STATUS, ECOLOGY AND MANAGEMENT OF COLONIAL WATERBIRDS NESTING IN HAMILTON HARBOUR, LAKE ONTARIO, 1988 - 1994

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ABSTRACT

During 1989 - 1994, 6 species of colonial waterbirds (Double-crested Cormorant, Black-crowned Night-Heron, Herring Gull, Ring-billed Gull, Caspian Tern and Common Tern) bred at Hamilton Harbour. With sizeable colonies of 6 waterbird species, including 2 (Black-crowned Night-Heron and Caspian Tern) that were recently recommended for the status of "rare" in Ontario, the Hamilton Harbour is one of the most important breeding sites on the Canadian Great Lakes.

Numbers of breeding pairs increased for all colonial waterbird species (except Black-crowned Night-Heron) during the period from 1988-1993. In 1994, numbers of Double-crested Cormorant, Black-crowned Night-Heron and Common Tern declined in the Harbour. These declines relate to major changes in both habitat use and colony locations which have resulted from competitive interactions between tree-nesting cormorants and night-herons and among ground-nesting species.

Increases in the number of cormorants nesting in cottonwood trees at Pier 27 during 1986-1988 correspond to decreased use and eventual abandonment of these trees by night-herons, and an overall decrease in the number of night-heron pairs breeding at Hamilton Harbour. After 1988, the majority of night-heron nests were located in sandbar willow bushes or on the ground at Pier 27 and by 1994, three-quarters of all nests were less than 1 m above the ground. From 1988 to 1994, the cottonwood trees at Pier 27 began dying and toppling over, shortly after cormorants established a colony there, and in 1991 many cormorants began nesting directly on the ground at Pier 27. Ground-nesting increased through 1993, but only one pair nested on the ground in 1994.

Interspecific competition among ground-nesting waterbirds has also resulted in species successions at various colony locations. Ring-billed Gulls are solely responsible for the desertion of Farre and Neare Island (1989 and 1990, respectively) and Eastport Pier 26 (1989) colony locations by Common Terns. Abandonment of tern sub-colonies within Windermere Basin also resulted primarily from exclusion by gulls, but growth of dense vegetation was responsible for desertion of some sub-colonies. The mechanism by which gulls usurp tern breeding areas appears to be their earlier arrival and initiation of clutches. Similarly, numbers of Herring Gull pairs nesting on the Hydro Islands increased during the early 1990s, corresponding to the exclusion of Ring-billed Gulls from Farre Island by 1993 and Neare Island by 1994. There were relatively small changes in the location of the Caspian Tern colony during 1988-1994, indicating that these terns are able to compete successfully with smaller, but more numerous Ring-billed Gulls for breeding space.

Management efforts at Hamilton Harbour have centred around control of Ring-billed Gull numbers through scaring tactics, the creation of Common Tern habitat and relocation of Caspian Terns to more secure nesting areas. Gull control (including use of monofilament lines, loud noises, shell crackers, and physical disturbance of roosting birds) has been successful at both Eastport and Stelco No. 2 Rod Mill. Gull control practices should be expanded in future to eliminate competition between both species of terns and Ring-billed Gulls for breeding space. The creation of a small island in Windermere Basin was successful in that it became readily colonized by Common Terns. Attempts to relocate Caspian Terns to modified habitats (1990, 1991) failed, but efforts to establish them on a nesting raft (1993, 1994) has proven more successful.

RÉSUMÉ

De 1989 à 1994, six espèces d'oiseaux coloniaux (Cormoran à aigrettes, Bihoreau, Goéland argenté, Goéland à bec cerclé, Sterne caspienne et Sterne commune) ont niché au port d'Hamilton. C'est à cause de ces colonies considérables de six espèces d'oiseaux aquatiques , incluant deux (Bihoreau et Sterne caspienne) lesquels ont récemment été recommandé à recevoir le titre de rare on Ontario, que le port d'Hamilton est devenu l'un des sites reproductifs des plus important des Grand lacs canadiens de même que dans tout l'Ontario.

De 1988 à 1993, le nombre de couples reproducteurs pour toutes les espèces d'oiseaux aquatiques coloniaux a augmenté à l'exception du Bihoreau. C'est en 1994 que les nombres du Cormoran à aigrettes, du Bihoreau et de la Sterne commune ont diminués dans le port. Ces diminutions sont reliées à des changements majeurs dans l'utilisation de l'habitat ainsi que les endroits où nichent les différentes espèces, ce qui a produit une interaction compétitive entre les nicheurs dans les arbres (Cormorans et Bihoreaux) et les autres espèces nichant au sol. L'augmentation de 1986 à 1988 du nombre de cormorans nichant dans les trembles sur la jetée 27, est relative à la diminution de l'utilisation et éventuellement l'abandon de ces arbres par les Bihoreaux et leur déclin général au port d'Hamilton.

Depuis 1988 , on retrouve la majorité des nids de Bihoreaux dans de jeunes trembles sur une pointe de sable où au sol sur la jetée 27. En 1994 , le trois quarts de tous leur nids se trouvait à moins d'un mètre du sol . Peu de temps après que les cormorans s'y sont établis, les trembles ont commencé à se briser et mourir. De ce fait, en 1991, plusieurs cormorans nichaient directement au sol sur la jetée 27. Ce nichage au sol a continué jusqu'en 1993, mais on a dénombré qu'un seul nid en 1994.

La compétition interspecifique entre les différents espèces d'oiseaux aquatiques nichant au sol a aussi entraîné la succession d'espèces a différents endroits dans la colonie. Ce sont les Goélands à bec cerclé qui sont responsables de l'abandon des colonies de Sterne commune aux îles Farre et Neare (1989 et 1990 respectivement) de même qu'à la jetée 26 d'Eastport en 1989.Ce sont les goélands qui ont aussi causé l'abandon de sous-colonies de sternes dans le bassin Windermere. Cependant, la croissance d'une végétation épaisse a aussi participé à l'abandon de certaines de ces sous-colonies. Les goélands réussissent à s'accaparer des sites de nidification parce qu'ils reviennent nicher sur les lieux plus tôt que les sternes . C'est au début des années 1990 que le nombre de paires de Goéland argenté nichant sur les îles d'Hydro Ontario a tellement augmenté, que le Goéland a bec cerclé a été éliminé de l'île Farre en 1993 et de l'île Neare en 1994.

Il y a eu très peu de changement dans le site de nidification de la Sterne caspienne de 1988 à 1994. Ceci démontre que ces sternes sont capable de faire concurrence aux plus petits mais beaucoup plus nombreux Goélands à bec cerclé qui occupaient déja le site.

Les efforts d'aménagement au port d'Hamilton ont été concentré sur le contrôle du nombre de Goéland à bec cerclé par des méthodes d'effarouchement, la construction d'habitat additionnel pour la Sterne commune, ainsi que le déplacement de la colonie de Sterne caspienne vers un endroit plus sécuritaire . Le contrôle de goélands (incluant l'utilisation de fils de pêche en monofilament, de bruits très forts , de fusées-pétards, ainsi que le déplacement physique d'oiseaux nicheurs) a rapporté du succès aux sites d'Eastport et de Stelco No. 2 Rod Mill . On devrait, dans un futur rapproché, augmenter les pratiques de contrôle des goélands afin d'empêcher la compétition existante pour les sites de nidification entre les deux espèces de sternes et le Goéland à bec cerclé . La construction d'un îlot dans le bassin Windermere a rapporté du succès puisque la Sterne commune y a immédiatement aménagée. Les tentatives d'aménager les Sternes caspiennes vers des habitats modifiés en 1990 et 1991 ont echouées. Cependant , on a eu un certain succès à les déplacer vers un

radeau pour nicher en 1993 et 1994.

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1. INTRODUCTION

Prior to the mid-1970s, few species of colonial waterbirds nested in Hamilton Harbour. During this period, population sizes were small and formation of breeding colonies was sporadic (Dobos *et al.* 1988). Over the last two decades, however, Hamilton Harbour has become one of the most important nesting sites for colonial waterbirds on the Great Lakes in terms of both species diversity and numbers of breeding birds (Blokpoel and Tessier 1991). The increased use of Hamilton Harbour as a nesting site for colonial waterbirds is mainly due to the creation of suitable nesting habitat which has resulted from developments at Eastport and Windermere Basin. In recent years, 6 species of waterbirds, Double-crested Cormorant (*Phalacrocorax auritus*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Herring Gull (*Larus argentatus*), Ring-billed Gull (*L. delawarensis*), Caspian Tern (*Sterna caspia*), and Common Tern (*S. hirundo*), have maintained regular breeding colonies in Hamilton Harbour (from 1965 - 1987, Dobos *et al.* 1988; 1988 - 1994, CWS unpubl. data).

The Hamilton Harbour colony locations are potentially important in terms of long-range conservation of some species of colonial waterbirds on the Great Lakes. For example, Common Terns have been experiencing long-term population declines in this region, and are designated as endangered, threatened, or of special concern in many of the states bordering the Great Lakes (Courtney and Blokpoel 1983, Kress *et al.* 1983, Blokpoel and Scharf 1991). Similarly, Caspian Terns are considered a vulnerable species in Canada (COSEWIC 1992) and designated as endangered and threatened in Wisconsin and Michigan, respectively (Blokpoel and Scharf 1991). Breeding populations of both tern species have increased at Hamilton Harbour since the establishment of colonies there during the mid-1980s.

Many changes have occurred in Hamilton Harbour since the late 1980s with respect to both the types of habitat available and the birds occupying them . Significant changes to the Harbour, which will directly impact the colonial waterbirds nesting there, are planned in the near future. First, some areas where nesting colonial waterbirds are most heavily concentrated (Piers 26, Windermere Basin) are either in the process of being developed or are designated as lands for future development. While construction activities at these sites do not yet appear to have affected the bird's breeding activities, it is inevitable that they will be displaced from these colony locations. Second, Hamilton Harbour has been designated as an "Area of Concern" and a Remedial Action Plan (RAP) for restoration of the Harbour was initiated by provincial and federal environmental agencies in 1986 (Hamilton Harbour RAP 1989). One component of this proposal is the creation of wildlife islands within Hamilton Harbour, which will, in part, provide nesting habitat for colonial waterbird species.

Attempting to manage populations of colonial waterbirds nesting in a highly populated, heavily industrialized urban setting such as Hamilton Harbour, is a challenging proposition. Some species, such as Ring-billed Gulls, are abundant in the Great Lakes area and nest readily in a variety of habitats. For this species, management problems centre around controlling an overabundance of individuals (e.g. Blokpoel and Tessier 1986, 1992). Other species appear to have more rigid nesting requirements (e.g. Common and Caspian Terns) and may be difficult to relocate when conflicts between human activities and nesting arise. Competition between or among species for nest sites (e.g. between Ring-billed Gulls and terns, between Double-crested Cormorants and Black-crowned Night-Herons) further complicates efforts to establish or maintain "desired" species (Morris and Hunter 1976). As natural nesting habitat (i.e. small islands) on the lower Great Lakes is rather scarce

for these birds, many of them will be forced to nest on artificial habitat usually in or near urban centres. The presence of breeding colonies at Hamilton Harbour presents a unique opportunity to study the factors affecting waterbird community dynamics. Furthermore, these colonies can also be used as a model system for developing long-term management policies for colonial waterbirds nesting in urban areas.

The purposes of this paper are (1) to continue from Dobos *et al.* (1988) and provide an update on the status of colonial waterbird breeding populations at Hamilton Harbour (1988-1994), (2) to describe how human changes to the landscape, together with natural succession and interspecific competition have affected nest distributions in the Harbour, (3) to report the results of conservation efforts for Common and Caspian Terns and of control efforts for Ring-billed Gulls, and (4) to provide a framework for making effective decisions regarding the future of colonial waterbirds nesting at Hamilton Harbour.

2. STUDY AREA

Hamilton Harbour (43°16'24"N, 79°46'46"W) with a surface area of 2150 ha and a mean depth of 13 m, is located at the extreme western end of Lake Ontario (Hamilton Harbour RAP 1989) . The Harbour is separated from Lake Ontario by a large sandbar, the Burlington Beachstrip, and water exchange occurs through the human-made Burlington Canal (Fig. 1). The southern shorelines of Hamilton Harbour are used primarily for industrial purposes (predominantly steel manufacturing and shipping related industries), while the north shore is mainly residential. Shoreline restructuring and filling during the past century have resulted in the loss of much of the original wetland habitat and water in the harbour has become heavily polluted by inputs from major industries and municipal sewage treatment facilities (Gebauer *et al.* 1993).

By the 1970s, little natural, undisturbed breeding habitat existed at Hamilton Harbour (Dobos *et al.* 1988) and, subsequently, colonial waterbird species have occupied artificially-created lands. All nesting has been restricted to four main areas of the harbour: (1) the Eastport facility (Piers 25, 26 and 27), (2) Neare and Farre Islands, (3) Windermere Basin, and (4) on Stelco No. 2 Rod Mill property opposite Piers 25 and 26 (Fig. 1). A description of each area is given below.

