AN ABSTRACT OF THE THESIS OF

RUTH A. WILSON for the degree of Master of Science

in FISHERIES AND WILDLIFE presented on 29 May, 1980

Title: SNOWY PLOVER NESTING ECOLOGY ON THE OREGON COAST

Abstract approved: Signature redacted for privacy.

E. Charles Meslow

The possibility of reduced abundance of western snowy plovers (Charadrius alexandrinus nivosus) in the face of an altered habitat prompted a study of snowy plover breeding activities and nesting habitat on the Oregon coast during 1978 and 1979. At 4 study areas with varying levels of recreational use, nests were located and observed. Cover characteristics of nesting habitat were assessed with line intercept and m^2 plot sampling. During May and June of each year, appropriate habitat on the coast was surveyed for snowy plovers.

Snowy plovers were persistent and adaptable in nesting activities but had low reproductive success (0.2 to 0.4 chicks fledged per female). Of 72 nests observed, at least 19 were lost to corvid predation and 11 were destroyed by storms and moving sand; 9 nests were successful. Factors responsible for loss of chicks prior to fledging were not determined. Relationships were not apparent between nest success and level of recreational activity among study areas. Extensive areas of flat, open sand with sparse cover (an average of 13%) characterized nesting habitat within a 20 m radius of nests. In the immediate vicinity of nests there was an average of 26% cover.

Surveys of appropriate habitat on the coast disclosed a maximum of 100 adults and fledged juveniles; 12 discrete beach segments were used by snowy plovers in the 2 years.

Snowy Plover Nesting Ecology on the Oregon Coast

by

Ruth A. Wilson

A Thesis

Submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Completed May 1980

Commencement June 1981

ACKNOWLEDGMENTS

I wish to thank Dr. E. Charles Meslow for his assistance and advice during the study and in preparation of the manuscript. The advice of Dr. John Crawford and Dr. William Krueger is also appreciated as is the field assistance and friendship of Roseann Deering, Jennifer Shay, and Marylou Schnoes, and the information provided by Gary Page and Wayne Hoffman. Also, thank you to my family and friends, they provided advice and encouragement and mentally shared many hours on beaches with me.

The study was conducted through the auspices of the Oregon Cooperative Wildlife Research Unit and funded by the Bureau of Land Management, Oregon Department of Fish and Wildlife, U.S. Army Corps of Engineers, U.S. Forest Service, and U.S. Fish and Wildlife Service.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

SNOWY PLOVER NESTING ECOLOGY ON THE OREGON COAST

INTRODUCTION

There was concern that coastal populations of the western snowy plover were declining in abundance in response to habitat alteration (Brittell et al. 1976; Craig 1977; W. Hoffman, unpubl. report; Marshall 1969; Page et al. 1979b; Widrig 1979). Rittinghaus (1961) identified 13 subspecies of the snowy plover on 6 continents. The western snowy plover occurred within North America, primarily on sand beaches of the Pacific coast and alkaline basins of inland areas (AOU 1957). Habitat of snowy plovers on the coast was described as the expanse of flat, dry sand above the ordinary wash of the tides (Bent 1929). Major changes to this habitat and on adjacent areas included sand stabilization with European beachgrass (Ammophila arenaria), community and industrial development, and increased recreational use. Extripation of snowy plovers was associated with habitat alteration on several beaches in southern California (Page, pers. comm.).

For the Oregon coast it was difficult to address questions that relate to change in abundance of snowy plovers because of scant historical information. Limited records prior to the 1970's primarily documented distribution (Gabrielson and Jewett 1940, p. 238; S. Jewett, unpubl. fieldnotes; A. Walker, study specimens, Oregon State University). The first comprehensive survey of the coast for snowy plovers was in August, 1972 when sand beaches of the state were walked and occurrence of birds recorded (W. Hoffman, unpubl, data); only 216 birds were sighted. Additional surveys conducted by the Oregon Department of Fish and Wildlife (ODFW) confirmed the low numbers of birds and

raised the question of declining abundance (ODFW, unpubl. reports). Differences in dates of surveys and indications of seasonal variation in snowy plover abundance (Page and Peaslee 1977, Page et al. 1979a) prevented definite conclusions regarding changes in abundance. However, the single area on the Oregon coast with comparable records over 10 years (South Beach, Lincoln Co., 1967-1977; Appendix I) indicated a steady decline. Major developments influencing South Beach from 1967 to 1977 included opening of a state park adjacent to the area used by snowy plovers and provision of vehicle access from the bordering jetty (Hoffman, unpubl. report).

A decline of a population in response to changes in habitat necessarily reflects changes in a) reproductive success, b) mortality, and/or c) population recruitment through immigration. During the breeding season snowy plovers appeared to use areas along the Oregon coast where levels of recreational activity were increasing (Appendix I). Furthermore, studies of the breeding biology of the bird indicated that nests, which were shallow depressions on sand substrate (Boyd 1972, Rittinghaus 1961), were susceptible to human disturbance. If snowy plover nest success was lower on areas with high recreational use than on areas with less recreational activity, the assumption that snowy plovers were declining in abundance because of habitat alteration would be supported. Therefore, an objective of this study was to determine snowy plover nest success on areas with different levels of recreational use. Specific information on snowy plover nesting activities on the Oregon coast was unavailable. Therefore, documentation of a) breeding phenology, b) reproductive success, c) nesting habitat,

and d) distribution and abundance during the breeding season was also integral to the study.

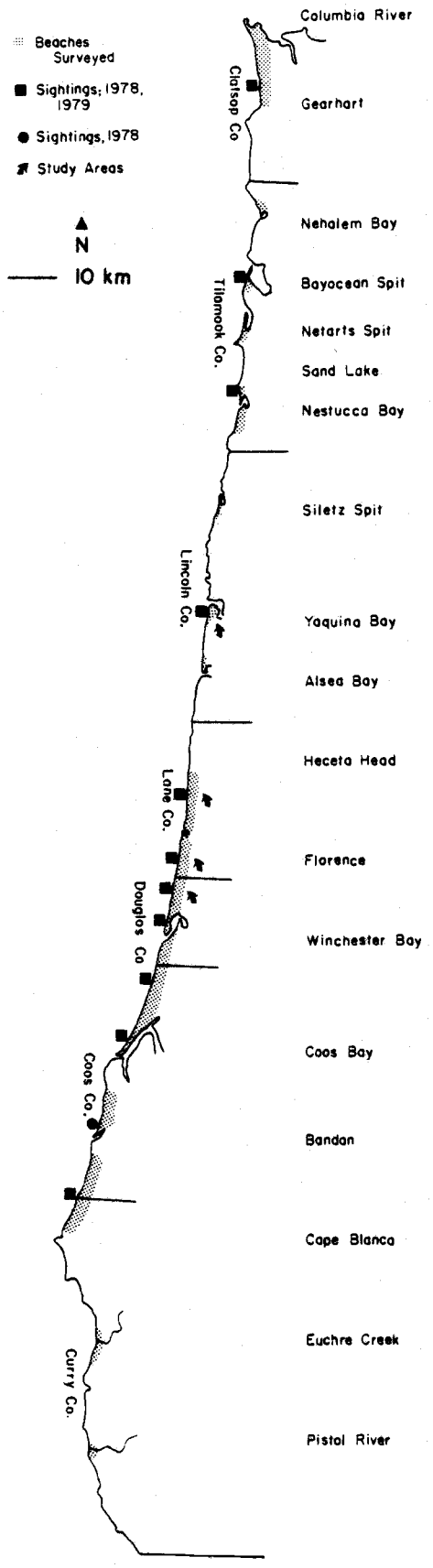
STUDY AREAS

Criteria for study area selection were varied levels of recreational activity, the presence of nesting snowy plovers, and reasonable accessibility. Three areas in the Coos Bay dune sheet (Cooper 1958) extending from Heceta Head to the Coos River (Sutton Creek outlet, Siltcoos River outlet, and Tahkenitch River outlet) and a fourth area, South Beach at Yaquina Bay, (Figure 1) met the criteria. Collectively the study areas encompassed approximately 60 ha; the largest was 21 ha. Adjacent beaches were excluded from study areas (also referred to as spit-interiors) with the beach/spit-interior boundary defined by the line of driftwood or vegetation at the level of high tides. All study areas were at outlets of streams or rivers and consisted of open sand substrate with patches of driftwood and vegetation. Study areas and beaches varied in size and configuration with seasonal movement of outlets during the period of study.

