USE OF NATURAL HABITAT AND ARTIFICIAL NEST SITES BY BLACK TERNS AT AN IMPOUNDMENT NEAR KINGSTON, ONTARIO, IN 1997.

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ABSTRACT

We studied the use of natural habitat and artificial platforms by nesting Black Terns (*Chlidonias niger*) over the 1997 breeding season at an impoundment near Kingston in southeastern Ontario. The impoundment had eight fairly distinct habitat types. Early in the season, nesting was restricted to the "Rushes Marsh" and "Willows Marsh", the only two areas in the impoundment with hemi-marsh conditions at that time. Late in the season, as the central portion of the Rushes Marsh became very dense, we observed an outward shift in the location of new nests in the Rushes Marsh. In addition, an area of thick mats of floating moss, which had developed later in the season next to the Willows Marsh, was used for nesting by a small number of terns.

We installed nesting platforms of different types in the Rushes Marsh and Willows Marsh. We also installed fences around some nests on platforms and around some nests on natural substrates to determine hatching success and early chick survival. Black Terns nested on 16 of 24 platforms installed in the Rushes Marsh. Of the three types, the "Wire Mesh" platform was the type most preferred by the terns and also had the highest hatching success. The mud and vegetation that we had added to the Wire Mesh platforms during their installation, remained well in place over the course of the breeding season. In addition, it was the most natural looking of the three types, the least visible to predators, and possibly the least attractive to other animals. Chick survival was apparently not reduced on Wire Mesh platforms in comparison with that in nests on natural substrates. A predation event in the Willows Marsh made it impossible to make any conclusions regarding platform type preferences and breeding success in that portion of the impoundment.

Our results suggest that in wetlands that have a shortage of natural nest substrates, but that are otherwise suitable, Black Terns may use artificial nesting platforms, particularly during the early breeding season. The presence of platforms may help to encourage Black Terns to stay at a breeding site rather than prospect for other wetlands to nest in. Breeding success should be similar to that on natural nest substrates if the Wire Mesh platform is used.

RÉSUMÉ

Nous avons examiné l'utilisation de l'habitat naturel ainsi que des radeaux de nidification artificiels par la Guifette noire (*Chlidonias niger*) durant la période de reproduction de 1997 dans un étang aménagé près de Kingston, dans le sud-est de l'Ontario. Huit habitats relativement distincts se trouvaient dans l'étang. Tôt en saison, la nidification se faisait uniquement dans "le Marais à scirpes" et dans "le Marais à saules", les deux seuls habitats de l'étang où les conditions pouvaient être décrites comme "demi-marais" [hemi-marsh]. Tard en saison, pendant que la partie centrale du Marais à scirpes devenait plus dense, nous avons observé dans le Marais à scirpes un déplacement vers l'extérieur dans le placement de nouveaux nids durant la saison. De plus, tard en saison un petit nombre de guifettes ont niché dans un endroit adjacent au Marais à saules où d'épais tapis de mousse flottante s'étaient formés.

Nous avons installé différents types de radeaux de nidification dans le Marais à scirpes ainsi que dans le Marais à saules. Nous avons aussi installé des clôtures autour de quelques nids situés sur des radeaux ainsi qu'autour de quelques nids sur des substrats naturels pour déterminer le succès d'éclosion et de survie des jeunes oisillons. Les guifettes ont niché sur 16 des 24 radeaux installés dans le Marais à scirpes. Des trois sortes de radeaux que nous avons installés, le modèle préféré par les guifettes et pour lequel le succès d'éclosion était le plus élevé était celui en grillage de fil métallique. La boue et la végétation morte que nous avions ajoutées aux radeaux en grillage de fil métallique pendant l'installation des radeaux, sont restées en place durant la période de nidification. De plus, ce modèle apparaissait très naturel, il était le moins visible par les prédateurs, et il était peut-être le moins attirant pour les autres animaux. Le succès des oisillons n'a apparemment pas été inférieur sur les radeaux en grillage métallique à celui observé dans les nids sur des substrats naturels. Un acte de prédation dans le Marais à saules a rendu impossible la détermination du type de radeau préféré ainsi que le succès d'éclosion dans cette partie de l'étang.

Nos résultats suggèrent que des radeaux de nidification artificiels peuvent être utilisés par la Guifette noire dans les terres humides qui manquent de substrats naturels de nidification tôt en saison, mais qui sont par ailleurs adéquates pour la reproduction. La présence de ces radeaux peut aider à encourager les guifettes à rester à un site de reproduction donné plutôt que d'aller explorer d'autres sites. Si on utilise des radeaux en grillage de fil métallique, le succès de reproduction devrait être similaire à celui des nids sur substrats naturels.

TABLE OF CONTENTS

1 INTRODUCTION

Black Terns nest semi-colonially in productive marshes. Important factors in habitat selection include: marsh size, exposure to wind and waves, type of vegetation, vegetation density, water depth, distance from shore, and human disturbance (Dunn and Agro 1995). A critical factor in habitat selection is the presence of hemi-marsh, an interspersion of emergent vegetation and open water (Austen *et al.* 1994). Adaptations of this species to marsh nesting include frequent renesting, moderate site tenacity, and highly porous eggshells suited to damp conditions (Dunn and Agro 1995).

The Black Tern population in North America has clearly declined over the past three decades, as has also been documented in Europe, where in addition the range is known to have declined (Alvo and Dunn 1996). In Ontario, this species is locally common, but it appears to be declining and has been proposed for threatened status (Austen *et al.* 1994).

One way of helping Black Terns may be to provide artificial nesting platforms in situations of limited nesting substrate. Such platforms are often accepted (de Bruin 1991; Alta and Wegerif 1991; Dunn and Agro 1995; Seriot 1996) and they can lead to higher productivity in areas with fluctuating water levels (Dunn and Agro 1995).

Preliminary work conducted in 1996 at the study site showed that early in the season the Black Terns nested in three areas with dead cattails (*Typha* sp.), but that late in the season they nested in an area of growing bulrushes (*Scirpus* sp.). The phenomenon of Black Terns changing nesting habitat during the season has not received much attention in the literature. The initial plan in 1997 was to focus on changes in the use of natural nesting habitat during the breeding season. However, early in the 1997 breeding season the number of Black Terns at the site was much lower than in 1996, and, unlike in 1996, there were no mats and clumps of dead cattail that could serve as Black Tern nest substrate. We therefore decided to install nesting platforms to test the usefulness of the three different types of platforms that were available to us at short notice.

Our four goals for 1997 were to:

- document the availability of natural nesting habitat over the breeding season;
- document any changes in the use of natural nesting habitat over the breeding season;
- evaluate the use of three types of artificial nesting platforms over the breeding season; and,
- compare breeding success on natural sites and platforms.

Based on our findings, we will make recommendations regarding the use of artificial nesting platforms.

2 STUDY AREA

The study site is an impoundment located on the 635-ha property of Ontario Hydro's oil-fired Lennox Generating Station (Lennox GS) (44°09'N 76°51'W), which is situated on the north shore of Lake Ontario at the mouth of the Bay of Quinte, about 8 km southwest of the village of Bath, Ontario, or about 20 km west-southwest of the city of Kingston (Figure 1). The region is characterized by Paleozoic sandstone, fossiliferous limestone and shales associated with the eastern flank of the Michigan basin (Beak Consultants Ltd. 1990).

The 56-ha impoundment is classified as a Provincially Significant Wetland under the provisions of the Planning Act (Neil MacLean, pers. comm.). It is located 900 m northwest of Lake Ontario (Figure 1). Between 1967 and 1978, American Beaver (*Castor canadensis*) activity led to an increase in the size of the wetland by 25 ha to its current size. This was at the expense of 15 ha of woodlot and 10 ha of agricultural land.

In 1981, a weir was built at the outflow in the southeast end through a cooperative management program between Ontario Hydro, the Ontario Ministry of Natural Resources and Ducks Unlimited Canada. A 1982 summer drawdown and subsequent reflooding resulted in a rich growth of aquatic plants, particularly in the southeastern portion of the wetland.

The flooding of the impoundment with the creation of shallow and deep marsh areas resulted in the use of the wetland by hundreds of migrating waterfowl in the spring and fall, as well as by breeding and staging waterfowl in the summer. The five lagoons created south of the impoundment also attracted waterfowl and shorebirds (Figure 1; Chubbuck 1983).

