STATUS AND ECOLOGY OF MUTE SWANS IN NEW YORK STATE

DRAFT Final Report

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1.0 INTRODUCTION

The mute swan (*Cygnus olor*) is a non-native species that was brought to New York from Europe in the late 1800s for ornamental purposes. Swans escaped captivity or were released from private collections and established feral (free-ranging) breeding populations in the lower Hudson Valley and on Long Island in the early 1900s (Andrle and Carroll 1988). The population has since grown to more than 2,500 birds and expanded to other areas of the state in recent years.

As the number of free-ranging mute swans increased in New York and other Atlantic Flyway states, concerns have grown about adverse impacts that may result (Rhode Island DEM 2006, Maryland DNR 2011, Virginia DGIF 2012). Mute swans feed primarily on submerged aquatic vegetation (SAV) and often uproot far more than they consume (Willey and Halla 1972, Scott and the Wildfowl Trust 1972, Ciaranca et al. 1997, Bailey et al. 2008). This can result in a measurable reduction in SAV (Allin and Husband 2003, Naylor 2004, Tatu et al. 2007), which provides food and shelter to many native fish and wildlife species. Lakes in Michigan with large mute swan populations showed a stunting of bluegill (*Lepomis macrochirus*) lengths when compared to lakes with little or no mute swans present (Wood et al. 2013). Mute swans and several native waterfowl species consume similar species of SAV, creating potential for interspecific competition at migratory stopover sites (Bailey et al. 2008). Swans are often aggressive defenders of their nesting territories and young, sometimes attacking and killing or displacing other waterfowl from suitable habitats (Willey 1968, Stone and Marsters 1970, Kania and Smith 1986, Conover and Kania 1994). Swans have also threatened or attacked humans, resulting in accidents and injuries (Willey and Halla 1972, Rhode Island DEM 2006, Animal People Online 2012). Swan feces contain high levels of coliform bacteria (Hussong et al. 1979), so the presence of large flocks could impact waters used for drinking, swimming, or shellfishing.

The potential for rapid expansion of free-ranging mute swan populations in New York, and concerns about associated ecological and human impacts, have existed for many years and prompted the work reported here. DEC’s Division of Fish and Wildlife and Division of Marine Resources (now combined as the Division of Fish, Wildlife and Marine Resources, or DFWMR) adopted a policy in 1993 that recognized mute swans as an undesirable species in habitats used by native fish and wildlife (DFWMR 1993). Although the policy advocated population control and mitigation of impacts, it has not been aggressively implemented to date.

A mute swan management plan was adopted by the Atlantic Flyway Council (AFC) in 2003 (AFC 2003), and it called for an 80% reduction of mute swan numbers in the Atlantic Flyway, from approximately 14,000 birds in 2002 to less than 3,000 birds by 2013. The population goal for New York was less than 500 birds by 2013, an 80% reduction from the 2002 estimate of more than 2,800 birds. The plan also recommended further research to document the effects of mute swans on migratory birds, their habitats, and other indigenous living resources, and to evaluate management programs associated with the plan.

To help achieve these management goals, DEC sought additional information on the status, ecology, and conflicts associated with mute swans in New York. Despite the existence of free-ranging mute swans for nearly a century, there had been no formal studies of this species in the state. A better understanding of the ecology and impacts of mute swans in New York was needed to evaluate and help gain public support for management programs. With that in mind, we initiated the research described in this report, and compiled other available data from New York, to meet the following objectives:

1. Document the distribution and abundance of mute swans in New York State;

2. Estimate mute swan productivity and survival to allow modeling of future population growth and response to potential management activities;

3. Assess the impacts of mute swans on submerged aquatic vegetation (SAV);

4. Document interactions between mute swans and other wildlife species; and

5. Document swan-related human conflicts reported to DEC or USDA Wildlife Services.

This report provides a baseline and foundation for future management of mute swans in New York, including the development and evaluation of population control programs. It is not intended to be an exhaustive summary of scientific literature on the ecology and impacts of mute swans because many others have done that already (e.g., Ciaranca et al. 1997; Maryland DNR 2001, 2011; Rhode Island DEM 2006, Craves and Susko 2010; Virginia DGIF 2012; Gayet et al. 2013) and there was no need to duplicate those efforts. However, we acknowledge their value in helping us identify issues, plan our research and prepare this report.

2.0 DISTRIBUTION AND ABUNDANCE

Despite some debate, mute swans are not native to North America (Ciaranca et al. 1997, Askins 2009, Elphick 2009). They are native to northern regions of Europe and Asia (Scott and the Wildfowl Trust 1972), and were first brought to the New World in the late 1800s to beautify parks and private estates in the lower Hudson Valley and on Long Island. Free-ranging mute swans became established in the wild after the release of 216 at Rhinebeck (Dutchess County) in 1910 and another 328 at Southampton and Oakdale (Suffolk County) in 1912 (Marcotte 1998). Intentionally released or escaped individuals have established breeding populations in other states along the Atlantic Coast, around the Great Lakes, and along portions of the Pacific Coast (Ciaranca et al. 1997, Petrie and Francis 2003, Rhode Island DEM 2006).

By the 1960s, mute swans were established over much of Long Island, but they were most numerous on bays and ponds at the east end. Inland, they were locally common only in Dutchess and Rockland Counties; elsewhere they were rare to uncommon and of local occurrence. Early high counts were documented at Mecox Bay (275 in December 1949), Moriches Bay (500 in December 1959), and Rockland Lake (65 in February 1965) (Bull 1974). Mute Swans began colonizing the lower Great Lakes in the mid-1960s and 1970s (Petrie and Francis 2003).

By the 1990s, mute swans were described as an abundant, increasing resident downstate, and very local but increasing upstate. The species became common on the west end of Long Island in the 1980s, with a count of 205 at Jamaica Bay Wildlife Refuge in 1994 (Marcotte 1998). Along the Hudson, the species was steadily increasing northward, with increasing numbers in Greene and Columbia counties. The first nesting north or west of the Hudson Valley likely occurred at Perch River Wildlife Management Area (Jefferson County) in the early 1980s. Breeding was first confirmed in the Rochester area in 1990, at Braddock Bay Wildlife Management Area (Monroe County) (McGowan and Corwin 2008).

