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Least Tern Populations in Coastal New Jersey: Monitoring and Management of a Regionally-Endangered Species

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ABSTRACT

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Least tern *Sterna antillarum* is endangered in New Jersey and New York and is being considered for the U. S. Federal List as threatened along the Atlantic Coast. Like many coastal, ground-nesting species, it has suffered habitat losses, increased predation, and increased human disturbance with increased human population. This paper presents an overview of ten years of monitoring and managing of least terns in New Jersey under the auspices of the Endangered and Non-Game Species Program of New Jersey. The program involves monitoring population levels and reproductive success, protecting colonies from people and predators, manipulating vegetation and habitat, and actively attracting least terns with decoys. In successive years a trend has indicated increased population levels, and reproductive success, and decreased and then increased number of colonies. During this time, monitoring and managing efforts have increased, suggesting that they are effective in very slowly restoring population levels.

ADDITIONAL INDEX WORDS: *Coastal, Atlantic birds, Sterna.*

INTRODUCTION

Coastal regions have undergone extensive development in the last fifty years, with resulting decreases in available acreage of salt marshes, mudflats and deserted sandy beaches. Coasts have been developed for homes, restaurants, marinas and recreational uses. Several substantial changes have occurred: (1) decreases in habitat devoid of people; (2) increases in stabilization of dunes, sandbars and beaches; (3) increases in natural predators because of increased food resources; (4) increases in man-influenced predators such as cats, dogs, and rats; and (5) increases in populations of some animals directly influenced by man (introduction of peregrine falcons *Falco peregrinus*, introduction of non-contaminated osprey *Pandio halietus* eggs). Osprey populations had decreased because of low reproduction due to contaminated eggs. Uncontaminated eggs from elsewhere were introduced to nests, increasing reproduction.

Species traditionally inhabiting coastal regions have been exposed to intense habitat pressure, increased human disturbance and increased predation and competition pressures. This has resulted in population changes in some native species; those that can accommodate human pressure will increase, and those that cannot decrease. Coastal and marine birds are particularly vulnerable because they frequently nest in large colonies on the ground without adequate antipredator behavior (see BURGER, 1984a, SOUTHERN *et al.*, 1985). In recent years, biologists, government officials, conservationists, and naturalists have alerted the public to decreases in animal populations, and extinctions or near-extinctions of native species. Such groups have combined to halt the processes, and where possible reverse the trends of decreasing population levels, with the long-term goal of recovery for these species (HADDON and KNIGHT, 1983). Many state conservation agencies have begun massive programs to monitor, protect and enhance populations of threatened or endangered species, working toward habitat protection for assemblages of species. Few of these efforts have been documented, and each new conservation group often retraces the steps of other, unknown groups. In this paper I discuss the methods used

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to protect and manage least terns (*Sterna antillarum*) in New Jersey from 1976-1985.

Along the east coast of North America, least terns breed on sandy beaches, often facing the ocean front (WOLK, 1974; BUCKLEY, 1979; THOMPSON and SLACK, 1982. In recent decades human activities have led to massive habitat loss for the terns and rapid declines in their numbers (GALLI, 1978a, 1978b). The United States Federal Endangered Species List includes the Western and interior races of the least tern (DOWNING, 1973; 1980; MASSEY, 1974), and the eastern race is being considered for addition. In other parts of the world the closely-related little tern (*Sterna albifrons*) is also declining in numbers (KING, 1981; HADDON and KNIGHT, 1983).

MONITORING, PROTECTING AND MANAGING LEAST TERNS

A recovery program for any species should contain three major parts: monitoring, protecting, and actively managing the species. Monitoring activities include censusing adult populations, assessing causes of colony and reproductive failures, and assessing reproductive success. These procedures can be non-invasive or can involve carefully controlled studies of marked nests or banded chicks. Protecting colonies involves actively protecting colonies from competitors, predators, and human disturbance. Management of colonies involves creation or improvement of habitat, controlling predators, and actively attempting to move or establish colonies in desired locations.

