ROSEATE TERN

Sterna dougallii

NORTHEASTERN POPULATION RECOVERY PLAN

FIRST UPDATE

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EXECUTIVE SUMMARY

Roseate Tern (Northeastern Population) Updated Recovery Plan

CURRENT STATUS: The roseate tern (*Sterna dougallii*), is a worldwide species that breeds in 2 discrete areas in the Western Hemisphere. One population currently breeds on islands along the northeastern coast of the United States from New York to Maine and northward into adjacent portions of Canada. Historically, it bred locally south to Virginia. The other population breeds on islands around the Caribbean Sea from the Florida Keys to the Lesser Antilles. Little is known about their winter distribution, but both populations are believed to winter off the northern coast of South America southward to eastern Brazil. On November 2, 1987, the U.S. Fish and Wildlife Service determined the population that nests in the Northeast to be endangered and that in the Caribbean to be threatened. Critical habitat has not been designated for either population.

The numbers of roseate terns nesting in the Northeast were greatly reduced (as were most seabirds) by commercial hunting for the millinery trade in the late 19th century. The population recovered with protection, increasing to about 8,500 pairs in the 1930's. Subsequently, numbers declined to about 4,800 pairs in 1952 and to a low of about 2,500 pairs in 1977 due to encroachment by gulls and habitat loss. The estimated total breeding population has fluctuated in the range of about 2,750 to 3,425 pairs since 1988, but the number of sites at which most of the birds nest remains critically low. In 1978, about 90% of the roseate terns in North America nested in 4 large colonies; in 1988, about 86% nested on only 2 small islands; one in Buzzards Bay, Massachusetts and the other off the eastern tip of Long Island, New York.

As of 1997, the losses of breeding birds at sites on western Long Island, NY and around Cape Cod, MA have been more than offset by an increase in the numbers of birds nesting in Buzzards Bay, MA, at Great Gull Island, NY and in the northern U.S. Gulf of Maine. Currently about 85% of the birds are concentrated in three colonies (Great Gull Island, NY; Bird and Ram Islands, MA). In 1997, the northeastern nesting population of the roseate tern was estimated at 3,382 pairs. These were distributed among 20 colony sites, where they nested in association with large numbers of common terns (*Sterna hirundo*).

LIMITING FACTORS: The concentration of roseate terns into a few large colonies has been attributed to loss of nesting sites and to predation. Prior to listing, herring and great black-backed gulls took over several of the offshore islands where common and roseate terns had nested in large numbers; other islands were lost to erosion. As a result, most roseate terns today are nesting at sites close to or on the mainland. These sites are accessible to predators such as owls, black-crowned night-herons and foxes. In the past it was possible for colonies to move in response to predation, but today the choice of available safe sites is limited.

In addition to predation, factors that can limit productivity may also include food availability near colonies, storm events and an imbalanced sex ratio. Several important roseate tern nesting sites are currently being impacted by severe erosion. Little is known about sources of mortality and limiting factors away from nesting sites, especially during migration and in wintering areas.

RECOVERY OBJECTIVE: The primary objective of the roseate tern recovery program is to promote an increase in breeding population size, distribution and productivity so as to warrant reclassification to threatened status and eventual delisting.

RECOVERY CRITERIA: Reclassification of the roseate tern population may be considered when the following criteria are met:

1. The Northeast nesting population (U.S. and Canada) is increased to 5,000 "peak period" nesting pairs (see Part II: Recovery, p.36).

2. A minimum of six large colonies (≥200 pairs) with high productivity (≥1.0 fledged young/pair for five consecutive years) exist within the current geographic distribution.

3. Long-term agreements to assure protection and management sufficient to maintain the population targets and average productivity in each breeding colony are in place.

4. Delisting of the population will be considered if the "peak period" nesting population reaches the historic high level of 8,500 pairs of the 1930's.

ACTIONS NEEDED: (These are in no particular order of significance)

1. Oversee breeding roseate terns and their habitat to help increase survival and productivity. This includes the physical maintenance, expansion and enhancement of nesting habitat.

2. Develop a management plan for monitoring wintering and migration areas.

3 Secure unprotected sites through acquisition and easements.

4. Develop outreach materials and implement education programs.

5. Conduct scientific investigations that will facilitate recovery efforts.

6. Review progress of recovery annually and revise recovery efforts as needed.

ESTIMATED COSTS (in thousands):

	NEED 1	NEED 2	NEED 3	NEED 4	NEED 5	NEED 6	TOTAL
FY1	303	53	*	5	90	0	451
FY2	469	107	*	5	80	0	661
FY3	924	157	*	5	85	0	1,171
Total	1,696	317	*	15	255	0	2,283

DATE OF RECOVERY: 2010

* land costs not known

* * *

This update of the Roseate Tern Recovery Plan - Northeastern Population reports on recovery progress to date and completion of certain tasks specified in the 1989 plan. It also delineates further actions needed to protect and fully recover this endangered species. Although this recovery plan has been approved by the U.S. Fish and Wildlife Service, it does not necessarily represent official positions or approval of cooperating agencies. This update and the 1989 plan were prepared by the Recovery Team, an advisory group to the U.S. Fish and Wildlife Service, appointed to delineate actions considered necessary to recover and/or protect the species. It also has been reviewed by members of a Technical Group with particular knowledge of the species but does not necessarily represent the views of all members of either the Recovery Team or the Technical Group.

Recovery plans published by the U.S. Fish and Wildlife Service are reviewed by the public[1] and submitted to additional peer review before they are adopted by the Service. Objectives of the plan will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the U.S. Fish and Wildlife Service. They represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Regional Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status and the completion of recovery tasks.

By approving this document, the Regional Director certifies that the data used in its development represents the best scientific and commercial data available at the time it was written. Copies of all documents reviewed in development of the plan are available in the administrative record, located at 300 Westgate Center Drive, Hadley, Massachusetts 01035.

Literature citation of this document should read as follows:

U.S. Fish and Wildlife Service. 1998. Roseate Tern Recovery Plan - Northeastern Population, First Update. Hadley, MA. 75 pp.

Additional Copies May Be Purchased From:

Fish and Wildlife Reference Service
5430 Grosvenor Lane, Suite 110
Bethesda, Maryland 20814 Tel. 301/492-3421 or 1-800/582-3421

Fees for recovery plans vary depending on the number of pages.

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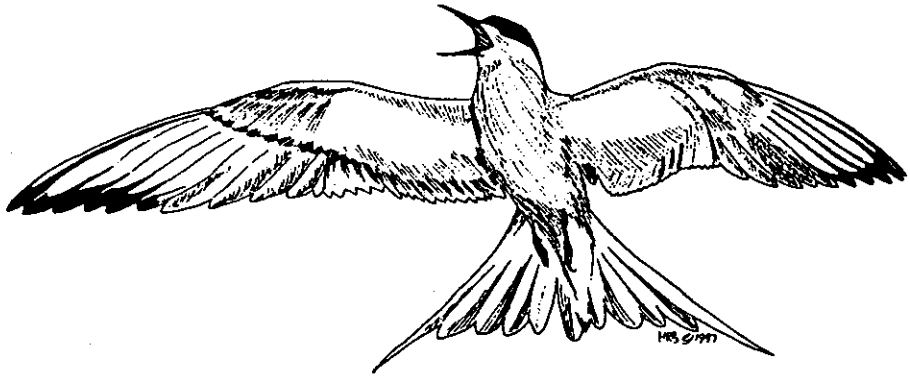
[1] A notice of availability of the draft updated recovery plan was announced in Federal Register vol. 63, number 62, dated April 1, 1998. Approximately 50 copies of the draft plan were distributed for public and agency review. During the 30-day comment period, one comment that suggested improvements to Figure 1 was received.

ACKNOWLEDGEMENTS

The original 1989 Recovery Plan has been updated for the U.S. Fish and Wildlife Service, Region 5 by the Roseate Tern Recovery Team. Initial drafts have been reviewed by a Technical Advisory Group whose members include Joanna Burger, Michael Gochfeld, Helen Hays, Stephen Kress, Ian Nisbet, Carl Safina and Jeffrey Spendelow. Comments and helpful suggestions were also received from other knowledgeable individuals including Bob Miller, Mary Parkin, Laura Sommers and Julie Victoria. Their input is greatly appreciated. Dorothy Graaskamp and Steve McRae of the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement, G.I.S. Program, provided valuable assistance in developing Figure 3. The Team extends a special note of appreciation to Paul Nickerson for his interest in the roseate tern and for his generous extension of time, guidance and encouragement. The Team also thanks artist Matthew Burne for the illustrations in the plan update and Jeannine Dubé who assisted with word processing and production.



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PART I
INTRODUCTION

The northeastern and Caribbean breeding populations of the roseate tern (*Sterna dougallii*) were designated respectively, as endangered and threatened, on 2 November 1987 (U.S. Fish and Wildlife Service 1987). A Recovery Plan for the northeastern population was approved on 20 March 1989 (USFWS 1989), and a separate Recovery Plan was approved for the Caribbean population (USFWS 1993). A review of the steps leading to the listing of this species under the Endangered Species Act is presented in the 1989 recovery plan. This document updates the Recovery Plan for the northeastern population to include new information that has become available since 1989.

The roseate tern is a worldwide species that breeds in two discrete areas in North America (Figure 1). The "northeastern population" includes birds that breed (or formerly bred) along the Atlantic coast of the United States from North Carolina to Maine. Small numbers of roseate terns also nest in the Maritime Provinces of Canada. The Canadian population was designated as threatened by the Committee on the Status of Endangered Wildlife in Canada in 1986 (Kirkham and Nettleship 1987). A recovery team was established and issued a Recovery Plan in June 1993 (Lock *et al.* 1993). The fate of the Canadian population is closely linked to that of the contiguous northeastern U.S. population, and the U.S. recovery team for this population maintains liaison and information exchange with the Canadian recovery team. The other North American population nests on islands around the Caribbean Sea from the Florida Keys and the Bahamas to the Netherlands Lesser Antilles.

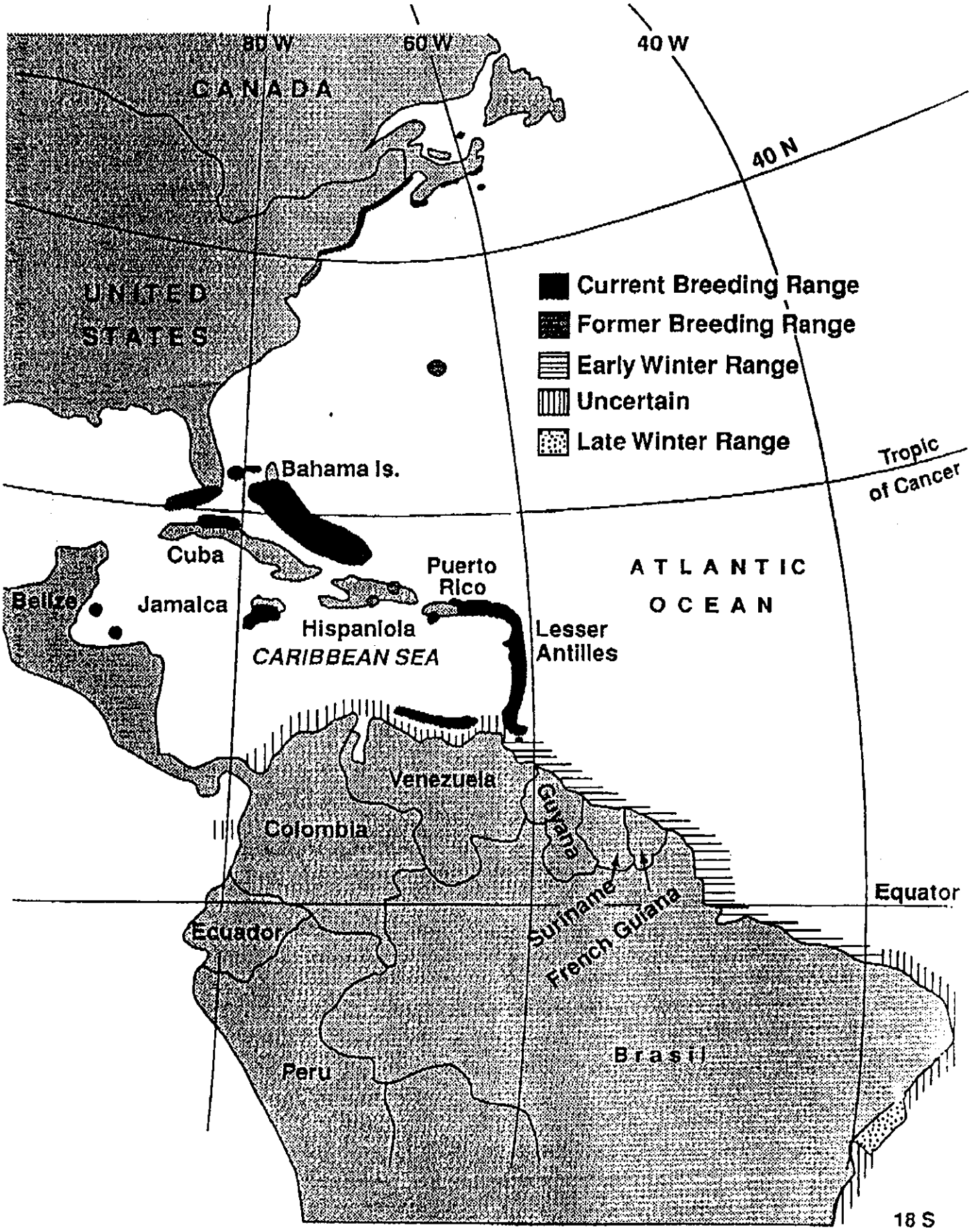
DESCRIPTION

Formal Description and Taxonomy

The roseate tern was first formally described in 1813 by Montagu in the Supplement to his *Ornithological Dictionary*, based on a specimen collected in Scotland; it was named after the collector of the first specimen, a Scotsman named MacDougall. The most complete technical description is found in the handbook by Cramp (1985); field identification is discussed in detail by Olsen and Larsson (1995). A biography of the species will appear shortly in the *Birds of North America* series (Gochfeld *et al.* in press).

Four subspecies of the roseate tern have been described, based on small differences in size and bill color. The nominate subspecies *S. d. dougallii* breeds locally in the Atlantic Ocean and the Caribbean Sea from eastern Canada and the British Isles south to South Africa. The subspecies *bangsi*, *korustes* and *gracilis* have scattered distributions on islands in the Indian and Pacific Oceans.

Figure 1. Breeding and winter distribution of roseate terns in the western hemisphere.



Appearance and Field Identification

The roseate tern is a medium-sized sea tern 35-40 centimeters (about 15 inches) long, including tail streamers up to 21 cm (8 inches), and weighing 100-120 grams (about 4 ounces). Its plumage superficially resembles that of the common tern (*S. hirundo*), among which it invariably nests in the Northeast. Roseate plumage also resembles those of the Forster's (*S. forsteri*) and Arctic (*S. paradisaea*) terns, with which it is found less often. In breeding plumage, the roseate tern is considerably paler than any of these species, silvery-gray above and creamy white below, with a black cap, black (but frosted) outer primaries and very long white tail-streamers. The underparts are suffused with pink ("roseate") and may appear pinkish in strong light. In northeastern birds, the bill is black, but becomes orange-red at the base during the breeding season; the legs are bright orange-red. Sexes are identical in plumage and can be distinguished in the field only by behavior.

In non-breeding plumage, adults lose the tail streamers and become white on the forehead and most of the crown; the bill and legs become black. They are then difficult to distinguish from common terns unless the distinctive call is heard or unless the white outer tail-feathers can be discerned. Juveniles have black bill and legs, blackish head with gray or buffy forehead, gray or sandy upper parts scaled with an intricate pattern of wavy black or dark brown markings and white or pale pink underparts. Downy chicks are easily distinguished from those of common terns by their hairy appearance (caused by the down sticking together in tufts) and dull purple legs, which become black within a few days after hatching.

The most characteristic call is a sharp "chi-vik", uttered in flight while hunting and, with variations in tone and emphasis, in a variety of social contexts. Alarm calls given at nesting colonies include a harsh "aaaach" and a musical "kliu". Juveniles accompanying their parents in late summer have a squeaky call "kri-vri".

Common x roseate tern hybrids have been described (Hays 1975; Zingo *et al.* 1994). Adult hybrids can be distinguished in the field by tail feathers that extend only a little beyond the ends of the folded wings and a mantle color intermediate between that of common and roseate terns. Both young and adult hybrids held in the hand can be easily distinguished by checking the primaries. Common terns have a white "V" in the black that runs along both sides of the vane of primaries 10-7 and usually 6. Roseate terns have no "V", but a straight edge between the black and the white. Hybrids have a combination of straight edges and "V's" in the primaries, the "V's" are irregular in size and the pattern of the "V's" in the left and right wings is not bilaterally symmetrical.

Hybrids arriving at colonies early in the season have black bills. This characteristic, with that of tail length, distinguishes them from common terns which, at this time of the season have bills that are about one third red. Roseate terns arrive in the colony with black bills and assume the red color beginning at about the time the young hatch (Donaldson 1968; Cormons 1976). Hybrids bills become red faster that do those of roseate terns.

DISTRIBUTION

The known breeding and winter distributions of roseate terns in the Western Hemisphere as of 1997 are shown in Figure 1. Birds of the northeastern population breed from Long Island, New York, east and north to Nova Scotia and Quebec (Iles Madeleines). Historically, the breeding range extended south to Virginia and North Carolina (single nesting record). Figure 2 shows nesting sites occupied one or more years in the northeastern U.S. and Canada in the years 1977-1988. Figure 3 shows all nesting sites used in the northeastern U.S. for the period 1989-1997 and illustrates the population's current concentration in the Massachusetts-Connecticut-New York (MA-CT-NY) area.

The birds migrate south through the West Indies to winter off the northern and eastern coasts of South America; the winter quarters are still not well defined. Recent findings have located wintering birds along the Brazilian coast as far as 18 South (Hays *et al.* 1997; Hays *et al.* in press; Hays *et al.* in prep.). See additional discussion below at "Migration and Wintering Areas".