2.1 Eastport

Most of the waterbird species breeding in Hamilton Harbour are located at the land mass comprising Piers 25, 26 and 27 (officially known as Eastport), created by filling operations carried out by the Hamilton Harbour Commissioners over the past 35 years (Dobos *et al.* 1988). Piers 26 and 27 both contain Confined Disposal Facility (CDF) ponds for the containment of contaminated sediments dredged from the harbour (Fig. 1). Approximately 150 eastern cottonwood trees (*Populus deltoides* , most >10 m) and 3 willow trees (*Salix* spp., 3-5 m) are scattered along the east and west shores of the dike comprising the western side of the CDF pond at Pier 27. The only other arboreal nesting habitat at Pier 27 consists of several dense clumps of sandbar willow shrubs (*Salix exigua*, all stems ≤ 2 cm). Pier 26 contains only 4 small, lone cottonwoods and 1 small Manitoba maple (all ≤ 5 m).

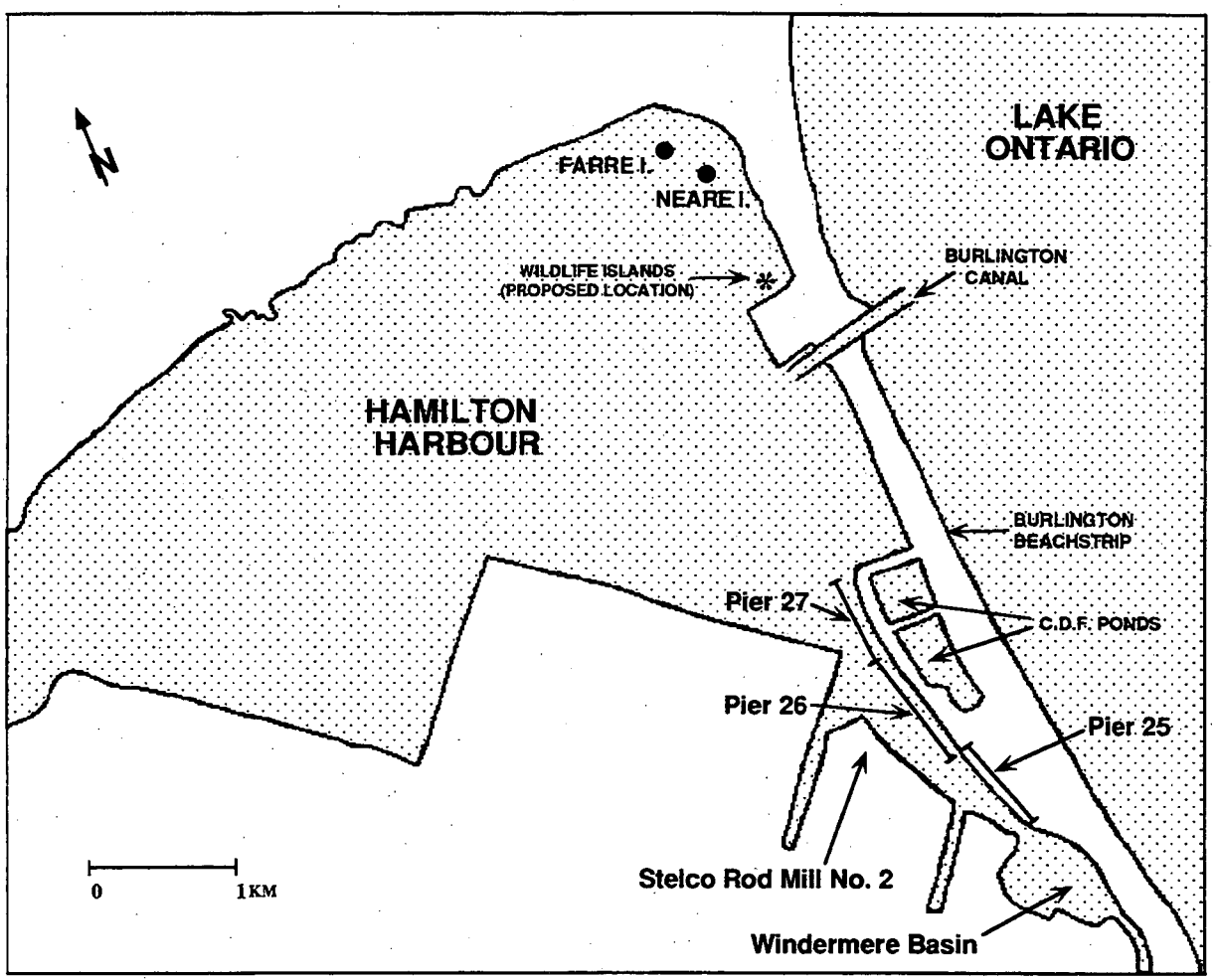

Fig. 1. Map of Hamilton and adjacent Lake Ontario, showing locations of colonial waterbird breeding colonies. Shaded areas represent water.

The majority of nesting habitat at Eastport is flat (with the occasional elevated mound) with a silt or clay substrate, either devoid of or sparsely vegetated with annual plant species (< 0.5 m). Over the past few years , however, there has been an increase in the proportion of land area covered with dense vegetation (< 1 m tall, e.g. stinging nettle, *Urtica dioica*, and 1 - 1.5 m tall, an unidentified mustard species).

2.2 Windermere Basin

Windermere Basin, with a surface area of 20 ha and mean depth of 2 m (Hamilton Harbour RAP 1989), is located at the southeast end of Hamilton Harbour (Fig. 1). Historically, it was a cattail (*Typha* spp.) marsh but was extensively altered by filling between 1957 and 1972 and the dredging of heavily contaminated sediments in 1989 (Gebauer *et al.* 1993). A spur dike was created in 1990 to reduce the water flow and precipitate heavier materials into the sediment. As of 1994, filling operations continued to increase the surface area of land in the Basin. The available nesting habitat at Windermere Basin consists of a flat silt, clay or gravel substrate sparsely covered with low-lying vegetation (< 0.5 m). The Basin was devoid of dense vegetation in 1990, but early-successional species (e.g. *Urtica dioica, Populus deltoides*) have since colonized some areas precluding nesting by colonial waterbird species.

2.3 Neare and Farre Islands

These two small (each approx. 30 m x 35 m) artificial islands (also known as the "Hydro Islands") located in the northeast corner of the Harbour were formerly used to support towers for hydro electric wires (Fig. 1). Both islands have a rocky cobble substrate with little or no plant cover, except for Farre Island where there is a lone Manitoba maple (*Acer negundo*, < 5 m).

2.4 Stelco No. 2 Rod Mill

This site is located southwest of the boundary between Piers 25 and 26, and separated from Eastport by approximately 300 m of water (Fig. 1). Two types of nesting substrate occur at this site. The first is a human-made dike (total surface dimension approx. 5 m x 1150 m) running along a rectangular pond on three sides. The dike is covered with crushed slag and portions of it are heavily vegetated. The second nesting habitat is a flattened area composed of clay substrate at the southwestern end of the aforementioned pond. This area is graded annually (P. Smith, pers. comm.) and has little vegetation cover.

3. METHODS

3.1 Population censuses

Population censuses were conducted in Hamilton Harbour by the Canadian Wildlife Service (C W S) from 1988 to 1994 to determine the number of breeding pairs and distribution of nests for all species of colonial nesting waterbirds (except Ring-billed Gulls, which were counted only in 1990, and Herring Gulls, which were nesting but not censused during 1988). Censuses were usually conducted during the last week of May or first two weeks of June, periods corresponding to either

the final week of incubation or the early chick-rearing stages during the "peak" (see Haymes and Blokpoel 1980) nesting period for each species. Census dates for each year are recorded in Appendices 1A-1F. Population counts represent all active nests (both scrapes and nests with eggs) found within Hamilton Harbour, which we assume to represent the number of breeding pairs. Stelco No. 2 Rod Mill was not censused during 1988, 1991, or 1992, which will affect population estimates for Common Terns only. The census methods we employed during this study are identical to those used by Dobos *et al.* (1988), allowing comparisons to be made between studies. To calculate mean annual population rates of increase (R) we used the formula $R = (N_t/N_0)^{1/t}$, where N_0 is initial population size, t is number of breeding seasons, and N_t is population size after t breeding periods (Begon and Mortimer 1986).

3.2 Determination of habitat use

During 1993, we performed a detailed survey of habitat use by Black-crowned Night-Herons and Double-crested Cormorants. For every nest (both species), we measured nest elevation (ground to lip of nest) and recorded the species and state (live, dying, dead) of each nesting tree. In 1994, all Black-crowned Night-Heron nests at Eastport were described according to their (1) position in trees, willow shrubs or on the ground, (2) height above ground, (3) height above water and (4) distance from water.

During 1991-1993 (24-26 May, all years), we recorded the location, number of nests, and habitat characteristics (nesting substrate, height and density of vegetation) for each Common Tern sub-colony location within Windermere Basin (terns nest in several distinct sub-colonies rather than in one dense colony). Sub-colony boundaries were defined by the nesting patterns of birds. We used a subjective scale to categorize vegetation densities at each sub-colony location as either no vegetation, sparse (comprising ≤ 25% surface area), moderate (comprising 25 - 75% of the surface area), or dense (comprising ≥ 75% surface area). We categorized the vegetation at each sub-colony location as having a mean height of either (1) less than 15 cm, (2) 15-30 cm, or (3) greater than 30 cm. We also noted the number of Ring-billed Gull pairs nesting in association with each tern sub-colony location.

3.3 Management Practices

3.3.1 Gull Control

Ring-billed Gulls began nesting on Stelco property at No. 2 Rod Mill and Hilton Works in 1983. Stelco has employed a combination of gull control techniques including installation of monofilament lines, frequent grading of nesting substrates early in the breeding season, and destruction of eggs and nests by hand, each year since 1986 to prevent Ring-billed Gulls from re-establishing colonies at these sites (Blokpoel and Tessier 1987, P. D. Smith, pers. comm.).

Gull control measures have also been employed at the main colony at Eastport. In 1992, intensive operations were carried out prior to and throughout the peak clutch initiation period at the Pier 25 and 26 port facilities. Disturbance of gulls was accomplished by driving an ATV over control areas at regular intervals from dawn-to-dusk. During 1993 and 1994, gull control practices intensified at this site and included the use of shell crackers, playback of loud noises, and occasional use of tethered birds of prey.

3.3.2 Habitat Modification for Caspian Terns

Prior to the arrival of terns at the Eastport site in early April, 1990, a shallow depression (20 m x 25 m surface area) was excavated west of the dike between the two CDF ponds in the southwestern section of Pier 27 (Gebauer and Hennessey 1990) and filled with water to a depth of 0.3 m. Excavated soil was mounded (15 m x 21 m surface area, 1.5 m height) at the north end of this depression and covered with crushed stone (1 cm particle size). Caspian Tern decoys and playback of courtship calls (daily, 0630-0830 and 1730-2030 hrs) were employed in order to attract and promote nesting by Caspian Terns. In 1991, the duration of Caspian Tern courtship call playback was increased to approximately 9hrs/day (between 0800 and 1900hrs) (Hebert 1991). No attempts were made to discourage Ring-billed Gull nesting at the Pier 26 site.

3.3.3 Nesting Raft for Caspian Terns

A single plywood raft (4.9 m x 9.8 m surface area) was positioned in the southwest corner of the CDF pond at Pier 26, close to the 1992 secondary location (i.e. colony B in 1994, for detailed location see Fig.7 on p. 20). The raft surface was composed of sand (mean depth of 5 cm) with scattered gravel (1 cm) and driftwood to provide natural topography, and a 0.3 m high hinged side panels. In 1993, the raft was made available to the terns when the tarpaulin covering was removed on 6 May. Caspian Tern decoys and playback of vocalizations (played 11 May-31 May 1993, mean = 6.1 hrs/day) were used to attract Caspians to colonize the raft (for further details see McMartin 1993). In 1994, the raft remained in the same position as the previous year and was opened on 10 May. Decoys and vocalizations were employed again to attract Caspian Terns. During both years, observations were made from a blind, approximately 55 m away, on the western shore of the CDF pond at Pier 26 (for more details see Lampman 1994).

3.3.4 Habitat Creation for Common Terns

To reduce the current and thus increase sedimentation in Windermere Basin, the Hamilton Harbour Commissioners constructed a submerged dyke (referred to as Spur Dyke) perpendicular to the shoreline (see Fig.8). At the request of CWS, the HHC increased the height of the terminal portion of the dyke to create a small island (Spur Island) in 1990. The surface of Spur Island, about 4m x 40m, was covered with small cobbles and gravel, as well as sparse, low-lying vegetation to provide suitable nesting substrate for Common Terns. Tall vegetation (e.g. nettles) had become established by 1993 and has been removed annually starting that year.

4. RESULTS AND DISCUSSION

An annual summary of the number of nests of each colonial waterbird species on Hamilton Harbour from 1975-1994 is presented in Table 1. Data from 1975-1987 have been previously reported in Dobos *et al.* (1988), and are cited here for historical perspective. Population trends, geographical distribution of nests, nesting habitat use, cases of interspecific competition, and control or conservation measures taken for each colonial waterbird species are presented and discussed separately below. Distributions of nests of each species in Hamilton Harbour between 1988-1994 appear in the Appendices.

