PERFORMANCE REPORT

STATE:	VIRGINIA	PROJECT NO.:	EW-2-1
PROJECT TITLE:	NONGAME AND ENDANGERED SPECIES INVESTIGATIONS		
STUDY TITLE:	SHOREBIRD INVESTIGATIONS	STUDY NO.:	VIII
JOB TITLE:	SHOREBIRD STUDIES	JOB NO.:	A-D
PERIOD COVERED:	July 1, 1988 - June 30, 1989		
JOB VIII-A OBJECTIVE:	To determine and monitor piping and Wilson's plover populations along the barrier islands and Tidewater, Virginia.		
JOB VIII-B OBJECTIVE:	To determine reproductive success of the plovers as possible.		
JOB VIII-C OBJECTIVE:	To determine flushing distances of the plovers.		
JOB VIII-D OBJECTIVE:	To determine habitat requirements of piping and Wilson's plovers on the barrier island beaches.		

SUMMARY:

A breeding survey was conducted along Virginia's barrier islands during the first week in June. A total of 121 breeding pairs of piping plovers was recorded. Wilson's plovers numbered 35 pairs. Intensive studies were completed on the breeding ecology and nesting success of the piping plover population on Metompkin Island.

A three year study of piping plovers was begun on Chincoteague National Wildlife Refuge. Preliminary results from the first season's field work are presented in Appendix A.

JOB VIII-A - To determine and monitor piping and Wilson's plover populations along the barrier islands and Tidewater, Virginia.

Breeding pairs of plovers on the barrier islands were determined by teams walking each of the islands and recording all single and paired plovers of both species. Results are shown in Table 1.

Table 1. Piping plover survey - 1989.

LOCATION ISLAND	PIPING PLOVER	PIPING PLOVER SINGLES	WILSON'S PLOVER PAIRS	WILSON'S PLOVER SINGLES
Smith	3	2	0	0
Myrtle	10	0	2	0
Ship Shoal	1	1	3	0
Wreck	0	0	0	0
Cobb	4	0	1	0
Hog	3	1	1	0
Parramore	0	0	0	0
Cedar	5	1	5	0
Metompkin	43	0	17	0
Assawoman	4	0	3	0
Wallops	5	0	3	1
Cedar Sandbar	1	0	0	0
S. Metomkin	3	0	0	0
NWR, Chincoteague on Assateague	32	0	0	0
Fisherman	2	0	0	0
Grandview Beach	4	0	0	0
Craney Island	1	0	0	0
Total	121	5	35	1

JOB VIII-B - To determine reproductive success of plovers as possible.

Detailed studies of piping plover nesting success were conducted on Metompkin Island and the adjacent sand bar.

A total of 346.75 hrs. was spent in field observations and data collection from March thru October, 1988. Piping plovers were censused beginning with their arrival on Metompkin Island on March 8 through departure in mid-October. Censusing was conducted by walking linear transects of the islands in entirety and recording the numbers of birds present. Care was taken to search the entire width of the beaches and not to repeat sightings. Having color-marked a portion of the population in 1987 was helpful in avoiding repeated counts of some individual birds. Notes were collected regarding concentrations of birds, foraging activity/location, and stage of the breeding cycle.

Beginning in April, nest searches were conducted whenever territorial pairs were discovered. Once located, nests were marked with prenumbered wooden stakes 10M north and south of the nest. Nest locations were then plotted on 1:24000 scale topographic maps so that they could be relocated to monitor egg production, clutch loss, and hatching success.

Nest locations of the congeneric Wilson's "thick-billed" plover (Charadrius w. wilsonia) were also marked and plotted to allow evaluation of similarities in nest site preferences between species.

Predation on piping plover eggs or young was evaluated through indirect evidence including predator tracks or egg shell fragments near the nest or through direct observations of predator activity. Clutch losses due to flooding were detected by visiting nests as soon as possible following higher than normal tides.

In an effort to prevent nest abandonment due to human disturbance, sensitive nesting areas on Metompkin Island and on Cedar Sand Bar were posted in cooperation with the Nature Conservancy, Virginia Department of Game and Inland Fisheries, and the U.S. Fish and Wildlife Service, and were patrolled regularly to detect offenders. Human visitation was also censused on Metompkin to determine trends in recreational usage of the island during the plover breeding season.

Trapping and banding of piping plovers was continued in 1988. Color banding was essential to establish confidence in recognition of specific breeding pairs for observations of territorial interactions, as well as for the visual assignment of broods to adult pairs allowing accurate estimates of fledgling productivity. Color marking also permitted an assessment of nest site and pair fidelity between years of the study. Adults and juveniles were fitted with an aluminum USFWS numbered band, two color bands, and a red, trailing plastic flag used for identification of birds by state of origin on wintering grounds in accordance with the recommendations of the Atlantic Coast Piping Plover Recovery Team. No more than two bands per leg were used on any bird in this study, and all red flags were fitted to the left leg.

The Metompkin area supported 30 pairs of piping plovers (29.1% of the Virginia breeding population) in 1988. Twenty-two nests were discovered in the study area, 20 on Metompkin Island ~~(map, figure 1)~~ and 2 on Cedar Sand Bar ~~(map, figure 2)~~. An additional 5 pairs on Metompkin and 3 pairs on Cedar Sand Bar were known breeders although their nests were not located.

