University of Alberta

Predator exclosures: a management technique to increase Piping Plover (*Charadrius melodus*) reproductive success in the Canadian prairies

By

Isabelle M. G. Richardson ©

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Predator exclosures: a management technique to increase Piping Plover (*Charadrius melodus*) reproductive success in the Canadian prairies** submitted by **Isabelle Marie Gisèle Richardson** in partial fulfillment of the requirements for the degree of Master of Science, in Wildlife Ecology and Management.

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ABSTRACT OF THESIS

Predator exclosures are a possible method of increasing the reproductive success of the endangered Piping Plover (Rimmer and Deblinger 1990, Powell 1991, Deblinger *et al.* 1992, Melvin *et al.* 1992, Smith *et al.* 1993, Vaske *et al.* 1994). During the summers of 1996 and 1997, 32 of 68 Piping Plover nests found on three lakes in Alberta and Saskatchewan were treated with predator exclosures. No treated nests (0/32) were lost to predation while 64% (23/36) of control nests were destroyed by predators. Daily survival rate was significantly higher for treated nests (P=0.0047) and nest success for treated and control nests was 59% and 22%, respectively. The fledging rate of 1.09 chicks per treated nest was significantly higher than the 0.50 chicks fledged per control nest (p=0.046), although these estimates are conservative. The results suggest that predator exclosures may be an important management technique for the recovery of the species. A protocol for the use of the exclosures was prepared as a result of this study.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Descriptive biology

The Piping Plover (*Charadrius melodus*) is one of five species of plovers with a single chest band that occur in North America. The remaining are the Ringed Plover (*C. hiaticula*), Semipalmated Plover (*C. semipalmatus*), Snowy Plover (*C. alexandrinus*) and Wilson's Plover (*C. wilsonia*). Of these, the Piping Plover most resembles the Semipalmated Plover in size and appearance. However, the Piping Plover is much lighter brown and more greyish on the upper parts and lacks black markings on the cheeks (Godfrey 1966). The back of the Piping Plover has been described as being the colour of dry sand as opposed to the wet sand colour of the Semipalmated Plover.

Godfrey (1966) described plovers as "plump-bodied shorebirds with short necks, rather large eyes, and short thickish bills." The Piping Plover indeed matches this description. This small (17-18 cm long; 43-63 g; Haig 1992) plover is identified by its pale brown to greyish upperparts, white underparts, bright orange legs, orange bill with a black tip and a black bar extending over the forehead from eye to eye. The single black breastband is sometimes incomplete; however, this is more common in the Atlantic population (Haig 1992).

Some subtle morphological differences exist between male and female Piping Plovers. Males tend to have more brightly coloured plumage, brighter orange on the bill and legs, and a more complete breastband (Cairns 1982, Haig 1992). In prairie birds, males often have a black 'mustache' which extends from the base of the bill towards the cheek (Haig 1992).

In the Northern Great Plains, nesting sites tend to be situated on sparsely vegetated sand or gravel beaches, adjacent to vast hyper-saline or alkali basins or semi-permanent alkali wetlands (Haig 1992). Open sand or graveled beaches are preferred as nesting sites, although a great variety exists within this description. In the Canadian prairies, where the current study took place, Piping Plovers prefer wide, sparsely vegetated to unvegetated sand and graveled beaches adjacent to brackish, saline and hyper-saline basins of varying size (Dundas 1995). Some pairs may also nest on small, semi-permanent alkali basins (Heckbert 1994, Dundas 1995, Heckbert and Cantelon 1996).

Three breeding populations of Piping Plovers are currently recognized: the Atlantic population breeds along the Atlantic Coast from North Carolina to Newfoundland; the Great Lakes population is currently restricted to a small portion of Lake Michigan; and the prairie population breeds in the northern Great Plains from Nebraska to the southern portion of the Canadian prairie provinces including Lake of the Woods in Ontario (Haig 1992, Plissner and Haig 1997). Wintering occurs along the Atlantic and Gulf Coasts of the United States and Mexico, and in northern Cuba and the Bahamas (Haig and Oring 1985, Plissner and Haig 1997). Piping Plovers banded in

Alberta and Saskatchewan have recently been sighted in Florida, Texas and Mexico during the winter months (Goossen 1990, I. Richardson, unpubl. data).

Piping Plovers arrive on their prairie breeding grounds from late April to early May (Whyte 1985, Pinel *et al.* 1991, Heckbert 1994, Heckbert and Cantelon 1996, I. Richardson, unpubl. data). Upon arrival to the nesting beaches, males immediately begin performing elaborate flight displays in their efforts to attract a mate and to establish their territories (Cairns 1977, Whyte 1985, Haig 1992). Nest building takes place as part of the courtship ritual and results in the formation of a simple nest consisting of a shallow, bowl-shaped scrape in the sand, lined with small bits of gravel, bone or salt flakes (Cairns 1977, Haig 1992, Dundas 1995). Typically, four light brown eggs with dark brown speckles will be laid over a period of six to seven days (Haig 1992) although clutches of up to five eggs are possible (Wershler and Wallis 1987, I. Richardson, unpubl. data). Incubation is shared equally between both sexes, which allows each adult to catch and eat its own food (Haig 1992). The female may lay several clutches if some attempts are unsuccessful, but adults typically raise only one brood per season (Wilcox 1959, Cairns 1982, Haig 1992). Piping Plovers successfully raising two broods in one season has been documented on the Atlantic Coast (Bottitta 1997).

At the end of the 28-day incubation period, the tiny gray and white downy chicks emerge from the eggs (Haig 1992). The newly hatched precocial young leave the nest within several hours after hatching to forage and feed with their parents. Young generally stay close to the male adult until they depart for the wintering grounds in late July or early August (Haig 1992). In the Great Plains, fledging age ranges from 21 to 28 days (Haig 1992), although young may be capable of sustained flight as early as 18 days of age (Murphy *et al.* in prep.(a)).

Project background

Observable declines in populations of Piping Plovers were first recognized in Canada in the 1940s. In 1978, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated the Piping Plover as a 'threatened' species in Canada (Bell 1978). In response to further population declines, the species was designated as 'endangered' in 1985, and remains as such today (COSEWIC 1998). Piping Plovers are also recognized as an 'endangered' animal under the Alberta Wildlife Act and the Manitoba Endangered Species Act (Prescott 1997). No legal designation exists in Saskatchewan. Although the species has been the subject of several breeding studies, relatively little is known about its wintering distribution, habitat requirements, and limiting factors (Haig 1992).

Ryan *et al.* (1993) used a stochastic simulation model to confirm that the Great Plains Piping Plover population is decreasing at an annual rate of 7%. A more recent analysis of the viability of Piping Plover metapopulations suggests that the Great Plains/Great Lakes metapopulation is unlikely to persist given current reproductive rates (Plissner and Haig, in review). Ryan *et al.* (1993), in their single-population analysis, found that an increase in recruitment rate from the current continental level of 0.86 fledglings per pair to 1.13 fledglings per pair would be needed to stabilize the

Great Plains Piping Plover population. Plissner and Haig (in review), however, suggested that 1.7 fledglings per pair would be needed for the Great Plains/Great Lakes metapopulation to persist over the next 100 years. Nevertheless, at such recruitment levels, population levels would still decline and recruitment of 2.0 fledglings per pair is be needed to maintain the population at current levels (Plissner and Haig, in review).

The low reproductive success of the Piping Plover has been attributed to several factors including recreational use of nesting beaches (Haig and Oring 1985, Flemming *et al.* 1988, Melvin *et al.* 1994), habitat destruction (Haig and Oring 1985, Smith *et al.* 1993), environmental effects such as flooding (Prellwitz *et al.* 1995, Espie *et al.* 1996) and nest predation (Haig and Oring 1985, Whyte 1985, Haig and Oring 1988, Deblinger *et al.* 1992, Smith *et al.* 1993). Nest predation as the primary source of egg loss has been reported in many studies: MacIvor (1990) in Cape Cod, Massachusetts; Patterson (1988) on Assateague Island, Virginia; Haig (1987) in Manitoba; Prindville (1986) in North Dakota; and Whyte (1985) in Saskatchewan. In Alberta, nest predation has also been identified as a significant limiting factor to the reproductive success of Piping Plovers (Heckbert 1994, Heckbert and Cantelon 1996). Although Piping Plovers have always had to contend with predation, ecological change as a result of human activity has altered the landscape and led to increasing densities of potential predators such as American crows (*Corvus brachyrhynchos*), gulls (*Larus* sp.), coyotes (*Canis latrans*), and striped skunks (*Mephitus mephitus*) (Melvin *et al.* 1991). Impacts of predation are often magnified, as Piping Plovers must contend with cumulative impacts of predation, human disturbance and habitat alteration and loss (Melvin *et al.* 1991).

Increased productivity as a result of using predator exclusion cages has been observed in studies carried out on Piping Plovers (Rimmer and Deblinger 1990, Powell 1991, Deblinger *et al.* 1992, Melvin *et al.* 1992, Vaske *et al.* 1994) and other shorebird species including Pectoral Sandpiper (*Calidris melanotos*; Estelle *et al.* 1996) and Snowy Plover (Parker *et al.* in prep.). Although the increase in nest success suggested by Ryan *et al.* (1993) is substantial, they recommend that such a large change might be feasible, in part, by protecting nests from predators. Plissner and Haig (in review), however, contend that the increase in recruitment suggested by their study may be out of reach of even the most ambitious management plans. Nevertheless, although high recruitment goals may not be achieved through a single management effort, initiatives aimed at improving reproductive success can be applied in combination with other recovery efforts in order to maximize benefits.

This study attempted to assess the feasibility of using predator exclusion cages as a large-scale management technique to increase Piping Plover reproductive success in the Canadian prairies. The study focused on two objectives. The first was to investigate the effectiveness of small (in relation to other designs used) predator exclusion cages in reducing incidents of predation on Piping Plover nests, thus improving currently low recruitment rates. Secondly, although some predator exclosures have been used in the Atlantic Provinces and in the United States, there exists a need for practical guidelines for wildlife managers to follow when using these devices. Therefore, as a result of this research, a protocol document outlining guidelines for survey techniques and construction, application and monitoring of predator exclosures was developed. The protocol document was intended for wildlife managers and has been written with that audience in mind.

