = sequential census, all 4 sites; ^ = sequential census; peninsular sites (≥2 peninsular sites); # = sequential census; one peninsular site and Montecristo.

		2002			2003	2004								2008		
Common name	Scientific name	17-Mar	9-Apr	21-Apr	2-Mar	2-Mar	4-Mar	5-Mar	6-Mar	7-Apr	8-Apr	9-Apr	10-Apr	11-Mar	6-Apr	9-Apr
Black-bellied Plover	*Pluvialis squatarola*	4	3	2	0	17	7	5	4	1	1	39	44	14	7	75
Snowy Plover	*Charadrius alexandrinus*	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Wilson's Plover	*C. wilsonia*	4	4	4	11	1	2	0	0	3	1	4	5	6	1	2
Semipalmated Plover	*C. semipalmatus*	0	0	10	0	12	14	15	0	0	0	0	0	5	8	1
Killdeer	*C. vociferous*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plover sp.	*Pluvialis* or *Charadrius* spp.	26	18	0	2	0	0	21	0	3	1	0	0	0	0	0
American Oystercatcher	*Haematopus palliates*	0	0	2	0	0	0	0	0	0	0	2	2	0	0	0
Black-necked Stilt	*Himantopus mexicanus*	0	0	0	6	8	6	1	8	0	0	0	1	15	5	0
American Avocet	*Recurvirostra americana*	400	0	15	37	133	0	27	116	47	0	92	42	88	124	0
Spotted Sandpiper	*Actitis macularius*	0	0	0	0	0	0	2	0	0	0	0	0	70	0	0
Greater Yellowlegs	*Tringa melanoleuca*	2	0	5	0	29	22	23	18	33	12	45	43	14	5	0
Willet	*T. semipalmata*	22	10	45	134	82	39	42	76	59	69	148	120	249	194	116
Lesser Yellowlegs	*T. flavipes*	0	0	0	19	0	0	0	0	0	0	0	0	9	3	1
Yellowlegs	*T. melanoleuca* and/or *flavipes*	2	0	0	0	0	0	0	0	0	0	0	0	15	8	9
Whimbrel	*Numenius phaeopus*	3	4	10	5	2	3	4	3	8	3	8	3	24	11	29
Long-billed Curlew	*N. americanus*	3	0	2	8	13	6	17	10	2	1	6	6	14	2	0
Marbled Godwit	*Limosa fedoa*	7	27	64	11	20	12	8	31	50	66	22	8	55	125	13
Large shorebirds (includes Willet, Whimbrel and Marbled Godwit)		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1100
Ruddy Turnstone	*Arenaria interpres*	0	1	6	0	0	0	0	0	0	0	0	0	0	5	0
Calidris spp. (Western, and Least Sandpiper, Dunlin)	*C. mauri, minutilla,* and/or *alpina*	241	138	256	3198	535	332	1755	2035	472	330	4129	4437	1108	1058	7095
Dowitcher spp.	*Limnodromus griseus* and/or *scolopaceus*	0	70	2	46	142	35	1	29	61	124	52	147	100	38	190

Table 2. (Continued) Relative abundance and species richness of shorebirds at Estero Santa Cruz, Sonora, México, during spring censuses (2002-2008). Effort: * = simultaneous census; all 3 peninsular sites and Montecristo; $ = sequential census, all 4 sites; ^ = sequential census; peninsular sites (≥2 peninsular sites); # = sequential census; one peninsular site and Montecristo.

		2002			2003	2004								2008		
Common name	Scientific name	17-Mar	9-Apr	21-Apr	2-Mar	2-Mar	4-Mar	5-Mar	6-Mar	7-Apr	8-Apr	9-Apr	10-Apr	11-Mar	6-Apr	9-Apr
Effort		^	^	^	*	^	^	^	^	^	^	#	#	^	^	$
Total		714	275	423	3475	994	478	1921	2330	739	608	4547	4858	1786	1594	8631
Species Richness		9	8	14	12	12	11	12	10	11	10	11	13	16	15	10
Percent Calidrids		34%	50%	61%	92%	54%	69%	91%	87%	64%	54%	91%	91%	62%	66%	82%

sites, and in the accuracy of our observers. This survey did not reveal any other Western Sandpiper concentrations (>100 individuals), although we did observe larger flocks of Marbled Godwits (224), Black-bellied Plovers (85) and Dowitchers (474) than in previous surveys.

