Spring Shorebird Migration from Mexico to Alaska:

Final Report 2002

Photos: Stuart MacKay

Nils Warnock
Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970
Mary Anne Bishop
Prince William Sound Science Center, P.O. Box 705, Cordova, AK 99574
John Y. Takekawa
San Francisco Bay Estuary Field Station, U.S. Geological Survey, P.O. Box 2012, Vallejo, CA 94592

Preliminary data reported herein are not for publication without permission from the authors

Spring shorebird migration from Mexico to Alaska:

Final Report 2002

NILS WARNOCK[1], MARY ANNE BISHOP[2], AND JOHN Y. TAKEKAWA[3]

[1] Point Reyes Bird Observatory, 4990 Shoreline Highway, Stinson Beach, CA 94970

[2] Prince William Sound Science Center, PO Box 705, Cordova, AK 99574

[3] U. S. Geological Survey, Western Ecological Research Center, San Francisco Bay Estuary Field Station, PO Box 2012, Vallejo, CA 94592

Suggested citation: Warnock, N., M.A. Bishop, and J.Y. Takekawa. 2002. Spring Shorebird Migration from Mexico to Alaska: Final Report 2002. Unpubl. Prog. Rep., Point Reyes Bird Observatory, Stinson Beach, CA, and U. S. Geological Survey, Vallejo, CA, 22pp.

EXECUTIVE SUMMARY

- We organized and coordinated the efforts of a team of 30 partners to examine the spring migration ecology of shorebirds at over 30 sites spanning 3 countries along the Pacific Flyway from Sinaloa, Mexico; California, Nevada, Oregon, and Washington; British Columbia, Alberta, Canada; to western Alaska.

- We successfully radio-marked 88 shorebirds in April 2002 at Bahía Santa María, Sinaloa, Mexico, comprising 59 Western Sandpipers and 29 Long-billed Dowitchers.

- The mean length-of-stay at Bahía Santa María for Western Sandpipers ($\bar{x} = 16.4 \pm 4.0$ days, $n = 59$) and Long-billed Dowitchers ($\bar{x} = 18.6 \pm 4.8$ days, $n = 29$) did not differ significantly by age, sex, body mass, or capture date.

- We documented 50 locations of Western Sandpipers (46%) past their banding sites, half of that detected in previous years. Some of the birds we marked may have remained at Bahía Santa María during the summer, reducing our detections.

- San Francisco Bay was the single most important stopover site for Western Sandpipers where 22% of the marked birds were detected, followed by Willapa Bay and Grays Harbor (20%). We relocated 12% at the Copper River Delta, far below the 70-90% of previous years, but this may have been due to some batteries expiring and radios falling off before birds reached Alaska. Two birds were relocated at Yukon-Kuskokwim Delta breeding areas.

- Western Sandpipers' mean length-of-stay past the banding site ranged from 1-5 days, and their longest stopover was at San Francisco Bay ($\bar{x} = 5.0 \pm 3.2$ days).

- Only one Long-billed Dowitcher was detected, at Carson Lake, NV in the western Great Basin. On the basis of our results and earlier work on waterfowl, we suspect that Long-billed Dowitchers at Bahía Santa María may have migrated through the Interior Highlands of Mexico along the eastern Pacific Flyway or western Central Flyway.

- Our project was showcased on the list-serve and web site of the Sister Shorebird Schools, an environmental education program sponsored by the U. S. Fish and Wildlife Service. Over 850 users from 36 states and 23 countries subscribe to the site, and during the migration, the web site received over 50,000 hits.

- Over the past decade, we have built a network of cooperators to examine the importance of coastal habitats used by shorebirds during the spring migration. These studies have revealed the complexity of migration strategies used within and among shorebird species along the Pacific Flyway. We are preparing an integrated proposal to complete analyses on wetland quality, bioenergetics, and connectivity, and to conduct 2 more radio-telemetry field seasons (2004 and 2006) focusing on the Pacific Flyway.

INTRODUCTION

As a group, shorebirds of North America have experienced declines in populations (Morrison 2001, Morrison and Hicklin 2001) over the last several decades. Reasons for the declines are unknown but habitat modification has figured prominently as a potential cause. As increasing amounts of habitats have been altered and destroyed, it is becoming critical for wildlife managers to understand how birds use habitats throughout their range. At present, we have little information on how individual birds use migration areas, especially during migration periods. Understanding the stopover ecology of shorebirds is also a critical component of understanding the complete life cycle of these birds (Skagen 1997). Conservation of migratory stopover sites relies not only on knowing how and when different areas of their migration landscape are used, but also on knowing what influences the use of and time spent at different areas of that landscape (Warnock and Bishop 1998).

Research on shorebird migration is identified as a priority in the United States Shorebird Conservation Plan (Brown et al. 2001). The migration strategies used by one of the best-studied shorebird species in North America, the Western Sandpiper (*Calidris mauri*), have been well described for the stretch between San Francisco and western Alaska (Iverson et al. 1996, Bishop and Warnock 1998, Warnock and Bishop 1998). Those studies, applying radio telemetry to document migration routes and timing, demonstrated that individual Western Sandpipers typically make short flights during their northward migration and use a variety of stopover sites. However, little is known about how Western Sandpipers migrate up the Pacific Flyway from areas south of San Francisco. Similarly, very little is known about the northward migration strategy used by the Long- billed Dowitcher (*Limnodromus scolopaceus*; Takekawa and Warnock 2000), and nothing is known about how either shorebird species migrates between Mexico and central California. In light of this, we set out to learn more about the migration strategies of Western Sandpipers and Long-billed Dowitchers along the Pacific Flyway.

We had the following objectives:

1. Determine the spring migration routes of Long-billed Dowitchers and Western Sandpipers between Sinaloa, Mexico and western Alaska.

2. Estimate length-of-stay of these birds at banding and stopover areas with a special focus of getting unbiased length-of-stay estimates for San Francisco Bay.

3. Evaluate the interrelationships of stopover sites during spring.

4. Compare these results with what is known about Long-billed Dowitcher and Western Sandpiper migration along the Pacific Flyway.

5. Improve public awareness of shorebird conservation by featuring the project on the USFWS Sister Shorebird School web site.

METHODS

We captured shorebirds during daylight hours at the Patolandia Duck Club in Bahía Santa María, Sinaloa, Mexico (Fig. 1, for more details of site see Engilis et al. 1998, Warnock 2002) between 7 - 15 April 2002. Western Sandpipers were mist-netted during the day in shallow, open-ponded areas of Bahía Santa María using taped alarm calls of Western Sandpipers to lure them in. Long-billed Dowitchers were trapped during the day at the inner edge of the cattail marsh of the bay. We trapped along narrow channels in the cattail marshes where dowitchers funneled through, set up shorebird decoys, and stationed two people with a mist net who flicked the net upwards when the dowitchers flew by.

