ALBERTA PIPING PLOVER PREDATOR EXCLOSURE AND POPULATION MONITORING PROGRAM

2005 Field Season Report

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In cooperation with:

Alberta
COMMUNITY DEVELOPMENT

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Alberta
SUSTAINABLE RESOURCE DEVELOPMENT
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EXECUTIVE SUMMARY

Nest predation continues to be a significant limiting factor to the Great Plains piping plover population. Previous studies conducted in east-central Alberta and in the United States have shown that the use of predator exclosures can significantly reduce piping plover nest predation. Since 2002, predator exclosures have been applied to as many nests as possible in Alberta with the goal of increasing nest success and ultimately enhancing fledging success.

As a part of this program, annual surveys are conducted on core breeding lakes in order to better gauge population numbers and movement. These surveys complement the International Census conducted every five years across North America and are designed to monitor changes in populations and distribution. They also provide researchers with an opportunity to re-sight piping plovers banded in Alberta in previous years, as well as those banded in other jurisdictions. The information collected from band recoveries assists wildlife managers in determining dispersal patterns as well as adult and juvenile survival and complements the banding program being undertaken in Saskatchewan.

Predator exclosures used during the 2005 field season followed the same specifications as the 2004 models (Engley et al. 2004). Both models were small, quick to apply and of a similar design, the only difference being that one design was prefabricated by a steel manufacturer and reinforced with 3/16 gauge steel. Both designs were initially topped with a 2 cm x 2 cm plastic mesh; however, other materials were applied in response to coyote attacks on exclosed nests in which the netting failed to prevent the coyotes from preying upon the eggs. These materials included a second layer of 2 cm x 2 cm plastic mesh, 1.25 cm x 1.25 cm hardware cloth, 1 cm x 1 cm steel mesh, or 5 cm x 5 cm stucco wire (the same material used to construct the sides).

A total of 119 nests were found in 2005. Of the 109 exclosed nests with known fate, apparent nest success was 85.3% (93/109). The fate of only one of 6 unexclosed nests was known and that nest was preyed upon. Mayfield nest success was calculated to be 38.3% for unexclosed nests and 77.3% for exclosed nests.

Population inventories were carried out on 28 waterbodies. In Alberta, a total of 206 adults were located on 22 different waterbodies and an additional 34 adults were seen on the adjacent lakes in Saskatchewan. Increased water levels led to a much higher number of birds on some lakes that have been dry for the past several years. Piping plovers were located on Mott Lake, on Canadian Forces Base Wainwright, for the first time. Fledging success was calculated to be 21.6% and we calculated that 0.74 chicks per pair were fledged in 2005.

All activities carried out during the course of this project were done in support of the "*Alberta Piping Plover Recovery Plan 2005-2010"*. In particular, these activities were conducted to address Section 8.2 Productivity Enhancement, Section 8.3 Information and Outreach and Section 8.4 Population Monitoring and Research of the Recovery Plan. Results from this project were presented at the fall 2005 Alberta Piping Plover Recovery Team meeting.

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Please note that the results and recommendations presented in this report do not necessarily represent official positions of our funding agencies.

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1.0 INTRODUCTION

The piping plover is designated as "Endangered" in Canada (COSEWIC 2005), "Threatened" in the United States (United States Fish and Wildlife Service 2005), "Vulnerable" by The World Conservation Union (IUCN 2004) and is listed as "Endangered" under Alberta's *Wildlife Act* (Prescott 1997). Low productivity, primarily resulting from nest predation, has been identified as a significant limiting factor to piping plover populations in the Great Plains (Whyte 1985, Haig 1992, Heckbert 1994, Richardson 1999). Results from studies carried out in east-central Alberta from 1995 to 1997 showed that through the use of predator exclosures, piping plover nest predation can be significantly reduced thus increasing productivity (Heckbert and Cantelon 1996, Richardson 1999). Results from other jurisdictions have had similar results (Rimmer and Deblinger 1990, Melvin et al. 1992, Larson et al. 2002, Murphy et al. 2003). The Alberta Piping Plover Recovery Team has endorsed the use and continued refinement of predator exclosures as a management technique in the *Alberta Piping Plover Recovery Plan 2005-2010 (*Alberta Piping Plover Recovery Team 2005). This program has been ongoing since 2002 (Engley and Schmelzeisen 2002, Schmelzeisen and Engley 2003, Engley et al. 2004) and in addition to exclosure application, this program includes inventories on many lakes with the potential to support plover populations. These annual surveys will assist wildlife managers in determining the population trends and distribution of Alberta's piping plovers. Field crews have also become increasingly involved with the information and education component of the Recovery Plan.

2.0 STUDY AREA

The majority of this program was carried out on waterbodies in east-central and southeastern Alberta. Two lakes occurring in whole or in part in extreme west central Saskatchewan were also included in the study because of their proximity to the Alberta lakes in the program. These lakes were Freshwater Lake and the westernmost of the Reflex Lakes (hereafter referred to as Reflex Lake).

3.0 MATERIALS AND METHODS

Four researchers in two field crews carried out the majority of the work. All fieldwork was completed by 4 August 2005. One crew was stationed at Dillberry Lake Provincial Park along the Saskatchewan border just north of Provost, Alberta and monitored lakes occurring near to the Dillberry site and in the Provost area. The second crew was stationed on a part-time basis at Whitney Lakes Provincial Park, east of Elk Point, Alberta from which they monitored Muriel Lake and Frog Lake. The remainder of their time was spent stationed in Hanna, Alberta where they could monitor lakes in the surrounding area. Additional staff from the Alberta Conservation Association and Alberta Sustainable Resource Development assisted in project activities on lakes outside of the core program area. Field crews contacted landowners whenever it was necessary to cross private land to gain access to a lake.

3.1 Nest searches and monitoring

Beginning on 10 May 2005, potential breeding lakes were surveyed for returning piping plovers. The locations of nests found during lake surveys were recorded in UTM NAD 83 by using handheld Global Positioning Systems. To avoid disturbance to incubating adults, nests were

monitored from 50-100 m away using binoculars or spotting scopes. Nests were only approached when exclosures were to be applied, when nest contents needed verification or when no signs of activity were seen from a distance. As a rule, nests were monitored weekly throughout the incubation period. The status of the nests was recorded as: active incubation, nest predation (i.e. predation of eggs), damage to exclosures, abandonments, and hatching. Nests were considered to be successful if at least one egg hatched (Murphy et al. 1999).

