of daylight with the level below 3 m, representing a marked increase in the availability of daylight feeding time.

The subsequent increase in weight that began in March was accompanied by a body moult to breeding plumage and it preceded the eventual migration to Alaska in April.

Conclusions

Observations from the lower mainland of British Columbia did not support the hypothesis that the winter weight fluctuations of Dunlin at this locality are a response to stresses such as a depletion of food items, a decrease in food availability and a dependence on night feeding. The observations that weight decreases at a time when food appears to be more available, when the weather is milder and when there is more opportunity for daylight feeding, support a second hypothesis that weight reserves represent a response to the probability of poor weather during the winter.

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Pienkowski, M.W., Lloyd, C.S. and Minton, C.D.T. 1979. Seasonal and migrational weight changes in Dunlins. Bird Study 26: 134-148.

Prater, A.J., Marchant, J.H. and Vuorinen, J. 1977. Guide to the identification and ageing of Holarctic waders. British Trust for Ornithology Guide No. 17. 168pp. Tring, Herts., British Trust for Ornithology.

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DISTRIBUTION AND ECOLOGY OF SHOREBIRDS IN ALASKA'S COASTAL ZONE: A REVIEW OF STUDIES IN THE OUTER CONTINENTAL SHELF ENVIRONMENTAL ASSESSMENT PROGRAM

by Peter G. Connors

With the impetus of proposed oil exploration on the Alaska continental shelf, the U.S. Department of the Interior began in 1975 the Outer Continental Shelf Environmental Assessment Program (OCSEAP) to guide decisions concerning Alaskan oil development. OCSEAP, administered by the National Oceanic and Atmospheric Administration (NOAA) and the Bureau of Land Management (BLM), has since provided financial and logistic support for hundreds of researchers from universities, state and federal agencies, and independent research organizations. Recognizing that shorebirds figure among the most prominent animal groups potentially affected by coastal oil development, OCSEAP has encouraged studies of the distribution and ecology of shorebirds at a variety of sites in coastal Alaska. To alert workers unfamiliar with OCSEAP to the kinds of information being developed within the program, I shall review below the projects most involved with the coastal shorebird research.

Before 1975, much shorebird work had been completed near Barrow by Pitelka and his coworkers and several studies added information at other coastal sites, but emphasis was on nesting periods and habitats, rather than on shoreline activities. Non-OCSEAP research has continued at several sites in recent years (e.g. Myers, J.P. and F.A. Pitelka, 1980. Seasonal abundance and habitat use patterns of shorebirds at two sites in northern Alaska. Wader Study Group Bulletin 29: 28-30).

The net result of these five years of OCSEAP-sponsored shorebird research has been a dramatic expansion in our understanding of migration routes, breeding distributions, habitat dependences, and susceptibilities to development of shorebirds along the coast of Alaska. We now know the breeding shorebird communities at a series of coastal sites from the Canadian border west and south to Nelson Lagoon (Figure 1), the timing of movements by migrants through these areas, and the seasonal patterns in habitat use by common species at particular sites. Several areas - among them the Copper River Delta, Nelson Lagoon and Point Barrow - support large concentrations of migrating shorebirds. We have accumulated information on the trophic relationships of many of the common species. And we now have a fairly complete picture of the dependence of many species on shoreline areas, particularly during post-breeding periods, to balance the more extensive information available from the breeding season. These data should allow us to predict the timing and intensity of bird use for other sites, to integrate these predictions with OCSEAP research on other trophic levels and on physical processes important to causing or dispersing oil pollution in arctic coastal areas, and, ultimately, to synthesize these diverse sets of information into predictions on how developing Alaska's petroleum resources may affect shorebird populations.