The Ducks Unlimited Canada plan is to lower the water level every seven years to rejuvenate the wetland. The water level was last lowered early in 1991, then brought back up in the fall of 1992. During 1992-1996, wetland vegetation re-established itself and began supporting wetland wildlife. [Although not directly relevant to the main objectives of this study, we include species lists of various animal taxa observed in 1997 in Appendices 1 and 2 for the benefit of future workers.]

Black Terns are known to readily accept artificial wetlands (Delahanty and Svedarsky 1993; Dunn and Agro 1995), so the species' presence at the impoundment of the Lennox GS is not surprising. In fact, this was the only site with an indication of breeding Black Terns in the

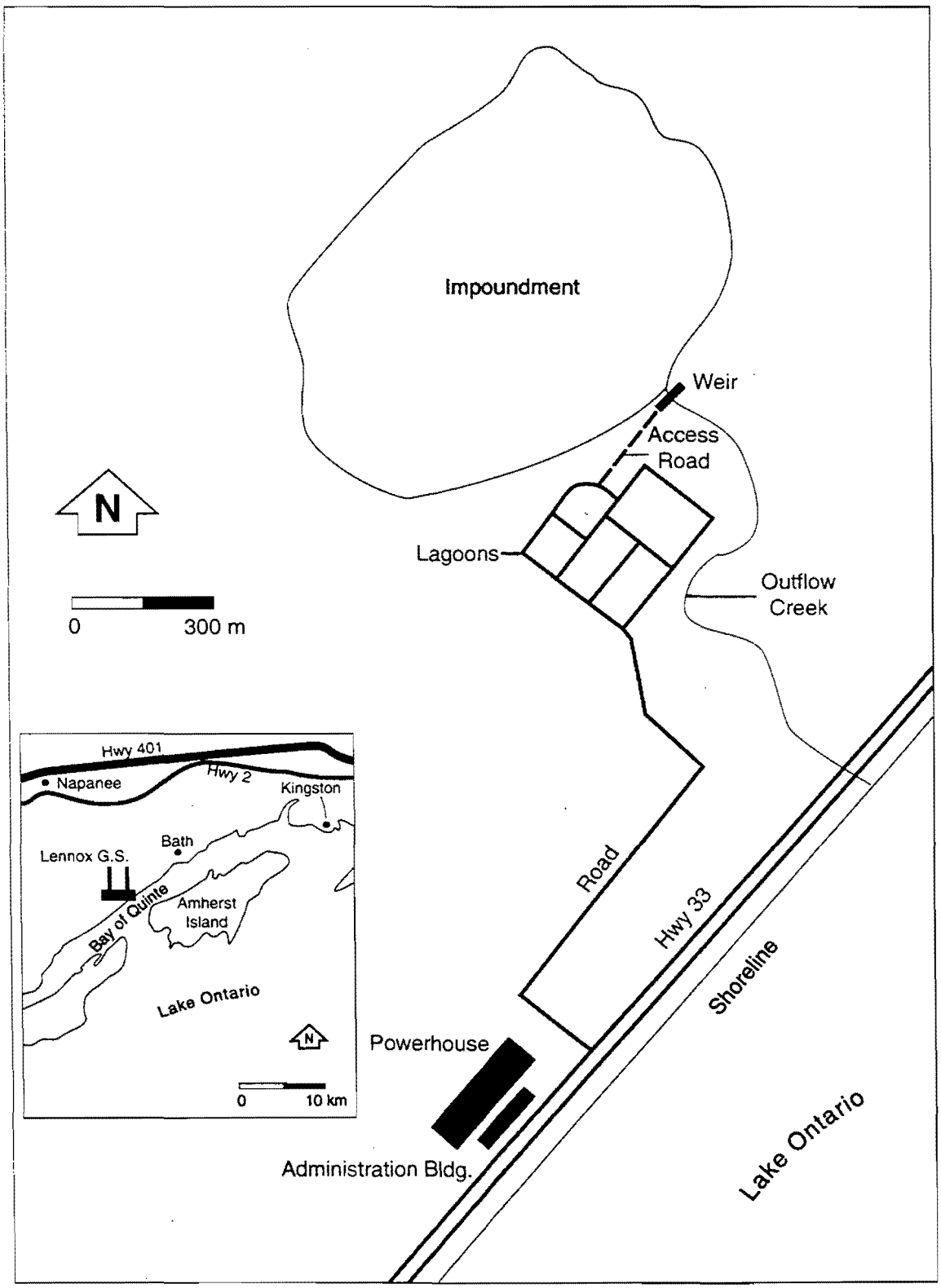

Figure 1. The impoundment, its weir and outflow creek, and lagoons on the property of Ontario Hydro's Lennox Generating Station. Inset: The area southwest of Kingston, Ontario, showing the location of the Lennox Generating Station.

county of Lennox and Addington in 1995 (Richardson 1996).

In 1980, the species was considered to have been a "formerly common resident" at the impoundment (Beak Consultants Ltd. 1990). Broughton recorded 52 individuals in 1978 (Vascotto *et al.* 1978). In 1991, two pairs were estimated at the site, while in 1994, at least 25 individuals were seen (Richardson 1994). The following year, Richardson (1996) made counts on two dates and concluded that "an estimate of 300-400 birds is clearly not unreasonable". In 1996, there were an estimated 150 pairs breeding at the impoundment (H. Blokpoel, unpubl. data).

3 METHODS

All our work was carried out during 13 visits to the impoundment, at least one visit per week, from 5 May to 25 July, 1997. We monitored the water level of the impoundment on each visit by measuring the distance from the top of the dam (i.e. the flat top of the stoplog bay's centre concrete tower) down to the water surface. We used a canoe and chest waders to move about in the impoundment. All the nests were accessible using chest waders.

3.1 Availability of Natural Nesting Habitat

We monitored the availability of natural nesting habitat in the impoundment by canoe every two to three weeks. These surveys noted the type of vegetation and other types of potential nesting substrate and assessed their potential as nesting habitat based on the literature and our own experience. We developed detailed sketch maps of the Rushes Marsh (Area H) and the Willows Marsh (Area C) (see Results for descriptions of these habitats) based on measurements taken in the field.

Rushes Marsh We measured extensions of the sides of the platform grid (see sub-section 3.3) out to: a) the limits of the hemi-marsh conditions, and b) the shoreline (Figure 2). Each nest location was plotted by taking measurements in two directions perpendicular to these line extensions.

Willows Marsh We established imaginary lines forming a "cross" of 200 m by 110 m (Figure 2). For every 20-m length of the cross, we plotted the extent of the Willows Marsh in both directions perpendicular to the main axis of the cross. Each point on the polygon depicting the Willows Marsh represents the extent of the Willows Marsh. We also plotted the locations of each nest and platform by taking two measurements in relation to the cross.