General guidelines for management of colonial birds exist (*cf* BUCKLEY and BUCKLEY, 1976) but specific procedures for species are seldom given. Individual techniques often have been discussed (see KRESS, 1977; 1983; MERTON, 1977; KOTLIAR and BERGER, 1984; JACKSON and JACKSON 1985), and additional information is available in unpublished and government reports (GALLI, 1978a; 1978b; JERNIGAN *et al.*, 1978; SOOTS and LANDEN, 1978). However there is a need for comprehensive summaries of methods and outcomes of monitoring, protecting and managing of particular species. In general, results of long-term monitoring and management are not available because in many instances such programs are too new for evaluation. In the following sections I will discuss general methodology, describe specific methods employed in New Jersey, and assess relative success of the practices.

MONITORING

Population Assessment

The initial phase of any recovery program involves determining population levels and locating colonies (or individuals). Initially all coastal areas should be searched to locate tern nesting sites.

One critical factor is the timing of census activities (ERWIN, 1980a; ERWIN *et al.*, 1981). If censuses are conducted only for least terns then they should be timed to coincide with late incubation (late June in New Jersey) when early-established colonies have young chicks, and late-established colonies are at the egg-laying or incubation stage. Unfavorable nesting conditions such as predators, excessive human disturbance or flood tides may result in shifts in colony sites even within the same year, or the terns may abandon breeding for that year. It is therefore critical to census yearly to accurately monitor colony use and quickly assess sharp decreases in population levels. Within a year, the more often censuses are conducted the more accurate will be the overall population estimates. We found that three censuses (early incubation, around hatching and at fledging: early June, late June, and mid-July) result in accurate and reliable population estimates. To avoid counting birds twice it is critical to try to determine if any entire colonies have shifted locations.

Usual methods of censusing use fixed-wing aircraft, helicopters or ground counts. Fixed-wing aircraft and helicopters have the advantage of rapid censusing of large coastal areas and easy access to all coastal regions. Thus the entire New Jersey coast can be censused by helicopter in two to three days. Helicopters have the further advantage of allowing slower airspeed (easier counting), with landing capabilities. Both aircraft types have the disadvantage of high cost and difficulties in estimating the number of nesting birds (unless the helicopter lands). Further, it is difficult or impossible to assess clutch size, hatching success, or fledging rate from aircraft. Aerial censuses can thus pro-

vide accurate counts of the number of terns present, but a conversion is required to determine the number of pairs. Some birds are away foraging, and others may be resting elsewhere. Another disadvantage is that a group of terns may not be nesting at all, but may merely be using the site for resting. Ground surveys are required to determine that terns are nesting at any new location.

Ground censuses are more accurate because they permit counts of numbers of adults and nests, and records of nest contents. However, they are labor-intensive, not all colonies can be easily reached by foot or in a boat, and without a large number of trained census-takers it is difficult to accurately conduct the census on the same days. Thus we often try to conduct all surveys over a 3–4 day period.

One difficulty with censusing is the mobility of the nesting population. When colonies are flooded or deserted for other reasons they often move elsewhere. Without marked birds it is difficult to be sure of the identity of the members of a new colony. Further, within colonies, pairs that have lost eggs often renest.

In New Jersey we combine census methods, using helicopters to census all species of colonial birds in a three-day period in mid-June, and ground censuses for monitoring population levels and reproductive success of critical species such as least terns, black skimmer (*Rynchops niger*) and piping plover (*Charadrius melodus*) (GALLI and KANE, 1979). Personnel involved in census activities attend at least one training session, are field-tested, use the same census forms, conduct the census with the same methodology at the same time of year, and report unusual problems whenever they occur. Most personnel have been censusing least terns for many years, and are dedicated to their protection. Interest and commitment are the two most important aspects of successful volunteer personnel. Where these qualities are not readily available, paid personnel are essential. I have found it wise to have every colony checked at least once by myself as coordinator, or by paid personnel to allow comparisons of population estimates and to insure equivalent coverage of every colony. If estimates differ, further counts are made, and in some cases personnel are eliminated from census-taking.