We weighed each bird captured to the nearest 0.05 g and measured (mm) exposed culmen, flattened wing, and tarsus. Western Sandpipers were sexed as males if their exposed culmen was ≤ 24.2 mm and as females if their exposed culmen was ≥ 24.8 mm (Page and Fearis 1971). The amount of fat in the Western Sandpiper's furcular cavity was scored between 0 and 5 (Warnock and Bishop 1998). We were unable to determine sex or estimate fat scores for Long-billed Dowitchers. We aged Western Sandpipers and Long-billed Dowitchers as first-year birds based on extensive wear of the inner wing coverts relative to adults (illustrated in Warnock and Warnock 2001). All birds were marked with a metal U. S. Fish and Wildlife Service (USFWS) band and banded with UV resistant color-bands. Fifty-nine Western Sandpipers had 1.0 g radio transmitters (estimated life 6 weeks, Holohil Systems Ltd., Woodlawn, Ontario, Canada) glued to their lower backs (see Warnock and Warnock 1993), while 29 Long-billed Dowitchers had 1.3 g radios (estimated life 10 weeks) attached with similar methods. The radio transmitter weight was 3% of the mass of a Western Sandpiper and <1% of the mass of a Long-billed Dowitcher. We affixed transmitters to the birds with cyanoacrylate glue (QuickTite™ Super Glue, Loctite Corp.©, Rocky Hill, CT).

Our ability to detect radios varied by method and equipment: range was < 2 km from the ground with a hand-held antenna, 2-4 km from the ground with a truck mounted antenna (3-7 km from a 120 m hill), and >10 km from an airplane (aerial range at Bahía Santa María was < 3 km, perhaps because the 2-element "H" antennas were not optimized). We used radio transmitters at all major stopover areas to test aerial telemetry equipment.

At Bahía Santa María, we regularly monitored the whole bay from the air from 11-29 April (Table 1). After 29 April, when aerial surveys ceased, we were only able to access the area where Long-billed Dowitchers were banded. We continued to monitor this area through 5 May. From Bahía Santa María up to and including the Copper River Delta, we regularly (>10 d monitoring) monitored 17 potential stopover sites and irregularly monitored 14 areas for our radio-marked birds (Table 1, Fig. 1). Trucks equipped with dual-Yagi, null-peak telemetry systems were used at San Francisco Bay. Hand-held, 3-element Yagi antennas were used at remaining ground monitoring sites. Aerial monitoring was conducted from planes equipped with exterior, dual-mounted antennas.

Figure 1. Location of banding site and sites surveyed for radiomarked Western Sandpipers and Long-billed Dowitchers in spring 2002.

Table 1. Telemetry methods (A = aerial, G = ground), number of surveys (V = variable number of surveys, conducted opportunistically during a study of Northern Pintails, *Anas acuta*), and field effort (days) for monitoring migratory movements of Western Sandpipers and Long-billed Dowitchers, April-June 2002. Surveys indicate the number of searches conducted.

Location	Method	Surveys	Monitoring Dates
<u>Mexico</u>			
Bahía Santa María	G	11	Apr 7-12, 30, May 1-3, 5[1]
	A	17	Apr 11-12, 14-24, 26-29
<u>Nevada</u>			
Carson Lake	G	3	Apr 21, May 6, 9
	A	2	May 2, 8
<u>California</u>			
Salton Sea	G	27	Apr 8-9, 11-12, 14-20, 2-27, 29-30 May 1-2, 6-7, 9-11, 13
San Diego Bay	G	26	Apr 8-20, 23-25, 29-30 May 1-4, 7-9, 13
Pt. Mugu	G	27	Apr 8-12, 16-18, 20, 22-30 May 3-8, 13, 20
Owens Lake	G	9	Apr 2, 5, 8, 16-17, 19-20, 23, 25
San Joaquin Valley	A	3	May 2, 5, 8
Elkhorn Slough	A	7	Apr 24, 27, 28 May 1-2, 4, 14
San Francisco Bay	A	16	Apr 10, 12, 14, 18, 22, 24, 27-28 May 1, 2, 4, 7, 9-10, 12, 14
South Bay	G	18	Apr 16-18, 23-25, 27-30 May 2-3, 6-9, 14
North Bay	G	6	Apr 30 May 1, 3, 6, 9, 14
Tomales Bay	A	10	Apr 18, 24, 27-28, May 4, 7, 9-10, 12, 14
Humboldt Bay			
South Bay	G	9	May 4-6, 8-13, 18
North Bay	G	25	Apr 22-25, 29-30 May 1-3, 5-11, 14-22
<u>Oregon</u>			
Klamath Basin	G	V[2]	Apr 27-30, May 1-15
Summer Lake Wildlife Area	G	V[2]	Apr 27-30, May 1-15
Malheur	G	V[2]	Apr 27-30, May 1-15
Bandon Marsh	G	10	Apr 28, 30 May 3, 4(2), 5-6, 9, 12, 17
Coos Bay	G	3	May 2, 7, 12
Bandon Marsh-Pacific City	A	1	May 13
Bandon Marsh-Columbia River	A	1	Apr 29
Lower Columbia River	G	1	May 22
	A	3	May 7, 11, 21
<u>Washington</u>			
Grays Harbor	G	14	Apr 21, 23, 25, 28, 30 May 2, 4, 6, 8, 10, 12, 15, 17, 19
	A	15	Apr 22, 24, 27, 29 May 1, 3, 5, 7, 9, 11, 13-14, 16, 18, 21
Willapa Bay	G	9	Apr 23, 25, 30 May 2, 6, 8, 10, 15, 17
	A	15	Apr 22, 24, 27, 29 May 1, 3, 5, 7, 9, 11, 13-14, 16, 18, 21
<u>British Columbia</u>			
Fraser River Delta	G	21	Apr 19, 22-30 May 2, 4-6, 11-16
Tofino Beach	G	6	Apr 23 May 1-4, 7

Alberta			
Central Alberta			
Lloydminster-Edmonton	A	1	May 24
Lloydminster-Slave Lake	A	1	May 25
Slave Lake-Utikuma Lake	A	1	May 26
Grand Prairie	A	1	May 28
Alaska			
Stikine River Delta	A	25	Apr 25, 27, 29 May 2, 4-24
Juneau			
Juneau Wetlands	G	21	May 1-2, 4-15, 17-18, 20-21, 23-25
Juneau and Taku Inlet	A	5	May 3, 9, 11, 15, 18
Berners Bay	G	24	Apr 27 – May 20
Yakutat Forelands	A	18	Apr 29, May 2-3, 6, 8, 10, 12-21, 24, Jun 6
Copper River Delta	A	25	Apr 29, May 1-2, 4-25
Upper Cook Inlet	A	7	Apr 28, May 1, 6, 7, 10, 13, 17
Upper Tanana River Valley	A	2	May 30, Jun 5
Bristol Bay			
South (King Salmon-Ilnik)	A	5	May 8, 12, 16, 19, 22
North (King Salmon-	G	1	May 7
E. Nushagak Bay)	A	5	Apr 29 May 3, 16, 19, 22
Lower Alaska Peninsula	A	3	May 4-6
Yukon-Kuskokwim Delta	A	4	May 15-17, Jun 4
Seward Peninsula	A	2	Jun 4-5
Bettles to Fairbanks	A	1	Jun 6
North Slope			
Deadhorse-Teshekpuk Lake	A	1	Jun 11
Deadhorse to Icy Cape	A	1	Jun 12
Ikpikpuk River-Icy Cape	A	1	Jun 13
Atqasak-Umiat	A	1	Jun 16

[1] Bahía Santa María coverage May 1-3 and 5 restricted to Long-billed Dowitcher banding area.
[2]Greater than 10 surveys done, although exact number not known; these areas surveyed by four trucks equipped with dual Yagi antennae set-ups. Locations surveyed in these three areas included the Lower Klamath NWR, Tule Lake NWR, Butte Valley Wildlife Area, Goose Lake, Warner Valley (especially near Crump Lake), Chewaucan Marsh, Summer Lake Wildlife Area, Malheur NWR and flooded fields to the north.