Still, Alaska's coastline is extensive and the ecological processes involved are complex. Basic distributional data continue to be needed because many areas of the Alaskan coast have been visited briefly, if at all. More information about trophic relationships is needed. And most critically, we need to examine how well patterns in use predict patterns in dependence. This will hinge upon a number of factors specific to shorebirds and oil - especially the behavioural responses of birds to oil slicks - and on issues arising in shorebird population biology as a whole, particularly the timing and mechanisms of population regulation. We lack critical understanding of the causes and effects of resource variability, both on breeding grounds, where productivity is determined, and in littoral habitats, where survival and migration success may be set. We have only the most general notions about how flexible birds are in responding to patterns in resource or environmental variability. Faced with locally depressed resources, or food made unavailable by an oil slick, will individuals respond by breeding elsewhere? Can they migrate successfully using alternate staging areas?

As we move from site-specific questions to a larger area view, our understanding decreases. What are the relationships on a community level over wide areas of the Alaskan arctic and points east and west? How are regional differences in shorebird communities related to available habitats or to migration routes? How far inland can shorebird populations be affected by coastal disturbances? How much may the success of birds nesting in Canada, Siberia or Alaska depend upon conditions in these other areas? Our knowledge of migration routes and winter areas of local arctic breeding populations of most species is very limited and generally inadequate to predict the effects of disturbances on populations elsewhere.

Have these applied studies - with practical goals in environmental management - stimulated interest in basic issues? Of course they have! Basic questions of shorebird biology have been raised or answered in all of the principal studies