HABITAT USE AND REQUIREMENTS

Breeding Habitat

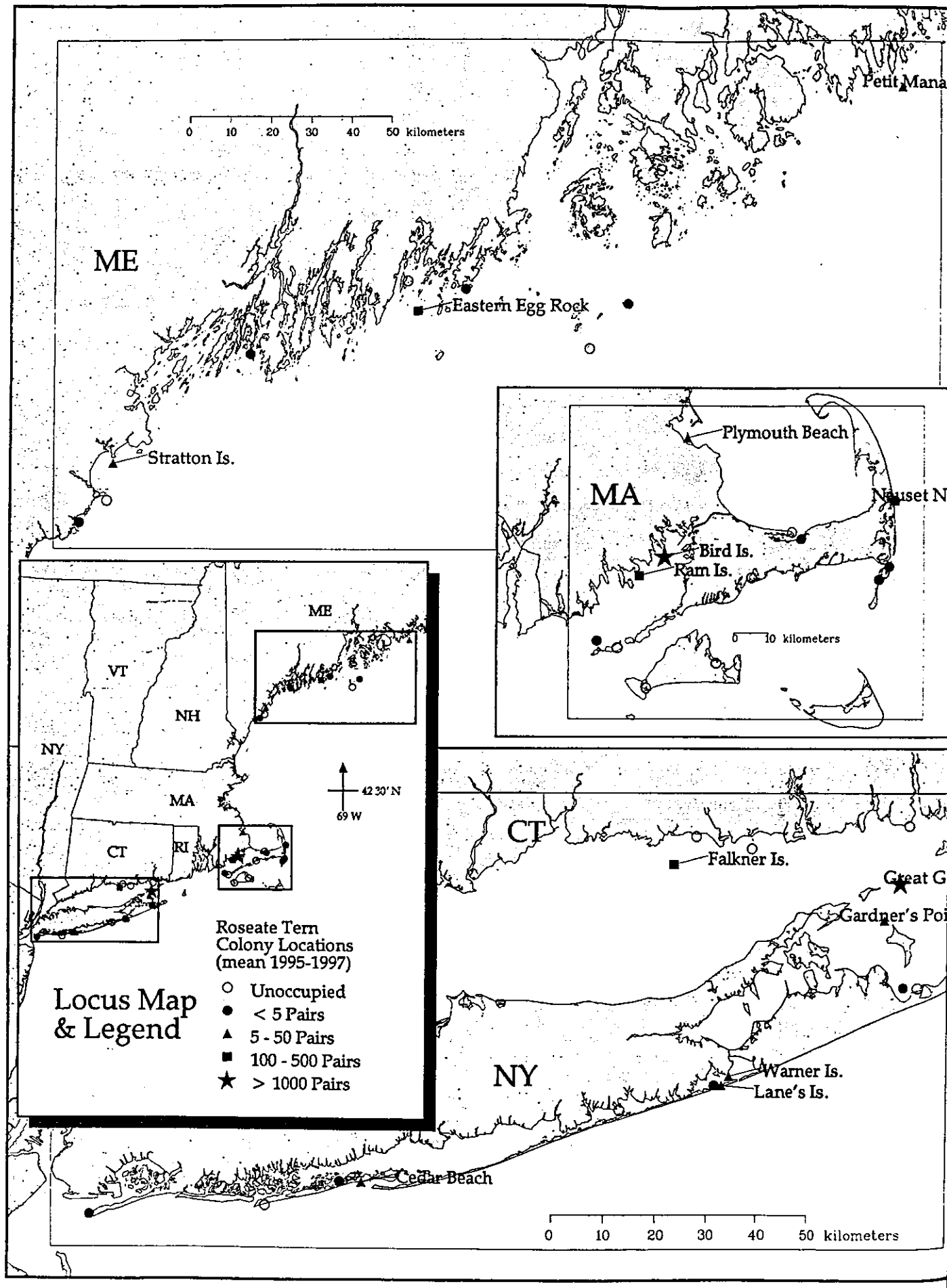
The roseate tern is exclusively marine, usually breeding on small islands, but occasionally on sand dunes at the ends of barrier beaches. All recorded nestings in the Northeast have been in colonies of common terns. Within these mixed colonies, roseate terns usually select the more densely vegetated parts of the nesting area (Burger and Gochfeld 1988b) or other areas that provide dense cover. Unlike most other temperate zone terns, roseate terns usually nest under or adjacent to objects that provide cover or shelter (Nisbet 1981). These objects include clumps of vegetation, rocks, driftwood or other man-made objects. Plants utilized for cover include beach grass (*Ammophila breviligulata*), seaside goldenrod (*Solidago sempervirens*), lambs quarter (*Chenopodium alba*), beach pea (*Lathyrus japonica*) and mustard (*Brassica* sp.). At some colony sites, vegetation grows to a height of 1-2 meters over the nesting sites during the breeding season, providing concealment for the eggs and chicks, but sometimes impeding access by the adults. At other colony sites, roseate terns nest under rocks, sometimes deep within crevices of rock rip-rap placed to protect island slopes from erosion. They readily adopt artificial sites such as nest boxes or partly-buried automobile tires (Spendelow 1982, 1993, 1994). Nests typically are 60 to 180 centimeters apart and density is sometimes as high as two or three nests per square meter within patches of suitable cover (Nisbet 1981; Burger and Gochfeld 1988b).

Foraging Habitat During the Breeding Season

During the breeding season, roseate terns forage over shallow coastal waters around the breeding colonies. They tend to concentrate in places where prey fish are brought close to the surface, either by predatory fish chasing them from below or by vertical movements of the water. Hence, they usually forage over shallow bays, tidal inlets and channels, tide-rips and sandbars over which tidal currents run rapidly (Nisbet 1981; Duffy 1986; Safina 1990a; Heinemann 1992; Casey, Kilpatrick and Lima unpubl. data). Roseate terns usually feed in clearer and deeper water than those favored by common terns from the same colony sites and rarely feed close to shore or in marshy inlets. At Bird Island, MA and Falkner Island, CT, some birds fly regularly up to 15-25 kilometers (km) to feed over shallow sandbars where fish can be caught reliably (Nisbet 1981; Heinemann 1992; Casey, Kilpatrick and Lima unpubl. data).

Figure 2. Roseate tern nesting sites in the northeastern U.S. and Canada occupied one or more years, 1977-1988.

Figure 3. Nesting sites used by roseate terns in the northeastern U.S., 1989-1997.



Premigratory Staging Areas

During premigratory staging in August-September, roseate terns feed over coastal waters between Long Island, New York and Maine. They rest and roost on islands and outer beaches and have been observed feeding over inlets, tide rips and sandbars (Shealer and Kress 1994; Nisbet unpubl. data). They also have been seen flying in from the sea to roosting sites on islands and beaches and hence probably feed offshore as well as inshore (Nisbet 1981).

Migration and Wintering Areas

There are no notes in the literature on habitat requirements or feeding behavior of northeastern roseate terns observed on migration. A bird reported on the Connecticut shore in the fall was recovered on the Pacific coast of Colombia 24 days later (Hays 1971). This would be a maximum time for migrating between the two areas as there is no way to know when the bird left Connecticut or arrived in Colombia. The timing indicates that, at least in this instance, the bird completed the trip in a little over three weeks, suggesting that it moved fairly quickly. The speed at which roseate terns fly once they start to fly south or north may mean that there are not many opportunities to observe them during their time of passage.

In January 1996 and February 1997 researchers from the Great Gull Island Project observed a small group of roseate terns feeding and roosting at a river mouth along the coast of Bahia south of Porto Seguro. The area was the site of a resort and there were bathers on the beach throughout most of the day. The roseate terns fed just offshore during the day and came in to roost before sunset either on the sandy point on the shore or on a sand island offshore. Pellets were picked up from the roosting area in order to determine prey items the birds were catching (Hays *et al.* in prep.). Later in February 1997, the researchers netted with Pedro Lima at Mangue Seco, a sandy point at the mouth of the Rio Real in Bahia just north of Salvador. Here the roseate terns came in to roost after dark and left before first light. It is possible that the birds at Mangue Seco may have been feeding too far away from the roosting site to get in before dark (Hays and Lima 1997; Hays *et al.* in press).

Trull (1988) did not find roseate terns feeding over the shallow, turbid waters where he saw common terns feeding along the northern South American coast. In other parts of the world, wintering roseate terns have been observed at sea following tuna and other predatory fish.

LIFE HISTORY AND ECOLOGY

The life history and ecology of the roseate tern have been summarized by Nisbet (1981), Glutz and Bauer (1982) and Cramp (1985). A biography of the species, incorporating data from recent intensive studies, will appear shortly in the *Birds of North America* series (Gochfeld *et al.* in press).

Breeding Behavior

Arrival, Courtship and Pair Formation

Roseate terns arrive in the Northeast in late April and early May and feed for a week or two in coastal waters before starting to occupy nesting areas. They have a spectacular aerial courtship display, in which three or more birds circle up to heights of 30-300 meters (100-1,000 feet) before the leading two birds descend together in a zigzag glide. During the pre-laying period, males feed females, often on the fishing grounds or on the shore nearby. They explore the colony sites for two to three weeks before laying, but do not select nest sites until almost ready to lay.

Egg-laying

Most eggs are laid between May 18 and June 22, about eight days later than those of common terns at the same sites. Small numbers of pairs continue to lay eggs in late June and throughout July. Data from ongoing studies indicate that some of these late-nesting birds are young birds two to four years old, but a few are older birds relaying after losing eggs or chicks earlier in the season. Eggs are laid in a shallow scrape on bare sand, soil or stones; the birds gradually accumulate nesting material during incubation, so that a substantial nest often results. The usual clutch size is one or two eggs; when two eggs are laid, they are usually about three days apart. The proportion of pairs laying two eggs is usually between 50 and 85 percent, so that the average clutch size is between 1.50 and 1.85 eggs. Clutches of two eggs predominate in the early part of the season, but one-egg clutches usually predominate in late June and July (Spendelow 1982; Burger *et al.* 1996).

A small minority of clutches (3-7% in most colonies) contain three or even four eggs. Hays (1993) described an instance where a male and two females successfully hatched and raised three young from a clutch of three eggs. Laying intervals for the eggs and down color of the chicks suggested that both females contributed to the clutch. Studies at Bird Island have shown that while some supranormal clutches are attended by trios (a male with two females or three females), most are attended by female-female pairs. When two females lay in the same nest, they both incubate the eggs and feed any chicks that hatch, but usually less than half the eggs are fertile (J. J. Hatch, I. C. T. Nisbet and J. A. Spendelow unpubl. data). Some two-egg clutches also are attended by female-female pairs. The sex ratio of breeders at Bird Island, MA is about 127 females:100 males (J. J. Hatch and I. C. T. Nisbet unpubl. data).

Incubation, Hatching, Chick Growth and Fledging

Both males and females incubate the eggs and brood and feed the chicks. The incubation period is about 23 days and begins when the first egg is laid. When two eggs are laid, they usually hatch about three days apart, so that the older chick is much larger than the younger chick (Nisbet and Cohen 1975); this disparity in size persists throughout the period of growth. The chicks are brooded by one parent for the first three to four days of life while the other parent forages for food. Older chicks do not need brooding except in cold or wet weather, but they are often attended by one parent. The chicks spend most of their time under vegetation or rocks (or inside artificial nest structures such as tires or boxes), emerging only to be fed. They grow rapidly and reach their asymptotic weight (95 to 105 grams) in about 15 days (Nisbet *et al.* 1995). They usually fledge at ages between 25 and 29 days. Fledglings are accompanied very closely by their parents and do not return to the nesting territory; they remain on the edge of the nesting colony and start to accompany their parents to the feeding grounds within four to five days. When two chicks are raised, the first to fledge is accompanied by the male parent, while the female remains behind for up to six days to feed and attend the second chick (Nisbet 1981; M.J. Teets, J.A. Spendelow and J.M. Zingo unpubl. data).

Productivity

Roseate terns in the larger Northeast colonies generally breed with high success; most recorded exceptions have been associated with predation or human disturbance. At least among early-nesting birds, hatching success usually exceeds 90 percent and in some colonies is as high as 95-99 percent. In the absence of predation, a main cause of hatching failure is lack of fertilization (usually observed in female-female pairs without attending males). In many reported cases, almost all the "A-chicks" (single chicks and older chicks in broods of two) have survived to fledging. Survival of "B-chicks" (younger chicks in broods of two) is more variable among colonies and years, ranging from as low as 20% to as high as 70% or more. Survival of B-chicks is much higher among those hatched early in the season than among later chicks (Burger *et al.* 1996). Most of the losses of B-chicks are associated with slow growth and appear to be due to starvation (Nisbet *et al.* 1995). The variability in these losses suggests that overall breeding success is limited by the rate at which the parents can bring food and that this depends on the quality of the parents, as well as on site-specific or year-specific conditions (Nisbet *et al.* 1995; Burger *et al.* 1996). In two unusual events, a trio of roseate terns raised three young (Hays 1993) and a widowed female raised a chick by herself (Spendelow and Zingo 1997).

Predators and Anti-Predator Adaptations

Reported predators of roseate terns in the Northeast include peregrines (*Falco peregrinus*) and great horned owls (*Bubo virginianus*), which sometimes take adults; black-crowned night-herons (*Nycticorax nycticorax*) (Collins 1970), which sometimes take eggs or chicks; herring and great black-backed gulls (*Larus argentatus* and *L. marinus*), which may sometimes take adults, eggs, chicks and fledglings; northern harriers (*Circus cyaneus*), which sometimes take chicks; and ants (*Lasius* and *Solenopsis* spp.), which sometimes attack and kill chicks at hatching (Nisbet 1981, 1992; Spendelow 1982; Safina *et al.* 1994). In response to nocturnal predators such as great horned owls, roseate terns often desert their colonies at night; this minimizes predation on adults, but can result in the loss of eggs and chicks to chilling and other factors (Nisbet 1981). Cases have also been reported in which red fox (*Vulpes vulpes)*, striped skunk *(Mephitis mephitis)*, brown rat (*Rattus norvegicus)*, long-tailed weasel (*Mustela frenata)*, mink *(M. vison)* or domestic cats or dogs gained access to tern colonies and killed substantial numbers of eggs or chicks, including those of roseate terns (Nisbet 1981, 1989).

It is difficult to generalize about the significance of predation on roseate terns in the Northeast, because incidents of predation are sporadic and effects have varied from colony to colony and from incident to incident. Also, many reports of predation did not distinguish clearly between effects on common and roseate terns. In many but not all reported cases, predation on adults appears to have fallen more heavily on roseate terns than on common terns nesting in the same colony (Nisbet 1989). In almost all cases, however, predation on eggs and chicks appears to fall less heavily on roseate terns than on common terns nesting in the same colony (Nisbet 1989), presumably because roseate eggs and chicks are better hidden. Roseate terns also appear to be quicker than other terns to move to other colonies in response to predation and they settle less frequently than common terns on mainland sites accessible to terrestrial predators. As roseate terns are less aggressive towards predators than are common terns, they appear to benefit from the aggressive behavior of that species (Burger and Gochfeld 1988a).

For the above reasons, the average productivity of roseate terns in the Northeast does not appear to be limited by predation to as great an extent as is that of the common tern (Nisbet 1981). However, the tendency of the roseate tern to shift colonies quickly in response to predation has contributed to its current concentration onto a limited number of relatively predator-free sites.

Feeding

Roseate terns are specialist feeders on small schooling marine fish, which they catch by plunging vertically into the water and seizing them in their bill. They appear to be able to dive deeper than other medium-sized terns, often plunging into the water from heights of up to 20 meters and remaining submerged for more than two seconds (Duffy 1986; Kirkham and Nisbet 1987). When feeding chicks, they usually carry single fish in their bill, but observations have been made of roseate terns carrying multiple fish (Hays *et al.* 1973).

Roseate terns usually feed over open water, often in tidal channels, tide rips or over sandbanks where currents bring fish into relatively shallow water. In such places, they usually hunt in loose aggregations, often flying long distances between dives. They also follow schools

of predatory fish such as bluefish (*Pomatomus saltatrix*), feeding on small fish driven to the surface from below, but do so less than do common terns (Duffy 1986) and may be less able to exploit such situations (Safina 1990b; Shealer and Burger 1993). A few roseate terns specialize in stealing fish from common terns, swooping down from above and wresting the fish from their bills (Dunn 1973; Nisbet unpubl. data). Roseate terns tend to return regularly to the same fishing areas, sometimes far from the breeding colony. Some birds in Massachusetts and Connecticut forage regularly up to 25 km away from the breeding colony, returning with single fish (Heinemann 1992; USFWS unpubl. data). Roseate terns fly much faster than common terns and appear well-adapted for long-distance commuting.

Northeastern roseates feed primarily on American sand lance (*Ammodytes americanus*), clupeids such as Atlantic herring (*Clupea harengus*) or blue-backed herring (*Alosa aestivalis*), mackerel (*Scomber scombrus*), small bluefish or anchovies (*Anchoa* spp.) (Nisbet 1981; Richards and Schew 1989; Safina *et al.* 1990; Heinemann 1992; Shealer 1996). Most of these fish brought to the colony are 60-100 millimeters long, sometimes ranging up to 130 mm or more. Adults, however, generally eat smaller fish, often 40-70 mm long. Other fish species are brought infrequently, in some cases after being stolen from common terns.

Staging and Migration

Juvenile roseate terns are dependent on their parents for food for at least six weeks after fledging. Family groups disperse throughout the breeding area in late summer, tending to concentrate on barrier beaches. During August and early September, flocks up to several thousand have been reported in major staging areas at certain inlets and barrier beaches between Long Island, New York and Cape Cod, Massachusetts. There the birds appear to feed offshore, returning to shore to rest and roost. Presently, the largest numbers are reported at Monomoy National Wildlife Refuge, Massachusetts, where many juveniles banded at other colonies have been observed, but birds from New York and Connecticut may go as far north as southern Maine (Shealer and Kress 1994).

Roseate terns migrate south in late August and early September; most have left staging areas by September 18. They are rare on the Atlantic Coast south of New Jersey and appear to migrate directly south across the western North Atlantic. Recoveries of roseate terns banded in nesting colonies in the northeastern U.S. have been summarized by Hamilton (1981) and Nisbet (1984). Most of these birds are passage birds that have dropped out during migration and been picked up and reported. A number of banded birds have been recovered in the West Indies (Dominican Republic to Trinidad) in September and October. Some arrive in northern South America before the end of August, but most recoveries have been from October onwards in Guyana and from November onwards in Brazil (Hamilton 1981; Nisbet 1984, 1989). Little is known of spring migration.

Wintering

Roseate terns have rarely been observed by ornithologists in winter. Until recently, most information on winter distribution was derived only from banding recoveries (Nisbet 1984) which it now appears have predominantly represented birds recovered during passage. These recoveries included quite a number of birds netted for market in Guyana by Balram Pertab during the October to December period.

In 1995, 1996 and 1997 researchers from the Great Gull Island Project surveyed the coast of South America for wintering terns during the months of January, February and March. In 1995 and 1996 they found a scattering of roseate terns along the coast of Bahia, Brazil south of Salvador and established a new southern limit at 18 South (Hays *et al.* 1997; Hays *et al.* in prep). In 1997, they netted birds with Pedro Lima, a Brazilian bander, at Mangue Seco, Bahia, Brazil. The concentration of terns at this site was estimated to be about 10,000 birds by Pedro's assistant and included perhaps 3,000 roseate terns. Lima's recoveries at Mangue Seco included banded roseate terns from all colonies in the northeast where roseates have been banded as well as birds from the Caribbean population. The birds at Mangue Seco arrive to roost after dark and leave before first light, possibly feeding too far offshore to get in before dark (Hays *et al.* in press).

One-year-old roseate terns apparently remain in the southern hemisphere throughout their first summer. Some two-year-olds also appear to remain in the southern hemisphere during the northern summer, but there is little evidence that older birds do so (Nisbet 1984; Shealer and Saliva 1992).

POPULATION STATUS AND DYNAMICS

Breeding Population Size and Distribution

Historical Trends Prior to Listing

Historical information on roseate terns in the Northeast was summarized by Nisbet (1980) and Gochfeld (1983). Kirkham and Nettleship (1987) summarized Canadian data. It should be stressed that available information on breeding population sizes prior to listing (Table 1) is fragmentary and that few counts or even estimates of colony sizes were reported until the 1930's. Information from the 1870's and 1880's indicates that the species bred locally on islands from Virginia to Sable Island, Nova Scotia. There is no precise information on numbers, but Nisbet (1980) estimated that thousands of pairs were then nesting in New Jersey, Massachusetts and perhaps Connecticut.

Numbers of roseate terns (and other seabirds) were severely reduced in the 1870's and 1880's by commercial hunting for the millinery trade and most of the colonies previously recorded appear to have been eliminated at that time. However, at least four sizeable colonies appear to have survived through this period: one or two in Long Island and/or Connecticut, Penikese and Muskeget Islands in Massachusetts and Sable Island in Nova Scotia. Nisbet (1980) estimated from contemporary accounts that the total number remaining at the lowest point in about 1890 was roughly 2,000 pairs.

Following protection efforts initiated in the 1890's and strengthened by the Migratory Bird Treaty Act of 1918, roseate terns increased rapidly and reoccupied most of the range and many of the colony sites that had been lost. Nisbet (1980) estimated that the total number breeding at the highest point in the 1930's was about 8,500 pairs, of which about three-quarters were in Massachusetts. However, numbers then decreased again until by the 1950's there were only about 4,800 pairs (Nisbet 1980). About the same number (4,700 pairs) could be accounted for in 1971-1972. Both the geographical range and the number of colonies decreased between 1935 and 1952, by which time the species became virtually absent as a breeder south of Long Island. Table 1A summarizes colony sites known to have supported 200 or more pairs prior to 1970.

