FINAL REPORT

ABUNDANCE AND DISTRIBUTION OF SHOREBIRDS USING INTERTIDAL HABITATS OF IZEMBEK NATIONAL WILDLIFE REFUGE, ALASKA

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ABSTRACT

We conducted repeated aerial and ground-based surveys in intertidal habitats of Izembek National Wildlife Refuge (NWR), Alaska, in autumn (July-October 1993), to assess the refuge's importance as a shorebird staging area. We conducted less intensive surveys in winter (November 1993, February 1994) and spring (May 1994) to characterize the shorebird population in these seasons. We recorded 28 of the 31 species of shorebirds known to occur on the refuge in autumn and estimated the size of the staging population to be between 78,000 and 285,000 birds. Rock Sandpiper, Dunlin, and Western Sandpiper accounted for over 95% of all birds recorded on aerial surveys. The wintering population consisted of about 9,000 individuals of two species, Rock Sandpiper and Sanderling. Our data qualify Izembek NWR for inclusion in the Western Hemisphere Shorebird Reserve Network.

Shorebird distribution varied both temporally and among species. In early autumn, the majority of shorebirds foraged on intertidal flats and roosted on sea beaches in the northeast portion of Izembek Lagoon, whereas, in late autumn most birds used intertidal flats in Moffet Lagoon. In late winter, birds were present only in ice-free areas near lagoon entrances. Rock Sandpipers were more likely than Dunlin to be found on Bering Sea beaches, and Dunlin were more prevalent than Rock Sandpipers in Moffet Lagoon.

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INTRODUCTION

Several estuaries and lagoons along the Pacific Coast of North America serve as staging areas for migrating shorebirds (Senner and Howe 1984, Gill et al. 1994). These areas provide feeding and resting opportunities for birds during their lengthy migrations between breeding and wintering grounds (Myers et al. 1987). Recent studies have emphasized the importance of these staging areas to the welfare of entire populations of migratory shorebirds and have highlighted the need to protect food and habitat resources at these sites (e.g., Hicklin 1987, Clark et al. 1993, Iverson et al. 1996).

In the past fifteen years, conservation biologists have formed organizations to promote international recognition of important staging areas with the understanding that recognition is the first step towards protection of any vulnerable resource. These organizations encourage groups in all countries within a flyway to identify and, if appropriate, to manage their important shorebird staging areas. The ultimate goal of such actions is to create a network or system of shorebird reserves that includes all critical sites throughout each species' range. The underlying tenet of these networks is that migrating shorebirds depend on specific sites to fuel their flights to succeeding sites. Thus, any degradation or disturbance to a site along a migratory route can interfere with migration and, in cases where a major portion of a population concentrates at one site, can adversely affect an entire population.

Two international organizations are involved in the conservation of Alaska shorebirds: the Western Hemisphere Shorebird Reserve Network (WHSRN), which is concerned with Nearctic populations, and the East Asian-Australasian Shorebird Reserve Network (EAASRN), which focuses on eastern Palearctic populations, but also recognizes the Nearctic component that migrates to Australasia and Oceania. These organizations have developed different criteria to designate and rank sites within their networks. WHSRN classifies sites based on the following criteria:

* Hemispheric sites support at least 500,000 shorebirds annually, or 30% of a species' flyway population;
* International sites support at least 100,000 shorebirds annually, or 15% of a species' flyway population;
* Regional sites support at least 20,000 shorebirds annually, or 5% of a species' flyway population; and
* Endangered species sites are critical to the survival of endangered species thus, no minimum number of birds is required.

EAASRN uses a modified version of the Ramsar Convention site designation criteria:

* Site regularly supports greater than 20,000 migratory shorebirds; or
* Site regularly supports greater than 1% of the individuals in a population of one species or subspecies of migratory shorebird; or
* Site supports appreciable numbers of an endangered or vulnerable population of migratory shorebird.

Along the Pacific flyway of North America, the WHSRN program has officially designated two hemispheric sites (Copper River Delta, Alaska, and San Francisco Bay, California), and three international sites (The Grasslands and Mono Lake, California, and Kachemak Bay, Alaska). Several other staging areas along this flyway qualify as important sites under both the WHSRN and EAASRN programs, but they await official designation (Gill et al. 1994). Researchers agree that numerous other areas, especially in

Alaska, qualify as either WHSRN or EAASRN sites, and efforts are being made to include them within one or both networks.

One such area is the Izembek-Moffet Lagoon complex of the Izembek National Wildlife Refuge (NWR) located on the western end of the Alaska Peninsula (Fig. 1). The importance of these lagoons to migratory waterfowl is well established, indeed, in 1986 they were identified as a wetland of international importance under the Ramsar Convention (Smart 1987). The value of these lagoons to shorebirds is less certain, but information collected prior to 1993 suggests the area might be important to several populations. This information includes: 1) records from refuge files indicating that thousands of migratory shorebirds used the area in late summer and autumn and that adjacent uplands and marshes supported large breeding populations of such species as Rock Sandpiper (see Appendix B for scientific names of shorebirds), Least Sandpiper, and Semipalmated Plover; 2) high single-count surveys during which > 26,000 shorebirds were recorded in autumn (R. E. Gill, unpubl. data); 3) the proximity (< 100 km) of the refuge to Nelson Lagoon-Mud Bay, a potential hemispheric site under the WHSRN program (Gill and Jorgensen 1979, Gill et al. 1994, R. E. Gill, unpubl. data); and 4) observations by refuge staff suggesting that Izembek and Moffet lagoons provide the only consistently available habitat for shorebirds wintering on the north side of the Alaska Peninsula (C. P. Dau, unpubl. data). Based on this preliminary information, in July 1993 the Alaska Science Center, in cooperation with staff of the Izembek NWR, began a study of these lagoons to assess their importance to shorebirds. Here we report the result of this study and provide an evaluation for the inclusion of Izembek-Moffet lagoons within the WHSRN and EAASRN programs.

STUDY AREA

Fieldwork for this study occurred 6 July-20 October 1993, 4 and 30 November 1993, 21 February 1994, and 11-24 May 1994. We focused on the two areas of Izembek NWR that contain significant amounts of habitat for migrating shorebirds: the interconnected Izembek and Moffet lagoons and Kinzarof Lagoon located along the south side of the peninsula and separated from Izembek Lagoon by a 5 km-wide peninsula (Fig. 1).

Izembek and Moffet lagoons comprise a 350 km^2 shallow embayment covered by extensive eelgrass meadows (*Zostera marina*) (157 km^2) and unvegetated tideflats (125 km^2), both of which are drained by numerous tidal channels (Markon 1987) (Fig. 2). The lagoons are surrounded by rocky and muddy shorelines and shielded from the Bering Sea by barrier islands and sand spits (Fig. 3). Coastal marshes and large expanses of tussock-heath tundra lie adjacent to the lagoons (Fig. 4) and are crisscrossed by several streams and one major river. The low relief (< 10 m) barrier islands are fringed seaward with sandy beaches and covered with beach rye (*Elymus arenarius*). The much smaller Kinzarof Lagoon (20 km^2) is characterized by low bluffs and pebble beaches along the north shore and covered throughout with eelgrass meadows (11 km^2) and unvegetated tideflats (6 km^2) (C. P. Dau, unpubl. data). The barrier islands of Kinzarof Lagoon are less elevated (< 2 m) and more sparsely vegetated than those enclosing Izembek and Moffet lagoons. Tides in Izembek and Moffet lagoons are both semi-diurnal and mixed semi-diurnal with a mean diurnal range of about 1.0 m (U.S. Department of Commerce 1993). Tides in Kinzarof Lagoon have a mean diurnal range of about 2.2 m and corresponding high and low tides occur on average about four hours later than in Izembek Lagoon.