All nests on Metompkin were discovered on the northern 3.5 mile segment of the island. The absence of breeding plovers on south Metompkin is likely due to intimidation and nest site competition from herring gulls (Larus argentatus) which breed there in large numbers (2000+ pairs in 1987, pers. obser.). One pair of plovers was repeatedly observed at the south point of south Metompkin early in the breeding season, but used the area only to forage, never venturing beyond the beginning of the herring gull colony. No other piping plovers or Wilson's plovers were observed on south Metompkin in 1988.

The highest census total for 1988 occurred on June 4 with 56 piping plovers observed on Metompkin and 10 on Cedar Sand Bar for a total of 66 present in the study area. Results of productivity calculations are given in Table 1.

Table 2. Piping Plover Productivity in Metompkin Island Study Area 1988.

CATEGORY	METOMPKIN ISLAND	CEDAR SAND BAR	STUDY[1] AREA
NESTS LOCATED	20	2	22
EGGS PRODUCED	80	10	90
EGGS HATCHED	49	3	52
CHICKS FLEDGED[2]	36	2	38
PAIRS PRODUCING EGGS/CHICKS	25	5	30
RENESTS	3	3	6
NON-BREEDING PAIRS	1	2	3
TOTAL NEST ATTEMPTS	28	8	36
PRODUCTIVITY ESTIMATE 1[3]	2.25	1.0	2.1
PRODUCTIVITY ESTIMATE 2[4]	1.44	0.4	1.26

[1]Study area includes Metompkin Island and Cedar Sand Bar

[2]Chicks surviving to 15 days of age are considered fledged.

[3]calculated as chicks fledged per nesting pair fledging at least one chick

[4]calculated as chicks fledged per nesting pair

Thirty-eight piping plover chicks were regarded as fledged in the Metompkin study area in 1988. Chicks were 15 days of age. However, 89.0% of those chicks known to survive to 15 days were also known to survive to 20 days of age. Observations of sustained flight are often used as criteria for fledgling classification. However, forced fledgings can be disruptive to chick foraging and a risk to predation, and were not used in this study.

Overall fledgling productivity is estimated at 1.26 chicks fledged per nesting pair (Table 2) for the Metompkin study area (2.1 chicks fledged per nesting pair fledging at least one chick - not a standardized figure) for 30 adult pairs known to produce eggs or young.

Comparisons of productivity estimates from 1987 to 1988 (Table 3) reveals a small increase in productivity (1.05 - 1.26) between years. This increase is not believed to be a significant one, and may be an artifact of improvements in field techniques between years.

Table 3. Summary of Productivity Data for Metompkin Island Study Area 1987 & 1988.

LOCATION	YEAR	NO. OF PIPING PLOVER NESTS LOCATED	X NO. OF EGGS PRODUCED PER NEST	X NO. OF EGGS HATCHED PER NEST	X DATE OF CLUTCH INITIATION	PRODUCTIVITY* ESTIMATE
METOMPKIN ISLAND STUDY AREA	1987	19	2.53		5/16	1.05 - 2.2
	1988	22	3.54	2.17	5/11	1.26 - 2.1

Table 4. Sources of Egg Loss in Metompkin Island Study Area 1988

	HUMAN DISTURBANCE	WASHOVER	PREDATION	UNKNOWN
% OF EGGS LOST	19.10	40.48	9.52	30.90

Of 90 eggs discovered in 1988, 57.78% were known to hatch successfully, with 42.22% lost to a variety of causes including human disturbance, flooding from washover, and predation (Table 4). All evidence of egg predation was indirect, and attributed to avian predators, especially herring gulls and fish crows (Corvus ossifragus) which were observed taking eggs from nearby least tern (Sterna albifrons) colonies. It is feasible that mammalian predation could account for some part of unknown egg losses (Table 4). Evidence (including tracks, scats, and predated egrets) of mammalian predators on Metompkin was discovered in 1988. However, mammals on Metompkin have not had a significant influence on piping plover breeding success to date.

Two full clutches of eggs were abandoned by adults as a result of frequent disturbance by recreationists, accounting for 19.1% of total egg loss. Greatest egg loss (40.48%) in 1988 occurred as a result of flooding of nests during higher than normal spring and storm tides occurring in May and June. At least 8 nests in the study area lost partial or entire clutches on June 3 when a northeast storm system coincided with a full moon high tide resulting in severe overwash.

Timing of clutch initiation (laying of the first egg) was 5 days earlier in 1988 (Table 3) than in 1987, and is likely related in general to an earlier arrival date. Considering the effects of washovers on Metompkin

Piping Plover, Wilson's Plover, and Human Visitation on North Metompkin Island 1988.