Table 1. Summary estimates of breeding pairs of roseate terns in northeastern North America prior to listing

Table 1. Summary estimates of breeding pairs of roseate terns in northeastern North America prior to listing.

Region	1870	1890	1931-35	1941	1952	1971-72	1978-79	1984
Quebec	-	-	-	-	-	5	-	1
Sable Island	hundreds?	hundreds	few?	few	-	130	12	15
Sn. Nova Scotia	hundreds?	hundreds?	200	100	100	120	20	95
Maine	few?	-	275	275	200	85	65	67
New Hampshire	-	-	30	60	-	-	-	-
Massachusetts	thousands	1500+	6500	5500	3900	2400	1600	1820
Rhode Island	few?	-	20	40	5	-	-	2
Connecticut	hundreds or thousands?	few?	1000?	1600	75	65	185	210
New York	hundreds?	50	400	100	500	1900	620	917
New Jersey	thousands?	-	10	5	5	2	-	-
Maryland	?	-	50	-	-	-	-	-
Virginia	hundreds?	few?	10	-	-	-	-	-
Total	thousands	2000	8500	7700	4800	4700	2500	3100

TABLE 1A. Colony-sites of roseate terns known to have supported 200 or more nesting pairs prior to 1970 as compiled from Nisbet (1973, 1980, 1989) and Kirkham and Nettleship (1987).

State or Province	Site name	Period occupied	Highest numbers (pairs) Year	Number	Last record	Notes	Reason for Abandonment: Plume hunting[o]	Erosion[p]	Predation[q]	Gulls[r]
Nova Scotia	Sable Is	continuous?	1880s	hundreds?	extant	a				
Maine	Stratton Is since 1920s	1931	200	extant	b				x	
New Hampshire	Londoner's Is	1920s-1950s	1935	hundreds?	ca.1955					x
Massachusetts	Gray's Beach	1950s-1970s	1973	400	1991	c			x	
	Billingsgate Is	until 1880s	?	?	?			x		
	Jeremy's Point	1940s-1974	1974	250	1974			x	x	
	Nauset Beach	sporadic	1915	thousands	1915	d			x	
	Tern Is	1920s-1950s	1935	ca.2,500	1953	e			x	
	Monomoy Is	1960s-1970s	1963	1,000	1981	f			x	
	Nantucket Is	1870s	1870	thousands?	1874	g	x			
	Muskeget Is	until 1940s	1938	3,300	ca.1948	h				x
	Tuckernuck Is	1936	1936	225	1936	i		x		
	Egg Is	1930s	1932	900	1939			x		
	Skiffs Is	1900s-1910s	?	?	1919			x		
	Nomans Land	1960s-1970s	1972	400	1979				x	x
	Penikese Is	until 1950s	1904?	ca.2,000	ca.1958					x
	Weepecket Is	until 1940 1930s	ca.800	1940					x	
	Bird Is	since 1930s	1982	1,800	extant					
	Ram Is	since 1930s	1947	ca.2,500	extant	j				x
Connecticut	Goose Is	1870s-1940s	1877	thousands	1951	k	x	x		
New York	Great Gull Is	1880s,1960s	1997	1,950	extant	l	x			

	Orient Point	1880s,1925-43	1934	400	1943		x	x
	Fire Is	1950s-1960s	1963	200	1960s			
	Lane's Is	1960s-1970s	1974	561	1977	m		x
New Jersey	Unspecified	until 1880s	?	abundant	1979	n	x	
Maryland	Assateague Is	1930s	1933	?	1930s			
	Sinepunxent Bay	1930s	?	common	1930s			
Virginia	Cobbs Is	until 1920s	ca.1880	?	1929		x	

Notes:

a No precise records of numbers until 1970s; still nests in small numbers.
b Abandoned 1960s; reoccupied 1988 (Table 2).
c One pair nested in 1997 (Table 2).
d Sporadic nesting since 1910s: recorded in 1915, 1936, 1940, 1955-56, 1992-1996; predation recorded in most years.
e Also nested in 1970-73 (150 pairs in 1970).
f Nested sporadically in 1987-1997 (Table 2).
g Also nested in 1949.
h Depleted by plume-hunting in 1880s; also nested in 1951 and 1968-1969.
i On sandbars west of Tuckernuck Is.
j Abandoned in 1973; reoccupied 1994 (Table 2).
k Abandoned 1888; reoccupied 1901 and 1941-1951.
l Abandoned 1888; reoccupied 1960 and now the largest colony (Table 2).
m Occupied 1960s-1970s; reoccupied 1987 and 1991-97 (Table 2).
n Extirpated 1880s; nested by small numbers 1923-1979.
o Site abandoned after plume-hunting in 1880s.
p Site destroyed by erosion.
q Site abandoned after predation.
r Site abandoned after occupation by gulls.

According to information summarized by Nisbet (1980) and Kress *et al.* (1983), a further rapid decline took place during the 1970's. The low point appears to have been reached in 1978-79, when only about 2,500 pairs were estimated in the northeastern U. S., plus about 100 pairs in Canada. Subsequent information suggests that the numbers in 1978-79 may have been underestimated, but the total probably was less than 3,000 pairs at that period. The decrease in the 1970's was accompanied by further losses of colony sites and by 1978 roughly 90% of the estimated total breeding population of roseate terns in the Northeast was concentrated at 4 colonies (Bird Island and Monomoy Island, MA; Great Gull Island, NY; and Falkner Island, CT). Throughout the period for which historical information is available, between 50% and 80% of the northeastern population appears to have been concentrated on islands around Cape Cod, Massachusetts (Nisbet 1980).

Current Status and Trends Since Listing

At the time of listing of the northeastern U.S. population of the roseate tern as an endangered species in 1987, different methodologies were in place at various colonies for estimating the numbers of breeding birds. At the large colonies, these methods included "peak period" and "total season" estimates based on nest counts. Data from many of the smaller colonies contained a mixture of these two types of estimates based on nest counts as well as estimates derived from counts of adults (often multiplied by an index factor), sometimes without verification that birds were actually nesting.

"Peak period" estimates are based on the number of nests found containing eggs at the time of hatching of the first chick and are thought to reflect initial nesting attempts by the older, more experienced and usually most productive segment of the breeding population. In contrast, "total season" estimates reflect the total number of nests established throughout the entire nesting season and may include late-nesting younger birds and renesting older birds whose first attempts have failed. The number of nests counted is converted on a 1:1 ratio to the number of nesting pairs without regard to whether nests are tended by typical male-female pairs, female-female pairs or any other multiple female nesting associations.

Since 1987, considerable progress has been made at refining and standardizing census protocols, resulting in better overall accuracy of estimates. The Team, with the assistance of its Technical Advisory Group, developed a recommended protocol for estimating breeding population size in April, 1995 (Appendix A). Because some of the smaller, remote colonies may be visited only once or twice in a nesting season, the Team has encouraged the use of "peak period" estimates of the numbers of nesting pairs and has adopted this basis for reporting population estimates and for gauging recovery progress. Hence, pair estimates discussed in the recovery plan text, unless otherwise indicated, are "peak period" estimates. For reference, "total season" estimates for 1988-1997 are shown by colony site and summarized by state in Appendices B and C respectively.

Pre-listing population estimates for the period 1977-87 were discussed in the 1989 Recovery Plan (USFWS 1989). Due to the lack of standardization of methodology, these

estimates are thought to be less reliable than those made since 1988; some were likely too low. If it is assumed that the 1977-1987 estimates might have been too low by as much as 30%, then recent data would be consistent with a more or less stable population since 1977. Alternatively, if they were reasonably accurate, the data would be consistent (except for the sharp decline between 1991-1992) with a moderate increase through 1997. The quality of the earlier data is such, however, that we cannot distinguish between these 2 interpretations of "long-term trends".

Figure 2 shows the distribution of roseate tern colony sites in the U.S. and Canada from 1977-88. Table 2 lists "peak period" estimates of the number of pairs of birds nesting at each U.S. colony site from 1988-1997 and Figure 3 shows the distribution of these colony sites for the same period. Table 3 summarizes the "peak period" estimates by state for the same period.

Post-listing "peak period" population estimates for the northeastern roseate tern (Tables 2 and 3) suggest the following short-term trends since 1988. Numbers are rounded to the closest 25 pairs. Overall, the nesting population appeared to increase from about 3,000 pairs in 1988 and 1990 to about 3,425 pairs in 1991. This was followed by a sharp decline of about 675 pairs (20%) to about 2,750 pairs in 1992 and then an increase to about 3,375 pairs in 1997. While part of the decline between 1991 and 1992 may have resulted from some birds having skipped breeding in 1992, low recruitment to the breeding population from the 1991 cohort of chicks and recent analyses of survival rates in adults, suggest that roseate terns suffered unusually high mortality between these 2 breeding seasons (J. Burger, G.D. Commons, M. Gochfeld, J. Hatch, H. Hays, I.C.T. Nisbet and J.A. Spendelow unpubl. data). The loss of experienced breeding adults from the MA-CT-NY area from 1991-1992 was about 33%, about twice the more typical 17%. The major cause of this high mortality is believed to have been an early-season hurricane ("Hurricane Bob") in August, 1991 that passed through staging areas and migration corridors used by the terns during post-breeding dispersal and migration. This was likely the most significant single event to limit the population since listing in 1987.

Overall Distribution and Concentration Into Major Colonies

Nisbet (1980) reported that the northeastern population of roseate terns had become concentrated into a few large colonies during the 1970's and Nisbet (1989) reported that the degree of concentration of the population into a few large colonies had increased during the 1980's. This trend continued into the early 1990's, but by the mid-1990's a large increase in breeding birds at the restored Ram Island, MA site (about 10 km from Bird Island, MA) and a moderate increase in the number of breeding birds on islands in the northern U.S. Gulf of Maine had occurred. These increases were offset by the almost complete loss of birds nesting on the outer parts of Cape Cod, MA and in the southwestern part of the breeding range at Cedar Beach, NY. Therefore, despite major changes in the distribution of birds at individual colony sites and within subregional areas as discussed in more detail below, the percentage of the population nesting in the two largest colonies dropped from 86% in 1988-1990 to a low of 65% in 1996. The percentage of the population nesting in the five largest colonies averaged 94% from 1988 through 1997.

Table 2. Estimated "peak period" numbers of nesting pairs of roseate terns in the northeastern U.S., 1988-1997.

Colony site/Area	(Lat/Long)	YEAR[1]									
Northern U.S. Gulf of Maine		**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Petit Manan Island, ME	44°22'N, 67°52'W	42	45	45	48	59	65	60	61	24	29
Conary Nub, ME	44°24'N, 68°30'W	-	-	-	0	0	1	1	0	0	0
Seal Island, ME	43°53'N, 68°44'W	-	0	0	4	0	0	0	2	0	1
Matinicus Rock, ME	43°47'N, 68°51'W	-	0	0	5	1	3	0	0	0	0
Large Green Island, ME	43°54'N, 69°01'W	6	0	0	0	-	-	-	0	0	-
The Brothers, ME	43°55'N, 69°14'W	-	-	-	-	-	-	-	1	1	1
Killick Stone, ME	43°56'N, 69°25'W	1	0	1	2	0	0	0	-	-	-
Eastern Egg Rock, ME	43°52'N, 69°23'W	5	17	38	50	51	59	63	86	126	138
Jenny Island, ME	43°46'N, 69°54'W	0	0	0	0	0	6	15	0	0	12
Stratton Island, ME	43°31'N, 70°19'W	8	2	18	14	8	7	3	1	10	56
Beach Island, ME	43°26'N, 70°20'W	0	1	0	0	-	0	0	0	-	-
Western Goose Rocks, ME	43°23'N, 70°25'W	6	12	0	0	0	0	0	1	0	-
Subtotal	Pairs	68	77	102	123	119	141	142	152	161	237
	Colonies	6	5	4	6	4	6	5	6	4	6
Cape Cod, Nantucket, and Martha's Vineyard, Massachusetts											
Plymouth Beach, MA	41°58'N, 70°39'W	6	11	1	15	20	25	22	30	18	10
Sandy Neck, MA	41°44'N, 70°17'W	-	-	-	-	-	-	-	-	-	0
Gray's Beach, Yarmouth, MA	41°43'N, 70°15'W	1	1	8	13	0	0	0	-	0	1
Nauset-Eastham, MA	41°49'N, 69°56'W	0	0	0	0	0	4	3	1	0	0
Nauset-New Island, MA	41°49'N, 69°56'W	60	60	25	20	10	5	2	2	6	11
Nauset-Chatham, MA	41°39'N, 69°57'W	0	0	0	0	4	2	0	-	1	0
North Monomoy Island, MA	41°38'N, 69°58'W	1	0	1	0	0	0	0	0	0	0
South Monomoy Island, MA	41°36'N, 69°59'W	0	0	0	0	0	0	0	-	3	0
Dead Neck-Sampsons Is., MA	41°37'N, 70°25'W	13	27	0	0	0	0	0	-	0	0
Haystack Point, MV, MA	41°24'N, 70°32'W	-	4	0	0	0	0	0	-	0	0
Menemsha Pond, MV, MA	41°20'N, 70°46'W	-	0	0	2	0	0	0	-	0	0
Subtotal	Pairs	81	103	35	50	34	36	27	33	28	22
	Colonies	5	5	4	4	3	4	3	3	4	3

Table 2. (Continued.)

Colony site/Area	(Lat/Long)	YEAR[1]									
Buzzards Bay, Massachusetts		**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Bird Island, MA	41°40'N, 70°43'W	1572	1473	1547	1728	1375	1319	1238	1250	996	1179
Ram Island, MA	41°37'N, 70°48'W	0	0	0	0	0	0	76	197	719	253
Nashawena Island, MA	41°26'N, 70°52'W	3	0	3	0	4	0	0	0	0	0
Penikese Island, MA	41°27'N, 70°56'W	-	-	-	-	-	-	-	-	-	0
Subtotal	Pairs	1575	1473	1550	1728	1379	1319	1314	1447	1715	1432
	Colonies	2	1	2	1	2	1	2	2	2	2
Central Connecticut Coast											
Duck Island, CT	41°15'N, 72°28'W	2	5	-	-	-	-	-	0	-	-
Tuxis Island, CT	41°16'N, 72°36'W	-	4	-	-	-	-	1	0	-	-
Falkner Island, CT	41°13'N, 72°39'W	147	96	150	149	107	130	123	125	135	136
Subtotal	Pairs	149	105	150	149	107	130	124	125	135	136
	Colonies	2	3	1	1	1	1	2	1	1	1
Eastern Connecticut and New York[2]: Eastern Long Island Sound and Gardiners Bay											
Shore Rock, Ocean Point, CT	41°18'N, 72°06'W	0	1	0	0	0	0	0	0	0	-
Great Gull Island, NY[3]	41°12'N, 72°07'W	1004	960	1026	1204	964	1040	1138	1056	1064	1455
Gardiners Point Island, NY	41°08'N, 72°09'W	-	-	-	-	-	-	0	157	4	23
Gardiners Island, NY	41°06'N, 72°07'W	-	0	-	-	0	-	0	0	0	0
Cartwright Point, NY	41°01'N, 72°06'W	-	0	-	-	0	4	14	0	1	5
Hicks Island, NY	41°01'N, 72°04'W	0	0	2	4	4	0	0	0	0	0
Subtotal	Pairs	1004	961	1028	1208	968	1044	1152	1213	1069	1483
	Colonies	1	2	2	2	2	2	2	2	3	3

Table 2. (Concluded.)

Colony site/Area	(Lat/Long)	YEAR[1]									
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Southern Long Island from Shinnecock Bay to Rockaway Inlet[2]											
Warner Islands, NY	40°51'N, 72°30'W	0	6	17	40	39	28	53	34	24	41
Lanes Island, NY	40°50'N, 72°31'W	0	0	0	6	16	12	-	59	36	16
Greater Greenbacks Island, NY	40°50'N, 72°32'W	0	0	0	0	0	0	0	0	0	2
East Inlet Is., Moriches, NY	40°47'N, 72°45'W	12	40	20	6	1	12	0	0	0	0
Cedar Beach, NY	40°38'N, 73°20'W	93	66	94	120	80	51	58	37	0	0
Goose Flat, NY	40°38'N, 73°23'W	-	-	-	-	-	-	0	0	0	9
West End Jones Beach, NY	40°35'N, 73°33'W	13	2	0	0	0	0	0	0	0	0
Breezy Point, Rockaway, NY	40°33'N, 73°57'W	0	0	0	0	0	2	2	2	2	4
Subtotal	Pairs	118	114	131	172	136	105	113	132	62	72
	Colonies	3	4	3	4	4	5	3	4	3	5
Total	Pairs	2995	2833	2996	3430	2743	2775	2872	3102	3170	3382
	Colonies	19	20	16	18	16	19	17	18	17	20
Concentration in largest colonies											
	% in 2 colonies	86	86	86	85	85	85	83	74	65	78
	% in 5 colonies	96	94	96	95	94	94	92	90	96	93

[1] "-" means no data were available at that site for that year.

[2] Data from New York was collected in a variety of ways and treated differently from the methods used in the annual reports by the New York State Department of Environmental Conservation. Data collected for the Metapopulation Project based on nest counts were used whenever possible. If the only data available at sites where roseate terns were known (or strongly suspected) to have actually laid eggs were counts of adults, the number seen on the survey date closest to the end of the peak period of laying was divided by two to obtain a conservative estimate of the number of nesting pairs.

[3] Although nests have been marked and counted at GGNY in all years since 1988, total numbers are uncertain because many nests at this site are concealed under boulders and cannot be located. Numbers in the table are estimates based on the observers' belief that about 20% of the nests were not found in most years. Because this adjustment factor is subjective, these estimates are uncertain by at least $\pm$10%.

Table 3. Estimated "peak period" numbers of nesting pairs of roseate terns in the northeastern U.S. by state, 1988-1997.

State	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
ME	68	77	102	123	119	141	142	152	161	237
MA	1656	1576	1585	1778	1413	1355	1341	1480	1743	1454
CT	149	106	150	149	107	130	124	125	135	136
NY	1122	1074	1159	1380	1104	1149	1265	1345	1131	1555
Totals	2995	2833	2996	3430	2743	2775	2872	3102	3170	3382

Based on geological and biological criteria, colony sites used by roseate terns in the northeastern U.S. can be grouped into six subregional areas: (1) Northern U.S. Gulf of Maine, (2) Cape Cod, Nantucket and Martha's Vineyard, Massachusetts, (3) Buzzards Bay, Massachusetts, (4) Central Connecticut Coast, (5) Eastern Connecticut and New York: Eastern Long Island Sound and Gardiners Bay and (6) Southern Long Island from Shinnecock Bay west to Great South Bay. Trends (1988-1997) within each of these six areas are discussed below with the numbers of pairs rounded to the closest five.

Northern U. S. Gulf of Maine

The "peak period" nesting population of roseate terns in U.S. colonies in the northern part of the Gulf of Maine increased from about 70 pairs in 1988 to about 235 pairs in 1997. Numbers of pairs at Petit Manan, ME grew rather slowly during the early part of this period and remained stable from 1992-1995 before dropping in 1996. Meanwhile, at Eastern Egg Rock, ME, the population increased in spurts, presumably as birds moved in from other sites in Muscongus, Casco and Penobscot Bays where (except at Stratton Island, ME) nesting usually was attempted for only one to three years before being abandoned.

Cape Cod, Nantucket and Martha's Vineyard, Massachusetts

The "peak period" nesting population in this area declined from a high of about 105 pairs in 1989 to a low of about 20 pairs in 1997. Major causes of the decrease during this period are believed to be predation by owls and possibly other predators such as foxes.