3.2 Exclosures

Exclosure application and monitoring techniques followed the procedures outlined by Richardson (1997). Once located, the majority of nests had predator exclosures applied to them within one day of discovery, regardless of stage of laying or incubation. One researcher carried the exclosure to the nest and secured it to the substrate. After application, each nest was monitored to ensure adults resumed incubation. If adults did not resume incubation within 60 minutes (less if the weather turned inclement) the exclosure would be removed (United States Fish and Wildlife Service 1996).

Predator exclosures used during the 2005 field season (Figure 1) were the same as those used in 2002, 2003 and 2004 (Engley et al. 2004). The first design (referred to as a Type I exclosure in this report) was circular in shape, made of a single length of 5 cm x 5 cm stucco wire approximately 2 m long and 40 cm high. The two ends of the stucco wire were overlapped by three sections and attached using 10 cm nylon cable ties forming a circular exclosure 60 cm in diameter. In an effort to prevent predatory birds from perching on the exclosures, the horizontal wire along the top of the exclosure was removed in order to expose the vertical wires, creating 5 cm spikes around the top of the exclosure. Each exclosure was held in place by five 25 cm nails, bent at the top. The nails were evenly spaced and inserted through the bottom section of the exclosure in order to secure it to the substrate.

The second design (referred to as a Type II exclosure in this report) was very similar to the first, but was slightly tapered towards the top to facilitate stacking of the exclosures. It was also reinforced with two 3/16 gauge steel rings, one around the bottom and one 5 cms below the vertical spikes that were exposed. Finally, three 3/16 gauge steel rods were attached to the exclosure vertically at even intervals.

Both exclosure designs were initially covered with a 2 cm x 2 cm plastic mesh that was secured with 10 cm nylon cable ties. This material was intended to help prevent avian predators from perching on top of the exclosure. However, other materials were used as the field season progressed in an attempt to mitigate against coyote attacks on the exclosures. These materials included a second layer of 2 cm x 2 cm plastic mesh, 1.25 cm x 1.25 cm hardware cloth, 1 cm x 1 cm steel mesh, or 5 cm x 5 cm stucco wire (the same material used to construct the sides).

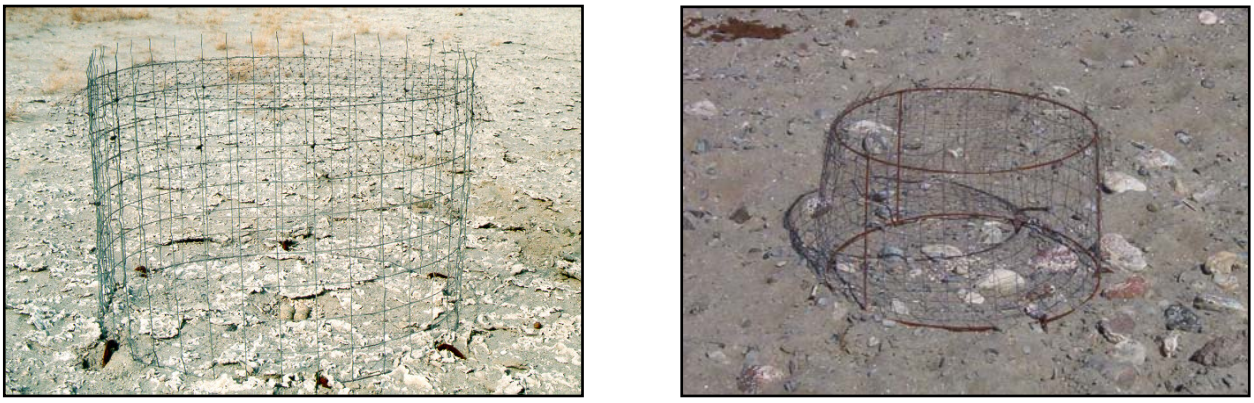

Figure 1. Type I (left) and Type II exclosure designs.

3.3 Population inventories

Adult surveys were conducted between 25 May and 7 June, during the peak of breeding activity, and followed guidelines outlined by Goossen (1990). Lakes were surveyed by walking approximately 60-70% of the way from the waters edge to the vegetation line and stopping periodically to scan for plovers. Location of adult plovers and breeding activity were recorded and mapped and all adults were checked closely for leg bands. Complete lake surveys were again conducted in July in order to assess habitat conditions and look for broods from nests that were never located.

3.4 Banding

Opportunistic banding of young plovers was also carried out. Young were captured using hand nets and marked with a combination of one metal, one black and white striped plastic band and one coloured Darvic^{TM} plastic band (green for birds banded in Alberta, white for birds banded on Freshwater lake). Bands were applied in combinations that allow band re-sightings to be traced back to the lake and year that the bird was banded. Researchers also weighed captured young in an attempt to link weight with age. In order to maximize the number of banded young that fledge, young were banded as close to age 18 days of age as possible.

3.5 Productivity analyses

Nest success was calculated by two methods.

1. Apparent nest success: Calculated by dividing the number of successful nests by the total number of nests with known fate. Apparent nest success usually overestimates nest survival rates because all nests are not found at initiation and some nests are not found at all. Nests found late in incubation are more likely to hatch than those found on the first day of incubation since they have a much shorter period of time to survive. To remedy this error, we also calculated:

2. Mayfield Nest Success: Calculated by determining Daily Survival Rate (DSR) of a group of nests (1-[#losses/number of exposure days]), raised to the power of 35, which is the number of days in the laying and incubation period of piping plovers (Murphy et al. 1999). Mayfield

success is the superior measure of calculating nesting success, as it considers only nests that are actually under observation for a known period of time (exposure days [Exp]; Mayfield 1961, 1975, Johnson 1979). Mayfield nest success was calculated separately for exclosed and unexclosed nests, and for all nests combined. In some cases a single nest may have contributed exposure days to both unexclosed and exclosed nest calculations.

