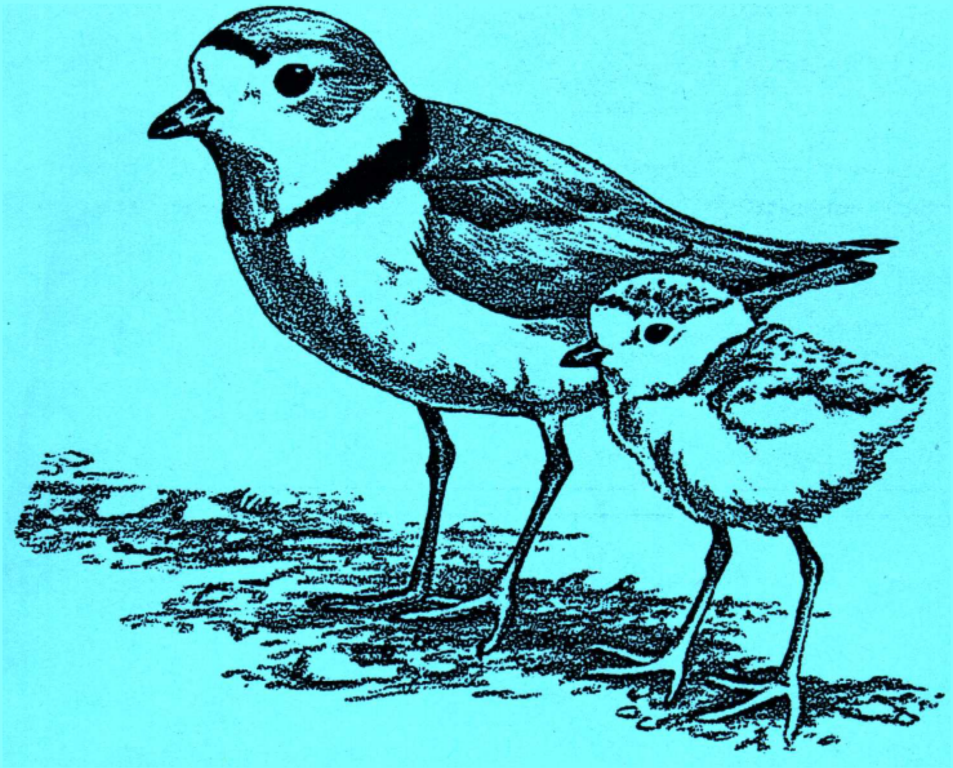
PIPING PLOVER *(Charadrius melodus)*
Atlantic Coast Population

REVISED RECOVERY PLAN



U.S. Fish and Wildlife Service
Hadley, Massachusetts

PIPING PLOVER *(Charadrius melodus)*

Atlantic Coast Population

REVISED RECOVERY PLAN

Prepared by the

Atlantic Coast Piping Plover Recovery Team

for the

U.S. Fish and Wildlife Service
Region Five
Hadley, Massachusetts

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EXECUTIVE SUMMARY
Atlantic Coast Piping Plover Revised Recovery Plan

CURRENT STATUS: The Atlantic Coast piping plover *(Charadrius melodus)* population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast from North Carolina south, along the Gulf Coast, and in the Caribbean. Since being listed as threatened in 1986, the population has increased from approximately 800 pairs to almost 1350 pairs in 1995; however, most of the apparent increase between 1986 and 1989 is attributable to increased survey effort in two States, and the population increase between 1989 and 1995 has been very unevenly distributed. Since 1989, the New England subpopulation has increased 346 pairs, while the New York-New Jersey and the Southern (DE-MD-VA-NC) subpopulations gained 62 and 18 pairs respectively, and the Atlantic Canada subpopulation declined by 34 pairs. Substantially higher productivity rates have also been observed in New England than elsewhere in the population's range. Recovery of the Atlantic Coast piping plover population is occurring in the context of an extremely intensive protection effort now being implemented on an annual basis. Pressure on Atlantic Coast beach habitat from development and human disturbance is pervasive and unrelenting, and the species is sparsely distributed.

HABITAT REQUIREMENTS AND LIMITING FACTORS: Piping plovers nest above the high tide line on coastal beaches, sandflats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes. Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes. Wintering plovers on the Atlantic Coast are generally found at accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets.

Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the species' decline. Disturbance by humans and pets often reduces the functional suitability of habitat and causes direct and indirect mortality of eggs and chicks. Predation has also been identified as a major factor limiting piping plover reproductive success at many Atlantic Coast sites, and substantial evidence shows that human activities are affecting types, numbers, and activity patterns of predators, thereby exacerbating natural predation.

RECOVERY OBJECTIVE: The primary objective of the revised recovery program is to remove the Atlantic Coast piping plover population from the List of Endangered and Threatened Wildlife and Plants by:
(1) achieving well-distributed increases in numbers and productivity of breeding pairs, and (2) providing for long-term protection of breeding and wintering plovers and their habitat.

RECOVERY CRITERIA: Delisting of the Atlantic Coast piping plover population may be considered when the following criteria have been met:

1. Increase and maintain for five years a total of 2,000 breeding pairs, distributed among four recovery units as follows: Atlantic Canada, 400 pairs; New England, 625 pairs; New York-New Jersey, 575 pairs; Southern (DE-MD-VA-NC), 400 pairs.

2. Verify the adequacy of a 2,000-pair population of piping plovers to maintain heterozygosity and allelic diversity over the long term.

3. Achieve five-year average productivity of 1.5 fledged chicks per pair in each of the four recovery units described in criterion 1, based on data from sites that collectively support at least 90% of the recovery unit's population.

4. Institute long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each recovery unit.

5. Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population.

ACTIONS NEEDED:

1. Manage breeding piping plovers and habitat to maximize survival and productivity.
2. Monitor and manage wintering and migration areas to maximize survival and recruitment into the breeding population.
3. Undertake scientific investigations that will facilitate recovery efforts.
4. Develop and implement public information and education programs.
5. Review progress towards recovery annually and revise recovery efforts as appropriate.

In furtherance of action 1, appendices to this plan include: (a) guidelines for managing recreational activities in piping plover breeding habitat to avoid direct mortality, harassment, and/or harm (Appendix G); and (b) guidelines for preparation and evaluation of permit applications for incidental take of piping plovers (Appendix H).

ESTIMATED COSTS (in thousands):

	NEED 1	NEED 2	NEED 3	NEED 4	NEED 5	TOTAL
FY 1	1885	150	330	60	3	2428
FY 2	1960	142	327	60	3	2492
FY 3	2035	142	287	60	3	2527
TOTAL	5880	434	944	180	9	7447

Costs beyond FY 3 will be determined as the recovery program proceeds.

DATE OF RECOVERY: A 168% increase in the New England population between 1989 and 1995 demonstrates that rapid recovery is possible with intensive protection efforts. Contingent on vigorous implementation of all recovery tasks, full recovery is anticipated by the year 2010.

ACKNOWLEDGMENTS

Susi von Oettingen of the U.S. Fish and Wildlife Service's New England Field Office and Mary Parkin and Paul Nickerson of the Northeast Regional Office provided invaluable help during all phases of preparation of this revised recovery plan.

During the last decade, hundreds of dedicated biologists and other professionals have contributed to the recovery efforts for the Atlantic Coast piping plover. The individuals listed below provided direct contributions to this recovery plan revision, by responding to special information requests or by reviewing sections of draft text. In many cases, their contributions represent compilations of information from dozens of additional individuals.

The Service gratefully acknowledges contributions of: Dr. Mark McCollough, Maine Department of Inland Fisheries and Wildlife; Julie Victoria, Connecticut Department of Environmental Protection; Lisa Gelvin-Innvaer, Delaware Division of Fish and Wildlife; Bob Cross, Virginia Department of Game and Inland Fisheries; Dave Jenkins, New Jersey Division of Fish, Game, and Wildlife; Laurie MacIvor, Maryland Natural Heritage Program; Ken Meskill, Michelle Alfieri, Mike Scheibel, and Bob Miller, New York State Department of Environmental Conservation; Tom Henson, North Carolina Wildlife Resources Commission; Jack Kumer, Carl Zimmerman, Kyle Jones, Jim Ebert, Bruce Lane, Ries Collier, and Michael Rikard, National Park Service; Cathy Brittingham and Meryl Goldin, The Nature Conservancy; Walker Golder, National Audubon Society; Bruce Johnson and Diane Amirault, Canadian Wildlife Service; Dr. Curt Griffin, University of Massachusetts; Dr. Joanna Burger, Rutgers University; Dr. Mark Ryan, University of Missouri, Columbia; Dr. Susan Haig, National Biological Survey, Corvallis, Oregon; Dr. Jeffrey R. Walters, Virginia Polytechnic Institute; Sue Philhower and Suzanne Wrenn, North Carolina State University, Raleigh; John Fussell, private consultant; Phil Wilkinson, South Carolina Department of Natural Resources; Robin Lepore, USDI Regional Solicitor's Office; Graham Taylor, Charlie Hebert, Jennifer Casey, Sherman Stairs, Irv Ailes, Donna Surabian, Vince Turner, Ed Moses, John Schroer, Jack Fillio, Sharon Ware, Tony Leger, Ben Nottingham, Karen Mayne, Dana Peters, Kevin DuBois, Nancy Schlotter, Katie Zeeman, Tim Fannin, John Hickey, Ken Carr, Nancy Hillery, Pat Bosco, Chris Dowd, Walt Quist, Earl Possardt, and Carl Melberg, U.S. Fish and Wildlife Service.

* * *

The following recovery plan revision describes recovery progress to date and delineates further actions required to recover and/or protect the threatened Atlantic Coast population of the piping plover *(Charadrius melodus)*. Attainment of recovery objectives and availability of funds will be subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

This plan does not necessarily represent the views or official position of any individuals or agencies other than the U.S. Fish and Wildlife Service. Recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

Literature citations should read as follows:

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TABLE OF CONTENTS

PART I: INTRODUCTION 1

Description and Taxonomy 3

Life History and Ecology 4
- Breeding 4
  - Arrival and Courtship 4
  - Nests 6
  - Nesting Densities 6
  - Egg-laying and Incubation 7
  - Brood-rearing 8
  - Defense of Nests and Chicks 11
  - Feeding Habitat and Habits 11
- Migration 13
- Wintering 14
  - Distribution 14
  - Habitat Selection 15
  - Habitat Use and Movements 15
  - Winter Site Fidelity 16
  - Intra- and Inter-specific Interactions 16

Population Status and Distribution 17
- Abundance 17
  - Trends Prior to 1985 17
  - Trends Since Listing Under the Endangered Species Act 18
- Productivity 24
- Survival 27
- Current Breeding Distribution 27
- Breeding Site Fidelity and Dispersal 28
- Habitat Carrying Capacity 29
- Vulnerability to Extinction 31
  - Demographic Factors 31
  - Genetic Factors 33

Reasons for Listing and Continuing Threats 33
- Loss and Degradation of Breeding Habitat 34
- Disturbance of Breeding Plovers by Humans and Pets 37
  - Non-motorized Beach Activities 39
  - Motorized Vehicles 40
  - Beach-cleaning 41
- Predation 41
- Threats to Wintering Piping Plovers 43
- Oil Spills and Other Contaminants 44

Implications for the Beach Ecosystem . . . 44
Current Conservation Efforts . . . 46
Regulatory Protection . . . 46
Protection and Management on Breeding Sites . . . 49
Protection and Management on Wintering Sites . . . 50
Role of Federal Lands in Recovery Efforts . . . 50
Coordination and Participation . . . 51
Recovery Strategy . . . 52

PART II: RECOVERY . . . 57

Recovery Objective . . . 57

Recovery Tasks . . . 61
1. Manage breeding piping plovers and habitat to maximize survival and productivity . . . 61
2. Monitor and manage wintering and migration areas to maximize survival and recruitment into the breeding population . . . 81
3. Undertake scientific investigations that will facilitate recovery efforts . . . 87
4. Develop and implement public information and education programs . . . 96
5. Review progress towards recovery annually and revise recovery efforts as appropriate . . . 98

PART III: IMPLEMENTATION . . . 99

Implementation Schedule . . . 101

APPENDICES . . . 109

Appendix A - Locations of Current and Potential Breeding Sites . . . 111

Appendix B - Current and Potential Breeding Site Information . . . 127

Appendix C - Summary of Current and Needed Breeding Site Management Activities . . . 139

Appendix D - Summary of Off-Road Vehicle Use at Breeding Sites . . . 157

Appendix E - Population Viability Analysis . . . 173

Appendix F - Guidelines for the Use of Predator Exclosures to Protect Piping Plover Nests . . . 187

Appendix G - Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take under Section 9 of the Endangered Species Act 191

Appendix H - Guidelines for the Preparation and Evaluation of Conservation Plans for Atlantic Coast Piping Plovers Pursuant to Section 10(a)(1)(B) and 10(a)(2) of the Endangered Species Act 199

Appendix I - Guidelines for Conducting Surveys for Piping Plovers in Atlantic Coast Wintering Habitat 205

Appendix J - Estimated Cost of U.S. Atlantic Coast Piping Plover Protection Activities During the 1993 Breeding Season 207

Appendix K - Known Piping Plover Wintering Sites on the Southern Atlantic Coast and the Caribbean 211

Appendix L - Summary of Comments on Draft Revised Recovery Plan and Service Responses 217

LITERATURE CITED 231

LIST OF FIGURES

Figure 1. Current Breeding and Wintering Distribution of Piping Plovers in North America 2
Figure 2. Atlantic Coast Breeding Chronology 5
Figure 3. Estimated Population by Region, 1986-1995 20
Figure 4. Average Productivity by Region, 1988-1995 26
Figure 5. Distribution of Piping Plovers on Outer Cape Cod, 1988-1993 32

LIST OF TABLES

Table 1. Summary of Chick Mobility Data 9
Table 2. Summary of Chick Time Budget Data 10
Table 3. Summary of Data on Distances at which Piping Plovers React to Disturbance 12
Table 4. Summary of Atlantic Coast Piping Plover Population Estimates, 1986 to 1995 19
Table 5. Comparison of 1991 and 1994 Population Estimates Based on "Window" Census with Estimates Based on 1990 Census Methodologies 21
Table 6. Summary of Piping Plover Productivity Estimates for the U.S. Atlantic Coast, 1987-1995 25
Table 7. Recovery Task Outline 59

PART I: INTRODUCTION

On January 10, 1986, the piping plover (*Charadrius melodus*) was listed as endangered and threatened under provisions of the Endangered Species Act of 1973 (ESA), as amended (U.S. Fish and Wildlife Service 1985). This species breeds only in North America in three geographic regions (Figure 1). The Atlantic Coast population breeds on sandy beaches along the east coast of North America, from Newfoundland to South Carolina. The Great Lakes population historically nested on sandy beaches throughout the Great Lakes, but has declined dramatically and now occurs on just a few sites on the upper lakes. The third population breeds on major river systems and alkali lakes and wetlands of the Northern Great Plains.

In the Final Rule listing the piping plover across its range, the U.S. Fish and Wildlife Service (USFWS) designated the Great Lakes population as endangered and the Atlantic Coast and Northern Great Plains populations as threatened. To facilitate recovery efforts for piping plovers over this wide geographic area, the USFWS appointed two recovery teams. The Great Lakes/Northern Great Plains Recovery Team developed a recovery plan (USFWS 1988a, 1994a) and makes management recommendations for those two plover populations, while the Atlantic Coast Recovery Team has fulfilled an identical role for plovers along the East Coast. Furthermore, two Canadian recovery teams provide guidance for activities to recover Atlantic Coast and Prairie piping plovers in that country (Canadian Wildlife Service 1989); coordination of recovery activities between the two countries is facilitated through exchange of observers (i.e., non-members) among recovery teams and frequent communications.

The plan outlined in this document is the first revision of the 1988 Atlantic Coast Piping Plover Recovery Plan (USFWS 1988e). It reports on progress to date and continuing recovery issues, and provides a strategy for recovery of the entire Atlantic Coast piping plover population, albeit site-specific recommendations are limited to the United States part of its range.

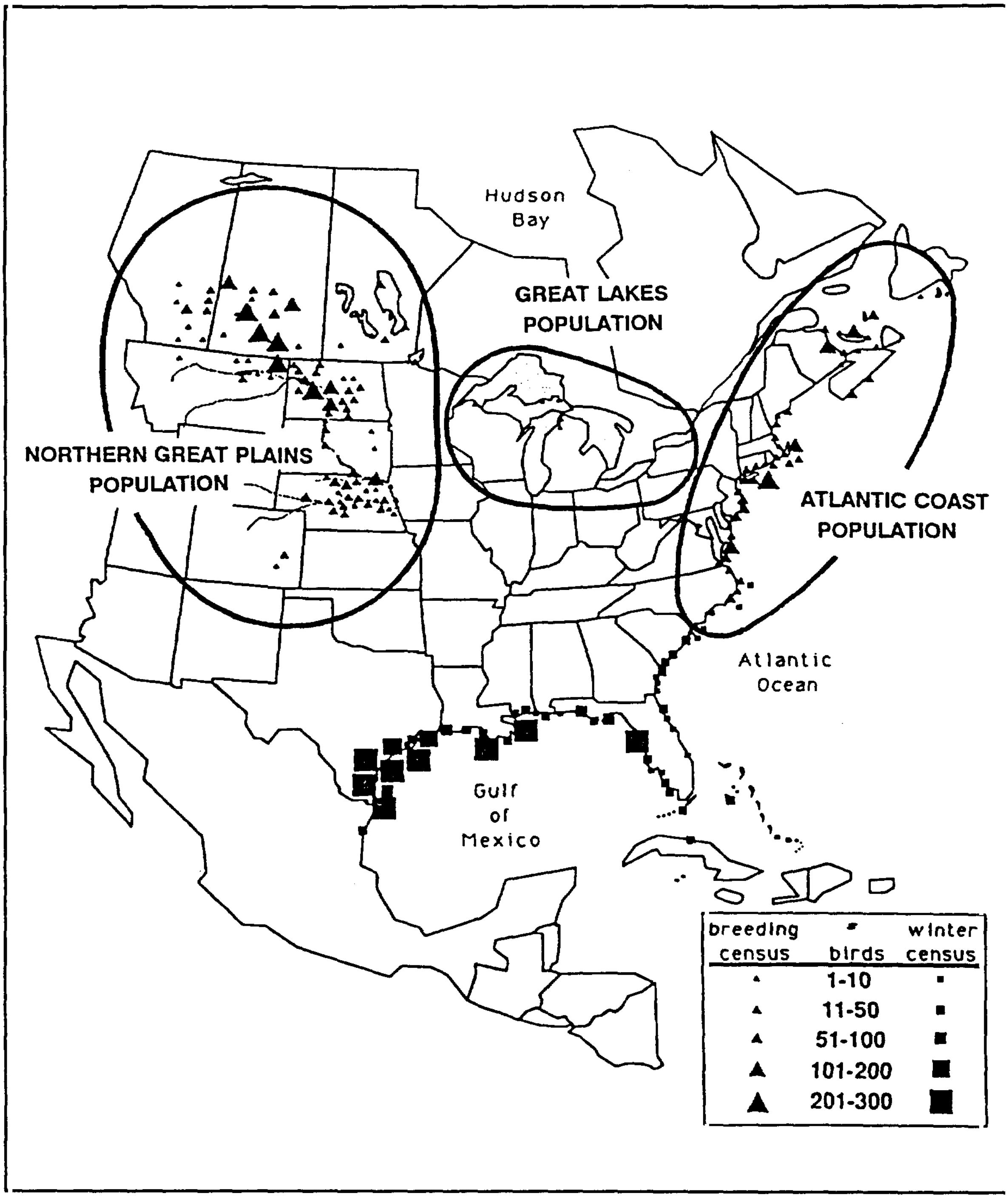

Figure 1. Current Breeding and Wintering Distribution of Piping Plovers in North America (taken from Haig and Plissner 1992)

DESCRIPTION AND TAXONOMY

The piping plover is a small Nearctic (i.e., North American) shorebird approximately 17 centimeters (7 inches) long with a wingspread of about 38 cm (15 in) (Palmer 1967). Wilcox (1959) found that breeding females were slightly heavier than males (55.6 grams vs. 54.9 g), had slightly shorter tail lengths (50.5 millimeters vs. 51.3 mm), but had similar wing lengths. Breeding birds have white underparts, light beige back and crown, white rump, and black upper tail with a white edge. In flight, each wing shows a single, white wing stripe with black highlights at the wrist joints and along the trailing edges. Breeding plumage characteristics are a single black breastband, which is often incomplete, and a black bar across the forehead. The black breastband and brow bar are generally more pronounced in breeding males than females (Wilcox 1939). The legs and bill are orange in summer, with a black tip on the bill.

In winter, the birds lose the black bands, the legs fade from orange to pale yellow, and the bill becomes mostly black. Palmer (1967) provides further details on the plumage and other characteristics of the piping plover.

For many years, ornithologists have debated the designation of two subspecies of piping plover. Moser (1942) argued that the extent and brightness of breastbands distinguished inland and Atlantic breeders, facilitating the acceptance of two subspecies, the inland *C. m. circumcinctus* and the coastal *C. m. melodus*, by the American Ornithologists' Union (AOU) (AOU 1945). Wilcox (1959) considered the subspecies *circumcinctus* of dubious validity, noting occurrence of complete breastbands on 18% of the birds that he trapped on Long Island, lack of appreciable differences in wing and tail measurements of birds with different plumage types, and absence of relationship among plumages of adults and offspring. Electrophoretic analyses (Haig and Oring 1988a) did not detect any genetic differences among local or regional populations in Saskatchewan, Manitoba, North Dakota, Minnesota, and New Brunswick. Although the AOU (1957, 1983) continues to officially recognize the two subspecies, Haig and Oring (1988a) conclude that current information does not support subspecies designation.

Protection of the entire species *Charadrius melodus* under the ESA reflects its precarious status rangewide, but the USFWS also recognizes three distinct piping plover population segments, one designated as endangered, two as threatened. Recovery objectives have been established for each population. Despite intensive censusing of breeding sites rangewide at least since 1986 as well as marking of more than 2,700 birds between 1981 and 1989 (J.L. Spinks, U.S. Fish and Wildlife USFWS, *in litt.* 1989), no interchange between Atlantic Coast and inland breeding populations has been reported. Although some mingling of birds from various breeding populations occurs in wintering habitat (Haig and Oring 1988b, Haig and Plissner 1993), all available evidence shows that Atlantic Coast piping plovers form a distinct breeding population. Dispersal within the Atlantic Coast population is discussed under Breeding Site Fidelity and Dispersal, page 28.

LIFE HISTORY AND ECOLOGY

BREEDING

The breeding chronology of the Atlantic Coast *Charadrius melodus* populations in the United States part of its range is illustrated in Figure 2. A description of breeding behavior and habitat use is provided below.

Arrival and Courtship

Piping plovers have been observed as early as February 24 in Virginia (Cross 1991), March 11 in New York (Goldin 1990), March 15 in Massachusetts (MacIvor 1990), and March 28 in Nova Scotia (Mills 1976, cited *in* Cairns 1977). Cross (1991) reported that feeding was the most common plover activity during March in Virginia. Cairns (1977) also reports early season flocking of unpaired birds in neutral feeding areas (i.e., areas not defended through territorial behaviors) in Nova Scotia.

By early April, males begin to establish territories (Patterson 1988, MacIvor 1990, Cross 1991), which they defend aggressively against adjacent males by performing "horizontal threat," "parallel run," and aerial displays, characterized by Cairns (1982). Parallel runs may cover distances up to 100 meters, while aerial displays may be performed from just above ground level up to approximately 35 m and are generally accompanied by continuous vocalization. Courtship rituals include tilt displays, tossing of shell fragments, and scraping of multiple shallow depressions in the sand. Cairns (1982) also provides descriptions of copulatory activities.

Piping plovers are monogamous, but usually shift mates between years (Wilcox 1959, Haig and Oring 1988c, MacIvor 1990) and, less frequently, between nesting attempts in a given year (Haig

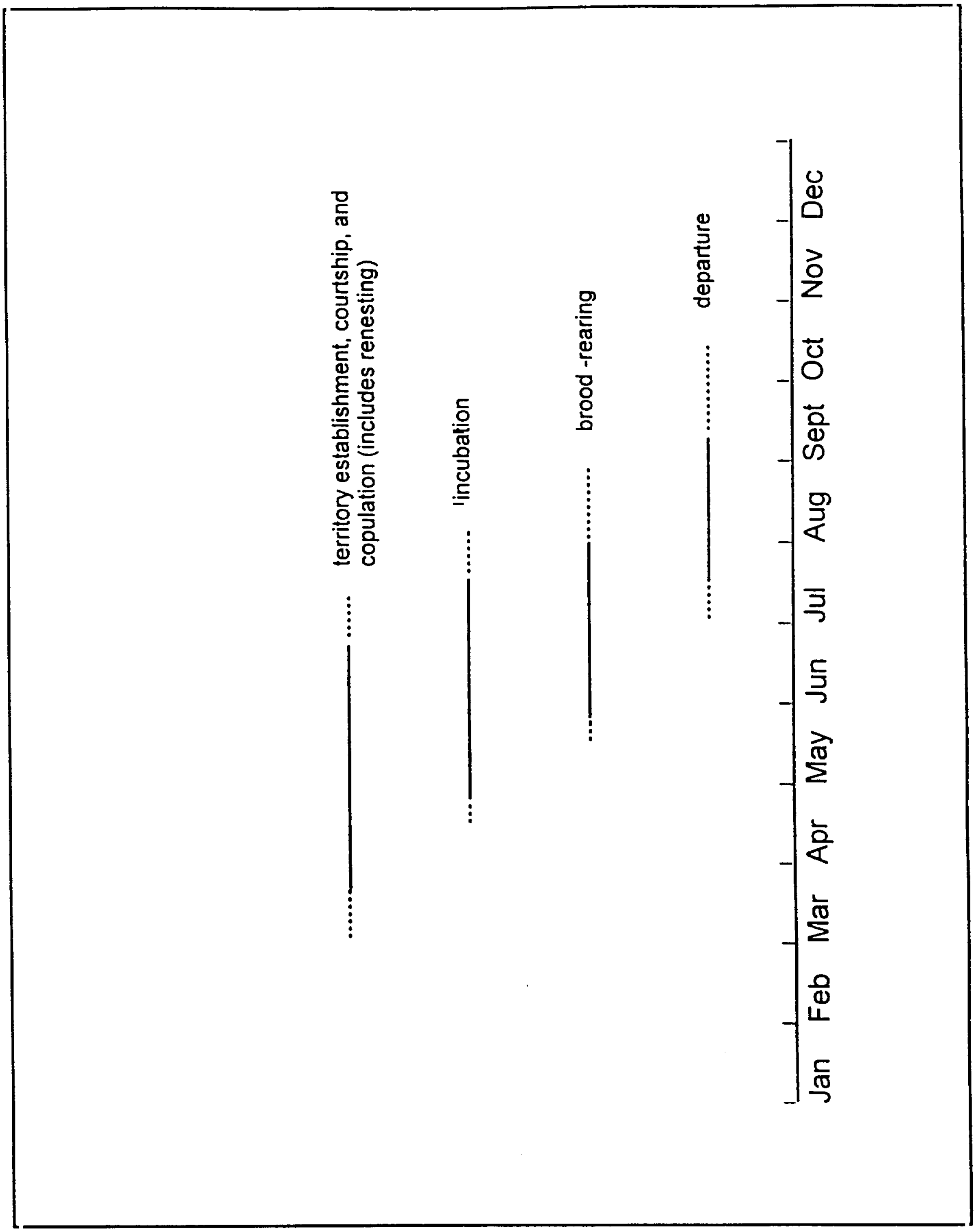

Figure 2. Atlantic Coast Breeding Chronology

and Oring 1988c, MacIvor 1990, Strauss 1990). Plovers are known to breed at one year of age (MacIvor 1990, Strauss 1990, Haig 1992), but the rate at which this occurs is unknown.

Nests

Piping plover nests are situated above the high tide line on coastal beaches, sandflats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout[1] areas behind primary dunes, and washover[2] areas cut into or between dunes. They may also nest on areas where suitable dredge material has been deposited. Nest sites are shallow scraped depressions in substrates ranging from fine grained sand to mixtures of sand and pebbles, shells, or cobble (Bent 1929, Burger 1987a, Cairns 1982, Patterson 1988, Flemming *et al.* 1990, MacIvor 1990, Strauss 1990). Nests are usually found in areas with little or no vegetation although, on occasion, piping plovers will nest under stands of American beachgrass (*Ammophila breviligulata*) or other vegetation (Patterson 1988, Flemming *et al.* 1990, MacIvor 1990).

Nesting Densities

Piping plovers are territorial nesters, defending both nesting and brood rearing territories from conspecifics[3] (Wilcox 1959, Cairns 1977). Observed nesting densities are highly variable, however. Wilcox (1959) reported that nests of adjacent pairs are usually spaced 200 feet or more apart and are seldom closer than 100 feet. Nests in Cairns' (1977) primary study area in Nova Scotia averaged about 50 m apart, but the shortest distance between two simultaneously active nests was 3 m. Elias-Gerken (1994) noted contrasting densities of pairs within her study area on New York's central barrier islands; in 1992, she located 2.1 pairs per kilometer on Westhampton Island and 1.8 pairs per km on Jones Island, compared with 0.2 pairs per km on Fire Island.

Data gathered to date at New England sites where productivity has been high and the population has increased in recent years suggest that, at most sites, observed nesting densities may be

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1 Blowouts are distinctive "bowl-like" areas within the interdune area caused by wind erosion behind the primary dune ridge; the ocean view is often obstructed.

2 Washover areas are created by the flow of water through the primary dune line with deposition of sand on the barrier flats, marsh, or into the lagoon, depending on the storm magnitude and the width of the beach (Leatherman 1979). Nests may be situated on portions of these storm-created areas that are relatively dry during the nesting season, while plovers may feed on any portions that stay moist.

3 Conspecifics are other members of the same species, in this case, other piping plovers.

a function of available breeding birds, which may be limited because of depressed productivity for many years. Dramatic increases in breeding densities have occurred without declines in productivity that might suggest overcrowding. For example, the piping plover population on the Cape Cod National Seashore in Massachusetts increased from 13 pairs in 1988 to 72 pairs in 1994, while average productivity in the same area increased from 0.9 chicks per pair in 1988 to 2.1 and 2.5 chicks per pair in 1993 and 1994, respectively (Brown and Hoopes 1993; S.M. Melvin, Massachusetts Division of Fisheries and Wildlife, *in litt.* 1994). Similarly, the number of breeding pairs at Crane Beach, Massachusetts increased from five pairs in 1986 to 18 in 1993; the lowest productivity recorded on the site during this period was 1.8 chicks per pair in 1990 (Rimmer 1994). In Maine, 15 pairs with average productivity of 1.7 chicks per pair nested at Seawall/Popham/Hunnewell Beach in 1993, where only two pairs were recorded in 1981 (J. Jones, Maine Audubon Society, *in litt.* 1992, 1993). The nesting population on about eight hectares at Goosewing Beach in Rhode Island increased from three pairs in 1986 to nine pairs in 1994, when productivity was over 2.6 chicks per pair (C. Raithel, Rhode Island Division of Fish and Wildlife, *in litt.* 1994).

Egg-laying and Incubation

Eggs may be present on the beach from mid-April to late July. Clutch initiation dates have been recorded as early as April 21 in Virginia (Cross 1991), April 15 in New York (C. Brittingham, The Nature Conservancy, pers. comm. 1994), April 20 in Massachusetts (MacIvor 1990), and April 24 in Nova Scotia (Cairns 1977).

Piping plovers generally fledge only a single brood per season, but may renest several times if previous nests are lost or, infrequently, if a brood is lost within several days of hatching (Wrenn 1991, Goldin 1994a, Rimmer 1994). A few extremely rare instances of adults renesting following fledging of an early brood have also been observed (J. Victoria, Connecticut Department of Environmental Protection, *in litt.* 1994; Bottitta *et al.* 1994). One female on Cape Cod was observed in five nesting attempts laying a total of 19 eggs in a season (MacIvor 1990). Renests often occur on the same site, but movements between sites have also been recorded (Cross 1990, MacIvor 1990).

A comparison of data from North Carolina (Coutu *et al.* 1990, McConnaughey *et al.* 1990, Wrenn 1991), Rhode Island (C. Raithel, files), and Nova Scotia (Cairns 1977), reveals completed clutches from first nest attempts as early as mid-April and as late as mid-June, with a peak in all three areas between April 30 and May 7. Nest initiation appears to be slightly later in Quebec, Prince Edward Island, and on the eastern shore of New Brunswick, with a peak of nest initiation in mid-May to early June (Morse 1982, Tull 1984, Shaffer and Laporte 1992). Although nests may be initiated as late as July 25, few nests hatch after July 15, and the latest recorded hatch date is July 31 in Massachusetts (MacIvor 1990).

Clutch size for an initial nest attempt is usually four eggs, one laid every other day. Eggs are pyriform in shape, with variable buff to greenish ground color marked with black or brown spots. Cairns (1977) and Wilcox (1959) reported mean egg lengths of 32.5 mm (n = 215) and 31.7 mm (n = 26), respectively. Plover nests and eggs are very difficult to detect, especially during the 6-7 day egg-laying phase when the birds generally do not incubate (Goldin 1994a).

Full-time incubation usually begins with the completion of the clutch, averages 27-30 days, and is shared equally by both sexes (Wilcox 1959, Cairns 1977, MacIvor 1990).

Brood-rearing

Eggs in a clutch usually hatch within four to eight hours of each other, but the hatching period of one or more eggs may be delayed by up to 48 hours (Cairns 1977, Wolcott and Wolcott 1994). Chicks are precocial[1], often leaving the nest within hours of hatching (Wilcox 1959, Cairns 1982, Wolcott and Wolcott 1994), but are tended by adults who lead the chicks to and from feeding areas, shelter them from harsh weather, and protect the young from perceived predators (see following section). Broods may move hundreds of meters from the nest site during their first week of life (Table 1). Chicks remain together with one or both parents until they fledge (are able to fly) at 25 to 35 days of age. Depending on date of hatching, flightless chicks may be present from mid-May until late August, although most fledge by the end of July (Patterson 1988, Goldin 1990, MacIvor 1990, Howard *et al.* 1993). After fledging, adults and young may congregate on neutral (non-territorial) feeding grounds prior to southward migration (Cairns 1977).

Most time budget studies reveal that chicks spend a very high proportion of their time feeding (Table 2). Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks after hatching; chicks that failed to achieve at least 60% of this weight gain by day 12 were unlikely to survive. Loegering (1992) found that chick weight and length of exposed bill measured at four or five days of age were significantly higher for chicks that ultimately fledged than for those not surviving.

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[1] Precocial birds are mobile and capable of foraging for themselves within several hours of hatching.

Table 1. Summary of Chick Mobility Data

Source	Location	Data
Patterson (1988: 40)	Maryland and Virginia	Eighteen of 38 broods moved to feeding areas more than 100 meters from their nests; 5 broods moved more than 600 meters (distance measured parallel to wrack line).
Cross (1989: 23)	Virginia	At 3 sites, observers relocated broods at mean distances from their nests of 153 m +/-97 m (44 observations, 14 broods), 32 m +/-7 m (8 observations, 3 broods), and 492 m +/-281 m (12 observations, 4 broods).
Coutu *et al.* (1990: 12)	North Carolina	Observations of 11 broods averaged 212 m from their nests; 3 broods moved 400-725 m from nest sites.
Strauss (1990: 33)	Massachusetts	Ten chicks moved more than 200 m during first 5 days post-hatch while 19 chicks moved less than 200 meters during same interval.
Loegering (1992: 72)	Maryland	Distances broods moved from nests during first 5 days post-hatch averaged 195 m in bay habitat (n=10), 141 m in interior habitat (n=36), and 131 m in ocean habitat (n=41). By 21 days, average movement in each habitat had, respectively, increased to 850 m (n=1), 464 m (n=10), and 187 m (n=69). One brood moved more than 1000 m from its nest.
Melvin *et al.* (1994)	Massachusetts and New York	In 14 incidents in which 18 chicks were killed by vehicles, chicks were run over ≤ 10 m to ≤ 900 m from their nests. In 7 of these instances, mortality occurred ≥ 200 m from the nest.

Table 2. Summary of Chick Time Budget Data

Source	Location	Data
Flemming (1984: 27)	Nova Scotia	Major chick activities were feeding (80.5% of time) and being brooded (15.7%). Percent of time spent feeding was 34% for chicks ages 0-5 days, and above 89% for all age-classes over 5 days old.
Loegering (1992: 74)	Maryland	Chicks 3-10 days old in bay beach, interior, and ocean habitats spent 76%, 80%, and 37% of their time feeding, respectively. Time spent foraging by chicks 11-20 days in the respective habitats was 82%, 88%, and 56%.
Elias-Gerken (1994: 51)	New York	On average, chicks spent 73-75% of their time foraging and 13-16% resting. Foraging accounted for 58-73% of time of chicks 0-2 days old, 73-75% for chicks 3-10 days old, 82-77% for chicks 11-20 days old, and 76-75% for chicks 21-25 days old.
Goldin (1993b: 44)	New York	In 1988, 61% of chick observations were of feeding, 11% being brooded or guarded, 10% maintenance, 10% locomotion, and 6% disturbance. In 1989, percentages were 59% feeding, 24% maintenance, 7% disturbance, 6% locomotion, and 4% being brooded or guarded.
Hoopes (1993: 33)	Massachusetts	Chicks devoted 35% of their time to feeding behaviors, 39% to maintenance, 15% to disturbance-related behaviors, 4% to locomotion, 2% to being brooded, and 5% to other behaviors.
Burger (1991: 44)	New Jersey	Chicks spent 22% of their time feeding, 27% alert, 39% running away from people, and 10% crouched.
Goldin (1993a: 16)	Rhode Island	Chicks devoted 72% of their time to feeding and 17% to maintenance behaviors; 4% of their time was spent in disturbance behaviors. All other behaviors accounted for 7% of their time.

Defense of Nests and Chicks

Cryptic coloration is a primary defense mechanism for this species; nests, adults, and chicks all blend with their typical beach surroundings. Chicks sometimes respond to vehicles and/or pedestrians by crouching and remaining motionless (Cairns 1977, Tull 1984, Goldin 1993b, Hoopes 1993). Adult piping plovers also respond to intruders (avian and mammalian) in their territories by displaying a variety of distraction behaviors, including squatting, false brooding, running, and feigning injury. Distraction displays may occur at any time during the breeding season, but are most frequent and intense around the time of hatching (Cairns 1977). Distances at which plovers react to human disturbance are summarized in Table 3.

Feeding Habitat and Habits

Plover foods consist of invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks (Forbush 1925, Bent 1929, Cairns 1977, Nicholls 1989, Gibbs 1986, Shaffer and Laporte 1994). Burger (1994) found more polychaete worms in core samples taken from intertidal areas where plovers were feeding than in random samples.

Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines[1], and shorelines of coastal ponds, lagoons, or salt marshes (Gibbs 1986, Coutu *et al.* 1990, Hoopes *et al.* 1992, Loegering 1992, Goldin 1993b). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986, Coutu *et al.* 1990, McConnaughey *et al.* 1990, Loegering 1992, Goldin 1993b, Hoopes 1993, Elias-Gerken 1994) and by stage in the breeding cycle (Cross 1990). Adults and chicks on a given site may use different feeding habitats in varying proportion (Goldin *et al.* 1990). During courtship, nesting, and brood-rearing, feeding territories are generally contiguous to nesting territories (Cairns 1977), although instances where brood-rearing areas are widely separated from nesting territories are not uncommon (see Table 1). Feeding activities of both adults and chicks may occur during all hours of the day and night (Burger 1994) and at all stages in the tidal cycle (Goldin 1993b, Hoopes 1993).

[1] Wrack is organic material including seaweed, seashells, driftwood and other materials deposited on beaches by tidal action.

Table 3. Summary of Data on Distances at which Piping Plovers React to Disturbance

Source	Location	Data
FLUSHING OF INCUBATING BIRDS BY PEDESTRIANS:		
Flemming *et al.* (1988: 326)	Nova Scotia	Adults usually flushed from the nests at distances <40 m; however, great variation existed and reaction distances as great as 210 m were observed.
Cross (1990: 47)	Virginia	Mean flushing distances in each of two years were 47 m (n=181, range = 5 m to 300 m) and 25 m (n=214, range = 2 m to 100 m).
Loegering (1992: 61)	Maryland	Flushing distances averaged 78 m (n=43); range was 20 m to 174 m. Recommended use of 225 m disturbance buffers on his site.
Cross and Terwilliger (1993)	Virginia	Mean flushing distance for all years on all sites (Virginia plover sites, 1986-91) was 63 m (n=201, SD=31, range = 7 m to 200 m). Differences among years were not significant, but differences among sites were.
Hoopes (1993: 72)	Massachusetts	Mean flushing distance for incubating plovers was 24 m (n=31).
DISTURBANCE TO NON-INCUBATING BIRDS:		
Hoopes (1993: 89)	Massachusetts	Mean response distance (all ages, all behaviors) was 23 m for pedestrian disturbances (range = 10 m to 60 m), 40 m for vehicles (range = 30 m to 70 m), 46 m for dogs/pets (range = 20 m to 100 m), and 85 m for kites (range = 60 m to 120 m).
Goldin (1993b: 74)	New York	Average flushing distance for adult and juvenile plovers was 18.7 m for pedestrian disturbances (n=585), 19.5 m for joggers (n=183), and 20.4 m for vehicles (n=111). Pedestrians caused chicks to flush at an average distance of 20.7 m (n=175), joggers at 32.3 m (n=37), and vehicles at 19.3 m (n=7). Tolerance of individual birds varied; one chick moved 260 m in direct response to 20 disturbances in 1 hour.

MIGRATION

Atlantic Coast piping plover migration patterns are not well documented. Most piping plover surveys have focused on breeding or wintering sites, and it is sometimes difficult to distinguish local nesting birds and fledged young feeding on neutral feeding areas from non-local breeders on stopover during southward migration. References to piping plover migration are contained in Bent (1929), Griscom and Snyder (1955), Bull (1964), Cairns (1977), Raithel (1984), Tull (1984), Haig and Oring (1985), McConnaughey *et al.* (1990), Nicholls and Baldassarre (1990a), Haig and Plissner (1993), and Collazo *et al.* (1995). Northward migration to the breeding grounds occurs during late February, March and early April, and southward migration to the wintering grounds extends from late July, August, and September. On the breeding grounds, transient birds have been observed following early autumn hurricanes (C. Raithel pers. obs.) and are occasionally sighted during October.

Both spring and fall migration routes are believed to follow a narrow strip along the Atlantic Coast. Appendix B identifies many breeding sites where concentrations of post-breeding and migrating plovers have been observed. There are several North Carolina sites where relatively large numbers of plovers have been observed during migration, including Oregon Inlet, Ocracoke Inlet/Portsmouth Flats, and New Drum Inlet, within the Cape Hatteras and Cape Lookout National Seashores (McConnaughey *et al.* 1990; S. Wrenn, North Carolina State University, pers. comm. 1994). In addition, plover numbers fluctuate at Ohio Key, Florida during spring and fall periods, suggesting use by migrant plovers (M. Brown pers. comm. 1988).

Sightings away from the outer beaches, either inland or offshore, are rare (Bull 1964, Barbour *et al.* 1973, Imhof 1975, Potter *et al.* 1980). Observations of color-marked birds from the Atlantic Coast suggest some crossover to Gulf Coast wintering areas (Haig and Plissner 1993); however, routes are unknown. Occasional sightings of piping plovers at distant islands, such as Bermuda (American Birds 1987, 1990; D. Wingate, Bermuda Aquarium and Natural History Museum, *in litt.* 1988), demonstrate that long-distance migrations are possible. Intensified survey efforts during migration periods should result in identification of additional important stopover areas.

WINTERING

Distribution

The piping plover's winter range extends along the Atlantic and Gulf Coasts from North Carolina to Mexico and into the Bahamas and West Indies (USFWS 1985, Haig and Oring 1985, Haig and Oring 1988b, Hoopes *et al.* 1989). Two fairly comprehensive surveys, one conducted between January 1983 and April 1984 and the other between December 1986 and March 1988, provided preliminary insight into winter distribution and contributed to the identification of specific wintering sites (Haig and Oring 1985, Nicholls and Baldassarre 1990a). The most comprehensive survey to date was the 1991 International Piping Plover Census, which tallied a total of 3,451 plovers, the largest number of birds ever accounted for during the winter period (Haig and Plissner 1993). While approximately 63% of the known adult plovers were observed during this rangewide survey, a large number of plovers are still unaccounted for during the wintering period.

Pooling sightings of banded birds from the 1991 International Census and earlier reports, Haig and Plissner (1993) reported 49 band sightings on the wintering grounds of plovers banded on the Atlantic Coast breeding grounds, including 41 birds (84%) sighted on the southern Atlantic Coast, five (10%) on the Gulf Coast, and three (6%) in the Florida Keys. Twenty-six piping plovers from inland breeding populations (14% of band sightings) were also reported wintering in North or South Carolina. The magnitude of crossover between coasts is difficult to ascertain, because few birds are seen on the Atlantic Coast in winter, and a relatively small proportion of the Atlantic Coast plovers are banded. The development of refined techniques for genetic testing may eventually assist in addressing this issue (S. Haig, National Biological Survey, *in litt.* 1994).

Plovers wintering on the Atlantic Coast are generally distributed in small groups; six was the average number of piping plovers per site during Nicholls' 1986-87 survey (Nicholls 1989). The barrier islands off Georgia and South Carolina (especially Deveaux Bank) appear to host the largest numbers of wintering birds. A few sites in North Carolina (e.g., Bird Shoals and Figure 8 Island) and Florida (Ward's Bank, Little Talbot Island, Ohio Key, Boca Grande Key) also have relatively high numbers for the Atlantic Coast.

Several sightings have been recorded in the Caribbean and more intensive searches may locate more birds. Haig and Oring (1985) reviewed museum records and did not find any records of birds wintering farther south than the Lesser Antilles. Additional searches along the Louisiana, Texas, and

Mexico Gulf beaches may result in upward revisions in wintering plover counts there. Indeed, the large proportion of birds found in Louisiana and Texas during the 1991 International Census suggests the possibility that more birds from the Atlantic Coast breeding population may be wintering on the Gulf Coast than previously surmised (Haig and Plissner 1993).

Habitat Selection

In general, wintering plovers on the Atlantic Coast are found at accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets. Plovers appear to prefer sandflats adjacent to inlets or passes, sandy mudflats along prograding spits, and overwash areas as foraging habitats. These types of substrates may have a richer infauna than the foreshore of high energy beaches and attract large numbers of shorebirds. Roosting plovers are generally found along inlet and adjacent ocean and estuarine shorelines and their associated berms (with wrack and other debris often used as wind-shields), and on nearby exposed tidal flats (Fussell 1990, Nicholls and Baldassarre 1990a).

Nicholls and Baldassarre (1990b) attempted to develop a predictive model of habitat use along the Atlantic and Gulf Coasts and identified variables that could be measured over a broad spectrum of sites. While a few general features, such as the presence of large inlets and large areas of sand or mudflats, appeared important, no single variable dominantly identified typical habitats. Thus, plover distribution may be influenced by a number of habitat variables, and it may be the presence of a diversity of microhabitats in close juxtaposition that separates the sites commonly used by wintering plovers from non-plover sites. While this study provided a preliminary overview of plover winter habitat, more investigation is needed to provide a fuller habitat characterization. Research is presently underway along the Texas Coast to more precisely characterize wintering habitat and to identify features predictive of plover use (Zonick and Ryan 1993). One important discovery from this latter study and the 1991 census was the high use of blue-green algal mats by wintering plovers in the Laguna Madre area. This discovery may broaden the search image for new wintering areas in Mexico and the Caribbean.

Habitat Use and Movements

Investigations during winter are few and have focused primarily on population density and distribution (Haig and Oring 1985, Haig and Oring 1988b, Nicholls and Baldassarre 1990a, Haig and Plissner 1993). Studies on the Alabama and Texas Coasts have provided insight into habitat use and movements, foraging efficiencies, and interspecific interactions. Johnson and Baldassarre (1988) found that different microhabitats in coastal Alabama -- sandflats, mudflats, beaches -- may serve different functional roles for wintering plovers depending on tidal stage, weather, and time of day. The study also found that plovers spend a high percentage of time foraging relative to other activities during the fall and midwinter. Tidal height appeared to be the most important factor affecting foraging time; higher tide negatively correlated with foraging. Zivojnovich and Baldassarre (1987) radio-tracked several wintering plovers in coastal Alabama and found them to utilize several sites within the general barrier island complex of Mobile Bay depending on tidal stage and weather. Ongoing research on the Texas Coast (Zonick and Ryan 1993) also indicates the importance of tides in plover habitat use.

The periodicity of local tides greatly influences the diurnal availability of foraging habitat (Zonick and Ryan 1993). Habitat along the Atlantic Coast is primarily influenced by lunar tides and is regularly available; thus, plover use of sites may be more predictable than in areas such as south Texas where tides are influenced by winds. Indeed, plovers may stay within one inlet area or barrier island complex on the Atlantic Coast (Fussell 1990). Observations of banded birds in Texas suggest that individual plovers shuttle between small, discrete areas from algal or tidal flats to beaches (Zonick and Ryan 1993). Haig and Oring (1985) noted a seasonal difference in habitat use along the Gulf Coast, with larger numbers of plovers occurring on sandflats adjacent to beaches and coastal inlets during the winter; more birds were observed on beaches during migration. Observations along the Texas Coast also suggest this seasonal habitat preference (T. Eubanks, Great Lakes/Northern Great Plains Piping Plover Recovery Team, pers. comm. 1992).

Winter Site Fidelity

Johnson and Baldassarre (1988) found relatively high site fidelity for plovers wintering in the Mobile Bay area in Alabama. Similarly, there are several reports of banded birds returning year after year to the same wintering sites on both the Atlantic and Gulf Coasts (S. Bogert pers. comm. 1988; T. Below, National Audubon Society, pers. comm. 1988; T. Eubanks pers. comm. 1989; Zonick and Ryan 1993; J. Fussell pers. comm. 1995).

Intra- and Inter-specific Interactions

During the winter, piping plovers are often found in association with several other shorebird species (Nicholls and Baldassarre 1990b, Eubanks 1992). Territorial and agonistic interactions have been observed with other piping plovers and similar-sized plover species -- semipalmated and snowy plovers (Johnson and Baldassarre 1988, Zonick and Ryan 1993). In Alabama, combined time spent in territorial and agonistic activities largely involved intraspecific interactions (Johnson and Baldassarre 1988). Piping plovers appear to be aggressive and may defend food patches during the winter period (Zonick and Ryan 1993). Piping plovers also appear to roost in multi-species flocks (Nicholls and Baldassarre 1990b, Zonick and Ryan 1993), but are often found in a tight cluster on the fringes of a flock (J. Nicholls, U.S. Fish and Wildlife Service, pers. obs.).

POPULATION STATUS AND DISTRIBUTION

ABUNDANCE

Trends Prior to 1985

Historical population trends for the Atlantic Coast piping plover have been reconstructed from scattered, largely qualitative records. Nineteenth-century naturalists, such as Audubon and Wilson, described the piping plover as a common summer resident on Atlantic Coast beaches (Haig and Oring 1987). By the beginning of the 20th century, uncontrolled hunting (primarily for the millinery trade) and egg collecting had greatly reduced the population, and in some areas along the Atlantic Coast the piping plover was close to extirpation. Following passage of the Migratory Bird Treaty Act in 1918 and changes in the fashion industry, piping plover numbers recovered to some extent (Haig and Oring 1985).

Raithel (1984) showed that Rhode Island piping plover numbers reached a 20th-century peak following the 1938 hurricane, which flattened dunes and destroyed shoreline developments. Rhode Island piping plover numbers declined after World War II, as habitat was lost to dune stabilization efforts and summer home construction. The population partially recovered following another severe hurricane in 1954 before beginning a steady decline which continued through the early 1980's.

Wilcox (1959) documented major fluctuations in piping plover numbers between Moriches Inlet and the village of Southhampton on Long Island, which he correlated with habitat changes. An increase from 20 pairs before the hurricane in 1938 to 64 pairs in 1941 attests to the piping plover's ability to rapidly colonize newly available habitat. The population then declined as habitat was lost to dune stabilization, summer homes, and road construction.

Available data suggest that the most recent Atlantic Coast-wide population decline began in the late 1940's or early 1950's (Haig and Oring 1985). Starting in 1972, the National Audubon Society's "Blue List" of birds with deteriorating status included the piping plover. Johnsgard (1981) described the piping plover as "... declining throughout its range and in rather serious trouble." The Canadian Committee on the Status of Endangered Wildlife in Canada designated the piping plover as "Threatened" in 1978 and elevated the species' status to "Endangered" in 1985 (Canadian Wildlife Service 1989).

Reports of local or statewide declines between 1950 and 1985 are numerous and many are summarized by Cairns and McLaren (1980) and by Haig and Oring (1985). While Wilcox (1939) estimated more than 500 pairs of piping plovers on Long Island, a 1990 survey recorded 197 pairs (Litwin *et al.* 1993). B. Blodget (Massachusetts Division of Fisheries and Wildlife, pers. comm. 1991) reports that there was little focus on gathering quantitative data on piping plovers in Massachusetts through the late 1960's, because the species was commonly observed and presumed to be secure. However, numbers of pairs of breeding piping plovers declined 50-100% at seven Massachusetts sites between the early 1970's and 1984 (Griffin and Melvin 1984). Further, recent experience of biologists surveying piping plovers has shown that counts of these cryptic birds sometimes go up with increased census effort. This suggests that some historic counts of piping plover numbers by one or a few observers, who often recorded occurrences of many avian species, may have underestimated the piping plover population. Thus, the magnitude of the species' decline may have been even more severe than available numbers imply.

Trends Since Listing under the Endangered Species Act

Table 4 and Figure 3 summarize 1986-1995 nesting pair counts furnished to the U.S. Fish and Wildlife Service by the State wildlife agencies and Canadian Wildlife Service (CWS). Table 5 compares 1991 and 1994 nesting pair counts shown in Table 4 with those obtained during the 1991 International Census and similar "window" censuses conducted in 1994. Estimates drawn from Table 4 are based on methodologies that vary slightly among the States and that, in most cases, may result in some double counting of birds that renest during the season. The 1991 International Census reflected a single survey of breeding sites conducted during the peak of the nesting season, June 1-9, 1991. A similar window census was conducted between May 28 and June 5, 1994. Most State coordinators believe that the International Census methodology undercounts their plover populations because some plovers that nest before or after are unpaired during the census window. The actual 1991 and 1994 nesting populations probably lie somewhere between the two figures shown in Table 5.

Table 4. Summary of Atlantic Coast Piping Plover Population Estimates, 1986 to 1995

STATE/REGION	PAIRS									
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Maine	15	12	20	16	17	18	24	32	35	40
Massachusetts	139	126	134	137	139	160	213	289	352	441
Rhode Island	10	17	19	19	28	26	20	31	32	40
Connecticut	20	24	27	34	43	36	40	24	30	31
NEW ENGLAND	184	179	200	206	227	240	297	376	449	552
New York	106[1]	135[1]	172[1]	191	197	191	187	193	209	249
New Jersey	102[2]	93[2]	105[2]	128	126	126	134	127	124	132
NY-NJ REGION	208	228	277	319	323	317	321	320	333	381
Delaware	8	7	3	3	6	5	2	2	4	5
Maryland	17	23	25	20	14	17	24	19	32	44
Virginia	100	100	103	121	125	131	97	106	96	118
North Carolina	30[3]	30[3]	40[3]	55	55	40	49	53	54	50
South Carolina	3	-	-	-	1	1	-	1	-	-
SOUTHERN REGION	158	160	171	199	201	194	172	181	186	217
U.S. TOTAL	550	567	648	724	751	751	790	877	968	1150
ATLANTIC CANADA	240	223	238	233	229	236	236[4]	236[4]	182	199
ATLANTIC COAST	790	790	886	957	980	987	1026	1113	1150	1349

[1] The recovery team believes that this estimate reflects incomplete survey effort. See discussion on page 22.

[2] The New Jersey plover coordinator conjectures that one quarter to one third of the apparent population increase between 1986 and 1989 is due to increased survey effort.

[3] The recovery team believes that the apparent 1986-1989 increase in the North Carolina population is due to intensified survey effort. See discussion on page 22. No actual surveys were made in 1987; estimate is that from 1986.

[4] 1991 estimate.

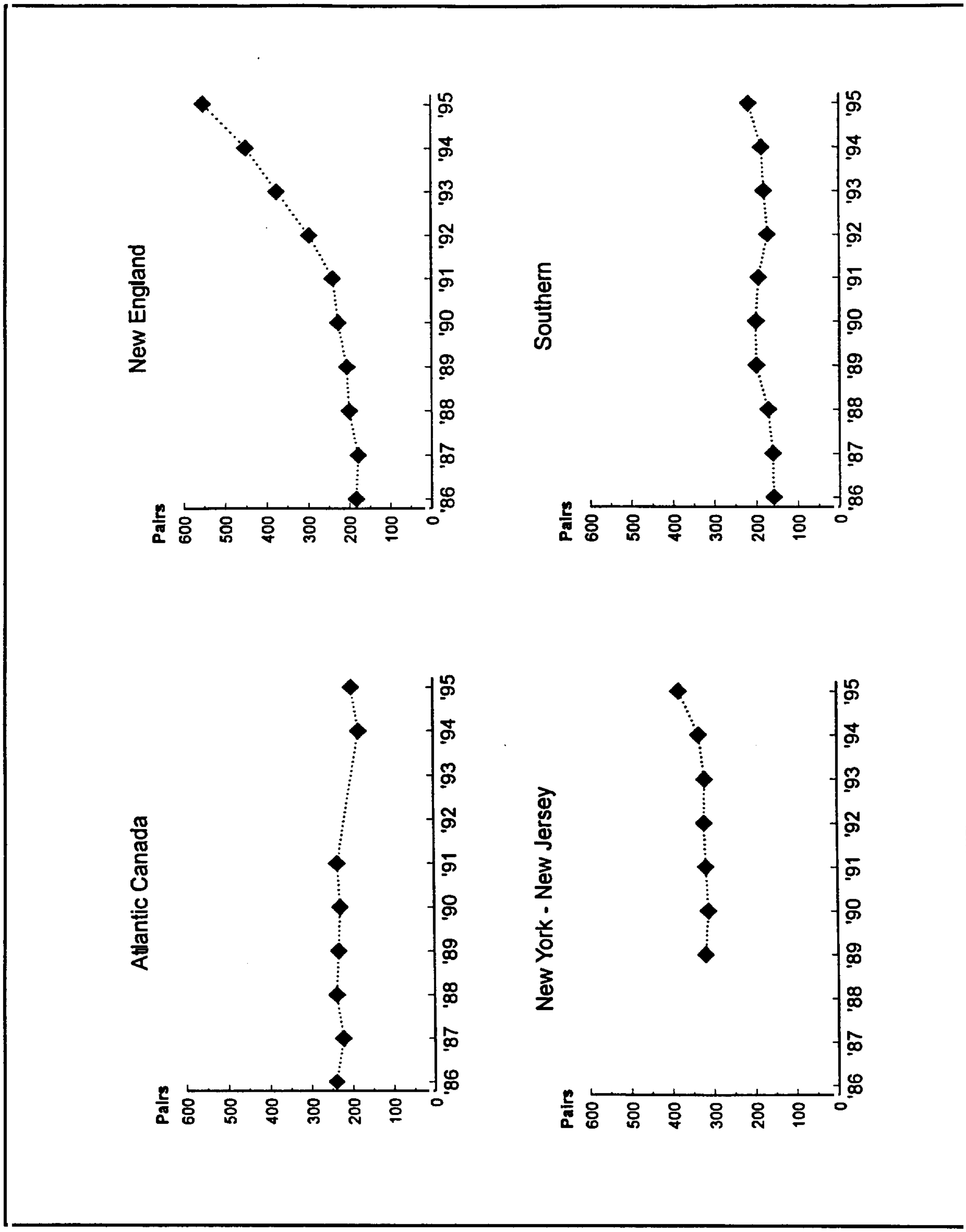

Figure 3. Estimated Population by Region, 1986-1995

Table 5. Comparison of 1991 and 1994 Population Estimates Based on "Window" Census with Estimates Based on 1990 Census Methodologies

STATE/REGION	1991		1994	
	Estimate Based on "Window" Census	Estimate Based on 1990 Census Methodology	Estimate Based on "Window" Census	Estimate Based on 1990 Census Methodology
Maine	18	18	33	35
Massachusetts	148	160	329	352
Rhode Island	22	26	29	32
Connecticut	30	36	25	30
NEW ENGLAND	218	240	416	449
New York	181	191	209	209[1]
New Jersey	122	126	102[2]	124
NY-NJ REGION	303	317	311	333
Delaware	5	5	2	4
Maryland	16	17	30	32
Virginia[3]	131	131	96	96
North Carolina	30	40	51	54
South Carolina	1	1	-	-
SOUTHERN REGION	183	194	179	186
U.S. TOTAL	704	751	906	968
ATLANTIC CANADA	236	236	182	182
ATLANTIC COAST TOTAL	940	987	1088	1150

[1] In 1994, New York adopted the window count as its standard census methodology.

