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MIGRATION OF WESTERN SANDPIPERS: LINKS BETWEEN THEIR ALASKAN STOPOVER AREAS AND BREEDING GROUNDS

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ABSTRACT.—Thirty-two radiomarked Western Sandpipers (*Calidris mauri*), tagged in California and Washington, were relocated at stopover and breeding sites north and west of the Copper River Delta, Alaska. At Cook Inlet, Alaska, seven of the nine relocated birds were at Redoubt and Kachemak bays. Only 1 of the 17 birds relocated on the Yukon-Kuskokwim Delta had been previously detected at Cook Inlet. Detections of birds in western Alaska provide evidence that the Yukon-Kuskokwim Delta is the final breeding destination for many of the birds migrating through San Francisco and other Pacific Coast areas. The Mulchatna River area, 325 km southeast of the Yukon-Kuskokwim Delta, may support a breeding population of Western Sandpipers. *Received 12 Jan. 1998, accepted 30 July 1998.*

The Western Sandpiper (*Calidris mauri*) has been the subject of much recent research (Warnock and Takekawa 1995, 1996; Butler et al. 1996; Iverson et al. 1996). As with most Arctic breeding shorebirds that migrate through North America, much remains to be learned about their use of different areas during various stages of the annual cycle. In Alaska, Western Sandpipers breed primarily on the Alaska Peninsula north of the Aleutian Range to Nelson Lagoon (Gill et al. 1981; Kessel and Gibson, pers. comm.), along the western and northern coasts from Bristol Bay and the Kashunuk River to the Seward Peninsula, and less frequently to Point Barrow and northeastern Siberia (American Ornithologists' Union 1983). They winter along both coasts of North America, from southern Washington and southern New Jersey south through Central America to Peru (Wilson 1994).

Work we have done with others (Iverson et al. 1996) showed that Western Sandpipers radiomarked at San Francisco Bay in April rapidly migrate north towards Grays Harbor and the Fraser River Delta and then northwest towards their breeding grounds, with stops at major estuaries along the coast. We tracked five birds as far northwest as Cook Inlet, Alaska, approximately 350 km west of the Copper River Delta, a key spring stopover area (Isleib 1979, Iverson et al. 1996). It has been speculated that Cook Inlet is the next important stopover site for Western Sandpipers migrating from the Copper River Delta (Isleib 1979, Senner 1979, Senner et al. 1981), but information remains scarce on spring migratory routes farther west. In this paper, we report on the migration of radiomarked Western Sandpipers captured in California and Washington to areas west of the Copper River Delta and their relative use of sites intermediate between

