# CONSERVATION PLAN FOR THE WESTERN SANDPIPER (*CALIDRIS MAURI*)

## Version 1.1

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Guillermo Fernández[1], Nils Warnock[2], David B. Lank[3], and Joseph B. Buchanan[4]

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WESTERN HEMISPHERE SHOREBIRD RESERVE NETWORK

## NOTE about Version 1.1:

The only difference between Version 1.1 (February 2010) and Version 1.0 (June 2006) is the addition of a Spanish executive summary.

## Conservation Plan Authors:

[1] Unidad Académica Mazatlán, Instituto de Ciencias del Mar y Limnología, UNAM. Av. Joel Montes Camarena, Apdo. Postal 811, Mazatlán 82040, Sinaloa, México; gfernandez@ola.icmyl.unam.mx

[2] PRBO Conservation Sciences, 4990 Shoreline Hwy., Stinson Beach, CA 94970; nwarnock@prbo.org

[3] Centre for Wildlife Ecology, Simon Fraser University, 8888 University Drive, Burnaby, BC V5H 1S6; dlank@sfu.ca

[4] Washington Department of Fish and Wildlife, 600 Capitol Way North, Olympia, WA 98501, buchajbb@dfw.wa.gov

## For further information:

Manomet Center for Conservation Sciences – www.manomet.org

Western Hemisphere Shorebird Reserve Network – www.whsrn.org

## Financial Contributors:

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## Front Cover Photo:

Western Sandpipers resting and foraging at Bahía Santa María, Sinaloa, Mexico.

Photo by Patricio Robles Gil, Agrupación Sierra Madre, S.C.

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## EXECUTIVE SUMMARY

The Western Sandpiper (*Calidris mauri*) is a small shorebird species that nests in coastal areas of western Alaska and Siberia. Most Western Sandpipers spend the non-breeding season at Pacific coastal sites. The combination of a restricted breeding range and a broad non-breeding distribution means that some Western Sandpipers migrate much farther than others. Western Sandpipers are differential migrants; males spend the winter farther north than females, and juveniles are disproportionately represented on the northern and southern edges of the distribution. There is also a life history difference as a function of migratory distance. Western Sandpipers spending their juvenile non-breeding season in northern Mexico migrate northward in their first spring, but many juveniles in Panama remain on the non-breeding grounds until their second spring.

Western Sandpipers use a substantial number of sites throughout their annual range, and some sites support very large numbers of birds. Major migratory sites include the Parte Alta de la Bahía de Panama, coastal northwestern Mexico, San Francisco Bay in California, Grays Harbor in Washington, the Fraser River delta in British Columbia, and Kachemak Bay, the Stikine River delta and the Copper River delta in Alaska. During winter, the largest documented concentrations of Western Sandpipers occur in San Francisco Bay in California, Laguna Madre in Tamaulipas–Texas, Laguna Ojo de Liebre in Baja California, Bahía Santa María and Ensenada Pabellones in Sinaloa, and Parte Alta de la Bahía de Panama. Although some of the most important sites are protected, many other sites are on unprotected lands.

Although the Western Sandpiper is one of the most common and best-studied shorebird species in North America, it warrants conservation planning because its population trends and limiting factors are poorly understood, their tendency to concentrate in a limited number of locations during migration and winter suggest a vulnerability to a variety of factors, and significant habitat loss or degradation is occurring in much of its non-breeding range. Determining the current population status of Western Sandpipers is a primary goal. Without this information, management of Western Sandpiper population would be difficult and lack direction. At migratory and wintering sites, potential or actual threats include habitat loss, habitat development, recreation, aquaculture, human disturbance, oil spills, water diversions, changing agricultural practices, and contaminants. There are still major gaps in the underlying factors that have the greatest influence on Western Sandpiper populations and demographic rates.

## RESUMEN EJECUTIVO

El *Calidris mauri* es una especie de ave playera de pequeña tamaño que anida en las zonas costeras del oeste de Alaska y de Siberia. La mayoría de *Calidris mauri* pasa la temporada de no reproducción en sitios costeros en la Costa Pacífica. La combinación de un rango restringido en la temporada de reproducción y una distribución amplia en la temporada de no reproducción significa que algunos individuos migran mucho más lejos que otros. Los *Calidris mauri* son aves migratorias diferenciales; los machos pasan el invierno más al norte que las hembras, y los juveniles se encuentran desproporcionadamente en los bordes al norte y al sur del área de distribución. También la historia natural es diferente en función a los recorridos migratorios. Los juveniles *Calidris mauri* que pasan la temporada de no reproducción en el norte de México migran hacía el norte en su primera primavera, pero muchos otros de Panamá permanecen en el sitio de no reproducción hasta su segunda primavera.

Los *Calidris mauri* utilizan un número sustancial de lugares en todo el rango, y algunos de estos sitios albergan grandes cantidades de aves. Los principales sitios de migración incluyen la Parte Alta de la Bahía de Panamá, la costa noreste de México, la Bahía de San Francisco en California, Grays Harbor en Washington, la Delta del Río Fraser en la Columbia Británica, y la Bahía de Kachemak, el Delta del Río Stikine, y el Delta del Río Copper en Alaska. Durante el invierno, las mayores concentraciones documentadas de *Calidris mauri* ocurren en la Bahía de San Francisco en California, la Laguna Madre en Tamaulipas/Texas, la Laguna Ojo de Liebre en Baja California, la Bahía Santa María y Ensenada Pabellones en Sinaloa, y la Parte Alta de la Bahía de Panamá. Aunque algunos de los sitios más importantes están protegidos, muchos otros se encuentran en tierras no protegidas.

Aunque el *Calidris mauri* es una de las aves playeras más comunes y estudiadas en Norteamérica, se merecen planificación de conservación a causa de varios factores: las tendencias de la población ya que los factores limitantes son poco conocidos; su tendencia a concentrarse en un número limitado de sitios durante la migración y en el invierno, la cual sugiere una vulnerabilidad a una variedad de factores; y la pérdida o degradación significativa de hábitat que está ocurriendo en gran parte del rango de no reproducción.

Determinar el estado actual de la población del *Calidris mauri* es un objetivo primordial. Sin esta información, las gestiones de conservación en pro de la población de la especie sería difícil y falta la orientación. En los sitios de migración o de invierno, las amenazas reales o potenciales incluyen la pérdida del hábitat, el desarrollo urbano, la recreación, la acuacultura, la perturbación humana, derrames de petróleo, cambios del curso del agua, cambios de las prácticas agrícolas, y los contaminantes. Todavía hay lagunas en el conocimiento de los factores que tienen la gran influencia en las poblaciones y en las tasas demográficas de *Calidris mauri*.

## PURPOSE

The Western Sandpiper (*Calidris mauri*) is one of most common and best-studied shorebird species in North America. Despite its large population numbers, various issues of concern have been identified, and these issues prompted the development of this conservation plan. The issues of concern include: (1) recent rates of habitat loss due to agricultural conversion, coastal development, and aquaculture management in the non-breeding range; (2) gaps in knowledge regarding population limiting factors; (3) its vulnerability to a variety of impacts due to a strong tendency to aggregate in spatially constrained or otherwise limited areas in the non-breeding season; (4) suspected declines in numbers, and (5) inadequate monitoring data for determining population trends. These concerns have prompted a number of organizations and agencies to assign special conservation status to the Western Sandpiper. For example, the United State Shorebird Conservation Plan lists the Western Sandpiper as a Species of High Concern (Brown et al. 2001, U.S. Shorebird Conservation Plan 2004), while the Canadian Shorebird Conservation Plan consider it a species of moderate concern with known or potential threats (Donaldson et al. 2000). With support from the Western Hemisphere Shorebird Reserve Network (WHSRN) and Manomet Center for Conservation Science, and with a grant from National Fish and Wildlife Foundation, we have begun to address these concerns by developing a conservation plan for the Western Sandpiper.

This conservation plan is the first step in a process to develop a multi-faceted conservation strategy for Western Sandpipers in the Western Hemisphere. We envision that the conservation strategy will eventually include significant progress in the following areas: a) development of effective means to protect and restore habitats at important sites, b) identification of and meaningful action to address limiting factors, c) enhancement of outreach efforts to improve dissemination of information to decision-makers and the public about issues relevant to conservation of Western Sandpiper populations and d) a comprehensive monitoring program. Implementation in these areas will be necessary to realize the values expressed in this conservation plan.

In this conservation plan we provide information that can be used by resource managers and the public to understand the ecology and behavior of Western Sandpipers, and the various conservation issues of importance to achieving population goals set forth in the United States Shorebird Conservation Plan (Brown et al. 2001). Specifically, in this plan we provide a brief overview of the species' ecology and status, identify important sites used by ≥ 1% of the species' global population, and describe major conservation threats and conservation actions needed at those sites. To develop the plan, we summarized information from published literature, unpublished data, and personal communications with shorebird scientists, resource managers, and amateur field ornithologists with special interest in shorebirds. To the extent possible, the scope of this document includes the Western Sandpiper's entire range and its full annual cycle. The site information includes high counts of Western Sandpipers, habitats used, threat factors that impact or potentially impact each site, and conservation actions needed to diminish or offset those threats. This plan was written in accordance with the United States and Canadian shorebird conservation plans (Brown et al. 2001, Donaldson et al. 2000), and utilized regional shorebird plans to identify research and education/ outreach needs that pertain to Western Sandpipers and/or important sites used by the species in Alaska (Alaska Shorebird Working Group 2000), coastal Washington and Oregon (Drut and Buchanan 2000), California (Hickey et al. 2003), and the Intermountain West (Oring et al. 2005). Our goal is to provide natural resource managers, funding agencies, and scientists with the information necessary to maintain or increase Western Sandpiper populations throughout the species' range.

## MANAGEMENT STATUS AND NATURAL HISTORY

### TAXONOMY

The Western Sandpiper (*Calidris mauri*) is a small (22-35 g) monotypic sandpiper (Wilson 1994). Although no races or discrete breeding populations of the species are recognized, genetic differences based on random amplified polymorphic DNA analyses were found between wintering grounds in Humboldt Bay, California, and South Island, South Carolina (Haig et al. 1997). Interestingly, the rather limited breeding distribution of Western Sandpipers does not suggest that this should occur. The extent of genetic differentiation between the small population on the Chukotski Peninsula of Siberia and the North America population is currently unknown.