Buzzards Bay, Massachusetts

From 1988-1990 the "peak period" nesting population at Bird Island fluctuated between 1,475-1,570 pairs before reaching a high of about 1,730 pairs in 1991. The population then declined to 1,320 pairs in 1993 and then dipped to about 995 pairs in 1996 before recovering somewhat to 1,180 pairs in 1997. Roseate terns recolonized the restored Ram Island site in 1993. This colony grew explosively to about 720 pairs in 1996 and then declined to about 255 pairs in 1997.

Overall, the nesting population in the Buzzards Bay area trended upward from 1988 through 1991 but then dropped below the 1988 level between 1992-1994. It increased again to a second high point in 1996, but then reversed again in 1997, falling back to about the 1995 level. The declines after 1991 were likely due to the combined effects of "Hurricane Bob" and increased emigration of young birds to other subregional breeding populations. The increase in 1995-1996, was due partially to the immigration to Ram Island of breeding birds from other colony sites, especially Great Gull Island, NY. The decline in 1997 was attributable to owl predation that disrupted settlement of birds at Ram Island, resulting in movement of birds to other subregional breeding populations.

Central Connecticut Coast

From 1988-1997 the "peak period" nesting population in this area fluctuated between highs of about 150 pairs in several years to lows of about 105 pairs in 1989 and 1992. For the years 1993-1997 the population in this area was relatively stable at about 130±5 pairs. Although up to 10 pairs nested at Duck and Tuxis Islands in 1989, few roseate terns appear to have used these sites in the 1990's, leaving Falkner Island as the only significant nesting colony in this area.

The productivity of roseate terns nesting at Falkner Island consistently has been lower than the productivity of roseate terns nesting at Bird Island, MA due mostly to differences in the survival of B-chicks (Nisbet *et al.* 1995). Also, an analysis of capture-recapture/resighting data of adults originally banded as chicks suggests that the nesting population at Falkner Island is not self-sustaining, but is being maintained by the recruitment of new nesting birds from more productive sites such as Bird Island, MA and, presumably, Great Gull Island, NY (Spendelow 1991).

Eastern Connecticut and New York: Eastern Long Island Sound and Gardiners Bay

Despite a temporary drop of about 250 "peak period" nesting pairs between 1991-1992, overall from 1988-1997 the nesting population in this area increased from lows of about 960-970 pairs in 1989 and 1992 to about 1,210-1,215 pairs in 1991 and 1995 respectively and then to a high of about 1,485 pairs in 1997. While the colony at Great Gull Island, NY appears to have increased in size during this period, analyses have not been done to determine to what extent this increase was due to immigration versus internal recruitment of new nesting birds. Roseate terns recolonized the restored Gardiners Point Island (Fort Tyler Ruins), NY site (10 km from Great Gull Island, NY) when two pairs nested in 1994. The colony increased to about 155 pairs in 1995, but the birds experienced low productivity (presumably due to gull predation), and only about five and 25 pairs nested there in 1996 and 1997 (H. Hays and M. Male unpubl. data).

Southern Long Island from Shinnecock Bay to Great South Bay, New York

The "peak period" nesting population in this area fluctuated from about 120 pairs in 1988 to a high of about 170 pairs in 1991 before dropping to about 60 and 70 pairs in 1996 and 1997. The colony at Cedar Beach, which was the fourth largest colony in the MA-CT-NY region in the 1980's, had several years of low productivity (thought to be due in large part to predation) during the late 1980's and early 1990's (Burger *et al.* 1996). This colony declined from 120 pairs in 1991 to less than 40 pairs that experienced complete reproductive failure in 1995, and no roseate terns laid eggs at this site in 1996 or 1997. The apparent desertion of this colony site may result in the movement of adults to other colony sites on the south shore of Long Island in the future.

The number of birds nesting in Shinnecock Bay, NY, remained fairly stable from 1991-1997 despite a large influx of late nesting birds at the Warner Islands in 1994. The roseate terns nesting at the Warner Islands appear to have had good reproductive success from 1993-1997 (M. England unpubl. data), but this small island is losing nesting habitat due to continued erosion.

Productivity

In colonies where it has been measured, overall productivity usually exceeds one chick fledged per pair and is sometimes as high as 1.4 to 1.5 chicks fledged per pair. However, reported measurements may be biased because most studies have focused on early-nesting birds (Nisbet 1981); productivity of late-nesting birds appears to be lower, but has been little studied to date (but see Spendelow 1982; Burger *et al.* 1996). Even in small colonies where only a few pairs of roseate terns nest among much larger numbers of common terns, the roseate terns frequently breed successfully. Occasional examples of low productivity are usually attributable to predation or less frequently to heavy rains and storm-driven waves during periods of high tides that overwash low-lying colony sites.

Postfledging Survival

The overall postfledging survival rate to age three of fledgling roseate terns raised at Falkner Island, CT from 1978-1985 (assuming a 10% "permanent emigration" rate of surviving young to other colony sites) was estimated to be about 0.16 (Spendelow 1991). Preliminary analyses of data collected recently from the largest colonies in the MA-CT-NY area (J. Burger, G. D. Cormons, M. Gochfeld, H. Hays, I. C. T. Nisbet and J. A. Spendelow unpubl. data), suggest that an assumption of an overall 10% "permanent emigration" rate for surviving young from all colony sites during this period may be low. Thus, the typical overall postfledging survival rate to age 3 of all roseate terns may average between 0.18 and 0.20.

Recruitment into the Breeding Population

Age at First Breeding

Only a few roseate terns attempt to breed as two-year-old birds (Donaldson 1971; Nisbet 1981; Spendelow 1991) and all records of known-sex two-year-old breeding birds are of males (J. J. Hatch, I. C. T. Nisbet and J. A. Spendelow unpubl. data). Most roseate terns make their first breeding attempt when three to four years of age, but a few apparently postpone breeding until at least five years of age (Spendelow 1991).

Natal-site Fidelity and Dispersal

A preliminary analysis of chicks banded at the four largest colonies in the MA-CT-NY area from 1986-1989 revealed that about 90% of the survivors returned to their natal site for their first breeding attempt and most of the birds that did move went to the next closest roseate tern colony site (J. Burger, G. D. Cormons, M. Gochfeld, H. Hays, I. C. T. Nisbet and J. A. Spendelow unpubl. data). Therefore, the (re)colonization of former/new sites may be done mostly by inexperienced and less productive birds.

Adult Survival and Fidelity/Movements Following First Breeding

An analysis of adults banded from 1988-1991 and recaptured or resighted from 1989-1992 at the four largest colonies in the MA-NY area indicated that there was a small (but significant) amount of temporal variation in annual survival rates of breeding adults. Most estimates ranged from about 0.78 to 0.85 (Spendelow *et al.* 1995). Attacks by predatory fish may be responsible for both the high rate of loss of colorbands from banded birds and for some of the overwinter mortality (Spendelow *et al.* 1994).

A recent preliminary analysis of data collected through 1996 at three of the same colony sites studied by Spendelow *et al.* (1995) indicates that the drop in the overall breeding population from 1991 to 1992 was due to high (33%) adult mortality, nearly double the average annual adult mortality rate (G. D. Cormons, J. J. Hatch, H. Hays, I. C. T. Nisbet and J. A. Spendelow, unpubl. data). This unusually high mortality rate of breeding adults may have resulted from the effects of "Hurricane Bob" whose path took it through the areas being used by staging and migrating terns in August, 1991.

Spendelow *et al.* (1995) also determined that with all movement among the largest colonies (and therefore almost all movement) accounted for, on average >90% of the surviving adults from each colony site returned to the same site the following year. Variations in movement probabilities were more closely associated with the identity of the destination colony site than with either the identity of the site of origin or the distances between colony sites. This result is consistent with the hypothesis that adults that move to a new site do so on the basis of active selection at the start of the next breeding season rather than selection based on past reproductive performance by themselves or other adults at other colony sites in prior breeding seasons (Spendelow *et al.* 1995).

Analyses to estimate the numbers and proportion of non-breeders of all potentially mature (i.e., at least three years old) birds in the population that return north to breeding areas, including the number of established breeders that "skip" breeding in some years, have not been attempted. Most cases of "skipping" that have been noted in the past at Falkner Island, CT appear to be the result of injuries and/or of females being unable to obtain a new male mate following the death or loss of a former mate (J. A. Spendelow unpubl. data).

Unequal Sex Ratio

There is an unequal sex ratio of about 127 females:100 males in the nesting population of roseate terns at Bird Island, MA (Nisbet and Hatch in press). There is also evidence for an even greater excess of females amongst mature non-breeders (J.A. Spendelow unpubl. data). Productivity of female-female pairs and other multi-female associations is only about 20-40% that of male-female pairs (J. J. Hatch, I. C. T. Nisbet and J. A. Spendelow unpubl. data) and therefore, the female-biased sex ratio means that males can be considered a limiting factor for overall population productivity. The causes of the unequal sex ratio have yet to be determined. Studies of differences in sex-specific survival rates are underway. It is possible that adult males have a lower annual survival rate than do females. Studies of possible effects of toxic contaminants in sexual development are being conducted in common terns.

Population Stability and Population Viability

As discussed above, considerable research has been conducted on the dynamics and structure of the northeastern population of the roseate tern. In some respects (e.g., metapopulation dynamics) the species is better known than most others, but no formal Population Viability Analysis (PVA) has been done for this population. This is because there is still insufficient information on certain population parameters to make reliable predictions of future trends or of the potential effects of alternative management procedures. The best estimates available for key population parameters -- 0.83 for average annual adult survival, 1.2 fledglings per pair for average productivity at the largest colonies and 0.20 for survival from fledging to first breeding -- would suggest that the breeding population should be decreasing slowly, in contrast to the observed steady increase (temporarily set back by events that occurred between the 1991-1992 breeding seasons) over recent years. The most uncertain of these estimates, that for survival from fledging to first breeding, is based on data from only one small (and probably atypical) colony (Spendelow 1991). Data are being collected that should improve this estimate and place it in a formal metapopulation context, but a multi-site analysis of postfledging survival will require theoretical advances in metapopulation modeling. With such advances, ongoing studies of this population should soon place the roseate tern in the forefront among well-studied species.

Assessing population viability, however, also requires prediction of future variations in population parameters, as well as detailed knowledge of the values of these parameters in the recent past. The population was listed as endangered because of low population size and the fact that most birds nested on a small number of sites. Highly concentrated into limited geographical areas during the breeding season, during post-breeding staging, and perhaps during migration and in winter, it could be seriously affected by sporadic adverse events, such as predation, disease, hurricanes or human persecution. Population decreases in the 1950's and 1970's and the sharp drop in breeding numbers in 1992, may have resulted mainly from one or another of these events. Nevertheless, the causes of these population declines remain poorly understood. It will be difficult to predict the frequency of recurrence of these adverse events or the likely population consequences of their occurrence in the future.

REASONS FOR LISTING

The primary reasons for listing the northeastern population of the roseate tern as endangered in 1987 were the concentration of the population into a small number of breeding sites and, to a lesser extent, a decline in total numbers (see USFWS 1989).

Reduction in colony sites

Between 1920 and 1979, at least 30 major roseate tern colony sites were abandoned or were subject to drastic reductions in numbers (Nisbet 1980). Although some of these changes were attributable to erosion or to predation, the most consistent factor (in at least 13 cases) was occupation of colony sites by herring gulls and/or great black-backed gulls. This factor was associated with loss of all the sites occupied by large numbers of roseate terns prior to 1960 (Nisbet 1980). Roseate terns displaced from these sites became concentrated on sites formerly less favored or on new sites. The new sites usually were closer to the mainland than were historically important colony sites and so generally were subject to more human disturbance and avian predation (Nisbet 1980).

Between 1979 and the listing of the species in 1987, one more major site (North Monomoy Island, MA) was abandoned and several others were occupied by roseate terns only sporadically and by few pairs. Most of the cases of abandonment were closely associated with predation, which had been heavy in the year(s) preceding abrupt declines in numbers. Abandonment was not always due to direct occupancy of the tern colony site by gulls. In some cases, gulls were nesting in areas adjacent to the terns and may have played some role in the declines (e.g., North Sugarloaf Island, Monomoy, Nomans Land, Hicks Island, Gardiners Island). Nisbet (1980, 1981, and in Kress *et al.* 1983) also has suggested that much predation on terns in the Northeast may be an indirect consequence of displacement by gulls, because (as noted above) the sites to which the terns have been displaced are generally closer inshore and more susceptible to predation. According to this hypothesis, while gulls were initially responsible for the loss of the most favored roseate tern colony sites, other predators were then responsible for the loss of some of the less favored sites, hence the result is the concentration of the present-day population at the last sites without significant predation.

Decline in Numbers

Information summarized in the *Life History and Ecology* section suggests that chick productivity of roseate terns at most colonies in the Northeast has been generally high in recent years. Based on an analysis of banding data, Nisbet (1980) suggested that high productivity had been maintained, at least in Massachusetts colonies, for several decades, including the years preceding the population declines of 1935-1952 and 1971-1978. Thus, the explanation for these declines is believed to be mortality after fledging. Population modeling by Spendelow *et al.* (1995) suggests that the annual survival rate of adults in this population is now about 82% and, thus, is lower than that of common terns and other seabirds. There is no evidence for substantial mortality of adults during the breeding season (Nisbet 1980), hence the most significant mortality probably occurs during migration or in winter.

Nisbet (1980, 1984) and others have suggested that human predation of terns in the winter quarters may have been a significant factor in the declines in the 1970's. During the 1970's, large numbers of banded roseate terns were recovered and reported from a small area in eastern Guyana. Investigation at this site showed that roseate and other terns were trapped while roosting at night on offshore sandbanks and were then sold for food in local markets (Hays, in

Hamilton 1981; Trull 1988). Between 1968 and 1977, about 1% of the juvenile roseate terns and about 2% of the adults banded in the Northeast were recovered and reported from Guyana, mostly by one market trapper. Since 1981, there has been a decline in band recoveries from this area and an increase in recoveries from shrimp boats off the coast of Guyana (Nisbet 1989).

While human-caused mortality may have been the major factor causing the population decline in the 1970's, the evidence for this remains circumstantial. Nothing is known about other mortality factors acting during migration or in winter quarters, including natural predation (e.g., by predatory fish or birds), food shortage or disease. Further investigation is needed.

CURRENT CONSERVATION AND RESEARCH EFFORTS

Restoration of Breeding Colony Sites

Since 1974, a number of tern colony sites in the Northeast have been restored or re-established through programs to remove nesting gulls using a variety of techniques, including avicide DRC1339. These programs include follow-up measures to prevent resettlement by gulls and measures to attract and protect terns.

In Maine, Eastern Egg Rock, Petit Manan Island and Stratton Island were restored by gull control operations (Kress 1983; Drennan *et al.* 1986, 1987) prior to the listing of the species in 1987. While the first two sites have supported slowly but steadily increasing numbers of nesting roseate terns since 1988, growth in the numbers of roseate terns nesting at Stratton Island has been irregular (Table 2). Since 1987, restoration efforts also have been conducted at several other Maine sites including Seal Island and Jenny Island, but roseate terns have not become firmly established at either site (Table 2). At Stratton and Jenny Islands, this is probably due to great horned owl and black-crowned night-heron predation.

In Massachusetts, the most successful restoration effort to date has been conducted at Ram Island in Mattapoisett (Blodget and Henze 1992; Harlow 1995). A gull control program conducted by the Massachusetts Division of Fisheries and Wildlife (MDFW) in 1990-1991 and onwards led to the resettlement of common terns in 1992 and to the first nesting by roseate terns in 1993. Roseate terns then increased rapidly to 76, 197 and 719 pairs in 1994, 1995 and 1996. Trapping and resighting of banded birds indicated that most of these nesting birds originated from Bird Island, MA and Great Gull Island, NY. The growth at Ram Island was reversed in 1997 due to a great horned owl that disrupted the settlement of terns and the number of nesting roseate terns declined to 253 (Table 2).

Since 1989, two other restoration projects have been started in Massachusetts with uncertain success. A small, pilot gull control program was conducted on Penikese Island in 1995, but was discontinued because of a lack of funding. A larger gull control program was conducted on Monomoy National Wildlife Refuge (MNWR) in 1996-1997. Six pairs of roseate

terns laid eggs in 1996 following the gull removal program but no chicks were fledged. Only one pair laid eggs in 1997, but was believed to have been successful in raising a chick to fledging. Except for a period in the 1970's, terns nesting at MNWR have been subjected to high levels of predation (Nisbet 1981, 1989; USFWS 1996).

In New York, a gull control operation initiated at Gardiners Point Island (Fort Tyler Ruins) in 1992 resulted in two nesting pairs of roseate terns in 1994. Numbers increased to 157 pairs in 1995. Monitoring and management of this colony proved difficult due to its remote location and only four and 23 pairs nested in 1996 and 1997. Poor nesting success in 1995 and subsequent lower numbers are believed to be attributable to continuing gull harassment and predation.

Efforts to discourage nesting by gulls and restore nesting terns at White and Seavey Islands in the Isles of Shoals, NH were initiated in 1997. A small number of common terns returned to the islands and nested successfully. Roseate terns were observed visiting the colony on three occasions (D. De Luca, pers. comm.).

In summary, three restoration projects, Eastern Egg Rock, ME, Petit Manan Island, ME and Ram Island, MA, have been highly successful at attracting and retaining roseate tern nesting populations. As of 1997, 15% of the roseate terns in the northeast population were nesting at restored sites. Two important lessons that have been learned from these projects are: (1) successful restoration of tern colonies requires several years' efforts to remove gulls, long-term follow-up to prevent gulls from resettling and also continuous human presence to protect the terns and to detect and counter/prevent predation or other disturbances and (2) sites for restoration must be chosen carefully to avoid attracting terns to areas that are subject to predation or are otherwise unsuitable for roseate terns. The Technical Working Group and the Recovery Team currently are preparing criteria for selecting restoration sites based on these experiences.

Site Ownership

The sites that support the largest colonies of roseate terns and most of those that support (or recently supported) medium-sized colonies, are owned by government agencies or private conservation organizations and are managed to protect the terns. These sites and their ownership are as follows:

Great Gull Island, NY: American Museum of Natural History; designated and managed for scientific research

Bird Island, MA: Town of Marion, MA; designated as a bird sanctuary and managed on behalf of the town by Massachusetts Audubon Society

Ram Island, MA: State of Massachusetts; Ram Island Wildlife Sanctuary, managed by the Division of Fisheries and Wildlife

Falkner Island, CT: U.S. Fish and Wildlife Service: Stewart B. McKinney National Wildlife Refuge

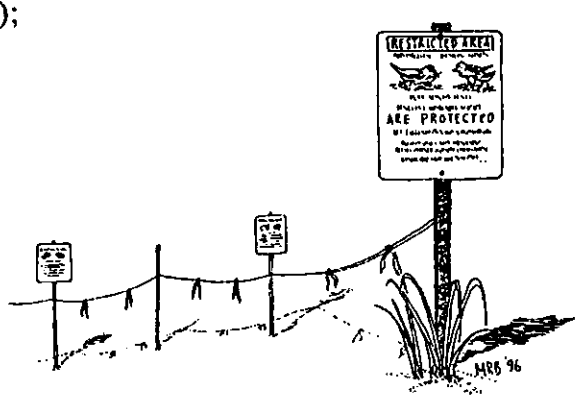
Eastern Egg Rock, ME:	Maine Bureau of Public Lands; managed on behalf of the state by National Audubon Society
Petit Manan Island, ME:	U.S. Fish and Wildlife Service: Petit Manan National Wildlife Refuge
South Warner Island, NY:	South Hampton Town Trustees; monitored by National Audubon Society personnel
Cedar Beach, NY:	Town of Babylon, NY and Long Island Parks and Recreation Comm. (Gilgo State Park); monitored and protected by personnel from Rutgers University and National Audubon Society (Scully Science Center)

Current Management and Monitoring Activities

As of 1997, some form of active management and/or monitoring program was in place for virtually all known roseate tern nesting sites. These programs are essential for the protection and maintenance of the medium and large-sized roseate tern colonies and hence the regional population of this species (Nisbet 1989). Large colonies, in particular, are expected to be the engines driving recovery. Consistent monitoring of all sites is very important for the information it provides on population distribution, abundance and productivity (Chapter 8 *in* Blodget and Melvin 1996).