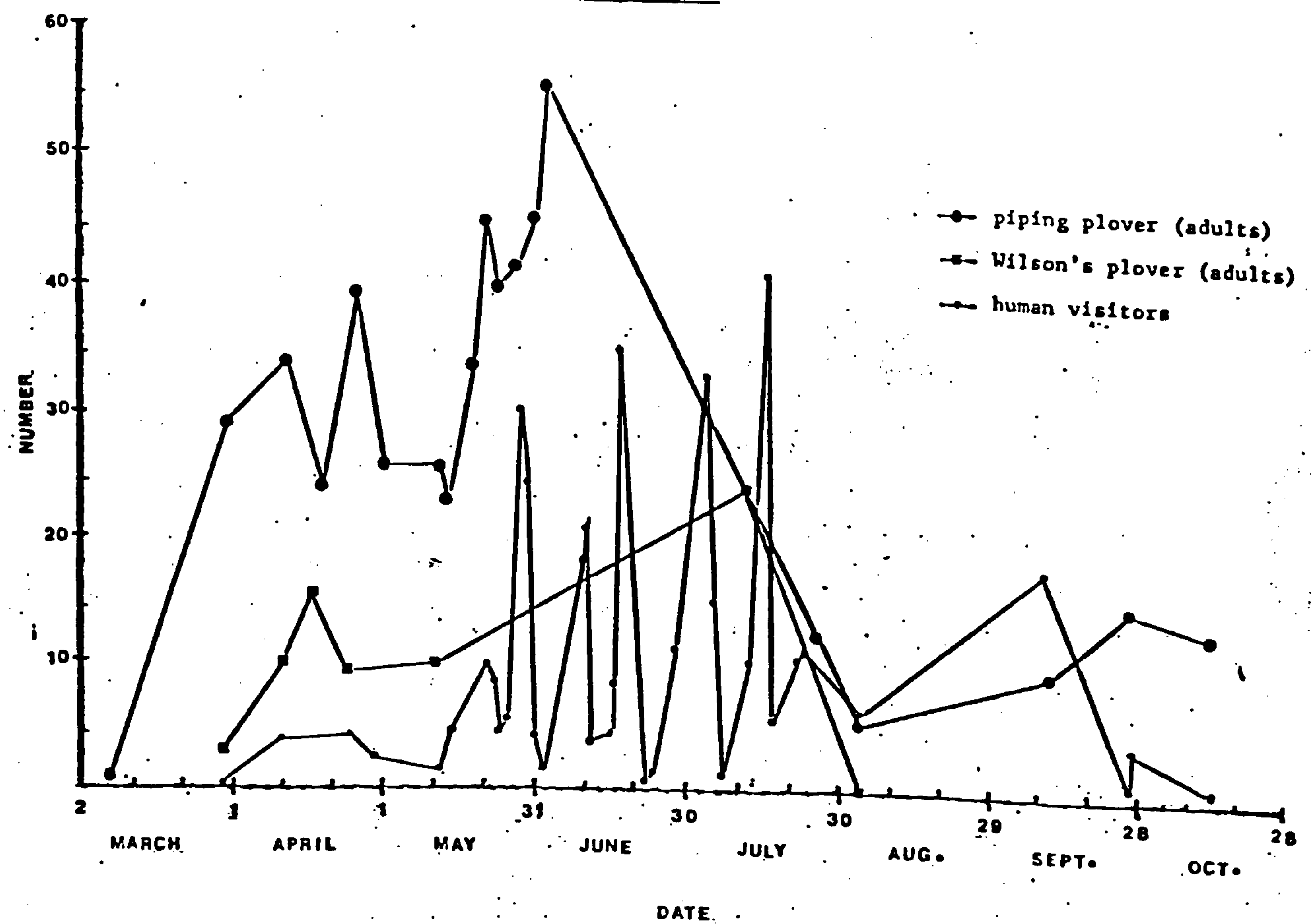

figure 3

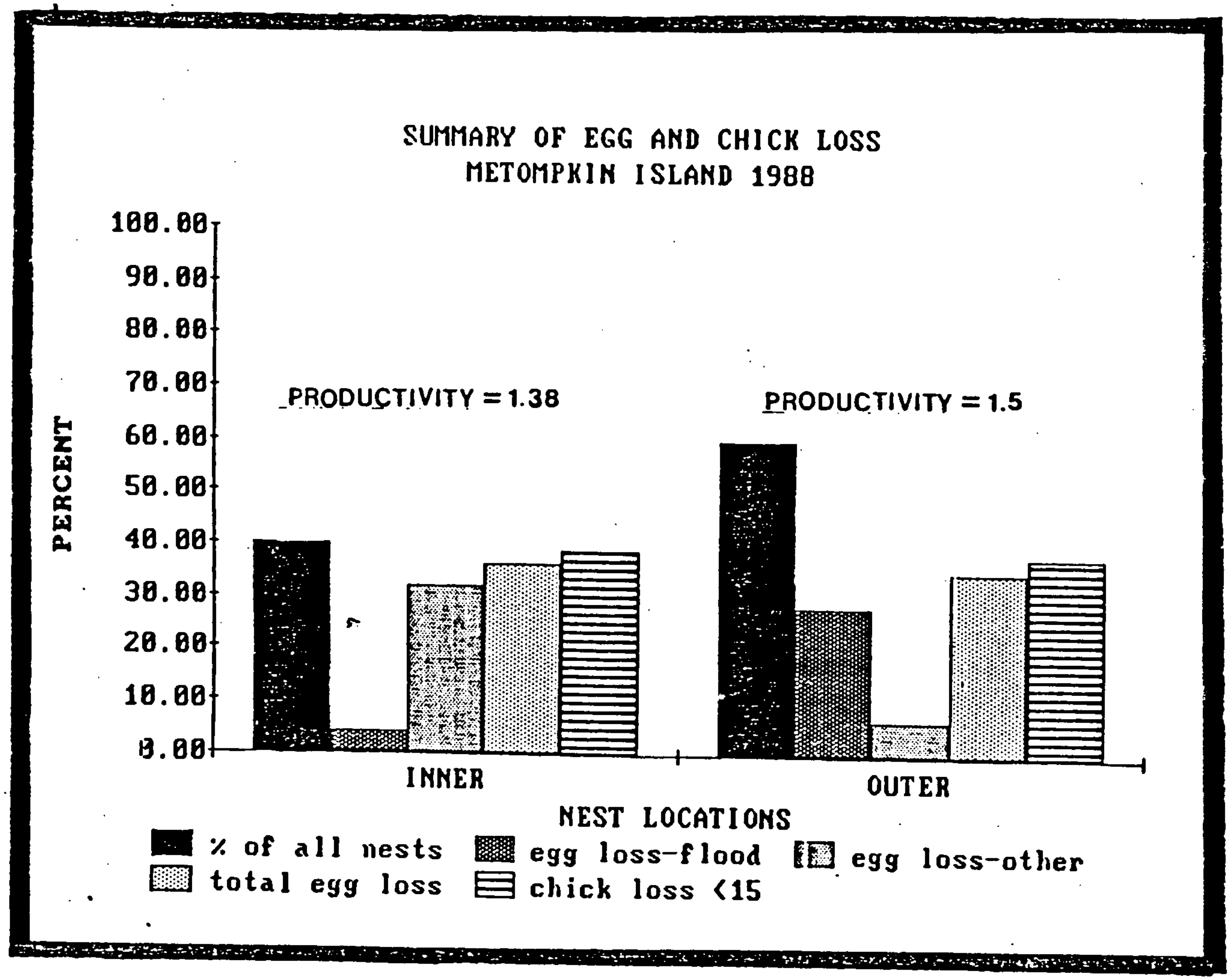
SUMMARY OF EGG AND CHICK LOSS
METOMPKIN ISLAND 1988
PERCENT
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
PRODUCTIVITY = 1.38
PRODUCTIVITY = 1.5
INNER
OUTER
NEST LOCATIONS
% of all nests
egg loss-flood
egg loss-other
total egg loss
chick loss <15