Estero Santa Cruz is less than two percent of the combined area of the two important Sinaloan estuaries, Ensenada Pabellones and Bahía Santa Maria, that support 30% of the wintering shorebird populations along the Pacific coast of North America (Engilis *et al.* 1998). Nevertheless, its shorebird species richness (21) was 72% of the richness of the much larger sites (29 spp.; Engilis *et al.* 1998). Moreover, we censused only in the estero itself—a narrower range of habitats than surveyed by Engilis *et al.* (1998) at the two Sinaloan estuaries. If we included other nearshore habitats (sandy beaches, rocky shorelines, and shallow subtidal zones) within 5 km of Estero Santa Cruz, an additional five species would have been added to our species list: Black Oystercatcher (*Haematopus bachmani*), Wandering Tattler (*Heteroscelus incanus*), Surfbird (*Aphriza virgata*), Sanderling (*Calidris alba*) and Red-necked Phalarope (*Phalaropus lobatus*). With the inclusion of these five species, species richness would be 90% of the combined Sinaloan sites.

It has been suggested (Senner 1979; Piersma 1987; Wilson 1994) and empirically confirmed (Iverson *et al.* 1996) that individual Western Sandpipers migrate independently, often in short "hops," which are less ecologically risky than long "jumps." Moreover, Western Sandpipers may not use migration flyways in the same way each year (Iverson *et al.* 1996). Because Western Sandpipers—the most abundant shorebird in the study area and along the entire Pacific Coast of North America (Wilson 1994; Butler *et al.* 1996)—migrate in multitudinous and variable independent pathways, it is of crucial conservation importance to maintain the ecological health of many stopover sites, and thus ecological flexibility for wintering and migrating shorebirds.

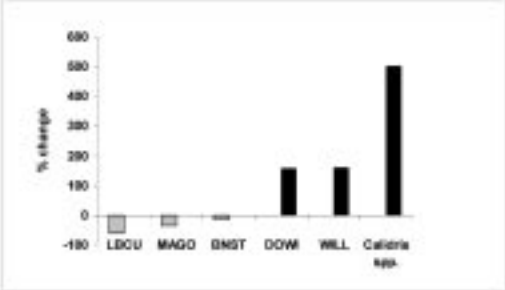

Figure 2. Seasonal percent change of shorebird abundance at Estero Santa Cruz, Sonora, México, from winter to spring 2006 (4 January-10 April). (LBCU = Long-billed Curlew; MAGO = Marbled Godwit; BNST = Black-necked Stilt; DOWI = Dowitcher spp.; WILL = Willet.).

Shorebird conservation efforts have primarily focused on coastal wetlands that seasonally harbor enormous shorebird concentrations. But wetlands such as Estero Santa Cruz, that consistently provide habitat for smaller numbers of shorebirds, also hold great conservation importance, and can potentially provide safety nets for shorebirds (especially juveniles), should these larger and better-known staging areas become ecologically degraded (Myers 1983). However, Estero Santa Cruz, like all esteros in the Gulf, has been degraded ecologically (Brusca and Findley 2005; Brusca *et al.* 2005; Glenn *et al.* 2006). Dams and diversions have reduced freshwater input into the estero; effects on estuarine organisms (i.e., shorebirds) are unknown, due to lack of baseline data prior to these anthropogenic habitat alterations. Over 95% of the mangrove marshes in the northern Gulf have been developed for shrimp aquaculture in recent years (Glenn *et al.* 2006). In addition to more direct forms of habitat destruction, these shrimp farms load excess nitrogen and phosphorus into wetlands and marine systems (Páez-Osuna and Ruiz-Fernández 2005). In spite of increasing regional impacts, Estero Santa Cruz still has minimal human activity on the mudflats, except for low-level shellfish harvesting at low tides, when shorebirds are widely dispersed. Estero Santa Cruz remains a regionally important wintering and migratory stopover habitat for shorebirds. Shorebird abundance here was not exceptionally high relative to sites of hemispherically significant concentration (e.g., Bahía Santa Maria). However, the consistency of shorebird presence across years and the estero's intermediate location between known areas of shorebird concentration, warrant continued conservation monitoring at Estero Santa Cruz.