Table 1. Number of breeding pairs of colonial waterbirds nesting at Hamilton Harbour, 1975-1994.

Year[1]	DCCO	BCNH	RBGU	HERG	CATE	COTE[2]
1975	0	6	0	0	0	0
1976	0	ND	0	7	0	0
1977	0	ND	0	14	0	0
1978	0	ND	17	ND	0	0
1980	0	1	329	102	0	0
1981	0	19	2400	130	0	0
1982	0	13	5000	50	0	N
1984	1	51	11224	202	0	N
1985	2	98	13778	150	0	225
1986	14	183	16000	106	48	N
1987	51	212	21207	225	134	553
1988	157	194	N	N	242	644
1989	140	104	N	329	175	667 (20)
1990	250	99	39621	343	184	1028 (246)
1991	416	60	N	N	220	585 (ND)
1992	592	132	N	272	337	753 (ND)
1993	685	134	N	300	301	954 (32)
1994	451	90	N	303	313	868 (193)

Abbreviations: DCCO (Double-crested Cormorant), BCNH (Black-crowned Night-Heron), RBGU (Ring-billed Gull), HERG (Herring Gull), CATE (Caspian Tern), COTE (Common Tern).

1 Data for 1975-1987 are taken from Dobos *et al.* (1988), Table 1. Censuses were not conducted during 1979 or 1983.

2 Totals for 1989, 1990, 1993 and 1994 include the number of COTEs nesting on Stelco property (in brackets). This colony was not censused in other years.

ND No data available.

N Nesting, but not censused.

4.1 Double-crested Cormorant

4.1.1 Nest Distribution and Abundance

Double-crested Cormorants were first recorded breeding at Hamilton Harbour in 1984, when a single pair nested on the ground on Farre Island (L. Simser, pers. comm.). The breeding population at Hamilton Harbour increased steadily to 685 pairs in 1993 (Table 1), a net rate of increase of 91.3% per annum. Rapid population growth has occurred elsewhere on Lake Ontario (Price and Weseloh 1986) and throughout the Great Lakes (Blokpoel and Scharf 1991, Weseloh and Ewins 1994, Ewins and Weseloh in press, Weseloh *et al.* in press). However, it is unclear whether the population growth of the Hamilton Harbour colony was more a function of immigration or recruitment. The trend of increasing population growth size at Hamilton Harbour was not carried into 1994 when the number of breeding cormorants dropped to 428 pairs (a decrease of 34%) (Table 1). With a decrease of this magnitude, it seems more likely that emigration rather than mortality played a key role. In 1994, the colony at Hamilton Harbour was the seventh largest of thirteen colonies on Lake Ontario (CWS 1994 unpubl. data).

4.1.2 Habitat Use and Competition

Since 1986, Double-crested Cormorants have nested mainly in the top branches of tall cottonwood trees located along the western shore of the northernmost CDF pond at Pier 27 (Fig. 1). Since then, these trees have gradually died, presumably as a result of guano deposition from nesting cormorants. In 1991 most cottonwoods were still partially foliated, but by 1993 only 24% (N=36) still remained alive. During 1993, a detailed study of nesting habitat use by cormorants and night-herons in the Harbour showed clear separation between these species with respect to (1) the types of vegetation in which nests were located (X^2=475.9, d.f.=4, p≤ 0.0001, Fig. 2A) and (2) nest platform elevations (X^2=502.8, d.f.=4, p≤ 0.0001, Fig. 2B). Double-crested Cormorants nested predominantly in dead trees (81.4% of total), 96% of these being the dead cottonwoods at Pier 27. The remainder of nests occurred on the ground (11.7% of total, all beneath sandbar willow bushes) or in the upper branches of live cottonwoods (6.9% of total, Fig. 2A).

During recent years, Double-crested Cormorants have expanded their nesting range beyond the trees at Pier 27. First, cormorants began nesting in the lone Manitoba maple on Farre Island (11 nests in 1991, 23 nests by 1994). Second, in 1992 Double-crested Cormorants began nesting directly on the ground, both in the area of the cottonwoods at Pier 27 and further to the south near the Pier 27/Pier 26 border (Fig. 1). The number of pairs nesting on the ground increased from 29 in 1992 to 90 in 1993 (all nests located in the vicinity of the cottonwood trees in 1993), suggesting that Double-crested Cormorants had saturated the available tree nesting habitat at Pier 27 and Farre Island. However, this trend did not continue into 1994 when there were fewer cormorants in Hamilton Harbour and only 1 ground nest was found at Pier 27. As the loss of cottonwood trees at Pier 27 is inevitable, any cormorants that remain at this location will be forced to nest on the ground. A possible outcome of a switch to ground nesting by cormorants at Hamilton Harbour is a decrease in mean fledgling production at this colony. During 1993, a study was conducted to compare breeding success of cormorants nesting directly on the ground at Pier 27 with sympatric conspecifics whose nest platforms were located in trees. Cormorants nesting in trees had a higher average fledgling success of 2.3 chicks/nest compared with a mean fledgling rate of 0.3 chicks/nest for those nesting directly on the ground (B. McMartin unpubl. data). However, this may be a result of the

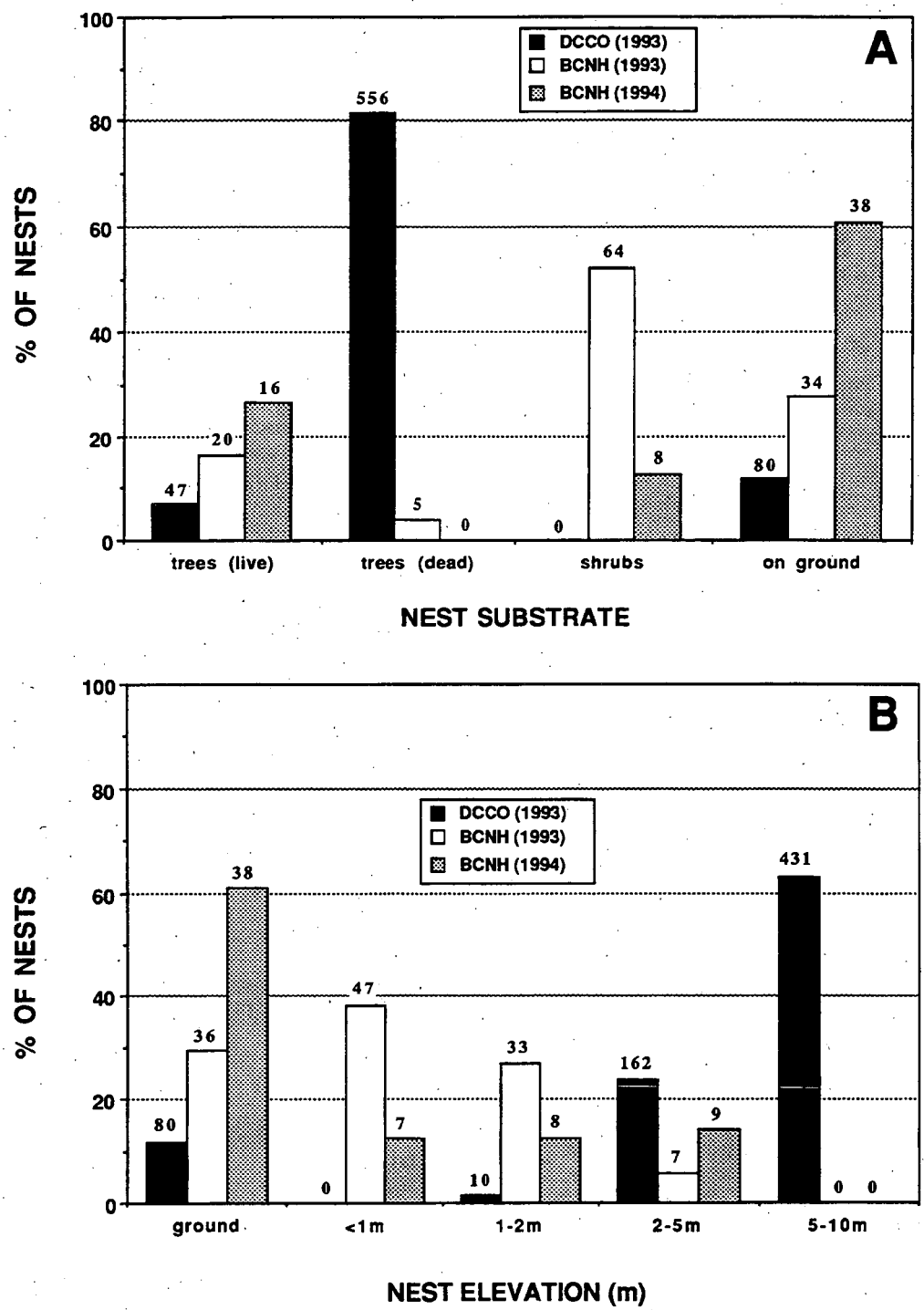

Fig. 2. Distribution of the type of (A) nesting substrates and (B) nest elevations of Double-crested Cormorants and Black-crowned Night-Herons breeding at Eastport (Piers 26 and 27) during 1993 and 1994 (night-herons only). Numbers above frequency bars represent the total number of nests belonging to each class.

more experienced birds arriving earlier and nesting in the trees and the younger, inexperienced breeders arriving later and having to nest on the ground. The poor reproductive success of ground nests in 1993 may be part of the reason that cormorants did not nest on the ground at Pier 27 in 1994 and presumably nested somewhere outside Eastport.

4.1.3 Conservation and Control

To date, no efforts have been made to manage the Double-crested Cormorant breeding population at Hamilton Harbour. DesGranges and Reed (1981) report on successful control efforts with cormorants in the St. Lawrence River.

In the very near future, management concerns will probably centre around the loss of tree nesting habitat at Pier 27. This will likely result in one or more of the following three scenarios: a habitat shift by cormorants to nesting directly on the ground at Pier 27 and Farre Island (which could detrimentally impact Herring Gulls already nesting there), a nesting site shift from Eastport to trees located along the north shore of Burlington Bay (i.e. Coote's Paradise, LaSalle Park, or private residences) or complete abandonment of Hamilton Harbour as a breeding location.

4.2 Black-crowned Night-Heron

4.2.1 Nest Distribution and Abundance

Black-crowned Night-Herons were first recorded nesting in Hamilton Harbour at Pier 27 in 1975, and by 1987 their numbers had increased to 212 pairs (Table 1), representing an average increase of 34.6% per year. Initially, night-herons nested in the middle branches of the cottonwood trees at Pier 27 (L. Simser, pers. comm.). However, most pairs gradually abandoned the cottonwoods during the 1986-1988 breeding seasons, corresponding to the increased use of these trees by an expanding Double-crested Cormorant population (Fig. 3). After 1988, Black-crowned Night-Herons remained at Pier 27, but nested mainly in thickets of sandbar willow located on the western dike of the CDF pond (Fig. 1). Since this switch in nesting habitat occurred, the number of Black-crowned Night-Herons breeding at Hamilton Harbour has fluctuated between 60 and 134 pairs (Table 1).

In recent years, night-herons have expanded from the original Pier 27 breeding site. In 1989, three night-heron nests were found in cottonwood trees on the mainland along Eastport Drive, opposite Neare Island. Two years later, small numbers of night-herons began nesting in the lower branches of the maple tree on Farre Island and have bred there since (N=14 nests, 1991; N=5, 1992; N=11, 1993; N=17, 1994). By 1994, night-herons were also found nesting in a Manitoba maple at Pier 26 (N=10), and on the ground of both Neare (N=1) and Farre Island (N=8).

This species appears to be expanding its range in southern Ontario, following population declines (possibly pesticide-induced) during the late 1960s and early 1970s (Goodwin 1987).

