Studies in Avian Biology No. 2:101–111, 1979.

SEASONAL HABITAT USE BY ARCTIC ALASKAN SHOREBIRDS

P. G. CONNORS, J. P. MYERS, AND F. A. PITELKA[1]

ABSTRACT.—Shorebirds display a wide range in seasonal patterns of habitat use along the arctic coast near Point Barrow, Alaska. Differences between species reflect habitat preferences, the timing of movements with respect to seasonal habitat availability, and whether the use is breeding, post-breeding, or migrational. During the breeding season (June and July), most activity is centered on the tundra, but by early August a marked coastal movement occurs, resulting in high densities of particular species in shoreline and adjacent habitats. In August and September, widespread use of littoral habitats develops, especially for such species as Red Phalarope, Ruddy Turnstone, and Sanderling. In contrast, Golden Plovers and Pectoral Sandpipers restrict most of their activities to the tundra. Other species exhibit intermediate patterns of habitat use. These patterns determine the dependence of each species on arctic coastal habitats, and the susceptibility of each species to disturbances related to outer continental shelf oil development.

Shorebirds comprise a major portion of the avifauna along the Beaufort and Chukchi coasts of arctic Alaska (Bailey 1948, Gabrielson and Lincoln 1959, Pitelka 1974). In fact, their breeding distributions are restricted in large part to arctic and subarctic regions (Palmer 1967). Moreover, on the coastal plain, they collectively are responsible for most of the insectivory in tundra trophic dynamics. This implies a strong dependence on environmental conditions prevailing within the region, and compels us to examine possible ways that the escalating development of North Slope energy resources may affect shorebird populations. A species list is provided in Table 1.

Much of the current development is oil-related, both on the coastal plain at Prudhoe Bay, Alaska, and spreading westward toward Barrow and inland over the Naval Petroleum Reserve area. Increasing activity focuses on extracting oil from the outer continental shelf. Use of natural gas deposits is also anticipated, and in the future mining coal may become an important activity. Because each of these developments will have different centers of activity and different environmental effects, their importance to shorebird populations will vary, influenced by changing patterns in habitat use by arctic coast species. An essential step in identifying possible consequences of development therefore involves examining seasonal changes in habitat use: How do different species use the arctic coast environment, and what effects do their use patterns have on susceptibility to oil-related disturbances?

In this paper we examine general patterns in habitat use by shorebirds common near Barrow, Alaska. Data were gathered during 1975 and 1976 on a series of transects constructed in littoral (shoreline) and tundra habitats in the Barrow area. The patterns suggest a preliminary classification of North Slope shorebirds in terms of their sensitivities to development activities.

STUDY AREA

Point Barrow (latitude 71°23′N, longitude 156°28′W) is the northernmost point on a gravel spit 12 km long marking the boundary between Beaufort and Chukchi seas (Fig. 1). The area around Point Barrow offers a diverse set of lowland habitats, including both littoral areas and tundra. Littoral habitats include brackish water mudflats and marsh pools, mud and gravel shores of sloughs and

[1] Museum of Vertebrate Zoology and Bodega Marine Laboratory, University of California, Berkeley, California 94720.

TABLE 1
SHOREBIRD SPECIES OCCURRING REGULARLY ALONG THE BEAUFORT AND CHUKCHI COASTS OF ALASKA

Regular Breeders
Semipalmated Plover, *Charadrius semipalmatus*
American Golden Plover, *Pluvialis dominica*[a]
Black-bellied Plover, *Pluvialis squatarola*
Ruddy Turnstone, *Arenaria interpres*[a]
Black Turnstone, *Arenaria melanocephala*
Common Snipe, *Capella gallinago*
Whimbrel, *Numenius phaeopus*
Red Knot, *Calidris canutus*
Pectoral Sandpiper, *Calidris melanotos*[a]
White-rumped Sandpiper, *Calidris fuscicollis*
Baird's Sandpiper, *Calidris bairdii*[a]
Dunlin, *Calidris alpina*[a]
Semipalmated Sandpiper, *Calidris pusilla*[a]
Western Sandpiper, *Calidris mauri*[a]
Stilt Sandpiper, *Micropalama himantopus*
Buff-breasted Sandpiper, *Tryngites subruficollis*
Long-billed Dowitcher, *Limnodromus scolopaceus*[b]
Bar-tailed Godwit, *Limosa lapponica*
Red Phalarope, *Phalaropus fulicarius*[a]
Northern Phalarope, *Lobipes lobatus*
Additional Migrants
Killdeer, *Charadrius vociferous*
Sharp-tailed Sandpiper, *Calidris acuminata*
Least Sandpiper, *Calidris minutilla*
Rufous-necked Sandpiper, *Calidris ruficollis*[c]
Curlew Sandpiper, *Calidris ferruginea*[c]
Sanderling, *Calidris alba*[b,c]
Hudsonian Godwit, *Limosa haemastica*