## POPULATION ESTIMATE AND TREND

Western Sandpipers are one of the most common shorebird species in North America, especially in the Pacific Flyway. The latest estimate of total population size is 3.5 million birds (range = 2.8–4.3 million; Bishop et al. 2000, Morrison et al. 2001). The data used to derive the population estimate were collected in 1992–1995. Although it is possible that a population decline is occurring (Brown et al. 2001), the magnitude of any change in population size is unknown.

There is uncertainty about the population trend due to lack of adequate monitoring in western North America. Several sources of information suggest declines in the numbers of migrating Western Sandpipers. In southwestern British Columbia, Western Sandpiper abundance has been monitored by Environment Canada since 1992 (Butler and Lemon 2001). Annual counts are made on the Fraser River delta during northward migration and on Sidney Island during southward migration. These survey data show declines in count data in both northward and southward migrations from 1992 to 2000 (Butler and Lemon 2001). However, the decade-long decline in Western Sandpiper numbers counted at Sidney Island during southward migration appears to be due to a decrease in stopover duration, rather than fewer individuals using the site (Ydenberg et al. 2004). A 25-year data set at Bolinas Lagoon, in northern coastal California, reveals a significant decline in Western Sandpipers using the site during the northward migration, although it is not clear if the decline represents a real population change (PRBO, unpubl. data). In western Washington, monitoring at Totten Inlet since 1980 indicates pronounced declines in high counts of Western Sandpipers during northward and southward migrations (J. Buchanan, unpubl. data). Also, maximum counts during northward migration in recent years at Bowerman Basin, in Grays Harbor, Washington, have been much lower than those reported there in 1981 and 1982 (Herman and Bulger 1981, Buchanan 2005). These findings, although inadequate to demonstrate a population decline, suggest cause for concern and highlight the need to develop and implement a comprehensive monitoring program.

## DISTRIBUTION

Western Sandpipers have a comparatively small breeding range and a vast distribution in the non-breeding season. The breeding range of Western Sandpipers is restricted to western Alaska and the Chukotski Peninsula in Siberia (Wilson 1994;
Figure 1). During winter, Western Sandpipers occur along the Pacific coast, primarily from California to Perú, and along the Atlantic coast from North Carolina to Surinam (Wilson 1994;

Figure 1). Comparatively small numbers of Western Sandpipers are found north along the Pacific coast to southwestern British Columbia and coastal beaches in Washington (Buchanan 2005; J. Buchanan, unpubl. data). The largest winter season concentrations occur in northwestern Mexico (Morrison et al. 1994, Engilis et al. 1998), including Bfaja California Peninsula (Morrison et al. 1992, Page et al. 1997), and in Panama (Morrison et al. 1998). During migration, Western Sandpipers are found in many coastal areas between the breeding and winter grounds. They also occur in interior regions, although in much smaller numbers (see below).

**MIGRATION**

Northward migration of Western Sandpipers is one of the great spectacles of the avian world as huge flocks make their way north along the Pacific coast to staging sites and breeding grounds in Alaska. Although the primary route of northward migration is along the Pacific coast (Wilson 1994), significant numbers migrate through interior regions of the Great Basin (only as far north as Oregon; Buchanan 2005) and the Central Valley of California (Shuford et al. 1998, 2002a). Northward migration may begin as early as February in tropical and subtropical wintering sites (Delgado and Butler 1993, Fernández et al. 2001). It is not clear whether individuals from these wintering locations migrate to a staging site to molt and gain body mass. Western Sandpipers migrate north through temperate latitudes generally between mid-April and mid-May, and males mostly migrate ahead of females (Butler et al. 1987, Buchanan 2002, Bishop et al. 2004). Once the migration has begun the birds move quickly; length of stay at migratory stopover sites typically ranges between 1 and 5 days (Iverson et al. 1996; Warnock and Bishop 1998; Warnock et al. 2002a, 2004). Radio-marked Western Sandpipers remain on or near the section of beach or tide flat where they were first detected through their entire stay, suggesting that individuals do not roam widely once they settle at the site (Butler et al. 2002).

In contrast to the northward migration, the southbound movement from the breeding grounds is more protracted. Western Sandpipers migrate south from mid-June to November; adults leave the breeding grounds before juveniles and females typically precede males within each age class (Butler et al. 1987, Ydenberg et al. 2005). Most Western Sandpipers migrate south along the Pacific Flyway but some birds move through the interior of North America toward the southeast United States and the Caribbean region (Wilson 1994). The length-of-stay during southward migration is about 1–5 days at temperate coastal sites (Butler et al. 1987).

Western Sandpipers annually migrate thousands of kilometers between breeding and wintering grounds. The Western Sandpiper is generally a short-hop migrant that travels non-synchronously, with birds potentially arriving at a stopover site from a multitude of departure points, and staying for a variable number of days (Butler et al. 1997, Warnock and Bishop 1998). Although many flights during migration are short (240–356 km/day), some flights are longer and may range up to 1850 km/day (Iverson et al. 1996, Warnock and Bishop 1998, Warnock et al. 2004).

Like many other shorebirds, Western Sandpipers undergo substantial physical changes prior to and during migration. During northward migration, Western Sandpipers weigh 25% more at stopover sites than during the winter, and nearly 40% of migratory mass increase consists of lean body components (Guglielmo and Williams 2003); and lipid mass generally ranges between 18% and 25% of total body mass (Buchanan et al. 1996). Relative to the winter period, body components associated with exercise (e.g., heart) and food processing (e.g., small intestine) increase in mass during northward migration, and there is no evidence of an adaptive reduction of the digestive system as a weight saving measure for migratory flight (Guglielmo and Williams 2003). Adult sandpipers exhibit differences between southward and northward migration in intestinal enzyme activities, which suggest that the northward diet is enriched with lipids but low in glycogen (Stein et al. 2005). Juveniles making their first southward migration have larger digestive systems, lower levels of fatty acid binding proteins, and a higher index of muscle damage than adults (Guglielmo et al. 1998, 2001, 2002). Although juveniles have a larger digestive system than adults, they have lower total enzymatic capacity, suggesting that juveniles may process food differently from adults and/or have a lower-quality diet (Stein et al. 2005). The physiological differences between age classes may indicate that young birds are unable to fully optimize physiologically for migration, and thus have a greater probability of mortality.

Western Sandpipers are differential migrants (Page et al. 1972, Nebel et al. 2002). Males spend the winter farther north than females, and juveniles are disproportionately represented on the northern and southern edges of the distribution. Within sex and age categories, individuals with longer bills and wing chords, and with disproportionately longer wings relative to the bill migrated farther south (O'Hara et al. 2006). Western Sandpipers spending their juvenile non-breeding season in the northern part of the winter range migrate northward in their first spring, whereas those spending their juvenile non-breeding season south of southern Mexico remain on the non-breeding grounds until their second spring (Fernández et al. 2004, O'Hara et al. 2005). These distribution patterns indicate that individual Western Sandpipers exhibit significant life history differences as a function of migratory distance to the winter grounds. It is possible that these differences in the age of first migration create alternate life history strategies, with shorter-distance migrants attempting to migrate and breed at a younger age, while longer-distance migrants maximize first year survivorship at the expense of an earlier potential breeding opportunity. If lifetime reproductive success of individuals migrating south to different latitudes is similar, annual survivorship should be higher at winter versus migration sites, in order to offset the earlier age of first reproduction of migrants. Survivorship estimates obtained at breeding and non-breeding grounds show some agreement, assuming similar levels of permanent emigration (Table 1). As predicted, local annual survivorship is lower in northern wintering sites (e.g., Mexico) than southern wintering sites (e.g., Panama).

## MAJOR HABITATS

### Breeding

Western Sandpipers breed in low Arctic and subarctic coastal plains in western Alaska and extreme eastern Siberia. The primary habitat used by Western Sandpipers is tundra dominated by dwarf birch (*Betula* spp.), dwarf willow (*Salix* spp.), crowberry (*Empetrum* spp.), and tussock grasses. Proximity of elevated areas for nesting and wetland areas for feeding is a requisite (Wilson 1994).

### Migration

During both southward and northward migrations, most Western Sandpipers frequent intertidal mudflats at coastal estuaries, while the margin of lakes and ponds are preferred habitat at interior sites (Wilson 1994). Tide flats with high silt content, or a mix of silt and sand appear to be favored foraging areas compared to substrates dominated by sand. Especially during the northward migration, significant numbers of Western Sandpipers use seasonal and permanent wetlands, large alkali lakes, sewage lagoons, and other shallow water bodies of the Central Valley of California and the Great Basin (Shuford et al. 1998, 2002a) and in other areas of the interior of North America such as the Cheyenne Bottoms in Kansas (Wilson 1994). Western Sandpipers also use dry or flooded agricultural lands during northward migration (Wilson 1994). Large numbers of Western Sandpipers use outer coastal sand beaches in Washington as foraging and roosting habitat, particularly in southbound migration (J. Buchanan, unpubl. data).

### Winter

Habitat preferences during winter are similar to those during migration periods. Western Sandpipers are able to forage in different microhabitats (Colwell and Landrum 1993), and move between a variety of available habitats, such as mud and sand flats, tidal sloughs, salt marshes, agricultural areas, and sewage ponds (Gerstenberg 1979, Warnock and Takekawa 1995, Engilis et al. 1998).

## CONSERVATION SITES

This portion of the plan identifies sites used by at least 1% of the global population of Western Sandpipers during wintering and migration periods. With the current population estimate being 3.5 million birds (Bishop et al. 2000, Morrison et al. 2001), we included all sites where high counts for any one season have been approximately 35,000 Western Sandpipers. However, we also included sites with counts exceeding 15,000, especially during migration. If the average length-of-stay during both migrations is 1–5 days at temperate coastal sites (Butler et al. 1987, Warnock and Bishop 1998), it is likely that these sites may host over 1% of the current estimated global population over the entire migration period.