In New Jersey we monitored the number of breeding pairs and number of active colony sites for ten years (Figure 1 top). The number of breeding pairs was low in the early years (except for 1976) and increased slightly thereafter. The high count in 1976 reflected a count from a helicopter census and may be unusually high because non-breeding birds were counted. The overall trend is for increasing population size although the numbers fluctuated greatly from year to year.

The number of colony sites decreased steadily until 1982 when a program to increase colony diversity was initiated (see Figure 1 middle). Thereafter the number of colony sites increased slowly. Maintaining colony diversity is essential so that populations are not concentrated in a few, vulnerable locations.

Reproductive Success

Many conservation and state census efforts have not attempted to determine reproductive success. This is short-sighted because only with accurate productivity estimates is it possible to assess the factors involved in colony failures (predation, human disturbance, floods), and predict future population levels. In long-lived species such as terns, it takes years before the effects of low reproductive success are demonstrated since the breeding population can remain stable or decrease slightly, with little recruitment of young birds into the population.

Reproductive success can be monitored at a few important colonies, or at the majority of colonies. Success can be assessed by individual nest checks, or by dividing the number of fledged young by the number of nests in a colony (see THOMPSON and SLACK, 1984). The latter method is easier because the colony does not have to be entered as regularly, thus the birds are less disturbed. This method requires as many visits to the colony, but assessments are made from the edge of the colony with binoculars. Another method we employ at some colonies is to individually mark a sample of nests with wooden tongue depressors (2 m from the nest to eliminate predator tracking) and to follow the fate of nest contents. Nests can be monitored two or three times a week to assess hatching rates and predator problems. Assuming the same methods are used each year, either procedure can be used to assess changes in reproductive success.

In the New Jersey colonies reproductive suc-

cess was low in the 1970's (as measured by a sample of colonies), and increased slightly thereafter (Figure 1). It is always possible to have a year with low productivity (such as 1983) when excessive flood tides washed out some nests at most colonies. Overall, however, reproductive success has slowly increased in a step-wise fashion.

The overall causes of reproductive failures for least tern in New Jersey were floods, predators, human disturbance, and vegetative encroachment (Figure 2). We considered that a colony failed completely if fewer than 0.25 young fledged per pair. Overall, complete colony failures declined during the ten-year program for reasons similar to those that raised reproductive success in successful colonies. Flood damage remained relatively constant. Losses due to encroachment of vegetation occurred only in 1979 and 1982 when density of vegetation resulted in decreased numbers of breeding pairs and increased rat predation on adults and young. Human disturbance as a cause of low productivity also decreased over the period, largely because of the employment of tern wardens at vulnerable colonies.

Production of 0.25 young per pair is low, but represents some production and may be sufficient for a long-lived seabird (LACK, 1968). Leg bands from Least Terns banded in New Jersey have been recovered at 20 and 22 years of age. Assuming each pair must only replace themselves with two reproducing offspring, that mortality during the first year is 70%, and that average mortality the second year is 10% (LACK, 1968), a pair may only need to fledge 10 young during their lifetime to replace themselves. Therefore, relative low success in any given year may not endanger the populations.

PROTECTION AND MANAGEMENT

Protecting and managing least tern colonies involves protecting least terns from people (ERWIN, 1980b) and predators, providing suitable nesting sites, and actively attracting terns to suitable sites. All of these methods have been employed in New Jersey.

Protection

Protecting least terns from people involves keeping people out of their colonies by a variety of means (see Figure 3). Personnel that monitor colonies should always explain the plight of the birds to people, and distribute educational material.