Monitoring began north of banding sites as soon as radio-marked birds were suspected of departing. Flights were conducted at altitudes of 300-1500m, with timing of flights varying by area. When a bird was located at a site, we monitored its presence until it had not been detected for at least 2 days or the bird had been relocated at another site. All monitoring at a site ceased when either all radio-marked birds had departed or when minimal migratory activity was observed.

We assumed there was no difference in the probability of detection by method (ground or air) and that all radio-marked birds at a banding or monitoring site were detected on a given day. We defined relocations as the number of monitoring sites at which a bird was detected and migration time as the interval (full day increments) between successive sites that a bird remained undetected. Length-of-stay (LOS) for each site was the number of days from first to the last detection. We assumed a detected bird remained on a site the entire day (i.e., LOS $\geq$ 1 day), and that it remained on site from the first to the last detection day. For birds arriving or departing on days we were unable to monitor (usually because of weather, Table 2), we estimated the arrival or departure date by taking the midpoint between dates we monitored. Statistical analyses were performed using STATA (Computing Resource Center, Santa Monica, CA 1999). Significance was determined if $P \leq 0.05$.

RESULTS

BANDING

Western Sandpipers - Comparing first-year to adult Western Sandpipers, we did not detect significant differences in body mass, culmen, or fat measurements (Mass, $F_{1,56} = 2.18$, $P = 0.15$; Culmen, $F_{1,56} = 1.83$, $P = 0.18$; Fat, $F_{1,56} = 0.71$, $P = 0.40$; Table 2). We did detect significant differences between males and females in body mass (ANOVA, $F_{1,56} = 4.93$, $P = 0.03$) and culmen measurements (ANOVA, $F_{1,56} = 215.3$, $P < 0.001$), but not in fat scores (ANOVA, $F_{1,56} = 0.64$, $P = 0.43$). Combining ages, females weighed, on average, about 1.4 g more than males (females, mean mass = 27.4 g ± 2.5 g, $n = 31$; males, mean mass = 26.0 g ± 2.3 g, $n = 28$). We failed to detect significant age and sex interactions of birds in body mass, culmen, or fat scores (ANOVA, $P > 0.42$ for all comparisons).

Long-billed Dowitchers - We failed to detect significant differences in body mass or culmen measurements between first-year and adult birds (Mass, $F_{1,27} = 3.31$, $P = 0.08$; Culmen, $F_{1,27} = 0.02$, $P = 0.88$; Table 2).

Table 2. Measurements of culmen length (mm), body mass (g), and fat of Western Sandpipers and Long-billed Dowitchers captured 7-15 April 2002 at Bahía Santa María, Sinaloa, Mexico. Measurements include mean ± SD, *n*.

	Sex	Adult	Juvenile
Western Sandpiper			
Mass	Male	26.4 ± 2.3, *14*	25.6 ± 2.3, *14*
	Female	27.9 ± 2.7, *16*	26.9 ± 2.1, *15*
Culmen	Male	22.7 ± 0.8, *14*	22.2 ± 0.9, *14*
	Female	26.8 ± 1.4, *16*	26.4 ± 1.1, *15*
Fat	Male	1.8 ± 1.2, *14*	1.8 ± 1.4, *14*
	Female	1.8 ± 1.3, *16*	1.2 ± 1.0, *15*
Long-billed Dowitcher			
Mass		109.2 ± 7.7, *21*	102.6 ± 10.9, *8*
Culmen		67.5 ± 5.2, *21*	67.1 ± 6.5, *8*

RELOCATIONS

Western Sandpipers - Of the 59 radio-marked Western Sandpipers that we potentially could have detected, we relocated 46% ($n = 27$) at one or more sites past their banding site (Table 3). Of the over 30 sites that we monitored, radio-marked birds were detected at 18 sites. In coastal California, we did not detect any birds south of Elkhorn Slough. We did not detect birds at any sites in northeast California or south-central Oregon, nor did we detect any birds east of Nevada nor at Alaska's North Slope and Seward Peninsula. San Francisco Bay was the single most important stopover site with 22% of our 59 radio-marked Western Sandpipers detected there. Combining Willapa Bay and Grays Harbor, 20% of our marked Western Sandpipers were detected there, while 12% of the marked Western Sandpipers were detected at the Copper River Delta.

Table 3. Relocation sites with mean length-of-stay and number of birds (LOS ± SD days, *n*) of Western Sandpipers radio-marked at Bahía Santa María, Mexico, April 2002. Only sites where at least one bird was detected are listed.

	Females		Males		Combined[2]
	Adult	First-year	Adult	First-year	
California					
Salton Sea	1.0 ± 0.0, *1*				
San Luis NWR			2.0 ± 0.0, *1*		
Elkhorn Slough			1.0 ± 0.0, *1*		
San Francisco Bay	5.0 ± 3.4, *5*	5.5 ± 2.1, *2*	4.7 ± 5.5, *3*	5.0 ± 3.1, *3*	5.0 ± 3.2, *13*
Humboldt Bay	1.0 ± 0.0, *1*				
Nevada					
Carson Lake			*1*[1]		
Oregon					
Bandon Marsh		1.0 ± 0.0, *1*	1.5 ± 0.7, *2*		1.3 ± 0.6, *3*
Coos Bay		1.5 ± 0.0, *1*		2.0 ± 0.0, *1*	1.8 ± 0.4, *2*
Siletz Bay				*1*[1]	
Yaquina Bay			*1*[1]		
Columbia River		*1*[1]			
Washington					
Willapa Bay	1.0 ± 0.0, *1*	1.0 ± 0.0, *1*	2.0 ± 0.0, *1*	1.0 ± 0.0, *1*	1.4 ± 0.5, *4*
Grays Harbor	1.5 ± 0.7, *2*		2.5 ± 1.8, *2*	1.5 ± 0.0, *1*	1.8 ± 1.0, *5*
British Columbia					
Fraser River				*1*[1]	
Alaska					
Stikine River				2.5 ± 0.0, *1*	
Yakutat Forelands			1.0 ± 0.0, *1*		
Copper River	1.7 ± 3.1, *3*	2.0 ± 0.0, *1*	3.0 ± 0.0, *1*	2.5 ± 0.7, *2*	2.1 ± 0.7, *7*
Y-K Delta	*1*[1]		*1*[1]		

[1]Unable to calculate length-of-stay.
[2] Sites listed when more than two birds relocated.

Of the 59 Western Sandpipers that we radio-marked at Bahía Santa María, 16 of them (27%: 4 adult females, 6 first-year females, 2 adult males and 4 first-year males) were still at the banding site on our last aerial survey day of their banding site (29 April). Four of these birds were subsequently relocated further north, but the detection rate of these birds was significantly lower than birds that left during our scheduled survey period (7 April - 29 April; $\chi^2_1 = 3.81$, $P = 0.05$).

Long-billed Dowitchers - Only one Long-billed Dowitcher was recovered outside of the banding area, an adult detected at Carson Lake, Nevada in the western Great Basin. One Long-billed Dowitcher was still being detected at the banding site on our last day of monitoring on 5 May.