It was fairly straightforward to define important sites that comprise of a discrete wetland, bay, or intertidal flat where ≥ 15,000 Western Sandpipers occur during a given season. In other cases, however, defining an important site was more complicated. Factors that made it difficult to identify important wintering sites included incompletely surveyed coastal and interior areas, and the unknown extent to which wintering flocks move among sites (including movements between roosting and foraging sites) affected at different times by the tide, and by conditions that change as the non-breeding season progresses. In addition, complexes of distinct sites in relatively close proximity to one another, such as the Greater Puget Sound area in Washington; Huizache–Caimanero and Marismas Nacionales in Mexico; Laguna Madre in Tamaulipas and Texas; and the Parte Alta de la Bahía de Panama collectively support large numbers of migrant and/or wintering Western Sandpipers. Although numerous individual sites in these complexes support only a few thousand birds each, the array of these "lesser" sites support many thousands of birds (Evenson and Buchanan 1997, Morrison et al. 1994, 1998, Angehr 2003). Another potential complication was the similarity between Western Sandpipers and Semipalmated Sandpipers (*Calidris pusilla*) in non-breeding plumage, which could result in challenges in separating species during aerial surveys (e.g. Morrison et al. 1994, Watts 1998).

### BREEDING SITES

The prime breeding range for Western Sandpipers is the Yukon–Kuskokwim Delta (B. J. McCaffery, pers. comm.), already recognized as WHSRN Site of Regional Importance. Detections of radio-marked Western Sandpipers provide evidence that the Yukon–Kuskokwim Delta is the final breeding destination for many of the sandpipers migrating along the Pacific Flyway (Bishop and Warnock 1998). However, given the dearth of data on the densities of Western Sandpipers distributed across the breeding range (e.g., Siberia, the lower Alaska Peninsula, the Bristol Bay region, Yukon–Kuskokwim Delta, Seward Peninsula, and northern Alaska), there is uncertainty about this estimate (B. J. McCaffery, pers. comm.).

## MIGRATION SITES

### Northward migration

Western Sandpipers typically make short flights during their northward migration and use a variety of sites to rest and refuel in preparation for the next flight (Iverson et al. 1996, Bishop and Warnock 1998, Warnock and Bishop 1998, Bishop et al. 2004). There is high variability in the number of Western Sandpipers at individual sites along the Pacific Flyway among years, which could reflect how birds respond to different conditions during migration (Iverson et al. 1996, Bishop and Warnock 1998, Warnock and Bishop 1998, Bishop et al. 2004). Twenty-five sites were identified as supporting at least 15,000 birds, and these sites appear to support a large proportion of the Western Sandpiper global population (Table 2). Based on high counts, the San Francisco Bay, Kachemak Bay, Grays Harbor, Copper River Delta, and Fraser River Delta are critical sites for Western Sandpipers (Figure 2 and Figure 3). The Cooper River Delta supports the largest northward aggregation of Western Sandpipers along the Pacific Flyway (Bishop et al. 2000).

Not surprisingly, 23 of 25 sites we identified were along the West Coast. Laguna Atascosa National Wildlife Refuge, part of the Laguna Madre complex in Texas, was the only important site identified from the Atlantic coast. Although most sites were coastal wetlands, several interior wetlands and alkali playas in the Western Great Basin (e.g., Lahontan Valley, Mono Lake, Lake Abert, and Goose Lake) and Salton Sea host important numbers of Western Sandpipers ( Figure 3). Relative to coastal wetlands, these interior sites have a greater degree of temporal and spatial variability, and some of these sites therefore may be comparatively more important for Western Sandpipers in some years than in others (Robinson and Warnock 1997, Shuford et al. 2002). Only one site south of the United States, the estuary of the Río Colorado, was identified as important for migratory Western Sandpipers (Figure 4). However, it is likely that various wetlands in Mexico and Central America support Western Sandpipers through their northward migration (e.g., Engilis et al. 1998), but comprehensive count data are lacking for these regions.

**Southward migration**

The southward migration has not been as well described as the northward migration. Nineteen sites were identified as being important during southward migration. High counts from this season are generally much lower than in northward migration (Table 2) because Western Sandpipers are more temporally and spatially dispersed than in the northward migration (B. Harrington, pers. comm.). Based on high counts, the Parte Alta de la Bahía de Panama (Figure 4), Fraser River Delta (Figure 2), and San Francisco Bay (Figure 3) are critical sites for Western Sandpipers. Cheyenne Bottoms, Kansas, is the only site east of the Pacific Flyway that is important for birds moving through the interior of North America (Figure 3) (Butler et al. 1996).

Some sites were important for both migration periods, including the Fraser River Delta in British Columbia; a complex of sites in Puget Sound (including Crockett Lake) and Grays Harbor in Washington; Bandon Marsh in Oregon; and San Francisco Bay, Salton Sea, Humboldt Bay, Elkhorn Slough, and Goose Lake in California. Two sites south of the U.S., the Parte Alta de la Bahía de Panama and Parque Nacional Natural Saquianga, were important for migratory Western Sandpipers (Figure 4).

## WINTERING SITES

We identified 19 sites that were important to Western Sandpipers during winter (Table 2). Based on high counts, the Laguna Madre, Ensenada Pabellones, Bahía Santa María, Parte Alta de la Bahía de Panama, and San Francisco Bay are critical sites for Western Sandpipers (Figure 3 and Figure 4). Most of the important sites were along the Pacific coast of Mexico. Only one site on the Gulf coast of Mexico, the Laguna Madre, was considered important for Western Sandpipers. Only one site south of Mexico, the Parte Alta de la Bahía de Panama, was identified as important for wintering birds.

There is among-year variability in the number of Western Sandpipers wintering along the Pacific Flyway (e.g., Morrison et al. 1994, Page et al. 1997, Mellink and de la Riva 2005). Wintering Western Sandpipers may arrive at non-breeding sites as early as September and remain at the site throughout the winter period (Smith and Stiles 1979, Rice 1995, Warnock and Takekawa 1996, Fernández et al. 2001, O'Hara 2002). However, some Western Sandpipers have shorter, but consistent, winter residency patterns (Fernández et al. 2001; D. E. Galindo, pers. comm.). Local and regional winter movements of shorebirds occur to take advantage of changing feeding opportunities at nearby estuaries or in response to weather conditions (Warnock et al. 1995, Evenson and

Buchanan 1997). During the winter season, Western Sandpipers exhibit strong local site fidelity (Warnock and Takekawa 1996, Fernández et al. 2001, P. D. O'Hara, pers. comm.).

## CONSERVATION THREATS

Western Sandpiper conservation is an issue of concern because, like other shorebird species, a number of features of their ecology make them vulnerable to degradation or loss of the resources on which they depend to accomplish their migrations (Myers et al. 1987). These features include: (1) a tendency to aggregate in a limited number of locations during migration and on the wintering grounds, so that deleterious changes can affect a large proportion of the population at once (Engilis et al. 1998, Butler and Lemon 2001, Bishop et al. 2004); (2) a limited reproductive output, subject to vagaries of weather and predator cycles in the Arctic, which in conjunction with long lifespan suggests slow recovery from population declines (Sandercock et al. 1999); (3) a migration schedule closely timed to seasonally abundant food resources and tidal regimes, suggesting that there may be limited flexibility in migration routes or schedules (Warnock et al. 2002a, 2004, Bishop et al. 2004); and (4) occupation and use of wetland habitats that are affected by a wide variety of human activities and developments, especially water diversion (Bildstein et al. 1991). The purpose of this section is to review the factors that represent threats to Western Sandpipers. We classified conservation threats in: habitat loss and degradation, environmental contamination, human disturbance, climate change, and diseases. For convenience, we discuss each of threats in all the sensitive periods (e.g., breeding, migration, and wintering) in the annual cycle of the Western Sandpiper. Although we have little information on the effects of the various factors on Western Sandpiper populations, it seems likely that they are in some cases additive, both within and among seasons.

### HABITAT LOSS AND DEGRADATION

Habitat loss and degradation may be the most important threat to Western Sandpipers. A variety of factors result in the loss or degradation of habitats important to shorebirds (Bildstein et al. 1991, Buchanan 2000). Given the minor role that humans still play in the Arctic regions, it is reasonable to suppose that Western Sandpipers breeding on the tundra have not been affected as much by habitat modification (but see sections below on environmental contamination and global climate change). Across the non-breeding distribution of Western Sandpipers, coastal wetlands have been drained for urban, agricultural, and shrimp-farming purposes. For example, in the Parte Alta de la Bahía de Panama, the western area is threatened by urban development as Panama City spreads eastwards and a new housing development was constructed on the coast at Costa del Este. It is not known how these developments, including the draining of shallow marshes and the construction of a seawall, have influenced the pattern of habitat use by Western Sandpipers (Angehr 2003). Considerable losses of habitat from agriculture development and shrimp farming have influenced Bahía Santa María, Ensenada Pabellones, and Laguna Huizache-Caimanero in Mexico (Carrera and Fuente de León 2003). The quality of several wetlands (e.g., Laguna Madre, Marismas Nacionales and the estuary of the Río Colorado) has been degraded through development of water-use systems, including the construction of channels and dikes (Carrera and Fuente de León 2003). In the Texas coast, the Intracoastal Waterway and other navigation channels have mainly two negative impacts in the ecology of the Laguna Madre and other tidal bay systems: (1) the introduction of salt water to non-saline marshes resulting in habitat changes and increased erosion, and (2) disrupt natural water circulation flows (B. Ortego, pers. comm.).

Habitat alteration with the potential to impact Western Sandpiper populations has occurred and is ongoing in the United States. The Salton Sea, one of the most important interior wintering areas in the United States for Western Sandpipers (Shuford et al. 2004), faces an uncertain future due to water diversion to accommodate the growing urban areas of southern California, a situation also seen at the Klamath Basin in northern California as well as at many other Pacific Flyway wetlands. The area of coastal tide flats available to shorebirds for foraging has declined in association with development of aquaculture although much of this development occurred decades ago. In California, there was a net decrease in Western Sandpiper use in areas developed for aquaculture (Kelly et al. 1996). Additionally, conversion of agricultural lands to urban and suburban development inconsistent with shorebird use is ongoing in many areas in the United States. In Texas, loss of rice production due to changing economics has caused significant reduction in available shorebird habitat for migrants and development along the coast is increasing; most of the original coastal prairie and its associated dispersion of shallow wetlands has disappeared (B. Ortego, pers. comm.). Finally, plans to restore large areas of salt pond complexes in San Diego and San Francisco Bay back to vegetated tidal marsh portend less available high-quality feeding and roosting habitat for migrating and wintering sandpipers (Warnock et al. 2002b, Stralberg et al. 2003).