Many of the management activities employed focus on the more abundant common tern. This is because roseate terns in the northeast always nest in association with large, successful colonies of common terns and hence restoration of roseate terns depends upon first restoring common terns at a site. Specific types of current management activities have included:

1) posting nesting areas with post and string fencing and appropriate signage (Chapter 7 *in* Blodget and Melvin 1996);



2) discouragement or control of competing species best exemplified by the reclamation of former terneries overrun by gulls (Blodget and Henze 1992; Kress 1983, 1997; USFWS 1996, 1997; D. De Luca pers. comm.);

3) use of decoys and continuous loop tape recordings of tern calls to attract terns to historically occupied sites in Maine (Kress 1983, 1997) and New Hampshire (D. De Luca pers. comm.);

4) provision of artificial nest sites for adults and high quality "chick hiding habitat" such as half buried tires and nestboxes at Falkner Island, NY (Spendelow 1994, 1996), tern "teepees" at Bird and Ram Islands, MA (Hecker pers. comm.) and nestbox "condominiums" at Great Gull Island, NY (Hays pers. comm.);

5) discouragement or control of predators, especially problem individual great horned owls and black-crowned night-herons at various sites;

6) vegetation management to provide more suitable nesting habitat; and

7) planning for the restoration of badly-eroded nesting substrate at Bird and Ram Islands, MA and the installation of erosion control structures at Falkner Island, CT.

Monitoring often results in the almost continuous presence of biologists at nesting colony sites and includes activities designed to minimize researcher disturbance, disturbance from other humans, competitors and predators. The colony sites at Petit Manan Island, ME, Eastern Egg Rock, ME, Ram Island, MA, Great Gull Island, NY and Falkner Island, CT are off-limits to visitors other than designated workers. Bird Island, MA and Cedar Beach, NY are public areas managed for multiple uses with minimal disturbance to nesting terns. At Bird and Ram Islands, MA and Falkner Island, CT the presence of biologists serves not only to prevent human intrusion into the nesting areas, but also to provide information and educational programs to visitors.

Due to differences in colony size and configuration, available nesting habitats and logistic constraints, specific monitoring procedures vary from site to site. However, six general types of procedures are used to varying degrees at many sites:

1) finding and marking nests and then following them to hatching or failure;

2) banding chicks with numbered metal bands for individual recognition;

3) locating and weighing chicks, using the weight gain/loss data as an index of (a) the quality of the chick's parents and (b) the probability of postfledging survival and eventual recruitment into the breeding population;

4) capturing and recapturing adults, putting bands and auxiliary markers (such as color bands, plumage colors, etc.) on some of them for quick identification in some behavioral and/or ecological studies where recapture is impractical or not necessary;

5) taking small samples of feathers from chicks and adults for monitoring heavy metal contamination (Burger *et al.* 1992; Burger and Gochfeld 1993) and for sexing individuals (Sabo *et al.* 1994); and

6) monitoring the effects of various research activities on the productivity of the colony and the behavior of the adults and young chicks.

Current Research Activities

Nisbet (1989) summarized the results of several studies done in the 1980's of foraging and feeding by roseate terns in the northeastern United States. Duffy (1986) compared the foraging of roseate and common terns in flocks near Great Gull Island, NY. Roseate terns plunged from greater heights and remained submerged for longer periods than did common terns, they were found proportionately less frequently than common terns in dense flocks and more frequently in dispersed groups, and they were successful more often when feeding in dispersed groups. In contrast to Nisbet (1981) and Dunn (1975) who emphasized the specialization of roseate terns for dispersed feeding and deep diving, Duffy (1986) emphasized the potential for competition between the two species and suggested that common terns were able to outcompete and exclude roseate terns from dense groups through aggressive interactions. Competition with common terns for access to food may be an important factor retarding or preventing growth of the roseate tern population at Falkner Island, CT, and this topic needs further study.

Extensive studies were made of the foraging and diet of roseate and common terns near Cedar Beach. These studies found that prey delivery rates to chicks were lower in 1985 than in 1984 and this apparently resulted in reduced chick survival in 1985 (Safina *et al.* 1988); the two species showed differences in habitat partitioning (Safina 1990a); the presence of schools of feeding bluefish mediated the competition between the two terns (Safina 1990b); there were differences in the roles of the sexes in feeding chicks (Wagner and Safina 1989); and there were seasonal and daily variations in prey brought back to chicks (Safina *et al.* 1990).

Seasonal variations in prey brought back to chicks also have been recorded by Richards and Schew (1989) and Shealer (1996) at Falkner Island, CT, by Kress (1992) at sites in the Gulf of Maine and by Nisbet (unpubl. data) at Bird Island, MA. Another important result of studies of foraging roseate terns from Bird Island, MA (Heinemann 1992) is that in 1989 most adults from this colony foraged in the same three small areas within which feeding was concentrated during surveys made in 1971, 1972, 1975 and 1980 (Nisbet 1981 and unpubl. data). Staff of the Stewart B. McKinney NWR have attempted to identify the main foraging areas used by the roseate terns nesting at Falkner Island, CT (Casey, Kilpatrick and Lima unpubl. data) and to integrate the results of this water-based foraging location study with results from a land-based study of chick-feeding by known-aged birds (Shealer 1996).

A comprehensive research project on the roseate tern was initiated in 1987 as a region-wide study of the population dynamics and ecology of the birds breeding in the MA-CT-NY area. This study, now called the Cooperative Long-term Roseate Tern Metapopulation Project, is coordinated by Dr. Jeffrey A. Spendelow of the Patuxent Wildlife Research Center (Patuxent) of the U.S. Geological Survey. Co-investigators currently include Drs. Ian C. T. Nisbet and Jeremy J. Hatch working at Bird Island, MA and Ram Island, MA, Helen Hays and Grace Cormons working at Great Gull Island, NY, Dr. David A. Shealer and James M. Zingo working with J. Spendelow at Falkner Island, CT, Drs. Joanna Burger and Michael Gochfeld working at several sites on Long Island, NY and Drs. James D. Nichols and James E. Hines at Patuxent developing new analytical techniques. Within the framework of the cooperative study, the co-investigators have been encouraged to develop site-specific study objectives and fieldwork methods as appropriate.

The goals of the first five-year (1987-91) Patuxent study were to: 1) develop methods to estimate some basic demographic parameters (Nichols *et al.* 1990; Nisbet *et al.* 1990), 2) determine nesting habitat use (Gochfeld and Burger 1987; Burger and Gochfeld 1988b; Spendelow 1996) and 3) potential limiting factors of roseate terns breeding in the area from Buzzards Bay west southwest to Long Island Sound and the south shore of Long Island. Specific objectives included determining annual variation in breeding population size, site-specific survival (Spendelow and Nichols 1989) and recruitment (Spendelow 1991) rates, chick growth patterns (Nisbet *et al.* 1995) and the relative importance of various factors affecting productivity (Spendelow 1996; Burger *et al.* 1996), including potential effects of research activities such as trapping adults (Burger and Gochfeld 1991; Zingo 1991; and Burger *et al.* 1995).

A main goal of the second five-year (1992-96) Patuxent study was to develop a variety of formal multi-state, capture-recapture/resighting models for use in examining the specific regional survival, movement and recruitment rates of this species (Spendelow *et al.* 1994, 1995) and for use with other endangered, threatened or declining metapopulations. With the development of a new PCR-based technique to identify the sex of terns (Sabo *et al.* 1994), Nisbet (1996) documented an unequal sex-ratio in the roseate tern nesting population at Bird Island, MA, with more females than males, and an apparent shortage of old males. The causes of this unequal sex-ratio and its consequences for productivity, other aspects of population dynamics and population recovery require further study. Future research goals of the Metapopulation Project include: (1) developing more new models for examining the causes and consequences of age- and sex-specific differences in demographic parameters and (2) integrating the results of feeding studies to the growth and survival of chicks on both an individual and colony-site basis.

Information Gaps

By far the most important data gap is the limited information about the distribution, behavior, survival and ecology of this population in its winter quarters. Another important data gap is our incomplete understanding of the role of food availability in limiting population distribution, chick growth and survival and overall productivity at the various colony sites. Other substantial information gaps include the lack of: (1) basic information from some colonies, (2) information on predation and its effects on colony movements, (3) information on the persistence of family groups and parental care post-dispersal and (4) information on how the biased sex ratio may be limiting population recovery. More detailed discussions of these data gaps are given by Nisbet (1989:55-57).

Current Public Information and Education Efforts

State and federal agencies and cooperating private management organizations have announced significant management initiatives and annual census results for the roseate tern in various newsletters and news releases. State management personnel have initiated an extensive network of contacts with other state, federal and municipal agencies, as well as private organizations concerning restoration efforts for the roseate tern. Federal personnel provide information to the public by periodic news releases documenting activities and to other federal agencies through the Section 7 consultation process.

Since the roseate tern is a marine species that nests at mostly remote offshore islands, it is rarely encountered or differentiated from other tern species by the general public. As a result, media interest in the species has historically been low. However, controversy since 1995 surrounding the U.S. Fish and Wildlife Service's gull management at Monomoy National Wildlife Refuge has attracted much media and political attention and has, without doubt, afforded the roseate tern unprecedented exposure.

Research and management personnel working at the various colonies provide on site public education to the occasional public visitor. Various informational brochures and fact sheets on the roseate tern have been developed by various agencies. A particularly unique and useful brochure entitled, "Island Ethics", was developed by the Petit Manan National Wildlife Refuge and the Gulf of Maine Project (USFWS 1994). It focuses on appropriate behavior when visiting seabird colonies and is an ideal educational handout to island visitors. In addition, extensive photography has been done and is incorporated in various ways in slide and video presentations.

The Metapopulation Project has contributed more than 45 scientific papers and other products on research findings to date. Current information about the monitoring and research work being done on roseate terns can be found at the "Roseate Tern Research" address on the "Research Showcase" page of the Patuxent Wildlife Research Center website at:

"http://www.pwrc.usgs.gov.resshowsl.htm"

RECOVERY STRATEGY

The strategy recommended by the Recovery Team for managing the northeastern population of the roseate tern and for effecting its recovery includes the following six activities:

1. Protection and stabilization of existing breeding colonies

Maintain suitable conditions for nesting roseate terns at existing breeding sites in the Northeast, to enhance them where possible and to protect and manage these sites to support continued population growth. Specific activities include wardening, posting, control of human visitation and surveillance for predation or other adverse factors. At some sites activities also may include erosion control, restoration of eroded areas, vegetation management, provision of artificial nest sites, control of encroaching gulls and control of other predators. Existing and potential breeding sites should be visited and censused each year to monitor changes in numbers and distribution.

2. Determine ecological characteristics and limiting factors

Continue to evaluate the factors that endangered this population and that may impede its recovery. These include ecological characteristics of the species and external factors that may limit its numbers and breeding success. An historical review and search of the literature on the species was completed prior to listing. Intensive research is being done to determine (a) habitat requirements for breeding, foraging and staging, (b) demographic characteristics, (c) predation and other causes of mortality and (d) factors limiting growth and survival of young. This research involves work at several colony sites. The biologists who conduct this research also serve as wardens and site managers.

3. Restoration/creation of breeding sites and enhancement of numbers

Increase the total population and reduce its present concentration at a small number of breeding sites by restoring former nesting colonies or creating new ones. Removal of local gull populations and possibly other competing species may be necessary, followed by active management to attract and protect nesting terns. Because roseate terns in the Northeast always nest in colonies of common terns, these measures initially are used to attract common terns. Selection of sites for restoration and other management measures depend on the results of research conducted under Activity 2.

4. Protection and management of terns in their winter quarters

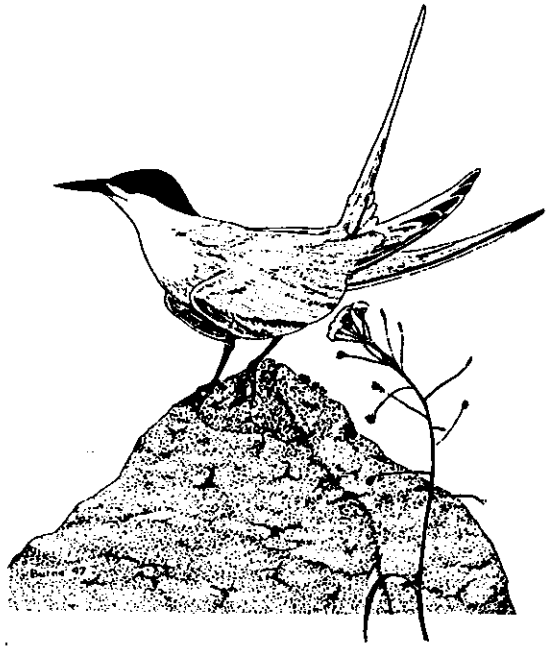
Protect and manage the population at the winter quarters where much of the annual mortality may occur. Progress made to date has been limited due to the high cost and logistical difficulties of conducting research across a vast area of the Caribbean Sea and southern Atlantic Ocean. Despite recent encouraging discoveries off the coast of Bahia, Brazil, the major wintering sites for most of the breeding population remain poorly known.

5. Administrative actions

Promote the recovery of roseate terns through regulatory actions within the U. S. or through international cooperation. Although most breeding sites are already in secure public ownership, new sites could be acquired by federal or state government agencies, while protection of other breeding sites or important feeding areas could be strengthened. The Recovery Team maintains liaison with the Canadian Recovery Team for the species. When management measures are devised for the species in their winter quarters (Activity 4), these should be promoted through existing international treaties and conventions.

6. Public involvement

Generate support for recovery activities through involvement and interest of the general public. Although the roseate tern is an attractive species whose management and recovery generally receive wide public support, increasing public awareness of its distribution, requirements and management needs, particularly in relation to the control of competing and predatory gulls, is needed.



PART II
RECOVERY

Recovery Objectives

Primary Objective: To increase the Northeast nesting population of roseate terns (U.S. and Canada) to 5,000 breeding pairs. This total should include at least six large colonies with high productivity within the current geographic distribution (see definitions below). This will reduce the possibility of extirpation of the northeastern population.

Secondary Objectives: (1) to expand the number of roseate tern breeding colonies to 30 or more sites;
(2) to expand the breeding range to historically occupied areas south of the current range.

A large colony will consist of at least 200 nesting pairs. The number of nesting pairs will be based on a one-time, "peak period" count of nests or estimate of breeding population at all colonies. Ideally, "peak period" estimates are based on nest counts on or about the date of first hatching (usually June 10-20). The guideline for high productivity will be at least 1.0 fledged young per pair for five consecutive years (recognizing that accurate measures of productivity are difficult to obtain and can be reduced by external circumstances).

The status of the endangered northeastern population of the roseate tern should be evaluated for reclassification to threatened when the primary objective is met. Delisting would be warranted if the nesting population reaches the historic high level of the 1930's (8,500 pairs).

Step-Down Outline

The following outline lists the tasks that need to be undertaken to meet the recovery objectives. The order in which they are presented is not based on importance. Some tasks are already under way; others may not be initiated for several years. A more detailed description of the tasks is presented in the Narrative section of the plan.

1. Manage roseate tern breeding populations and habitat to increase numbers, productivity and distribution.

    1.1 Conduct annual surveys of tern colonies to determine distribution and abundance of roseate terns and assess their productivity

        1.11 Determine location of tern colonies with nesting roseate terns
        1.12 Determine numbers of pairs of roseates and other terns at each site
        1.13 Assess productivity at major colonies

1.2 Evaluate the suitability of existing and potential nesting habitat to support an expanding population.

1.21 Develop criteria for evaluating colony sites
1.22 Evaluate existing colonies for potential to increase populations
1.23 Identify former colony sites and evaluate present habitat at those sites
1.24 Identify potential sites with no history of roseate nesting and evaluate habitat
1.25 Determine proximity of suitable feeding habitat to existing and potential nesting habitat
1.26 Rank sites with greatest potential to support expanding populations

1.3 Develop active protection and management programs at existing and potential colony sites.

1.31 Determine ownership of all existing and potential nesting sites
1.32 Contact landowners and provide protection recommendations
1.33 Protect currently unprotected sites through acquisitions or easements
1.34 Develop and implement management strategies
1.341 Control human access on a site-specific basis
1.3411 Post colony areas and fence where needed
1.3412 Limit recreational use and access to nesting islands
1.3413 Place restrictions on pets
1.3414 Provide wardens to enforce protective measures
1.3415 Provide public education
1.342 Discourage activities that may degrade suitability of potential tern nesting islands
1.343 Introduce measures to control competing species
1.3431 Protect existing tern colonies from gull intrusions
1.3432 Establish buffer between nesting gulls and terns on larger islands
1.3433 Establish gull-free nesting areas for terns on selected islands or other sites
1.3434 Control competition from other species, including the common tern, if necessary
1.344 Introduce measures to discourage or control predators
1.3441 Great horned owls and other raptors
1.3442 Black-crowned night-herons
1.3443 Gulls
1.3444 Rats and other mammals, including feral cats
1.3445 Ants, snakes, etc.
1.3446 Crows and other avian predators
1.345 Protect, create and expand nesting habitat at designated sites
1.3451 Expand and enhance some existing islands with dredged material

1.3452 Create new island habitats with dredged material
1.3453 Evaluate use of rip-rap for erosion control and to provide roseate nesting habitat
1.3454 Manage vegetation to provide optimum nesting habitat
1.3455 Add artificial nest shelters
1.346 Prepare contingency plans for protection of prey species

2. Monitor and manage staging areas and wintering areas

2.1 Monitor staging areas in late summer
2.11 Identify staging areas used and times when they are used
2.12 Determine factors that influence use of these areas
2.2 Appraise need for protection of beach roosting sites and manage if need is established
2.3 Determine need for and feasibility of management on wintering areas
2.4 Promote international cooperation in research and management in wintering areas

3. Continue ongoing scientific investigations and initiate new studies to enhance and facilitate recovery effort

3.1 Maintain close liaison with ongoing research efforts on terns in North America and elsewhere

3.2 Improve and standardize population surveys

3.21 Improve and standardize methods for computing breeding populations in all colonies
3.22 Develop method for estimating numbers in staging area concentrations, including young-of-the-year

3.3 Conduct studies to locate winter quarters and determine winter survival

3.31 Survey spatial and temporal distribution of winter birds
3.32 Explore factors relating to food and habitat on wintering areas
3.33 Investigate factors relating to winter survival

3.4 Conduct long-term studies of dynamics of Northeastern population

3.41 Continue studies of banded birds at major colonies and calculate survival
3.42 Improve and standardize methods for computing productivity
3.43 Initiate population studies, including banding as needed, on small colonies or new colonies
3.44 Evaluate possible impacts of banding studies on reproductive success
3.45 Evaluate possible effects of banding/colorbanding on overwinter survival

3.46 Investigate factors affecting fledgling survival and recruitment
3.47 Investigate factors causing unequal adult sex ratios and determine sex-specific survival rates of adults

3.5 Characterize habitat selection at nest sites

3.51 Compare habitat selection among colonies and between common and roseate terns
3.52 Investigate manipulation of vegetation to enhance tern production

3.6 Conduct studies of feeding ecology and how it relates to colony productivity

3.61 Identify and characterize preferred feeding areas
3.62 Study foraging behavior of breeding and staging aggregations
3.63 Study availability, population trends and factors affecting important prey fish
3.64 Determine relationships between food availability and breeding success on an individual and colony-site basis

3.7 Evaluate possible adverse impacts of contaminants and diseases

3.71 Assess potential impacts of oil spills
3.72 Evaluate potential food web accumulation of toxic contaminants, including heavy metals and pesticides
3.73 Evaluate potential impact of paralytic shellfish poisoning (red tide) and other toxic algae
3.74 Assess potential and actual disease problems

3.8 Conduct ecological studies of important competitors and predators

3.81 Study aspects of successful competing species that may adversely impact roseate terns
3.82 Investigate the ecology of important predators that may have indirect or direct impact

3.9 Refine and test methodology for attracting terns to nest at new sites

4. Develop and distribute educational material

4.1 Obtain drawings and photos for use in various releases

4.2 Print and distribute informational brochures and posters

4.3 Provide press releases to inform the public

4.4 Develop or coordinate production of slide shows and movies, and information for dissemination on the World Wide Web

4.5 Coordinate with Canadian Wildlife Service and appropriate Maritime Provinces in an information exchange

4.6 Encourage and assist international conservation organizations to promote education in Latin American wintering areas

4.7 Provide information and assistance to Federal and State agencies, municipalities, and private organizations and individuals that own or manage roseate tern nesting habitat

4.8 Produce and distribute progress reports and other informational summaries

Narrative

The following narrative provides details and justification for each task listed in the step-down outline.