LENGTH-OF-STAY AT BANDING SITE

The mean length-of-stay of Western Sandpipers ($\bar{x}$ = 16.4 ± 4.0 days, n = 59) at Bahía Santa María was significantly shorter than the mean length-of-stay of Long-billed Dowitchers ($\bar{x}$ = 18.6 ± 4.8 days, n = 29; ANOVA $F_{1,86}$ = 4.98, P = 0.03); however, the mean length of stays should be treated as minimum estimates since 15 Western Sandpipers and 7 Long-billed Dowitcher were still at Bahía Santa María when we stopped monitoring for Western Sandpipers there.

Table 4. Length-of-stay of shorebirds at Bahía Santa María in April 2002 by age and sex. Length-of-stay reported as $\bar{x}$ ± SD, *n*.

	Sex	First year	Adult
Western Sandpiper	Female	16.3 ± 4.3, *15*	16.3 ± 5.2, *16*
	Male	16.1 ± 3.5, *14*	16.9 ± 2.3, *14*
Long-billed Dowitcher	Combined	19.5 ± 4.0, *8*	18.2 ± 5.1, *21*

We found no evidence that length-of-stay of either species of bird was affected by age and sex of birds (Table 4), body mass of birds (Fig. 2), or banding date (Fig. 2).

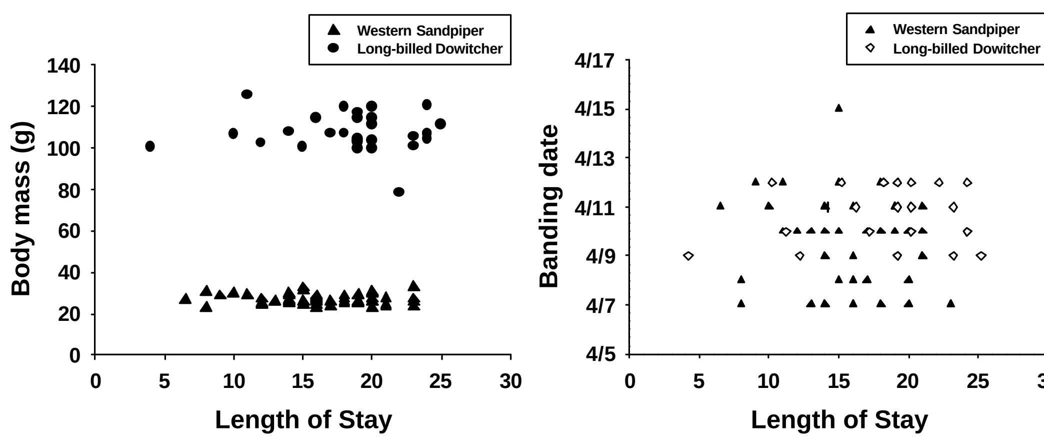

Figure 2. Effect of body mass and banding date on length-of-stay (days) of Western Sandpipers and Long-billed Dowitchers at Bahía Santa María, Sinaloa, Mexico, April 2002.

LENGTH-OF-STAY PAST THE BANDING SITE

Western Sandpipers - We were able to determine 40 length-of-stay estimates based on relocations of 27 birds detected north of Bahía Santa María (Table 3). Due to incomplete search efforts, we were unable to calculate length-of-stay for birds detected at 6 sites (Table 2). Past the banding site, mean length-of-stay at 12 other sites we monitored ranged from 1-5 days, with mean length-of-stay of birds stopping at San Francisco Bay more than double any other stopover site (Table 2).

Within sites, there were no obvious patterns of age or sex of birds affecting their length-of-stay at stopover sites (Table 2). At San Francisco Bay, where sample size was sufficient for testing, age and sex did not explain significant amounts of variation in length-of-stay (log transformed) of Western Sandpipers (ANOVA; Age, $F_{1,10} = 0.60$, $P = 0.46$; sex, $F_{1,10} = 0.49$, $P = 0.50$). Length-of-stay of Western Sandpipers at San Francisco Bay was significantly related to their arrival date at San Francisco Bay (adjusted $r^2 = 0.57$, $P = 0.002$, $n = 13$; Fig. 3); on average, early arriving birds stayed longer than late arriving birds.

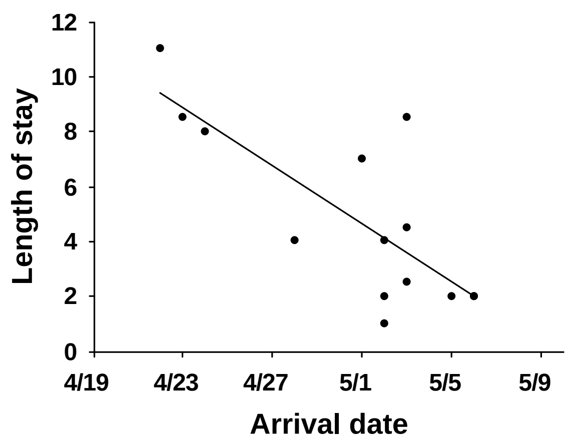

Figure 3. Relationship between arrival date and length-of-stay of Western Sandpipers at San Francisco Bay, California, spring 2002.

Long-billed Dowitchers **-** Due to incomplete search efforts, we were unable to calculate length-of-stay for the one Long-billed Dowitcher detected at Carson Lake, Nevada.

PUBLIC OUTREACH AND EDUCATION

Our work in Sinaloa was the focus of an award winning television show in Sinaloa, Mexico shown in May 2002. Our project was featured both on PRBO's web site and Sister Shorebird Schools' (SSS) list serve and web site. The SSS is an environmental education program sponsored by the US Fish and Wildlife Service. An overview of our project was provided to SSS list-serve subscribers on 23 April 2002. Subsequently, 6 list-serve updates described the movements of selected Dunlin and Dowitchers. The Shorebird Sister Schools website linked to the PRBO Conservation Sciences web page that featured the tracking project. As of August 2002, the project continues to be posted on the web site, and all list-serve messages are archived under "Where are they today". We estimate that information on our project reached several thousand people. Over 850 users from 23 countries and 36 US states subscribe to the site, including many school classes. During May 2001 when our study was being conducted, the web site received nearly 50,000 hits.

DISCUSSION

SITES USED IN MIGRATION

Over the past decade, we have built a network of cooperators to examine the importance of coastal habitats used by shorebirds during the spring migration. The 2002 spring shorebird migration study marks the fifth season (1992, see Iverson et al. 1996; 1995, 1996, see Bishop and Warnock 1998, Warnock and Bishop 1998; and 2001, see Warnock et al. 2001) that we have successfully radio-marked and followed shorebirds over large areas of the Pacific Flyway. These studies have revealed the complexity of migration strategies used within and among shorebird species along the Pacific Flyway. For the first time, we marked birds south of San Francisco Bay, at Bahía Santa María, Sinaloa, Mexico. Little had been known about how individual shorebirds migrated from Mexico through western United States and Canada.