CHAPTER 1

Predator exclosures to protect Piping Plover nests

STUDY AREA

In 1996, the study site included Killarney Lake (52°35'N;110°06'W) and the westernmost of the Reflex Lakes (52°40'N;110°00'W; hereafter referred to as Reflex Lake) both located in east-central Alberta (Figure 1). In 1997, Freshwater Lake (52°37'N;109°59'W), in west-central Saskatchewan, was added to the study site due to its close proximity to the two existing study lakes and its relatively large population of breeding Piping Plovers.

Killarney Lake is shallow, permanent, and moderately saline with a surface area of 4.4 km^2 and a shoreline length of 10.3 km (Mitchell and Prepas 1990). The exposed unvegetated shoreline is 10 to over 100 m in width as water typically recedes throughout the summer. The nesting habitat is localized with gravel and sand substrate and extensive alkali deposits (Hofman 1994). There is extensive graveled shore with sandy substrate on the south and southwest shores (Wershler 1989). The most productive nesting area is located on the large peninsula on the southwest side of the lake (Heckbert 1994, Heckbert and Cantelon 1996; Figure 2).

Reflex Lake is deep, permanent and hyper-saline (Wershler 1990). The exposed unvegetated shoreline is 10 to 30 m in width and consists of sand and gravel substrate

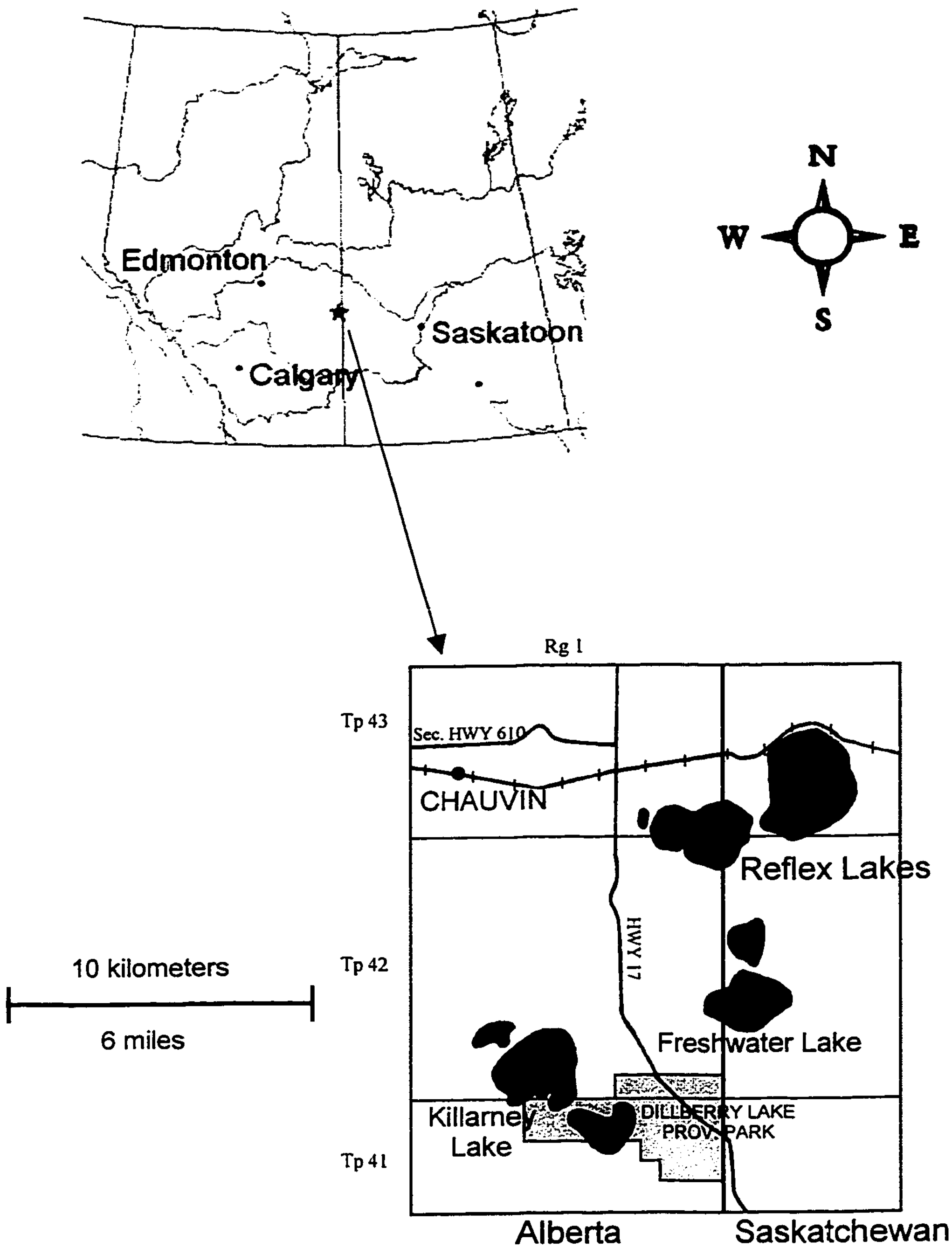


Figure 1. Location and map of study site.

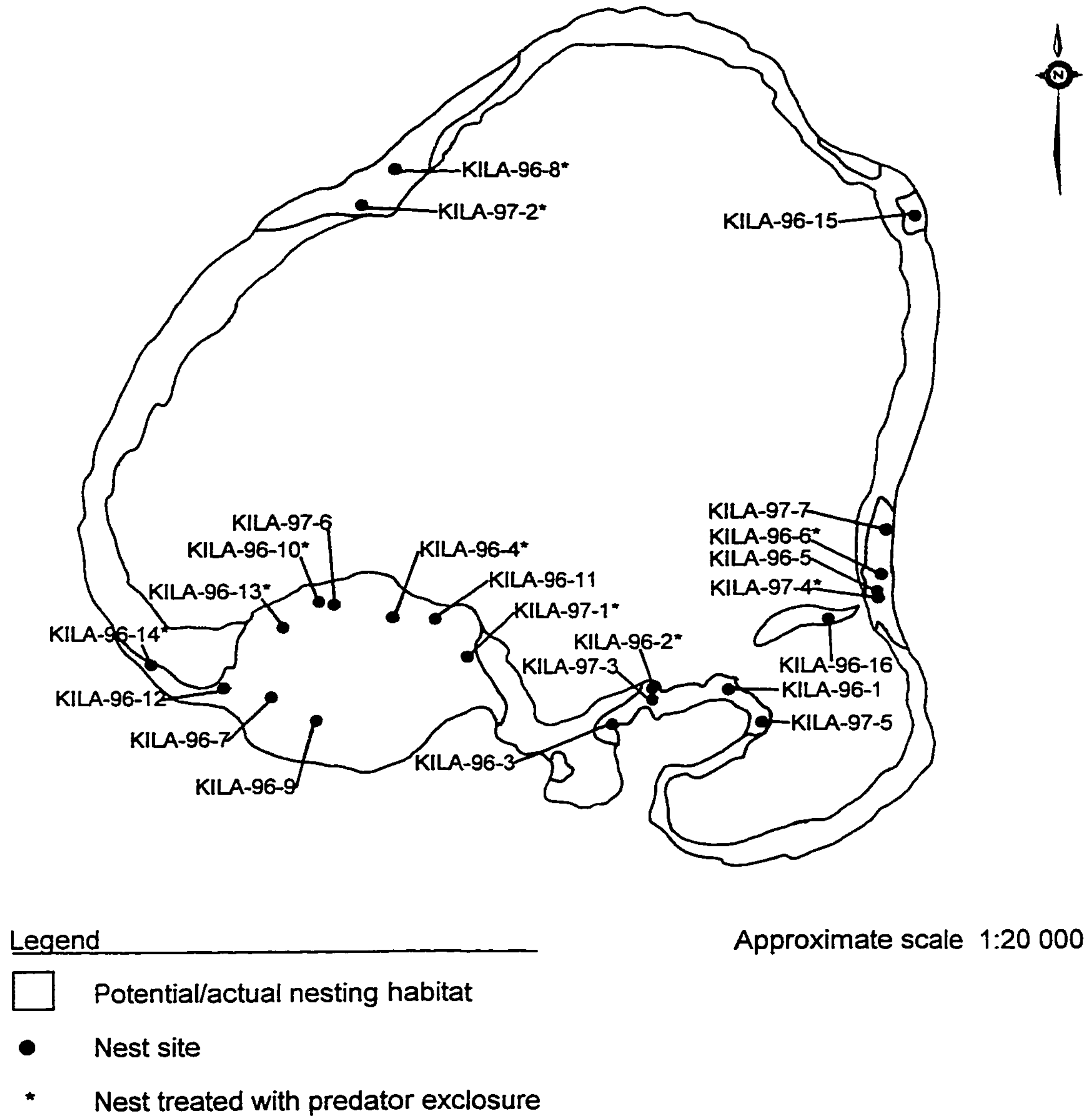


Figure 2. Nesting habitat and nesting sites on Killarney Lake, Alberta, 1996-1997.

(Hofman 1994). Alkali beach with mud and shallow water occurs along the shore (Wershler 1990). There are rocky points on the west, north and south shores and seepages on the west and south shores. Most Piping Plovers nest on the large west point and nesting also occurs on the unnamed pond adjacent to the west shore (Heckbert 1994, Heckbert and Cantelon 1996; Figure 3). A cabin development exists on the southwest side of the lake.

Freshwater Lake, located on and directly east of the Alberta/Saskatchewan border, is a small lake with a lightly vegetated, soft mud shoreline. The only suitable nesting area occurs in a strip of sparsely vegetated sand and gravel beach along the west side of the lake (Figure 4).