[a] Eight species common as breeders near Barrow.
[b] Two species common as migrants near Barrow.
[c] Also known to breed occasionally at least near Barrow.

lagoons, and gravel ocean beaches. In the absence of storms, vertical tidal fluctuations are less than 30 cm, and horizontal water line movement is almost undetectable. Occasional wind-driven tides maintain salt marsh and brackish pool habitats above the normal water line. In general, wave action is slight because of the influence of sea ice. The tundra is highly polygonized, and varies from low wet marshes to drier ridges with occasional wet troughs and no more than 2–3 m higher than the neighboring lowlands. Tundra vegetation and landforms in the study area are described in Britton (1957).

METHODS

Marked transects were established throughout the study area in a wide range of littoral and tundra habitats accessible within 20 km of Point Barrow. In littoral areas we censused 22 transects, totaling 18.4 km long by 50 m wide along shorelines and 2.3 km long by 100 m wide on mudflats and salt marsh areas, for a total littoral transect area of 115 ha; on the tundra we censused 10 transects, each 1 km × 100 m wide, total area of 100 ha. All transects were censused at least once during each 5-day period from 1 June 1976 through 17 September 1976. A smaller set of transects was censused similarly from 30 June 1975 through 2 September 1975. In this paper we analyze data only from the more complete 1976 season.

We present the data in two ways: (1) To describe the overall pattern of habitat use by Barrow shorebirds and to consider individual species' movements we use actual transect census totals. Total

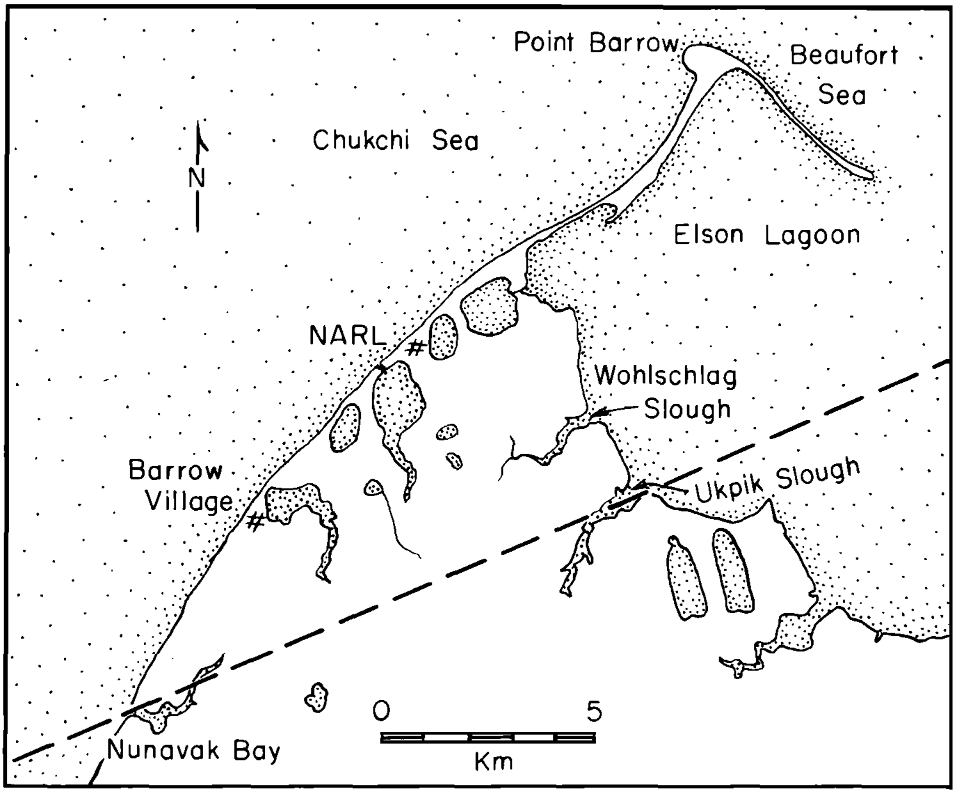

FIGURE 1. Map of study area near Point Barrow, Alaska. Habitats sampled by transects are all north of the dashed line.