Two other species of swans, both native to North America, occur in New York State. Tundra swans (*Cygnus columbianus*) breed in the high Arctic and occur regularly during fall and spring migration in western and central New York. Most of the Atlantic Flyway population (up to 100,000 birds) winters in North Carolina, but up to several hundred tundra swans have overwintered on the Niagara River and around the Montezuma Wetlands Complex in recent years (B. Swift, DEC, unpublished data). Trumpeter swans (*Cygnus buccinator*) are a temperate-breeding swan that was once nearly extirpated, but restoration efforts in many central and western states and Canada have increased the Interior population to more than 9,800 birds (Groves 2012). Trumpeters are less migratory than tundra swans, typically moving south only when forced to find food during winter. Trumpeter swans first began breeding in New York in the mid 1990s, but the origin of these birds is uncertain (Carroll and Swift 2000). As of 2010, there were an estimated 50 trumpeter swans residing year-round in New York (B. Swift, DEC, unpublished data), supplemented in winter by swans moving south out of Ontario, where an extensive restoration program has been carried out for more than 20 years (Lumsden 2013).

Quantitative information on the distribution and abundance of mute swans in New York was available from several sources. These included the New York State Breeding Bird Atlas (NYSBBA), summer swan surveys by DEC, winter waterfowl counts, and Christmas Bird Counts (CBCs). Information from each of these sources is summarized below.

Breeding Bird Atlas - The NYSBBA documented the geographic range of all bird species breeding in New York State during 1980-1985 (Andrle and Carroll 1988) and 2000-2006 (Corwin and McGowan 2008). The atlas project divided the state into approximately 5,300 25-km^2 blocks, and field surveys were conducted in each to document evidence of breeding by more than 250 species of birds. Observation data were used to classify each block as having possible, probable, or confirmed evidence of breeding by each species.

The first atlas found free-ranging mute swans in 218 (4% of all) blocks, with breeding confirmed in 180 blocks, throughout Long Island and the lower Hudson Valley, northward to Dutchess and Ulster counties. The only upstate locations were a pair confirmed breeding at Perch River Wildlife Management Area, and another individual seen in Genesee County (Fig. 1).

The second atlas found mute swans in 407 (8% of all) blocks, with breeding confirmed in 252, scattered more widely throughout the state. It remained common on Long Island, being confirmed all along the north and south shores. By the second atlas, however, the species had expanded its breeding range up the Hudson Valley to Columbia County, and it was well established around Lake Ontario, likely a result of colonization from free-ranging populations in

Ontario (Petrie and Francis 2003). Breeding was also confirmed inland away from the Great Lakes and the Hudson River Valley in nearly a dozen counties (Fig. 1). The origin of these inland occurrences is unknown; some may have been birds that dispersed from wild populations, others may have escaped from captivity.

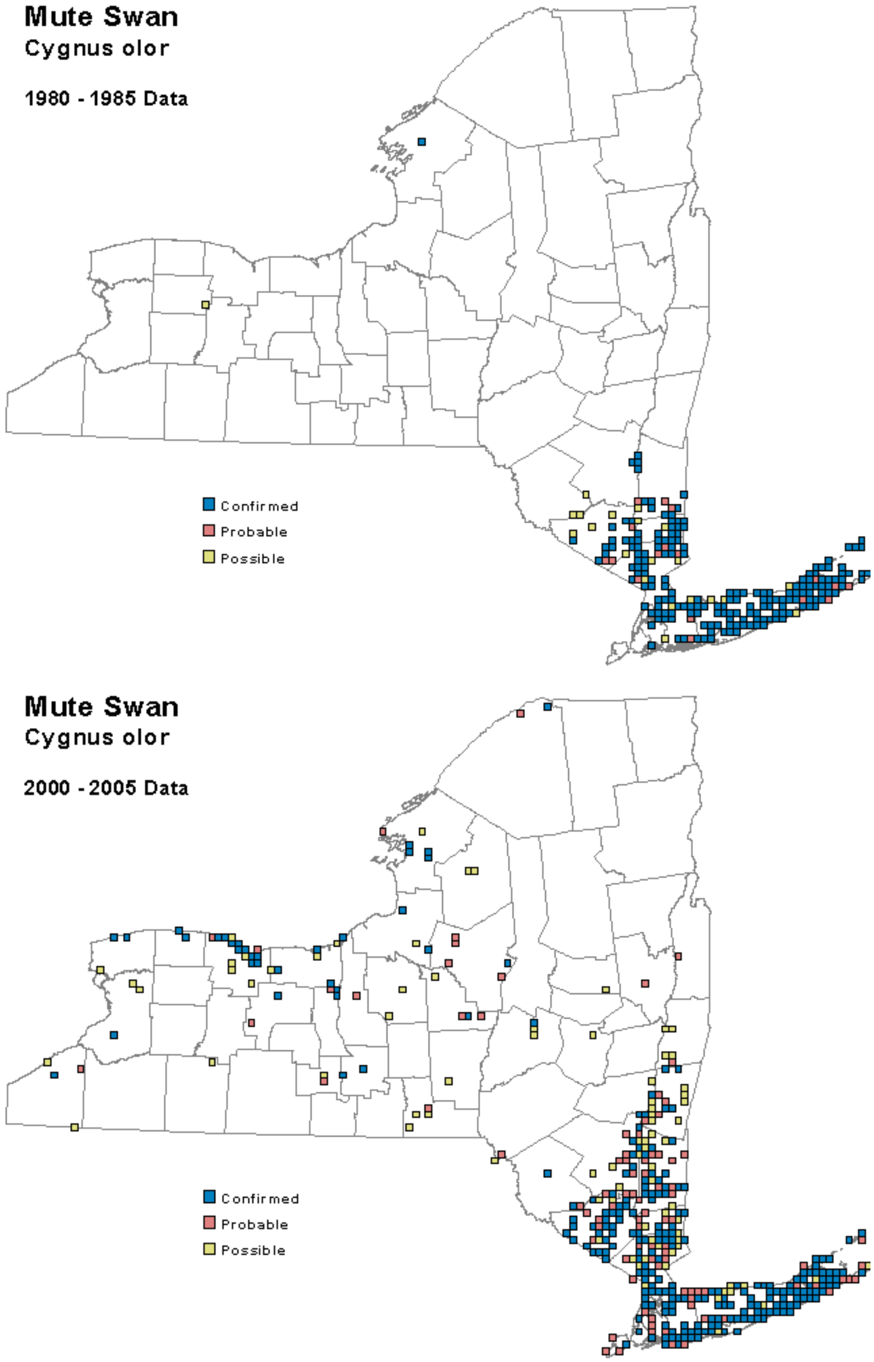

Figure 1. Breeding distribution of the mute swan based on New York State Breeding Bird Atlas data, 1980-1985 (Andrle and Carroll 1988) and 2000-2006 (McGowan and Corwin 2008).