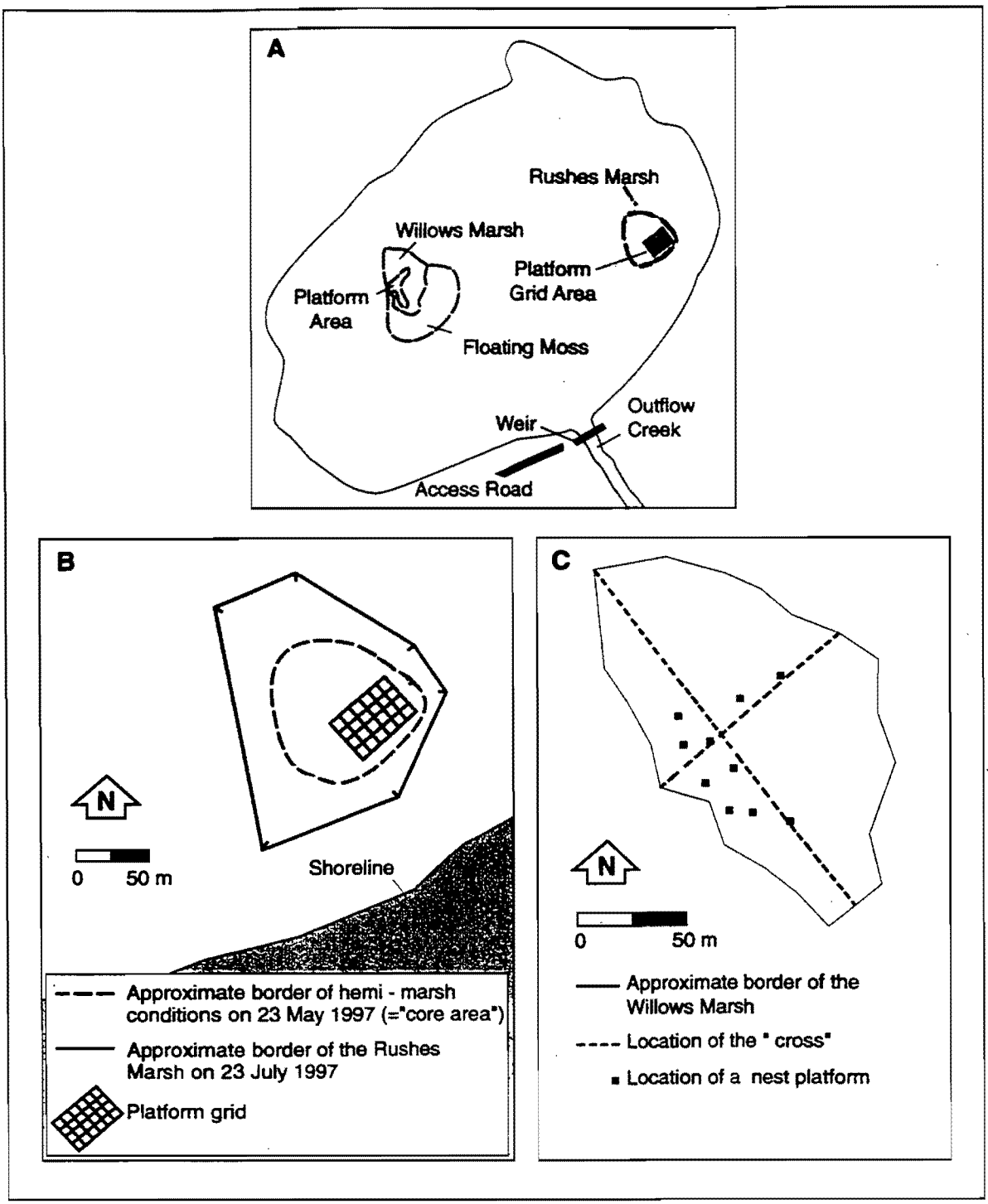

Figure 2. Sketch maps of the two areas in which the Black Terns nested. A) The impoundment, showing the locations of the Willows Marsh with its platform area, and the Rushes Marsh with its platform grid area. B) The Rushes Marsh, showing the marsh "core area" (i.e. hemi-marsh conditions on 23 May 1997, when the platforms were installed) and the extent of the bulrushes on 23 July 1997 (when the extent of the marsh was measured). C) The Willows Marsh, showing the locations of its border, the "cross", and the nest platforms.

3.2 Use of Natural Nesting Habitat

The Rushes Marsh and the Willows Marsh were completely surveyed for nests on each visit. Checks were also made periodically for evidence of nesting in other habitats within the impoundment. We believe we found almost all the nests on natural sites. We actively searched for new nests on natural sites up to and including July 10. Thereafter, we stopped actively searching but continued to monitor known nests. One new nest was found nonetheless in the Willows Marsh on 17 July.

Nests on natural sites were identified by pushing a numbered stake (120 cm x 31 mm x 19 mm) into the substrate 3 m north of the nest. We defined active nests as sites with at least one egg that was not obviously dumped. Dumped eggs were defined as those that were not in a nest and which, on our following visit, showed signs of not having been incubated recently (i.e. they had no luster and/or were encrusted with mud and/or vegetation). Additional evidence that an egg had been dumped was the absence of any new eggs on our second visit; however, the presence of one egg in itself was not proof of dumping because some single eggs were incubated and resulted in hatching. During the course of the study we found 2 dumped eggs.

During each visit to the impoundment, we recorded the contents of each nest (e.g. numbers of eggs and chicks) and any other noteworthy observations (whether eggs were pipping, muskrat activity, etc.). We assumed that pipped eggs went on to hatch.

3.3 Use of Artificial Nest Platforms

3.3.1 Platform Types

We used three types of platforms: (1) "Wooden Tray", (2) "Wire Mesh", and (3) "Bare Planks". Sketches of these three types are shown in Figure 3. All three platform types were roughly the same size. The Wooden Trays, designed after a similar platform used for Forster's Terns (*Sterna forsteri*) (Wisconsin Dept. of Natural Resources, pers. comm.), had styrofoam bottoms and wooden walls. The Wire Mesh design had a frame of PVC tubing and a wire mesh surface. It was designed in Europe and introduced at Presqu'ile Provincial Park by Teeuw (1995). The Bare Planks platform was designed by staff at Presqu'ile Provincial Park, who sawed the tops of discarded picnic tables into squares.

3.3.2 Platform Installation and Marking

Platforms were installed in the Rushes Marsh and in the Willows Marsh. They were placed on the water surface and anchored in place with a brick that we lodged in the marsh bottom. Vegetation and mud from the immediate vicinity was used to provide a natural nesting

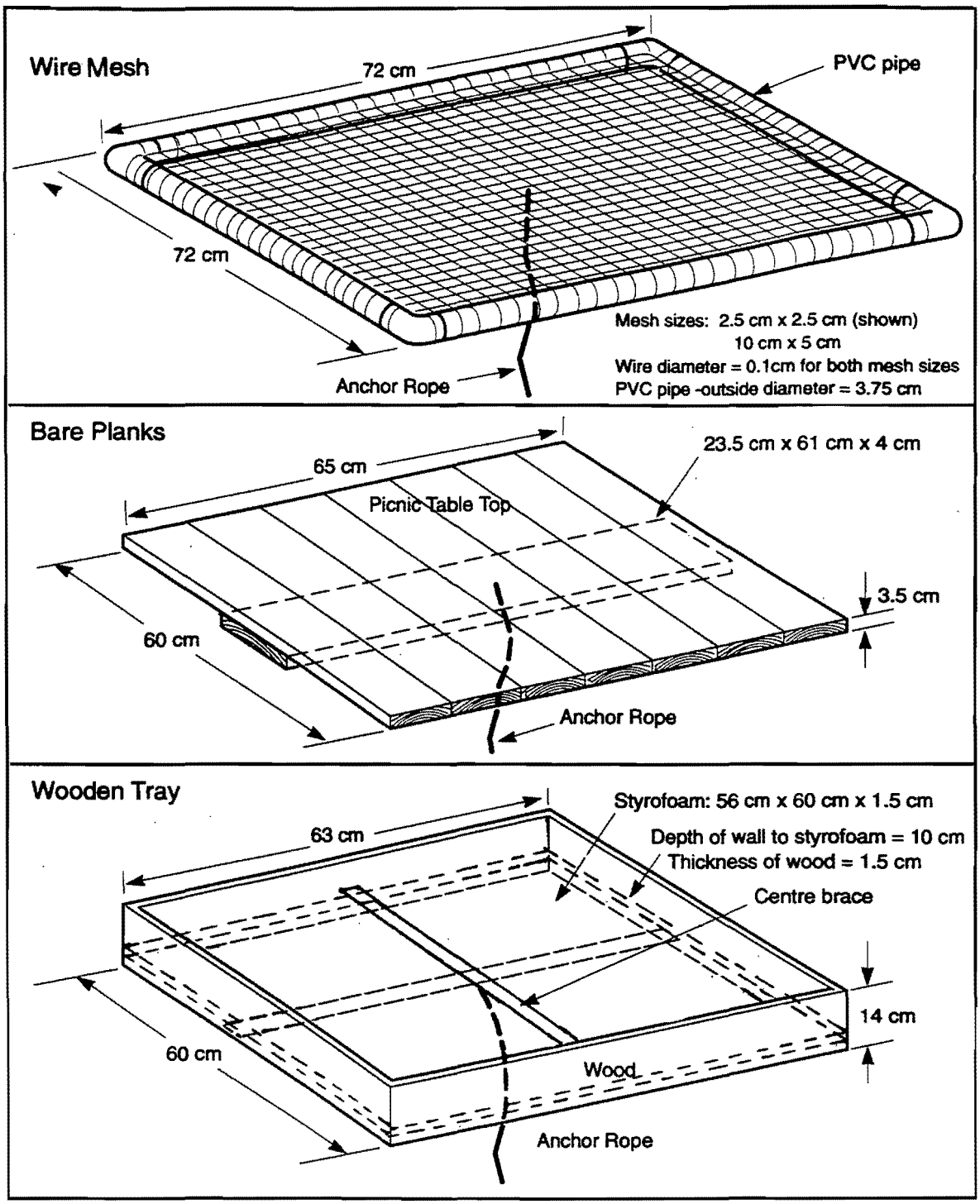

Figure 3. Sketches of the three platform types.

substrate. Seen from above after being installed and covered with vegetation and mud, the Wire Mesh and Bare Planks platforms simply looked like floating mats of mud and vegetation; no part of either of these platforms was visible from above. The walls of the Wooden Tray, on the other hand, were quite visible; once installed, the Wooden Tray looked like a drawer full of vegetation and mud floating on the surface. Most of the Bare Planks platforms became increasingly visible during the season as wind dried the substrate and blew it away; in addition, the activity of muskrats and moulting ducks displaced some material.

