Conservation of Western Sandpipers Along the Pacific Flyway

Year-end Report
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Data reported herein are part of an ongoing study and are not for citation or publication without permission from the authors

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Introduction

The Western Sandpiper *Calidris mauri* is the most numerous shorebird along the Pacific Flyway, with estimated numbers of 6.5 million birds in the 1970's (Isleib 1979) to 1.3 million in the late 1980's and early 1990's (Page and Gill 1994). This neararctic shorebird breeds principally in the subarctic zone of western Alaska, on the Yukon-Kuskokwim Delta, with smaller numbers in northern Alaska and NE Russia. Birds winter from California to Peru, along the southern Atlantic Coast, and the Gulf of Mexico to Central and South America (A.O.U. 1957,Wilson 1994).

Along the Pacific Flyway, five coastal migratory stopover sites have been documented to support significant (>500,000 birds) use by migrating western sandpipers in spring: San Francisco Bay, CA (Kjelmyr et al. 1991), Grays Harbor, WA (Wilson 1993), Fraser River Delta, BC (Butler et al. 1987, Butler 1994), Stikine River Delta, AK (Iverson and Walsh 1994) and the Copper River Delta, AK (Isleib 1979, Bishop and Green 1993). Interior sites in the Central Valley of California and the Great Basin of the western United States have also been shown to host large numbers of migrating westerns, but the use of these interior areas remains poorly understood.

Recent work on western sandpipers has revealed significant details on winter home range use (Warnock and Takekawa, in press) and migration patterns (Iverson et al., in review) using radiotelemetry technology. However, there are significant gaps in our knowledge of the migration ecology of western sandpipers utilizing both coastal and interior staging and stopover sites along the Pacific Flyway.

In order to clarify some of the remaining gaps in our knowledge of western sandpipers, the 1995 western sandpiper telemetry study was undertaken with the following objectives.

1. Determine interannual variation in phenology and routes of migratory western sandpipers in spring.
2. Estimate length of stay at stopover areas.
3. Assess the relationship between body mass, sex, and travel time between stopover areas.

4. Evaluate interrelationships of stopover sites in spring.
5. Generate a theory of the migration strategy of western sandpipers along the Pacific Flyway.

This report presents the results for the spring 1995 field season.

Methods

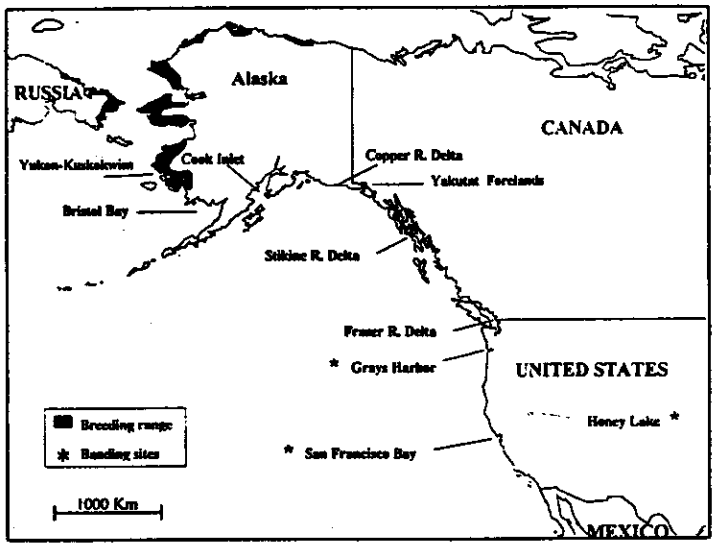

Figure 1. Locations of 1995 Western Sandpiper banding and tracking sites.

Western sandpipers were captured between 17 - 30 April 1995 (Table 1) at two coastal sites, San Francisco CA and Grays Harbor WA, and at an interior Great Basin wetland, Honey Lake CA. Birds were trapped during daylight hours with mist nets set up in salt ponds, mudflats and fresh-water ponds. Each bird was weighed to the nearest 1g. Other measurements (mm) taken included exposed culmen, flattened wing and tarsus. Each bird was scored between 0-5 according to the amount of fat in the furcular cavity (0 = no fat, 5 = fat bulging out of cavity). All birds received a metal USFWS band on the upper right leg. Sex was determined by length of the exposed culmen (Page and Fearis 1971). Due to extensive molt, age based on wing covert characteristics was not attempted (Page et al. 1972).