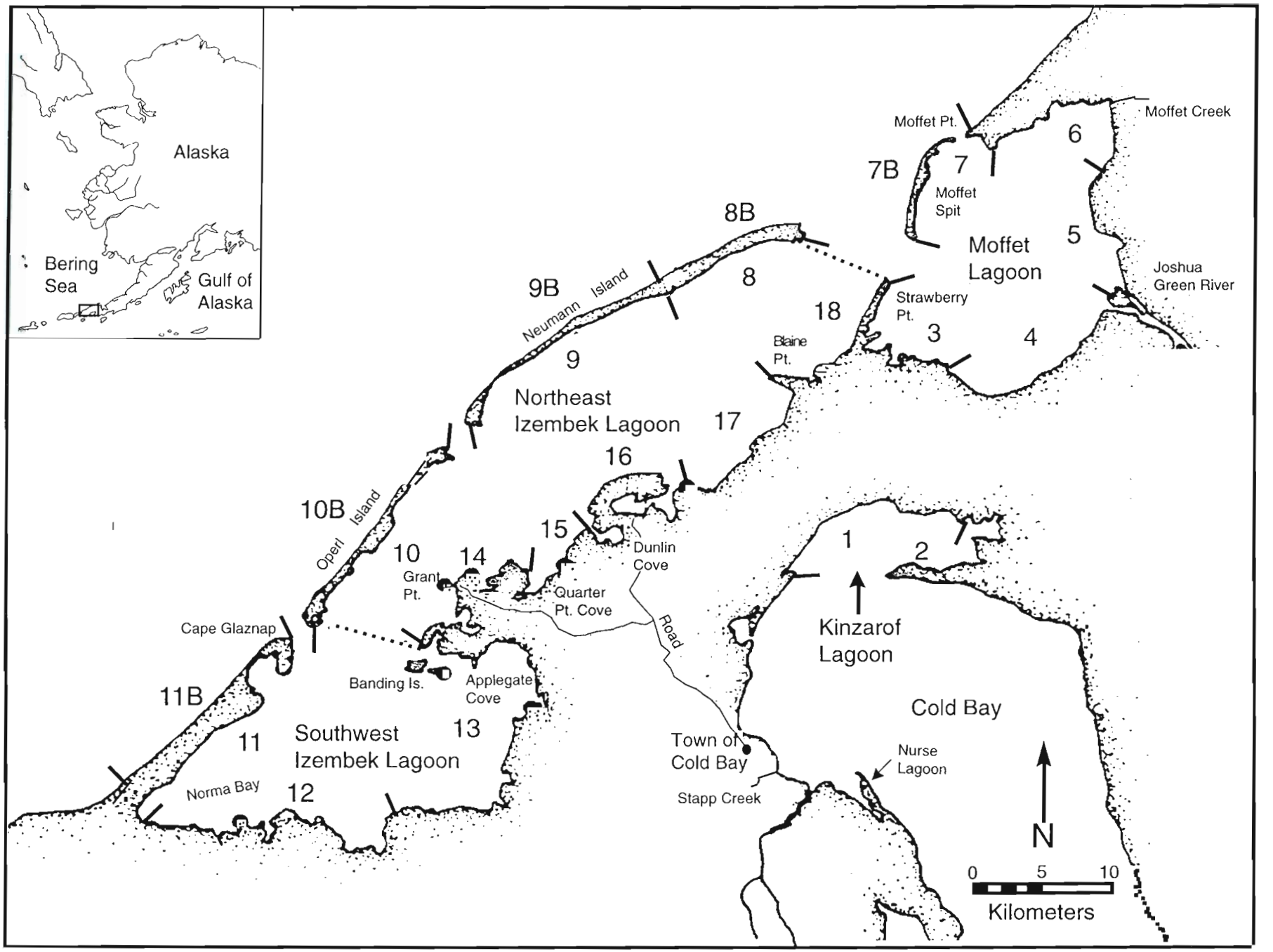

Figure 1. The study area at Izembek NWR, showing the 4 census areas and the 16 segments surveyed during aerial and ground efforts.

Figure 2. Shorebirds on eelgrass meadows and intertidal flats in Moffet Lagoon.

Figure 3. The outer beach of Neumann Island.

Figure 4. Coastal marshes in northeast Izembek Lagoon.

Autumn Conditions

Day length at latitude 55° N latitude decreases markedly throughout the autumn, from about 16 h on 1 August to 11.5 h on 1 October, and to 8.5 h by 1 November. The climate of the distal Alaska Peninsula is basically maritime but becomes more continental in winter when ice covers portions of the Bering Sea. Local weather during July-October is characterized by low clouds, wind, and rain. Mean daily temperature decreases from about 10.5° C during July and August to 8.3° C in September and 4.2° C in October. Differences between daily maximum and minimum temperature average less than 2° C between July and October. Fog and complete cloud cover are common on most (80%) days during July and August. Precipitation occurs on no fewer than 27 days each month between July and October and averages 5.6 cm in July and 11.0 cm in October. Snow squalls are common by mid-October, but total less than 6.0 cm accumulation for the month. The mean annual velocity of surface wind is 27 kph. During July and August winds are predominantly from the southeast and northwest at an average speed of 29 and 25 kph, respectively. Beginning in late September, prevailing winds occur from the southwest to the northwest at an average speed of about 20 kph. This shift coincides with a shift in the major northeast Pacific storm track from the southern Bering Sea south into the Gulf of Alaska. From September through November an average of 3-5 major low pressure systems per month move across the Northeast Pacific and pass just south of the Alaska Peninsula (Brower et al. 1988, U.S. Department of Commerce 1993).

METHODS

The size and remoteness of the study area required us to use a combination of aerial surveys, ground-based sampling, and a limited color-marking program to achieve our objectives. We used aerial surveys to assess: a) the size of the autumn (July-October) and winter (November-February) shorebird populations, b) the relative abundance of each species throughout the season, and c) the distribution of shorebirds throughout the study area. We used ground-based sampling to adjust aerial estimates of relative abundance (see following), and to track temporal changes in age composition of populations. Color-marked individuals allowed us to assess intra-lagoon movements of birds. This approach has been used successfully in similar studies at other large estuaries [e.g., Bay of Fundy (Hicklin 1987), Yukon Delta (Gill and Handel 1990), San Francisco Bay (Page et al. 1992)].

To coordinate aerial and ground efforts, we divided the study area into 18 survey segments (Fig. 1). Segments were delineated based on habitat type and prominent landmarks. For most analyses, survey segments were grouped by major physiographic components of the study area: southwest and northeast Izembek Lagoon, Moffet Lagoon, and Kinzarof Lagoon. We measured abundance of the different shorebird habitats within these groupings (Table 1). The intertidal areas of southwest Izembek Lagoon and Kinzarof Lagoon were dominated by eelgrass meadows, northeast Izembek Lagoon was covered almost equally by eelgrass meadows and unvegetated tideflats, while Moffet Lagoon was dominated by unvegetated tideflats (Table 1).

Table 1. Composition of shorebird habitats within the four census areas of the study area.[1]

	Izembek Lagoon[2]							
	Southwest		Northeast		Moffet Lagoon[2]		Kinzarof Lagoon[3]	
Habitat	ha	%	ha	%	ha	%	ha	%
Eelgrass meadow	6,400	74.4	7,300	54.5	2,000	25.0	1,100	61.1
Unvegetated tideflat	1,400	16.3	5,500	41.0	5,600	70.0	600	33.3
Barrier island	800	9.3	600	4.5	400	5.0	100	5.6
Total	8,600	100.0	13,400	100.0	8,000	100.0	1,800	100.0

[1] See Fig. 1 for delineation of census areas within the study area.
[2] Values from 1987 Landsat image (Markon 1987) rounded to the nearest hundred.
[3] Values measured by planimeter from 1:36,000 aerial photos and rounded to the nearest hundred.

Aerial Surveys

Surveys were made in a PA-18 at altitudes of 30-50 m and airspeeds of 110-150 kph. Birds were surveyed within each 15-day period in autumn, twice in early winter and once in late winter (Table 2). A complete survey included the shoreline perimeters of Izembek and Moffet lagoons (254 km) and Kinzarof Lagoon (32 km). To optimize counting, we surveyed around daylight high tides when birds were concentrated in dense flocks at roosts or feeding areas. The aircraft was positioned from 50-100 m seaward of the tide line along most segments of each survey. The rear seat observer counted all shorebirds landward of the aircraft while the pilot counted birds that were either flying over the water or roosting and feeding on floating mats of eelgrass. If large expanses of intertidal flats were exposed, parallel transects were flown across the flats until the entire area was surveyed. We attempted to identify all shorebirds to species. When this was not possible, flocks were classified into one of three categories: a) small shorebirds (i.e., Rock Sandpiper, Dunlin, Western Sandpiper, Sanderling, Least Sandpiper, Baird's Sandpiper, Semipalmated Plover, and phalaropes); b) medium shorebirds (i.e., Red Knot, Short- and Long-billed Dowitcher, Sharp-tailed Sandpiper, and Pectoral Sandpiper); and c) mixed flocks of Rock Sandpiper and Dunlin. We recorded observations onto cassette tape and mapped all large concentrations of birds. The same pilot and observer flew most surveys (Table 2).

Table 2. Aerial surveys of Izembek, Moffet, and Kinzarof lagoons, 1993-1994.

Survey	Date[1]	Census period	Start relative to high tide[2]	Pilot/observer
Autumn 1993				
1	6 Jul	1-15 Jul	+1:11	Dau/Gill
2	22 Jul	16-30 Jul	+0:08	Dau/Gill
3	6 Aug	31 Jul-14 Aug	+0:05	Larned/Gill
4	22 Aug	15-29 Aug	−1:33	Dau/Gill
5	1 Sep	30 Aug-13 Sep	−1:12	Dau/Gill
6	16 Sep	14-28 Sep	+2:32	Dau/Gill
7	17 Sep	14-28 Sep	+2:25	Dau/Gill
8	1 Oct	29 Sep-13 Oct	−1:53	Dau/Tibbitts
9	13 Oct	29 Sep-13 Oct	+2:45	Dau/Gill
10	18 Oct	14-28 Oct	-0:11	Dau/Gill
Early winter (1993-1994)				
1	4 Nov	1-15 Nov	-4:04	Dau/Mason
2	30 Nov	16-30 Nov	−3:22	Dau
Late winter (1993-1994)				
1	21 Feb[3]		-1:45	Dau/Ward

[1] The following segments (see Fig. 1) were not surveyed on these dates: 6 July (8b, 9b, 11b); 22 July (7b, 10b, 11b); 22 August (7b); 16 September (7b, 11b); 17 September (11b 12, 13, 14, 15); 1 October (7b); 4 November (1, 2).

[2] Expressed as hours and minutes before (-) or after (+) predicted high water at Grant Point, Izembek Lagoon (see Fig. 1).

[3] Segments 3-5 and 14-18 were covered by ice and therefore unavailable to shorebirds.