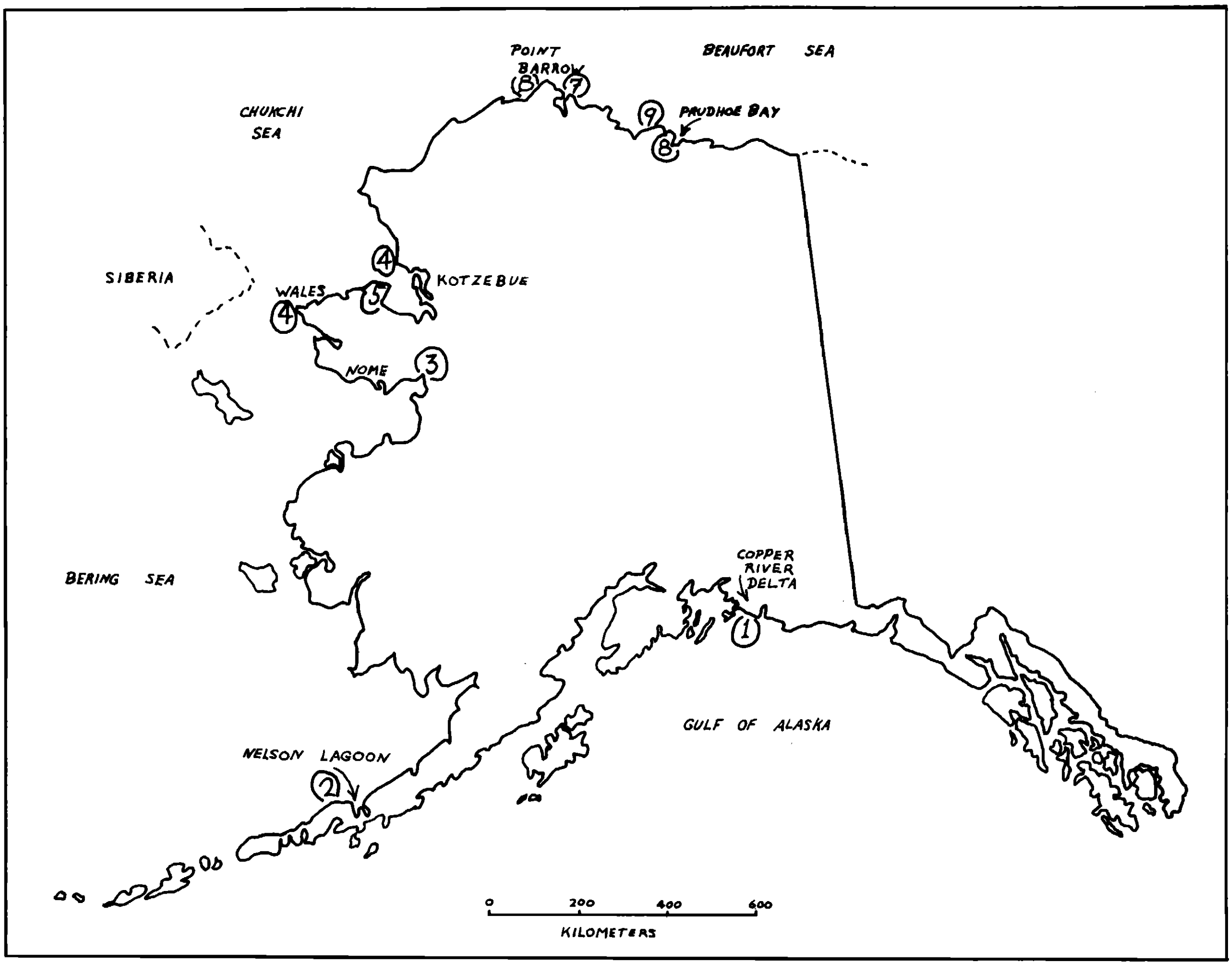

Figure 1. Map of Alaska, showing locations of OCSEAP shorebird study sites. Numbers refer to text.

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listed below, in areas of energetics, migration dynamics, resource use strategies, and in topics less central to the study objectives. I am most familiar with the peripheral questions emerging from my own work. What is the relationship between breeding populations of the two races of American Golden Plover, Pluvialis dominica dominica and P. d. fulva, in the extensive Alaskan coastal area where they are sympatric? Is an observed correlation between shoreline foraging distribution of phalaropes and wind direction in relation to the shoreline mediated through effects on plankton distribution, heat loss energetics, or prey visibility and capture dynamics? At a site where Western Sandpipers Calidris mauri and Semipalmated Sandpipers C. pusilla both nest in high densities, do their use of resources overlap? Apparently they do, and as competition theory would predict, interspecific aggression is much more common than among other sympatric Calidris species which overlap less in resource use.

OCSEAP, primarily through the efforts of a few key scientist-administrators within the program, has repeatedly shown an appreciation of the practical importance of shorebird research in evaluating impacts of coastal oil development in arctic and subarctic areas as well as the fundamental interest to shorebird biologists and other scientists of questions raised here. It falls on the hopeful investigator to propose studies which will provide answers or clear guidelines for administrators who must make environmental-economic decisions, while at the same time contributing to our general understanding of shorebirds and their environment.

List of OCSEAP shorebird studies

The accompanying map of Alaska (Figure 1) shows the major shorebird study sites described below. Some studies have been single season projects; others are continuing. The location and sequence of projects has been governed partly by the schedule of leasing proposed for different coastal sections. I list projects here by region, moving clockwise around the Alaskan coast. Government reports to the contracting agency are listed in abbreviated form, as follows: the series entitled Environmental Assessment of the Alaskan Continental Shelf (Outer Continental Shelf Environmental Assessment Program, National Oceanic and Atmospheric Administration, Boulder, Colorado 80303, U.S.A.) is referred to as E.A.A.C.S.

I. Gulf of Alaska

1. Nutritional significance of the Copper River-Bering River intertidal system to spring migrating shorebirds breeding in Western Alaska. Principal Investigators: Stanley E. Senner, George C. West, David W. Norton, University of Alaska, Fairbanks, Alaska.

During a brief period in spring migration the delta system of these two rivers supports virtually the entire western Alaska breeding populations of Western Sandpiper Calidris mauri and Dunlin C. alpina. Few other sites are available for northward migrating sandpipers in southern Alaska. Senner et al. established the critical importance of this stopover in replenishing fat reserves in migrating Dunlins with censuses, marking and collection of birds for analysis of stomach contents, lipid and calcium levels. Western Sandpipers showed less weight gain on the delta system, and apparently stop at another site soon after their departure from this system. The researchers also examined migration dynamics of these species along the entire west coast of North America, based partly on comparative analysis of collected birds from other regions during migration.

