

HABITAT UTILIZATION BY WINTERING AND MIGRATING SHOREBIRDS ON HUMBOLDT BAY, CALIFORNIA

R. H. GERSTENBERG¹

ABSTRACT.—During 1968-69, a study was made of shorebirds on Humboldt Bay, California. Eight different shorebird habitat types were recognized, and 34 different species of shorebirds used them. Five additional species were recorded as vagrants only.

The mud flat habitat was found to be the most important with 29 species occurring. Three (Willet, Marbled Godwit and Black-bellied Plover) were recorded there in more than 75 percent of censuses. Average density throughout the year was 33 birds per hectare. Seasonally, the highest number of species occurred in the fall, the highest density in the spring.

As the incoming tide flooded the mud flats, most birds roosted on the salt marsh surrounding the bay; however, extremely high tides would force all birds to uplands or freshwater marshes. At high tide some species such as the Black-bellied Plover, Killdeer and Least Sandpiper moved directly to upland areas. Heavy use of uplands did not occur until after the first rains in late fall. Such use increased further after heavy rains washed silt and debris onto mud flats. A sewage pond was used by 21 species, the most frequent being the Least Sandpiper and the most dense the Northern Phalarope.

Movement during winter centered about availability of mud flats as feeding area. Few birds were found using other areas when mud flats were available. When tides limited daytime use of mud flats, alternate feeding areas became important. But salt marsh was used as feeding area by only eight species, just prior to or after high tide. An exodus from the area was noted when alternate areas became unavailable because of flooding. Little movement occurred between extreme ends of the bay except during migration. Few locally marked birds were seen at other California stations.

Recent investigators on the Pacific Coast have recognized 11 habitat types used by shorebirds. Storer (1951) found five in his small study area on San Francisco Bay and later Recher (1966) studied 10 in a much broader study. Smail and Lenna (1969) identified eight habitats in a coastal estuary north of San Francisco Bay. All recognized the importance of the mud flat habitat but also the diversity needed by shorebirds in intertidal areas.

Humboldt Bay on the north coast of California is known to be a major migration and wintering area for shorebirds. Little has been documented concerning their numbers, species composition, seasonal movement and use of available habitats. This paper deals with the habitat utilization by wintering and migrating shorebirds of this bay. The study was conducted in 1968 and 1969 (Gerstenberg 1972).

STUDY AREA AND METHODS

Humboldt Bay is a long narrow coastal bay about 24 kilometers long. It is protected from the ocean by two narrow sand spits and is roughly hour-glass in shape with an outlet to the sea in the middle. There are four small freshwater creeks which empty into the east side of the bay.

Nine shorebird habitats were present in Humboldt Bay (Table 1) and systematic censusing was done in eight. An intertidal zone occurred at both jetties of the harbor entrance which was not censused.

There were 2950 hectares of mud flat available at mean low tide. Because time and height of low tide varies from day to day, the amount of mud flat available to feeding birds varies daily and seasonally.

In mid channel near the mouth of Elk River and on the south spit of the bay the substrate is coarse forming sand flats. There were sand islands in North Bay that were formed when the channels were deepened. Sand beaches occurred on the seaward side of both spits.

Along the shore and extending through the mud flats into the fields and freshwater creeks were

¹ Reedley College, Reedley, California 93654.