Fledging success was calculated using a modified Mayfield approach following Flint et al. (1995). This method, which has been employed for a variety of species, including piping plovers (Elias et al. 2000), determines daily survival rates of chicks (1-[#chicks lost/total exposure days]) based on periods of time when broods are actually under observation. This method is also useful in that it allows inclusion of broods that were not followed through the entire chick period because either (a) return visits could not be made at a time when fledging (>20 days) should have occurred, or (b) broods were of unknown nest origin, so the specific number of chicks hatched was unknown. Fledging was assumed to occur at 20 days, and fledging success was therefore calculated as DSR^{20} (Engley et al. 2004). This calculation yields a conservative value, as calculations are based only on chicks that are actually observed, and some chicks are undoubtedly missed during visits.

Overall production per nesting attempt (OPN) in the province during 2005 was calculated as:

OPN = (Mayfield Nesting Success) x (Mean # eggs laid) x (% eggs in successful nest hatching) x (Mayfield Fledging Success).

Because productivity goals established in the provincial and national recovery plans (Alberta Piping Plover Recovery Team 2005, Goossen et al. 2002) are expressed as chicks/pair, rather than chicks/nesting attempt, we multiplied OPN by 1.2, based on the observation that the number of nests on well-surveyed Alberta lakes is typically 20% higher than the number of pairs known to occur on those lakes in the same year (Prescott and Engley, unpubl. data).

4.0 RESULTS

4.1 Population Inventories

Population inventories were conducted on 27 waterbodies in Alberta (Table 1, Figure 2). A total of 206 adults were located on 22 lakes during the course of these surveys. An additional 34 adults were located in Saskatchewan (20 on Freshwater Lake and 14 on the Saskatchewan side of Reflex Lake). Two adults were seen on Mott Lake, a lake never before surveyed for piping plovers.

Table 1. Alberta piping plover population inventories for 2005.

Lake	Adult Survey	Lake	Adult Survey
Reflex[1]	16(14)	Foster	6
Muriel	28	West	6
Killarney	22	Piper	5
Freshwater[1]	(20)	Rider	5
Red Deer	16	Baxter	4
Frog	15	Dowling	4
Birch	12	Little Fish	4
Akasu	9	Cipher	2
Chain #4	9	Mott	2
Clark	9	Albert	0
Handhills	9	Beaverhill	0
Horseshoe	8	Border	0
McLaren	8	Chain #1	0
Sunken	7	Gooseberry	0
		Total	**206 (34)**

[1] Numbers in parentheses are birds that were counted in Saskatchewan.

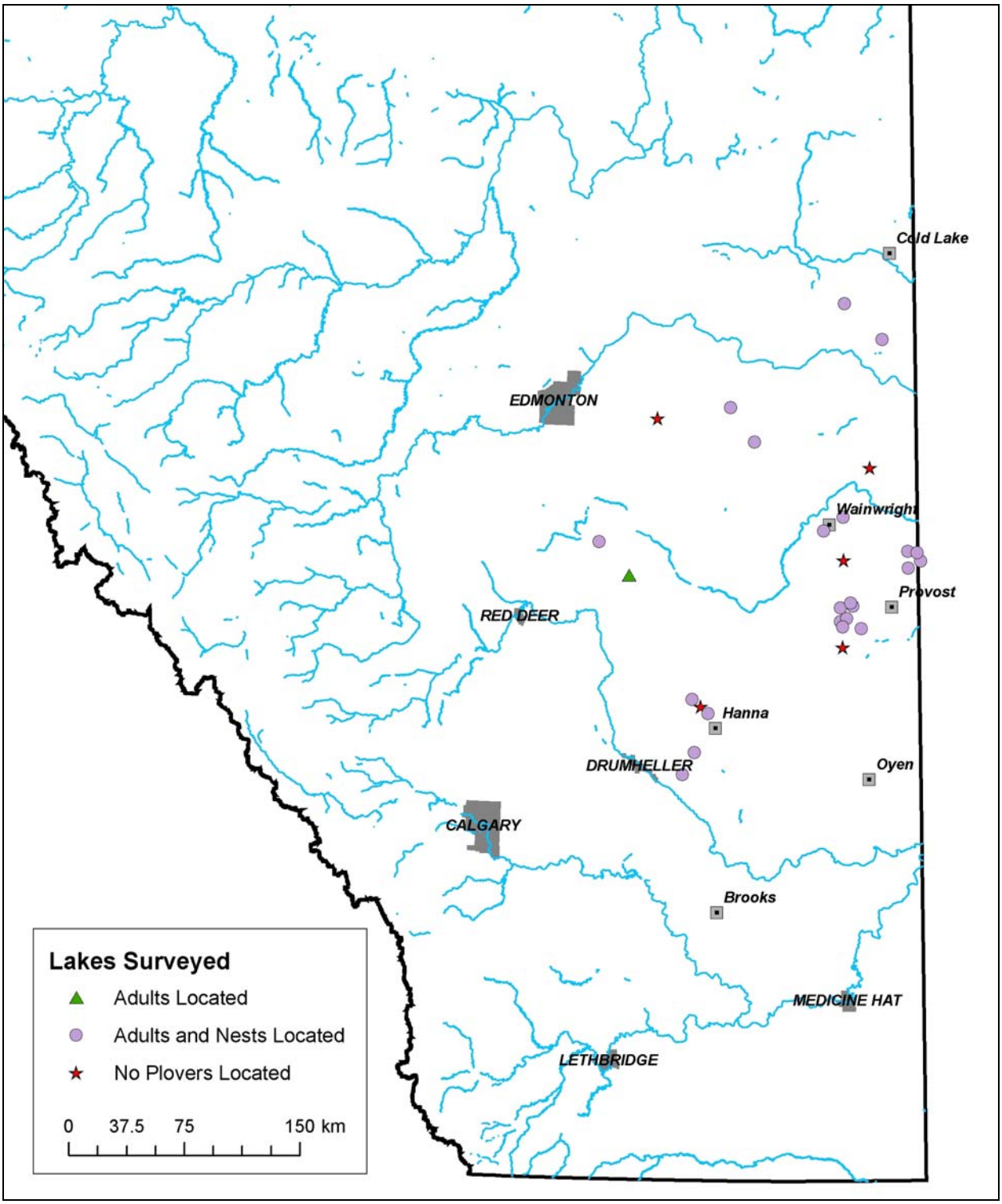

Figure 2. Location of lakes surveyed for piping plovers in 2005.