Atlas data clearly documented the range expansion of mute swans in New York over the past 30 years (and the arrival of trumpeter swans), but they did not provide estimates of population size. For that, we have other sources of information, discussed below.

Summer Surveys - Since 1986, DEC has participated in tri-annual surveys designed specifically to monitor distribution, abundance and productivity of mute swans throughout the Atlantic Flyway. The goal of these surveys was to make as complete a count as possible of mute swans in each state, and to determine the number of young produced in each. The surveys are conducted between August 1 and September 15, a time period when swans are least likely to be moving about due to their summer molt (when they are flightless) and well after hatching normally occurs. In New York, the surveys are accomplished by aerial surveys over coastal areas and downstate reservoirs, supplemented by ground counts where swans are observed opportunistically. Although some swans may be missed due to access limitations, the sheer size of the state, and other logistic constraints, we believe that most large flocks are counted.

Results of the summer surveys suggest a general increase in the number of mute swans residing in New York since 1986, although counts from 2011 were incomplete. For all 9 surveys, total counts averaged about 2,145 swans, but the number counted during the last 4 complete surveys (1999-2008) exceeded the numbers observed during the previous 4 surveys (1986-1996), except in the Hudson Valley (Table 1, Fig. 2). The most dramatic change was around Lake Ontario, where fewer than 30 mute swans were counted through 1996, but more than 160 were counted on every survey since 2002. On average, there were approximately 80 successful breeding pairs, producing about 3 cygnets each, for a total of about 240 new swans produced per year. The overall number of cygnets per adult was relatively stable over time, at about 0.13 (Table 1).

Table 1. Numbers of mute swans counted during late summer surveys in New York State.

	1986	1989	1993	1996	1999	2002	2005	2008	2011[1]	Mean
Total	1,835	1,905	2,069	1,644	2,429	2,848	2,146	2,624	1,807	2,145
Long Island	1,488	1,273	1,605	1,172	1,618	1,835	1,673	2,099	1,605	1,596
Hudson Valley	327	602	422	428	733	803	287	335	33[1]	441
Lake Ontario	0	15	22	29	52	193	175	175	169	92
Other	20	15	20	15	26	17	11	15	11	17
Adult/subadults	1,609	1,748	1,823	1,421	2,206	2,520	1,879	2,311	1,601	1,902
Cygnets	206	157	246	223	223	328	267	313	228	243
Broods	62	58	79	52[2]	79	102	97	106	85	80
Cygnets/brood	3.3	2.7	3.1	2.7[2]	2.8	3.2	2.8	3.0	2.7	2.9
Cygnets/adult	0.13	0.09	0.13	0.16	0.10	0.13	0.14	0.14	0.14	0.13

[1] Surveys were incomplete in 2011 due to impacts of Hurricane Irene in the Hudson Valley region.
[2] Number of broods in 1996 was uncertain, so cygnets/brood was based on known broods only.

Winter Waterfowl Surveys - Two long-running winter waterfowl surveys provide data on distribution and abundance of mute swans in New York. DEC and the U.S. Fish and Wildlife Service conducted aerial surveys covering most of the major water bodies in the state during early January from the late 1940s to the 1990s. However, the observers and areas covered in this survey have undergone some major changes since 1997 that render more recent data difficult to compare to prior years. Since 1955, the New York State Ornithological Association (NYSOA, formerly the Federation of New York State Bird Clubs) has coordinated less formal, but more extensive ground surveys during mid January that included nearly all areas surveyed by DEC and many smaller waterfowl concentration areas. Counts of mute swans from these two winter surveys were highly correlated and trend estimates were similar (+5.1% and +6.2% increase per year, respectively; Swift and Hess 1999). Because comprehensive aerial surveys are no longer conducted, only the NYSOA data are included in this report.

NYSOA counts averaged approximately 500 mute swans during the 1970s, followed by a period of rapid growth during the 1980s. Winter counts peaked at approximately 2,300 birds in 1992, and have remained at 1,500-2,000 birds since 1998. Long Island typically accounts for at least two-thirds of the statewide total (Fig. 3), and total counts for that region appear relatively stable at approximately 1,200 swans since 1990. In contrast, counts in the Hudson Valley region have declined sharply in recent years, whereas counts around Lake Ontario increased dramatically since their first appearance in the mid 1990s, with more than 200 birds in recent years (Fig. 3). Results of the NYSOA surveys are available at: http://www.nybirds.org/ProjWaterfowl.htm.

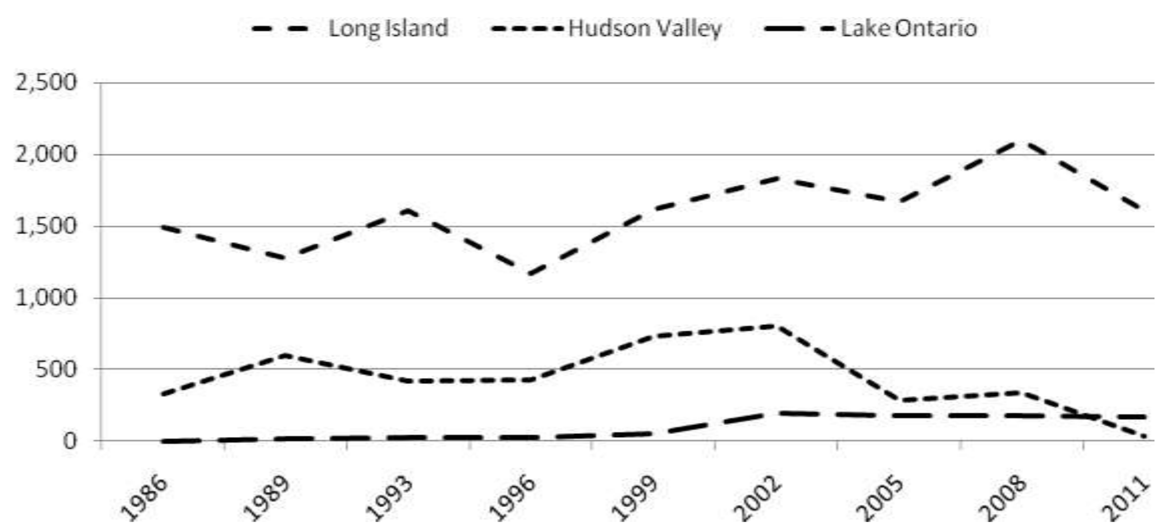

Figure 2. Number of mute swans counted during summer surveys in regions of New York State.