The State owns and manages all beaches of the Oregon coast. Adjacent public and private ownership begins at the mean winter high tide level. Siltcoos and Tahkenitch study areas were within and adjacent to the Oregon Dunes National Recreation Area, an area of open and vegetated sand dunes and deflation plains. Similarly, sand dunes and deflation plains bordered Sutton study area. South Beach study area was a beach segment beginning south of the south jetty at Yaquina Bay. Preliminary observations indicated high levels of recreational activity at South Beach, intermediate levels at Sutton and Siltcoos, and virtually no activity at Tahkenitch.

Temperatures on the Oregon coast were generally mild year around

Figure 1. Beaches surveyed during 1978 and 1979 for snowy plovers and locations of study areas.


Beaches Surveyed
Sightings; 1978, 1979
Sightings, 1978
Study Areas
N
10 km
Columbia River
Clatsop Co
Gearhart
Nehalem Bay
Bayocean Spit
Tillamook Co.
Netarts Spit
Sand Lake
Nestucca Bay
Siletz Spit
Lincoln Co.
Yaquina Bay
Alsea Bay
Heceta Head
Lane Co.
Florence
Douglas Co
Winchester Bay
Coos Bay
Coos Co.
Bandon
Cape Blanco
Euchre Creek
Curry Co.
Pistol River

and precipitation abundant. During the 1978 and 1979 field seasons temperatures and levels of precipitation followed seasonal trends (ESSA 1970-1979). Typically, from May through August combinations of low precipitation, warm temperatures, and strong, northwest winds resulted in extensive sand movement on the study areas.

METHODS

Snowy plovers were captured and color-banded for individual recognition to estimate abundance and evaluate reproduction. Nineteen adults were captured with drop traps and noose carpets prior to the 1979 nesting season. I captured 17 chicks by hand during 1978 and 1979.

To determine reproductive success snowy plover nests were located by searching each study area at least weekly between 0600 and 1100 from 1 April to 10 August, 1978 and 17 March to 31 July 1979. Additional searches occurred in March, 1978 and August, 1979. Simultaneous surveys were made to assess snowy plover abundance on the study areas. Mean monthly survey observations of snowy plovers were used to assess differences in abundance among months (March to August) and study areas. Snowy plover nests were readily found on calm, dry mornings when tracks radiating from nest sites were obvious. Nests were checked at intervals varying from 1 to 6 days during 1978 and on a daily basis at Sutton, Siltcoos, and Tahkenitch and from 1 to 4 days at South Beach in 1979. Once a clutch was complete (3 eggs or the onset of incubation) observer activity at nests was minimized by checking nests from a distance (generally greater than 20 m) unless a nest was vacant or eggs were not visible.

Categories and level of recreational activity on each area were evaluated between the hours of 1000 to 1500 on weekends (25 days in 1978, 31 days in 1979) from April to July. Minutes of activity on study areas and adjacent beaches were recorded for humans, vehicles, and dogs. Mean monthly indices for each activity were calculated for

days with fair to good weather (47 days). Differences in activity levels were tested between years; cumulative monthly indices were tested for differences among months and areas for each activity.

After hatching or loss of a nest, I assessed nesting habitat by measuring cover characteristics at the nest site (20 m radius of nest) and at a paired site selected randomly within 75 m of each nest. At each site distance to nearest driftwood and European beachgrass was determined on 6 20-m transects radiating at 60 degree intervals from the nest or center of the random site. Additional indices to cover of driftwood, European beachgrass, total live vegetation (including beachgrass), and total cover (all previous components plus dead vegetation and miscellaneous debris) were calculated as the total cm of each parameter intercepted on the 6 transects (Canfield 1949), in segments of 0-0.5 m, 0-1.0 m, 0-1.5 m, 0-2.0 m, and 0-20 m on the transects. M^2 plots centered over the sites provided comparative estimates of cover. These indices were used to calculate percent cover of nesting habitat and test for differences between characteristics of nest sites and randomly selected sites. Cover indices for driftwood and European beachgrass, the predominant nonliving and living cover components, were used as representative variables for the latter analysis.

Distribution and abundance of snowy plovers on the Oregon coast were evaluated with 2 surveys (on foot) of sand beaches from 23 April to 23 June 1978 and 11 May to 20 June 1979. Beaches were selected based on records of use by snowy plovers and similarity to beaches with use by snowy plovers; approximately 240 km of beach meeting these

criteria were surveyed. In 1979, 50 to 60 km of beaches not meeting these criteria were surveyed to ensure adequate coverage, notably areas with dredge materials on the interior of the north spit of the Coos River. Timing of surveys followed a recommendation by Page and Peaslee (1977) to ensure the best estimate of breeding adults.

RESULTS

Nesting Phenology and Success

The snowy plover was a persistent nester over a long nesting season but had low reproductive success. Seventy-two nests were found on the study areas (48 in 1978, 24 in 1979; Table 1). I believed the only nests escaping detection were those initiated and destroyed between searching episodes, a quantity for which I had no estimate. The earliest estimation of snowy plover nest initiation was mid-March, 1978; the latest nesting activities were in 1978 when a clutch hatched 6 August and another was projected to hatch 14 August (Figure 2). Nest initiation was most frequent in April and May (31 and 32% respectively of all nests).

Average nest success (the proportion of nests with at least 1 egg hatching) was 13% over the 2 years (Table 1). Highest success (60%) was at South Beach; success at the other areas was less than 7%.

Predation by the common crow and inclement weather contributed to nest loss (Table 1). Nest loss associated with weather generally occurred when sand movement buried eggs or moved eggs from nest scrapes. The reason for loss of 30 nests was not determined because rain or blowing sand removed evidence. Recreational activity and predators other than corvids were not implicated in nest loss.

The majority of nest losses not associated with moving sand or storms occurred early in the incubation period. I believed the potential for assigning loss to moving sand and storms was proportional to the life of the nest. Each day of incubation increased the

Table 1. Measures of snowy plover reproduction on 4 study areas on the Oregon coast, 1978 and 1979

	South Beach		Sutton		Siltcoos		Tahkenitch		
	1978	1979	1978	1979	1978	1979	1978	1979	Total
No. Nests	8	2	14	11	15	7	11	4	72
No. Successful Nests	4	2	1	0	1	0	0	1	9
[a]Fates of Unsuccessful Nests	0-0-0	0-0-0	3-5-0	2-2-1	5-3-0	4-1-1	2-0-1	3-0-0	19-11-3 (30)[b]
[c]Max. No. Adults	8	5	13	10	8	9	15	5	73
No. Nests/ Max. No. Adults/2	2	0.8	2.2	2.2	3.8	1.6	1.5	1.6	2.0
No. Chicks	10	4	2	0	2	0	0	3	21
No. Chicks Fledged	1	1	0-2	0	0	0	0	2	4-6

[a]Listed in order of number of nests known lost to corvids-destroyed by rain storms or moving sand-abandoned.
[b]The fate of 30 nests was undetermined.
[c]The highest number of adults observed on each area from March to July.