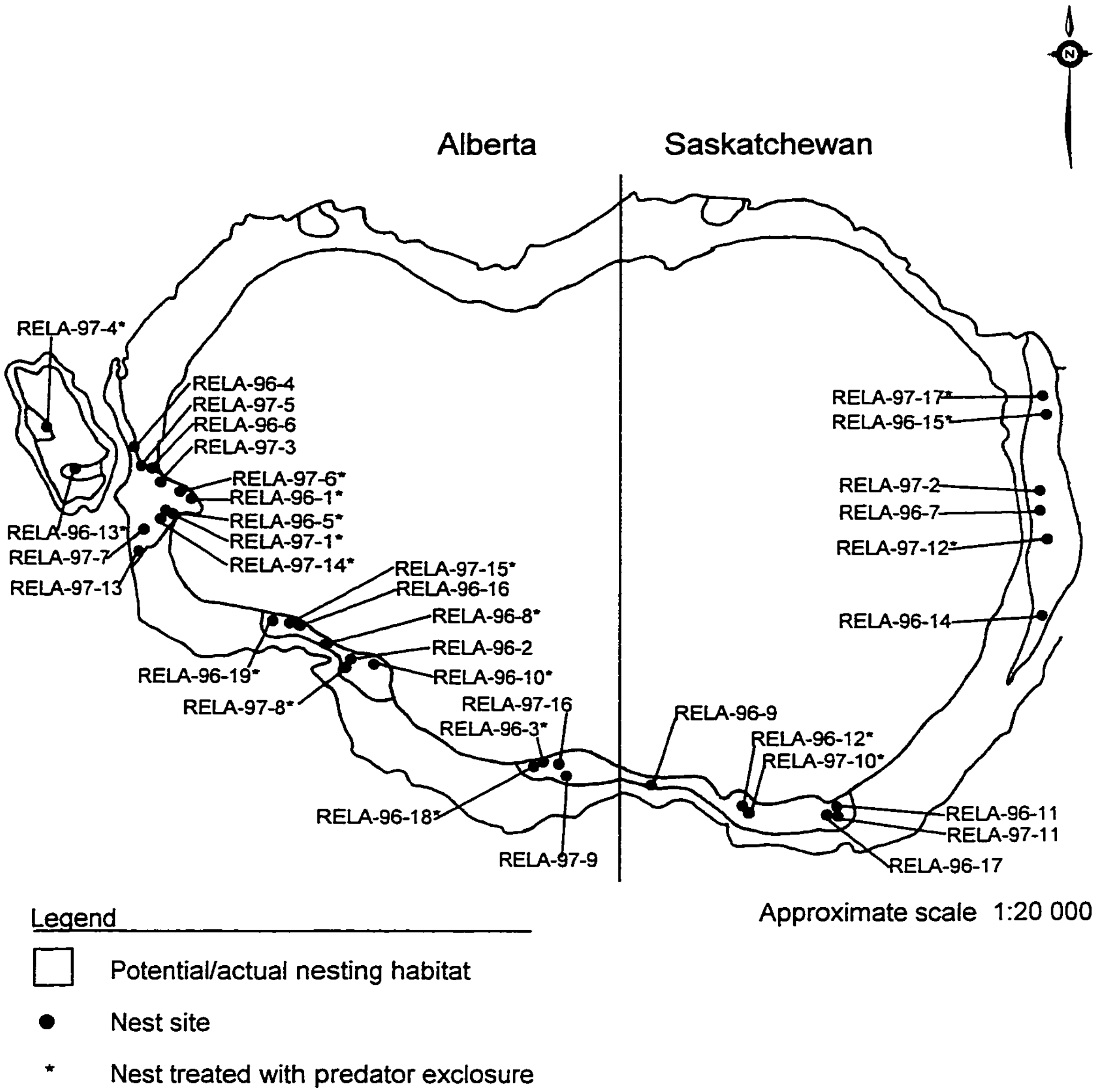


Figure 3. Nesting habitat and nesting sites on Reflex Lake, Alberta, 1996-1997.

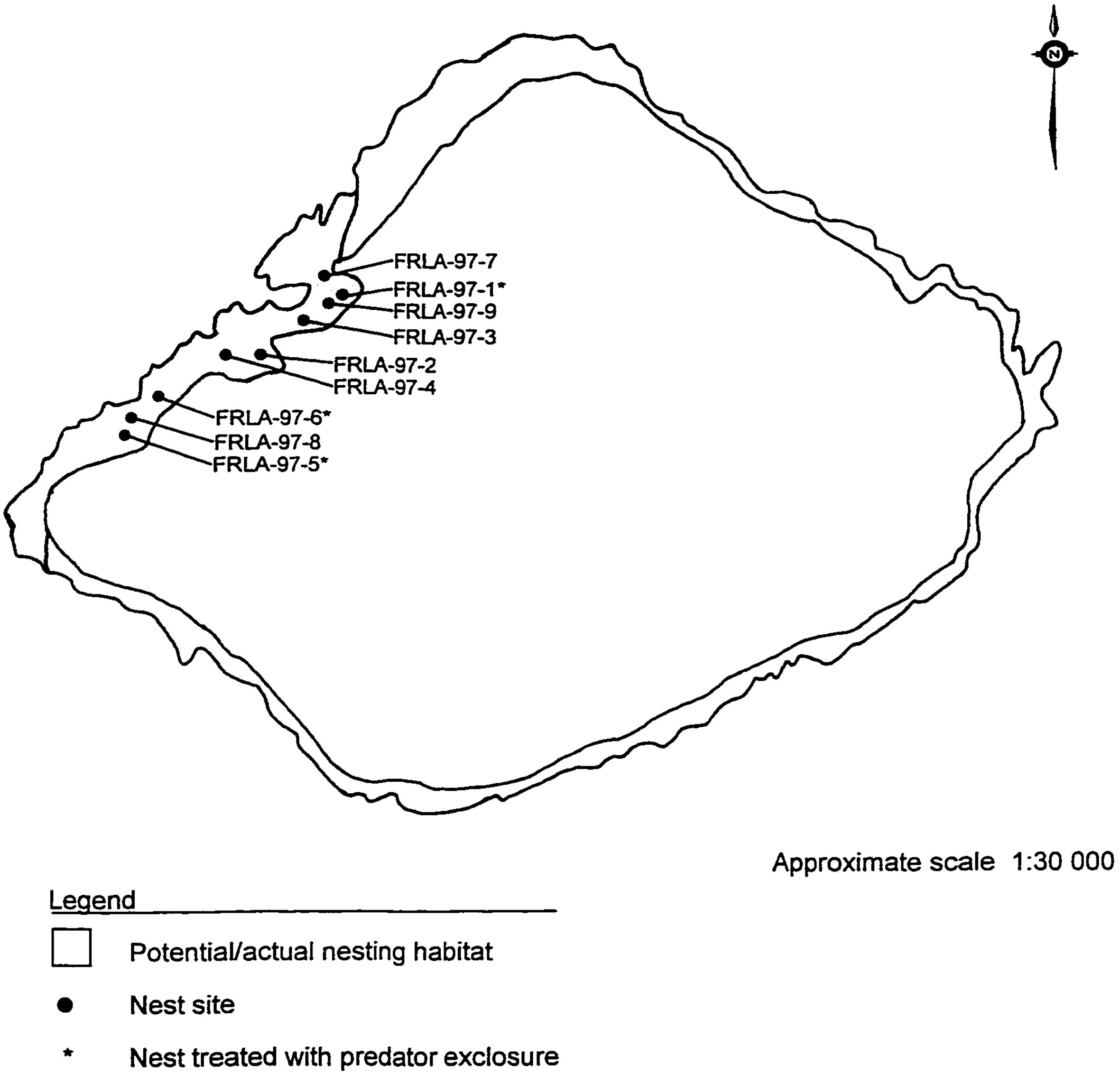


Figure 4. Nesting habitat and nesting sites on Freshwater Lake, Saskatchewan, 1997.

METHODS

The design of exclosures (Figure 5) chosen for this study was based on two factors. Consultation with wildlife managers in Alberta made it clear that in order for the cages to be used in a provincial management initiative, the design must be inexpensive (less than $15 CAN per cage), simple to construct and apply, and easy to transport. The final design also complied with the recommendations made by Deblinger *et al.* (1992) in their evaluation of cage designs used in previous studies. The predator exclosures used were, square-pyramidal in shape, made of four stucco wire mesh (5 cm by 5 cm) panels with a bottom width of 1.2 m, and a top width of 0.6 m. The sides of the panels were attached together with the ends of the cut stucco wire, resulting in a freestanding square pyramid. Once an exclosure was placed over a nest, one re-bar, 10 mm in diameter and approximately 1.5 m in height, was placed at each of the four corners for stabilization. Each exclosure was secured in place by inserting the ends of the re-bar into the substrate as well as inserting two 10-cm nails, bent at the top, into the ground on each of the four sides of the cage. Finally, to prevent aerial predators from entering the exclosure, the top of the exclosure was woven with bailing twine at 10 to 15 cm intervals.

Beginning in early spring (1 May 1996 and 29 April 1997), the study lakes were surveyed on foot for returning Piping Plovers by two researchers. Each lake was surveyed every two days and survey protocol followed the recommendations of

Figure 5. Predator exclosure on Reflex Lake.

Goossen (1990). Nests were located by monitoring adult Piping Plovers with a spotting scope from a distance of approximately 50 to 70 m. When found, nests were marked from 4 m away in order to help in relocating them during the application of exclosures. Nest sites were mapped by aid of air photos. Clutch initiation date and approximate hatching date were determined by direct observation and backdating of the egg-laying pattern based on a 34-day laying and incubation cycle (Haig 1992, Heckbert and Cantelon 1996).

Discovered nests were alternately designated as 'treatment' (enclosed) or 'control' resulting in sequential assignment of experimental groups and near-balanced sample sizes. To apply an exclosure to a nest, two researchers placed the fully constructed exclosure over the nest, and secured each corner of the structure to the substrate with the re-bar and with the bent nails at the bottom. Time measurements were taken for: (1) the time taken for researchers to leave the spotting scope to approach the nest, apply the exclosure to the nest, and return to the spotting scope ('application time'), (2) the time elapsed between the return of the researchers to the spotting scope until the adult resumed incubation of the nest ('return time'), and (3) the total time the incubating adult was off the nest during the application of the exclosure ('total flushing time'). Both control and treatment nests were marked and, for comparative purposes, return time and total flushing time were also measured during marking of control nests. After treatment, nests were observed for a maximum of two hours for the resumption of incubation. All nests were revisited every two days or less to check for predation, continuation of incubation or any changes in status.

To determine hatching success accurately, nests were monitored daily beginning three days prior to the estimated hatching date until hatching occurred. Potential nest and chick predators were noted when observed. Predation was assumed to have occurred when eggs disappeared from a nest well before the expected hatch date and where no unidentified (i.e. without leg bands) young were observed in the surrounding area.

To determine fledging rate accurately, hatched young were captured by hand and banded with colour celluloid leg bands in unique combinations corresponding to their nest of origin. Aluminum leg bands were also placed on all banded birds. The chicks were returned within close proximity to the parents and care was taken to ensure parents did not lose sight of their brood at any time during the procedure. To minimize stress on young birds, banding was carried out during the cool part of the day and any inclement weather was avoided. Broods were monitored for survival every five days until fledging at 25 days of age (Haig 1992).