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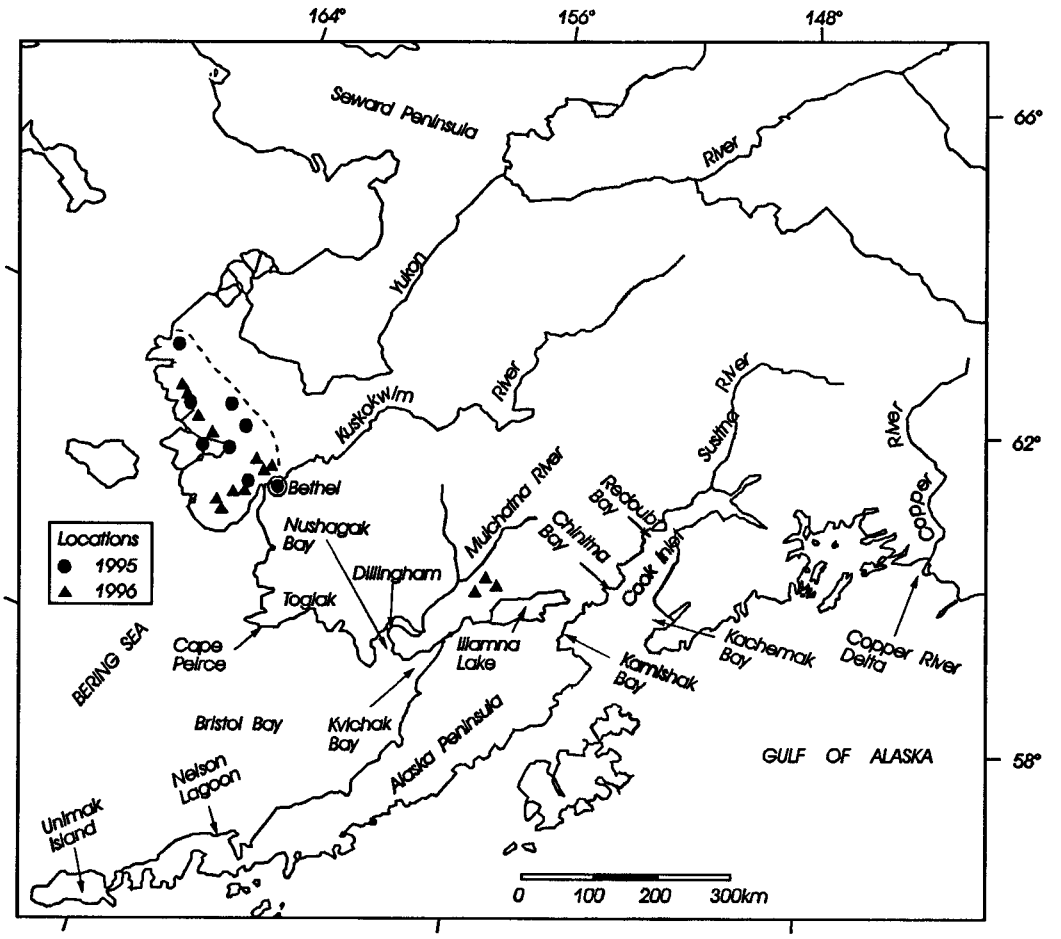

FIG. 1. Alaska monitoring sites west of the Copper River Delta and relocations of radiotagged Western Sandpipers on known and probable breeding grounds. Dashed line denotes eastern extent of Yukon-Kuskokwim Delta survey area.

the Copper River Delta and the Yukon-Kuskokwim Delta.

METHODS

We captured Western Sandpipers between 17–30 April 1995 (n = 61) and 17 April–3 May 1996 (n = 71) at San Francisco Bay, California; Grays Harbor, Washington; and Honey Lake, California (a western Great Basin wetland). Birds were trapped and radiomarked using methods described by Warnock and Warnock (1993) and Warnock and Bishop (1998). Sex was determined based on exposed culmen measurements (males < 24.2 mm, females > 24.8 mm; Page and Fearis 1971). Radiotransmitters were active up to 42 days and had a retention time of at least seven weeks (Warnock and Warnock 1993). Detection of radio signals varied by method: range was less than 2 km from the ground using a hand-held antenna and 4–10 km from an airplane.

Cooperators communicated daily about departures and arrivals of radiomarked birds at each site. We searched for radiomarked sandpipers from fixed-wing aircraft at five areas west of the Copper River Delta, Alaska: Cook Inlet, Lake Iliamna to Mulchatna River (1996 only), Bristol Bay, Alaska Peninsula, and Yukon-Kuskokwim (YK) Delta (Fig. 1). Aerial flights varied in number and timing by area and year (Table 1), and were conducted 150–1200 m above ground level depending on the area and weather. Yagi or H antennas were fixed to each wing strut of the aircraft. During 1996, additional monitoring was conducted from the ground at Cape Peirce and Susitna Flats.

Three cooperators regularly monitored intertidal areas at Cook Inlet from Chinitna Bay north to Susitna Flats on the west side of the inlet, and at Kachemak Bay/Fox River Flats area (hereafter referred to as Kachemak Bay) on the east side of the inlet. Intertidal areas at Bristol Bay were monitored regularly at Cape

TABLE 1. Telemetry methods (A = aerial, G = ground) and field effort (days) for monitoring migratory movements of radiomarked Western Sandpipers west of the Copper River Delta, Alaska, April–May 1995, 1996.