Delineating colonies with string or wire, posting with signs, and surrounding colonies with snow fencing all serve as barriers to human intrusion. We found in New Jersey that string or wire fences were very effective human deterrents in conjunction with educational signs, but not even a snow fence will deter those who are determined to enter a colony and vandalize the birds. In one colony motorcyclists rode through the fencing, scattering chicks in every direction. String or wire fencing is particularly useful for large colonies where snow fencing is prohibitive because of expense or manpower. String or wire, with bright plastic streamers to prevent unwitting injury, can be

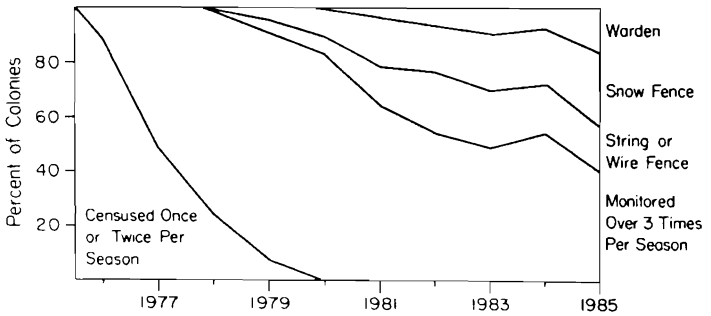

Figure 1. Changes in population levels, colony numbers and reproductive success of least terns in New Jersey from 1976-1985.

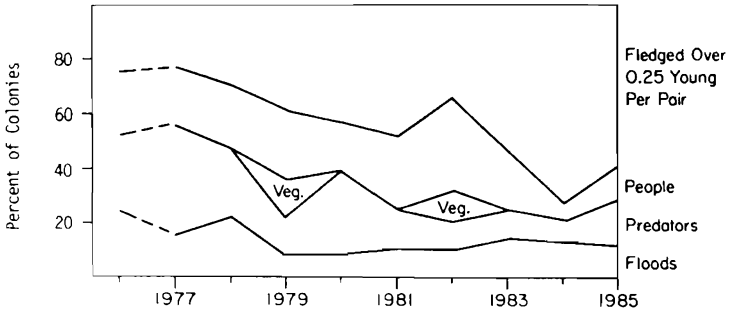

Figure 2. Causes of colony failures of least terns from 1976-1985. A colony failure occurred when fewer than 0.25 young were fledged per pair.

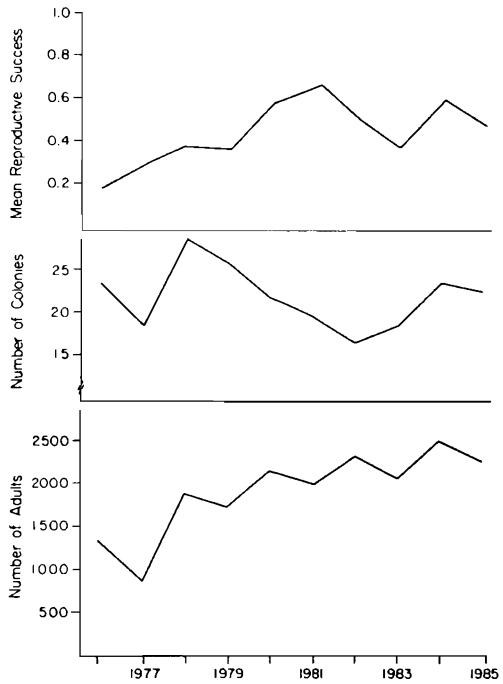

Figure 3. Percent of least tern colonies in New Jersey exposed to different management practices, 1976-1985.

hung between any kind of posts, placed 5–10 m apart. Most people will walk around snow fencing rather than through it, but it is not effective in remote colonies where people party or picnic at night since entire fences may be taken down piece by piece to be used for bonfires. Snow fencing must be attached to metal or wood posts at intervals of about 3 m, otherwise it will be blown over by strong winds. Further, snow fencing and string should be removed at the end of the season so that people know they are excluded only from these sections of the beach when terns are nesting.

We found the most effective protection for least tern colonies was the presence of a full-time warden throughout the day for five or more

days a week. Such a person serves many functions including: (1) keeping people out of the colony, (2) mending fences and re-posting signs, (3) disseminating information to the interested public, (4) relocating signs and fences if terns expand the colony, (5) keeping dogs out of the colony, (6) assessing predator damage while it is still possible to act, and (7) assessing reproductive success. If wardens move slowly through the colony, the birds quickly habituate to their presence. Wardens should wear dark clothing, keep their hands to their sides, not wave objects, walk slowly, and not look directly at the birds (see BURGER and GOCHFELD, 1981). Where possible, wardens should monitor the colonies on weekends.