Traditional nest success was calculated by dividing the number of successful nests (those hatching at least one chick) by the total number of nests initiated. Daily survival rates were calculated using the Mayfield method (Mayfield 1961, 1975). Conventional methods of comparing observed nest success, such as dividing successful nests by the total number of nests, usually overestimate success because all nests are not found at initiation and, indeed, some nests are not found at all (Mayfield 1961, 1975). To remedy this error, the Mayfield method not only takes into account the number of nests, but also the elapsed time of exposure (expressed as nest-days) for each nest (Mayfield 1975). For instance, a nest found on 12 May and still active on 20 May would have eight exposure days if the nest had been observed on every one of the eight days. If the nest was observed on the 12 May only and was found destroyed on 20 May, the nest would only be credited with four exposure days since it is not known exactly which day it was destroyed on. The estimated daily mortality rate of a group of nests is equal to the total number of nests lost while under observation divided by the total nest-days. For example, during this study in 1996, 17 treated nests were observed for a total of 400 nest-days. Three losses occurred while the nests were under observation. Therefore, the daily mortality rate (DMR) for treated nests in 1996 was 3/400 = 0.0075 losses per nest-day. The daily survival rate (DSR) of a nest is simply 1 – DMR or in this case 1 – 0.0075 = 0.9925.

Mayfield nest success is the probability that a nest survives the entire nesting period (Mayfield 1961, 1975, Johnson 1979). Therefore, Mayfield nest success during this study was calculated as DSR^{34} (i.e. the nesting period lasted 34 days; see 'Descriptive Biology' section, above). Exclosure effectiveness was measured by comparing survival rates using the program CONTRAST to calculate a generalized Chi-squared statistic (Hines and Sauer 1989; see Sauer and Williams 1989 for a thorough explanation of the procedure) at the 0.05 significance level.

Because adults were not marked, no assumptions were made about the identity of pairs making subsequent nesting attempts after nest loss. Each nest, and not the pair of birds associated with that nest, was considered the experimental unit. Therefore, it was possible for a pair of birds to initiate both control and treatment nests during one breeding season. Consequently, fledging success was measured as the number of young fledged per nest and not per pair. Fledging rates and time measurements were compared using independent *t*-tests at the 0.05 significance level.

RESULTS

The study was carried out from 1 May to 31 July 1996 and 29 April to 25 July 1997. Sixty-eight nests were found during the two years of study (35 in 1996, 33 in 1997) and 32 of these were treated with predator exclosures (Table 1).

Table 1. Summary of enclosed and control nest locations on study lakes, 1996-97.

Lake	Enclosed Nests			Control Nests			Total
	1996	1997	Sub-total	1996	1997	Sub-total	
Freshwater	n/a	3	3	n/a	6	6	9 (13%)
Killarney	7	3	10	9	4	13	23 (34%)
Reflex	10	9	19	9	8	17	36 (53%)
Total	17	15	32	18	18	36	68

The median nest initiation date was 21 May (range 8 May to 25 June) and the median hatching date was 22 June (range 8 June to 26 July). No differences in nest initiation or hatching dates were detected between the years of study ($P<0.05$). Exclosures were applied a mean of 7.71 d after clutch initiation (S.E.=3.68; range 3 to 23 d) and the mean installation time for exclosures was 2 min 53 sec (S.E.=1 min 8 sec; range 1 min 22 sec to 8 min 48 sec). Mean return time of adults was 2 min 41 sec (S.E.= 2 min 20 sec; range 5 sec to 11 min 55 sec) and mean total flushing time during the application of exclosures was 5 min 22 sec (S.E.=2 min 11 sec; range 1 min 53 sec to 12 min 17 sec). Neither mean return time or mean flushing time was significantly different between enclosed and control nests ($p=0.42$, $p=0.17$, respectively).

Of the total number of nests found, 66% of treated nests were successful in hatching chicks whereas only 33% of control nests were successful (Table 2 and 3). Overall, hatching success was significantly higher for treated nests than for control nests (P=0.015), however, hatching success of treated nests in 1996 was significantly higher than in 1997 (P=0.03). Whereas treated nests in 1996 had significantly higher hatching success than control nests (P=0.01), the same did not hold true in 1997 (P=0.52).

Table 2. Nest success of control nests, 1996-97.

Lake	Number of Nests Initiated			Number of Successful Nests[1]			Traditional Hatching Success[2]		
	1996	1997	Total	1996	1997	Total	1996	1997	Total
Freshwater	-	6	6	-	1	1	-	0.17	0.17
Killarney	9	4	13	2	2	4	0.22	0.50	0.31
Reflex	9	8	17	5	2	7	0.55	0.25	0.41
Total	18	18	36	7	5	12	0.39	0.28	0.33

[1] Successful nests were considered to be those that hatched at least one egg
[2] Number of successful nests divided by number of nests initiated

Table 3. Nest success of enclosed nests, 1996-97.

Lake	Number of Nests Initiated			Number of Successful Nests[1]			Traditional Hatching Success[2]		
	1996	1997	Total	1996	1997	Total	1996	1997	Total
Freshwater	-	3	3	-	3	3	-	1.00	1.00
Killarney	7	3	10	7	2	9	1.00	0.67	0.90
Reflex	10	9	19	7	2	9	0.70	0.22	0.47
Total	17	15	32	14	7	21	0.82	0.47	0.66

[1] Successful nests were considered to be those that hatched at least one egg
[2] Number of successful nests divided by number of nests initiated

Over the two years of study, the daily survival rate (i.e. the probability of the nest surviving during one day of the nesting period) of treated nests was significantly higher than that of control nests (P=0.0047; Table 4). Daily survival rates for treated nests in 1996 were not significantly different than in 1997 (P=0.0626), however, non-significance was marginal. Comparisons of daily survival rates of treated and control nests in individual years did not show a significant difference between experimental groups in 1997 (P=0.2584; Table 4).

Table 4. Daily survival rates of enclosed and control nests

Year(s)	Enclosed		Control		Significance[3] (P)
	DSR[1]	**MNS**[2]	**DSR**	**MNS**	
1996	0.9925	77%	0.9545	21%	0.0069
1997	0.9745	42%	0.9577	23%	0.2584
Overall	0.9846	59%	0.9561	22%	0.0047

[1] Daily Survival Rate
[2] Mayfield Nest Success
[3] Significance refers to comparison of Daily Survival Rates only

The mean number of fledged young per nest was significantly higher for treated nests than control nests (p=0.046; Table 5). Just as daily survival rates between experimental groups in 1997 were not significantly different, fledging rates for treated and control nests in that year were not significantly different (p=0.50; Table 5). When only successful nests from the two years of study were considered, no significant difference was detected between fledging rates for treated and control nests (p=0.56).

Table 5. Overall fledging rates[1] for enclosed and control nests, 1996-97.

Year	Enclosed	Control	Significance (p)
1996	1.29	0.44	0.033
1997	0.87	0.56	0.50
Overall	1.09	0.50	0.046

[1] Mean number of fledged young per nest

Predators destroyed 64% (23/36) of control nests but caused no failures of treated nests (0/32). In all cases, predation resulted in the disappearance of the full clutch of eggs. The typical appearance of the nest bowl after predation consisted of nest lining materials scattered around the original nest bowl, with no mammalian prints in close vicinity to the bowl. On four occasions, what appeared to be avian footprints were seen in or around nest bowls after predation had occurred, but no egg fragments were ever found.

Eleven treated nests failed during the two years of study: four failures were due to damage to exclosures caused by cattle, one failure resulted from the predation of an adult (the remains of an adult Piping Plover were found immediately outside the exclosure; the clutch remained complete and intact), one was an unexplained abandonment (late in incubation; the clutch remained intact) and five were the result of abandonments likely caused by a severe weather event in 1997 (heavy spring snowfall and below-average temperatures).

Cattle damage to exclosures resulted in four nest abandonments (three in 1996 and one in 1997). In all four cases, at least one of the sides of the cage was pushed in and severe trampling was visible around the perimeter of the structure. However, cattle damage did not always result in nest abandonment. For example, in 1997, cattle were observed loafing around an exclosure on the east side of Reflex Lake. The adult Piping Plovers were calling and running several metres away from the exclosure and the crowd of cattle. After the cattle had been encouraged to leave the area by the researchers, the nest was observed for one hour. Although the adults remained nearby, neither parent resumed incubating the eggs. Upon revisiting the nest the next day the nest was being incubated and eventually hatched successfully.

Five enclosed nests failed in 1997 were due to abandonments likely resulting from a severe weather event. All five nests were initiated prior to May 21 when the study area experienced heavy snowfall and sub-zero temperatures. The abandonments occurred from six to 21 days after clutch initiation and after both parents had been observed incubating the eggs after the application of the exclosures. All five abandonments occurred after May 21.

Potential predators recorded near or in nesting sites during the study included the following. Potential mammalian nest predators included coyotes (*Canis latrans*), weasels (*Mustela* spp.), and red fox (*Vulpes vulpes*). American Crows (*Corvus brachyrhynchos*), gulls (*Larus* spp.), and Black-billed Magpies (*Pica pica*) were considered potential predators of chicks and eggs. Short-eared Owls (*Asio flammeus*), Sharp-shinned Hawks (*Accipiter striatus*), Peregrine Falcons (*Falco peregrinus anatum*), Merlins (*Falco columbarius*), and weasels were occasionally observed and considered to be potential predators of both adults and chicks. Few mammalian predators were observed near nesting areas and only coyotes were observed on nesting beaches. Coyote tracks were occasionally observed on some areas of the study lakes and were regularly observed on a portion of Killarney Lake near an active den. Most observations of potential predators were of avian species.

American Crows were abundant around the study lakes and were commonly observed on nesting beaches. Although no direct observations of predation occurred, bird footprints, believed to be those of American Crows, were observed at four destroyed nest sites. Ring-billed Gulls were abundant on Reflex Lake and may have been another important nest predator. On the large west point on Reflex Lake, large numbers of Ring-billed Gulls were regularly observed in and around nesting areas.

All-terrain vehicle (ATV) tracks were observed infrequently on Killarney Lake and Freshwater Lake, but occurred well away from nesting areas. However, nesting substrates were damaged on the large west point on Reflex Lake on two occasions. The most severe damage occurred on 1 July 1997, when numerous deep tire tracks were encountered on nesting substrates and brood-rearing areas along the west side of the lake. Although the existing nests were not damaged, ATV use within brood-rearing areas may have been the cause of some chick mortality.