areas of littoral and tundra transects are comparable (115 ha vs. 100 ha, respectively), so these data approximate areal densities. We do not use densities in this case because of spatial differences in bird use between habitats: Along shorelines most shorebird activity is concentrated within a narrow strip and is best calculated as a linear density; in contrast, mudflat and tundra habitats require areal densities. Because transect dimensions in both habitats remained constant throughout the season, transect census totals allow seasonal comparisons in use of tundra and littoral habitats; at the same time they show directly the numbers of individuals occurring along our transects.

(2) To examine the importance to birds of tundra vs. littoral habitat we calculate an index of relative littoral use, U_L, which corrects for the difference in areal extent between these two habitat categories within the local Barrow study area. For this calculation the region of interest lies north of a line from Nunavak Bay to Ukpik Slough (Fig. 1). Using a shoreline width of 50 m (width used for censusing), the ratio of total tundra to total littoral habitat is 12.9. The relative use of littoral habitat, U_L in the Barrow area is defined as

$$U_L = \frac{D_L}{D_L + 12.9 D_T},$$

where D_L = density in littoral habitat and D_T = density in tundra habitat. The correction factor (12.9) is sensitive to the position of the line used to define the region of interest. We placed it as indicated in Figure 1 in order to include only the area sampled by our transect arrays. The index, U_L, thus reflects the importance of littoral habitats only in relation to the immediately adjacent tundra.

RESULTS

The census data yield a phenology of habitat use in the Barrow area. In this preliminary treatment we make only one habitat distinction, categorizing tran-

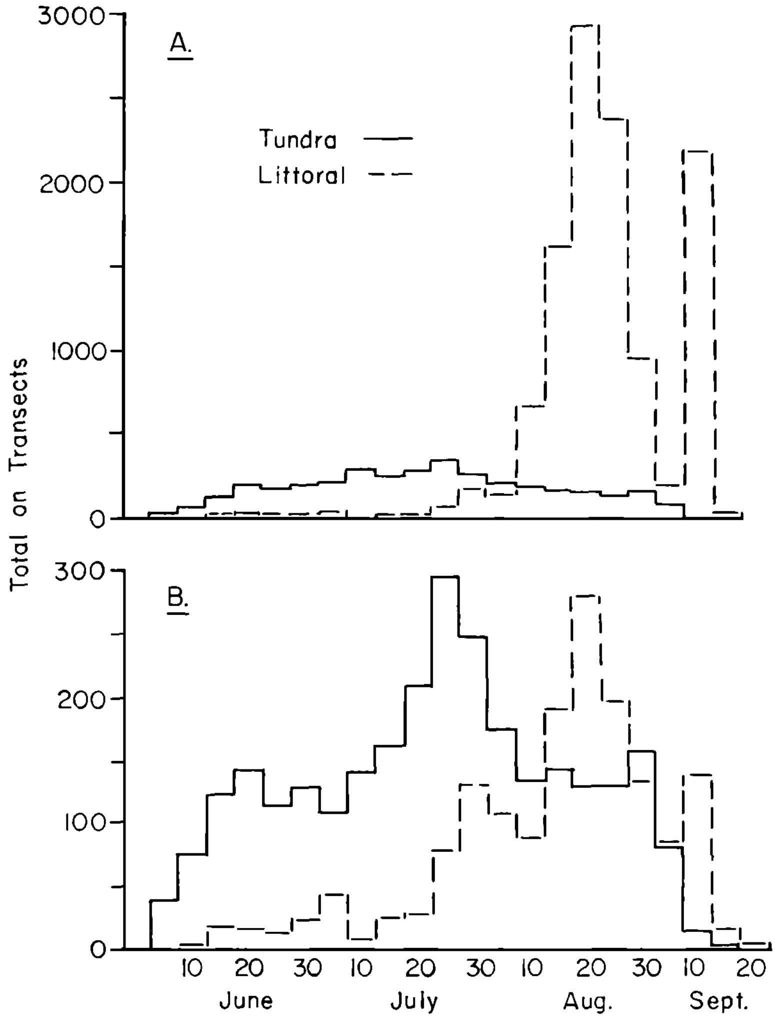

FIGURE 2. Seasonal habitat use, tundra vs. littoral, for all shorebirds combined (A) and for all shorebirds except Red Phalaropes (B).

sects as either littoral or tundra. Subsequent papers will consider changing patterns within tundra and littoral zones in more detail.