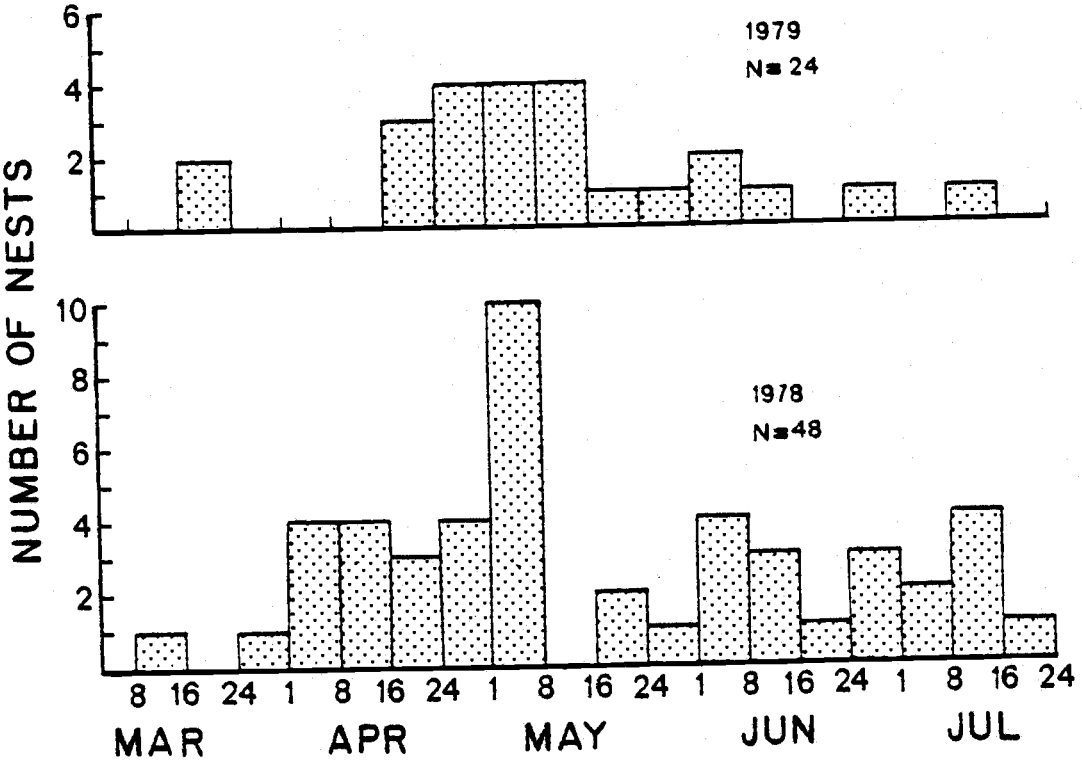


Figure 2. Estimated dates of snowy plover nest initiation for nests found at South Beach, Sutton, Siltcoos, and Tahkenitch study areas.

probability of exposure to detrimental weather conditions. Of the 24 nests found in 1979, 3 were destroyed by blowing sand. Five additional nest sites were drastically altered by moving sand and 1 by a storm tide after egg loss yet prior to end of the projected incubation period. Nest loss to inclement weather possibly was as high as 38% (9 of 24 nests) in 1979. Comparable data was unavailable for 1978.

General observations indicated a high incidence of renesting. In 1979 a pair at Sutton made at least 3 nesting attempts and a pair at Siltcoos made at least 2 attempts. Another female nested unsuccessfully at least twice with a mate at Siltcoos, moved to Sutton for a 3rd attempt following death of her 1st mate, and returned to Siltcoos for a 4th attempt with a 3rd mate. Her final mate was involved in at least 2 earlier nesting attempts.

An estimate of nesting success (the proportion of females eventually hatching at least 1 egg) was 25%. As an estimate of breeding females I used 1/2 the maximum number of adults observed during the period of nest initiation. Estimates of number of nests per female ranged from 0.8 to 3.8 with a mean of 2.0 (Table 1).

Fledging success (the proportion of chicks surviving to flight stage) was low on all study areas. Twenty-one eggs hatched (11.6% of eggs discovered) and 4 to 6 chicks fledged (0.1 to 0.2 fledglings per female). At South Beach, where 14 chicks hatched from eggs in 6 successful nests, only 2 (14%) chicks survived through the fledging period. When humans or dogs were in the vicinity of adult snowy plovers and unfledged chicks, I observed adult snowy plovers exhibiting characteristic distraction displays (Simmons 1951); chicks were left

unattended until humans or dogs left.

Recreational Activity

Levels of recreational activity were not different either between years ($p>0.05$, Paired Student's t-test) or among months ($p>0.05$, ANOVA). Human, vehicle, and dog activity levels were different among areas (Table 2). South Beach had highest levels of human and dog activity and Siltcoos had highest levels of vehicle use; Siltcoos had higher levels of human and dog activity than Tahkenitch ($p<0.05$, Newman-Keuls). Activity levels of all types were higher on adjacent beaches than on spit-interiors where snowy plovers nested (Table 2). The low number of successful nests precluded statistical analysis for differences among nest success, and types and levels of recreational activity among study areas. However, consistent trends were not observed between high levels of activity and low nest success; snowy plovers at South Beach, the area with highest levels of human and dog activity, had highest nest success.

Nest Site Characteristics

Sixty-five snowy plover nest sites and paired random sites were analysed to determine cover characteristics of the sites; 7 sets of sites were excluded because of alteration prior to measurement. On line transects, indices to cover within 0.5 m of the sites showed greatest dissimilarity between nest sites and random sites (Table 3). Therefore, m^2 plot cover estimates at nests and transect measurements within 0.5 m of nests were selected as predictors of snowy plover nesting

Table 2. Levels of recreational activity observed on weekends on study areas and adjacent beaches, April to July 1978 and 1979; reported as min of activity per ha per hr of observation.

Activity	South Beach (n=100 hrs)	Siltcoos (n=97.5 hrs)	Sutton (n=110 hrs)	Tahkenitch (n=85 hrs)
Humans[a]	134 (80)[b]	78 (63)	26 (80)	1 (90)
Vehicles[a]	0 (96)[c]	5 (80)	1 (93)	0 (99)[c]
Dogs [a]	8 (76)	8 (64)	3 (71)	0 (78)[c]

[a]Levels of human ($p<0.001$), vehicle ($p<0.025$), and dog ($p<0.001$) activity differed between areas (tested as mean monthly level of activity per observation period, ANOVA).

[b]Numbers in parentheses indicate % of activity observed on beach versus spit-interior; in all cases tested there were significant differences between activity levels on beach and spit-interior (Paired Student's t-test, $p<0.05$).

[c]Activity level was less than 0.5 min/ha/hr and differences between activity levels on beach versus spit-interior were not tested.

Table 3. Cover characteristics of snowy plover nest sites and paired randomly selected sites. A to D indicate % of habitat feature encountered on 6 transects radiated from the center of the sites within the indicated segments. E and F indicate minimum distance to driftwood and European beachgrass on the 6 transects. G and H indicate cover estimates from m^2 plots centered over the sites.