4.2.2 Habitat Use and Competition

During 1993, a detailed study of nesting habitat use (partly described in Section 4.1.2) of cormorants and night-herons showed a separation between the 2 species with respect to

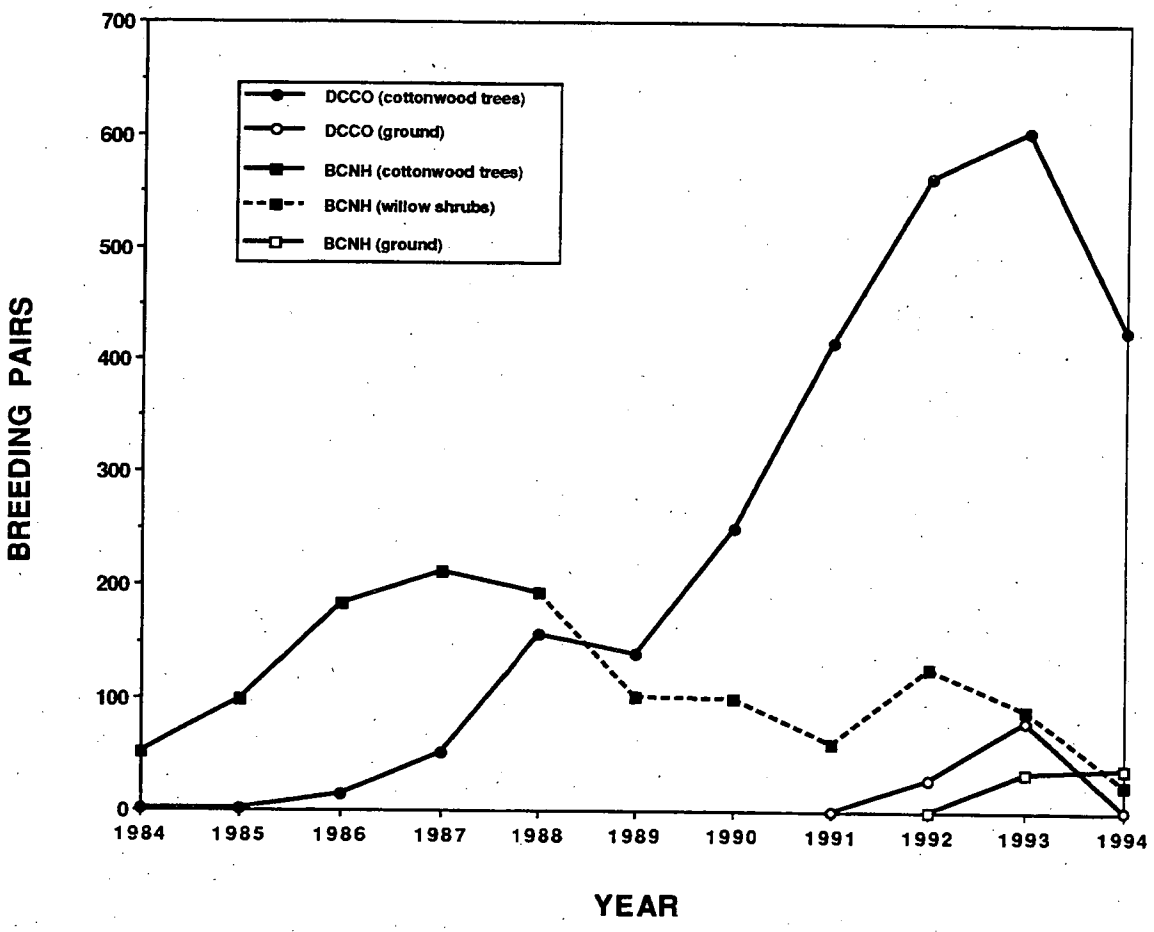

Fig. 3. Changes in the numbers of Double-crested Cormorant and Black-crowned Night-Heron nests in trees (closed symbols) and on the ground (open symbols) at Eastport (Pier 26 and 27) during 1984-1994. Prior to 1986, night-herons nested exclusively in cottonwood trees and after 1988, they nested predominantly in sandbar willow shrubs.

to vegetation and nest elevation. Of the cormorant nests in trees, 98% were built more than 2 m above the ground (Fig. 2B). In contrast, 94% of Black-crowned Night-Heron nests occurred at elevations less than 2 m (Fig. 2B). In 1994, 85% of night-heron nests were less than 2 m above the ground. The remaining 15% occurred at elevations between 2-5 m in a Manitoba maple at Pier 26, a new location for Black-crowned Night-Herons in 1994. The mean height of night-heron nests in Hamilton Harbour is lower than the average of 2-3 m previously reported for Ontario (Peck and James 1983, Sandilands 1984). In 1993, approximately two-thirds of night-herons nested in thickets of sandbar willow, while nests on the ground (all beneath sandbar willow) and in live cottonwoods accounted for 29.2% and 16.3% of the total, respectively. Only 4% of all Black-crowned Night-Heron nests occurred in dead trees (Fig. 2A). In 1994, the majority (61%) of night-heron nests were built either directly on the ground or incorporated into willow shrubs at ground level. Only 8 nests (13%) were built in the branches of sandbar willows. All remaining night-heron nests were located in live trees (4 cottonwood, 1 Manitoba maple, see Fig. 2A).

One or a combination of the following hypotheses may explain the nesting habitat shift from cottonwoods to sandbar willow by Black-crowned Night-Herons during the late 1980s. Night-herons may have abandoned the cottonwood trees as nesting platforms as a result of (1) direct competition with Double-crested Cormorants for nest branches, or indirectly because of (2) guano and debris falling on them and their nests from the cormorant nests above, or (3) defoliation of the cottonwoods caused by cormorant guano. We did not collect any data that would allow us to determine whether there was direct competition for nesting platforms between herons and cormorants. However, several factors indicate that the nesting habitat shift by night-herons from cottonwood trees to willow shrubs was probably mediated by alteration of the night-herons nesting habitat rather than through direct competition with cormorants for nest space. First, before the arrival of cormorants at Hamilton Harbour, night-herons nested only in the middle and lower branches of trees. This appears to be the dominant pattern in many Black-crowned Night-Heron colonies on the Great Lakes (e.g. Mugg's, Middle, East Sister, Chantry, Scotch Bonnet, Little Galloo, and Snake Islands, DVW pers. obs.). At Hamilton Harbour, cormorant nests were found in the upper branches of cottonwood trees (>4 m, Fig. 2B), clearly separated from the night-herons. Second, Black-crowned Night-Herons prefer concealed areas to build their nests (Palmer 1976, Cramp 1985), so the cottonwoods would have become less suitable nesting habitat once they began to lose their leaves. Finally, from 1992 - 1994, all trees used jointly by night-herons and cormorants were fully foliated. While the exact mechanism remains unknown, it is apparent that the nesting habitat shift by Black-crowned Night-Herons was caused to some extent by the change in habitat resulting from the presence of cormorants.

The present night-heron nesting habitat in sandbar willow appears to be secure from encroachment by cormorants, as most branches are less than 2 cm in diameter and would be unable to support the combined weight of cormorant adults and their nest platforms. However, 5 night-heron nests lost eggs and nesting material in 1994 (KPL unpubl. data). Larger sticks were added to 4 of these nests, likely by cormorants, but none of these were ever completed. Cormorants have displaced night-herons from nesting sites in bushes at other Lake Ontario colonies, specifically from red osier dogwood (*Cornus stolonifera*) shrubs at Little Galloo Island and lilac (*Syringa vulgaris*) bushes at Pigeon Island (DVW pers. obs.). As the sandbar willow shrubs at Pier 27 grow larger, they may become suitable for use by cormorants, which in turn could lead to the eventual displacement of night-herons from this nesting site.

There may also be reproductive costs for night-herons associated with the habitat switch from cottonwood trees to willow bushes. Two-thirds of all nests were less than 1 m off the ground in 1993, three-quarters in 1994, making them more susceptible to mammalian predators or disturbance

by dogs or people. Furthermore, most night-heron nests associated with sandbar willow (either in the shrubs or on the ground) were located along the western shore of Pier 27 within the splash zone and were subject to inundation during periods of high winds. On one occasion (2 June 1993) when the colony was visited after a storm, the contents of 40% (12 of 30) of Black-crowned Night-Heron ground nests were found to be wet. On several other occasions, nests were found soaked with dead chicks in them. In 1994, 65% (40 of 62) of the nests were less than 1.0 m from the water's edge and some (11%) were built either partially or entirely over the water. Most of these nests were inundated during stormy weather and 3 nests were eventually washed away. Hatching success was 48% for Black-crowned Night-Herons at Pier 27 in 1994, compared to 78% for night-herons nesting in trees at Tommy Thompson Park in Toronto (Burgess 1989). Although several factors (such as nest flooding, predation and human disturbance) are affecting the reproductive success of Black-crowned Night-Herons at Pier 27, all are related to the vulnerability of present nesting sites in sandbar willows and on the ground.

Night-herons were also found nesting on the ground (22 June 1994) in small numbers on both Neare (N = 1) and Farre Islands (N = 8) in 1994. The single nest on Neare Island and 4 of the 8 nests on Farre Island were located in rocky depressions, about 50 cm deep, which provided the only available cover (other than the saturated maple nesting site on Farre Island). The success of these nests is unknown, as they were not monitored.

4.2.3 Conservation and Control

To date, no efforts have been made to manage the night-heron breeding population at Hamilton Harbour. More detailed studies need to be carried out to determine the exact nature of competitive interactions between night-herons and cormorants, and to determine the effects of these interactions on night-heron nesting habitat selection and breeding success. Further studies could compare reproductive success of night-herons nesting on the ground with those nesting in trees and shrubs. Such data are critical for formulating long-term management strategies pertaining to Black-crowned Night-Heron nesting habitat requirements.

4.3 Herring Gull

4.3.1 Nest Distribution and Abundance

Herring Gulls nest primarily along the northern and western shores of Pier 27, along the dike between the two CDF ponds, and along the western shores of both CDF ponds (Fig. 1). Herring Gulls were first recorded nesting in Hamilton Harbour in 1976 (N=7 nests, Table 1). Nests were initially confined to the northern end of the waterbird colony at Pier 27, and the greatest concentration of nests has remained in this area. There is a clear demarcation between Herring and Ring-billed Gull breeding areas on the western dike of Pier 27, approximately 170 m south of the northwest corner of Pier 27. Herring Gulls expanded from Pier 27 and began nesting on Farre Island in 1988 and Neare Island in 1989, and isolated nests have occurred throughout Windermere Basin and Pier 26 since 1990 and 1991, respectively. The number of Herring Gulls nesting in the Harbour increased gradually after colonization, and since 1989 the breeding population has remained stable at approximately 300 pairs (Table 1). Throughout the lower Great Lakes, breeding numbers of Herring Gulls have steadily increased over the past two decades (Blokpoel and Tessier, 1991). As of 1993, the Hamilton Harbour colony was the second largest on Lake Ontario (DVW unpubl. data).

4.3.2 Habitat Use and Competition

At Pier 27, Herring Gull numbers do not appear to have increased to the detriment of any other species, as areas where their numbers have increased are areas that they had previously occupied exclusively. This does not appear to be the case on either Neare or Farre Island, where Herring Gulls are the latest in a succession of other waterbird species that have occupied these areas. Ring-billed Gulls appear to have displaced Common Terns during 1989-90 (see sections 4.4.3 and 4.6.2), while desertion of the islands by the Ring-billed Gulls corresponds with the colonization and subsequent increase in the numbers of Herring Gulls nesting there (Figs. 4 and 5). In future, Herring Gulls might themselves be displaced from the Hydro Islands, as cormorants began nesting in the tree on Farre Island in 1991 and large numbers of cormorants were observed loafing on Neare Island in 1993 and 1994 (DJM, KPL pers. obs.).

The move in 1992 and 1993 by cormorants from cottonwood trees to the ground at Pier 27 suggested that a competition for nesting habitat would develop between the cormorants and the Herring Gulls that had traditionally nested on the ground at the north end of Pier 27. Gorski *et al.* (1990) reported that when Great Cormorants and Herring Gulls nested at the same locality, interactions between the two species were either commensal or competitive, depending on the spatial structure of the habitat. On a forested island where both species nested sympatrically, gulls benefitted from the association by feeding on fish dropped by the cormorants. In contrast, on a treeless island competition for nest space was observed with a corresponding reduction in the number of breeding gulls.

4.3.3 Conservation and Control

No efforts have been made to manage the Herring Gull breeding population at Hamilton Harbour.

4.4 Ring-billed Gull

4.4.1 Nest Distribution and Abundance

Since the establishment of a Ring-billed Gull breeding colony in Hamilton Harbour, the number of nests has increased dramatically from 17 in 1978 (Dobos *et al.* 1988) to 39621 counted during the most recent complete census in 1990 (Table 1). This increase represents a mean annual growth rate of 90.8%, and is similar to the rates of growth at other nesting locations on the Great Lakes that were also colonized during the mid-1970s (Blokpoel and Tessier 1986, 1991). From 1976 to 1984 the number of Ring-billed Gulls nesting on the Great Lakes more than doubled, representing a mean annual rate of increase of 11% for this population (Blokpoel and Scharf 1991).

The largest concentration of Ring-billed Gull nests in Hamilton Harbour occurs throughout the Eastport facility on Pier 27 (although not sympatric with areas occupied by Herring Gulls), and over most of Pier 26 to a few hundred metres south of the most southerly CDF (Fig. 1). Intensive control operations have kept gulls from nesting at Pier 25. Breeding Ring-billed Gulls expanded from Eastport into other areas of the Harbour, specifically to Neare and Farre Islands (colonized sometime between 1981-1985, absent by 1994), Stelco property (1983) and Windermere Basin (1989, Fig. 1).