[2] The 1994 New Jersey window census was conducted by relatively inexperienced surveyors. State biologists believe that some birds were present but undetected during the "window," and that the actual State population is closer to the estimate based on 1990 methodology.

[3] Virginia uses only a window census.

The apparent rangewide increase in numbers of pairs from 790 pairs in 1986 to 957 pairs in 1989 is thought to at least partially reflect the effects of increased survey effort following the proposed listing in 1985. Intensified survey effort may have played an especially important role in population estimates for three States:

- North Carolina: 1986-87 estimates were made by compiling results of site surveys from previous years (R. Dyer, U.S. Fish and Wildlife Service, pers. comm. 1993). The first comprehensive state-wide field survey in North Carolina was conducted by volunteers in 1988 (Carter 1988). Piping plover research conducted in 1989 and 1992-94 on the two national seashores that together account for more than 80% of the North Carolina population involved intensive search effort in those years (Coutu *et al.* 1990, McConnaughey *et al.* 1990, Collazo *et al.* 1994). LeGrand (1991) states that, while the North Carolina population trend over the last few decades is unknown, "it can be assumed that the apparent increase in the past 10 years is due to much better survey coverage, especially on the relatively remote Core Banks and Portsmouth Island."

- New York: K. Wich (New York State Department of Environmental Conservation, *in litt.* 1993) states that although protection of beach-nesting birds in New York increased after 1983, survey effort also intensified, especially at sites such as Breezy Point in Queens County and Westhampton Beach in Suffolk County. While the relative contributions of each cannot be determined, he believes that "the stability of more recent estimates probably accurately reflects the status of New York's plover population." Ducey-Ortiz *et al.* (1989) documented an increasing plover monitoring effort in New York between 1984 and 1988 and found that, when results from 54 uniformly monitored sites in that State were analyzed, the population trend did not increase or decrease significantly.

  Downer and Leibelt (1990) likewise cite intensified survey effort as a major contributor to the increased estimate of the New York population between 1984 and 1989. Furthermore, inferences that the apparent 1986-88 New York population gain was caused by increased efforts to protect beach-nesting birds there fail to explain why the State population estimate has remained static since 1989, despite continuing improvements in protection.

- New Jersey: C.D. Jenkins (New Jersey Division of Fish, Game and Wildlife, *in litt.* 1993) conjectures that increased survey intensity accounts for one-quarter to one-third of the population increase observed between 1987 and 1989 in New Jersey.

The recovery team believes that increases in U.S. Atlantic Coast population estimates between 1989 and 1995 reflect the actual population trend. However, the net increase of 426 pairs was very unevenly distributed. The New England subpopulation increased 346 pairs (+168%), while the New York-New Jersey and the Southern (DE-MD-VA-NC) subpopulations gained 62 (+19%) and 18 (+9%) pairs, respectively.

Census data suggest that the overall piping plover population in Atlantic Canada is declining (Flemming and Gautreau *in* CWS 1994; B. Johnson, Canadian Wildlife Service, *in litt.* 1994). Estimates obtained during the 1991 International Census reflect by far the most intensive survey effort to date for the Canadian portion of the plover's Atlantic Coast range. During the second half of the 1980's and through 1991, numbers of breeding pairs appeared stable or slightly improving in Newfoundland, Quebec, New Brunswick, and Prince Edward Island (provincial summaries *in* CWS 1994). A decline from 66-71 pairs counted in Nova Scotia in 1983 to 48-54 pairs in 1987 seemed to have been arrested but not reversed as of 1991 (Austin-Smith *et al.* in CWS 1994). A comprehensive census of all sites that were occupied by plovers in 1991 was conducted in 1994. Results of that census suggest that the Atlantic Canada subpopulation is currently experiencing a sharp decline, except in Newfoundland (eight pairs and one single adult in 1994 compared with three pairs and one single adult in 1991) and the Magdalen Islands (up to 48 pairs in 1994 from 38 in 1991). Substantial declines were recorded in New Brunswick (63 pairs and 19 single adults in 1994, compared with 203 adults [91 pairs] in 1991) and Prince Edward Island (26 pairs and eight single adults, compared with 110 adults [51 pairs] in 1991). Reports from Nova Scotia placed the Provincial population at 37 pairs and 8 single adults compared with 110 adults (51 pairs) in 1991. Some of this apparent decline may be attributable to surveying only the sites that were occupied in 1991, and it is possible that some birds nesting at sites that were unoccupied in 1991 went undetected in 1994. Surveys conducted in 1995 showed an increase in the Atlantic Canada subpopulation, from 182 pairs in 1994 to 199 pairs in 1995 (the latter figure includes three pairs in St. Pierre-et-Miquelon) (D. Amirault, Canadian Wildlife Service, *in litt.* 1995). The possibility that some plovers that formerly nested in Atlantic Canada have shifted their breeding sites to New England or other parts of the range also cannot be conclusively ruled out, but information about plover dispersal patterns gained from studies of banded birds (see pages 22-23) suggests that this is unlikely to be a substantial factor in the downward trend seen since 1991 in Canadian plover numbers (see Table 4). It is anticipated that results of the upcoming 1996 International Census and comparison with 1991 data will furnish the most accurate indicator of the five-year trend in the Atlantic Canada subpopulation.

PRODUCTIVITY

Comparisons of productivity data reported prior to 1989 were confounded by inconsistent definitions of "fledged young" and reporting methods (e.g., some reports provided fledged chicks per nesting pair while others provided the number of nests fledging at least one young). Beginning in 1989, the USFWS adopted "25 days of age or flying (whichever comes first)" as the standard definition of a fledged chick for the purposes of tracking plover productivity on the U.S. Atlantic Coast (USFWS 1988b). (It should be noted that 25-day-old chicks are often unable to fly, and, therefore, may remain vulnerable to off-road vehicles and other sources of mortality.) Since the vast majority of chick losses in most studies occurred during the first 15 days post-hatch (Elias-Gerken 1994, Loegering 1992, Coutu *et al.* 1990, MacIvor 1990, McConnaughey *et al.* 1990), data on chick survival for periods of less than 25 days may be informative, but care should be exercised when making comparisons among data sets.

Population modeling by S.M. Melvin and J.P Gibbs (1994) (see Appendix E) yielded an estimate of 1.24 chicks fledged per pair needed to maintain a stationary population. However, modeled populations with this productivity rate remained highly vulnerable to extinction (35% probability of extinction within 100 years for a 1,200-pair population with mean productivity of 1.25 chicks per pair). Modeling also revealed that extinction probabilities are very sensitive to changes in productivity. For example, extinction probability over 100 years for a 2,000-pair population with observed survival rates was 4% when average productivity was 1.50 chicks per pair; this extinction probability increased to 22% when other parameters were held constant and average productivity was 1.25 chicks per pair. The probability that the population would drop below 500 pairs over 100 years increased from 26% when average productivity was 1.5 chicks per pair to 82% when average productivity was 1.25 chicks per pair.

Table 6 and Figure 4 summarize productivity data from 1987 to 1995. Averages reflect data from 95% of nesting pairs in New England, 73% in New York-New Jersey, and 61% in the southern States. In general, the seven-year weighted averages correlate with population trends observed since 1989. New York and North Carolina productivity figures, which are below those needed to effect population growth, support the concept that the apparently large increases in those States' population estimates between 1986 and 1989 are due to increased survey effort (see discussion on page 22). Average productivity figures for Atlantic Canada appear to be high for a declining population, but

Table 6. Summary of Piping Plover Productivity Estimates for the U.S. Atlantic Coast, 1987-1995

STATE/REGION	CHICKS FLEDGED/PAIR[1]								
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1988-1995 AVG[2]
Maine	1.75 (12)	.75 (20)	2.38 (16)	1.53 (17)	2.50 (18)	2.00 (24)	2.38 (32)	2.00 (35)	2.38 (40)	2.05 (202/202)
Massachusetts	1.10 (89)	1.29 (114)	1.59 (123)	1.38 (125)	1.72 (156)	2.03 (206)	1.92 (264)	1.80 (334)	1.62 (426)	1.72 (1748/1865)
Rhode Island	1.13 (17)	1.60 (19)	1.47 (19)	.90 (26)	.77 (26)	1.55 (20)	1.80 (30)	2.00 (32)	1.68 (38)	1.50 (210/215)
Connecticut	1.29 (24)	1.70 (27)	1.79 (34)	1.63 (43)	1.39 (36)	1.45 (40)	.38 (24)	1.47 (30)	1.35 (31)	1.43 (265/265)
NEW ENGLAND		1.32 (180)	1.68 (192)	1.38 (211)	1.62 (236)	1.91 (290)	1.85 (350)	1.81 (431)	1.67 (535)	1.69 (2425/2547)
New York	.90 (39)	1.24 (42)	1.02 (62)	.80 (70)	1.09 (158)	.98 (130)	1.24 (125)	1.34 (131)	.97 (188)	1.09 (906/1589)
New Jersey	.85 (93)	.94 (105)	1.12 (128)	.93 (126)	.98 (126)	1.07 (134)	.93 (127)	1.16 (124)	.98 (117)	1.02 (987/1002)
NY-NJ REGION		1.03 (147)	1.09 (190)	.88 (196)	1.04 (284)	1.03 (264)	1.08 (252)	1.25 (255)	.97 (305)	1.05 (1893/2591)
Delaware		.00 (3)	2.33 (3)	2.00 (6)	1.60 (5)	1.00 (2)	.50 (2)	2.50 (4)	2.00 (5)	1.67 (30/30)
Maryland	1.17 (23)	.52 (25)	.90 (20)	.78 (14)	.41 (17)	1.00 (24)	1.79 (19)	2.41 (32)	1.73 (44)	1.33 (195/195)
Virginia		1.02 (64)	1.16 (32)	.65 (63)	.88 (43)	.59 (39)	1.45 (49)	1.65 (58)	1.00 (86)	1.05 (434/897)
North Carolina			.59 (49)	.43 (14)	.07 (14)	.42 (41)	.74 (53)	.36 (53)	.45 (49)	.49 (273/396)
SOUTHERN REGION		0.85 (92)	.88 (104)	.72 (97)	.68 (79)	.62 (106)	1.18 (123)	1.37 (147)	1.06 (184)	.97 (932/1518)
U.S. AVERAGE	1.04 (297)	1.11 (419)	1.28 (486)	1.06 (504)	1.22 (599)	1.35 (660)	1.47 (725)	1.56 (833)	1.35 (1024)	1.33 (5250/6656)
ATLANTIC CANADA		1.65 (46)	1.58 (99)	1.62 (105)	1.07 (137)	1.55 (135)	.69 (78)	1.25 (60)	1.69 (105)	1.39 (765/1789)

[1] Parentheses indicate number of pairs on which productivity is based.

[2] Parentheses indicate number of pairs on which productivity is based/estimated number of nesting pairs in the State or region between 1988 and 1995.

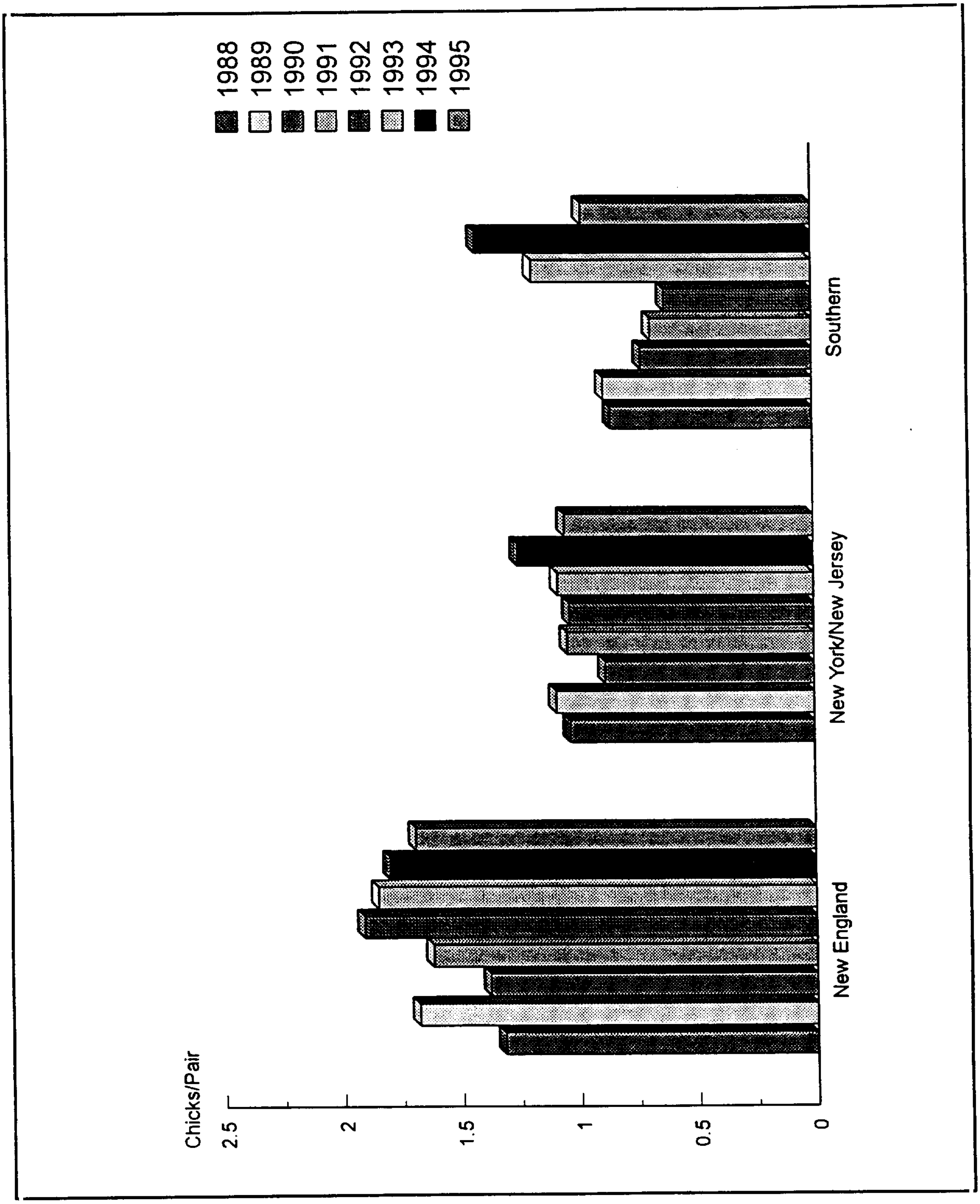

Figure 4. Average Productivity by Region, 1988-1995

productivity data are available for only 43% of nesting pairs. Since productivity data are often gathered at sites that are also the most intensively protected, available data may not be representative.

SURVIVAL

Resightings of 103 adult plovers and 61 chicks color-banded on Outer Cape Cod between 1985 and 1988 yielded estimates of mean annual survival of 0.74 for birds > 1 year old and 0.48 for chicks (see Appendix E). Loegering (1992) estimated annual survival rates of 0.67-0.72 for 53 adults and 0.41 for 29 chicks banded on Assateague National Seashore in Maryland between 1987 and 1989. R. Cross (Virginia Department of Game and Inland Fisheries, unpubl. data) estimated annual survival rates of 0.75 and 0.83 for adults and 0.44 for chicks.

Population viability modeling (Melvin and Gibbs 1994; Appendix E) shows that extinction probabilities are also very sensitive to changes in survival rates (such long-term declines in survival rates could occur due to continuing declines in availability or quality of wintering or migration habitat; increased human disturbance on wintering grounds; increased mortality due to disease, parasites, or environmental contaminants; increased predation; or reduced longevity or fitness due to unforeseen genetic factors). For example, modeling showed a 4% extinction probability over 100 years for a 2,000-pair population with average productivity of 1.5 chicks per pair and survival rates observed on outer Cape Cod, Massachusetts between 1985 and 1988. When declines in adult and chick survival rates of 5% and 10%, respectively, were modeled holding other parameters constant, the extinction probability increased from 4% to 32%, and the probability that population size would drop below 500 pairs increased from 26% to 90%.

CURRENT BREEDING DISTRIBUTION

Piping plovers continue to breed successfully at or near the extremes of their historic range. At the northern extent, piping plovers continue to breed on Newfoundland's southern coast, although they were not located on the northeastern or western coasts of Newfoundland, the Gaspe Peninsula, or the Lower North Shore of the Gulf of Saint Lawrence during the 1991 International Census (CWS 1994). The Magdalen Islands, north of Prince Edward Island, have reported increasing numbers of breeding pairs and recent productivity rates that range from 1.4 to 2.0 chicks per pair (Shaffer and LaPorte 1992). At the southern extent, breeding pairs have been documented sporadically at Waites Island, South Carolina near the border with North Carolina (Murray and McDavitt 1993; P. Wilkinson, South Carolina Department of Natural Resources, pers. comm. 1996). Four pairs nesting at Holden

Beach in southern North Carolina in 1993 fledged 1.0 chicks per pair (J. Nicholls *in litt.* 1993), well above the State average.

While the extent of the current range does not appear to be substantially different from the historic range, piping plovers are absent from many former nesting beaches on the Atlantic Coast (Cairns and McLaren 1980, Litwin *et al.* 1993, CWS 1994, Virginia Department of Game and Inland Fisheries 1994). Current sparsity of nesting pairs is of particular concern in the southern part of the plover's Atlantic Coast range. Although the New Jersey population increased between 1986 and 1989 and has remained stable since, the proportion of the State's population located in three areas administered by the National Park Service (NPS) and the USFWS has increased from 24% in 1987 to 49% in 1994. The proportion of birds nesting in the southern part of New Jersey during the same period declined from 43% to 31% (Jenkins 1993, C.D. Jenkins *in litt.* 1993 and 1994). C.D. Jenkins (pers. comm. 1993) attributes the multi-year decline in southern New Jersey to cumulative effects of low productivity and to habitat erosion during winter storms without reciprocal habitat accretion or creation (e.g., dune overwash). In Delaware, only 2-5 pairs of plovers nested between 1992 and 1995, compared with 40 birds estimated to have nested in the State in 1980 (J. Thomas, Delaware Division of Fish and Wildlife, *in litt.* 1986), and Assateague Island, Maryland is now the nearest nesting site south of Delaware. Only two pairs nested on Currituck Outer Banks in 1994, the sole remaining breeding site between Fisherman Island, Virginia on the northern side of the Chesapeake Bay and Cape Hatteras Point, North Carolina, and no nesting was documented at Currituck in 1995 despite 47 surveys between April 29 and July 30 (USFWS 1995b).

The relatively large distance between nesting sites in Atlantic Canada and New England decreases opportunities for movements of breeding birds into Atlantic Canada. This, in turn, heightens concerns about recent declines in plover nesting densities there.

BREEDING SITE FIDELITY AND DISPERSAL

In New York, Wilcox (1959) recaptured 39% of the 744 adult plovers that he banded in prior years (many were recaptured during several successive seasons and all but three of them were retrapped in the same nesting area), but recaptured only 4.7% of 979 plovers that he banded as chicks. He also observed that males exhibited greater fidelity to previous nest sites than females. Strauss (1990) observed individuals that returned to nest in his Massachusetts study area for up to six successive years. Also in Massachusetts, 13 of 16 birds banded on one site were resighted the following season, with 11 nesting on the same beach (MacIvor *et al.* 1987). Of 92 adults banded on

Assateague Island, Maryland, and resighted the following year, 91 were seen on the same site, as were 8 of 12 first-year birds (Loegering 1992). R. Cross (unpubl. data) reports that 10 of 12 juveniles banded on Assateague Island, Virginia and resighted one and/or two years later were on the Virginia or Maryland portions of Assateague Island, while the other two were observed on other Virginia barrier islands.

On the Atlantic Coast, almost all observations of inter-year movements of birds have been within the same or adjacent States. Of 316 birds color-marked in Massachusetts between 1982 and 1989 (L.H. MacIvor, C.R. Griffin, and S.M. Melvin, unpubl. data; Strauss 1990), only one instance of subsequent nesting outside of that State (in Connecticut) has been observed (S.M. Melvin pers. comm. 1993). Two of 121 plovers banded on Assateague Island were resighted breeding in New Jersey; one resighting took place during the same breeding season as the banding, while the second bird moved to New Jersey the following year (Loegering 1992). Because banding of Atlantic Coast piping plovers ceased after 1989 (see discussion on page 87), it is possible that more birds are now dispersing from highly productive States, although a strong correlation between high productivity and an increase in population size continues in New England. If populations in some areas approach carrying capacity of available habitat, it is possible that dispersal rates will increase.

HABITAT CARRYING CAPACITY

The carrying capacity of habitat to support breeding plovers is subject to fluctuation with the dynamic coastal formation processes that affect topography, vegetation, and other habitat characteristics. These fluctuations can be affected by natural factors, such as long-shore sand transport patterns and storm frequency, and by human intervention through shoreline development and stabilization projects (see discussion of loss and degradation of breeding habitat, pages 34-37). For this reason, estimates of carrying capacity, especially on a local basis, may be subject to change over time, and may require periodic revision to reflect changes in habitat conditions.

While it is expected that carrying capacity will fluctuate locally, and perhaps even within a State over time, it is anticipated that the long-term carrying capacity of the Atlantic Coast's piping plover habitat (and that of regional subpopulations, which correspond to the recovery units laid out on page 55) will be maintained if natural coastal habitat formation processes are not interrupted. *Shoreline development and stabilization projects may, however, erode carrying capacity locally and regionally (see pages 34-37) and, therefore, have potential to compromise the survival and recovery of the population.*

Appendix B provides estimates of carrying capacity of current and potential U.S. breeding sites in 1993. These estimates, made by the State plover coordinators in consultation with the recovery team and, in some cases, biologists who manage specific sites, were compiled to appraise the carrying capacity for the entire U.S. Atlantic Coast portion of the plover's range in order to facilitate population viability analysis (PVA) (see Appendix E). In some cases, estimates were based on knowledge that a larger population had occurred at one time on a site where habitat characteristics have remained similar during the intervening years. Other estimates were based on information about current activities on a site, recent productivity data, and knowledge of population densities at other sites with comparable habitat. Biologists based their projections on the assumption that most of the traditional human uses on the site would continue, although increased intensity of management efforts (including curtailing of off-road vehicle use) might be needed to attain capacity estimates on some sites. Estimates were also designed to be below levels at which density-dependent effects on productivity would be triggered. The recovery team believes that the carrying capacity of more than 1,925 pairs estimated for U.S. Atlantic Coast in 1993 (Appendix B) is *very conservative*. For example, revised estimates made by the Massachusetts Division of Fisheries and Wildlife (MDFW) in 1995 place the carrying capacity of habitat in that State at over 1,100 pairs (MDFW 1996); this upward revision of Massachusetts' carrying capacity is primarily due to an increase in projected nesting densities to 16-24 pairs per linear mile in the highest quality habitats, based on observations of productive nesting pairs approaching those densities in a rapidly increasing population rather than not on changes in habitat characteristics (S.M. Melvin pers. comm. 1995). However, all carrying capacity estimates in Appendix B, including those for New England, are based on much lower projections of nesting densities. Furthermore, in order to allow for the possibility that plover habitat requirements may be more stringent at the edge of the range than the core, estimates for the southern recovery unit are substantially more conservative than those for New England.

In Atlantic Canada, no systematic effort to estimate carrying capacity of all breeding habitat has been conducted; however, available information suggests that recent population numbers are far below carrying capacity. Based on analyses of nesting patterns between 1987 and 1992 in the Magdalen Islands, Shaffer and Laporte (1992) have projected capacity for 65 pairs, where 48 were counted in 1994. On Prince Edward Island, 57 beaches with suitable piping plover habitat were surveyed in 1991, but plovers were located at only 20 of these sites (McAskill *et al.* in CWS 1994). K. Knox (Newfoundland Wildlife Division, *in litt.* 1993) estimated that three sites where seven pairs bred in 1993 could support 20 pairs, while a currently unoccupied beach adjacent to one site could support another 8-10 pairs. Biologists surveying 24 sites in Antigonish, Pictou, and Shelbourne Counties in Nova Scotia estimated that these beaches could furnish habitat for more than 65 pairs, compared with the 20 pairs they actually observed there in 1994 (M. Goldin, The Nature Conservancy, *in litt.* 1994; S. von Oettingen, U.S. Fish and Wildlife Service, *in litt.* 1994). R. Williams (Nova Scotia Department of Natural Resources, *in litt.* 1993) estimated that six sites where 10 pairs nested in Queens County, Nova Scotia in 1993 could support 19 pairs if the regional population were to expand.

Data from Outer Cape Cod where the number of breeding pairs quadrupled between 1988 and 1993 show that relatively high nesting densities can be achieved without a loss of productivity (Figure 5). The breeding population at the Sandy Hook Unit of Gateway National Recreation Area in New Jersey grew from 18 pairs in 1990 to 36 pairs in 1994, and, again, productivity increased steadily over that time period, from 1.17 chicks per pair in 1990 to 1.94 in 1994 (Jenkins 1993, C.D. Jenkins *in litt.* 1993 and 1994). In Maryland, the plover population on Assateague Island increased from 19 pairs in 1993 to 44 pairs in 1995, yet high productivity -- 2.41 and 1.73 chicks per pair -- was achieved in both 1994 and 1995, respectively. Other examples of population increases attended by high productivity in New England are cited under Nesting Densities, pages 6-7.

VULNERABILITY TO EXTINCTION

Demographic Factors

The population viability analysis conducted by Melvin and Gibbs (1994) to assess the risk of population extinction (Appendix E) estimated probabilities of extinction as well as probabilities that the population would fall below thresholds of 50, 100, and 500 pairs during the next 100 years. Important model inputs, including fecundity (number of chicks fledged per pair) and mean annual survival rates for immature (less than one year old) and mature piping plovers, were based on actual field data.

Melvin and Gibbs (1994) calculated a mean fecundity of 1.21 chicks fledged per pair during the five-year period 1989-1993 for the U.S. portion of the Atlantic Coast population. The modeled scenarios that most closely approximate the current status of the Atlantic Coast piping plover population -- 1,200 and 1,500 pair populations with average productivity of 1.25 chicks per pair -- showed, respectively, extinction probabilities of 35% and 31% over 100 years, and 95% and 92% probabilities of the population dropping below 500 pairs during the same time period. Furthermore, the overall vulnerability to extinction is exacerbated by the fact that increases in both annual Atlantic Coast average fecundity and population over the last five years are largely attributable to the New England portion of the range. Because of their smaller size, subpopulations face an even larger risk of

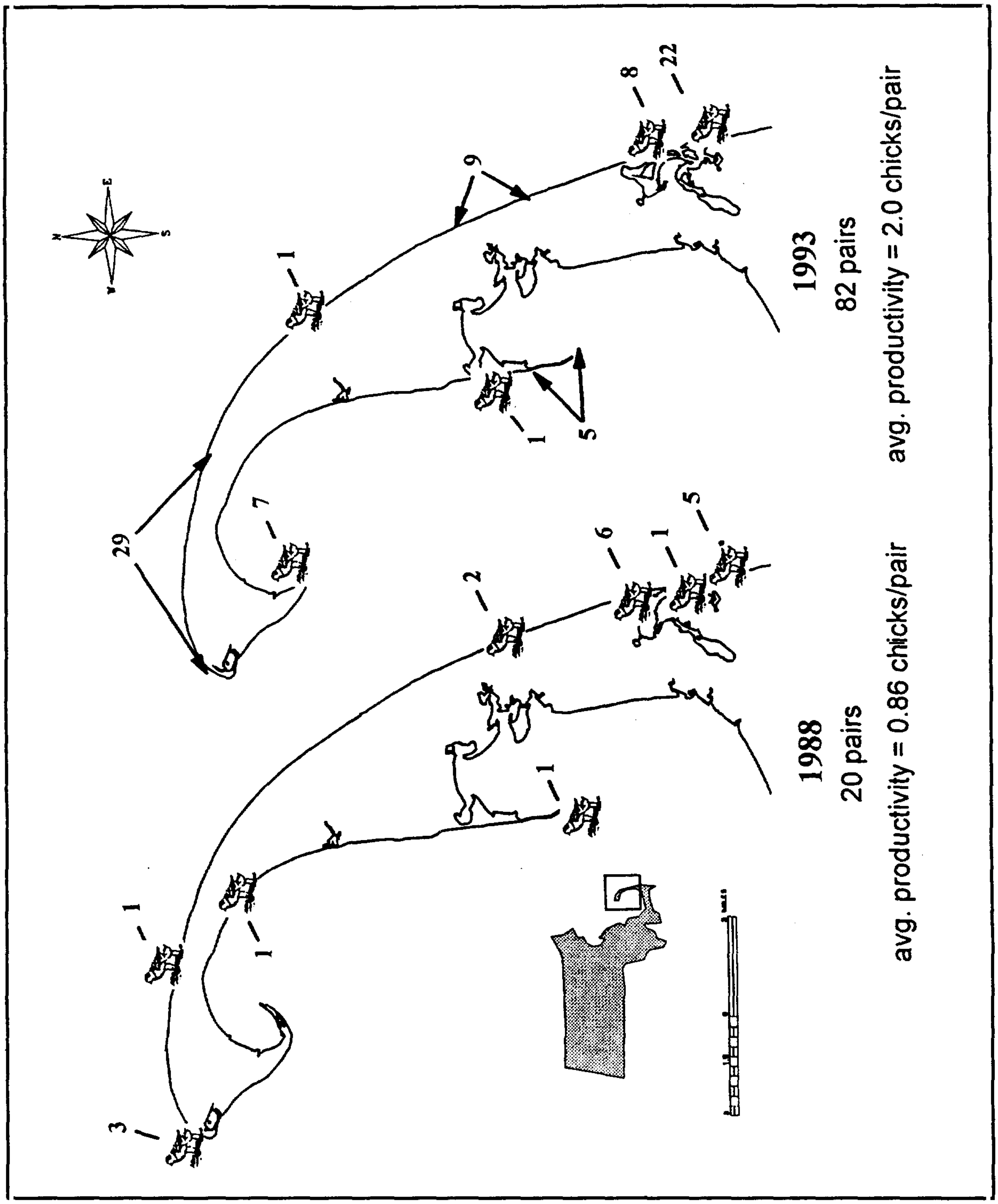

Figure 5. Distribution of Piping Plovers on Outer Cape Cod, 1988-1993

extirpation, and this is especially true in areas outside New England where average fecundity has been substantially below the coast-wide average.

The PVA indicates that extinction probabilities for Atlantic Coast plovers are very sensitive to changes in fecundity and survival rates and variability within these parameters (see pages 24 and 27). While extinction probabilities are less sensitive to initial population size, this does not diminish the importance of population size to population survival. Increasing population size will delay time to extinction, allowing implementation of measures to improve survival and productivity rates. The larger and more dispersed the Atlantic Coast population is, the less will be the overall effects of environmental stochasticity, catastrophes, or inconsistent management.

Genetic Factors

In addition to effects of demographic factors, modeled in the PVA, populations may be vulnerable to extinction due to loss of genetic diversity. The risk of loss of genetic diversity is related to effective population size (N_e), i.e., the number of individuals actually passing their genes on to the next generation. An N_e of 500 was cited by Franklin (1980) and Frankel and Soulé (1981) as the ***minimum*** necessary to maintain long-term genetic fitness and evolutionary potential. No formal estimates of N_e/N have been made for the Atlantic Coast piping plover. It appears that a large percentage of breeding plovers fledge young that are subsequently recruited into the breeding population, but the species' sparse distribution results in highly non-random mating that may pose a barrier to gene flow.

REASONS FOR LISTING AND CONTINUING THREATS

While hunting is thought to have been a major factor contributing to the decline of the piping plover in the late 19th and 20th centuries, shooting of the piping plover and other migratory birds has been prohibited since 1918 pursuant to the provisions of the Migratory Bird Treaty Act. Habitat loss and degradation, disturbance by humans and pets, and increased predation were cited as important causes of the downward trend that started in the late 1940's (USFWS 1985) and continues to the present time in some portions of the Atlantic Coast.

LOSS AND DEGRADATION OF BREEDING HABITAT

The wide, flat, sparsely vegetated barrier beaches preferred by the piping plover are an unstable habitat, dependent on natural forces for renewal and susceptible to degradation by development and shoreline stabilization efforts.

Destruction of beach habitat by residential, resort, and seawall development constitutes irrevocable habitat loss for piping plovers. The Coastal Barriers Task Force (1983) has stated:

> Prior to World War II, more than 90% of the nation's coastal barrier real estate existed as undeveloped natural areas, largely inaccessible to the public...
>
> By 1950, urbanized coastal barrier acreage in the Northeast amounted to 13% of the total coastal barrier acreage in Massachusetts, 22% in Connecticut, 23% in Rhode Island, 27% in New York, and 37% in New Jersey...
>
> By 1974, the amount of urban coastal barrier acreage had increased to 22% of the total acreage in Massachusetts (a 69% increase over 1950), 35% in Rhode Island (a 52% increase), 35% in New York (a 30% increase), 42% in Connecticut (a 91% increase), and 47% in New Jersey (a 27% increase).

In Maine, construction of seawalls, jetties, piers, homes, parking lots, and other structures has reduced historic nesting habitat by more than 70%; where more than 20 miles of historic habitat may have supported more than 200 pairs of piping plovers (Maine Department of Inland Fisheries and Wildlife 1994), 32 pairs nested in 1993 on habitat with an estimated capacity of 52 pairs (M. McCollough, Maine Department of Inland Fisheries and Wildlife, *in litt.* 1994). Wilcox (1959) pointed to summer home and road construction as causes of declining plover nesting along Moriches Bay on Long Island, New York between 1939 and 1951. Raithel (1984) cited coastal development and shoreline stabilization, including construction and dredging of permanent breachways, building of breakwaters, and planting of dune areas, as major contributors to the decline of the piping plover in Rhode Island. Creation of a parking lot in the early 1980's is cited by C. Raithel (*in litt.* 1994) as reducing habitat at East Matunuck State Beach, "formerly one of Rhode Island's largest Least Tern and Piping Plover sites," an area that he now estimates can provide habitat for only three pairs of plovers. Analysis of four years of piping plover nest location data on a New York site found that the nests were significantly farther from concrete walkways leading from the dunes to the berm than were random points, suggesting that the walkways decrease the carrying capacity of the beach (Hoopes 1995).

The location of developments on beaches where they are vulnerable to erosion often leads to impacts that go far beyond the footprint of the facilities themselves. Requests from private communities within the Fire Island National Seashore, New York to construct artificial dunes on adjacent undeveloped National Park Service lands in 1993 (NPS 1993a) exemplify situations where shoreline development has created demand to stabilize adjacent habitat.

The magnitude of impacts of development and shoreline stabilization on availability of piping plover habitat in Atlantic Canada is unclear. Austin-Smith *et al.* (*in* CWS 1994) "suspect that the intentional stabilization of beaches at some traditional breeding sites has led to decreased incidence of overwashes and blowout, thus reducing favored habitat for nesting plovers" in Nova Scotia. On the other hand, Chaisson *et al.* (*in* CWS 1994) state that "human-induced habitat change is a relatively minor concern in the coastal dune system" of northeastern New Brunswick.

Impacts of shoreline developments are often greatly expanded by the attendant concerns for protecting access roads. For example, much of Hatteras Island in North Carolina remains "undeveloped," but approximately 56 miles of continuous dune line is maintained to protect State Highway 12, which runs the length of the island, through Cape Hatteras National Seashore and Pea Island National Wildlife Refuge (NWR). Piping plovers nest only on the roadless spits at Cape Point and Hatteras Inlet (Coutu *et al.* 1990), no longer nesting on Pea Island, where they once occurred (Cairns and McLaren 1980). On unroaded Cape Lookout National Seashore, by contrast, piping plover nesting areas in 1990 included not only the spits at the current inlets, but several former inlets and large moist sand flats (McConnaughey *et al.* 1990). Biologists believe that dune maintenance conducted to protect more than eight miles of access road is one of several factors contributing to very low density of piping plovers at Island Beach State Park in New Jersey (C.D. Jenkins pers. comm. 1993). Almost five miles of beach habitat in Duxbury and Plymouth, Massachusetts, are affected by dune stabilization to protect over-land access to 290 homes located on upland habitat at the end of the peninsula (C. Wasserloos, Federal Emergency Management Agency, *in litt.* 1993).

Jetties and groins may cause significant habitat degradation by robbing sand from the down-drift shoreline. For example, the Coastal Barriers Study Group (1987) and the Ocean City, Maryland and Vicinity Water Resources Study Reconnaissance Report (U.S. Army Corps of Engineers 1994) attribute the accelerated, landward shoreline recession of the north end of Assateague Island in Maryland (the only remaining piping plover breeding area in that State) to cumulative effects on the natural drift system from inlet stabilization and nourishment of the rapidly eroding beaches at Ocean City. Loss of sand down-drift of a jetty or groin may be partially offset by habitat accretion on the updrift side of a structure. Breezy Point at the western end of southern Long Island, New York serves as a striking example of concentrated piping plover numbers on the accreting side of a jetty (A. Hecht, U.S. Fish and Wildlife Service, pers. obs.). However, beaches on the accreting side of jetties may also be subject to plant succession that makes them less attractive to piping plovers over time.

Wilcox (1959) described the effects on piping plovers from catastrophic storms in 1931 and 1938 that breached the Long Island barrier islands, forming Moriches and Shinnecock Inlets and leveling dunes. Only 3-4 pairs of piping plovers nested on 17 miles of barrier beach along Moriches and Shinnecock Bays in 1929; however, following the creation of Moriches Inlet in 1931, plover numbers increased to 20 pairs along a two-mile stretch of beach by 1938. Wilcox added that Moriches Inlet moved one mile west between 1931 and 1956. In 1938, a hurricane opened Shinnecock Inlet and also flattened dunes along both bays. In 1941, plover numbers along the same 17-mile stretch of beach peaked at 64 pairs. Numbers then gradually decreased, a decline that Wilcox attributed to deposition of dredged sand to rebuild dunes, planting of beach grass, and construction of roads and summer homes. Analysis of aerial photographs of Fire Island, immediately west of Wilcox' study area, by Leatherman and Allen (1985), showed that during the same time period as Wilcox' study, coverage of Fire Island by overwash declined from 26% in 1938 to 11% in 1954 and 2% in 1960.

A study of nest site selection on the central barrier islands of southern Long Island, New York (Elias-Gerken 1994) found that beach segments where piping plover broods had access to ephemeral pools or bayside foraging areas were strongly selected by nesting plovers. The creation of a new inlet and a large overwash zone in Elias-Gerken's study area by a December 1992 storm coincided with colonization of these areas by nesting plovers the following season. On beaches without ephemeral pools or access to bayside mudflats, the probability of plover nesting increased with increasing width of "open vegetation," which she characterized as a "storm-maintained, early successional habitat."

Habitat availability for nest site selection is decreased where blowouts or gaps in the foredune are "plugged," increasing the foredune slope. An investigation into effects of foredune slope on nest site selection by piping plovers was conducted by Strauss (1990), using collected data on nest sites of piping plovers at Sandy Neck in Barnstable County, Massachusetts from 1984-87. Strauss' study area included a flat, sparsely vegetated sandspit; steep, mature, vegetated foredunes; and blowouts or gaps in the foredune caused by wind or wave action. Although mature foredunes, including many areas where former or incipient blowouts had been deliberately plugged with discarded Christmas trees and/or snowfences, constituted 83% of the beachfront, none of 80 plover nest attempts occurred seaward of the steep foredunes. Furthermore, foredune profiles of blowout (n=26) and sandspit nests (n=34) were significantly less steep than those of 40 random profiles.

On some beaches, artificial or stabilized dunes and vegetation may also impair piping plover nest site selection and/or chick survival by blocking access to bayside feeding areas. Loegering and Fraser (1995) found that those flightless plover chicks on Assateague Island, Maryland able to reach bay beaches and the island interior had significantly higher survival rates than those which foraged solely on the ocean beaches. Their management recommendations stressed the importance of sparsely vegetated access routes to bayside beaches maintained by overwash (see footnote 2, page 6). Overwash was also cited as an important component of interior habitat maintenance, and Loegering and Fraser expressly discouraged deposition of dredged material and artificial dune building. Piping plover broods on some portions of the barrier beach on Chappaquiddick Island, Martha's Vineyard, Massachusetts, have been observed walking across a gently sloped barrier beach from ocean to bayside feeding areas with the turning of almost every tide (T. Chase, The Trustees of Reservations, pers. comm. 1992), and concern has been expressed that installation of snowfences to build dunes on this beach will degrade piping plover and least tern habitat (P. Huckery, Massachusetts Division of Fisheries and Wildlife, *in litt.* 1994).

DISTURBANCE OF BREEDING PLOVERS BY HUMANS AND PETS

The increasing intensity of human recreation dating from the end of World War II on Atlantic Coast piping plover breeding sites was a major threat cited in the 1986 listing of the piping plover. The Coastal Barriers Task Force (1983) states, "In the thirty-five years following World War II, many factors have combined to produce an explosion in the demand for the kinds of recreational opportunities that coastal barriers provide." Factors contributing to this "explosion" include a 47% growth in the populations of the 19 States bordering the Atlantic Ocean and Gulf Coast between 1950 and 1980; increasing affluence and leisure time; increasing use of motor vehicles, bringing coastal barriers within easy access to more people; and an increasing diversity of recreational demands. Many examples serve to illustrate the role of beach recreation in the post-1950 decline of the piping plover and the need to continue and (in some locations) intensify efforts to protect piping plovers from human disturbance:

- Few vehicles were observed in 1950 at Sandy Neck, in Barnstable, Massachusetts. By 1981, 2,234 permits were given for off-road vehicles at this same beach, and in 1989, 4,000 off-road vehicle permits were issued (Blodget 1990). Between 1984 and 1989, the piping plover population on the same beach declined from 14 pairs to five pairs, and productivity between 1984 and 1988 was extremely low (0.33 chicks per pair), although it improved substantially after the core of the nesting area was closed to vehicles starting in 1989 (Strauss 1990; E. Strauss, University of Massachusetts, Boston, pers. comm. 1991). Further vehicle restrictions to prevent crushing of nests and chicks were instituted in 1990, and the population increased to 18 pairs with a productivity of 2.1 chicks per pair by 1994 (S.M. Melvin *in litt.* 1994).

- Visitation to Cape Cod National Seashore increased from 2,830,000 visits in 1966 to 4,979,000 visits in 1981; during that same period, annual visits to Cape Hatteras National Seashore increased from 1,133,000 to 1,635,000 (Coastal Barriers Task Force 1983). By 1987-1993, average annual visitation at Cape Hattaras National Seashore had increased to 2,125,000 (D. Avrin, National Park Service, pers. comm. 1994). Another national seashore, Fire Island, saw an increase in average annual visitation from 449,000 visits in 1967-1976 to 815,000 visits in 1988-1993 (D. Avrin pers. comm. 1994).

- Cape Henlopen State Park in Delaware was first opened to off-road vehicle use in 1978 (Delaware Department of Natural Resources and Environmental Control 1993). Piping plover counts on that site dropped from eight (adults) in 1979 (J. Thomas *in litt.* 1986) to none in 1988. In 1990, Delaware State Parks implemented restrictions on vehicles in the vicinity of plovers, and there are now tenuous signs that plovers may reestablish at Cape Henlopen (L. Gelvin-Innvaer, Delaware Division of Fish and Wildlife, *in litt.* 1994).

- Vehicle use is prohibited on all beaches in New Brunswick (R. Chaisson, Atlantic Piping Plover Working Group, *in litt.* 1993) and Prince Edward Island (McAskill *et al.* in CWS 1994) and on Province-owned beaches in Nova Scotia. However, remote locations of many small nesting beaches makes enforcement extremely difficult, and plover censusers frequently report vehicles and tire tracks on beaches (Boates *et al.* 1994, CWS 1994, S. von Oettingen pers. comm. 1994).

Various management techniques, including fencing and posting of nesting sites and the exclusion of vehicles from areas where chicks are present, can mitigate impacts of beach recreation on piping plovers, but must be implemented annually as long as the demand for beach recreation continues.

Non-motorized Beach Activities

Non-motorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Pedestrians on beaches may crush eggs (Burger 1987b, Hill 1988, Shaffer and Laporte 1992, Cape Cod National Seashore 1993, Collazo *et al.* 1994). Unleashed dogs may chase plovers (McConnaughey *et al.* 1990), destroy nests (Hoopes *et al.* 1992), and kill chicks (Cairns and McLaren 1980; Z. Boyagian, Massachusetts Audubon Society, pers. comm. 1994).

Concentrations of pedestrians may deter piping plovers from using otherwise suitable habitat. Ninety-five percent of Massachusetts plovers (n = 209) observed by Hoopes (1993) were found in areas that contained less than one person per 8100 m^2 of beach. Elias-Gerken (1994) found that piping plovers on Jones Beach Island, New York selected beachfront that had less pedestrian disturbance than beachfront where plovers did not nest. Sections of beach at Trustom Pond NWR in Rhode Island were colonized by piping plovers within two seasons of their closure to heavy pedestrian recreation (C. Blair and J. Kurth, U.S. Fish and Wildlife Service, pers. comm. 1988 and 1990, respectively). Burger (1991, 1994) found that presence of people at several New Jersey sites caused plovers to shift their habitat use away from the ocean front to interior and bayside habitats; the time plovers devoted to foraging decreased and the time spent alert increased when more people were present. Burger (1991) also found that when plover chicks and adults were exposed to the same number of people, the chicks spent less time foraging and more time crouching, running away from people, and being alert than did the adults.

Pedestrians may flush incubating plovers from nests (see Table 3, page 12), exposing eggs to avian predators or excessive temperatures. Repeated exposure of shorebird eggs on hot days may cause overheating, killing the embryos (Bergstrom 1991), while excessive cooling may kill embryos or retard their development, delaying hatching dates (Welty 1982). Pedestrians can also displace unfledged chicks (Strauss 1990, Burger 1991, Hoopes *et al.* 1992, Loegering 1992, Goldin 1993b), forcing them out of preferred habitats, decreasing available foraging time, and causing expenditure of energy.

Fireworks are highly disturbing to piping plovers (Howard *et al.* 1993). Plovers are also intolerant of kites, particularly as compared to pedestrians, dogs, and vehicles; biologists believe this may be because plovers perceive kites as potential avian predators (Hoopes *et al.* 1992).

Motorized Vehicles

Unrestricted use of motorized vehicles on beaches is a serious threat to piping plovers and their habitats. The magnitude of this threat is particularly significant because vehicles extend impacts to remote stretches of beach where human disturbance would be very slight if access were limited to pedestrians. For example, approximately 0.5 mile of life-guarded beach at Race Point Beach on the Cape Cod National Seashore received an average of 334,000 visits in 1989 and 1990 (I. Tubbs, National Park Service, pers. comm. 1990). In addition, 2,338 off-road vehicle season permits and 290 permits for self-contained camping vehicles were sold at Cape Cod National Seashore in 1989; off-road vehicle permittees (most of whom made multiple trips on their permits) extended impacts to an additional 8.1 miles of beach that receive only light use by pedestrians walking beyond the 0.5 miles of life-guarded beach (K. Jones, National Park Service, pers. comm. 1991).

Vehicles can crush eggs (Wilcox 1959; Tull 1984; Burger 1987b; Patterson *et al.* 1991; United States of America v. Breezy Point Cooperative, Inc., U.S. District Court, Eastern District of New York, Civil Action No. CV-90-2542, 1991; Shaffer and Laporte 1992) as well as adults and chicks. In Massachusetts and New York, biologists documented 14 incidents in which 18 chicks and two adults were killed by vehicles between 1989 and 1993 (Melvin *et al.* 1994). Goldin (1993b) compiled records of 34 chick mortalities (30 on the Atlantic Coast and four on the Northern Great Plains) due to vehicles. Biologists that monitor and manage piping plovers believe that many more chicks are killed by vehicles than are found and reported (Melvin *et al.* 1994). Beaches used by vehicles during nesting and brood-rearing periods generally have fewer breeding plovers than available nesting and feeding habitat can support. In contrast, plover abundance and productivity has increased on beaches where vehicle restrictions during chick-rearing periods have been combined with protection of nests from predators (Goldin 1993b, S.M. Melvin pers. obs.).

Typical behaviors of piping plover chicks increase their vulnerability to vehicles. Chicks frequently move between the upper berm or foredune and feeding habitats in the wrack line and intertidal zone. These movements place chicks in the paths of vehicles driving along the berm or through the intertidal zone. Chicks stand in, walk, and run along tire ruts, and sometimes have difficulty crossing deep ruts or climbing out of them (Eddings *et al.* 1990, Strauss 1990, Howard *et al.* 1993). Chicks sometimes stand motionless or crouch as vehicles pass by, or do not move quickly enough to get out of the way (Tull 1984, Hoopes *et al.* 1992, Goldin 1993b). Wire fencing placed around nests to deter predators (Rimmer and Deblinger 1990, Melvin *et al.* 1992) is ineffective in protecting chicks from vehicles because chicks typically leave the nest within a day after hatching and move extensively along the beach to feed (see Table 1, page 9).

Vehicles also significantly degrade piping plover habitat or disrupt normal behavior patterns. They may harm or harass plovers by crushing wrack into the sand and making it unavailable as cover or a foraging substrate (Hoopes *et al.* 1992, Goldin 1993b), by creating ruts that can trap or impede movements of chicks (J. Jacobs, U. S. Fish and Wildlife Service, *in litt.* 1988), and by preventing plovers from using habitat that is otherwise suitable (MacIvor 1990, Strauss 1990, Hoopes *et al.* 1992, Goldin 1993b, Hoopes 1994). Vehicles that drive too close to the toe of the dune may destroy "open vegetation" that may also furnish important piping plover habitat (Elias-Gerken 1994).

Beach-cleaning

While removal of human-created trash on the beach is desirable to reduce predation threats, the indiscriminate nature of mechanized beach-cleaning adversely affects piping plovers and their habitat. In addition to the danger of directly crushing piping plover nests and chicks and the prolonged disturbance from the machine's noise, this method of beach-cleaning removes the birds' natural wrackline feeding habitat (Eddings and Melvin 1991, Howard *et al.* 1993).

PREDATION

Predation has been identified as a major factor limiting piping plover reproductive success at many Atlantic Coast sites (Burger 1987a, MacIvor 1990, Patterson *et al.* 1991, Cross 1991, Elias-Gerken 1994). As with other limiting factors, the nature and severity of predation is highly site-specific. Predators of piping plover eggs and chicks include red foxes, striped skunks, raccoons, Norway rats, opossums, crows, ravens, gulls, common grackles, American kestrels, domestic and feral dogs and cats, and ghost crabs.

Substantial evidence exists that human activities are affecting types, numbers, and activity patterns of predators, thereby exacerbating natural predation. Non-native species such as feral cats and Norway rats are considered significant predators on some sites (Goldin *et al.* 1990, Post 1991; see also Appendix C). At other locations, the introduction of predator species to islands has resulted in increased predation pressure on piping plovers and their young. For example, skunks have been introduced to Martha's Vineyard in Massachusetts (T. French, Massachusetts Division of Fish and Wildlife, pers. comm. 1989). Humans have also indirectly influenced predator populations; for instance, human activities have abetted the expansions in the populations and/or range of other species such as gulls (Erwin 1979, Drury 1973) and opossum (Gardner 1982). The availability of trash at summer beach homes increases local populations of skunks and raccoons (Raithel 1984). Strauss (1990) found that the density of fox tracks on a beach area was higher during periods of more intensive human use.

In addition to direct predation on piping plovers, herring, great black-backed, and ring-billed gulls compete with plovers for space and may cause piping plovers to abandon former nesting areas. Raithel (1984) noted that piping plovers no longer nest on the northern tip of Block Island, Rhode Island, where a large gull colony now occurs. Nesting pairs of piping plovers declined at Monomoy NWR in Massachusetts as a large gull colony grew rapidly during the 1960's and 1970's (USFWS 1988c). Cross (1988) attributed the absence of breeding plovers on South Metompkin Island (contrasted with 30 and five pairs, respectively, on islands immediately to the north and south) to intimidation and nest site competition from 2,000+ pairs of herring gulls. Cartar (1976) suggested that invading gulls were a major factor in plover nest destruction at Long Point, Ontario. The USFWS believes that nesting gulls pose a substantial threat to piping plovers and other nesting shorebirds at Breezy Point, New York and, consequently, has encouraged the National Park Service to eliminate the gull colony (N. Kaufman and P. Nickerson, U.S. Fish and Wildlife Service, *in litt.* 1992 and 1994, respectively).

Increased depredation by crows may be an indirect adverse impact of woody vegetation plantings. Elias-Gerken (1994) observed these avian predators perching and nesting in exotic Japanese black pines along the Ocean Parkway on Jones Island, New York and hypothesized that this vegetation and other artificial perches exacerbated depredation by crows there.

Migrating peregrine falcons are transitory inhabitants of most Atlantic Coast plover breeding sites (and nest on a few artificial sites in Virginia, Maryland, and New Jersey) and are incidental predators of piping plovers. In response to recovery efforts for that species, peregrine numbers are now increasing. Incidents of piping plover depredation by peregrines may be increasing relative to the 1950's and 1960's when the latter species' numbers were very depressed, but even at full recovery levels there is no reason to believe that peregrines will become a significant piping plover predator (P. Nickerson pers. comm. 1994).

THREATS TO WINTERING PIPING PLOVERS

Overall winter habitat loss is difficult to document, but some historical accounts indicate that degradation has occurred along the Atlantic Coast (Stevenson 1960). A variety of anthropogenic disturbance factors has been noted that may affect plover survival or utilization of wintering habitat (Nicholls and Baldassarre 1990a, Haig and Plissner 1993). These factors include recreational activities (motorized and pedestrian), inlet and shoreline stabilization, dredging of inlets, beach maintenance and renourishment, and pollution (e.g., oil spills) (Nicholls and Baldassarre 1990a, Haig and Oring 1985, Haig and Plissner 1993).

Wintering habitat, like Atlantic Coast breeding habitat, is dependent on natural forces of creation and renewal. Man-made structures along the shoreline or manipulation of natural inlets can upset this dynamic process and result in habitat loss or degradation (Melvin *et al.* 1991). For example, dredging of inlets can affect spit formation adjacent to inlets, while jetties can cause widening of islands and subsequent growth of vegetation on inlet shores. Over time, both result in loss of plover habitat. Additional investigation is warranted to determine the extent to which these disturbance factors affect wintering plovers (Melvin *et al.* 1991). This is a particularly pressing problem in Texas because of several major U.S. Army Corps of Engineers projects (Corps), which could affect plover wintering habitat (Haig and Plissner 1993).

Nicholls (1989) found higher densities of both people and off-road vehicles on those wintering sites where piping plovers were absent than those where they were present. Although these differences were not statistically significant, she cited the need for further investigation of recreational impacts on wintering plovers (J. Nicholls *in litt.* 1989).

Severe cold weather and storms are believed to take their toll on wintering plovers. After an intense snowstorm swept the entire North Carolina Coast in late December 1989, high mortality of many coastal bird species was noted (Fussell 1990). Piping plover numbers decreased significantly from approximately 30-40 to 15 birds. While no dead piping plovers were found, circumstantial evidence suggests that much of the decrease was mortality (Fussell 1990). Hurricanes may also result in direct mortality or habitat loss, and if piping plover numbers are low enough or if total remaining habitat is very sparse relative to historical levels, population responses may be impaired with even short-term habitat losses. Wilkinson and Spinks (1994) suggest that, in addition to the unusually harsh December 1989 weather, low plover numbers seen in South Carolina in January 1990 (11 birds, compared with more than 50 during the same time period in 1991-1993) may have been influenced by effects on habitat and food availability caused by Hurricane Hugo, which came ashore there in September 1989. Hurricane Elena struck the Alabama Coast in September 1985, and subsequent surveys noted a reduction of foraging intertidal habitat on Dauphin and Little Dauphin Islands (Johnson and Baldassarre 1988). Birds were observed foraging at Sand Island, a site that was previously little used prior to the hurricane.

OIL SPILLS AND OTHER CONTAMINANTS

Oil spills pose a threat to piping plovers throughout their life cycle. Oiled plovers have been reported from Breezy Point, New York; Sandy Hook and Mantoloking, New Jersey; Trustom Pond, Rhode Island; Horseneck Beach, Massachusetts; and Matagorda Island NWR, Texas (USFWS files).

Fourteen abandoned plover eggs from five New Jersey sites were analyzed for presence of organochlorine and heavy metal burdens in 1990 (USFWS 1991a). Although DDE, PCB's, and chlordane metabolites were detected in all samples, levels did not appear to threaten reproduction. Mercury concentrations ranged from 0.077 to 1.07 ppm wet weight; with the exception of 1.07 ppm wet weight mercury in eggs from Brick Township, New Jersey, mercury residues in that study appeared below those thought causative of avian reproductive anomalies.