Ground-Based Sampling

From early August to late October we regularly sampled flocks of shorebirds from the ground (Table 3). Within a few days of each aerial survey, we attempted to visit the segments where shorebirds had been observed (Appendix A) and collect information on relative abundance and age composition of each species. We traveled to these areas by small boat, float-plane, all-terrain vehicle, or on foot and sampled the first accessible flocks we encountered. During each sample, we estimated total numbers by counting by 1s, 10s, 50s, or 100s, depending on the relative size of the flock; smaller flocks were counted once and larger flocks (>1,000 birds) were counted 2-3 times. For each flock, we recorded information on stage of tide, wind direction and speed, flock behavior (roosting or feeding), and weather. The configuration of each flock was sketched in relation to macro- and micro-habitat features and we noted the location of transects used to derive information on relative abundance and age composition (see following). We worked from an *a priori* assumption that different species and ages were not randomly distributed throughout a flock (Fig. 5). Thus, for large or dispersed flocks, we sub-sampled birds by scanning with 20-60x spotting scopes along perpendicular transect lines and identifying individuals to species and age (the latter based on differences in plumage). Transects were spaced roughly equidistant throughout flocks of uniform density or were concentrated in denser portions of flocks where birds were irregularly spaced. Widths of transects were also adjusted according to the density of birds within a flock or in different portions of a flock. Information from all transects within a segment and survey period was pooled to generate a ground-based estimate of relative abundance for that segment and period; samples were excluded if we examined <10% of the total individuals within a flock.

We pooled information from all transects within periods to estimate age composition of each population. Our ability to estimate age of birds was limited by the molt chronology of each species; differences in plumage between adult and juvenile Rock Sandpipers, Sanderlings, and Western Sandpipers were discernable in the field into mid-September while those of Dunlin, Pacific Golden-Plover, and Ruddy Turnstone could be detected into mid-October.

Figure 5. Mixed-species flock of shorebirds on intertidal flats.

Table 3. Summary of ground-sampling effort within the study area, July-October 1993.[1]

	Northeast Izembek Lagoon						Moffet Lagoon			All other areas[5]		
	Beach habitats[2]			Lagoon habitats[3]			Lagoon habitats[4]			All habitats		
Census period	Obs. hrs	Flocks sampled	Birds sampled	Obs. hrs	Flocks sampled	Birds sampled	Obs. hrs	Flocks sampled	Birds sampled	Obs. hrs	Flocks sampled	Birds sampled
1-15 Jul	0			1	2	1,400	0			0		
16-30 Jul	1	2	3,173	1	1	168	0			0		
31 Jul-14 Aug	19	11	8,707	8	4	2,378	0			4	1	114
15-29 Aug	16	9	8,430	54	25	12,058	0			0		
30 Aug-13 Sep	97	17	12,811	79	12	3,015	37	10	4,672	8	0	0
14-28 Sep	80	15	6,983	43	17	9,880	31	3	330	14	3	1,057
29 Sep-13 Oct	37	1	14	62	17	10,391	30	11	18,432	9	0	0
14-28 Oct	6	2	1,070	10	7	5,787	37	6	11,543	2	0	0
Total	256	57	41,188	258	85	45,077	135	33	34,977	37	4	1,171

[1] See Fig. 1 for location of areas within the study area.
[2] Includes survey segments 8b, 9b, 10b
[3] Includes survey segments 8, 9, 10, 14, 15, 16, 17, and 18.
[4] Includes survey segments 3, 4, 5, 6, and 7.
[5] Includes survey segments 1, 2, 7b, 11, 12, and 13.

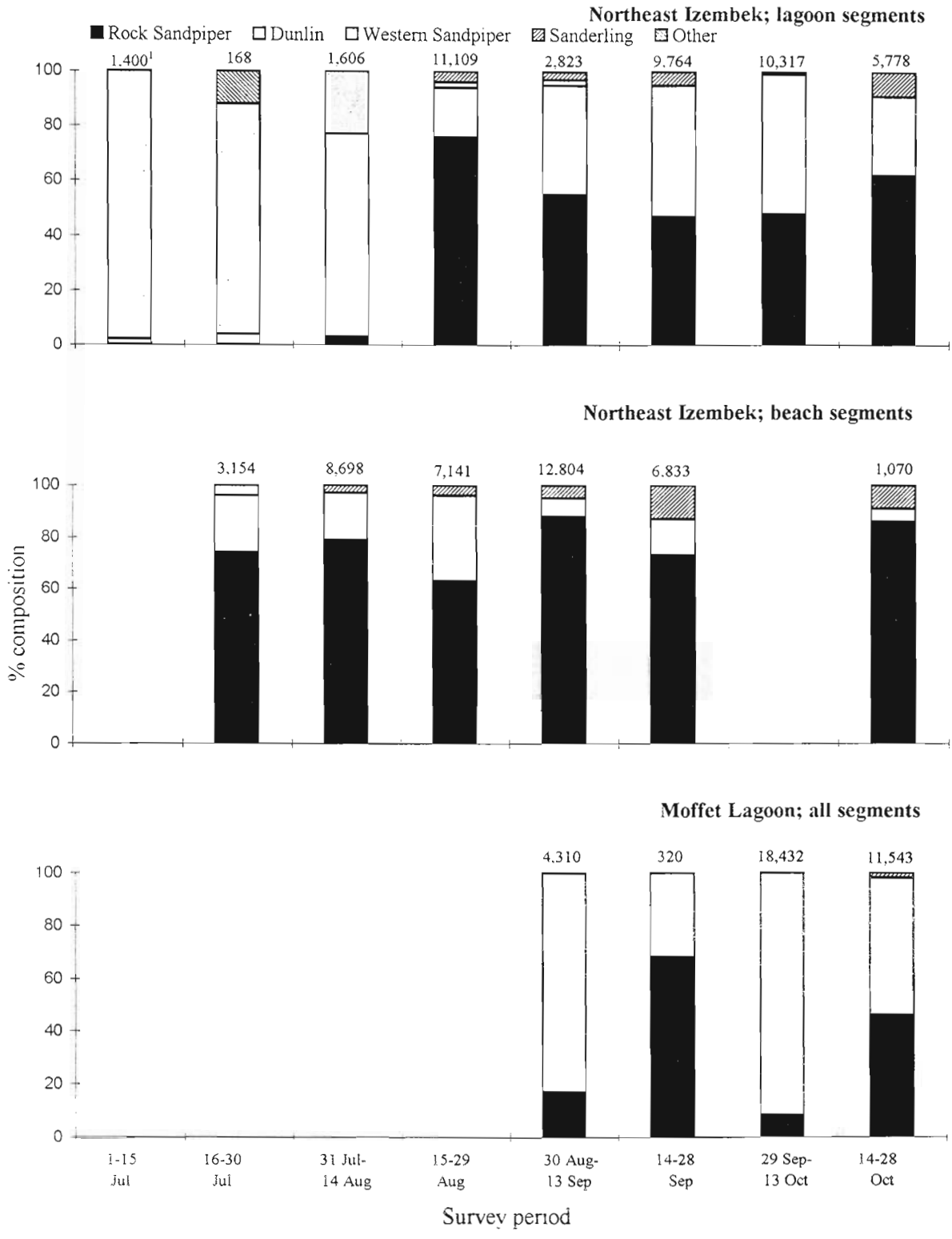

Figure 6. Ground-based estimates of seasonal species composition of the small sandpiper populations in selected census areas and segments of Izembek and Moffet lagoons, July-October 1993.

[1] Number of birds examined.

Relative Abundance

Relative abundance of each species during each survey period was estimated in one of two ways. On aerial surveys in which all birds were identified to species, we summed aerial counts across segments to derive a survey total for each species. On surveys that we were not able to identify all birds to species, we determined the relative abundance of each species within each segment by multiplying the number of unidentified birds by the proportion of each species estimated to be in that segment based on ground data (Fig. 6). These estimates were added to the number of directly identified birds to generate an adjusted survey total for each species (Appendix A). We did not derive adjusted totals for segments where ground-based information was unavailable (Table 3, Fig. 6).

Distribution And Local Movements

We examined patterns of shorebird distribution by comparing the number of birds per km of shoreline. We did this among the 13 aerial surveys, the 4 survey areas, and the 18 survey segments. We assessed the distribution of individual species among survey areas and survey periods by comparing information on relative abundance obtained during ground-based censuses. We evaluated the extent of local movements by marking individuals of three common species. Birds were captured with a CODA net gun, mist nets strung along the tide line at dusk, and mist nets held horizontally and walked over roosting birds. Dunlin and Rock Sandpipers received one or more colored plastic leg bands. The breast, belly, and vent of Sanderlings were dyed yellow with a dilute solution of picric acid. We searched for marked individuals whenever shorebird flocks were encountered and noted resighting locations on maps.

Calculation Of Population Size And Turnover

We assumed that aerial surveys provided reasonable estimates of the true number of shorebirds present during each survey period. We used the aerial survey data to estimate the size of the autumn and winter shorebird populations in two ways: a) we summed the peak counts for individual species; and b) we summed all survey totals. The first method generated a minimum population estimate because it assumed no turnover of individuals among surveys, whereas the second method generated a liberal estimate because it assumed complete turnover among all surveys. We determined the extent and pattern of turnover within a population by examining changes in its age composition throughout the study period.