Publications:

Senner, S.E. 1977. E.A.A.C.S. Annual Reports, vol. 4: 576-592.

Senner, S.E. 1977. The ecology of Western Sandpipers and Dunlins during spring migration through the Copper-Bering River delta system, Alaska. Thesis, University of Alaska, Fairbanks. 108pp.

Senner, S.E. and Norton, D.W. 1977. Shorebirds and oil development in the Copper River Delta area, Alaska. In D.W. Norton, ed., Science in Alaska, Proc. 27th Alaska Sci. Conf., Fairbanks.

Senner, S.E. and West, G.C. 1978. E.A.A.C.S. Annual Reports, vol. 3: 877-908.

Senner, S.E. 1979. An evaluation of the Copper River Delta as a critical habitat for migrating shorebirds. Studies in Avian Biology 2: 131-146.

II. Bering Sea

2. Avifaunal assessment of Nelson Lagoon, Port Moller and Herendeen Bay, Alaska. Robert E. Gill, U.S. Fish and Wildlife Service, Anchorage, Alaska.

Using aerial and ground transect censusing, Gill and several coworkers documented heavy seasonal use of this lagoon system on the Alaska Peninsula by several species of shorebirds. Few birds visit the site in spring, but total populations on Nelson Lagoon reached an average of 60,000 shorebirds during fall migration in the two years of study. Peak numbers of 50,000 Dunlins, 15,000 Western Sandpipers and 8,000 Bar-tailed Godwits Limosa lapponica were recorded, suggesting Nelson Lagoon is a major fall staging area for these species. Gill et al. compared shorebird use of different habitat areas within Nelson Lagoon, conducted food resource measurements and trophic studies, and contrasted this estuary with others in the area. Extensive banding and marking (2,400 shorebirds in 1977) provided data to discuss local movements, turnover rates and dispersal and migration strategies of the most common species.

Publications:

Gill, R.E., Jorgensen, P.D., De Gange, A.R. and Kust, P. 1977. E.A.A.C.S. Annual Reports, vol. 4: 594-632.

Gill, R.E., Petersen, M., Handel, C., Nelson, J., De Gange, A., Fukuyama, A and Sanger, G. 1978. E.A.A.C.S. Annual Reports, vol. 3: 69-131.

Gill, R.E. and Jorgensen, P.D. 1979. A preliminary assessment of timing and migration of shorebirds along the North Central Alaska Peninsula. Studies in Avian Biology 2: 113-124.

3. Avian community ecology of the Akulik-Inglutalik River delta, Norton Bay, Alaska. Gerald F. Shields, Leaonard J. Peyton, Univ. of Alaska, Fairbanks, Alaska.

During two breeding seasons, Shields and Peyton studied avian nesting productivity on the delta and migratory use of mudflats and other delta habitats by all bird species. They banded about 800 shorebirds. Their work records the seasonal movements of shorebirds and supplies information on habitat use for an estuary from a little-known section of Alaska's coast.

Publication:

Shields, G.F. and Peyton, L.J. 1979. E.A.A.C.S. Final Reports, vol. 5: 608-710.

III. Chukchi Sea

4. Shorebird dependence on arctic littoral habitats. Peter G. Connors, Bodega Marine Laboratory, University of California, Bodega Bay, California.

This study examined littoral zone use by all shorebird species along the arctic coasts of the Chukchi and Beaufort seas. Regular censusing throughout the summer season of fixed transects in tundra and shoreline habitats provided seasonal habitat use patterns, principally at two sites in the southern Chukchi area: Wales, at Bering Strait, and near Cape Krusenstern. Supplemented by trophic studies and by wider area censuses, Connors and coworkers used these data to assess the relative importance of different coastal habitats and sites and the relative susceptibility of species to oil development impacts.