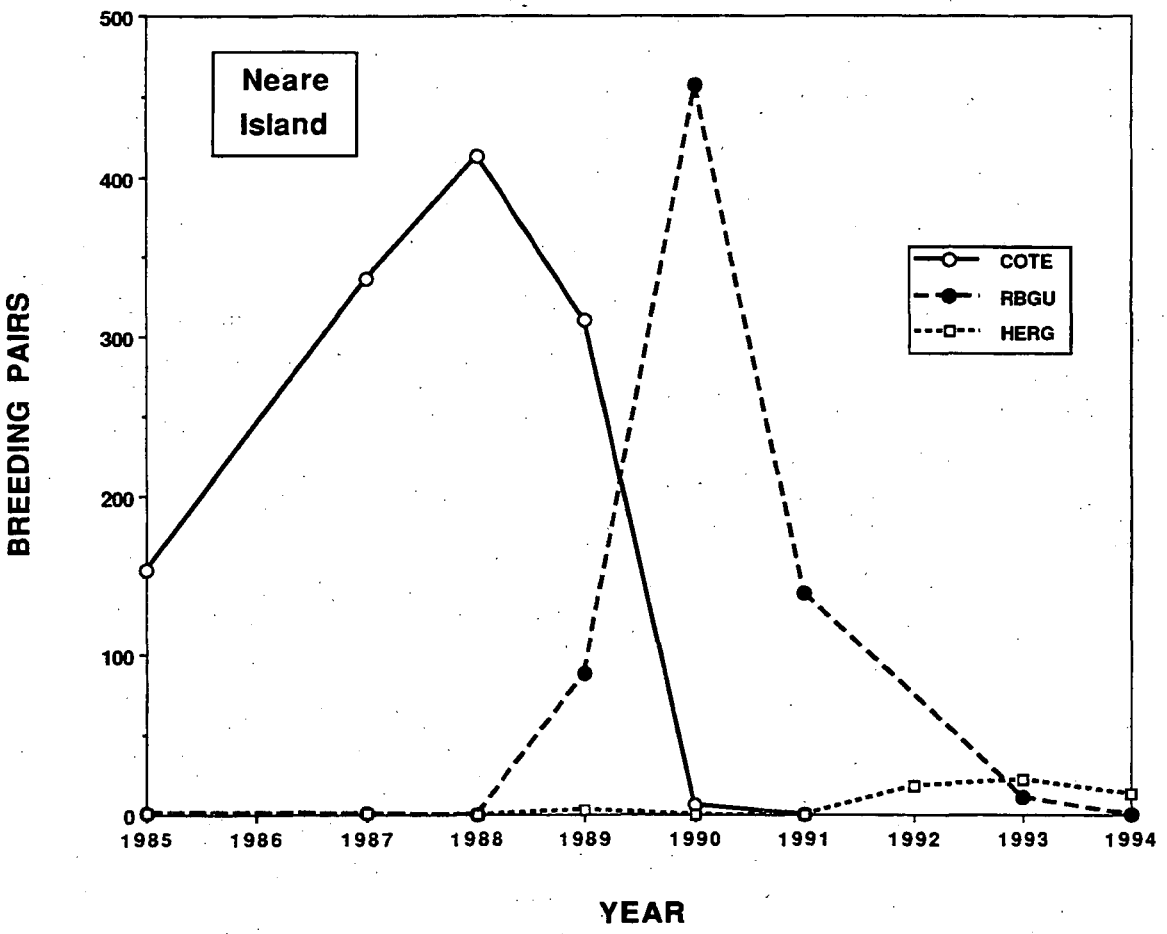

Fig. 4. Changes in the number of nests of colonial waterbirds breeding on Neare Island from 1985-1994 (COTE = Common Tern, RBGU = Ring-billed Gull, and HERG = Herring Gull).

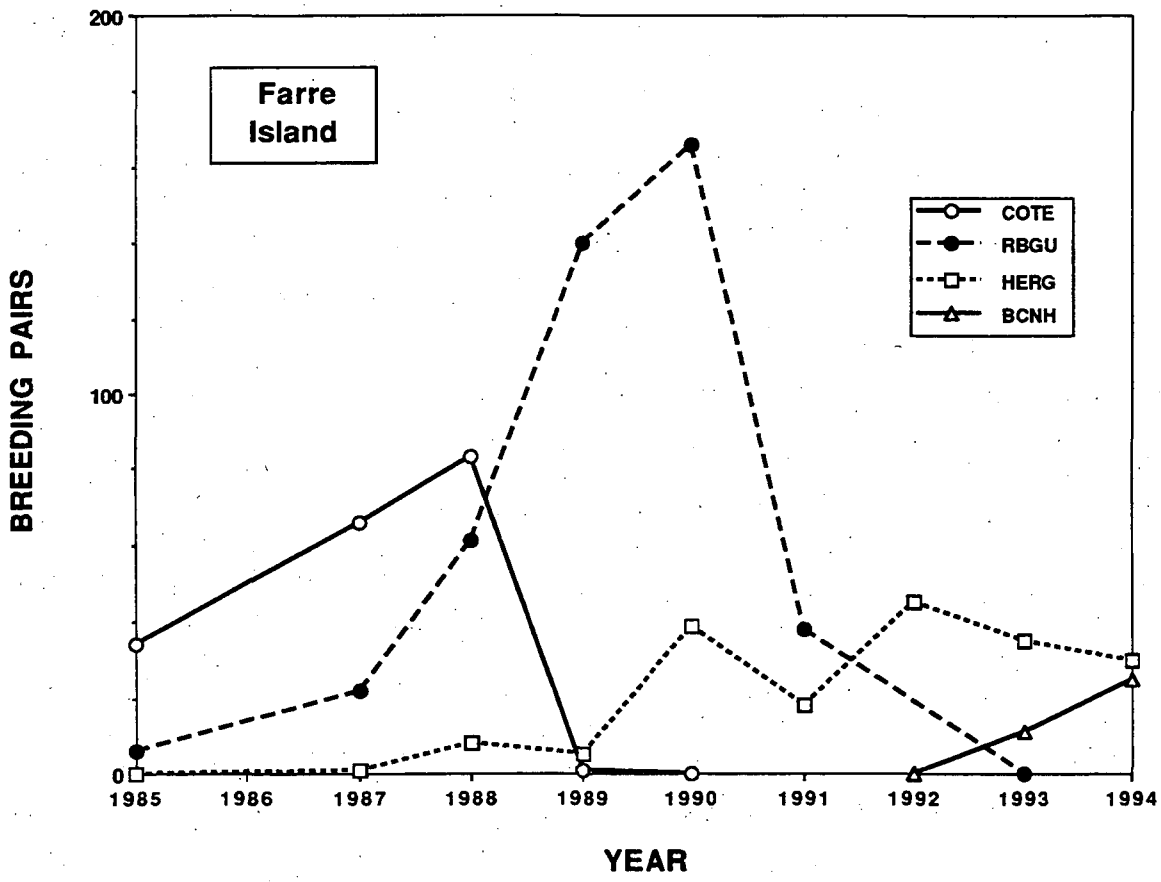

Fig. 5. Changes in the number of ground nests of colonial waterbirds breeding on Farre Island from 1985-1994 (COTE = Common Tern, RBGU = Ring-billed Gull, HERG = Herring Gull, and BCNH = Black-crowned Night-Heron).

4.4.2 Habitat Use and Competition

In Hamilton Harbour, Ring-billed Gulls nest at a variety of artificial sites such as construction areas, dikes, dredge spoil areas, and piles of rubble in the Harbour's east end. This flexibility in nesting requirements has allowed these gulls to quickly colonize new areas within the Harbour, as they have done throughout the Great Lakes (Blokpoel and Tessier 1986). The only areas where Ring-billed Gulls did not nest at Eastport were areas covered with tall (approx. 1 m), dense vegetation, mostly mustard (an unidentified species).

4.4.3 Conservation and Control

At Hamilton Harbour, management problems involving Ring-billed Gulls centre around an overabundance of individuals and arise from conflicts with either human interests, or other bird species. The first type of problem is illustrated by the expansion of nesting Ring-billed Gulls from the main colony at Pier 27, either onto properties owned by Stelco or onto those under development by the Hamilton Harbour Commissioners (HHC). Ring-billed Gulls first began nesting on Stelco property in 1983 at two sites. The first colony, at No. 2 Rod Mill, grew quickly from approximately 100 nests in 1983 to an estimated 4650 nests by 1985 (Blokpoel and Tessier 1987). The second colony, at Hilton Works, increased from 124 nests in 1983 to between 250-300 nests early in the 1986 breeding season. Stelco began gull control operations (see section 3.3.1) at both colony locations in 1986, which have continued to be successful in preventing Ring-billed Gulls from re-establishing colonies at these sites. These controls must be carried out annually, as gulls attempt to nest there each spring (P. D. Smith pers. comm.). Gull control operations at the main Ring-billed Gull colony at Eastport were also successful in preventing gulls from nesting at Pier 25 and the targeted areas of Pier 26.

The second important management problem posed by increasing numbers of breeding Ring-billed Gulls at Hamilton Harbour is the exclusion of Common Terns from preferred nesting sites where gull control measures have not been practiced. Ring-billed Gulls were responsible for the abandonment of Neare and Farre Islands by Common Terns (Figs. 4 and 5), as well as the abandonment of several tern sub-colony sites within Windermere Basin (described in detail in Section 4.6.2). The number of Ring-billed Gull pairs nesting at Windermere Basin increased from 10 in 1989 to 1747 in 1994 (Fig. 6). Gulls do not compete directly with terns for breeding space, but arrive at Hamilton Harbour and initiate breeding 2-4 weeks earlier (Morris and Hunter 1976, HB, DJM unpubl. data), effectively precluding use of these sites by terns. Displacement of the terns from sub-colony locations at Windermere Basin will become a more serious problem as the number of gulls nesting there continues to increase. This topic will be dealt with further in Section 4.6.

4.5 Caspian Tern

4.5.1 Nest Distribution and Abundance

Prior to 1986, there were no records of Caspian Terns nesting in Hamilton Harbour. In that year, a small sub-colony (sub-colony A, Fig. 7, N=48 nests) formed in the northwest corner of Pier 26, approximately 100 m south of the Pier 26/27 boundary (Fig. 1). By 1987, the number of Caspian Tern pairs nesting at this location had increased to 134 (Table 1). These individuals likely emigrated from a nearby colony (Tommy Thompson Park, Toronto Outer Harbour) where the breeding

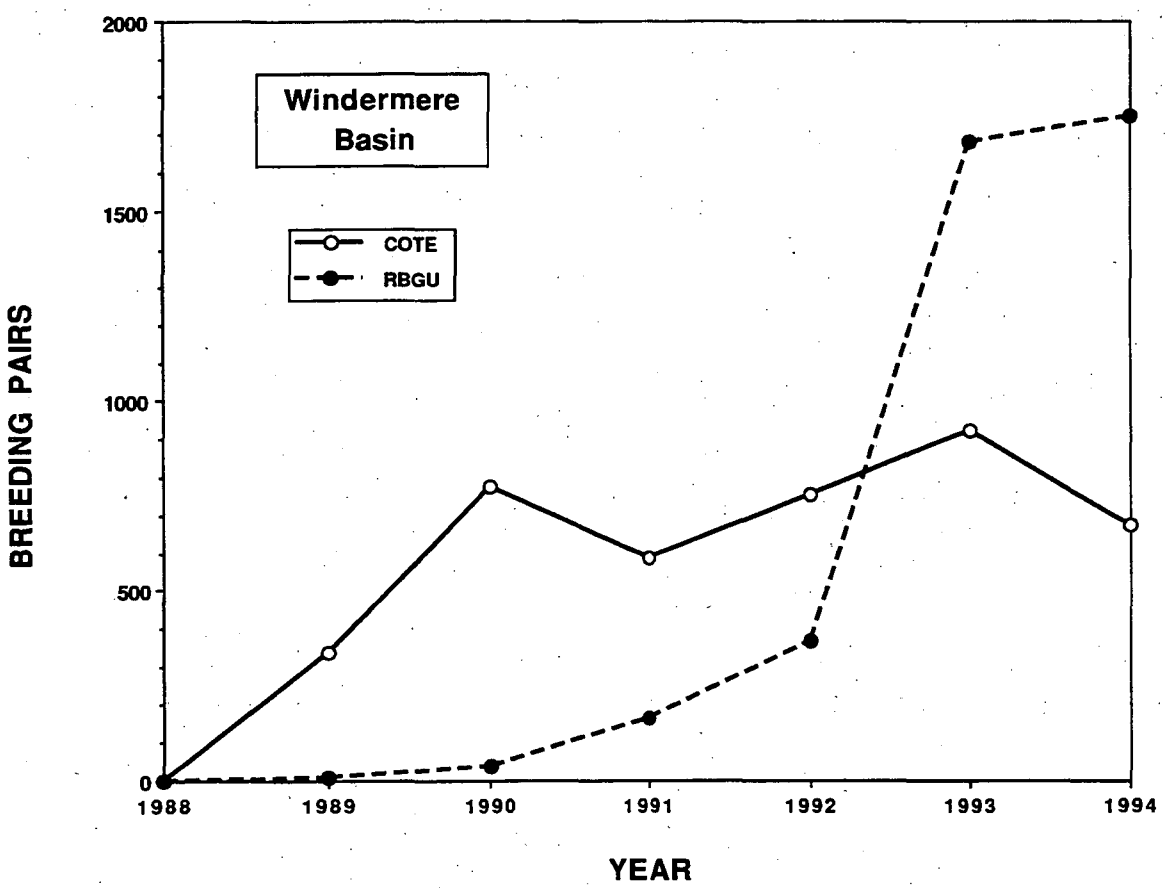

Fig. 6. Changes in the number of nests of colonial waterbirds breeding at Windermere Basin during 1988-1994 (COTE = Common Tern , RBGU = Ring-billed Gull).