RESULTS

Species Diversity

We recorded 28 species of shorebirds on the study area in autumn; 20 of these also occurred as spring migrants and 8 as local breeders (Table 4, Appendix B). In addition, two races of Rock Sandpiper (*Calidris p. couesi* and *C. p. ptilocnemis*) were present on the area throughout autumn. The former breeds locally and was the more common of the two forms; the latter breeds on the Pribilof Islands and on St. Matthew and Hall islands in the Bering Sea (Conover 1944). Of the 31 species of shorebirds that have been recorded on Izembek NWR (Table 4), 24 are Nearctic in origin, 1 is Palearctic, and 7 could be of either Nearctic or Palearctic origin or both depending on as yet unknown structuring of their breeding populations.

The species diversity of shorebirds recorded during the study steadily increased from 9 in early July to a peak of 23 by late

Table 4. Seasonal occurrence of shorebirds recorded from the study area.[1]

	Status[2]			
Species	Autumn migrant	Winter resident	Spring migrant	Breeder
Black-bellied Plover	x		?	
Pacific Golden-Plover	x		x	
Semipalmated Plover	x		x	x
Spotted Redshank	x			
Greenshank	+			
Greater Yellowlegs	x		?	
Lesser Yellowlegs	+		x	
Wandering Tattler	x		x	?
Gray-tailed Tattler	x			
Whimbrel	x		x	
Bristle-thighed Curlew	x		x	
Hudsonian Godwit	+		?	
Bar-tailed Godwit	x		+	
Marbled Godwit	x		x	
Ruddy Turnstone	x	+	x	
Black Turnstone	x		+	?
Red Knot	x		?	
Sanderling	x	x	x	
Semipalmated Sandpiper	x			
Western Sandpiper	x		x	+
Least Sandpiper	x		x	x
Baird's Sandpiper	x			
Pectoral Sandpiper	x		?	
Sharp-tailed Sandpiper	x			
Rock Sandpiper	x	x	x	x
Dunlin	x	+	x	x
Short-billed Dowitcher	x		x	x
Long-billed Dowitcher	x		+	
Common Snipe	x		x	x
Red-necked Phalarope	x		+	+
Red Phalarope	x		+	
Total species	31	4	20	8

[1] The study area included Izembek, Moffet, and Kinzarof lagoons as well as adjacent wetlands and uplands.
[2] x = species recorded during this study; + = occurrence documented by others with records on file at Izembek NWR; ? = not known locally but documented on the Alaska Peninsula.

August. Number of species stabilized over the next several weeks, decreased to 18 by mid-October, and declined sharply in late October to only 2 species, Rock Sandpiper and Sanderling. These same two species were the only ones present on the winter surveys.

Abundance

Numbers of shorebirds using the study area mirrored the temporal pattern of species diversity. The initial aerial survey on 6 July yielded about 19,000 birds (Fig. 7, Appendix A).

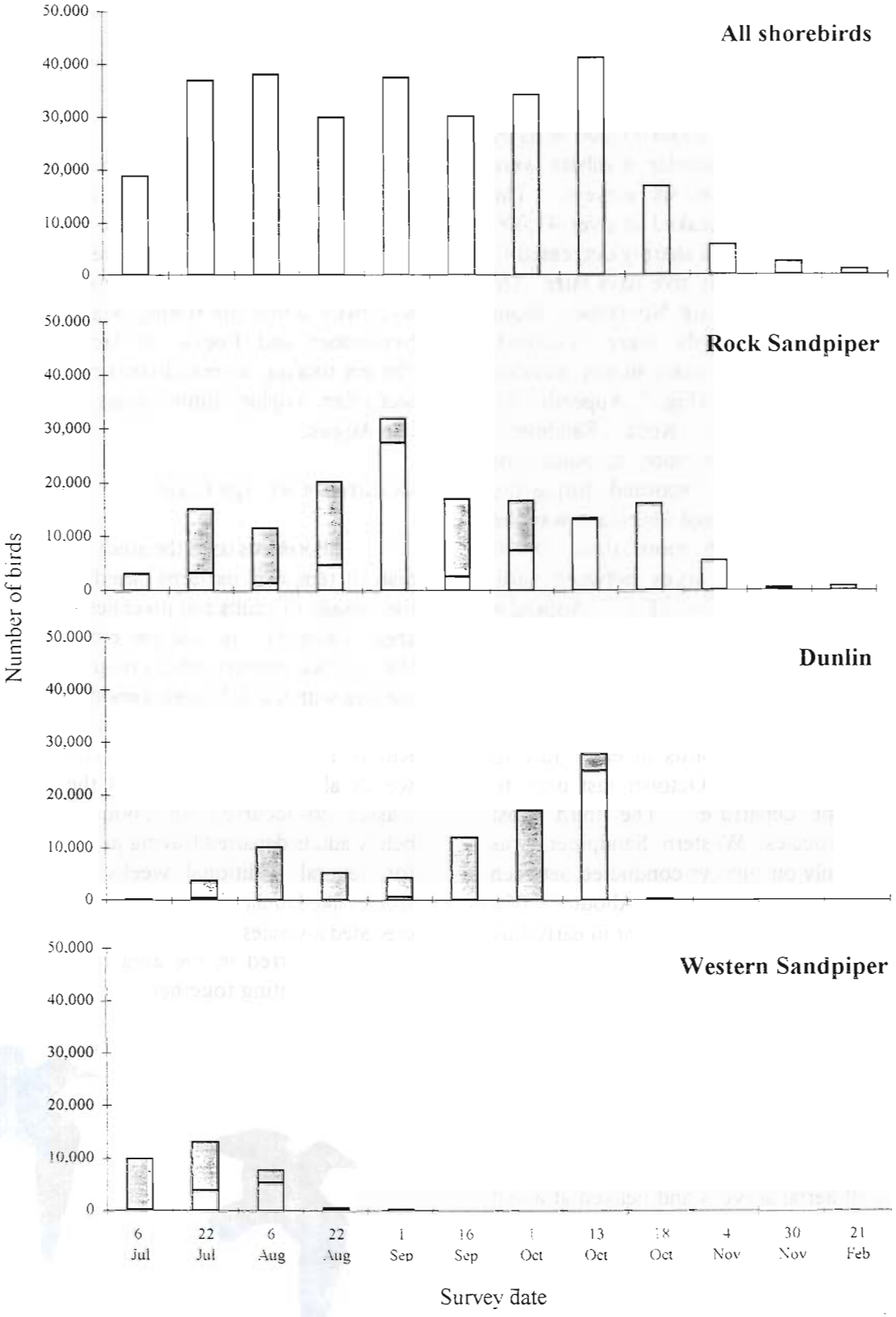

Figure 7. Direct (open) and adjusted (filled) survey totals of all shorebirds and the three most abundant species recorded during aerial surveys of Izembek, Moffet and Kinzarof lagoons, 1993-1994. Adjusted totals were derived by applying ground-based estimates of relative abundance to flocks containing unidentified birds (see text for details).

Numbers increased to about 37,000 birds by the next survey and similar numbers were recorded over the next six surveys. The shorebird population peaked at over 41,000 birds on 13 October and sharply decreased to about 17,000 birds only five days later. On surveys in early and late November, about 6,000 and 3,000 birds were recorded, respectively. The 21 February survey revealed slightly over 1,000 birds (Fig. 7, Appendix A).

Three species, Rock Sandpiper, Dunlin, and Western Sandpiper, accounted for over 95% of all birds recorded during the aerial surveys. The most abundant was the Rock Sandpiper, with more than 10,000 present during each survey between early August and mid-November (Fig. 7, Appendix A). The population of Rock Sandpipers peaked at over 32,000 birds on the 1 September survey. Dunlin, the next most abundant species, steadily increased in number from a few hundred birds in early July to almost 28,000 by mid-October just prior to their abrupt departure. The third most abundant species, Western Sandpiper, was recorded only on surveys conducted between July and early September. About 10,000 Western Sandpipers were present in early July when surveys began and their numbers increased over the next two weeks to about 13,000 birds. By early August their numbers had decreased to about 8,000 birds and they were recorded in very low numbers subsequently.

Ruddy Turnstones and Sanderlings accounted for about 3% of birds recorded during all aerial surveys and peaked at about 2,000 and 1,000 birds, respectively (Appendix A). Semipalmated Plovers exhibited a brief peak in abundance in late July but were rarely detected at other times. The remaining birds (< 1% of all survey totals) consisted of 14 species with cumulative survey totals of between 1 and 275 individuals.

Several species passed through the study area on non-survey days or frequented unsurveyed habitats (Appendix B), and thus were under-represented in survey totals. For example, thousands of Red Phalaropes flew southwest along the Bering Sea coast on 16 September and flocks of Pacific Golden-Plovers, totaling several dozens of birds, were seen often in upland tundra areas, especially in late August.

Occurrence By Age Class

Shorebirds used the study area in three distinct temporal patterns based primarily on the passage of adults and juveniles through the area (Table 5). In one pattern, typified by Western Sandpipers, adults migrated through the area within a 2-3 week period and prior to any juveniles. In another pattern, exhibited by Ruddy Turnstones, adults arrived about four weeks ahead of juveniles and the two age-classes co-occurred for about two weeks before adults departed leaving juveniles behind for several additional weeks. Finally, in species like Dunlin and Rock Sandpiper, adults preceded juveniles by 4-6 weeks and both age-classes occurred in the area for 2-4 weeks before emigrating together.