Location	Method	Monitoring dates 1995	Monitoring dates 1996
Cook Inlet			
Susitna Flats-N. Redoubt Bay	G		24–25 April, 8–15 May[c]
	A	2, 4, 6, 8, 10, 12, 13, 16, 18 May	
Redoubt-Chinitna Bays	A, G	3–5, 8–10, 12, 14 May[a]	1, 3, 6–11, 13, 14 May[d]
Kachemak Bay/Fox River Flat	A	29 April–16 May[b]	28 April–17 May[e]
Lake Iliamna-Mulchatna River	A		29, 31 May
Bristol Bay			
Kvichak-Nushagak Bays	A	2, 3, 5, 11, 15, 16 May	28 April–22 May, 5 June[f]
Unimak-Nelson Lagoon, Alaska Peninsula	A	11, 17, 18 May	7, 10, 14, 15, 17, 20, 29, 31 May, 1 June[g]
Dillingham-Togiak	A		30 April, 17, 20, 21 May
Cape Peirce, Hagemeister St.,	G		3–28 May
Yukon-Kuskokwim Delta	A	13, 22, 23 May	8, 10, 13, 16, 20, 23 May

[a] 1995: Flight 12 May, Redoubt Bay to Iliamna Bay; flight 14 May, Redoubt Bay to Cape Douglas.
[b] 1995: No flights 30 April, 5, 6 May.
[c] 1996: Ground effort at Susitna River.
[d] 1996: Redoubt Bay to Augustine Island 7–8 May only; other flights Chinitna Bay to West Foreland (N. Redoubt Bay).
[e] 1996: No flight at Kachemak Bay 30 April, 1, 12 May.
[f] 1996: No flights 5, 6, 12, 13, 16, 20 May. Most flights Egegik to Cape Constantine. Flight 9 May included Kulukak Bay. Flight 5 June inland from Naknek to Kulukak Bay.
[g] 1996: West side of Alaska Peninsula. Flights varied, Unimak (east) to Moffet Bay, and Cold Bay to Nelson Lagoon. 7 May flight followed coastline.

Peirce (westernmost Bristol Bay, 1996 ground coverage only), and Nushagak and Kvichak bays. On the Alaska Peninsula between Unimak and Nelson Lagoon, lowland areas within 32 km of the coast were monitored for radiomarked sandpipers concurrent with low-level aerial surveys for other wildlife species (Table 1). Upland areas were also monitored opportunistically on four flights between Togiak and Dillingham. Potential breeding habitat was surveyed for radioed birds twice between Lake Iliamna and Mulchatna and once at Bristol Bay. On the YK Delta, regular monitoring flights for breeding birds alternated between upland areas northwest and southwest of Bethel.

For analyses, dates were converted into Julian dates (JD). Statistical analyses were performed using STATA (ver. 5.0, StataCorp, College Station, TX 1997). Significance level for tests was $P \leq 0.05$. Data are reported as $\bar{x} \pm 1$ SD.

RESULTS

Of 132 Western Sandpipers radiomarked in California and Washington, we detected 32 at monitoring sites north and west of the Copper River Delta: 14 in 1995 and 18 in 1996 (Table 2). In 1996, one bird was detected at two locations, first in the western Cook Inlet and 12 days later on the YK Delta. Earliest date for monitoring was 28 April (Kachemak Bay,

TABLE 2. Detections of radiomarked Western Sandpipers at areas north and west of the Copper River Delta, Alaska. May 1995, 1996.

		No. banded[a]		Cook Inlet		Bristol Bay		Mulchatna[b]	Yukon-Kuskokwim Delta	
Banding location	Sex	1995	1996	1995	1996	1995	1996	1996	1995	1996
San Francisco	Male	16	11	0	0	0	2	1	2	0
	Female	13	15	3	3	1	0	1	1	3
Honey Lake	Male	12	7	0	0	0	0	0	0	0
	Female	6	5	0	0	0	0	1	1	0
Grays Harbor	Male	7	21	1	1	1	0	0	1	6
	Female	7	6	1	0	0	0	0	2	0
	Unknown	0	1	—	0	—	0	0	—	1

[a] Does not include banded birds that lost radios, had interference with other radios in the Bristol Bay area or were known to be predated.
[b] Not monitored in 1995.

1996) and the first bird was detected on 2 May (1995) at Kachemak Bay.