Overall, we had a lower likelihood of detecting radio-marked Western Sandpipers (46%) and Long-billed Dowitchers (3%) past their banding site than in previous years when relocations ranged from 84-91% of all possible birds (Warnock and Bishop 1998, Warnock et al. 2001). Most striking was the fact that we detected only one of 29 Long-billed Dowitchers that we marked past their banding site despite our intensive search efforts throughout the Pacific Flyway. Our previous results when attaching transmitters with glue has been highly reliable, including work on dowitchers in 2001 (see Warnock et al. 2001). It is unlikely that we would have missed these birds along the coast as last year we had high probabilities of detecting dowitchers on the coast, especially at the Copper River Delta (76% detection rate there in 2001, Warnock et al. 2001), where no dowitchers were detected this year.

Telemetry studies in the early 1990s indicated an interchange of migratory birds from the West Coast to the Interior Highlands regions of northern Mexico for Northern Pintails (R. Migoya, pers. comm.) and Greater White-fronted Geese (*Anser albifrons*; JYT, unpubl. data). Thus, we suggest that many of the Long-billed Dowitchers that migrate northwards through Sinaloa take an interior route through Chihuahua and then up through the western side of Great Plains through the United States where they are common during migration (Skagen et al. 1999, Takekawa and Warnock 2000). It may be that these birds then continue up the Central Flyway through Canada and end up on the North Slope of Alaska (see map of Pacific Flyway in Lincoln 1952). Marked Long-billed Dowitchers from the North Slope have subsequently been found in Kansas (Takekawa and Warnock 2000), demonstrating a northern Alaska - Central Flyway connection.

Our recoveries of Western Sandpipers also were illuminating despite our lower recovery rate compared to previous years. In southern California, no Western Sandpipers were detected along the Pacific coast south of Elkhorn Slough, despite substantial search efforts at San Diego Bay and Pt. Mugu, two sites that traditionally host some of the highest numbers of migrating Western Sandpipers in southern California each spring (Page et al. 1992). Western Sandpipers detected at coastal southern California sites may be coming up from Baja California, Mexico where large numbers winter (Page et al. 1997). We had one recovery at the Salton Sea, with concentrated but frequent search effort at the southeastern section of the sea (the Sonny Bono Salton Sea NWR and the state operated Wister Unit), where greatest concentrations of Western Sandpipers at the Salton Sea occur (Shuford et al. 2000). This recovery, along with resightings of color-banded Western Sandpipers from Panama (Butler et al. 1996) indicates that at least some Western Sandpipers from Mexico, Central and South America migrate up through the Gulf of California to the Salton Sea before continuing their northward migration either up the Pacific Coast or through the interior of the Pacific Flyway.

At interior sites north of the Salton Sea in California and Nevada we had limited search effort that still yielded three birds. A Western Sandpiper and a Long-billed Dowitcher were detected in the Lahontan Valley, NV in the western Great Basin and a Western Sandpiper was detected in the southern Central Valley at San Luis NWR. This indicates that some birds from the western coast of Mexico migrate north through the western Great Basin and some head up through the Central Valley and then move to the coast. Neither of the birds detected in Nevada were detected again, but the San Luis bird was picked up at Willapa Bay and Grays Harbor in Washington. The Summer Lake, Malheur, and Lower Klamath Lake region, an interior area of south-central Oregon and north-eastern California that is known to support large numbers of migrating shorebirds including Western Sandpipers and Long-billed Dowitchers (Warnock et al. 1998), did not yield any radio-marked shorebirds despite a great deal of search effort there. This suggests that our marked birds migrating north through the interior crossed over to the coast before reaching south-central Oregon.

This season, our single site with the most recoveries of Western Sandpipers (22%) was the San Francisco Bay. Our results support the conclusions of Page and others (1999) that with the exception of the Copper River Delta, San Francisco Bay is perhaps the single most important coastal spring site for Western Sandpipers in the western United States. North of San Francisco, we recovered Western Sandpipers at most sites that we regularly surveyed. For the first time, we monitored for and detected radio-marked Western Sandpipers at coastal sites in Oregon, demonstrating the importance of coastal wetlands of this state to migrating Western Sandpipers. The Willapa Bay and Grays Harbor area of Washington was also an important area for our radio-marked Western Sandpipers, as has been demonstrated in past years (Iverson et al. 1996, Warnock and Bishop 1998).

North of Washington, although sites where we found birds were similar to previous years, our recovery rates of radio-marked Western Sandpipers dropped off. This was especially noticeable at the Copper River Delta, through which the majority of the estimated world's population of Western Sandpipers passes in the spring (Bishop et al. 2000). Despite similar search effort to previous years of study, we relocated only 12% of radio-marked Western Sandpipers there this spring, compared to 70-90% relocation in previous years. This suggests that many radios were either expiring or falling off birds before they reached the Copper River Delta, a strong possibility since we were stretching the limits of the battery life of the radios we put on Western Sandpipers. This would not have been the case for Long-billed Dowitchers since their radios had a battery life of 10 weeks.

Another factor that could explain lower recovery rates at the Copper River Delta is if some Western Sandpipers bypassed the Copper River Delta by following the same route as Long-billed Dowitchers and migrating up the eastern side of the Pacific Flyway and the western Central Flyway, through Alberta, up the Mackenzie River to northern Alaska (see Senner and

Martinez 1982), where Western Sandpipers are known to breed (Senner and Martinez 1982, Johnson and Herter 1989). Western Sandpipers do occur in the Central Flyway in small numbers during the spring (Skagen et al. 1999), and southward migrating birds from British Columbia have subsequently been detected in Kansas (Senner and Martinez 1982), indicating some connection between the flyways. The two Western Sandpipers we tracked from Mexico to breeding grounds on the Yukon-Kuskokwim Delta were both detected further south at coastal sites in California and Washington, indicating a coastal migration route for these breeding birds.

LENGTH-OF-STAY AT BANDING SITES

Aside from the change in banding location, our estimates of length-of-stay at the banding site were most different compared with results from previous years. Mean length-of-stay of Long-billed Dowitchers at their banding site in San Francisco Bay in 2001 was about 8 days (Warnock et al. 2001), while at Sinaloa it was over 18 days. Similarly, for Western Sandpipers banded at more northerly sites in San Francisco, Honey Lake and Grays Harbor, mean length-of-stay ranged from 2.6 (Honey Lake) to 9.1 days (San Francisco), compared with over 16 days at Sinaloa. Several factors may help explain the longer mean length-of-stay at Sinaloa.

First of all, inclusion of birds that are not actually migrating may inflate the Sinaloa estimates. In many shorebird species, first year birds do not attempt to breed and often stay at their wintering sites (McNeil et al. 1994, del Hoyo et al. 1996). It is estimated that at Bahía Santa María approximately 10% of Western Sandpipers do not migrate, the majority of them first year birds (G. Fernandez pers. comm.). Due to financial constraints, we stopped aerial telemetry flights on 29 April. This prevented further monitoring of the Western Sandpiper banding area (only accessible from the air), although we were able to monitor the banding area for Long-billed Dowitchers from the ground until 5 May. Of the 16 Western Sandpipers that were still being detected only 4 of them were subsequently relocated to the north, a significantly lower resighting rate than birds we detected leaving, suggesting that many of these birds either did not leave or migrated up the Central Flyway. It appears as if most of the Long-billed Dowitchers migrated from Bahía Santa María.

