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USE OF PREDATOR EXCLOSURES TO PROTECT PIPING PLOVER NESTS

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Abstract.—Between 1986–1989 we surrounded 26 Piping Plover (*Charadrius melodus*) nests with wire mesh predator exclosures at a coastal breeding site in Massachusetts. A triangular exclosure of 5 × 5 cm wire mesh, with a 30.5 m perimeter and black twine in parallel rows over the top was designed to surround a nest and prevent mammalian and avian predation. Piping Plover adults and chicks moved freely along the ground through the wire mesh of the exclosures, and the behavior of the plovers appeared normal. Ninety-two percent (24/26) of treated nests successfully hatched one or more eggs. During the same period, only 25% (6/24) of untreated nests at the study site hatched, with most losses (94%, 17/18) the result of predation. The higher hatching rate of treated nests suggests that exclosures may reduce nest loss, increase hatching success, and enhance productivity.

UTILIZACIÓN DE CERCADOS PARA PROTEGER NIDOS DE *CHARADRIUS MELODUS*

Sinopsis.—Durante 1986–1989 cercamos, para proteger contra depredadores, áreas de anidamiento de individuos de *Charadrius melodus* en una localidad de Massachusetts. Alambre con huecos de 5 × 5 cm se colocó en forma triangular para cercar un perímetro de 30.5 m y en parte superior se colocó bramante negro en líneas paralelas. Adultos y polluelos de las aves se podían mover libremente a traves del alambre del cercado. La conducta de las aves pareció normal. Eclosionaron uno o más huevos del 92% (24/26) de los nidos cercados. Por su parte en las áreas controles (durante el mismo periodo de tiempo), se observó eclosionamiento en tan solo el 25% (6/24) de los nidos, atribuyendose la mayoría de las perdidas (94%, 17/18) a la depredación por parte de aves y mamíferos. La mayor frecuencia de eclosionamiento en las áreas experimentales sugiere que los cercados muy bien pudieran reducir la perdida de nidos, aumentar el éxito de eclosionamiento y mejorar la productividad.

In 1986, while studying a small breeding population of Piping Plovers (*Charadrius melodus*) on a barrier beach in northeastern Massachusetts, we discovered that mammalian and avian predation were severely limiting nesting success. Management alternatives included lethal and non-lethal predator control. Lethal control of predators is controversial, time consuming and often temporary (USFWS 1988). Non-lethal methods have been proven successful for protecting certain species of ground- or near-ground nesting birds from predators. These include techniques such as electric fencing (Sargeant et al. 1974, Forster 1975, Minsky 1980), metal barriers (Post and Greenlaw 1989) and wire mesh exclosures (Nol and Brooks 1982). We decided to test a wire mesh exclosure designed specifically to protect Piping Plover nests.

The Piping Plover is a small, ground-nesting shorebird designated as threatened (U.S. northern Great Plains and the Atlantic coast) or endangered (U.S. Great Lakes and Canada) throughout its breeding range. Human disturbance and habitat loss have contributed to the decline of this species (Cairns and McLaren 1980, Haig and Oring 1985, Sidle

1985, Flemming et al. 1988). The role of predation in the population decline of the plover is not well understood. However, reports from the Great Plains (Haig 1985), Great Lakes (Wiens and Cuthbert 1984) and Atlantic coast (Ailes 1985, Cairns 1982, MacIvor et al. 1987, Rimmer 1988) suggest predation causes declines in annual breeding success and may reduce the size of local breeding populations. Nest protection in these areas may be a valuable management tool and important to the recovery of the species.

In this paper we describe a predator exclosure designed to protect individual Piping Plover nests from mammalian and avian predators. Our goal was to test the effectiveness of a simple, inexpensive predator exclosure with the following requirements: (1) predators should be unable to penetrate an exclosure; (2) exclosures should allow unimpeded movements of plover adults and chicks to and from the nest; and (3) plover breeding behavior should not be disrupted. If successful, we predicted that predation levels at the study site would decrease and hatching success would increase.