4.2 Nest Summaries

A total of 119 nests were found on 22 waterbodies (Figure 2, Table 2). The lakes with the highest number of recorded nests were Muriel Lake (n=17) and Killarney Lake (n=16). All other lakes had 10 or fewer recorded nests. For all nests where a full clutch size was known, mean clutch size was 3.96 $\pm$ 0.03 (n=112). Overall, apparent nest success was 84.5% (93/110) for nests with known fate. For nests that were treated with exclosures, 85.3% were successful (93/109). For nests where exclosures were not applied (n=6), only one had a known fate and it failed due to predation. Nest fate was unknown for a total of nine nests (five unexclosed and four exclosed). Mayfield nest success was calculated to be 38.3% for unexclosed nests (DSR = 0.9730 $\pm$ 0.0267, Exp = 37) and 77.3% (DSR = 0.9927 $\pm$ 0.0018, Exp = 2178) for exclosed nests. A test of significance was not conducted because of the small number of nests and exposure days for unexclosed nests. Overall, Mayfield nest success for all nests found in 2005 was 76.4% (DSR = 0.9923 $\pm$ 0.0019, Exp = 2215).

Table 2. Piping plover nest summaries for Alberta and adjacent Saskatchewan lakes in 2005.

Lake	Exclosed nests			Unexclosed nests			Overall		
	No. of Nests	Successful nests	Nest Success	No. of Nests	Successful nests	Nest Success	No. of Nests	Successful nests	Nest Success
Akasu	5	5	1.00	0	0	0.00	5	5	1.00
Baxter[1,2]	2	0	0.00	1	0	0.00[2]	3	0	0.00
Birch	7	6	0.86	0	0	0.00	7	6	0.86
Chain #4	5	5	1.00	0	0	0.00	5	5	1.00
Cipher	1	0	0.00	0	0	0.00	1	0	0.00
Clark	5	4	0.80	0	0	0.00	5	4	0.80
Dowling	1	1	1.00	0	0	0.00	1	1	1.00
Foster[2]	0	0	0.00	3	0	0.00	3	0	0.00
Freshwater	9	7	0.78	0	0	0.00	9	7	0.78
Frog	4	4	1.00	0	0	0.00	4	4	1.00
Handhills	4	4	1.00	0	0	0.00	4	4	1.00
Horseshoe	7	5	0.71	0	0	0.00	7	5	0.71
Killarney[1]	15	10	0.71	1	0	0.00	16	10	0.67
Little Fish	4	3	0.75	0	0	0.00	4	3	0.75
McLaren[1]	3	2[2]	1.00[2]	0	0	0.00	3	2	1.00
Muriel[2]	16	16	1.00	1	0	0.00	17	16	1.00
Mott	1	1	1.00	0	0	0.00	1	1	1.00
Piper	3	3	1.00	0	0	0.00	3	3	1.00
Red Deer	7	7	1.00	0	0	0.00	7	7	1.00
Reflex	10	8	0.80	0	0	0.00	10	8	0.80
Sunken	1	1	1.00	0	0	0.00	1	1	1.00
West	3	1	0.33	0	0	0.00	3	1	0.33
TOTALS[1,2]	**113**	**93**	**0.85**	**6**	**0**	**0.00**	**119**	**93**	**0.85**

[1] The fates of BALA-05-01, BALA-05-02, KILA-05-14, MCLA-05-02 were unknown and were therefore left out of nest success calculations. The total number of exclosed nests with a known fate = 109.

[2] The fates of BALA-05-03, FOLA-05-01, FOLA-05-02, FOLA-05-03, MULA-05-16 were unknown and were therefore left out of nest success calculations. The total number of unexclosed nests with a known fate = 1.

The following is a breakdown of the fates of the 119 nests found during the summer of 2005 (also see Table 3):

- 93 nests hatched with the exclosures applied.
- 7 nests with exclosures applied were predated by coyotes (all were Type II exclosures).
- 3 nests with exclosures applied were abandoned due to attempted nest predation by coyotes.
- 1 nest with exclosure applied was abandoned due to cattle disturbance.
- 1 nest with exclosure applied was abandoned due to vehicle activity.
- 4 nests with exclosures applied were abandoned for unknown reasons.
- 4 nests with exclosures applied had unknown fates.
- 1 nest with no exclosure applied was predated.
- 5 nests with no exclosures applied had unknown fates.

Table 3. Summary of nest failures and their causes.

Cause of nest failure	**Exclosed**		**Unexclosed**
	Type I	Type II	
Attempted nest predation	2	1	0
Cattle disturbance	1	0	0
Nest predation	0	7	1
Unexplained abandonment	2	2	0
Vehicle disturbance	1	0	0
Totals	**6**	**10**	**1**

4.3 Banding

Sixty-six young plovers were banded in 2005 (Table 4). This brings the total number of young banded since recovery efforts began in the summer of 1998 to 643. There were 84 re-sightings of birds banded previously in Alberta, Saskatchewan or on the wintering grounds and 31 could be traced back to their banding year and lake of origin (Appendix 2).

4.4 Fledging Success

Mayfield fledging success was calculated to be 21.6% (DSR = 0.9263 $\pm$ 0.0050, Exp = 2712).

Based on the mean clutch size (3.96 eggs), percent of eggs hatching (94.5%) Mayfield nest success (76.4%) and Mayfield fledging success at 20 days (21.6%), overall production per nesting attempt for 2005 was estimated to be 0.62 chicks/nest or 0.74 chicks/pair.

Table 4. Summary of young banded in 2005.

Lake	Band combination[1]	No. of young banded
Birch	(--,GB/W:--,m)	6
Chain #4	(m,G:--,B/W)	4
Freshwater	(--,W:B/W,m)	7
Frog	(m,--:--,B/WG)	1
Horseshoe	(--,B/Wm:--,G)	7
Killarney	(--,--:B/W,Gm)	19
Little Fish	(--,GB/W:m,--)	5
McLaren	(--,--:G,B/Wm)	5
Muriel	(m,--:B/W,G)	3
Red Deer	(m,--:--,GB/W)	3
West Reflex	(m,G:B/W,--)	6
		Total: 66

[1] Band combinations read as follows: upper left, lower left: upper right, lower right. Dashes (--) mean no bands were located on that part of the leg. Consecutive letters mean bands were stacked, where the first letter refers to the band used highest on the leg. Band types include the following: B/W=black over white striped plastic band, W=white darvic band, G=green darvic band, m=uncoloured metal band with serial number.