DISCUSSION

The predator exclosures used were effective in reducing Piping Plover nest predation, and increasing hatching and fledging success. During this two-year study over two-and-a-half times more enclosed nests were successful in hatching off chicks than control nests. Potential nest predators were restricted from reaching nests, and no nests were directly destroyed by predators once exclosures had been applied. Although no statistical difference in nest success was measured between control and enclosed nests in 1997, this does not mean that the predator exclosures were ineffective. Enclosed nests were still almost twice as successful as control nests in that year. Especially when dealing with an endangered species this result is certainly biologically significant if not statistically significant.

It is unclear what caused the reduction in the success of treated nests in 1997 as compared to 1996. In general, the study had a relatively small sample size; therefore, the outcome of just a few nests affected the results strongly. However, the small sample was not reflective of poor researcher effort but of the small population of Piping Plovers in general. Severe weather in 1997 likely affected nest success adversely, as sub-zero temperatures may have made it difficult for adults to keep eggs warm. However, we would expect nest success to have been lower for control nests as well, but this was not the case as nest success of control nests in 1997 was slightly higher than in 1996. However, on Reflex Lake, where seven of the eight treated nest failures in 1997 occurred, both treated and control nests had lower success in that year. All five of the weather related failures occurred on this lake. The collecting of snow on the binding twine at the top of the exclosures, may have been enough to cause the abandonment of some nests but this does not explain why abandonments resulted only on Reflex Lake.

Weather related losses of treated nests in 1997 likely masked possible benefits of using the exclosures. However, such losses are not unusual; Haig (1987) attributed 23.8% of nest failures to severe weather in Manitoba. Nevertheless, the results attained in 1996 are likely more typical and it is reasonable to predict that results pooled over several years are likely to be above that of this relatively short study.

The productivity of enclosed nests over the two years of study did not exceed the recruitment levels recommended by Ryan *et al.* (1993) or Plissner and Haig (in review) to stabilize population declines. However, because productivity was measured as chicks fledged per nest (and not per pair), and because it is possible for some pairs to make several nesting attempts during one breeding season, productivity estimates are conservative. A less conservative estimate, and likely more reflective of actual fledging rates, based on numbers of breeding pairs per lake and an estimate of the number of re-nests that occurred, may be closer to 1.46 chicks per pair. Using 25 days as fledging age may have further restricted productivity estimates. Murphy et al. (in prep.(a)) suggest that the large distances traveled by near-fledged chicks and early fledging may result in underestimating recruitment rates. They recommend that instead of the conventional fledging age of 25 days, fledging rates should reflect numbers of chicks observed at 18 to 20 days. A re-analysis of fledging data using 18 and 20 days as fledging age, results in recruitment rates for enclosed nests of 1.25 and 1.15 chicks per nest, respectively. Adjusting again for number of pairs and re-nests, fledging rates for enclosed nests during the study may have been as high as 1.68 chicks per pair.

The theory that predation was a significant cause of low reproductive success in the study area (Heckbert 1994, Heckbert and Cantelon 1996) was supported during this study. However, as with many other Piping Plover studies (Cairns 1977, Whyte 1985, Prindville 1986, Heckbert 1994, Heckbert and Cantelon 1996), no incidents of predation were witnessed, and the identity of nest predators was unclear. Destroyed nests were similar in appearance. Nest lining materials were often scattered around the original nest bowl, full clutches were always taken, and no shell fragments remained. Cairns (1977) observed adults removing shell fragments after hatching and carrying them approximately 40 m away. Whyte (1985) observed this same behaviour at a nest that was stepped on and believed that egg fragments may also be removed from the nest by the adults after predation. Whyte (1985) typically found destroyed nests with dried egg material in the nest lining and a few small egg fragments in and around the scrape but found no other evidence such as prints to elude to the identity of predators.

Crows were suspected as being a primary predator on the eggs. Crows were regularly observed flying very low over breeding areas apparently searching the shore. On a few occasions, what appeared to be crow prints were observed around nest scrapes.

Piping Plover nest predation by American Crows has been suspected in many studies (Whyte 1985, MacIvor 1990, Kruse 1993, Heckbert 1994, Dundas 1995).

Ring-billed gulls were also common on nesting beaches and were another likely nest predator. Gulls, especially Ring-billed and Herring Gulls (*Larus argentatus*), have been reported as major Piping Plover nest predators in other studies. Whyte (1985) suspected Ring-billed Gulls as the primary nest predator at Big Quill Lake, Saskatchewan and Mayer (1991) observed gulls depredating Piping Plover nests in North Dakota. Ring-billed Gull predation on Piping Plover nests was also observed by Ratcliff (1979) at Lake of the Woods, Ontario. Ratcliff (1979) reported the appearance of the nest after the incident to have many visible gull footprints around the scrape. Although it is not clear whether the obvious footprints were the result of soft sand, this description is not consistent with any of the depredated nests from this study.

The purpose of the predator exclosures is to protect the eggs from being destroyed by predators. However, due to the precocial nature of the species, the cages do nothing to protect chicks after they have hatched. In fact, the results from this study showed that once chicks from both control and enclosed nests had hatched and were out on the beaches, they suffered the same fate. Smith *et al.* (1993) found that recruitment rates could be improved further by erecting electric fences around nesting and feeding areas to protect against terrestrial chick predators such as coyotes, weasels and skunks.

Damage to exclosures caused by cattle caused the abandonment of four enclosed nests during the study. All four nests occurred on Reflex Lake where cattle were regularly observed on the beaches. In contrast, livestock pastures surrounding Killarney and Freshwater Lake are fenced to restrict cattle from accessing the shorelines of the lakes. Cattle rubbing on exclosures has also been reported by Heckbert and Cantelon (1996), Mabee (1996) and R. Murphy (pers. comm.). Cattle accessing nesting beaches does not only pose problems when exclosures are being used, however. Extensive damage to beach substrates caused by cattle trampling can cause deterioration of nesting and feeding areas. Deep footprints left by the heavy animals may also pose a threat to small chicks if they fall into them.

Although only one case of adult predation was recorded during this study, this potential problem needs to be considered by anyone using predator exclosures as a management tool. Recently, in the Great Plains, several adult Piping Plovers were killed directly outside of predator exclosures (Murphy *et al.* in prep.(b)). The multiple kills were eventually linked to a single Great Horned Owl (*Bubo virginianus*) apparently 'keying in' on the exclosures. Monitoring of exclosures during the nesting period is important to reduce the damage caused by so-called 'smart predators'.

Human disturbance of Piping Plover nesting areas was most apparent on Reflex Lake. All terrain vehicle use and recreational use of nesting beaches was likely higher than at the other study lakes due to the existence of the cabin development. Although signs were erected on two areas of the lake in 1995 (Heckbert and Cantelon 1996), further consultation with cabin owners may help to educate residents about the sensitivity of the nesting habitat.

The small, portable design of the exclosures used in the study was beneficial to not only the researchers but the birds as well. It was important that the design, potentially to be used in a large-scale management initiative, be inexpensive, easy to transport and quick to apply. Furthermore, the short time taken to erect the small structures minimized the amount of time adults were off their nests during application. Heckbert and Cantelon (1996), while using a much larger design of exclosure in the same study area, reported a mean installation time of 18.0 min compared to less than 3 min during this study. Adults were kept off their nests for a mean of 25.1 min by Heckbert and Cantelon (1996) while during this study adults were off their nests for approximately 5 min. Acceptance of the exclosures by the adult Piping Plovers did not prove to be a concern as adults invariably returned to incubate eggs within the exclosures and no difference was detected between return times to control versus enclosed nests. Although the current design may need modification in the future, alterations should not compromise the benefits of the current design of exclosures.

Although the focus of this study was targeted towards one species and a specific result, the effects extended beyond the confines of the research. For example, the benefits of excluding cattle from Piping Plover habitat do not only apply to the species in question. Fencing on Reflex Lake completed after the end of this study has improved habitat conditions for a number of avian species including Long-billed Curlew (*Numenius americanus*), Willet (*Catoptrophorus semipalmatus*), Marbled Godwit (*Limosa fedoa*), American Avocet (*Recurvirostra americana*), Le Conte's Sparrow (*Ammodramus leconteii*) and Nelson's Sharp-tailed Sparrow (*Ammodramus nelsoni*). A further positive spin-off from the research has resulted from the banding of the chicks. By October 1998, eight sightings of Piping Plovers banded during this study were reported from the wintering grounds thus adding valuable information to a poorly understood portion of Piping Plover biology.

The benefits of using predator exclosures support their continued use on Piping Plover breeding lakes in the Canadian prairies. The Atlantic and Prairie Piping Plover Recovery Teams support the use of predator exclosures as an important tool in the recovery of the species (Goossen *et al.*, in prep.). Biologists are frequently faced with a shortage of conservation dollars and must make decisions as to the most effective use of available financial and manpower resources. The results from this study show that recruitment rates can be more than doubled through the use of this relatively inexpensive and simple management tool. It is not the intention of this study to imply that predator exclusion cages are the singular solution or a permanent or long-term solution for the maintenance of a viable Piping Plover population. They are, however, in some cases, a necessary and effective tool to maintain local/regional populations while core limiting factors are being researched and resolved.

RECOMMENDATIONS

1. In order to maximize the success of exclosures, cattle should be restricted from nesting areas while nests are active (i.e. May through July). Fencing to restrict cattle from entering nesting areas has been successful on Killarney Lake, Freshwater Lake, and recently on Reflex Lake. Portable electric fencing may also be utilized where permanent fencing is not possible. Since nest sites may change between years, electric fencing can be moved and a 'buffer zone' can be created around a single nest or a cluster of nests. The possibility of placing rigid 'scratching posts' away from nest sites to attract cattle to those rather than to exclosures should be examined in future projects.

2. Research should continue to improve current designs and techniques in order to maximize increases in productivity. Ways of reducing the impact on nest success associated with cattle damage, weather and adult predation should be investigated. For example, suggestions by local raptor experts include designing the exclosures so that the top ends in a sharp spike, thus eliminating perch sites for raptorial birds (G. Court, pers. comm.). Other management techniques should also be investigated as to their benefits to further improving recruitment rates. For instance, the use of portable electric fencing around nest sites could be employed to restrict terrestrial chick predators.