Rushes Marsh On 23 May, we delineated a rectangular grid (60 m x 40 m) on the southeast side of the part of the Rushes Marsh that exhibited hemi-marsh conditions on that date (Figure 2). We used wooden stakes (240 cm x 3.1 cm x 1.9 cm) coloured with spray paint to mark the four corners of the grid (north, east, south, west). This greatly facilitated navigation within the Rushes Marsh, particularly later in the season as the emergent vegetation grew dense and tall (Appendix 3).

The grid was divided into 24 squares of 10 x 10 m (Figure 2), and one platform was placed at the centre of each square. Eight platforms of each of the 3 types were used. We randomized the location of each platform. Platforms were furnished with mud and dead and/or live bulrushes from the immediate vicinity.

Willows Marsh We installed 10 platforms in the Willows Marsh on 5 June (Figure 2). Five platforms of each of two types were installed: Bare Planks and Wire Mesh. We did not use Wooden Trays because preliminary results from the Rushes Marsh indicated very low use of that type by Black Terns. Because the first nests in the Willows Marsh were located northeast of the long axis of the cross, platforms were installed along the southwest side in an effort to fill available nesting habitat. We alternated the placement of the two platform types. Platforms were furnished with mud and freshly cut willow branches from the immediate vicinity.

3.3.3 Platform Monitoring

All platforms were monitored weekly. Nests on platforms were identified by the platform number. For each platform we recorded the presence of an active nest, numbers of eggs and chicks, and any other noteworthy observations (whether eggs were pipping, muskrat activity, use of platforms by other aquatic birds, etc.). All the platforms were monitored until 23 July.

3.4 Breeding Success on Natural and Artificial Sites

Shortly after hatching, chicks will leave the nest if disturbed. This makes the monitoring of hatching success and chick survival unreliable without the installation of an enclosure around the nest. We therefore installed wire mesh fences around 11 platforms with nests and 14 nests

on natural sites in a part of the Rushes Marsh with similar conditions. On each visit during which we fenced nests, we attempted to keep the number on platforms and on natural sites roughly equal. In the Willows Marsh we installed fences around two platform nests and eight natural nests.

The fences were 3 m in circumference and 22 cm high, with a mesh size of 13 mm x 13 mm. Each fence was arranged roughly in a circle around the natural nest (or, for platform nests, around the platform) with the two ends wired together to prevent chicks from escaping. Fences were fixed in place by stapling them to four wooden stakes (120 cm x 31 mm x 19 mm) that were pounded in the marsh bottom and that protruded at least 20 cm above the water surface. The bottom of the mesh was set at about 8 cm below the water surface to prevent chicks from escaping below the fence. The remaining 14 cm above the water surface prevented chicks from escaping over the mesh.

Fences were adjusted regularly according to changing water levels. Nest fencing was carried out from 11 June to 10 July, and fenced nests were monitored as late as 25 July. Fences were left in place long enough to allow chicks to survive over a period of two consecutive visits to the impoundment (minimum 6 days). During our weekly visits we recorded the number and size of chicks present. After we were able to confirm whether the chicks survived over two visits, we removed the fences.

4 RESULTS

4.1 Availability of Natural Nesting Habitat

4.1.1 Water Level Changes

Throughout the 1997 field season, the impoundment's weir had eight wooden blocks in each of the two stoplog bays. Water flowed over the weir on all four visits made during 5-22 May (Appendix 4). By 23 May, however, flow had ceased. The level had dropped 23.3 cm by the time we made our last measurement on 25 July. The only rise we observed during those two months was during a period of heavy rain in mid-June. The overall drop in water level over the study period was likely a key factor involved in the habitat changes that occurred through the breeding season.

4.1.2 Habitat Types and Changes over the 1997 Breeding Season

By far the largest part of the impoundment was swamp characterized by the presence of standing and fallen dead timber. Early in the season, some of this habitat may have been usable by Black Terns for nesting, although it may have been too stable a substrate, which

could have been attractive to predators and other animals. Later in the season, however, areas within this habitat may have become more suitable because of the presence of floating scum (mud and rotting vegetation) that had floated from the bottom to the surface and thus created substrates that could potentially have been used for nesting (Area A, Figure 4).

Area B, in the northwest part of the impoundment, was characterized by dead tall willow shrubs. This area seemed to be unsuitable for the same reason as Area A. Adjacent was Area C, the "Willows Marsh". It was a hemi-marsh composed of water interspersed with islands of Slender Willow (*Salix petiolaris*) and some Narrow-leaved Meadowsweet (*Spiraea alba*). The substrate of these islands was mud, which could be used for nesting.

Immediately to the southeast of the Willows Marsh was a band of shallow open water that later in the season became suitable for nesting because it became covered by a dense mat of floating moss (Area D).

At the southwest part of the impoundment, Area E had a few standing dead trees and a number of fallen trees, and was similar to Area A. Later in the season, however, as the water level dropped, many dead cattail stems (*Typha sp.*) appeared. Area E had been used for nesting by Black Terns early in 1996, with nests being constructed on the dead cattail clumps.

Area F, along the northeast shore, had scattered clumps of the bulrush Woolgrass (*Scirpus cyperinus*). These clumps seemed to be too dense and tall for terns to nest on.

Adjacent to the northeast boundary of Area F was Area G, which had a thick dense blanket of European Frog-bit (*Hydrocharis morsus-ranae*), an invasive plant introduced to North America in the 1930s which typically grows in dense floating mats (White *et al.* 1993). This area was likely unsuitable for nesting because it was devoid of emergent vegetation.

Area H, the "Rushes Marsh", was a hemi-marsh of Softstem Bulrush (*Scirpus validus*) located in the east end of the impoundment. It seemed to be typical of preferred nesting habitat of Black Terns. We defined the approximate area of hemi-marsh conditions on 23 May as the "core area" (Figure 2). The bulrush grew much taller and denser over the breeding season, particularly in the core area, which became unsuitable for nesting. At the same time, much of the area surrounding the core area had very few, short rushes on 23 May, and subsequently became hemi-marsh suitable for nesting.

Floating vegetation observed throughout the impoundment included European Frog-bit (in much lower concentrations than in Area G) and two types of duckweed: Ivy-leaved Duckweed (*Lemna trisulca*) and Larger Duckweed (*Spirodela polyrhiza*). The duckweed was observed only later in the season.