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LITERATURE CITED

American Ornithologists' Union (AOU). 1998. Checklist of North American Birds, 7th ed. American Ornithologists' Union, Washington, D.C.

Banks, R. C., C. Cicero, J. L. Dunn, A. W. Kratter, P. C. Rasmussen, J. V. Remsen, Jr., J. D. Rising and D. F. Stotz. 2006. Forty-seventh supplement to the American Ornithologists' Union Check-list of North American Birds. *Auk* 123: 926-936.

Brusca, R. C. 1980. *Common intertidal invertebrates of the Gulf of California.* University of Arizona Press, Tucson.

Brusca, R. C. 2007. Invertebrate biodiversity in the Northern Gulf of California. Pages 418-504 *in* (R. S. Felger and B. Broyles, Eds.) *Dry borders: Great natural reserves of the Sonoran Desert.* University of Utah Press, Salt Lake City.

Brusca, R. C. and L. T. Findley. 2005. The Sea of Cortez. Pages 11-24 *in* (M. E. Hendrickx, R. C. Brusca and L. T. Findley, Eds.) *A distributional checklist of the macrofauna of the Gulf of California, Mexico, Part 1. Invertebrates.* Arizona-Sonora Desert Museum, Tucson, AZ.

Brusca, R. C., L. T. Findley, P. A. Hastings, M. E. Hendrickx, J. Torre Cosio and A. M. van der Heiden. 2005. Macrofaunal diversity in the Gulf of California. Pages 179-202 in (J.-L. E. Cartron, G. Ceballos and R. S. Felger, Eds.) *Biodiversity, ecosystems, and conservation in northern México.* Oxford University Press, New York.

Butler, R. W., F. S. Delgado, H. de la Cueva, V. Pulido and B. K. Sandercock. 1996. Migration routes of the Western Sandpiper. *Wilson Bulletin* 108: 662-672.

Cervantes Abrego, M. and R. E. Muratalla Contreras. 1996. Preliminary study of shorebird habitat and

feeding conditions at Lobos Bay, Sonora, Mexico. *International Wader Studies* 8: 42.

Engilis, A. Jr., L. W. Oring, E. Carrera, J. W. Nelson and A. M. Lopez. 1998. Shorebird surveys in Ensenada Pabellones and Bahía Santa Maria, Sinaloa, Mexico: Critical Winter Habitats for Pacific Flyway shorebirds. *Wilson Bulletin* 110: 332-341.

Fernández, G. J., R. Carmona and H. de la Cueva. 1998. Abundance and seasonal variation of Western Sandpipers (*Calidris mauri*) in Baja California Sur, Mexico. *Southwestern Naturalist* 43: 57-61.

Fleischner, T. L. and M. Riegner. 1993. Winter birds of Bahía Kino, Central Gulf of California Coast, Sonora, Mexico. *Ecológica* 3: 29-34.

Glenn, E. P., P. L. Nagler, R. C. Brusca and O. Hinojosa-Huerta. 2006. Coastal wetlands of the northern Gulf of California: inventory and conservation status. *Aquatic Conservation: Marine and Freshwater Ecosystems* 16: 5-28.

Guzmán, J., R. Carmona, E. Palacios and M. Bojórquez. 1994. Seasonal distribution of aquatic birds in Estero de San José del Cabo, B.C.S., Mexico. *Ciencias Marinas* 20: 93-103.

Harrington, B. A. 1993. A coastal, aerial shorebird survey on the Sonora and Sinaloa coasts of Mexico. *Wader Study Group Bulletin* 67: 44-49.