During the nesting period in June and July, activity centers on the tundra (Fig. 2). Shorebirds' main prey base during this interval consists of freshwater zooplankton and insect larvae and adults (Holmes and Pitelka 1968). As juveniles fledge in late July and August, shorebirds occur on mudflats, lagoon edges, and ocean shorelines in increasing numbers, shifting to a diet of oligochaetes and insect larvae on mudflats and a wide variety of marine zooplankton along the shore (Connors and Risebrough 1977). By mid-August the littoral zone becomes a major foraging area for many species. This situation continues through early September, after which time few shorebirds remain in the Barrow area. The switch from tundra to littoral resources occurs in parallel with an increased avail-

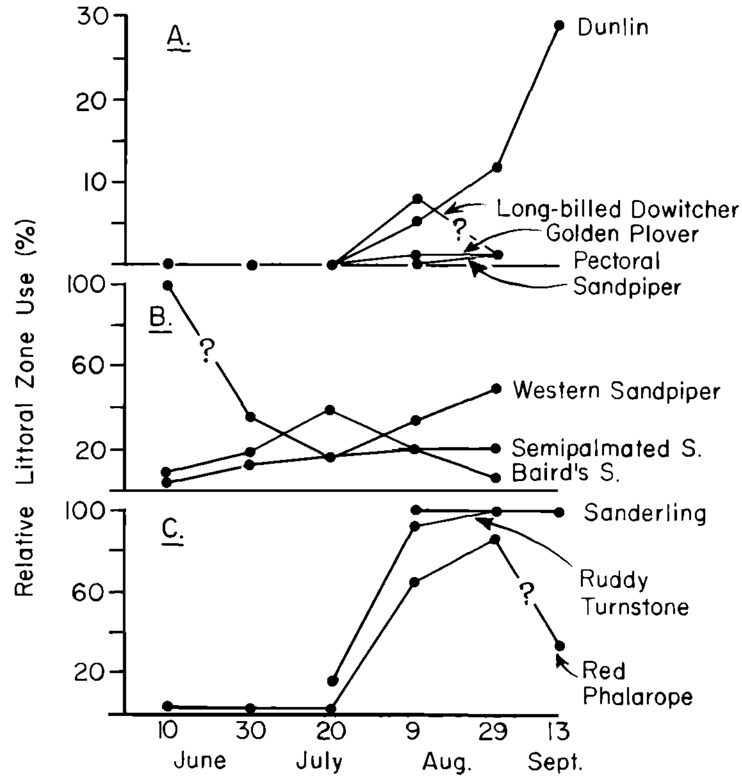

FIGURE 3. Relative use of littoral habitats by shorebird species in study area (see text). A includes species from categories I and II, Table 2; B corresponds to category III, C to category IV.

ability of littoral habitat. Prior to July sea ice effectively precludes birds from using most marine shoreline habitats.

The overall seasonal pattern in Figure 2 actually consists of several distinct habitat use patterns representing the responses of particular species to the mosaic of arctic coastal habitats near Barrow. The species comprising the shorebird community differ with respect to their seasonal use of littoral and tundra habitats.

TABLE 2
HABITAT USE PATTERNS OF COMMON SHOREBIRDS NEAR BARROW, ALASKA

Category	Breeding	Post-breeding adult	Post-fledging juvenile	Species
I	T[a]	T	T	Golden Plover, Pectoral Sandpiper
II	T	T + L	T + L	Dunlin, Long-billed Dowitcher
III	T + L	T + L	T + L	Western, Semipalmated, Baird's Sandpipers
IV	T	T + L	L	Red Phalarope, Ruddy Turnstone, Sanderling

[a] T, tundra; L, littoral.