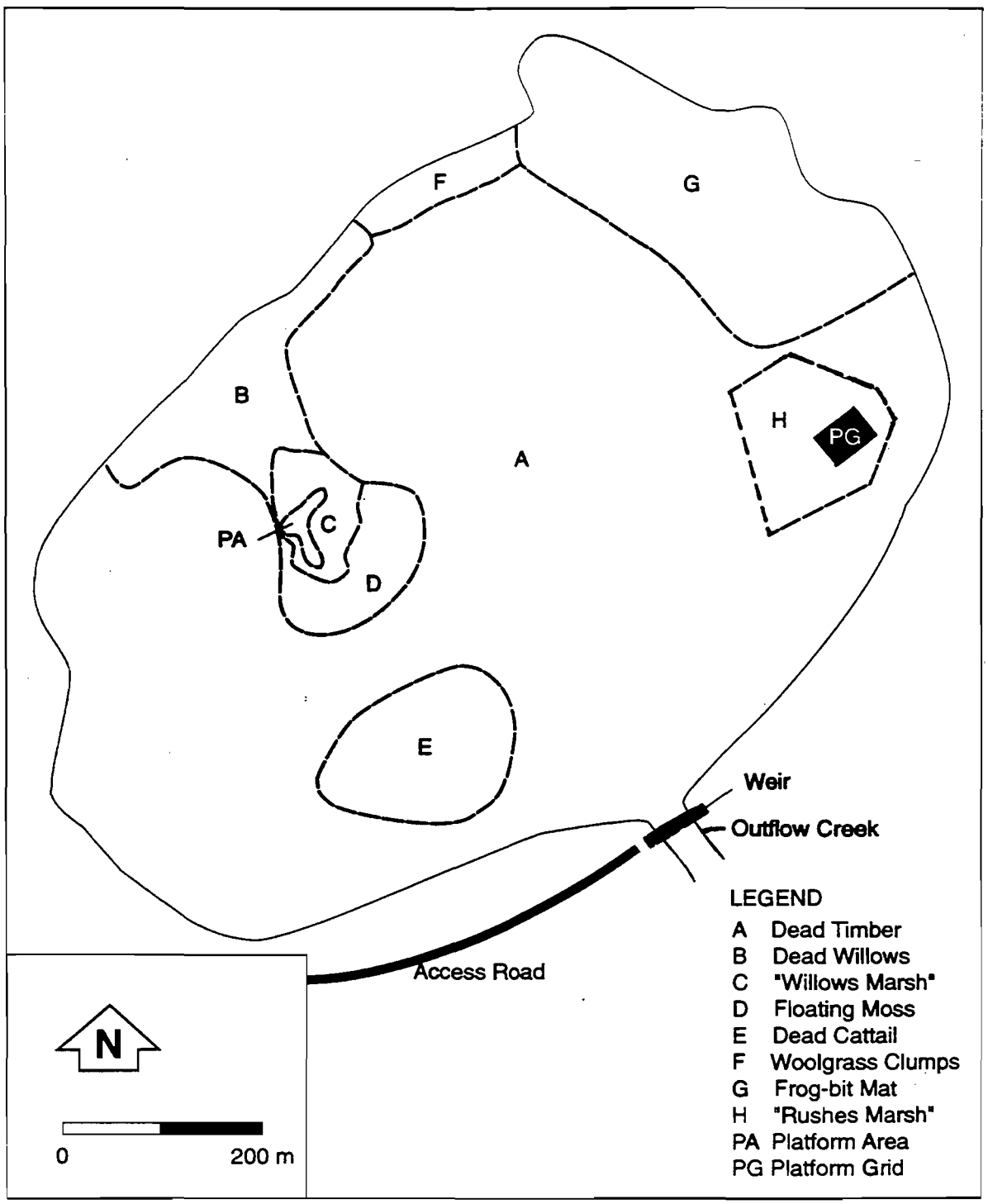

Figure 4. Sketch map of the impoundment with the habitat types in mid July. Also shown are the locations of the platform grid (PG) in the Rushes Marsh (H) and the platform area (PA) in the Willows Marsh (C).

in the Willows Marsh (C).

4.2 Use of Natural Nesting Habitat

Black Terns nested in two distinct parts of the impoundment. The majority nested in the Rushes Marsh, while a smaller number nested in the Willows Marsh. Later in the season, a few nests were found just outside the Willows Marsh in Area D.

4.2.1 Temporal Changes in Nest Habitat Use

The first visit when we found nests with eggs was 3-5 June. At this time we noted quantities of bottom scum that had floated up to the water surface in a number of areas in the impoundment, creating several possible nest sites for Black Terns. In the Rushes Marsh, muskrats were increasing the potential number of tern nesting sites by cutting fresh green rushes, often leaving them in floating piles.

Rushes Marsh We found a total of 41 Black Tern nests on natural sites. On two of these sites new clutches were laid after the original clutch disappeared.

The proportion of nests on natural sites initiated inside the core area of the marsh decreased from 43% (6 of 14 nests) early in the season to 30% (7 of 23) in mid-season to 0% (0 of 4) late in the season (Table 1), but this decrease was not statistically significant (X^2=2.7; 2 df; p>0.2). When nests on natural sites and platform nests were combined, the proportion of nests initiated inside the core also decreased, from 62% (13 of 21 nests) early in the season to 50% (16 of 32) in mid-season to 0% (0 of 4) late in the season (Table 1), and this difference also was not significant at the p = 0.05 level (X^2=5.2; 2 df; p<0.1).

These combined results show that over the nesting season there was a shift outward from the core, as is also shown in Figure 5. This shift seems to have been due to: 1) platforms (particularly favoured ones) becoming occupied early on, along with natural sites in the core, thus reducing the number of potential nesting sites inside the core, 2) the increasing height and density of Softstem Bulrush inside the core, probably leading to less favourable conditions for nesting, and 3) an increase in the availability of favourable nest sites outside the core. The proportion of nests in the Rushes Marsh that were on platforms decreased from 33% to 28% to 0% over the three periods.

Willows Marsh We found five Black Tern nests on natural substrates in the Willows Marsh on 3 June, then installed 10 platforms on 5 June. On 12 June we found an additional two nests, one of which was on a platform. Unfortunately, on the following visit (19 June) we found no eggs on any of the seven nests, indicating that a predator had likely taken all the eggs (Figure 6).

Table 1. Chronology of nest inititiation on three platform types and on natural substrates in the Rushes Marsh over the breeding season.

Period[a]	Inside Core Area				Outside Core Area	Total
	Platform Type			Natural Site	Natural Site	
	Wire Mesh	Bare Planks	Wooden Tray			
Early	6	1	0	6	8	21
Mid	1	5	3	7	16	32
Late	0	0	0	0	4	4
Sub-totals	7	6	3	13	28	-
TOTALS	16			41		57

[a] Early: 3 - 12 June; Mid: 13 - 26 June; Late: 27 June - 10 July

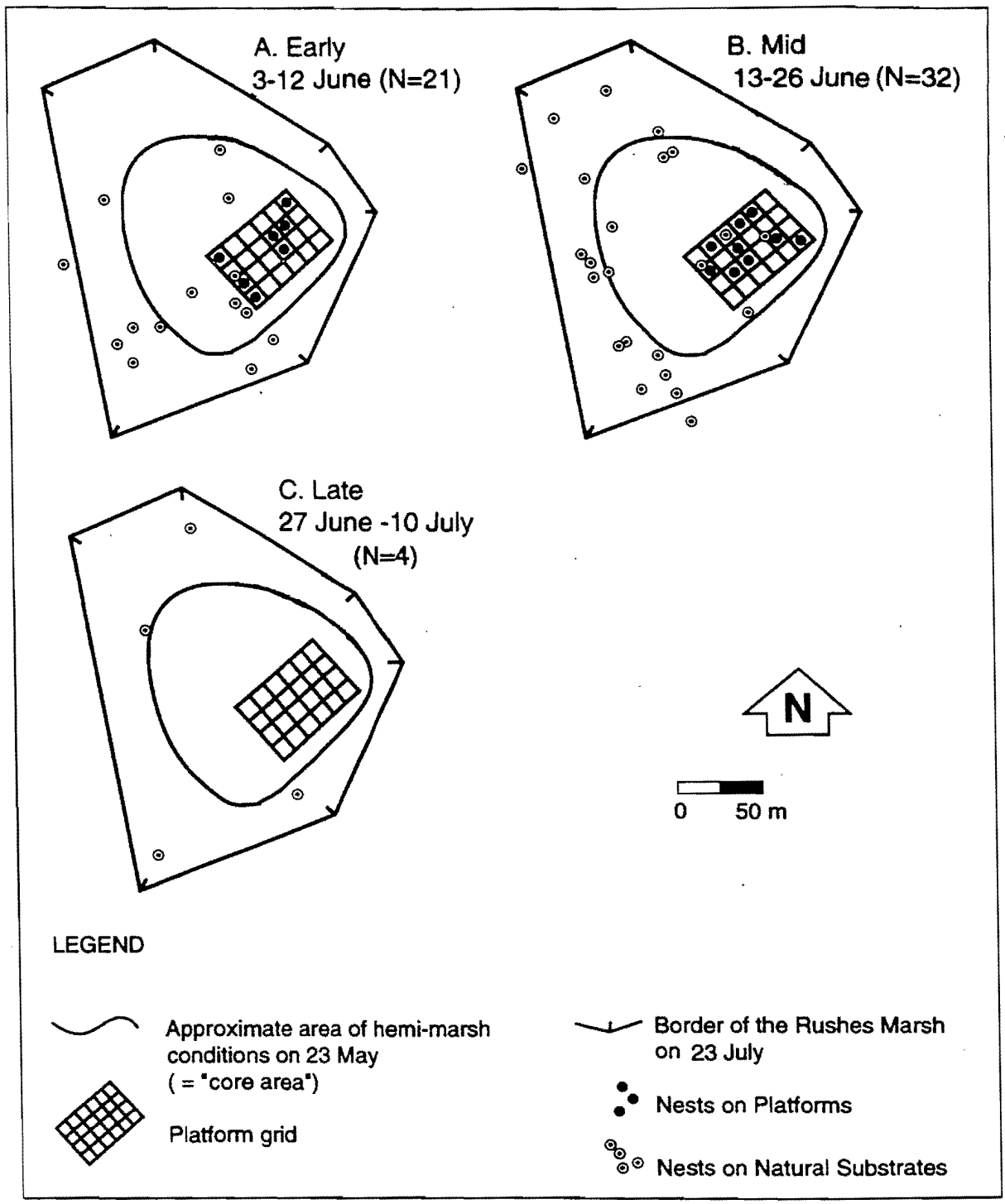

Figure 5. Sketch maps presenting the chronology of nest initiation for all nests found in the Rushes Marsh. A. Early, B. Mid, C. Late.