Habitat Feature	Nest Sites		Random Sites	
	Mean	SE	Mean	SE
A. Driftwood Cover (%) n=65				
0-0.5 m	26	3	5	1
0-1.0 m	20	2	6	1
0-1.5 m	17	2	6	1
0-2.0 m	16	2	7	1
0-20 m	11	1	9	1
B. Total Cover (%) n=65				
0-0.5 m	28	3	5	1
0-1.0 m	21	2	7	1
0-1.5 m	18	2	8	1
0-2.0 m	17	2	8	1
0-20 m	13	1	11	1
C. Live Vegetation Cover (%) n=65				
0-0.5 m	0.9	0.3	0.4	0.1
0-1.0 m	0.7	0.2	0.5	0.2
0-1.5 m	0.6	0.2	0.6	0.2

continued

Table 3. Continued

Habitat Feature	Nest Sites		Random Sites	
	Mean	SE	Mean	SE
C. Live Vegetation Cover (continued)				
0-2.0 m	0.6	0.1	0.7	0.2
0-20 m	1.0	0.2	1.0	0.2
D. European Beachgrass Cover (%) n=65				
0-0.5 m	0.5	0.2	0.2	0.1
0-1.0 m	0.4	0.1	0.4	0.2
0-1.5 m	0.3	0.1	0.5	0.2
0-2.0 m	0.4	0.1	0.6	0.2
0-20 m	1.0	0.2	1.0	0.2
E. Minimum Distance to Driftwood (cm) n=65	13	4	80	15
F. Minimum Distance to European Beachgrass (cm) n=60[a]	171	32	337	59
G. M^2 Plot Drift Cover (%) n=65	25	3	8	2
H. M^2 Plot Total Cover (%) n=65	26	3	8	2

[a]European beachgrass was not encountered on any transects for 5 nest sites and 5 random sites.

habitat. Within m^2 plots centered over nest sites, total cover averaged 26% (s=21) of which 95% was driftwood and less than 2% was live vegetation. Similarly, on the 0.5 m transects, 82% (s=30) of total cover was driftwood; 7% (s=16) was vegetation. For nest sites with live vegetation recorded on the 0.5 m transects (n=22), 93% (s=22) of the vegetation was European beachgrass. Eggs were on sand substrate although several nests occurred on logs with the eggs in holes or depressions filled with sand. Within the 20-m radius of nests and random sites, total cover averaged 13 and 11%, respectively.

Driftwood and European beachgrass cover estimates for nest sites did not differ among areas, nor did estimates for random sites ($p>0.05$, MANOVA). However, nest sites and random sites were dissimilar ($p<0.05$, MANOVA); nest sites had more cover than random sites. It appeared that snowy plovers preferred only a moderate level of cover; 91% of the nest sites had less than 50% driftwood cover and 92% had less than 5% live vegetation cover within the m^2 plots centered over the nests.

Distribution and Abundance

Among the study areas I observed differences in abundance of snowy plovers ($p<0.005$, ANOVA). Sutton supported the highest abundance ($p<0.05$, Newman-Keuls); South Beach, Siltcoos and Tahkenitch were similar. Differences in abundance were not apparent between months although trends similar to those observed in California (Page et al. 1979a) were evident on 2 of the 4 study areas (Sutton and Siltcoos, Figure 3). In July, 1978 and again in June and July, 1979 individuals previously nesting at South Beach were sighted at Sutton and indicated

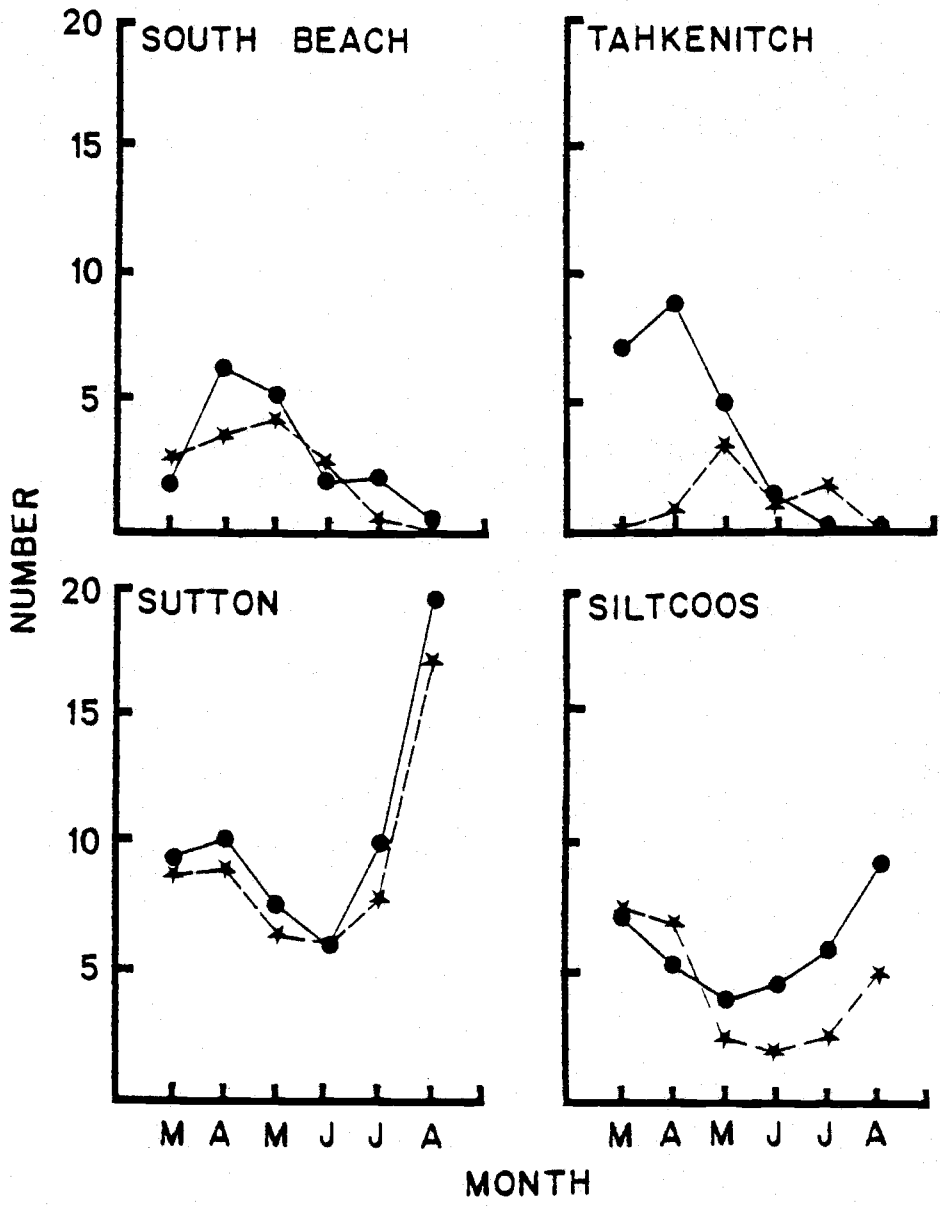


Figure 3. Mean monthly survey observations of snowy plovers (adults) based on weekly surveys at South Beach, Sutton, Siltcoos, and Tahkenitch study areas; solid line, 1978; dashed line, 1979; March to August. Differences in abundance were significant between areas ($p<0.005$) but not between months ($p>0.25$, ANOVA). Sutton supported the highest number ($p<0.05$, Newman-Keuls).

movement between study areas following nesting activities.

On the Oregon coast the snowy plover was limited in distribution and abundance during the breeding season. Survey results were relatively consistent between years except for the north spit of the Coos River. Fifty-six % of the birds recorded on the spit in 1979 were in the interior; because the interior was not surveyed in 1978, results for the 2 years were not comparable. Excluding the north spit of the Coos, in 1978, 90 adults and fledged juveniles were observed on 11 beaches; an average of 14 birds occurred on the 4 study areas in June. Similarly, in 1979, 55 snowy plovers were recorded on 10 beaches; an average of 12 were on the study areas. Survey totals for both years including results from the north spit of the Coos were 93 (1978) and 100 (1979, Figure 1, Table 4). Because the age of flying individuals was undetermined, adults and fledged juveniles were grouped, although the majority of individuals identified were adults. Areas with records of use during the breeding season (March to August) where snowy plovers were not observed were Clatsop Spit, Nehalem Spit, Netarts Spit, Nestucca Spit, Neskowin Beach, Siletz Spit, Alsea Spit, Pistol River Spit, and Euchre Creek (W. Batterson, pers. comm.; Gabrielson and Jewett 1940; W. Hoffman, unpubl. data; ODFW, unpubl. report).