IMPLICATIONS FOR THE BEACH ECOSYSTEM

The plight of the piping plover is an indicator of an entire ecosystem in very serious trouble. Since the the piping plover's 1986 listing, the roseate tern (*Sterna dougallii*) has been listed as endangered in the range of its northeastern population (USFWS 1987a), and two other beach-dwelling species native to the Atlantic Coast -- the northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*) (USFWS 1990a) and the seabeach amaranth (*Amaranthus pumilus*) (USFWS 1993a) -- have been listed under the Endangered Species Act as threatened species. Loggerhead sea turtles, listed as threatened since 1978, nest on 10 current or potential plover nesting beaches in North Carolina. Eighty-two percent of the 181 current and potential U.S. breeding sites listed in Appendix B support other Federal- or State-listed species or have historical records of species that are now Federally listed; for instance, seabeach amaranth currently coincides with nesting piping plovers on most beaches in North Carolina and on the south coast of Long Island, New York, but it is now extirpated from southern Massachusetts, Rhode Island, New Jersey, Delaware, Maryland, and Virginia (Weakley and Bucher 1992). Likewise, the only extant ocean beach populations of northeastern beach tiger beetle (this species is also found on the Chesapeake Bay shoreline) occur on two Massachusetts sites that are also used by piping plovers, although this insect was once considered abundant on ocean beaches from Massachusetts to New Jersey (USFWS 1994d). Unlike many endangered or threatened species, none of the Atlantic beach species mentioned above is an endemic species; thus, their status indicates widespread ecological problems.

These threatened and endangered beach species that breed along the Atlantic Coast have many threats in common with the piping plover. Habitat loss and degradation due to shoreline development and beach stabilization and crushing by off-road vehicles are cited as major factors contributing to the listing of the northeastern beach tiger beetle (USFWS 1990a) and seabeach amaranth (USFWS 1993a). The most prominent threat to the endangered roseate tern is the loss of nesting sites to expanding numbers of nesting herring and great black-backed gulls (USFWS 1987a), also a significant cause of reduced piping plover numbers and productivity at some Atlantic Coast nesting beaches.

If the precarious status of these species is a symptom of an embattled ecosystem, then remedial efforts aimed at the restoration of the natural processes that maintain this system, rather than single-species "fixes," are likely to have the greatest long-term benefits. Important components of ecologically sound barrier beach management include perpetuation of natural dynamic coastal formation processes; management of human recreation to prevent or minimize adverse impacts on dune formation, vegetation, and the invertebrate and vertebrate fauna; and efforts to counter the effects of human-induced changes in the types, distribution, numbers, and activity patterns of predators.

No piping plover recovery efforts implemented to date have been detrimental to the natural functions of the beach ecosystem. Furthermore, many protection efforts for piping plovers have also benefitted other sensitive beach species such as least terns and seabeach amaranth, and the reverse (benefits to piping plovers from protection efforts targeted at other species, such as least terns) has also occurred. However, some piping plovers protection measures have been tailored to the specific needs of this species in ways that limit benefits to the beach ecosystem as a whole. For example, in an effort to reduce conflicts with beach users, off-road vehicle management recommendations in Appendix G seek to minimize the size and duration of vehicle closures. While these short-duration closures prevent mortality and harassment of piping plovers and provide some benefits to other beach-nesting birds, they amount to insufficient protection for northeastern beach tiger beetles. An extreme example of single-species protection is the use of predator exclosures to reduce depredation of plover eggs; nonetheless, in many situations, exclosures provide by far the most effective and efficient protection against prolific entrenched predators, where reductions in predator numbers would be very difficult to achieve and very temporary. Implementation of more ecosystem-oriented approaches to piping plover protection would provide important benefits to other rare species and merit serious consideration, but it should be recognized that, in many cases, these approaches would entail significantly higher costs and/or cause more conflicts with human beach users.

CURRENT CONSERVATION EFFORTS

Piping plover protection efforts along the Atlantic Coast have accelerated rapidly since 1985. Many ongoing activities are discussed in the Recovery Tasks section of this plan.

REGULATORY PROTECTION

Section 9 of the Endangered Species Act prohibits any person subject to the jurisdiction of the United States from taking (i.e., harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting) listed wildlife species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. Regulations implementing the ESA (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Appendix G, Guidelines for Managing Recreational Activities in Piping Plover Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the ESA, contains recommendations to beach managers and property owners.

Section 10 of the ESA and related regulations provide for permits that may be granted to authorize activities otherwise prohibited under Section 9, for scientific purposes or to enhance the propagation or survival of a listed species. States that have cooperative agreements under Section 6 of the ESA may provide written authorization for take that occurs in the course of implementing conservation programs. For example, State agencies have authorized certain biologists to construct predator exclosures for piping plovers. It is also legal for employees or designated agents of certain Federal or State agencies to take listed species without a permit if the action is necessary to aid sick, injured, or orphaned animals or to salvage or dispose of a dead specimen.

Section 10 also allows permits to be issued for take that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the USFWS determines that certain conditions have been met. An applicant for an incidental take permit must prepare a conservation plan that specifies the impacts of the take, the steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, the alternative actions to the take that the applicant considered, and the reasons why such alternatives are not being utilized. Appendix H contains guidelines for the preparation and evaluation of conservation plans for Atlantic Coast piping plovers pursuant to Section 10(a)(1)(B) and 10(a)(2) of the ESA.

Section 7 of the ESA requires Federal agencies to consult with the USFWS prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. Section 7 obligations have caused Federal land management agencies to implement piping plover protection measures that go beyond those required to avoid take, for example, by conducting research on threats to piping plovers. Other examples of Federal activities that may affect piping plovers along the Atlantic Coast, thereby triggering Section 7(b) consultation, include permits for beach nourishment or disposal of dredged material (U.S. Army Corps of Engineers) and funding of beach restoration projects (Federal Emergency Management Authority).

In September 1994, fourteen Federal agencies, including the U.S. Fish and Wildlife Service, National Park Service, U.S. Coast Guard, U.S. Army Corps of Engineers, and Department of Defense, signed a Memorandum of Understanding affirming their commitments to carry out programs for the conservation of species listed under the ESA and the ecosystems upon which they depend, including implementing appropriate recovery actions that are identified in recovery plans.

Executive Order 11644, Use of Off-Road Vehicles on the Public Lands, and Executive Order 11989, Off-Road Vehicles on Public Lands, pertain to lands under custody of the Secretaries of Agriculture, Defense, and Interior (except for Native American Tribal lands). Executive Order 11644 requires administrative designation of areas and trails where off-road vehicles may be permitted. Executive Order 11989 states that "... the respective agency head shall, whenever he determines that the use of off-road vehicles will cause or is causing considerable adverse effects on the soil, vegetation, *wildlife, wildlife habitat* ... immediately close such areas or trails to the type of off-road vehicles causing such effects, until such time as he determines that such effects have been eliminated and that measures have been implemented to prevent future recurrence" (emphasis added).

Piping plovers are also protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712). Prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct.

The Coastal Barriers Resource Protection Act of 1982 (CBRA), as amended by the Coastal Barrier Improvement Act of 1990 (P.L. 101-591), provides certain protections to designated units of the Coastal Barrier Resources System (System), including many sites where piping plovers breed or winter on the Atlantic Coast. Except for a few specified exemptions, Section 6 of CBRA bans all Federal expenditures within units of the System. Section 6 also requires that Federal agencies consult with the USFWS prior to committing funds for any exempted activities.

Almost all States within the breeding range of the Atlantic Coast piping plover list the species as State-threatened or -endangered (Northeast Nongame Technical Committee 1993), and many State endangered species laws and regulations prohibit take of State-listed species. As a further protection, the Maine Department of Inland Fisheries and Game (1995) has designated nine sites as Essential Habitat for piping plovers and least terns; this designation prohibits significant alteration or unreasonable harm to the Essential Habitat from projects requiring a permit or license from, or to be funded or carried out by, a State agency or municipal government.

Other State regulations also protect piping plovers and/or their habitat. For example, the Massachusetts Wetlands Protection Act (Massachusetts General Laws Chapter 131, Section 140) requires that proposed projects that occur in wetlands (including beaches) be designed to avoid short-term or long-term adverse effects on the habitat of any rare species of wildlife (Melvin and Roble 1990). Opinions, based on this law, provided by the Massachusetts Division of Fisheries and Wildlife on the impacts of proposed dredging have recommended restrictions on the timing or location of beach nourishment in order to prevent adverse effects on piping plover habitat (S.M. Melvin pers. comm. 1990). In New York, compliance with the New York Tidal Wetlands Act and the New York State Environmental Quality Review Act usually results in conditions on dredging permits that restrict the season or location of operation; these restrictions are designed to protect piping plovers and other State-listed wildlife (S. Sanford, New York State Department of Environmental Conservation, pers. comm. 1990). It should be noted, however, that revisions in the New York Tidal Wetlands Act are currently under discussion, and that potential changes lessening or eliminating jurisdiction over shoals, mudflats areas and areas adjacent to tidal wetlands could result in decreased protection of these habitats in the future (USFWS 1995b).

In some cases, piping plovers benefit from State regulations intended to protect other natural resources. For instance, the Connecticut Coastal Resources Management Division prohibits most dredging projects in that State between May 30 and September 30 to avoid impacts to shellfish beds (R. Rozsa, Connecticut Coastal Resources Management Division, pers. comm. 1989).

PROTECTION AND MANAGEMENT ON BREEDING SITES

Current breeding site protection efforts are documented in Appendix C (Summary of Current and Needed Breeding Site Management Activities). Most common management strategies include protection of nests with predator exclosures (see Appendix F); signing and symbolic fencing of nesting areas; restrictions on motorized vehicles in the vicinity of flightless chicks; wardening of nesting areas, especially in areas where public use is heavy; and public information and education.

The magnitude of the piping plover protection effort on the breeding grounds may be gauged from information in Appendix J (Estimated Cost of U.S. Atlantic Coast Piping Plover Protection Activities during the 1993 Breeding Season). Estimates compiled by the State wildlife agencies show that approximately $1.8 million was spent to protect 875 pairs of plovers that nested on the U.S. portion of the range in 1993. This figure includes more than 85,000 person-hours by paid staff, but does not reflect approximately 32,750 hours of volunteer labor. Comprehensive estimates of protection costs in Atlantic Canada are unavailable, but a substantial effort is also being exerted to protect piping plovers there. Report #3 prepared by Recovery of Nationally Endangered Wildlife (RENEW 1993) reported expenditures of more than $154,000 (Canadian) and 6.5 person-years of effort (cost not included in the expenditures figure) to protect Atlantic plovers in the year ending March 31, 1993. The 1992 efforts reported by RENEW were supplemented by 84 volunteers who provided wardening through the Piping Plover Guardian Program on 20 beaches in Nova Scotia and on Prince Edward Island (Atlantic Canada Piping Plover Recovery Team 1992); in 1993, the Guardian Program expanded to include beaches in Newfoundland and New Brunswick and a full-time paid coordinator (Atlantic Canada Piping Plover Recovery Team 1993). RENEW (1994) reported increases in expenditures for protection of Atlantic Coast piping plovers to $205,000 (Canadian) during the 1993 breeding season, not including unquantified paid and volunteer time.

Although a few piping plover recovery expenditures represent investments in basic research with broad applicability to piping plover management, the vast majority of the piping plover protection effort involves labor-intensive, on-site efforts such as the posting and fencing of nesting areas, wardening, and construction of predator exclosures. Such efforts can effectively reduce impacts to piping plovers, but they do not remove the root causes of threats such as intensive recreational use and elevated predation pressure. These protection efforts will have to be continued each season in perpetuity if the piping plover population is to be recovered and maintained.

PROTECTION AND MANAGEMENT ON WINTERING SITES

Efforts to protect piping plover wintering habitat on the Atlantic Coast have focused primarily on:

(1) Surveys to identify wintering sites. In addition to the 1991 International Census of wintering sites, several State nongame programs have conducted surveys to further identify specific wintering sites.

(2) Recommendations to prevent habitat degradation made through the Section 7 consultation process on a project-by-project basis. A 1991 workshop was held in North Carolina specifically for representatives of State and Federal regulatory agencies to inform them of the plover's habitat needs and ecology, and requirements to protect and consult on this species.

(3) Acquisition and recognition of a few key sites. The Nature Conservancy (TNC) recently purchased Little Tybee Island in Georgia and turned the site over to the State for conservation purposes. The National Key Deer Refuge, including two plover wintering sites, was recently recognized as a part of the Western Hemispheric Shorebird Reserve Network (WHSRN). The WHSRN also has recently developed a Piping Plover Registry Program, which seeks to promote international recognition of landowner efforts to preserve piping plovers (J. Sibbing, Western Hemispheric Shorebird Reserve Network, *in litt.* 1993).

ROLE OF FEDERAL LANDS IN RECOVERY EFFORTS

Federal lands administered by the NPS, USFWS, National Aeronautics and Space Administration (NASA), U.S. Coast Guard, U.S. Army Corps of Engineers, and U.S. Air Force supported approximately 370 nesting pairs of piping plovers in 1995. These 370 pairs constituted 32% of the U.S. Atlantic Coast population and 27% of the entire breeding population, including Atlantic Canada. The carrying capacity of Federal lands as estimated in 1993 was 635 pairs, approximately 33% of the estimated capacity of all U.S. breeding sites.

Most Federally administered breeding sites are very intensively managed. Consistent with National Wildlife Refuge System Administration Act and Refuge Recreation Act requirements regarding compatibility of refuge activities, plover habitat within most national wildlife refuges is closed to public use during the breeding season. Cape Cod, Fire Island, and Assateague National Seashores and the Gateway National Recreation Area have written plans detailing how piping plovers will be protected. Nesting areas on NASA's Wallops Island are also closed to public entry during the breeding season.

Protection of piping plovers and their habitat on Federal lands is important not only because of the direct benefits to plovers that use these areas, but because plover protection programs on Federal lands serve as examples to non-Federal landowners.

COORDINATION AND PARTICIPATION

Recovery efforts at the State level are coordinated by the State wildlife agencies; population-wide coordination is supplied by the recovery team with oversight by the USFWS. Since 1988, the USFWS has prepared and distributed annual status updates on the Atlantic Coast piping plover population. These are widely requested and provide biologists, beach managers, user groups, and other interested parties with timely information about progress towards recovery. Periodic rangewide wintering censuses (e.g., the 1991 and 1996 International Censuses) provide important information on the plover's status and stimulate awareness of important wintering sites. Bi-annual meetings of biologists involved in plover conservation within the Atlantic Coast breeding range afford opportunities for exchange of important information about plover ecology and management techniques. Similar but less frequent meetings have focused on protection of wintering plovers and their habitat. The U.S. Atlantic Coast, Atlantic Canada, and Great Lakes/Northern Great Plains recovery teams maintain communication and frequently exchange observers at team meetings. These meetings and other communications among the recovery teams and State plover coordinators assure prompt evaluation and distribution of new information. For example, dissemination of information about design and use of predator exclosures has required a significant effort over the last eight years; experts have traveled to various States and to Canada to help resolve difficulties with exclosures.

Participation of affected agencies, organizations, and user groups in planning and implementing U.S. recovery efforts has been fostered primarily at the State level. Various working groups provide continuing forums for discussion and adjustment of recovery efforts. Examples include the Massachusetts Barrier Beach Task Force, formed in 1992 under the auspices of

Massachusetts Coastal Zone Management Office with members from four State agencies, as well as user groups, municipal governments, conservation groups, and the USFWS (Massachusetts Barrier Beach Task Force 1994). Coordination of plover survey efforts and threat assessment in New York has been facilitated by the Long Island Colonial Waterbird Association since before the listing of the plover under the ESA; in March 1995, the New York State Department of Environmental Conservation, Division of Fish and Wildlife, formed a Regional Piping Plover Management Coordination Group comprising State, Federal, and local government agencies and private organizations to intensify piping plover recovery efforts on Long Island (K.J. Meskill and C.T. Hamilton, New York State Department of Environmental Conservation, *in litt.* 1995). In Delaware, multi-agency participation in piping plover protection has been implemented through the Delaware Beach Issues Group, an ongoing working group of State agencies; participating agencies also maintain communication with interested and affected private organizations and groups and with Federal agencies (L. Gelvin-Innvaer pers. com.).

RECOVERY STRATEGY

The original recovery objective for the Atlantic Coast piping plover, established in the 1988 recovery plan, was to "increase the Atlantic Coast population of the piping plover (U.S. and Canada) to a self-sustaining population of 1,200 breeding pairs, while maintaining the current distribution" (USFWS 1988e). As stated in that plan, this objective represented "a compromise between a complete recovery from the 50-80% population decline over the preceding 50 years, versus what [the recovery team believed] could realistically be achieved in the face of continuing loss (both physical and functional) of habitat from increasing human recreation and development pressures." This recovery objective, formulated in the initial stages of the recovery effort, reflected the best judgment at that time of the most knowledgeable piping plover specialists.

Since 1988, recovery efforts have produced additional information to test whether the original objective provides for a "self-sustaining population." In particular:

- Experience gained in New England, where piping plover numbers doubled between 1988 and 1993 while maintaining high levels of productivity, has expanded the definition of suitable habitat and shown that populations can grow very rapidly where they are intensively managed to reduce impacts of human-induced mortality, human disturbance, and predation. As a result, biologists have greatly increased their estimates of habitat carrying capacity. Current estimates of carrying capacity of known and potential U.S. breeding sites are provided in Appendix B; the U.S. Fish and Wildlife Service believes these estimates remain very conservative, especially for the southern portion of the range (see discussion on page 30).

- Information about movements of piping plovers and gene flow, while limited, is substantially improved since 1988. It suggests that movements are probably sufficient to maintain gene flow within the Atlantic Coast population. However, observations have shown that the vast majority of marked birds select breeding sites in the same (or adjacent) State as their natal beaches and return to the same or adjacent States in ensuing breeding seasons. This pattern of fidelity to the natal region is supported by the close correlation between productivity rates and subsequent population trends.

- New data on survival and fecundity rates have facilitated computer modeling of long-term population viability under varying scenarios. The PVA for the Atlantic Coast piping plover (Appendix E, Melvin and Gibbs 1994) incorporated productivity data from the entire U.S. portion of the Atlantic Coast range and estimated survival rates for plovers that breed on outer Cape Cod. Results were examined to determine the sensitivity of population persistence to each factor.

As a result of this new information, the recovery team has conducted a detailed re-evaluation of the original recovery objective, resulting in substantial revisions and refinements.

The following principles will guide future recovery efforts for the Atlantic Coast piping plover population:

1. Sufficiency of population size and productivity will be based on a >95% probability of persistence for 100 years. All populations face varying probabilities of extinction due to stochastic events that affect survival and productivity. At given average rates of survival and productivity, and variability around these averages, large populations have lower probabilities of extinction than small ones. Population viability analysis is a form of risk analysis applied to the issue of population extinction. It is a structured and systematic analysis of the interacting factors, including abundance, rates of survival and productivity, demographic and environmental stochasticity, and catastrophes, that determine a population's risk of extinction. In recent years, PVA's have been used as tools in establishing recovery goals for threatened and endangered species such as the northern spotted owl and the desert tortoise. Information about the Atlantic Coast piping plover PVA is provided in Appendix

E. Modeling was conducted to estimate probabilities of extinction, as well as probabilities that the population would fall below thresholds of 50, 100, and 500 pairs. The results of this modeling are the basis for the revised quantitative delisting objectives.

2. Population increases should be evenly distributed throughout the plover's Atlantic Coast range. This principle was reflected in the 1988 recovery objective stipulation that the population increase had to be achieved "while maintaining the current distribution." Dispersal of the population across its breeding range serves as a hedge against catastrophes, such as hurricanes, oil spills, or disease that might depress regional survival and/or productivity. Maintaining robust, well-distributed subpopulations should reduce variance in survival and productivity of the Atlantic Coast population as a whole, facilitate interchange of genetic material between subpopulations, and promote recolonization of any sites that experience declines or local extirpations due to low productivity and/or temporary habitat succession.

To facilitate an even distribution of the population, the recovery team has delineated four recovery units -- Atlantic Canada, New England, New York-New Jersey, and Southern -- and assigned a portion of the population target to each. These units are large enough that their overall carrying capacity should be buffered from changes due to natural habitat formation processes at individual nesting sites, while still assuring a geographically well-distributed population.

Current information indicates that most Atlantic Coast piping plovers nest within their natal region, that regional population trends are related to regional productivity, and that intensive regional protection efforts contribute to increases in regional piping plover numbers (see Breeding Site Fidelity and Dispersal, page 28). However, at least low levels of dispersal are ongoing within the Atlantic Coast piping plover population, and recovery units do not represent biologically distinct population segments as defined in the USFWS policy regarding the recognition of distinct vertebrate population segments under the Endangered Species Act (USFWS 1996a).

A premise of this plan is that the overall security of the Atlantic Coast piping plover population is profoundly dependent upon attainment and maintenance of the minimum population levels for the four recovery units. Any appreciable reduction in the likelihood of survival of a recovery unit will also reduce the probability of persistence of the entire population.

3. Measures should be taken to prevent loss of genetic diversity over the long term. Small populations risk loss of genetic diversity through inbreeding and random genetic drift. In the short term, such a loss may reduce individual fitness and productivity. Over the long term, loss of genetic diversity may erode the evolutionary potential of a population or species, reducing its ability to adapt to changes in its environment, and thereby increasing its risk of extinction. An N_e of 500 was cited by Franklin (1980) and Frankel and Soulé (1981) as the *minimum* effective population size necessary to maintain long-term genetic fitness and evolutionary potential. Since no formal estimates of N_e/N are currently available for piping plovers, and because the species' sparse distribution results in highly non-random breeding that may pose a barrier to gene flow, the revised delisting criteria require the USFWS to verify that the target population is sufficiently large to maintain long-term genetic fitness.

4. Mechanisms should be provided to prevent a reversal of population increases following delisting under the ESA. All of the piping plover protection mechanisms devised to date are labor-intensive activities that are effective only if implemented annually. While increasing piping plover numbers will reduce the probability of extinction, these gains will be quickly eroded if actions to mitigate threats from predation and human-caused mortality, disturbance, and habitat degradation are not continued. The PVA shows that even a population that is several-fold times that provided in the 1988 recovery objective must sustain high productivity and survival and low variance in those parameters in order to persist over the long term. This will require continued intensive management to ensure high productivity and maintenance of wintering and breeding habitat quantity and quality.

While protection of piping plovers and their habitat will require a significant long-term commitment, the benefits go beyond survival of this one species. Protection of piping plovers and their habitat responds to the stated purposes of the ESA (Section 2(b)), by "provid[ing] a means whereby the ecosystems on which endangered species and threatened species depend may be conserved." Since 1988, two more species that share the piping plover's beach habitat over parts of its range, the northeastern beach tiger beetle and seabeach amaranth, have been added to the list of threatened species. This and the observed response of other beach-nesting birds to piping plover protection efforts has increased biologists' awareness of the piping plover as an indicator of the health of the fragile beach ecosystem.


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PART II: RECOVERY

RECOVERY OBJECTIVE

The objective of this revised recovery plan is to ensure the long-term viability of the Atlantic Coast piping plover population in the wild, thereby allowing removal of this population from the Federal List of Endangered and Threatened Wildlife and Plants (50 CFR 17.11 and 17.12). The Atlantic Coast piping plover population may be considered for delisting when the following recovery criteria have been met:

Criterion 1: Increase and maintain for five years a total of 2,000 breeding pairs, distributed among four recovery units as specified below:

Recovery Unit:	*Minimum Subpopulation:*
Atlantic Canada	400 pairs
New England	625 pairs
New York-New Jersey	575 pairs
Southern (DE-MD-VA-NC)	400 pairs

Attainment of these targets for each recovery unit will increase the probability of survival and recovery of the entire population by (1) contributing to the population total, (2) reducing vulnerability to environmental variation (including catastrophes), and (3) increasing likelihood of interchange among recovery units. Attainment of the subpopulation goals stipulated above are particularly important for the Atlantic Canada and the Southern recovery units because of their current small numbers (under 200 pairs each), sparse distribution over relatively large geographic areas, and potential to substantially contribute to the viability of the entire Atlantic Coast population.

Criterion 2: Verify the adequacy of a 2,000-pair population of piping plovers to maintain heterozygosity and allelic diversity over the long term. This may be accomplished through implementation of recovery task 3.8 (page 95). Despite a high probability that this criterion can be satisfied, the potential risks associated with loss of genetic diversity justify documentation of N_e/N.

Criterion 3: Achieve five-year average productivity of 1.5 fledged chicks per pair in each of the four recovery units described in criterion 1. Data to evaluate progress toward meeting this criterion should be obtained from sites that collectively support at least 90% of the recovery unit's population. The population viability analysis in Appendix E shows that a population of only 2,000 pairs would remain highly vulnerable to extinction unless average productivity is sustained above 1.5 chicks per pair. However, since the PVA is based on several assumptions that *may* underestimate survival rates for some or all recovery units and/or the percentage of one-year-old adults that breed, this productivity figure may be revised downward if (1) it is demonstrated that survival rates are higher in some regions, and (2) a scientifically credible stochastic model that incorporates the best available estimates of survival and other demographic variables shows that lower productivity rates will assure a 95% probability of survival for 100 years (see task 3.5). Adjustments to this criterion may be applied to the population as a whole or to one or more of the four recovery units, as supported by observed productivity and population trend data.

Criterion 4: Institute long-term agreements among cooperating agencies, landowners, and conservation organizations that will ensure protection and management sufficient to maintain the population targets and average productivity for each recovery unit as specified in criteria 1 and 3. In addition to protection and management, these agreements should provide for adequate monitoring to effectively detect declines in productivity or population declines caused by decreasing survival rates. Agreements may allow for less than full protection of some piping plovers if it can be assured that these individuals are surplus to the maintenance of an evenly distributed, 2,000-breeding-pair population, with an average productivity of 1.5 chicks per pair (or an adjusted productivity rate as per criterion 3) in each recovery unit.

Criterion 5: Ensure long-term maintenance of wintering habitat, sufficient in quantity, quality, and distribution to maintain survival rates for a 2,000-pair population. This criterion may be satisfied through formal agreements or identification of sites free from significant recognizable threats.

Table 7 outlines the recovery tasks needed to meet these recovery criteria, and the Recovery Tasks section describes each task in detail.

Table 7. Recovery Task Outline

1. Manage breeding piping plovers and habitat to maximize survival and productivity.

   1.1 Monitor status and management of Atlantic Coast piping plovers.
      1.11 Monitor population trends, productivity, and distribution in each recovery unit.
      1.12 Monitor plover breeding activities at nesting sites to identify limiting factors.
   1.2 Maintain natural coastal formation processes that perpetuate high quality breeding habitat.
      1.21 Discourage development that will destroy or degrade plover habitat.
      1.22 Discourage interference with natural processes of inlet formation, migration, and closure.
      1.23 Discourage beach stabilization projects.
      1.24 To compensate for disruption of natural processes, create and enhance nesting and feeding habitat, especially in the vicinity of existing stabilization projects.
         1.241 Encourage deposition of dredged material to enhance or create nesting habitat.
         1.242 Discourage vegetation encroachment at nesting sites.
         1.243 Draw down or create coastal ponds to make more feeding habitat available.
   1.3 Reduce disturbance of breeding plovers from humans and pets.
      1.31 Reduce pedestrian recreational disturbance.
         1.311 Fence and post areas used by breeding plovers, as appropriate.
         1.312 Implement and enforce pet restrictions.
         1.313 Prevent disturbance from disruptive recreational activities on beaches where breeding plovers are present.
      1.32 Reduce disturbance, mortality, and habitat degradation caused by off-road vehicles, including beach-raking machines.
      1.33 Provide wardens and law enforcement officers to facilitate protective measures and public education.
   1.4 Reduce predation.
      1.41 Remove litter and garbage from beaches.
      1.42 Deploy predator exclosures to reduce egg predation where appropriate.
      1.43 Remove predators where warranted and feasible.
   1.5 Protect piping plovers and their breeding habitat from contamination and degradation due to oil or chemical spills.
   1.6 Develop mechanisms to provide long-term protection of plovers and their habitat.
      1.61 Provide intensive protection of breeding piping plovers on national wildlife refuges.
      1.62 Seek long-term agreements with landowners.
      1.63 Acquire important habitat if and when it becomes available.
      1.64 Ensure that any Section 10 permits issued contribute to Atlantic Coast piping plover conservation.

2. Monitor and manage wintering and migration areas to maximize survival and recruitment in the breeding population.

   2.1 Monitor known and potential wintering sites.
      2.11 Monitor abundance and distribution of known wintering plovers.
      2.12 Survey beaches and other suitable habitat to determine additional wintering sites.
      2.13 Identify factors limiting the quantity and quality of habitat or its use by piping plovers at specific wintering sites.

- 2.2 Protect essential wintering habitat by preventing habitat degradation and disturbance.
  - 2.21 Protect habitat from impacts of shoreline stabilization, navigation projects, and development.
  - 2.22 Protect wintering habitat from disturbance by recreationists and their pets.
  - 2.23 Protect piping plovers and their wintering habitat from contamination and degradation due to oil or chemical spills.
  - 2.24 Apprise resource/regulatory agencies of threats to wintering piping plovers and their habitats.
  - 2.25 Evaluate and update lists of essential wintering habitat as data become available.
  - 2.26 Provide for long-term protection of wintering habitat, including agreements with landowners and habitat acquisition.
- 2.3 Protect piping plovers during migration.
  - 2.31 Identify important migration stop-over habitat.
  - 2.32 Identify and mitigate any factors that may be adversely affecting migratory stop-over habitat or its use by piping plovers.

3. Undertake scientific investigations that will facilitate recovery efforts.

- 3.1 Investigate the wintering ecology of piping plovers.
  - 3.11 Characterize wintering habitat.
  - 3.12 Determine the spatial and temporal use of wintering habitat.
  - 3.13 Evaluate foraging behavior and resources for specific microhabitats at wintering sites.
  - 3.14 Investigate the effects of human disturbance on wintering plovers.
- 3.2 Refine characterization of plover breeding habitat.
  - 3.21 Compare plover foraging resources along Atlantic Coast breeding habitat.
  - 3.22 Determine moisture-related requirements for plovers and their chicks.
  - 3.23 Evaluate impacts of artificial inlet closure and other beach stabilization projects on piping plover breeding habitat suitability.
- 3.3 Monitor levels of environmental contaminants in piping plovers.
- 3.4 Develop and test new predator management techniques to protect nests and chicks.
  - 3.41 Develop and test conditioned aversion techniques.
  - 3.42 Extend testing of artificial coyote territories to exclude red foxes.
  - 3.43 Evaluate threats from ghost crabs and develop appropriate control techniques.
  - 3.44 Develop and test electric fences.
- 3.5 Analyze population trends and productivity rates to monitor plover survival rates.
- 3.6 Determine temporal distribution of plover mortality.
- 3.7 Develop a metapopulation model that will estimate extinction probability for the Atlantic Coast piping plover population.
- 3.8 Estimate effective population size for the Atlantic Coast piping plover population.
- 3.9 Develop safe techniques for marking plovers.

4. Develop and implement public information and education programs.

- 4.1 Develop new and updated piping plover information and education materials.
- 4.2 Establish a network for distribution of information and education materials.

5. Review progress towards recovery annually and revise recovery efforts as appropriate.

RECOVERY TASKS

1. **Manage breeding piping plovers and habitat to maximize survival and productivity.**

Experience over the last eight years has shown that piping plover populations can increase dramatically in response to intensive protection efforts. These efforts are time-consuming, costly, and sometimes require temporary restrictions on off-road vehicles and/or restrictions on artificial dune building and other coastline stabilization projects, but they are generally highly effective.

Most U.S. Atlantic Coast piping plover management programs have been coordinated by the State wildlife agencies with integral participation from Federal and local agencies, other State agencies, and private organizations and individuals. In North Carolina, where approximately 80% of plover nesting activity currently occurs on Federal lands, the U.S. Fish and Wildlife Service is the primary coordinating agency. In some cases, such as Massachusetts, networks of cooperators who implement protection measures have become very large, and forums for discussion of beach management issues are active (see discussion on page 52). It is anticipated that these cooperator networks and meetings of affected groups will continue to play an integral role in the plover recovery effort. While the main focus of coordination efforts is expected to remain at the State level, the need for some planning among "stakeholders" (cooperators and affected parties) at the recovery-unit level is also anticipated.

A summary of current and needed management activities on breeding sites is provided in Appendix C. Piping plover habitat is extremely dynamic, and factors affecting breeding success, such as types and numbers of predators, can change quickly, modifying protection needs. It is especially likely that additional protection needs will be identified for sites in New York and North Carolina, and at any site where intensified monitoring to identify limiting factors has been recommended.

Management and protection of piping plovers on Federal lands is especially important. Plover management on Federal lands directly affects breeding success of approximately 32% of the current U.S. Atlantic Coast population. In addition, protection on Federal lands furnishes leadership by example to non-Federal land managers.

1.1 Monitor the status and management of Atlantic Coast piping plovers, both population-wide and at specific nesting sites. Reliable ongoing monitoring will be crucial to ensuring that plover protection efforts are contributing effectively and efficiently to the species' recovery. At a recovery-unit level (task 1.11), annual monitoring of numbers, location, and productivity will provide measures of overall progress towards recovery and facilitate identification of areas where additional priority should be accorded to management and protection. Site-specific monitoring (task 1.12) to identify factors that may be limiting plover abundance and/or productivity will ensure that site protection needs have been accurately identified and management is being effectively implemented.

1.11 Monitor population trends and effects of management through annual surveys of population abundance, distribution, and productivity in each recovery unit. An annual inventory of the numbers, location, and productivity of breeding pairs provides information on population trends, changes in distribution, recruitment, and other population parameters (also see task 1.12). Survey efforts in most Atlantic Coast States improved significantly between 1986 and 1989 and have now become fairly standardized. Expanded efforts to assure complete counts of breeding pairs on all sites are still needed in North Carolina and New York; increased standardization of data collection methodology and quality control of surveys are also needed in New York. Productivity data have been obtained for more than 80% of U.S. Atlantic Coast plovers since 1991, and seven States have collected productivity data for more than 90% of all pairs that nested during the last eight seasons. Productivity data from an increased percentage of pairs is needed in New York and Virginia, while North Carolina should continue to maintain productivity data collection rates attained in 1993-1995.

In 1991 and 1994, all States and Provinces conducted window censuses (see page 20) over a nine-day period in late May and early June. A window census was also conducted in the U.S. in 1995, and all States and Provinces are planning a coordinated window census as part of the upcoming 1996 International Piping Plover Breeding Census. Because the window census reduces the probability of double-counting birds that renest during the season, it is the most precise index of population trends. The USFWS recommends that highest priority be given to this census in the future, although "traditional" State censuses should also be continued if resources allow.

Dates for future window censuses are as follows:

1996 - June 1 to June 9
1997 - May 31 to June 8
1998 - May 30 to June 7
1999 - May 29 to June 6
2000 - May 27 to June 4

Every effort should be made to visit all sites occupied in recent years by plovers during the standard census window. If a site cannot be surveyed during the window, it should be surveyed as soon thereafter as possible; counts from sites surveyed after the window should be so noted in the State report. If time permits, sites that have not been occupied in recent years should also be surveyed during the window, with priority on the most suitable habitat.

Where sites are intensively monitored during the window, the highest count of pairs known to be simultaneously active on the site during the window period should be used; if a pair leaves the site early in the window, monitors should communicate with any biologists who intensively monitor adjacent sites to avoid double counts. If hatch dates of pairs that are detected after the window are such that the pair must have been on site during the window, these pairs may also be included in the window count, since they could not have been counted on another site. Data on other pairs recorded on a site before and after the window may be useful for site evaluation purposes, but should not be added to the State or provincial window census total.

While recognizing the constraints on available personnel in Atlantic Canada, the recovery team has urged that the window census be conducted annually there, especially in view of the apparent decline in plover numbers between 1991 and 1994. If necessary, the Canadian census window should be expanded and biologists from the U.S. should be recruited to assist with the Canadian census.

The population size criterion of the Atlantic Coast piping plover recovery goal (recovery criterion 1) is based on a count of "breeding pairs." Breeding pairs of piping plovers may be counted towards this goal if good evidence of breeding activity is observed. This may include observations of territoriality and courtship, even if no nests or chicks are located, and may likewise include observations of nests and chicks, even if only one adult is seen. However, unmated territorial adults should not be counted, and care must be exercised to prevent counting incubating adults and their non-tending mates as separate pairs.

For the purposes of measuring productivity, plovers are considered fledged if they attain 25 days of age or are seen in flight (whichever comes first; see discussion on page 24). Data on chick survival for periods less than 25 days are useful for site management purposes, but should not be included in State averages reported to the USFWS. Exceptions may occur where a "correction factor," based on a number of years of good site-specific data, has been developed and its use has been approved by the USFWS. Landowners and beach managers must also recognize that many 25-day-old plover chicks are incapable of flight and therefore remain vulnerable to mortality from off-road vehicles (see task 1.32).

1.12 **Monitor plover breeding activities at nesting sites to identify factors that may be limiting abundance of nesting plovers and/or productivity.** In addition to nesting pair counts and productivity, monitoring of breeding sites should include other information important to determination of site protection needs. Whenever possible, data collection should include:

- Dates when monitoring began and ended
- Nesting chronology (dates when plovers were first and last seen on the site, nest establishment dates, dates when unfledged chicks are present on the site)
- Locations of nests and brood foraging territories
- Known and suspected causes of nest and chick loss
- Indices of predator abundance
- Locations of commonly used foraging areas during each stage of the breeding cycle
- Available information about use of the site by post-breeding or migrating plovers, other shorebirds, and other rare species

Goldin (1994a) provides a detailed discussion of site monitoring and data collection methodology[1]. Excellent examples of annual summaries of plover monitoring data are provided by Hoopes (1994), Rimmer (1994), Bottitta *et al.* (1993), Hake (1993), and others.

1.2 **Maintain natural coastal formation processes that perpetuate high quality breeding habitat.** Barrier beach habitats preferred by piping plovers are storm-maintained ecosystems; habitat protection must recognize and seek to perpetuate its natural dynamism. Barrier beaches absorb wind and wave forces of coastal storms, thereby providing storm protection to property and other resources on nearby mainland areas (Coastal Barriers Task Force 1983, Massachusetts Barrier Beach Task Force 1994). Not coincidently, many rare species, including piping plovers, northeastern beach tiger beetles, seabeach amaranth, least terns, common terns, black skimmers, and Wilson's plovers, are dependent on the habitat maintained by these coastal storm events (see Appendix B).

Two Federal agencies, the U.S. Army Corps of Engineers and the Federal Emergency Management Agency (FEMA), manage major programs affecting barrier beach dynamics. The Corps maintains harbors and navigation channels in coastal waters, constructing and maintaining jetties, groins, and breakwaters; suitable material (uncontaminated sand of desirable particle size) dredged during channel and harbor maintenance is also used to nourish nearby beaches. Permits issued by the Corps are also required for dredging and beach nourishment conducted by the States, local governments, or private parties. FEMA provides grants for repair of storm related damage in coastal areas and hazard mitigation in areas vulnerable to flooding, and administers the National Flood Insurance Program. FEMA also provides funds for the restoration of "engineered beaches," constructed and maintained in conformance with certain design criteria. Section 7 of the ESA provides both FEMA and the Corps with opportunities to make major contributions to conservation of plover habitat. In addition, expenditures within units of the Coastal Barrier Resources System by the Corps, FEMA, and other Federal agencies may be restricted by the requirements of the Coastal Barriers Resource Protection Act (see page 48).

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1 Copies available from U.S. Fish and Wildlife Service, Weir Hill Road, Sudbury, MA 01776, Attn: Anne Hecht.

1.21 Discourage construction of structures or other developments that will destroy or degrade plover habitat. To the greatest extent possible, conflicts between rare species and property protection should be avoided by directing construction of houses, resorts, parking lots, and other facilities to areas of low vulnerability to flooding and erosion. This, in turn, will avert the need to stabilize shorelines to protect property. In addition to degrading physical suitability of plover habitat, beach development also increases the likelihood of disturbance to plovers through associated recreational activity.

Beach development should be discouraged through conservation easements, acquisition, zoning, and other means. When beach development cannot be avoided, the following protections should be implemented: (1) construction should take place outside the nesting season, (2) developers and others should be forewarned that subsequent plans to stabilize the shoreline will result in additional habitat degradation and that these impacts may affect evaluation of permits under the jurisdiction of the Corps or State coastal management agencies, and (3) property owners should tailor recreational activity on the beach to minimize disturbance of territorial and nesting plovers, their eggs, and chicks.

Impacts of shoreline developments are often greatly expanded by the attendant concerns for protecting access roads. It may be possible to substantially reduce the overall impacts of shoreline property protection on habitat by rethinking how access is provided. Planners should weigh the economic and environmental costs of maintaining overland access, and compare them with costs and environmental effects of alternative modes of access, including boat services, scheduled ferries, and emergency air evacuation.

Fragmentation and degradation of plover breeding habitat caused by construction of walkways, piers, and other structures should also be avoided.

1.22 Discourage interference with natural processes of inlet formation, migration, and closure. Sandspits associated with inlets and recently closed inlets comprise a large proportion of Atlantic Coast piping plover habitat. Rock jetties severely degrade plover habitat by destroying the intertidal zone and robbing sand from the down-drift shoreline, resulting in eroded beaches that may be less suitable for breeding plovers. While this might be partially offset by habitat accretion on the up-drift side of the structure, these artificially stabilized areas could also be subject to accelerated plant succession that decreases their suitability over time.

Inlet stabilization may also contribute to net losses of plover habitat by preventing the formation of new inlets. Cape Lookout National Seashore in North Carolina serves as a prime example of an area where existing and relatively recently closed inlets comprise a large proportion of habitat currently occupied by breeding plovers. The natural inlet formation and closure process maintains availability of habitat; as succession of vegetation causes loss of habitat on the oldest former inlets, new habitat is formed at new and recently closed inlets. Stabilization of existing inlets through dredging would perpetuate habitat on the immediately adjacent spits, but is likely to result in a substantial net loss of habitat as currently occupied former inlets become progressively more heavily vegetated. Even on spits adjacent to a maintained inlet channel, a net loss of plover habitat may occur if inlet migration is forestalled, since recently sedimented areas often constitute prime plover nesting and foraging areas (L.K. Gantt, U.S. Fish and Wildlife Service, *in litt.* 1995).

The creation of an "artificial overwash" when the Corps closed Pikes Inlet on Long Island, New York in 1993 appears to have created prime nesting habitat that attracted 14 pairs of piping plovers in 1994, and 19 pairs in 1995. However, biologists have expressed concern that artificial habitat formed in this way may be susceptible to accelerated succession that will decrease its long-term carrying capacity compared to what it might have been if the inlet had been allowed to persist, migrate, and eventually close on its own (Elias-Gerken and Fraser 1994; S.W. Morgan, U.S. Fish and Wildlife Service, *in litt.* 1995) .

1.23 **Discourage beach stabilization projects including snowfencing and planting of vegetation at current or potential plover breeding sites.** Snowfencing and plantings of American beach grass (*Ammophila breviligulata*), sea oats (*Uniola paniculata*), and other vegetation accelerate the processes that degrade habitat and should be avoided. Installation of snowfences and "planting" of discarded Christmas trees in blowouts, overwashes, or elsewhere on the beach should also be avoided. To the extent possible, the natural processes of overwash and blowouts that perpetuate characteristics of preferred habitat should be allowed to continue unimpeded. For more detail, see pages 36-37.

1.24 **To compensate for disruption of natural process, create and enhance nesting and feeding habitat, especially in the vicinity of existing stabilization projects such as jetties, groins, and other artificial beach stabilization projects.** While preventing development of areas subject to erosion should be the first line of defense in barrier beach protection, a comprehensive beach management policy must also recognize that many current erosion and sedimentation problems are the consequence of past property and/or inlet "protection" efforts. Many of these problems are indicative of complex natural sand movement patterns in interaction with updrift erosion/ sedimentation control projects. Correcting these situations to best protect habitat of rare wildlife requires maintenance of natural long-shore sand budgets and minimization of interference with natural patterns of sand accretion and depletion. Because they appear to mimic natural sand transport and deposition processes, sand-bypass systems may offer opportunities to reduce impacts of erosion while potentially enhancing the habitat of species such as piping plovers that favor accreting beaches; however, long-term monitoring of impacts on the beach ecosystem, including piping plovers and other shorebirds, is needed to confirm or disprove this hypothesis.

1.241 **Encourage deposition of dredged material to enhance existing nesting habitat or create new nesting habitat.** Near-shore (littoral drift) disposal of dredged material also appears to be beneficial for perpetuating high quality piping plover habitat. However, monitoring of habitat characteristics before and after selected projects is needed, particularly in cases of large operations occurring on sites where piping plovers nest or are deemed likely to nest following the disposal operation. For example, pre- and post-deposition beach profiles and faunal studies were compared after approximately 50,000 cubic yards of dredged material from the Ocean City Inlet were piped over Assateague Island and released on the ocean side in 1990. This study did not reveal any effects on the benthic infauna or topography that could be attributed to this small dredged material disposal operation (USFWS 1991b).

On-shore disposal of dredged material for beach nourishment is often recognized as an activity with potential to benefit piping plover nesting habitat. However, conditions must be placed on disposal operations to prevent inadvertent impacts to breeding plovers (Melvin *et al.* 1991). Sand deposition, laying of sand transport pipes, and use of machinery to spread the sand can cause serious disturbance, even direct mortality, to nesting birds. Therefore, on-shore activities must be scheduled during seasons when birds are not present. In some cases, beach nourishment can be conducted during the plover breeding season in areas that the birds are not currently using. In addition, dredged material must be clean sand or gravel of appropriate grain size and must be graded to a natural slope. Dozens of informal consultations between the USFWS and the Corps regarding impacts of appropriately conditioned beach nourishment proposals have culminated in determinations that the proposed projects will not adversely affect piping plovers.

While beach nourishment generally benefits piping plovers in the short term, especially where beaches are seriously eroded, there are situations where nourishment of eroding beaches impedes overwash that would otherwise create and maintain ephemeral pools and bayside mudflats, also preferred plover feeding habitats. See, for example, concerns expressed by Loegering and Fraser (1995), discussed briefly on page 37 of this plan. Individual situations must be evaluated to determine and weigh the probable adverse and beneficial effects of natural erosion on plover habitat suitability. In addition, potential impacts of beach nourishment on other sensitive beach-dwelling species, including seabeach amaranth and northeastern beach tiger beetles, should be carefully considered in areas where these species may be present.

1.242 **Discourage vegetation encroachment at nesting sites.** In some areas, especially those where natural processes that set back succession of vegetation are impeded by coastal management practices, land managers should consider remedial efforts to remove or reduce vegetation that is encroaching on piping plover nesting and foraging habitat or obstructing movement of chicks from oceanside nesting areas to bayside feeding flats.

Mechanical scarification of back-dune areas has been successfully used to maintain habitat suitability at Maschaug Pond, Rhode Island (C. Raithel *in litt.* 1994). In addition, a small-scale vegetation removal experiment was conducted at Cape Hatteras National Seashore in 1993. The results were encouraging, with piping plovers and other shorebirds using the treated area for nesting and foraging immediately (J. Nicholls *in litt.* 1994). This program was expanded during the next two seasons, and in 1995, it encompassed approximately 90 acres at Cape Point and 20 acres at Hatteras Spit (Collier and Lyons *in* NPS 1995).

1.243 **Draw down or create coastal ponds where feasible to make more feeding habitat available.** Drawdown of coastal ponds and impoundments during the breeding season could create productive feeding habitat as well as increase suitable nesting sites. Trustom Pond and Quicksand Pond in Rhode Island are two examples of sites where artificial breaching of coastal ponds is carefully timed to enhance piping plover feeding habitat (USFWS 1987b, Goldin 1994b). Water levels on the North Wash Flats impoundment at Chincoteague National Wildlife Refuge in Virginia are also being managed to enhance plover nesting and feeding habitat. Site-specific breach and drawdown programs should be initiated on an experimental basis at selected sites along the plover's coastal range to encompass the migration and breeding period. Experimental pool/pond creation (with careful monitoring) should be attempted in areas where brood foraging areas may be limited, such as at the Currituck NWR in North Carolina and the Wild Beach at the Chincoteague NWR in Virginia. Results of these experimental projects should be incorporated as appropriate into long-range management strategies. Such projects may also create opportunities for studying moisture requirements of piping plovers (see task 3.22) by comparing pre- and post-project habitat use and survival of chicks.

1.3 **Reduce disturbance of breeding plovers from humans and pets.** Disturbance by humans and pets is a continuing threat to Atlantic Coast plovers, whose habitat is a favorite recreation ground for millions of people. Various management techniques can mitigate impacts of beach recreation on piping plovers, but must be implemented annually as long as the demand for beach recreation continues.

Appendix G contains guidelines for managing recreational activities in piping plover breeding habitat to avoid take under Section 9 of the Endangered Species Act. These guidelines, developed by the Northeast Region of the USFWS with assistance from the U.S. Atlantic Coast Piping Plover Recovery Team, represent the USFWS's best professional advice to beach managers and landowners regarding the management options that will prevent direct mortality, harm, or harassment of piping plovers and their eggs due to recreational activities. However, some Federal land managers have endangered species protection obligations under Section 7 of the ESA or under Executive Orders 11644 and 11989 that go beyond adherence to these guidelines (see pages 47 and 48). Other land managers can also make valuable contributions to the piping plover recovery effort and protection of the beach ecosystem through voluntary implementation of stronger protection measures than those specified in Appendix G.

1.31 **Reduce pedestrian recreational disturbance.** Disturbance from pedestrians can be reduced but not entirely eliminated through intensive management. Various management strategies have been devised to mitigate the impacts of very high demand for pedestrian recreation. Implementation of these strategies may involve different amounts of human effort and provide varying levels of benefits to piping plovers.

Common strategies include limiting the number of access points to the beach, since concentrations of beachgoers tend to occur closest to parking areas. Several land management agencies prohibit boat landings on all or part of their beaches to prevent disturbance to feeding plovers and other shorebirds and/or to prevent boaters from walking through adjacent nesting areas. These types of protection measures should be determined on a site-by-site basis; factors that should be considered include the configuration of habitat on the site as well as types and amounts of ongoing recreational activity. On many national wildlife refuges, where protection of wildlife is the paramount purpose of Federal ownership, complete closures of plover habitat during the breeding season should be continued.

1.311 **Fence and post areas used by breeding plovers as appropriate.** Unless a beach is closed to public entry or use is extraordinarily light, posting of nesting areas is recommended to prevent obliteration of scrapes, crushing of eggs, and repeated flushing of incubating adults. Signs and posts should be carefully designed to discourage perching of potential avian predators. Experience at many Atlantic Coast beaches has shown that use of symbolic fences (one or two strands of light-weight string tied between posts) substantially improves compliance of beachgoers with signs and decreases people's confusion about where entry is prohibited.

Appendix G indicates that a 50-meter buffer distance around nests is adequate to prevent harassment of the majority of incubating piping plovers. However, data from various sites distributed across the plover's Atlantic Coast range indicate that larger buffers may be needed in some locations (see Table 3). Even in situations where they are not strictly required to avoid take, larger buffers may also contribute to recovery, for example by allowing chicks to spend more uninterrupted time feeding and perhaps fledge sooner and/or gain more weight prior to migration.

On portions of beaches that receive heavy human use in April, May, and June, areas where territorial plovers are observed should be symbolically fenced to prevent disruption of territorial displays and courtship. Since nests can be difficult to locate, especially during egg-laying, this will also prevent accidental crushing of undetected nests. Although not currently recommended as necessary to avoid take, fencing or signing of prime feeding areas to exclude or reduce numbers of pedestrians can also contribute to the survival and well-being of unfledged chicks. This may be especially beneficial at times of unusually hot weather, at times and locations where pedestrian activity is very intense, and/or at times when newly hatched chicks are present.

1.312 **Implement and enforce pet restrictions.** Unleashed pets, primarily dogs, are known to chase piping plovers, destroy nests, and kill chicks. A study conducted on Cape Cod found that the average distance at which piping plovers were disturbed by pets was 46 m, compared to 23 m for pedestrians. Furthermore, the birds reacted to the pets by moving an average of 57 m, compared with 25 m when the birds were reacting to a pedestrian. The duration of the disturbance behavior stimulated by pets was also significantly greater than that caused by pedestrians (Hoopes 1993).

Pets should be leashed and under control of their owners at all times from April 1 to August 31 on beaches where piping plovers are present or have traditionally nested. Pets should be prohibited on these beaches from April 1 through August 31 if, based on observations and experience, pet owners fail to keep pets leashed and under control. A half-page information sheet entitled "Why Dogs and Plovers Don't Mix" has been prepared by The Nature Conservancy, Rhode Island Office[1].

1.313 **Prevent disturbance from fireworks, kite-flying, ball-playing, and other potentially disruptive activities on beaches where breeding plovers are present.** Fireworks are highly disturbing to piping plovers and should be prohibited on beaches where plovers nest from April 1 until all chicks are fledged. In addition to the possibility of direct injury caused by the explosions or debris, piping plovers and terns will often abandon their nests and broods during fireworks displays, exposing eggs and chicks to weather and predators (Howard *et al.* 1993; R. Powell, The Nature Conservancy, *in litt.* 1994). If a flightless chick were to become permanently separated from its parents during the confusion, mortality would be almost certain. An August 1993 fireworks display in New Jersey caused permanent abandonment of a least tern colony located more than 250 m away (C.D. Jenkins *in litt.* 1993); a 1994 fireworks display caused temporary abandonment and displays of distress by a tern colony located more than 3/4 mile away (C.D. Jenkins pers. comm. 1994).

In addition to adverse effects from the noise and lights of the pyrotechnics, commercial fireworks displays often draw large crowds that may pose threats to nearby plovers (W. Donato and S.W. Morgan, U.S. Fish and Wildlife Service, *in litt.* 1995). When fireworks displays can be situated to avoid

1 Copies available from U.S. Fish and Wildlife Service, Weir Hill Road, Sudbury, MA 01776, Attn: Anne Hecht.

disturbance from the pyrotechnics, careful planning should still be conducted to assure that spectators will not walk through and throw objects into plover nesting and brood-rearing areas. Sufficient personnel must also be on-site during these events to enforce plover protection measures and prevent use of illegal fireworks in the vicinity of the birds.

Given plovers' aversion to kites (see page 40), prohibition of kite flying within 200 m of nesting or territorial adult or unfledged juvenile piping plovers between April 1 and August 31 is recommended.

Hazards to plovers from ball-playing are exacerbated by tendencies for stray balls to land in closed areas where they can smash nests and where efforts to remove them can disturb territorial or incubating birds. These activities should be prohibited within hitting and throwing distance of piping plover nesting areas.

1.32 **Reduce disturbance, mortality, and habitat degradation caused by off-road vehicles, including beach-raking machines.** Minimum protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks on beaches where vehicles are permitted are recommended in Appendix G. Since restrictions to protect unfledged chicks often impede vehicle access along a barrier spit, a number of management options affecting the timing and size of vehicle closures are presented; some of these options are contingent on implementation of intensive plover monitoring and management plans by qualified biologists. It is recommended that landowners seek review of and concurrence with such monitoring plans from either the USFWS or the State wildlife agency.

Appendix D summarizes the current status of off-road vehicle use on current and potential plover breeding sites along the U.S. Atlantic Coast. Management strategies that substantially reduce off-road vehicle impacts have been implemented at many plover breeding sites since 1986. Threats from inadequate management continue at some U.S. sites, however, and need to be addressed.

In Atlantic Canada, off-road vehicles are prohibited on most beaches, but violations occur in many locations. Communications from the Atlantic Piping Plover Working Group (R. Chiasson, *in litt.* 1993) urged the Solicitor General of New Brunswick to increase enforcement of the New Brunswick Trespass Act and requested that the Minister of Environment and Lands, Newfoundland and Labrador, prohibit all-terrain vehicles on beaches occupied by plovers. Continuation and expansion of these efforts is strongly recommended.

A half-page information sheet entitled "Why Vehicles and Plovers Don't Mix" has been prepared by TNC's Rhode Island Office[1].

1.33 **Provide wardens and law enforcement officers to facilitate protective measures and public education.** On many sites, patrolling to ensure that beachgoers stay out of fenced areas and adhere to other plover protection measures is conducted by biologists who also monitor birds, but non-biological staff and volunteers have made invaluable contributions to plover conservation both by deterring disturbance and by providing opportunities for public education. Wardens are particularly important on heavily used beaches during the peak recreational season. Manuals for volunteer wardens have been prepared by Dougherty and Motivans (undated), Halifax Field Naturalists (1992), and Goldin (undated).

Law enforcement agents play a crucial role in educating landowners, user groups, and others about their legal responsibilities with regard to protection of threatened and endangered species. Enforcement personnel are also trained to conduct thorough investigations into potential violations of the ESA and other wildlife conservation statutes. The local USFWS law enforcement office should be informed *immediately* whenever evidence of suspected take of piping plovers is encountered.

1.4 **Reduce predation.** Predation is a major factor limiting plover productivity at many Atlantic Coast beaches. As discussed on pages 41-42, natural threats from predation have been exacerbated by many human activities in the coastal zone. In addition, the cumulative impacts on piping plovers from predation, habitat loss, and human disturbance and small population

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1 Copies available from U.S. Fish and Wildlife Service, Weir Hill Road, Sudbury, MA 01776, Attn: Anne Hecht.

size decrease the plover's ability to withstand predation. Due to the magnitude of predation threats to plovers and limitations associated with all currently available solutions, it is strongly recommended that on-site managers employ an integrated approach to predator management that considers a full range of management techniques.

An ecosystem approach to reducing impacts of predation would argue in favor of redressing the human-abetted changes in types and numbers of predators, as well as environmental changes (for example in the predators' food sources) that foster unnatural numbers of some predators. Wherever feasible, such approaches are encouraged. However, many highly prolific predators are now so firmly entrenched in and around many plover nesting areas that results from this type of approach may be ineffective and/or temporary.

Some land managers, such as the National Park Service, may need to re-evaluate and clarify their policies on the management of predator populations and/or habitat where predation might be limiting local piping plover populations. In particular, policies that prohibit management of native predator populations even when human-abetted factors have caused substantial increases in their natural abundance may be counterproductive to the overall goal of protecting "natural" ecosystems.

Although most activities to reduce impacts of predation have been implemented by on-site biologists, U.S. Department of Agriculture's Animal Damage Control (USDA-ADC) biologists and State wildlife agency furbearer biologists have made important contributions to the planning and, in some cases, implementation of predator management activities. Professional trappers have played a key role in some predator-removal programs.

A discussion of scientific studies recommended to test experimental methods of reducing impacts of predation is included under task 3.4.

1.41 **Remove litter and garbage from beaches.** Beach litter and garbage attract predators such as skunks and gulls that are known to prey on piping plover nests and/or chicks. Beachgoers should be discouraged from leaving or burying trash or food scraps on the beach. Trash cans on the beach should be emptied frequently to reduce attractiveness and availability of their contents to scavenging predators.

Emptying cans in the evening instead of leaving them overnight is preferable. Fish-cleaning stations should be located well away from plover breeding areas.

Although removal of trash from the beach reduces predation threats, beach-raking should not be conducted during the nesting season. Beach-cleaning machines can crush plover nests and chicks, and they remove the plovers' natural wrackline feeding habitat. Trash should be selectively removed from the beach, but natural materials, including shells and seaweed, should be left intact.