5.0 DISCUSSION

Activities for this project were undertaken in support of the *Alberta Piping Plover Recovery Plan 2005-2010* (Alberta Piping Plover Recovery Team 2005). Exclosure applications addressed section 8.2 Productivity Enhancement. Landowner liaisons addressed Section 8.3 Information and Outreach. Population inventories and banding of young addressed recovery actions under section 8.4 Population Monitoring and Research.

5.1 Population Inventories

The number of piping plovers recorded in Alberta in 2005 was substantially higher than in any year since large-scale recovery efforts began in 1998. The 206 plovers recorded is an increase of 37% (n=56) over the number recorded in Alberta during the 2001 International Piping Plover Census (Prescott 2001). Intensive management through this program and through the Alberta Piping Plover Habitat Enhancement Program, along with higher than average water levels in 2005 have likely resulted in this increase. It is worthy to note that population numbers in the U.S alkali lakes core area were up over 10% from 2004 numbers (Ryba 2005) and piping plover numbers in the Missouri River system were at record high levels in 2005, up 11% from previous record highs set in 2004 (Greg Pavelka, pers. comm.). In addition, numbers in various parts of Saskatchewan were either stable or increased in 2005 (Paul Goossen, pers. comm., Cheri Gratto-Trevor, pers. comm.). This is encouraging, since it appears that the increase in numbers in Alberta is not simply a result of birds moving from other jurisdictions.

5.2 Nest success

Contrary to our previous belief, Type II exclosures did not fare better in areas with high coyote activity than Type I exclosures. In fact, just the opposite occurred. Twenty five percent of the

nests in Type II exclosures were preyed upon or abandoned due to predators (8/32) whereas this occurred at just 2.5% (2/81) of the nests in Type I exclosures. Given that the Type II exclosures were much more visible than the Type I exclosures, field crews reasoned that the coyotes were finding nests visually. There was no pattern to the predation dates relative to exclosure dates, and predation occurred only at Type II exclosures even when Type I exclosures were located on the same lakes in close proximity to the effected nests. The added reinforcement to the sides did not help. In all but one of the coyote attacks, the coyote simply broke through the plastic mesh on top of the exclosure.

In response to these attacks, we applied other stronger materials to the tops of the exclosures. We experimented with three types of wire tops. Following these changes, a single Type II exclosure was pulled off a nest by a coyote and the eggs were preyed upon. An added feature of the wire tops was that the edges of the wire could be bent when attached to create a horizontally spiked rim around the top perimeter of the exclosure.

As a result of the relatively poor performance of the Type II exclosures in 2005 we chose to compare nest success between Type I and Type II exclosure for all three years in which they have both been used (2003-2005). Nest success for Type I exclosures was 84.7% (DSR = 0.9953 $\pm$ 0.0012, Exp = 3167). For Type II exclosures Mayfield nest success was 71.2% (DSR = 0.9906 $\pm$ 0.0025, Exp = 1484). The difference was not found to be significant. ($\chi^2 = 2.87$, $P < 0.10$).

5.3 Fledging success

A number of studies have been conducted to try to gauge fledging success of piping plovers and several different ages are used to consider a young plover fledged. Haig (1992) used 25 days, Larson et al. (2002) used 16 days and Murphy et al. (1999) recommended using 18-20 days. For the purposes of this study, any young seen that were 18 days or older were considered to have fledged. However, reduced funding in 2005 only allowed us to put minimal effort into brood monitoring giving us a poor estimate of fledging success. As a result, the calculations of chick per pair were based solely on mean fledging rates calculated using the modification to the Mayfield method presented by Flint et al. (1995). This method has been shown to be extremely accurate when compared to observed fledging rates for piping plovers (Engley et al. 2004).

The fledging rate for piping plovers was extremely low in 2005. Historically, fledging rates in Alberta have been approximately 40% (Prescott and Engley, in prep.). In 2005, it was just 21.6%. An extremely wet summer may have contributed to this. A number of severe weather events occurred throughout the breeding range in Alberta about the time eggs were hatching. In addition, high water levels on many lakes confined chicks to a narrow strip of shoreline. This likely made them easier targets for predators than when water levels are lower and they have large expanses of beach on which to disperse. Water levels on most lakes were at their highest levels since comprehensive data collections began in 1998. Even with the poor fledging rates in 2005, we calculated that the actual number of young that fledged in 2005 was higher than in 2004.

We continue to band birds to assist with estimating number of fledged young and for tracking movements. However, we see a large number of banded birds where one or more of the colour plastic bands have fallen off. This often makes it impossible to determine the lake and year in

which the bird was banded without recapturing the adult to read the metal band. Although the return of information from banded birds is less than desirable, discontinuing the banding component of this program at this point would not be beneficial. Participants at the Northern Great Plains Piping Plover Science Workshop considered banding of plovers to be a priority throughout the Great Plains (Westworth et al. 2004).

6.0 RECOMMENDATIONS

Exclosures continue to be very effective in increasing nest success for piping plovers. As a result, the application of predator exclosures should continue on as large a scale as funding will allow. Nest predation is not the only management issue that needs to be addressed with regards to piping plover recovery efforts. We make the following recommendations to those involved with piping plover recovery efforts in Alberta:

- Minor revisions should be made to exclosure design and application in an attempt to mitigate the effect of coyote predation on enclosed nests. After experimenting with three types of wire tops, we concluded that the stucco wire tops on Type I exclosures were the best combination since they were more rigid and less visible than those with mesh tops. However, a rigid top may allow predatory birds to perch on top of the exclosure (the reason that the plastic mesh tops were originally chosen). The Alberta Piping Plover Recovery Team suggested looking into methods of mitigating perching such as covering the wire top with "pigeon spikes".
- Exclosures should be left on beaches during the winter months to 'acclimate' predators to their presence when there is no prey inside. This may deter predators from keying into the exclosures during the breeding season.
- Continue recording brood age and numbers on all Alberta lakes for plover chicks at various ages. This will help to reduce project costs as fledging success can accurately be calculated from the modified Mayfield method DSR^{20} following Flint et al. (1995).
- A review of the banding program should be undertaken to determine methods of minimizing band loss to increase information gained from this component of the work. In the meantime, to reduce costs banding should be done on lake where a number of young can be banded with minimal effort.
- Continue to work with landowners and record habitat information. This information should be passed on to the coordinator of the Alberta Piping Plover Habitat Enhancement Program, where efforts can be made to reduce the impacts of livestock and vehicles.
- Experiment with alternative methods of predator deterrence. Removal of corvid nests during the winter should continue on lakes in areas with high piping plover populations.
- Carry out all actions through this program with the support of the Alberta Piping Plover Recovery Team. The Alberta Conservation Association is a member of the Recovery Team and will seek approval for all program actions prior to them being implemented in 2006.