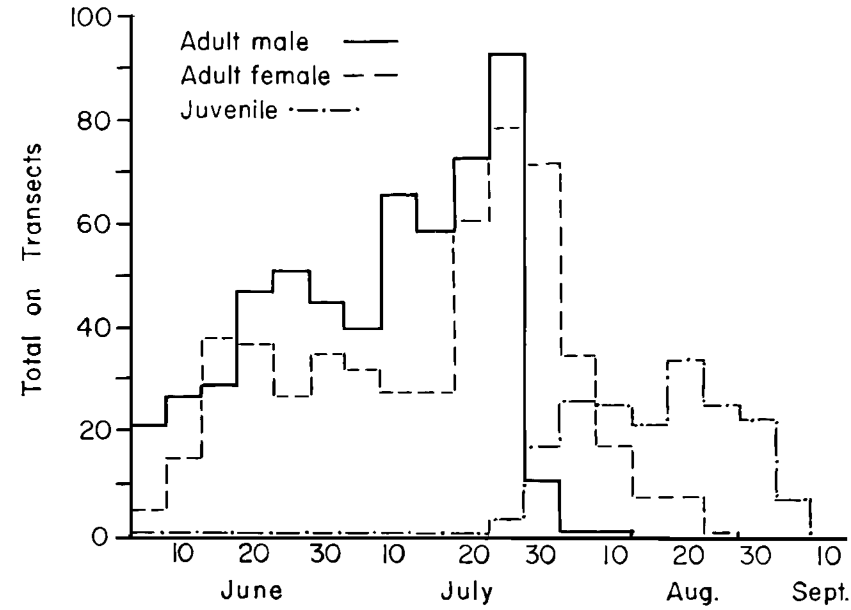

FIGURE 4. Seasonal use of tundra habitats by Pectoral Sandpipers.

This can be seen in Figure 3 which presents the relative use of littoral habitat, U_L (see Methods), during successive 20-day periods throughout the summer.

Species vary in the extent to which they move to littoral habitats. Some, such as Golden Plovers, never leave the tundra, while others, for example Ruddy Turnstones, switch almost entirely. Between these extremes are several intermediate patterns varying in extent and timing of the littoral movement. Part of this variation results from differential movement of age and sex classes to littoral habitats. Table 2 presents four categories of seasonal habitat use patterns, based on these considerations, which summarize interspecies variation. The same four categories are suggested by the 20-day period comparisons in Figure 3.

Category I includes Golden Plovers and Pectoral Sandpipers, the two species most restricted to tundra habitats throughout the summer season. Both appear only sparingly in the littoral zone near Barrow, despite major migrational buildups on the adjacent tundra. Pectoral Sandpipers, for example, show progressive movements of post-breeding males, post-breeding females, and fledged juveniles at tundra sites (Fig. 4), yet only occasionally do individuals appear on littoral transects (Fig. 3A).

Members of Category II confine their breeding activities to the tundra, but include significant use of both habitats during subsequent periods. Dunlins exhibit this pattern: In June and early July, Dunlins use tundra resources almost exclusively. As littoral sites become available, post-breeding adults and fledged juveniles occur increasingly in these habitats. Throughout the summer, however, Dunlins continue to exploit tundra habitats. Long-billed Dowitchers are uncommon as breeders near Barrow, but a substantial movement of migrating juveniles in August, highly variable from year to year, occurs in both habitats.

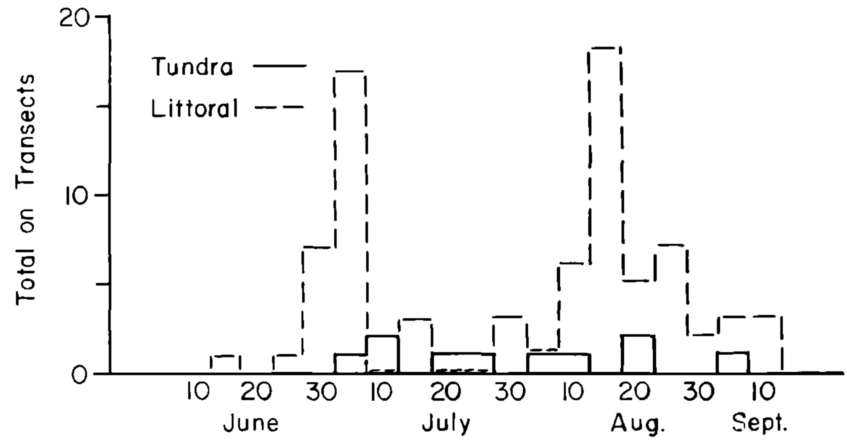

FIGURE 5. Seasonal habitat use, tundra vs. littoral, by Western Sandpipers.