Mudflats and saltmarshes of northern Seward Peninsula and Kotzebue Sound supported much higher densities of migrant shorebirds than did nearby tundra nesting areas. Habitat use, and therefore oil susceptibility, differed for some species between this area and the Beaufort coast, where similar data were gathered (see below). Evidence suggests that juveniles of two species born in Siberia (Sharp-tailed Sandpiper Calidris acuminata and Pacific Golden Plover Pluvialis dominica fulva) regularly cross Bering Strait in late summer to feed in North American saltmarshes before migrating southwestward to wintering areas in Asia and the Pacific.

Publications:

Connors, P.G. and Risebrough, R.W. 1978. E.A.A.C.S. Annual Reports, vol. 2: 84-166, and 1979, vol. 1: 271-329.

Connors, P.G. and Connors, C.S. 1978. Wet coastal tundra I (breeding birds census, Cape Krusenstern, Alaska). American Birds 32: 118.

Hirsch, K. and Woodby, D. 1978. Wet coastal tundra II (breeding bird census, Wales, Alaska). American Birds 32: 118-119.

Connors, P.G., Woodby, D., and Connors, C.S. 1979. Wet coastal tundra I (breeding bird census, Cape Krusenstern, Alaska). American Birds 33: 102.

5. Avian community ecology at two sites on Espenberg Peninsula in Kotzebue Sound, Alaska. Peter G. Mickelson, University of Alaska, Fairbanks, Alaska.

Cape Espenberg contains a large area of coastal wet tundra supporting high densities of nesting waterfowl and shorebirds, and is bordered by sandy beach and protected mudflat. Mickelson and his coworkers spent two complete summers and part of a third at the site, measuring nest densities, clutch sizes, habitat use, phenology, and predation rates. They recorded 85 species; two waterfowl (Pintail Anas acuta and Common Eider Somateria mollissima) and four shorebirds (Dunlin, Western Sandpiper, Semipalmated Sandpiper and Northern Phalarope Phalaropus lobatus) occurred in peak numbers in the thousands.

The study also recorded aerial surveys of southern Kotzebue Sound and measured use of shoreline habitats at Cape Espenberg. Of 34 nesting species, 13 were dependent on marine food sources during part or all of the nesting and brood rearing season.

Publication:

Schamel, D., Tracy, D., Mickelson, P.G. and Seguin, A. 1979. E.A.A.C.S. Final Reports, vol. 5: 289-607.

IV. Beaufort Sea

6. Identification, documentation and delineation of coastal migratory bird habitat in Alaska. George J. Divoky, Point Reyes Bird Observatory, Stinson Beach, California.

With a team of field workers, Divoky used ships, airplanes and an army of foot soldiers to survey extensive areas of the Beaufort and Chukchi coasts during summer 1976. Results include average densities by month of bird species or species groups in different coastal habitats. Data are most complete for seabird breeding densities of loons, waterfowl and larids along the coast. For some coastal areas, the observations made during visits by these hardy biologists remain the only information we have of shorebird densities and habitat associations.

Publications:

Divoky, G.J. 1978. E.A.A.C.S. Annual Reports, vol. 1: 482-569, and 1979, vol. 1: 330-599.

7. The distribution, abundance and feeding ecology of birds associated with pack ice. George J. Divoky, Point Reyes Bird Observatory, Stinson Beach, California.

This project has had two foci. Firstly, seabird numbers have been sampled in a series of ship cruises in the Bering, Chukchi and Beaufort seas. Most of the work has applied to seabirds, but Divoky and his team present densities of phalaropes at sea in several areas and have gathered shoreline transect data through several seasons for phalaropes and other shorebirds at Cooper Island. Secondly, this project uses a regular program of nearshore plankton sampling to provide information on annual variation of this important parameter for comparison with shorebird densities.

Publications:

Divoky, G.J. 1976. E.A.A.C.S. Annual Reports, vol. 3: 53-106; 1977, vol. 2: 525-573; 1978, vol. 2: 167-509; and 1979, vol. 1: 330-599.