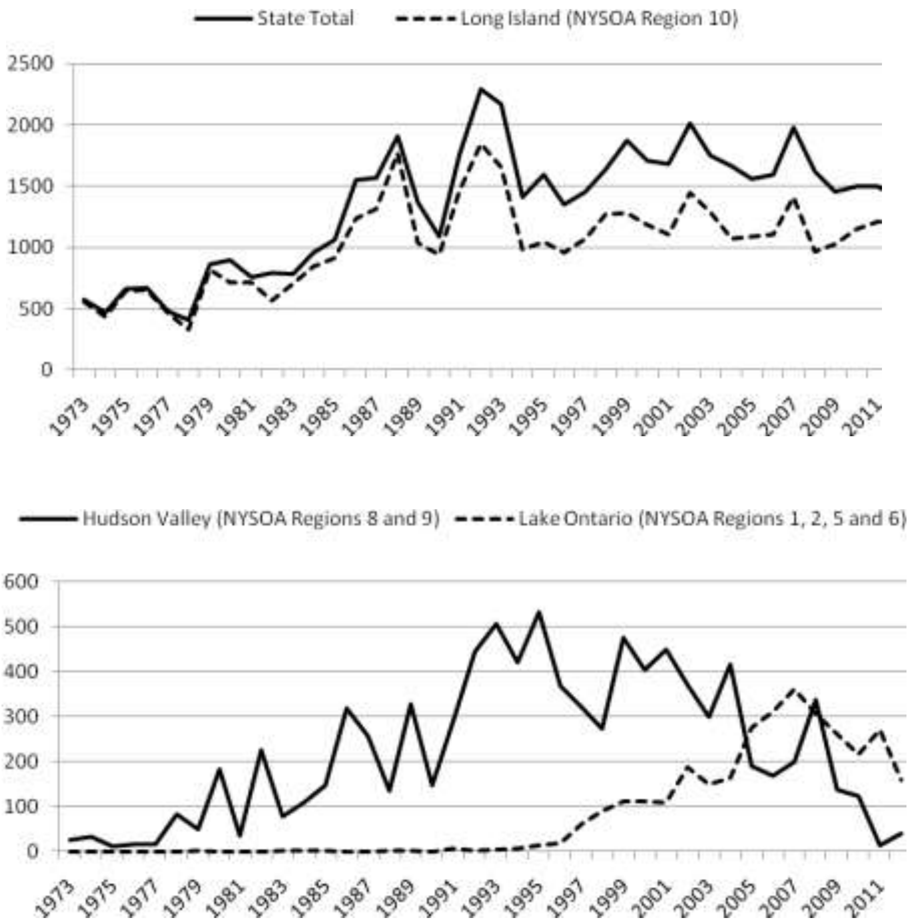

Figure 3. Total number of mute swans observed during January waterfowl counts coordinated by the New York State Ornithological Association, 1973-2012.

Christmas Bird Counts - Thousands of volunteers have participated in the National Audubon Society's Christmas Bird Counts (CBCs) during the past 100 years. Counts are conducted within a 15-mile radius of fixed locations throughout North America, with approximately 250 of these count areas ("circles") located in New York State. Within each circle, participants fan out and compile a complete count of all birds observed on a single day between mid December and early January each year. Combining the data from all areas provides further documentation of mute swan population growth in New York. Prior to 1930, no more than 30 mute swans were counted in the state, and total counts did not exceed 200 until the early 1950s. Total counts reached more than 1,000 for the first time in 1976, and exceeded 2000 in 1987. Total counts have generally been between 2,000 and 2,600 mute swans since 1988 (Fig. 4).

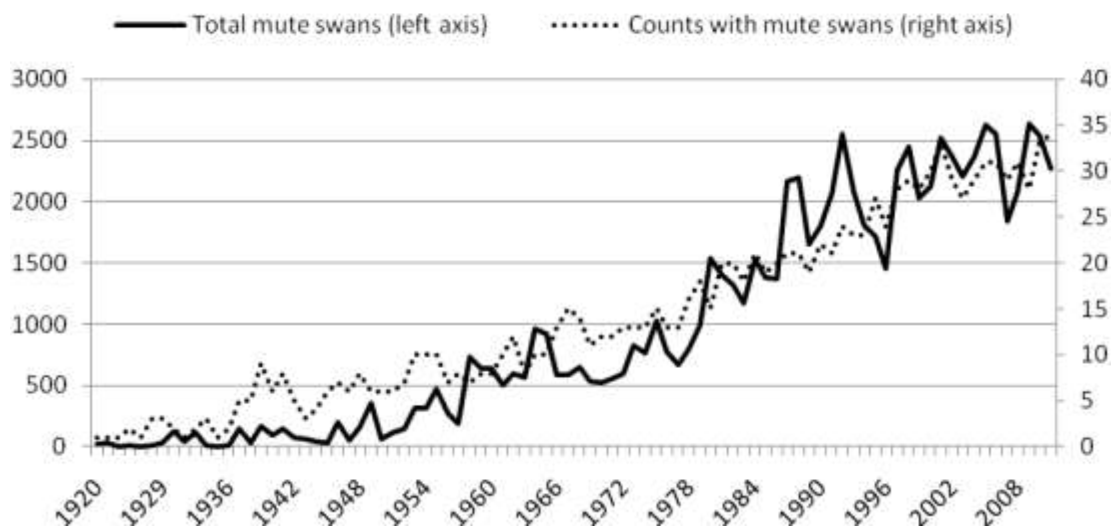

Figure 4. Total number of mute swans counted during Christmas Bird Counts in New York State, 1920-2011 (source: National Audubon Society, 2013; Christmas Bird Count Historical Results [Online], http://netapp.audubon.org/cbcobservation, accessed August 13, 2013).

Conclusions - Mute swans are now well established as a breeding species in New York State, especially on Long Island and in the lower Hudson Valley, where they have existed for close to 100 years. Populations in those regions appear to have stabilized in recent years (and may be declining in the Hudson Valley), perhaps as a result of density-dependent effects on reproduction (Nummi and Saari 2003). In contrast, a new population became established around Lake Ontario during the 1990s and has been in a period of rapid growth. In the absence of management, the Lake Ontario population could grow by as much as 18% per year, as has been estimated for other areas of the Atlantic Flyway and Great Lakes region (Reese 1980, Allin et al. 1987, Petrie and Francis 2003, Rhode Island DEM 2006, Craves and Susko 2010, Meyer et al. 2012). Other inland populations in New York are not known to exist, but occasional reports of birds at many isolated locations with suitable habitat suggest that much additional range expansion is possible.