Species in Category III utilize littoral as well as tundra habitats near Barrow during the breeding season, and post-breeding migrational movements occur in both habitats. Western Sandpipers (Fig. 5) and Semipalmated Sandpipers (Fig. 6) occur in littoral areas throughout the breeding season, foraging along stream sloughs, mudflats, and lagoon edges near their tundra nesting sites. The Western Sandpiper exhibits a late June, early July peak of apparently non-breeding adults, and a mid-August peak of migrating juveniles, both heavily littoral. Semipalmated Sandpiper densities are fairly constant through the breeding season in both habitats, with a build-up of migrating adults in late July followed by a sudden and very sharp peak of migrating juveniles around August 1. This juvenile movement is striking. The peak is actually sharper than shown in Figure 6, since this graph averages a very high and a very low count within the August 1 period. In both 1975 and 1976, juveniles appeared along lagoon shores and on mudflats as a sudden wave, with densities dropping a few days later. Figures 5 and 6 also indicate that the juvenile migrational peaks of these two ecologically similar species occur at different times, offset by 5 to 10 days, greatly reducing the overlap in time of their occurrences on the limited mudflats near Barrow. A third species within this category, Baird's Sandpiper, nests in a variety of habitats near the coast at Barrow, ranging from tundra high polygons to (occasionally) gravel beaches. As Figure 3B indicates, it occurs in littoral and tundra habitats throughout the season.

Species in Category IV shift from almost exclusive use of tundra for breeding to heavy dependence on littoral areas by post-fledging juveniles (Fig. 3C). Figure 7 presents the seasonal occurrence of different Red Phalarope age and sex classes on tundra transects. In early June, adult males and females increase in density in a 1:1 ratio, but associate only until clutches are completed. In late June and early July, females abandon nests and flock together as southward migration begins. Males incubate and attend the young until the latter are nearly fledged, at which time the males begin to flock and leave the Barrow region. Fully fledged young then begin a dramatic movement to littoral areas, as reflected by the August peak in Figure 2A, which is composed almost entirely of Red Phalaropes (com-

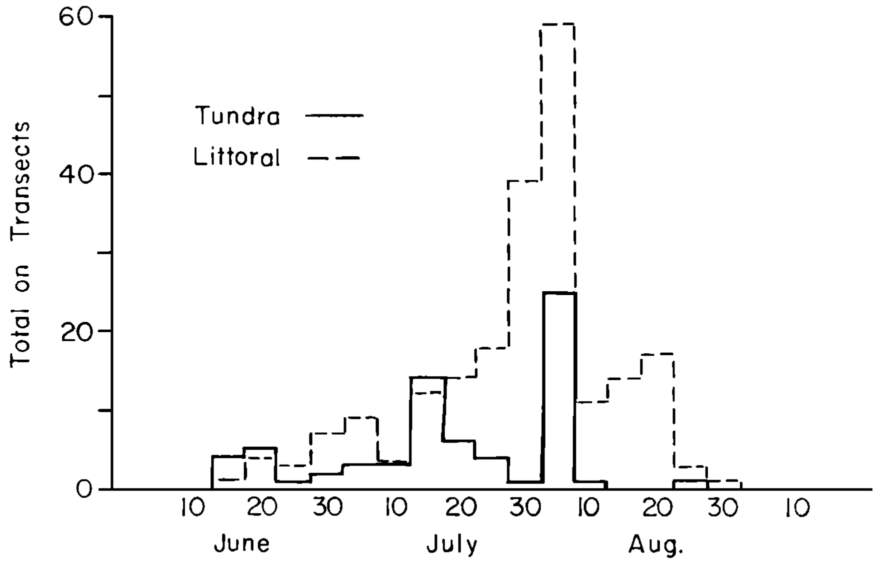

FIGURE 6. Seasonal habitat use, tundra vs. littoral, by Semipalmated Sandpipers.

pare Figs. 2A and 2B). The abrupt shift from tundra to littoral areas at the end of July includes a fairly heavy movement of migrating adult males, but the bulk of the shoreline phalarope activity consists of juveniles. Thus the difference in migration schedule between adult females, adult males, and juveniles accompanies pronounced differences in habitat use: Females seldom appear in littoral sites; males do so to an extent which changes with annual variation in the timing of sea-ice melt; and juveniles flood the littoral zone.

Ruddy Turnstones (Fig. 3C) display the same habitat use pattern in more modest proportions. After the young fledge, adults occur briefly in littoral areas, soon leaving the Barrow region. Throughout August and early September, juveniles are common on the beaches. Sanderlings, rare breeders near Barrow, occur in small numbers as spring migrants; in late summer, juveniles are common along gravel shorelines.