figure 4

in 1988, timing of clutch initiation may be related to the observed decrease in the mean number of eggs hatched per nest (Table 3).

Figure 3 illustrates the comparative results of census totals for piping plovers, Wilson's plovers, and human visitors on north Metompkin Island from March through October of 1988. Peak numbers for both plovers occur synchronously with peak human visitation in the seven week time period from early June to mid July. Distinct peaks of human visitation occur on mid summer weekends during the critical phases of early brood-rearing for piping plovers, and probably negatively influences plover breeding success.

Figure 4 shows a comparison of egg and chick losses between inner beach and outer beach habitat categories on Metompkin Island in 1988. Of 20 nests located, 8 (40%) were found in the inner beach category, while 12 (60.0%) were found on the outer beach. Total egg loss and chick loss were roughly equal between habitat categories (inner egg loss=36.0%, chick loss=30.89%, outer egg loss=34.8%, chick loss=28.26%). However, the source of egg loss differed between habitats. Most egg loss (28.26%) on the outer beach was due to flood, whereas only 6.52% was attributed to other causes including disturbance, predation, and unknown causes. Only slight egg loss (4.0%) at inner beach nests was attributed to flood, while most egg loss there (32.0%) resulted from other causes.

Although the causes of egg loss were different, fledging success between inner and outer beach nests remained relatively constant (inner=1.38, outer=1.5). Different selective pressures on egg survival have similar influences on juveniles survival and subsequent recruitment into the breeding population.

Observations of brood-rearing behavior on Metompkin indicate that although plovers may select either inner beach or outer beach habitats for egg laying, parent birds from both habitat categories raise their broods at inner beach locations along salt marsh and mud flat edges, moving their broods to such locations soon after hatching if necessary. This may explain the observed similarity in fledgling productivity between inner beach and outer beach habitats which occurs despite the disparity in selective pressures on egg survival.

Thirty piping plovers were banded during May, June, and July of 1988 in the Metompkin study area. Sixteen were adults (7 males, 9 females), and 14 were prefledged juveniles.

Fourteen (73.68%) piping plovers banded in the study area in 1987 were resighted or recaptured there in 1988 (Table 5). There was no observed occurence of band loss, and there was no known injury to plovers resulting from banding procedures. There were 44 plovers banded during 1987 and 1988 that were known to be present in the study area in 1988, representing a minimum of 44.31% of the Metompkin population (including fledged young) present in 1988.

Piping plovers on Metompkin appear to be monogamous as they are in other breeding populations. Sixty percent of those birds in this study with known color marked mates, retained their mate from 1987 to 1988 (Table 4).

Philopatry to nest sites from the previous year was also high, with 57.89% of known breeders in 1987 returning to breed again on the same island in consecutive years. In addition to returning to the same island, plovers are also faithful to the same nesting localities on the island. The mean distance from 1987 nests to 1988 nests was 517.71 $\pm$ 703.82 ft. (range 0.0 - 2057 ft.) for seven known individuals.

Table 5. Nest Site and Pair Fidelity in the Metompkin Island Study Area.

NO. OF PIPING PLOVERS BANDED ADULTS	YOUNG	% RESIGHTED 1988	% NESTING CONSECUTIVELY IN THE STUDY AREA 1987-1988	$\bar{X}$ DISTANCE FROM 1987-1988 NEST (n=7)	% KNOWN MATE RETENTION 1987-1988
18*	1*	73.68	57.89***	517.71	60.0
16**	14**				

*1987
**1988
***one plover which nested on Metompkin Island in 1987 was known to nest successfully on Cedar Island in 1988.

Piping plover nest locations on Metompkin Island and Cedar Sand Bar appeared to be clumped around mud flats which may provide vegetational cover and an abundant prey base for chicks.