TABLE 1
SHOREBIRD USE OF EIGHT HABITAT TYPES AT HUMBOLDT BAY, CALIFORNIA, 1968-1969^a

Species	Mud flat	Sand flat	Tidal slough	Salt marsh	Up-land	F/W marsh	Sewage pond	Sand beach
PLOVERS								
Black-bellied Plover	77.7 3.93	81.4 9.32	46.3 5.89	40.7 16.18	78.4 6.02	6.4 0.05		28.6 15.32
Killdeer	9.0 0.16	21.0 0.46	44.2 3.63	7.4 0.07	78.4 1.36	59.6 0.73	22.8 0.20	28.6 0.30
Black Turnstone	27.9 0.64	60.5 2.29	68.8 36.57	29.6 0.57			0.9 0.01	
Ruddy Turnstone	12.5 0.23	18.5 0.28	4.6 0.30	11.1 0.15	9.8 0.01		3.5 0.01	
Semipalmated Plover	12.9 0.28	35.8 2.03	7.0 2.03	7.4 0.77		9.0 0.18	3.5 0.01	14.3 0.15
Snowy Plover		1.3 0.01						42.8 1.32
Golden Plover		1.3 0.01		3.6 0.02	8.3 0.01			14.3 0.15
SHORT-LEGGED SHOREBIRDS								
Dunlin	45.3 54.80	43.2 24.46	44.2 35.58	48.2 124.80	51.0 35.83	6.4 0.53	21.9 0.25	
Western Sandpiper	56.8 48.19	59.2 24.83	27.9 49.05	40.7 596.80	58.8 10.37	12.8 2.12	47.4 1.94	28.6 3.68
Least Sandpiper	46.3 11.34	38.3 3.29	53.5 25.20	7.4 0.82	52.9 0.56	28.4 2.52	70.2 4.42	28.6 56.83
Sanderling	27.5 6.30	80.2 32.37						100.0 68.94
Northern Phalarope	1.0 0.07				7.8 0.02	2.8 0.02	51.7 22.49	
Red Phalarope	0.3 0.01				2.1 0.01	3.2 0.31	22.6 1.32	28.6 0.74
Wandering Tattler	4.1 0.01	11.2 0.12						
Wilson's Phalarope	0.7 0.01						12.2 0.15	
Spotted Sandpiper	0.3 0.01	1.3 0.01				1.1 0.01	13.8 0.06	
Pectoral Sandpiper	0.3 0.01			3.6 0.02	2.1 0.01		2.6 0.01	
Rock Sandpiper	0.3 0.01							
Sharp-tailed Sandpiper					2.1 0.01			
Rufous-necked Sandpiper	0.3 0.01							
Semipalmated Sandpiper							0.9 0.01	

TABLE 1. (CONTINUED)

Species	Mud flat	Sand flat	Tidal slough	Salt marsh	Up-land	F/W marsh	Sewage pond	Sand beach
MEDIUM SIZED SHOREBIRDS								
Dowitcher	46.3	30.8	44.2	59.3	41.6	31.2	35.2	14.3
(two species)	18.16	17.42	17.30	128.50	1.63	0.74	0.46	0.15
Greater Yellowlegs	10.1	2.5	20.9	7.4	60.8	46.8	1.7	
	0.10	0.02	1.36	0.07	0.10	0.53	0.01	
Knot	4.2	9.9		7.2	6.0			
	0.12	1.11		0.57	0.01			
Common Snipe				3.6	18.7	58.8	3.5	
				0.02	0.04	3.46	0.02	
Lesser Yellowlegs	0.7		4.4		8.3		6.1	
	0.01		0.15		0.01		0.02	
Stilt Sandpiper	0.3	1.3		3.6				
	0.01	0.01		0.02				
LONG-LEGGED SHOREBIRDS								
Marbled Godwit	86.4	76.5	53.5	74.1	7.8	1.0	1.8	14.3
	18.29	5.15	6.81	338.50	0.43	0.01	0.66	0.15
Willet	85.7	76.5	93.0	66.7	3.9	11.8	12.3	57.1
	6.89	4.04	54.86	63.26	0.10	0.47	0.11	0.59
Long-billed Curlew	26.8			37.0	2.0			
	0.26			2.40	0.02			
Whimbrel	10.8	13.6	16.3	7.2				28.6
	0.09	0.19	0.99	7.97				0.30
American Avocet	8.7			18.5	2.0		7.9	
	0.19			0.17	0.01		0.47	
Bar-tailed Godwit	0.7							
	0.01							
Number of visits	294	84	45	23	49	119	115	8
Hectares censused	48.08	14.16	1.54	15.58	93.08	10.44	20.23	4.86
Ave. no./census/5 ha	33.32	25.50	48.76	329.40	10.95	2.11	6.60	26.72

* For each species, the upper row of values are frequencies, or percent of censuses in which each was recorded; the lower row gives the average number of individuals per 5 ha per census.

large tidal sloughs. Old pilings and small mud flats were found along the banks, some of which had log rafts attached.

Adjacent to the mud flats and elevated 5 to 100 cm were salt marshes. Much of this habitat had been removed when a dike was built in the early 1900's around most of the bay. The marshes were dominated either by a mixture of common pickleweed (*Salicornia pacifica*) and salt grass (*Distichlis spicata*) or by cord grass (*Spartina foliosa*). The diked area on the landward side consisted mainly of seeded pastures (red clover *Trifolium pratense*, velvet grass *Holcus lanatus*, bent grass *Agrostis* sp., Italian rye grass *Lolium multiflorum* and orchard grass *Dactylis glomerata*) with meandering channels which drained water. Livestock grazed the pastures closely and were periodically removed to allow the vegetation to regrow. During the rainy season the pastures became saturated with water and scattered ponds were formed in the lower areas. Permanent freshwater marshes were created in low areas of poor drainage.