DISCUSSION

Assessing possible consequences of environmental disturbances requires two general classes of information concerning the nature of the physical disturbance and the ecological features of the area, especially the identity and characteristics of its species. The first of these depends upon collaboration between engineer, physical scientist, and biologist, because it entails not only the physical details of a particular development, but also its probability of occurrence, possible extent in geographic and habitat terms, and its time scale, as well as those of secondary effects. An excellent example of the desired level of collaboration is offered by Weller et al. (1978).

The second set of factors are more strictly biological. They rest upon four interacting considerations which must be established for each species:

1) Distribution. What species occur in the affected area; what is the nature of

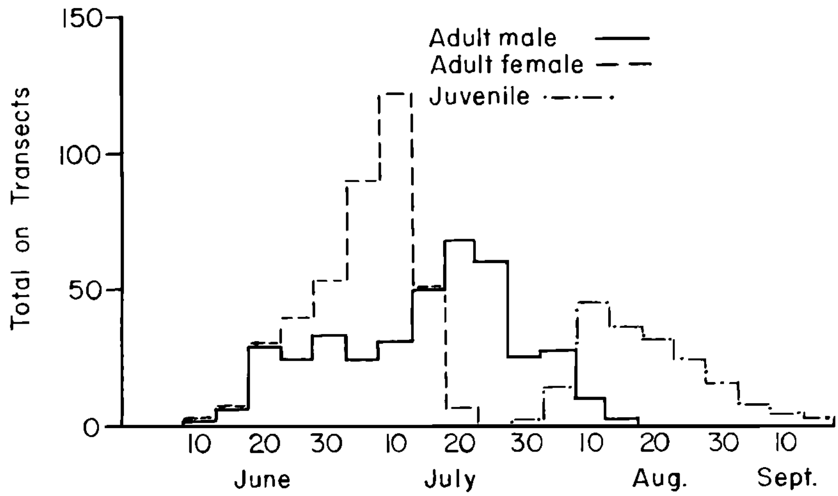

FIGURE 7. Seasonal use of tundra habitats by Red Phalaropes.

their activities (breeding, migration, etc.); how do population densities change seasonally and between years; is the area of critical importance for the local population; and how important is the area to the overall welfare of the species?

2) Habitat use. Different patterns of habitat use may render one species more susceptible than another by influencing its exposure to the disturbance. General differences in habitat preference (e.g. tundra vs. littoral) determine the probability of contact with the disturbance. For example, littoral zone habitats are more susceptible than tundra to damage from offshore oil spillage. Likewise, drainage patterns will determine the habitat effects of many tundra disturbances. On a finer scale, microhabitat differences will influence the severity of any effects arising from birds contacting spills within a general habitat type, as for example, the difference between shorebirds foraging above the water line vs. those wading or swimming.

3) Trophic relationships. The vulnerability of food resources to damage by development activities, as well as the dependence of a shorebird species on potentially affected food items and its ability to switch to other unaffected resources will influence sensitivity.

4) Social system and behavior. Differences in the seasonal occurrence and activities of different age and sex classes will set the schedule of exposure to any possible disturbance. Resulting population consequences will depend strongly upon which sex or age class is affected, and when the impact occurs during the reproductive cycle. Population dispersion patterns and individual spacing behaviors may also affect vulnerability to such events as oil spills, or the increase in predation caused by predator attraction to refuse sites. Under this heading also come a series of questions related to the effect of foraging behavior on exposure to different disturbances, and on responses to the disturbances themselves. For example, how tolerant are species of a particular disturbance, such as noise, during breeding or non-breeding activities?

Reviewing oil pollution impacts on bird populations in the North Atlantic,

TABLE 3
SHOREBIRDS POTENTIALLY AFFECTED BY OIL DEVELOPMENT NEAR BARROW, ALASKA

Coastal plain tundra		Littoral and offshore
Lowland	Upland	
Red Phalarope	Golden Plover	Red Phalarope
Pectoral Sandpiper	Ruddy Turnstone	Sanderling
Long-billed Dowitcher	Semipalmated Sandpiper	Ruddy Turnstone
?	Baird's Sandpiper	Semipalmated Sandpiper
?	Dunlin	Western Sandpiper
	?	Baird's Sandpiper
	?	Dunlin
		Long-billed Dowitcher
		?
		?