Twenty-six distinct mud flat zones were identified along the linear length of north Metompkin Island. Length of the mud flats was variable (mean=376.7 $\pm$ 406.7 ft., range = 15.0 - 1756.0 ft.). Almost half of the islands' north to south length (49.74%) is composed of mud flats directly adjacent to the beach along its western edge. The remainder (56.26%) of the islands' beach length lies adjacent to salt marsh. In 1988, 16 pairs nested directly adjacent to a mud flat rather than to a salt marsh.

Results of a quadrat-dependent analysis of special pattern (Morisita 1959) of nest locations (Table 6) reveal that nests are aggregated rather than randomly or evenly dispersed throughout the available habitat on north Metompkin. Environmental patchiness in relation to food resources, predation risk, nesting substrate and intraspecific social interactions may account for the patchiness in nest distribution.

The quantitative expression, H, generated by this index is affected not only by diversity, but also by the number of categories, and is thus adjusted to the final expression, J, in Table 7. J can range in value from 0.0 to 1.0 with a low J indicating a low diversity of nest locations, and a high J indicating a high diversity of nest locations.

A low to mid-range J value for 1987 nests (0.5345) and for 1988 nests (0.4229) suggests that most nests are distributed unevenly between categories each year. In 1987, nests are clumped towards the inner beach, while in 1988, nests are clumped towards the outer beach. However, a J value of 0.5638 for data pooled from both years suggests that nests are clumped towards inner beach habitats throughout the duration of the study.

A t-test (comparing the variance of H values) is used to test the null hypothesis that the diversities of nest locations are the same for 1987 vs 1988, 1987 vs 1987 + 1988, and 1988 vs 1987 + 1988 (Table 8). No significant difference can be detected for any of the sample sets, suggesting that there is no difference in the degree of nest clumping between inner beach and outer beach habitat categories between years.

Partitioning of the available nesting habitat on Metompkin Island into four habitat categories allows a comparison by G test (Sokal and Rolf 1980) of the observed versus the expected number of nest locations in each habitat category (Table 9). This procedure tests the null hypothesis that piping plovers use each habitat in exact proportion to its availability. Expected frequencies are calculated based on an equal opportunity for birds to select inner, outer, mud flat adjacent, or no mud flat adjacent habitats as nesting sites. Ten different sample sets were chosen to compare frequencies of nest locations in all categories for both years and for both years data pooled.

Significant differences from the expected frequencies were found in four sample sets, all nests 1987 comparing inner vs outer beach, outer nests 1988, all nests 1988, and all nests 1987 + 1988 comparing mud flat adjacent vs no mud flat adjacent categories.

Whenever the null hypothesis of habitat use in exact proportion to availability was rejected, Utilization/Availability testing (Neu, C.W. 1974) was employed to determine which habitats were used significantly more or less than expected, that is, which habitats were specifically preferred or avoided (Table 10). This method establishes 95% confidence intervals around the observed proportion of nest locations and compares them to the expected proportion of nest locations.

Table 6. Morisita's Index of Dispersion for Piping Plover Nest Location on Metompkin Island 1987, 1988, and 1987 + 1988.

YEAR	NUMBER OF NESTS (N)	QUADRAT SIZE	TOTAL AREA	MORISITA'S I	DISPERSION	P
1987	19	0.167	100%	1.269	CLUMPED	<.05
1988	20	0.167	100%	1.206	CLUMPED	<.05
1987+88	39	0.091	100%	1.247	CLUMPED	<.05

JOB VIII-C - To determine flushing distances of the plovers.

See Appendix A. (Data not tabulated for barrier islands).

JOB VIII-D - To determine habitat requirements of piping and Wilson's plovers on the barrier island beaches.

In July and August of 1988, after most young had fledged, measurements were collected at each nest site of physical parameters including distances in feet to the nearest salt marsh, mud flat, ocean high tide line, dune, vegetation, interspecific, and intraspecific neighbor. The size and frequency of occurence of mud flats along the beach were also measured. These measurements were used to identify environmental and biological nest site preferences.

Aerial photographs (1:12000 scale) were used to pinpoint nest locations from both years, and to partition all available nesting habitat on the island into 250 ft.x 250 ft. quadrats for an analysis of the spatial pattern of nest locations. A total of 132 quadrats were established. Nests were expected to be aggregated around mud flats along the inner beach where plovers might find greater prey abundance.

The establishment of a grid system, precise measurements of physical attributes of the island, and accurate plotting of nest locations allows the recognition of four distinct nesting habitat categories: outer beach (closer to the ocean than to a marsh or mud flat), inner beach (closer to a marshy or mud flat than the ocean), mud flat adjacent (sites which are directly adjacent to a mud flat), and no mud flat adjacent (site which are not directly adjacent to a mud flat). Statistical tests were employed to determine if plovers exhibit specific preference or avoidance for any of these habitat categories.

In order to determine the degree of nest site diversity between inner beach and outer beach habitat categories (i.e. the certainty of finding nests in one category rather than the other), calculation of Shannon's index of diversity for nests located on Metompkin Island in 1987 and 1988 (Table 7) was done.

Table 7. Indices of Diversity of Piping Plover Nest Locations in Two Habitat Categories on Metompkin Island 1987, 1988 & 1987-88.

SAMPLE	CATEGORY INNER NESTS	OUTER NESTS	H	J*
1987	14	2	0.1636	0.5435
1988	8	12	0.2923	0.4229
1987+1988	22	14	0.02902	0.5638

*J=1.0 indicates high diversity, ie. nest locations are distributed evenly between categories.

Table 8. t-Test Comparisons of Indices of Diversity.