A prominent factor resulting in degradation of shorebird habitat is the colonization of exotic, invasive plant species in estuaries. The exotic *Spartina alterniflora* (cordgrass) is rapidly colonizing estuaries in the Pacific Flyway. At Willapa Bay, Washington, the colonization by *Spartina alterniflora* has reduced the amount of feeding area available to Western Sandpipers by as much as

50% (Jaques 2002), and has had substantial impact on most of the areas that formerly supported the largest concentrations of shorebirds in the Bay (Buchanan and Evenson 1997, Buchanan 2003). Stralberg at al. (2004) modeled the spread of *Spartina alterniflora* in San Francisco Bay and the predicted loss of habitat value for shorebirds ranged from 9% to 80%. They identified the upper mudflats, due to their greater exposure time, and the east and south shore mudflats, areas used by high numbers of birds, as the areas of greatest potential for *Spartina* invasion. Sites vulnerable to *Spartina* invasion range from San Francisco Bay in California, to Puget Sound, Washington, and possibly include the Fraser River estuary in British Columbia (Daehler and Strong 1996, Buchanan 2003, Stralberg et al. 2004). In 2000, the California State Coastal Conservancy established the Invasive Spartina Project (ISP) in San Francisco Estuary. The ISP is comprised of a number of components including outreach, research, permitting, mapping, monitoring, and the allocation of funds for efforts to eliminate populations of nonindigenous *Spartina*.

## ENVIRONMENTAL CONTAMINATION

The main pollutants of concern to Western Sandpiper populations are oil from spills and agricultural and industrial chemicals. Oil spills pose local threats to Western Sandpipers almost anywhere along the coast of North America, where major stopover and staging sites are in close proximity to shipping channels and refineries. Oil and gas development is a driving force behind Alaska's economy and also the largest potential threat to shorebirds in the state (Alaska Shorebird Working Group 2000). The most likely areas for large spills in Alaska of great significance to Western Sandpipers are Prince William Sound (Copper River Delta), Cook Inlet, and the Arctic Coastal Plain (Alaska Shorebird Working Group 2000). Major spills are a threat along the Washington and Oregon coasts and major inland waters, as an immense amount of marine vessel traffic passes through these waters annually (Drut and Buchanan 2000). A major oil spill at some of these sites during seasons of peak use could have catastrophic consequences to the Western Sandpiper population. In the coast of Texas, all navigation channels are heavily used by the petroleum industry and chemical spills are realities (B. Ortego, pers. comm.).

Chemicals used for agriculture or other purposes, either individually or in combination, have the potential to harm shorebirds on-site or following run-off (Buchanan 2000). Pesticide levels in coastal wetlands and tide flats along the Pacific Coast are unknown. Although the use of DDT has been banned throughout much of the Western Hemisphere many other potentially toxic pesticides and chemicals continue to be used. There has been little monitoring of contaminants in Western

Sandpipers in western North America or elsewhere in the species' range (e.g., Schick et al. 1987, Rattner et al. 1995, McFarland et al. 2002).

Several large wetlands used during migration and winter (e.g., northwest Mexico, Panama, and various locations in the United States) are bordered by agricultural land where Western Sandpipers may be exposed to potentially harmful chemicals (Drut and Buchanan 2000, Buchanan 2000). The Parte Alta de la Bahía de Panama, for example, may be accumulating residues of pesticides and other chemicals used for agriculture in adjacent areas (Angehr 2003). Additionally, the quality of water entering wetlands from adjacent urban and agricultural areas has declined in some areas. Enrichment with excessive levels of naturally occurring materials (including nutrients) may change the vegetative community of coastal wetlands. For example, the extensive growth of cattail marshes in coastal wetlands of Sinaloa and Nayarit as a consequence of agricultural runoff enriched with organic matter may decrease the quality of these wetlands to Western Sandpipers (Carrera and Fuente de León 2003). Panama City does not have sewage treatment facilities, and untreated sewage and industrial waste is discharged directly to the Parte Alta de la Bahía de Panama (Angehr 2003) with unknown consequences to the benthic community and shorebird populations. However, the Autoridad Nacional del Ambiente has plans to develop a wastewater treatment plant for this region. In San Francisco Bay, the reduced water circulation and discharge from industrial sources are responsible for the highest levels of some trace elements in the area that may affect Western Sandpipers (Hui et al. 2001). Water salinization is a documented problem in the intermountain west and perhaps elsewhere (Rubega and Robinson 1997). Although pesticides and other environmental contaminants have the potential to impact shorebirds locally, the mortality or reproductive failure associated with bioaccumulation needs further study.

## HUMAN DISTURBANCE

There is growing recreational use of estuarine and other shallow water areas by humans, but the effects of these activities on migrating and/or wintering Western Sandpipers are unknown. Disturbance from human activities (e.g., pedestrians, motorized vehicles, water craft, pets, and hunting) are potential threats to Western Sandpipers along the coast of Washington and Oregon (Drut and Buchanan 2000, Buchanan 2000) and likely elsewhere. In several wetlands in Mexico (e.g., Bahía Santa María and Ensenada Pabellones) and Panama, foraging Western Sandpipers are disturbed by shellfish harvest activities. Although this shellfish harvesting is not for commercial purposes, Western Sandpipers incur an energetic cost from the disturbance because of the number of flush responses due to the close presence of humans and dogs on the mudflats. The consequences of human disturbance, in terms of physical condition or survival, are unknown and should be the focus of research (e.g., Gill et al. 1996, 2001a, Yasué 2005, Goss-Custard et al. 2006).

## CLIMATE CHANGE

Potential effects of global warming are serious concerns in many areas and in all seasons. Of concern in the subarctic and Arctic breeding grounds of the Western Sandpiper is the unknown effect of global warming on breeding success. It is well documented that major breeding areas like the Yukon-Kuskokwim Delta in Alaska are being affected through fewer days with snow-cover and warmer days on average. It is not well-understood, however, how this warming may affect the reproduction and survival of Western Sandpipers.

An increase in sea-level resulting from melting of polar ice fields has the potential to reduce the extent of tidal flat foraging areas for shorebirds (Bildstein et al. 1991, Page et al. 1999, Lindström and Agrell 1999, Piersma and Lindström 2004). In addition, global warming may have influenced the distribution, frequency, and intensity of storms (Michener et al. 1997, Warnock et al. 2001). The impact of hurricane force storms on coastal bird populations can be especially severe with birds killed and habitat destroyed (Michener et al. 1997). The effects of rapid climate change, including potential consequences such as an increase in sea-level and exacerbation of severe weather events, may affect conditions on wintering grounds of the Western Sandpiper in a manner far beyond present comprehension. It is suspected that effects of climatic cycles (e.g., El Niño/Southern Oscillation) may influence the abundance, population structure, survival, and premigratory mass gain of Western Sandpipers wintering in Ecuador (P. D. O'Hara unpubl. data).

## DISEASES OUTBREAKS

A number of diseases are known to have has negative impacts on bird populations (at least at local levels) in western North America or have the potential to do so in the future. Avian botulism is a paralytic disease caused by ingestion of a toxin produced by the bacterium, *Clostridium botulinum*. There are several types of toxin produced by strains of this bacteria and birds are most commonly affected by type C botulism after ingesting the toxin directly or by eating invertebrates (e.g., chironomids, fly larvae) containing the toxin (USGS National Wildlife Health Center 2005). Outbreaks occur throughout the United States and Canada, generally from July through September, and thousands of birds may die during a single outbreak. West Nile Virus has spread rapidly across

North America in the last several years, affecting many species of birds since it was discovered in the Western Hemisphere. The virus has killed species in most Orders of North American birds and is particularly deadly to corvids. Avian influenza is an infection of birds caused by type A strains of influenza viruses, and is a major global concern to human and animal health. Influenza A viruses are not limited to domestic poultry; however, all birds are thought to be susceptible to infection with influenza A viruses to some degree, depending on the species. Migratory waterfowl, especially wild ducks, are thought to be the natural reservoir of the full range of avian influenza viruses (Canadian Cooperative Wildlife Health Centre 2005). The extent to which diseases, such as avian botulism, West Nile virus, and avian flu, affect Western Sandpipers is also unknown. However, Western Sandpipers have been killed by avian botulism on the Canadian Prairies (Adams et al. 2003), and West Nile virus has been reported in the Western Sandpiper (Center for Disease Control 2005).

## CONSERVATION STRATEGIES AND ACTIONS

### CURRENT OR POTENTIAL PROGRAM OR RESEARCH COLLABORATORS

After synthesizing what we know about Western Sandpiper ecology, the location of important sites, and identification of threats, the next step will be to conduct a broad-scale, international, collaborative project to fill gaps in our knowledge about sandpipers and threats to the species' future so that specific conservation actions can be developed and implemented. Agencies and organizations that have been involved in Western Sandpiper research, bird surveys, and/or monitoring, and which may represent potential future collaborators for combined efforts to investigate outstanding questions about Western Sandpipers, are listed below. More details regarding specific individuals and their contact information are included in APPENDIX 1.

**Canada**

Canadian Wildlife Service

Canadian National Shorebird Working Group

Centre for Wildlife Ecology, Simon Fraser University

Ducks Unlimited Canada

North American Bird Conservation Initiative (Canada)

**United States**

Alaska Shorebird Working Group

California State University, Long Beach

Cascadia Research Collective

Ducks Unlimited, Inc.

Gulf Coast Joint Venture

Humboldt State University

Intermountain West Joint Venture

Kansas State University

Lower Columbia River Estuary Partnership

Manomet Center for Conservation Sciences

North American Bird Conservation Initiative (US)

National Audubon Society

Pacific Coast Joint Venture

PRBO Conservation Sciences

Prince William Sound Science Center

San Francisco Bay Joint Venture

Shorebird Sister School Program

Sonoran Joint Venture

The Nature Conservancy

US Geological Survey, San Francisco Bay Field Station

US Geological Survey, Alaska Science Center

US Shorebird Plan Council

Washington Department of Fish and Wildlife

Western Hemisphere Shorebird Reserve Network

Yukon Delta National Wildlife Refuge

**Mexico**

Centro de Investigación Científica y de Educación Superior de Ensenada

Colegio de la Frontera Sur

Comisión Nacional para el Conocimiento y uso de la Biodiversidad (CONABIO)

Dirección General de Vida Silvestre, SEMARNAT

Ducks Unlimited de Mexico, A.C.