In 1957 the City of Arcata built a 20-ha oxidation pond for secondary sewage treatment on the north side of the bay. This large freshwater pond provided water, food and roosting sites for many species of birds. Water parsley (*Oenanthe sarmentosa*) and knotweed (*Polygonum persicaria*) oc-

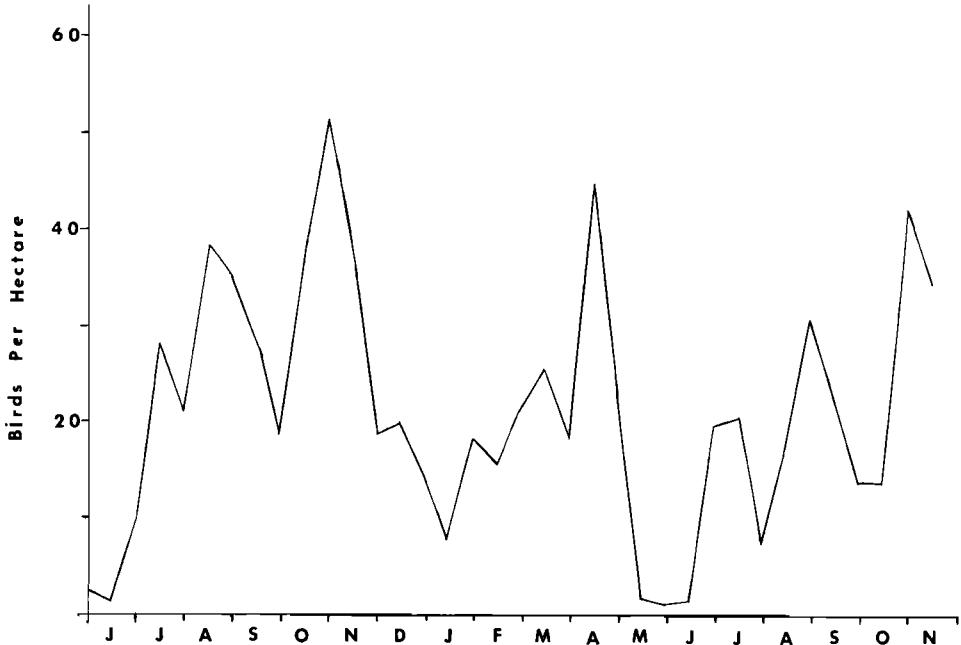


FIGURE 1. Shorebirds per hectare on selected sites in Humboldt Bay, California, from June 1968 to November 1969.

curred along the edges of the pond with bulrush (*Scirpus acutus*, *S. paludatus*) and willow (*Salix* sp.) in scattered stands.

Most of the censusing was accomplished on small representatives of each habitat type, between two and 20 hectares in size. A census was usually taken on a weekly or biweekly basis, dependent on the tidal sequence. All shorebirds in the area were counted.

During the study nearly 4000 shorebirds were trapped using mist nets and a rocket net (Gerstenberg and Harris 1976). Many were color marked for identification in the field.

RESULTS

Thirty-four species of shorebirds were found using the eight habitats studied at Humboldt Bay (Table 1). Five species were found only once or twice on one habitat. Twenty percent were found on all habitats and 35 percent were found on six or more habitats.

Mud flats were the most heavily utilized habitat in the bay. Use of most other habitats was related to the daily tidal sequence. When the mud flats were exposed, birds were found feeding on them. At high tide when the mud was flooded the birds either roosted near the edge of the bay or moved to alternate habitats. This general pattern varied when tides were exceedingly high, forcing the birds off adjacent sites to alternate habitats or when heavy rains flooded pastures, swelled creeks entering the bay and silted the mud flats, forcing the birds to pastures or out of the area.

Shorebird use of a habitat is related to the number of birds in an area and the availability of the habitat as a feeding or roosting site. Similar to other areas in California, most use of Humboldt Bay is by migrating and wintering shorebirds (Fig. 1). Low numbers and species were found in late May and June (summer)