SAMPLE	H_1	H_2	t	p
1987 vs 1988	0.1636	0.2923	-4.392 [1]	ns
1987 vs 1987+1988	0.1636	0.2902	-4.2857 [2]	ns
1988 vs 1987+1988	0.2923	0.2902	0.1385 [3]	ns

[1] $t_{.05(2)120}=2.265$
[2] $t_{.05(2)120}=2.265$
[3] $t_{.05(2)200}=2.236$

Table 9. Results of G-Tests Comparing the Observed Versus the Expected Number of Piping Plover Nest Locations in 4 Habitat Categories on Metompkin Island, Va. 1987-88.

SAMPLE		HABITAT TYPE INNER BEACH	OUTER BEACH	MUD FLAT ADJACENT	NO MUD FLAT ADJACENT	N	G	P
ALL NESTS 1987	OBS	14	2	---	---	16	10.12	<.005
	EXP	8	8	---	---			
ALL NESTS 1988	OBS	8	12	---	---	20	0.81	NS
	EXP	10	10	---	---			
ALL NESTS 1987+1988	OBS	22	14	---	---	36	1.79	NS
	EXP	18	18	---	---			

Table 9 (continued)

INNER NESTS 1987	OBS	--	--	9	5	14	1.16	NS
	EXP	--	--	7	7			
OUTER NESTS 1987	OBS	--	--	2	0	2	2.77	<.10*
	EXP	--	--	1	1			
ALL NESTS 1987	OBS	--	--	11	5	16	2.31	NS
	EXP	--	--	8	8			
INNER NESTS 1988	OBS	--	--	6	2	8	2.09	NS*
	EXP	--	--	4	4			
OUTER NESTS 1988	OBS	--	--	10	2	12	5.82	<.025
	EXP	--	--	6	6			
ALL NESTS 1988	OBS	--	--	16	4	20	7.71	<.01
	EXP	--	--	10	10			
ALL NESTS 1987+1988	OBS	--	--	24	12	36	4.08	<.05
	EXP	--	--	18	18			
TOTAL	OBS	44	28	78	30			
	EXP	36	36	54	50			

*Expected frequency too small (6 or less) to test hypothesis.

Table 10. Results of Preferrence/Avoidance Tests of Piping Plover Nesting Habitats on Metompkin Island, Virginia 1987-1988.

SAMPLE	INNER BEACH	OUTER BEACH	MUD FLAT ADJACENT	NO MUD FLAT ADJACENT
ALL NESTS 1987	PREFERRED[1]	AVOIDED[2]	---	---
ALL NESTS 1988	G-TEST NS	G-TEST NS	---	---
ALL NESTS 1987+1988	G-TEST NS	G-TEST NS	---	---
INNER NESTS 1987	---	---	G-TEST NS	G-TEST NS

Table 10 (continued)

OUTER NESTS 1987	---	---	EXP. FREQ.<6	EXP. FREQ.<6
ALL NESTS 1987	---	---	G-TEST NS	G-TEST NS
INNER NESTS 1988	---	---	EXP. FREQ	EXP. FREQ.<6
OUTER NESTS 1988	---	---	PREFERRED	AVOIDED
ALL NESTS 1988	---	---	PREFERRED	AVOIDED
ALL NESTS 1987+1988	---	--	PREFERRED	AVOIDED

[1]preferred habitats are those in which piping plover nests were found significantly more often than expected.

[2]avoided habitats are those in which piping plover nests were found significantly less often than expected.

Utilization/Availability testing can only be used when a significant G test has been established and when the calculated expected frequency is greater than six. In those cases where the test was appropriate, a distinct preference was shown for nesting habitats on the inner beach and habitats directly adjacent to a mud flat, and avoidance was demonstrated for outer beach habitats not direclty adjacent to mud flats.

Predation and disturbance of breeding pairs of piping plovers are limiting factors to nesting success on Metompkin Island, however, not to the extent found elsewhere in Virginia. At Chincoteague National Wildlife Refuge, predation accounted for 60% of all nest losses and human visitation was estimated at 1.5 million visitors per year in 1987 (Ailes I. 1988).

Of greater interest in this study are the restrictions imposed on population density which may occur as a result of natural causes including prey availability and spatial requirements. Such restrictions are magnified by man-induced increases in disturbance and predator introduction.

Animal foods (such as those consumed by piping plovers) often show peaks of activity (Schoener, J.W. 1974). Temporal differences in prey availability could influence nest site selection decisions for piping plovers. Although no quantitative data are presented here on prey availability, observations throughout the plover breeding season indicate that foraging site preferences appear to shift several times. Most adult piping plovers were observed foraging on marine worms in the intertidal ocean surf zone from time of arrival through courtship and again late in the season after most young had fledged. During incubation and brood rearing, however, foraging activity was mostly restricted to mud flats, marsh edges, and dry beach areas adjacent to the nest site. Prey items taken during incubation and brood rearing periods differed from those taken early and late in the season, and consisted of insects, insect larvae, and small crustaceans (amphipods), with few large prey taken. The observed shifts in foraging site preference may be explained by temporal changes in prey abundance, insects and other small prey items becoming more numerous as mean daily temperature rises. Or the decreased handling time necessary for smaller prey consumed during incubation and brood rearing may provide higher energetic returns in a shorter time period allowing a greater amount of time to be devoted towards the parental duties of incubation and defense.

Loss of preferred or even suitable nesting habitat may be the greatest factor restricting piping plover population growth in Virginia. The observed clumping of nests at inner beach locations and the demonstrated preference for inner beach nest sites adjacent to mud flats in this study suggests that such habitats probably represent optimal nesting habitat for piping plovers although this may not be the case in other parts of its breeding range according to existing environmental conditions.