Table 1. Banding locations, and telemetry monitoring methods and schedule for studying movements of western sandpipers during spring migration, April-May 1995

Location	Banding Dates	Telemetry Method	Monitoring Dates
California			
San Francisco (SF)	Apr 17-19, 21-23	daily ground	Apr 18-May 5
		5 flights	Apr 24,28 May 1,4,8
Honey Lake (HL)	Apr 27,28,30	daily ground	Apr 29-May 9
Humboldt Bay		intermittent ground	
Washington			
Grays Harbor (GH)	Apr 24,25, 28	daily ground	Apr 24-May 8
		7 flights	Apr 27,29 May 1,3,5,7,9
British Columbia			
Fraser River Delta (FR)		daily ground	Apr 25-May 18
Tofino Beach		daily ground	Apr 21 -May 8
Alaska			
Stikine River Delta (SR)		daily flights	Apr 27-May 1-11, 15[1]
		ground	May 12,13
Yakutat Forelands (YF)		10 flights	May 4,6-10,13,15,17-19
Copper River Delta (CR)		daily flights	Apr 28-May 22[2]
Upper Cook Inlet			
Susistna-N.Redoubt Bay		9 flights	May 2,4,6,8,10,12,13,16,18
Lower Cook Inlet			
Redoubt-Chinitna Bays		8 flights	May 3-5,8-10,12,14
Kachemak Bay		daily flights	Apr 29-May 16[3]
Bristol Bay (BB)		8 flights	May 2,3,5,11,15,16,17,18
Yukon-Kuskokwim Delta (YK)		3 flights	May 13,22,23

[1] No flight April 28; [2] No flights May 6, 21; [3] No flights April 30, May 5,6

specific radiotransmitters. Generally, range was 1-2 km from the ground using a hand-held antenna, 2-4 km from the ground using a truck system (5-8 km from a 120 m hill), and 4-10 km from an airplane. We placed test radios at five locations (San Francisco Bay, Grays Harbor, Stikine River Delta, Copper River Delta and Lower Cook Inlet) to test equipment.

Monitoring for radiomarked western sandpipers was done from the ground and air. Trucks equipped with dual-Yagi, null-peak telemetry systems were used at San Francisco Bay and Honey Lake, CA. Hand-held, 3-element Yagi antennae were used for ground monitoring at Grays Harbor, WA , Fraser River Delta and Tofino Beach, British Columbia. Aerial monitoring was done from planes equipped with exterior, dual-mounted antennas.

We monitored transmitters from the ground and from aircraft at 14 known or suspected stopover sites from San Francisco, CA to the Yukon-Kuskokwim Delta, AK (Fig. 1, Table 1). Monitoring began north of banding sites as soon as radio-marked birds were suspected of departing. Flights were conducted at altitudes of 300-1000m, with timing of flights varying by area. Monitoring ceased when either all radio-marked birds had departed, or when minimal migratory activity was observed in an area.

We assumed there was no difference in the probability of detection from the ground or air, and that all radiomarked birds at a banding or monitoring site were detected on a given day. We defined relocations as the number of stopover sites a bird was detected and migration time as the interval between successive sites that a bird remained undetected in full one day increments. A length of stay (LOS) for each site was the number of days from the first to the last detection. We assumed that a bird remained at a site for the entire day that it was detected (i.e. LOS always greater than or equal to one day) and that it remained at the site from the first to last detection day. At the Copper River, high winds prevented aerial flights on 6 May. For the Copper River, we assumed that birds detected 5 May departed 5 May ($n = 2$), and birds detected 7 May arrived 6 May ($n = 7$).

Statistical analyses were performed using STATA (Computing Resource Center, Santa Monica CA 1992. We used one-way analysis of variance to analyze mean migration time between sites. Pearson's χ^2 was used to test for differences in relocation sites between male and female wetern sandpipers. The Kruskal-Wallis non-parametric one-way analysis of variance was used to determine if days spent at banding sites and stopover sites varied significantly by location or sex. We used Kendall's Tau test to examine the relationship between length of stay of sandpipers to sites other than their banding site in relation to distance from the Copper River. For all test results, P-values ≤ 0.05 were termed significant.

We used the following abbreviations for sites: SF = San Francisco Bay, CA; HL = Honey Lake, CA; HB = Humboldt Bay, CA; GH = Grays Harbor, WA; FR = Fraser River Delta and Tofino Beach, BC; SR = Stikine River, AK; YF = Yakutat Forelands, AK; CR = Copper River Delta, AK; CI = Cook Inlet, AK including Fox River Flats, Kachemak Bay,

and western Cook Inlet from Susitna Flats to Chinitna Bay; BB = Bristol Bay, AK; YK = Yukon-Kuskokwim Delta, AK.