Longer length-of-stay at Bahía Santa María vs. more northerly sites and inter-species differences in length-of-stay of Western Sandpipers and Long-billed Dowitchers may also be related to both timing of migration and location of the breeding grounds. Breeding Long-billed Dowitchers are one of the latest arriving shorebirds on the eastern side of the North Slope of Alaska (Takekawa and Warnock 2000), with early arrival dates at Prudhoe Bay, AK on 25 May (Hohenberger 1994). In contrast, Long-billed Dowitchers arrive to breeding areas in western Alaska beginning the first week of May (Takekawa and Warnock 2000). Any Western Sandpipers migrating up to northern Alaska would face similar constraints in timing of migration due to the later snow melt-off and more unpredictable weather in northern vs. western Alaska (Holmes 1971, 1972).

As has been the case in the past (Warnock and Bishop 1998, Warnock et al. 2001), we failed to find any significant effects of sex, body mass, or banding date on length-of-stay at the banding site. Additionally, we found no significant effect of age. Part of these effects may be masked by the banding effect that we have documented in the past (Warnock and Bishop 1998, Warnock et al. 2001), which causes birds to stay longer at the site where they are banded than they would if they were not handled. Past the banding site, we also failed to find significant effects of sex or age on a bird's length-of-stay.

LENGTH-OF-STAY PAST BANDING SITES

With the exception of stopover lengths at San Francisco Bay, Western Sandpipers moved rapidly through stopover sites, spending on average 1-2 days per site. These estimates are similar to those we have recorded for Western Sandpipers in previous years of study (Iverson et al. 1996, Warnock and Bishop 1998).

For the first time, we obtained unbiased estimates of turnover (unaffected by the effects of banding) at San Francisco Bay. Compared to the more rapid turnover estimates at other sites, mean length-of-stay of Western Sandpipers at San Francisco Bay was about 5 days. These data support the idea that San Francisco Bay serves as a staging site rather than a stopover site for Western Sandpipers. There are probably few true staging sites for shorebirds in North America, sites where birds spend relatively longer amounts of time increasing their body mass in response to a superabundant food resource (see Warnock and Bishop 1998). At San Francisco Bay it is likely that the combination of relatively large tracts of intertidal mudflats in juxtaposition with large expanses of salt ponds offer opportunities for intense periods of feeding. With the salt ponds present, Western Sandpipers can and do feed through the day and night, switching between habitats depending on tide height (Warnock and Takekawa 1995, 1996).

Also for the first time, we obtained length-of-stay estimates of shorebirds stopping at coastal wetlands in Oregon. Similar to other stopover areas, birds moved rapidly, turning over in one to two days. This was also true for sites along the Washington coast. Western Sandpipers used Grays Harbor and Willapa in a similar way, generally stopping for less than two days before continuing. Previous turnover estimates for these birds at these sites in Washington have also been rapid (Iverson et al. 1996, Warnock and Bishop 1998). Dunlin and Short and Long-billed Dowitchers marked last year used Grays Harbor and Willapa Bay differently than Western Sandpipers. Dowitchers stayed on average up to 5 days at these sites. Dowitchers stopped longer at Willapa Bay than Grays Harbor while Dunlin stopped longer at Grays Harbor than Willapa Bay (Warnock et al. 2001). Our mean two-day stopover lengths at the Copper River Delta are comparable with results from previous years (Iverson et al. 1996, Warnock and Bishop 1998).

Except for San Francisco Bay, low sample sizes at sites north of the banding area preclude a detailed examination of effects that potentially affect length-of-stay. At San Francisco Bay, time of arrival had the largest effect on stopover length with late-arriving birds staying shorter periods of time than early-arriving birds. At the Copper River Delta, the length-of-stay of male Western Sandpipers was also negatively related to arrival date whereas we failed to find this relationship in females (Warnock and Bishop 1998, Warnock et al. 2001). Farmer and Wiens (1999), in a study of Pectoral Sandpipers (*Calidris melanotos*) migrating through the Central Flyway in the spring, showed a similar relationship with birds banded at more northerly sites having shorter lengths of stay the later they were banded in the season. Undoubtedly, this is related to the need for late-arriving shorebirds to get to the breeding grounds in time to breed. Shorebirds migrating towards breeding grounds in the subarctic and Arctic face time constraints, and males probably face tighter constraints than females the closer they get to the breeding grounds, as has been suggested for Western Sandpipers (Warnock and Bishop 1998) and Pectoral Sandpipers (Farmer and Wiens 1999). Eggs laid too early in the season face freezing (Green et al. 1977), while for chicks hatching too late in the short breeding season there is an increased probability of food shortages (Holmes 1972) and, in some years, greater predation (Oring and Lank 1986, Jönsson 1991). However, energetic costs for females may be equally or more important than time considerations because egg production is energetically expensive (MacLean 1969, Blem 1990).

SUMMARY

This study, combined with our previous work on other shorebirds, reveals the complexity of migration strategies used within and among shorebird species along the Pacific Flyway. Shorebirds rely on an interconnected web of wetlands along the Pacific Flyway. In some cases, it appears as if shorebirds wintering along the Pacific Flyway move eastward and migrate northward through the Central Flyway. In the future, we need to expand our scale of study in order to adequately understand how these shorebirds are using their landscape on a global scale. Many areas along the Pacific Flyway are used as stopover sites by Western Sandpipers and Long-billed Dowitchers, but San Francisco Bay (at least for Western Sandpipers) appears to serve as a staging area. Exactly how individual sites are used by these migrating birds, especially what types of prey are consumed, how birds accumulate fat for migration at these sites, and what specific habitats within sites are important remain largely unknown. Research in these areas is especially desirable. Our length-of-stay estimates will allow for more accurate estimates of numbers of shorebird passing through particular sites to be obtained.

FUTURE RESEARCH

Over the past decade, this project has been very successful because it utilized an extensive network of partners. However, it is an extremely time-intensive and labor-intensive effort to coordinate with uncertain funding. Thus, we are planning to work with our partners and funding sources to complete the study within the next 5 years. We are preparing an integrated proposal to complete analyses on wetland quality, bioenergetics, and connectivity, and to conduct 2 more radio-telemetry field seasons (2004 and 2006) focusing on the Pacific Flyway. With this approach, we hope to develop a strong scientific compilation for use in management plans to protect key shorebird migration habitats in the Pacific Flyway.

ACKNOWLEDGMENTS

A study of this breadth would not have been possible without the significant help and cooperation from multiple people and organizations. We thank the many individuals and organizations that helped us with monitoring, funding, public outreach, and logistics. We received helpful comments from Nicole Athearn and Isa Woo on the draft report. Lars Pomora helped with maps, and Stuart MacKay provided the photographs on the cover. This is contribution number 993 of Point Reyes Bird Observatory.