Table 4. Observations of snowy plovers and nesting activities along the Oregon coast during 1978, 1979.

Beaches Surveyed	Dates of Surveys		Adults and Fledged Juveniles		Chicks		Nests		Nest Scrapes	
	1978	1979	1978	1979	1978	1979	1978	1979	1978	1979
Peter Iredale State Park to Gearhart	31 May	7 Jun	4	4	-[a]	-	-	-	-	+
Bayocean Spit	2 Jun	9 Jun	21	7	-	-	-	-	+	-
Sand Lake	19 May	10 Jun	5	3	-	-	+	-	+	-
N. Spit Umpqua	23 Apr	8 Jun	10	4	+	-	+	+	+	+
Tenmile Creek	12 May	21 May	7	2	+	-	+	-	+	-
N. of Coquille R.	21 Jun	16 Jun	7	-	+	-	+	-	+	-
N. of Floras Lake	17-18 Jun	17-18 Jun	22	23	+	-	+	+	+	+
Study Areas										
South Beach	Mean No. from Weekly Jun Surveys		2.1	2.8	+	+	+	+	+	+
Sutton			5.9	6.0	+	-	+	+	+	+
Siltcoos			4.5	2.0	+	-	+	+	+	+
Tahkenitch			1.4	1.0	-	+	+	+	+	+
Totals (excluding N. Spit Coos)			89.9	54.8						
N. Spit Coos[b]	5 May	20 Jun	3	45	+	+	-	+	+	+

[a] + indicates observation of chicks, nests, or nest scrapes (for the study areas and N. Spit Umpqua, Tenmile Creek, and N. Spit Coos observations were not restricted to dates of survey); - indicates chicks, nests, or nest scrapes were not observed.
[b] N. Spit Coos was considered separately because of incomplete survey data for 1978.

DISCUSSION

Persistence and adapt bility were evident in nesting efforts of snowy plovers during a long nesting season. Yet, observations during this study indicated that snowy plovers experienced low reproductive success on the Oregon coast in 1978 and 1979. Natural factors, principally corvid predation and wind driven sand reduced nest success. Other studies of western snowy plover nesting activities similarly identified natural factors, primarily varying levels of corvid, gull, and mammalian predation, as predominant influences on nest success; human activity was only incidently implicated (Boyd 1972, Page et al. 1977, Page et al. 1979b). The cause of loss of snowy plover chicks prior to fledging was not observed during this study nor did other studies adequately document loss of young. Therefore, the direct impact of human activity on fledging success remains unknown.

Based on information from other studies, snowy plover breeding phenologies on the Oregon and California coasts were similar (Page et al. 1977). General features of nesting habitat were also similar (Page and Peaslee 1977) and, in terms of cover characteristics, resembled nesting habitat in alkaline regions (Boyd 1972). Comparable information on reproductive success was only available from California and varied from 2.2 to 0.5 chicks fledged per female, depending on year and location (Page et al. 1977, Page et al. 1979b). Therefore, lowest estimates from California approached levels of reproductive success estimated for the Oregon coast. However, the average level of nest success observed on the Oregon coast (13%) was lower than

levels reported from other studies. Nest success of 40 to 85% was reported for interior and coastal sites in California (Page et al. 1977) and Boyd (1972) reported greater than 50% nest success at an alkaline basin in Kansas. I observed a higher incidence of nest loss to wind and storm activity than reported elsewhere. Furthermore, I believed nest loss associated with sand movement would have been greater than observed if predation was less influential in early stages of incubation. It appeared that the probability of exposure to detrimental weather conditions increased with life of a nest. Possibly, the Oregon coast, which is on the northern extent of the subspecies range (AOU 1957), provided sub-optimal nesting habitat compared to other regions used by the bird. Constraint of timing, frequency, and success of nesting events by harsh environments has been frequently suggested for birds (Barry 1962, Dzubin 1969, Marshall 1952, Parmelee and Payne 1973). Therefore, if predation were removed, nest success on the Oregon coast might still be low.

The 1978 and 1979 coastal surveys suggested that snowy plover distribution was not as extensive as previously noted. Snowy plovers were only observed at 12 of 21 sites with records of use during the breeding season. Snowy plovers were most frequently observed on beaches adjacent to river outlets and along beach strands where vegetation was breached by wave activity. Since the amount of dense vegetation on the Oregon coast dramatically increased with introduction of European beachgrass (Appendix II, Wiedemann 1966) and since dense vegetation was not selected by snowy plovers for nesting habitat, possibly introduction of European beachgrass reduced distribution of

the bird. Changes in distribution of the least tern (Sterna albifrons, Massey 1974) and piping plover (Charadrius melodus, Wilcox 1959), species which also nest on sandy beaches, have been associated with changes in vegetation cover. Likely consequences of restricting distribution of a population are reduced abundance and/or increased population influence by local factors. Therefore, the presence of European beachgrass may have indirectly effected snowy plover abundance by influencing the bird's distribution.

One of the greatest values of a preliminary study is identification of questions for future research. Before decisions are made that relate the low reproductive success observed during 1978 and 1979 with a population decline of the western snowy plover, information on snowy plover mortality rates on the coast, possible immigration, and levels of reproductive success over several more years is essential. If the following assumptions are made: a) snowy plovers on the Oregon coast are isolated from other populations, b) there is 100% survival of fledged juveniles from fledging to the following spring, c) all first year adults breed, and d) survivorship and fecundity are equal for all breeders, then, based on the reproductive success observed during this study, snowy plovers would require an annual adult survival of 80% for population maintenance (Henny et al. 1970). The assumptions of 100% survival and breeding of first year adults, and equal fecundity across age groups are unlikely for birds (Welty 1975). Therefore, 80% is a minimal estimate of survival required unless immigration summplements the population, or my observations of reproductive success were during years of poor reproduction and years of low

reproductive success are compensated by years of high success. Information on shorebirds, as a group, indicates wide distribution (Pitelka 1979); frequent use of multiple-nesting strategies (Jenni 1974), an adaptation associated with unstable habitats (Emlen and Oring 1977, Orians 1969); and relatively high rates of adult survival (45 to 85% per year; Boyd 1962; Lack 1954, p. 92). The killdeer (Charadrius vociferous), a congener of the snowy plover, commonly inhabits areas influenced by human activity. These features of charadriiforms confound interpretation of the importance of 2 years of low reproductive success on the overall status of a population of snowy plovers. Concern for the bird on the Oregon coast is appropriate because of low abundance and restricted distribution. The appropriate expression of that concern should be continued monitoring of population performance, and until additional information is available minimizing change on areas used by the bird.

LITERATURE CITED

American Ornithologists' Union. 1957. Check-list of North American birds. 5th ed. Lord Baltimore Press, Inc., Baltimore, Md. 691pp.

Barry, T. W. 1962. Effect of late seasons on Atlantic brant reproduction. J. Wildl. Manage. 26:19-26.

Bent, A. C. 1929. Life histories of North American shorebirds. U. S. Natl. Mus. Bull. 146:246-252.

Boyd, H. 1962. Mortality and fertility of European charadrii. Ibis 104:368-387.

Boyd, R. L. 1972. Breeding biology of the snowy plover at Cheyenne Bottoms Waterfowl Management Area, Barton County, Kansas. M.S. thesis, Kansas State Teachers College, Emporia. 86pp.

Brittell, J. D., J. M. Brown, and R. L. Eaton. 1976. Marine shoreline fauna of Washington, Vol. II. Washington Dept. Game and Ecol. Olympia, Wa. 341pp.

Canfield, R. 1941. Application of the line interception method in sampling range vegetation. J. Forestry 39:388-394.

Cooper, W. S. 1958. Coastal sand dunes of Washington and Oregon. Geol. Soc. Am. Memoir 72, Baltimore, Waverly Press. 169pp.

Craig, A. M. 1977. The snowy plover-a bird that needs watching. Outdoor Calif. 38:31-32.