1.42 **Deploy predator exclosures to reduce egg predation where appropriate.** Current guidelines for the use of predator exclosures to protect piping plover eggs are contained in Appendix F. Exclosures are a valuable tool for countering human-abetted predation threats to piping plover eggs, but they are not appropriate for use in all situations, nor do they provide any protection for mobile plover chicks, which generally leave the exclosure within one day of hatching and move extensively along the beach to feed.

First trials of wire fences to prevent predation of piping plover nests on the Atlantic Coast occurred in 1987, when seven exclosures were used on four sites. Over 70 nests on 14 sites were exclosed in 1988, and in 1989 State plover coordinators reported use of exclosures to protect nests of 141 pairs of plovers along the U.S. Atlantic Coast (USFWS 1989a). By 1993, exclosures were deployed in every State and at least three Canadian Provinces in the plovers' Atlantic Coast breeding range.

Rimmer and Deblinger (1990) found that 24 of 26 nests (92%) protected by exclosures hatched at least one egg, while only six of 24 (25%) unexclosed nests hatched at a Massachusetts site over four years. Melvin *et al.* (1992) reported 90% (26/29) hatching of exclosed nests versus 17% (4/24) for unexclosed nests at six sites on Outer Cape Cod, Massachusetts. Information on 211 exclosures used in eight States and three Canadian Provinces in 1990 was evaluated to assess the effectiveness of various designs and construction techniques (Deblinger *et al.* 1992, Vaske *et al.* 1994).

Although exclosures are contributing to improved productivity and population increases in some portions of the plover's Atlantic Coast range, problems have been noted in some localities. Loegering (1992) reported loss of six nests in exclosures without tops in Maryland in 1988, but nest loss stopped after string tops were added. Van Schoik (The Nature Conservancy, *in litt.* 1993) documented loss of 12 nests over just a few days on Jones Beach Island, New York to common crows (*Corvus brachyrhynchos*) that entered exclosures covered with parallel rows of string; no further losses occurred when net tops were installed. Cross (1991) found that exclosed nests hatched significantly more often than unexclosed nests over three years on three sites in Virginia, but hatch rates were not significantly improved at all sites or in all years; furthermore, two instances of foxes depredating adult plovers occurred in the vicinity of exclosures. Foxes or coyotes systematically depredated 5-10 exclosures at each of three widely separated sites in 1995 (USFWS files). Several instances of adult plover entanglement in string or net tops, with and without attendant mortality, have been reported (USFWS files). Predator exclosures have been associated with abandonment of snowy plover (*Charadrius alexandrinus*) nests on California beaches, where fox track patterns suggest that the birds were subjected to intense harassment by foxes (M. Parker, U.S. Fish and Wildlife Service, pers. comm. 1994). Other potential risks associated with exclosures include vandalism or disturbance of the birds by curiosity seekers. Therefore, exclosures must be carefully constructed, monitored, and evaluated by qualified persons.

1.43 **Remove predators where warranted and feasible.** Lethal and non-lethal means of predator control have been used with mixed success to protect piping plovers on Atlantic Coast beaches. Fox trapping has been credited with the substantially increased plover abundance and productivity on Little Beach Island in New Jersey (D. Beall, U.S. Fish and Wildlife Service, pers. comm. 1990), but has produced limited results at the Chincoteague NWR in Virginia (USFWS 1993b). Trapping of feral cats at a number of nesting sites has reduced threats from these non-native and very efficient plover chick predators.

Removal of predators should be pursued where feasible and warranted and where trapping can be conducted efficiently. Situations that may especially warrant predator removal include those where non-native predators such as feral cats and Norway rats are present, where predators have been introduced to islands, where range extensions have been human-abetted, or where high rates of chick predation (which cannot be countered with predator exclosures) are occurring.

Herring, great black-backed, and ring-billed gulls pose a special threat to breeding plovers because they not only depredate nests and chicks, but also usurp plover nesting sites. These now numerous gulls have greatly expanded their range and numbers, especially along the U.S. portion of the Atlantic Coast, as a result of human-supplied food sources (primarily dumps and fish offal). Gulls should be prevented from establishing and expanding nesting colonies at plover nesting areas, and existing gull colonies at plover nesting sites should be removed.

1.5 **Protect piping plovers and their breeding habitat from contamination and degradation due to oil or chemical spills.** Oil/chemical spill emergency response plans should provide for protection of known plover breeding areas. In the event of a spill in the vicinity of a piping plover nesting or feeding area, efforts should be made to prevent oil/chemicals from reaching these beaches. Clean-up operations should be prompt, but special care must be exerted to prevent accidental crushing of and/or excessive disturbance to nests or chicks by clean-up personnel and equipment.

If piping plovers or their habitat sustain injury due to oil/chemical spills or leaks, the responsible parties should clean the areas to their original condition or the Federal government (U.S. Coast Guard) should do it as part of the Federal clean-up effort; appropriate claims should also be filed under the Natural Resource Damage Assessment (NRDA) regulations to recover damages and undertake relevant restoration work. Since 1991, restoration costs awarded under the NRDA regulations for piping plovers believed lost as a result of two Atlantic Coast oil spills have been received by Federal and State governments, and restoration work to remedy injury from these spills is underway.

1.6 **Develop mechanisms to provide long-term protection of plovers and their habitat.** Removal of the Atlantic Coast piping plover population from the protection of the ESA will require long-term protection to assure protection and management sufficient to maintain a highly productive recovered population (see recovery criterion 4). Long-term protection will be needed on both Federal and non-Federal lands, since even if Federal lands attain their full capacity of approximately 635 pairs estimated in 1993, protection of plovers and habitat to support more than 950 additional pairs on non-Federal lands must also be ensured.

Development of long-term protection mechanisms may trigger additional opportunities for participation of various stakeholders in discussions of management options. Discussions of tradeoffs among various protection strategies and allocation of responsibilities across available habitat may be appropriate if it appears that a productive recovered population can be maintained with lower levels of protection than that initially required to attain delisting criteria 1 and 3.

1.61 **Provide intensive protection of breeding piping plovers on national wildlife refuges.** Wildlife protection, especially the preservation, restoration, and enhancement of threatened and endangered species and migratory birds, is the primary goal of national wildlife refuges (USFWS 1982). Piping plover habitat on national wildlife refuges has been accorded highly intensive protection, including closures during the nesting season where appropriate, to minimize adverse effects of disturbance. In some cases where human activity is extremely low or where plover use is unusually sparse, other protection measures short of closure are being used. These protection programs should be continued and should be periodically evaluated to ensure that they are providing sufficient plover protection.

1.62 **Seek long-term agreements with landowners.** Prototype agreements should be worked out at sites where there is a history of intensive and successful piping plover protection, a high degree of commitment to the piping plover protection program, and where experienced on-site shorebird biologists can provide expertise to devise and test alternative types of agreements. Possible candidate sites for prototype agreements might include the Cape Cod National Seashore (administered by the NPS) and Crane Beach (managed by The Trustees of Reservations) in Massachusetts; Goosewing Beach (owned by TNC) in Rhode Island; and Assateague Island National Seashore (NPS) in Maryland. Ingenuity will be required to develop agreements that are flexible enough to respond to the changeable nature of habitat conditions and site-specific threats and avoid unnecessary restrictions on other beach uses, yet also ensure adequate protection for piping plovers.

1.63 **Acquire important habitat if and when it becomes available.** Federal and State conservation agencies and private conservation organizations should continue efforts to acquire piping plover habitat as it becomes available. Piping plover habitat lies within approved acquisition boundaries of several national wildlife refuges, including Rachel Carson NWR in Maine, Trustom Pond NWR in Rhode Island, Stewart McKinney NWR in Connecticut, and Chincoteague and Fisherman Island NWRs in Virginia. The USFWS and other organizations should also undertake further efforts to identify other important sites that may become available for acquisition, and the USFWS should continue to monitor excess Federal lands for plover habitat and apply for it as it becomes available.

1.64 **Ensure that any Section 10(a)(1)(B) permits issued contribute to Atlantic Coast piping plover conservation.** Section 10(a)(1)(B) of the ESA provides for permits that have the potential to contribute to the conservation of listed species. Appendix H contains guidelines for the preparation and evaluation of conservation plans for piping plovers on the Atlantic Coast pursuant to this section of the ESA. These guidelines are intended to: (1) guide potential applicants in developing plans that minimize and mitigate the impacts of take and (2) assist the USFWS in evaluating the impacts of any proposed conservation plans on the recovery of the Atlantic Coast piping plover population. The Section 10 permit process may be a valuable mechanism for developing the long-term protection agreements called for in delisting criterion 4, especially in areas where significant population growth has already occurred and productivity exceeds 1.5 chicks per pair.

2. **Monitor and manage wintering and migration areas to maximize survival and recruitment into the breeding population.**

The population viability analysis conducted by Melvin and Gibbs (Appendix E) shows that probability of persistence of the Atlantic Coast piping plover population is highly sensitive to changes in survival rates. Since piping plovers spend 55-80% of their annual cycle associated with wintering areas, factors that affect their well-being on the wintering grounds can substantially affect their survival and recovery. Piping plover wintering areas are also used by many other shorebirds; their protection will contribute to the conservation of a richly diverse and important ecosystem.

Most sightings of banded birds from the Atlantic Coast breeding population have been made on the southern Atlantic Coast (see Wintering Distribution section, page 14). However, sightings of Atlantic Coast birds in the Florida Keys and on the Gulf Coast (16% of sightings) as far west as Texas and the large number of wintering birds unaccounted for during southern Atlantic Coast surveys lend credence to suggestions that more Atlantic Coast piping plovers than previously surmised may depend on Gulf Coast wintering habitat. Since the draft Revised Recovery Plan for Piping Plovers Breeding on the Great Lakes and Northern Great Plains (USFWS 1994a) contains recovery tasks for Gulf Coast wintering habitat, this plan focuses primarily on protection of wintering habitat on the southern Atlantic Coast; however, implementation of these protections involves overlap of responsibilities for the two populations. Likewise, tasks recommended in the Great Lakes/Northern Great Plains draft revision may be equally crucial to recovery of the Atlantic Coast breeding population.

Monitoring and protection tasks for migrating and wintering piping plovers are included in subtasks below, while research needs associated with wintering areas are included under task 3.1 and its subtasks. New information gained from research efforts must be promptly incorporated into protection efforts.

The USFWS recommends integration of the monitoring and protection tasks specified below into State action plans. State action plans that include all shorebirds or entire coastal systems may be effective vehicles for piping plover protection, as long as explicit attention is focused on the management and protection of Federally listed species such as the piping plover. State action plans should include the following components:

(1) Monitoring -- Several key sites per State should be selected for annual monitoring to serve as indices of population fluctuations.

(2) Identification of protection and management needs -- Management plans should be developed and implemented for sites with special protection and management needs.

(3) Education needs -- The need for volunteer meetings or workshops for regulatory agencies should be considered. For example, a 1991 workshop was held in North Carolina specifically for representatives of the regulatory agencies to inform them of the plover's habitat needs and ecology, as well as requirements to protect and consult on this species.

(4) Recognition of important sites -- Special recognition of key sites should be encouraged.

2.1 Monitor known and potential wintering sites. Recent wintering surveys have identified many new wintering sites, but there is a need for better information about spatial and temporal use patterns, habitat trends, and threats. This can be advanced through a continuing monitoring program.

2.11 Monitor abundance and distribution of known wintering plovers through periodic wintering surveys. A comprehensive rangewide survey (i.e., International Census) of wintering sites patterned after Haig and Plissner (1993) should be conducted at intervals of approximately five years to assess population trends, discover additional wintering sites, and determine relative site importance. Major wintering sites along both the Atlantic and Gulf Coast should be surveyed annually to provide additional information on site importance and to assess population fluctuations on a site-by-site basis. An improved understanding of the species' overall distribution, habitat use patterns, and site fidelity will facilitate assessment of impacts of proposed projects during ESA Section 7 consultations and State project reviews, development of management plans, and prioritization of protection programs. Suggested guidelines for conducting piping plover surveys in Atlantic Coast wintering habitat are found in Appendix I.

2.12 Survey beaches and other suitable habitat to determine additional wintering sites. Two surveys during the 1980's along with the 1991 International Census have provided important insight into plover winter distribution. To date, however, only 63% of the known adult population has ever been accounted for during the winter period. The recovery team believes that discovery of major new wintering sites on the southern Atlantic Coast (North and South Carolina, Georgia, and the east Coast of Florida) is unlikely. Surveys to locate more sites should focus on Louisiana, Texas, the Caribbean, and the Mexican Gulf Coast, where coastal islands and bay systems have been less fully surveyed to date owing to their relative inaccessibility. A second International Piping Plover Wintering Census was conducted in January 1996, and data, now under compilation, may contribute information on new sites.

2.13 Identify factors limiting the quantity and quality of habitat or its use by piping plovers at specific wintering sites. Potential direct and indirect threats to wintering plovers and their habitat have been identified, but a better understanding of the exact mechanisms and degree of impacts on the birds is needed. Some of this information will be obtained through formal scientific investigations (discussed in tasks 3.11 through 3.14), but much information can and should be acquired through monitoring the response of habitat and birds to various factors, including natural coastal formation processes, dredging and other channel maintenance, and recreational activities. Careful documentation of all observations is a key component of such monitoring. Opportunities to incorporate monitoring into plans for Federal activities subject to Section 7 of the ESA, such as dredging and discharges regulated by the Corps, should be sought. For example, a 1994 biological opinion regarding the reopening of Packery Channel, between Mustang and North Padre Islands, Texas, recommended that the Corps conduct pre- and post-project monitoring of the area's tidal amplitude, size of intertidal flats, salinity, vegetation, and invertebrate populations (R. Perez, U.S. Fish and Wildlife Service, *in litt.* 1994).

2.2 Protect essential wintering habitat by preventing habitat degradation and disturbance. All known wintering areas (listed in Appendix K of this plan and in Appendix 3 of the draft Revised Recovery Plan for Piping Plovers Breeding on the Great Lakes and Northern Great Plains) are currently considered essential to piping plover conservation. Probability of extinction of both Atlantic Coast and inland populations is extremely sensitive to changes in survival rates (Appendix E and Ryan *et al.* 1993). Furthermore, recovery of the three breeding populations is contingent on availability of wintering habitat for more than double the current number of piping plovers (USFWS 1994a and this document). As information needed to accurately estimate carrying capacity of wintering habitat becomes available in the future, it may be possible to identify habitat that is not considered essential to plover conservation (see task 2.25); however, for now all known wintering sites are considered essential habitat and should be protected.

2.21 Protect habitat from direct and indirect impacts of shoreline stabilization, navigation projects, and development. Coastal development projects should be carefully assessed with regard to piping plovers. Recommendations from USFWS (under the ESA and the Coastal Barrier Resources Act, if the latter is applicable) and/or State agencies should focus on avoiding or minimizing adverse impacts to wintering habitat. Where adverse effects cannot be avoided, agencies should document impacts so that cumulative effects on this species' habitat can be assessed.

2.22 **Protect wintering habitat from disturbance by recreationists and their pets.** Piping plover wintering sites are highly variable in their amount of recreational activity and its proximity to areas used by plovers. Where a site-specific evaluation determines that recreation poses a threat to plovers, appropriate protection measures should be implemented. Among Atlantic Coast wintering sites, those in Florida currently face the greatest threats from human disturbance.

Nicholls (1989) found an average of 3.5 people and 0.7 off-road vehicles per km at sites without piping plovers compared with 1.4 people and 0.2 vehicles per km within the plover's Atlantic Coast wintering range. On the Gulf Coast, recreational activity was also higher at non-plover sites (6.5 people and 0.4 vehicles per km) than sites where Nicholls found plovers (0.7 people and 0.2 vehicles per km). However, these differences were not statistically significant on either the Gulf or Atlantic Coast (J. Nicholls, *in litt.* 1989), and more information about the mechanisms and effects of disturbance on wintering plovers and their habitat is needed (see task 3.14). As information becomes available, it should be incorporated into conservation efforts.

2.23 **Protect piping plovers and their wintering habitat from contamination and degradation due to oil or chemical spills.** Contamination from oil or chemical spills or leaks poses a significant threat to wintering piping plovers. Efforts must be made to minimize the likelihood of such events in the vicinity of plover wintering areas. Oil/chemical spill emergency response plans should provide for protection of known plover wintering areas, as should State plover, shorebird, or coastal ecosystem protection plans. In the event of a spill in the vicinity of a known piping plover wintering area, surveys should be conducted and efforts should be made to prevent oil/chemicals from reaching plover use areas, and restoration efforts should begin expeditiously. If piping plovers or their habitats do sustain injury due to oil/chemical spills or leaks, appropriate claims should be filed under the NRDA regulations to recover damages and undertake relevant restoration work.

2.24 Apprise resource and regulatory agencies of threats to wintering piping plovers and their habitats. Periodic workshops should be held to inform resource management and regulatory agencies about threats, research and management needs, etc. A coordinated approach to conservation of plover wintering areas should be encouraged.

2.25 Evaluate and update lists of essential wintering habitat as data become available. As new plover wintering areas are discovered and data needed to assess the carrying capacity, essential characters, and juxtaposition of wintering habitats become available, the current lists of essential wintering habitat (see task 2.2 and Appendix K) should be expanded or refined as appropriate.

2.26 Provide for long-term protection of wintering habitat, including agreements with landowners and habitat acquisition. Wintering areas deemed important (essential) should be protected through management plans and/or written agreements. Conservation easements and acquisition of wintering sites should be considered. Priority should be accorded to important sites facing the most imminent threats of permanent habitat loss or degradation.

2.3 Protect piping plovers during migration. Although piping plover migration patterns are poorly understood, it is likely that migration involves considerable expenditure of the bird's energy that may affect survival and/or productivity. Although monitoring and protection of breeding and wintering sites are currently higher priorities than active protection during migration, further investigations and protection measures may be warranted in the future.

2.31 Identify important migration stop-over habitat. Appendix B identifies many breeding sites where concentrations of post-breeding and migrating plovers are observed, and the importance of a few stop-over sites, such as several North Carolina sites, has been recognized. However, regular monitoring of plover breeding sites usually ceases with the fledging of chicks, and monitoring of wintering sites is often timed to coincide with peak use (late fall and early winter) rather than migration periods. Even when surveys are conducted during migration periods, data collection is usually limited to counting the number of plovers observed. Collection of information on turn-over rates is hampered by the lack of marked birds, but should be noted whenever banded or otherwise identifiable birds are encountered.

2.32 **Identify and mitigate any factors that may be adversely affecting migratory stop-over habitat or its use by piping plovers.** Further investigations into factors that may affect the well-being of plovers during migratory stop-overs may facilitate their protection, particularly on sites that receive relatively heavy plover use and/or face threats that may affect their suitability as stop-over habitat.

3. Undertake scientific investigations that will facilitate recovery efforts.

Research efforts over the last fifteen years have substantially increased our understanding of piping plover protection needs and facilitated conservation efforts; however, major gaps remain. Activities related to censusing to determine population trends, surveys to locate new breeding or wintering areas, and monitoring to determine abundance, productivity, and causes of nest or chick loss are basic components of on-site management and are included in tasks 1 and 2.

One factor that will affect experimental design for many Atlantic Coast piping plover research projects is the current lack of a safe method of marking individual birds. Beginning in 1982, several research projects using color-banding of Atlantic Coast piping plovers were initiated to facilitate determination of survival rates, dispersal, and other research objectives. Task 1.12 in the 1988 recovery plan called for the development and implementation of a coordinated color-banding and marking program, and such a scheme was deployed in coordination with the Great Lakes and Northern Great Plains Recovery Team. In late 1989, however, following receipt and analysis of information regarding piping plovers with injuries that appeared to be related to the use of bands and legflags, the Northeast Region of the USFWS placed a moratorium on the use of these devices (J. Gillett and R. Lambertson, U.S. Fish and Wildlife Service, *in litt.* 1989 and 1990). Although biologists have continued to report sightings of birds banded prior to 1990, this moratorium has impeded efforts to expand information about piping plover survival rates, dispersal patterns of breeding birds, and many important aspects of plover wintering ecology. Additional discussion of this matter is included under task 3.9.

3.1 **Investigate the wintering ecology of piping plovers.** Research currently in progress on the Texas Coast will provide much valuable information on piping plover wintering ecology.

However, the Texas coastal system is complex, and habitat selection and use may be somewhat different from other areas along the Atlantic and Gulf Coasts. Possible research sites on the Atlantic Coast and Florida Keys include:

- Rachel Carson's Estuary/Cape Lookout National Seashore in North Carolina,
- Deveaux Bank in South Carolina,
- Tybee/Little Tybee Island/Williamson Island in Georgia,
- Cumberland Island National Seashore in Georgia,
- Ward's Bank/Talbot Island in Florida, and
- Ohio Key/Woman's Key/Boca Grande Key in the Florida Keys.

Several sites on the Florida Gulf Coast would serve as suitable research sites, including:

- Marco Island/Sand Dollar Island in Collier County,
- Lee County sites (Estero Island, Cayo Costa State Park, North Captiva Island, Bunches Beach), and
- Pinellas County sites (Honeymoon Island, Three Rooker Bar, Caladesi Island).

3.11 **Characterize wintering habitat.** Research is needed to identify winter foraging and roosting habitat characteristics along the Atlantic Coast. Features should be identified on both the local (e.g., substrate type) and landscape level (e.g., the availability or diversity of microhabitats in coastal complexes). Information on habitat characteristics and use will help in locating new and protecting existing wintering sites.

3.12 **Determine the spatial and temporal use of wintering habitat.** Analysis of data from aerial photographs using computerized Geographic Information Systems may provide insight about the relative importance of the proximity of foraging and roosting habitat. Time budget analyses and observations of marked birds may also yield more information on the spatial and temporal (tidal, year-to-year, wind-influenced) use of habitat, whether or not there are prime and alternate feeding and roosting sites, and importance of sites during weather and tidal extremes.

3.13 **Evaluate and compare foraging behavior and resources for specific microhabitats at wintering sites.** Research on foraging efficiencies and prey availability (and possibly fecal sampling and analysis) needs to be conducted on the Atlantic Coast to determine relative importance of different microhabitats, e.g., sandflats, mudflats, sandy mudflats, beach. It may also be desirable to include Florida Gulf Coast sites in such studies.

3.14 **Investigate the effects of human disturbance on wintering plovers.** The degree to which human disturbance and off-road vehicles affect the distribution, habitat use, energetics, and survival of wintering piping plovers needs further study (Melvin *et al.* 1991); investigation of the mechanisms by which human activities affect the birds is also needed.

3.2 **Refine characterization of plover breeding habitat.** Information about important characteristics of Atlantic Coast piping plover breeding habitat has been substantially advanced through a number of formal research projects, as well as through high quality documentation of plover breeding activities at many intensively monitored sites. However, further study is needed to facilitate more rigorous projection of carrying capacity from habitat characteristics.

There are also unanswered questions about potential differences in plover habitat requirements within the breeding range (1,500+ miles) of the Atlantic Coast population. In particular, it is presently unclear whether the apparent coincidence of nesting plovers sites in the southern part of the range with access to lightly vegetated bayside intertidal areas and ephemeral pools is indicative of greater dependency of breeding plovers on these habitats at lower latitudes (Loegering and Fraser 1995, Elias-Gerken 1994, Elias-Gerken and Fraser 1994) than is seen in New England. Elucidation of this issue would greatly facilitate decisions about what types of protection measures are most likely to benefit plovers in the New York-New Jersey and Southern recovery units.

Two aspects of habitat characterization that have been identified as high priorities for further research are discussed in tasks 3.21 and 3.22. Some researchers have also suggested that the presence/absence of overwintering ghost crab populations results in different habitat use patterns across the plover's range (see task 3.43). Because they occur in important habitats, effects of artificial inlet closure and other beach stabilization projects on suitability of plover habitat should also be carefully evaluated (task 3.23).

3.21 Compare plover foraging resources along the Atlantic Coast breeding habitat. Several studies (Loegering 1992, Goldin 1993b, Hoopes 1993, Elias-Gerken 1994) have focused on plover foraging ecology, analyzing data on habitat use (time budgets), foraging rates, and invertebrate abundance. Loegering and Fraser (1995) and Elias-Gerken (1994) have further suggested that plover requirements for foraging resources may be more specialized south of New England. However, because terms and definitions used to categorize habitat types and protocols for sampling foraging rates and invertebrate abundance varied among the studies, it is difficult to compare results. More important, these differences confound application of results from these intensive studies to a variety of management issues at other sites along the coast, including estimates of carrying capacity and decisions about habitat protection priorities, both within and among sites. A study is needed that uses a consistent protocol to compare the abundance and availability of prey in different habitats at a geographically dispersed set of sites along the Atlantic Coast. Ideally, this research would encompass portions of the study areas of the studies cited above, as well as other selected sites distributed along the plovers' Atlantic Coast range, including Canada. Such a study should also evaluate sites to determine whether the use of off-road vehicles (at any time of year) affects the types and/or numbers of invertebrates present during the plover breeding season.

3.22 Determine requirements of breeding plovers and their chicks for moisture and other factors that may affect thermal regulation, hydration, and salt excretion. Several studies, reports, and other communications from the southern end of the plover's breeding range (Coutu *et al.* 1990, Wolcott and Wolcott 1994, Collazo *et al.* 1995, Lyons and McGrane 1995) have suggested that heat and lack of moisture may affect chick survival and constrain habitat suitability, especially in North Carolina. Research is needed to elucidate effects of moisture and heat on habitat suitability, carrying capacity, and productivity.

3.23 Evaluate impacts of artificial inlet closure and other beach stabilization projects on piping plover breeding habitat suitability. As noted on pages 6, 11, and 37 and under task 1.2 and its subtasks, piping plovers nest and forage in storm-maintained habitats, including sandspits, overwashes, and blowouts, and the species' survival and recovery as well as the well-being of other early succession beach-dwelling species is dependent on the maintenance and perpetuation of these habitat characteristics. However, inlets have been artificially closed in the past (for example, at Westhampton Beach, Long Island, New York in 1962, 1980, and 1993 (Cashin Associates 1993)). An "Interim Breach Management Plan" has recently been formulated to expeditiously close any future storm-created inlets that might occur in the barrier islands between Fire Island Inlet and the eastern end of Shinnecock Bay on Long Island (U.S. Army Corps of Engineers 1995). Other beach stabilization projects, such as snowfencing and vegetation planting, are sometimes implemented despite their deleterious effects on plovers and their habitat. Additional information is needed to more fully determine the type, extent, and duration of impacts on plover habitat suitability from these types of coastal modifications and to facilitate more complete analysis of impacts on regional plover populations. Such studies should also seek to define possible project modifications that will minimize adverse impacts on piping plovers, other Federally-listed species, and the beach ecosystem. Studies may also facilitate creation and enhancement of nesting and feeding habitat to mitigate unavoidable adverse effects of artificial beach stabilization (see task 1.24).

3.3 **Monitor levels of environmental contaminants in piping plovers.** To date, very limited testing has been conducted to assess contaminant levels in piping plovers that might affect survival or reproductive success (see Reasons for Listing and Continuing Threats, page 44). Some unhatched eggs and dead chicks from several Massachusetts and New York sites have been collected for this purpose, but no assessment has yet been performed. Concern in New England is focused primarily on comparison of samples from the vicinity of Buzzards Bay (near the site of a major Superfund clean up) with samples from elsewhere. As abandoned eggs and/or chicks that are not needed for law enforcement investigations become available, they should be collected for potential contaminants assessment. A protocol for collecting, handling, and shipping samples was developed by USFWS environmental contaminants specialists and endangered species biologists for use in New York in 1995[1]. Egg removal and

1 Copies may be obtained from USFWS, Weir Hill Road, Sudbury, Massachusetts 01773, Attn: Anne Hecht; however, use of this protocol should only be made following coordination with local USFWS or State environmental contaminants and endangered species biologists.

salvaging of dead chicks should only be done by individuals possessing proper authorizations as provided for in 50 CFR 17.21 and 17.31. Sites with the greatest potential for contaminant problems should also be identified and given priority for assessment. Samples should be assessed for standard organochlorine compounds and, in locations where there is reason to believe they may be present at levels sufficient to affect plovers, for heavy metals.

All sampling should be opportunistic, based on availability of eggs that are known to be substantially beyond their expected hatch date. Eggs should never be removed from the beach as long as there is any realistic chance that they might hatch. In the case of unhatched eggs from a partially hatched clutch, eggs should not be collected until at least 72 hours after the known hatch date of the other eggs. Full clutches should not be collected unless it is known that 40 or more days have elapsed since the last egg was laid. Collection of abandoned clutches should only be done after substantial monitoring over at least five days has established that the adults are not going to return *and* that the on-site biologist has conferred with a State or USFWS endangered species biologist. The widespread use of predator exclosures to protect nests hinders scavenging of eggs that fail to hatch.

3.4 Develop and test new predator management techniques to protect nests and chicks. Although a number of techniques to reduce predation, described under tasks 1.41-1.43, are currently in use, all have disadvantages and limitations on their applications. Predator exclosures are labor-intensive, may increase susceptibility of nests to vandalism or abandonment, may contribute to injuries to incubating adults, and afford no protection to chicks. Predator removal is labor-intensive and sometimes controversial, and results are often temporary. Trapping methods are not available for all species, such as Norway rats, crows, and ghost crabs. Removal of trash and litter from the beach eliminates one of many factors that attracts predators to the beach, but will not redress major imbalances in the numbers or ranges of predators in the coastal zone. A number of potential predator management techniques have been suggested and others may be proposed in the future (see following tasks). Assistance from the USDA-ADC and from State wildlife agency furbearer biologists should be sought on these matters.

3.41 Develop and test conditioned aversion techniques. Proposals to test conditioned taste aversion on red foxes in Maryland (MacIvor 1991) and Virginia (Cross 1992) were not implemented due to difficulties obtaining permission to field test the proposed aversive compound, emetine. Pros and cons of other aversive techniques, including electrified exclosures, trap and release, and use of such techniques in conjunction with predator birth control (to prevent conditioned adults from reproducing) are briefly discussed by Melvin (1993). While there appear to be many obstacles to development of effective aversion techniques that can be efficiently applied in the field, there are substantial potential advantages to be realized from an aversive technique that can reduce predation on both eggs and chicks and that might be conducted at times when plovers are not present.

3.42 **Extend testing of artificial coyote territories to exclude red foxes.** Cross (1993) tested the use of coyote scent marks (scats and urine) to deter red foxes from two plover habitats in Virginia. Lack of statistically significant differences in fox activity in experimental and control areas caused the author to conclude that this technique may not be very promising. However, differences detected on the beach site that is most like other Atlantic Coast plover nesting areas and the occurrence of heavy rains during much of the study period suggest that another trial is warranted, perhaps at another site. Protocols described by Cross (1993) might be replicated at a site where fox activity is high and wild coyotes are absent.

3.43 **Evaluate threats from ghost crabs and develop control techniques, if appropriate.** Several studies (e.g., Cross 1991, Loegering *et al.* 1995) have cited ghost crabs as potentially important predators of piping plovers on Assateague Island, Maryland and Virginia. Other biologists have raised questions about whether ghost crabs may also be an important factor limiting plover nest site selection and/or productivity from North Carolina to New Jersey. Preliminary research conducted in Virginia (Wolcott and Wolcott 1994) was designed to gather information on ghost crab-piping plover interactions and habitat factors affecting ghost crab distributions and abundance, with the intent of eventually testing alternative methods of reducing impacts of ghost crab predation on plovers. Results of the 1994 field work suggest that the extent of direct ghost crab predation on piping plovers may be less significant than previously thought, although responses of adult plovers to ghost crabs indicate that the presence of ghost crabs may deter plovers from using some habitats, and may thereby cause indirect impacts on plover productivity. Testing of correlations between plover use of high energy beaches and occurrence of overwintering ghost crab populations may help elucidate this issue.

3.44 **Develop and test electric fences.** With assistance from USDA-ADC specialists, plover biologists in Maine have experimented with use of electric fences around exclosures to deter "smart predators" that have learned to dig under or climb into exclosures (Maine Audubon Society 1995). These small electric fences must be carefully constructed to avoid any potential harm to plovers and other non-target species. Assistance should be sought from ADC, use should be carefully monitored, and results should be documented.

Mayer and Ryan (1991) found that electric fences enclosing areas of 0.4-2.4 hectare reduced mammalian predation of piping plover nests and chicks in North Dakota. Experience on the Atlantic Coast, however, has found that large electric fences are very difficult to deploy and maintain in coastal areas where salt air corrodes battery terminals and where predators will often wade around fences through the surf zone (C. Hebert and E. Moses, U.S. Fish and Wildlife Service, pers. comm. 1993). If electrification techniques that are less susceptible to corrosion can be devised, further experimentation with electric fences around nesting sites may be warranted.

3.5 **Analyze population trends and productivity rates to monitor plover survival rates.** As noted under delisting criterion 3 (page 58), the PVA (Appendix E) is based on assumptions that may underestimate survival rates for some or all recovery units or the percentage of one year old adults that breed. Although lack of safe marking techniques currently precludes direct measurement of survival rates, they can be estimated using population trend and productivity data; these survival rates and other demographic variables can then be used in stochastic model to verify productivity rates needed to assure a 95% probability that the population will persist for 100 years. Accomplishment of this task is contingent on high quality data on the number of breeding pairs and productivity (see task 1.11).

3.6 **Determine temporal distribution of plover mortality.** Extinction probabilities for piping plovers are highly sensitive to changes in survival rates, but times, locations, and causes of post-fledging mortality are poorly understood. Determining where in the annual cycle (e.g., post-breeding, migration, winter, pre-breeding, breeding) mortality occurs and under what circumstances, as well as the sexes and age classes of affected birds, would greatly facilitate efforts to increase survival of fledged birds. However, lack of safe marking techniques (see discussion under tasks 3.0 and 3.9) and information on migration patterns and wintering locations of the majority of Atlantic Coast plovers (see tasks 2.1 and 2.3) will constrain efforts to better understand plover mortality.

3.7 **Develop a metapopulation model that will estimate extinction probability for the Atlantic Coast piping plover population.** A metapopulation model would more realistically simulate actual population dynamics than the single population model developed by Melvin and Gibbs (Appendix E). This type of model could be especially useful to biologists assessing the impacts of site-specific or regional projects for ESA Section 7 consultations. Such a model would also contribute to evaluation of applications for permits under Section 10(a)(1)(B) of the ESA.

3.8 **Estimate effective population size for the Atlantic Coast piping plover population.** An estimate of the ratio of effective population to total population (N_e/N) for the Atlantic Coast piping plover is needed to evaluate the adequacy of the recovery goal to prevent loss of heterozygosity and allelic diversity over the long term. Determination of N_e/N is of particular concern with regard to piping plovers, because their very sparse distribution results in highly non-random mating. One possible approach would involve refinement of the current Atlantic Coast piping plover demographic model to incorporate mating/distribution patterns, followed by computer simulations to estimate the rate of loss of hypothetical alleles over various time periods. Other approaches should be considered, as appropriate.

3.9 **Develop safe techniques for marking plovers.** As discussed under task 3, the lack of safe techniques to individually mark piping plovers complicates many aspects of piping plover research. Development of a technique for marking birds so that they can be individually identified from a distance would be especially useful to many potential research projects. It is crucial, however, that marking not interfere with the birds' normal behaviors, increase risk of predation, or cause injuries. Experimentation with new techniques must be conducted cautiously, and may need to include pre-testing on non-listed surrogate species.

Dr. S.M. Haig, research biologist with the National Biological Survey and Great Lakes and Northern Great Plains Recovery Team Leader (*in litt.* 1994), has initiated efforts to develop population-specific molecular markers for breeding populations that could be used to trace the origin of wintering birds, and perhaps facilitate other research.

4. **Develop and implement public information and education programs.**

Millions of beach recreationists encounter Atlantic Coast piping plover nesting and wintering areas each year. The responses of these beach users to signs and symbolic fences requesting that they avoid certain areas and/or modify their behavior (for example, by leashing pets or not using kites) can directly affect the productivity and fitness of piping plovers on those beaches. Public information and education (I&E) efforts play a key role in obtaining compliance of beachgoers with plover protection measures that, in turn, affect the birds' recovery. Central messages to the beach-going public include: (1) respect areas fenced or posted for protection of plovers and other rare beach species; (2) do not approach or linger near piping plovers or their nests; (3) if pets are permitted on beaches used by plovers, keep the pets leashed; and (4) don't leave or bury trash or food scraps on beaches, as garbage attracts predators that may prey upon plover eggs or chicks.

Due to the important role of I&E in the plover recovery effort, the USFWS developed an Information and Education Plan for the Piping Plover, Atlantic Coast Population (USFWS 1989b). This plan identifies audiences, materials and forums, strategies for reaching audiences, distribution plans and responsibilities, and costs. I&E materials about piping plovers developed by the USFWS since 1986 include:

Brochures - in English (updated in 1994) and Spanish (1991)
Posters (1986, now out of print)
Postcards (reprinted in 1994)
Public service announcements - radio and television (1990)
Environmental education lesson plans - target audience 5th through 7th grade, includes a scripted slide show (1993)
Interpretive signs

Additionally, the Canadian Wildlife Service; the National Park Service; State, Provincial, and local governments; and private organizations have produced a large array of high quality I&E materials about piping plovers, including posters, brochures, public service announcements, press packages, and interpretive signs in English and French. A 16-minute piping plover video was produced in 1990 by the National Fish and Wildlife Foundation.

Expanded efforts to increase public awareness of protection needs of piping plovers, other rare beach species, and the beach ecosystem are needed.

4.1 **Develop new and updated piping plover information and education materials.** There is a continuing need to develop new piping plover I&E materials to reach new target audiences, take advantage of advancing media, and stimulate continuing public interest and awareness. In addition, all materials must be kept reasonably current regarding the status of the species and protection efforts. At present, there is a need to integrate more information into plover I&E materials about the role of piping plover conservation efforts in protecting the beach ecosystem and about the plight of other rare beach-dwelling species. An updated video is needed, and might be efficiently produced in conjunction with updated public service advertisements. Three line drawings purchased by the USFWS in 1986 and a fourth drawing donated by the artist (Julie Zickefoose) in 1990 have been used extensively over the last decade in brochures, posters, signs, etc., throughout the species' range. A fresh and expanded selection of drawings is now needed.

4.2 **Establish a network for distribution of information and education materials.** While development of I&E materials is a major task, distribution of these materials to target audiences requires an even larger commitment of time and other resources. Atlantic Coast beaches are within a few hours' drive of many major metropolitan areas, resulting in a very large population of potential beachgoers. Some efforts have been aimed at use of mass media, such as radio and television announcements, but the majority of piping plover I&E distribution efforts have targeted specific user groups at beach parking lot entry stations and kiosks, visitor centers, and marinas. I&E materials have been distributed to beach-front homeowners and to applicants for off-road vehicle permits. Environmental education lesson plans contain many participatory activities and have been very popular among elementary and middle school groups. Major distributional efforts have been exerted by State and national parks, national wildlife refuges, and private conservation organizations.

5. **Review progress towards recovery annually and revise recovery efforts as appropriate.**

The piping plover's wide range, intensity of management, and the large number of people involved in its conservation dictate that new information reaches biologists in the field promptly. This ensures that human resources and money are devoted to the highest priority needs.

Communication, evaluation, and coordination must continue to play a major role in plover recovery efforts. The USFWS should continue to compile and distribute annual status updates, and other communication efforts focused on the U.S. Atlantic Coast breeding range must be maintained. If requested by Canadian agencies and organizations, efforts to share information and expertise with biologists in Atlantic Canada should be expanded. Coordination and communication among biologists within the plover's wintering range should also be increased.

PART III: IMPLEMENTATION

The following Implementation Schedule outlines actions and estimated costs for the recovery program in the U.S. portion of the piping plover's Atlantic Coast range over the next three years, beginning in 1997. Responsible organizations and costs for the Canadian portion of the range are not included, since these are covered under the Canadian Piping Plover Recovery Plan (CWS 1989), now under revision.

The U.S. Fish and Wildlife Service believes that projected protection costs could be substantially reduced by selecting protection strategies that are more restrictive of other beach users. For example, 1993 protection costs (average cost per pair) were considerably higher at National Park Service units than those at national wildlife refuges; this is partially due to the costs associated with protecting plovers on NPS beaches that receive heavy public use, whereas refuge beaches are generally closed to public use during the breeding season. While the USFWS believes that it is neither feasible nor desirable to completely eliminate beach recreation in most plover habitat, it also recognizes that management strategies that protect plovers on beaches where public use is also maintained require a continuing commitment of person-power, and are inherently expensive.

The Implementation Schedule lists and ranks tasks that should be undertaken within the next three years. This schedule will be reviewed annually until the recovery objective is met, and priorities and tasks will be subject to revision. Tasks are presented in order of priority.

Key to Implementation Schedule Column 1:

Task priorities are set according to the following standards:

Priority 1: Those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: Those actions that must be taken to prevent a significant decline in species population, or some other significant impact short of extinction.

Priority 3: All other actions necessary to provide for full recovery of the species.

Key to Agency Designations in Column 5:

USFWS - U.S. Fish and Wildlife Service
R5 - USFWS Region 5 (Maine to Virginia)
R4 - USFWS Region 4 (North Carolina to Louisiana)
R2 - USFWS Region 2 (Texas)
ES - USFWS Division of Ecological Services (includes Endangered Species and Contaminants)
RW - USFWS Division of Refuges and Wildlife (includes Realty)
LE - USFWS Division of Law Enforcement
PA - USFWS Public Affairs
ADC - U.S. Department of Agriculture, Animal Damage Control
Corps - U.S. Army Corps of Engineers
FEMA - Federal Emergency Management Agency
USCG - U.S. Coast Guard
NPS - National Park Service
SWA - State Wildlife Management Agencies
SCRA - State Coastal Regulatory Agencies
LMAO - Land Management Agencies and Organizations and other Cooperators. This includes Federal, State, and local land management agencies, private organizations and individuals that own and manage piping plover breeding and wintering habitat, and private conservation groups that provide on-site protection of lands owned by others. The USFWS/RW and NPS are not included in this group; however, the Corps and USCG, in their capacity as owners of piping plover breeding or wintering habitat, are included. A partial listing of agencies and organizations in the LMOA group includes: National Aeronautics and Space Administration, U.S. Air Force, State park and recreation agencies, municipal and county governments, TNC, The Trustees of Reservations, National Audubon Society, Massachusetts Audubon Society, Maine Audubon Society, and Connecticut Audubon Society.
Rsch - Research Institutions

IMPLEMENTATION SCHEDULE

Atlantic Coast Piping Plover Revised Recovery Plan

April 1996

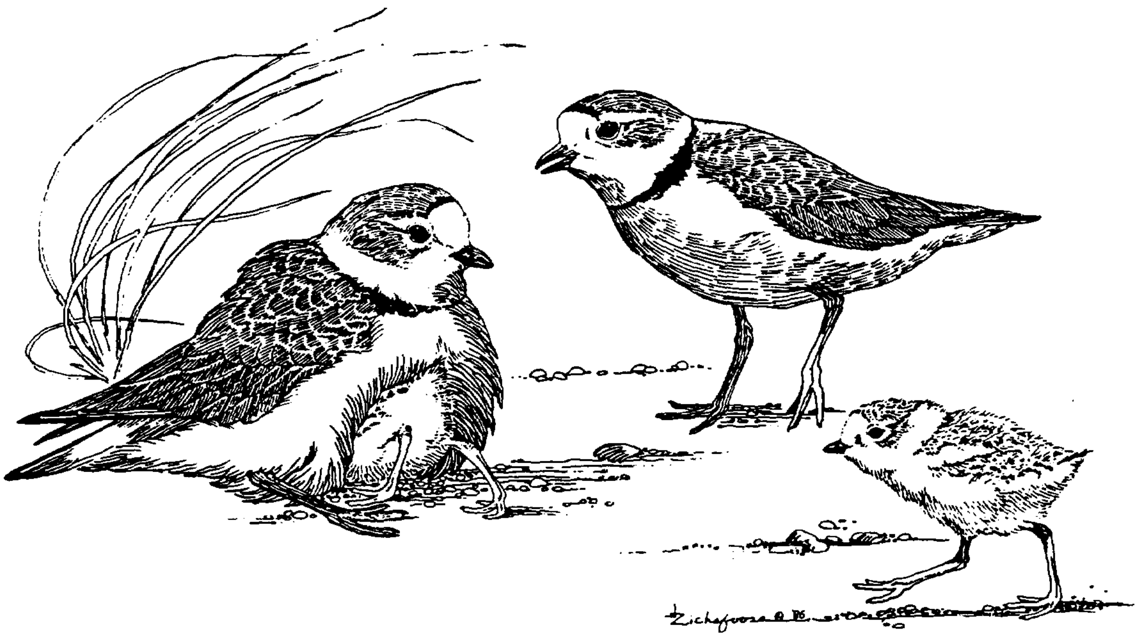
Priority	Task Description	Task Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
1	NY/NJ and Southern Units: Monitor plover breeding activities at nesting sites to identify limiting factors.	1.12	annual	R5 ES,RW R4 ES,RW	SWA LMAO NPS	Included in tasks 1.3 and 1.4			
1	Discourage at current or potential breeding sites: new structures or other developments; interference with natural inlet processes; beach stabilization projects.	1.21 1.22 1.23	ongoing	R5 ES R4 ES	Corps FEMA SWA SCRA NPS LMAO	contingent on numbers and types of projects proposed			
1	NY/NJ and Southern Units: Reduce disturbance of breeding plovers from humans and pets.	1.3	annual	R5 ES,RW,LE R4 ES,RW,LE	SWA LMAO NPS	1150	1200	1250	Includes costs for task 1.12 in NY/NJ and Southern Units. Costs could be reduced by adopting less labor-intensive management practices, but greater impacts on beach users would be incurred.
1	NY/NJ and Southern Units: Reduce predation.	1.4	annual	R5 ES,RW R4 ES,RW	ADC NPS SWA LMAO				
1	Protect breeding plovers and habitat from oil and chemical spills.	1.5	as needed	R5 ES,RW R4 ES,RW	USCG SWA SCRA	contingent on number and magnitude of spills			
1	Protect wintering habitat from shoreline stabilization, navigation projects, and development.	2.21	on-going	R4 ES R2 ES	Corps FEMA NPS SWA SCRA	contingent on numbers and types of projects proposed			
1	Protect wintering plovers and habitat from oil and chemical spills.	2.23	as needed	R4 ES R2 ES	USCG SWA SCRA	contingent on number and magnitude of spills			
2	Monitor plover abundance, distribution and productivity in each recovery unit.	1.11	annual	R5 ES R4 ES	SWA	10	10	10	Cost of data compilation only; data collection by site reflected in tasks 1.3 and 1.4.

Priority	Task Description	Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
2	New England: Monitor plover breeding activities at nesting sites to identify limiting factors.	1.12	annual	R5 ES,RW	SWA NPS LMAO	included in tasks 1.3 and 1.4			
2	Enhance nesting and feeding habitat, especially where existing stabilization projects have disrupted natural coastal processes.	1.24	ongoing	R5 ES,RW R4 ES,RW	Corps NPS SWA LMOA SCRA	25	25	25	
2	New England: Reduce disturbance of breeding plovers from humans and pets.	1.3	annual	R5 ES,RW,LE	SWA NPS LMAO	700	725	750	Includes cost for task 1.12 in New England. Costs could be reduced by adopting less labor-intensive management practices, but greater impacts on beach users would be incurred.
2	New England: Reduce predation.	1.4	annual	R5 ES,RW	ADC NPS SWA LMAO				
2	Monitor abundance and distribution of wintering plovers at known sites.	2.11	annual	R4 ES,RW R2 ES,RW	SWA NPS LMAO	30	30	30	Costs are for NC, SC, GA, and FL.
2	Determine additional wintering sites.	2.12	ongoing	R4 ES R2 ES	SWA LMAO	20	20	20	
2	Identify limiting factors at specific wintering sites.	2.13	ongoing	R4 ES,RW R2 ES,RW	SWA NPS LMAO	25	25	25	
2	Protect wintering plovers from disturbance.	2.22	annual	R4 ES,RW,LE R2 ES,RW,LE	SWA NPS LMAO	40	40	40	Most costs will be incurred in FL.
2	Apprise agencies of threats to wintering piping plovers and habitats.	2.24	ongoing	R4 ES R2 ES	SWA	10	10	10	
2	Update lists of essential wintering habitat.	2.25	ongoing	R4 ES R2 ES	SWA	10	2	2	$10K in FY1 is to compile updates from 1996 International Census.

Priority	Task Description	Task Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
2	Investigate piping plover wintering ecology.	3.1	4 years	R4 ES R2 ES	SWA NPS Rsch	75	75	75	Plus $75K in FY4.
2	Compare foraging resources along Atlantic Coast breeding habitat.	3.21	3 years	R5 ES R4 ES	SWA NPS Rsch	85	85	85	
2	Determine moisture-related requirements of breeding plovers and chicks.	3.22	3 years	R5 ES R4 ES	SWA NPS Rsch	50	50	50	
2	Evaluate impacts of artificial inlet closure and other beach stabilization projects on habitat suitability.	3.23	5 years	R5 ES R4 ES	Corps NPS SCRA Rsch	75	75	75	Plus $75K in FY4 and FY5.
2	Monitor levels of contaminants.	3.3	Ongoing	R5 ES	SWA	20	20	2	
2	Inform and educate the public.	4.	on-going	R5 ES,PA R4 ES,PA	SWA	60	60	60	
3	Provide long-term protection for breeding plovers and habitat.	1.6	7 years	R5 ES,Realty R4 ES,Realty	SWA NPS LMOA	TBD*			
3	Provide long-term protection for wintering plovers and habitat.	2.26	7 years	R4 ES,Realty R2 ES,Realty	SWA NPS LMOA	TBD			
3	Identify important migration habitat.	2.31	ongoing	R4 ES R5 ES	SWA	15	15	15	
3	Identify and mitigate adverse effects on migration habitat.	2.32	TBD	R4 ES R5 ES	SWA	TBD			
3	Develop conditioned taste aversion techniques.	3.41	3 years	R5 ES,RW	ADC NPS SWA	TBD			
3	Test artificial coyote territories.	3.42	2 years	R5 ES	ADC NPS	15	15		

Priority	Task Description	Task Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
3	Evaluate threats from ghost crabs.	3.43	TBD	R5 ES,RW R4 ES,RW	Rsch		TBD		
3	Develop and test electric fences.	3.44	TBD	R5 ES,RW	ADC		TBD		
3	Analyze population trends and productivity to determine survival rates.	3.5	Every 4 years	R5 ES	Rsch		7		Repeat in FY 6.
3	Determine temporal distribution of mortality.	3.6	TBD	R5 ES	Rsch		TBD		
3	Develop a metapopulation model to estimate extinction probability.	3.7	1 year	R5 ES	Rsch	10			
3	Estimate effective population size.	3.8	1 year	R5 ES	Rsch		10		
3	Develop safe plover marking techniques.	3.9	TBD	R5 ES	Rsch		TBD		
3	Review progress and revise recovery efforts	5.	annual	R5 ES	SWA	3	3	3	

* To be determined



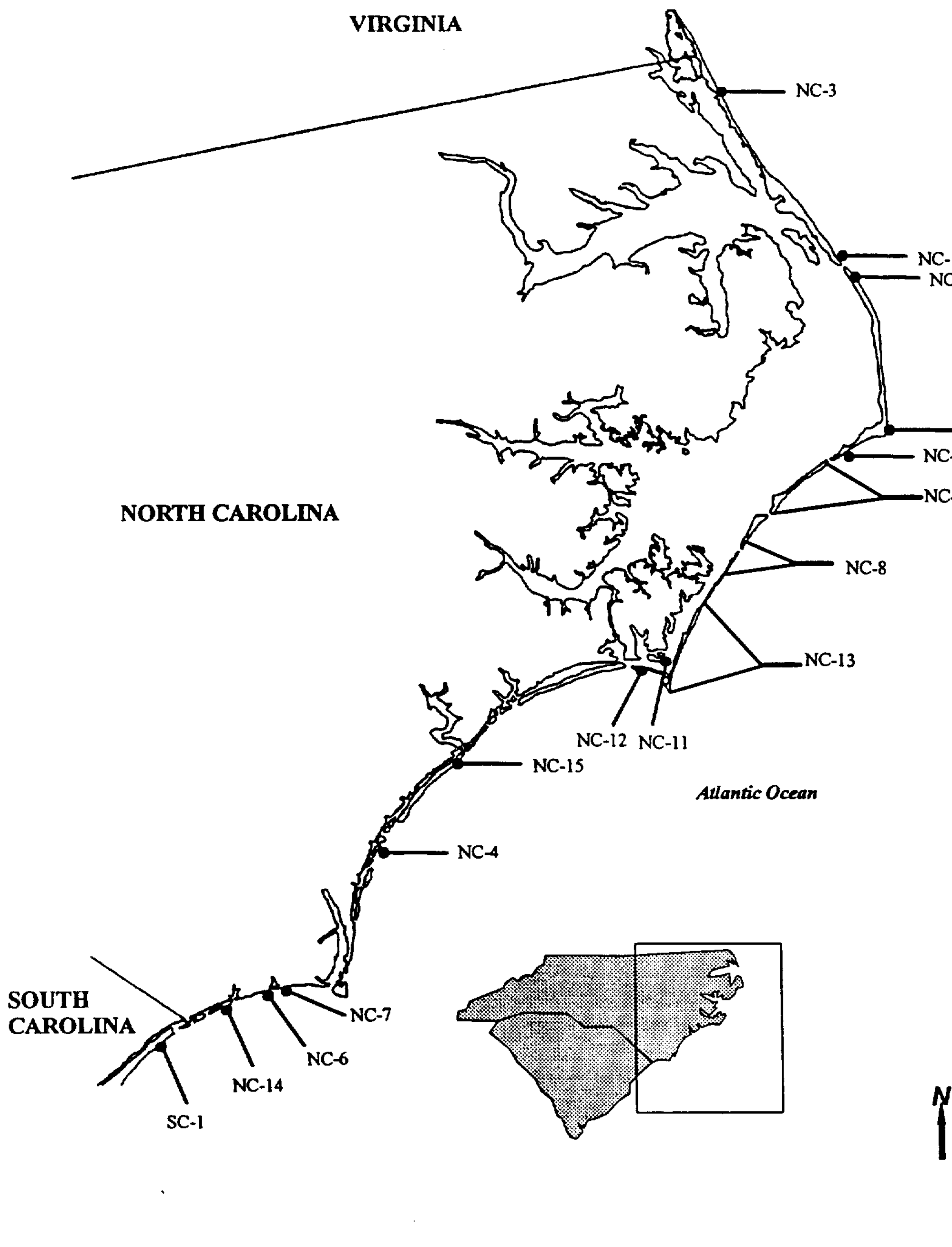
APPENDICES

A. Locations of Current and Potential Breeding Sites
B. Current and Potential Breeding Site Information
C. Summary of Current and Needed Breeding Site Management Activities
D. Summary of Off-Road Vehicle Use at Breeding Sites
E. Population Viability Analysis
F. Guidelines for the Use of Predator Exclosures to Protect Piping Plover Nests
G. Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act
H. Guidelines for the Preparation and Evaluation of Conservation Plans for Atlantic Coast Piping Plovers Pursuant to Section 10(a)(1)(B) and 10(a)(2) of the Endangered Species Act
I. Guidelines for Conducting Surveys for Piping Plovers in Atlantic Coast Wintering Habitat
J. Estimated Cost of U.S. Atlantic Coast Piping Plover Protection Activities During the 1993 Breeding Season
K. Known Piping Plover Wintering Sites on the Southern Atlantic Coast and the Caribbean
L. Summary of Comments on Draft Revised Recovery Plan and USFWS Responses

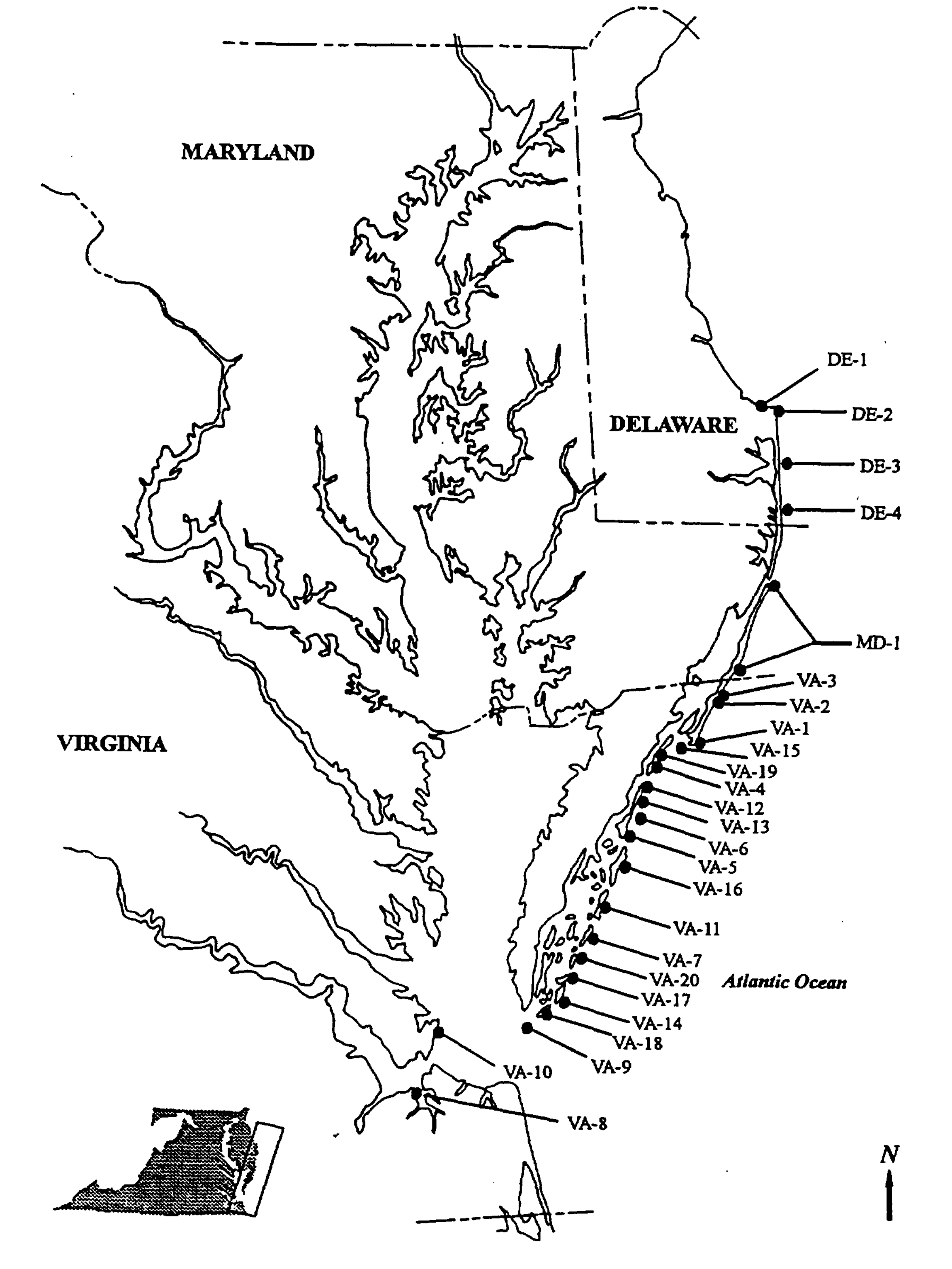
APPENDIX A: LOCATIONS OF CURRENT AND POTENTIAL BREEDING SITES

The following maps show locations of the current and potential U.S. Atlantic Coast piping plover breeding sites described in Appendices B, C, and D. Site numbers on the maps are referenced to the numbers in parentheses after site names in the left-hand column of each successive table.