COOPERATORS AT BANDING AND MONITORING SITES

Bahía Santa María, Sinaloa, Mexico
Simon Fraser University
  Guillermo J. Fernandez Aceves
PRONATURA Mexico, Sinaloa Chapter
  Xicotincatl (Xico) Vega Picos
Patolandia Hunting Club
  Gilberto Salomon Sainz
  Hugo Medina Cazares
Shorebird Banding, Inc.
  Stuart MacKay
Environmental Flying Services
  Sandra Lanham
Pronatura Noroeste/Universidad Autonoma de Sinaloa
  Miguel Guevara
Point Reyes Bird Observatory
  Sarah Warnock

Salton Sea, CA
California Department of Fish and Game, Wister Unit
  Jack Crayon
US Fish and Wildlife Service, Sonny Bono Salton Sea National Wildlife Refuge
  Tom Anderson, Christopher Burditt, Varya Litovka, Charles Pelizza, Genady Smirnof, R. Schrag

San Diego Bay, CA
US Fish and Wildlife Service, Tijuana Slough National Wildlife Refuge
  Brian Collins, Arnold Grassi, Yaz Ikegaya, Nuri Pierce, Todd Stands
Chula Vista Nature Center
  Charles Gailband

Pt. Mugu, CA
US Navy, Environmental Division
  Emilie Craig, Tom Keeney, Nathan Lang, Martin Ruane

Owens Lake, CA
Point Reyes Bird Observatory
  Chris Rintoul

San Francisco Bay, CA
US Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge
  Joelle Buffa, Katherine De Cristina, Margaret Kolar, Clyde Morris, Milena Viljoen

US Geological Survey, San Francisco Bay Estuary Field Station
    Corey Tarwater, Susan Wainwright-De La Cruz
Ecoscan Resource Data
    Bob Van Wagenen
Humboldt Bay, CA
US Fish and Wildlife Service, Arcata Fish and Wildlife Office
    Ryan Mathis
US Fish and Wildlife Service, Humboldt Bay National Wildlife Refuge
    Eric Nelson, Shannon Smith
Humboldt State University
    Tracy Caddy, Phil Capitilo, Nancy Fox, Rebecca Green
Carson Lake, Lahontan Valley, NV
US Fish and Wildlife Service, Stillwater National Wildlife Refuge
    Bill Henry
Summer Lake and Klamath Lakes, OR
US Geological Survey
    Dan Battaglia, Joe Fleskes
Coos Bay, OR
US Fish and Wildlife Service, Oregon Coast National Wildlife Refuge Complex
    David Pitkin, Dave Lauten, Kathy Castelein
Willapa Bay and Grays Harbor, WA
US Fish and Wildlife Service, Nisqually National Wildlife Refuge
    Erin Harrington, Jason Law, J. Lippert, Nanette Seto, Jean Takekawa
US Fish and Wildlife Service, Willapa Bay National Wildlife Refuge
    Kirsten Brennan, Alan Clark, Deborah Jaques, Tom Kollasch, Charlie Stenvall
US Fish and Wildlife Service, Migratory Bird Management
    Ray Bentley
Rite Brothers Aviation
    Jeff Wells
Washington Department of Fish and Game
    Val Judkins, Joe Buchanan
Tofino Beach, British Columbia
    Adrian Dorst
University of Victoria
    Sarah Coulter
Fraser River Delta, British Columbia
Canadian Wildlife Service, Pacific Wildlife Research Centre
    Rob Butler, Patricia Kretz, Moira Lemon
Central Alberta
US Fish and Wildlife Service, Migratory Bird Management
    Elizabeth Buelna
Stikine River Delta, AK
USDA Forest Service, Wrangell Ranger District, Tongass National Forest
    Kurt Aluzas, Melissa Cady, Bob Traufer,
Juneau, AK
USDA Forest Service, Juneau Ranger District, Tongass National Forest

Gwen Baluss, Robbie Piehl, Larry Rickards, Neal Tex, Don Youkey
USDA Forest Service, Chugach National Forest
Rob Spangler

Yakutat Forelands, AK
USDA Forest Service, Yakutat Ranger District, Tongass National Forest
Nate Catterson, Dan Gillikin, Bill Lucey

Copper River Delta, AK
Fishing and Flying
Gayle Ranney
Prince William Sound Science Center
Craig Reiser
Cordova Ranger District, Chugach National Forest
Milo Burcham

Cook Inlet, AK
US Geological Survey, Alaska Research Center
Alan Brelsford, Robert Gill, John Terenzi

Upper Tanana River Valley, AK
US Fish and Wildlife Service, Tetlin National Wildlife Refuge
Buddy Johnson, Keith W. Larson

Alaska Peninsula, AK
US Fish and Wildlife Service, Izembak National Wildlife Refuge
Kristine Sowl

Bristol Bay, AK
US Fish and Wildlife Service, Becharof National Wildlife Refuge
David Cox, Jodi Doster, Susan Savage
US Fish and Wildlife Service, Migratory Bird Management
Chris Dau, Bill Larned, Ed Mallek,

Cape Pierce, AK
US Fish and Wildlife Service, Togiak National Wildlife Refuge
Rob MacDonald, Mike Hinkes

Yukon-Kuskokwim Delta, AK
US Fish and Wildlife Service, Yukon Delta National Wildlife Refuge
Fred Broerman, Brian McCaffrey, Jody Oyen, George Walters,
US Fish and Wildlife Service, Migratory Bird Management
Bruce Conant, Debbie Groves , Chris Dau, Ed Mallek

North Slope, Alaska
US Fish and Wildlife Service, Migratory Bird Management
Bill Larned

PUBLIC OUTREACH AND EDUCATION

Our efforts to educate people to the marvels of shorebird migration were greatly aided by:
Sue Abbott, Education Program, Point Reyes Bird Observatory
Jonathan Bart, Forest and Rangeland Ecosystem Science Center, USGS
Hilary Chapman, Sister Shorebird Schools, US Fish & Wildlife Service
Geoff Geupel, Terrestrial/Latin America Program, Point Reyes Bird Observatory
Catherine Hickey, Wetlands Program, Point Reyes Bird Observatory

Melissa Pitkin, Education Program, Point Reyes Bird Observatory
Chris Restall, Forest and Rangeland Ecosystem Science Center, USGS
Sarah Warnock, Wetlands Program, Point Reyes Bird Observatory

EQUIPMENT:
We thank the following individuals and agencies for advice on and/or loan of equipment:
Fred Anderka, Holohil Systems
Craig Ely, U. S. Geological Survey, Alaska Science Center
David Irons, US Fish and Wildlife Service, Region 7, Migratory Bird Management
Steve Ranney, Fishing and Flying

FUNDING SOURCES:
Chase Wildlife Foundation
Goldman Fund
US Fish & Wildlife Service
- Nisqually National Wildlife Refuge
- Willapa Bay National Wildlife Refuge
- Pacific Coast Joint Ventures
- Region 1, Ecological Services, Coastal Program - San Francisco Bay Program
- Region 1, Migratory Birds and Habitat Programs
- Region 7, Migratory Bird Management, Nongame Migratory Birds
- Puget Sound Program, Western Washington Fish and Wildlife Office

USDA Forest Service
- Copper River International Migratory Bird Initiative
- Region 10, Wildlife, Fisheries, Ecology & Watershed

SPECIAL THANKS TO:
Ellen Campbell, US Forest Service Region 10 Wildlife, Fisheries, Ecology & Watershed
Lynn Chase, Chase Wildlife Foundation
Dan Logan, Cordova Ranger District, Chugach National Forest
Mary Mahaffy, US Fish & Wildlife Service, Puget Sound Program, Western Washington Fish and Wildlife Office.
Rick Morat, US Fish & Wildlife Service Coastal Program - San Francisco Bay Program
Maura Naughton & Tara Zimmerman, US Fish & Wildlife Service, Migratory Birds and Habitat Programs
Nanette Seto & Jean Takekawa, Nisqually National Wildlife Refuge
Carey Smith, US Fish & Wildlife Service, Pacific Coast Joint Ventures
Kent Wohl, US Fish & Wildlife Service, Migratory Bird Management

LITERATURE CITED

Bishop, M. A., and N. Warnock. 1998. Migration of Western Sandpipers: links between their Alaskan stopover area and breeding grounds. Wilson Bull. 110:457-462.