For discussion purposes, the total number of mute swans in the state is probably close to 2,200 birds as of 2012, with about 1,600 on Long Island, up to 400 in the Hudson Valley, and about 200 around Lake Ontario. Future changes in distribution and abundance of mute swans should be evident from the various survey programs that are conducted in New York State.

3.0 LEGAL STATUS AND MANAGEMENT POLICIES

As noted earlier, the mute swan is a non-native species that was introduced to North America for ornamental purposes. The legal status of such species, especially those living in a wild state, is often unclear under state and federal laws and regulations. However, a fairly clear record exists with respect to the legal status of mute swans in New York.

The status of mute swans under federal law was clarified in 2005 after considerable legal debate. For many years, the U.S. Fish and Wildlife Service (USFWS) took the position that because mute swans were non-native, they were not protected under the Migratory Bird Treaty Act, and thus, USFWS had no jurisdiction over this species. Some individuals and groups who wanted to protect mute swans from state-sponsored control programs took exception to the USFWS stance and filed suit in federal court. A U.S. Court of Appeals ruled in December 2001 that mute swans in Maryland and 12 other states (including New York) were protected under federal law. The court reasoned that the Migratory Bird Treaty includes ducks, swans, and geese and makes no exception for non-native species.

After the 2001 court ruling, USFWS issued a Draft Environmental Assessment (EA) in June 2003, proposing to allow states to reduce mute swan populations in the Atlantic Flyway. Swan supporters went back to court, challenging the Draft EA and claiming that a full Environmental Impact Statement was required. A federal court issued temporary injunctions in two separate lawsuits, and the Draft EA was withdrawn by USFWS in September 2003. USFWS advised all states that permits to control mute swans could not be issued until after an environmental impact study was completed, a process that could take several years.

Congress responded to the above court rulings by passing the “Migratory Bird Treaty Reform Act” in December 2004. This act clarified that the Migratory Bird Treaty Act applied only to bird species that are native to the United State or its territories. The Reform Act defined “native to the U.S. or its territories” to mean “occurring in the U.S... as the result of natural biological or ecological processes”, and added that “a migratory bird species that occurs in the U.S... solely as a result of intentional or unintentional human-assisted introduction shall not be considered native to the U.S...”. In March 2005, USFWS published an official list of non-native species to which the MBTA did not apply (USFWS 2005). The list included mute swan, meaning that the legal status of mute swans was once again up to each state to decide.

Mute swans have had legal protection in New York since 1946, when the species was specifically added to the definition of protected birds in the Environmental Conservation Law (ECL). Specific listing of mute swans as a protected bird was later deemed unnecessary and removed from the ECL in 1975. This was based on the definition of “migratory game birds”, which includes all members of the family Anatidae that exist in a wild state, and all migratory game birds are “protected birds” in the ECL. Take of protected wildlife species is not prohibited by state law, but requires some authorization by DEC. Thus, while all wild waterfowl in New York are “protected”, there are lawful hunting seasons for most and permits are issued for take of some species to alleviate conflicts with human interests.

Under current State regulations, mute swans may not be taken by hunting in New York State. However, because swans are classified as migratory game birds in the ECL, DEC does have the authority to establish seasons and bag limits for this species. Some hunters in New York have expressed interest in hunting mute swans, especially on Long Island, where the species often occurs in association with other waterfowl (ducks and geese) that may be legally hunted. Hunting for tundra swans is allowed by federal law in some states (e.g., North Carolina) and is very popular. Hunters in Pennsylvania, Virginia, and North Carolina (and perhaps other states) are currently allowed to take mute swans, but estimates of the numbers taken are not available.

Growing concern about problems associated with non-native invasive species has resulted in new initiatives to prevent establishment and promote control of such species. The New York State Legislature created an Invasive Species Task Force in 2003, and they defined invasive species as any species that is: 1) non-native to the ecosystem under consideration, and; 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. They specifically included mute swan among the list of “familiar invasives” (New York State Invasive Species Task Force 2005). As discussed elsewhere in this report, mute swans fit the description of an invasive species because of their rapidly increasing numbers and potential impacts on other waterfowl, natural ecosystems and people. The task force recommended prevention and control of invasive species, and restoration of native species and habitat conditions in ecosystems that have been invaded. In October 2013, DEC officially proposed designation of mute swans as a “prohibited species” pursuant to the invasive species law (ECL section 9-1705). This designation would restrict the sale, purchase, possession, propagation, introduction, importation, transport and disposal of mute swans for commercial purposes.

While not a legal document, the Atlantic Flyway Council (AFC) adopted a mute swan management plan in 2003 that called for substantial reductions in the number of feral mute swans in the flyway by 2013 (AFC 2003). States were expected to implement actions to achieve the plan goals, including a goal of no more than 500 mute swans in New York, a reduction of about 80%. The plan also reiterated a number of policy recommendations that AFC had adopted in 1997. Many wildlife conservation organizations, including the Association of Fish and Wildlife Agencies, National Audubon Society, and the American Bird Conservancy expressed strong support for reducing feral mute swan populations in accordance with the flyway management plan.

Within this legal framework, a mute swan management policy was developed in 1993 by DEC’s Division of Fish and Wildlife and Division of Marine Resources, and that policy has guided DEC’s actions to the present time. That policy authorized and encouraged mute swan population control efforts, and it supported actions necessary to alleviate site-specific conflicts associated with these birds. However, control efforts by DEC and others have occurred on a limited basis, often because of staff time constraints. As a result, the population has not been reduced to the extent desired, and the potential for population growth and significant impacts still remains. Much of the research reported herein was conducted to inform the development of a new management plan for mute swans in New York.

4.0 PRODUCTIVITY

Mute swans have a high reproductive rate and capacity for population growth, as documented in many studies (e.g., Willey and Halla 1972, Reese 1975, Reese 1980, Chasko 1986, Knapton 1993, Ciaranca et al. 1997, Conover and Kania 1994, Coleman et al. 2001). However, we wanted to obtain current data specific to New York State. During 2004-2006, we conducted field studies to estimate the number of cygnets fledged per nesting pair of swans. Productivity data were collected by monitoring nests and broods on Long Island and in the Lower Hudson Valley and Lake Ontario regions of New York from approximately May 1 through September 1. In addition to overall productivity estimates, we documented average clutch size, hatching rate, and monthly cygnet survival from nest and brood survey data.