TABLE 2
FREQUENCY AND DENSITY OF SHOREBIRDS ON MUD FLATS, HUMBOLDT BAY

Species	Frequency			Birds/census/5 ha		
	High ^a	Mid	Low	High	Mid	Low
Black-bellied Plover	62.2	81.6	100.0	10.01	6.10	25.70
Killdeer	8.9	11.8		0.64	0.25	
Black Turnstone	9.6	44.8	44.5	0.40	1.53	2.27
Ruddy Turnstone	7.5	17.6	16.7	0.32	0.57	0.32
Semipalmated Plover	13.0	11.8	11.1	0.94	0.49	0.37
Dunlin	48.0	44.8	44.5	2412.00	741.30	81.30
Western Sandpiper	75.4	33.1	94.4	350.80	15.76	210.80
Least Sandpiper	67.1	21.3	55.6	73.64	7.12	14.63
Sanderling		59.5	5.6		16.48	0.12
Wandering Tattler		8.8			0.07	
Dowitcher (two species)	53.4	39.7	77.8	124.04	6.08	77.59
Greater Yellowlegs	16.4	2.9	16.7	0.82	0.05	0.25
Knot	1.4	5.1	22.2	0.05	0.30	0.82
Marbled Godwit	80.8	90.4	94.4	100.60	29.40	30.64
Willet	79.5	90.4	95.5	13.15	11.71	37.31
Long-billed Curlew	50.7		16.7	2.40		0.25
Whimbrel	6.8	15.4		0.22	0.17	
American Avocet	16.4		5.6	1.63		0.07

^a High, mid and low refer to intertidal level on mud flats.

when shorebirds used the mud flats almost exclusively. This was due in part to the unavailability of alternate habitats which had dried up or become rank with vegetation. Fall brought an influx of birds beginning in early July. There were several waves of movement due to differential movement by species, age and sex groups. In early fall (July to 15 August) the Short-billed Dowitcher (*Limnodromus griseus*) and Western Sandpiper (*Calidris mauri*) moved through, while in late fall (15 August to 30 November) the Dunlin (*Calidris alpina*) was migrating. Use of alternate habitats increased as they became more available.

From December to mid March (winter) numbers were relatively stable; however, movement out of the area did occur when there was adverse weather. A bird marked in December was seen 350 kilometers south in January after heavy rains occurred. Use of alternate habitats decreased as flooding made the habitats unavailable.

Spring migrants began to arrive in March and moved through the bay until early May. Again there was a series of waves as the spring migrants moved through. Little movement between the north and south ends of the bay occurred except during migration. Few marked birds were seen far from the original place of marking.

Twenty-nine species of shorebirds were recorded on the mud flats (Table 1). Three species, Marbled Godwit (*Limosa fedoa*), Willet (*Catoptrophorus semipalmatus*) and Black-bellied Plover (*Pluvialis squatarola*) were seen on more than 75 percent of the censuses. Average density through the year was 33 birds per hectare. Highest density occurred on 30 April 1969 when 370 birds per hectare were present on a high mud flat and on 14 November 1968 when 307 birds per hectare were present.

Mud flats were separated into three subdivisions according to when the area became exposed in the tidal sequence. High-level mud flats were the first to become exposed and were located near the edge of the bay. Mid-level flats were exposed during most tidal sequences and were located away from the edge of the bay or in areas where the flats were lower in elevation. Low-level flats were fully exposed only on a minus tide.

The Willet, Marbled Godwit and Dunlin showed little preference for any particular level of mud flat (Table 2); however, use of the higher mud flats were more concentrated for the Marbled Godwit and Dunlin. Killdeer (*Charadrius vociferus*) and Whimbrel (*Numenius phaeopus*) were found only on high or mid-level flats. Knots (*Calidris canutus*) were found most often on low level flats.

Sanderlings (*Crocethis alba*) used mud flats adjacent to the sand flats or mud flats which had high sand content. Long-billed Dowitchers (*Limnodromus scolopaceus*) were found on the high-level mud flats feeding in deep channels usually when freshwater areas were not available.

Seasonally the highest number of species, and the highest density (Table 3), were found during fall. The Marbled Godwit was found on mud flats more than 70 percent of the time during all seasons while the Willet occurred similarly except during summer. The Western Sandpiper was most numerous during spring and the Dunlin during late fall and through winter.

The incoming tide forced shorebirds off the mud flats to alternate habitats. Most birds would spend at least some time on the adjacent salt marshes before moving to other areas. Few birds were found using the salt marshes during low tide. As the tide began to recede from high, some birds started feeding in the higher channels which meandered through the marshes. Eight species were seen feeding in such situations. During this time there was an influx of birds moving from other habitats. Mass movement just prior to the exposure of the mud flats occurred regularly.

Sixteen species were recorded roosting on the salt marshes (Table 1), the most frequent the Marbled Godwit and the most numerous the Western Sandpiper. Density on this habitat (330 birds per hectare) was high because the birds were in a small area.

Sand flats occurred in the mid channel and in south bay. Twenty-one species were recorded with the most regular being the Black-bellied Plover, Sanderling, Marbled Godwit and Willet. Sanderling, Dunlin and Western Sandpiper were the most numerous. Density was 26 birds per hectare. Use was most heavy during fall (46 birds per hectare) with less use during winter and spring and almost none during summer (Table 3). Heavy rain during winter caused silting of the flats after which bird use decreased. Sanderlings were in highest numbers from early fall through spring.