1. Manage roseate tern breeding populations and habitat to increase numbers, productivity and distribution.

Most of the largest nesting colonies have been used traditionally for many years. The numbers of nesting pairs in these colonies have fluctuated only slightly from year to year (with the exception of the decline noted between 1991 and 1992) and productivity has been generally good. At other locations, however, the numbers of nesting pairs have varied greatly from year to year and productivity has often been poor. A key to meeting the primary objective is to establish more large colonies with consistent annual use and good productivity. Management experience at some of the existing colonies suggests that the species will respond to appropriate actions on the breeding grounds.

1.1 Conduct annual surveys of tern colonies to determine distribution and abundance of roseates and assess their productivity.

Since the roseate terns always nest with common terns in the Northeast, it is necessary to survey all tern colonies where roseate terns may occur and carefully census the roseates. This requires familiarity with the species and its nests and young.

Intensive, season-long studies of nesting roseate terns at some colonies indicate that late-nesting birds augment the numbers of pairs represented in "peak period" estimates.. "Peak period" is defined as the date of first hatch. Late-nesting terns are likely to be first-time nesters that contribute little to colony production. Some of the late-nesting terns may also be renesting individuals whose initial nestings failed elsewhere. Because season-long marking studies at all colonies are not feasible, a single, "peak period" census is recommended as a minimal measure of the annual breeding population and for gauging recovery progress. Governed by the dates of first hatch, "peak period" censuses should generally be accomplished June 10-20 (Appendix A). A follow-up survey two to three weeks later is desirable, if possible, to determine if the colony may have reached its peak late and if it is still active and productive. The relationship between "peak period" counts and total seasonal breeding populations is being studied.

1.11 Determine location of tern colonies with nesting roseates.

Results of an inventory of coastal waterbird colonies in 1977 disclosed at least 126 sites with nesting common terns from Maine to New York (Erwin and Korschgen 1979). One or more pairs of roseate terns nested at 22 of those sites. The most recent update of this inventory in 1994-95 revealed about 130 common tern sites, of which 18 also had one or more pairs of nesting roseate terns (Blodget, unpubl. data). Nearly all the colonies were on islands and required boat access. Although terns often nest in the same locations year after year, some sites are abandoned and new ones established annually, so surveyors must carefully scrutinize a large number of traditional tern nesting sites, be alert to new sites and carefully search for roseate tern nests.

1.12 Determine numbers of pairs of roseates and other terns at each site.

When feasible, complete nest counts of terns of all species should be obtained (if young have not hatched) as well as an estimate of total terns flying over the nesting area and the number or percentage of roseates among those. If only an estimate of breeding roseate terns is obtained, it should exclude any non-nesting adults that sometimes loaf nearby. A calculation of nesting pairs based on adults present will require careful adjustment, since up to 45% of the nesting adults may be away from the colony site at any given time.

1.13 Assess productivity at major colonies.

Research now ongoing at several colony sites involves studies of marked young. Even so, productivity figures based on either young fledged per nesting attempt or per nesting pair are difficult to obtain because young leave nests long before fledging and are difficult to locate. Data on the quality of chicks and fledglings as determined by growth rates and asymtotic masses are also of value in estimating productivity at sites where the fate of all chicks cannot be determined with certainty. Weighing chicks on a regular basis provides useful information to assess chick quality and make judgements about the probability of survival to fledging or the probability of postfledging survival.

1.2 Evaluate the suitability of existing and potential nesting habitat to support an expanding population.

In order to achieve the primary objective of population expansion, both existing and potential nesting habitats must meet several suitability criteria. Since the population of roseate terns peaked at about 8,500 pairs in the 1930's, many colony sites have been abandoned due, in part, to loss of suitable nesting habitat.

1.21 Develop criteria for evaluating colony sites.

The two or three largest colonies of roseate terns have successfully fledged substantial numbers of young for many consecutive years. They have done so despite major differences in the general appearance and types of nest cover at those sites. Some sites, formerly occupied by productive colonies of roseate terns, have been ultimately abandoned after experiencing several consecutive years of reproductive failure. Other sites, long used by common terns, have no record of nesting by roseate terns. The Recovery Team will prepare a list of site criteria, based on current or historic successful colonies. These site criteria will include both features of the colony site and features of the surrounding marine environment.

1.22 Evaluate existing colonies for potential to increase populations.

The largest and most successful colonies of roseate terns nest in association with very large and successful colonies of common terns. Currently, common terns outnumber roseate terns at all sites. Roseate terns prefer portions of nesting islands with more vegetation or rocks under which nests are partially concealed. Although roseate terns seem to require association with a thriving colony of common terns, there may be a maximum density of the combined species that an island can support. In order for roseate tern populations to increase, it may be necessary to manage habitat to favor them at the expense of common terns. Numbers of both roseate and common terns may also be limited by prey availability, although only preliminary information on such limitation is presently available. Site criteria should be applied to existing colonies to determine their potential to support more roseate terns.

1.23 Identify former colony sites and evaluate present habitat at those sites.

Sites where roseate terns have nested at some time during the past 50 years are well documented. Some have been abandoned by the roseates but common terns have remained; others have lost both species. Was desertion due to habitat changes at nest sites or to other unknown factors? Will modifying habitat encourage return of either or both species? Limiting factors of nesting habitat and nearby feeding areas must be identified before management actions are implemented.

1.24 Identify potential sites with no history of roseate nesting and evaluate habitat.

Some sites with no record of use by terns or use by common terns only, could possibly become sites for roseate tern nesting with only slight modifications of habitat. Site criteria should be used to evaluate their potential.

1.25 Determine proximity of suitable feeding habitat to existing and potential nesting habitat.
Accessible feeding areas may be critical determinants of the suitability of colony sites. Hence the location, composition and temporal patterning of food resources are essential to habitat assessment. Foraging sites of common and roseate terns overlap substantially, but a colony of commons that forages in ways and places rarely used by roseates might not attract roseates, regardless of how attractive the nesting substrate is.

1.26 Rank sites with greatest potential to support expanding populations.
Expansion or establishment of roseate tern populations can be accomplished at only a limited number of sites. Management practices with the best potential should be listed for each of those sites and priorities assigned.

1.3 Develop active protection and management programs at existing and potential colony sites.
The larger, well-established colonies of roseate/common terns have been closely studied by research groups in recent years. The presence of researchers during the nesting season has provided protection from human incursions including vandalism, and some protection against predation. Some management measures have been incorporated. These include discouraging gull nesting and some manipulation of nesting cover. Little or nothing has been done at smaller roseate tern colonies or at potential sites. Federal and State agencies should work closely with research groups now studying terns to develop uniform protection and management plans that best implement recovery objectives. The actual and potential impacts of intensive research studies should be evaluated with designed studies.

1.31 Determine ownership of all existing and potential nesting sites.
Land ownership of sites now or formerly used by roseate terns or used by common terns should be determined in order to effect protective measures. Most of the nesting islands are in public ownership, but appropriate agencies should be appraised of the importance of the properties for terns.

1.32 Contact landowners and provide protection recommendations.
The need for protective measures and the potential for management should be discussed with both private and public landowners.

1.33 Protect currently unprotected sites through acquisitions or easements.
Although all sites of major roseate tern colonies are now protected to some extent, efforts should be made to acquire some sites currently used only by common terns that have good potential for roseate terns, as well as any unprotected sites used by roseate terns in recent years.

1.34 Develop and implement management strategies.
After factors that limit productivity have been identified, measures should be taken to reduce or eliminate them. The factors should be examined on a site-by-site basis and addressed by specific management actions. If existing management activities are beneficial, they may be incorporated in the management strategies for other sites. Seasonal closures of entire islands are desirable. Protection of food resources or feeding areas should be considered.

1.341 Control human access on a site-specific basis.
Undeveloped islands along the densely populated coasts of New England and Long Island are popular destinations for summer boaters, who may spend a long day picnicking and frolicking in or near a tern colony, often accompanied by one or more dogs. Such disturbance can be devastating to tern reproduction. Nocturnal use by fishermen is less frequent, but can be equally disturbing. Overnight camping and Fourth-of-July fireworks displays have occurred at some sites. Measures should be taken to control these activities. Control should be closely coordinated with local authorities.

1.3411 Post colony areas and fence where needed.
Various types of signs have been used to designate portions of islands where terns nest. Sometimes the signs are accompanied by a "symbolic fencing" - a strand of twine strung between posts and flagged with ribbon tied at intervals to enhance visibility. Known sites where roseate terns nest may include signs with "endangered species" designation. Studies should be conducted to determine how far from actual nest sites signs should be located and if more than "symbolic fencing" is needed. If entire islands are closed, large and readable signs should warn boaters not to land and give dates of closure. Signs and fences should be removed immediately after the nesting season.

1.3412 Limit recreational use and access to nesting islands.
Access restrictions such as total closures or permits should be considered and used if necessary during the nesting season. If used, firm dates (e.g., May 1 through August 1) for closure should be established in advance and adhered to unless terns fail to nest.

1.3413 Place restrictions on pets.
On tern islands with no human habitation, dogs should be absolutely banned during the nesting season. If terns nest on an island where humans reside, a leash requirement for pets should be advocated. Feral cats should be removed.

1.3414 Provide wardens to enforce protective measures.
Management agencies should work to assure that all roseate tern nesting sites are patrolled or tended by researchers, biologists, warden-biologists or island keepers. The Service should take the lead in protecting and managing roseate terns on refuges. State fish and wildlife agencies should take a similar lead on state-owned properties and work with private owners and organizations to assure that privately- and municipally-owned nesting sites have appropriate protection and management strategies in place. It is also important to protect colonies of common terns where roseate terns might become established in the future.

1.3415 Provide public education.
Support should be given to private organizations that now supply educational material. Wardens and volunteers can provide information to the public about seabird colonies, terns and their need for protection. Informational brochures, such as "Island Ethics", produced by the U.S. Fish and Wildlife Service and the Gulf of Maine Project, should be distributed as needed.

1.342 Discourage activities that may degrade suitability of potential tern nesting islands.
Efforts must be taken to maintain favorable habitat for roseate terns on certain islands that are not now used for nesting by either common or roseate terns. Development or other activities that would permanently render the islands unsuitable for terns should be discouraged by acquisition, easements or other protective measures.

1.343 Introduce measures to control competing species.
The extirpation or drastic reduction in numbers of roseate tern colonies in New England and Long Island has most frequently been caused by the usurpation of tern nesting sites by herring and great black-backed gulls. These gulls arrive on the nesting grounds weeks before the terns, establish territories and defend them. The population expansion of these large, aggressive gulls has resulted in the displacement of roseate terns from their traditionally preferred sites to alternative locations which frequently are closer inshore, more prone to predation and, therefore, less productive. Thus, encroachment by gulls on the nesting colonies is probably the greatest threat to nesting terns in the northeastern United States. Competing gulls should be discouraged or removed from roseate tern nesting sites.

Where possible, regional solutions to reducing gull populations should be sought and encouraged. Open landfills provide an important food subsidy for gulls. During stressful winter periods, this food source may be a particularly important one, especially to subadult gulls. Therefore, food available to gulls at open landfills should be better managed. The prevention of gulls from feeding at landfills or the outright closure of open landfills should be pursued aggressively throughout the region. The desired result will be a gradual reduction of gull numbers to lower levels.

1.3431 Protect existing tern colonies from gull intrusions.
Preventing the invasion of tern colony sites by large gulls will require annual management. Strategies that have been used with varying effectiveness involve nest and egg destruction, shooting (prior to tern arrival), cage traps and gull toxicant 1339. The application of these strategies should be conducted to prevent establishment of nesting gulls in tern colonies with minimal disturbance to terns.

1.3432 Establish buffer between nesting gulls and terns on larger islands.
Nesting gulls on the larger islands should be separated from tern colonies by a buffer strip of at least 200 meters. Currently, the most effective way to remove nesting gulls is through a primary treatment of bread cubes containing gull toxicant 1339 when 80 percent of the gull nests contain two or more eggs. If indicated, a secondary treatment should follow in four weeks. The technique may have to be repeated a second year to remove all established nesters. In subsequent years, new gulls should be discouraged from becoming established through a combination of increased human activity at the site and continuous break-up of nesting starts.

1.3433 Establish gull-free nesting areas for terns on selected islands or other sites.
As previously noted, the take-over of certain high quality tern-nesting islands by gulls has been a major factor in the decline of the roseate tern. Roseate terns, and the large numbers of common terns among which they nest, have been concentrated in a few colonies where invasion by nesting gulls has been reversed or prevented. The few remaining colonies of roseate terns are

productive, but concentration makes them more vulnerable to possible disasters such as storms, oil spills, predation or disease outbreaks. It is important to disperse part of the nesting population to other sites. High priority should be given to reestablishing tern colonies on islands where roseate terns were historically successful. This will require removal of all nesting gulls on the small, favored islands. Initially, two islands meeting those requirements and within the feeding range of roseate terns at the two major colonies should be selected. The best available techniques should be employed to remove the nesting gulls.

1.3434 Control competition from other species, including the common tern, if necessary.
Competition for nesting habitat with the large gulls is usually obvious and there is considerable documentation on this subject. However, there is little information on possible competition with laughing gulls or even with the common terns among which the roseates nest. It should be determined what roseate tern nesting habitats are most vulnerable and at what point they may be usurped, by what species and how. It may be necessary to manage vegetation on certain sites to favor the roseate tern.

1.344 Introduce measures to discourage or control predators.
In northeastern North America, expanding populations of herring and great black-backed gulls over many years have driven terns from their historic and largely predator-free offshore nesting islands to inshore islands and, on occasion, the mainland itself where nesting birds are more accessible to predators. Terns nesting on mainland beaches and salt marshes experience the heaviest predation; those birds nesting on islands within one kilometer of the mainland are also vulnerable. Contingency plans should be developed for predator control of selected species at each of the most important roseate tern nesting sites.

1.3441 Great horned owls and other raptors
Individual great horned owls may learn to specialize in preying on terns and may regularly visit nearshore tern nesting islands. When this occurs, these owls should be removed as soon as possible, preferably by trapping or, if that fails, by shooting them at their mainland nesting or roosting sites rather than at the tern colony. Federal and State permits are required to shoot or capture owls. The use of pole traps is restricted and requires special approval from the FWS. If the nest can be located in late winter, a balchatri noose-carpet can be used to remove incubating adults. The presence of an owl in a tern colony may cause all birds to leave their nests and not return until dawn. This greatly increases the potential losses of eggs and young to other causes. Occasionally, a short-eared owl, peregrine falcon or other raptor may harass or kill terns at a specific nesting colony over an extended period. If the predator cannot be scared off, and if the direct or indirect effects of its activities are potentially serious to tern productivity, live-trapping and transporting of a non-nesting offending bird should be considered. Other deterrents may have to be developed if nesting raptors are involved.

1.3442 Black-crowned night-herons.
Individual black-crowned night-herons may develop specialized hunting techniques that allow them to be highly successful in locating young terns and eggs. Those birds that develop this trait should be removed as soon as feasible. If the heron's probable approach path to the nesting colony is known, it could be intercepted at a distance from the colony where shooting would create less disturbance.

1.3443 Gulls.
Nest site competition by large gulls is not their only adverse effect on terns; some gulls also prey on both tern chicks and fledglings, and may even take adult terns. Gulls involved in such actions should be eliminated if possible, probably by shooting. If marauding gulls are from a nearby colony that is small (less than 100 pairs), elimination of the colony should be considered. In some cases the gulls may be non-nesting birds that loaf near the tern colony. Shelters may help protect young terns from these avian predators.

1.3444 Rats and other mammals, including feral cats.
Roseate terns, like most colonial-nesting seabirds, normally select small islands free of mammalian predators to raise their young. If a mammal such as a fox gains access to a colony, it can return night after night until all production is wiped-out. The remote islands historically preferred by terns also have been the sites for lighthouses and military fortifications. While these islands were inhabited by humans, pet cats and dogs and brown (Norway) rats frequently discouraged tern nesting and reduced productivity. The rats sometimes persisted long after human habitation ended. Applications of rat-specific poison may be needed in some situations. They should be applied in the non-nesting season.

The usurpation of favored nesting islands by gulls has sometimes forced terns to nest on portions of large nearshore islands, on beaches connected to the mainland and even along the edges of salt marsh. In those locations, access by foxes, skunks, weasels, mink, raccoons, rats and other predatory mammals is more likely to occur and protective measures may be necessary. This could include the trapping and removal of offending mammals, or in some cases, shooting.

1.3445 Ants, snakes, etc.
The only known instances of snake predation on young terns have been by garter snakes on Nomans Land, an island south of Martha's Vineyard, Massachusetts. Garter snakes occur at other coastal locations but not in numbers that would have much effect on tern production.

Certain species of ants kill young terns when eggs are pipping or soon after hatching. The problem may be augmented by delayed hatching resulting from nocturnal desertion by adult terns (often caused by great horned owls). Manipulation of vegetation may suppress populations of these ants and judicious use of ant poisons, possibly as "ant traps" placed next to roseate tern nests, may be warranted at some sites.

1.3446 Crows and other avian predators.

Other avian predators that have been observed in roseate tern colonies and are suspected of preying on eggs or chicks include American crows (*Corvus brachyrynchos*) and fish crows (*C. ossifragus*) and ruddy turnstones (*Arenaria interpres*). Although crows are attacked by common terns and most usually learn to avoid nesting areas, individual crows or groups that learn to feed on tern eggs may become a problem. In such cases attempts should be made to trap or shoot them. Generally, when predation on roseate terns is suspected, attempts should be made to identify the predators and to remove them if permitted.

1.345 Protect, create and expand nesting habitat at designated sites.

Management of the nesting population in the Northeast focuses on the need for suitable island habitats with access to good food supplies. In addition to protecting important sites from human activity, predation and competition from gulls, there is potential for improving habitat on existing sites. This should increase capacity and production.

1.3451 Expand and enhance some existing islands with dredged material.

Islands used by roseate terns vary greatly in general characteristics. However, most are low areas exposed to some erosion and tidal overwash. This reduces the amount of nesting area available and sometimes results in major losses of eggs and young to flooding. The breakdown of containment structures, many years of erosion, recent severe storms and rising sea levels are together, or in various combinations, threatening many sites. For example, Bird and Ram Islands, MA and Warner Island, NY all have substantial areas which are unusable due to flooding at high tides. Continued unchecked, erosion will increasingly compromise capacity and productivity at these sites and slow the recovery effort. Dredged material from approved projects (such as the Cape Cod Canal maintenance dredging) should be used to enhance these islands. Any such addition of material should be limited to the non-nesting portion of the year. Rip-rap material along the periphery of these islands would help to protect them from continued erosion. Permits issued for such projects should include specific conditions regarding fill material, grading, vegetation plantings and firm completion date.