STUDY AREA AND METHODS

We conducted field work at Crane Beach in Ipswich, Massachusetts (42°41′N, 70°47′W) from 15 Apr. to 15 Aug., 1986–1989. Crane Beach is a 9.0 km barrier island characterized by sand dunes dominated by American beachgrass (*Ammophila breviligulata*) and associated with an extensive estuary. Historically, Piping Plovers have nested along the upper beach and within the sand dunes at Crane Beach (Putnam 1856, Townsend 1905, White 1960). Each spring since 1970, plover and tern nesting areas have been posted and fenced with a single strand of wire to reduce levels of human disturbance.

This study was conducted in three stages: (1) pretreatment documentation of predation on Piping Plover nests (1986); (2) experimentation with a small number of predator exclosures (1987); and (3) expanded treatment of Piping Plover nests following successful trials (1988 and 1989). In addition, we observed plover behavior at each known nest in each year and identified local predators by direct observation and tracks (Murie 1974). We assessed predator pressure primarily using an index of tracks observed around individual plover nests, and secondarily using predation levels on Least Tern (*Sterna antillarum*) nests at the study site. Predator tracks were counted once annually around active nests using a modified line-intercept method (Gysel and Lyon 1980). Four lines were extended at 90 degree intervals from the nest and any predator track intercepted within 50 meters of the nest was recorded as one occurrence. The mean number of occurrences of tracks per nest comprised the index for one year. Depending on results of the predator pressure index among years, combining hatching success data over years might be justified.

The assignment of nests to the treated or untreated group was nonrandom and biased by our desire to maximize plover productivity. In 1986, no nests were treated while we studied the impact of predation.

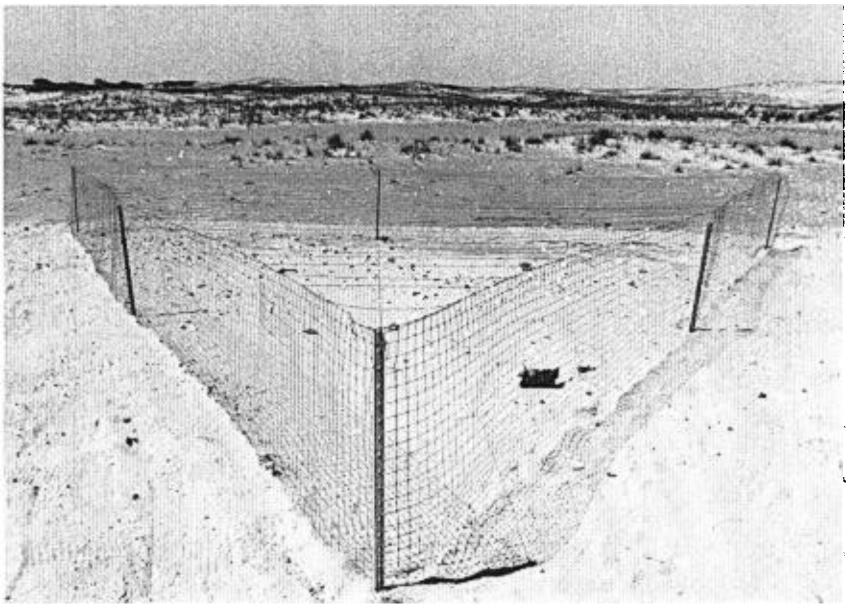

FIGURE 1. Predator exclosure with an equilateral triangle shape shown protecting a Piping Plover nest at Crane Beach.

Beginning in 1987, we proceeded cautiously with exclosures and treated only second nest attempts of pairs that had failed previously that breeding season. In 1986 and 1987, we deliberately left certain nests untreated, but in 1988 and 1989, we attempted to treat all known nests to maximize local productivity. In the later two years, our untreated group included nests found recently destroyed, nests found intact but destroyed before treatment, and undetected nests known to have hatched at least one chick.