Statistical clumping can be used to deduce ecologically meaningful phenomena such as habitat patchiness, mutual avoidance or attraction among individuals, or the operation of predators on concentrated resources, but one must be careful about concluding that spacing out is not occuring (Cornell, H.V. 1982). Piping plovers on Metompkin Island may be aggregated about inner beach, mud flat adjacent habitats, but still may be spacing out via social interactions within these habitats and, thus limiting availability of optimal patches.

Territorial behavior, especially territory size, may vary with the environment so as to maximize the fitness of the individual (Patterson, I.J. 1980). Brown (1969) has suggested three levels of population limitation which coincide with three levels of habitat suitability. In category one, populations are low relative to availability of good quality habitat, and no individuals are excluded from breeding in optimal habitat. In category two, population level is high relative to availability of good quality habitat, and some individuals are forced to accept sub-optimal habitats. Piping plovers in the Metompkin Study area appear to fit well into Brown's second category. Socially subordinate birds, unable to compete for inner beach, mud flat adjacent habitats where prey abundance and antipredator benefits are greatest, may be forced to accept sub-optimal habitats on the outer beach. It is important, however, to realize that birds breeding in second choice habitats are not excluded from the breeding population. They continue as contributors to overall population recruitment.

From a management perspective, the implications of the observed preference for foraging and nesting habitat selections in the Metompkin study area are clear. Piping plovers utilize both inner and outer beach zones, although to different extents, throughout the breeding season. A significant decrease in the availability of either habitat or an increase in human activity in either habitat will likely result in decreased piping plover nesting success and, consequently, set backs to recruitment into the Virginia population. This may be especially relevent in cases where allowance of recreational use of only the intertidal surf zone of the beach is an option.

Restriction of human activity to the surf zone does not quarantee that plovers at adjacent inner beaches will not be disturbed. Such activities are also likely to disrupt birds using outer beach habitats where inner beach habitats have become limited.

PIPING PLOVER POPULATION ON THE WEST SIDE OF THE CHESAPEAKE BAY:

GRANDVIEW BEACH:

A total of five pairs of piping plovers were observed at Grandview Beach, Hampton during the 1989 breeding season. All five pairs were territorial and attempted to nest. Four nests were successful and produced 13 young. On July 15, 1989 ten fledged young and eight adults were observed foraging along the bayside shore line.

There were continued pressures from human disturbance, unleashed pets, and limited vehicular traffic to the area. Vehicle tracks were observed eight feet from one of the piping plover nests.

CRANEY ISLAND:

Although piping plovers have been regularly observed in late April and early May at Craney Island, Portsmouth for the past three years, no nesting attempts have been recorded. On June 10, 1989, the first piping plover nest, containing three eggs, was found. It was located in close proximity to the large least tern colony of about 300 pairs, but separated by a road. Vegetation was sparse but located directly in front of the nest providing some protection from water runoff along the road. In late June, severe storms caused extensive washing within the available habitat of the piping plover territory, but the nest withstood the washing.

Hank Williamson, supervisor for the Craney Island project, was informed of the presence of the species and observed the adults in the nesting territory. Piping plovers face the same problems at least terns. The presence of large flocks of gulls on the boundaries of Craney Island as well as human disturbance pose a threat to these beach nesters. Creation of appropriate habitat within this area will continue through the cooperative efforts of the Army Corps of Engineers, Ruth A. Beck, College of William and Mary, and the Virginia Department of Game and Inland Fisheries.

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TARGET DATE FOR COMPLETION: Continuing

STATUS OF PROGRESS: On Schedule

SIGNIFICANT DEVIATIONS IN PROGRESS: None

RECOMMENDATIONS: Continue Study

COST THIS SEGMENT: Federal $16,291.75 State $3,208.25 Total $19,500.00

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APPENDIX A

CHINCOTEAGUE NATIONAL WILDLIFE REFUGE

PLOVER REPORT

Summary of Results

Population Estimate

Suitable piping plover nesting habitat on Chincoteague National Wildlife Refuge was surveyed daily from 1 March through 27 July. Thirty-two breeding pairs of piping plovers were present on the refuge in 1989, and 36 nests were discovered in three distinct nesting areas. Most nests were found in the area known as Tom's Cove hook, an area closed to all public access during the piping plover breeding season. Twenty nests (55.56%) were located on the hook. Eight nests (22.22%) were found on the wild beach, and 8 nests (22.22%) were also found in the area known as the north wash flats.

Nesting Success and Fledgling Productivity

Overall hatching success for 1989 was 73.23% with 93 of 127 eggs hatching. At least one egg hatched from 83.3% of all nests located. Hatching success, however, varied between nesting areas with a hatch rate of 92.0% on the wild beach, 66.67% on the wash flats, and 69.33% on the hook. Of 34 eggs lost, the greatest number (41.18%) were lost to predation, mostly avian (fish crow). Flooding and strong winds associated with severe storms accounted for 35.29% of total egg losses.

Most chick mortality occurred during the first 48 hours after hatching, and is attributed to a variety of causes. Observations of newly hatched broods confirmed high chick mortality due to ghost crab predation, especially on the wild beach. Thirty-two percent of all chick mortality was attributed to predation by ghost crabs. Severe weather also resulted in high chick mortality. Fifteen recently hatched chicks were lost when 5.1 inches of rain fell within 24 hours on 16 July causing extreme flooding in brood-rearing areas on the hook and wash flats.