Bishop, M. A., P. M. Meyers, and P. F. McNeley. 2000. A method to estimate migrant shorebird numbers on the Copper River Delta, Alaska. J. Field Ornithol. 71:627-637.

Blem, C. R. 1990. Avian energy storage, p. 59-113. *In* D. M. Power [ed.], Current Ornithology. Plenum Press, New York.
Brown, S., C. Hickey, B. Harrington, and R. Gill. 2001. The U. S. Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.
Butler, R. W., F. S. Delgado, H. de la Cueva, V. Pulido, and B. K. Sandercock. 1996. Migration routes of the Western Sandpiper. Wilson Bull. 108:662-672.
Del Hoyo, J., A. Elliott, and J. Sargatal, Eds. 1996. Handbook of the birds of the world. Vol. 3. Hoatzin to auks. Lynx Edicions, Barcelona.
Engilis, A., Jr., L. W. Oring, E. Carrera, J. W. Nelson, and A, M. Lopez. 1998. Shorebird surveys in Ensenada Pabellones and Bahía Santa María, Sinaloa, Mexico: critical winter habitats for Pacific Flyway shorebirds. Wilson Bull. 110:332-341.
Farmer, A. H., Jr., and J. A. Wiens. 1999. Models and reality: time-energy trade-offs in Pectoral Sandpiper (*Calidris melanotos*) migration. Ecology 80:2566-2580.
Green, G. H., J. J. D. Greenwood, and C. S. Lloyd. 1977. The influence of snow conditions on the date of breeding of wading birds in north-east Greenland. J. Zool. 183:311-328.
Hohenberger, C. J., W. C. Hanson, and E. E. Burroughs. 1994. Birds of the Prudhoe Bay region, northern Alaska. Western Birds 25:73-103.
Holmes, R. T. 1971. Latitudinal differences in the breeding and molt schedules of Alaskan Red-backed Sandpipers (*Calidris alpina*). Condor 73:93-99.
Holmes, R. T. 1972. Ecological factors influencing the breeding season schedule of Western Sandpipers (*Calidris mauri*) in subarctic Alaska. Am. Midl. Nat. 87:472-491.
Iverson, G. C., S. E. Warnock, R. W. Butler, M. A. Bishop, and N. Warnock. 1996. Spring migration of Western Sandpipers (*Calidris mauri*) along the Pacific coast of North America: a telemetry study. Condor 98:10-21.
Johnson, S. R., and D. R. Herter. 1989. The birds of the Beaufort Sea. BP Exploration (Alaska), Inc., Anchorage, AK
Jönsson, P. E. 1991. Reproduction and survival in a declining population of the southern Dunlin *Calidris alpina schinzii*. Wader Study Group Bull. 61:56-68.
Lincoln, F. C. 1952. Migration of birds. Doubleday and Co., New York.
MacLean, S. F., Jr. 1969. Ecological determinants of species diversity of Arctic sandpipers near Barrow, Alaska. Ph.D. diss., Univ. California, Berkeley, CA.
McNeil, R., M. Tulio Diaz, and A. Villeneuve. 1994. The mystery of shorebird over-summering: a new hypothesis. Ardea 82:143-152.
Morrison, R. I. G. 2001. Trends in shorebird populations in North America using Breeding Bird Survey data. Bird Trends 8:12-15. Canadian Wildlife Service, Ottawa.
Morrison, R. I. G, and P. Hicklin. 2001. Recent trends in shorebird populations in the Atlantic Provinces. Bird Trends 8:16-19. Canadian Wildlife Service, Ottawa.
Oring, L. W., and D. B. Lank. 1986. Polyandry in Spotted Sandpipers: the impact of environment and experience, p. 21-42. *In* D. Rubenstein and P. Wrangham [eds.], Ecological aspects of social evolution. Princeton Univ. Press, Princeton, NJ.
Page, G., and B. Fearis. 1971. Sexing Western Sandpipers by bill length. Bird-Banding 42:297-298.
Page, G. W., W. D. Shuford, J. E. Kjelmyr, and L. E. Stenzel. 1992. Shorebird numbers in wetlands of the Pacific Flyway: a summary of counts from April 1988 to January 1992. Unpublished progress report, Point Reyes Bird Observatory, Stinson Beach, CA 94970.

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. J. Field Ornithol. 68:562-574.

Page, G. W., L. E. Stenzel, and J. E. Kjelmyr. 1999. Overview of shorebird abundance and distribution in wetlands of the Pacific Coast of the contiguous United States. Condor 101: 461-471.

Senner, S. E., and E. F. Martinez. 1982. A review of Western Sandpiper migration in interior North America. Southwestern Naturalist 27:149-159.

Shuford, W. D., N. Warnock, K. C. Molina, B. Mulrooney, and A. Black. 2000. Avifauna of the Salton Sea: Abundance, distribution, and annual phenology. Contribution No. 931 of Point Reyes Bird Observatory. Final report for EPA Contract No. R826552-01-0 to the Salton Sea Authority, 78401 Highway 111, Suite T, La Quinta, CA 92253.

Skagen, S. K. 1997. Stopover ecology of transitory populations: the case of migrant shorebirds. Ecol. Studies 125:244-269.

Skagen, S. K., P. B. Sharpe, R. G. Waltermire, and M. B. Dillon. 1999. Biogeographical profiles of shorebird migration in midcontinental North America. Biological Science Report USGS/BRD/BSR-2000-0003. U.S. Government Printing Office, Denver, CO.

Takekawa, J. Y., and N. Warnock. 2000. Long-billed Dowitcher (*Limnodromus scolopaceus*) *In* The Birds of North America, No. 493 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington D. C.: The American Ornithologists' Union.

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

Warnock, N., and S. Warnock. 1993. Attachment of radiotransmitters to sandpipers: review and methods. Wader Study Group Bull. 70: 28-30. Reprinted 1993. Stilt 23: 38-40

Warnock, N., and S. Warnock. 2001. Sandpipers, phalaropes, and allies. Pages 273-287 in The Sibley guide to bird life and behavior. Chanticleer Press, Inc., NY.

Warnock, N., S. M. Haig, and L. W. Oring. 1998. Monitoring species richness and abundance of shorebirds in the western Great Basin. Condor 100:589-600.

Warnock, N., M. A. Bishop, and J. Y. Takekawa. 2001. Spring migration of Dunlin and dowitchers along the Pacific Flyway. Unpublished progress report, Point Reyes Bird Observatory, Stinson Beach, CA 94970.

Warnock, S. 2002. Herding dowitchers. Observer 149: 3.

Warnock, S. E., and J. Y. Takekawa. 1995. Habitat preferences of wintering shorebirds in a temporally changing environment: Western Sandpipers in the San Francisco Bay estuary. Auk 112:920-930.

Warnock, S. E., and J. Y. Takekawa. 1996. Wintering site fidelity and movement patterns of Western Sandpipers *Calidris mauri* in the San Francisco Bay estuary. Ibis 138:160-167.