Nest locations were identified between April and June each year by locating pairs or single swans believed to be males guarding a nest site using ground, aerial, and boat surveys, as well as reports from landowners and DEC staff. Actual nests at each location were found by thoroughly searching the areas with binoculars from a canoe or boat. Nests were considered active if eggs were present or if incubating behavior was noted (e.g., individual observed sitting on nest). If eggs were present but broken, or present but the nest was abandoned (e.g., no breeding pair was present and the eggs felt cold or exhibited a foul odor), the nest was classified as failed. If no nest was found during the initial search, the site was not included in future monitoring activities.

All nest locations were recorded with a hand-held GPS unit. Nests were monitored through the hatch to determine nest success and hatching rates. Information collected from active nests included clutch size and numbers of eggs hatched. Hatching rates were calculated as the percentage of eggs laid that hatched, including eggs laid in nests that failed for any reason.

Once nests hatched, periodic visits to each site were planned to monitor brood size and survival. Water bodies that had multiple broods were more difficult to monitor, but size and color (white or gray) of the cygnets helped differentiate some family groups over time. Color seemed to be a useful identification tool since white cygnets were white from hatch and gray cygnets remained gray to gray-brown until their adult plumage grew in (post-fledging). Large or isolated water bodies sometimes required boat or aerial surveys to locate family groups throughout the brood-rearing period. Broods discovered after the hatching period during routine surveys were also recorded and monitored to supplement overall productivity data regardless of whether the actual nest was found. For these broods, the proportions of failed nests found during pre-hatch periods were used to adjust productivity calculations for broods found post-hatch. Program Mark (version 4.2, G. White, Colorado State University) was used to calculate monthly cygnet survival from brood monitoring data. The Known Fate model was used since brood data were collected from specific broods at specific locations. Any brood whose fate was not known due to an inability to re-observe it was removed from the data set prior to analysis.

Several logistical problems limited our data collection each year, so most of the results presented here combine data for all years of the study. In 2004, we did not begin field work until May, well into the nesting season, so we had a small sample of active nests (n=15) to monitor that year. In 2005, we began with a larger sample of nests (n=51), but brood monitoring ended in early August when the project leader was out for medical reasons. In 2006, we did not locate as many nests (n=17) because we were primarily interested in cygnet survival data that we lacked from the year before. Because of these circumstances, nest success and cygnet survival estimates from 2004 and 2006 were combined with the data collected in 2005 to calculate mean productivity parameter estimates for each year (Table 2).

We obtained multiple cygnet counts for 48 broods during summer 2004. Due to the small number of broods found in May, we combined data for those with broods first observed in June. Of cygnets found in May or June, we estimated that 53% survived to fledging. Of cygnets found in July, 84% survived to fledging, and 100% of cygnets first found in August were observed again in late September (Table 3).

Table 2. Productivity parameter estimates for mute swans in New York, 2004-2006.

Parameter	2004	2005	2006	Mean/yr
Nesting pairs	52	86	38	59
Nests found	15	51	17	28
Eggs/nest	5.6	4.9	4.8	5.1
Hatch/nest	4.3	n/a	n/a	4.3
Successful nests	13	46	n/a	n/a
% nest success	87	90	n/a	89
Broods	50	24	28	34
Cygnets	132	91	79	101
Cygnets/pair	2.5	2.2	2.3	2.3
Cygnets/brood	2.6	3.8	2.8	3.1

In 2005, we obtained multiple counts for 17 broods that were first observed in June. However, the last counts that year occurred between July 15 and August 3, when the project leader went out for medical reasons. Thus, the "final" counts and survival for that season were not to fledging, and were adjusted for normal losses from July to fledging, using the 0.84 estimate from 2004. In 2006, we obtained multiple counts for 19 broods that were first observed during late April to June. Survival to mid or late August for these cygnets was estimated at 71%, after which we assumed survival was close to 100%. Overall nest success averaged 89% (Table 2) and survival probability for all cygnets first observed during April to June (soon after hatching) averaged 62% (Table 3).

In addition to field data collected in this study, other productivity information was available for mute swans in New York. Tri-annual summer swan surveys conducted by DEC have yielded counts of adult and young mute swans since 1986 (see earlier section on Population Status). The number of cygnets per brood in those surveys has averaged 2.9 and the number of cygnets per adult swan in the population averaged 0.13 (Table 1). Data collected by DEC staff and others involved in treating mute swan nests and eggs to prevent hatching provided additional information on clutch size; a total of 430 nests with 2,495 eggs were treated during 2005 to 2012, an average of 5.8 eggs per nest (see Management section later). This was similar to the 5.1 eggs per nest found during our nesting studies.

Although the nest and egg, brood monitoring, and productivity data from other sources were all collected somewhat independently, the resulting productivity estimates were quite similar. Based on the data presented above, we suggest that the following are reasonable estimates for various productivity parameters for mute swans in New York: mean number of eggs per nest - 5.5; mean number of hatched eggs per nest - 4.5; survival of cygnets from hatch to fledging (mid-August) - 60%; mean number of cygnets per successful pair – 2.9; and mean number of cygnets per nesting pair - 2.6. The overall productivity estimate was similar to results of Knapton (1993; 3.1 fledged per pair), Coleman et al. (2001; 2.7 young per pair), and other studies cited above.

Table 3. Survival to fledging of cygnets in broods observed in New York, 2004-2006.

When Brood was First Observed	No. of broods	Initial cygnets	Cygnets/ brood	Final cygnets	Cygnets/ brood	Survival prob
May 12-26, 2004	6	33	5.5	20	3.3	0.61
June 3-24, 2004	15	71	4.7	35	2.3	0.49
July 7-24, 2004	18	57	3.2	48	2.7	0.84
August 19-27, 2004	9	19	2.1	19	2.1	1.00
June 3-21, 2005	17	80	4.7	56	3.3	0.59[1]
April 26 - May 23, 2006	8	42	5.3	31	3.9	0.74
June 1-22, 2006	11	42	3.8	29	2.6	0.69
All observed before July	57	268	4.7	167	2.9	0.62

[1] Final cygnet counts in 2005 were in late July to early August, so their survival to final fledging was estimated using a correction factor (0.84) from birds first observed in July 2004.

We did not estimate the number of non-breeding adult or sub-adult swans per breeding pair, but the tri-annual surveys suggest an average of about 25 adult or subadult swans for every brood (i.e., successful breeding pair; see Table 1). Assuming 2.9 fledged cygnets per successful pair, we estimate that mean annual productivity for mute swans in New York is approximately 0.13 fledged cygnets per adult/subadult bird in the population. At the currently estimated population of approximately 2,200 swans (1,900 adult/subadults), annual production of more than 80 broods and about 250 new swans per year can be expected.