7.0 LITERATURE CITED

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APPENDIX 1. Original nest data from 2005 field season.

Nest Number	Exclosure Type	Mesh Cover Used	Eggs Laid	Eggs Hatched	Fate	Comments
AKLA-05-01	I	2 cm^2 Plastic	4	4	Successful	
AKLA-05-02	I	2 cm^2 Plastic	4	3	Successful	
AKLA-05-03	I	2 cm^2 Plastic	4	4	Successful	
AKLA-05-04	I	2 cm^2 Plastic	4	4	Successful	
AKLA-05-05	I	2 cm^2 Plastic	4	3	Successful	
BALA-05-01	II	2 cm^2 Plastic	4	?	Unknown	Adult was incubating when the nest was last visited.
BALA-05-02	II	2 cm^2 Plastic	4	?	Unknown	Adult was incubating when the nest was last visited.
BALA-05-03	None	None	4	?	Unknown	Adult was incubating when the nest was last visited.
BILA-05-01	I	2 cm^2 Plastic	4	1	Successful	
BILA-05-02	I	2 cm^2 Plastic	4	4	Successful	
BILA-05-03	I	2 cm^2 Plastic	4	4	Successful	
BILA-05-04	I	2 cm^2 Plastic	4	4	Successful	
BILA-05-05	I	2 cm^2 Plastic	4	4	Successful	
BILA-05-06	I	2 cm^2 Plastic	4	4	Successful	
BILA-05-07	I	2 cm^2 Plastic	4	0	Abandonment	Attempted coyote depredation
CHL4-05-01	I	2 cm^2 Plastic	4	4	Successful	
CHL4-05-02	I	4 cm^2 Plastic	4	4	Successful	
CHL4-05-03	I	4 cm^2 Plastic	4	3	Successful	
CHL4-05-04	I	Stucco	4	3	Successful	
CHL4-05-05	I	2 cm^2 Plastic	4	4	Successful	
CILA-05-01	II	2 cm^2 Plastic	4	0	Abandonment	Reason for abandonment unknown
CLLA-05-01	I*	2 cm^2 Plastic *	4	4	Successful	* Exclosure was replaced with a Type II exclosure with a 1.25 cm^2 steel mesh top on June 15.
CLLA-05-02	I*	2 cm^2 Plastic *	4	4	Successful	* Exclosure was replaced with a Type II exclosure with a 1.25 cm^2 steel mesh top on June 15.
CLLA-05-03	II	2 cm^2 Plastic	4	0	Predated	Coyote depredation
CLLA-05-04	I	Stucco	4	4	Successful	
CLLA-05-05	I	Stucco	4	3	Successful	
DOLA-05-01	I	2 cm^2 Plastic	4	3	Successful	
FOLA-05-01	None	None	?	?	Unknown	Adult was incubating when the nest was last visited
FOLA-05-02	None	None	?	?	Unknown	Adult was incubating when the nest was last visited
FOLA-05-03	None	None	?	?	Unknown	Adult was incubating when the nest was last visited
FRLA-05-01	II	2 cm^2 Plastic *	4	3	Successful	* Cover was replaced with a 1 cm^2 steel mesh on June 14.
FRLA-05-02	II	2 cm^2 Plastic	4	4	Successful	
FRLA-05-03	II	2 cm^2 Plastic *	4	4	Successful	* Cover was replaced with a 1 cm^2 steel mesh on June 14.
FRLA-05-04	II	1 cm^2 Steel	4	4	Successful	

Nest Number	Exclosure Type	Mesh Cover Used	Eggs Laid	Eggs Hatched	Fate	Comments
FRLA-05-05	II	2 cm^2 Plastic	4	0	Predated	Coyote depredation
FRLA-05-06	I	2 cm^2 Plastic (x2)	4	4	Successful	
FRLA-05-07	I	Stucco	4	4	Successful	Attempted coyote depredation
FRLA-05-08	I	Stucco	4	4	Successful	
FRLA-05-09	I	Stucco	1	0	Abandonment	Reason for abandonment unknown
FROG-05-01	I	2 cm^2 Plastic	4	3	Successful	
FROG-05-02	I	2 cm^2 Plastic	4	4	Successful	
FROG-05-03	I	2 cm^2 Plastic (x2)	4	4	Successful	
FROG-05-04	I	2 cm^2 Plastic (x2)	4	4	Successful	
HALA-05-01	II	2 cm^2 Plastic	4	4	Successful	
HALA-05-02	I	2 cm^2 Plastic	4	4	Successful	Cattle damaged the original exclosure. It was replaced with the same exclosure type and mesh cover on June 6.
HALA-05-03	I	2 cm^2 Plastic	4	3	Successful	
HALA-05-04	I	Stucco	4	4	Successful	
HOLA-05-01	I	2 cm^2 Plastic	4	0	Abandonment	Reason for abandonment unknown
HOLA-05-02	I	2 cm^2 Plastic (x2)	4	3	Successful	
HOLA-05-03	I	2 cm^2 Plastic	4	4	Successful	
HOLA-05-04	I	2 cm^2 Plastic (x2)	4	0	Abandonment	Attempted coyote depredation
HOLA-05-05	I	Stucco	4	4	Successful	
HOLA-05-06	I	Stucco	3+	2+	Successful	Nest found with 1 egg and 1 YOY, 2 YOY were seen at a later date in the area and 1 egg was still in the nest.
HOLA-05-07	I	Stucco	4	4	Successful	
KILA-05-01	II	2 cm^2 Plastic	4	0	Failed	Coyote depredation
KILA-05-02	II	2 cm^2 Plastic	4	0	Failed	Coyote depredation
KILA-05-03	None	None	?	0	Predated	Coyote depredation – nest wasn't approached when found therefore the egg count is undetermined
KILA-05-04	II	Stucco	4	4	Successful	
KILA-05-05	II	Stucco	4	4	Successful	
KILA-05-06	I	2 cm^2 Plastic (x2)	4	4	Successful	
KILA-05-07	II	2 cm^2 Plastic (x2)	4	4	Successful	
KILA-05-08	II	2 cm^2 Plastic (x2)	4	0	Predated	Coyote depredation.
KILA-05-09	I	Stucco	4	4	Successful	
KILA-05-10	I	Stucco	4	4	Successful	
KILA-05-11	I	Stucco	4	4	Successful	
KILA-05-12	I	Stucco	4	4	Successful	
KILA-05-13	II	Stucco	4	0	Abandonment	Reason for abandonment unknown
KILA-05-14	I	Stucco	4	?	Unknown	Adult was incubating when the nest was last visited.
KILA-05-15	I	Stucco	4	3	Successful	
KILA-05-16	I	Stucco	4	3	Successful	
LFLA-05-01	I	2 cm^2 Plastic	4	4	Successful	
LFLA-05-02	I	2 cm^2 Plastic	4	3	Successful	