In New Jersey we tried to use wardens at the largest and most productive colonies, to snow or string fence intermediate-sized colonies, and to check very small and new colonies once a week for signs of problems. Using cost-benefit analysis, we are trying to maximize population levels and increase reproductive success with our limited budget. Over the years the types and intensity of our protection measures have increased (Figure 3). We believe these procedures have contributed to decreases in people and predator problems (refer to Tables 1 and 2).

Predator Control

Any ground-nesting species is vulnerable to predators (ATWOOD, 1986). Least terns in New Jersey are vulnerable to a number of avian and mammalian predators including crows, hawks, owls, gulls, fox, cats, dogs, rats, and raccoons (Table 2).

Predators pose different threats; crows and rats eat only eggs, gulls and dogs eat eggs and chicks, and owls, hawks, cats, and fox can eat adults as well (Table 2). Against predators that pose a threat only to eggs and chicks (but not adults), least terns and other larids engage in mobbing and overt attack (KRUUK, 1964, LEMMETYINEN, 1971). Mobbing is effective in deterring predators in a number of species including terns (MCNICHOLL, 1973; FUCHS, 1977; VEEN, 1977) and gulls (KRUUK, 1964).

Against predators that kill adults, larids will mob in large groups, but usually avoid overt attacks because they could be snatched from the air. Larids mob foxes and hawks, but they usually remain well above them (KRUUK, 1964). Further, larids have no defenses against nocturnal predators (SOUTHERN and SOUTHERN, 1979; SOUTHERN *et al.*, 1985; and ATWOOD, 1986), and such disturbances often cause desertion of larid colonies (PATTON and SOUTHERN, 1977). Complete colony failure because of predators that kill adults as well as young can result in permanent colony desertion (BURGER, 1984b). Thus it is critical to eliminate the threat of predators, particularly those that cause colony desertions. Complete colony failure because of predators that kill adults as well as young can result in permanent colony desertion (BURGER, 1984b).

In New Jersey we employed a variety of predator-control techniques including snow fencing, electric fencing (see MINSKY, 1980), live-trapping or poisoning rats, and lowering reproductive success of predators (gulls, Table 2). Snow fencing was effective in deterring most dogs and foxes, while electric fencing kept out all dogs, foxes, and raccoons. We found it difficult, however, to maintain electric fences, and other measures are preferable where possible.

Live-trapping and removal was effective for raccoons and skunks where only one or two occurred near the colony. In these cases we trapped animals and relocated them to other places far from the tern colonies.

Table 1. *Vegetation control for Least Tern nesting sites in New Jersey.*

Vegetation Problem	Solution	Colony Example	Outcome
Severe overgrowth (Cover as high as 100%)	Manual removal. Plow bare swaths through the vegetation.	Absecon Boulevard	Terns nested in open bare-sand swath; numbers increased.
	Deposit spoil on top of vegetation.	Absecon Boulevard	Terns nest on open sand.
Encroachment of *Phragmites.*	Manually remove underground stems.	Cedar Bonnet Mike's Island Atlantic Boulevard	Terns occupy the bare spots.
Increase in low ground cover.	Manually remove stems to clear patches.	Mike's Island Barnegat Inlet Island	Terns nest in the bare spots; numbers increase.