population decreased from 197 nests in 1985 to 45 nests in 1987, the last year Caspian Terns bred there (Dobos *et al.* 1988, Blokpoel and Tessier 1991). During 1988, Caspian Terns nested in 2 distinct sub-colonies at Hamilton Harbour: the main sub-colony (sub-colony A, Fig. 7, 154 nests) was located where terns nested during the previous 2 years and a secondary sub-colony (sub-colony B, Fig. 7, 88 nests) was located 100 m south and east of sub-colony A on the southwest shore of the CDF pond at Pier 26. Prior to the 1989 breeding season, considerable grading and filling activity occurred in the area to the south of the most southerly CDF pond (Fig. 1). In that year, Caspian Terns nested only in sub-colony A (Fig. 7, 175 nests) at the same location as previous years. Desertion of the sub-colony B location (Fig. 7) in 1989 may have resulted from alteration of nesting substrate by the construction, or high water levels that occurred early in the breeding season. This secondary sub-colony, (sub-colony B location, Fig 7) re-formed again during 1990 (29 nests), 1991 (49 nests), 1992 (52 nests) and 1994 (67 nests). During 1990, the primary Caspian Tern sub-colony re-located approximately 200 m south of its 1986-1989 location (location A, Fig. 7) and has remained in the same general area of Pier 26 since. This sub-colony (location C, Fig. 7) consisted of 155 nests in 1990, 171 nests in 1991, and 285 nests in 1992. During 1993, 273 terns nested at the sub-colony C location, while a further 28 nests were located at the western end of the dike running between the two CDF ponds at Pier 26 and 27 (location D, Fig. 7). In 1994, no Caspian Terns nested on the dike between the two CDF ponds, as this area was occupied by Herring Gulls earlier in the breeding season. During 1994, the majority of Caspian Terns nested either at location C (Fig. 7, total of 203 nests over breeding season) as they had in previous years, or at a new sub-colony approximately 75 m to the north and separated by nesting Ring-billed Gulls (location E, Fig. 7, cumulative total of 204 nests). A small number of Caspian Terns also nested at location B (Fig. 7, cumulative total of 67 nests).

The number of Caspian Tern pairs nesting on Hamilton Harbour has increased steadily since its formation in 1986 to 313 nests recorded during 1994 (Table 1). During 1994, the Hamilton Harbour colony was fourth largest of the 5 colonies on Lake Ontario (682 nests at Little Galloo I., 448 nests at Pigeon I., 370 nests at Gull I., and fewer than 100 nests at False Duck I., DVW unpubl. data). The Caspian Tern is considered vulnerable in Canada (COSEWIC 1992) and is designated as either rare, endangered or threatened in some U. S. states that border the Great Lakes (Blokpoel and Scharf 1991). Therefore, in spite of its relatively small size, the colony at Hamilton Harbour is an important one in terms of long-term conservation of Caspian Terns on the Great Lakes.

4.5.2 Habitat Use and Competition

At Hamilton Harbour, Caspian Terns nest in association with Ring-billed Gulls, as is the case with most Caspian Tern colonies in Ontario (Blokpoel 1987). Caspian Terns originally established their nesting site on the periphery of the Ring-billed Gull colony, but as gulls expanded their nesting areas, the tern colony became surrounded by gulls. The main Caspian Tern nesting sites at Pier 26 are slightly depressed areas with substrates of dredged material. Some of these areas are , in some years, either covered with water or the substrate is soft and muddy during early spring. Such conditions discourage nesting by Ring-billed Gulls even though they arrive at the colony and initiate breeding earlier than Caspian Terns (HB unpubl. data).

It is well known that Ring-billed Gulls have usurped several Common Tern nesting sites in the Great Lakes (reviewed by Courtney and Blokpoel 1983), but it is much less clear to what extent, if any, they can take over Caspian Tern nesting sites. At Tommy Thomson Park in the Toronto Outer Harbour, Ring-billed Gulls were strongly encroaching on the Caspian tern nesting area before the

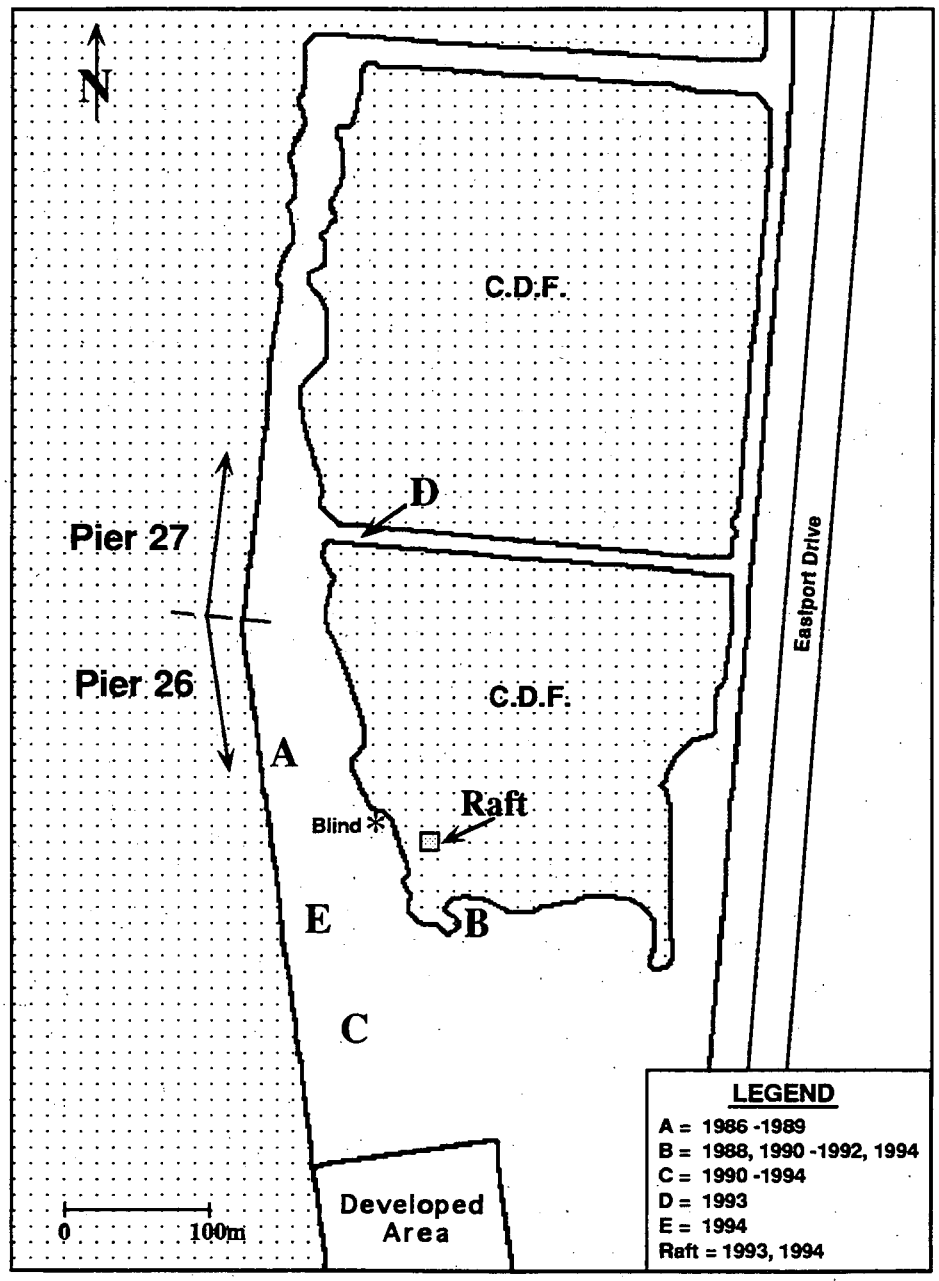

Fig. 7. Map of Eastport Piers 26 and 27 showing locations of Caspian Tern sub-colonies (A-E) during 1986-1994. Shaded areas indicate water.

terns gradually abandoned that site in 1986 and 1987 and began nesting elsewhere , most likely at Eastport where a Caspian Tern colony became established in 1986 and more than doubled in 1987 (Dobos et al. 1988). However, human disturbance and increasing height of the vegetation that surrounded the knoll where the terns were nesting at Tommy Thomson Park probably contributed to the abandonment of that area by the terns.

In 1986 another new Caspian Tern colony became established at Little Galloo Island in the US waters of eastern Lake Ontario. Little Galloo Island had been "saturated" at least to human eyes with nesting colonial waterbirds, including more than 70,000 pairs of Ring-billed Gulls. It is noteworthy that the colonizers began building their nests late in the season on the muddy rim of an interior pond that was slowly drying out . Earlier in the season , that area would still have been water-covered and thus unavailable for Ring-billed Gulls (Weseloh and Blokpoel 1993).The terns apparently competed successfully with the smaller Ring-billed Gulls once these wet areas dried out and became available as nesting space. However, new colonies are not always associated with these ephemeral ponds. For example, at Timber Island in the Canadian waters of eastern Lake Ontario, a new Caspian Tern colony became established in 1994 but that one was located on a dry, pebbly beach where there was also extensive nesting by Herring and Ring-billed Gulls as well as cormorants (M. Richardson pers. comm.).

4.5.3 Conservation and Control

A few attempts have been made to improve or create artificial nesting habitat for Caspian Terns at the Eastport colony location. In 1990 and 1991, existing habitat was modified in order to attract terns and exclude gulls, while in 1993 and 1994, attempts were made to relocate the terns onto a specially designed raft. The results of each of these artificial habitat experiments are described in turn.

(a) Habitat Modification – Large numbers of Ring-billed Gulls built nests at the designated Caspian Tern site shortly after it was prepared in 1990 (described in Section 3.3.2), and it was never used by Caspian Terns. Attempts to relocate terns to the modified nesting habitat during the 1991 breeding season were unsuccessful again as large numbers of Ring-billed Gulls established nests in the area prior to initiation of the terns' breeding season (Hebert 1991).

(b) Nesting Raft – During 1993 and 1994, an attempt was made to manage Caspian Terns in Hamilton Harbour by offering them a nesting raft as an alternative breeding site. Such efforts had previously been successful for Common Terns at Tommy Thompson Park (Toronto Outer Harbour, Dunlop *et al.* 1991). In 1993, one Caspian Tern pair established a nest on the raft and raised two chicks to at least 26 days (McMartin 1993).

In 1994, this approach met with greater success when 6 Caspian Tern nests were established on the raft between 21 June and 27 July (Lampman 1994). These late nesting dates may be an indication that there was no impetus to drive terns to use the raft earlier in the season. Even though a tarp eliminated some habitat at sub-colony B, there was apparently enough left to accommodate terns there and at the other sub-colonies (A, C and E, see Fig.7). It was not until vegetation in sub-colony B had grown to over 1.0 m and had encroached on much of the previously suitable habitat, that the raft was utilized. In fact, the raft colonization began the same time that the final clutch was initiated in sub-colony B (J. Sirdevan pers. comm.).

The small group of Caspians which nested on the raft in 1994 may represent some

combination of inexperienced, first-time nesters and/or re-nesters. At least 3 of these pairs were known to have had failed nests in sub-colony B earlier in the 1994 breeding season. But, whatever the explanation, it is clear that Caspian Terns can be relocated to artificial rafts to at least a limited extent. This is highly encouraging because it makes it likely that this species can also be made to nest on specially designed wildlife islands that will be created in Hamilton Harbour.

4.6 Common Tern

The distribution of Common Tern nests within Hamilton Harbour has been influenced largely by competitive interactions with Ring-billed Gulls. Therefore, data pertaining to 'Nest Distribution', 'Habitat Use', and 'Competition' are presented in the same section.

4.6.1 Abundance

In 1994, 868 pairs of Common Terns nested at Hamilton Harbour (Table 1) making it the largest ternery on the Canadian side of Lake Ontario (CWS 1994 unpubl. data).

4.6.2 Nest Distribution, Habitat Use and Competition

The first reported nestings of Common Terns in the Hamilton area were in the late 1940s, and terns were first recorded nesting at Hamilton Harbour in 1961 (N=3 nests, Dobos *et al.* 1988). A substantial breeding colony was established on the Hydro Islands in 1966, where the number of Common Tern nests increased from 66 in that year to more than 150 in 1972 (Morris and Hunter 1976, Dobos *et al.* 1988). However, the Hydro Islands were inundated as the result of extremely high water levels during 1973, and Common Terns were forced to nest (N=42 nests) on the adjacent mainland. This colony was subsequently abandoned in 1974 (Morris and Hunter 1976), and Common Terns did not breed again in Hamilton Harbour until 1982 (Table 1). From 1982-1986, Common Terns nested exclusively on Neare and Farre Islands, and the number of pairs nesting there (predominantly on Neare I.) increased steadily to 402 by the beginning of the 1987 breeding season.