Dzubin, A. 1969. Comments on carrying capacity of small ponds for ducks and possible effects of density on mallard production. Saskatoon Wetlands Seminar, Can. Wildl. Serv. Rept. 6:138-160.

Emlen, S. T., and L. W. Oring. 1977. Ecology, sexual selection, and the evolution of mating systems. Science 197:215-223.

Environmental Sciences Service Administration, U.S. Dept. Commerce. 1970-1979. Climate atlas of the United States. U.S. Gov. Printing Office. Washington, D.C.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon State College, Corvallis, Or. 650pp.

Henny, C. J., W. S. Overton, and H. M. Wight. 1970. Determining parameters for populations using structural models. J. Wildl. Manage. 34:690-703.

Jenni, D. A. 1974. Evolution of polyandry in birds. Amer. Zool. 14:129-144.

Lack, D. 1954. The natural regulation of animal numbers. Oxford, Clarendon Press, London. 343pp.

Marshall, A. J. 1952. Non-breeding among arctic birds. Ibis 94:310.

Marshall, D. B. 1969. Endangered plants and animals of Oregon, III. Birds. Special Rept. 278 Ag. Exper. Sta. Oregon State Univ., Corvallis, Or. 23pp.

Massey, B. W. 1974. Breeding biology of the California least tern. Proc. Linnean Soc. New York 72:1-24.

Orians, G. H. 1969. On the evolution of mating systems in birds and mammals. Am. Nat. 103:589-603.

Page, G. W., and S. C. Peaslee. 1977. Status of the snowy plover on the northern California coast, Part II: numbers and habitat description. State of Calif. Nongame Wildl. Investigation Rept., Calif. Dept. Fish and Game. 8pp.

_____, J. S. Warriner, J. C. Warriner, and R. M. Halbeisen. 1977. Status of the snowy plover on the northern California coast, Part I: reproductive timing and success. State of Calif., Nongame Wildl. Investigation Rept., Calif. Dept. Fish and Game. 10pp.

_____, L. E. Stenzel, and C. M. Wolfe. 1979a. Aspects of the occurrence of shorebirds on a central California estuary. Studies in Avian Biol. 2:15-32.

_____, D. W. Winkler, and C. W. Swarth. 1979b. Breeding success of snowy plovers at Mono Lake, California. U.S. Fish and Wildl. Ref. and Wildl. Res. Rept. 21pp.

Parmelee, D. F., and R. B. Payne. 1973. On multiple broods and the breeding strategy of arctic sanderlings. Ibis 115:218-226.

Pitelka, F. A. 1979. The Pacific coast shorebird scene. Studies in Avian Biol. 2:1-11.

Rittinghaus, H. 1961. Der seeregenpfeifer. Die Neue Brehm-Bucherei. A Ziemsen Verlag, Wittenberg, Lutherstadt. 126pp.

Simmons, K. E. L. 1951. Distraction-display in the kentish plover. British Birds 44:181-187.

Welty, C. J. 1975. The life of birds. W. B. Saunders Co., Philadelphia. 623pp.

Widrig, R. 1979. The shorebirds of Ledbetter Point: a twelve month census with notes on other records from Willapa Bay, Washington. Independently published, Ocean Park, Wa. 55pp.

Wiedemann, A. M. 1966. Contributions to the plant ecology of the Oregon coastal sand dunes. Ph.D. thesis, Oregon State Univ., Corvallis. 258pp.

Wilcox, L. 1959. A twenty year banding study of the piping plover. Auk 76:129-152.

APPENDICES

Appendix I. Records of snowy plovers in Oregon[a]

A. Fieldnotes of Stanley G. Jewett, University Portland State Museum of Natural History; Tacoma, Washington.

SKINS IN COLLECTION

Sex	Location	Date
Female	Netarts Spit, Tillamook Co.	6 Jan 1913
Male	Netarts Spit	16 May 1913
Female	Netarts Spit	16 May 1913
Female	Netarts Spit	29 Aug 1921
Male	Newport, Lincoln Co.	20 Jul 1928
Male	Netarts Spit	18 Aug 1928
Female	Netarts Spit	18 Aug 1928
Female	Netarts Spit	15 Aug 1929
Female	Tillamook Bay, Tillamook Co.	20 Dec 1932
Male	Pacific City, Tillamook Co.	4 Nov 1932
Female	Pacific City	4 Nov 1932
Male	Taft, Lincoln Co.	24 Nov 1933
Male	Taft	24 Nov 1933

OBSERVATIONS

Number	Location	Date
2, 1 col.	Netarts Spit	29 Dec 1912
Several	Netarts Spit	1 Jan 1913
Pair, col.	Netarts Spit	16 May 1913
7, col.	Netarts Spit	15 Apr 1914
3 Pair	Newport	27 Apr 1941
Several	Bayocean Spit, Tillamook Co.	6 Jul 1914
?	Netarts Spit	Sep 1929
2	Neskowin, Tillamook Co.	9 May 1925
6	Netarts Spit	18 Aug 1928
2	Netarts Spit	15 Aug 1929
8-10	Pacific City	4 Mar 1932
1, col.	Bayocean Spit	30 Dec 1932
2	Flavel Beach, Clatsop Co.	23 Feb 1933

[a]Counties are indicated the first time the location is cited.

Appendix I. Continued.

B. Results of August, 1972 survey by W. Hoffman (unpubl. data).

Location	Total No.	No. Imm.	No. Mat.	No. ?	Date
N. of S. Jetty, Columbia R., Clatsop Co.	0[a]	-	-	-	4 Aug
S. Jetty to Peter Iredale, Clatsop Co.	1	-	-	1	5
Peter Iredale to Gearhart, Clatsop Co.	23	10	13	-	6-7
Nehalem Spit, Tillamook Co.	1	1	-	-	9
Bayocean Spit	7	2	3	2	10
Netarts Spit	3	2	-	1	11
Sand Lake, Tillamook Co.	7	4	3	-	13
Nestucca Spit, Tillamook Co.	0	-	-	-	13
Neskowin Beach	4[b]	2	2	-	4 Jul-7 Sep
Siletz Spit, Lincoln Co.	0	-	-	-	15 Aug
South Beach, Lincoln Co.	13	8	5	-	17
Alsea Bay, N. Spit, Lincoln Co.	3	1	2	-	18
Lilly Lake to Sutton Creek, Lane Co.	47	6	7	34	19-20
Oregon Dunes National Recreation Area: Locations near Goose Pasture, Tahkenitch R., N. Spit Umpqua, Tenmile Creek, opposite Hauser; Lane, Douglas, and Coos Cos.	23	10	11	2	20-23
N. Spit Coos R., Coos Co.	39	13	17	9	23
Bullard's Beach, Coos Co.	10	4	6	-	25
Bandon to New River, Coos and Curry Cos.	32	-	-	32	25-26
Pistol R. Spit, Curry Co.	0	-	-	-	28
Euchre Creek, Curry Co.	7	3	4	-	29

[a]Area censused during periods of strong wind; H. Nehls reported to Hoffman 5-10 pairs.
[b]1 family group located and observed by MacDonald as reported to Hoffman.

Appendix I. Continued.