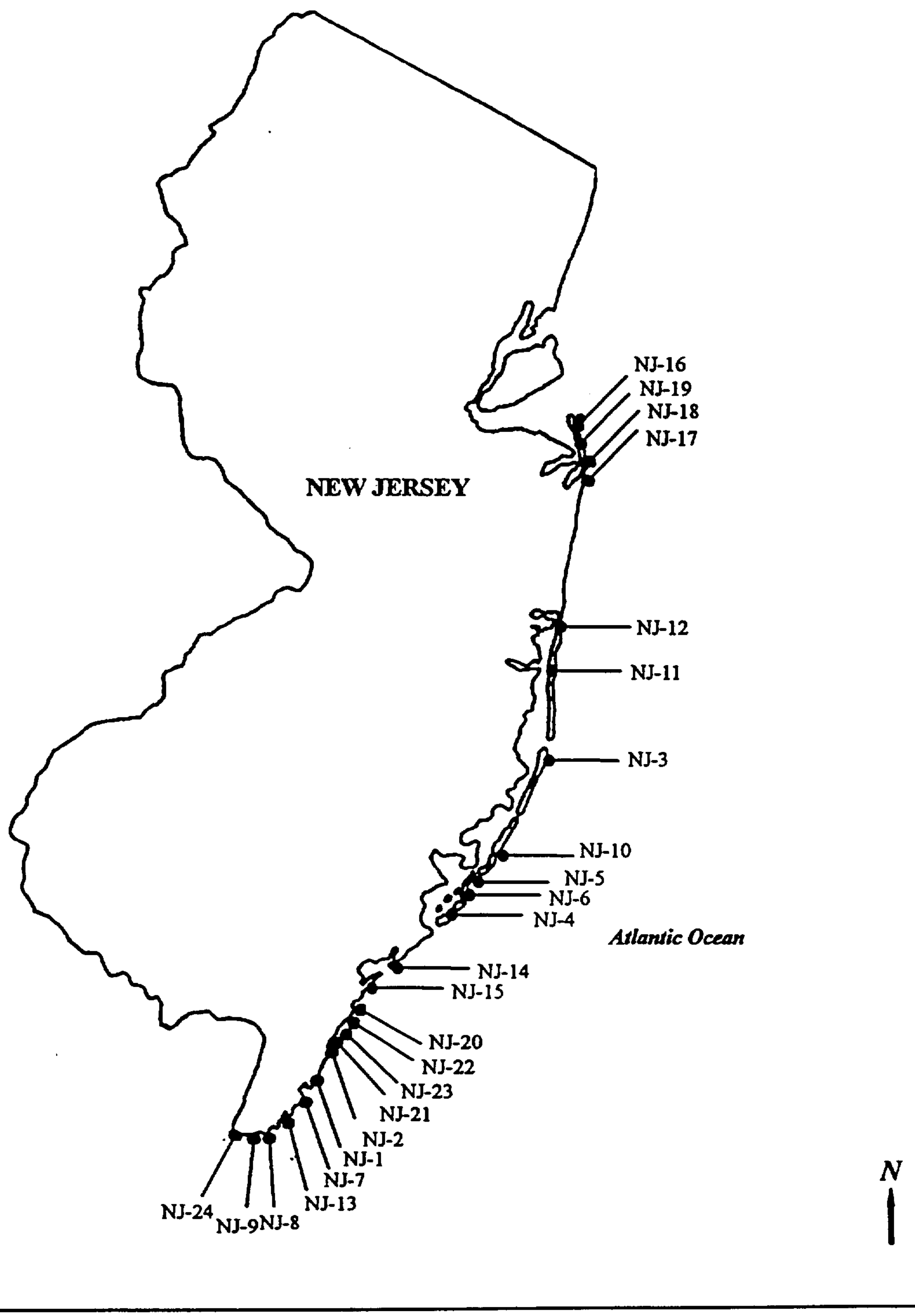
North Carolina Sites



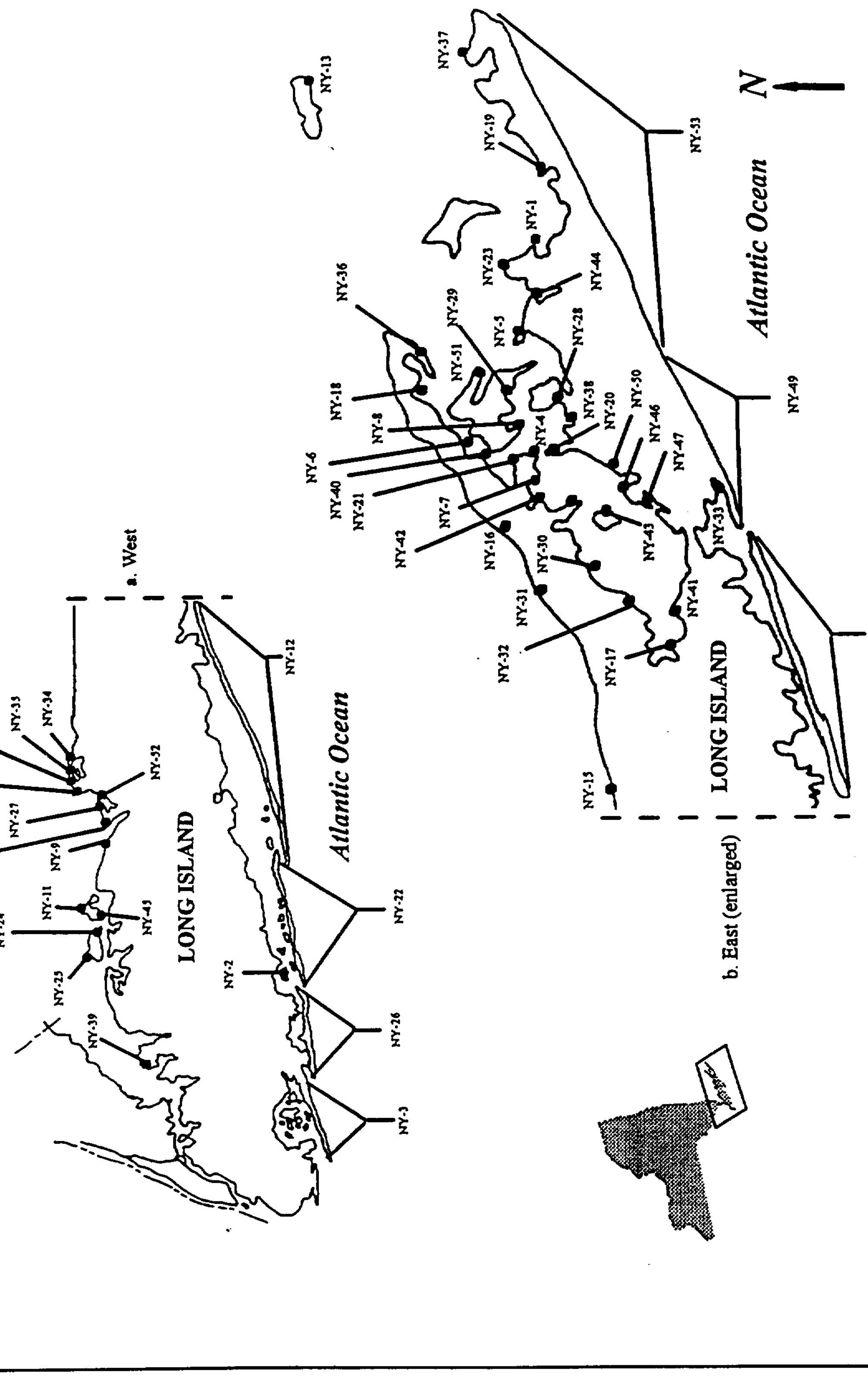
Delaware, Maryland, and Virginia Sites



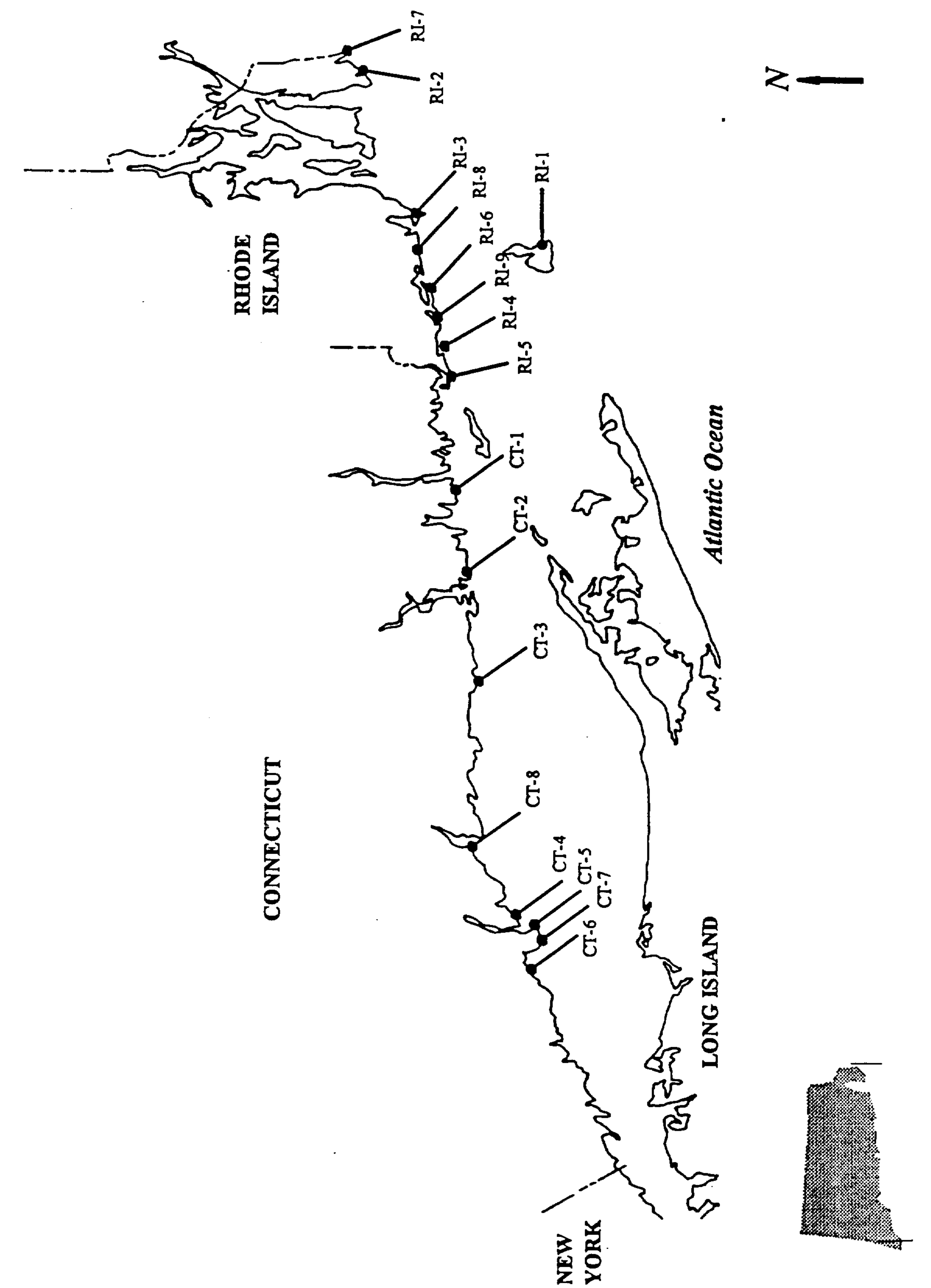
New Jersey Sites



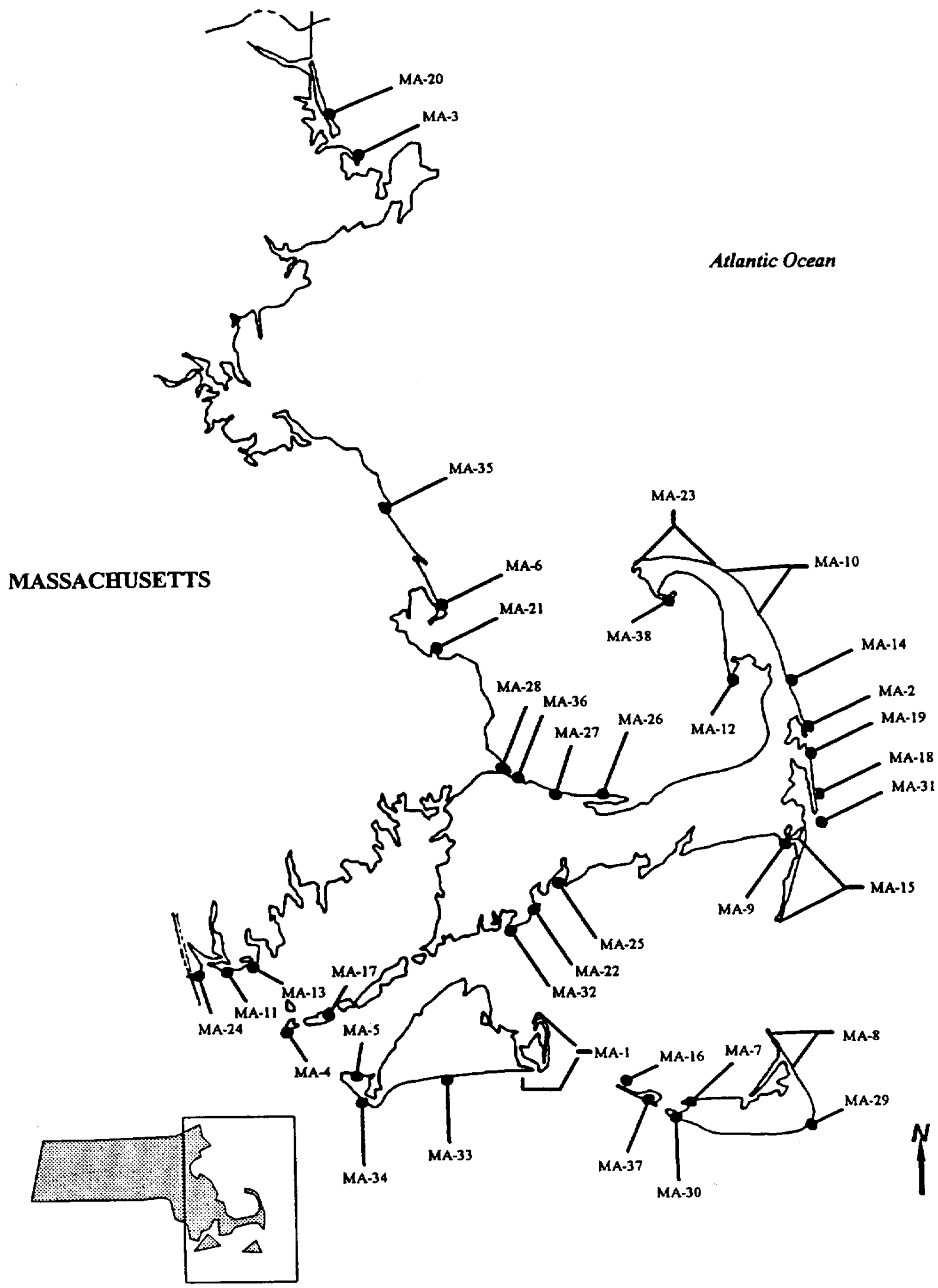
Long Island, New York Sites



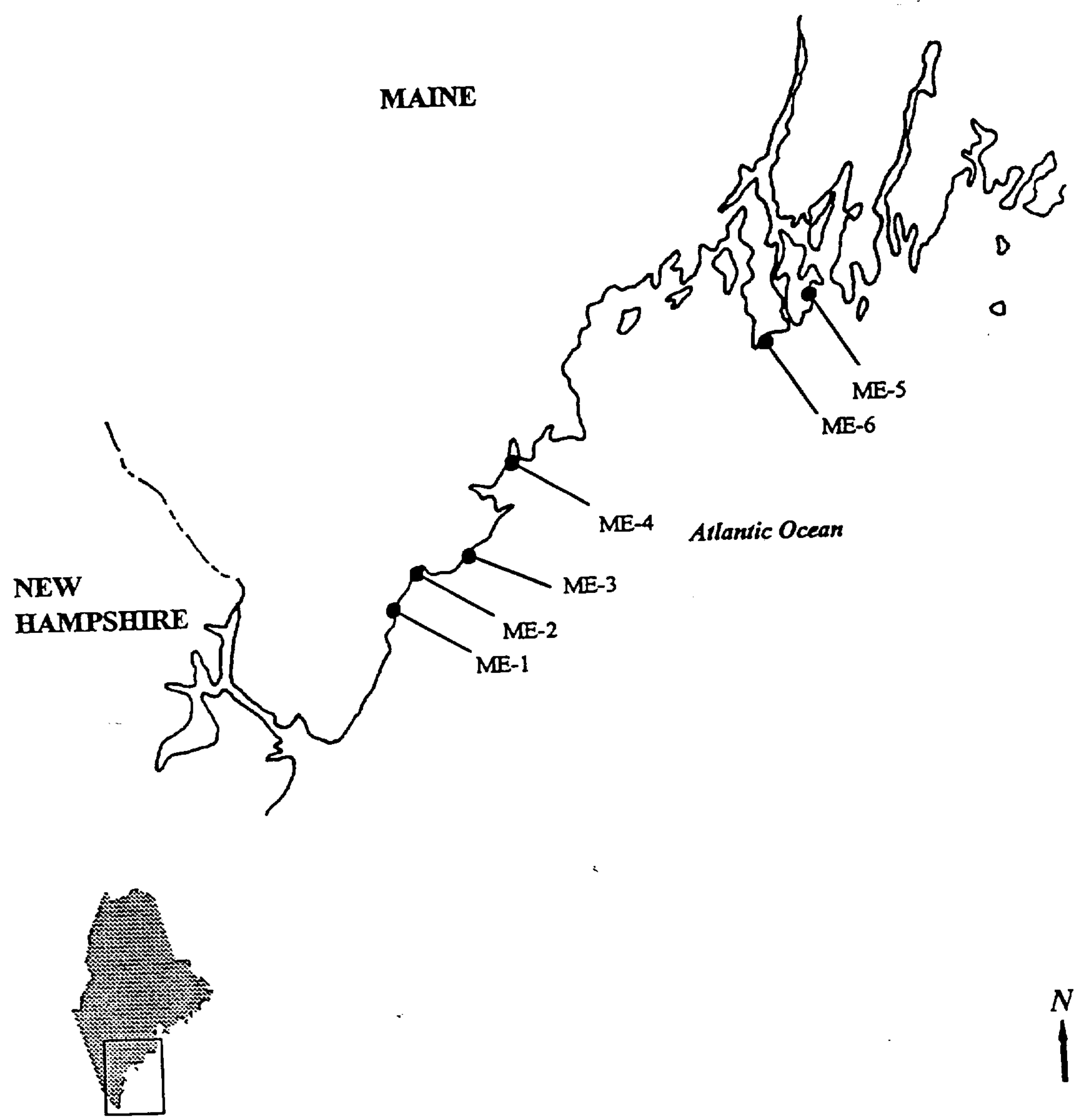
Connecticut and Rhode Island Sites



Massachusetts Sites



Maine Sites



APPENDIX B:
CURRENT AND POTENTIAL BREEDING SITE INFORMATION

This table provides site-specific information about current plover use of U.S. Atlantic Coast breeding sites, estimated site capacity, rare species co-occurring on these sites, and site ownership.

The term "site" merits some discussion in this context. In some portions of the piping plover's range, breeding sites are naturally discrete and their limits are easily defined. In other areas, habitat is more continuous, and current use by piping plovers may be highly dispersed. In still other areas, once continuous stretches of habitat have been subdivided by shoreline stabilization structures, creating two or more smaller sites where larger ones once existed. Some sites have several landowners; in other cases, a single landownership contains several piping plover nesting sites. Some States define their sites in terms of the nearest access point (as a means of communicating the location of nesting concentrations), thereby subdividing some continuous stretches of habitat. One State defines an island to be a site, while another considers the clusters of breeding pairs at each end of a barrier island to be separate sites. A site, therefore, is an ambiguous concept, often artificially imposed on habitat areas. This limits the usefulness of current or potential numbers of breeding pairs in an area as a means of evaluating the importance of a site to the conservation of this species.

Capacity estimates (column 4) represent a conservative appraisal of carrying capacity in 1993. As noted on pages 30-31, these estimates were developed for the purpose of facilitating the population viability analysis, Appendix E. However, this recovery plan is premised on the recognition that piping plover habitat is inherently dynamic, and that the carrying capacity of individual sites is subject to change over time. These carrying capacity estimates, which reflect habitat conditions and piping plover breeding densities observed in 1993, should *not* be interpreted as site-specific management goals. Any use of carrying capacity projections for local management purposes or as a measure of management effectiveness must be based on current habitat conditions and updated as those conditions change over time. For example, the Massachusetts Division of Fisheries and Wildlife reviewed and revised its estimates of carrying capacity in 1995, as an important component of the conservation planning strategy for their application for incidental take under Section 10 of the ESA (see Appendix H).

The depth of available information about piping plover breeding activities varies among States and, in some cases, within States. Virginia biologists noted that due to the highly dynamic character of their unstabilized barrier islands, habitat suitability and carrying capacity of individual islands is especially subject to fluctuations over time. However, they expressed confidence that overall carrying capacity within Virginia can be maintained if natural coastal formation processes remain unimpeded. Biologists in New York and North Carolina have expressed particular concern about the accuracy of their site capacity estimates and caution that new information may warrant revised projections. As in Virginia, North Carolina biologists cautioned that suitability of individual sites fluctuates over very short time frames.

KEY TO "OTHER RARE SPECIES" AND "OWNER" COLUMNS

OTHER RARE SPECIES CO-OCCURRING ON SITES:

AO	American oystercatcher
AP	*Amaranthus pumilus*
AT	Arctic tern
BP	brown pelican
BS	black skimmer
Cdd	*Cicindela dorsalis dorsalis*
Cdm	*Cicindela dorsalis media*
CT	common tern
GBT	gull-billed tern
LT	least tern
LOG	loggerhead turtle
PF	peregrine falcon (breeding)
WP	Wilson's plover
F	Federally-listed species
H	historic occurrence
S	State-listed species

OWNER:

P	Private (except TNC and TTOR)
S	State
TNC	The Nature Conservancy
TTOR	The Trustees of Reservations
NPS	National Park Service
NASA	National Aeronautics and Space Administration
Corps	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
NES	National Estuarine Sanctuary
FWS	U.S. Fish and Wildlife Service
C	County
M	Municipal
U	Unknown

NOTE: In all States except Maine, Massachusetts, and some parts of Virginia, the State holds title to the intertidal zone. To save space on this table, State ownership of this area has not been shown for each site. However, the intertidal zone is an extremely important component of piping plover habitat.

U.S. ATLANTIC COAST PIPING PLOVER BREEDING SITE INFORMATION

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
SOUTH CAROLINA						
Waites Island (SC-1)	1	U	2	spring, fall, winter use	WP,LT,AO	State/university
NORTH CAROLINA						
Bodie Island (So. end) (NC-1)	0	-	2	frequent use; winter use also	WP, LT, AO	NPS
Cape Hatteras Point (NC-2)	5 to 6	0.66	12	fall migration	GBT^S, WP, BS^S, AT, AP^F, CT, LT, Sooty tern, AO, LOG^F	NPS
Currituck Outer Banks (NC-3)	2	0.5	10	spring and fall migration	AP^F, LT	FWS/P
Figure 8 Island (NC-4)	0	-	2	migratory and winter use (increasing)	AP^F, LOG^F, AO, LT, CT, BS	P
Hatteras Inlet (No. side) (NC-5)	3	0.66	8	frequent use	AP^F, BS^S, CT, LT, AO, WP, GBT^S	NPS
Holden Beach/Shallote Inlet (NC-6)	4	1.0	6	winter use	AP^F, LOG^F, AO, willet, *Sesuvium portulacastrum*	P
Long Beach/Lockwood Folly's Inlet (NC-7)	0	-	1	winter use	AP^F, LOG^F, AO, WP, willet	P
North Core Banks (NC-8)	28	0.68	51	significant numbers; winter use also	AP^F, LT, LOG^F, GBT^S, BS^S, CT, WP, AO	NPS
Ocracoke Island (No. and So. ends) (NC-9)	3	0.33	8	low numbers	AP^F, LT, LOG^F, AO, CT	NPS
Pea Island NWR (NC-10)	0	-	1		LOG^F, LT, CT, AO, BS^S, GBT^S	FWS
Rachel Carson's Estuary/Bird Shoals (NC-11)	0	-	1	migratory and winter use	WP, LT, AO, BS^S, CT, GBT^S, willet	NES
Shackleford Banks (NC-12)	0	-	3	some winter use	GBT^S, WP, CT, BS^S, LT, AO, willet	NPS
South Core Banks (NC-13)	7	1.0	16	significant use	AP^F, GBT^S, BS^S, LOG^F, CT, LT, WP, AO	NPS

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Sunset Beach (NC-14)	0	-	1		LT, CT, BS^{S}, AP^{F}, LOG^{F}	P
Topsail Beach (NC-15)	1	U	1		AP^{F}, LOG^{F}, LT, CT, BS^{S}, AO, WP, LOG^{F}, willet	P
VIRGINIA						
Assateague/Tom's Cove Hook (VA-1)	17	1.24	35	√	Cdm, LT^{S}, WP^{S}, AO	FWS
Assateague/Wash Flats (VA-2)	0	0	10	√	PF^{F}, LT^{S}	FWS
Assateague/Wild Beach (VA-3)	10	0.8	25	√	Cdm, AO, LT^{S}	FWS
Assawoman Island (VA-4)	10	2.0	20	√	WP^{S}, LT^{S}, Cdm, AO, CT, GBT^{S}, BS	FWS
Cedar Island (VA-5)	12	U	20	√	WP^{S}, LT^{S}, CT, Cdm, AO, BS	FWS/P/TNC
Cedar Sandbar (VA-6)	0	-	5	√	LT^{S}, CT, GBT^{S}, BS, AO, Cdm	FWS/P
Cobb Island (VA-7)	4	U	10	√	WP^{S}, PF^{F}, LT^{S}, CT, AO, heronry, BS, GBT^{S}	TNC
Craney Island (VA-8)	5	1.4	15	√	WP^{S}, LT^{S}, Am. avocet, black-necked stilt, short-eared owl	Corps
Fisherman Island (VA-9)	0	-	10	√	PF^{F}, Cdm, AO, heronry, royal tern, sandwich tern	FWS/P
Grandview Beach (VA-10)	0	-	15	√	AO, LT^{S}, Cdm	M
Hog Island (VA-11)	1	U	5	√	PF^{F}, CT, LT^{S}, AO, heronry, Cdm, GBT^{S}, BS	TNC
Metompkin Island, North (VA-12)	28	1.75 (4 pairs)	50	√	WP^{S}, PF^{F}, CT, LT^{S}, GBT^{S}, BS, AO, Cdm	FWS/TNC
Metompkin Island, South (VA-13)	0	-	10		AO, BS, CT, Cdm, GBT^{S}	TNC
Myrtle Island (VA-14)	9	U	20	√	Cdm, AO, WP^{S}, CT, GBT^{S}	TNC
New Island (VA-15)	0		5	√	AO, CT, BS, Cdm	S
Parramore Island (VA-16)	0	-	5	√	PF^{F}, Cdm, AO	TNC/USCG

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Ship Shoal (VA-17)	1	U	5	√	WP^{S}, Cdm	TNC
Smith Island (VA-18)	4	U	10	√	WP^{S}, AO, Cdm	TNC/P
Wallops Island (VA-19)	3	1.33	10	√	PF^{F}, WP^{S}, LT^{S}, AO	NASA
Wreck Island (VA-20)	2	U	5	√	WP^{S}, AO, GBT^{S}, CT, BS, heronry	S
MARYLAND						
Assateague Island National Seashore (MD-1)	19	1.7	45	fall migration stopover	Cdm^{S}, AP^{FH}, CT, LT, WP^{S}, AO, *Susuvium maritima*^{S}, roseate tern^{FH}, *Cicindela lepida*, major migratory shorebird stopover (esp. in fall)	NPS/S
DELAWARE						
Beach Plum Island Nature Preserve (DE-1)	0	-	2 to 3		LT, CT^{H}, GBT^{H}, *Cicindela marginata, Cicindela hirticollis*	S
Cape Henlopen State Park (DE-2)	2	.25	6 to 8	√	LT, roseate tern^{FH}, *Cicindela lepida*, CT, Forster's tern^{H}, BS^{H}, PF^{F}, major migratory shorebird stopover	S
Delaware Seashore State Park (DE-3)	1 pair seen through mid-May	0	8	√	AP^{HF}, LT, AO, BS^{H}, CT^{H}, royal tern^{H}	S
Fenwick Island State Park (DE-4)	0	-	1 to 2	√	LT, AO	S
NEW JERSEY						
Avalon Complex - Avalon Dunes and Avalon North (NJ-1)	8	0.25	14		LT^{S}, Cdm^{H}	M
Avalon Complex - Townsend's Inlet (NJ-2)	1	1.00	5	fall migration	LT^{S}, Cdm^{H}	M
Barnegat Light (NJ-3)	12	0.67	15	spring, post-breeding, fall	LT^{S}, BS^{S}, CT, AO, Cdd^{FH}	M
Brigantine Beach, South (NJ-4)	8	.38	20	spring	LT^{S}, Cdm^{H}	M

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Brigantine Inlet - Brigantine Inlet (NJ-5)	0	-	6	especially in spring	Cdm^{H}	S
Brigantine Inlet - Little Beach (NJ-6)	19	1.1	>25	probably	Cdm, LT^{S}	FWS
Champagne Island (Hereford Inlet) (NJ-7)	0	-	3	fall migration	LT^{S}, BS^{S}, CT, AO, Cdm^{H}	U
Coast Guard North (Two Mile Beach) (NJ-8)	0	-	5	occasional spring	LT^{S}	USCG
Coast Guard South (NJ-9)	6	0.67	8		LT^{S}	USCG/P/M
Holgate (NJ-10)	14	.36	25	large numbers post-breeding on So. end	Cdd^{HF}, BP, LT^{S}, BS^{S}	FWS
Island Beach State Park (NJ-11)	0	-	14	fairly high numbers in spring	LT^{S}, Cdd^{FH}	S
Mantoloking Beach (NJ-12)	4	1.5	8		Cdd^{FH}	P/M
North Wildwood (NJ-13)	5	0	8		LT^{S}, Cdm^{H}	M
Ocean City Complex - Longport (NJ-14)	0	-	4	used in spring; fall use possible		P
Ocean City Complex - Waverly Beach (NJ-15)	1	0	5	post-breeding use	LT^{S}	M
Sandy Hook - Coast Guard Beach (NJ-16)	6	2.00	8	possible spring use	LT^{S}, Cdd^{F} (reintroduction experiment conducted in 1994 and 1995)	USCG
Sandy Hook - Critical Zone (NJ-17)	5	0.6	5			NPS
Sandy Hook - Gunnison Beach (NJ-18)	5	2.5	20			NPS
Sandy Hook - North Beach (NJ-19)	9	2.2	25			NPS
Sea Isle City Complex - Corson's Inlet (NJ-20)	5	1.2	10	spring, post-breeding, fall	LT^{S}, BS^{S}, AO, Cdm^{H}	S
Sea Isle City Complex - Sea Isle City (NJ-21)	6	1.0	12			M
Sea Isle City Complex - Strathmere (NJ-22)	6	.33	12	spring, post-breeding, fall	LT^{S}, BS^{S}, AO, Cdm^{H}	M
Sea Isle City Complex - Whale Beach (NJ-23)	4	1.00	14	post-breeding and fall	LT^{S}	M
South Cape May Meadows (NJ-24)	3	1.33	6	post-breeding	LT^{S}, CT, BS^{S}	TNC

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
			NEW YORK			
Accabonac Harbor (NY-1)	4[1]		6	probable	LT^{S}	M
Alder Island (NY-2)	1[1]		U	U	AO	M
Breezy Point to Far Rockaway (NY-3)	22[1]	*NPS*: 1.53 (15 pairs) *private*: 0.77 (13 pairs)	≥45	post-breeding concentrations at Breezy Point in 1988, 1989, 1991, 1993	*NPS*: LT^{S}, roseate tern^{F}, CT^{S}, AP^{F}, BS^{S} *private beach*: LT^{S}	NPS/P/M
Cedar Beach Point (NY-4)	0[1]		2	U	LT^{S}, osprey^{S}	M
Cedar Point (NY-5)	4[1]		8	probable	LT^{S}	C
Conkling Point (NY-6)	2[1]		2 to 3	U	LT^{S}, CT^{S}	P
Corey Creek Mouth (NY-7)	0[1]	0 (1 pair)	2	U	LT^{S}, osprey^{S}	P
Crab Creek/Shell Beach (NY-8)	4[1]		11	probable	LT^{S}	M/P
Crab Meadow Beach (NY-9)	1[1]		3	U	LT^{S}	M/P
Cutchogue Harbor (NY-10)	1[1]	1.0	4	U	LT^{S}, osprey^{S}	TNC/P
Eatons Neck Point (NY-11)	0[1]		6	probable	LT^{S}, CT^{S}, BS^{S}	P/USCG
Fire Island (NY-12)	11[1]	1.62 (8 pairs)	45	yes	LT^{S}, AP^{F}, Cdd^{FH}, *Polygonum glaucum*	NPS/S/C/P/M
Fishers Island (NY-13)	1[1]		U	U	LT^{S},AO	P
Flax Pond Beach (NY-14)	0[1]		2	U	LT^{S}	M/P/S
Fresh Pond Landing (NY-15)	1[1]	0	2	U	LT^{S}, osprey^{S}	S
Goldsmith Inlet (NY-16)	0[1]		≥1	U	LT^{S}	C
Goose Creek Flanders Bay (NY-17)	0[1]		1	U	LT^{S}, CT^{S}	C

[1] Estimates of nesting pairs for New York sites are a drawn from a "window" census and may differ from estimates shown in other reports or from the number of pairs on which productivity data is based.

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Gull Pond West (NY-18)	0[1]		2	U	LT[S]	M/P
Hicks Island/Goff Point (NY-19)	2[1]		≥4	yes	roseate tern[F], LT[S], CT[S], BS[S], AO	S
Jessup Neck (NY-20)	1[1]	1.0	3	yes	LT[S], post-breeding roseate terns[F]	FWS/C
Jockey Creek Spoil Island (NY-21)	0[1]		U	U	CT[S], LT[S]	P
Jones Island (NY-22)	39[1]	1.30 (47 pairs)	50 to 60	yes	roseate tern[F], LT[S], CT, AP[F], Cdd[FH], BS[S], *Polygonum glaucum*	S/M/P
Lionhead Beach (NY-23)	1[1]		3	U	LT[S]	P/M
Lloyd Neck East Beach (NY-24)	0[1]		U	U	LT[S], CT[S]	FWS
Lloyd Point (NY-25)	1[1]		4	probable	LT[S], CT[S]	S/P
Long Beach Island (NY-26)	19[1]		≥ 21	yes	LT[S], Cdd[FH]	M/C/P
Long Beach Peninsula (NY-27)	0[1]		4	U	LT[S]	M/P
Long Beach Sag Harbor (NY-28)	0[1]		4	U	LT[S]	M
Majors Point to Gibsons Beach (NY-29)	3[1]		6 to 8	yes	LT[S], osprey[S], *Polygonum glaucum*	TNC
Marratooka Point to Kimogener Point (NY-30)	0[1]		2	U	LT[S], osprey[S]	P
Mattituck Inlet (NY-31)	0[1]		2	U	osprey[S], LT[S], CT[S]	M/P
Miamogue Point/Jamesport Town Beach (NY-32)	2[1]	0	3	U	LT[S]	M
Middle Pond Inlet (NY-33)	1[1]	0	2	yes	LT[S]	M/P
Mount Misery Point (NY-34)	0[1]		5	U	roseate tern[F], LT[S], CT[S]	C
Old Field Beach (NY-35)	0[1]		4	U	LT[S], CT[S]	M/C
Orient Beach (NY-36)	5[1]	1.9 (7 pairs)	12	yes	LT[S], osprey[S], *Polygonum glaucum*	S
Oyster Pond (NY-37)	2[1]		U	U		S
Pine Neck (NY-38)	2[1]		4	U	LT[S]	M
Plum Point (NY-39)	0[1]		U	U	LT[S]	P
Port of Eygpt (NY-40)	3[1]		3	U	LT[S], CT[S], BS[S], roseate tern[F]	P

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Red Cedar Point/Red Creek Pond (NY-41)	1[1]		6	probable	LT[S], CT[S]	P/U
Richmond Creek (NY-42)	0[1]		2	U	LT[S]	P
Robins Island (NY-43)	0[1]		2	U	LT[S], osprey[S]	P
Sammys Beach Peninsula (NY-44)	1[1]		5	probable	LT[S], CT[S], roseate tern[F], BS[S], AO	M
Sand City (NY-45)	2[1]		≥5	probable	LT[S], CT[S], BS[S]	M
Sebonac Creek (NY-46)	3[1]		4	probable	LT[S]	P
Sebonac Neck (NY-47)	3[1]	3.5 (2 pairs)	4	probable	LT[S]	M/P
Short Beach (NY-48)	3[1]		4	U	LT[S]	M
Southhampton Beach to Fairfield Pond Lane Beach (NY-49)	4[1]		20 to 30	probable	LT[S], AP[F], Cdd[FH]	C/P/M
Towd Neck/Wooley Pond (NY-50)	0[1]		6	U	LT[S]	P/M
Upper Beach/Lower Beach (NY-51)	1[1]		5	U	LT[S], *Polygonum glaucum*	M/C
Youngs Island (NY-52)	0[1]		2	U	LT[S], CT[S]	M
Wainscott Pond to Montauk Beach (NY-53)	6[1]		15 to 20	probable	LT[S], Cdd[FH]	S/M
West Meadow Beach (NY-54)	0[1]		3	U		M/P
Westhampton Island (NY-55)	36[1]	0.76 (29 pairs)	50 to 60	yes	LT[S], AP[F], BS[S], CT[S], AO, Cdd[FH], *Polygonum glaucum*	M/C/P
CONNECTICUT						
Goshen Cove (CT-1)	1	2.0	3			S/P
Griswold Point (CT-2)	7	.29	10		LT[S], Cdd[FH]	TNC/M/P
Hammonasset Beach (CT-3)	1	0	7		LT[S], AO[S]	S/P
Housatonic River Complex - Milford Point (CT-4)	3	.66	8 to 10		LT[S]	S/FWS
Housatonic River Complex - Short Beach (CT-5)	1	0	5		LT[S]	M
Lewis Gut Complex - Pleasure Beach (CT-6)	1	0	10 to 15		LT[S]	M

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Lewis Gut Complex - Long Beach (CT-7)	6	.5	15		LT[S]	M
Sandy Point (CT-8)	3	0	15		LT[S]	M
RHODE ISLAND						
Block Island (RI-1)	0	-	U			FWS/U
Briggs Beach (RI-2)	4	0	7	limited		P
East Matunuck State Beach (RI-3)	1	U	3			S
Maschaug Beach (RI-4)	4	4.0	8		LT	P
Napatree Point (RI-5)	4	1.0	7		AO, LT, large concentration of post-breeding roseate terns[F]	M/P
Ninigret (RI-6)	2	3.0	10		LT	FWS/S/P
Quicksand Pond (RI-7)	8	2.6	15	significant use	LT	TNC
Trustom Pond (RI-8)	8	0.9	10	√ (low numbers)	LT	FWS
Weekapaug (RI-9)	0		5 to 10			Fire Dist.
MASSACHUSETTS						
Chappaquiddick Island (Norton Point to the Gut) (MA-1)	9	1.33	40	√	LT[S], AO, CT[S], Cdd[FH]	C/P/S/M/ TTOR
Coast Guard Beach (MA-2)	8	1.25	10	√	LT[SH]	NPS
Crane Beach (MA-3)	18	1.94	25	√	LT[S]	TTOR
Cuttyhunk Island (MA-4)	5	2.25 (based on 4 pairs)	7		LT[S], CT[S]	P
Dogfish Bar, Martha's Vineyard (MA-5)	4	1.25	5			P
Duxbury Beach (MA-6)	4	2.0 (based on 4 pairs)	15		LT[S]	M
Eel Point (MA-7)	1	3.0	5	pre-breeding	AO	P

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Great Point/The Galls (MA-8)	9	1.0	25	use probable, surveys needed	LT^S, northern harrier^S	FWS/TTOR/ USCG
Harding Beach (MA-9)	1	4.0	3		LT^S	M
Head of the Meadows to Cahoon Hollow (MA-10)	1	3.0	10			NPS/M
Horseneck Beach/Gooseberry Neck (MA-11)	6	1.67	12		Cdd^F	S/P/M
Jeremy Pt./Great Island (MA-12)	6	1.83	10			NPS/P
Little Beach/Barney's Joy (MA-13)	11	2.2 (based on 10 pairs)	15	√	LT^S	P
Marconi Beach (LeCount Hollow to Nauset Light Beach) (MA-14)	9	2.44	15		Cdd^{FH}	NPS/M
Monomoy Islands (MA-15)	4	2.0	>30	√	LT^S, roseate tern^F, CT^S, short-eared owl^S, northern harrier^S	FWS
Muskeget Island (MA-16)	7	U	10		short-eared owl^S	P/M
Nashawena Island (MA-17)	2	4.0	10		LT^S	P
Nauset Beach (Chatham & Orleans) (MA-18)	16	2.25	50			M/P
Nauset Spit (Plover Island - Orleans) (MA-19)	21	1.71	30	√	LT^S, CT^S, AO, BS, AT	M
Plum Island (MA-20)	10	2.1	20	√	LT^S	FWS/S
Plymouth Beach (MA-21)	4	1.0	10	√	LT^S, roseate tern^F, CT^S, arctic tern^S	M
Popponesset Spit (MA-22)	3	U	4		LT^S	P/M
Race Point Beach to High Head (MA-23)	29	2.07	60	√	LT^S, *Mertensia maritima*	NPS
Richmond Pond/Cockeast Pond/Acoaxet (MA-24)	1	1.0	4			P
Sampson's Island - Dead Neck (MA-25)	6	0.17	6			P
Sandy Neck (MA-26)	15	2.47	25	√	LT^S	M
Scorton Creek/East Sandwich (MA-27)	6	1.83	6			M/P
Scusset Beach (MA-28)	4	2.25	5			S

SITE	1993 NESTING PAIRS	1993 PRODUCTIVITY Chicks/Pair	ESTIMATED CAPACITY (Pairs)	MIGRATORY PLOVER USE	OTHER RARE SPECIES	OWNER
Siasconset/Low Beach/Tom Nevers (MA-29)	1	0	≥20		LT[SH], northern harrier[S]	USCG/M/P
Smith Point (MA-30)	0	-	≥5	possible; need surveys	post-breeding roseate terns[F]	P/M
South Beach Island (MA-31)	13	2.15	30	√	LT[S], CT[S], AO, northern harrier[S]	M
South Cape Beach/Washburn Island (MA-32)	3	2.33	5		LT[S]	S
South Shore, Martha's Vineyard (Chilmark Pond to Edgartown Great Pond) (MA-33)	6	1.67	30			P, TTOR
Squibnocket Beach (MA-34)	4	3.0	7		Cdd[F], AP[FH]	P
Third Cliff (MA-35)	3	1.67	3	√		U.S. Air Force/M/P
Town Neck/Springhill - Sandwich (MA-36)	4	0.5	6		LT[S]	M/P
Tuckernuck Island (MA-37)	0	_	≥5		northern harrier[S], short-eared owl[S]	P
Wood End/Long Point - Provincetown (MA-38)	7	2.57	15			NPS
MAINE						
Crescent Surf/Laudholm Beaches (ME-1)	5	4.0	8	some migratory use	LT[S], occasional roseate tern[F] feeding	FWS/M/P
Goose Rocks/Batson River (ME-2)	2	3.5	4		LT[S]	P
Higgins Beach/Ram Island (ME-3)	3	1.7	5			P
Pine Point/Western Beach (ME-4)	3	3.0	5		LT[S] (occasional use), harlequin duck wintering site	M/P
Reid State Park (ME-5)	3	1.7	5			S
Seawall/Popham/Hunnewell Beach (ME-6)	15	1.7	25	post-breeding concentrations	RT[F], LT[S]	S/P

APPENDIX C:
SUMMARY OF CURRENT AND NEEDED BREEDING SITE MANAGEMENT ACTIVITIES

This table provides site-specific summaries of current management on U.S. Atlantic Coast breeding sites and identified needs for additional management.

The depth of available information about piping plover breeding activities varies among states and, in some cases, within states. Biologists in New York and North Carolina have expressed particular concern that management needs may not have been comprehensively identified.

KEY TO ADDITIONAL MANAGEMENT NEEDS:

BOAT	Control boat landings
COOP	Seek landowner cooperation
DUNE	Discontinue and/or modify artificial dune building activities
ENF	Additional enforcement of protective rules/regulations
FER	Control feral animals
I&E	Additional efforts to inform and educate beach users
MOA	Obtain written memorandum of agreement from landowner providing for site protection
MON	Intensify monitoring to identify limiting factors
NOUR	Nourish beach
ORV	Intensify management of off-road vehicles
PET	Intensify enforcement of restrictions on pets
PCON	Predator control (other than exclosures)
SGN	Additional signage of nesting and/or foraging areas
SYM	Symbolically fence nesting areas
VEG	Control vegetation
XCL	Deploy predator exclosures
WARD	Intensify wardening

U.S. ATLANTIC COAST BREEDING SITE MANAGEMENT ACTIVITIES

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
SOUTH CAROLINA							
Waites Island (SC-1)	0	sporadic					MON
NORTH CAROLINA							
Bodie Island (So. end) (NC-1)		1		√			MON, SGN (early season)
Cape Hatteras Point (NC-2)	≥4	3-4		√			WARD (esp. during peak periods), XCL, PCON, VEG, ENF, I&E, FER, PET, clarify signs
Currituck Outer Banks (NC-3)	sporadic	≥5	√	on FWS lands		Experimental exclosure	SYM, SGN, XCL, ORV, FER, COOP, control domestic animals
Figure 8 Island (NC-4)		1x/2-3 weeks	√	√			MON
Hatteras Inlet (No. Side) (NC-5)	≥4	3-4		√			XCL, PCON, VEG, MON (brood foraging), monitor potential impacts from ORV's, ENF, WARD, I&E, FER, PET, clarify signs
Holden Beach/Shallote Inlet (NC-6)		1-2	√				MON, SYM, COOP
Long Beach/Lockwood Folly's Inlet (NC-7)		1 day/mo	√				MON, SYM, COOP
North Core Banks (NC-8)	≥4	≥5	√	√	√		XCL (additional nests), PCON, VEG
Ocracoke Island (No. and So. ends) (NC-9)	≥4	3-4		√			XCL, PCON, MON, WARD, ENF, I&E, FER, PET, clarify signs
Pea Island NWR (NC-10)		2x/mo					MON
Rachel Carson's Estuary/ Bird Shoals (NC-11)		sporadic					MON
Shackleford Banks (NC-12)		sporadic					MON
South Core Banks (NC-13)	≥4	1-2		√			MON, XCL, PCON, ENF, WARD
Sunset Beach (NC-14)		sporadic					MON

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Topsail Beach (NC-15)		sporadic	√				MON, SYM, SGN, COOP, FER
VIRGINIA							
Assateague/Tom's Cove Hook (VA-1)	3	7	√		√	Tom's Cove Hook managed in accordance with *Environmental Assessment on Management of Piping Plover on Tom's Cove Hook* (USFWS 1988d); sites closed to public access; predator trapping	Implement *Recommendations for Improving Productivity of Piping Plovers at Chincoteague NWR* (Melvin 1993) and recommendations in *Piping Plover Monitoring and Management, 1993* (USFWS 1993c).
Assateague/Wash Flats (VA-2)		7	√		√		
Assateague/Wild Beach (VA-3)	7	7	√			Site is far from public access points; access prohibited above high tide line; predator trapping	
Assawoman Island (VA-4)	2-3	2-3				Access point is far from nesting area; predator trapping when necessary	MON, ENF, I&E (on the mainland, targeting boaters), possible predator exclusion fence where island joins Wallops Is.
Cedar Island (VA-5)	2	2	√	√		Landowner contacts, I&E, predator trapping when necessary	MON, ENF, more I&E, ORV
Cedar Sandbar (VA-6)	2	2	√			Predator trapping when necessary	MON, I&E, ENF
Cobb Island (VA-7)		1-2	√				MON, I&E
Craney Island (VA-8)	3-4	3-4	√	√		Dredge spoil mgt, predator removal, vehicle barriers, MOA with Corps	MON, update MOA, XCL
Fisherman Island (VA-9)		1	√			Predator trapping when necessary; FWS portion is closed to public access year-round	MON
Grandview Beach (VA-10)	3-4	3-4	√	√ (critical areas)		I&E, MOA, informational signs	MON, I&E, ENF, update MOA, BOAT

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Hog Island (VA-11)	1-2	1-2	√				MON, I&E
Metompkin Island, No. (VA-12)	1-2	1-2	√			Predator trapping when necessary (FWS portion)	MON, I&E, WARD, SYM
Metompkin Island, So. (VA-13)	1-2	1-2	√				MON, I&E
Myrtle Island (VA-14)	1-2	1-2	√				MON, I&E
New Island (VA-15)	1-2	1-2	√				MON, I&E
Parramore Island (VA-16)	1-2	1-2	√				MON, I&E, MOA (with USCG)
Ship Shoal (VA-17)	1-2	1-2	√				MON, I&E
Smith Island (VA-18)	1-2	1-2	√				MON, I&E
Wallops Island (VA-19)	2-3	2-3	√			No public access; predator trapping when necessary	PCON, MON, possible predator exclusion fence across south end
Wreck Island (VA-20)	1-2	1-2	√				MOA, MON, I&E
MARYLAND							
Assateague Island National Seashore (MD-1)	≥5	7 (north end) 2-3 (south end, early season)	√	√	√	Management described in *Piping Plover Management Plan* (NPS 1993c) - includes I&E, management of boat landing locations, protection of bayside mudflats from disturbance, and pet control	Monitor and maintain beach formation processes
DELAWARE							
Beach Plum Island Nature Preserve (DE-1)	1-2	1-2		√		State plover management plan and annual beach management plan apply if birds are present	MON, PCON, I&E

SITE	1993 MANAGEMENT WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	ADDITIONAL MANAGEMENT NEEDS
Cape Henlopen State Park (DE-2)	≥5	≥5		√	√	Intensive disturbance-prevention program described in *Delaware Piping Plover Management Plan* (DNREC 1990) and annual State beach management plans, cat removal, pet restrictions, I&E, control boat landings	PCON, PET, more I&E
Delaware Seashore State Park (DE-3)	≥5	≥5		√	√		Better signs, more I&E, PCON, PET, VEG
Fenwick Island State Park (DE-4)	1-2	1-2		blowouts & washovers		State plover management plan applies if birds are present	MON, PET, FER, PCON, I&E
NEW JERSEY							
Avalon Complex - Avalon Dunes and Avalon North (NJ-1)	wkend/hol	1-2		√		Exclosures used occasionally in past, I&E	MON, WARD, MOA, PCON, I&E, NOUR, fencing of nesting area earlier in the season, discontinue beach-raking, DUNE (Avalon Dunes portion)
Avalon Complex - Townsend's Inlet (NJ-2)	wkend/hol	1-2		√			MON, WARD, PCON, DUNE
Barnegat Light (NJ-3)	≥4	1-2		√		Fencing of large area (4' high) to enclose any nest attempts	MON, WARD, additional informational signs, MOA, possible PCON, possible XCL, VEG (long-term concern), FER
Brigantine Beach (So. Beach and Inlet) (NJ-4)	wkend/hol	1-2		√	√	Snow fencing for beach access corridor	Additional pasture fencing, additional educational signs, WARD, I&E, ENF, PCON, MOA, discontinue beach-raking (South Beach portion)
Brigantine - Little Beach (NJ-5)		4-5/mo				Predator (fox) removal, site closed to public access	MON
Brigantine Inlet - Brigantine North (NJ-6)		2/mo				Efforts limited due to absence of breeding birds in recent years	MON (early season), PCON (foxes), I&E, ORV restrictions, fence large area of suitable nesting habitat pre-season, WARD (if plovers establish nests)

SITE	1993 MANAGEMENT WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	ADDITIONAL MANAGEMENT NEEDS
Champagne Island (Hereford Inlet) (NJ-7)		2/mo		√ (terns and skimmers)		Efforts limited due to absence of breeding birds in recent years	MON (early season), pasture fencing, WARD, ENF
Coast Guard North (Two Mile Beach) (NJ-8)		1-2				Efforts limited due to absence of breeding birds in recent years	MON (early season) FER (cats), possible XCL, possible NOUR
Coast Guard South (NJ-9)		1-2		√		Dune to ocean snow fencing during breeding season to protect plover and tern nests	FER (cats), PCON (foxes), coordinate with USCG, continue NOUR
Holgate (NJ-10)	≥4	≥5		√		Beach is closed to public during plover nesting season, predator removal	Control avian predators, possible XCL
Island Beach State Park (NJ-11)		2/mo				Feral cat removal	DUNE, PCON (foxes), ORV, ENF, MON (early season), curtail public feeding of foxes
Mantoloking Beach (NJ-12)		1-2		used in the past			NOUR, greater coordination with municipal officials, MON/WARD (minor increase)
North Wildwood (NJ-13)	≥4	1-2		√			Restrict ORV's; discontinue beach-raking, ENF, WARD, pasture fence nesting area, increase informational signage, reduce disturbance in intertidal feeding areas, MOA
Ocean City Complex - Longport (NJ-14)		sporadic					NOUR, PCON, PET, ORV
Ocean City Complex - Waverly Beach (NJ-15)	≥4	1-2		√			NOUR, FER (cats), WARD, other efforts to reduce disturbance, discontinue beach-raking
Sandy Hook - Coast Guard Beach (NJ-16)		3-4		√	√	Management described in *Environmental Assessment, Management Plan for the Threatened Piping Plover* (NPS 1992). Predator removal conducted at Gunnison and North Beach.	MON, WARD, ENF, I&E
Sandy Hook - Critical Zone (NJ-17)	≥4	≥5		√	√		WARD, ENF, I&E
Sandy Hook - Gunnison Beach (NJ-18)	≥4	≥5		√	√		WARD, ENF, I&E
Sandy Hook - North Beach (NJ-19)	≥4	≥5		√	√		WARD, ENF, I&E, reduce gull predation

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Sea Isle City Complex - Corson's Inlet (NJ-20)	wkend/hol	1-2		√	pre-93	Rope fencing	DUNE, PCON (foxes), MON, WARD
Sea Isle City Complex - Sea Isle City (NJ-21)	wkend/hol	1-2		√		Additional monitoring, wardening, and fencing by municipal employees	NOUR (north end), PCON, PET (north end), MOA, MON, WARD, discontinue beach-raking
Sea Isle City Complex - Strathmere (NJ-22)	wkend/hol	1-2		√		Occasional exclosures used in past, highly visible rope and signs	PCON, informational signs, BOAT, ENF, WARD, PET, possible ghost crab control, MON
Sea Isle City Complex - Whale Beach (NJ-23)	wkend/hol	1-2		√		Occasional exclosures used in past	NOUR, PCON (fox), possible ghost crab control, WARD, MON
South Cape May Meadows (NJ-24)	≥4	≥5	√	√	√	Snow fencing to exclude predators, signage/symbolic fencing at low tide feeding areas	PET (dogs), NOUR (or other measures to counteract erosion due to Cape May jetties), limit vehicle use to emergencies only
NEW YORK							
Accabonac Harbor (NY-1)	infrequent	1-2		√		Interpretive sign, snow fencing to mark vehicle closure area	MON, ENF, I&E, MOA, ORV, PET, PCON, XCL, WARD
Alder Island (NY-2)	very infrequent	2/season					MON, BOAT, VEG, MOA
Breezy Point to Far Rockaway (NY-3)	7 (NPS only)	*NPS*: 7 *Priv*: 5-6 *Municipal*: 0-2/season	√ (private lands)	√ (NPS only)	√ (NPS only)	*NPS*: management described in *Environmental Assessment, Management Plan for the Threatened Piping Plover* (NPS 1989); gull management; feral cat removal *Private lands*: feral cat removal; symbolic fencing at ends of walkways to channel pedestrian foot traffic	*NPS*: ENF, investigate potential impacts of rats, monitor gull colony and increase control efforts if appropriate *Private lands*: increase efforts to trap feral cats, possible rat control, possible XCL, increase restrictions on beach-raking, increased fenced area around nests outside the main nesting area, MOA *Municipal lands*: MON, WARD, SYM, SGN, I&E
Cedar Beach Point (NY-4)		1-2		√			ENF, I&E, MON, ORV, PET, XCL, VEG, WARD
Cedar Point (NY-5)	≥5	2-3		√	√	Interpretive sign, snow fence to mark vehicle closure area	ENF, I&E, MON, ORV, PCON, BOAT

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Conkling Point (NY-6)		1-2					COOP, I&E, MOA, XCL, SGN, SYM, MON, WARD, possible PCON
Corey Creek Mouth (NY-7)		2-3					BOAT, I&E, XCL, SGN, SYM, PCON, VEG, NOUR, MON, MOA, WARD
Crab Creek/Shell Beach (NY-8)	≥3	7		√	√	Interpretive sign, snow fence to mark vehicle closure area	ENF, I&E, NOUR, PET, PCON, VEG, WARD
Crab Meadow Beach (NY-9)	very infrequent	1		√			ENF, I&E, MOA, MON, PET, ORV, PCON, XCL, WARD
Cutchogue Harbor (NY-10)		1-2	√				BOAT, I&E, MON, PET, SYM, XCL, WARD
Eatons Neck Point (NY-11)	infrequent	1		√			BOAT, PCON, I&E, MON, XCL, WARD, MOA, ORV, SYM, VEG, possible PET
Fire Island (NY-12)	*NPS*: 7 *State*: ≥2 *County*: infrequent	5-7 (due to research project in 1992-93)[1]		√	√ (on NPS and State lands)	*State:* interpretive signs, brochures, and programs *NPS*: management described in *Environmental Assessment, Management Plan for Shoreside Species Breeding Habitat* (NPS 1994a)	*State and County lands*: BOAT, NOUR, FER, PCON, XCL, ENF, ORV, I&E, MON, WARD, PET, discontinue beach-raking (State lands) *NPS*: MON, evaluate impacts from fox, I&E
Fishers Island (NY-13)	unknown	2/season					MON, SGN, SYM, XCL, I&E, MOA, COOP
Flax Pond Beach (NY-14)		3/season					BOAT, I&E, MON, SGN, SYM, WARD
Fresh Pond Landing (NY-15)		2-3		√			BOAT, XCL, MON, PET, WARD, ENF, I&E
Goldsmith Inlet (NY-16)	infrequent	2-3/season					MON
Goose Creek Flanders Bay (NY-17)		2/season					MON
Gull Pond West (NY-18)	infrequent	2/season					COOP, MON, MOA
Hicks Island/Goff Point (NY-19)	≥3	1-3	√ (Hicks Island)	√ (Goff Point)		Interpretive sign, snow fence to mark vehicle closure area	BOAT, ENF, I&E, MON, ORV (in unprotected portion of Goff Point), PET, PCON, VEG, XCL, WARD, possible FER

[1] In 1994, monitoring declined to approximately 1x/week on State and County lands.