Table 2. *Predator control measures employed in New Jersey to protect Least Terns.*

Predator	Damage	Tern Response	Control Measures
Native species			
Fox	Eats adults, young, eggs.	Desertion.	Snow fence to exclude fox.
	Keeps adults from incubating eggs.	Low success. Mob fox.	Live-trap and removal, electric fencing.
Owl	Nocturnal predation of adults and young.	Partial desertion.	None at present.
Gull	Eat eggs and chicks.	Mob gulls. Low reproductive success.	Selective depression of reproductive success. Discourage them from nesting near terns.
Human Commensals			
Cat	Nocturnal predation of adults and chicks.	Desertion.	Live-trap and removal.
Dog	Kills chicks.	Desertion.	Snow fence to prevent entry of people.
	Stress to adults by keeping them off their nests.	Low success. Mobs dogs.	Sign posts for owners of dogs.
Rats	Nocturnal predation on eggs and chicks.	Local desertion. Low success.	Place poison or gas in rat burrows before start of tern breeding season. Use rat dogs to dig up rats where there are few.
Raccoon	Egg and chick predation.	Local desertion.	Live-trap and removal.
Peregrine[a]	Eats adults and fledged young.	Mob falcon. Lower success.	Place Peregrine towers at least 5 km from tern colony.

[a]Introduced as a breeding species on salt marshes.

Gulls pose a minor threat as predators on eggs and chicks. Because of the sparse nesting pattern in most least tern colonies, gulls do not usually specialize on them. When gulls attempt to nest very near a tern colony, harassment (frequent entering of the colony or egg destruction) can be used to discourage the gulls before the tern colony is established in the spring.

Cats and owls pose a particular problem because they eat chicks and adults at night; terns have no defense except for nest desertion. We have not developed an effective method for discouraging owls, largely because their populations are decreasing and they also require protection. In some cases cats can be live-trapped with bait, but they are often wary.

Peregrine falcons are unique predators because they were reintroduced to New Jersey, and released in salt marshes, which is not their native habitat. Peregrines killed some young fledgling terns, but this stopped when we moved peregrine release towers far from tern colonies. The initial problem of peregrine predation of least terns illustrates the importance of carefully considering all aspects of re-introduction plans, and anticipating potential problems with existing wildlife populations.

Habitat Manipulation and Vegetation Removal

The physical conditions of a nesting colony can be altered by excessively high winter storm tides depositing sand, inappropriately placed snow fence (resulting in dune formation), or removal of sand bay bulldozers. In these cases the habitat should be restored using bulldozers. Scattering clam shells about the colony will make the site more attractive as least terns frequently prefer areas with shells, and young derive some protection from wind by hiding behind large shells.

Least terns usually nest on beaches or barrier islands (BUCKLEY, 1979; BURGER, 1984a, 1984b). With decreases in suitable habitat they often are forced to nest on dredge spoil islands and spoil deposited on barrier beaches and the mainland (see CARREKER, 1985). Spoil sites generally are not exposed to the high tides of winter storms and so succession proceeds from suitable open areas to newly vegetated sites where terns do not nest (JACKSON and JACKSON, 1985). Thus vegetation encroachment, particularly from *Phragmites* in New Jersey, eventually becomes a serious problem on most

spoil sites (Table 2). Terns will not nest in or near dense *Phragmites*. We usually removed stems manually by pulling them up before the problem became too severe. Terns prefer colony sites with little vegetation cover (X = 2.7% ± 3.2, KOTLIAR and BURGER, 1986). We have manually cleared small sections throughout some colony sites. Although herbicides can be used we have preferred manual removal because of environmental contamination associated with herbicides. Where vegetation cover is very dense we used tractors and plows to turn the soil, and placed sand on top of the disturbed areas. Terns will readily use new spoil areas although they prefer some grass or low herb cover for chicks to hide in.

Vegetation cover must be assessed each year in every colony so the habitat does not become covered with vegetation. It is far more difficult to remove vegetation once dense cover is established than to remove small amounts of vegetation regularly. Further, it is difficult to attract terns back to a site once it has been deserted. With appropriate management of colony sites, terns will use them for many years (ATWOOD and MASSEY, 1988).

Attracting Least Terns

Managers and conservationists may want to attract least terns to a new, suitable, safe site, or back to an old site abandoned because of people, predators or vegetation cover. Before terns are induced to nest at a site, it must be made safe and the habitat suitable. In some cases terns will reuse or establish a colony without further intervention once a site is made attractive again. Thus it is often sufficient to remove vegetation, supply sand, remove predators, and eliminate human disturbance. Terns fly over many sites in spring before establishment of active colonies.