C. Records of Oregon Department of Fish and Wildlife; C. Bruce, Corvallis, Oregon.

Number	Location	Date
1	S. Jetty Umpqua to Tenmile Creek, Douglas Co.	1 Jul 1976
14	Sutton Creek	26 Apr
22	N. Spit Coos R.	21 Aug
7	Siltcoos R. to Tahkenitch R., Lane and Douglas Cos.	1 Sep
35	Sutton Creek	1 Sep
22	N. Spit Umpqua R.	1 Sep
11	S. of New River Estuary, Curry Co.	2 Sep
10	Netarts Spit	7 Jan 1977
30	Sutton Creek	2 Feb
21	N. Spit Coos R.	2 Feb
8	Siltcoos R. to Tahkenitch R.	3 Feb
13	N. Spit Umpqua R.	12 May
17	Sutton Creek	15 May
11 ad, 2 jv	Sutton Creek	28 Jun
2 ad, 3 jv	Siltcoos R. to Tahkenitch R.	29 Jun
2 ad	Tahkenitch R. to Threemile Creek, Douglas Co.	29 Jun
15 ad	N. Spit Umpqua R.	29 Jun
6	South Beach	19 Sep
8	Sunset Beach, Clatsop Co.	?
1 jv	Brought to Marine Science Center from South Beach, died	23 Jul
NESTS		
1, 3 eggs	South Beach	20 Jul 1976
1, 1 egg	Lilly Lake to Sutton Creek	26 Apr 1977
1	Alder Lake (N. of Sutton Creek in open dunes)	May 1977
2, 2 and 3 eggs	South Beach	22 Jun 1977

Appendix I. Continued.

D. Records of Oregon Department Fish and Wildlife; J. Collins, Roseburg, Oregon.

Month	Number			
	Siltcoos R.	Bullards Beach	Euchre Cr.	Pistol R.
Aug 1978	-[a]	0	0	0
Sep	9	3	1	0
Oct	8	0	4	0
Nov	12	0	2	1
Dec	-	-	2	-
Jan 1979	4	-	-	-
Feb	12	-	3	-
Apr	6	-	1 (1 nest)	-
May	-	1 ad, 1 jv	-	-
Jul	1	1	1	-
Aug	4	-	-	-
Sep	6	-	-	-
Oct	6	-	4	-

[a]Dash indicates survey was not done for area during the month.

E. Records of Oregon Department Fish and Wildlife; J. Thiebes, Tillamook, Oregon.

Number	Location	Date
2	S. of S. Jetty of Columbia R.	25 Jul 1975
2	Kinchloe Point, Tillamook Bay	25 Jul
2	Bayocean Spit	30 Aug
4	Bayocean Spit	19 Sep
2	Bayocean Spit	10 Oct
2	Bayocean Spit	20 Mar 1976
4	Bayocean Spit	3 Apr
2	Bayocean Spit	19 Jun
12	Columbia and Sunset Beaches, Clatsop Co.	16 Jul
17	Bayocean Spit	31 Jul
10	Netarts Spit	6 Jan 1977
6	S. of S. Jetty of Columbia R.	6 Jan

Appendix I. Continued

E. ODFW, Thiebes; continued.

Number	Location	Date
2	Bayocean Spit	9 Jun 1977
9	Columbia and Sunset Beaches	14 Jun
Nests		
1	Bayocean Spit	10 Jun 1976
3	Columbia and Sunset Beaches	14 Jun 1977
1	Bayocean Spit	9 Jun 1977

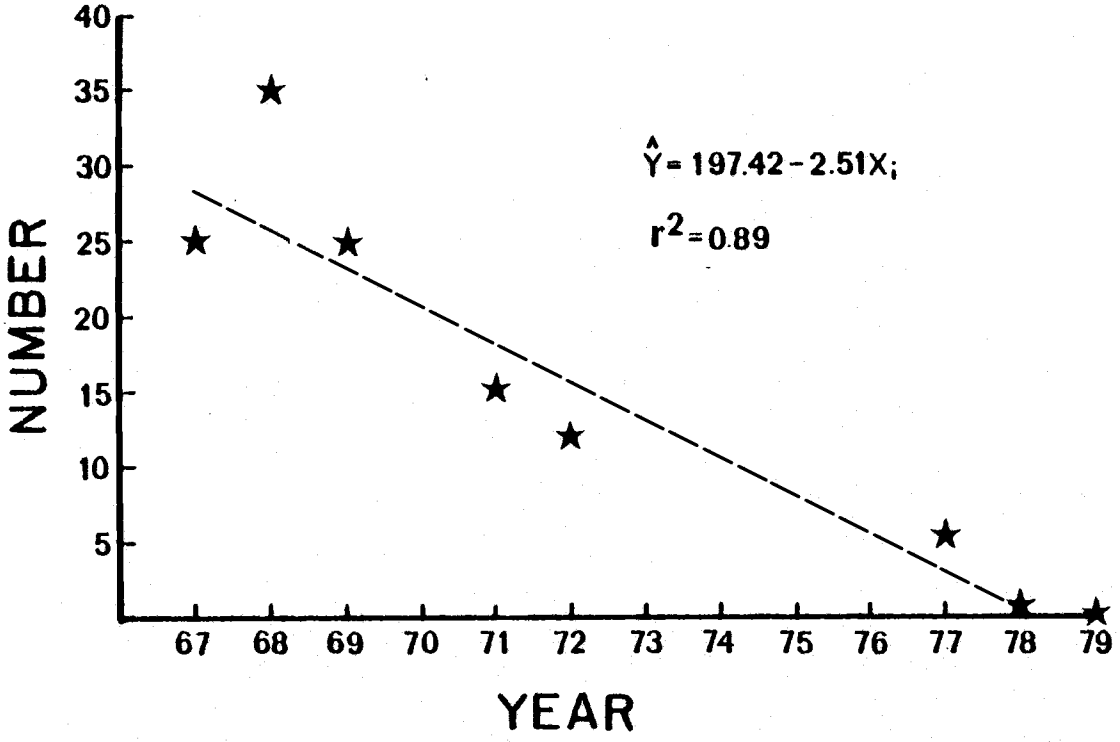
F. Records of R. M. Deering, observations during survey activities for U.S. Army Corps of Engineers on N. Spit Coos River (1978).

Number	Date
26, oceanside	30 Sep
20, oceanside	15 Oct
21, oceanside	21 Oct
20, oceanside	28 Oct
4, oceanside	4 Nov
1, bayside	10 Nov
9, oceanside	11 Nov
19, oceanside	25 Nov
6, oceanside	2 Dec
2, oceanside	9 Dec

Appendix I. Continued

G. Observations by author, independent of coastal and study area surveys.

Number	Location	Date
6 ad	Tenmile Creek Outlet	28 Mar 1978
0	Threemile Creek Outlet	25 Mar
0	Threemile Creek Outlet	2 Apr
0	N. Spit Alsea	6 Apr
0	N. Spit Coos	11 Apr
10-13	N. Spit Coos	6 Jul
19	N. Spit Umpqua	14 Jul
0	Threemile Creek Outlet	14 Jul
1 ad, 1 jv	Tenmile Creek Outlet	21 Jul
3 ad	Tenmile Creek Outlet	3 Aug
0	Threemile Creek Outlet	9 Aug
16 ad, 1 jv	N. Spit Umpqua	9 Aug
22 ad, 3 jv	N. Spit Coos	10 Aug
2 ad	N. Spit Coos	20 Mar 1979
10 ad	N. Spit Umpqua	21 Apr
1 ad	Tenmile Creek Outlet	27 Apr
7 ad	N. Spit Coos	4 May
1 ad	N. Spit Umpqua	18 May
1 ad	Tenmile Creek Outlet	21 May
6 ad, 1 jv (oceanside)	N. Spit Coos	1 Jun
7 ad, 2 jv (bayside)		
7 ad, 1 jv (oceanside)	N. Spit Umpqua	9 Jul
5 ad, 2 jv (deflation plain)		
0	Tenmile Creek Outlet	13 Jul
15 ad, 7 jv, 4 ? (oceanside)	N. Spit Coos	20 Jul
1 ? (bayside)		



H. Decline in abundance of snowy plovers at South Beach, Lincoln Co., based on August surveys by Hoffman, ODFW, and this study.

Appendix I. Continued

I. Comparison of numbers of adult and fledged juvenile snowy plovers observed on surveys of Oregon coast sites in August, 1972 and 1978.