SITE	1993 MANAGEMENT: WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	ADDITIONAL MANAGEMENT NEEDS
Jessup Neck (NY-20)	*FWS*: ≥5	*FWS*: 5-7 *Cty*: 1-2		√	√ (on FWS)	*FWS*: 90% of beach closed to public access during breeding season	*FWS*: additional efforts to identify limiting factors, BOAT, I&E, SGN *County*: BOAT, ENF, I&E, MON, ORV, XCL, WARD, possible PCON
Jockey Creek Spoil Island (NY-21)		2/season					MON, VEG
Jones Island (NY-22)	2-3	5-7 (due to 1992-93 research project); declined to 1-2/ week in 1994		√	√	Interpretive exhibits, brochures, and programs; designated "refuge" areas at Overlook Beach ephemeral ponds *Gilgo State Park*: partial ORV closures starting in June	*State Parks*: NOUR, I&E, ORV, ENF, MON, PCON, WARD, discontinue beach grooming (Jones Beach State Park), PET, BOAT (prevent boaters landing on the bayside from walking through nesting area) *Town beaches*: NOUR (Oyster Bay), I&E (Oyster Bay), ORV, ENF, MON, PCON, WARD, discontinue beach grooming, prohibit fireworks (Babylon)
Lionhead Beach (NY-23)	infrequent	1		√	√		WARD, MON, MOA, I&E, PET, PCON, XCL
Lloyd Neck East Beach (NY-24)	infrequent	2/season and other sporadic		√		50% of beach closed during nesting season	MON, I&E
Lloyd Point (NY-25)	infrequent	1-2		√			BOAT, ENF, I&E, MON, PET, PCON, XCL, WARD
Long Beach Island (NY-26)	≥4	3-5		√	√	Cat removal	MOA, ENF, I&E, MON, DUNE, discontinue beach grooming, VEG, PCON, WARD, ORV, PET and/or FER
Long Beach Peninsula (NY-27)	≥5	1-2				MOA (village beach)	MON, XCL, PCON, ENF, ORV, VEG, PET
Long Beach Sag Harbor (NY-28)	≥5	3/season					ENF, I&E, MOA, MON, XCL, WARD
Majors Point to Gibsons Beach (NY-29)	≥1	1		√	√	Access prohibited to all but TNC staff	BOAT, MON, PCON
Marratooka Point to Kimogener Point (NY-30)		1					BOAT, MON, COOP, NOUR, I&E, MOA, XCL, SGN, SYM, PET, ENF, WARD
Mattituck Inlet (NY-31)	very infrequent	3/season					MON
Miamogue Point/Jamesport Town Beach (NY-32)	infrequent	2-3		√		Snowfencing to mark vehicle closure	BOAT, I&E, ENF, MON, PCON, XCL, NOUR, VEG, MOA, PET, WARD

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Middle Pond Inlet (NY-33)		2-3		√			ENF, WARD, XCL, MOA, BOAT, NOUR, PET, I&E, MON, PCON, FER
Mount Misery Point (NY-34)		4/season					BOAT, ENF, I&E, FER, MON, PET, PCON, XCL, WARD
Old Field Beach (NY-35)		3/season					BOAT, ENF, I&E, MOA, PET, PCON, SGN, SYM, WARD
Orient Beach (NY-36)	≥5	2-3		√	√ (half of nests)	Interpretive signs and programs	DUNE, PCON, XCL (more), MON, ENF, I&E, ORV, NOUR, WARD
Oyster Pond (NY-37)	infrequent	2/season					MON, MOA
Pine Neck (NY-38)	infrequent	1-2		√		Interpretive sign, snow fencing to mark vehicle closure area	BOAT, ENF, FER, I&E, MOA, MON, ORV, PET, PCON, VEG, XCL, WARD
Plum Point (NY-39)	unknown	2/season					MON
Port of Egypt (NY-40)	infrequent	5/season	√				NOUR, VEG, MOA, MON, I&E, PCON (rats), SYM, XCL, WARD
Red Cedar Point/Red Creek Pond (NY-41)		1-2		√		Access to Red Cedar Point is restricted except for one homeowner	BOAT, I&E, ENF, MOA, MON, PET, XCL, possible PCON, WARD
Richmond Creek (NY-42)		5/season					BOAT, MON, NOUR, MOA, SYM, SGN, I&E, PET
Robins Island (NY-43)	7	2/season					MON, possible VEG, possible NOUR
Sammys Beach Peninsula (NY-44)	infrequent	≥5		√		Interpretive signs, snow fence to mark vehicle closure area	ENF, I&E, MOA, MON, PET, PCON, XCL, WARD, ORV (unprotected section)
Sand City (NY-45)	≥5	1		√		Nesting area closed to all public access	I&E, MON, PCON, VEG, XCL
Sebonac Creek (NY-46)	≥2	6/season	√			"No boat landing" signs	BOAT, I&E, MOA, MON, PET, PCON, SYM, XCL
Sebonac Neck (NY-47)	very infrequent	3-4		√			COOP, MOA, SGN, SYM, XCL, ORV, PET, PCON, I&E, BOAT, ENF, WARD, MON
Short Beach (NY-48)	7	3-5		√	√		MON, I&E, PCON, VEG, WARD, PET

SITE	1993 MANAGEMENT WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	ADDITIONAL MANAGEMENT NEEDS
Southhampton Beach to Fairfield Pond Lane Beach (NY-49)	infrequent	1-2		√	√ (some nests)	Interpretive sign, snow fence to prevent pedestrian incursions into nesting area	BOAT, COOP, DUNE, ENF, FER, I&E, MOA, MON, NOUR, ORV, PET, PCON, SGN, SYM, XCL (more), WARD
Towd Neck/Wooley Pond (NY-50)	very infrequent	4/season					BOAT, ENF, I&E, MOA, MON, ORV, PET, PCON, XCL, WARD
Upper Beach/Lower Beach (NY-51)	infrequent	≥5		√		Interpretive sign, snow fence to prevent pedestrian incursions into nesting area	I&E, MON, ORV, PET, XCL, WARD
Youngs Island (NY-52)	infrequent	3/season	√				MON, VEG, PCON
Wainscott Pond to Montauk Beach (NY-53)	infrequent	1-2		√	√ (half nests)	Interpretive signs, snow fence to mark vehicle closure areas	BOAT, ENF, I&E, MOA, MON, ORV, PET, PCON, XCL, WARD
West Meadow Beach (NY-54)	very infrequent	3/season					I&E, MON
Westhampton Island (NY-55)	variable	[1]		√ (Town of South-hampton and some private lands)	√ (some nests)		*Cupsogue County Park*: BOAT, MON, NOUR, PCON, SGN, SYM, XCL, ENF, PET, WARD *Village of Westhampton Dunes*: BOAT, XCL, MON, SYM, WARD, PET, FER, PCON, I&E *Other Town and Village beaches*: MON, NOUR, FER, PCON, I&E, MOA, XCL, ORV, ENF, PET, WARD, discontinue beach grooming *Private*: MON, COOP, FER, PCON, I&E, MOA, SGN, SYM, XCL, ORV, ENF, PET, WARD, discontinue beach grooming
CONNECTICUT							
Goshen Cove (CT-1)	wkend/hol	1-2	√ (early season, before symbolic fencing)	√	√		WARD
Griswold Point (CT-2)	≥4	3-4		√	√	Live trapping for mammals	PCON (raccoons and gulls), VEG
Hammonasset Beach (CT-3)	wkend/hol	1-2		√	√		FER (dogs), PCON (foxes), PET, I&E, VEG
Housatonic River Complex - Milford Point (CT-4)	wkend/hol	3-4		√	√	Brochures about cat problems	PET (cats), VEG

[1] 5-7/week, between Pikes Inlet and Rogers Pavilion; 2/week on the west side of Pikes Inlet; 4x/season at Cupsogue County Park; 2-3/week east of Rogers Pavilion.

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Housatonic River Complex - Short Beach (CT-5)	wkend/hol	1-2	√ (early season, before symbolic fencing)	√	√	Efforts to minimize impacts of beach-raking	Assess/restrict beach-raking, WARD, VEG
Lewis Gut Complex - Pleasure Beach (CT-6)	wkend/hol	1-2		√	√		Rat control, WARD
Lewis Gut Complex - Long Beach (CT-7)	wkend/hol	≥5		√	√		Rat control, WARD
Sandy Point (CT-8)	wkend/hol	1-2		√	√		WARD, ENF (night patrol), I&E
RHODE ISLAND							
Block Island (RI-1)		1/month					MON (early season), assess other needs
Briggs Beach (RI-2)	≥4	≥5		√	√		MON
East Matunuck State Beach (RI-3)		1/month	√	√			MON, WARD, VEG
Maschaug Beach (RI-4)	≥4	≥5		√	√	Scarification of back dunes to prevent vegetation encroachment	Monitor vegetation encroachment and take steps to control if necessary
Napatree Point (RI-5)	≥4	≥5		√	√		I&E, MON (identify causes of chick mortality), ENF
Ninigret (RI-6)	wkend/hol	3-4		√	√		WARD, ORV, I&E
Quicksand Pond (RI-7)	≥4	≥5		√	√	Breach pond to enhance chick foraging habitat, management described in *Breeding History of, and Recommended Monitoring and Management Practices for Piping Plovers at Goosewing Beach* (Goldin 1994b)	
Trustom Pond (RI-8)	≥4	≥5		√	√	Predator removal; breach pond to enhance chick foraging habitat; management described in *Piping Plover Management for 1990* (USFWS 1990b).	Assess causes of chick mortality

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Weekapaug (RI-9)		1/month					MON, evaluate possible ORV impacts; if plovers establish at site -- WARD, SYM, SGN
MASSACHUSETTS							
Chappaquiddick Island (Norton Point to the Gut) (MA-1)	≥5	≥5		√	√	Management on State land described in *Leland Beach Management Plan* (TTOR 1992)	SYM, ORV
Coast Guard Beach (MA-2)	≥5	≥5		√	√	Management described in *NPS Standard Operating Procedure #6, Shorebird Management* (NPS 1994b)	
Crane Beach (MA-3)	≥5	≥5		√	√		
Cuttyhunk Island (MA-4)		1/month					MON, WARD, PET, SYM, ORV
Dogfish Bar, Martha's Vineyard (MA-5)	3-4	3-4		√	√		
Duxbury Beach (MA-6)	≥5	≥5		√			Protect chicks from vehicles on access road between ocean and bayside beaches
Eel Point (MA-7)	3-4	3-4		√			
Great Point/The Galls (MA-8)	≥5	≥5		√		Trap and remove feral cats	FER, ORV
Harding Beach (MA-9)	3-4	3-4		√			PET, NOUR
Head of the Meadows to Cahoon Hollow (MA-10)	1-2	1-2		√	√	Management on NPS lands described in *Standard Operating Procedure #6, Shorebird Management* (NPS 1994b)	MON
Horseneck Beach/Gooseberry Neck (MA-11)	4-5	4-5		√	√		Increase symbolic fencing, further limits on use of ORV's
Jeremy Pt./Great Island (MA-12)	3-4	3-4		√	√	Management on NPS lands described in *Standard Operating Procedure #6, Shorebird Management* (NPS 1994b)	

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Little Beach/Barney's Joy (MA-13)	≥5	≥5		√	√		COOP, ORV
Marconi Beach (LeCount Hollow to Nauset Light Beach) (MA-14)	≥5	≥5		√	√	Management on NPS lands described in *Standard Operating Procedure #6, Shorebird Management* (NPS 1994b)	
Monomoy Islands (MA-15)	3-5	2-4		√	one	Areas with history of breeding plovers or where plovers are observed in any stage of breeding cycle are posted off-limits to pedestrians	Gull control to reclaim nesting habitat, MON, additional XCL
Muskeget Island (MA-16)	1-2/season						MON
Nashawena Island (MA-17)	≥3 - 1994	≥1		√	√		MON, WARD
Nauset Beach (Chatham and Orleans) (MA-18)	≥5	≥5		√	√		More monitoring/wardening as plover population increases, DUNE, COOP
Nauset Spit (Plover Is.) (MA-19)	≥5	≥5		√	√		MON
Plum Island (MA-20)	≥5	≥5		√	√	Management on FWS beach described in *Piping Plover and Least Tern Management Program, Parker River NWR* (USFWS 1993d); FWS beach closed to public access April 1 to July 1, or whenever chicks fledge (which ever is last)	
Plymouth Beach (MA-21)	≥5	≥5		√			DUNE, ORV
Popponesset Spit (MA-22)	≥5	≥5		√	√		
Race Point Beach to High Head (MA-23)	≥5	≥5		√	√	Management on NPS lands described in *Standard Operating Procedure #6, Shorebird Management* (NPS 1994b)	

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
Richmond Pond/Cockeast Pond/Acoaxet (MA-24)	1-2 (Richmond Pond) 2/mo (Cockeast and Acoaxet)				√		MON, SYM, XCL, COOP
Sampson's Island - Dead Neck (MA-25)	≥5	≥5		√	√		
Sandy Neck (MA-26)	≥5	≥5		√	√		
Scorton Creek/East Sandwich (MA-27)	≥5	≥5		√	√		
Scusset Beach (MA-28)	≥5	≥5		√	√		
Siasconset /Low Beach/Tom Nevers (MA-29)	1-2	1-2					MON, WARD, SYM, I&E, ORV
Smith Point (MA-30)	1-2	1-2					MON, WARD, SYM, I&E, ORV
South Beach Island (MA-31)	≥5	≥5		√	√		MON, PET, prevent establishment of nesting gulls, reduction of gull population on Monomoy would benefit this site by reducing loafing gull population
South Cape Beach/Washburn Island (MA-32)	≥5 (South Cape Beach) 1/month (Washburn Island)			√	√		SYM, MON
South Shore, Martha's Vineyard (MA-33)	1- >4	1- >4		√	√		MON
Squibnocket Beach (MA-34)	1-2	1-2		√	√		MON
Third Cliff (MA-35)	1-2	1-2		√	√		MON, I&E, WARD
Town Neck/Springhill (MA-36)	≥5	≥5		√	√		PET
Tuckernuck Island (MA-37)		1/season		√	√		MON, PET
Wood End/Long Pt. (MA-38)	2-3	2-3		√	√	Management on NPS lands described in *Standard Operating Procedure #6, Shorebird Management* (NPS 1994b)	

SITE	1993 MANAGEMENT						ADDITIONAL MANAGEMENT NEEDS
	WARDEN days/week	MONITOR days/week	SIGN/ NO FENCE	SYMBOLIC FENCE	EXCL	OTHER	
MAINE							
Crescent Surf/Laudholm Beaches (ME-1)	1-2	1-2		√	√	Occasional skunk removal, ME Essential Habitat	MOA (detailing recreational use on Wells Estuarine Reserve), WARD, possible PCON, possibly obtain more easements
Goose Rocks/Batson River (ME-2)	1-2	1-2		√	√	Occasional predator removal, ME Essential Habitat	Conservation easements on undeveloped lots, I&E with local landowners
Higgins Beach/Ram Island (ME-3)	1-2	1-2		√	√	ME Essential Habitat	MON, possible need for conservation easements, I&E with local landowners
Pine Point/Western Beach (ME-4)	1-2	1-2		√	√	ME Essential Habitat	Interpretive signs, PET
Reid State Park (ME-5)	3-4	3-4		√	√	Occasional predator removal, predator management plan under development, ME Essential Habitat	Develop beach management plan, interpretive signs, I&E, WARD
Seawall/Popham/Hunnewell Beach (ME-6)	3-4	3-4		√	√	ME Essential Habitat	Develop beach habitat management plan, PCON, PET (dogs at Hunnewell), interpretive signs, I&E, WARD

APPENDIX D:
SUMMARY OF OFF-ROAD VEHICLE USE AT BREEDING SITES

This table summarizes current use of off-road vehicles at U.S. Atlantic Coast breeding sites. Where vehicle activity allowed on a site is different during the piping plover season than when birds are not present, the table provides information about vehicle use during the breeding season. At some sites, use of vehicles during the breeding season is managed in accordance with detailed protocols or management plans designed to avoid take of breeding plovers, eggs, and chicks. Where applicable, these have been summarized in the right-hand column, "Measures to Prevent Take."

OFF-ROAD VEHICLE USE AT U.S. ATLANTIC COAST BREEDING SITES

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
SOUTH CAROLINA							
Waites Island (SC-1)	√						
NORTH CAROLINA							
Bodie Island (So. end) (NC-1)		1	√			√	No breeding on this site in recent years; site is being monitored.
Cape Hatteras Point (NC-2)		3-4	√			√	Known nesting and foraging areas posted off-limits prior to season; monitoring to detect any new foraging areas and immediate fencing of any new areas where plovers are observed; regular enforcement patrols.
Currituck Outer Banks (NC-3)		√	√	√	√	√	Nesting areas on FWS lands posted; private lands posted with landowner permission; foraging areas unprotected.
Figure 8 Island (NC-4)	√						
Hatteras Inlet (No. side) (NC-5)		3-4	√			√	Same as Cape Hatteras Point.
Holden Beach/Shallote Inlet (NC-6)	√						
Long Beach/Lockwood Folly's Inlet (NC-7)	√						
North Core Banks (NC-8)		5-7	√	√		√	Same as Cape Hatteras Point.
Ocracoke Island (No. and So. ends) (NC-9)		3-4	√			√	Same as Cape Hatteras Point.
Pea Island NWR (NC-10)		7 (sea turtle monitoring)					No plovers nesting on this site in recent years.
Rachel Carson's Estuary/ Bird Shoals (NC-11)	√						
Shackleford Banks (NC-12)		3 (sea turtle monitoring)					No plovers nesting on this site in recent years.

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
South Core Banks (NC-13)		1-2	√			√	Same as Cape Hatteras Point.
Sunset Beach (NC-14)	√						
Topsail Beach (NC-15)			√				Municipal ordinance prohibits ORV's on beaches during plover/seaturtle nesting season.
VIRGINIA							
Assateague/Tom's Cove Hook (VA-1)		7	1				
Assateague/Wash Flats (VA-2)	√						
Assateague/Wild Beach (VA-3)		7	1				
Assawoman Island (VA-4)	√						
Cedar Island (VA-5)				10	5		1990 Corps permit restricts use of private vehicles by users of community pier during plover breeding season (pier has not yet been constructed). Signs and symbolic fencing in vicinity of nesting areas on north end. FWS has sent letters to property owners regarding plover vulnerability to ORV's and other disturbance.
Cedar Sandbar (VA-6)	√						
Cobb Island (VA-7)	√						
Craney Island (VA-8)		3					Road barriers, signs.
Fisherman Island (VA-9)		1	1				
Grandview Beach (VA-10)	√						
Hog Island (VA-11)				3		1	Signs in vicinity of nesting areas.
Metompkin Island, North (VA-12)	√						

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Metompkin Island, South (VA-13)	√						
Myrtle Island (VA-14)	√						
New Island (VA-15)	√						
Parramore Island (VA-16)			2-3				
Ship Shoal (VA-17)	√						
Smith Island (VA-18)	√						
Wallops Island (VA-19)	√						
Wreck Island (VA-20)	√						
MARYLAND							
Assateague Island National Seashore (MD-1)		10	southern area only			only on southern Maryland portion, and where no broods are present	*Piping Plover Management Plan* (NPS 1993c) minimizes ORV use and provides for intensive training of monitors operating ORV's; main northern nesting area is closed to recreational ORV use and NPS patrols use boats for non-emergency access. Beach in southern Maryland is monitored regularly, ORV's are restricted from areas within 200 m around nests and from brood foraging areas; nests in this area have been rare in recent years.
DELAWARE							
Beach Plum Island Nature Preserve (DE-1)			northern 1/3 only			northern 1/3 only	No plovers nesting at this area in recent years. Any nests established or broods will be protected per *Delaware Piping Plover Management Plan* (DNREC 1990) and an *Annual Beach Management Plan*.

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Cape Henlopen State Park (DE-2)		only to transport exclosure materials	√			√	*Delaware Piping Plover Management Plan* (DNREC 1990) prohibits ORV's (and pedestrians) within 100 yards of nests and chicks.
Delaware Seashore State Park (DE-3)			√			√	
Fenwick Island State Park (DE-4)			√			√	Same as Beach Plum Island Nature Preserve.
NEW JERSEY							
Avalon Complex - Avalon Dunes and Avalon North (NJ-1)		1 (early season use to erect fences)	≥50				Nesting area fenced, I&E with municipal officials and employees.
Avalon Complex - Townsend's Inlet (NJ-2)		only to erect and remove fences	2				Nesting area fenced, I&E with municipal officials and employees.
Barnegat Light (NJ-3)		1	20				Nesting area fenced, I&E with municipal officials and employees.
Brigantine South (So. Beach and Inlet) (NJ-4)		2	25			*S. Beach*: 75 trips on about 20% of beach *Inlet*: 200	Approximately 80% of habitat at S. Beach is closed to vehicles; sym. fence protects nests; I&E; volunteer wardens.
Brigantine Inlet - Little Beach (NJ-5)	√						
Brigantine Inlet - North Brigantine (NJ-6)		2/mo				350	No plovers nesting at this site in recent years.
Champagne Island (Hereford Inlet) (NJ-7)	√						
Coast Guard North (Two Mile Beach) (NJ-8)			14				Fencing to protect nests, I&E with USCG personnel..
Coast Guard South (NJ-9)	√						
Holgate (NJ-10)			21				FWS ORV use only.

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Island Beach State Park (NJ-11)		1/mo	50			400	Northern end closed to ORV's, beach-nesting birds mentioned in I&E program required to obtain ORV permit.
Mantoloking Beach (NJ-12)	within Mantaloking		5 (ATV's)				Some I&E with Brick Township personnel.
North Wildwood (NJ-13)		1	100+		14		Sym. fence around nesting area, I&E with municipal officials and employees.
Ocean City Complex - Longport (NJ-14)						√ (amount unknown)	
Ocean City Complex - Waverly Beach (NJ-15)			15				Inform city managers of nest/brood locations.
Sandy Hook - Coast Guard Beach (NJ-16)		4					Only NPS natural resource vehicles are permitted.
Sandy Hook - Critical Zone (NJ-17)		7					
Sandy Hook - Gunnison Beach (NJ-18)							
Sandy Hook - North Beach (NJ-19)							
Sea Isle City Complex - Corson's Inlet (NJ-20)		1	21				Fencing of nesting area, inform park personnel.
Sea Isle City Complex - Sea Isle City (NJ-21)		1	30			+/-1	Fencing of nesting area, I&E with and strong cooperation of municipal employees.
Sea Isle City Complex Strathmere (NJ-22)	√						
Sea Isle City Complex - Whale Beach (NJ-23)	√						
South Cape May Meadows (NJ-24)			1x/week				

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
				NEW YORK			
Accabonac Harbor (NY-1)		only to erect fences	√		√	√	Vehicle closures on approximately 80% of beach during nesting season.
Alder Island (NY-2)	√						
Breezy Point to Far Rockaway (NY-3)			√				*NPS*: Pedestrian escort required in front of permittee's trash removal truck. *Private*: Vehicles not allowed in nesting areas; pedestrian escort required in front of each trash removal and beach cleaning vehicle.
Cedar Beach Point (NY-4)		only to erect fences				illegal use	
Cedar Point (NY-5)		√	√			√	One side of peninsula is closed to vehicles during nesting season, but some plovers nest on the side where vehicles are used.
Conkling Point (NY-6)	√						
Corey Creek Mouth (NY-7)	√						
Crab Creek/Shell Beach (NY-8)	√						Beach closed to vehicles during the nesting season.
Crab Meadow Beach (NY-9)		only to erect fences	√				
Cutchogue Harbor (NY-10)	√						
Eatons Neck Point (NY-11)			√	√			
Fire Island (NY-12)		√ (on State and County land)	√ (on State and County land)	√ (on private land)	√ (on private land)	√ (on State and County land)	NPS prohibits ORV use during the nesting season; area where birds currently nest at Smith Point County Park is closed to recreational ORV's, but other suitable habitat is open to vehicles.
Fishers Island (NY-13)	unknown						
Flax Pond Beach (NY-14)	√						
Fresh Pond Landing (NY-15)	√						

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Goldsmith Inlet (NY-16)	unknown						
Goose Creek Flanders Bay (NY-17)	√						
Gull Pond West (NY-18)						illegal use	
Hicks Island/Goff Point (NY-19)		only to erect fences	√		√ (on portion of Goff Point beach)		No vehicle access to Hicks Island. Tip of Goff Point is closed to vehicles during nesting season, but other sections of this beach are impacted by vehicles.
Jessup Neck (NY-20)		√	√			√	No vehicle use on FWS lands; all use occurs on County park.
Jockey Creek Spoil Island (NY-21)	√						
Jones Island (NY-22)		√	√			√ (Sore Thumb and parts of Gilgo State Park)	Vehicle closures during plover nesting season at Gilgo State Park. Recreational vehicle use prohibited at Cedar and Overlook Beaches during the plover nesting season. At Jones Beach State Park most chicks forage away from official vehicles (recreational use not allowed) at ephemeral pools landward of the front beach.
Lionhead Beach (NY-23)	√						
Lloyd Neck East Beach (NY-24)			√				
Lloyd Point (NY-25)	√						
Long Beach Island (NY-26)		√	√				
Long Beach Peninsula (NY-27)		√	√				
Long Beach Sag Harbor (NY-28)						illegal use	
Majors Point to Gibsons Beach (NY-29)	√						

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Marratooka Point to Kimogener Point (NY-30)	√						
Mattituck Inlet (NY-31)	√					illegal use	
Miamogue Point/Jamesport Town Beach (NY-32)		only to erect fence				illegal use	
Middle Pond Inlet (NY-33)	√						
Mount Misery Point (NY-34)		only to erect fence				illegal use	
Old Field Beach (NY-35)	√						
Orient Beach (NY-36)		only to erect fencing	√		√		Reduced use of park vehicles in vicinity of fenced nests and broods.
Oyster Pond (NY-37)			√			√	
Pine Neck (NY-38)						√ (on approx. 50% of suitable habitat)	Peninsula is closed to vehicles during the nesting season, but approximately 50% of habitat is open to vehicle use.
Plum Point (NY-39)	unknown						
Port of Egypt (NY-40)	√						
Red Cedar Point/Red Creek Pond (NY-41)		only to erect fencing					
Richmond Creek (NY-42)	√						
Robins Island (NY-43)	√						
Sammys Beach Peninsula (NY-44)		only to erect fencing				√ (on 10% of habitat)	Approximately 90% of habitat is closed to vehicles during nesting season.
Sand City (NY-45)	√						
Sebonac Creek (NY-46)		only to erect fencing					
Sebonac Neck (NY-47)		only to erect fencing	√			√	

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Short Beach (NY-48)		√	√			√	
Southhampton Beach to Fairfield Pond Land Beach (NY-49)		√	√		√	√	
Towd Neck/Wooley Pond (NY-50)		only to erect fencing	√			√	
Upper Beach/Lower Beach (NY-51)		only to erect fencing	√		√	√	
Youngs Island (NY-52)	√						
Wainscott Pond to Montauk Beach (NY-53)		√	√		√	√	Vehicle closures on some portions of beach.
West Meadow Beach (NY-54)				unknown			
Westhampton Island (NY-55)		√	√	√ (mostly east of Quogue)		√ (mostly east of Quogue)	There is currently no ORV access to Cupsogue County Park. Agreement with Village of Westhampton Dunes prohibits ORV use on the ocean beach.
				CONNECTICUT			
Goshen Cove (CT-1)	√						
Griswold Point (CT-2)	√						
Hammonasset Beach (CT-3)	√						
Housatonic R. Complex - Milford Point (CT-4)	√						
Housatonic R. Complex - Short Beach (CT-5)			√				Vehicles drive seaward of symbolic fencing.
Lewis Gut Complex - Pleasure Beach (CT-6)	√						
Lewis Gut Complex - Long Beach (CT-7)	√						
Sandy Point (CT-8)						1-2 (illegal)	Symbolic fencing.

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
				RHODE ISLAND			
Block Island (RI-1)						unknown	No piping plovers nesting on this site since 1978.
Briggs Beach (RI-2)				7			
East Matunuck State Beach (RI-3)			1				
Maschaug Beach (RI-4)			2			50+	Vehicle use is discontinued after mid-May, before chicks hatch.
Napatree Point (RI-5)	√						
Ninigret (RI-6)	√						ORV use prohibited on beach front from April 1 to September 15. Some illegal use (estimated +/- 5 trips/week) occurs on western end prior to Memorial Day weekend.
Quicksand Pond (RI-7)	√						
Trustom Pond NWR (RI-8)		5-7					
Weekapaug (RI-9)							Vehicle travel limited to backdune road; no plovers using this site in recent years.
				MASSACHUSETTS			
Chappaquiddick Island (Norton Point to the Gut) (MA-1)			>15	5		>200	75% of nesting habitat closed to ORV's April 1; all areas with unfledged chicks closed to all vehicles in accordance with *Guidelines for Managing Recreational Use of Beaches to Protect Piping Plovers, Terns, and Their Habitats in Massachusetts* (MDFW 1993).
Coast Guard Beach (MA-2)	√						
Crane Beach (MA-3)		10	√				
Cuttyhunk Island (MA-4)				≤5		≤10 (ATV's)	
Dogfish Bar, Martha's Vineyard (MA-5)	√						

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Duxbury Beach (MA-6)			>7	>200		>200	75% of nesting habitat closed to ORV's April 1; 100 yard closure provided around all broods on front beach. Road between ocean and bayside beaches is a source of potential mortality for chicks moving between feeding sites.
Eel Point (MA-7)	√						Closed to vehicle traffic March 30.
Great Point/The Galls (MA-8)		7	√			>100	75% of nesting habitat closed to ORV's April 1; all areas with unfledged chicks closed to all vehicles in accordance with *Guidelines for Managing Recreational Use of Beaches to Protect Piping Plovers, Terns, and Their Habitats in Massachusetts* (MDFW 1993).
Harding Beach (MA-9)	√						
Head of the Meadows to Cahoon Hollow (MA-10)			7				
Horseneck Beach/ Gooseberry Neck (MA-11)			>10				
Jeremy Point/Great Island (MA-12)		4					
Little Beach/Barney's Joy (MA-13)			1-2				
Marconi Beach (MA-14)	√						
Monomoy Islands (MA-15)	wilderness island - no vehicles allowed						
Muskeget Island (MA-16)	√						
Nashawena Island (MA-17)	√						

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Nauset Beach (Chatham and Orleans) (MA-18)		5	5	>10		>50 (peak)	95% of nesting habitat closed to ORV's April 1; all areas with unfledged chicks closed to all vehicles in accordance with *Guidelines for Managing Recreational Use of Beaches to Protect Piping Plovers, Terns, and Their Habitats in Massachusetts* (MDFW 1993).
Nauset Spit/Plover Island (MA-19)		7	5			>50	
Plum Island (MA-20)		5				√ (State reservation only)	*FWS refuge*: closed to vehicles during nesting season. *State Park*: 95% of nesting habitat closed to ORV's April 1; all areas with unfledged chicks closed to all vehicles in accordance with *Guidelines for Managing Recreational Use of Beaches to Protect Piping Plovers, Terns, and Their Habitats in Massachusetts* (MDFW 1993).
Plymouth Beach (MA-21)		5	5			>200	90% of nesting habitat closed to ORV's April 1; about 60% of chick rearing habitat closed to ORV's when unfledged chicks are present.
Popponesset Spit (MA-22)	√						
Race Point Beach to High Head (MA-23)		7	7			>100	95% of nesting habitat closed to ORV's April 1; all areas with unfledged chicks closed to all vehicles in accordance with *Guidelines for Managing Recreational Use of Beaches to Protect Piping Plovers, Terns, and Their Habitats in Massachusetts* (MDFW 1993).
Richmond Pond/Cockeast Pond/Acoaxet (MA-24)	√						
Sampson's Island - Dead Neck (MA-25)	√						
Sandy Neck (MA-26)		5	5	√		>100	80% of nesting habitat closed to ORV's April 1; all areas with unfledged chicks closed to all vehicles in accordance with *Guidelines for Managing Recreational Use of Beaches to Protect Piping Plovers, Terns, and Their Habitats in Massachusetts* (MDFW 1993).

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Scorton Creek/East Sandwich (MA-27)	√						
Scusset Beach (MA-28)	√						
Siasconset/Low Beach/ Tom Nevers (MA-29)						<50	Areas with unfledged chicks closed to all vehicles in accordance with *Guidelines for Managing Recreational Use of Beaches to Protect Piping Plovers, Terns, and Their Habitats in Massachusetts* (MDFW 1993); suitable nesting habitat remains open to vehicle use which may be deterring birds from establishing territories and nests.
Smith Point (MA-30)				>10		>100	
South Beach Island (MA-31)	√						
South Cape Beach/ Washburn Island (MA-32)	√						
South Shore, Martha's Vineyard (MA-33)				√		√	
Squibnocket Beach (MA-34)	√						
Third Cliff (MA-35)	√						
Town Neck/Springhill (MA-36)	√						
Tuckernuck Island (MA-37)	√						
Wood End/Long Point (MA-38)		2					
MAINE							
Crescent Surf/Laudholm Beaches (ME-1)	√						
Goose Rocks/Batson River (ME-2)	√						
Higgins Beach/Ram Island (ME-3)	√						

SITE	NONE (emergency)	PP MON/MGT trips/week	OTHER MGT trips/week	RESIDENTS trips/week	SERV/COMM trips/week	RECREATION trips/week	MEASURES TO PREVENT TAKE
Pine Point/Western Beach (ME-4)	√						
Reid State Park (ME-5)			2-3/year				Mgr. aware of plover locations.
Seawall/Popham/ Hunnewell Beach (ME-6)	√						

APPENDIX E:
POPULATION VIABILITY ANALYSIS

Population viability analysis (PVA) is a structured and systematic analysis of the interacting factors, including abundance, rates of survival and productivity, demographic and environmental stochasticity, and catastrophes, that determine a population's risk of extinction. PVA's have a variety of applications, including, in recent years, use as tools in establishing recovery goals for some threatened and endangered species. General information on PVA's and their use is found in a large and growing body of scientific literature. Persons who want to learn about population viability analysis may find information in Shaffer (1987); Begon and Mortimer (1986), chapter 3; Lindenmayer *et al.* (1993); National Research Council (1995), chapter 7; and numerous other sources.

A draft of the following PVA for the Atlantic Coast piping plover, dated 7 April, 1994, was sent to 13 experts outside the recovery team for review and comment. Five substantive responses were received. Three comment letters expressed overall support for data, methodology, and recommendations, but suggested that model parameters, especially survival rates and co-efficients of variation of survival and fecundity, might be excessively optimistic (i.e., the actual population is less secure than the model predicts). Two other commenters felt that survival rates for plovers in the southern part of the range might be higher than those observed in Massachusetts, perhaps due to shorter migration distances. One of these letters also stated that various model parameters, especially co-efficients of variation of survival and fecundity used to model catastrophic events, were overly pessimistic. Two commenters felt that more "sensitivity analyses" (to better gauge the factors that contribute most to population viability) would make the PVA more useful. Finally, two letters indicated that a metapopulation model would more accurately reflect actual population dynamics than one which treats Atlantic Coast piping plovers as one panmictic[1] population.

In response to these comments and as a result of further discussions among the modelers, recovery team, and U.S. Fish and Wildlife Service biologists, refinements in the analysis were made and additional scenarios were modeled. However, a metapopulation model has yet to be developed.

Although the PVA continues to treat Atlantic Coast piping plovers as a single population, S.M. Melvin and J.P. Gibbs (pers. comm. 1994) agree that a metapopulation model would be more predictive of actual population dynamics. A "metapopulation" comprises a number of smaller subpopulations distributed across separate habitat patches. Within a metapopulation, there are barriers that inhibit dispersal between subpopulations, and environmental conditions may vary between habitat patches.

A metapopulation structure may increase or decrease the extinction probability of the population as a whole. Each of the subpopulations, because of its smaller size, may be more susceptible to extirpation than the larger population. The potential for loss of small local populations

[1] A "panmictic" breeding population is subject to random mating.

is greater the smaller the subpopulation, the greater the distance between subpopulations, and the poorer the ability of the species to disperse between habitat patches to augment or re-colonize adjacent populations and habitat. On the other hand, a metapopulation may have a greater probability of persistence than a single large population, if subpopulations are relatively independent with regard to environmental conditions and if individuals can readily disperse between subpopulations. Thus, it is not possible to predict in advance if and how metapopulation modeling would change our understanding of piping plover population dynamics.

Development of a metapopulation model for the Atlantic Coast piping plover will be a near-term priority of the recovery program, and has been included in recovery task 3.7. This type of model will improve our understanding of population viability and will also assist biologists assessing the impacts of proposed projects undergoing Section 7 consultation and any Section 10(a)(1)(B) permit applications.

The population viability model developed for the Atlantic Coast piping plover by Melvin and Gibbs (1994) follows.

VIABILITY ANALYSIS FOR THE ATLANTIC COAST POPULATION OF PIPING PLOVERS

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We developed a stochastic population growth model, based on age-specific survival rates and varying levels of fecundity and population size, to estimate probabilities that the Atlantic Coast population of piping plovers would fall to extinction or below various population thresholds during the next century. The model described below has been modified from our earlier draft (7 April 1994) as a result of comments received from USFWS biologists and several reviewers. We present revised estimates of extinction probabilities and offer recommendations for delisting criteria for the Atlantic Coast population.

METHODS

The Model

Gibbs performed initial analyses using Lotus Spreadsheet software with an @-Risk add-on, but then rewrote the model as a computer program in Turbo-Pascal, which greatly increased its simplicity, speed, and flexibility. The model recognizes three age classes (fledglings, adults 1 year old, and adults > 1 year old) and is based on an annual post-breeding census of the population. Only the female portion of the population is modeled; we assume a 1:1 sex ratio. The number of fledglings present in the population at the time of census is calculated as:

(1) $F(t+1) = F(t)*SF*CP*PB + A(t)*SA*CP$,

and the number of adults present as:

(2) $A(t+1) = F(t)*SF + A(t)*SA$,

where:

F = number of fledglings,
SF = annual survival rate of fledglings,
CP = female chicks fledged per female per year (chicks per pair divided by 2),
PB = proportion of 1-year old adults breeding,

A = number of adults,
SA = annual survival rate of adults

Equation (1) represents the production of fledglings in the census year. The first half of the equation represents the production of fledglings by 1-year-old birds (i.e., surviving fledglings produced the previous year). Note that the previous year's fledglings, F(t), survive their first winter (i.e., *SF) before they breed (i.e., *CP), and that only a portion of these 1-year-olds breed (i.e., *PB). Similarly, the second half of the equation represents adults alive the previous year that survive the winter (i.e., *SA) and then breed (i.e., *CP). All surviving adults > 1 year old and 50% of 1-year-olds are assumed to breed if the population has not reached carrying capacity.

Equation (2) represents survival of fledglings through their first winter to adulthood, i.e., F(t)*SF, and survival of adults from one year to the next, i.e., A(t)*SA, and calculates the total number of adult females expected to be present at a post-breeding census of the population.

The effect of habitat limitation on the population is modeled by transforming breeding adults produced in excess of an input carrying capacity (K) into nonbreeding "floaters". Floaters experience the same survival rates as other adults, and re-enter the breeding population during a subsequent season if a breeding opportunity becomes available (i.e., if the population falls below K).

Environmental-related variation is modeled in two ways. First, survival rates are permitted to vary annually according to normal distributions of means and coefficients of variation (CV) estimated from banding studies and truncated at 0 and 1. Annual variation in survival of adults 1 year old and > 1 year old is assumed to be perfectly correlated. Second, annual values of fecundity are permitted to vary according to a normal distribution of mean and CV estimated from field studies and truncated at 0. Demographic stochasticity is modeled by drawing a random number of individuals in any year from a binomial distribution of n = number of individuals alive the previous year and P = the probability of survival. Similarly, a number of first-year breeders is determined from a binomial distribution of n = number of fledglings surviving to their first year and P = the proportion of 1-year-old birds breeding.

Each simulation consisted of 5,000 iterations. The number of breeding adults was tallied at year 100 of each iteration to calculate probabilities that the population (N) = 0 or $\leq$ 50, 100, and 500 pairs.

The current model incorporates two additional scenarios that we believe are realistic: (1) reduced fecundity for pairs that exceed the recovery objective, and (2) Allee effects if the population falls below 100 pairs. Each is discussed briefly below.

1. Reduced fecundity for pairs that exceed recovery objective.

We assume that until the recovery objective for abundance is reached, maximum legal protection and "on-the-ground" management will be afforded to all breeding pairs in order to achieve some fecundity objective and sustain population growth. However, it is realistic to assume that if the population exceeds the recovery objective for abundance, protection, and management will be relaxed for "surplus" pairs that exceed this objective. This could occur by reducing or eliminating efforts to monitor nesting plovers, manage pedestrians, vehicles, or predators, or protect habitat, and through "incidental take" allowed under Section 10 permits. We believe such reductions in management intensity would lead directly to reduced fecundity.

In the revised model, we assume that if the Atlantic Coast population increases above the recovery objective for abundance, mean fecundity for surplus pairs will drop to 0.5 chicks/pair. We believe that 0.5 chicks fledged/pair is a realistic and, perhaps, optimistic fecundity that could be expected for Atlantic Coast plovers if intensive management and legal protection were to be eliminated. For example, mean annual fecundity for piping plovers in North Carolina from 1988 to 1993 was only 0.54, in spite of increasingly intensive management.

2. Allee effect.

Allee effects are density dependent effects that draw small populations away from carrying capacity and toward extinction (Allee 1931, Allee *et al.* 1949, Ferson and Akcakaya 1990). Examples of Allee effects might include reduced reproductive output when population densities become so low that males and females have difficulty finding each other to breed, or reduced survival or fecundity caused by inbreeding.

We believe mean fecundity of the Atlantic Coast population could decrease substantially if the population declined to very low levels, simply as a result of increasing proportions of the population failing to reproduce because of their inability to find and successfully pair with a member of the opposite sex. On the breeding grounds, the Atlantic Coast population is distributed over > 3,000 km of coastline, from North Carolina to Newfoundland. Although piping plovers are very mobile and seem to be good dispersers, a population that fell below 100 pairs would be distributed over the landscape at a very low density and the probability of encountering and attracting an unpaired member of the opposite sex during any given 3-month nesting season might be low.

We have incorporated an Allee effect into the model by assuming that if the Atlantic Coast population declines below a threshold of 100 pairs, mean fecundity will decline at a linear rate from the input fecundity when $N = 100$ pairs to 0.0 when $N = 0$ pairs. We believe that, if anything, we have been conservative in our modeling of an Allee effect. If the Atlantic Coast population fell substantially below 100 pairs, we might expect additional increases in extinction probability caused by : 1) increased coefficients of variation for both fecundity and survival, and 2) increased negative effects of demographic stochasticity on fecundity (for example, if only 4 plovers returned to Maine or Maryland in a given year, there is a 12.5% probability that all 4 would be of the same sex).

Inputs

Fecundity

Mean and CV of fecundity (chicks fledged per pair) were calculated from data reported for the U.S. portion of the Atlantic Coast population (USFWS 1993e). Mean and CV of fecundity in a given year were calculated as weighted averages across states, with population sizes as weights. These annual values were then averaged across years (unweighted) to calculate an overall mean and CV of fecundity. For the five-year period 1989-1993, we calculated a mean fecundity of 1.21 chicks fledged per pair and CV of 0.15 for the U.S. portion of the Atlantic Coast population. However, we increased the CV of fecundity input to the model to 0.4, to represent greater variance in fecundity that might occur over the 100-year simulation period. We believe such long-term variance in fecundity is realistic and could be caused by catastrophes or long-term variation in quality or availability of breeding habitat, predator populations, or intensity and effectiveness of management on the breeding grounds.

We assumed that only 50% of 1-year-old birds breed, and that 100% of adults > 1 year old breed. Small numbers of piping plovers have been reported to remain on wintering areas during the breeding season (Haig and Oring 1988b) and ≤ 5-10% of plovers reported in Massachusetts during May and June appear unpaired. Cairns (1977) reported that 15-16% of the piping plovers at her study area in Nova Scotia appeared to be unpaired or did not nest. In Manitoba, Haig and Oring (1988a,b) reported that many adults did not find a mate or nest in a given year, but that 1-year-old birds "frequently bred".

Survival

We estimated mean annual survival rates for two age classes of piping plovers (fledgling to 1 year old, and > 1 year old), based on resightings of birds color-banded in Massachusetts (L.H. MacIvor, C.R. Griffin, and S.M. Melvin, University of Massachusetts-Amherst, unpubl. data). MacIvor *et al.* color-banded 103 breeding adults and 61 flightless chicks (aged 10 to 25 days) on beaches from Chatham to Provincetown on outer Cape Cod, Massachusetts, from 1985 to 1988. They captured incubating adults using wire box traps (Wilcox 1959) and captured chicks by hand. They banded all birds with a single aluminum legband and unique combinations of 2 or 3 plastic colored legbands. They searched for banded plovers on outer Cape Cod from mid March through the end of August or first week in September in 1986 through 1989, and solicited observations of color-banded plovers from other biologists in Massachusetts and elsewhere along the Atlantic Coast. They estimated mean annual survival rates and coefficients of variation for both fledglings and birds > 1 year old, based on resightings of color-marked birds, using Program Jolly (Pollock *et al.* 1990). We input mean annual survival rates of 0.74 for adults > 1 year old and 0.48 for fledglings (from fledging to 1 year old) (MacIvor *et al.* unpubl. data). We increased the coefficients of variation for survival input to the model to 0.20 for both age classes (Table A), to account for potential long-term increases in variance of survival rates caused by catastrophes or other factors.

Carrying Capacity

We estimated the current carrying capacity (K) for the entire Atlantic Coast population (including Canada) at 2,000 pairs. This estimate was made by the Atlantic Coast Piping Plover Recovery Team following discussions with biologists coordinating plover efforts in all the Atlantic Coast states and provinces, and is felt to be conservative. Experience in New England, where plover numbers have doubled since 1986, has expanded our definition of suitable habitat and demonstrated that habitats may support far more pairs and higher productivity than previously estimated. Furthermore, efforts to assure dynamic functioning of plover habitat by allowing natural processes of erosion and accretion to occur could yield major improvements in habitat quality in some parts of the species' range.

Extinction Thresholds

In discussions during winter, 1994, the recovery team agreed that the recovery goal for the Atlantic Coast population of piping plovers should provide a > 95% probability of persistence (i.e., < 5% probability of extinction) for 100 years. Because extinction obviously represents the antithesis of recovery, the recovery team was also interested in estimating probabilities that the Atlantic Coast population would fall below thresholds of 50, 100, and 500 pairs during the next 100 years.

Table A summarizes the parameter estimates that we input to our model, and compares them with inputs used by Ryan *et al.* (1993) to model the Great Plains population of piping plovers.

RESULTS

Fecundity Needed For A Stationary Population

We estimated a mean annual fecundity of 1.245 chicks fledged per pair is needed to maintain a stationary population, based on empirical estimates of adult and immature survival and percentages of the two adult age classes that breed each year.

A review of census results for the Atlantic Coast population between 1989 and 1993 suggests that the actual fecundity needed to maintain a constant population may be slightly lower, perhaps 1.0 to 1.1 chicks /pair. Observed mean fecundity for the U.S. portion of the Atlantic Coast population between 1989 and 1993 was 1.21; during that time, population estimates increased by 21%, from 724 to 875 pairs (note, however, this increase resulted entirely from an 82% increase in the New England subpopulation driven by a mean fecundity of 1.69 during this period). Populations in New York and New Jersey remained relatively constant during this period, with mean fecundities of only 1.04 and 0.97, respectively. The Delaware to North Carolina subpopulation experienced a 10% population decline between 1989-1993; mean annual fecundity from 1988 to 1993 was 0.84.

There are several possible explanations for these apparent discrepancies between model results and actual observations:

1. The survival estimates used in the model may be underestimates. Survival rates were calculated based on re-sightings between 1986 and 1989 of plovers banded on outer Cape Cod from 1985 to 1988. Any banded birds not re-sighted were assumed to be dead, however some of these may have dispersed outside the study area and gone undetected. In the model, if we increased mean fledgling survival by only 5%, this lowered the fecundity needed for a stationary population to 1.15.

2. Survival rates for plovers breeding outside Massachusetts may be different than the estimates we used in the model. R. Cross (Virginia Department of Game and Inland Fisheries, unpubl. data) estimated annual survival rates of 75% and 83% for adults and 44% for fledglings at Chincoteague National Wildlife Refuge in Virginia. Loegering (1992) estimated survival rates of 67-72% for adults and 41% for fledglings on Assateague Island National Seashore in Maryland. It is possible that plovers nesting in Canada or New England may have lower survival rates than birds that nest farther south, because of higher mortality resulting from longer migration flights.

3. The assumption that only 50% of 1-year-olds breed may be an underestimate. Increasing the percentage of 1-year-olds assumed to breed to 75% decreased the model's prediction of stationary fecundity to about 1.15.

4. When both #1 and #3 above were changed in the model simultaneously, fecundity needed for a stationary population was reduced to 1.05.

5. We cannot discount the possibility that some surplus birds produced in New England are dispersing to other Atlantic Coast states or provinces and helping to "subsidize" other subpopulations that would otherwise be declining because of inadequate fecundity.

6. Each year since 1989, fecundity estimates have not been available for 17-33% of the U.S. Atlantic Coast population. If fecundities are substantially different for unmonitored segments of the U.S. or Canadian populations, this could mean that the actual mean fecundity for the entire Atlantic Coast population is slightly different than the estimates we input to the model.

Extinction Probabilities

We first calculated extinction probabilities for the entire Atlantic Coast population (U.S. and Canada combined) based on estimates of survival rates from MacIvor *et al.* (Table B). When mean fecundity = 1.25 (our estimate needed for a stationary population), the goal of < 5 % extinction probability for 100 years was not met even when population size and carrying capacity were increased to 10,000 pairs.

When we increased fecundity to 1.50, a population of 2,000 pairs was needed to achieve the goal of < 5% extinction probability. Even at this level, however, the population had a 10% chance of falling below 50 pairs and a 26% chance of falling below 500 pairs (Table B).

We next examined extinction probabilities for the entire Atlantic Coast population when mean survival rates decreased by 5 and 10 % for 1-year-old and > 1-year-old birds, respectively, during the first 50 years of the simulation, and then remained stable (within bounds set by coefficients of variation) for the remaining 50 years of the simulation period (Table C). We suggest that declining survival rates over the next 50 years may represent a realistic scenario that should be considered in recovery planning. Such long-term declines in survival might be caused by one or more of the following:

1) continuing declines in availability or quality of winter or migration habitat,

2) increased human disturbance on wintering grounds,

3) increased mortality from disease or parasites,

4) increased mortality from toxic chemicals (e.g., oil spills),

5) increased predation rates, perhaps resulting from increased numbers of peregrine falcons, red foxes, or feral cats along the Atlantic Coast, and/or

6) reduced fitness or longevity caused by unforeseen genetic factors.

Results of simulations presented in Table C demonstrate the sensitivity of extinction probabilities to even small changes in survival rates. With declining survival, a mean fecundity of 1.50 results in declining populations with high probabilities of extinction within 100 years. Even a population as large as 10,000 pairs has a 29% probability of extinction in 100 years.

Extinction probabilities for Atlantic Coast plovers were more sensitive to fecundity, survival rates, and variability in those parameters than to initial population size, at least within the narrow range of population sizes set by our estimate of carrying capacity. If it is unrealistic to substantially increase population size beyond 2,000 pairs, then the alternative must be to maintain fecundity at high enough levels to provide a margin of safety. This is not to say, however, that population size is not important. We believe the best ways to buffer against decreased fecundity and survival or increased variance in those parameters are to: (1) manage intensively to insure adequate fecundity and survival, and (2) maximize population size and number of breeding and wintering sites for each subpopulation. The larger and more evenly distributed the Atlantic Coast population is, both on the breeding and wintering grounds and during migration, the less will be the overall effects of environmental stochasticity, catastrophes, or reduced or inconsistent management. Given the difficulty of managing to improve survival, optimizing both abundance and distribution of all subpopulations would seem to be the best buffer against declines in mean survival for the population as a whole. Also, increasing population size may delay time to extinction, allowing managers more time to develop strategies to improve survival or fecundity.

GENETIC CONSIDERATIONS

Potential effects of population genetics on the long-term viability of the Atlantic Coast population of piping plovers are poorly understood. Haig and Oring (1988) used protein electrophoresis to examine genetic variability and differentiation between piping plover chicks (n=122) from Saskatchewan, Manitoba, North Dakota, Minnesota, and New Brunswick. For the 36 presumptive loci examined, they concluded that genetic variability within populations was comparable to other bird species, that inbreeding was not a significant factor within any of the populations sampled, and that little genetic differentiation had occurred between populations. Lack of differentiation between populations may be explained either by relatively recent declines and isolation of regional populations, or by adequate gene flow within and between populations to offset effects of genetic drift. Patterns of mating, dispersal, and distribution in piping plovers (Haig and Oring 1988a,b) are probably adequate to allow rates of gene flow > 1 individual/population/generation between Atlantic Coast subpopulations, the most conservative estimate of amount of gene flow needed to offset effects of genetic drift (Wright 1931).

Effective population size (N_e) (Frankel and Soulé 1981) has not been estimated for the Atlantic Coast population. Demographic characteristics that undoubtedly reduce N_e below actual population size (N) for the Atlantic Coast population include:

1) non-random mating within the population (exacerbated by a distribution pattern of breeding birds scattered along a narrow band of habitat > 2,000 km long),

2) unequal reproductive contributions between individuals and subpopulations,

3) differential reproductive contributions between age classes.

However, N_e / N may be higher for piping plovers than for some other vertebrates because: (1) percentage of adults > 1 year old not attempting to breed in a given year may be ≤ 10%; (2) dispersal of ≥ 1 individual ≥ 100 km per generation probably occurs (Haig and Oring 1988b; MacIvor, Griffin and Melvin, unpubl. data); (3) sex ratio is approximately 1:1; and/or (4) variation in overall population size has been small, at least over the past eight years of intensive monitoring and management.

Several workers have estimated N_e for vertebrates at 0.2-0.5 of actual population size (N) (Barrowclough and Coats 1985, Harris and Allendorf 1989, Mace and Lande 1991). If N_e for piping plovers falls within this range, then a recovery objective of a population of 1,200 pairs of Atlantic Coast piping plovers (USFWS 1988e) would, at best, fall perilously close to the often-quoted minimum N_e of 500 individuals needed to preserve sufficient genetic variation in a population to maintain long-term fitness and evolutionary potential (Franklin 1980, Frankel and Soulé 1981). Hopefully, the demographic and behavioral characteristics of piping plovers are such that N_e / N is substantially > 0.5. We believe that an estimation of N_e for the Atlantic Coast population should be identified as a recovery task in the revised recovery plan.

RECOMMENDED DELISTING CRITERIA

Based on results of the viability analysis summarized and discussed above, we recommend the following recovery objectives for Atlantic Coast piping plovers to meet the conceptual goal of assuring > 95% probability of persistence for 100 years.

1. Increase all 4 subpopulations to current estimates of carrying capacity: Atlantic Canada = 400 pairs, New England = 600 pairs, New York/New Jersey = 550 pairs, Delaware to North Carolina = 450 pairs.

Throughout the year, the Atlantic Coast population should be as evenly dispersed as possible, distributed among many well-managed, productive nesting sites during the breeding season and many high-quality, secure sites during winter. Carrying capacity of winter habitat for Atlantic Coast piping plovers is unknown.

This recommendation increases by 800 pairs the population objective contained in the 1988 recovery plan for the Atlantic Coast population (USFWS 1988e). That objective was established before estimates of survival rates were available, and without benefit of our current understanding of potential carrying capacity or responses of populations to management of predation, human disturbance, and off-road vehicles. That objective was also not based on any quantitative viability analysis, but simply sought to achieve a sizeable (50%) increase over the 1986 population estimate. At the time, such an increase was felt to be a reasonable compromise between what could actually be accomplished through management, and what historical populations had been. Analysis presented in this document (Table B) suggests that, even when mean fecundity is 1.5, a population of 1,200 pairs has an 11% probability of extinction and a 55% chance of falling below 500 pairs, if variances of survival and fecundity are ≥ 0.2 and 0.4, respectively.

We caution that a recovery objective of 2,000 pairs (4,000 individuals) falls within the range of minimum population size currently recommended for long-term viability in vertebrates. While population biologists have been reluctant or unable to establish definite rules-of-thumb for population sizes that insure viability over given time periods, several have suggested "several thousand" to ≥ 10,000 individuals as minimum levels needed to insure 95% probability of persistence for 1 or more centuries (Soulé 1987, Belovsky 1987, Thomas 1990). Recent papers by Wilcove *et al.* (1993) and Tear *et al.* (1993) have criticized the USFWS for not listing species earlier, before they decline to such low levels that recovery is more difficult or unlikely, and for establishing unrealistically low recovery goals.

We recognize that the Atlantic Coast population of piping plovers currently represents about 1/2 of the world's population of this species. However, at present we have little confidence that the Great Plains population will contribute to the viability of the Atlantic Coast population, given the lack of evidence of interchange between the two populations, and the current projections of rapid population decline recently predicted by Ryan *et al.* (1993) for the Great Plains population.

2. Maintain mean fecundity of 1.5 chicks fledged per pair for each of the 4 subpopulations and the Atlantic Coast population as a whole.

We caution that in a future scenario of declining survival and increased variance of survival and fecundity (Table C), a population of 2,000 pairs with mean annual fecundity of 1.5 has an extinction probability of 31%, well above the <5% rule-of-thumb established by the recovery team. Managers must continue to vigilantly monitor critical demographic parameters of the Atlantic Coast population (see criterion 5), and be prepared to adjust abundance or fecundity objectives upward if declining survival or increased variances become evident.

We also recognize the possibility that survival rates for Atlantic Coast plovers may vary latitudinally, in which case adoption of subpopulation-specific fecundity objectives may be warranted in the future.

3. 1 and 2 above should be achieved for at least 5 consecutive years.

4. Institute long-term management programs that are sufficient to maintain existing carrying capacity, adequate fecundity and survival rates, and low variances in these parameters after delisting.

5. Institute long-term monitoring programs that will be adequate to effectively detect declines in fecundity or population declines caused by declining survival rates.