1.3452 Create new island habitats with dredged material.

Common terns frequently nest on new islands created by deposition of dredged material. Occasionally they are joined by roseate terns. If creation of such islands in suitable locations is allowed by agencies responsible for dredge and fill permits, they can be managed to encourage suitable vegetation and to discourage predators and competitors.

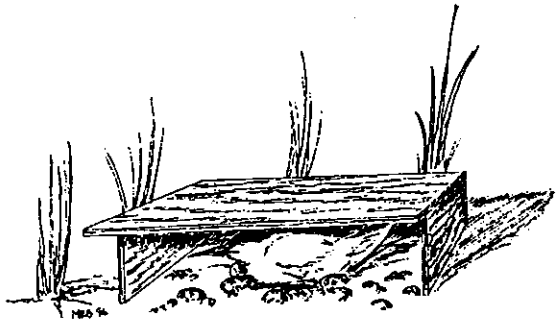
1.3453 Evaluate use of rip-rap for erosion control to provide roseate nesting habitat.

At Great Gull Island, NY, most roseate terns nest in rock crevices created when the island was rip-rapped for storm damage protection. These nesting sites offer the benefit of protection from most predators. Use of rip-rap to create additional nesting substrate incidental to erosion control projects should be evaluated. Such an evaluation should include careful description of the actual rip-rap design utilized by nesting roseate terns at Great Gull Island, NY. If colony sites are to be protected from erosion with rip-rap, project design should take into consideration the appropriateness and advantages of use of revetment like that at Great Gull Island, NY.

1.3454 Manage vegetation to provide optimum nesting habitat.
Roseate terns prefer to nest in denser vegetation than common terns, or in rock crevices or under large boulders or boards. Brush and persistent perennial vegetation, however, can become too dense for even the roseate terns. At Bird Island, MA, the dead stalks of robust annuals are removed each spring. At Great Gull Island, NY, meadow voles were re-introduced in 1981 to consume the dense grasses (Hays 1984). At Eastern Egg Rock, ME, rock salt has been used to maintain open patches of bare ground surrounded by higher vegetation. Elsewhere, strips and cleared patches of vegetation have been used.

On other islands, sufficient cover may be lacking, or insects or drought may reduce vegetation during the nesting season. Site-specific management practices should be employed as needed.

1.3455 Add artificial nest shelters.
At Falkner Island, CT, roseate terns readily nest in half-buried tires and in nest boxes (Spendelow 1993, 1994, 1996). Those using such shelters have higher success than those that do not. Other types of structures may work just as well. Overhead screens of some type may provide young terns with protection from gulls, night-herons and raptors in areas with sparse vegetation.



1.346 Prepare contingency plans for protection of prey species.
In some areas, the populations of roseate terns, and their productivity, may be limited by the availability of sand lance or other prey species. Although too little is known of such limitations to justify management of prey populations at this time, contingency plans should be prepared to respond to various threats, including commercial exploitation.

2. Monitor and manage staging areas and wintering areas.
After the nesting season (about mid-August) most roseate terns that nest in the northeast gather in the vicinity of certain outer islands and beaches for a few weeks before migrating. These areas should be more precisely delineated and then monitored to assure security for the species. Newly-discovered wintering areas along the Brazilian coast should be carefully delineated and appropriate conservation efforts made to provide security for the species.

2.1 Monitor staging areas in late summer.
These areas, where both post-breeding adults and fledged young gather, are important because the birds need to molt feathers and attain sufficient body fat prior to migration to wintering areas. These areas should be monitored to assure that birds are not unduly disturbed during this period.

2.11 Identify locations of staging areas and times when they are used.
Staging concentrations of roseate terns have been observed at Monomoy Island and Nauset Beach on Cape Cod and Nantucket Island in Massachusetts; Napatree Point on the Connecticut/Rhode Island border; Milford, Connecticut and Fire Island, New York. Surveys should be conducted to: (a) locate and define the areas used by staging birds during both day and night, (b) estimate approximate peak numbers of both adults and young using each site, (c) identify the chronology of use of each area and (d) identify the periods of day and tide that staging beaches are used.

2.12 Determine factors that influence use of these areas.
Studies should be conducted to correlate feeding areas and food resources with shoreline roosting areas. Shoreline configuration and use by other species of birds should be evaluated.

2.2 Appraise need for protection of beach roosting sites and manage if need is established.
Night roosting sites may need protection from human disturbance, dogs or predators. Sandbars used as loafing sites during daytime low tide periods also may need some protection. This could be particularly true for post-fledged juveniles that are still being fed by adults.

2.3 Determine the need for and feasibility of management on wintering areas.
There is some evidence that mortality in wintering areas is suppressing recovery of roseate tern populations. If this is substantiated by further investigations and causes are identified, the potential for protective management should be appraised.

2.4 Promote international cooperation in research and management in wintering areas.
Partnerships with South American countries should be established to conduct cooperative studies and provide protective measures if needed. Recently, roseate terns have been found roosting on the shore in eastern Brazil. These and other locations where roseate terns may be found resting on shore or on fishing boats should be identified for further research and protection.

3. Continue ongoing scientific investigations and initiate new studies to enhance and facilitate recovery effort.
The attainment of recovery objectives is contingent on management which, in turn, depends on sound research findings. Ongoing studies such as the population dynamics research being conducted by Patuxent Wildlife Research Center should continue. Other studies that will fill information gaps identified in the recovery process should be initiated. The use of standardized or compatible procedures that allow the combination and integration of data from several sites, and of individual studies at the same site, should be strongly encouraged.

3.1 Maintain close liaison with ongoing research efforts on terns in North America and elsewhere. Although studies of roseate terns in North America are limited by the small number of nesting colonies, research being conducted in the British Isles and elsewhere can contribute useful information to aid the recovery effort. Studies of closely related species such as the common tern and Arctic tern also may provide important information.

3.2 Improve and standardize population surveys.
Basic to any studies of the species is the need for accurate population surveys. These surveys should include both annual calculations of nesting populations to monitor trends and counts of local feeding or roosting concentrations. Since this species usually associates with common terns and sometimes with other similar species, it may be necessary to inventory all the terns present and then estimate the percentage of roseate terns among them. Workshops and guides should be developed to train observers.

3.21 Improve and standardize methods for computing breeding populations in all colonies.
Methods now in use range from one-time annual surveys of tern colonies in which any adult roseate terns seen are counted to season-long studies of marked nests that total all nesting attempts. A standardized method, in which nests at "peak period" are counted, may provide the best index for monitoring population trends and distribution. Where all nests can not be counted (or should not be because of disturbance) a carefully designed sampling procedure should be conducted.

3.22 Develop method for estimating numbers in staging area concentrations, including young-of-the-year.
This presents some particular problems because these flocks come to shoreline roosts at dusk and contain both adults and juveniles of mixed species. Suitable techniques should be developed.

3.3 Conduct studies to locate winter quarters and determine winter survival.
More precise information is needed about winter distribution and ecology. Information is needed on food and habitat factors in the wintering areas that may affect survival of wintering birds and birds that remain on the wintering grounds through their first and even second year of life.

3.31 Survey spatial and temporal distribution of winter birds.
An adequate determination of where, when, and how many roseate terns occur along the coast of South America is essential to further studies on wintering areas. It is likely that breeding populations from both the Northeast and the Caribbean winter in the same area.

3.32 Explore factors relating to food and habitat on wintering area.
Factors relating to winter distribution and winter survival need to be investigated. What species of fish are preyed on, where are they plentiful and what habitats do they utilize? What are the characteristics of winter areas favored by roseate terns?

3.33 Investigate factors relating to winter survival.
The low annual survival rate of adult roseate terns is believed to be a major reason for the slow recovery from population declines in the 1970's and in 1992. Since there is little measurable mortality at nesting colonies during the breeding season, it is suspected that most mortality occurs during migration or on the wintering grounds. Now that information is beginning to be obtained about roseate tern distribution in winter (Hays *et al.* 1997, Hays *et al.* in prep.), studies of their winter ecology and factors determining survival should be undertaken.

3.4 Conduct long-term studies of dynamics of Northeastern population.
Additional life history parameters need to be obtained and variation between colonies in terms of survival, recruitment, intercolony movement, etc., determined. These will provide the information needed for development of population models. Long-term studies are needed because this is a long-lived species in which some individuals may not reach sexual maturity until their fifth year.

3.41 Continue studies of banded birds at major colonies and calculate survival.
Various studies coordinated by the Patuxent Wildlife Research Center will make it possible to calculate age- and sex-specific adult survival and intercolony movement rates, recruitment of new breeders and reproductive success at each major colony. They will also provide information integrating the results of foraging studies with various aspects of the population dynamics and productivity of known-age and -origin individuals.

3.42 Improve and standardize methods for computing productivity.
Productivity is generally expressed either in terms of young fledged per nesting attempt or nesting pair. Several factors make these figures difficult to obtain, even in intensively studied colonies. Young birds leave nests long before fledging and are difficult to locate. Late nestings, renestings and possibly some non-breeding adults complicate the calculation of nesting pairs.

3.43 Initiate population studies, including banding as needed, on small colonies or new colonies.[2]
Colonies in which only small numbers of roseate terns nest may have productivity and other features of population dynamics that differ considerably from those of the large colonies. It is important to know how small colonies (particularly any new colonies) perform, since establishment of new, productive colonies is essential to recovery. Are new colonies comprised mostly of young birds? Will old birds prospect for new sites? Does productivity change as a colony matures?

3.44 Evaluate possible impacts of banding studies on reproductive success.
Intensive studies of colonial birds that involve trapping of nesting adults and catching and banding chicks pose the possibility of substantial nest desertion and chick mortality. Researchers now studying roseate terns take many precautions to minimize negative impacts and general observations indicate that the terns become habituated to regular visits. However, because the roseate tern is endangered, additional studies of possible impacts should be conducted.

3.45 Evaluate possible effects of banding/colorbanding on survival.
Metal bands and colorbands put on the legs of roseate terns may slide or be pulled down the foot, resulting in the injury or loss of the limb. The cause(s) of this are unknown, but it has been suggested that the bands may be snagging on various objects or that banded and/or colorbanded birds may be more susceptible to being attacked or caught by predatory fish and/or humans. Studies are needed to determine what effect banding, colorbanding or tagging birds with various combinations of metal bands, colorbands or other marking devices may be having on survival.

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[2] Capture, handling and banding of roseate terns requires approval from Region 5, U.S. Fish and Wildlife Service, as well as the Bird Banding Laboratory of the Patuxent Wildlife Research Center. Auxiliary marking, for example, the use of color bands, requires additional authorization from Patuxent.

3.46 Investigate factors affecting fledgling survival and recruitment

Relatively little is known about the various factors that may affect young roseate terns from the time they leave their natal colony (soon after fledging) until they may eventually join the breeding population as new recruits between three to five years later. Some of the potential factors affecting fledgling survival and recruitment to the breeding population include the length of dependency on parent(s) for food, the age that young birds first prospect for nest sites at nesting colonies, the age of first breeding and sex-specific survival rates for years one to three.

3.47 Investigate factors causing the unequal adult sex ratios and determine sex-specific survival rates of adults

The unequal sex ratio in the adult breeding population effects reproductive success in several ways. It results in the formation of female-female (FF) pairs, trios (both maleFF and FFF) and other multi-female groups. These atypical nesting associations often produce supernormal clutches of three or four eggs, but they also may be responsible for the laying and subsequent abandonment of single eggs, where one female lays an egg in one site and the other lays at a second site. The hatching success of eggs produced by multi-female associations usually is lower than that of eggs produced by typical male-female pairs. Factors causing the imbalanced sex ratio need to be elucidated.

3.5 Characterize habitat selection at nest sites.

For colonial waterbirds, habitat selection during the breeding season is important because the birds are confined to the selected site during the long incubation period and much of the chick-rearing period. In dense colonies of mixed species, differences in habitat selection may lead to partitioning among species.

3.51 Compare habitat selection among colonies and between common and roseate terns.

Although roseate terns nest in a wide variety of habitats, studies of nest site selection in some tern colonies indicate that they prefer more densely vegetated sites than common terns. Similar studies should be conducted at all colonies where roseate terns nest. Site selection should be correlated with nesting success. The possible impact of rapid vegetation growth on late-nesting terns should be examined.

3.52 Investigate manipulation of vegetation to enhance roseate tern production.

Studies of habitat selection for nest sites should show what types of nest cover are associated with maximum production. If some types of vegetation result in low productivity or are completely avoided by nesting terns, manipulation practices such as mowing, herbicides or creating openings should be explored.

3.6 Conduct studies of feeding ecology and how it relates to colony productivity.

Available information shows that nesting roseate terns feed almost entirely on small fish, primarily young of the American sand lance (sand eel). They may fly several miles from the colony to obtain the fish. If currently high populations of sand lance decline drastically or if schools of small fish are scarce or too distant from the tern colony in a given year, productivity may suffer. In extreme cases, the terns may desert eggs or young. Continued studies of the relationship between productivity and prey availability are needed and should extend to other colonies. If prey availability proves to be a significant factor limiting roseate terns, coordinated studies of prey abundance and availability should be initiated.

3.61 Identify and characterize preferred feeding areas.
After young terns hatch, the favored feeding areas of the adults may be located by following flight lines. Roseate terns often feed in areas apart from those used by common terns even though both species feed extensively on sand lance. The characteristics of areas that support schools of young sand lance or other prey fish should be described for each major colony of roseate terns. Are some local areas used for several successive years?

3.62 Study foraging behavior of breeding and staging aggregations.
More needs to be known about the foraging behavior of nesting roseate terns. Why do they tend to feed in areas different from common terns? What conditions favor successful feeding (in terms of minimum plunges needed)? Does successful feeding activity attract other birds to an area or are other cues involved. How soon are fledged young able to obtain their own food? Are young still fed by adults on staging areas?

3.63 Study availability, population trends and factors affecting important prey fish.
Because the sand lance is so essential for roseate terns in their major nesting range, more information is needed about population trends and the factors that influence them, as well as factors relating to availability of prey. What are the major prey species for roseate terns that nest beyond the range where sand lance are plentiful and for roseate terns on migration and wintering areas?

3.64 Determine relationships between food availability and breeding success on an individual and colony-site basis.
Feeding behavior and foraging locations of roseate terns appear to differ markedly among colony sites in the Northeast. At some sites, breeding birds regularly visit preferred feeding locations up to 25 km distant; at others many if not most adults feed within 5 km of the colony. The distribution of suitable feeding locations and availability and predictability of prey fish at these locations may influence breeding success, and hence may determine the long-term suitability of a breeding site. Although food availability is difficult to measure, more studies of foraging locations, feeding behavior and prey distribution are needed. This will require tracking birds to feeding locations over several years and relating their foraging success at different locations to the growth and survival of their chicks, both on an individual and on a colony-site basis.

3.7 Evaluate possible adverse impacts of contaminants and diseases.
The major breeding areas for roseate terns in the Northeast are in or near estuaries with high potential for disastrous pollution impacts. Because such large percentages of the birds nest in aggregations at only two or three locations, the impact of an oil spill or disease outbreak could be particularly devastating.

3.71 Assess potential impacts of oil spills.
The shipping lanes leading to Boston, New York and other major cities in southern New England are important corridors for oil imports. Accidents are always possible, though less likely in summer. Offshore areas on the continental shelf have been explored for oil and gas and, although no developable finds have been located to date, future discoveries could increase the potential impacts. Oil storage facilities along urban rivers leading to estuaries are perhaps the greatest potential threats. The impact of spilled oil on prey fish as well as on the roseate terns should be assessed.

3.72 Evaluate potential food web accumulation of toxic contaminants, including heavy metals and pesticides.
The industrialized cities of the Northeast are potential sources for a wide variety of toxic chemicals that could enter the estuaries. Some heavy metals and pesticides can be accumulated through food chains and could reach significant levels in estuarine fish that provide major food for certain birds such as the roseate tern (Hays and Risebrough 1972). The sediments of New Bedford Harbor, not far from the feeding areas used by Bird and Ram Island, MA terns, are heavily contaminated by PCB's. Agricultural chemicals such as DDT that are banned in the United States may still be used in some South American countries where the terns winter. These contaminants could be picked up by adults and adversely affect reproductive success. Residues in unhatched eggs or dead birds should be monitored. Specimen material should be archived pending availability of funding for analyses.

3.73 Evaluate potential impact of paralytic shellfish poisoning (red tide) and other toxic algae.
Outbreaks of shellfish poisoning caused by blooms of the marine dinoflagellate (*Gonyaulax excavata*) have become almost annual occurrences along the New England coast in recent years. Extensive shorelines have been closed to shellfish harvest for up to several weeks, usually in the May-June period. The toxins produced by the red tide organisms are considered harmful only to warm-blooded vertebrates that feed on filter-feeding mollusks which have concentrated toxins in their tissues. At Monomoy, some terns died after consuming sand lance that had accumulated toxin, possibly by feeding on cape pods or mysids, during a bloom of this algae. Other kinds of algae blooms may result in mass mortalities of shellfish and finfish, and could deplete food resources used by the terns.

3.74 Assess potential and actual disease problems.
Disease has not been identified as a significant problem in this species in North America, but terns of other species have succumbed to avian cholera and botulism. Cholera has become an increasingly serious threat to seabirds in recent years, perhaps resulting from contamination in the poultry industry. Rains that collect nutrient-rich guano in shallow pools create ideal conditions for outbreaks of the bacteria. Such outbreaks have occurred frequently on Maine islands in recent years. At least one such outbreak involved a tern colony, resulting in many dead birds and desertion by others. An arbovirus was collected from dead roseate terns at a nesting colony in the Indian Ocean and was believed to have been transmitted by ticks (Bourne *et al.* 1977).

3.8 Conduct ecological studies of important competitors and predators.
Competition for space on preferred nesting islands and predation on eggs and young may be the productivity factors most subject to management. Prior to management, more information is needed about most of these species and their relationship to the terns. Diagnostic cues for identification of nocturnal predators are needed.

3.81 Study aspects of successful competing species that may adversely impact roseate terns.
The common terns, among which the roseate terns nest, seem to be increasing in most parts of their coastal breeding range. Is this at the expense of roseate terns? Laughing gulls are not currently competitors with roseate terns in the major colonies, but do have the potential. The historically important tern colony on Muskeget Island, MA (west of Nantucket) was displaced by a large colony of laughing gulls about 1940.

3.82 Investigate the ecology of important predators that may have indirect or direct impact.
There is some evidence that avian predation in tern colonies involves only small numbers of birds that have developed specialized feeding habits. More information is needed. Are only a few individuals from large colonies of gulls or night-herons involved in taking eggs and young? Can they be effectively deterred or removed? What is the total impact of a diurnal raptor such as a peregrine during nesting season and what measures should be taken to alleviate the problems? The overall impact of nocturnal desertion caused by owl predation needs more study.

3.9 Refine and test methodology for attracting terns to nest at new sites.
The use of carved decoys and tape recordings of tern calls seems to have been effective in restoring nesting colonies of other species of terns at some locations. The potential of the technique for roseate terns should be explored.

4. Develop and distribute educational material.
The development and distribution of effective informational and educational materials enhance public support for the achievement of primary and secondary recovery goals. Both research and management will be facilitated through continuing extension efforts. Although these materials should be focused on the roseate tern, they should note the close association and similar problems faced by other terns.

4.1 Obtain drawings and photographs for use in various releases.
Pen and ink drawings, color slides and prints should be obtained to augment the effectiveness of printed materials released to the public. Publicity efforts should capitalize on the beauty and gracefulness of the species in heightening public awareness and support.

4.2 Print and distribute informational brochures and posters.
Informational literature should be distributed to the general public, and especially targeted toward special interest groups such as boaters, fishermen and other beach users just prior to and during the nesting season. These materials will heighten public awareness and facilitate public cooperation in reducing disturbances at nesting colonies. Standardized signs designating the presence of an endangered species should be prepared and distributed for posting colony sites. This material should complement, and not duplicate, pamphlets and interpretive signs currently in use.