North American Bird Conservation Initiative (Mexico)

Pronatura, A.C. Noroeste. Dirección de Conservación Sinaloa

Pronatura, A.C. Noroeste. Dirección de Conservación Baja California Sur

Probatura Noreste A.C.

Universidad Autónoma de Baja California Sur

**Panama**

Autoridad Nacional del Ambiente (ANAM)

Panama Audubon Society

University of Panama

**Colombia**

Asociación Calidris

Ministerio de Ambiente, Vivienda y Desarrollo Territorial

Red Nacional de Observadores de Aves

**Ecuador**

Ministerio del Ambiente, República del Ecuador

Aves & Conservación

**Perú**

Instituto Nacional de Recursos Naturales (INRENA)

## CONSERVATION ACTIONS

### Habitat Conservation

Along the Pacific coast of northwest Mexico, especially in Sonora, Sinaloa, and Nayarit, habitat restoration is a priority conservation action. The habitat goal is to protect, restore, and enhance habitat conditions necessary to achieve Western Sandpiper population goals. Achieving this habitat goal will likely provide important habitats for other shorebird species as well. Western Sandpiper conservation will be most effective when scale factors are considered in the planning process. Because human activities in these areas have harmed critical sites for Western Sandpipers, an education and outreach program would be valuable to increase awareness of Western Sandpiper ecology and conservation issues and the importance of protecting coastal wetlands in the region.

Salt ponds in San Francisco Bay, California, provide habitat for large numbers of Western Sandpipers and other waterbird species (Warnock et al. 2002b). It is critical to reconsider the plans to restore salt pond habitat into tidal marsh habitat because of the potential risk of loosing species diversity and numbers. Maintaining ponds of varying salinities and depths should be a management priority. For further recommendations see Warnock et al. (2002b).

Opportunities for effective habitat conservation for shorebirds are probably enhanced when important sites are properly recognized at local, regional and international scales. For this reason, there is be great value in formally establishing or identifying new protected areas and sites that meet WHSRN or Ramsar Convention criteria. To qualify for inclusion in WHSRN, a site must be of demonstrated importance for shorebirds at regional (at least 20,000 birds annually or 1% of the biogeographic population for a species), international (at least 100,000 birds annually or 10% of the biogeographic population for a species), or hemispheric (at least 500,000 birds annually or 30% of the biogeographic population for a species) scales. According to the Ramsar Convention, a wetland should be considered internationally important if it regularly supports 20,000 or more shorebirds or 1% of the individuals in a population of one species. Examples of such candidate sites (relative to documented use by Western Sandpipers) include Cook Inlet, Stikine River Delta, Ensenada Pabellones, Seal Creek-Ahrnklin River Estuary, Estero Lobos, Estero Mar Muerto, Willapa Bay, Puget Sound, and Huizache-Caimanero.

Important sites should be protected through various means including acquisition, conservation easement, and development of voluntary conservation plans. A private land conservation program will be essential to maintain important sites for Western Sandpipers in Mexico, Panama, and other Latin American countries. The main purpose of such a conservation easement program should be the conservation and sustainable management – in perpetuity – of privately-owned or communal lands important to Western Sandpipers. Furthermore, these legally-binding agreements should respect ownership or other rights of traditional users and include as an incentive access to federal or other funds that would be available to promote restoration or better and more sustainable use of natural resources of the site. It is critical to acquire properties or develop conservation easements in Washington (e.g., Port Susan Bay in Puget Sound, unprotected areas in Grays Harbor and Willapa Bay), Oregon (e.g., Tillamook Bay), California (e.g., San Francisco Bay), and Mexico (e.g., Bahía Santa María, Ensenada Pabellones, and Huizache-Caimanero).

We recognize the need for better involvement and coordination among stakeholders with interests and/or responsibilities relating to Western Sandpiper conservation and management. These parties include government agencies (federal, state, and local), non-governmental organizations, private landowners, and the public. Involvement and coordination, particularly within and among resource management agencies, is minimal or lacking in many instances and must be improved if Western Sandpiper management needs are to be adequately addressed.

**Habitat Assessment**

Coarse-resolution thematic maps derived from remotely sensed data and used in a GIS environment play an important role in Western Sandpiper conservation, research and management throughout the species' annual cycle. It is necessary to develop and implement a classification scheme of habitat types relevant to Western Sandpipers within each of the critical sites during migration and winter periods. This should provide for better coordination among countries, states and provinces. Within sites, information needed to guide conservation planning is deficient, especially in Mexico and Panama. The next step should be to secure empirical data necessary to derive landscape models that are applicable to conservation planning at regional scales for Western Sandpipers. For example, predictive models could be used to identify additional potentially valuable areas used by Western Sandpipers in the non-breeding season. Habitat models based on empirical data should inform decisions regarding Western Sandpiper habitat conservation at multiple spatial scales. The ability to link information about site use by Western Sandpipers to GIS-based wetland data will enable us to more effectively guide wetland protection efforts.

**Implementation of Conservation Plans in Latin America**

Several important sites in Mexico (e.g., Ojo de Liebre-Guerrero Negro, Laguna San Ignacio, the estuary of the Río Colorado, and Marismas Nacionales), in Panama (e.g., Parte Alta d el Bahía de Panama), and in Colombia (e.g., Parque Nacional Natural Saquianga) are protected areas. Nonetheless, it is necessary to implement local and national conservation plans to secure additional critical habitats for Western Sandpipers in those countries. The conservation plans of some protected areas (e.g., Reserva de la Biosfera del Vizcaino –Ojo de Liebre-Guerrero Negro and Laguna San Ignacio) do not consider Western Sandpipers or other shorebird species as part of their priority actions. In particular, development of shorebird surveys and habitat assessment to determine population trends should be a priority. For example, the Reserva de la Biosfera del Alto Golfo y Delta del Río Colorado has a shorebird monitoring program, which main goals are to determine patterns of species richness and abundance of shorebirds in the protected area and the linkage of these shorebird information with conservation actions in the protected area and the Mexican Shorebird Conservation Plan.

## RESEARCH AND MONITORING NEEDS

Although the Western Sandpiper is one of the best-studied shorebird species in North America, there are still major gaps in knowledge about factors that limit Western Sandpiper populations and have the greatest influence on fitness and survival. The purpose of this section is to give an overview of the research and monitoring needs relevant for effective conservation of Western Sandpiper populations. In many ways research and monitoring needs are closely related and will require cooperation and coordination among agencies, organizations, and individuals at local, regional, national, and international levels.

### RESEARCH NEEDS

#### Migratory Connectivity: Breeding – Wintering sites

There is a general understanding of the major routes used by Western Sandpipers during both southward and northward migrations (Butler et al. 1996). Migration routes and the stopover ecology of Western Sandpipers have been well-described for birds migrating northward between San Francisco Bay and western Alaska (Iverson et al. 1996, Bishop and Warnock 1998, Warnock and Bishop 1998, Warnock et al. 2002a, 2004, Bishop et al. 2004). However, the inability to determine the geographic origin of individual birds, necessary to understand migratory connectivity and its consequences to population dynamics, is a major impediment in understanding Western Sandpiper ecology. This is especially important given that Western Sandpipers are differential migrants by sex, age, and body size. A major unresolved issue is the location of breeding grounds used by Western Sandpipers that occur in the Southeastern United States during the winter. Similarly, the migration route used by these birds is not known. The use of stable isotopes, genetic information, and radio telemetry may help determine migratory strategies of these birds.

#### Habitat Quality and Habitat Loss

In the face of habitat loss, individual sites should support birds at a higher density unless or until carrying capacity has been reached. Individuals in these systems will thus experience greater negative effects from density-dependent processes and may be more likely to experience reduced physical condition, reduced productivity and higher mortality (Goss-Custard et al. 1995, Gill et al. 2001b). There are limited data on food resources at stopover and wintering sites (Elner and Seaman 2003). The consequences of losing critically important habitats at migration or wintering areas are unknown for Western Sandpipers, but are potentially severe.

**Life-cycle Synthesis**

Both the distribution and abundance of Western Sandpipers are limited by processes occurring throughout the annual cycle; events during one stage of the cycle influence populations in subsequent stages. To enhance conservation efforts for this species, we need to understand the relative effects on population dynamics of impacts that are manifested during breeding, winter, and migratory periods. The use of demographic modeling to elucidate the processes that substantially influence population dynamics within different broad regions of winter occurrence should be a priority.

Adult survival has the greatest potential on rates of population change in shorebirds and other long-lived vertebrates (Hitchcock and Gratto-Trevor 1997, Sandercock 2003). Thus, one of the main goals of research should be to identify stressors, throughout the annual cycle, that influence demographic parameters such as adult survival. Ideally, it will be important to identify where Western Sandpipers experience these stressors, and then seek to determine whether they are associated with measures of population performance. Seasonal estimates of survival for breeding, migration, and wintering (by subtracting from annual estimates) would be valuable to have. Also, data on juvenile dispersal and juvenile survival, especially during the southward migration, are highly relevant to migratory connectivity.

## MONITORING NEEDS

**Population Status**

One of the most basic yet critical information gaps regarding the Western Sandpiper is the need for adequate population monitoring to determine population trends. At present, we lack the ability to decide whether observed population declines in several estuarine systems are real or a result of other factors (e.g., changes in turnover rate, redistribution among sites, etc.). Determining the current population status of Western Sandpipers should be a high priority goal. Without this information, conservation and management of Western Sandpiper populations will likely be difficult and lack direction. The overall goal will be to maintain current population levels of the Western Sandpiper. Population targets have been developed in the U.S. Shorebird Conservation Plan (Brown et al. 2001). However, these targets are preliminary and will likely be refined using more comprehensive information. Future refinement will be particularly important to improve Western Sandpiper conservation and management efforts. There should be two general approaches to population monitoring: (*i*) the population-level, and (*ii*) site-specific and regional assessments. The latter will be used to evaluate Western Sandpiper responses to habitat changes and to further refine our understanding of the location of important sites in specific regions during the non-breeding season. If possible, there should be a link between Western Sandpiper population monitoring and shorebird survey efforts, such as International Shorebird Surveys and the Program for Regional and International Shorebird Monitoring, to integrate and strengthen existing shorebird survey efforts. The closer coordination and expanded survey effort at important stopover sites will provide a strong, statistically valid framework for detecting trends in Western Sandpiper populations and assist local managers in meeting their shorebird conservation goals.