Later, between 26 June and 17 July, we found another five nests, which we believe were probably renesting attempts. One of the five nests was on a platform. All six nests on natural sites initiated before the predation event were on willow clumps. Of the four nests on natural sites initiated afterwards, however, only one was on a willow clump. The remaining three were on floating moss in Area D, adjacent to the Willows Marsh.

4.3 Use of Nesting Platforms

Rushes Marsh During the course of the breeding season 16 (67%) of the 24 platforms installed in the grid were used by Black Terns for nesting. Of the 8 platforms of each type installed, 7 (88%), 6 (75%) and 3 (38%) of the Wire Mesh, Bare Planks, and Wooden Tray platforms, respectively, were used. Use of the Wire Mesh and Bare Planks platforms was significantly greater than the use of Wooden Trays (X^2, $p<0.05$; Table 1). In addition, early in the season 86% (6 of 7) of the platforms used were Wire Mesh, compared to only 11% (1 of 9) in mid-season (Table 1). Thus Wire Mesh platforms were selected first. After most of them were occupied, nest initiation shifted to the other two types. These results strongly suggest that the order of preference of platform types from most to least preferred is: Wire Mesh, Bare Planks, then Wooden Tray.

Willows Marsh Both of the platforms used in the Willows Marsh were Bare Planks.

4.4 Hatching Success on Platforms vs. Natural Sites

Rushes Marsh Of the 25 fences that we installed around nests, 8 were knocked over or became suspended above the water surface when the water level dropped; any chicks present could then have escaped. In the 17 nests that remained intact until hatching could be confirmed, 8 were on natural substrates (which all hatched at least one chick) and 9 were on platforms (8 of which hatched at least one chick) (Table 2).

For 15 nests (7 on natural and 8 on artificial substrates), the fences remained intact long enough to allow us to determine the hatching success of all the eggs laid. Hatching success on the platforms was 73% (16 eggs hatched of 22 laid), and this was significantly lower than on natural sites, on which all 19 eggs laid went on to hatch ($p<0.02$, $N=41$). However, hatching success varied considerably among platform types: from 86% on Wire Mesh platforms to 67% on Bare Planks platforms to 0% for the two eggs on the Wooden Tray. Wire Mesh Platforms had a slightly lower success than natural sites, but this difference was not significant at the $p=0.05$ level.

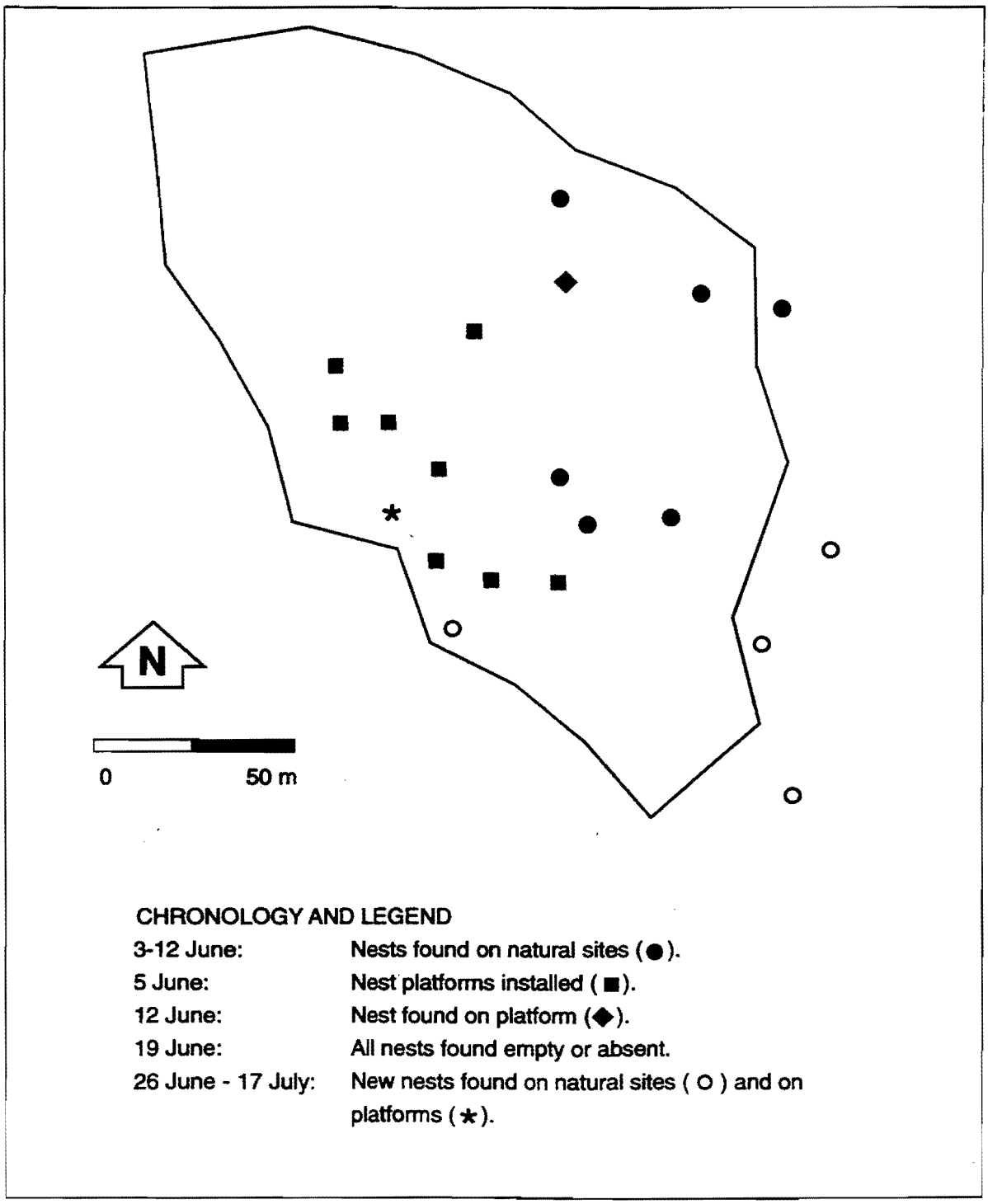

Figure 6. Chronology and distribution of nests and platforms in the Willows Marsh during 3 June - 17 July.

Table 2. Hatching success in fenced nests in the Rushes Marsh, by substrate type. Hatching success is defined as: (a) the proportion of fenced nests with at least one egg hatched, and (b) the proportion of eggs that hatched.

Nest Substrate Type	(a) Hatching Success as the Proportion of Fenced Nests with at Least One Egg Hatched			(b) Hatching Success as the Proportion of Eggs that Hatched		
	Total # Fenced Nests	# Nests With Hatching	HS (%)	Total # Eggs Laid in Fenced Nests (# nests)	# Eggs Hatched	HS (%)
Natural Substrate	8	8	100	19 (7)	19	100
Wire Mesh	6	6	100	14 (5)	12	86
Bare Planks	2	2	100	6 (2)	4	67
Wooden Tray	1	0	0	2 (1)	0	0
TOTAL	17	16	94	41 (15)	35	85

Willows Marsh Hatching success was 0% for the six nests that we had fenced early in the season, because a predator destroyed all the eggs. For the remaining five nests found after the predation event, we fenced four (one on a platform and three on natural substrates). Of those, two hatched (one nest on a platform and one on a natural substrate), one natural-substrate nest was predated, and the fourth nest on a natural substrate still had eggs on our final visit.

4.5 Chick Survival on Platforms vs. Natural Substrates

Rushes Marsh Only 7 fenced nests had fences that were intact at the appropriate times to allow us to determine the number of chicks that survived over two consecutive visits. Two were on natural sites and 5 were on platforms. Chick survival was 100% on all 7 (Table 3).

Of the 8 Wire Mesh platforms, 6 were fenced. Of those, 4 had large mesh and 2 had small mesh. Hatching occurred on all 6. However, in only 3 cases were the fences intact at the appropriate time to determine survival over 2 visits: the 1 small-meshed fence had 3 chicks survive, whereas for the 2 large-meshed fences 1 nest had 3 chicks survive while the other had only 1. These data are two few to assess whether there was a difference in success between the 2 mesh sizes.