We designed and implemented the exclosure (Fig. 1) to protect plover nests without disturbing the nesting behavior of the breeding pair. An equilateral triangle shape was used to attempt to deflect predators away from the nest. The triangle had a perimeter of 30.5 m (100 ft), being large in size in order to provide a safe buffer area between the centered nest and exclosure edge. Six metal posts driven vertically into the ground supported sides of 5 × 5 cm (2 × 2 in) galvanized, woven wire mesh 75–80 cm (38–40 in) above ground and 20–25 cm (8–10 in) buried. Tops of supporting posts were below the top of the wire mesh sides to eliminate any possible perch for avian predators, and the base of each side was buried to stop burrowing predators. The final feature was heavy (100–150 pound test) black twine placed in parallel rows 15 cm (6 in) apart across the top of the exclosure. Originally, clear monofilament fishing line was used over the exclosure. Although it appeared to effectively deter avian predators, it was so invisible that we changed to a more visible black twine. The total cost per exclosure was approximately fifty ($50.00)

U.S. dollars, and all materials were reusable, thus reducing costs further in subsequent years.

Construction was typically conducted in early morning hours to avoid the extreme mid-day heat. To minimize disturbance, we limited our activities around nests to 30 min or less. In several instances we returned to a nest within 24 h to complete exclosure construction. After each exclosure was constructed, we moved at least 50 m from the nest and monitored incubation resumption. If incubating adults did not resettle on the nest within 30 min, we were prepared to remove the exclosure immediately. Each exclosed nest was monitored daily for signs of disturbance or abandonment. When a treated nest hatched and the chicks had moved out of the exclosure, the structure was dismantled within 1–3 d and all materials stored for future use.

RESULTS

Treated vs. untreated nests.—Twenty-six plover nests were treated with predator exclosures during the study (3 in 1987; 8 in 1988; 15 in 1989) and 24 nests were untreated (13 in 1986; 4 in 1987; 3 in 1988; 4 in 1989). Treated nests had significantly higher hatching success than untreated nests (Table 1, $\chi^2 = 20.84$, $P < 0.001$). The mean number of chicks hatched per nest was 3.50 for treated nests and 1.00 for untreated nests. Predators destroyed 71% (17/24) of untreated nests, but had no known impact on treated nests. The untreated group consisted of 17 nests deliberately untreated, three nests found intact, but destroyed before treatment, three nests found destroyed and one undetected nest that hatched four chicks.

Observed behavior of plovers appeared similar at treated and untreated nests. Adults invariably returned to incubate eggs normally following exclosure construction in less than 15 min. (range 0.5–14 min., $n = 26$), and adults and chicks moved freely through the wire mesh fence at ground-level. Incubation periods at treated nests were similar to those at untreated nests. Adult plovers were observed flying into and out of exclosures without any apparent difficulty but this was uncommon behavior, occurring only twice when unauthorized beachgoers entered closed areas and disturbed incubating adults. In general, behavior of plovers at treated nests appeared normal.

Predator observations.—Predators and predator tracks were observed regularly in plover nesting areas. Data collected showed that the predator track index was similar from year to year (1987: 11.8/nest; 1988: 10.3/nest; 1989: 11.0/nest), and that predation levels on Least Tern nests at Crane Beach were annually high, ranging from 40–90% each year throughout the study (Rimmer, unpubl. data). Mammals observed directly or identified using tracks in order of relative abundance were Red Fox (*Vulpes vulpes*), Striped Skunk (*Mephitis mephitis*), Opossum (*Didelphis virginiana*), Raccoon (*Procyon lotor*) and Dog (*Canis familiaris*). Avian species similarly recorded and in order of relative abundance were American Crow (*Corvus brachyrhynchos*), Common Grackle (*Quiscalus*

TABLE 1. Hatching success (nests hatching one or more eggs) of Piping Plover nests at Crane Beach, Ipswich, Massachusetts between 1986–1989.