3. Symbolic fencing (usually a single-strand of rope restricting entry to a nesting area) and signs should be used to minimize human disturbance of nesting areas. Although many nesting areas in Alberta and Saskatchewan are remote, signs and single-strand symbolic fencing will ensure nesting sites remain undisturbed during the nesting season (see 'Other factors' section in Chapter 2, below). Public education should also accompany recovery efforts to increase the likelihood of success. Interpretive talks, casual chats with locals, and informative brochures are ways of fostering positive attitudes from the public about endangered species. The use of local volunteers as interpreters and stewards of Piping Plovers has been successful in the Atlantic Provinces. Similar approaches to conservation could be adopted in the Canadian prairies.

4. Ongoing nest monitoring must be incorporated into any large-scale Piping Plover management initiative using predator exclosures. Although the results show that the cages were successful in increasing nest success, factors such as adult predation or cattle damage may present complications in the future. Our knowledge of the technique is not sufficient to warrant placing exclosures on nests in the spring and leaving them unattended until the end of the nesting season.

5. Population monitoring on key breeding sites should be incorporated into any management initiative in order to track local population trends. Some monitoring has already occurred in Alberta where annual counts on several breeding lakes have been carried out since 1989.

6. In order to impact population levels, predator exclosures should be used on all Piping Plover breeding lakes in the Canadian prairies as part of an intensive recovery effort. The third International Piping Plover Census planned for the year 2001 creates an opportunity to assess population levels, therefore, any predator exclosure initiative should continue until at least that year. A provincial or regional project coordinator should be assigned to oversee the activities associated with any predator exclosure project. Project coordinators should be in charge of raising funds, coordinating volunteer help and ensuring techniques used minimize negative impacts on the birds. A research component should also be part of such an initiative.

CHAPTER 2

Guidelines for the use of predator exclosures to protect Piping Plover nests[1]

BACKGROUND

This document makes recommendations on the construction, installation and monitoring of predator exclosures and is based on the experiences of those involved in predator exclosure studies in Alberta and throughout the range of the Piping Plover. This protocol will minimize the *ad hoc* use of predator exclosures and will enable wildlife managers to use these structures in an efficient and well-researched manner, which, in turn, will minimize impacts on the birds.

USING PREDATOR EXCLOSURES

CAUTION! Piping Plovers are an endangered species and are strictly protected by the Migratory Bird Convention Act and the Alberta Wildlife Act. Extreme care must be taken when dealing with this species. Do not undertake this initiative unless Environmental Protection, Wildlife Management Division has given approval and the required provincial and federal permits have been acquired.

[1] Reprinted from Richardson (1997)

How do predator exclosures work?

Predator exclosures are designed to exclude avian and mammalian predators from eggs while allowing the adult Piping Plovers easy access to the nest. The eggs and nest are protected by the structure during the laying and incubating stage; however, predator exclosures only protect the chicks for a short while after they have hatched. Within hours after hatching, Piping Plover chicks leave the immediate nest area to forage with their parents (Haig 1992). Chicks elude predators by crouching down and blending in with the substrate while their parents draw the predator away by feigning injury. The success of predator exclosures is based on the premise that by achieving a higher hatching success, there is greater chance that more young will survive to fledging and return to breed in subsequent years.

When should predator exclosures be used?

Nest predation is likely the greatest threat to Piping Plover nesting success on the Great Plains (Prescott 1997). Although Piping Plovers have always had to contend with predation, ecological change as a result of human activity has altered the landscape and led to increasing densities of potential predators such as American Crows (*Corvus brachyrhynchos*), gulls (*Larus* sp.), coyotes (*Canis latrans*), and striped skunks (*Mephitus mephitus*) (Melvin *et al.* 1991). Impacts of predation are often magnified, as Piping Plovers must contend with cumulative impacts of predation, human disturbance and habitat alteration and loss (Melvin *et al.* 1991). Although predator exclosures are not a singular cure, research shows that positive increases in nesting success are likely to result from their widespread use on nesting beaches in Alberta. Therefore, in most cases, it is reasonable to conclude that benefits will be gained by the use of predator exclosures around Piping Plover nests.

Other deciding factors

The utility of predator exclosures on a particular waterbody may be influenced by the existence of limiting factors other than nest predation. In some cases, using them in combination with other conservation techniques, such as signs, symbolic fencing, and public education, can increase the success of predator exclosures, and in other cases, caution must be used before committing to the use of the structures.

1. Factors that increase utility

Flooding- Some Piping Plover nesting habitat occurs on reservoir lakes or on basins where spring run-off or water-management leads to rising water levels during the nesting period (Espie *et al.* 1996). As a result, re-nests are interspersed along with the surviving nests on diminishing beach areas. Nests crowded into small areas have been shown to have greater chances of being found by predators that are systematically searching the area (Byrkjedal 1980).

Vegetation encroachment- This may result in Piping Plovers being crowded in small areas or in pairs leaving heavily vegetated areas in search of other nesting habitat (Cantelon *et al.* 1995). Again, crowding of nests in small areas may increase the probability of nest predation and thus, predator exclosures may prove especially useful.

2. Factors that reduce utility

Cattle- Increased use of predator exclosures in recent years has identified some risk in relation to using the structures on beaches accessed by cattle. Heavy trampling around, and damage to, exclosures caused by cattle may result in abandonment of the nest by Piping Plover adults. Most damage to exclosures occurs during large deerfly (Diptera: Tabanidae: *Crysops* spp.) hatches when cattle are congregating on beaches inhabited by plovers and are attracted to exclosures for the purpose of using them as 'scratching posts'. Ideally, cattle should be fenced out of nesting beaches during the nesting season (May to early August), or, minimally, while exclosures contain nests. If predator exclosures are used on beaches accessed by cattle, they should be closely monitored for disturbance.

If severe damage or trampling around exclosures occurs, the first defense should be to contact the landowner and have the cattle removed from the area until after the nest has hatched. If this is not possible, electric fencing can be placed around the nesting site. Another alternative that may divert the cattle away from the exclosure is to erect sturdy structures that act as 'scratching posts' at different locations along the beach away from where plovers are nesting. If all efforts prove fruitless and the behaviour of the adults indicates that abandonment is likely to result from continued disturbance by the cattle, the exclosure should be removed.

3. Other factors

Recreation- Recreation and human disturbance is a major limiting factor of Piping Plover reproductive success (Melvin *et al.* 1991, Haig 1992). Public education must be the first step when the interests of people conflict, or appear to conflict, with the interests of an endangered species. Meeting with interest groups, giving interpretive talks and posting signs can go a long way in fostering positive attitudes towards Piping Plover recovery efforts. Included with this document is an information sheet that can be copied and given out to interest groups or landowners.

Nesting areas subjected to the smallest amount of human disturbance should have signage and symbolic fencing incorporated with the use of exclosures. The most effective signs are those which are easily read at a distance, identify the area as a restricted sensitive shorebird nesting area, include a picture or silhouette of a plover, and have the name of the management agency involved (Melvin *et al.* 1991). Stringing single strand symbolic fencing around the nesting area alleviates confusion as to where the boundaries of the restricted area exist.

Guidelines for decision-making

The following is a description of an ideal location for the use of predator exclosures. Clearly, not all these conditions will apply to all Piping Plover breeding lakes in Alberta. Use this list and the other information included in this document as a guideline to make decisions on the applicability of predator exclosures on a site-specific basis.

The ideal candidate waterbody is one where:

1. Piping Plover populations on the basin have been studied over several years and predation of nests is known to be a significant limiting factor to reproductive success. In Alberta, several of these lakes have been identified including Killarney Lake and West Reflex Lake.
2. One or more other limiting factors exist that increase the necessity for predator exclosures.
3. The appropriate landowners and/or agencies have given approval for access to the nesting habitat and access routes.
4. The nesting habitat is easily accessed.
5. Cattle do not have access to the nesting habitat from May until August (see 'Other Deciding Factors' section, above).
6. The person/people involved in using the exclosures has time to do the recommended amount of monitoring (see 'Monitoring' section, below).
7. Any interest groups and/or landowners in the area are supportive of the endeavor.

INITIATING THE PROCESS

Identifying a Piping Plover

Piping Plovers (17-18 cm long) are one of several of the species with a single black neckband. Important characteristics during breeding include a short, stubby orange and black bill, orange legs, and a white rump conspicuous in flight. A dark band extends over the forehead from eye to eye. The colour of a Piping Plover's back has been described as resembling that of dry sand. In the early spring, the Semipalmated Plover (*Charadrius semipalmatus*), with its darker 'wet sand' coloured back, may be seen as it migrates to its arctic breeding grounds. The snowy plover (*Charadrius alexandrius*), whose breeding range overlaps that of the Piping Plover, has a similar pale back like the Piping Plover, but is smaller, has a longer, thinner dark bill and has greyish legs.

Male and female Piping Plovers can be distinguished on most occasions and with a little practice. In general, males tend to have a more complete breast band, brighter plumage, more bright orange on the bill, and a more pronounced white eyeline (Cairns 1982, Haig 1992). Many prairie males also have a black 'mustache', which extends over the bill and towards the cheeks (Haig 1992).

Breeding chronology

Adult Piping Plovers arrive on the breeding grounds in Alberta in late April into early May (Heckbert and Cantelon 1996, Prescott 1997). The first nests of the season are initiated in early May with most first nests being initiated around the second week of May (Heckbert and Cantelon 1996, Prescott 1997). If prior nesting attempts are unsuccessful, Piping Plovers may re-nest several times but typically will only raise one brood per season (Haig 1992). In Alberta, some late nests have been recorded in July (Alberta Fish and Wildlife 1991). Hatching generally begins in early June with the peak occurring near June 20 (Heckbert and Cantelon 1996). Departure for the breeding grounds continues from late July to early August.

Locating Piping Plover nests

Note: During your surveys, take time to examine each plover you encounter for leg bands. Make note of colour and/or metal bands and their position on the leg(s).

> **REMEMBER!** Extreme caution must be taken when surveying Piping Plover breeding habitat. Steps should be taken to minimize damage to the habitat and disturbance to birds at all times. All Terrain Vehicles should only be used to travel to nesting areas and should not be driven directly on nesting beaches.