Table 5. Percentage of juvenile shorebirds on the study area during 15-day census periods, July-October 1993.

	Census period						
Common name	1-15 Jul	16-30 Jul	31 Jul-14 Aug	15-29 Aug	30 Aug-13 Sep	14-28 Sep	19 Sep-13 Oct
Pacific Golden-Plover					27.2 (279)[1]	98.7 (290)	100.0 (19)
Ruddy Turnstone			5.0 (20)	13.5 (436)	62.1 (95)	95.8 (142)	100.0 (14)
Sanderling			0 (70)	2.5 (362)	92.8 (111)	59.7 (439)	
Western Sandpiper	<1.0 (1,369)	1.4 (70)	100.0 (11)	100.0 (188)	100.0 (57)		
Rock Sandpiper			14.1 (790)	14.1 (2,166)	50.2 (201)	46.7 (30)	
Dunlin			6.8 (1,289)	11.5 (1,804)	6.7 (1,503)	99.3 (276)	33.6 (629)

[1] Sample sizes shown in parentheses.

Distribution

In autumn, the mean number of birds per km of shoreline was highest in northeast Izembek Lagoon and Moffet Lagoon at 159 ± SE and 191 ± SE birds/km of shoreline, respectively (Table 6). On a finer scale, south Neumann Island (segments 9 and 9b) and northeast Moffet Lagoon (segment 6) contained an average of > 500 birds/km of shoreline. Shorebirds were also numerous (> 125 birds/km of shoreline) on the tidal flats at north Neumann (segment 8) and Operl (segment 10) islands, between Blaine and Strawberry points (segment 17), and east and west Moffet Lagoon (segments 4 and 7). In contrast, southwest Izembek Lagoon and Kinzarof Lagoon hosted very few shorebirds with 10 ± SE and 23 ± SE birds/km of shoreline, respectively.

Aerial surveys also revealed that shorebird distribution, particularly that of small sandpipers, varied temporally (Fig. 8). In early autumn, number of birds per km of shoreline was highest in northeast Izembek Lagoon, whereas in late autumn, Moffet Lagoon became more important. The shorebirds that used southwest Izembek Lagoon did so in late July and birds occurred in Kinzarof Lagoon on three surveys only (6 July, 1 September, 1 October). During the early winter surveys, the majority (93%) of birds were found in Moffet Lagoon (segment 5) and on the Bering Sea beach of Operl Island (segment 10b), and in late winter, birds were present only in ice-free areas near lagoon entrances in segments 8, 9, and 10 (Appendix A).

Table 6. Mean number of shorebirds per kilometer of shoreline recorded on aerial surveys throughout different census areas of the study area, July-October 1993.

Census area[1]	Segment[1]	Km of shoreline	Mean no. birds/km	SE	No. surveys
Kinzarof Lagoon					
	1	17.7	5	3	10
	2	13.5	46	17	10
	All	31.2	23	9	
Southwest Izembek Lagoon					
	11	14.2	28	10	10
	12	18.7	5	4	9
	13	31.1	8	3	9
	11b	10.3	1	<1	6
	All	74.3	10	3	
Northeast Izembek Lagoon					
	8	4.8	126	48	10
	9	12.9	603	140	10
	10	12.1	206	68	10
	14	26.4	4	2	9
	15	9.3	58	27	9
	16	20.0	22	10	10
	17	8.5	226	158	10
	18	8.3	64	21	10
Northeast cont.	8b	5.2	56	43	9
	9b	12.1	522	191	9
	10b	10.1	37	23	9
	All	127.7	159	23	
Moffet Lagoon					
	3	11.4	34	16	10
	4	11.6	407	194	10
	5	6.8	27	15	10
	6	4.0	624	253	10
	7	9.7	173	101	10
	7b	6.4	15	13	6
	All	49.9	191	39	

[1] See Fig. 1 for locations of census areas and segments.

Individual species of small sandpipers varied in their use of the different areas and segments of the study area (Fig. 6, Appendix A). The lagoon segments of northeast Izembek Lagoon were important for most species at some period in autumn. Rock Sandpipers were more likely than Dunlin to be found on sea beaches in northeast Izembek, and Dunlin were more prevalent than Rock Sandpipers in Moffet Lagoon, particularly in early October.

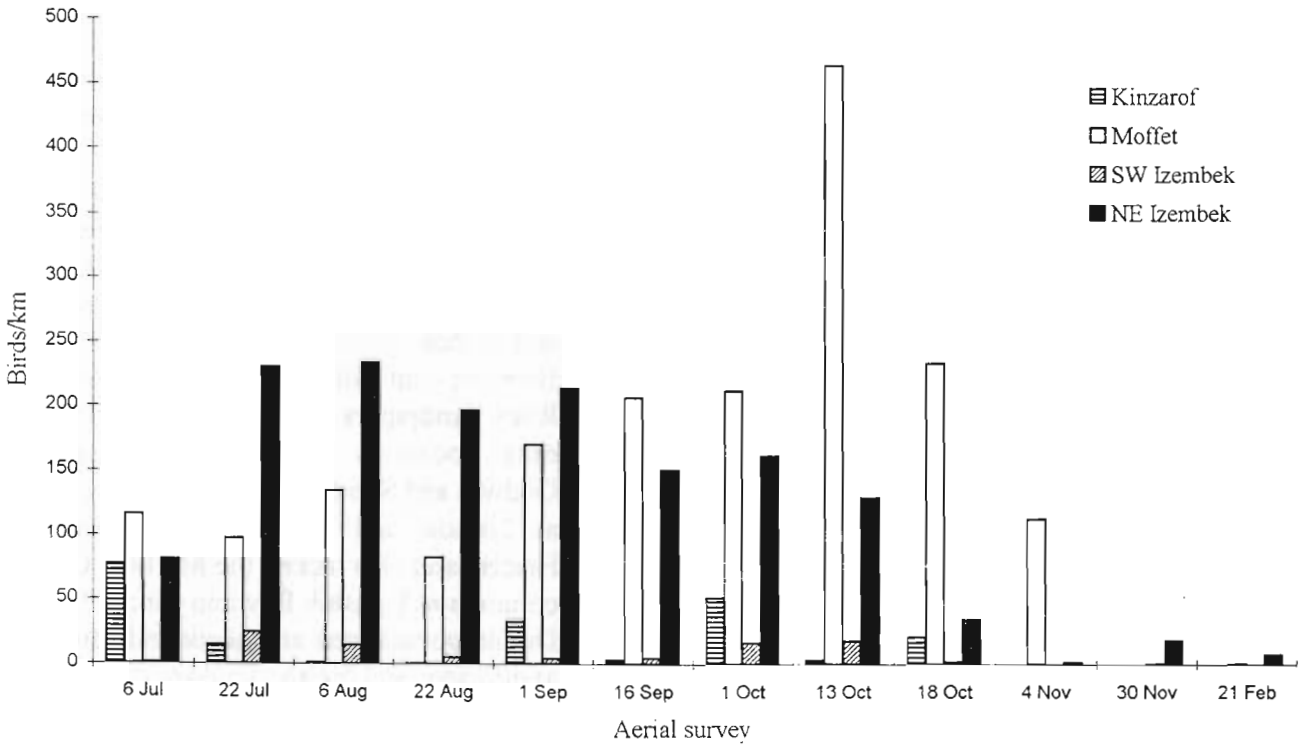

Figure 8. Number of shorebirds per kilometer of shoreline recorded on aerial surveys of Izembek, Moffet, and Kinzarof lagoons, 1993-1994.

Local Movements

We color-marked 119 Rock Sandpipers, 7 Sanderlings, and 6 Dunlin during 12 capture sessions between 11 September and 12 October. Almost all birds were captured at a few sites on the south end of Neumann Island (segments 9 and 9b); one Dunlin was captured in Dunlin Cove (segment 15). Marked Rock Sandpipers were resighted several times within 1-11 days of banding on tideflats and sea beaches adjacent to capture sites, once at Blaine Point (segment 17), and once at Moffet Lagoon (segment 4). One of the marked Rock Sandpipers was resighted three years later at Nelson Lagoon, about 100 km northeast of its banding site. Marked Sanderlings were resighted several times within 3-10 days of banding on sea beaches adjacent to their capture site and once at Moffet Lagoon (segment 6). Marked Dunlin were never resighted after capture.

Population Estimates And Turnover

The sum of peak counts for individual species totaled over 78,000 birds. The sum of survey totals was about 285,000 birds in autumn and 9,000 birds in winter. We were unable to use mark-resighting ratios as a measure of turnover within populations because too few individuals were banded; however, temporal variation in age composition indicated that turnover did occur in all populations that were monitored (Table 5, Appendix B). For example, the percentage of juvenile Sanderlings on the study area increased from 3 to 93% during the census period in early September, this information coupled with aerial survey totals for this species (Appendix A) indicated that most adults left the study area during this period and were replaced by a third as many juveniles.