Chick mortality due to mammalian predation was relatively low, probably as a result of intensive predator trapping efforts conducted prior to and during the plover breeding season. Only four chicks (7.14% of total chick loss) were believed lost to foxes.

Fledgling productivity at Chincoteague NWR for 1989 is reported here in Table 1. Productivity is reported as the number of chicks fledged per nest and as the number of chicks fledged per nest that fledged at least one chick. Chicks were considered as fledged if extended flight was observed or if they were known to survive to 25 days of age. Fledgling productivity ranges from 1.06 to 2.0 chicks depending on which estimator is used. These results, however, must be considered as preliminary, and may increase as field observations continue to determine a final productivity estimate. Results to date indicate a 26% increase

Table 1 - Piping Plover Chick and Fledgling Productivity

AREA	BREEDING PAIRS	NO. OF NESTS	PAIRS FLEDGING AT LEAST 1 CHICK	NO. OF CHICKS	NO. OF FLEDGLINGS	CHICKS/NEST	FLEDGLINGS/ PAIR	FLEDGLINGS/PAIR FLEDGING ≥ 1 CHICK
HOOK	19	20	10	52	22	2.60	1.15	2.2
WILD BEACH	7	8	3	23	4	2.88	0.57	1.33
WASH FLATS	6	8	4	18	8	2.25	1.33	2.0
TOTAL	32	36	17	93	34	2.58	1.06	2.0

over 1988 estimates from 0,84 to 1.06 chicks fledged per nesting pair on the refuge.

Predator Controls

With mammalian predation by foxes and raccoons established as a leading cause of piping plover egg and chick loss in 1988, mammal trapping efforts were intensified in the 1989 season. During 73 trap nights from 3 March through 16 July, 22 foxes and 53 raccoons were trapped and destroyed on the refuge.

Predator proof exclosures were erected around 24 piping plover nests (hook=17, wild beach=3, wash flats=4) to protect the nests from mammalian and avian predators. Predator exclosures were successful in preventing mammals from removing eggs, however, fish crows were able to remove 8 eggs (3 nests) despite the use of exclosures.

Ghost crabs were found to be a significant predator on piping plover chicks on the refuge. Although no actual predation incident was witnessed by observers, ghost crabs were observed attacking adult plovers and newly hatched chicks on numerous occasions. Ghost crab predation was highest on the wild beach where 65% of all chicks were determined to be lost to ghost crabs.

A survey of active ghost crab burrows was conducted on the wild beach on 22 July in an attempt to determine ghost crab density and distribution there. Burrows were counted in 0.1 acre circular plots. The mean number of burrows per plot was 148.5 (N=24, SD=82.37, range=24-288). Density was higher outside of the most active plover nesting area (mean=183.89 burrows/0.1 A, SD=62.27, N=19, range=81-288), and lower within the most active plover nesting area (mean=53.0 burrows/0.1 A, SD=39.26, N=5, range=24-120).Piping plovers nesting on the wild beach appear to be selecting nest sites with the lowest ghost crab density, although other factors are involved in nest site selection.

Fish crows were frequently observed attempting to take young piping plovers, and were mobbed on sight by anywhere from 2-12 resident piping plovers. No chick loss could be attributed to fish crows.

On one occasion a laughing gull was observed in an unsuccessful predation attempt on a brood of three 1 day old piping plover chicks.

Herring gulls were regularly censused as potential predators on the hook and wild beach from 17 May to 19 July. On the hook, a mean of 65.0 herring gulls (SD=30.6, N=4) were present, whereas a mean of 53.0 (SD=64.2, N=4) herring gulls were found on the wild beach. No egg or chick loss was attributed to herring gulls on the refuge in 1989.

Habitat Selection and Utilization

Field work is currently in progress to characterize piping plover nesting habitat at Chincoteague NWR by collecting measurements of physical habitat parameters at each known nest location. Collection of habitat data was delayed to avoid disturbance during the nesting season and is now proceeding on schedule. Data will be analyzed to determine the density, distribution, and spacing pattern of plover nests. Results will be compared between major nesting areas on the refuge.

Attempts to determine home range size for selected breeding pairs of piping plovers were unsuccessful. The presence of the observer collecting home range data was found to alter the birds' behavior, thus interfering with home range evaluation. Further, the collection of home range data through observational techniques was judged as too disruptive to nesting birds, and was therefor discontinued. Presently, consideration is being given to the use of radio telemetry for the study piping plover habitat utilization through home range evaluation in the 1990 field season.

Flushing distances for breeding adult piping plovers were recorded throughout the breeding season in order to determine disturbance levels and to gain a preliminary estimate of nesting territory requirements. Similar mean flushing distances were observed in the three major nesting areas on the refuge (hook=47.84 M, N=125, SD=35.94, range= 5-300; wild beach=46.92 M, N=25, SD=17.14, range= 15-82; wash flats=47.06 M, N=31, SD=31.09, range= 10-122).

Piping Plover Banding

Banding of adult and juvenile piping plovers was conducted from 28 April - 14 July. Banding was essential to this study in order to accurately assess fledgling productivity and to facilitate observations of feeding and brood-rearing behaviors. Adult piping plovers were captured on the nest using a drop trap. Juvenile piping plovers were captured by hand at prior to fledging age. All plovers captured were color banded for individual recognition. A total of 25 adult piping plovers and 27 prefledged juveniles were banded in 1989 (Tables 2 & 3). In addition, 11 previously banded piping plovers were recaptured on the refuge in 1989.