Nest Number	Exclosure Type	Mesh Cover Used	Eggs Laid	Eggs Hatched	Fate	Comments
LFLA-05-03	I	2 cm^2 Plastic (x2)	4	4	Successful	
LFLA-05-04	I	2 cm^2 Plastic (x2)	4	0	Abandonment	A vehicle crushed the exclosure.
MCLA-05-01	I	Stucco	4	3	Successful	
MCLA-05-02	I	2 cm^2 Plastic	3+	3+	Unknown	Nest was found with 3 eggs on June 1 but wasn't revisited until July 1. No eggs were in the nest and no YOY were seen when revisited.
MCLA-05-03	I	2 cm^2 Plastic	4	4	Successful	
MOLA-05-01	I	Stucco	3	3	Successful	
MULA-05-01	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-02	I	2 cm^2 Plastic	4	3	Successful	
MULA-05-03	II	2 cm^2 Plastic	4	4	Successful	
MULA-05-04	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-05	I	2 cm^2 Plastic	4	2	Successful	
MULA-05-06	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-07	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-08	I	2 cm^2 Plastic	4	3	Successful	
MULA-05-09	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-10	II	2 cm^2 Plastic	4	4	Successful	
MULA-05-11	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-12	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-13	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-14	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-15	I	2 cm^2 Plastic	4	4	Successful	
MULA-05-16	None	None	1+	?	Unknown	Nest found with 1 abandoned / unhatched egg, no YOY were seen.
MULA-05-17	I	2 cm^2 Plastic	4	4	Successful	
PILA-05-01	II	2 cm^2 Plastic	4	4	Successful	
PILA-05-02	I	2 cm^2 Plastic	4	4	Successful	
PILA-05-03	II	2 cm^2 Plastic	4	4	Successful	
RELA-05-01	II	2 cm^2 Plastic	4	0	Depredation	Coyote depredation
RELA-05-02	II	2 cm^2 Plastic *	4	4	Successful	* Top replaced with 1.25cm^2 steel mesh on June 14.
RELA-05-03	II	2 cm^2 Plastic *	4	4	Successful	* Top replaced with 1.25cm^2 steel mesh on June 14.
RELA-05-04	I	2 cm^2 Plastic	4	4	Successful	
RELA-05-05	II*	2 cm^2 Plastic *	4	4	Successful	* Top replaced with 1 cm^2 steel mesh on June 14. Exclosure replaced with a Type I exclosure with 2 cm^2 Plastic (x2) top on June 24.
RELA-05-06	II	1 cm^2 " Steel	4	0	Depredation	Coyote depredation
RELA-05-07	I	Stucco	4	4	Successful	
RELA-05-08	I	2 cm^2 Plastic	4	3	Successful	
RELA-05-09	I	2 cm^2 Plastic (x2)	3	3	Successful	
RELA-05-10	I	2 cm^2 Plastic (x2)	4	4	Successful	

Nest Number	Exclosure Type	Mesh Cover Used	Eggs Laid	Eggs Hatched	Fate	Comments
RDLA-05-01	I	2 cm^2 Plastic	4	4	Successful	
RDLA-05-02	I	2 cm^2 Plastic	4	4	Successful	
RDLA-05-03	I	2 cm^2 Plastic	4	4	Successful	
RDLA-05-04	I	2 cm^2 Plastic	4	4	Successful	
RDLA-05-05	II	2 cm^2 Plastic	4	4	Successful	
RDLA-05-06	II	2 cm^2 Plastic	4	4	Successful	
RDLA-05-07	II	2 cm^2 Plastic	4	4	Successful	
SULA-05-01	I	Stucco	4	3	Successful	
WELA-05-01	II	Stucco	4	0	Abandonment	Attempted coyote depredation
WELA-05-02	I	Stucco	4	0	Abandonment	Cattle crushed the exclosure.
WELA-05-03	I	Stucco	4	2	Successful	Exclosure damaged by cattle

APPENDIX 2. Adult plover band recoveries in 2005.

Band combinations read as follows: upper left, lower left: upper right, lower right. Dashes (--) mean no bands were located on that part of the leg. Question marks (?) mean that it is not known whether a band was on that part of the leg or not. Consecutive letters mean bands were stacked, where the first letter refers to the band used highest on the leg. Letters divided by a slash ("/") indicate a stripped band of two colors (ie B/W = a black over white striped band) Uncoloured metal bands are indicated by a lower case "m". Bands with flags are abbreviated with a lower case "f" after the color (ie Wf=white band with a flag). The following abbreviations are used for plastic band colors: W=white, Y=yellow, O=orange, R=red, G=green, dG=dark green, pG=pale green, dB=dark blue, pB=pale blue, B=black, S=silver(grey).

Example: (m,SY:Wf,pG) reads metal band on the upper left leg, a grey over yellow band on the lower left leg, a flagged white band on the upper right leg, and a pale green band on the lower right leg.