Nine radiomarked birds were detected at four sites in Cook Inlet, including four at Redoubt Bay, three at the Kachemak Bay, and one each at Tuxedni and Chinitna Bays (western Cook Inlet). Six of the nine birds (66%) had previously stopped on the Copper River Delta, including one bird that returned to the Copper River after a one day stay at Kachemak Bay. Arrival dates at Cook Inlet ranged from 2–14 May ($\bar{x}$ = 9 May ± 4 days, n = 9). We failed to find a significant difference between arrival date of San Francisco birds and Grays Harbor birds (Kruskal-Wallis: χ^2_1 = 2.40, $P > 0.05$), but the power of this test is low (Table 2).

Four radiomarked birds were detected in northeast Bristol Bay: three at Kvichak Bay and one on the Igushik River near Nushagak Bay. Two of the four birds had stopped at the Copper River Delta. The other two birds had been previously detected only at their San Francisco and Grays Harbor banding sites. Arrival dates at Bristol Bay ranged from 3–11 May ($\bar{x}$ = 8 May ± 4 days, n = 4). No radiomarked birds were detected on survey flights along the Alaska Peninsula, at the Cape Peirce ground monitoring site, nor on flights between Dillingham and Togiak.

Combining years, 20 birds were relocated on known or suspected breeding grounds (Table 2, Fig. 1). One male and two females were located between the Stuyahok and Koktuli rivers northeast of the confluence of the Nushagak and Mulchatna rivers on 29 and 31 May 1996. All three birds had previously stopped at the Copper River Delta. On the YK Delta, 17 birds were detected at locations up to 120 km from the coast. Ten of the 17 birds are known to have stopped on the Copper River. Two birds, both banded at Grays Harbor, were not detected at any monitoring site except the YK Delta.

Although ground crews at the YK Delta first recorded Western Sandpipers on 8 May in 1995 and 7 May in 1996 (Ely, pers. comm.), first date of detection for the 17 radiomarked Western Sandpipers at the YK Delta was 13–23 May ($\bar{x}$ = 20 May ± 4 days, n = 17). We found no significant difference in first date of detection at the YK Delta for birds radiomarked at San Francisco (n = 6) and birds radiomarked at Grays Harbor (n = 10, Kruskal-Wallis: χ^2_1 = 3.40, $P > 0.05$; insufficient data to test Honey Lake birds). We also failed to find a significant difference in the number of Honey Lake birds (1 of 30) and the number of San Francisco birds (6 of 55) detected at the YK Delta (χ^2_1 = 1.47, $P > 0.05$), and in number of Grays Harbor (10 of 42) vs San Francisco birds detected at the YK Delta (χ^2_1 = 2.9, $P > 0.05$). Grays Harbor birds were significantly more likely to be detected at the YK Delta than Honey Lake birds (χ^2_1 = 5.7, P = 0.02).

DISCUSSION

Isleib (1979) suggested that after the Copper River Delta, lower Cook Inlet (Kachemak and Kamishak Bays; Fig. 1) provided the next suitable stopover habitat for Western Sandpipers migrating toward their breeding grounds. Kamishak Bay has rarely been monitored because of its remote location (only one survey during this study) whereas historically as many as 100,000 small sandpipers have been recorded at Kachemak Bay and Redoubt Bay (upper Cook Inlet, approximately 110 km northwest of Kachemak Bay) on same day surveys (Gill and Tibbitts, unpubl. data). During our study, seven of the nine Cook Inlet detections were at Kachemak and Redoubt Bays. Peak day shorebird numbers for these two areas were relatively low: fewer than 20,000 shorebirds at Redoubt Bay (1996 only; Bennett, pers. comm.) and fewer than 11,000 birds at Kachemak Bay in both years (West, pers. comm.; Kleinleder, pers. comm.). In contrast, during spring 1997 peak day numbers of more than 150,000 Western Sandpipers were recorded on 10 May in Redoubt Bay (Gill and Tibbitts, unpubl. data). These numbers suggest that use of Cook Inlet by Western Sandpipers varies between years, and 1995 and 1996 may have been low use years.