DISCUSSION

Site Qualification

Our data demonstrate that the lagoons within the Izembek NWR qualify for inclusion in the WHSR network. The specific category of qualification depends on interpretation of our results. We believe that the true size of the shorebird population that uses the refuge lies between our estimates of 78,000 and 294,000 birds. Therefore, the refuge easily qualifies as a WHSRN regional site (i.e., > 20,000 Nearctic shorebirds) even if we use the lower estimate. Most probably, the refuge also qualifies as a WHSRN international site because the lower estimate of 78,000 birds quickly surpasses the required threshold number (> 100,000 Nearctic shorebirds) by applying modest turnover rates to survey data and/or by including the individuals that used the refuge prior to the initiation of our autumn surveys (i.e., breeding birds and spring migrants) and those that occurred in unsurveyed habitats. For example, adult Western and Least sandpipers complete their southward migration in 2-3 weeks beginning in late June (Gill and Jorgenson 1979) and thus there is a good possibility that our surveys did not detect the major segments of their populations. Izembek NWR's qualification as an EAASRN site is problematic because breeding origins of many of the migrant shorebird populations in Alaska have yet to be established. It is very possible that > 1% of the individuals of a Palearctic population used Izembek and Moffet lagoons during autumn migration, however, EAASRN site qualification must await future studies.

Alaska Peninsula Comparisons

The timing of the autumn shorebird migration at Izembek and Moffet lagoons appeared to be similar to that of other Alaska Peninsula estuaries although species abundance and composition differed [Nelson Lagoon (Gill and Jorgenson 1979); the bays of Kvichak, Egegik, Ugashik, and Mud, Cinder Lagoon, Port Heiden, and Seal Islands (Gill and Handel 1981, R. E. Gill unpubl. data)]. Izembek and Moffet lagoons hosted more Rock Sandpipers and Ruddy Turnstones than other locations but lacked the Bar-tailed Godwits and Short-billed Dowitchers common at Nelson and Cinder lagoons and Port Heiden, and also lacked the Marbled Godwits common at Ugashik Bay and Cinder Lagoon. Dunlin populations at Egegik and Mud bays, and Cinder and Nelson lagoons each reached peaks almost twice as high as the one we recorded at Izembek and Moffet lagoons. The Izembek-Moffet complex is unique in that its staging habitats provide the final opportunity for migrating shorebirds to feed and rest before embarking on long over-water flights to wintering areas as far away as South America and South Pacific islands.

Factors Influencing Distribution

Distribution of calidridine shorebirds appeared to be influenced by location of feeding and roosting habitats. The most intensive use occurred in segments which contained, or were adjacent to, unvegetated tideflats and sea beaches. Low level use occurred in segments that were dominated by eelgrass meadows and these segments were preferred by relatively uncommon autumn migrants, such as Short-billed Dowitchers and Sharp-tailed Sandpipers. Weather conditions also influenced distribution. In early autumn, most calidridine sandpipers foraged on exposed unvegetated tideflats within northeast Izembek Lagoon and roosted on nearby sea

beaches. By late autumn, strong onshore winds precluded roosting on the beach and birds remained adjacent to feeding areas during high tides.

Information Needs

This study was the first attempt to specifically assess an area in Alaska for WHSRN and EAASRN criteria. While we are confident in our results, we realize their limitations, and recommend that subsequent efforts in Alaska should focus on measuring species-specific turnover rates, estimating error rates for aerial survey data, and developing methods to census migrants in upland habitats. Further efforts at Izembek NWR should focus on determining inter-annual variability in autumn and winter use of the refuge and in refining current methods for assessing densities of breeding shorebirds.

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Appendix A. Numbers of individual species recorded on aerial surveys in segments, census areas, and the entire study area, and the adjusted survey totals[1] at Izembek NWR, 1993-1994. Shaded areas indicate the segment was not surveyed on that date.

Survey/ species	Kinzarof Lagoon			Moffet Lagoon							Southwest Izembek Lagoon				
	Segment		Area total	Segment						Area total	Segment				Area total
	1	2		3	4	5	6	7	7b		11	11b	12	13	
6 July															
Dunlin			0							0					0
Marbled Godwit			0							0	1				1
Rock Sandpiper	285	46	331	330	1,518	340		27		2,215				8	8
Ruddy Turnstone	20		20			57				57					0
Semipalmated Plover			0							0					0
Unid. small shorebird	245	1,823	2,068		2,120	276	1,101	31		3,528				43	43
Western Sandpiper			0							0	40				40
Yellowlegs spp.			0							0					0
Total	550	1,869	2,419	330	3,638	673	1,101	58	0	5,800	41		0	51	92
22 July															
Black-bellied Plover			0							1					0
Dowitcher spp.			0							0				35	35
Dunlin			0							0					0
Golden Plover spp.			0							6	4		5		9
Red-necked Phalarope			0							2					0
Rock/Dunlin			0							0					0
Rock Sandpiper		66	66	331	185	775	508	20		1,819	250		90	246	586
Ruddy Turnstone		66	66	77	6		215	180		478			20	266	286
Semipalmated Plover			0							0					0
Wandering Tattler			0							0				1	1
Unid. small shorebird		335	335			9				9			149	345	494
Western Sandpiper			0	233	855		1,438			2,526	402				402
Yellowlegs spp.			0	1	5		15			21				2	2
Total	0	467	467	645	1,057	784	2,176	200		4,862	656		264	895	1,815

Appendix A. Continued.

Survey/ species	Kinzarof Lagoon			Moffet Lagoon							Southwest Izembek Lagoon				
	Segment		Area total	Segment						Area total	Segment				Area total
	1	2		3	4	5	6	7	7b		11	11b	12	13	
6 August															
Black-bellied Plover			0						7	7					0
Dowitcher spp.			0							0			8	12	20
Golden Plover spp.			0							0	15				15
Least Sandpiper			0							0			40		40
Rock/Dunlin			0							0					0
Rock Sandpiper		33	33		500			7		507				4	4
Ruddy Turnstone		1	1		31				15	46			8	12	20
Sanderling			0						5	5					0
Semipalmated Plover			0							0					0
Wandering Tattler			0							0				1	1
Unid. med. shorebird			0							0					0
Unid. small shorebird			0	1,716	4,315	51		26	40	6,148	20		580	405	1,005
Western Sandpiper			0							0					0
Yellowlegs spp.			0							0			1		1
Total	0	34	34	1,716	4,846	51	0	33	67	6,713	35	0	637	434	1,106
22 August															
Dunlin			0							0	2				2
Golden Plover spp.			0							0					0
Red Knot			0							0					0
Rock/Dunlin			0							404					0
Rock Sandpiper			0		400			4		1,627	200	8		173	401
Ruddy Turnstone		15	15	272	1,185	8	22	140		5				1	1
Sanderling			0					5		1					0
Semipalmated Plover			0							0					0
Unid. med. shorebird			0					1		0					0
Unid. small shorebird			0		1,835		20			1,878	2				2
Western Sandpiper			0		200			23		200					0
Yellowlegs spp.			0							0					0
Total	0	15	15	272	3,620	8	42	173		4,115	224	8	0	174	406

Appendix A Continued

Survey/ species	Kinzarof Lagoon			Moffet Lagoon							Southwest Izembek Lagoon				
	Segment		Area total	Segment						Area total	Segment				Area total
	1	2		3	4	5	6	7	7b		11	11b	12	13	
1 September															
Black-bellied Plover			0					5		5					0
Dowitcher spp.			0							0					0
Dunlin			0					500	82	582					0
Golden Plover spp.		70	70							0					0
Rock/Dunlin			0		1,250					1,250					0
Rock Sandpiper	26	6	32	20	6,031	2	87	10	261	6,411	27	2		291	320
Ruddy Turnstone		24	24	2	13			34	56	105		5			5
Sanderling	5	2	7	1	17			15	13	46					0
Semipalmated Plover			0							0					0
Unid. small shorebird	95	793	888	40			30	18		88					0
Whimbrel	1		1				1			1					0
Yellowlegs spp			0	2			2			4					0
Total	127	895	1,022	65	7,311	2	120	582	412	8,492	27	7	0	291	325
16 September															
Dowitcher spp.		80	80				15			15					0
Golden-Plover spp.			0							0					0
Red Knot			0					20		20					0
Rock/Dunlin			0	20			1,740	6,140		7,900	325				325
Rock Sandpiper			0	165	1		1,500	459		2,125				17	17
Ruddy Turnstone		2	2							0				25	25
Sanderling			0				200			200					0
Sharp/Pectoral			0							0			6		6
Unid. med. shorebird			0							0					0
Unid. small shorebird		30	30							0					0
Whimbrel			0							0					0
Yellowlegs spp.			0				20			20					0
Total	0	112	112	185	1	0	3,475	6,619		10,280	325		6	42	373

Appendix A Continued.

Survey/ species	Kinzarof Lagoon			Moffet Lagoon							Southwest Izembek Lagoon				
	Segment		Area total	Segment						Area total	Segment				Area total
	1	2		3	4	5	6	7	7b		11	11b	12	13	
17 September															
Dowitcher spp.			0							0					0
Dunlin			0					40		40					0
Golden-Plover spp			0							0					0
Rock/Dunlin			0				4,048	479		4,527	67				67
Rock Sandpiper			0	1,146	16					1,162					0
Ruddy Turnstone			0							0					0
Sanderling			0					192	7	199					0
Yellowlegs spp.			0				28	5		33					0
Total	0	0	0	1,146	16	0	4,076	716	7	5,961	67				67
1 October															
Golden-Plover spp			0							0					0
Rock Sandpiper	150	1,459	1,609	121	600	120	1,110			1,951	1,085			113	1,198
Ruddy Turnstone			0							0		2			2
Sanderling			0							0		25			25
Unid. med. shorebird			0					6		6					0
Unid. small shorebird			0				8,270	300		8,570					0
Yellowlegs spp.			0				25			25					0
Total	150	1,459	1,609	121	600	120	9,405	306		10,552	1,085	27	0	113	1,225
13 October															
Dunlin			0	105	12,400					12,505					0
Golden-Plover spp.			0	2						2					0
Red Phalarope			0							0					0
Rock Sandpiper		100	100	2	6,030	20	1,125	4		7,181	1,085			275	1,360
Ruddy Turnstone			0							0					0
Sanderling			0					9		9					0
Unid. small shorebird			0		3,000		440	4		3,444					0
Yellowlegs spp.			0				25			25				1	1
Total	0	100	100	109	21,430	20	1,590	17	0	23,166	1,085	0	0	276	1,361

Appendix A. Continued.