Least terns can be drawn to a site using decoys and vocalizations (KOTLIAR and BURGER, 1984). Decoys can be carved from wood by duck decoy manufacturers, fashioned from styrofoam, or constructed from flat boards. We found that rounded decoys painted like least terns were most effective in attracting terns. Tern decoys can be supplemented with conch shells (with black caps) to produce a larger, dense colony. To avoid loss of decoys we used conch shells effectively to attract terns. Shells should be placed in pairs and solitarily at inter-shell distances of 1.5 m. Least tern decoys should be spaced about 1.5 m apart to allow room for territory-prospecting pairs to establish themselves between the decoys. Decoys placed in pairs and as solitary birds were more effective in attracting terns than either all pairs of decoys, or all solitary decoys (BURGER, 1988). Decoys should be placed on the colony every day from mid-May before the terns arrive until early June. Once terns occupy the site they will attract other least terns and decoys can be removed.

We used decoys at four sites in New Jersey to re-establish colonies on abandoned sites (Table 3). Terns bred successfully at three sites. The fourth site (Island Beach) was an alternative to Mike's Island; once the terns settled on Mike's Island, they did not use Island Beach so we did not use decoys there in 1984. Decoys were very effective at attracting terns at recently abandoned sites where they had nested successfully for several years.

Use of decoys is very time-consuming and labor-intensive. Decoys are expensive ($6–8/each), and cannot be left unattended because they are very attractive as souvenirs for people at the beach. We recommend it only as a final effort for colony sites that are completely predator-free, devoid of human disturbance and were without terns in the preceding year.

CONCLUSIONS

An effective monitoring effort and management plan for least terns (*Sterna antillarum*) involves monitoring population levels and reproductive success, protecting colonies from people and predators, manipulating habitat, and actively attracting terns. Not all management procedures are required at each site in every year, but population levels and reproductive success must be monitored yearly at each site to assess potential problems where population are declining or unstable.

Protection of colonies is an on-going job that must be performed yearly at sites with a history of human disturbance. Posting and fencing must be done each spring, and the material removed after the breeding season.

Table 3. *Results of decoy experiments to attract Least Terns to abandoned sites.*

Island	Date Colony was Last Used	1983 Number Nesting	1983 Success[a]	1984 Number Nesting	1984 Success
Experimental Islands					
Mike's	1980	20	0.85	42	1.19
Island Beach[b]	1981	1[c]	—		
Cedar Bonnet	1981	7	1.0	62	0[d]
Experimental Plot[e]	1980	3[f]	0	12	1.20

[a] Number fledged per pair.
[b] No experimentation in 1984.
[c] Landed but did not nest.
[d] A dog in the colony one weekend killed all young chicks and the adults deserted.
[e] At Brigantine beach.
[f] Washed out by heavy rain.

People are much more cooperative when fences are used only during the proper time periods. Educational signs are critical to developing a knowledgeable and caring public. When wardens are required they must be used each year for effective protection. Investment in a warden generally increases reproductive success, thus tern populations protected by wardens contribute substantially to future adult populations.

Manipulation of vegetation, habitat modification and use of decoys are all procedures that may be necessary from time to time. They are labor-intensive, and should be used as early as possible at any colony before the problem becomes severe. Annual or biannual vegetation removal may be sufficient to maintain suitable colony sites. Drastic measures, such as decoy work, are required only when other practices have not been instituted soon enough, or when new colonies are desired at suitable sites.

Monitoring, protecting, and managing of an endangered population of least terns, or any other endangered species, is likely to be an ongoing project requiring yearly expenditures of time and money. The job is not likely to end, and people interested in conservation of these species must accept the continuing nature of the required protection. Successfully maintaining stable tern populations may be, in reality, maintaining increasing levels of terns when we consider the yearly decreases in available habitat. With continued effort we can expect to maintain existing population levels of least terns even in the face of increasing human population levels.

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