5.0 SWAN CAPTURE AND BANDING

To estimate annual survival rates and document seasonal movements, we captured and neck-banded 160 free-ranging adult mute swans. Banding was done in all three regions of New York that have established feral populations of mute swans (Long Island, Hudson Valley, and Lake Ontario; Table 4). Only adult or subadult swans were neck-banded because young-of the-year were too small to retain a collar at the time of banding (August-September).

Most swans were captured using a catch-pole, which was a modified aluminum extension pole (approximately 2 m fully extended) that had a smooth, rounded hook at one end. The hook was placed quickly around a swan’s neck so that the bird could be pulled in toward the person making the capture. Individual birds on nests were often so protective that they could be easily approached on foot or by boat to capture them with the catch-pole. Most non-breeding adults, as well as some nesting swans, were captured during the molt with the aid of a motorboat (after

Willey and Hanna 1972). This method required at least two people; a driver and a person with a catch-pole who stayed at the bow of the boat. Individual swans were chased and circled with the boat until they could be hooked with the catch-pole and pulled back to the boat (Fig. 5). It was best if the boat driver could overtake the swans quickly to prevent a long and tiring chase that might have resulted in excessive stress or injury to the swans. On a few other occasions, where swans were fed by people, they were simply lured with bread and hand-captured.

Table 4. Numbers of adult mute swans neck-banded for survival and movement studies in New York, 2004 - 2007.

General Area	2004	2005	2006	2007	Total
Lake Ontario – Monroe County	13	5	10	0	28
Hudson Valley – Ulster, Orange, Rockland, Westchester counties	18	0	9	3	30
Long Island – Nassau, Queens counties	23	0	0	0	23
Long Island – Suffolk County	26	12	37	4	79
Total	80	17	56	7	160

Figure 5. E. Cooper capturing a mute swan on the Hudson River using a catch-pole.

All adult swans we captured were fitted with white plastic neck-collars (~4" tall) that had unique 4-character alpha-numeric codes in black, as well as USFWS aluminum leg bands (Fig. 6). The sex of each swan captured was determined by cloacal characteristics. All banding and data collection was done at the site of capture and all birds were released immediately after being processed.

Figure 6. R. Malecki holds a neck-banded mute swan just prior to release on the Hudson River.

6.0 ADULT SURVIVAL

Mute swans are long-lived birds, with a potential life expectancy of close to 20 years (Scott and the Wildfowl Trust 1972, Reese 1980, Coleman et al. 2001). Adult swan survival in New York was estimated from observations and recoveries of neck-collared swans. As noted above, we did not estimate survival of juvenile swans because most were too small for neck collars at the time of capture.

Project staff recorded all sightings of collared swans made during forays into the field. Staff visited most swan capture locations on several occasions after birds were marked, but we did not make systematic or exhaustive efforts to locate collared swans each season. Many additional sightings of collared swans, as well as dead recoveries, were reported to DEC by the public. We solicited such observations via a mute swan information page on the DEC website and on the New York State Ornithological Association (NYSOA) website. We also obtained reports of banded mute swans observed or found dead that were received by the USGS Bird Banding Laboratory (BBL) in Laurel, Maryland.

Field activities for this project were largely completed by fall 2006, but incidental sightings and additional reports from the public continued through summer 2009, and those were included in the analysis. We documented approximately 550 sightings or recoveries of 131 neck-banded swans from our own field observations and reports sent to DEC or the BBL. Additional records continue to be added to the data base, but those have not been analyzed further.

Survival estimates for adult swans were based only on birds neck-banded during 2004-2005, because of the reduced staff observation efforts after fall 2006. As of August 2009, we documented one or more observations or recoveries for 86 (89%) of the 97 swans collared in 2004-2005. Sixty-five (76%) of those observed were confirmed alive at least one year or more after banding, and 45 (52%) were confirmed alive at least two years after banding; the latter equates to a 72% mean annual survival rate over two years (Table 5). Only 22 (26%) of the swans banded in 2004-2005 were seen in 2007 or later, reflecting the limited observation effort after 2006. However, 19 (86%) of those 22 were seen during 2005-2006, and we used this "observation probability" to adjust the direct survival estimates to account for birds alive but not seen. Using only known observations of marked swans tends to underestimate survival, because some birds may lose their collars or go unobserved for long periods of time.

The resulting adjusted estimate of annual adult survival was 87% per year. Even this estimate may be low, as sightings of several swans not seen as of summer 2009 have since been reported.

Table 5. Summary of all known observations or recoveries of mute swans neck-banded in New York reported to DEC or the USGS Bird Banding Laboratory during 2004-2007.

Year banded	No. banded	No. seen ≥ Apr 2004	No. seen ≥ Apr 2005	No. seen ≥ Apr 2006	No. seen ≥ Apr 2007	No. seen ≥ Apr 2008
2004	80	72	54	37	14	5
2005	17	na	14	11	8	3
2006	56	na	Na	45	18	11
2007	7	na	Na	na	3	3

7.0 CAUSES OF MORTALITY

The most common causes of death among swans are accidents, starvation, vandalism, adverse weather, and disease, including lead poisoning (Scott and the Wildfowl Trust 1972, Coleman et al. 1991). During our study, there were 38 known field fatalities of neck-banded swans, and four other birds were recaptured in a debilitated state and removed from the study. These accounted for 26% of all swans that we banded. More than half (n=21) were documented by or reported to project staff, but many others (n=17) were reported directly to the BBL. Cause of death was unknown for many fatalities because most were birds found dead in the field long after they had died. Among the known causes of death for swans in this study, three were shot or captured by wildlife agency staff for management purposes; one died of malnutrition due to fishing line caught in its throat; one was struck by a train; one was killed by the operator of a jet ski; and one died from lead poisoning (J. Okoniewski, DEC, unpublished data). The remainder died of unknown causes.

Four neck-banded swans were live-captured and removed from the study when they were reported by local residents as emaciated, injured, or behaving abnormally. All were taken to a local wildlife rehabilitator or veterinarian for evaluation or treatment. Two died in captivity and two were treated and released near the sites where they were found. One of the birds was found to have lead poisoning and likely would have died if not treated. In the other case, the reason for the bird's debilitated state was unknown. Collars were removed prior to the swans being released back to the wild, even though there was no evidence that the neck collars had contributed to the poor health of swans we recaptured.