Survey/ species	Kinzarof Lagoon			Moffet Lagoon							Southwest Izembek Lagoon				
	Segment		Area total	Segment						Area total	Segment				Area total
	1	2		3	4	5	6	7	7b		11	11b	12	13	
18 October															
Dunlin			0							0					0
Rock Sandpiper	40	612	652	7			4,490	7,075		11,572	45			80	125
Sanderling			0				52	8		60		11			11
Unid. small shorebird		2	2							0					0
Yellowlegs spp.		9	9							0					0
Total	40	623	663	7	0	0	4,542	7,083	0	11,632	45	11	0	80	136
4 November															
Rock Sandpiper						5,200		114		5,314					0
Sanderling						300				300					0
Total				0	0	5,500	0	114	0	5,614	0	0	0	0	0
30 November															
Rock Sandpiper			0												0
Sanderling			0									45			45
Total	0	0	0	0	0	0	0	0	0	0	0	45	0	0	45
21 February															
Rock Sandpiper	6		6						2	2					0
Sanderling			0						29	29	10				10
Total	6	0	6				0	0	31	31	10	0	0	0	10

Appendix A. Continued.

Survey /species	Northeast Izembek Lagoon Segment 8	9	10	8b	9b	10b	14	15	16	17	18	Area total	Survey total	Adjusted survey total
6 July														
Dunlin								2				2	2	143
Marbled Godwit												0	1	1
Rock Sandpiper	205		150					8	23	46	38	470	3,024	3,064
Ruddy Turnstone	8											8	85	85
Semipalmated Plover													0	50
Unid. small shorebird	325	5,832	1,631				95	1,111	88	387	583	10,052	15,691	5,639
Western Sandpiper												0	40	9,861
Yellowlegs spp.	1											1	1	1
Total	539	5,832	1,781			0	95	1,121	111	433	621	10,533	18,844	18,844
22 July														
Black-bellied Plover												0	1	1
Dowitcher spp.												0	35	35
Dunlin			400									400	400	3,824
Golden Plover spp.			6					11				38	53	53
Red-necked Phalarope												0	2	2
Rock/Dunlin					12,400					1,850		14,250	14,250	0
Rock Sandpiper	10		204					478				692	3,163	15,235
Ruddy Turnstone	18	200		3	186		16	45	116	813	292	1,689	2,519	2,519
Semipalmated Plover													0	1,383
Wandering Tattler												0	1	1
Unid. small shorebird	436	7,200	142	18	861		175	750	221	1,179	960	11,942	12,780	838
Western Sandpiper								850				850	3,778	13,091
Yellowlegs spp.												0	23	23
Total	464	7,400	752	21	13,468		191	2,134	337	3,842	1,252	29,861	37,005	37,005

Appendix A. Continued.

Survey /species	Northeast Izembek Lagoon Segment 8	9	10	8b	9b	10b	14	15	16	17	18	Area total	Survey total	Adjusted survey total
6 August														
Black-bellied Plover							4			125		129	136	136
Dowitcher spp.							40	50				90	110	110
Golden Plover spp.												0	15	15
Least Sandpiper												0	40	40
Rock/Dunlin					10,050	300						10,350	10,350	0
Rock Sandpiper					31		70	200		500		801	1,345	11,580
Ruddy Turnstone		342			332	4	1		5	419	7	1,130	1,197	1,197
Sanderling				1	21							22	27	88
Semipalmated Plover								2	4			6	6	38
Wandering Tattler												0	1	1
Unid. med. shorebird						2						2	2	2
Unid. small shorebird	65	8	200	1,801	103		299	795		7,935	1,335	12,541	19,694	7,153
Western Sandpiper									2,033	3,200		5,233	5,233	7,658
Yellowlegs spp.							2	3				5	6	6
Total	65	350	200	1,822	10,537	306	416	1,050	2,042	12,179	1,342	30,309	38,162	38,162
22 August														
Dunlin										1		1	3	5,286
Golden Plover spp.									1			1	1	1
Rock/Dunlin	400				8,000				12			8,412	8,816	404
Rock Sandpiper	748	19	236		515	355	50	52	15	4	675	2,669	4,697	20,223
Ruddy Turnstone	30	583		4	6	15	3	12	14	8	2	677	698	698
Sanderling	5				471	21						497	498	1,025
Semipalmated Plover												0	0	26
Unid. med. shorebird								1				1	1	1
Unid. small shorebird		10,475	2,440				4	153	100		2	13,174	15,054	1,880
Western Sandpiper											5	5	205	429
Yellowlegs spp.								2			2	4	4	4
Total	1,183	11,077	2,676	4	8,922	391	57	220	142	13	686	25,441	29,977	29,977

Appendix A. Continued.

Survey /species	Northeast Izembek Lagoon Segment 8	9	10	8b	9b	10b	14	15	16	17	18	Area total	Survey total	Adjusted survey total
1 September														
Black-bellied Plover												0	5	5
Dowitcher spp.							6	2		13		21	21	21
Dunlin												0	582	4,367
Golden Plover spp.							4			9		13	83	83
Rock/Dunlin												0	1,250	0
Rock Sandpiper	2,071	320	160	24	15,362	1,901	9	190	36	575	2	20,650	27,413	32,039
Ruddy Turnstone	3	68		31	46	15	7		7	53		230	364	364
Sanderling	25	15		8	85	22	2			2		159	212	344
Semipalmated Plover													0	33
Unid. small shorebird		5,900	700					6				6,606	7,582	0
Whimbrel												0	2	2
Yellowlegs spp.								5		5		10	14	14
Total	2,099	6,303	860	63	15,493	1,938	28	203	43	657	2	27,689	37,528	37,528
16 September														
Dowitcher spp.							9		5			14	109	109
Golden-Plover spp.			2			1		4			2	9	9	9
Red Knot												0	20	20
Rock/Dunlin	861	14,666	3,054									18,581	26,806	325
Rock Sandpiper				10	11			100	65	33	123	342	2,484	17,043
Ruddy Turnstone			7				9	1		6		23	50	50
Sanderling		226	112		194	1		1	2			536	736	736
Sharp/Pectoral												0	6	6
Unid. med. shorebird							10					10	10	10
Unid. small shorebird												0	30	0
Whimbrel											1	1	1	1
Yellowlegs spp.								4				4	24	24
Total	861	14,892	3,175	10	205	2	28	110	72	39	126	19,520	30,285	30,285

Appendix A. Continued.

Survey /species	Northeast Izembek Lagoon — Segment 8	9	10	8b	9b	10b	14	15	16	17	18	Area total	Survey total	Adjusted survey total
17 September														
Dowitcher spp.		15							29			44	44	44
Dunlin												0	40	13,768
Golden-Plover spp.		17	14									31	31	31
Rock/Dunlin		21,480	2,690						106			24,276	28,870	67
Rock Sandpiper	400				1	18			19	45	1	484	1,646	16,721
Ruddy Turnstone						2						2	2	2
Sanderling		251			116							367	566	566
Yellowlegs spp.												0	33	33
Total	400	21,763	2,704	0	117	20			154	45	1	25,204	31,232	31,232
1 October														
Dunlin												0	0	17,056
Golden-Plover spp.				3	4	1						8	8	8
Rock Sandpiper			1,900	3	1	198	81		400			2,583	7,341	16,691
Ruddy Turnstone	3				1						15	19	21	21
Sanderling		300			3							303	328	525
Unid. med. shorebird												0	6	6
Unid. small shorebird	200	15,595	2,208						30			18,033	26,603	0
Yellowlegs spp.												0	25	25
Total	203	15,895	4,108	6	9	199	81	0	430	0	15	20,946	34,332	34,332
13 October														
Dunlin		7,180	5,000									12,180	24,685	27,843
Golden-Plover spp.						4						4	6	6
Red Phalarope											1	1	1	1
Rock Sandpiper	7	100	3,050			60	70	4	408	125	711	4,535	13,176	13,455
Ruddy Turnstone					1							1	1	1
Sanderling					3							3	12	19
Unid. small shorebird												0	3,444	0
Yellowlegs spp.												0	26	26
Total	7	7,280	8,050	0	4	64	70	4	408	125	712	16,724	41,351	41,351

Appendix A. Continued.