The migratory route of birds flying past the Copper River Delta is still uncertain. Only 1 of the 17 birds relocated on the YK Delta breeding grounds had been previously detected at Cook Inlet, but we may have missed others because our coverage was not complete. Birds could be using Cook Inlet in large numbers for short periods of time, perhaps only when weather prohibits passage over the mountains. During our study, average length

of stay for birds stopping at Cook Inlet was less than two days (Warnock and Bishop 1998). Within one day's time, birds could fly from the Copper River Delta directly west over the Kenai Peninsula and Cook Inlet, continuing up the Drift River into interior western Alaska (Gill, pers. comm.), a distance of approximately 500 km.

Some Western Sandpipers may overfly Cook Inlet on the way to their breeding grounds. Daily aerial coverage during our two seasons at Kachemak Bay yielded only 3 of 127 radiomarked birds. Furthermore, with the exception of Redoubt Bay, our extensive coverage of northern Cook Inlet (Trading Bay and Susitna Flats) revealed no radiomarked birds. None of the birds detected at Cook Inlet were found in either the Bristol Bay area or the Mulchatna River area. Cook Inlet may serve as a stopover for birds breeding north of the YK Delta. Other studies support this suggestion. Senner and coworkers (1981) detected significant morphometric differences between Western Sandpipers stopping at Cook Inlet (Kachemak Bay) and those stopping at the Copper River Delta. More recently, relocations of Western Sandpipers colormarked at winter sites in Mexico, Panama, and Peru included several resightings of northward bound birds at the Copper River Delta, but none within Cook Inlet (Butler et al. 1996). Clarification of the origin and destination of Western Sandpipers using Cook Inlet requires further study.

Small numbers of Western Sandpipers stop regularly on the intertidal areas in northeastern Bristol Bay. Western Sandpipers are known to breed on the Alaska Peninsula (Gill et al. 1981; Dewhurst, pers. comm.; Kessel and Gibson, pers. comm.), but we detected no radiomarked birds on the Peninsula nor at Cape Peirce the westernmost end of Bristol Bay, where Western Sandpipers breed in low numbers (Winker, pers. comm.). However, our coverage of these areas was limited.

To the east of Bristol Bay, in the Mulchatna River area, we detected three radiomarked birds. It is possible that these birds were late migrants. Egg laying on the YK Delta ranges from 19 May–20 June (Brandt 1943, Gabrielson and Lincoln 1959, Holmes 1972), and these three birds were detected on 29 and 31 May. Peak egg laying on the YK Delta occurs during the last few days of May. However, the three birds we detected on the Mulchatna River area had not been detected at the Copper River Delta since 10 (n = 2) and 15 May (n = 1). Given the rapid rate of travel and quick turnover at stopovers that we have observed in migrating Western Sandpipers (Warnock and Bishop 1998) it seems highly unlikely that these birds would have taken so long to traverse this section of their migration route. In 1997, at New Stuyahok, approximately 70 km southwest of the Mulchatna sightings, Brann and Andres (unpubl. data) recorded Western Sandpipers as possible breeders. We suggest the area around Mulchatna River supports a breeding population of Western Sandpipers. Ground work is needed to clarify this potential breeding range extension.

Our 17 detections of radiomarked Western Sandpipers at interior sites at the YK Delta provide evidence that the YK Delta is the final breeding destination for many of the birds migrating through San Francisco and other Pacific Coast areas. Determination of whether there are significant differences in detections of birds at breeding areas based on their spring banding location is hampered by our small sample sizes and limited coverage. In the two years of this study, we detected only two Honey Lake birds at potential breeding areas: one on the YK Delta and the other at Mulchatna. Honey Lake birds may migrate farther north to breeding areas on the Seward Peninsula, a major breeding area (Kessel 1989) that we did not monitor.

In summary, we have documented a link between coastal and inland stopover sites for Western Sandpipers migrating from San Francisco and Honey Lake, California, and Grays Harbor, Washington, north to breeding grounds on the YK Delta of western Alaska. Our detections suggest that birds departing the Copper River Delta migrate quickly to their breeding areas, with brief intermediate stops. Further studies on the relationships between spring migration routes and specific breeding areas are warranted, especially with an increased search effort of potential breeding areas. These data would complement and expand our understanding of the ecology and evolution of Nearctic migrants.

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