Area	1972[a]	1978
South Beach	13	0.5 (n=2)[b]
Sutton	47	20.7 (n=3)
Siltcoos	0	9.0 (n=3)
Tahkenitch	7	0 (n=2)
Tenmile Creek	9	3 (n=1)
North Spit Umpqua	3	17 (n=1)
North Spit Coos	39	26 (n=1)
	118	76

[a]Records from survey by Hoffman in 1972, single survey results.
[b]Observations based on number of surveys indicated.

Appendix II. Changes in Cover Characteristics of Sand Beaches of the Oregon Coast

INTRODUCTION

European beachgrass (Ammophila arenaria), an exotic introduced in the late 1930's for sand stabilization (USDA 1940), is the dominant plant adjacent to sand beaches of the Oregon coast (Wiedemann 1966). Western snowy plovers (Charadrius alexandrinus nivosus) nest along sand beaches of the coast (Gabrielson and Jewett 1940, p. 238) on expanses of flat, open sand (Bent 1929). Although the bird prefers up to 20% cover, predominantly driftwood, in the immediate vicinity of the nest, within a larger radius (20 m) less than 20% cover is characteristic (this study); dense vegetation is avoided. Knowledge of change in availability of habitat resembling snowy plover nesting habitat following introduction of European beachgrass is important in assessing the bird's status on the Oregon coast.

MATERIALS AND METHODS

Changes in vegetation and driftwood cover on the Oregon coast were assessed by comparing recent aerial photographs (1975 to 1978) with photographs taken prior to establishment of European beachgrass (1939) Photographs of 4 river outlets and a 5th beach segment backed by a foredune were compared. Within defined areas the proportion of area with greater than 20% cover was determined; proportions available on recent and 1939 photographs were compared.

RESULTS AND DISCUSSION

Prior to introduction of European beachgrass a foredune was not evident along the Oregon coast and vegetation cover greater than 20% was uncommon along sandy beaches (Figure 1). Estimates of increases in habitat with greater than 20% cover at river outlets from 1939 to the present varied from 4 to 36% (Table 1). These were considered minimal estimates of change on the coast because seasonal movements of river outlets appeared to maintain flat, open sand spits. The loss of unvegetated habitat on the beach with a foredune was estimated at 88%, a magnitude of change that appeared typical of many sand beaches of the Oregon coast.

Because of insufficient data on snowy plovers in 1939, correlations between habitat change and snowy plover distribution and abundance were inappropriate. However, dramatic decrease in availability of habitat with cover characteristics resembling habitat currently preferred by snowy plovers occurred with introduction of European beachgrass.

Figure 1. A comparison of aerial photographs (1939 and 1976) of Tahkenitch River outlet and adjacent beach and dune areas to depict changes that accompanied introduction of European beachgrass for sand stabilization.

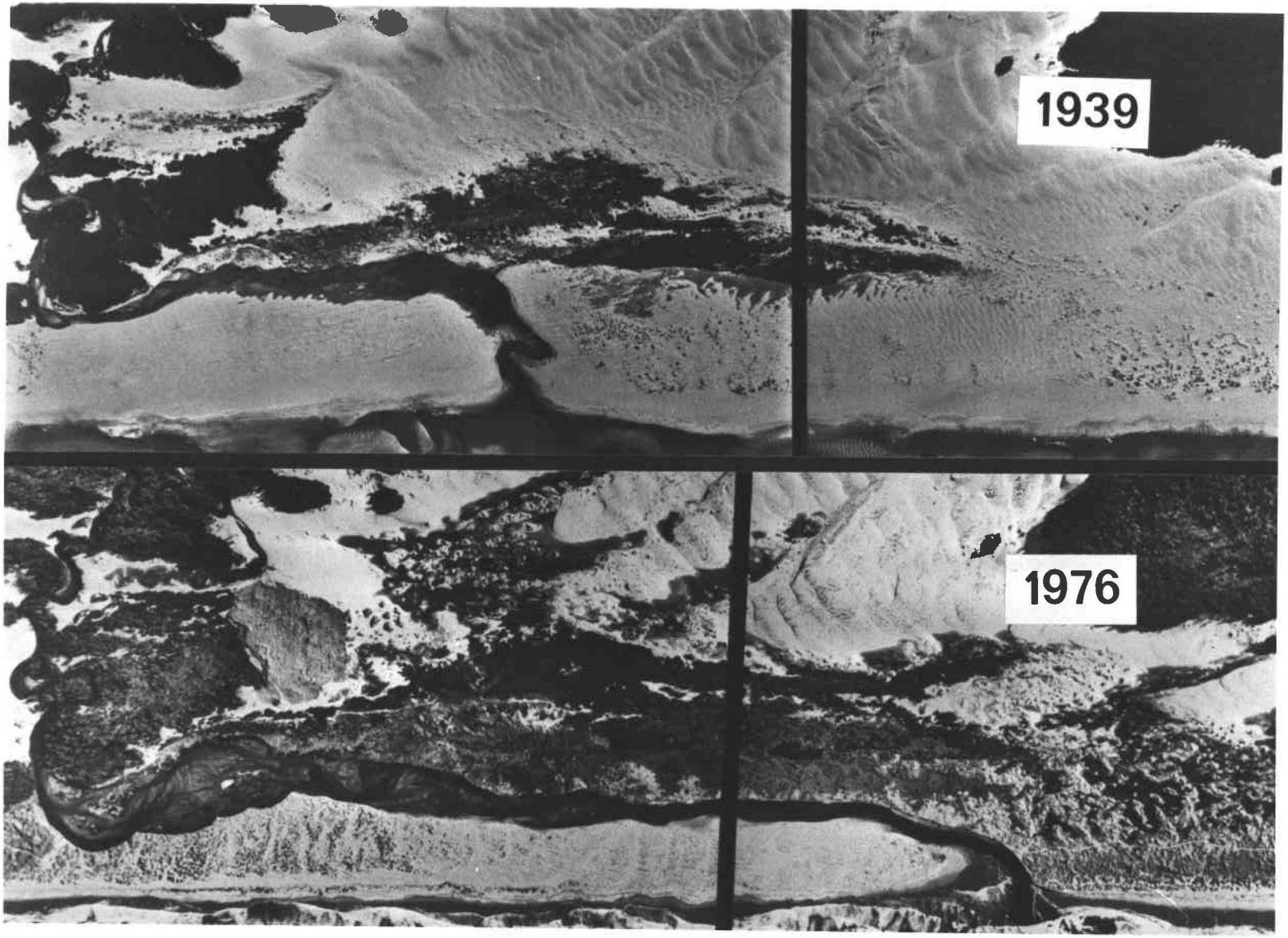

1939
1976

Table 1. Changes in vegetation and driftwood cover from 1939 to the mid-1970's; minimal estimates of change on select areas along the Oregon coast based on comparisons of aerial photographs.

Location	Total Ha Examined		% Area with Cover >20%		% Increase in Area with >20% Cover
	1939	mid-1970's	1939	mid-1970's	
South Beach	28.5	16.0	2	11	9
Sutton	14.5	21.0	0	10	10
Siltcoos	22.5	18.5	0	4	4
Tahkenitch	30.0	29.0	0	36	36
Beach with Foredune	24.0	28.0	0	88	88

LITERATURE CITED (Appendix II)

Bent, A. C. 1929. Life histories of North American shorebirds. U.S. Natl. Mus. Bull. 146:246-252.

Gabrielson, I. N., and S. G. Jewett. 1940. Birds of Oregon. Oregon State College, Corvallis, Or. 650pp.

United States Department of Agriculture Soil Conservation Service. 1940. Controlling Oregon coastal dunes. Washington, D.C.: 10pp.

Wiedemann, A. M. 1966. Contributions to the plant ecology of the Oregon coastal sand dunes. Ph.D. thesis, Oregon State Corvallis. 258pp.