Nests	*n*	Number hatched	Number failed
Treated	26	24 (92%)[a]	2 (8%)
Untreated	24	6 (25%)	18 (75%)
Total	50	30 (60%)	20 (40%)

[a] = Hatching success significantly different (χ^2 = 20.84, $P < 0.001$) and higher than untreated nests.

quiscula), Herring Gull (*Larus argentatus*), Great Black-backed Gull (*Larus marinus*) and Great Horned Owl (*Bubo virginianus*). Tracks of Red Fox and Striped Skunk intercepted exclosures on five separate occasions. In each case, the tracks appeared to be deflected away from the nest, never continuing around the full perimenter of the exclosure. We have no evidence that a mammalian or avian predator ever penetrated an exclosure and destroyed a nest. However, Great Horned Owl tracks were identified inside one exclosure (the nest remained intact with both adults present the following day), and a Herring Gull was observed three times, during one day, perched on an exclosure. Whether they were attracted by the exclosure itself or by some activity within is unknown. At 18 untreated nests, predation was attributed to Red Fox (n = 8), American Crow (n = 5), Striped Skunk (n = 3), Herring Gull (n = 1).

DISCUSSION

Predation clearly limited nesting success of Piping Plovers at Crane Beach prior to exclosure use in 1987. The hatching success of untreated nests throughout the study was substantially lower than untreated nests studied by Cairns (1982: 72–79%) in Nova Scotia and by Wilcox (1959: 91%) on Long Island, New York. Since predator pressure appeared constant throughout the study, we were able to compare hatching success over all years and determine that treated nests had significantly higher hatching success than untreated nests. Plover adults invariably returned to incubate eggs within exclosures, and no nests were destroyed by predators at any time following exclosure implementation.

Nol and Brooks (1982) used a small (1 m^2) wire mesh exclosure for Killdeer (*Charadrius vociferus*) nest protection with limited success. They observed that small mammalian predators could enter the exclosure through the side openings (7–12 cm) and that larger mammalian predators could reach through the same openings and take eggs. They also observed that predators appeared to be attracted to exclosures. A larger sized exclosure and smaller openings for passage through the exclosure appeared to eliminate these problems in our study. In addition, despite reports by Nol and Brooks (1982) and Reynolds (1985), we found no evidence that predators were attracted to nests by exclosures or by any human scent associated with the site. We are confident that the exclosure described in our study can effectively protect Piping Plover nests, and possibly nests of other small beach-nesting shorebirds, from a wide range of mammalian and avian predators. We recommend this exclosure for managers attempting to increase hatching rates and chick production.

We observed during this study that Piping Plover chicks hatching earlier in the breeding season had, in general, a higher survival rate. Our data show that chicks hatching before 1 July (the traditional beginning of summer in Massachusetts) had a 79% (78/99) survival rate compared to a 26% (4/15) survival rate for chicks hatching after 1 July. Flemming et al. (1988) reported that human disturbance on Nova Scotia beaches altered chick feeding behavior and resulted in lower survival rates compared to chicks studied at undisturbed beaches. Cairns (1982) reported that plover chicks in Nova Scotia that failed to achieve 60% of their normal body weight by day 12 were unlikely to survive to fledging.

Most adult plovers return to their breeding areas in Massachusetts in March and April when beach use by humans is relatively low. However, beaches and other waterways become more crowded as weather warms, typically reaching a peak towards the later part of the plover breeding season in June and July. Following a typical chronological breeding schedule (Cairns 1982, Wilcox 1959, Rimmer unpubl. data), plover chicks should fledge in July. Nest loss from predation often stimulates renesting, resulting in young, vulnerable chicks on crowded, disturbed beaches in midsummer. Although our data set is small, it suggests that protection of early nests can reduce renesting and enhance chick survival.

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