8. Shorebird dependence on arctic littoral habitats. Peter G. Connors, Bodega Marine Laboratory, University of California, Bodega Bay, California.

This study of shorebird habitat paritioning and seasonality, migratory movements and trophic dependences in littoral areas of the arctic coast measured bird densities on shoreline transects at Point Barrow for four summers and at several other sites during brief visits. Contrasted with tundra transect densities collected by J.P. Myers and F.A. Pitelka, the data defined a marked post-breeding shift of most shorebird species from tundra to littoral habitats; compared with similar data from southern Chukchi sites (see 4 above) they showed regional and species differences in seasonal habitat use patterns. These led to ratings of relative susceptibility of each species to oil development effects. For example, concentrations of juvenile phalaropes forage in shallow water on nearshore zooplankton, accumulating fat prior to southward migration and are therefore sensitive to nearshore changes arising from oil development. Dunlin and Long-billed Dowitchers Limnodromus scolopaceus, feeding primarily on dipteran larvae, also shift to littoral habitats in late summer, but to a lesser extent. Foraging experiments with captive Red Phalaropes Phalaropus fulicarius suggested rapid learning by naive birds after brief contact with thin oil films, and a subsequent avoidance of oil (Connors and Gelman, in prep.).

A single season of transect data comparing shorebird use of disturbed and undisturbed habitats in the Prudhoe Bay oilfield led to predictions of the effects of oil development on breeding and post-breeding shorebird populations. Some disturbances (dust effects, habitat destruction) may reduce densities, while others (artificial gravel pits, drainage changes) may increase local bird use.

Publications:

Connors, P.G. and Risebrough, R.W. 1976. E.A.A.C.S. Annual Reports, vol. 2: 401-456; 1977, vol. 3: 402-524; 1978, vol. 2: 84-166; 1979, vol 1: 271-329; and 1980, in press.

Connors, P.G., Myers, J.P. and Pitelka, F.A. 1979. Seasonal habitat use by arctic Alaskan shorebirds. Studies in Avian Biology 2: 101-111.

9. Beaufort Sea barrier island-lagoon ecological process studies. Avian ecology in Simpson Lagoon, 1977. S.R. Johnson, LGL Limited, 10110-124, Edmonton, Alberta, Canada.

Red and Northern phalaropes were the most common shorebirds encountered on transects monitored as part of a multidisciplinary study of a coastal lagoon ecosystem. Shorebird densities averaged higher on the oceanside island beach than on the lagoonside beach or mainland beach, with most phalaropes foraging in very shallow water. In a sample of 46 phalarope stomachs, principal prey items were copepods, amphipods and mysids. In spite of high densities of migrating phalaropes along the lagoon shorelines in August, Johnson estimated the energy available in mysids and amphipods was more than an order of magnitude in excess of phalarope energy requirements.

Publication:

Johnson, S.R. 1978. Beaufort Sea Barrier Island-Lagoon Ecological Process Studies. E.A.A.C.S. Section 2: 1-112.

Four other studies have contributed primarily distributional data for phalaropes at sea or for these and other shorebirds on barrier islands and mainland shores.

10. Seasonal distribution and abundance of marine birds. Calvin J. Lensink, James C. Bartonek, Craig S. Harrison, U.S. Fish and Wildlife Service, Anchorage, Alaska.

11. Identification, documentation and delineation of coastal migratory bird habitat in Alaska. Paul D. Arneson, Alaska Department of Fish and Game, Anchorage, Alaska.

12. Birds of coastal habitats on the south shore of the Seward Peninsula, Alaska. William H. Drury, College of the Atlantic, Bar Harbor, Maine.

13. Avifaunal utilization of the offshore island area near Prudhoe Bay, Alaska. Douglas Schamel, George Mueller, Institute of Marine Science, University of Alaska, Fairbanks, Alaska.

Peter G. Connors, Bodega Marine Laboratory, University of California, Bodega Bay, California 94923, U.S.A.