Willows Marsh There were insufficient data to compare chick survival on platforms as opposed to on natural substrates.

4.6 Number of Black Terns at the Impoundment

The largest number of active Black Tern nests on any visit was 52 nests on 26 June (Table 4). The number of active nests on any given visit should give a minimum value of the number of breeding pairs, allowing for a few pairs that may not have had a nest yet, others that may have lost a nest and not renested yet, plus nests on natural substrates that we could have missed (although we believe the latter number to be very small). The total number of nests over the whole season was 57 for the Rushes Marsh and 12 for the Willows Marsh, or 69 for the impoundment. The number of breeding pairs should be lower than 69 assuming that some renesting took place. Thus our best estimate of the number of breeding pairs at the impoundment in 1997 is 52-69.

The total number of active nests and the maximum number of terns at any time during a visit were not well correlated (Table 4). This was to be expected because: (a) after 23 May, with nesting underway, it became increasingly difficult to make accurate counts as most birds on nests were out of view, (b) the terns nested in two areas within the impoundment that were relatively distant from each other, and (c) as hatching increased, more birds were likely foraging for their chicks away from the impoundment.

Table 3. Chick survival[a] in fenced nests on natural substrates and on three platform types in the Rushes Marsh.

Nest Substrate Type	No. of Nests	No. of Chicks Hatched	Chicks that Survived	
			Number	%
Natural Sites	2	5	5	100
Wire Mesh	3	7	7	100
Bare Planks	1	1	1	100
Wooden Tray	1	0	0	0
TOTAL	7	13	13	100

[a] Survival is based on the presence of chicks on two consecutive weekly visits, i.e. a minimum of 6 days.

Table 4. Largest number of adults seen and number of active nests found during visits to the impoundment.

Date	Number of Adults Seen	Number of Active Nests
5 May	1	0
8 May	3	0
14 May	60+	0
22-23 May	60+	0
26 May	NA	0
3-5 June	37+	18
11-12 June	40+	22
19 June	50+	35
26 June	45+	52
2-3 June	NA	38
10 July	NA	30
17 July	NA	17
23-25 July	NA	8

5 DISCUSSION

5.1 Availability and Use of Natural Nesting Habitat

Black Terns need a substrate on which to lay their eggs. In this study, the availability of nest substrates in the impoundment greatly increased over the course of the season due to a combination of dropping water levels, the development of floating scum, the growth of mats of vegetation, and the presence of piles of stems of newly emerged vegetation.

Rushes Marsh The observed outward shift of nest sites in the Rushes Marsh over the course of the nesting season seems to confirm that Black Terns prefer hemi-marsh conditions over denser marsh conditions or totally open water, as described by Cramp (1985) and Dunn and Agro (1985). It is important to note that the density of the rushes varied somewhat, not only between the inside and outside of the core, but also within each area. Muskrat feeding activity was likely responsible for much of the low density area. This heterogeneity may be the reason why the outward shift in location over the season that we observed was not statistically significant. Our data suggest that in the absence of platforms an outward shift might have occurred, but the only way to test this would be to do a similar study without platforms.

Willows Marsh The fact that the four late nests in Area D were on floating moss suggests that that habitat was more favourable than the willow clumps of the adjacent Willows Marsh. We believe that nests on the floating moss were less accessible to mammalian predators, which would have had to traverse the very dense, thick floating moss that we had much difficulty traversing by canoe.

The great decrease in the number of birds at the impoundment from 1996 to 1997, and the availability of nesting substrate early in the 1996 season but not in 1997, make us believe that the platforms may have had a role in keeping some birds at the site in 1997. Earlier installment of platforms would possibly have been even more effective by keeping a greater number of terns at the site. Nest site fidelity is moderate in Black Terns: they tend to return to the same sites for breeding from year to year, but will change sites when vegetation or water conditions change (Dunn 1987). Even within the same breeding season, they may renest up to 42 km from the original nest site (Dunn and Agro 1995).

5.2 Platform Use

Because we monitored the platforms on each visit to the impoundment, we found all the platform nests except a very small number that could potentially have been initiated and destroyed in the interval between two consecutive visits.

5.2.1 Different platform types

Of the three platform types installed, clearly the least useful one was the Wooden Tray -- the terns did not seem to like it, and the few they did use produced no chicks. Similarly, Teeuw (1995) reported that Black Terns used only one of 22 Wooden Tray platforms. We suspect that one problem with the Wooden Tray is that it is too stable, allowing muskrats and predators, many of which are heavier than Black Terns, to mount them. The stability of the Wooden Tray seems to come from the walls. Although we never saw any predators on any of the platforms, we found signs of muskrat activity (i.e. balls of aquatic vegetation, fresh cut green rushes, dung) on the Wooden Trays much more often than on the other platforms. Other problems with the Wooden Tray may be that its substrate dries out and that its sides facilitate detection by predators.

The main problem with the Bare Planks is that it tends to lose its vegetation, which often dries and gets blown off. The Bare Planks and Wooden Tray, being made of wood, tend to rot after a few years and must be replaced (Teeuw 1995).

The Wire Mesh is clearly the best of the three designs. It is the one that is preferred by the terns, it has the highest hatching success (virtually as high as on natural sites), and chick survival is not compromised.

The Wire Mesh is also the most natural looking of the three platform types. When it is installed and covered with the proper amount of vegetation, it is not visible because the tubing sits below the water surface while the wires are covered by vegetation. Its wire arrangement keeps the vegetation and mud in contact with the water, thereby ensuring that it does not dry out and blow away.

The Wire Mesh platforms that were available to us had two mesh sizes (10 cm x 5 cm, and 2.5 cm x 2.5 cm). Four of six large meshed platforms lost some or all of their vegetation, whereas neither of the two small-meshed ones lost their vegetation. The mesh should be small enough for eggs and chicks not to fall through, but large enough for vegetation to be woven through during installation. Given the size of newly hatched chicks, the optimal mesh size should be about 1.5 cm x 1.5 cm.

It is important to cover the Wire Mesh platform with enough vegetation to cover the mesh and render it invisible from above, and to make the structure heavy enough so that the PVC tubing is submerged and also invisible from above. It is also important to ensure the vegetation is woven through the mesh to prevent it from being blown off.

On the other hand, it should not be made too heavy because it may become more attractive to other animals. Whatever the reason for another species' attraction to a platform, it is unlikely

to benefit the terns. This is suggested by the aggression that Black Terns show toward many species that enter the nesting area, including some non-predators. We observed Black Terns attacking the following species: Red-tailed Hawk (*Buteo jamaicensis*), Peregrine Falcon (*Falco peregrinus*), Common Moorhen (*Gallinula chloropus*), Ring-billed Gull (*Larus delawarensis*), Red-winged Blackbird (*Agelaius phoeniceus*), and Muskrat. Additional species that Teeuw (1995) observed being attacked by Black Terns in Presqu'ile Bay were: American Bittern (*Botaurus lentiginosus*), Great Blue Heron (*Ardea herodias*), Mallard (*Anas platyrhynchus*), Osprey (*Pandion haliaetus*), Herring Gull (*Larus argentatus*), Common Tern (*Sterna hirundo*), and American Crow (*Corvus brachyrynchus*).

Our results also suggest that platforms with walls should be avoided. Walls had been included in the design of the Wooden Tray to prevent eggs from rolling off the platform (Teeuw 1995), a problem identified earlier by Pouliot (1993). However, we found that as long as the Wire Mesh was furnished with vegetation that was threaded through the mesh to keep it intact, the eggs were kept in place on the vegetation. The only case we observed of eggs rolling off the platform, with any of the three designs, was from a Bare Planks that had lost the vegation and mud, including the nest.

Another important consideration is whether to remove the platforms at the end of the season and then re-install them early the following season, or simply to leave them in the wetland. One possible problem with leaving them in is that they could potentially become damaged by ice during the winter. Another problem is that changes in the habitat structure from one year to the next could leave platforms in a less favourable area the following year. Ice movements could potentially shift the platforms out of the prime habitat. We do not know to what extent platforms will be used if they are left in a habitat that becomes less suitable, but this presumably depends on the suitability of the habitat based on other factors, such as the extent and type of vegetation around the platforms, the presence of perches nearby, distance from shore, etc. These possible disadvantages of leaving platforms in at the end of the season must be weighed against the main advantage (i.e. the time saved at the end of one season and at the beginning of the next).