Lake	Band combination	Apparent sex	Dates observed	Original banding location
Akasu*	(--,m:B/W,Y)	M	May 27, June 10,17,24,30	Reflex, AB 2002
Birch*	(--,m:B/W,--)	M	June 8	AB
Birch*	(W,m:O,R)	F	June 24	Diefenbaker, SK 2004
Birch	(--,B/Wm:--,Y)	U	July 14	Horseshoe, AB 2004
Foster*	(W,dB;?, m)	F	June 9	?
Freshwater	(m,SY:Wf,pG)	M	May 13	Diefenbaker, SK 2003
Freshwater	(m,--:B/W,--)	M	May 13, June 6	AB
Freshwater*	(W,m:--,OO)	M	May 13, June 6 (FRLA-05-05), June 16, July 4 (KILA-05-14)	Manitou, SK 1998 rebanded on Manitou, SK 2002
Freshwater	(m,SS:Wf,G)	F	May 22, June 22	Bliss, SK 2003
Freshwater	(--,--:--,m)	M	May 22, June 22	?
Freshwater	(B/W,--:?,?)	F	June 6	AB
Freshwater	(--,m:B/W,Y)	M	June 6	Reflex, AB 2002
Freshwater	(m,OpG:Wf,pG)	M	June 22	Diefenbaker, SK 2002
Freshwater	(B/W,--:m,--)	U	June 17	AB
Freshwater	(--,--:--,m)	F	June 22	?
Frog	(--,m:--,Y)	M	June 15	?
Frog	(--,--:--,m)	M	May 23	?
Frog	(--,G:B/W,m)	M	May 23	Muriel, AB 2003
Frog	(W,--:m,--)	F	May 23	?
Frog	(--,--:B/W,m)	F	May 23	AB
Handhills*	(W/B,--:m,--)	F	June 22, June 30, July19	AB
Handhills	(?,?:?,m)	U	June 30	?
Horseshoe*	(--,--:Ym,--)	M	June 1	AB 1996 or 1997
Horseshoe	(--,m:--,--)	U	June 30	?
Horseshoe	(--,--:--,m)	F	July 5	?
Killarney*	(Bf,dBY:m,Y)	F	May 21, June 22	Diefenbaker, SK 2004
Killarney*	(--,m:B/W,--)	F	May 21	AB
Killarney	(B/W,--:--,m)	M	June 2	AB
Killarney	(?,--:?,Y)	F	June 2	?
Killarney*	(?,m:--,Y)	F	June 6	?
Killarney *	(--,m:B/W,Y)	M	June 6, June 22, July 13	Reflex, AB 2002
Killarney*	(--,m:B/W,Y)	F	June 16	Reflex, AB 2002
Killarney	(--,m:--,--)	M	June 21	?
Killarney	(W,dB:--,m)	F	July 4	Diefenbaker, SK

Killarney*	(--,m:W/B,--)	F	July 4	AB
Killarney	(--,m:W/B,Y)	M	July 13	Reflex, AB 2002
Killarney	(--,m:B/W,W)	F	July 13	Freshwater, SK 2003
Killarney	(--,Y:m,?)	F	July 13	?
Killarney	(--,W:B/W,m)	U	July 20	Freshwater, SK 2005
Little Fish*	(O,m:W/B,--)	F	June 21	Chain #4, AB 2002
Little Fish	(--,m:--,--)	F	June 29	?
McLaren	(--,--:--,m)	U	May 14	?
McLaren	(W,Y:--,m)	M	May 14	Diefenbaker, SK
McLaren*	(--,--:B/W,m)	M	June 1	AB
McLaren*	(--,m:B/W,--)	F	June 1	AB
Muriel*	(--,--:B/W,m)	M	May 16 - July 4	AB
Muriel	(--,m;W/B,--)	M	May 16- June 3	AB
Muriel	(dB/R,m:--,Y)	M	May 21	Reflex, AB 2003
Muriel	(--,m:W/B,--)	M	May 16, May 21	AB
Muriel*	(--,--:B/W,m)	F	May 16 - June 24	AB
Muriel	(--,m:W/B,--)	M	May 22 - June 14	AB
Muriel	(W,BB:--,m)	M	May 22	Captive release of Diefenbaker fledglings on Chaplin, SK 2002
Muriel*	(--,m:B/W,--)	M	May 22 - July 14	AB
Muriel	(--,m:W/B,G)	M	June 3	Muriel, AB 2002
Muriel*	(m,--:W/B,Y)	F	June 3, July 21	Muriel, AB 2004
Muriel	(Bf,RG:m,O)	M	June 3,4	Diefenbaker, SK 2002
Muriel	(--,m:W/B,--)	F	June 3	AB
Muriel	(--,m:B/W,--)	U	June 14	AB
Muriel	(--,m:--,--)	M	June 14, July 14	?
Muriel*	(m,--:--,B/WY)	M	June 14, June 15, July 4, July 21	Frog, AB 2004
Muriel	(m,SR:Wf,pG)	F	July 4	Chalpin, SK 2003
Muriel	(--,m:--,--)	U	July 21	?
Piper*	(--,m:B/W,--)	F	June 4	AB
Piper*	(--,B/Wm:--,--)	F	June 4, June 30	AB
Piper	(--,--:B/W,m)	F	June 21	AB
Piper*	(B/W,m: --,Y)	M	July 12	Reflex, AB 2003
Reflex	(--,m:B/W,O)	U	May 15	Dowling, AB 2002
Reflex	(--,m:B/W,W)	M	May 15, May 22	Freshwater, SK 2003
Reflex*	(--,m:--,--)	M	May 15, July 2	?
Reflex*	(B/W,--:m,--)	M	May 15, May 20, June 5, July 11	AB
Reflex	(--,--:--,m)	U	May 22, June 5	?
Reflex	(--,B/Wm:--,Y)	F	June 5	Horseshoe, AB 2004
Reflex	(m,pB:Wf,pG)	M	June 5	SK
Reflex*	(B/W,m:--,--)	M	June 5, July 11, July 20	AB
Reflex*	(W/B,m:--,--)	M	June 24, July 20	AB
Reflex*	(m,--:B/W,--)	M	June 24, July 20	AB
Reflex	(m,RdB:Wf,O)	U	July 2	Baxter, AB 2000. Rebanded on Diefenbaker, SK 2002
Reflex	(pB,m:--,--)	M	July 2	SK
Reflex*	(Y, --:B/W,m)	F	July 20	Chain #4, AB 2003
Red Deer*	(B/W,m:--,Y)	U	June 6	Reflex, AB 2003
Red Deer*	(m,--:B/W,Y)	U	June 6	Muriel, AB 2004
Red Deer*	(--,--:B/W,m)	U	June 6	AB
Red Deer*	(B/W,m:--,--)	U	June 6	AB
Sunken	(--,m:dB/R,--)	U	June 4	AB

* These birds nested in Alberta in 2005.