During 1987, terns also began nesting at two locations on Pier 26 (N=151 nests). The main colony (colony A) was located on top of an elbow-shaped dike on the water's edge at the south-west corner of the most southerly CDF pond (Fig. 1). A smaller colony (colony B, approximately 30 pairs) was located further to the south in a flat area covered with rubble. During 1987, Ring-billed Gulls did not nest sympatrically with these Common Terns. However, during 1988, gulls began nesting on top of the dike at colony A and all terns nested instead on the shoreline at the bottom of the dike, which had been exposed as the result of decreased water levels in the CDF pond. In total, there were 148 Common Tern nests at Pier 26 in 1988.

Although the number of Common Terns nesting in Hamilton Harbour remained relatively unchanged during 1988 (N=644 nests) and 1989 (N=667 nests), the distribution of breeding sites in the 2 years were very different (Appendix D.). During 1989, water levels in the CDF pond at Pier 26 increased and inundated the terns' nesting habitat from the previous year at colony A, while the colony B location was subjected to grading and filling activities during the non-breeding season. As a result, Common Terns did not nest at either Eastport sub-colony in 1989. Common Terns also abandoned Farre Island as a breeding location in 1989, and the number of nests at Neare Island decreased substantially compared to the previous breeding season (1988, N=413 nests, 1989, N=310 nests, Figs. 4 and 5). During 1989, terns displaced from Eastport and the Hydro Islands nested

instead at a newly established colony in Windermere Basin (see below). By 1990, Neare Island was also completely deserted by terns.

The decrease in the number of breeding terns on both Neare and Farre Islands corresponds to the colonization (1985 and 1989 for Farre and Neare Islands, respectively) and increase in numbers of Ring-billed Gulls nesting at these locations (Figs. 4 and 5). Other factors known to cause desertion of Common Tern colonies such as loss of nesting habitat through vegetation growth or high water levels, human disturbance, or predation (see Morris and Hunter 1976) do not adequately explain the decline in numbers of terns breeding at these sites. For example, the surfaces of these islands are devoid of vegetation (except for a tree on Farre I.). Insular sites are also less accessible to humans or ground predators. Therefore, competitive exclusion of terns by Ring-billed Gulls appears to be the sole explanation for their eventual abandonment of Neare and Farre Islands.

During 1989, Common Terns established a new nesting area in Windermere Basin, located at the extreme southeastern end of Hamilton Harbour (Fig. 1). Nesting habitat, in the form of a series of gravel-covered dikes (continuous with the mainland), was created during the dredging of Windermere Basin between the 1988 and 1989 breeding seasons. During 1989, half of all Common Terns nesting in the Harbour (N=336 nests) were found in Windermere Basin, and by 1990 (with the exception of a small colony at Stelco No. 2 Rod Mill) the entire breeding population was located there. After 1989, the number of Common Terns nesting at Windermere Basin increased steadily to 922 pairs (Fig. 6) out of a total of 954 pairs at Hamilton Harbour in 1993 (Table 1, Appendix 1D). The proportion of terns breeding at Windermere Basin dropped to 675 pairs out of 868 pairs in 1994, with the remainder of the population located at Stelco, No. 2 Rod Mill.

Filling and grading activity has been ongoing at Windermere Basin since the tern colony was established there in 1989. This construction, together with successional changes in vegetation, have resulted in considerable annual variation in the nesting habitat available to terns with respect to both topography and nesting substrate. The influx of breeding Ring-billed Gulls into Windermere Basin since 1989 has also affected tern nesting patterns. Consequently, Common Terns have traditionally nested in several distinct sub-colony locations throughout Windermere Basin rather than in one dense colony. There have been as many as twelve sub-colony locations at Windermere Basin since 1989 (Fig. 8), although not all were active during each of these years. To determine the factors affecting the settlement patterns of terns within Windermere Basin, we recorded features of the nesting substrate and numbers of terns and gulls breeding at each sub-colony location during 1991-1993 (Table 2). The results of this survey are presented below.

During 1991-1993, there were increases in the number of Common Terns nesting at four sub-colony locations (sites C, D, E, and L, Table 2, Fig. 8). At sub-colonies C, D, and L, nesting substrate remained unchanged among years and Ring-billed Gulls were either completely absent or ephemeral and present only in small numbers. Sub-colony E is an exception to these trends as there were simultaneous increases in the numbers of tern and gull pairs nesting at this location (Table 2). The CDF pond adjacent to sub-colony E was drained after the 1991 breeding season and large portions were backfilled during the non-breeding periods of 1992, 1993 and 1994. The creation of new nesting habitat at this location probably reduced the intensity of competition for nesting space between these 2 species, and may explain why the number of terns breeding at sub-colony E increased in spite of the corresponding increase in Ring-billed Gulls. Although gulls do not appear to be excluding terns from nesting sites, chick predation rates in 1993 were high at sub-colony E relative to those recorded previously in other areas of Windermere Basin (DJM unpubl. data).

Three of the sub-colony locations (sites A, B, and G, Fig. 8) showed a decrease in the number of breeding terns, corresponding to increases in the numbers of Ring-billed Gull pairs nesting there.

At all three sites, nesting substrate did not change among years (Table 2). Reductions in the number of terns nesting at other sub-colony locations (sites F, H, I, and J, Table 2, Fig. 8) can be solely attributed to the growth of tall (0.3-0.5 m), dense vegetation at these sites. Overgrowth of vegetation has been reported previously as the primary cause of colony abandonment by Common Terns (reviewed by Courtney and Blokpoel 1983, Reed *et al.* 1991).

Abandonment of sub-colony location K by Common Terns can not readily be explained by either changes to nesting substrate or encroachment by gulls (Table 2). This location possess suitable Common Tern nesting habitat (see Blokpoel *et al.* 1978, Richards and Morris 1984) and although gull numbers have increased they have not expanded into areas formerly occupied by terns. During 1992, all nests in sub-colony K were depredated during the egg stage (DJM unpubl. data). It is possible that this depredation caused terns to abandon sub-colony K and relocate to other areas of Windermere Basin in 1993.

High depredation rates at certain sub-colonies within Windermere Basin may be a reflection of scattered, low density nesting. In 1994, a limited study was conducted comparing hatching success of terns breeding at mainland sub-colonies C, D and E (Fig. 8, N = 40 nests), with those breeding on Spur Island (sub-colony L, Fig. 8, N = 40 nests). Only 48% of eggs hatched from mainland nests (mean clutch size = 2.8, ± 0.27 S.D.; mean hatching success = 1.35 ± 0.85 S.D.), while 90% hatched on Spur Island (mean clutch size = 2.5 ± 0.26 S.D.; mean hatching success = 2.25 ± 0.65 S.D.). Since most of the losses on the mainland were recorded after expected hatch dates, it is possible that nests were depredated shortly after hatching rather than prior to hatching, resulting in an underestimate of mean hatching success of these nests. However, of chicks hatched on the mainland, only 2 lived to 9 days and no others survived past 5 days. In contrast, chick survival on Spur Island was high during the period that marked broods were actively followed (3-egg clutches were monitored until the first-hatched chick in each brood was 6 days old : mean brood size = 2.03 ± 0.83 S.D., 68% of chicks survived at least 4 days). Furthermore, all chicks that died during this period were discovered within nest scrapes, and the cause of death can likely be attributed to either thermal stress or starvation. The higher hatching success and chick survival of terns nesting on Spur Island compared with conspecifics nesting on mainland sites can probably be attributed to the higher nesting density and insular nature of this nesting site. Both factors would be advantageous in terms of avoidance of and defense against potential predators, particularly mammals.

4.6.3 Conservation and Control

Common Terns nesting on the Great Lakes represent a closed, demic population (Haymes and Blokpoel 1978) which has been experiencing a long-term decline. Consequently, in many of the U.S. states bordering the Great Lakes, Common Terns are designated as either endangered, threatened, or of special concern (Courtney and Blokpoel 1983, Kress *et al.* 1983, Blokpoel and Scharf 1991). As the conglomeration of tern colonies at Hamilton Harbour is one of the largest on the Great Lakes, a concentrated effort should be made to maintain the viability of this colony location.

The creation of nesting habitat for Common Terns at Spur Island has met with good success. Although no terns nested on Spur Island in 1991 (the year after it was created), terns colonized the island in 1992 and since that year they have bred annually with good reproductive success. In contrast, terns nesting on the mainland in Windermere Basin usually have had very poor reproductive success due to human disturbance and mammalian predators.

Apart from the creation of Spur Island and subsequent substrate modification at that site, no

Table 2. Changes in the numbers of active Common Tern and Ring-billed Gull nests, and vegetation cover at Common Tern sub-colony locations within Windermere Basin during the peak-nesting periods of 1991-1993.

sub-colony	Tern nests			Gull nests			Vegetation Density[1] (Height in cm)[2]		
	1991	1992	1993	1991	1992	1993	1991	1992	1993
A*	0	103	0	0	350	800	*	S (<15)	NC
B	0	88	6	0	0	84	S (<15)	NC	NC
C	108	81	152	20	0	2	S (<15)	NC	NC
D	18	65	66	0	0	0	S (<15)	NC	NC
E*	78	145	586	0	0	307	S (<15)	M (<15)	NC
F	17	1	0	0	0	0	S (<15)	S (15-30)	M (15-30)
G	62	115	15	0	0	235	S (<15)	NC	S (>30)
H	33	0	0	0	0	0	M (<15)	D (15-30)	NC
I	151	13	2	0	0	48	S (<15)	D (<15)	D (15-30)
J	80	0	0	0	0	0	S (<15)	D (<15)	NC
K	19	17	0	145	15	200	S (<15)	NC	NC
L	19	125	95	0	0	2	NV	S (<15)	NC
totals	585	753	922	165	365	1678			

1 Vegetation densities are catagorized as:
NV = no vegetation
S = sparse (comprising ≤ 25% of sub-colony surface area)
M = moderate (approx. half of surface area)
D = dense (≥75% surface area).
NC = no change in vegetation cover between breeding seasons.

2 The mean height of vegetation at each sub-colony was categorized as being either (1) less than 15cm, (2) between 15 and 30cm, or (3) greater than 30cm.

* Areas affected by construction activity. Filling and grading activity occurred at sub-colony A during the 1991 breeding season. Sub-colony E location includes a CDF pond which was mostly flooded in 1991, drained prior to the 1992 breeding season, and partially back-filled during the 1992 and 1993 breeding seasons.

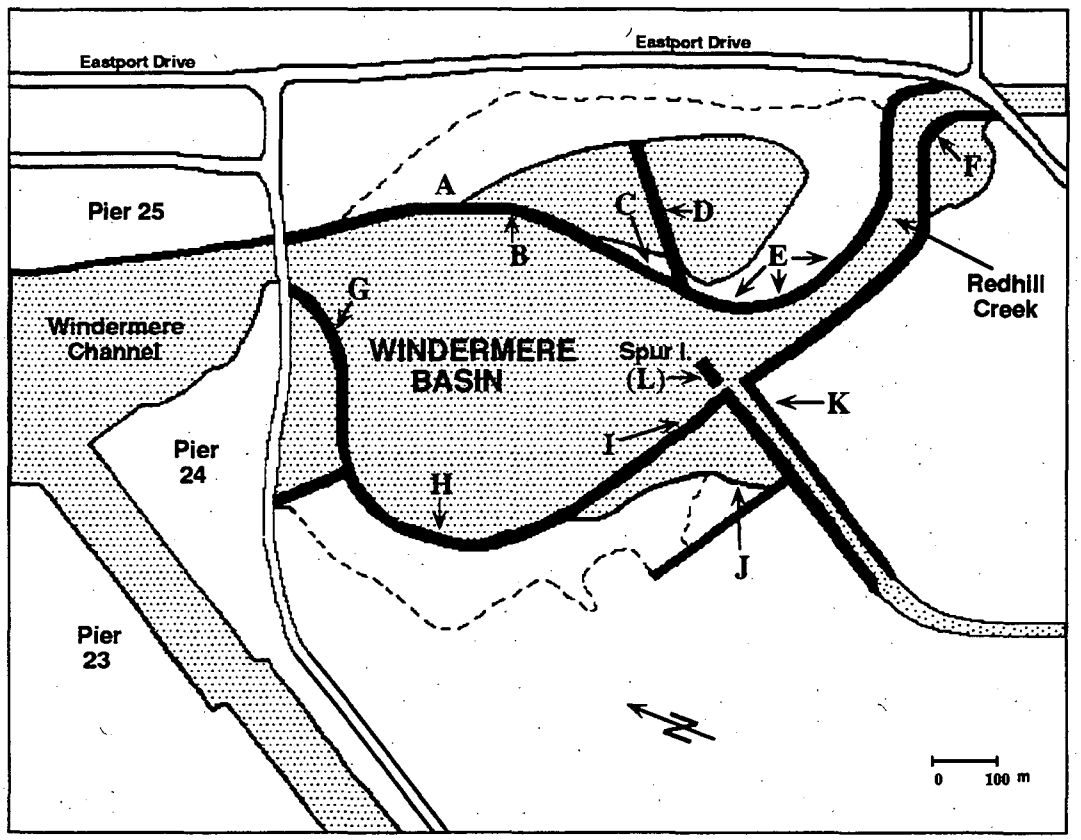

Fig. 8. Map of Windermere Basin, showing Common Tern sub-colony locations (A-L) during 1991-1994. Shaded areas indicate water and thick black lines represent human-made dikes. The dotted line represents the Windermere Basin shoreline in 1988, prior to filling operations.

efforts have been made to manage the Common Tern breeding population at Hamilton Harbour. While human activity has both inadvertently and deliberately created suitable habitat for the terns at Windermere, continuing earth-moving activities threaten future nesting in this area. However, as we have demonstrated for Windermere Basin, losses of tern nesting habitat have resulted primarily from take-over of these sites by Ring-billed Gulls. Displacement of Common Terns from breeding sites by gulls has been a recurrent pattern at Hamilton Harbour (Morris and Hunter 1976, this review) and has been implicated at numerous other colonies on the Great Lakes (Morris and Hunter 1976, Morris *et al.* 1980, reviewed by Courtney and Blokpoel 1983). This pattern of displacement of Common Terns from breeding sites by gulls must be addressed if these terns are to maintain a breeding colony in Windermere Basin , or indeed in Hamilton Harbour in general. While Ring-billed Gulls are responsible for reductions in the number of terns nesting at some sites, other factors, such as maintenance of the terns' preferred nesting substrate (including vegetation control), must also be considered in any future management plans.