Results

Relocations of radiomarked birds. Of the 68 western sandpipers marked with radiotransmitters, four birds were depredated at Grays Harbor, WA, probably by a single Peregrine Falcon (*Falco peregrinus*). Additionally, one radio failed and two had such strong interference that the radios were not detectable. The remaining 61 birds departed their banding site.

Fifty-two of the 61 birds (84%) were detected at 10 locations beyond their banding sites for a total of 85 relocations (Fig. 1, Table 2).

Table 2. Relocations of Western Sandpipers at sites north of banding sites: Spring 1995. SF = San Francisco Bay, CA, HL = Honey Lake, CA; GH = Grays Harbor, WA; FR = Fraser River Delta, BC; SR = Stikine River Delta, AK, YF = Yakutat Forelands, AK; CR = Copper River Delta, AK, CI = Cook Inlet, AK; BB = Bristol Bay, AK; YK = Yukon-Kuskokwim Delta, AK.

Banding Location		Banded (*n*)	Recovered (*n*)	%	HB	GH	FR[1]	SR	YF	CR	CI[2]	BB	YK
SF	Male	15	15	100	0	4	6	3	2	10	0	0	2
	Female	14	9	64	0	1	2	0	0	6	3	1	1
	Total	29	24	83	0	5	8	3	2	16	3	1	3
HL	Male	12	10	83	0	2	2	1	5	8	0	0	0
	Female	6	4	67	0	0	1	0	0	3	0	0	1
	Total	18	14	78	0	2	3	1	5	11	0	0	1
GH	Male	7	7	100	-	-	1	2	0	5	1	1	1
	Female	7	6	86	-	-	1	0	1	5	1	0	2
	Total	14	13	93	-	-	2	2	1	10	2	1	3
Total	Male	34	32	94	0	6	9	6	7	23	1	1	3
	Female	27	19	70	0	1	4	0	1	14	4	1	4
	Total	61	51	84	0	7	13	6	8	37	5	2	7

[1]Includes Fraser River Delta and Tofino Beach, British Columbia.
[2]Includes Kachemak Bay and western Cook Inlet from Susitna Flats to Chinitna Bay.

San Francisco Bay birds were relocated at an average (± SD) of 1.4 ± 0.9 (range 0 - 3) sites; Honey Lake 1.3 ± 1.0 (range 0 - 3) sites; and Grays Harbor 1.5 ± 0.7 (range 0 - 2)

sites. The Copper River Delta, AK was the single most important stopover site with 37/61 birds (61%) detected (Table 2).

Relocations of male and female westerns were significantly different for birds marked at San Francisco Bay ($\chi^2 = 10.2$, df = 3, $P = 0.017$) and all locations combined ($\chi^2 = 10.3$, df = 3, $P = 0.016$), but not for Grays Harbor, WA ($\chi^2 = 0.8$, df = 3, $P = 0.844$) and Honey Lake, CA ($\chi^2 = 4.8$, df = 2, $P = 0.089$). Males were more likely to be relocated before the Copper River Delta, AK, whereas females were more likely to be relocated at or after the Copper River Delta, AK. Seven birds (3 males, 4 females) were relocated on the Yukon-Kuskokwim Delta AK breeding grounds.

Length of stay at banding sites.- Days spent at a banding site after being radiomarked varied significantly by location (Kruskall-Wallis, $\chi^2 = 19.1$, df = 2, $P = 0.001$) with westerns banded at Honey Lake staying the shortest amount of time (Table 3). Combining all locations, no significant differences between male and female length of stay at the banding site were detected (Kruskall-Wallis, $\chi 2 = 3.2$, df = 1, P = 0.073).

Table 3. Length of stay of radiomarked birds at banding site, April-May 1995.