6. Conduct a detailed estimation of effective population size for the Atlantic Coast population.

This analysis should be based on the best available data, and should seek to determine if a population size of 2,000 pairs is sufficient to maintain long-term genetic diversity.

Table A. Comparison of parameter estimates used in modeling Atlantic Coast and Great Plains populations of piping plovers.

		Atlantic Coast		
Parameter		Observed	Input	Great Plains[1]
Adult survival:	Mean	0.7387	0.70-0.74	0.66
	CV	0.0805	0.20	0.50
Imm. survival:	Mean	0.4836	0.44-0.48	0.46 - 0.66
	CV	0.1011	0.20	0.50 - 0.71
Fecundity:	Mean	1.21	variable	0.86
	CV	0.15	0.40	0.59
Fecundity needed for stationary population		1.245	variable	1.13
Proportion of adults > 1 year-old breeding		-	1.00	1.00
Proportion of 1 year-olds breeding		-	0.50	1.00

[1] Source: Ryan *et al.* 1993

Table B. Extinction probabilities for Atlantic Coast piping plover population.

Survival estimates for adults and fledglings are 0.7387 and 0.4836, respectively; these means remain stable during the simulation period, and vary randomly each year within bounds set by coefficients of variation (CV) of survival = 0.2 for both age classes. CV of fecundity is 0.4. Proportion of 1-year-old birds breeding = 0.5, proportion of > 1 year-old birds = 1.0. Number of iterations = 5000; simulation period = 100 years. Fecundity = mean number of chicks fledged per pair; K = carrying capacity; N = population size (number of pairs) = recovery objective. Fecundity is reduced for pairs that exceed the recovery objective; Allee effects are invoked if N < 100 pairs.

			Probability @ 100 years			
Fecundity	K	N	N=0	N≤50	N≤100	N≤500
1.25	2,000	1,200	35	78	81	95
1.25	2,000	1,500	31	73	76	92
1.25	2,000	2,000	22	59	63	82
1.25	3,000	3,000	23	58	61	81
1.25	4,000	4,000	23	57	62	82
1.25	5,000	5,000	23	56	60	82
1.25	10,000	10,000	20	56	60	82
1.50	2,000	1,200	11	26	29	55
1.50	2,000	1,300	9	22	24	50
1.50	2,000	1,400	8	22	24	47
1.50	2,000	1,500	9	20	22	44
1.50	2,000	1,600	6	18	20	44
1.50	2,000	1,700	7	17	19	40
1.50	2,000	1,800	6	16	17	39
1.50	2,000	1,900	5	13	15	36
1.50	2,000	2,000	4	10	11	26

Table C. Extinction probabilities for Atlantic Coast piping plovers assuming declining survival.

Mean adult and fledgling survival rates begin at 0.74 and 0.48, respectively, then decline by 5 and 10% respectively, at a linear rate between year 1 and 50, then remain stable at 0.70 and 0.44, respectively, between year 50 and 100. Coefficients of variation (CV) of survival estimates are 0.2 for both age classes. CV of fecundity is 0.4. Proportion of 1 year-old birds breeding is 0.5; proportion of > 1 year-old birds breeding is 1.0. Number of iterations = 5000; simulation period = 100 years. Fecundity = mean number of chicks fledged per pair; K = carrying capacity; N = population size (number of pairs) = recovery objective. Fecundity is reduced for number of pairs that exceed the recovery objective, and Allee effects are invoked if N < 100 pairs.

			Probability @ 100 years			
Fecundity	K	N	N=0	N≤50	N≤100	N≤500
1.50	2,000	1,200	40	87	90	97
1.50	2,000	1,500	39	84	86	97
1.50	2,000	2,000	32	70	76	90
1.50	3,000	3,000	32	70	74	91
1.50	4,000	4,000	29	68	73	91
1.50	5,000	5,000	28	66	72	90
1.50	10,000	10,000	29	68	73	91

APPENDIX F:
GUIDELINES FOR THE USE OF PREDATOR EXCLOSURES TO PROTECT PIPING PLOVER NESTS

NOTE: A stand-alone version of these guidelines, dated February 1996, that includes background information and literature cited is available, on request, from the U.S. Fish and Wildlife Service, Weir Hill Road, Sudbury, MA 01776, Attn: Anne Hecht. Most of this background information is also found in task 1.42, pages 77-78 of this plan. See also pages 41-43 in the Introduction of the plan for a summary of how predation pressure has contributed to the plover's threatened status.

Pre-use Evaluation

Since the use of exclosures is not without risks, the predation threat must be assessed and the potential benefits and risks evaluated. Rates of nest depredation observed during the previous season, abundance of predator tracks on the beach, and other indicators of predator numbers and activity should be considered. Even on beaches that are generally suitable for exclosures, some individual nest sites may be physically inappropriate, such as where the beach face is too steep.

Exclosures draw attention to the exact location of nests, which may attract potential vandals as well as people who are simply curious about these rare birds. Measures to minimize this threat include use of symbolic fences and signs to keep people far away from the exclosures, public information brochures, interpretive displays, wardens, and law enforcement.

Authorization

Any person constructing predator exclosures must have a letter of authorization from the State wildlife agency designating him/her an agent of the State for the purpose of constructing and monitoring the exclosures. Authorization letters should list any approved deviations from recommendations on exclosure design, construction, or monitoring provided in these guidelines. Persons authorized to deploy exclosures should be very familiar with the biology and behavior of piping plovers. These authorizations are necessary to meet legal requirements under Sections 9 and 10 of the Endangered Species Act; they also facilitate timely communication of any revisions to these guidelines with those deploying exclosures.

Exclosure Design

Exclosures should be constructed of 2 X 2 inch or 2 X 4 inch welded wire fence and supported by at least four sturdy metal or wooden stakes. Fences should be buried at least 8 inches in the sand (12 inches is better) and should be a *minimum of 36 inches* above the sand. Tops of posts supporting the fence must be below the top wire to prevent use of the posts as perches by crows and other avian predators (other signs and posts in the area should be similarly designed to discourage perching).

Triangular, rectangular, and circular exclosure designs have all been used effectively. *Minimum distance from the nest to the fence should be five feet* (ten foot diameter for a circular exclosure). Exclosures that are taller and/or wider than the minimum dimensions reduce risks that an incubating plover will hit the fence if it is startled and make it harder for a potential predator to discern what is inside, and their use is strongly encouraged.

If avian predators such as crows, grackles, ravens, or gulls are present in the area, either a net or twine top must be installed, as exclosures may cue these avian predators to the nest location. On some sites, common or fish crows (*Corvus brachyrynchos* and *C. ossifragus*) have systematically penetrated twine tops, but net tops appear more likely to invite other bird species to perch on them, creating a risk that the incubating plovers may abandon the nest. Material used for net tops (generally fruit-tree or blueberry netting) should have a mesh size of *3/4 inches* or less; mesh should lie flat and form square holes without stretching (do not use nets that are intended to be stretched). Nets should be cut to fit the top of the exclosure with minimum overhang, pulled taut, and securely attached to wire fence with hog clips or similar devices. Alternatively, seining twine may be strung in parallel rows about 6 to 8 inches apart across the top of the exclosure. Use of monofilament, which was used in the past to top exclosures, is no longer recommended and only parallel rows of twine should be strung (no perpendicular patterns); both monofilament and perpendicular string patterns have been associated with entanglement of adult plovers. Rigid tops, including fencing, should *never* be used on top of exclosures, as they attract perching birds.

Construction

Exclosure construction is most safely and efficiently accomplished with a crew of two to four persons. Construction should be practiced around a "dummy nest" until the operation can be done smoothly. Construction time should not exceed 20 minutes and can generally be accomplished in less than 10 minutes without sacrificing quality of construction (i.e., secure installation of posts and careful attachment of wire fencing and tops). Unless the incubating bird stays on the nest, a basket or similar device should be inverted on the nest to mark its location. Once construction is completed, rake or otherwise smooth out the sand immediately around the fence so that the surface of the sand is flush with the bottom wire, assuring easy access for birds walking through the fence.

Exclosures should be constructed after a full clutch of eggs has been confirmed. Exceptions allowing for exclosure of incomplete clutches may be approved by State agencies for beaches where egg predation is very likely to occur before clutch completion and plover monitoring is done by experienced biologists.

Exclosures should be constructed early or late in the day, to avoid exposing the eggs to the hot sun and to prevent attracting curious bystanders. Construction during rainy, very windy, or otherwise inclement weather must also be avoided.

Monitoring

As soon as construction is completed, all persons should move well away from the nest, preferably to a location out of sight of the birds. The nest should be monitored until an adult returns to the nest, resumes incubation, and then exchanges with its mate. If neither adult returns to the nest within 60 minutes or the birds' behavior appears abnormal, the exclosure should be removed.

Exclosed nests should be monitored at least every other day from a safe distance. At sites where this frequency of monitoring is not feasible, risks and benefits of exclosure use should be carefully evaluated and use of exclosures should only proceed with explicit authorization from a representative of the State wildlife agency.

Monitors should be alert for evidence that crows, gulls, or other birds are perching on exclosure fences or tops. Loss of several nests to the same predator species during a short time period or tracks that suggest a predator is systematically visiting exclosures should be immediately reported to the State wildlife agency and the USFWS. Both perching and evidence of "smart predators" that may be cued to exclosures should be evaluated immediately to determine whether exclosures should be modified or removed (see next section). Monitors should also assure that sand, wrack, or other debris around the base of the exclosure does not obstruct the ability of the plovers to walk under the bottom horizontal wire around a significant portion of the exclosure (plovers almost always walk into the exclosures).

Whenever exclosure failure (nest depredation or abandonment) is detected, a thorough investigation of the site should be made. Tracks, fur, means of entry, or egg-shell remains may aid the identification of predators. Means of predator entry into the exclosure may suggest needed modifications in exclosure design. In cases of suspected nest abandonment, an extremely thorough search of the area should be made for any signs of adult mortality, including predator track patterns; signs of a struggle; or plover feathers, bones, or other remains. The area should also be monitored for several days for sightings of one or both adults.

Removal of Exclosures

Where "smart" foxes or coyotes are systematically entering exclosures or tracks suggest that they are harassing plovers, exclosures should be immediately removed and efforts should be initiated to trap and remove the offending fox(es) or coyote(s).

Where avian species are perching on top of exclosures on more than a very infrequent basis, monitors may attempt prudent modifications, such as substitution of string tops for netting and/or clipping and removing the top row of wire on the fencing. However, if these modifications do not promptly alleviate the problem, subsequent plover nests on that site should not be exclosed during the remainder of the season. Whether or not exclosures that have already been erected should be removed should be determined by weighing the risk of nest abandonment by the incubating plovers due to perching against the risk of nest depredation if the exclosure is removed. It may be prudent to remove a few exclosures and monitor nest survival before removing all exclosures from the site.

Reporting

Please REPORT ANY OBSERVATIONS OF POTENTIAL PROBLEMS TO YOUR STATE WILDLIFE AGENCY IMMEDIATELY. Situations that are especially important to report include any evidence of adult plover mortality or unusual numbers of nest depredations or abandonments. Please also send copies of reports regarding exclosure problems to:

U.S. Fish and Wildlife Service
Weir Hill Road
Sudbury, MA 01776
Attention: Anne Hecht
Telephone: 508-443-4325; Fax: 508-443-2898

APPENDIX G: GUIDELINES FOR MANAGING RECREATIONAL ACTIVITIES IN PIPING PLOVER BREEDING HABITAT ON THE U.S. ATLANTIC COAST TO AVOID TAKE UNDER SECTION 9 OF THE ENDANGERED SPECIES ACT

NOTE: A stand-alone version of these guidelines dated April 15, 1994 is available, on request, from the U.S. Fish and Wildlife Service, Weir Hill Road, Sudbury, MA 01776, Attn: Anne Hecht. The stand-alone version also includes a brief synopsis of the legal requirements that afford protection to nesting piping plovers, a brief summary of the life history of piping plovers and potential threats due to recreational activities during the breeding cycle, and literature cited.

The following information is provided as guidance to beach managers and property owners seeking to avoid potential violations of Section 9 of the Endangered Species Act (16 U.S.C. 1538) and its implementing regulations (50 CFR Part 17) that could occur as the result of recreational activities on beaches used by breeding piping plovers along the Atlantic Coast. These guidelines were developed by the Northeast Region, U.S. Fish and Wildlife Service, with assistance from the U.S. Atlantic Coast Piping Plover Recovery Team. The guidelines are advisory, and failure to implement them does not, of itself, constitute a violation of the law. Rather, they represent the USFWS's best professional advice to beach managers and landowners regarding the management options that will prevent direct mortality, harm, or harassment of piping plovers and their eggs due to recreational activities.

Some land managers have threatened and endangered species protection obligations under Section 7 of the ESA or under Executive Orders 11644 and 11989 (see pages 47-48) that go beyond adherence to these guidelines. Nothing in this document should be construed as lack of endorsement of additional piping plover protection measures implemented by these land managers or those who are voluntarily undertaking stronger plover protection measures.

The USFWS recommends the following protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks.

MANAGEMENT OF NON-MOTORIZED RECREATIONAL USES

On beaches where pedestrians, joggers, sun-bathers, picnickers, fishermen, boaters, horseback riders, or other recreational users are present in numbers that could harm or disturb incubating plovers, their eggs, or chicks, areas of at least a 50-meter radius around nests above the high tide line should be delineated with warning signs and symbolic fencing[2]. Only persons engaged in rare species monitoring, management, or research activities should enter posted areas. These areas should remain fenced as long as viable eggs or unfledged chicks are present. Fencing is intended to prevent accidental crushing of nests and repeated flushing of incubating adults, and to provide an area where chicks can rest and seek shelter when large numbers of people are on the beach.

Available data indicate that a 50-meter buffer distance around nests will be adequate to prevent harassment of the majority of incubating piping plovers. However, fencing around nests should be expanded in cases where the standard 50-meter radius is inadequate to protect incubating adults or unfledged chicks from harm or disturbance. Data from various sites distributed across the plover's Atlantic Coast range indicate that larger buffers may be needed in some locations (see Table 3, page 12). This may include situations where plovers are especially intolerant of human presence, or where a 50-meter-radius area provides insufficient escape cover or alternative foraging opportunities for plover chicks.[3]

In cases where the nest is located less than 50 meters above the high tide line, fencing should be situated at the high tide line, and a qualified biologist should monitor responses of the birds to passersby, documenting his/her observations in clearly recorded field notes. Providing that birds are not exhibiting signs of disturbance, this smaller buffer may be maintained in such cases.

On portions of beaches that receive heavy human use, areas where territorial plovers are observed should be symbolically fenced to prevent disruption of territorial displays and courtship. Since nests can be difficult to locate, especially during egg-laying, this will also prevent accidental crushing of undetected nests. If nests are discovered outside fenced areas, fencing should be extended to create a sufficient buffer to prevent disturbance to incubating adults, eggs, or unfledged chicks.

Pets should be leashed and under control of their owners at all times from April 1 to August 31 on beaches where piping plovers are present or have traditionally nested. Pets should be prohibited on these beaches from April 1 through August 31 if, based on observations and experience, pet owners fail to keep pets leashed and under control.

Kite flying should be prohibited within 200 meters of nesting or territorial adult or unfledged juvenile piping plovers between April 1 and August 31.

Fireworks should be prohibited on beaches where plovers nest from April 1 until all chicks are fledged.

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[2] "Symbolic fencing" refers to one or two strands of light-weight string, tied between posts to delineate areas where pedestrians and vehicles should not enter.

[3] For example, on the basis of data from an intensive three year study that showed that plovers on Assateague Island in Maryland flush from nests at greater distances than those elsewhere (Loegering 1992), the Assateague Island National Seashore established 200 meter buffers zones around most nest sites and primary foraging areas (NPS 1993b). Following a precipitous drop in numbers of nesting plover pairs in Delaware in the late 1980's, that State adopted a Piping Plover Management Plan that provided 100 yard buffers around nests on State park lands and included intertidal areas (DNREC 1990).

MOTOR VEHICLE MANAGEMENT

The USFWS recommends the following minimum protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks on beaches where vehicles are permitted. Since restrictions to protect unfledged chicks often impede vehicle access along a barrier spit, a number of management options affecting the timing and size of vehicle closures are presented here. Some of these options are contingent on implementation of intensive plover monitoring and management plans by qualified biologists. It is recommended that landowners seek concurrence with such monitoring plans from either the USFWS or the State wildlife agency.

Protection of Nests

All suitable piping plover nesting habitat should be identified by a qualified biologist and delineated with posts and warning signs or symbolic fencing on or before April 1 each year. All vehicular access into or through posted nesting habitat should be prohibited. However, prior to hatching, vehicles may pass by such areas along designated vehicle corridors established along the outside edge of plover nesting habitat. Vehicles may also park outside delineated nesting habitat, if beach width and configuration and tidal conditions allow. Vehicle corridors or parking areas should be moved, constricted, or temporarily closed if territorial, courting, or nesting plovers are disturbed by passing or parked vehicles, or if disturbance is anticipated because of unusual tides or expected increases in vehicle use during weekends, holidays, or special events.

If data from several years of plover monitoring suggest that significantly more habitat is available than the local plover population can occupy, some suitable habitat may be left unposted if the following conditions are met:

1. The USFWS OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

   A. Estimates the number of pairs likely to nest on the site based on the past monitoring and regional population trends.

   AND

   B. Delineates the habitat that will be posted or fenced prior to April 1 to assure a high probability that territorial plovers will select protected areas in which to court and nest. Sites where nesting or courting plovers were observed during the last three seasons as well as other habitat deemed most likely to be pioneered by plovers should be included in the posted and/or fenced area.

   AND

C. Provides for monitoring of piping plovers on the beach by a qualified biologist(s). Generally, the frequency of monitoring should be not less than twice per week prior to May 1 and not less than three times per week thereafter. Monitoring should occur daily whenever moderate to large numbers of vehicles are on the beach. Monitors should document locations of territorial or courting plovers, nest locations, and observations of any reactions of incubating birds to pedestrian or vehicular disturbance.

AND

2. All unposted sites are posted immediately upon detection of territorial plovers.

Protection of Chicks

Sections of beaches where unfledged piping plover chicks are present should be temporarily closed to all vehicles not deemed essential. (See the provisions for essential vehicles below.) Areas where vehicles are prohibited should include all dune, beach, and intertidal habitat within the chicks' foraging range, to be determined by either of the following methods:

1. The vehicle free area should extend 1,000 meters on each side of a line drawn through the nest site and perpendicular to the long axis of the beach. The resulting 2,000-meter-wide area of protected habitat for plover chicks should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles.

OR

2. The USFWS OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Provides for monitoring of all broods during the chick-rearing phase of the breeding season and specifies the frequency of monitoring.

AND

B. Specifies the minimum size of vehicle-free areas to be established in the vicinity of unfledged broods based on the mobility of broods observed on the site in past years and on the frequency of monitoring. Unless substantial data from past years show that broods on a site stay very close to their nest locations, vehicle-free areas should extend at least 200 meters on each side of the nest site during the first week following hatching. The size and location of the protected area should be adjusted in response to the observed mobility of the brood, but in no case should it be reduced to less than 100 meters on each side of the brood. In some cases, highly mobile broods may require protected areas up to 1,000 meters, even where they are intensively monitored. Protected areas should extend from the oceanside low water line to the bay-side low water line or to the farthest extent of dune habitat if no bayside intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles. In a few cases, where several years of data document that piping plovers on a particular site feed in only certain habitat types, the USFWS or the State wildlife management agency may provide written concurrence that vehicles pose no danger to plovers in other specified habitats on that site.

Timing of Vehicle Restrictions in Chick Habitat

Restrictions on use of vehicles in areas where unfledged plover chicks are present should begin on or before the date that hatching begins and continue until chicks have fledged. For purposes of vehicle management, plover chicks are considered fledged at 35 days of age or when observed in sustained flight for at least 15 meters, whichever occurs first.

When piping plover nests are found before the last egg is laid, restrictions on vehicles should begin on the 26th day after the last egg is laid. This assumes an average incubation period of 27 days, and provides a 1 day margin of error.

When plover nests are found after the last egg has been laid, making it impossible to predict hatch date, restrictions on vehicles should begin on a date determined by one of the following scenarios:

1. With intensive monitoring: If the nest is monitored at least twice per day, at dawn and dusk (before 0600 hrs and after 1900 hrs) by a qualified biologist, vehicle use may continue until hatching begins. Nests should be monitored at dawn and dusk to minimize the time that hatching may go undetected if it occurs after dark. Whenever possible, nests should be monitored from a distance with spotting scope or binoculars to minimize disturbance to incubating plovers.

OR

2. Without intensive monitoring: Restrictions should begin on May 15 (the earliest probable hatch date). If the nest is discovered after May 15, then restrictions should start immediately.

If hatching occurs earlier than expected, or chicks are discovered from an unreported nest, restrictions on vehicles should begin immediately.

If ruts are present that are deep enough to restrict movements of plover chicks, then restrictions on vehicles should begin at least five days prior to the anticipated hatching date of plover nests. If a plover nest is found with a complete clutch, precluding estimation of hatching date, and deep ruts have been created that could reasonably be expected to impede chick movements, then restrictions on vehicles should begin immediately.

Essential Vehicles

Because it is impossible to completely eliminate the possibility that a vehicle will accidently crush an unfledged plover chicks, use of vehicles in the vicinity of broods should be avoided whenever possible. However, the USFWS recognizes that life-threatening situations on the beach may require emergency vehicle response. Furthermore, some "essential vehicles" may be required to provide for safety of pedestrian recreationists, law enforcement, maintenance of public property, or access to private dwellings not otherwise accessible. On large beaches, maintaining the frequency of plover monitoring required to minimize the size and duration of vehicle closures may necessitate the use of vehicles by plover monitors.

Essential vehicles should only travel on sections of beaches where unfledged plover chicks are present if such travel is absolutely necessary and no other reasonable travel routes are available. All steps should be taken to minimize number of trips by essential vehicles through chick habitat areas. Homeowners should consider other means of access, e.g., by foot, water, or shuttle services, during periods when chicks are present.

The following procedures should be followed to minimize the probability that chicks will be crushed by essential (non-emergency) vehicles:

1. Essential vehicles should travel through chick habitat areas only during daylight hours, and should be guided by a qualified monitor who has first determined the location of all unfledged plover chicks.

2. Speed of vehicles should not exceed five miles per hour.

3. Use of open 4-wheel motorized all-terrain vehicles or non-motorized all-terrain bicycles is recommended whenever possible for monitoring and law enforcement because of the improved visibility afforded operators.

4. A log should be maintained by the beach manager of the date, time, vehicle number and operator, and purpose of each trip through areas where unfledged chicks are present. Personnel monitoring plovers should maintain and regularly update a log of the numbers and locations of unfledged plover chicks on each beach. Drivers of essential vehicles should review the log each day to determine the most recent number and location of unfledged chicks.

Essential vehicles should avoid driving on the wrack line, and travel should be infrequent enough to avoid creating deep ruts that could impede chick movements. If essential vehicles are creating ruts that could impede chick movements, use of essential vehicles should be further reduced and, if necessary, restricted to emergency vehicles only.

SITE-SPECIFIC MANAGEMENT GUIDANCE

The guidelines provided in this document are based on an extensive review of the scientific literature and are intended to cover the vast majority of situations likely to be encountered on piping plover nesting sites along the U.S. Atlantic Coast. However, the USFWS recognizes that site-specific conditions may lead to anomalous situations in which departures from this guidance may be safely implemented. The USFWS recommends that landowners who believe such situations exist on their lands contact either the USFWS or the State wildlife agency and, if appropriate, arrange for an on-site review. Written documentation of agreements regarding departures from this guidance is recommended.

In some unusual circumstances, USFWS or State biologists may recognize situations where this guidance provides insufficient protection for piping plovers or their nests. In such a case, the USFWS or the State wildlife agency may provide written notice to the landowner describing additional measures recommended to prevent take of piping plovers on that site.

APPENDIX H:
GUIDELINES FOR THE PREPARATION AND EVALUATION OF CONSERVATION PLANS FOR ATLANTIC COAST PIPING PLOVERS PURSUANT TO SECTION 10(A)(1)(B) AND 10(A)(2) OF THE ENDANGERED SPECIES ACT

Section 10(a)(2) of the Endangered Species Act requires U.S. Fish and Wildlife Service evaluation of conservation plans accompanying applications for incidental take[4] of threatened and endangered species that occurs in the course of otherwise lawful activities. The ESA requires applicants to prepare conservation plans that specify "... the impact which will likely result in such taking; [and] what steps the applicant will take to minimize and mitigate [such] impacts..." (Section 10(a)(2)(A)(ii) and (iii)). Approval of permit applications is contingent on a finding by the USFWS that, "the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking; ... [and] the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild" (Section 10(a)(2)(B)(ii) and (iv). In amending the ESA to provide for incidental take permits, Congress directed the USFWS to "consider the extent to which the conservation plan is likely to enhance the habitat of the listed species or increase the long-term survivability of the species or its ecosystem" (H.R. Report No. 97-835, 97th Congress, 2nd Session).

Detailed information about Section 10 permits may be found in the Draft Interim Handbook of Habitat Conservation Planning and Incidental Take Permit Processing (USFWS 1994b). A seven-page brochure, entitled "What's all this stuff about 'Habitat Conservation Planning' and 'Incidental Take Permits?'" (USFWS 1994c) provides an introduction to the general Section 10 process. To date, one Section 10 permit for piping plovers has been issued by the USFWS; dated April 1996, this permit was issued to the Massachusetts Division of Fisheries and Wildlife.

The guidelines in this document are specific to the Atlantic Coast piping plover and are intended to:

(1) guide potential applicants in developing conservation plans for piping plovers on the Atlantic Coast that minimize, mitigate, and monitor the impacts of take, and allow continued steady progress towards recovery, and

(2) assist the USFWS in evaluating the impacts of any proposed conservation plans on the survival and recovery of the Atlantic Coast piping plover population.

These guidelines are based on (1) the population viability model for the Atlantic Coast piping plover population (Appendix E), (2) information on piping plover ecology, and (3) general principles of conservation biology. However, it should be emphasized that they are guidelines, not strict

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[4] "Take," as defined under the ESA is discussed on page 46 of this recovery plan.

requirements. Applications for incidental take permits and conservation plans that do not stringently adhere to these guidelines will be evaluated for their merit. Carefully crafted Section 10(a)(1)(B) permits have the potential to contribute to long-term protection of this species (see recovery task 1.64) if they recognize the species' biological requirements and the dynamic nature of its habitat; adopt a cautious approach that does not unduly reduce plover productivity, abundance, distribution, and density; and provide for adjustments based on new information, especially information about impacts of the conservation plan on plovers within the affected area.

It is not possible to foresee all types of incidental take of piping plovers and/or conservation plans that may be proposed in applications for Section 10(a)(1)(B) permits. These guidelines anticipate conservation plans addressing two types of take: (1) mortality or harassment of breeding plovers, their eggs, and chicks due to inadequate protection from motorized and non-motorized recreational activities or from other (non-recreational) types of off-road vehicle use, and (2) harm due to significant habitat modification or degradation that results in death or injury to piping plovers by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering (see 50 CFR 17.3). Some of these guidelines are germane to both of these types of take, while others are relevant to one or the other. If conservation plans for other types of take are proposed, development of additional guidelines may be appropriate.

Guidelines for Minimizing, Mitigating, and Evaluating Harassment or Mortality of Breeding Plovers, their Eggs, and Chicks

Guidelines 1 through 7 address situations where take will occur because less protection is afforded than that recommended in Appendix G (Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take under Section 9 of the Endangered Species Act). These guidelines (1 through 7) assume that allowable take under Section 10 will cause limited reductions in productivity of breeding plovers, but will not cause take of breeding adults or permanently degrade habitat suitability.

1. **Permits for incidental take that will reduce productivity of breeding plovers should only be allowed within recovery units[5] where the subpopulation has already achieved at least 70% of its portion of the recovery goal as specified on page 57 of the recovery plan.** Take under Section 10 should not be permitted until plover numbers reach 440 pairs in the New England recovery unit, 400 pairs in New York-New Jersey recovery unit, and 280 pairs in the Southern recovery unit. The recovery team believes that 70% of a recovery unit's population goal should be the minimum threshold for allowing reductions in plover productivity. However, even after the 70% threshold is attained, conservation plans should maintain a cautious approach to take, especially if other recovery units lag substantially in their progress towards recovery.

[5] Recovery units, their role in the recovery effort for the Atlantic Coast Piping Plover, and recovery unit subpopulation targets are discussed on pages 54-55 and 57 of this plan.

Attainment of 70% of the recovery goal will provide a minimal buffer against any unforeseen events that might send the plover subpopulation in a recovery unit into a steep decline. Spreading these increases across the four recovery units will reduce vulnerability to catastrophes that would exist if gains were limited to one or two geographic regions. Furthermore, experience in many areas where population increases have occurred has shown that key information on how to best protect piping plovers in an area and the experience needed to implement this protection is gained during the process of increasing productivity and effecting regional population growth. The recovery team believes that a solid population increase is a vital pre-condition to implementing a conservation plan that allows take without appreciably reducing the likelihood of the survival and recovery of the Atlantic Coast piping plover population.

2. **Piping plovers within the conservation plan area should attain average productivity of at least 1.5 chicks per pair for three years prior to authorization of take, and the conservation plan should assure that average productivity within the conservation plan area remains at or above this level.** Current information (see Appendix E) shows that this is the productivity rate needed to assure continued progress towards recovery. This minimum productivity level may be adjusted for specific recovery units if new data on survival or other demographic variables shows that different productivity levels will assure continued progress towards full recovery.

Negative impacts on species' security can be further reduced by plans that seek to minimize the variance in productivity by maintaining productivity of 1.5 chicks per pair at *each site* within the conservation plan area.

3. **Conservation plans should assure that the plover population within the plan area continues to increase, unless the area has attained its estimated carrying capacity.** The plan should provide an estimate of future population growth rates within the area to be covered under the permit. If the area is believed to be saturated, then the plan must assure that the population does not decline.

4. **Whenever possible, conservation plans should encompass plovers and habitat within an entire State or other large region.** Piping plover habitat is subject to frequent and unpredictable natural changes due to coastal formation processes, including both occurrence of and lack of major storm events, that may change its suitability. Variable predation pressure, flood-tides during the nesting season, recreation pressure, and intensity of management furnish other examples of factors that may affect productivity of plovers at given sites. Relatively large planning units will increase opportunities for averaging effects of these types of events on plover distribution and productivity, and will facilitate meaningful evaluation of the impacts of the conservation plan on species' recovery. Smaller planning areas will be highly vulnerable to factors that confound evaluation of the plan's impacts. While larger conservation planning areas are preferable to smaller ones, the recovery team recognizes that multi-State plans may be administratively infeasible.

5. **Whenever possible, permits should be issued for an initial period of 2 to 6 years.** In cases where take is due to recreational or other activities that can be adjusted in response to observed impacts on piping plovers, permits should be subject to review after 2 to 6 years. This will allow a reasonable period for gauging the effects of the permit and will also provide opportunities to

reevaluate permits in light of changes in the overall status of the population. Shorter permit periods (1 to 3 years) may be particularly desirable in the early stages of Section 10 permitting for piping plovers.

6. **Whenever possible, conservation plans should allow plovers to select their nesting sites/feeding areas and then allocate allowable take to areas where the smallest number of birds will be affected, rather than establishing fixed areas where take will occur.** While factors affecting plover productivity are becoming better understood, there are still many gaps in biologists' ability to predict where on a given beach plovers will breed most successfully. Furthermore, plover habitat is subject to coastal formation processes that may modify habitat quality over time. Under conditions of low human disturbance, plovers' nesting and feeding preferences remain the best indicators of which habitat should be protected in a given year. Conservation plans that maintain maximum opportunities for plovers to select their nesting and feeding areas are likely to have lower long-term impacts on plover recovery than those that designate fixed beach areas where take may occur each year. If a conservation plan establishes a fixed area where take will occur regardless of changes in habitat quality, allowable levels of take should be lower than when a more flexible plan allows areas where take may occur to be moved in response to the birds' preferences.

7. **Conservation plans should equitably distribute responsibilities to avoid take among non-Federal landowners.** Much physically suitable piping plover habitat remains unoccupied or under-occupied because recreational use precludes successful plover breeding or because regional populations have declined well below carrying capacity. However, piping plovers have demonstrated an ability to recolonize and substantially increase their numbers at sites where vigorous protection measures have been implemented (recovery plan, pages 6-7 and 31), often at significant expense to the landowner or another organization. The continued cooperation of these entities in recovery efforts for this and other threatened and endangered species may be compromised if they perceive that others who have taken less vigorous steps to protect birds and/or habitat will be allowed to take eggs or chicks of the few plovers that occur on their beaches. Indeed, the entire recovery effort may founder if cooperators believe that their efforts to increase productivity are creating opportunities for permitted take by other parties. For this reason, conservation plans that create incentives for contributing to the recovery effort are preferable. Such plans might allocate take temporally (allowing take on all beaches in an area after a certain level of chick production has been achieved each year) or in proportion to number of chicks fledged on each beach in recent seasons.

Guidelines for Minimizing, Mitigating, and Evaluating Harm Due to Significant Habitat Modification

The following guidelines pertain to situations where significant habitat modification or degradation will result in death or injury to piping plovers by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering.

8. **Take that reduces the carrying capacity of piping plover habitat should be authorized only if there is sufficient protected habitat elsewhere in the recovery unit to support the minimum subpopulation specified in delisting criterion 1, page 57 of the recovery plan.** In cases where habitat will be degraded by construction of structures, roads, parking-lots, or other medium- or long-

term habitat modifications, plover recovery must not be precluded by reductions in the overall carrying capacity. Allowances should also be made for natural changes in habitat suitability due to coastal formation processes, including both occurrence and lack of major storm events. Allowable take should be allocated very cautiously in portions of the plover's range where carrying capacity is less well understood. The recovery team anticipates that confidence in estimates of carrying capacity will increase in these areas as productivity increases and effects of population growth on distribution and density of nesting pairs are determined.

9. **Any reduction in habitat suitability must be mitigated by increased productivity and abundance of plovers nesting elsewhere within the recovery unit; increases to offset take should occur as close geographically as possible to the site where the habitat degradation occurs.** Piping plovers that have nested on a given site display a high degree of fidelity to that site (see page 28 of the recovery plan), and some pairs may continue to nest on a site even if habitat has been degraded in ways likely to reduce their productivity. Therefore, availability of alternative suitable habitat is not sufficient to mitigate impacts of habitat degradation. To compensate for decreases in productivity of plovers that may continue to nest on degraded sites or that may not breed at all, mitigation must also include measures to enhance productivity of plovers on other sites where they are already established. Sites where plovers are currently under-managed and productivity is low are likely to yield greater marginal increases in productivity than sites where substantial efforts are already in place.

<u>General Guidelines</u>

The following guidelines may be pertinent to Section 10 permits for either (1) harassment or mortality of breeding plovers, their eggs, and/or chicks, or (2) significant habitat modification.

10. **A given amount of take will cause less reduction in overall security of the population if it is distributed over multiple sites than if it is concentrated at one or a few sites.** A species' overall security is enhanced by distributing breeding individuals among multiple sites. This reduces the population's vulnerability to environmentally-driven variance due to events such as predation, oil-spills, or flood-tides (Goodman 1987). In addition, a species' security is eroded by formation or enlargement of gaps in its range that decrease inter-site immigration and colonization rates (Gilpin 1987). As stated under guideline #2, conservation plans should strive to maintain productivity of 1.5 chicks per pair at each site within the conservation plan area. Take should also be avoided at the edges of any existing gaps in the species' breeding range.

11. **Conservation plans should contribute to the health of the beach ecosystem.** Provision of "a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved" (Section 2(b)) is a stated purpose of the ESA; Congressional direction to the USFWS with regard to Section 10 permits further directs consideration of impacts on a species' ecosystem (H.R. Report No. 97-835, 97th Congress, 2nd Session). Preparation and evaluation of conservation plans, therefore, should consider impacts on natural beach formation processes, vegetation, and other wildlife. On any site where the Federally listed northeastern beach tiger beetle (*Cicindela dorsalis dorsalis*), seabeach amaranth (*Amaranthus pumilus*), or roseate tern (*Sterna dougallii*) may be

affected, conservation plans must consider impacts on those species. Impacts on any species that are candidates for Federal listing or Federal species of concern should also be considered; for example, dune blue curls (*Trichostema sp.*), is a plant that occurs on vegetated secondary dunes in North Carolina and is a Federal species of concern. See page 45 of the recovery plan for a discussion of other rare species (including State-listed species) that may occur in piping plover habitat.

12. **Conservation plans should provide for monitoring of piping plovers on all affected sites, including any sites where protection is to be increased to mitigate reductions in habitat suitability.** Monitoring is essential to assuring that components of the conservation plan that address guidelines 2, 3, 6, and 9 are working effectively. Data collection should include information listed in task 1.12 of the recovery plan, as well as other information that may be pertinent to implementation and evaluation of a particular conservation plan. The plan should also specify minimum skills, knowledge, and experience of the monitors.

APPENDIX I:
GUIDELINES FOR CONDUCTING SURVEYS FOR PIPING PLOVERS IN ATLANTIC COAST WINTERING HABITAT

The following guidelines have been adapted from J. Fussell (1990) and T. Eubanks (1992) and are included in the recovery plan to assist individuals in conducting piping plover surveys along the Atlantic Coast. These guidelines should assist U.S. Fish and Wildlife Service biologists in ensuring that useful information is collected by Federal action agencies for Section 7 consultations.

Surveying piping plovers can be difficult because they appear to depend on a variety of habitats throughout the winter season, and habitat use varies depending on tidal regime, weather conditions, season, and disturbance. Plovers are often found in tight clusters on prime feeding sites, and may be overlooked, especially in large shorebird concentrations. While some ornithologists find censusing of plovers on roosting habitat to be the most efficient (Fussell 1990), an inexperienced eye may easily miss a cluster of roosting plovers, because they are often huddled down in the sand or along the wrack line (Eubanks 1992).

The following are important considerations for conducting piping plover winter surveys:

1. Consult Available Information: Prior to conducting a survey, consult the local USFWS Field Office and/or State Nongame/Heritage Program for the most up-to-date listing of known piping plover wintering sites in the State (also see list of known and potential piping plover wintering sites on the southern Atlantic Coast, Appendix K). Available information on a site may negate the need for a survey, or may vary the scope and/or intensity of the survey. It is important to note the nearest known plover occurrence in relation to the project site, because it may provide some insight into possible piping plover occurrence within the survey/project area.

2. Survey Timing and Frequency: In order to determine presence of piping plovers at a site, a series of field surveys should be conducted during the winter period. It is recommended that at least one survey be conducted per week (or four surveys per month) over a three-month period. Surveys should preferably be conducted during December and January when the plovers are most sedentary, and during one month in the migration period (August 1 - October 15 or February 15 - April 15). Piping plovers exhibit diurnal shifts in habitat use, thus observations should be conducted for a minimum of five hours during daylight hours and should be evenly distributed throughout this period. Survey time periods should be conducted during daylight hours from 30 minutes after sunrise to 30 minutes before sunset and should include a wide range of tidal conditions and habitat types. The amount of time necessary to survey each site will obviously depend on the amount and type of habitat to be covered. Areas should be surveyed slowly and thoroughly (large mixed flocks of roosting shorebirds especially need to be thoroughly and carefully searched in order to locate piping plovers).

3. Other pertinent data: Surveyors should note the presence or absence of other shorebird species during each survey. This information may be helpful in assessing the probability of piping plovers

frequenting a specific coastal site. Also, weather conditions and tidal stage should be noted because habitat use may vary depending on these factors. Habitats with and without plovers should be characterized.

4. Surveyor Qualifications: Surveyors should be knowledgeable about shorebird identification, and be capable of discerning a piping plover in winter plumage from other small plovers. Surveyors should also be familiar with plover ecology and behavior to ensure a thorough survey.

5. Survey Conditions: Surveys should not be conducted during poor weather (e.g., heavy winds > 25 mph, heavy rains, severe cold) since birds may seek protected areas during these times.

6. Recording of Data: Daily surveys should be recorded and summarized and plover locations should be recorded on maps indicating areas surveyed and habitat types. A sample form for data collection is provided below.

SUGGESTED SURVEY FORM

Site Name (and County):
Date:
Time Begin/End:
Weather Conditions: (temp., wind speed and direction, cloud cover)
Tidal Stage (incoming low, outgoing low, incoming high, outgoing high):
Area of Coverage (km/mi):
Ownership of Site:
Number of Plovers Observed:
Habitat (sandflat, mudflat, beach):
Historical Information on Site:
Nearest Known Plover Occurrence (site name/miles or km):
Banded Plovers (combinations):
Other Shorebird Species Observed:
Approximate Number of Shorebirds Seen Within Census Area:
Additional Comments Pertinent to the Survey:

(Include a map of the survey area with plover locations marked on it. Photocopies of aerial photos are particularly useful.)

APPENDIX J: ESTIMATED COST OF U.S. ATLANTIC COAST PIPING PLOVER PROTECTION ACTIVITIES DURING THE 1993 BREEDING SEASON

The recovery team received assistance from State piping plover coordinators, national wildlife refuges, national parks, and others in compiling the attached summary of expenditures associated with protection of piping plovers on U.S. Atlantic Coast beaches in 1993. Definitions of costs to be included in various categories were provided by the recovery team. Efforts were made to include plover management costs incurred by Federal, State, and local government agencies, as well as private organizations. These figures reflect only direct cost of protection activities; they do not include any positive or negative impacts on local or regional economies that may have occurred due to changes in land use.

With very few exceptions, costs furnished to the recovery team were incorporated into the summary without revision. The recovery team believes that estimates provided by cooperating organizations include both under- and over-estimates of true costs, but that the summary of 1993 costs accurately reflects the *overall* magnitude of the Atlantic Coast piping plover protection effort. Cost figures reflect several one-time, extraordinary expenditures that are unlikely to be repeated annually in the same locations, however, experience over nine years of piping plover recovery efforts has shown that comparable extraordinary costs are likely to be incurred somewhere in the plover's range each season.

Piping Plover Protection Effort
October 1, 1992 - September 30, 1993

State	On-site Management			Data Compilation, Reports, Planning			Admin. costs ($)	Off-site Info. and Education		Transportation ($)	Materials and Equip. ($)	Other ($)	Total ($)
	paid staff hours	paid staff $	volunteers (hrs)	paid staff hours	paid staff $	volunteers (hrs)		hours	$				
Maine	3,190	23,400	900	880	19,200	30	3,000	190	2,200	3,500	1,700	1,400	54,400
Massachusetts	23,200	226,200	9,340	4,040	62,500	600	32,000	1,400	17,8000	39,600	24,100	92,000	494,200
Rhode Island	5,690	75,200	2,610	630	8,700	360	3,700	150	3,100	2,700	10,300	800	104,500
Connecticut	1,800	17,500	760	280	3,900	10	1,300	100	2,100	1,600	1,300	0	27,700
New York	14,610	213,100	10,9400	4,800	134,800	140	45,000	700	13,4000	47,600	44,600	151,400	649,900
New Jersey	6,370	85,200	3,910	1,350	34,100	20	29,200	320	6,200	8,700	17,800	4,900	186,100
Delaware	1,520	11,200	130	430	5,700	150	1,100	120	1,300	2,000	3,100	0	24,400
Maryland	6,410	60,600	550	920	7,000	30	8,700	160	3,000	9,700	1,800	0	90,800
Virginia	3,000	48,900	1,980	550	9,800	80	5,000	150	3,500	17,500	4,800	1,700	91,200
North Carolina	560	7,600	190	310	4,200	20	2,800	20	300	6,200	1,500	37,500	60,100
Regional	0	0	0	1,040	38,000	0	7,000	50	4,000	0	0	0	49,000
TOTAL	66,350	768,900	31,310	15,230	327,900	1,440	138,800	3,360	56,900	139,100	111,000	289,700	1,832,300

APPENDIX K: KNOWN PIPING PLOVER WINTERING SITES ON THE SOUTHERN ATLANTIC COAST AND THE CARIBBEAN

The following list of wintering sites was compiled in order to identify areas along the Atlantic and Florida Gulf Coasts believed essential to piping plover conservation. This list incorporates all presently known wintering sites along the Atlantic and Florida Gulf Coasts, but should be viewed as a preliminary list. The Great Lakes/Northern Great Plains recovery plan lists all essential habitat on the Gulf Coast. Wintering habitat, like Atlantic Coast breeding habitat, is dynamic and sites may become more or less suitable through time. Sites that provide good habitat one year may not do so in the future, and sites with poor habitat may develop suitable habitat in the future. In North Carolina, for instance, sites such as Holden Beach/Shallote Inlet and Figure 8 Island/Rich Inlet may have improved through tidal flat development, as plover numbers have increased there in the past several years; however, sites such as Shackleford Banks and Bird Shoals have had fewer plovers in recent years and may be deteriorating in habitat quality (e.g., increased vegetation). Thus, prioritization of sites may be difficult because of the dynamic nature of plover habitat. The following list incorporates data from approximately 1983 to 1993 (Haig and Oring 1985, Hoopes *et al.* 1989, Fussell 1990, Nicholls and Baldassarre 1990a, Haig and Plissner 1992).

Note: * denotes more than one discrete wintering area per site.

NORTH CAROLINA: Wintering sites along the northern coast from Dare County to Carteret County are primarily within public ownership and receive some degree of protection and management. Wintering sites south of Carteret County are primarily on private or town-owned beaches; human disturbance during the winter may be a problem at some sites.

Currituck/Dare County

- Currituck Outer Banks*
- Cape Hatteras National Seashore
    - Oregon Inlet/Bodie Island
    - Cape Point
    - Hatteras Inlet

Hyde County

- Cape Hatteras National Seashore
    - Ocracoke Island*

Carteret County

- Cape Lookout National Seashore
    - Portsmouth Island/North Core Banks*
    - South Core Banks*
    - Shackleford Banks*

Rachel Carson's Estuary/Bird Shoals
Bogue Banks/Bogue Inlet

New Hanover County
Figure 8 Island
Wrightsville Beach/Mason Inlet
Masonboro Island/Masonboro Inlet
Carolina Beach/Carolina Beach Inlet
New Hanover/Brunswick Counties
Fort Fisher State Recreation Area/Corncake Inlet
Brunswick County
Zeke's Island Estuarine Preserve
Long Beach/Lockwood Folly's Inlet
Holden Beach/Shallote Inlet
Sunset Beach/Mad Inlet
Bird Island/Mad and Little River Inlets

SOUTH CAROLINA: The most suitable sites in South Carolina are remote and are accessible only by boat. In addition, most sites are either State or Federally-owned and are being maintained as wildlife sanctuaries.

Horry County
Waites Island/Little River Inlet
Georgetown County
Huntington Beach State Park/Murrells Inlet
North Island/North Inlet
South Island
Charleston County
Cape Romain NWR/Cape Island
Seabrook Island
Deveaux Bank
Beaufort County
Hilton Head Island/south end
Hunting Island State Park
Harbor Island/St. Helena Sound
Little Caper's Island/Pritchard's Inlet

GEORGIA: As in South Carolina, most of the wintering sites in Georgia are relatively inaccessible. Many sites are State- or Federally-owned, and some of the privately-owned sites are restricted to the general public.

Chatham County
- Tybee Island
- Little Tybee Island
- Williamson Island
- Wassaw Island NWR
- Ossabaw Island

Liberty County
- St. Catherine's Island*

McIntosh County
- Blackbeard Island NWR
- Sapelo Island

Glynn County
- Little St. Simon's Island
- Pelican Spit
- Jekyll Island

Camden County
- Cumberland Island National Seashore*
- Little Cumberland Island

FLORIDA ATLANTIC COAST: Some sites are in public ownership; however, there are few management and protection efforts for the piping plover. Human disturbance may be a problem at several sites.

Duval County
- Ward's Bank
- Talbot Island
- Little Talbot Island

St. John's County
- Anastasia State Recreation Area/St. Augustine Inlet
- Fort Mantanzas National Monument/Mantanzas Inlet

Volusia County
- Smyrna Dunes Park/Ponce Inlet

Martin County
- Martin County

Dade County
- Crandon Park
- Virginia Key

Monroe County

Caloosa Cove/Plantation Key
Ohio Key
The Donut/West Summerland Key
Boca Grande Key
Woman's Key
Bahia Honda State Recreation Area
Carl Ross Key

FLORIDA GULF COAST: Similar to Florida Atlantic Coast. Human disturbance and shoreline/inlet manipulations may be a threat.

Collier County

Marco Island/Sand Dollar Island

Lee County

Bunche Beach
Cayo Costa State Park
Fort Myers Beach/Estero Island
North Captiva Island

Charlotte County

Charlotte Beach State Recreation Area

Sarasota County

Midnight Pass

Manatee County

Beer Can Island
Anna Maria Island
Passage Key NWR

Pinellas County

Caladesi Island State Park
Dunedin Causeway
Dunedin Pass/Clearwater Beach
Fred Howard County Park
Fort Desoto State Park
Honeymoon Island State Park
Sand Key
Sunshine Skyway
Three Rooker Bar

Pinellas/Pasco County

Anclote Key State Park

Taylor County

Hagen's Cove

Franklin County
- Alligator Point/Phipp's Reserve
- Carabelle Beach
- Dog Island
- Lanark Reef
- St. George Island State Park
- St. Vincent's NWR

Gulf County
- Cape San Blas
- St. Joseph Peninsula State Park
- St. Joseph Bay

Bay County
- East Crooked Island/Tyndall Air Force Base
- West Crooked Island/Tyndall Air Force Base
- Shell Island/Tyndall Air Force Base

Santa Rosa County
- Santa Rosa Island/Eglin Air Force Base

Escambia County
- Gulf Islands National Seashore - Santa Rosa, Fort Pickens, and Perdido Key Areas
- Grand Lagoon State Park

OUTSIDE THE UNITED STATES:

Caribbean
- Cuba
- Puerto Rico
- Bermuda
- Virgin Islands/St. Croix
- Bahamas
  - St. Andros Island
  - Allan Cay
  - Waderick Cay
  - East Plana Cay
  - Eleuthera Island
- Greater Antilles
  - Grand Turk Island
  - New Providence Island

Mexico-Gulf Coast (see Haig and Plissner 1992)

APPENDIX L: SUMMARY OF COMMENTS ON DRAFT REVISED RECOVERY PLAN AND USFWS RESPONSES

In February 1995, the U.S. Fish and Wildlife Service released the Draft Revised Recovery Plan for the Piping Plover, Atlantic Coast Population for a 90-day comment period ending on May 8, 1995. Availability of the plan for comment was announced in the *Federal Register* (USFWS 1995a) and via a news release to media contacts throughout the species' U.S. range.

In accordance with USFWS policy (USFWS and NOAA 1994), requests for peer review of the draft plan were sent to experts outside the USFWS. In particular, these experts were asked to comment on (1) issues and assumptions relating to the biological and ecological information of the plan, and (2) scientific data related to the tasks in the proposed recovery program. Requests for peer review were sent to the following individuals:

Dr. Susan Haig, National Biological Service, Corvallis, Oregon
Dr. Robert Deblinger, Massachusetts Division of Fisheries and Wildlife
Dr. Guy Baldassarre, State University of New York, Syracuse

During the comment period, more than 350 additional copies of the draft plan were distributed to affected government agencies, organizations, and interested individuals.

Twenty-seven comment letters were received during the official comment period; six additional letters were received by the USFWS between May 8 and May 25, 1995. Affiliations of the originators of these thirty-three comment letters is tabulated below:

Peer reviewers	2 letters
Federal agencies	4 letters
State and Provincial governments	8 letters
Local governments	7 letters
Recreation groups	2 letters
Environmental or conservation organizations	4 letters
Academic institutions	1 letter
Landowner Association	1 letter
Individuals	4 letters

The letters received from the independent peer reviewers, as well as all other comment letters on the draft plan, are on file at the U.S. Fish and Wildlife Service, Weir Hill Road, Sudbury, Massachusetts, 01776.

Comments from Peer Reviewers and USFWS Responses

1. *Suggest showing State totals for nesting pairs and carrying capacity estimates for sites in Appendix B.* This has not been done because both the recovery team and the USFWS want to preclude erroneous interpretation of the 1993 carrying capacity estimates as either site-specific or State recovery goals (see comment #28, below). As noted on pages 29-30 and in the introduction to Appendix B, piping plover habitat is inherently dynamic, and the carrying capacity of individual sites is expected to fluctuate over time. The carrying capacity estimates represent a conservative "snap-shot" of carrying capacity based on habitat conditions in 1993, and their primary purpose was to facilitate population viability modeling.

2. *If possible, the plan should discuss the relative impact of each threat.* The relative impact of threats to piping plovers varies substantially from site to site, and may even vary between years at a given site. Therefore, effective and efficient plover protection requires careful and frequent on-site evaluation. Fortunately, a dedicated and skilled cadre of biologists from the various organizations and agencies involved in plover management at many sites are being attentive to this need, which will require on-going effort.

In addition, it is important to recognize that protection of piping plovers is often ineffective unless all threats are addressed comprehensively. For example, plover productivity will not be enhanced by reductions in egg depredation if the chicks are subsequently subjected to unrestricted off-road vehicle traffic; similarly, benefits from management of recreational activities will be much less effective if high rates of nest depredation are not alleviated. Benefits of protection efforts that increase plover productivity will not be realized if habitat loss and degradation reduce opportunities for recruitment into the breeding population.

For both of the reasons stated above, the USFWS believes that ongoing, site-specific evaluation of factors limiting productivity, as specified in task 1.12 is the most effective means for assessing and portraying relative threats.

3. *The plan should provide more information on how Section 10 permits will be implemented.* Information about the Section 10 application process is contained in the Draft Interim Handbook of Habitat Conservation Planning and Incidental Take Permitting Processing, referenced in Appendix H of the plan. The guidelines contained in this plan (Appendix H) are intended to help potential applicants formulate biologically-sound conservation plans, without constraining potentially innovative ways of accomplishing this goal. The Section 10 permit recently issued to Massachusetts Division of Fisheries and Wildlife provides one example of how such permits might "work" for piping plovers, but the USFWS anticipates that different approaches may be formulated by future applicants.

4. *Will it be possible to manage the plover for a recovery goal that is very close to the estimated capacity of current habitat?* See the expanded discussion of carrying capacity on pages 29-30 of the final plan. The recovery team believes that estimates provided in Appendix B are very conservative; furthermore, these estimates were designed to be below levels at which density dependent effects on

productivity would be triggered. Indeed, several New England sites are now very close to or have exceeded the capacity estimates stated in the draft plan, while maintaining high productivity.

Current experience suggests that management for a 2,000-pair population will require intensive protection, but is quite feasible. However, if future events shows that habitat capacity is more limited or that it is very difficult to manage for the target population, alternatives for achieving recovery, such as increasing the average productivity criterion and/or decreasing the variance in productivity, might be evaluated. Experience to date, however, suggests that it will be more feasible to manage for a 2,000-pair population than for average productivity above 1.5 chicks per pair.

5. *Is it biologically feasible to restore currently unsuitable or degraded habitat, in order to increase the overall capacity of plover habitat rangewide? Are there Federal programs available to do this?* There are at least two possible approaches to increasing the carrying capacity of piping plover habitat: (1) reducing impediments to natural coastal processes that form and maintain habitat (tasks 1.22 and 1.23) and (2) pro-active habitat enhancement (task 1.24). While there is no Federal program that has these tasks as its primary purpose, task 1.2 discusses the roles of the U.S. Army Corps of Engineers and the Federal Emergency Management Agency, particularly with regard to tasks 1.22 and 1.23. A number of organizations, including the National Park Service, USFWS, and The Nature Conservancy have been engaged in habitat enhancement; these efforts need to be continued and expanded. For example, the USFWS is seeking funding for habitat enhancement projects at Chincoteague and Currituck National Wildlife Refuges. Another opportunity to increase available habitat is through removal of herring and great black-backed gulls from otherwise suitable habitat (see task 1.43), and the USFWS has proposed such a gull removal program for the Monomoy National Wildlife Refuge in Massachusetts (USFWS 1996b).

6. *The plan needs to provide more information on how the carrying capacity estimates were derived.* See added discussion on pages 29-30 and 127 of the final plan.

7. *The plan should provide an estimate of the difficulty of achieving increases in populations at various sites.* Difficulty of achieving increases at various sites is a function of factors (including predation pressure and physical habitat suitability), that may vary across time (see response to comment #2, above) as well as social and political factors, which are also highly changeable. The local human and financial resources available to deal with threats are another variable that will affect the ability to achieve protection at given sites. The USFWS believes that top priority should be placed on maximizing productivity and abundance of plovers on Federal lands. Allocation of resources to non-Federal sites must be continually evaluated with consideration to all factors cited above.

8. *The plan should provide more background on the PVA process, including the incorporation of stochastic events.* Several references to materials that describe PVA have been added to the introductory paragraph in Appendix E for the benefit of those who wish to learn more about this process. Information about how the stochastic events have been incorporated into the PVA is found on pages 177 and 178, but there are few data available on the effects of catastrophic events on the Atlantic Coast piping plover.

9. *The plan should identify additional research needs important to recovery:*

a. Breeding habitat characterization - would contribute to refinement of carrying capacity estimates and help prioritize sites for recovery effort; should also attempt to correlate changes in habitat characteristics with changes in carrying capacity. See task 3.2 in the final plan.

b. Temporally partition mortality (within the annual cycle). This has been added to the final plan as task 3.6.

<u>Other Major Substantive Comments and USFWS Responses</u>

1. *Capacity estimates for the edge of the range need to reflect the possibility that nesting densities may be much lower there than in the core of the range.* As noted on page 30 of the final plan, the recovery team believes that estimates for the southern edge of the plover's range are very conservative, especially compared with those for New England.

2. *The plan should identify additional research needs important to recovery:*

a. Role of heat on egg mortality; role of heat and moisture availability on chick survival. This has been added to the final recovery plan as task 3.22. There may be opportunities to incorporate such research into potential pool/pond creation projects (see task 1.243).

b. Correlation between frequency of intertidal feeding and incidence of ghost crabs throughout the species' range. This is reflected in the expanded narrative accompanying task 3.43 in the final plan.

c. Determine effects on a local or regional populations from an event that causes widespread loss of productivity, including renest rates, productivity of renests, effects on population in subsequent years, etc. This information is available for a variety of sites in the species' range, including those where very poor productivity has occurred in one or more years. However, analysis of the data is sometimes confounded by lack of information on productivity in previous years, difficulty in tracking movements between sites/regions, and confounding factors that may exert simultaneous impacts on plovers.

3. *If increased survey intensity accounts for some of the increase in population estimates between 1986 and 1988, then maybe the piping plover should not have been listed in the first place.* Although the actual Atlantic Coast plover population at the time of listing was probably larger than estimates made in the early to mid-1980's, it was nonetheless very small (less than a thousand pairs), and productivity was below the rate needed to maintain a stationary population. Furthermore, the PVA estimates that (even with current population and productivity, which are much higher than in 1988) the Atlantic Coast piping plover population has an approximately 31-35% probability of extinction over 100 years. In addition, experience gained since listing has shown that threats to the security of the

plover on the Atlantic Coast are considerably more serious than the USFWS believed at the time of the listing.