**Habitat Use**

The loss of habitat important to shorebirds has been particularly dramatic in the last 100 years (Bildstein et al. 1991, Page and Gill 1994). Although some of the most important sites (e.g., the Copper River Delta, Fraser River Delta, San Francisco Bay, Bahía Santa María, and the Parte Alta de la Bahía de Panama) are protected to some extent from direct industrial and urban development, many other sites are unprotected lands or on lands not specifically managed to address Western Sandpiper habitat needs. Thus, the goal will be to monitor the condition, distribution, availability, use, and productivity (i.e., the functional value) of Western Sandpiper habitat. Although many important sites for Western Sandpipers have been identified and are presented in this report, research is needed to understand the value of smaller sites, particularly those in complexes that collectively support large numbers of birds. It will be necessary to develop specific habitat-use and distribution information for Western Sandpipers at each site. If possible, there should be a link between the population monitoring efforts and site/habitat assessment.

**Environmental Contaminants**

Determining the effects of contaminants on the health of Western Sandpipers is an important research and monitoring need. The goal will be to evaluate impacts of contaminants on Western Sandpipers including: lead, agricultural chemicals, industrial chemicals and oil during migration and winter.

## EVALUATION

The key to successful implementation of this plan will be coordination at international, national and local scales, and will need to include public and private agencies, conservation organizations, and individuals to ensure its success. In the United States, the Western Sandpiper and Regional Shorebird Conservation plans (e.g., Alaska, Northern and Southern Pacific Coast, and the Intermountain West) should be coordinated to foster cooperative conservation and research efforts of Western Sandpipers throughout the annual cycle. It will be particularly important to continue coordination with existing collaborative efforts such as the Western Sandpiper Network, Western Hemisphere Shorebird Reserve Network, and the Shorebird Research Group of the Americas, as well as other organizations involved in on-the-ground conservation (e.g., the various Joint Ventures). For example, the Gulf Coast Joint Venture added the Western Sandpiper as a focus species.

This plan is the first step toward an on-the-ground conservation program for Western Sandpipers. A crucial next step is to distribute this document to collaborators within the Western Sandpiper's range. This will raise the level of awareness regarding Western Sandpiper conservation issues and/or needs and leverage additional support for actions already underway, as well as provide support for initiating new actions. The effectiveness of the overall strategy should be evaluated at various phases and with respect to different important actions: implementation of conservation actions, fulfillment of priority information needs, and education and public awareness about Western Sandpiper conservation and habitat protection. Quantifiable measures of implementation success might include Western Sandpiper habitat models and GIS conservation planning tools. Use of planning tools by government officials and conservation organizations to hasten establishment of regional reserves will be further indications of success. However, this plan should be modified as necessary as specific strategies for conservation, research, and monitoring actions change. Other measures of success will include positive species responses to management actions and, ultimately, demonstration of stable or increasing populations at all spatial scales.

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**Table 1**. Survival estimates for Western Sandpipers studied at breeding (B) and wintering sites (W).

<table>
<tr><th rowspan="2">Location</th><th rowspan="2">Season</th><th colspan="2">Survival estimates</th><th rowspan="2">Source</th></tr>
<tr><th>$\phi$</th><th>return rates</th></tr>
<tr><td>Nome, Alaska (64º N)</td><td>B</td><td>Males: 0.57– 0.62<br>Females: 0.55– 0.59</td><td></td><td>Sandercock et al. 2000</td></tr>
<tr><td rowspan="2">Yukon-Kuskokwim Delta, Alaska (61º N)</td><td>B</td><td></td><td>Males: 0.58<br>Females: 0.49</td><td>Holmes 1971</td></tr>
<tr><td>B</td><td>Males: 0.78<br>Females: 0.65</td><td></td><td>M. Johnson, B.J. McCaffery, and D.R. Ruthrauff, unpubl. data</td></tr>
<tr><td>Punta Banda, Mexico (31º N)</td><td>W</td><td>Adult males: 0.49<br>Juvenile males: 0.45</td><td></td><td>Fernández et al. 2003</td></tr>
<tr><td>Cabo Rojo, Puerto Rico (18º N)</td><td>W</td><td>Adults: 0.56<br>Juveniles: 0.61</td><td></td><td>Rice 1995</td></tr>
<tr><td>Chitré, Panama (8º N)</td><td>W</td><td>Males: 0.54<br>Females: 0.62</td><td></td><td>O'Hara 2002</td></tr>
</table>

**Table 2.** List of important Western Sandpipers sites (or complexes of sites) during the annual cycle. Site designation criteria: WHSRN = Western Hemisphere Shorebird Reserve Network; IBA = Important Bird Area; RAMSAR = Ramsar site; BIRE = Biosphere Reserve; NWR = National Wildlife Refuge, SWA = State Wildlife Area; PA = Protected Area.

| Site | Province– State | Country | Southward | Winter | Northward | Site Designation | Source |
|---|---|---|---|---|---|---|---|
| Yukon-Kuskokwim Delta | Alaska | U.S. | 50,000 | | | WHSRN, IBA, NWR | Gill and Handel 1990 |
| Kachemak Bay | Alaska | U.S. | | | 600,000 | WHSRN | Senner et al. 1981 |
| Copper River Delta | Alaska | U.S. | | | 269,421 | WHSRN | Bishop et al. 2000 |
| Cook Inlet | Alaska | U.S. | | | 100,000 | | Alaska Shorebird Working Group 2000 |
| Stikine River Delta | Alaska | U.S. | | | 100,000 | | Alaska Shorebird Working Group 2000 |
| Seal Creek-Ahrnklin River Estuary | Alaska | U.S. | | | 52,434 | | Andres and Browne 1998 |
| Fraser River Delta | British Columbia | Canada | 20,000 | | 223,500 | WHSRN, IBA | Butler and Lemon 2001, CWS unpubl. data |
| Tofino Flats | British Columbia | Canada | 35,000 | | | IBA | Paulson 1993 |
| Grays Harbor | Washington | U.S. | 30,000 | | 520,000 | WHSRN, NWR | Herman and Bulger 1981, Buchanan 2005 |
| Willapa Bay | Washington | U.S. | | | 82,575 | IBA, NWR (part) | Buchanan and Evenson 1997, Page et al. 1999 |
| Puget Sound | Washington | U.S. | 61,360 | | 53,884 | Some sites are SW or PA | Buchanan and Evenson 1997, Page et al. 1999 |
| Crockett Lake | Washington | U.S. | 20,000 | | 20,000 | IBA | Buchanan 2005 |
| Columbia River Estuary | Oregon | U.S. | | | 91,220 | NWR (part) | PRBO unpubl. data |
| Malheur National Wildlife Refuge | Oregon | U.S. | 23,000 | | | IBA, NWR | Littlefield 1990 |
| Bandon Marsh National Wildlife Refuge | Oregon | U.S. | 20,000 | | 15,000 | IBA, NWR | Nehls 1994 |
| Lake Abert | Oregon | U.S. | | | 15,000 | IBA | Nehls 1994 |
| Goose Lake | Oregon | U.S. | 16,853 | | 15,000 | | Shuford et al. 2002 |
| Tillamook Bay | Oregon | U.S. | 15,000 | | | IBA | Nehls 1994 |

| Site | Province– State | Country | Southward | Winter | Northward | Site Designation | Source |
|---|---|---|---|---|---|---|---|
| San Francisco Bay | California | U.S. | 221,298 | 145,868 | 717,357 | WHSRN, IBA | Stenzel and Page 1988, PRBO unpubl. data |
| Humboldt Bay | California | U.S. | 26,089 | 19,176 | 50,000 | WHSRN, IBA | Colwell 1994, PRBO unpubl. data |
| Mugu Lagoon | California | U.S. | | | 56,998 | IBA | PRBO unpubl. data |
| Elkhorn Slough | California | U.S. | 19,000 | 16,786 | 15,000 | WHSRN, IBA | Harvey and Connors 2002, PRBO unpubl. data |
| Salton Sea | California | U.S. | 54,374 | 22,526 | 67,343 | IBA, NWR (part) | Shuford et al. 2004 |
| Mono Lake | California | U.S. | | | 19,107 | WHSRN | Shuford et al. 2002a |
| South Grasslands | California | U.S. | | | 17,489 | WHSRN | PRBO unpubl. data |
| Lahontan Valley | Nevada | U.S. | | | 58,950 | WHSRN, IBA, NWR (part) | Neel and Henry 1997 |
| Carson Lake | Nevada | U.S. | 20,000 | | 17,781 | IBA | PRBO unpubl. data |
| Great Salt Lake | Utah | U.S. | 17,000 | | | WHSRN | PRBO unpubl. data |
| Cheyenne Bottoms Wildlife Management Area | Kansas | U.S. | 21,500 | | | WHSRN, RAMSAR, WMA | Skagen et al. 1999 |
| Laguna Madre | Tamaulipas-Texas | Mexico-U.S. | | 373,000 | 21,311 | WHSRN, RAMSAR, NWR, IBA, PA | Skagen et al. 1999, B. Ortgeo and L. Elliott unpubl. data |
| Delta del Río Colorado | Baja California-Sonora | Mexico | | 74,885 | 54,920 | WHSRN, RAMSAR, IBA, BIRE | Mellink et al. 1997 |
| Laguna Ojo de Liebre-Guerrero Negro | Baja California | Mexico | | 101,731 | | WHSRN, RAMSAR, IBA, BIRE | Page et al. 1997 |
| Laguna San Ignacio | Baja California | Mexico | | 15,806 | | RAMSAR, IBA, BIRE | Page et al. 1997 |
| Estero Lobos | Sonora | Mexico | | 58,000 | | IBA | Morrison et al. 1992 |
| Estero Tobari | Sonora | Mexico | | 33,000 | | IBA | Morrison et al. 1992 |
| Bahía Lechugilla-Topolobampo | Sinaloa | Mexico | | 27,000 | | IBA | Morrison et al. 1992 |
| Bahía Santa María | Sinaloa | Mexico | | 332,000 | | WHSRN, RAMSAR, IBA | Engilis et al. 1998 |