Survey methods

Nesting beaches should be surveyed by walking approximately 60-70% of the way between the water's edge and the vegetation. Depending on the width of the beach, you may wish to adjust your position nearer or further from the water, and you may need to do two passes to cover beaches greater than 100 m in width. Move along parallel to the water's edge, while sometimes weaving closer to the water, and scan the entire beach as plovers can be seen anywhere from the water's edge to the vegetation line (Goossen 1990).

Finding nests

Although timing varies among years, nest searches should be conducted during peak nest initiation or shortly thereafter (i.e. around the third week of May). You may need to return a few times to find as many nests as possible.

Upon arriving on the breeding grounds, males immediately begin to establish territories and advertise for a mate by performing elaborate flight displays and calls. As part of the courting ritual, a male can be seen squatting, leaning forward and kicking out behind him as he scrapes out a shallow nest bowl. Several of these nest scrapes may be formed before both mates will choose one (Cairns 1982, Haig 1992).

Several clues exist that make it easier to locate nests. Pairs of plovers can be identified by their behaviour. Copulation, though more frequent during laying, continues throughout the nesting period as a way of maintaining the bond between the pair (Haig 1992). Once a pair bond has been established, both adults will pick a nest scrape and line it with tiny bits of gravel, bone or salt flakes through a ritual called 'stone tossing'. This behaviour continues throughout the laying cycle and some birds can be seen stone tossing during incubation. If both male and female are seen stone tossing into one scrape, it is likely they have chosen it as their nest and laying may have already begun or will begin soon.

When two plovers are identified as a pair, monitor each one carefully as both males and females share in the incubation duties. If one bird of a pair is seen sitting down very still and very close to the ground for a long period, it is likely sitting on a nest. Depending on the laying stage, eggs may not be incubated constantly, so although neither bird may be sitting, it does not mean that a nest does not exist. With patience, you will soon be rewarded by seeing one of the adults walk determinedly to an area on the beach and sit on a nest. When sitting, the plover will look down and straddle the eggs. Then, while fluffing the feathers on the chest area, it will squat, wiggle down and adjust itself over the eggs.

Marking the nest

Once a nest has been identified, it is important to mark it temporarily in order to find it easily when applying the exclosure. Look at the nest through the spotting scope and use landmarks such as rocks, pieces of wood or vegetation to help you memorize its location. Keep in mind that the way a nest looks through the spotting scope is not how it looks when you are standing beside it. If two people are available, one person can remain at the spotting scope and coach the second person to the nest.

REMEMBER! When walking in nesting habitat, extreme caution must be taken to avoid stepping on nests. To minimize this danger, try walking on large stones and check underfoot before each step. Remember that the nest you are attempting to protect may not be the only one in the area.

Approach the nest until you are approximately four metres away. At this distance, you avoid coming too close to the nest while still being able to see the eggs through your binoculars. Count the eggs and place a tongue depressor or other marking device four metres away from the nest bowl, perpendicular to the vegetation (or the spotting scope). If the exclosure will be applied during the same visit, the nest can be marked using a natural object such as a stick or a rock.

However, if a subsequent visit is required, it is recommended that, to reduce confusion when relocating the nest, an easily identified object like a tongue depressor be used. Marking the nest will decrease the chances of stepping on it when applying the exclosure. The location of the nest should be recorded and preferably mapped by aid of an airphoto or topographical map (Goossen 1990).

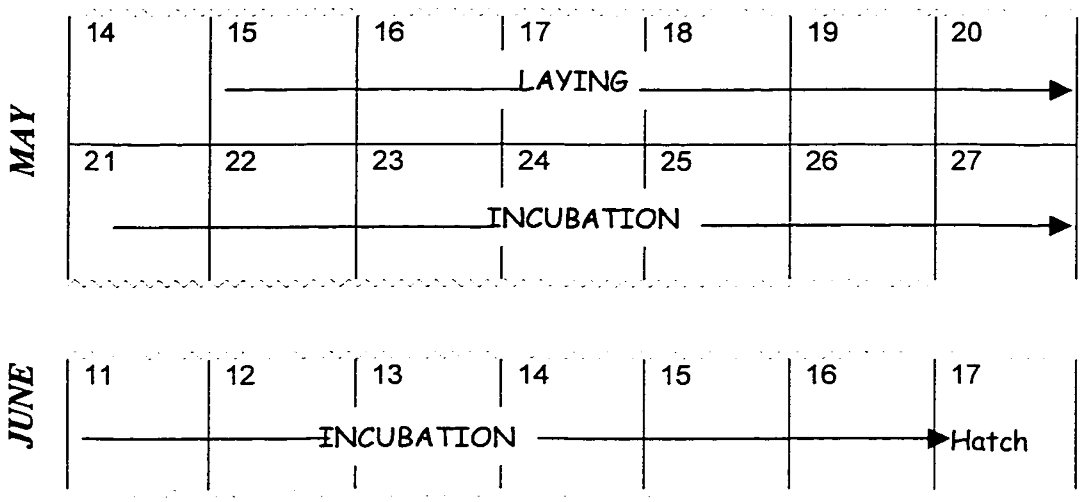
Estimating hatching dates

Estimating the hatching date of a nest will help you plan times to monitor the nest and to determine hatching success. Skilled observers with experience handling the eggs of an endangered species may choose to use techniques such as floating eggs[2] to estimate hatching dates. However, concerns have been raised about damage caused to eggs during floating and, consequently, non-intrusive methods such as backdating are recommended for the inexperienced observer. This task is better achieved when several visits have been made to the nesting area, as a single visit will rarely allow you to age a nest.

Hatching estimates are facilitated through knowledge of the chronology of the nesting cycle. Piping Plovers typically lay four eggs over a six or seven-day period with the first egg laid on day one and the other three eggs being laid every other day thereafter (Haig 1992). The incubation period lasts for an average of 28 days, totaling in a nesting period of approximately 34 days (Haig 1992).

[2] See Schwalback 1988 for guidelines on floating eggs to determine Piping Plover hatching dates.

Nests found with an incomplete clutch are aged by backdating of the laying cycle. A typical clutch contains four eggs (Haig 1992) but 3-egg and 5-egg clutches are possible. To illustrate the technique, let us say we find a nest on 19 May with three eggs. In order to estimate the earliest hatching date, we will assume that the third egg was laid the day before the nest was found. Using the 6-day laying cycle and a 28-day incubation cycle as a guideline, we can infer that the chronology of this nest looks like this:



For nests found with complete clutches, the task of estimating hatching dates is more difficult. Because incubation begins after the last egg has been laid, you can conclude that the nest cannot hatch any later than 28 days after the date it was found. Although crude, depending on how often you have monitored the nesting area and/or the pair before the nest was found, make a guess as to whether you have found the nest late or early in the incubation cycle and adjust the estimated hatching date accordingly.

For example, let us say we find a nest on 28 May with four eggs in it. We had visited the area a few days prior on 25 May and although we identified a pair and we suspected they had begun nesting, we were unsuccessful in finding a nest. In this case, it is reasonable to assume that the nest has been found early in incubation. Estimate that the eggs will hatch a few days short of the length of incubation. In our case, we would expect hatching to occur around 20 June.

If a nest is found on the first visit, or when no prior knowledge of the breeding pair is available, use the above information to make the best guess about when the nest will hatch. At a minimum, you will have an idea of the earliest and latest date the nest will hatch.

CONSTRUCTION AND APPLICATION OF PREDATOR EXCLOSURES

Several designs of predator exclosures have been used across the Piping Plover's range. The design included in this document has been tested in Alberta in 1995-1997 and is based on recommendations made by Deblinger *et al.* (1992) in their evaluation of different predator exclosure designs. These predator exclosures can be assembled in less than one hour, cost less than $15 (CAN) each in supplies, are easily transported and can be applied to a nest in about three minutes.

Materials needed:

4.8 m of galvanized stucco wire (5.0 cm x 5.0 cm grid, approximately 1.2 m in height)

4 iron re-bars (1.5 m)

8, 10.0 cm iron spikes bent at 90° approximately 1/3 of the way down

20 hog clips (optional)

hog clip pliers (optional)

binder twine

needle nose pliers

wire cutters

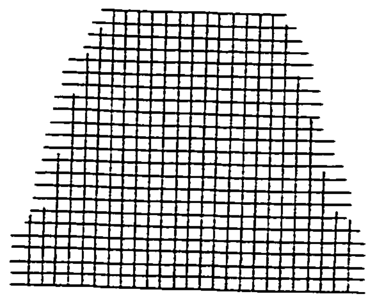
measuring tape

mallet

Steps for constructing a predator exclosure

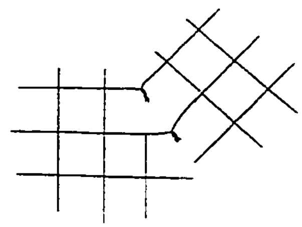
Step 1. Cutting the panels

Using wire cutters, cut four stucco wire panels with bottom width of 1.2 m and top width of 60 cm. As you cut on an angle, leave 2-3 cm of extra wire to use when attaching the panels.

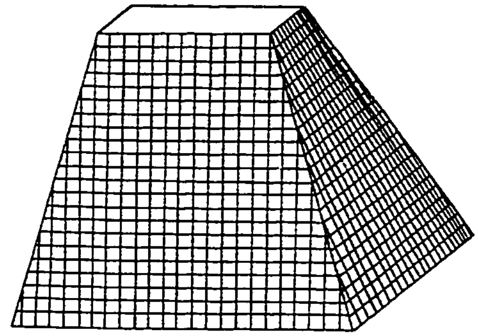


Step 2. Attaching the panels

Attach the four panels together by intertwining the cut ends of the stucco wire or attach the panels using five hog clips per side.

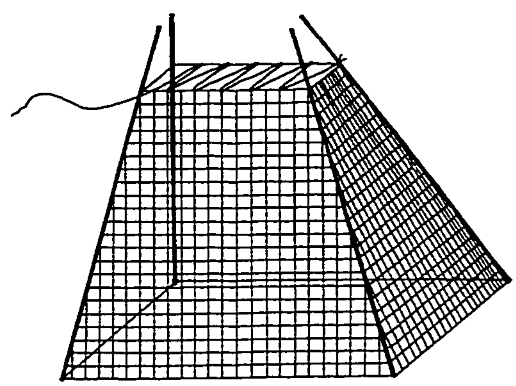


The result should be a square-pyramidal structure that stands on its own. Clip or tuck in all cut wire ends, especially near the bottom of the structure, as plovers could injure themselves when entering or exiting. To transport, the exclosure can be flattened to the size of two panels, and carried on one's back. It can be easily re-shaped once you have arrived at the nesting site.