Bourne (1968) suggests that the most detectable consequences entail direct mortality from oil fouling, especially with waterfowl and seabirds. With the exception of phalaropes, the normal foraging behaviors of shorebirds reduce their immediate susceptibility to fouling relative to surface diving species. However, significant numbers of shorebirds of several species were found dead after spills in two estuaries in England in 1961 and 1966, presumably from direct toxic effects of oil. Compounding these direct actions, damage to habitat or prey populations is presumed to have been responsible for decreases ranging from 20% to 100% in several species' winter population sizes from one year to the next (Harrison 1967, Buck and Harrison 1967).

Our data on arctic coastal plain shorebirds allow preliminary estimates of the relative susceptibility of different species to effects of these kinds, in that they identify the species present, document their abundances, and describe general habitat use (Tables 3 and 4). They are tentative because they do not include all of the considerations listed above; our work continues to examine these issues and will refine the estimates. Table 3 lists the common shorebird species near Barrow, identifying those possibly affected by two general types of development, offshore vs. onshore. The question marks in the table indicate our uncertainty with respect to the type and magnitude of potential developments and their

TABLE 4
RELATIVE SUSCEPTIBILITY OF COMMON BARROW SHOREBIRDS TO LITTORAL ZONE DISTURBANCES

High	Moderate	Low
Red Phalarope	Semipalmated Sandpiper	Golden Plover
Sanderling	Western Sandpiper	Pectoral Sandpiper
Ruddy Turnstone	Baird's Sandpiper	
	Dunlin	
	Long-billed Dowitcher	

associated disturbances, as well as our need for more information on the biology of several of the less common species.

Table 4 estimates relative susceptibilities of the common Barrow shorebirds to disturbances in the littoral zone arising from outer continental shelf oil development. It is based primarily on the patterns reflected in Figure 2: the greater each species' relative use of littoral zone habitat, the more likely it is to be affected by such development. But we have also weighted our estimates with qualitative criteria based on population sizes and the magnitude of concentrations in littoral areas. The result is a somewhat subjective prediction of how likely a species is to suffer adversely from littoral zone oil-related activities in the Barrow area. As such they should provide a useful preliminary guide in management and planning decisions for coastal lowlands near Barrow.

ACKNOWLEDGMENTS

These studies were supported by the Bureau of Land Management and the National Oceanic and Atmospheric Administration as part of the Outer Continental Shelf Environmental Assessment Program (OCSEAP) and by the Energy Research and Development Administration (now Department of Energy). Carolyn Connors, Russell Greenberg and Frank Gress contributed greatly to the field effort. L. P. Myers helped in preparing the manuscript. We thank the Naval Arctic Research Laboratory (NARL) for logistic support.

LITERATURE CITED

BAILEY, A. M. 1948. Birds of Arctic Alaska. Colorado Mus. Nat. Hist., Popular Ser. 8.

BRITTON, M. E. 1957. Vegetation of the arctic tundra. Oregon State Coll. Biol. Colloq., 18:26–61.

BOURNE, W. R. P. 1968. Oil pollution and bird populations. Pp. 99–121 *in* J. D. Carthy and D. R. Arthur, eds., Biological Effects of Oil Pollution on Littoral Communities. Field Studies Council, London.

BUCK, W. F. A., AND J. G. HARRISON. 1967. Some prolonged effects of oil pollution on the Medway Estuary. WAGBI Yearbook, 1966–71. 32–33.

CONNORS, P. G., AND R. W. RISEBROUGH. 1976. Shorebird dependence on arctic littoral habitats. Pp. 401–455 *in* Environmental Assessment of the Alaskan Continental Shelf, Vol. 2, Marine Birds. Environmental Research Laboratories, Boulder, Colorado.

GABRIELSON, I. N., AND F. C. LINCOLN. 1959. The Birds of Alaska. Stackpole Co., Harrisburg, Pa.

HARRISON, J. G. 1967. Oil pollution fiasco on the Medway Estuary. Birds 1:134–136.

HOLMES, R. T., AND F. A. PITELKA. 1968. Food overlap among coexisting sandpipers on northern Alaskan tundra. Syst. Zool. 17:305–318.

PALMER, R. S. 1967. Species accounts. Pp. 143–267 *in* G. D. Stout, ed., The Shorebirds of North America. Viking Press, New York.

PITELKA, F. A. 1974. An avifaunal review for the Barrow region and north slope of arctic Alaska. Arctic and Alpine Research, 6:161–184.

WELLER, G., D. NORTON, AND T. JOHNSON (eds.). 1978. Environmental assessment of the Alaskan continental shelf, interim synthesis: Beaufort/Chukchi. NOAA Environmental Research Laboratories, Boulder, Colo.