| Site | Province– State | Country | Southward | Winter | Northward | Site Designation | Source |
|---|---|---|---|---|---|---|---|
| Ensenada Pabellones | Sinaloa | Mexico | | 335,000 | | IBA | Engilis et al. 1998 |
| Bahía Navachistes-San Ignacio | Sinaloa | Mexico | | 24,000 | | IBA | Morrison et al. 1992 |
| Laguna Huizache-Caimanero | Sinaloa | Mexico | | 38,500 | | IBA | Morrison et al. 1994 |
| Marismas Nacionales | Sinaloa-Nayarit | Mexico | | 35,544 | | WHSRN, RAMSAR, IBA | Morrison et al. 1994 |
| Laguna Cuyutlán | Colima | Mexico | | 15,300 | | | Morrison et al. 1994 |
| Estero Mar Muerto | Oaxaca | Mexico | | 41,000 | | | Morrison et al. 1994 |
| Parte Alta de la Bahía de Panama | Panama | Panama | 282,801 | 205,188 | | WHSRN, RAMSAR, IBA | Morrison et al. 1998, Watts 1998 |
| Parque Nacional Natural Saquianga | Nariño | Colombia | | 15,000 | | IBA, PA | Asociación Calidris unpubl. data |

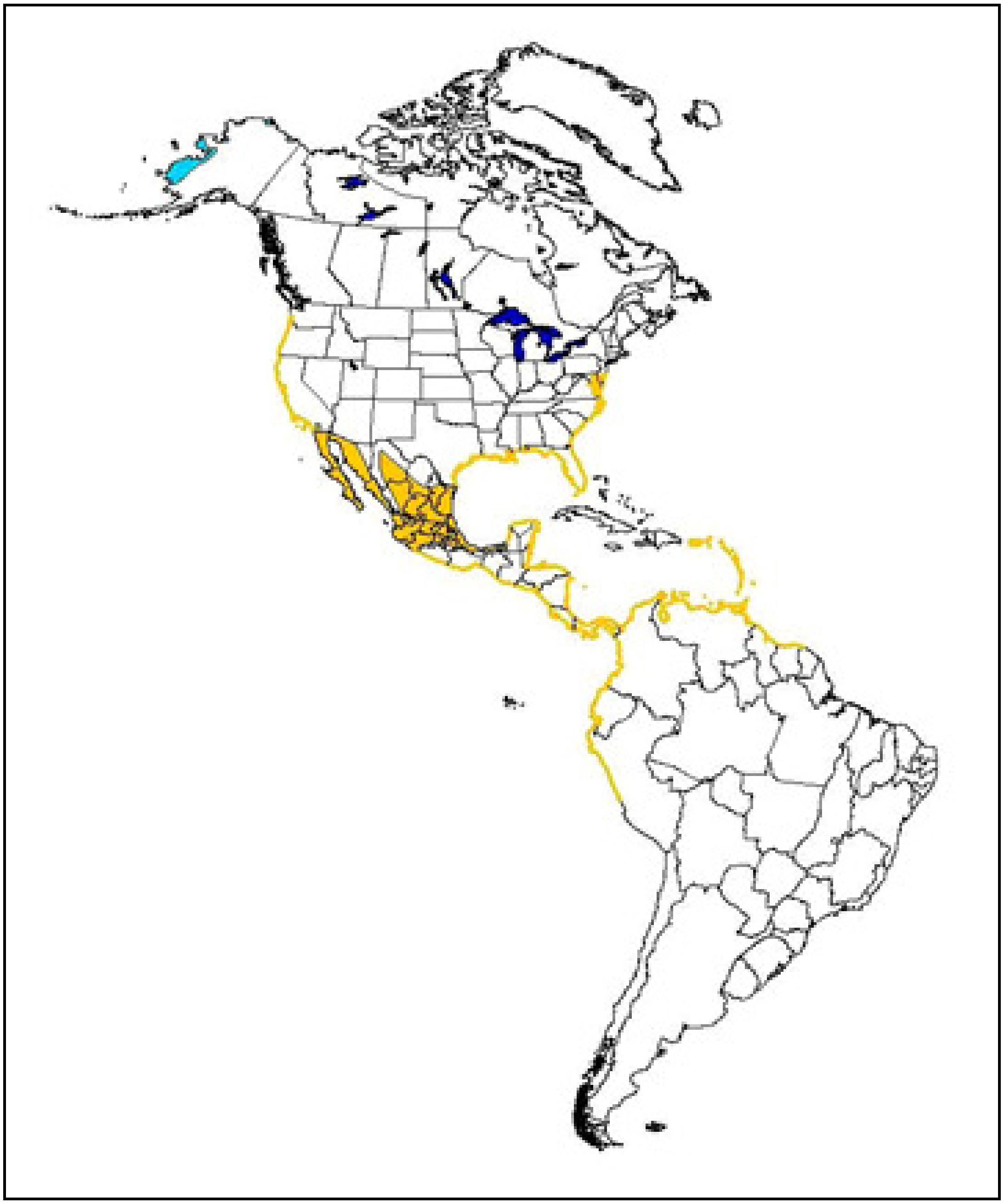

**Figure 1.** Breeding and wintering distribution of the Western Sandpiper (from Wilson 1994).


**Figure 2.** Important sites for Western Sandpipers in Canada and Alaska.

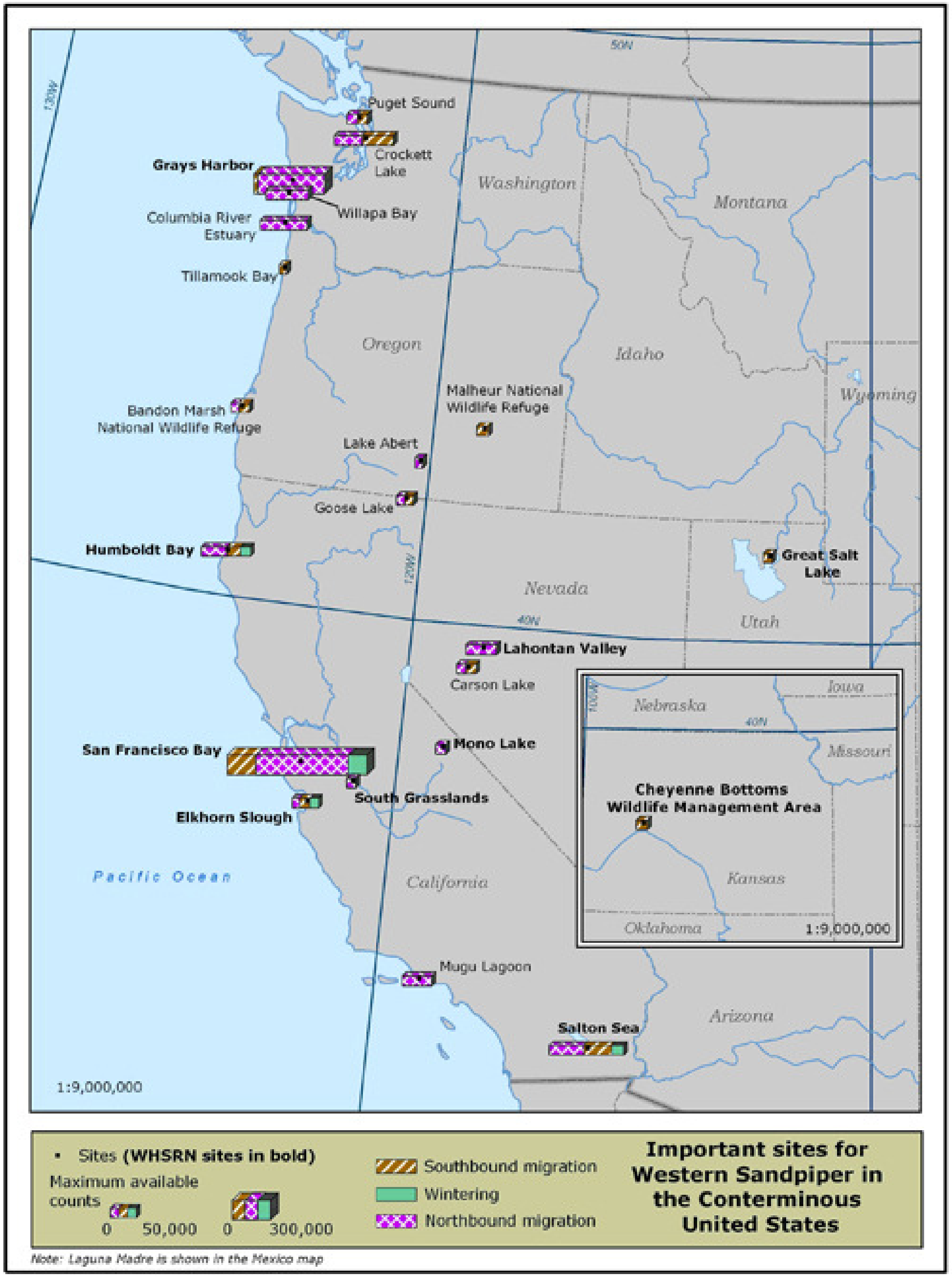


**Figure 3.** Important sites for Western Sandpipers in the Conterminous United States.

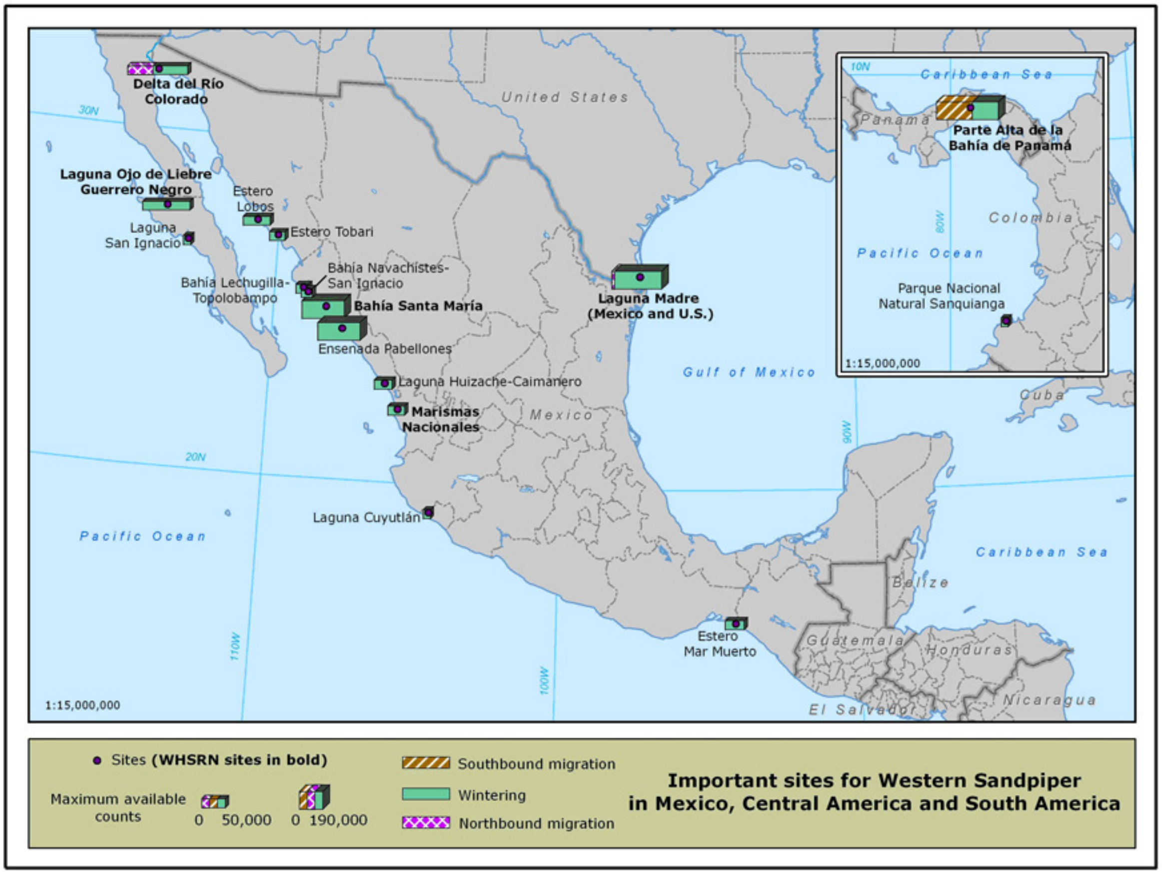


**Figure 4.** Important sites for Western Sandpipers in the Conterminous United States.

## APPENDIX 1

List of, and contact information for, Western Sandpiper contacts and potential future collaborators.

| Name | Title | Affiliation | Location | Country | Phone | E-mail |
|---|---|---|---|---|---|---|
| **Amorós, Samuel K.** | | | Lima | Perú | | samorosk@yahoo.com |
| **Banda, Alfonso** | Biólogo | Pronatura Noreste A.C. | Matamoros, Tamaulipas | Mexico | (52) 868-819-4933 | abanda@pronaturane.org |
| **Baird, Patricia** | Adjunct Professor | California Sate University, Long Beach | Long Beach, California | USA | 562-985-1780 | patbaird@csulb.edu |
| **Berlanga, Humberto** | Biologist | Coordinador Mexico-NABCI | Mexico, D.F. | Mexico | (52) 55-5528-9125 | hberlang@xolo.conabio.gob.mx |
| **Bishop, Mary Anne** | Avian Ecologist | Prince William Sound Science Center | Cordova, Alaska | USA | 907-424-5800 | mbishop@pwssc.gen.ak.us |
| **Buchanan, Joseph B.** | Wildlife Biologist | Washington Department of Fish and Wildlife | Olympia, Washington | USA | 360-902-2697 | buchajbb@dfw.wa.gov |
| **Butler, Robert W.** | Senior Research Scientist | Pacific Wildlife Research Centre CWS | Delta, British Columbia | Canada | 604-940-4672 | rob.butler@ec.gc.ca |
| **Carmona, Roberto** | Profesor – Investigador | Universidad Autónoma de Baja California Sur | La Paz, BCS | Mexico | (52) 612-1280-775 | beauty@uabcs.mx |
| **Carrera, Eduardo** | Director | Ducks Unlimited de Mexico, A.C. | Monterrey, Nuevo León | Mexico | (52) 81-8335-1212 | ecarrera@dumac.org |
| **Castillo Cortes, Luis Fernando** | Director | Asociación Calidris | | Colombia | | calidris@calidris.org.co |
| **Correa, Jorge** | Profesor – Investigador | Colegio de la Frontera Sur | Chetumal, Quintana Roo | Mexico | (52) 983-835-0440 | coyotecorrea@yahoo.ca |
| **Colwell, Mark A.** | Professor of Wildlife | Humboldt State University | Arcata, California | USA | 707-826-3723 | mac3@axe.humboldt.edu |
| **Cueva, Horacio de la** | Investigador | Centro de Investigación y Educación Superior de Ensenada | Ensenada, Baja California | Mexico | (52) 646-175-0500 x 242-51 | cuevas@cicese.mx |

| Name | Title | Affiliation | Location | Country | Phone | E-mail |
|---|---|---|---|---|---|---|
| **Duncan, Charles** | Executive Office Director | Western Hemisphere Shorebird Reserve Network | Portland, Maine | USA | 207-871-9295 | cduncan@manomet.org |