Banding Site	Males (x ± SD)	*n*	Females (x ± SD)	*n*
San Francisco, CA	7.9 ± 5.4	16	10.8 ± 3.9	13
Honey Lake, CA	3.2 ± 2.4	12	3.2 ± 2.1	6
Grays Harbor, WA	7.1 ± 3.8	7	9.0 ± 5.5	6

Length of stay at staging and stopover sites.- No significant difference in the length of stay of male or female western sandpipers at stopover sites other than their banding sites was found (Kruskall-Wallis, $\chi^2 = 0.3$, df = 1, $P = 0.6$). Length of stay of western sandpipers at stopover sites was correlated to distance from the Copper River Delta (Kendall's Tau = -0.37, $P = 0.0045$, $n = 30$). Longest length of stay was for birds stopping at Grays Harbor, WA (not including birds banded there) (x=3.7 days), while the shortest length of stay was at Yakutat Forelands, a site just to the south of the Copper River Delta, AK (Table 4).

Table 4. Estimates of length of stay for radio-equipped western sandpipers at stopover sites, spring 1995.

Site	Male			Female			Combine		
	x	SD	*n*	x	SD	*n*	x	SD	*n*
GH	4.2	2.9	6	1	0	1	3.7	2.9	7
FR	2.6	1.2	9	2.8	1.3	4	2.6	1.2	13
SR	2.2	1.1	5	0	0	0	2.2	1.1	5
YF	1.2	0.4	5	0	0	0	1.2	0.4	5
CR	2.0	1.1	23	1.9	1.1	14	2.0	1.1	37
CI	0	0	0	1	0	1	1	0	1

Mean migration time between sites.- Mean travel time for westerns, measured in terms of day last seen at the banding site to day first detected at the Copper River Delta, varied significantly between the three banding sites (Table 5)($F_{2,35} = 18.0$, $P = 0.0000$). Honey Lake birds took the longest, averaging 248 km/day, followed by San Francisco birds that traveled at an average of 392 km/day and Grays Harbor birds at 437 km/day. Males radiomarked at San Francisco and Honey Lake took significantly longer to reach the Copper River Delta than females (SF: $F_{1,14} = 9.40$, $P = 0.0084$; HL: $F_{1,9} = 5.58$, $P = 0.0425$), but we failed to detect a difference between males and females marked at Grays Harbor ($F_{1,10} = 0.01$, $P = 0.9085$).

Discussion

Radiotelemetry studies are crucial for determining migratory strategies of individual shorebirds. Through the help of numerous cooperators we were able to monitor 14 major stopover areas from San Francisco, CA to the Yukon-Kuskokwim Delta, AK. Over 80% of the birds marked in California and Washington were relocated in Washington, British Columbia and Alaska. Birds ($n = 7$) were detected on their breeding grounds on the Yukon-Kuskokwim Delta, AK, some over 4000 km away from their banding sites. Scientifically, a great deal of new knowledge was gathered.

Relocations revealed that the single most important stopover site for the radiomarked birds was the Copper River Delta, AK, where 61% of the birds were detected. This detection rate is almost identical to what Iverson et al. (in review) found (62%) in the 1992 radiotelemetry study of western sandpipers. Previously, Isleib (1979) estimated that > 90% of western sandpipers stop at CR during their northward migration .

Table 5. Mean number of travel days of Western Sandpipers between sites, 1995.

Depart-Arrive	Km	x	*n*	SD	Min	Max	x Speed km/day
San Francisco to:							
Grays Harbor	1110	3.0	5	2.0	1	6	370
Male (M[1])		3.5	4	1.9	2	6	317
Female (F[2])		1	1	-	1	1	1110
Fraser	1350	3.5	8	1.8	1	6	386
Male		3.2	6	1.7	1	5	422
Female		4.5	2	2.1	3	6	300
Stikine-M	2410	6.0	2	2.8	4	8	402
Yakutat-M	2940	9.5	2	3.5	7	12	309
Copper	3250	8.3	16	2.8	4	15	392
Male		9.6	10	2.6	6	15	339
Female		6.0	6	1.4	4	8	542
Cook Inlet-F	3590	7.0	3	4.4	4	12	513
Bristol Bay-F	4000	6.0	1	-	6	6	667
Yukon-Kuskok.	4200	22.3	3	5.7	16	27	188
Male		21.5	2	7.8	16	27	195
Female		24	1	-	24	24	175
Honey Lake to:							
Grays Harbor-M	790	5.5	2	2.1	4	7	144
Fraser	1030	7.0	3	4.4	2	10	147
Male		5.5	2	4.9	2	9	187
Female		10	1	-	10	10	103
Stikine -M	2090	8	1	-	8	8	261
Yakutat-M	2620	12.5	4	5.1	6	17	210
Copper	2930	11.8	11	2.9	7	18	248
Male		12.9	8	2.4	10	18	
Female		9.0	3	2.6	7	13	
Yukon-Kuskok-F	3880	22	1	-	22	22	176
Grays Harbor to:							
Fraser-M&F	240	1	1	-	1	1	240
Stikine-M	1300	3.0	2	2.7			433
Copper	2140	4.9	11	2.2	3	9	437
Male		4.8	6	2.3	3	9	446
Female		5.0	5	2.3	3	9	428
Cook Inlet	2480	8.0	1	-	1	1	310
Bristol Bay-M	2890	4.0	2	2.8			963
Yukon-Kusk	3090	14.4	5	6.2	5	21	215
Male		12.7	3	7.1	5	19	243
Female		17.0	2	5.7	13	21	182