Most shorebird use of the tidal slough was on the mud flats exposed along the sides and the bottom. Fourteen species were found with the Willet the most frequent and the Western Sandpiper the most numerous (Table 1). Highest usage occurred during early fall and spring. Ten to 12 species were usually present throughout the year except summer. The most numerous species during fall was the Western Sandpiper and during the spring the Dunlin was the most numerous.

Large numbers of shorebirds, sometimes exceeding 40,000 birds, used the log rafts and pilings along the sides of the slough for roosting at high tide.

TABLE 3
SEASONAL USE (BIRDS/HECTARE) OF EIGHT HABITATS, HUMBOLDT BAY

Season	Mud flat	Sand flat	Tidal slough	Sewage pond	F/W marsh	Upland	Salt marsh	Sand beach
Early Fall	31.03	46.46	47.03	1.82	0.01	0.57	82.60	5.35
Late Fall	47.68	26.54	21.56	55.00	36.01	21.00	389.60	29.77
Winter	32.23	16.69	41.86	0.64	0.91	20.93	512.20	
Spring	46.47	9.50	62.26	15.77	5.48	3.34	124.40	
Summer	2.12	1.40	2.60	0.66	0.01	0.00	1.60	

At high tide species such as the Black-bellied Plover, Killdeer and Least Sandpiper (*Calidris minutilla*) moved directly to upland areas where they were seen feeding in the open pastures or along the edges of marshes or water areas. Other species such as the Short-billed Dowitcher and Dunlin would also move to the uplands but usually only to roost. Heavy use of the uplands did not occur until the first rains had dampened the soil. Use would increase as water saturated the fields causing worms to become exposed. At this time Marbled Godwits would move to the fields.

Twenty species of shorebirds were found in upland areas with the most frequent being the Black-bellied Plover, Killdeer and Greater Yellow-legs (*Tolanus melanoleucus*) (Table 1). The most numerous was the Dunlin. Highest density occurred during winter.

Freshwater marshes occurred throughout the area and shorebird use was related to water content in the marsh and tidal sequence. A marsh was unsuitable for use when flooded or when too little water was present and vegetation was rank. Fourteen species were found in this habitat. The Killdeer nested in suitable marshes and was found throughout the year. Both Common Snipe (*Capella gallinago*) and Killdeer were found on 60 percent of the census (Table 1). The Common Snipe was the most numerous (3.5 birds per 5 hectare) which was very low when compared to other feeding areas. Seasonally the heaviest use was during the spring with little or no use during summer and early fall (Table 3).

A habitat not studied in other coastal areas was the sewage lagoon. It provided roosting sites on dikes and feeding areas along the shore and in the pond. There were 20 species present with the most numerous being the Northern Phalarope (*Lobipes lobatus*) which occurred as a spring and fall migrant. Other species frequently found were the Least and Western sandpipers. The Least Sandpiper used the area as an alternate feeding site and was found over 70 percent of the time. Seasonally the heaviest use occurred during late fall and spring. Little use was found during winter or summer (Table 3).

During the fall of 1969 a small stretch of sand beach was censused. Thirteen species were seen (Table 1) with the Sanderling being found on every census and occurring as the most numerous species. The Least Sandpiper and the Black-bellied Plover were found in largest numbers and the Willet was found on most census in low numbers.

Recher (1966) noted that spring movement was more rapid and movement time more compressed than fall. This caused the population density to be higher in spring than fall. In Humboldt Bay density on mud flats was highest in late fall

when Dunlin were moving through the area and late spring when Western Sandpipers were migrating. The overall density on the mud flat was slightly higher in spring than fall and only the tidal slough and freshwater marsh had higher densities in spring. The total population would be higher in the fall than in the spring because winter mortality had taken place.

Recher (1966) also noted that more mud flat was available for longer periods in April and May than in the fall. This would cause the birds to be dispersed more evenly throughout the mud flat. In Humboldt Bay alternate habitats were more available in spring than fall. Winter rains had made marshes and uplands available providing more habitat.

Importance of alternate habitats depended on the individual species needs. The Least Sandpiper appeared always to be feeding. They moved from the mud flat to upland or freshwater marshes, continuing to feed. Other species such as the Marbled Godwit or Dunlin roosted on the salt marsh after feeding and only if the tidal sequence was especially long would they seek alternate feeding sites. During periods of stress the alternate areas became more important, especially during winter storms or spring migration. Thus, although the mud flat is the most important habitat studied, alternate habitats are essential to maintain the shorebird density and species in Humboldt Bay.

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