Step 3. Final construction at the nest site

Once you have arrived at the nesting area, position yourself 50-70 m away from the nest, in order to minimize disturbance to the birds. Re-shape the exclosure so that it is a freestanding structure once again. Weave the four re-bars into each of the corners of the exclosure so that the bottoms of the re-bars are flush with the bottom of the exclosure. Finally, weave the binding twine across the top of the exclosure at 10-15 cm intervals.



Applying the exclosure to the nest

> **REMEMBER!** Predator exclosures should not be applied during extreme weather conditions as adults will flush from the nest when approached, leaving the eggs vulnerable to changes in temperature. Try to apply exclosures early in the morning or in the evening when temperatures are mild and not likely to harm unattended eggs.

Step 4. Placing the exclosure around the nest

Once the nest has been clearly marked (see 'Locating Piping Plover Nests' section, above), one or two people should approach the nest carrying the completely assembled exclosure and the eight bent spikes. Center the exclosure around the nest. Pulling the sides taught, insert the protruding re-bar into the substrate. If it is difficult to push in the re-bars, they may be pounded into the ground using a mallet. **Do not use rocks to pound re-bar as pieces may come loose and fall onto the eggs.** If a mallet is unavailable, push the re-bar in as far in as possible. Finally, place two bent spikes at the bottom of each of the four sides to secure the bottom of the exclosure into the substrate. You may now return to the spotting scope.

Step 5. Checking for resumption of incubation

Once the exclosure has been applied, your job is not over. The nest must be watched at least until one of the adults enters the exclosure and resumes incubating the eggs. By retreating to 100 m or more from the nest, you reduce the additive stress on the birds and may reduce the time taken for them to return to the nest. Depending on the magnification of the spotting scope, adults can be easily seen entering the exclosure from distances greater than 200 m (45x magnification). Often, this occurs within five minutes of exclosure application; however, in some cases adults may approach the nest several times but not enter the exclosure for up to one hour or more. Although very rare, in such a case, the nest should be watched for up to two hours (or less if the weather becomes inclement), at which time, if an adult has not returned, the exclosure should be removed.

If time permits, the exclosure should be monitored for acceptance by both adults. Once one adult has returned to incubate the eggs, the nest should be watched until the second adult comes to relieve the first of its incubation duties. While you are waiting, you may want to look for other nests or prepare to erect other exclosures. Depending on the incubation stage, trade-off of incubation duties occurs every 30 to 120 minutes (Haig 1992). If time restraints exist, make note of the sex of the incubating adult (see 'Identifying a Piping Plover' section, above) and try to return later to check for acceptance by the second adult. If symbolic fencing and signs are being used, they should be applied at this time.

To minimize stress to young chicks, the exclosures should be removed no sooner than 3 to 4 days after hatching when the chicks have left the immediate nest area.

Keeping an eye on the exclosures

Ideally, exclosures should be checked weekly. At a minimum, they should be checked at least once during the incubation cycle to confirm continued incubation is taking place and at least once after the estimated hatching date to confirm that the nest has hatched.

Any information about predator exclosures gathered by users is valuable for refining procedures and updating current data. During nest checks, if one of the adults is sitting on the nest, assume that incubation is proceeding normally. If no adult plover is seen in the exclosure or near the nest, the eggs may have hatched or the status of the nest has changed in some way.

During incubation, it is unusual for both adults to be away from the nest for extended periods. Within a few days of the expected hatching date, or when the hatching date is unknown, the absence of adults from the exclosure may mean that there are chicks nearby. One or two days after hatching the adults and chicks will move away from the nest scrape to feed and brood as a group while remaining within their territory. The first clue that the nest has hatched should be the vocalizations and the agitated behaviour of the adults as you near their territory. If only adults are spotted, take a closer look. Because young chicks cannot thermo-regulate, their parents will brood them by taking them under their wings and bellies. A brooding adult looks large and puffed up and will squat or sit close to the ground. If you have guessed correctly, you may see small legs peeking out from the adult's feathers and once they have warmed up or feel it is safe, the chicks will begin to emerge.

If you observe a nest for 15 minutes without seeing an adult on the nest, you should slowly approach the nest. As you do so, keep checking the nest for the return of an adult. When you reach the nest, record any changes in status or problems associated with the exclosures.

A. Have the eggs disappeared well before the expected hatching date. If so...

- Take another close look to see if there are chicks with adults nearby. The predicted hatching may have been inaccurate.
- Is there evidence of penetration of the exclosures by predators? Look for signs of digging under the exclosure or penetration through the binding twine. In addition, look for egg fragments or other signs left by the predators.

B. Are the eggs intact within the exclosure with no adults exhibiting agitated behaviour nearby? If so...

- Does the nest look abandoned? Is the exclosure undamaged and/or has sand begun to cover the eggs?
- Is there damage to the exclosure or immediate surroundings that has been caused by cattle? Look for heavy trampling around the perimeter of the exclosure and/or the sides being pushed in. Look to see if the cattle are still nearby.

- Is there evidence that the adults have been depredated[3]? Look for remains such as feathers, blood, bones or a carcass.

Brood monitoring

Monitoring of broods after they have hatched provides valuable information on the effectiveness of predator exclosures and the reproductive success of Piping Plovers. Typically, adults and young remain within 200m of the nest until the young fledge. On any visit to the nesting area, make note of the following:

- Number of young and adults
- The approximate age of the young and/or general appearance of the young, from downy chicks to fledglings[4].
- Whether young are from known or unknown nests. Remember that if there are several broods of varying ages on a beach it may be difficult to decipher them.

A form has been provided to aid in recording this information and other observations associated with this initiative.

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[3] Recently, in the Great Plains, several adult plovers were killed directly outside of predator exclosures by avian predators that seemed to be keying on the structures (Murphy et al. *in prep.*(b)). The majority of these incidents occurred within hours or days of hatching and is believed to have been caused by the increased activity and vocalizations of the parents due to the impending hatch (Murphy et al. *in prep.*(b)). If evidence of so called 'smart predators' exists in an area, all predator exclosures should be removed.

[4] Fledged or near fledged young resemble adult Piping Plovers with winter plumage. There is less contrast between the back and underparts, neck and headband are inconspicuous, and the bill is completely dark.

SUMMARY

Predator exclosures have been shown to significantly increase Piping Plover reproductive success. To date, exclosures have had limited use in Alberta associated with specific studies in small areas. The information contained in this document will enable wildlife managers from different jurisdictions, to utilize predator exclosures for the purpose of conserving the species.

Although years of research have led to the information contained in this document, there are still some things wildlife managers would like to know about exclosures. For instance, further research should be initiated into design alternatives that may make the exclosures less attractive to cattle and/or smaller and more portable. As exclosures become widely used in Alberta, it is anticipated that more of these questions will be answered.

Compilation of results is important and necessary to evaluate the success of this endeavor. Data should always be collected when using predator exclosures. A form, which can be reproduced, has been provided to help record your observations. Please fill one out for each exclosure you use and send it to the address below at the end of the breeding season.

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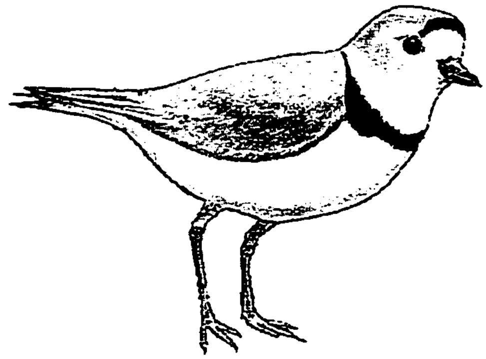
APPENDIX

Piping Plover Information Sheet

Piping Plover Predator Exclosure Data Sheet

Piping Plover
Information Sheet



What is a Piping Plover?

Piping Plovers are small migratory shorebirds that breed on beaches, alkali flats and sandflats in North America. In Alberta, these birds prefer to nest on sparsely vegetated gravel or sand beaches adjacent to large hyper-saline or alkali lakes and wetlands.

Closely related to the killdeer, the Piping Plover is much smaller, has a pale brown back and has one black neckband. A black band extends from one eye to the other; it has orange legs and a short black-tipped orange bill. Listen for its "*peep-lo*" alarm call.

Why is it endangered?

The Piping Plover's population levels have been decreasing since the 1940's. It is currently considered endangered in Canada and Alberta. Current threats include recreational use of their nesting beaches, habitat destruction, flooding due to water management and nest predation.

What is being done to help the Piping Plover?

Nest predation has been identified as a major threat to the survival of the Piping Plover across its range. Cages called predator exclosures are being erected around nests by wildlife managers to protect the eggs from predators such as crows, gulls, red foxes, coyotes and skunks.

What can you do to help?

Piping Plovers are very secretive birds and are easily disturbed. Refrain from approaching nesting areas or predator exclosures. If you see others disturbing the birds, please ask them to leave the area and educate them about the plight of this little bird.

If you have any further questions please contact your local Alberta Fish and Wildlife office or contact ____________________ at __________________.

Visit the Environmental Protection web site at http://www.gov.ab.ca/~env/ for more information on Piping Plovers and other species at risk in Alberta.

Piping Plover Predator Exclosure Data Form

Lake:____________________Your nest number:__________Year:___________

Legal Land Description:_______________Observer:______________________

Organization:______________________Contact Name:____________________

Address:___________________________________Phone:_______________

Date nest found:____________Number of eggs in nest:______________

Maximum clutch size: 1 2 3 4 5 Certain? Y N

Estimates: Clutch initiation:_______________Hatching date:_______________

Cattle have access? Y N Human Disturbance? None Light Heavy

Type?___________

Other management? Signs Symbolic fencing Other

Record of Nest Checks:

Date	Nest active? Y or N	Comments (additional comments can be put on the back)

Actual date of hatch:____________________Certain or Approximate

Number of eggs hatched: 0 1 2 3 4 5 Unknown

Record of Brood Checks:

Date	Total number of young	Young from this nest	Comments (additional comments can be put on the back)

Number of Young Fledged: 0 1 2 3 4 5 Unknown

Nest loss due to: none cattle human water predator other:________________

***Use the back of this form for additional comments or maps and to record any leg band sightings.

Please return to:
Steve Brechtel, Natural Resources Service, Wildlife Management Division, 7th Floor O.S. Long man Building, 6909-116 St, Edmonton, AB. T6H 4P2