5.2.2 Breeding Success on Platforms vs. Natural Sites

Our results suggest that hatching success is as high on Wire Mesh platforms as on natural sites, and that as long as small-meshed Wire Mesh platforms are used, chick survival will not be compromised.

5.2.3 The Problem of Platform Use by Other Animal Species

Apart from predators and muskrats, other animals that find Black Tern nesting platforms attractive are: turtles, which use them for basking (Richardson 1996), raccoons (*Procyon*

lotor), for sitting and eating molluscs (Richardson 1996), and waterfowl, for molting. We observed waterfowl feathers on 11 of 24 platforms in the Rushes Marsh (mostly after 10 July): five Wooden Trays, four Bare Planks and only two Wire Meshes.

We were able to follow the use of platforms by terns and muskrats over the breeding season. Of the 24 platforms installed, 13 had evidence of muskrat activity on at least one of our visits. Of those 13: six had muskrat activity but no tern nest during the season; four had a tern nest followed by muskrat activity; one had muskrat activity followed by a tern nest; the remaining two had muskrat activity followed by a tern nest followed by more muskrat activity. All this suggests considerable competition for (or at least co-use of) platforms. Of the 13 platforms with evidence of muskrat activity, six were Wooden Trays, but only four were Wire Meshes and three were Bare Planks.

Muskrats seemed to prefer the Wooden Tray to the other platforms, possibly because of the higher stability provided by its walls. We found a tern on a nest 30 cm from a muskrat lying in the corner of the same Wooden Tray -- both departed upon our arrival. On our next visit we found a muskrat and balls of vegetation -- the tern nest had been destroyed.

We observed muskrats on numerous occasions, observed young in the summer, and noted extensive muskrat activity in the Rushes Marsh: fresh cut rushes, balls of vegetation used in the construction of lodges, and flat mounds apparently used by muskrats for feeding. In the Willows Marsh, on the other hand, we found no muskrat lodges, nor did we see any muskrats or signs of their activity. The impoundment is one of the most important areas of reproduction in the region for muskrats (Chubbuck 1983).

5.2.4 Recommendations Regarding the Use of Nesting Platforms

Platforms can be used to increase the number of potential nesting substrates. This can probably help Black Terns by allowing them to nest in wetlands that are generally favourable but which may lack potential nesting substrates, especially during the early part of the season.

If platforms are to be used, we recommend the Wire Mesh type fitted with small mesh. When studies of reproductive success are necessary, we recommend using higher fences than the ones we used in 1997. This should reduce the likelihood of chicks escaping under fence bottoms left higher than the water as a result of dropping water levels between visits, while at the same time leaving enough width above the water to prevent escape over the fence. We thus recommend a height of 30 cm, which has been used more successfully (Dunn 1979). Alternatively, one can use a floating fence (E. Dunn, pers. comm.).

5.3 Future Work

Several studies, including this one, have shown that nesting platforms are used by Black Terns, and that hatching success and chick survival are not adversely affected. What has not been determined is whether platforms can increase the number of breeding pairs in colonies over the long term (Shambaugh 1996) or whether platforms can be used to entice Black Terns to nest in hitherto unused wetlands.

Future work could examine the usefulness of platforms in a variety of representative habitats currently used and unused by Black Terns over a substantial geographic area (e.g. southern Ontario). The results of such a study would allow for an evaluation of the usefulness of platforms as a conservation tool in a variety of habitats over large geographic areas.

Future work could also be done to refine the Wire Mesh platform by making it smaller and therefore: 1) cheaper to build, 2) easier to transport and install, and possibly 3) of less interest to other animal species. Another improvement might be to use screen instead of wire mesh. This would eliminate the necessity of threading the vegetation through the wire mesh, which would save time. It would also eliminate the possibility of chicks falling through, while allowing the vegetation to stay wet by being in contact with the water.

Finally, it might be useful to determine whether Black Terns will nest on platforms that are already fenced. This would allow managers who feel it necessary to measure breeding success to install platforms and fences at the same time, and therefore not be obliged to visit nests while they are active.

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8 APPENDICES

Appendix 1. List of species of various animal groups, except dragonflies and damselflies, observed at the impoundment in 1997.

Amphibians (seen or heard)
Spring Peeper
Gray Treefrog
Striped Chorus Frog
Northern Leopard Frog
Green Frog
Bullfrog

Reptiles (seen)
Painted Turtle
Common Garter Snake

Mammals (seen)
American Beaver (trees cut by beaver)
Muskrat
Raccoon
White-tailed Deer

Birds (seen or heard)
Common Loon (flying over)
Pied-billed Grebe*
Least Bittern
Great Blue Heron*
Green Heron
Black-crowned Night-Heron
Canada Goose*
American Black Duck
Mallard*
Blue-winged Teal*
Gadwall
American Wigeon
Bufflehead
Turkey Vulture
Osprey
Northern Harrier
Red-tailed Hawk
Peregrine Falcon
Ruffed Grouse
Virginia Rail
Sora
Common Moorhen*
American Coot
Killdeer
Greater Yellowlegs
Lesser Yellowlegs
Solitary Sandpiper
Spotted Sandpiper
Least Sandpiper
Dunlin
Common Snipe
Wilson's Phalarope
Ring-billed Gull
Caspian Tern
Forster's Tern
Black Tern*
Rock Dove
Mourning Dove
Ruby-throated Hummingbird
Belted Kingfisher
Northern Flicker
Eastern Wood-Pewee
Willow Flycatcher
Eastern Phoebe
Great Crested Flycatcher
Eastern Kingbird
Purple Martin
Tree Swallow*

* Nest found or young of the year seen

Appendix 1 (cont.)

Birds (cont.)
Northern Rough-winged Swallow
Bank Swallow
Barn Swallow
Blue Jay
American Crow
Black-capped Chickadee*
Marsh Wren
Swainson's Thrush
American Robin*
Gray Catbird
Cedar Waxwing
European Starling
Warbling Vireo
Red-eyed Vireo
Yellow Warbler*
Yellow-rumped Warbler
Blackpoll Warbler
Chipping Sparrow
Field Sparrow
Song Sparrow
Swamp Sparrow
Red-winged Blackbird*
Eastern Meadowlark
Common Grackle*
Northern Oriole*
American Goldfinch

Fish
Central Mudminnow
Brook Stickleback
Northern Redbelly Dace
Fathead Minnow
Pumpkinseed

Molluscs
Lymnea stagnalis
Stagnicola elodes
Physa gyrina
Helisoma trivolvus
Sphaerium lacustre

* Nest found or young of the year seen

Appendix 2. List of dragonflies and damselflies present on 19 June 1997 at the impoundment[a].

Species	Adult(s) seen	Adult(s) collected	Larvae collected	Exuviae collected	Emergence in lab.
Lestes sp.			x		
Nehalennia irene		x			
Coenagrion resolutum		x			
Enallagma ebrium	x				
Enallagma sp.			x		
Ischnura verticalis	x				
Coenagrionidae sp.			x		
Aeshna sp.				x	
Anax junius	x		x		
Cordulia shurtleffi				x	
Dorocordulia libera				x	
Tetragoneuria cyanosura				x	
Libellula quadrimaculata	x		x	x	
L. pulchella	x		x	x	x
L. luctuosa		x	x		x
L. julia	x				
L. lydia	x				
Erythemis simplicicollis			x		
Sympetrum sp.			x		
Leucorrhinia intacta	x			x	x
Celithemis elisa		x			
Pachydiplax longipennis			x		x

[a] All data courtesy of Mr. Benoit Ménard.

Appendix 3. Growth of the Softstem Bulrush at the impoundment.

Date (1997)	Height Above Water Surface (cm)	
	Average Height	Maximum Height
14 May	17	30
23 May	--	35
5 June	76	92
19 June	--	100
2 July	--	115[a]
11 July	100	138
23 July	100	165

[a] Flowers first appear

Appendix 4. Water level of the impoundment.[a]

Date (1997)	Water Level (cm)	Water Flowing Over Weir
5 May	89.9	Y
8 May	89.9	Y
14 May	89.9	Y
22 May	89.9	Y
23 May	93.6	N
26 May	93.6	N
28 May	95.0	N
3 June	96.4	N
5 June	97.0	N
11 June	100.5	N
12 June	100.5	N
19 June	99.2	N
26 June	98.5	N
2 July	102.7	N
3 July	102.7	N
10 July	105.2	N
11 July	105.5	N
17 July	109.8	N
23 July	111.7	N
25 July	113.2	N

[a] Water level was measured by taking the distance from the top of the weir (i.e. the flat top of the stoplog bay's centre concrete tower) down to the water surface.