[1]M = Male; [2]F = Female

Our findings, however, suggest that 90% may be a high estimate. We were more likely to detect males at the CR and males were significantly more likely to stop before reaching CR. And, males from San Francisco, CA and Honey Lake, CA took significantly longer to reach CR than did females. This may be a function of both the male body condition and their smaller body size. Another important site in 1995 was the Fraser River Delta, BC, where 21% of the marked birds were relocated.

We found no differences between sexes in the length of stay of birds at banding sites or at stopover sites. Length of stay of birds at their banding sites varied significantly by site, however, Honey Lake birds accounted for most of the differences observed. Honey Lake westerns stayed about half the time (3.2 days vs. 7+ days) after being radiomarked than did the San Francisco and Grays Harbor birds. Suitable shorebird habitat within the Great Basin can vary greatly between years depending on rainfall, and within season conditions can change significantly within a few days. This may select for rapid turnover at these types of sites as suggested by Skagen and Knopf (1994) for shorebirds migrating across the Great Plains.

Away from banding sites, turnover of radiomarked westerns was generally rapid (1-4 days), and the closer birds got to the Copper River Delta, the faster the turnover rate was. These turnover rates are similar to rates (1-3 days) estimated by Butler et al. (1987) for westerns migrating southwards. Birds marked at SF and HL and subsequently seen at GH stayed an average of 3.7 days at GH, considerably shorter than birds marked at GH (see Table 3). This points to the possibility of a radio effect. Shorebirds can lose significant body mass within a few hours in captivity (Warnock 1994), but radiomarked westerns in this project were generally released within 20 minutes of capture. It may be that radiomarked birds require a few extra days to acquire additional reserves to offset carrying a radio; although, then one would have expected HL birds to have remained longer than their 3.2 day average since birds banded at SF and GH stayed between 7-10 days on average.

For the first time, we established northward migration routes for Western Sandpipers passing through the western Great Basin and Grays Harbor, WA. Western Great Basin birds, represented by birds marked at HL, were relocated at coastal sites from

Grays Harbor, WA to the Yukon-Kuskokwim Delta, AK. Honey Lake birds were typically found in the last pulses of birds to migrate through the sites from Grays Harbor, WA to the Copper River Delta, AK. As previously mentioned, Honey Lake birds had the slowest rate of migration to the Copper River Delta, AK. In the western Great Basin, the spring of 1995 was very wet, and feeding habitat was abundant.

With favorable conditions, these birds may migrate slowly through the Great Basin before shifting to the coast. Westerns can be abundant in the Willamette Valley, OR during spring (Paulson 1993). A possible migration route for these interior migrating western sandpipers is to travel up the western side of the Great Basin into the Willamette Valley of Oregon to the Columbia River, and then shift westward to the Washington coast. Few Honey Lake birds were picked up south of Yakutat Forelands, AK, (n=6) but monitoring at sites south of Alaska may have ended too early for some of these birds. Seventy-two percent of the birds marked at Honey Lake were detected at either YF or CR.

Birds radiomarked at Grays Harbor, WA were generally first detected at the CR, and they also appear to utilize a coastal migration route. A total of 36% of the birds marked at GH were detected at coastal sites to the south of the CR, while 71% were detected at the CR.

Patterns for SF birds were similar to those found by Iverson et al. (in review) in 1992, with a few exceptions. A larger proportion of SF banded birds were detected at GH (17% in 1995 vs. 4% in 1992). Coverage at GH in 1992, however, was from the ground and only at the Bowerman Basin area. No birds were detected at Humboldt Bay, CA, although coverage there was limited. Given the large size of Humboldt Bay, CA (Gerstenberg 1979), aerial coverage is probably needed to accurately search for birds there. Forty-five percent of the SF birds were detected between GH and FR, and 55% were detected at the CR.

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