Survey /species	Northeast Izembek Lagoon: Segment 8	9	10	8b	9b	10b	14	15	16	17	18	Area total	Survey total	Adjusted survey total
18 October														
Dunlin									250			250	250	250
Rock Sandpiper	39	950	800	37	1,712	85	65	19	30	22		3,759	16,108	16,108
Sanderling			30	383	104	22						539	610	610
Unid. small shorebird												0	2	2
Yellowlegs spp.												0	9	9
Total	39	950	830	420	1,816	107	65	19	280	22	0	4,548	16,979	16,979
4 November														
Rock Sandpiper					4		9		10		150	173	5,487	5,487
Sanderling												0	300	300
Total	0	0	0	0	4	0	9	0	10	0	150	173	5,787	5,787
30 November [1]														
Rock Sandpiper						220					220	440	440	440
Sanderling						2,000					5	2,005	2,050	2,050
Total	0	0	0	0	0	2,220	0	0	0	0	225	2,445	2,490	2,490
21 February														
Rock Sandpiper	520	90	40	3	51	20						724	732	732
Sanderling	192	1	65	45	5							308	347	347
Total	712	91	105	48	56	20						1,032	1,079	1,079

[1] Adjusted survey totals derived from ground-based estimates of species relative abundance (see text for details).

Appendix B. Annotated species accounts of shorebirds recorded using Izembek NWR between July 1993 and May 1994.[1]

Black-bellied Plover (*Pluvialis squatarola*). This species was a relatively uncommon autumn migrant that favored freshwater ponds and mudflats from late August through early October. It was never recorded on aerial or ground surveys, but a total of 8 flocks, of beween 1 and 14 birds each, was seen during other investigations.

Pacific Golden-Plover (*P. fulva*). Pacific Golden-Plovers were a common autumn migrant; the first birds were seen on 22 July and they were not recorded after 16 October. We considered all golden-plovers recorded on aerial surveys to be this species because we never observed any American Golden-Plovers *(P. dominicus*) on the area during the course of our investigations. By mid-September most adults had departed, leaving predominantly juveniles thereafter. Throughout the study, birds favored Bering Sea beaches and upland tundra areas where they occurred in flocks of 1-10 individuals. The largest flock, of 126 birds, was seen on mudflats near the mouth of Joshua Green River on 30 August. A few small flocks of Pacific Golden-Plovers migrated through in mid-May.

Semipalmated Plover (*Charadrius semipalmatus*). This species was locally common in autumn where it was found along the muddy shores of Kinzarof Lagoon, Stapp Creek, Dunlin Cove, and Blaine Point, and occasionally with other sandpipers on mudflats of northeast Izembek Lagoon and Moffet Lagoon. Semipalmated Plovers were common breeders and nested along the road system and atop blown-out tundra ridges throughout the refuge. Most nests were initiated in mid-May. Most breeding birds departed in July; the majority (42 of 46) seen after 4 August were juveniles.

Greater Yellowlegs (*Tringa melanoleuca*). This was a common autumn migrant that usually frequented coastal freshwater meadows near Grant Point and in eastern Moffet Lagoon. Birds were present from 6 August through 16 October; all but 1 of 95 birds seen were juveniles. We considered all yellowlegs recorded on aerial surveys to be this species because only Greater Yellowlegs were seen from the ground in autumn (cf. Lesser Yellowlegs *T. flavipes*).

Lesser Yellowlegs (*T. flavipes*). A single bird was seen inland of Moffet Creek on 18 May.

Wandering Tattler (*Heteroscelus incanus*). Single birds, likely the same individual, were seen on Banding Island during aerial surveys on 22 July and 6 August, and another was seen from the ground near the base of Strawberry Point on 31 August. Two birds were seen feeding along the shore at Grant Point on 24 May.

Gray-tailed Tattler (*H. brevipes*). On 14 October a single bird was heard calling and observed feeding along the wrack line of the Bering Sea beach about 6 km east of Moffet Point.

Whimbrel (*Numenius phaeopus*). This species was infrequently seen using the study area in autumn, but between 29 and 31 August a significant movement of birds occurred over the study area. Most observations were of flocks of between 25 and 150 birds (including both adults and juveniles) flying

high and to the southeast across the Alaska Peninsula. In May, pairs and single birds were seen along the Grant Point road and Moffet Spit.

Bristle-thighed Curlew (*N. tahitiensis*). Seven curlews of this species were identified on the study area between 31 August and 19 September. A fresh carcass was also found on Cape Glazenap on 12 September, apparently killed by a falcon. On 9 May a flock of three was seen near the mouth of Moffet Creek and on 18 May a flock of three males and one female was seen in wet meadow habitat about three km inland from the mouth of Moffet Creek.

Bar-tailed Godwit (*Limosa lapponica*). Bar-tailed Godwits were uncommon in the area. A single adult was seen on 8 August and thereafter only juveniles were noted, usually in groups of 1-4 birds in the northeast portion of Izembek Lagoon. The last godwits were seen on 15 October.

Marbled Godwit (*L. fedoa*). A lone bird was flushed from mudflats near Cape Glazenap during an aerial survey on 6 July. On 13 May a single bird flushed from a wet meadow west of Grant Point.

Ruddy Turnstone (*Arenaria interpres*). This species was generally common from late summer and into autumn. Adults were most abundant in July and August, juveniles in August and early September. A flock of 20 was seen flying to the northwest over the Moffet Creek area on 18 May.

Black Turnstone (*A. melanocephala*). A single bird was seen on 6 September along rocky shore just south of Grant Point.

Red Knot (*Calidris canutus*). This large sandpiper was uncommon during most of the study. A flock of 125 birds was seen near Blaine Point on 6 August and this species was not recorded again until 27 August. Thereafter groups of between 1 and 20 birds, occasionally intermixed with smaller sandpipers, were seen on Bering Sea beaches or on mudflats of northeast Izembek Lagoon. All but 1 of the 40 birds we examined closely were juveniles.

Sanderling (*C. alba*). Sanderlings were a fairly common autumn migrant and an uncommon winter resident and spring migrant. They usually occurred on Bering Sea beaches and adjacent intertidal habitats. Sanderlings exhibited two peaks in abundance, the first occurred in early September when juveniles moved into the area.

Semipalmated Sandpiper (*C. pusilla*). An adult was seen in a large flock of mostly Western Sandpipers at Dunlin Cove on 7 July and another adult was seen on 29 August in upper Quarter Point Cove, also among other small sandpipers.

Western Sandpiper (*C. mauri*). This species was a common to locally abundant migrant in July and early August. Birds tended to use the mudflats and small embayments of northeast Izembek Lagoon and Moffet Lagoon; they occurred less frequently in Kinzarof and Nurse lagoons. The few birds seen after late August were all juveniles. Small numbers of these sandpipers moved through the area in May.

Least Sandpiper (*C. minutilla*). This species is a locally common breeder and early summer migrant, with most gone from the area by early August. All of the birds (n = 25) we examined between 1 August and 13 September were juveniles. Most birds preferred graminoid meadows and pond margins adjacent to the lagoons during breeding and post-breeding periods. They were especially attracted to such areas near the mouths of creeks in southern Applegate Cove and Kinzarof Lagoon.

Baird's Sandpiper (*C. bairdii*). One juvenile was seen on Neuman Island mudflats on 23 September and another at Grant Point Cove on 6 October.

Pectoral Sandpiper (*C. melanotos*). Pectoral Sandpipers were uncommon autumn migrants most often seen on muddy pond margins and wrack-covered lagoon beaches. Sightings of this species ranged from 23 August to 6 October; all birds that were examined closely were juveniles. Six birds that were either Pectoral or Sharp-tailed sandpipers were detected in Norma Bay during the 16 September aerial survey.

Sharp-tailed Sandpiper (*C. acuminata*). This species mirrored the Pectoral Sandpiper in its habitat preferences of Izembek Lagoon. Sightings of birds, all juveniles (n = 30), occurred between 17 September and 17 October.

Rock Sandpiper (*C. ptilocnemis*). The Rock Sandpiper was the most abundant shorebird on the study area during all seasons. In autumn, birds usually roosted on Bering Sea beaches, especially during molt, and foraged on mudflats and eelgrass beds throughout Moffet Lagoon and northeast Izembek Lagoon. Small numbers of birds remained on ice-free areas throughout winter. Rock Sandpipers initiated nests in mid-May primarily on tussock-heath tundra but also on sparsely vegetated ridges and along intertidal areas.

Dunlin (*C. alpina*). This species is a locally common breeder and was an abundant migrant throughout the study area between early July and early- to mid-October. Birds frequented Bering Sea beaches during molt and used intertidal flats of Moffet Lagoon and northeast Izembek Lagoon.

Short-billed Dowitcher (*Limnodromus griseus*). This species breeds locally and was regularly found during autumn (6 August-23 September) in Izembek and Kinzarof lagoons. All of the 38 birds closely examined were juveniles.

Long-billed Dowitcher (*L. scolopaceus*). Long-billed Dowitchers immigrate to Izembek Lagoon from more northerly breeding grounds. They generally arrive later and stay later (29 August-4 October) than Short-billed Dowitchers. Almost all (70 of 75) of the birds we identified as this species were juveniles.

Common Snipe (*Gallinago gallinago*). Snipe were rarely seen on intertidal habitats, but they are a common breeding species throughout adjacent wetlands.

Red-necked Phalarope (*Phalaropus lobatus*). Two were recorded on the 22 July aerial survey and a flock of four and a single bird were seen from the ground on 20 and 23 September, respectively.

Red Phalarope (*P. fulicarius*). This species was a common late summer and autumn migrant over nearshore waters of the Bering Sea and occasionally about the mouths of major channels into Izembek Lagoon. Rarely were birds found inside the lagoons.

[1] Biologists were present on the ground from 6 July-20 October 1993 and 11-24 May 1994.