Harrington, B. A. 1994. A coastal, aerial survey in Sonora, Sinaloa, and Nayarit, Mexico, January 1994. Manuscript report. Manomet Observatory for Conservation Sciences, Manomet, Massachusetts. 15 pp.

Hinojosa-Huerta, O., S. DeStefano, Y. Carillo-Guerrero, W. Shaw and C. Valdes. 2004. Waterbird communities and associated wetlands of the Colorado River delta, Mexico. *Studies in Avian Biology* 27: 52-60.

Iverson, G. C., S. E. Warnock, R. W. Butler, M. A. Bishop, and N. Warnock. 1996. Spring migration of Western Sandpipers along the Pacific coast of North America: a telemetry study. *Condor* 98: 10-21.

Lluch-Cota, S. E. and 28 co-authors. 2007. The Gulf of California: review of ecosystem status and sustainability challenges. *Progress in Oceanography* 73: 1-26.

López-Uriarte, E., A. Escofet, E. Palacios and S. González. 1997. Migrant shorebirds at sandy beaches located between two major wetlands on the Pacific Coast of Baja California (Mexico). *Natural Areas Journal* 17: 212-218.

Mellink, E., E. Palacios, and S. González. 1997. Nonbreeding waterbirds of the delta of the Rio Colorado, México. *Journal of Field Ornithology* 68: 113-123.

Morrison, R. I. G, R. K. Ross and S. Torres. 1992. Aerial surveys of Nearctic shorebirds wintering in Mexico: Some preliminary results. *Canadian Wildlife Service. Progress Notes* 201: 1-11.

Myers, J. P. 1983. Conservation of migrating shorebirds: staging areas, geographic bottlenecks, and regional movements. *American Birds* 37: 23-25.

Páez-Osuna, F. and A. C. Ruiz-Fernández. 2005. Environmental load of nitrogen and phosphorus from extensive, semi-intensive, and intensive shrimp farms in the Gulf of California ecoregion. *Bulletin of Environmental Contamination and Toxicology* 74: 681-688.

Page, G. W., E. Palacios, L. Alfaro, S. Gonzalez, L. E. Stenzel and M. Jungers. 1997. Numbers of wintering shorebirds in coastal wetlands of Baja California, Mexico. *Journal of Field Ornithology* 68: 562-574.

Pettit, D. R. 2000. Habitat use by landbirds along Nearctic-Neotropical migration routes: implications for conservation of stopover habitats. *Studies in Avian Biology* 20: 15-33.

Piersma, T. 1987. Hop, skip, or jump? Constraints on migration of arctic waders by feeding, fattening, and flight speed. *Limosa* 60: 185-194.

Rappole, J. H. 1995. *The ecology of migrant birds: a Neotropical perspective*. Smithsonian Institution Press, Washington, D.C.

Ruiz-Campos, G., E. Palacios, J. A. Castillo-Guerrero, S. González-Guzmán and E. H. Batche-González. 2005. Spatial and temporal composition of the avifauna from small coastal wetlands and adjacent habitats in northwestern Baja California, Mexico. *Ciencias Marinas* 31: 553-576.

Senner, S. E. 1979. An evaluation of the Copper River Delta as a critical habitat for migrating shorebirds. *Studies in Avian Biology* 2: 131-146.

Warnock, N. and M. A. Bishop. 1998. Spring stopover ecology of migrant Western Sandpipers. *Condor* 100: 456-467.

Warnock, N., J. Y. Takekawa and M. A. Bishop. 2004. Migration and stopover strategies of individual Dunlin along the Pacific Coast of North America. *Canadian Journal of Zoology* 82: 1687-1697.

Wilson, W. H. 1994. Western sandpiper. *In* A. Poole and F. Gill, Eds. *The Birds of North America*, No. 90, Academy of Natural Sciences, Philadelphia, PA.

Zárate-Ovando, B., E. Palacios, H. Reyes-Bonilla, E. Amador and G. Saad. 2006. Waterbirds of the Lagoon Complex Magdalena Bay—Almejas, Baja California Sur, Mexico. *Waterbirds* 29: 350-364.