4. *Including the Canadian portion of the population in the recovery goal holds recovery in the U.S. "hostage" to management in a foreign country where U.S. law has no authority.* Available data show that plovers in the two countries form a distinct vertebrate population as defined in the ESA, and inclusion of the Canadian portion of the range in the recovery plan is consistent with the species' listing. While delisting of the plover is contingent on improvement in the status of plovers in Atlantic Canada, the establishment of four recovery units within the Atlantic Coast population can facilitate some relaxation of protection under both Sections 7 and 9 of the ESA in U.S. recovery units where the species' numbers and productivity have attained levels that provide sufficient security for the species.

5. *Increasing the recovery goal after population estimates have increased is an unfair change in the "rules of the game."* The USFWS does not revise recovery goals without compelling data. Both plover demographic data and techniques for simulating population dynamics have improved substantially since 1988. Furthermore, the 1988 goal specified that the increases need to be spread across the species' range. Since an extremely large proportion of the actual increase in population since listing has occurred in New England, the Atlantic Coast plover population remains considerably more vulnerable to catastrophes than gains in total numbers might suggest.

6. *Beaches designated for public recreation are being converted to wildlife refuges without the benefit of legislation.* With the exception of national wildlife refuges, the USFWS is not aware of any plover nesting sites where recreational use has been eliminated, even seasonally. Off-road vehicle use has been curtailed for part of the year at some sites.

7. *Mobile sportsfishermen are a potential source of volunteers to assist with plover protection.* Volunteers, including mobile sportsfishermen, have indeed made valuable contributions to plover protection at some sites; there may be opportunities for increased assistance from such groups in the future.

8. *Photos of dead plovers in tire tracks are "fakes."* The USFWS is aware of one situation where a plover was found dead in a tire rut, moved to a freezer, returned to the site several days later to show investigators where and how it was discovered, and was photographed during this time. The USFWS is not aware of any instances of plovers that died from other causes being photographed in tire tracks.

9. *Emphasis on protecting plovers from motorized vehicles is disproportionate to the actual threat.* The USFWS and others have placed substantial emphasis on reducing many threats to plovers, including pedestrian disturbance, pets, predation, and habitat degradation. However, off-road vehicles remain one of the most *controversial*, and therefore one of the most visible aspects of the recovery program. Plover protection from off-road vehicles is not disproportionate to the threat, but the controversial nature of the issue means that it receives more public attention than other recovery activities.

10. *Restrictions on off-road vehicles are not as stringent for essential vehicles as for recreational vehicles and therefore mortalities are still occurring.* The USFWS agrees that any vehicle is a potential source of mortality to unfledged plover chicks, and therefore recommends that use of "essential" vehicles be avoided whenever possible. However, the USFWS also believes that mortalities from recreational vehicles are under-detected relative to mortalities from essential vehicles. The probability of encountering a dead chick in a single set of tire tracks on sites where a few vehicle trips per week occur is much higher than that of locating a dead chick on a site where frequent vehicle passes create many tire ruts that must be searched before subsequent traffic obliterates a carcass.

11. *Buffers to protect plovers from off-road vehicles should be the same as for pedestrians.* Impacts of pedestrians and off-road vehicles on plovers are very different, with vehicles exerting more serious injuries than pedestrians. Data in Table 1 show that buffers recommended for vehicles in Appendix G are the minimum necessary to avoid chick mortalities.

12. *The FWS and NPS are allowing dune restoration, which is deleterious to plover habitat, at Fire Island Seashore.* Threats described in a recovery plan are not automatically prohibited under the ESA. Reasons for concurrence with very limited dune construction within 500 feet of developed communities in 1993 and 1994 are summarized in an August 12, 1995 letter to the Fire Island Seashore (D.A. Stilwell, U.S. Fish and Wildlife Service, *in litt.* 1993). Future shoreline protection plans under the Fire Island Interim Storm Damage Protection Plan will be the subject of consultation between the USFWS and the Corps; the USFWS has already expressed grave concerns about the potential impacts of this project on plovers.

13. *Rules on National Seashores prohibiting vehicles from driving adjacent to beach grass foster vegetation encroachment into nesting habitat and exacerbate nest loss due to flooding.* Low rates of nest inundation are observed on many beaches where the "rhizome rule" has been enforced for many years, as well as on sites where off-road vehicles are not permitted at any time of year. Contrary to this comment, Elias-Gerken (1994) suggests that vehicles driving too close to beach grass prevent the development of sparse vegetation, found to be a characteristic of suitable nesting habitat in her Long Island study area.

14. *There is a discrepancy between actual population trends and those projected using survival rates from Massachusetts and observed productivity rates.* Most of the alleged discrepancy arises because the model adds the non-breeding one year old adults that survive their second winter into the breeding population the following year, while the commenter omitted this step.

15. *Delisting criterion #3, requiring that productivity of 1.5 chicks per pair be maintained for five years will increase the population beyond 2,000 pairs.* Stochasticity of survival and productivity rates means that average productivity needed to achieve a low probability of extinction is above that required to maintain a stationary population. However, the recovery plan anticipates that only 2,000 pairs will receive intensive protection over the long term. Indeed, the PVA assumes much lower productivity for pairs in excess of the recovery goal.

16. *A Section 10 permit should be issued to allow off-road vehicle use in Massachusetts.* A Section 10 permit that includes *limited* relaxation of current restrictions on off-road vehicle use was issued to MDFW in April 1996.

17. *The plan should be more specific about what type/level of protection will be needed once abundance and productivity objectives are achieved.* This need is identified in delisting criteria 4 and 5 and implementing actions are described in tasks 1.6 and 2.26. The USFWS agrees that types and intensity of long-term protection must be more specifically defined, but believes that achieving this will require experimentation and dialogue with affected parties. It would be especially premature to attempt definition of long-term protection needs in portions of the species' range where little increase in abundance has been achieved and productivity remains low. In addition, the ESA requires a minimum of five years of monitoring after any recovered species is delisted.

18. *Piping plover productivity figures should be compared with those for related species to determine whether the current emphasis on boosting productivity is appropriate.* Available data on productivity of other *Charadriidae* are from one or a few sites over limited time periods. The wide variation observed in Atlantic Coast piping plover productivity across sites and years suggests that data from one or two study sites may be a poor indicator of "normal" productivity for a species.

19. *How was the recovery goal target of 400 pairs for Atlantic Canada obtained?* This target was formulated on the basis of published and unpublished literature, discussions with Canadian biologists and reports from U.S. biologists familiar with Canadian sites and current protection efforts (see, for example, discussion on pages 30-31).

20. *Guideline #6 in Appendix H will be difficult to meet on some beaches with limited access points.* The USFWS does not anticipate that every guideline in Appendix H would have to be met for a Section 10 permit to be issued, especially guidelines such as #6 which include the caveat "whenever possible." However, the closer that conservation plans can come to meeting all the guidelines, the lower the anticipated impacts to the security of the plover population.

21. *Recommendations (in Appendix F) for monitoring exclosures every other day are not feasible for some sites.* Experience with exclosures in 1995, especially at three sites where "smart" foxes systematically depredated large numbers of exclosures, have reinforced the value of frequent monitoring. In situations where exclosures cannot be monitored every other day, it is recommended (page 189) that biologists carefully weigh the relative risks and benefits of exclosures on the site.

22. *Potential productivity of piping plovers may be lower at the edge of the range than in the core.* This may be true. However, productivity must be high enough to counter mortality rates and maintain a large enough population to buffer against stochastic events. However, since survival rates may differ across the species' range, delisting criterion #3 provides that adjustments to for productivity goals can be made for one or more recovery units if it is demonstrated that lower productivity rates will still assure a 95% probability of persistence for the population.

23. *Allowing take via Section 10 permits will send a message to the public that take is biologically sound and will encourage increased violations of local protection measures.* Appendix H contains very specific guidance about the circumstances under which take can be sustained without compromising plover recovery.

24. *What survival rate assumptions were used to formulate the 1988 recovery goal?* No data on survival rates were available in 1988.

25. *The recovery plan should recognize that competing land uses will affect the ability of some sites to contribute to recovery.* The USFWS recognizes that a number of factors will affect the contribution of each site to recovery. However, since suitable habitat is limited and competing uses are intense on most sites, efforts must be made to maximize the contribution of each. Except on national wildlife refuges, where the primary management objective is wildlife protection, it is considered neither feasible nor desirable to completely eliminate recreational use, but protecting piping plovers on sites that support multiple uses will require a continuing labor-intensive effort.

26. *The plan should give increased recognition to the dynamic nature of plover habitat and potential fluctuations in plover numbers and productivity over time.* The plan recognizes that plover habitat is dynamic and that suitability of various sites will vary over time (see pages 29-30 and 127). This consideration was a major factor in the decision to formulate relatively large recovery units (see page 55) and also underlies guideline #4 in Appendix H.

27. *The factors cited in comment #26 must be factored into any long-term protection agreements.* This concept has been incorporated into task 1.62. However, it must also be recognized that 2,000 pairs is a very small breeding population and intensive management will be needed to control the variance in productivity if such a small population is to persist over the longterm.

28. *Goals need to be set on a large enough spatial scale to allow for changes in suitability due to natural coastal formation processes.* The USFWS concurs. This is why delisting criteria are based on multi-State recovery units. Text has been added to the final plan (page 127) to clarify that the carrying capacity estimates in Appendix B are not site-specific goals.

29. *Intensive protection efforts will not translate into breeding success without maintenance of physical habitat characteristics.* The USFWS concurs and has emphasized this point in task 1.2 and related subtasks. However, the converse is also true -- that is, maintenance of habitat characteristics will not translate into breeding success without protection from other threats, including human disturbance and unnaturally high predation rates.

30. *Where plover numbers are expanding and/or management funds decreasing, it may become difficult to follow broods to 25 days for the purpose of determining productivity. A productivity figure based on survival to a lower age may be more feasible and provide more accurate data.* If a number of years of good data from an area is available, it may be possible to develop a "correction factor" that projects survival to 25 days based on rates of survival to a younger age. Even where available data is sufficient to accurately project productivity, however, intensive monitoring may be

needed until chicks fledge on many sites in order to determine when intensive public use management activities are no longer needed.

31. *Incidental take under Section 10 should be limited to one year "experimental" permits.* Guideline #5 in Appendix H recommends that, when possible, permits should be initially issued for two to six years to allow a reasonable period for gauging the effects of the permit and also to provide opportunities to reevaluate permits in light of changes in the overall status of the population. The guideline also recognizes that shorter permit periods (one to three years) may be particularly desirable in the early stages of Section 10 permitting for piping plovers. A one-year permit might be appropriate, for example, if a permit allows a relatively large amount of take or is based on relatively untested management techniques. The value of frequent re-permitting must, however, be carefully evaluated against the time and effort required to prepare and review a comprehensive permit application. Furthermore, one year of "experimentation" may be too short to provide meaningful feedback on the effects of the permit.

32. *It is inappropriate to "reward" areas where progress towards recovery has occurred by allowing relaxation of restrictions to reduce threats, specifically threats from off-road vehicles.* The guidelines in Appendix H are designed to identify locations where species' numbers and productivity have increased to the point where take can be allowed without compromising the plovers' survival and recovery. Furthermore, the guidelines are not specifically aimed at restrictions on vehicles, but are intended to guide preparation of conservation plans that might also involve non-motorized activities and/or significant habitat modification.

33. *Section 10 permits are not appropriate for off-road vehicle use because of the magnitude of damage they do to plovers and their habitat.* Impacts of any proposed activities, including off-road vehicle use, on the birds and their habitat will be considered during evaluation of Section 10 permit applications for piping plovers.

34. *Appendix H does not address the requirement that Section 10 applications analyze the alternatives to take induced by off-road vehicles.* Appendix H is only intended to provide a conservation planning guidance relative to the biology and demographics of Atlantic Coast piping plovers; more generic requirements, such as analysis of alternatives, are found in Federal regulations.

35. *Off-road vehicle use should not be sanctioned under Section 10 because it is not a "development project." Also, Appendix H does not specifically call for permittees to assist with plover conservation.* Although many Section 10 permits have been issued for development projects, the only limitation posed in the ESA is that they must be issued for an "otherwise lawful activity." Section 10(a)(2)(A) of the ESA requires conservation plans prepared by applicants to specify measures to minimize and mitigate impacts of the proposed taking.

36. *Issuance of Section 10 permits is inappropriate because critical habitat has not been designated for the piping plover.* Directions regarding designation of critical habitat and issuance of Section 10 permits are contained in separate sections of the ESA and are unrelated.

37. *Issuance of Section 10 permits is contrary to delisting criterion #4, because it will erode long-term protection efforts.* The plan identifies the need for long-term protection of plovers, but it also recognizes that the intensity of management required to sustain a recovered population *may* be less than that required to attain initial gains. The guidelines in Appendix H are specifically designed to promote continued progress towards recovery and long-term protection efforts. Task 1.64 states that the Section 10 permit process may be a valuable mechanism for developing the long-term protection agreements called for in delisting criterion #4, especially in areas where significant population growth has already occurred and productivity exceeds 1.5 chicks per pair.

38. *Section 10 permits for off-road vehicle use are contrary to the concept of conserving the ecosystem upon which the plover depends.* Guideline #11 recommends that applicants and evaluators of plans consider how they contribute to the health of the beach ecosystem. Specific incremental impacts on the beach ecosystem from any proposed Section 10 authorization should also be identified.

39. *Guideline #1 in Appendix H (achievement of 70% of a recovery unit's population target) is arbitrarily low and should be "in the 95% range."* For reasons stated under guideline #1, the USFWS believes that the 70% is appropriate as a minimum threshold. However, the plan also states that, "even after the 70% threshold is attained, conservation plans should maintain a cautious approach to take, especially if other recovery units lag substantially in their progress towards recovery." Furthermore, guideline #2 recommends that conservation plans assure that average productivity remain at or above 1.5 chicks per pair, a rate that will facilitate continued population growth.

40. *Commenter raises uncertainties concerning estimated carrying capacity for Delaware.* A USFWS biologist and the commenter conducted an on-site review of habitat carrying capacity in Delaware in September 1995, and estimates in the draft plan were confirmed.

41. *Establishment of four recovery units is not supported by taxonomic reasons, and their establishment will make it virtually impossible to achieve target numbers.* Recovery units are not intended to reflect taxonomic distinctions. Rather, they are primarily designed to increase security of the species by assuring that it is well-distributed. Contrary to the notion that recovery units will make it more difficult to achieve target numbers, they will facilitate prompt recognition of improved status of the species in parts of the range where numbers and productivity have improved. See also response to comment #4.

42. *The actual and anticipated costs of recovery (Appendix J and the Implementation Schedule) are not justifiable. These costs do not reflect costs to State and local governments.* As stated in Appendix J, costs reported there were assembled with the assistance of the State wildlife agencies, all of which incorporated cost information from other State agencies and local government, as well as private organizations.

As noted in the Implementation Schedule, tasks 1.3 and 1.4, Comments column (pages 101 and 102), the USFWS believes that protection costs could be reduced substantially by electing protection strategies that are more restrictive of other beach users. For example, 1993 protection costs (average cost per pair) were considerably higher at NPS units than those at national wildlife refuges; this is partially due to the costs associated with protecting plovers on NPS beaches that receive heavy public use, whereas refuge beaches are generally closed to public use during the breeding season. While the USFWS believes that it is neither feasible nor desirable to completely eliminate beach recreation in all plover habitat, it also recognizes that a management strategy that protects plovers on beaches where public use is also maintained requires a continuing commitment of person-power, and is inherently expensive. See also text added to the introduction to the Implementation Schedule, page 99 in the final plan.

43. *How will adjustments to delisting criterion 3 be made to reflect any differences in survival rates in recovery units, especially if banding is not safe?* See task 3.5 in the final plan.

44. *Experience in New Jersey shows that dogs should be banned from beaches when chicks are present.* Dogs are a definite threat to plovers (see pages 39 and 72). Guidelines in Appendix G recommend that dogs be prohibited during the breeding season if, based on observations and experience, pet owners fail to keep pets consistently leashed and under control. This may be appropriate in New Jersey, and, if so, the USFWS would strongly endorse such a policy.

45. *Any decreases in Section 6 funding before or after delisting will curtail protection efforts. Effort should be devoted to devising less labor-intensive protection methods.* The USFWS is very concerned about the cost of the current protection effort and the need to sustain these efforts over the long-term. For example, task 3.4 cites the labor-intensive (and, therefore, expensive) nature of many current methods of reducing threats from predators, and seeks to develop new predator management techniques that are both more effective and efficient. However, as noted under comment #42, many of the costs associated with plover protection are attributable to the difficulties of trying to protect piping plovers on sites where intensive public use is also being maintained. One possible focus of participation planning (see page 61 final plan) may be to seek ways to spread the costs of protection efforts among the stakeholders; it may also be appropriate for regional or local stakeholder groups to further evaluate the trade-offs between protection costs and maintaining public use.

46. *The recovery plan should provide for recovery strategies that depart from the guidelines in Appendix G.* The recovery plan cannot recommend activities that are likely to violate Section 9 of the ESA, unless a legal exemption is provided under Section 10. Appendix H is intended to facilitate the exemption process.

47. *The plan fails to designate critical habitat.* As provided in Section 4(a)(3) of the ESA, critical habitat designation is a listing process, rather than a recovery planning process. Furthermore, considerable progress towards recovery of the Atlantic Coast piping plover has occurred, especially in New England, without designation of critical habitat.

48. *The plan accords too low a priority to habitat protection. (Commenter cites low priority numbers assigned in the implementation schedule to tasks for long-term habitat protection).* A number of habitat protection tasks, including discouraging habitat development, interference with natural coastal processes, and beach stabilization projects are priority 1 tasks. The tasks cited in this comment letter, which address development of long-term protection strategies, clearly fit the definition

of priority 3 tasks (they are not necessary to prevent significant declines or some other significant impact short of extinction). This does not, however, diminish the importance of these priority 3 tasks for achieving full recovery, as all tasks are considered necessary components of the recovery program.

49. *Delisting should not occur when a 2,000-pair population has been maintained for five years; these increases will be quickly eroded unless threats to plovers and their habitat have been "adequately dealt with."* The USFWS agrees maintenance of population gains and productivity after delisting must be ensured. This is why the delisting criteria 4 and 5, page 58 were included to provide for long-term protection of the species and its breeding and wintering habitat.

50. *The plan fails to specify how criterion #2 (verification of the adequacy of the 2,000-pair goal to maintain genetic diversity) will be accomplished.* Task 3.8 addresses this need. One possible approach is referenced, but the possibility of using other methodologies is also acknowledged.

51. *The plan should provide more details on how long-term protection of habitat will be provided, especially for wintering habitat in other countries.* See response to comment #17. In the case of wintering habitat, it will be especially difficult to define detailed long-term protection strategies until more immediate needs to locate wintering sites and determine the threats are accomplished. Recovery tasks build on each other, and more specific long-term protection strategies will be developed as more information becomes available.

52. *The plan should summarize all Section 7 consultations and their outcomes.* This information is not necessary or appropriate for recovery plans.

53. *The plan should provide more information on efforts to "foster ecosystem-level protection." Specifically, will the USFWS issue a multi-species recovery plan for the Atlantic Coast beach and dune ecosystem?* Although the USFWS is not currently planning to prepare a multi-species or ecosystem beach recovery plan for the Atlantic Coast, recovery plans (approved or draft) have been prepared for the various listed beach-dwelling species. The USFWS is also actively employing various other mechanisms to foster ecosystem level protection, including attention to rare beachstrand species in plans under development by the USFWS Ecosystem Teams.

54. *Carrying capacity estimates in Appendix B may be conservative, since some Massachusetts breeding sites are not included and estimates appear conservative.* The USFWS agrees with this comment. See discussion on page 30. However, given the limited application of these data in the plan (for the PVA) and the natural fluctuations in carrying capacity that occur due to the dynamism of the habitat, comprehensive revision of these estimates at this time is not warranted. The methodology proposed by the commenter for estimating carrying capacity is similar to the process used by MDFW to determine "provisional abundance objectives" for Massachusetts plover sites in 1995.

55. *The guidelines in Appendix G will end all future beach visitation.* Guidelines in Appendix G allow for uninterrupted pedestrian recreation on beaches and allow for minimizing duration and size of closures to vehicles, contingent on intensive monitoring. Widespread implementation of these guidelines in Massachusetts and elsewhere has been achieved while maintaining intensive beach use.

56. *The plan should note the association between least terns and piping plovers, and possible benefits to plovers from least tern protection efforts.* See page 46.

57. *Commenters recommend the addition of several sites to Appendices A-D.* These have been included in the final plan.

58. *Are the four recovery populations based on the anticipated metapopulation structure?* This was not the intent of the recovery unit delineations. As explained on pages 54-55, the units are primarily designed to assure that the recovered population is well-distributed. The units were also designed to be large enough to buffer their carrying capacity against localized changes in habitat quality due to natural coastal formation processes and variation in other environmental factors. Development of a metapopulation model is called for in task 3.7.

59. *Is there any evidence that dispersal occurs when habitat suitability declines?* Declines in abundance on some sites have been documented when habitat declines (for example, at Cadden Beach/Kejimikujik National Park in Nova Scotia; see also Wilcox 1959). However, it is not clear whether this is due to declining fidelity of adults that have nested on the site in recent years or to decreased rates of colonization by either first-time breeders or adults dispersing from other sites.

LITERATURE CITED

Allee, W.C. 1931. Animal aggregations: A study in general sociology. University of Chicago Press, Chicago, Illinois.

Allee, W.C., A.E. Emerson, O. Park, T. Park, and K.P. Schmidt. 1949. Principles of animal ecology. Saunders, Philadelphia, Pennsylvania.

American Birds. 1987. 41(4): 1321.

American Birds. 1990. 44(4): 1013.

American Ornithologists' Union. 1945. Twentieth supplement to the checklist of North American birds. Auk 62: 436-449.

American Ornithologists' Union. 1957. Checklist of North American birds. 5th edition. Baltimore, Maryland. 691 pp.

American Ornithologists' Union. 1983. Checklist of North American birds. 6th edition. Lawrence, Kansas. 877 pp.

Atlantic Canada Piping Plover Recovery Team. 1992. Minutes of the 5th Atlantic Canada Piping Plover Recovery Team Meeting, November 9 and 10, 1992. Canadian Wildlife Service, Sackville, New Brunswick. 5 pp.

Atlantic Canada Piping Plover Recovery Team. 1993. Minutes of the Atlantic Piping Plover Recovery Team Meeting, November 9 and 10, 1993. Canadian Wildlife Service. Sackville, New Brunswick. 8 pp.

Barbour, R.W., C.T. Peterson, D. Rust, H.G. Shadowen, and A.J. Whitt, Jr. 1973. Kentucky Birds. University Press of Kentucky, Lexington.

Barrowclough, G.F. and S.L. Coats. 1985. The demography and population genetics of owls, with special reference to the conservation of the spotted owl (*Strix occidentalis*). Pages 74-83 *in* R.J. Gutierrez and A.B. Carey (eds.), Ecology and management of the spotted owl in the Pacific Northwest. Gen. Tech. Rep. PNW-185. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Begon, M. and M. Mortimer. 1986. Population Ecology. Sinauer Associates, Inc., Sunderland, Massachusetts.

Belovsky, G.E. 1987. Extinction models and mammalian persistence. Pp. 35-37 *in* M.E. Soulé (ed.), Viable populations for conservation. Cambridge University Press, New York, New York.

Bent, A.C. 1929. Life histories of North American Shorebirds. U.S. Natural Museum Bulletin 146: 236-246.

Bergstrom, P.W. 1991. Incubation temperatures of Wilson's plovers and killdeers. Condor 91: 634-641.

Blodget, B.G. 1990. People, beaches and birds: The piping plover story. Massachusetts Wildlife. Pp. 18-25.

Boates, J.S., P. Austin-Smith, G. Dickie, R. Williams, and D. Sam. 1994. Nova Scotia piping plover atlas. Kentville, Nova Scotia. 86 pp.

Bottitta, G.E., L. Herbeck, W. Hulslander, and J. Kumer. 1993. Management and monitoring of the piping plover at Assateague Island National Seashore, Maryland. Unpublished report. Assateague Island National Seashore, Berlin, Maryland. 69 pp.

Bottitta, G.E., J. Kumer, G.S. Schumaker, and K. Hommerbocker. 1994. Management and monitoring of the piping plover at Assateague Island National Seashore, Maryland. Unpublished report. Assateague Island National Seashore, Berlin, Maryland. 45 pp.

Brown, J.M. and E.M. Hoopes. 1993. Breeding ecology of piping plovers in Cape Cod National Seashore. South Wellfleet, Massachusetts. 11 pp. and appendix.

Bull, J. 1964. The birds of the New York area. Reprinted by Dover Publications in 1975. Pp. 185-186.

Burger, J. 1987a. Physical and social determinants of nest site selection in piping plover in New Jersey. Condor 98: 811-818.

Burger, J. 1987b. New Jersey endangered beach-nesting bird project: 1986 research. Unpublished report. New Jersey Department of Environmental Protection, Trenton, New Jersey. 37 pp.

Burger, J. 1991. Foraging behavior and the effect of human disturbance on the piping plover (*Charadrius melodus*). Journal of Coastal Research 7: 39-52.

Burger, J. 1994. Nocturnal foraging behavior of breeding piping plovers (*Charadrius melodus*) in New Jersey. Auk 111(3): 579-587.

Burger, J. 1994. The effect of human disturbance on foraging behavior and habitat use in piping plover (*Charadrius melodus*). Estuaries 17(3): 695-701.

Cairns, W.E. 1977. Breeding biology and behaviour of the piping plover *Charadrius melodus* in southern Nova Scotia. M.S. Thesis. Dalhousie University, Halifax, Nova Scotia. 115 pp.

Cairns, W.E. 1982. Biology and behavior of breeding piping plovers. Wilson Bulletin 94: 531-545.

Cairns, W.E. and I.A. McLaren. 1980. Status of the piping plover on the east coast of North America. American Birds 34: 206-208.

Canadian Wildlife Service. 1989. Canadian piping plover recovery plan. Ontario, Canada. 18 pp.

Canadian Wildlife Service. 1994. The 1991 international piping plover census in Canada. S.P. Fleming (ed.). Ontario, Canada. 59 pp.

Cape Cod National Seashore. 1993. Piping plover nest found trampled by pedestrian. News release. Cape Cod National Seashore, South Wellfleet, Massachusetts. 2 pp.

Cartar, R. 1976. The status of the piping plover at Long Point, Ontario, 1966-1975. Ontario Field Biologist 30:42-45.

Carter, D. 1988. 1988 survey of the breeding status of the piping plover in North Carolina. Unpublished draft report. 6 pp.

Cashin Associates, P.C. 1993. The environmental impacts of barrier island breaching with particular focus on the south shore of Long Island, New York. Prepared for State of New York, Division of Coastal Resources and Waterfront Revitalization, Albany, New York. 44 pp. and appendix.

Coastal Barriers Study Group. 1987. Draft report to Congress: Coastal barrier resources system. Executive summary. Department of the Interior, Washington, D.C. 25 pp.

Coastal Barriers Task Force. 1983. Final environmental impact statement: Undeveloped coastal barriers. Department of the Interior, Washington, D.C.

Collazo, J.A., J.R. Walters, and J.F. Parnell. 1994. Factors affecting reproduction and migration of waterbirds on North Carolina Barrier Islands. 1993 annual progress report. North Carolina State University, Raleigh, North Carolina. 57 pp.

Collazo, J.A., J.R. Walters, and J.F. Parnell. 1995. Factors affecting reproduction and migration of waterbirds on North Carolina barrier islands. Final report to the National Park Service, Cape Hatteras and Cape Lookout National Seashores.

Coutu, S.D., J.D. Fraser, J.L. McConnaughy, and J.P. Loegering. 1990. Piping plover distribution and reproductive success on Cape Hatteras National Seashore. Unpublished report to the National Park Service. 67 pp.

Cross, R.R. 1988. Report of piping plover research activities on Metompkin Island. College of William and Mary, Williamsburg, Virginia. 23 pp.

Cross, R.R. 1989. Monitoring, management and research of the piping plover at Chincoteague National Wildlife Refuge. Unpublished report. Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 80 pp.

Cross, R.R. 1990. Monitoring, management and research of the piping plover at Chincoteague National Wildlife Refuge. Unpublished report. Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 68 pp.

Cross, R.R. 1991. Monitoring, management, and research of the piping plover at Chincoteague National Wildlife Refuge. Unpublished report. Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 76 pp.

Cross, R.R. 1992. Research Proposal: Conditioned taste aversion: A field test on piping plover egg predators. Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 14 pp.

Cross, R.R. 1993. Protection of piping plover (*Charadrius melodus*) eggs and chicks from red foxes (*Vulpes vulpes*) through the artificial establishment of coyote (*Canis latrans*) home ranges. Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 14 pp.

Cross, R.R. and K. Terwilliger. 1993. Piping plover flushing distances recorded in annual surveys in Virginia 1986-1991. Virginia Department of Game and Inland Fisheries, Richmond, Virginia. 5 pp.

Deblinger, R.D., J.J. Vaske, and D.W. Rimmer. 1992. An evaluation of different predator exclosures used to protect Atlantic Coast piping plover nests. Wildlife Society Bulletin 20: 274-279.

Delaware Department of Natural Resources and Environmental Control. 1990. Delaware piping plover management plan. Dover, Delaware. 5 pp.

Delaware Department of Natural Resources and Environmental Control. 1993. Cape Henlopen State Park beach management plan: 1993. Dover, Delaware. 5 pp.

Dougherty, S. and K. Motivans. Undated. The Long Island piping plover and tern protection program: A manual for plover/tern stewards and volunteers. The Nature Conservancy, Long Island, New York. 24 pp.

Downer, R.H, and C.E. Leibelt. 1990. 1989 Long Island colonial waterbird and piping plover survey. Research report of the New York State Department of Environmental Conservation, Stony Brook, New York. 200 pp.

Drury, W. H. 1973. Population changes in New England seabirds. Bird Banding 44: 267-313.

Ducey-Ortiz, A.M., T.S. Litwin and D.C. MacLean. 1989. 1988 Long Island colonial waterbird and piping plover survey. Unpublished report. Seatuck Research Program, Cornell Laboratory of Ornithology, Islip, New York. 8 pp.

Eddings, K.J., and S.M. Melvin. 1991. Biology and conservation of piping plovers at Breezy Point, New York, 1991. Unpublished report submitted to the U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 38 pp.

Eddings, K.J., C.R. Griffin, and S.M. Melvin. 1990. Productivity, activity patterns, limiting factors, and management of piping plovers at Sandy Hook, Gateway National Recreation Area, New Jersey. Unpublished report. Department of Forestry and Wildlife Management, University of Massachusetts, Amherst. 79 pp.

Elias-Gerken, S.P. 1994. Piping plover habitat suitability on central Long Island, New York barrier islands. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 48 pp.

Elias-Gerken, S.P. and J.D. Fraser. 1994. Piping plover foraging ecology on Pike's Beach, Southampton, New York. Final report submitted to the U.S. Fish and Wildlife Service, Sudbury, Massachusetts. 61 pp.

Erwin, R.M. 1979. Historical breeding records of colonial seabirds and wading birds, 1900-1977, Cape Elizabeth, Maine to Virginia. Supplement to final report prepared for U.S. Fish and Wildlife Service, Coastal Ecosystems Project, Newton Corner, Massachusetts.

Eubanks, T. 1992. The piping plover in Texas: Winter survey guidelines. Draft report for Great Lakes/Northern Great Plains piping plover recovery team. 17 pp.

Ferson, S. and H.R. Akcakaya. 1990. RAMAS/age user manual. Modeling fluctuations in age-structured populations. Exeter Software, Setauket, New York. 113 pp.

Flemming, S.P. 1984. The status and responses of piping plovers to recreational activity in Nova Scotia. Honors Thesis. Acadia University, Wolfville, Nova Scotia. 150 pp.

Flemming, S.P., R.D. Chiasson, P.C. Smith, P.J. Austin-Smith, and R.P. Bancroft. 1988. Piping plover status in Nova Scotia related to its reproductive and behavioral responses to human disturbance. Journal of Field Ornithology 59(4): 321-330.

Flemming, S.P., R. D. Chiasson, and P.J. Austin-Smith. 1990. Piping plover nest-site selection in New Brunswick and Nova Scotia. Unpublished report. Department of Biology, Queen's University, Kingston, Canada. 31 pp.

Forbush, E.H. 1925. Birds of Massachusetts and other New England States. Volume I. Massachusetts Department of Agriculture.

Frankel, O.H. and M.E. Soulé. 1981. Conservation and evolution. Cambridge University Press. Cambridge, England.

Franklin, I.R. 1980. Evolutionary change in small populations. Pp. 135-149 *in* M.E. Soulé and B.A. Wilcox (eds.), Conservation biology: An evolutionary-ecological perspective. Sinauer Associates, Sunderland, Massachusetts.

Fussell, J.O. 1990. Census of piping plovers wintering on the North Carolina Coast - 1989-1990. Unpublished report to the North Carolina Wildlife Resources Commission. 54 pp.

Gardner, A.L. 1982. Virginia opossum. Pp. 3-36 *in* J.A. Chapman and G.A. Feldhamer (eds.), Wild mammals of North America. John Hopkins University Press. Baltimore, Maryland.

Gibbs, J.P. 1986. Feeding ecology of nesting piping plovers in Maine. Unpublished report to Maine Chapter, The Nature Conservancy, Topsham, Maine. 21 pp.

Gilpin, M.E. 1987. Spatial structure and population vulnerability. Pp. 125-139 *in* M.E. Soulé (ed.), Viable populations for conservation. Cambridge University Press, New York.

Goldin, M.R. 1990. Reproductive ecology and management of piping plovers (*Charadrius melodus*) at Breezy Point, Gateway National Recreation Area, New York -- 1990. Unpublished report. Gateway National Recreation Area, Long Island, New York. 16 pp.

Goldin, M.R. 1993a. Piping Plover (*Charadrius melodus*) management, reproductive ecology, and chick behavior at Goosewing and Briggs Beaches, Little Compton, Rhode Island, 1993. The Nature Conservancy, Providence, Rhode Island. 64 pp.

Goldin, M.R. 1993b. Effects of human disturbance and off-road vehicles on piping plover reproductive success and behavior at Breezy Point, Gateway National Recreation Area, New York. M.S. Thesis. University of Massachusetts, Amherst, Massachusetts. 128 pp.

Goldin, M.R. 1994a. Recommended monitoring and management methodology and techniques for piping plovers (*Charadrius melodus*). Report for U.S. Fish and Wildlife Service, Hadley, Massachusetts. 15 pp.

Goldin, M.R. 1994b. Breeding history of, and recommended monitoring and management practices for, piping plovers (*Charadrius melodus*) at Goosewing Beach, Little Compton, Rhode Island (with discussion of Briggs Beach). Report for U.S. Fish and Wildlife Service, Hadley, Massachusetts. 36 pp.

Goldin, M.R. Undated. Rhode Island piping plover and tern conservation program: A manual for piping plover and tern volunteers. Providence, Rhode Island. 26 pp.

Goldin M.R., C. Griffin, and S. Melvin. 1990. Reproductive and foraging ecology, human disturbance, and management of piping plovers at Breezy Point, Gateway National Recreation Area, New York, 1989. Progress report for U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 58 pp.

Goodman, D. 1987. How do any species persist? Lessons for conservation biology. Conservation Biology 1: 59-62.

Griffin, C.R. and S.M. Melvin. 1984. Research plan on management, habitat selection, and population dynamics of piping plovers on outer Cape Cod, Massachusetts. University of Massachusetts. Research proposal submitted to U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 5 pp.

Griscom, L. and D.E. Snyder. 1955. The birds of Massachusetts. Peabody Museum. Salem, Massachusetts. P. 88.

Haig, S.M. 1992. Piping plover. *In* A. Poole, P. Stettenheim, and F. Gill (eds.), The Birds of North America, No. 2. Philadelphia: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.

Haig, S.M. and L.W. Oring. 1985. The distribution and status of the piping plover throughout the annual cycle. Journal of Field Ornithology 56: 266-273.

Haig, S.M. and L.W. Oring. 1987. The piping plover. Audubon Wildlife Report. Pp. 503-519.

Haig, S.M. and L.W. Oring. 1988a. Genetic differentiation of piping plovers across North America. Auk 105(4): 260-267.

Haig, S.M. and L.W. Oring. 1988b. Distribution and dispersal in the piping plover. Auk 105(3): 630-638.

Haig, S.M. and L.W. Oring. 1988c. Mate, site and territory fidelity in piping plover. Auk 105(4): 268-277.

Haig, S.M. and J.H. Plissner. 1992. The 1991 international piping plover census. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 200 pp.

Haig, S.M. and J.H. Plissner. 1993. Distribution and abundance of piping plovers: Results and implications of the 1991 International census. Condor 95: 145-156.

Hake, M. 1993. 1993 summary of piping plover management program at Gateway NRA Breezy Point district. Unpublished report. Gateway National Recreation Area, Long Island, New York. 29 pp.

Halifax Field Naturalists. 1992. The 1992 piping plover guardian volunteer manual. Halifax, Nova Scotia. 19 pp.

Harris, R.B. and F.W. Allendorf. 1989. Genetically effective population size of large mammals: An assessment of estimators. Conservation Biology 3: 181-191.

Hill, J.O. 1988. Aspects of breeding biology of piping plovers (*Charadrius melodus*) in Bristol County, Massachusetts in 1988. Unpublished report. University of Massachusetts, Amherst, Massachusetts. 44 pp.

Hoopes, E.M. 1993. Relationships between human recreation and piping plover foraging ecology and chick survival. M.S. Thesis. University of Massachusetts, Amherst, Massachusetts. 106 pp.

Hoopes, E.M. 1994. Breeding ecology of piping plovers nesting at Cape Cod National Seashore - 1994. National Park Service, South Wellfleet, Massachusetts. 34 pp.

Hoopes, E.M. 1995. Piping plover nest distribution with respect to concrete walkways at the Breezy Point Cooperative, New York, 1991-1994. Report for the U.S. Fish and Wildlife Service, Sudbury, Massachusetts. 6 pp.

Hoopes, E.M., C.R. Griffin, and S.M. Melvin. 1989. Atlantic Coast Piping Plover winter distribution survey. Unpublished report to the U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 6 pp.

Hoopes, E.M., C.R. Griffin, and S.M. Melvin. 1992. Relationships between human recreation and piping plover foraging ecology and chick survival. Unpublished report. University of Massachusetts, Amherst, Massachusetts. 77 pp.

Howard, J.M., R.J. Safran, and S.M. Melvin. 1993. Biology and conservation of piping plovers at Breezy Point, New York. Unpublished report. Department of Forestry and Wildlife Management, University of Massachusetts, Amherst. 34 pp.

Imhoff, T. 1975. Birds of Alabama. Alabama Department of Conservation and Natural Resources. Pp. 221-222.

Jenkins, C.D. 1993. Piping plover survey and threat assessment. New Jersey endangered beach-nesting bird project. Federal Aid Report, Projects No. XIV and XIVA. New Jersey Division of Fish, Game, and Wildlife, Trenton, New Jersey. 29 pp.

Johnsgard, P.A. 1981. The plovers, sandpipers, and snipes of the world. University of Nebraska Press, Lincoln, Nebraska. 423 pp.

Johnson, C.M. and G.A. Baldassarre. 1988. Aspects of the wintering ecology of piping plovers in coastal Alabama. Wilson Bulletin 100: 214-233.

Leatherman, S.P. 1979. Barrier island handbook. National Park Service Cooperative Research Unit, University of Massachusetts, Amherst, Massachusetts. 101 pp.

Leatherman, S.P. and J.R. Allen, eds. 1985. Geomorphic analysis, Fire Island Inlet to Montauk Point, Long Island, New York. Reformulation study submitted to the U.S. Army Corps of Engineers, New York District.

LeGrand, H.E. Jr. 1991. The piping plover in North Carolina -- Population trends for breeding and wintering birds. *In* Biology and management of piping plovers in North Carolina, abstracts of presentations held April 2-3, 1991, Duke University Marine Laboratory Auditorium, Beaufort, North Carolina.

Lindenmayer, D.B., T.W. Clark, R.C. Lacy, and V.C. Thomas. 1993. Population viability analysis as a tool in wildlife conservation policy: With reference to Australia. Environmental Management 17(6): 745-758.

Litwin, T.S., A. Ducey-Ortiz, R.A. Lent, and C.E. Liebelt. 1993. 1990-1991 Long Island colonial waterbird and piping plover survey. Volume I. New York State Department of Environmental Conservation, Stony Brook, New York. 109 pp.

Loegering, J.P. 1992. Piping plover breeding biology, foraging ecology and behavior on Assateague Island National Seashore, Maryland. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 247 pp.

Loegering, J.P. and J.D. Fraser. 1995. Factors affecting piping plover chick survival in different brood-rearing habitats. Journal of Wildlife Management 59(4): 646-655.

Loegering, J.P., J.D. Fraser, and L.L. Loegering. 1995. Ghost crabs prey on a piping plover chick. Wilson Bulletin 107(4): 768-769.

Lyons, M. and A. McGrane. 1995. 1995 piping plover season, Cape Hatteras National Seashore. Unpublished report. National Park Service, Manteo, North Carolina. 35 pp.

Mace, G.M. and R. Lande. 1991. Assessing extinction threats: Toward a reevaluation of IUCN threatened species categories. Conservation Biology 5: 148-157.

MacIvor, L.H. 1990. Population dynamics, breeding ecology, and management of piping plovers on outer Cape Cod, Massachusetts. M.S. Thesis. University of Massachusetts, Amherst, Massachusetts. 100 pp.

MacIvor, L.H. 1991. Research proposal: Conditioned taste aversion: A technique to reduce red fox predation at piping plover nests on Assateague Island National Seashore. Maryland Department of Natural Resources, Annapolis, Maryland. 8 pp.

MacIvor, L.H., C.R. Griffin, and S.M. Melvin. 1987. Management, habitat selection, and population dynamics of piping plovers on outer Cape Cod, Massachusetts: 1985-1987. Submitted to National Park Service, Cape Cod National Seashore, South Wellfleet, Massachusetts.

Maine Audubon Society. 1995. Piping plover and least tern newsletter, winter/spring 1995-1996. Falmouth, Maine. 4 pp.

Maine Department of Inland Fisheries and Wildlife. 1995. Atlas of essential wildlife habitats for Maine's endangered and threatened species. 1995 edition. Augusta, Maine. Pp. 8-11.

Massachusetts Barrier Beach Task Force. 1994. Guidelines for barrier beach management in Massachusetts. Massachusetts Coastal Zone Management Program, Boston, Massachusetts. 265 pp.

Massachusetts Division of Fisheries and Wildlife. 1993. Guidelines for managing recreational use of beaches to protect piping plovers, terns, and their habitats in Massachusetts. Natural Heritage and Endangered Species Program, Field Headquarters, Westborough, Massachusetts. 14 pp.

Massachusetts Division of Fisheries and Wildlife. 1996. Conservation plan for piping plovers in Massachusetts. Submitted to U.S. Fish and Wildlife Service. Westborough, Massachusetts. 35 pp. and appendices.

Mayer, P.M. and M.R. Ryan. 1991. Electric fences reduce mammalian predation on piping plover nests and chicks. Wildlife Society Bulletin 19: 59-63.

McConnaughey, J.L., J.D. Fraser, S.D. Coutu, and J.P. Loegering. 1990. Piping plover distribution and reproductive success on Cape Lookout National Seashore. Unpublished report to the National Park Service. 83 pp.

Melvin, S.M. 1986-1993. Status of piping plovers in Massachusetts, annual summaries. Unpublished report. Massachusetts Division of Fisheries and Wildlife, Westborough, Massachusetts.

Melvin, S.M. 1993. Recommendations for improving productivity of piping plovers at Chincoteague National Wildlife Refuge. University of Massachusetts, Amherst, Massachusetts. 14 pp.

Melvin, S.M. and J.P. Gibbs. 1994. Viability analysis for the Atlantic Coast population of piping plovers. Unpublished report to the U.S. Fish and Wildlife Service, Sudbury, Massachusetts. 16 pp.

Melvin, S.M. and S.M. Roble. 1990. Massachusetts' Wetlands Protection Act: A tool for protecting rare wildlife habitat. Pp. 224-228 *in* D.J. Leopold (ed.), Ecosystem Management: Rare Species and Significant Habitats. Proceedings of 15th Annual Natural Areas Conference.

Melvin, S.M., A. Hecht, and C.R. Griffin. 1994. Piping plover mortalities caused by off-road vehicles on Atlantic Coast beaches. Wildlife Society Bulletin 22: 409-414.

Melvin, S.M., C.R. Griffin, and L.H. MacIvor. 1991. Recovery strategies for piping plovers in managed coastal landscapes. Coastal Management 19: 21-34.

Melvin, S.M., L.H. MacIvor, and C.R. Griffin. 1992. Predator exclosures: A technique to reduce predation of piping plover nests. Wildlife Society Bulletin 20: 143-148.

Morse, M. 1982. 1982 piping plover survey, Prince Edward Island National Park. Unpublished report. Canadian Wildlife Service, Sackville, New Brunswick, and Parks Canada, Charlottetown, Prince Edward Island. 37 pp.

Moser, R.A. 1942. Should the belted piping plover be recognized as a valid race? Nebraska Bird Review 10: 31-37

Murray, R. and M.W. McDavit. 1993. First nest records of piping plover in South Carolina. Chat 57(1): 10-11.

National Park Service. 1989. Environmental assessment on management for the threatened piping plover, Breezy Point District, Gateway National Recreation Area. Brooklyn, New York. 25 pp.

National Park Service. 1992. Environmental assessment on management plan for the threatened piping plover, Sandy Hook Unit, Gateway National Recreation Area. Sandy Hook, New Jersey. 23 pp.

National Park Service. 1993a. Draft guidelines for mitigation of primary dune beaches immediately adjacent to development district lands and Fire Island National Seashore as threats to exempted communities. National Park Service, Fire Island National Seashore, Patchogue, New York. 3 pp.

National Park Service. 1993b. Piping plover Management plan. Assateague Island National Seashore, Berlin, Maryland. 24 pp.

National Park Service. 1994a. Environmental Assessment on management plan for shoreside species breeding habitat. Fire Island National Seashore, Patchogue, New York. 29 pp.

National Park Service. 1994b. Standard operating procedure #6, shorebird management. Cape Cod National Seashore, South Wellfleet, Massachusetts. 14 pp.

National Park Service. 1995. Proceedings of the National Park Service Atlantic Coast piping plover conference, November 2-3, 1995. Assateague Island National Seashore, Berlin, Maryland. 55 pp.

National Research Council. 1995. Science and the Endangered Species Act. National Academy Press, Washington, D.C. 162 pp.

New York Governor's Coastal Erosion Task Force. 1994. Final report. Summary of recommendations. 9 pp.

Nicholls, J.L. 1989. Distribution and other ecological aspects of piping plovers (*Charadrius melodus*) wintering along the Atlantic and Gulf Coasts. M.S. Thesis. Auburn University, Auburn, Alabama. 150 pp.

Nicholls, J.L. and G.A. Baldassarre. 1990a. Winter distribution of piping plovers along the Atlantic and Gulf Coasts of the United States. Wilson Bulletin 102: 400-412.

Nicholls, J.L. and G.A. Baldassarre. 1990b. Habitat selection and interspecific associations of piping plovers along the Atlantic and Gulf Coasts of the United States. Wilson Bulletin 102: 581-590.

Northeast Nongame Technical Committee. 1993. Legal categories of rare species in the northeastern States. Northeast Nongame Technical Committee, Northeast Association of Fish and Wildlife Agencies. 22 pp.

Palmer, R.S. 1967. Piping plover. *In* Stout, G.D. (ed.), The shorebirds of North America. Viking Press, New York. 270 pp.

Patterson, M.E. 1988. Piping plover breeding biology and reproductive success on Assateague Island. M.S. Thesis. Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 131 pp.

Patterson, M.E., J.D. Fraser, and J.W. Roggenbuck. 1991. Factors affecting piping plover productivity on Assateague Island. Journal of Wildlife Management 55(3): 525-531.

Pollock, K.H., J.D. Nichols, C. Brownie, and J.E. Hines. 1990. Statistical inference for capture-recapture experiments. Wildlife Monographs No. 107. 97 pp.

Post, T. 1991. Reproductive success and limiting factors of piping plovers and least terns at Breezy Point, New York, 1990. New York State Department of Environmental Conservation, Long Island City, New York. 36 pp.

Potter, E.G., J.F. Parnell, and R.P. Teulings. 1980. Birds of the Carolinas. University of North Carolina Press, Chapel Hill, North Carolina.

Raithel, C. 1984. The piping plover in Rhode Island. Rhode Island Natural Heritage Program, Providence, Rhode Island. Unpublished report. 13 pp.

RENEW. 1993. Recovery of nationally endangered wildlife. Report #3. Canada. 55 pp.

RENEW. 1994. Recovery of nationally endangered wildlife. Report #4. Canada. 30 pp.

Rimmer, D.W. 1994. Piping plover research and management program at the Richard T. Crane, Jr. Memorial Reservation, Ipswich, Massachusetts. 1993 Report. The Trustees of Reservations. 9 pp and graphs.

Rimmer, D.W., and R.D. Deblinger. 1990. Use of predator exclosures to protect piping plover nests. Journal of Field Ornithology 61: 217-223.

Ryan, M.R., B.G. Root, and P.M. Mayer. 1993. Status of piping plover in the Great Plains of North America: A demographic simulation model. Conservation Biology 7: 581-585.

Shaffer, F. and P. Laporte. 1992. Rapport synthése des recherches relatives au pluvier siffleur (*Charadrius melodus*) effectuées aux Iles-de-la-Madeleine de 1987 à 1991. Association québèçoise des groupes d'ornithologues et Service canadien de la faune. 78 pp.

Shaffer, F. and P. Laporte. 1994. Diet of piping plovers on the Magdelen Islands, Quebec. Wilson Bulletin 106(3): 531-536.

Shaffer, M. 1987. Minimum viable populations: Coping with uncertainty. Pp. 69-86 *in* M.E. Soulé (ed.), Viable populations for conservation. Cambridge University Press, New York, New York.

Soulé, M.E. 1987. Where do we go from here? Pp. 175-183 *in* M.E. Soulé (ed.), Viable populations for conservation. Cambridge University Press, New York, New York.

Stevenson, H. 1960. A key to Florida birds. Peninsular Publishing Co., Tallahassee, Florida. 158 pp.

Strauss, E. 1990. Reproductive success, life history patterns, and behavioral variation in a population of piping plovers subjected to human disturbance (1982-1989). Ph.D. Dissertation. Tufts University, Medford, Massachusetts. 143 pp.

Tear, T.H., J.M. Scott, P.H. Hayward, and B. Griffith. 1993. Status and prospects for success of the Endangered Species Act: A look at recovery plans. Science 262: 976-977.

The Trustees of Reservations. 1992. Leland Beach management. Proposal to Massachusetts Division of Marine Resources, Boston, Massachusetts. 11 pp.

Thomas, C.D. 1990. What do real population dynamics tell us about minimum viable population size? Conservation Biology 4: 324-327.

Tull, C.E. 1984. A study of nesting piping plovers of Kouchibouguac National Park 1983. Unpublished report. Parks Canada, Kouchibouguac National Park, Kouchibouguac, New Brunswick. 85 pp.

U.S. Army Corps of Engineers. 1994. Ocean City, Maryland and vicinity water resources study reconnaissance report. Baltimore District.

U.S. Army Corps of Engineers. 1995. Fire Island to Montauk Point, Long Island, New York draft breach contingency plan executive summary and draft environmental assessment. New York District.

U.S. Fish and Wildlife Service. 1982. Refuge manual. Washington, D.C.

U.S. Fish and Wildlife Service. 1985. Endangered and threatened wildlife and plants: Determination of endangered and threatened status for the piping plover: Final rule. Federal Register 50 (238): 50726-50734.

U.S. Fish and Wildlife Service. 1987a. Endangered and threatened wildlife and plants: Determination of endangered and threatened status for two populations of the roseate tern: Final rule. Federal Register 52 (211): 42064-42068.

U.S. Fish and Wildlife Service. 1987b. Draft environmental assessment on the master plan, Trustom Pond National Wildlife Refuge (incorporated without reprinting in January 1988 final environmental assessment). Newton Corner, Massachusetts. 73 pp.

U.S. Fish and Wildlife Service. 1988a. Recovery plan for piping plovers breeding on the Great Lakes and Northern Great Plains. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 160 pp.

U.S. Fish and Wildlife Service. 1988b. Summary of Atlantic Coast piping plover management and research meeting, November 29, 1988. Newton Corner, Massachusetts. 42 pp.

U.S. Fish and Wildlife Service. 1988c. Environmental assessment of the master plan of the Monomoy National Wildlife Refuge. Newton Corner, Massachusetts. 186 pp.

U.S. Fish and Wildlife Service. 1988d. Environmental assessment on the management of the piping plover on Toms Cove Hook. Chincoteague NWR, Chincoteague, Virginia. 20 pp.

U.S. Fish and Wildlife Service. 1988e. Atlantic Coast piping plover recovery plan. U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 77 pp.

U.S. Fish and Wildlife Service. 1989a. 1989 status update: U.S. Atlantic coast piping plover. Unpublished report. U.S. Fish and Wildlife Service, Newton Corner, Massachusetts. 34 pp.

U.S. Fish and Wildlife Service. 1989b. Information and education plan for the piping plover, Atlantic Coast population. Newton Corner, Massachusetts. 19 pp.

U.S. Fish and Wildlife Service. 1990a. Endangered and threatened wildlife and plants: Determination of threatened status for the Puritan tiger beetle and the northeastern beach tiger beetle: Final rule. Federal Register 55 (152): 32088-32904.

U.S. Fish and Wildlife Service. 1990b. Piping plover management for 1990: A compatibility determination for Trustom Pond National Wildlife Refuge. Charlestown, Rhode Island.

U.S. Fish and Wildlife Service. 1991a. Environmental contaminants in New Jersey Coast piping plover (*Charadrius melodus*) eggs. Pleasantville, New Jersey. 12 pp.

U.S. Fish and Wildlife Service. 1991b. Characterization of the macro-infauna of the Lower Beach at Assateague Island, Maryland before and after dredged material disposal. Annapolis, Maryland. Report prepared for U.S. Army Corps of Engineers, Baltimore District. 14 pp.

U.S. Fish and Wildlife Service. 1993a. Endangered and threatened wildlife and plants: *Amaranthus pumilus* (seabeach amaranth) determined to be threatened: Final rule. Federal Register 58 (65): 18035-18042.

U.S. Fish and Wildlife Service. 1993b. Annual predator control program. Chincoteague National Wildlife Refuge, Chincoteague, Virginia. 19 pp.

U.S. Fish and Wildlife Service. 1993c. Piping plover monitoring and management, summer 1993. Chincoteague, Virginia. 18 pp.

U.S. Fish and Wildlife Service. 1993d. Piping plover and least tern management program. Parker River National Wildlife Refuge, Newburyport, Massachusetts. 26 pp.

U.S. Fish and Wildlife Service. 1993e. 1993 status update: U.S. Atlantic Coast piping plover. Unpublished report. U.S. Fish and Wildlife Service, Sudbury, Massachusetts. 7 pp.

U.S. Fish and Wildlife Service. 1994a. Draft revised recovery plan for piping plovers breeding in the Great Lakes and Northern Great Plains. Twin Cities, Minnesota. 121 pp.

U.S. Fish and Wildlife Service. 1994b. Preliminary draft handbook for habitat conservation planning and incidental take permit processing, September 15, 1994. Arlington, Virginia.

U.S. Fish and Wildlife Service. 1994c. What's all this stuff about "Habitat Conservation Planning" and "Incidental Take Permits"? Region 1, Portland, Oregon. 7 pp.

U.S. Fish and Wildlife Service. 1994d. Northeastern beach tiger beetle *(Cicindela dorsalis dorsalis)* recovery plan. U.S. Fish and Wildlife Service, Annapolis, Maryland. 46 pp.

U.S. Fish and Wildlife Service. 1995a. Notice of availability of a draft revised recovery plan for the piping plover, Atlantic Coast population, for review and comment. Federal Register 60 (24): 7067-7068.

U.S. Fish and Wildlife Service. 1995b. Endangered species monitoring on the Currituck Banks, including Currituck NWR, North Carolina. Mackay Island National Wildlife Refuge, Knotts Island, North Carolina. 5 pp.

U.S. Fish and Wildlife Service. 1996a. Policy regarding the recognition of distinct vertebrate population. Federal Register 61 (26): 4721-4725.

U.S. Fish and Wildlife Service. 1996b. Draft environmental assessment: Restoration of avian diversity on Monomoy National Wildlife Refuge. Chatham, Massachusetts. 40 pp.

U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration. 1994. Endangered and threatened wildlife and plants: Notice of interagency cooperative policy for peer review in Endangered Species Act activities. Federal Register Vol. 59, No. 126, July 1, 1994.

Vaske, J.J., D.W. Rimmer, and R.D. Deblinger. 1994. The impact of different predator exclosures on piping plover nest abandonment. Journal of Field Ornithology, 65 (2): 201-209.

Virginia Department of Game and Inland Fisheries. 1994. Performance report for U.S. Fish and Wildlife Service, Division of Federal Aid , July 1, 1993-June 30, 1994. Richmond, Virginia.

Weakley, A.S. and M.A. Bucher. 1992. Status survey of seabeach amaranth (*Amaranthus pumilus* Rafinesque) in North and South Carolina, second edition (after Hurricane Hugo). U.S. Fish and Wildlife Service, Asheville, North Carolina. 178 pp.

Welty, J.C. 1982. The life of birds. Sauders College Publishing, Philadelphia, Pennsylvania. 754 pp.

Wilcove, D.S., M. McMillan, and K.C. Winston. 1993. What exactly is an endangered species? An analysis of the U.S. endangered species list: 1985-1991. Conservation Biology 7: 87-93.

Wilcox, L. 1939. Notes on the life history of the piping plover. Birds of Long Island 1: 3-13.

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

Wilkinson, P.M. and M. Spinks. 1994. Winter distribution and habitat utilization of piping plovers in South Carolina. Chat 58 (1): 33-37.

Wolcott, T.G. and D.L. Wolcott. 1994. Contribution of the ghost crab (*Ocypode quadrata*) to poor fledging success by piping plover (*Charadrius melodus*) on an ocean beach. North Carolina State University, Raleigh, North Carolina. 11 pp.

Wrenn, S.D. 1991. Piping plover reproductive success on Cape Hatteras National Seashore: Report on the 1990 breeding season. Unpublished report to National Park Service. 34 pp.

Wright, S. 1931. Evolution in Mendelian populations. Genetics 16: 97-159.

Zivojnovich, M. and G.A. Baldassarre. 1987. Habitat selection, movements, and numbers of piping plovers wintering in coastal Alabama. Unpublished report to Alabama Department of Conservation and Natural Resources. 16 pp.

Zonik, C. and M. Ryan. 1993. Ecology and conservation of wintering piping plovers and snowy plovers. Unpublished interim report. University of Missouri, Columbia, Missouri. 37 pp.