4.3 Provide press releases to inform the public.
Press releases provided to local news media should be made available immediately prior to implementation of scheduled management activities such as public access restrictions at nesting sites.

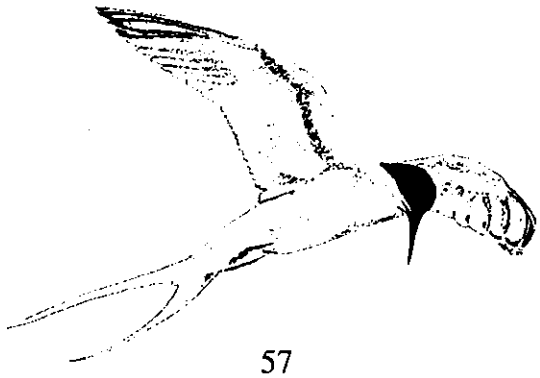
4.4 Develop or coordinate production of slide shows, movies and information for dissemination on the World Wide Web.
Slide shows and short movies should be produced and made available for use in public presentations and for dissemination on the World Wide Web. Especially important is the production of audio-visual materials targeted toward summer recreationists in the vicinity of the large roseate tern nesting colonies.

4.5 Coordinate with Canadian Wildlife Service and appropriate Maritime Provinces in an information exchange.
Technical information and ideas involving survey, management and research on roseate terns should be shared on a periodic basis with Canadian wildlife personnel.

4.6 Encourage international conservation organizations to promote education in Latin American wintering areas.
Educational and information materials should be made available to the appropriate international conservation organizations in an effort to promote conservation ethics in the winter quarters.

4.7 Provide information and assistance to Federal and State agencies, municipalities and private organizations and individuals that own or manage roseate tern nesting habitat.
Management guidelines should be made available to land owners and managers to provide for the maintenance and/or development of suitable roseate tern nesting habitat. A mailing list of such interested parties should be compiled.

4.8 Produce and distribute progress reports and other informational summaries.
Annual status reports and other informational summaries must be provided to all interested parties on a timely basis to stimulate and maintain the public's interest. Popular magazine articles should also be prepared.



PART III
IMPLEMENTATION SCHEDULE

The Implementation Schedule lists and prioritizes tasks that should be undertaken within the next three years in order to achieve recovery of the population of roseate terns that nests in the Northeast. This process will be reviewed annually until the recovery objective is met and priorities and tasks will be subject to revision. The schedule is outlined according to the order in which tasks are presented in the Step-Down Outline and Narrative. Some tasks are listed only at the general level; others as more discrete tasks.

Priority (Column 1):

1. Those actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
2. Those actions that must be taken to prevent a significant decline in species population or some other significant negative impact short of extinction.
3. All other actions necessary to provide for full recovery of the species.

Agency Roles (Column 5)

Abbreviations:

ES	-	Ecological Services
FWS	-	U.S. Fish and Wildlife Service, Region 5
SWA	-	State Wildlife Agencies
PO	-	Private Organizations (Audubon, etc.)
TC	-	Local town or county agencies
COE	-	Army Corps of Engineers
RW	-	Refuges and Wildlife
LE	-	Law Enforcement
USGS	-	U.S. Geological Survey
EPA	-	Environmental Protection Agency
USDA	-	U.S. Dept. of Agriculture

Priority	Task Description	Task Number	Task Duration	Responsible Organization USFWS	Responsible Organization Other	Cost Estimates ($000) FY1	FY2	FY3	Comments
2	Determine location of tern colonies with nesting roseates.	1	annual	ES	SWA, USGS,PO	2K	2K		Most colonies known. Some shifting occurs.
2	Determine numbers of pairs of roseates and other terns at each site.	2	ongoing	ES, RW	SWA, USGS,PO, AMNH	15K		15K	
2	Assess productivity at major colonies.	3	annual	ES	SWA,PO, AMNH	25K		25K	
2	Develop criteria for evaluating colony sites.	1.21	3-4 years	ES	SWA, USGS, PO	5K			
2	Evaluate existing colonies for potential to increase populations.	1.22	ongoing	ES	SWA, PO	2K	2K	2K	
3	Identify former colony sites and evaluate present habitat at those sites.	1.23	one time	ES	SWA, PO	5K			
3	Identity potential sites with no history of roseate nesting and evaluate habitat and competing species.	1.24	ongoing	ES	SWA, PO	5K	2K	2K	as needed
2	Determine proximity of suitable feeding habitat to existing and potential nesting habitat.	1.25	ongoing	ES	SWA, PO			5K	
3	Rank sites with greatest potential to support expanding populations.	1.26	annual	ES	SWA, USGS, PO	2K	2K	2K	
2	Determine ownership of all existing and potential nesting sites.	1.31	ongoing	ES	SWA	1K			Most are known

2	Contact landowners and	1.32	ongoing	ES	SWA				

2	Contact landowners and provide protection recommendations.	1.32	ongoing	ES	SWA	1K	1K		1K
2	Protect currently unprotected sites through acquisition or easements.	1.33	ongoing	ES, Realty	SWA, LMAO				Land costs unpredictable
2	Develop and implement management strategies, incorporating existing management activities.	1.34	ongoing	ES,RW,LE	SWA	10K		10K	
1	Reduce nest site competition with herring and great black-backed gulls including reducing nesting gull populations when necessary.	1.3431	annual	ES, RW	SWA, USDA	170K	150K	105K	Assumes some successes and reduction of level of effort in years 2 and 3
1	Discourage or control predators.	1.344	annual	ES,RW	SWA,USDA	5K	5K	5K	Can vary greatly year to year
1	Physically maintain, enhance and expand nesting habitat.	1.3451	6 years	ES	SWA,TC, COE	50K	250K	750K	Costs speculative; encompasses erosion control, restoration of badly eroded habitat and habitat nourish-ment activities
3	Identify staging areas used and times when they are used.	2.11	one time	ES	SWA, PO		4K		Study family groups and length of parental care
3	Determine factors that influence use of staging areas.	2.12	one time	ES	SWA, PO			4K	

3	Appraise need for protection of beach roosting sites and manage if need is established.	2.2	3 years	ES, LE	SWA, PO	2K	1K	1K	
1	Conduct studies to locate winter quarters and determine winter survival.	3.3	annual	ES	SWA	50K	100K	150K	
2	Determine need for and feasibility of management on wintering areas.	2.3	ongoing	ES	SWA, PO				Depends on outcome of 3.3
2	Promote international cooperation in research and management in wintering areas.	2.4	ongoing	ES	SWA	3K		3K	Depends on outcome of 3.3
2	Improve and standardize methods for computing breeding populations in all colonies.	3.21	complete	ES	SWA, USGS, PO				Update again in 2001
2	Evaluate possible impacts of banding studies on reproductive success.	3.44	1-2 years	ES	SWA, PO	10K			Underway, completion by 98
3	Evaluate possible effects of banding/colorbandings on overwinter survival.	3.45	3-4 years	ES	SWA, PO	5K	5K	5K	Done in conjunction with current efforts
2	Investigate factors affecting fledgling survival and recruitment.	3.46	5 years	ES	SWA, PO	15K	15K	15K	
2	Investigate factors causing unequal adult sex ratios and determine sex specific survival rates of adults.	3.47	annual	ES	SWA, PO	15K	15K	15K	

3	Identify and characterize preferred feeding areas.	3.61	3 years	ES	SWA, PO	15K	15K	15K	
3	Determine relationships between food availability and breeding success on an individual, age class, and colony-site basis.	3.64	3 years	ES	SWA, PO	5K	5K	5K	
3	Evaluate possible adverse impacts of contaminants and diseases.	3.7	annual	ES	ES, EPA, PO	25K	25K	25K	Chemical analyses costs
2	Refine and test methodology for attracting terns to nest at new sites.	3.9	3 years	ES	SWA, PO	5K	5K	5K	Final recommendations within 3 years
3	Develop and distribute educational material.	4	ongoing	ES	SWA, EA	5K	5K	5K	

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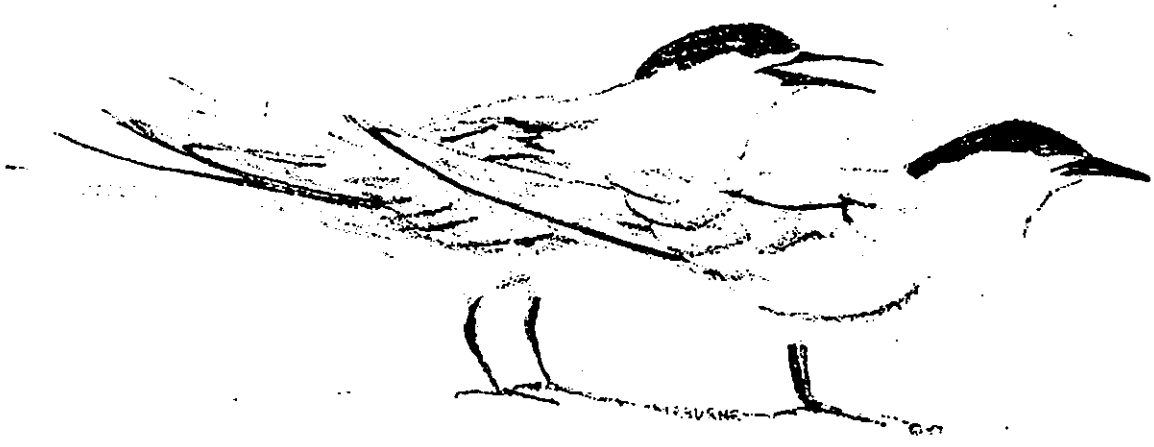

Appendix A

Recommended Protocol for Estimating Breeding Population Size of Roseate Terns at Northeastern U.S. Breeding Colonies

Roseate Tern (Northeastern Population) Recovery Team
Technical Advisory Committee
April 1995

Researchers lacking experience with roseate terns should familiarize themselves with fieldwork methods reported in the literature (e.g., Spendelow 1982, Colonial Waterbirds 5:19-31; Nisbet *et al.* 1990, Colonial Waterbirds 13:85-91) and consult with Chairman Jeff Spendelow or another member of the Technical Advisory Committee (TAC, see list below) before attempting fieldwork on this endangered species. If you are planning to work on a new/small colony containing < 100 pairs of terns of all species combined, caution is advised to keep disturbance to a minimum.

If possible, three nest-count censuses should be made at all colony sites with 25 or more pairs of breeding roseate terns. (If daily or weekly visits can be made, or productivity will be studied, please contact Jeff Spendelow about procedures for filling out nest history cards.) At sites with <25 breeding pairs, it may be possible to first locate nests (or locate adults, if nests are not easily visible) by viewing the colony from the edge with binoculars or a spotting scope. Because terns in new or small colonies may begin nesting later than those in large or medium-sized colonies, visits to smaller colonies may need to be made 7-10 days later than visits to the larger colonies. A third visit may not be necessary at some sites unless there is evidence from the second visit to indicate that more birds may be laying after mid-July.

1) The first census should be made when the first roseate tern chicks hatch (about 15 June), and, if possible, all nests found should be marked. This nest count will give us an estimate of the number of birds that attempted to nest during the "peak period" of nesting.

2) The second census should be made about 23-25 days later (8-10 July) so that all fertile eggs from the marked "peak period" nests should have hatched. All new nests should be counted and marked, the number of nests from the first census that were abandoned or with eggs that failed to hatch should be counted, and, if so advised, an effort should be made to band all chicks.

3) The third census, if done, should be made about 23-25 days later (1-5 August) using the same procedures described above for the second census.

Data from these censuses should be reported to the Chairman of the TAC for assimilation into the metapopulation study. For more information on recommended procedures or the timing of censuses to be made along your area of the coast each year, please call any of the following TAC members:

Maine	Steve Kress
Massachusetts	Ian C.T. Nisbet
Connecticut	Jeff Spendelow
NY (E'n Long Is.)	Helen Hays
NY (W'n Long Is.)	Joanna Burger

Appendix B. Estimated "total season" nesting pairs of roseate terns in the northeastern U.S., 1988-1997.

Colony site/Area	(Lat/Long)	YEAR[1]									
Northern U.S. Gulf of Maine		**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Petit Manan Island, ME	44°22'N, 67°52'W	42	48	50	52	61	65	60	61	24	29
Conary Nub, ME	44°24'N, 68°30'W	-	-	-	0	0	1	1	0	0	0
Seal Island, ME	43°53'N, 68°44'W	-	0	0	4	0	0	0	2	0	1
Matinicus Rock, ME	43°47'N, 68°51'W	-	0	0	5	1	3	0	0	0	0
Large Green Island, ME	43°54'N, 69°01'W	6	0	0	0	-	-	-	0	0	-
The Brothers, ME	43°55'N, 69°14'W	-	-	-	-	-	-	-	1	1	1
Killick Stone, ME	43°56'N, 69°25'W	1	0	1	2	0	0	0	-	-	-
Eastern Egg Rock, ME	43°52'N, 69°23'W	5	17	38	50	51	59	63	88	126	138
Jenny Island, ME	43°46'N, 69°54'W	0	0	0	0	0	6	15	0	0	12
Stratton Island, ME	43°31'N, 70°19'W	8	2	18	14	8	7	3	1	20	66
Beach Island, ME	43°26'N, 70°20'W	0	1	0	0	-	0	0	0	-	-
Western Goose Rocks, ME	43°23'N, 70°25'W	6	12	0	0	0	0	0	1	0	-
Subtotal	Pairs	68	80	107	127	121	141	142	154	171	247
	Colonies	6	5	4	6	4	6	5	6	4	6
Cape Cod, Nantucket, and Martha's Vineyard, Massachusetts											
Plymouth Beach, MA	41°58'N, 70°39'W	6	11	1	15	20	25	22	30	18	10
Sandy Neck, MA	41°44'N, 70°17'W	-	-	-	-	-	-	1	-	-	0
Gray's Beach, Yarmouth, MA	41°43'N, 70°15'W	1	1	8	13	0	0	0	-	0	1
Nauset-Eastham, MA	41°49'N, 69°56'W	0	0	0	0	0	4	3	1	0	0
Nauset-New Island, MA	41°49'N, 69°56'W	60	60	25	20	10	5	2	2	7	11
Nauset-Chatham, MA	41°39'N, 69°57'W	0	0	0	0	4	2	0	-	1	0
North Monomoy Island, MA	41°38'N, 69°58'W	1	0	1	0	0	0	0	0	0	0
South Monomoy Island, MA	41°37'N, 69°59'W	0	0	0	0	0	0	0	0	6	1
Dead Neck-Sampsons Is., MA	41°37'N, 70°25'W	13	27	0	0	0	0	0	-	0	0
Haystack Point, MV, MA	41°24'N, 70°32'W	-	4	0	0	0	0	0	-	0	0
Menemsha Pond, MV, MA	41°20'N, 70°46'W	-	0	0	2	0	0	0	-	0	0
Subtotal	Pairs	81	103	35	50	34	36	28	33	32	23
	Colonies	5	5	4	4	3	4	4	3	4	4

Colony site/Area	(Lat/Long)	YEAR[1]									
Buzzards Bay, Massachusetts		**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Bird Island, MA	41°40'N, 70°43'W	1670	1540	1700	1780	1550	1500	1440	1420	1070	1329
Ram Island, MA	41°37'N, 70°48'W	0	0	0	0	0	2	124	235	750	275
Nashawena Island, MA	41°26'N, 70°52'W	3	0	3	0	4	0	0	0	0	0
Penikese Island, MA	41°27'N, 70°56'W	-	-	-	-	-	-	-	-	-	1
Subtotal	Pairs	1673	1540	1703	1780	1554	1502	1564	1655	1820	1605
	Colonies	2	1	2	1	2	2	2	2	2	3
Central Connecticut Coast											
Duck Island, CT	41°15'N, 72°28'W	2	5	-	-	-	-	-	0	-	-
Tuxis Island, CT	41°16'N, 72°36'W	-	4	-	-	-	-	1	0	-	-
Falkner Island, CT	41°13'N, 72°39'W	190	165	170	180	130	160	140	130	150	150
Subtotal	Pairs	192	174	170	180	130	160	141	130	150	150
	Colonies	2	3	1	1	1	1	2	1	1	1
Eastern Connecticut and New York[2]: Eastern Long Island Sound and Gardiners Bay											
Shore Rock, Ocean Point, CT	41°18'N, 72°06'W	0	1	0	0	0	0	0	0	0	-
Great Gull Island, NY[3]	41°12'N, 72°07'W	1200	1152	1181	1405	1093	1450	1469	1356	1350	1846
Gardiner's Point Island, NY	41°08'N, 72°09'W	-	-	-	-	-	-	2	160	4	27
Gardiners Island, NY	41°06'N, 72°07'W	-	0	-	-	0	-	0	0	0	0
Cartwright Point Island, NY	41°01'N, 72°06'W	-	0	-	-	0	4	14	5	1	6
Hicks Island, NY	41°01'N, 72°04'W	0	0	2	4	4	0	0	0	0	0
Subtotal	Pairs	1200	1153	1183	1409	1097	1454	1485	1521	1355	1879
	Colonies	1	2	2	2	2	2	3	3	3	3

Appendix B. (Concluded.)

Colony site/Area	(Lat/Long)	YEAR[1]									
		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Southern Long Island from Shinnecock Bay to Rockaway Inlet[2]											
Warner Islands, NY	40°51'N, 72°30'W	0	6	20	40	39	30	90	42	30	45
Lanes Island, NY	40°50'N, 72°31'W	0	0	0	6	16	12	-	59	36	16
Greater Greenbacks Island, NY	40°50'N, 72°32'W	0	0	0	0	0	0	0	0	0	2
East Inlet Is., Moriches, NY	40°47'N, 72°45'W	12	40	20	6	1	12	0	0	0	0
Cedar Beach, NY	40°38'N, 73°20'W	93	66	94	120	80	51	75	37	0	0
Goose Flat, NY	40°38'N, 73°23'W	-	-	-	-	-	-	0	0	0	9
West End Jones Beach, NY	40°35'N, 73°33'W	13	2	0	0	0	0	0	0	0	0
Breezy Point, Rockaway, NY	40°33'N, 73°57'W	0	0	0	0	0	2	2	2	2	4
Subtotal	Pairs	118	114	134	172	136	107	167	140	68	76
	Colonies	3	4	3	4	4	5	3	4	3	5
Total	Pairs	3332	3164	3332	3718	3072	3400	3527	3633	3596	3980
	Colonies	19	20	16	18	16	20	19	19	17	22
Concentration in largest colonies											
	% in 2 colonies	86	85	86	86	86	87	82	76	67	80
	% in 5 colonies	96	94	96	95	95	95	93	91	96	94

[1]"-" means no data were available at that site for that year.

[2]Data from New York was collected in a variety of ways and treated differently from the methods used in the annual reports by the New York State Department of Environmental Conservation. Data collected for the Metapopulation Project based on nest counts were used whenever possible. If the only data available at sites where roseate terns were known (or strongly suspected) to have actually laid eggs were counts of adults, the number seen on the survey date closest to the end of the peak period of laying was divided by two to obtain a conservative estimate of the number of nesting pairs.

[3]Although nests have been marked and counted at GGNY in all years since 1988, total numbers are uncertain because many nests at this site are concealed under boulders and cannot be located. Numbers in the table are estimates based on the observers' belief that about 20% of the nests were not found in most years. Because this adjustment factor is subjective, these estimates are uncertain by at least ±10%.

Appendix C. Estimated "total season" nesting pairs of roseate terns in the northeastern U.S. by state, 1988-1997.

State	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
ME	68	80	107	127	121	141	142	154	171	247
MA	1754	1643	1738	1830	1588	1538	1592	1688	1852	1628
CT	192	175	170	180	130	160	141	130	150	150
NY	1318	1266	1317	1581	1233	1561	1652	1661	1423	1955
Totals	3332	3164	3332	3718	3072	3400	3527	3633	3596	3980