| **Elliott, Lee** | Conservation Metric Coordinator | The Nature Conservancy of Texas | San Antonio, Texas | USA | 210-224-8774 | lelliott@tnc.org |
| **Elner, Robert W.** | Head | Pacific Wildlife Research Centre CWS | Delta, British Columbia | Canada | 604-940-4674 | bob.elner@ec.gc.ca |
| **Estela, Felipe** | Biólogo | Red Nacional de Observadores de Aves | Cali, Valle del Cauca | Colombia | (57) 2-681-2853 | felipe@calidris.org.co |
| **Estrada, Aurea** | Biólogo | Ducks Unlimited de Mexico | Mexico, D.F. | Mexico | (52) 55-5794-7082 | aestrada@dumac.org |
| **Fernández, Guillermo** | Investigador | Instituto de Ciencias del Mar y Limnologia, UNAM | Mazatlan, Sinaloa | mexico | (52) 669-985-2845 | gfernandez@ola.icmyl.unam.mx |
| **Gill, Robert** | Research Wildlife Biologist | Alaska Science Center USGS | Anchorage, Alaska | USA | 907-786-3514 | robert_gill@usgs.gov |
| **Gratto-Trevor, Cheri** | Research Scientist | Canadian Wildlife Service | Saskatoon, Saskatchewan | Canada | 306-975-6128 | cheri.gratto-trevor@ec.gc.ca |
| **Haase, Ben** | | | Salinas (Guaynas) | Ecuador | | |
| **Harrington, Brian H.** | Senior Scientist | Manomet Center for Conservation Science | Manomet, Massachusetts | USA | 508-224-6521 | bharr@manomet.org |
| **Johnston González, Richard** | Investigador Asociado | Asociación Calidris | Cali, Valle del Cauca | Colombia | (57) 2-681-2853 | rjohnston@calidris.org.co |
| **Lank, David B.** | University Research Associate | Centre for Wildlife Ecology SFU | Burnaby, British Columbia | Canada | 604-291-3010 | dblank@sfu.ca |
| **Lemon, Moira J. F.** | Wildlife Research Technician | Pacific Wildlife Research Centre CWS | Delta, British Columbia | Canada | 604-940-4689 | moira.lemon@ec.gc.ca |
| **McCaffery, Brian J.** | Wildlife Biologist | Yukon Delta National Wildlife Refuge | Bethel, Alaska | USA | 907-543-1014 | Brian_McCaffery@fws.gov |

| Name | Title | Affiliation | Location | Country | Phone | E-mail |
|---|---|---|---|---|---|---|
| **Mellink, Eric** | Investigador | Centro de Investigación y Educación Superior de Ensenada | Ensenada, Baja California | Mexico | (52) 646-175-0500 x 242-58 | emellink@cicese.mx |
| **Ortego, Brent** | Wildlife Diversity Biologist | Texas Parks and Wilidfe Department, Wildlife Division Region IV | Victoria, Texas | USA | (361) 576-0022 x 24 | bortego@viptx.net |
| **Palacios Castro, Eduardo** | Investigador | CICESE-La Paz, Pronatura A.C. Noroeste, Dirección de Conservación Baja California Sur | La Paz, BCS | Mexico | (52) 612-121-3031 x111 | epalacio@cicese.mx |
| **Pulido, Victor** | Director | Programa Humedales del Perú | La Molina, Lima | Perú | (511) 867-2369 | wetperu@amauta.rcp.net.pe |
| **Ruthrauff, Daniel R.** | Wildlife Biologist | Alaska Science Center USGS | Anchorage, Alaska | USA | 907-786-3432 | druthrauff@usgs.gov |
| **Sandercock, Brett K.** | Assistant Professor | Division of Biology Kansas State University | Manhattan, Kansas | USA | 785-532-0120 | bsanderc@ksu.edu |
| **Takekawa, John** | Research Wildlife Biologist | USGS San Francisco Bay Estuary Field Station | California | USA | 707-562-2000 | john_takekawa@usgs.gov |
| **Vega Picos, Xicoténcatl** | Director | Pronatura A.C. Noroeste, Dirección de Conservación Sinaloa | Culiacán, Sinaloa | Mexico | (52) 667-759-1616 | xicovega@itesm.mx |
| **Warnock, Nils** | Co-Director | PRBO Conservation Sciences | Stinson Beach, California | USA | 415-868-0371 | nwarnock@prbo.org |
| **Williams, Tony D.** | Professor | Centre for Wildlife Ecology SFU | Burnaby, British Columbia | Canada | 604-291-3535 | tdwillia@sfu.ca |
| **Ydenberg, Ronald C.** | Professor | Centre for Wildlife Ecology SFU | Burnaby, British Columbia | Canada | 604-291-4282 | ydenberg@sfu.ca |