Aggressive management practices must be employed in order to achieve the goal of a sustained tern population in Windermere Basin. We recommend either physical exclusion of Ring-billed Gulls (e.g. fencing, monofilament lines), active disturbance (e.g. using shell crackers, playback of loud noises), or removal of their scrapes and eggs at Spur Island. Exclusion of gulls from this area prior to initiation of their clutches is a more acceptable option than destruction of nest contents. To be successful, gull control must be exercised from arrival of gulls at Hamilton Harbour in early-March (HB unpubl. data) until after the terns' main period of clutch initiation during the second week of May (DJM unpubl. data). A second recommendation is that dense vegetation be removed annually from Spur Island prior to the arrival of terns at that breeding colony (mid-April, DJM unpubl. data).

Plans call for the establishment of Common Tern colonies on 2 of the 3 wildlife islands slated for completion during the summer of 1996. Because Common Terns are often the first to colonize new sites, it is likely that the newly created wildlife islands will readily attract Common Terns, especially if suitable habitat is kept gull-free and equipped with decoys. However, to maintain terneries on the wildlife islands, it will be necessary to implement a program of annual gull control and removal of tall, dense vegetation.

We recommend continued management of Spur Island as a Common Tern nesting site because it has proven to be a readily managed, productive site and, as such, can help produce potential colonizers for the nearby wildlife islands.

5. CONCLUSIONS

As we have shown, the major nesting areas of colonial waterbirds in Hamilton Harbour are at Eastport, at Windermere Basin, and on other properties under the jurisdiction of the Hamilton Harbour Commissioners. Both Pier 26 and Windermere Basin are under development at present, while Pier 27 is not slated for development in the foreseeable future (B. Edwards, HHC pers. comm.). The Migratory Bird Treaty Convention, under which migratory birds and their nesting habitats are protected, only protects habitat while it is occupied (i.e. during the breeding season). Therefore, development of the birds' nesting habitat during the autumn and winter is within the limits of the Convention. As a consequence, many of the management studies conducted at Hamilton Harbour have been directed towards encouraging 'desirable species' (e.g. Common Terns, Caspian Terns and Black-crowned Night-Herons) to move to secure nesting areas elsewhere in the harbour. Establishment of permanent, protected habitats, suitable for supporting the diverse waterbird

community at Hamilton Harbour, is essential if these species are to continue to breed there. At present, plans are underway (as part of the Remedial Action Plan for Hamilton Harbour) to create three wildlife islands in Hamilton Harbour in the vicinity of Neare and Farre Islands to support representatives of all the colonial waterbird species currently nesting in the harbour.

While the establishment and protection of permanent nesting habitats is critical for maintaining the presence of breeding waterbirds here, active management of these populations and the habitats they occupy is equally important. We have demonstrated that (1) interspecific competition for nesting space, and (2) changes to breeding habitats resulting from plant community succession (probably accelerated by the large amounts of nitrogen deposited at colony sites), are the most important factors affecting the present breeding distribution of colonial waterbirds within Hamilton Harbour. It is likely that both of these factors (competition and succession) have always affected nest site selection in these species, even before human activities began to impact waterbird habitat use. For example, many seabirds nest in relatively unstable habitats (e.g. areas affected by wave action or periodic flooding) and must colonize new habitats on a regular basis. Strong group adherence in these species has been proposed as a mechanism facilitating rapid colonization of new nesting sites (refer to McNicholl 1975). However, in Hamilton Harbour, the breeding habitat available to these birds has been compressed to such an extent that they are no longer able to move to new nesting sites as the old ones become unsuitable. It is the spatial constraints placed on these birds which intensifies competition for nesting space among different species. In other words, animals that have evolved behavioural strategies for dealing with a dynamic environment, are forced instead to nest in an artificially static one. Unless habitats are also maintained in an artificially static state, interspecific competition among waterbird species will most likely result in local population declines of some species rather than small-scale colony relocations in the future.

Preservation of colonial waterbird breeding colonies at Hamilton Harbour in the future must, therefore, involve active management of these populations, both annually and within breeding seasons (see Morris *et al.* 1992). Management practices should include: (1) the creation and maintenance of wildlife islands, (2) maintenance of nesting substrates on the wildlife islands specific to the needs of each species, (3) control of vegetation at sites of ground nesters on the wildlife islands, (4) active prevention of encroachment by Ring-billed Gulls on the breeding sites of other species (especially terns), through displacement of courting gulls and destruction of their scrapes and nests prior to the arrival of terns at their colony locations, and (5) control of predators and restriction of access by humans to wildlife islands. We also recommend regular monitoring of population numbers and breeding success for each species to determine the effect of colony relocation on reproductive parameters and the effectiveness of implemented management programs. Currently, data to address these issues are being collected cooperatively by researchers from the Canadian Wildlife Service, Brock University and McMaster University. Active management of waterbird populations and their nesting habitats within Hamilton Harbour is a labour-intensive proposition. Local stakeholders, such as naturalist clubs, should be encouraged to become more involved in this process.

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Appendix 1A: Distributions of Double-Crested Cormorant nests within Hamilton Harbour, 1988-1994. Census dates are in brackets.

Year	Neare Island	Farre Island	Windermere Basin	Eastport Pier 26	Eastport Pier 27	Stelco	Total
1988	0 (06Jun)	0 (06Jun)	0[a]	0	157 (NA)	ND	157
1989	0 (16Jun)	0 (16Jun)	0 (03Jun)	0	140 (NA)	0 (19May)	140
1990	0 (14May)	0 (14May)	0[a]	0	250 (12-15May)	0 (10Jul)	250
1991	0 (05Jun)	11 (05Jun)	0 (24May)	0	416 (NA)	ND	416
1992	0 (25May)	12 (25May)	0 (25May)	0	580 (17Jun)	ND	592
1993	0 (21May)	21 (21May)	0 (26May)	0	664 (03Jun)	0 (27May)	685
1994	0 (22Jun)	23 (22Jun)	0 (30May)	0	405 (05Jun)	0 (06Jun)	428

[a] Based on visits to area throughout breeding season.
ND No data available.
NA Dates not available.

Appendix 1B: Distributions of Black-crowned Night-Heron nests within Hamilton Harbour, 1988-1994. Census dates are in brackets.

Year	Neare Island	Farre Island	Windermere Basin	Eastport		Stelco	Total
				Pier 26	Pier 27		
1988	0 (06Jun)	0 (06Jun)	0[a]	0	194 (NA)	ND	194
1989	3* (16Jun)	0 (16Jun)	0 (03Jun)	0	101 (NA)	0 (19May)	104
1990	0 (14May)	0 (14May)	0[a]	0	99 (20Jun)	0 (10Jul)	99
1991	0 (05Jun)	14 (05Jun)	0 (24May)	0	60 (NA)	ND	60
1992	0 (25May)	5 (25May)	0 (25May)	0	127 (17Jun)	ND	132
1993	0 (21May)	11 (21May)	0 (26May)	1	122 (03Jun)	0 (27May)	134
1994	1 (22Jun)	25 (22Jun)	0 (30May)	15	47 (16May-09Jul)[a]	0 (06Jun)	88

* Birds nested on mainland shoreline of Burlington Beachstrip opposite Neare Island.
a Based on visits to area throughout breeding season.
ND No data available.
NA Date not available.

Appendix 1C: Distributions of Herring Gull nests within Hamilton Harbour, 1988-1994. Census dates are in brackets.

Year	Neare Island	Farre Island	Windermere Basin	Eastport Pier 26	Eastport Pier 27	Stelco	Total
1988	0 (06Jun)	8 (06Jun)	0[a]	N[a,*]		ND	UNK
1989	3 (16Jun)	5 (16Jun)	0 (03Jun)	0 (NA)	321	0 (19May)	329
1990	0 (14May)	39 (14May)	3 (12-15May)	0 (12May)	297	4 (10Jul)	343
1991	0 (05Jun)	18 (05Jun)	2 (24May)	170[b,*] (05Jun)		ND	188[b]
1992	18 (25May)	45 (25May)	3 (25May)	209* (25May)		ND	272
1993	22 (21May)	35 (21May)	5 (26May)	9 (12May)	226	3 (27May)	300
1994	13 (22Jun)	30 (22Jun)	1 (30May)	260[a,*]		0 (06Jun)	304

a Based on visits to area throughout breeding season.
b Incomplete census.
* No distinction made between Piers 26 and 27 during census.
N Nesting, but not censused.
ND No data available.
NA Dates not available.
UNK Total number unknown.

Appendix 1D: Distributions of Ring-billed Gull nests within Hamilton Harbour, 1988-1994. Census dates are in brackets.

Year	Neare Island	Farre Island	Windermere Basin	Eastport* Piers 26&27	Stelco	Total
1988	0 (06Jun)	61 (06Jun)	0[a]	N	ND	UNK
1989	88 (16Jun)	140 (16Jun)	10 (03Jun)	N	0 (19May)	UNK
1990	457 (14May)	166 (14May)	37 (12-15May)	38773 (12-15May)	188 (10Jul)	39621
1991	139 (05Jun)	38 (05Jun)	165 (24May)	N	ND	UNK
1992	N[a] (25May)	N[a] (25May)	367 (25May)	N	ND	UNK
1993	11 (21May)	0 (21May)	1678 (26May)	N	0 (27May)	UNK
1994	0 (22Jun)	0 (22Jun)	1747 (30May)	N	20 (06Jun)	UNK

a Based on visits to area throughout breeding season.
* No distinction made between Piers 26 and 27 during censuses.
ND No data available.
N Nesting but not censused.
UNK Total number unknown.

Appendix 1E: Distributions of Caspian Tern nests within Hamilton Harbour, 1988-1994. Census dates are in brackets.

Year	Neare Island	Farre Island	Windermere Basin	Eastport Pier 26	Eastport Pier 27	Stelco	Total
1988	0 (06Jun)	0 (06Jun)	0[a]	242 (06Jun)	0	ND	242
1989	0 (16Jun)	0 (16Jun)	0 (03Jun)	175 (NA)	0	0 (19May)	175
1990	0 (14May)	0 (14May)	0[a]	184 (05Jun)	0 (21Jun)	0 (10July)	184
1991	0 (05Jun)	0 (05Jun)	0 (24May)	220 (27 May)	0 (06Jun)	ND	220
1992	0 (25May)	0 (25May)	0 (25May)	337 (03Jun)	0	ND	337
1993	0 (21May)	0 (21May)	0 (26May)	273 (19May)	28	0 (27May)	301
1994	0 (22Jun)	0 (22Jun)	0 (30May)	313* (01Jun)	0	0 (06Jun)	313*

a Based on visits to area throughout breeding season.
ND No data available.
NA Dates not available.
* A total of 480 nests was recorded over the entire breeding season.

Appendix 1F: Distributions of Common Tern nests within Hamilton Harbour, 1988-1994. Census dates are in brackets.

Year	Neare Island	Farre Island	Windermere Basin	Eastport Pier 26	Eastport Pier 27	Stelco	Total
1988	413 (03Jun)	83 (03Jun)	0[a]	148 (06Jun)	0	ND	644
1989	310 (16Jun)	1 (16Jun)	336 (06Jul)	0 (NA)	0	20 (19May)	667
1990	6 (06Jun)	0 (06Jun)	776 (12Jun)	0 (12-15May)	0	246 (10Jul)	1028
1991	0 (05Jun)	0 (05Jun)	585 (24May)	0[a] (24May)	0[a]	ND	585
1992	0 (25May)	0 (25May)	753 (25May)	0[a] (25May)	0[a]	ND	753
1993	0 (21May)	0 (21May)	922 (26May)	0[a] (26May)	0[a]	32 (27May)	954
1994	0 (22Jun)	0 (22Jun)	675 (30May)	0[a] (30May)	0[a]	193 (06Jun)	868

[a] Based on census and visits to area throughout breeding season.
ND No data available.
NA Dates not available.