Additional information on mortality of mute swans was provided by DEC's Wildlife Pathology Unit (WPU). During the time of our study, 39 dead mute swans were submitted to WPU for examination. Starvation or emaciation was implicated in 41%, with 11 (28%) dying from winter starvation and five (13%) from unexplained emaciation. Impact trauma, including collisions with vehicles or structures, was diagnosed for seven (18%) swans, and infectious or parasitic disease was diagnosed for six (15%); other individual birds died of various causes, and about 10% were undetermined (J. Okoniewski, DEC, unpublished data). From 1972-2007, WPU examined 125 mute swans, with starvation/emaciation the principal cause of death for about 30%; trauma, including blunt impact, shooting, fishing tackle related injuries and other forms, accounted for about 26%; infectious and parasitic disease, including aspergillosis and trematodiasis, accounted for 14%; and mortality related to lead or pesticide poisoning or oiling accounted for 10%. Most of the remainder were "open" cases with the cause of death not determined (J. Okoniewski, DEC, unpublished data).

Published reports (Coleman et al. 1991), in addition to our own records, suggest that starvation during severe winters could be a major factor affecting mute swans in New York. Because these birds feed almost exclusively on aquatic vegetation, and they do not typically migrate to milder locations during winter, sudden and severe cold weather can often result in physiological stress and starvation losses when feeding areas freeze over for extended periods of time. This often results in public concern for welfare of the birds, expressed through pleas for supplemental feeding or rescue of affected birds. To the extent that such efforts help swans survive those conditions (Coleman et al. 2001), local populations may be sustained at levels higher than the habitat can support, resulting in even greater potential for mortality in future years.

8.0 POPULATION MODELING

Based on our productivity and survival estimates, the total number of mute swans in New York State is projected to be relatively stable, although observed trends differ among regions of the state. We estimated an overall productivity rate of approximately 13 fledged cygnets per 100 adult/subadults in the population, and we estimated adult survival at approximately 87%. The combined effects of these two parameter estimates suggest a statewide population decline of approximately 2.5-3.0% per year during our study, which was consistent with population survey data discussed earlier in this report. However, the relatively small population of swans on Lake Ontario was clearly in a period of rapid growth until very recently (Table 1), but due to small sample sizes, the data we collected did not allow us to calculate productivity and survival for each region of the state.

9.0 MOVEMENTS

As noted above, we documented approximately 550 sightings or recoveries of 131 neck-banded swans from our own field observations and reports sent to DEC or the USGS Bird Banding

Laboratory (BBL). These data were examined to assess the extent to which mute swans banded in New York underwent seasonal or other movements beyond their local capture location. Mute swans collared in Rhode Island during the late 1960s did not exhibit true migration, but small flocks annually moved about within Rhode Island and also moved into Massachusetts, Connecticut and Long Island (Willey and Halla 1972).

Observation and recovery data were in two distinct formats, requiring a somewhat different analysis for each. Our own observations (n=388 sightings of 113 different swans) were compiled in a detailed and descriptive manner, with specific water bodies, nearby landmarks, or other location information recorded in the field or from reports received directly from the public. These data were inspected to compare each sighting or recovery location with the original banding location, and any that indicated movement of >50 km (31 miles) were noted. Other location data obtained from the BBL (n=144 reports for 75 different birds, including some of same birds we observed) were much less precise, as they included latitude-longitude information to the nearest 10-min block, but did not specify exact locations or water bodies where the birds were observed. We noted all reports of birds that were located >4 blocks (~58 km, or 36 mi) away from their banding location, which was similar to the movement distance we used for our own data.

From summer 2004 through summer 2009, we documented only 9 (8%) of 113 banded mute swans at locations >50 km (~30 mi) from where they were banded. Bands reported to BBL indicated that 14 (19%) of 75 birds in our study had moved more than four 10-min blocks in any direction. When the two data sets were combined, 19 (14%) of 134 neck-banded birds were documented to have moved >50 km from where they were banded. However, even the farthest movement documented was less than 200 km (120 miles); this was by three different swans banded during August on the Hudson River near Kingston (at the mouth of Rondout Creek) that were seen during winter near Barnegat Bay, New Jersey. This was the only other state, and the farthest south, that any of our swans were reported from. In all, 13 different swans were seen in New Jersey on at least one occasion.

Birds banded along Lake Ontario (at Irondequoit Bay or Braddock Bay) were most sedentary. Only one (4%) of 28 birds banded (24 seen at least once) in that region was ever reported to be >50 km from the banding location; that bird was seen on Lake Ontario west of Toronto. All other sightings of these birds were along the lake shore between Braddock Bay and Sodus Bay, or were within the Irondequoit Creek watershed in Monroe County. We had no reports of these birds moving south (e.g., to any of the Finger Lakes), even during harsh winters.

Swans banded on Long Island were nearly as sedentary as those banded on Lake Ontario. Only four (4%) of 102 birds banded on Long Island moved >50 km, and nearly all movements followed shorelines or water bodies. All swans banded on the south shore of Nassau County remained in that area (n=16 birds seen at least once), between Jamaica Bay and South Oyster Bay. All swans banded on the north shore of Suffolk County (i.e., Nissequogue River, Stony Brook Harbor and Conscience Bay) remained along the north shore (n=17 birds seen at least once), between Huntington Harbor and Port Jefferson, a span of only 32 km (20 mi). None of these birds were ever reported seen on the south side of Long Island or across Long Island Sound in Connecticut or Rhode Island. Similarly, most sightings of swans banded in central or eastern

Long Island (i.e., around Riverhead and Moriches Bay) were from the south shore, with only four of 25 birds known to move as much as 50 km. All four were banded in or near the Forge River (Moriches Bay) during August 2004; two were seen in New Jersey, one was seen in southern Nassau County, and one was seen along the Hudson River near Peekskill. The latter bird was the only swan that moved from one major region of New York to another.

Mute swans banded in the Hudson Valley were more mobile than swans banded in other regions of the state. At least 15 (50%) of 31 birds banded in that region (23 of which were seen at least once) were seen nearly 50 km or more from their banding location. Nearly all of these birds had moved south along the Hudson River corridor, including 10 that were seen in New Jersey. Eight (80%) of those were in New Jersey between November and March, suggesting that most had moved south in response to winter weather conditions. No birds banded in the Hudson Valley region were ever seen out on Long Island, but one bird banded at Lake Meahagh (Westchester County) was reported at Oakwood Lake, about 58 km (36 mi) south in northeast Queens.

To further document seasonal movements and habitat use of mute swans, we attached satellite-tracked GPS transmitters to 18 adult birds (15 male, 3 female) at eight different locations during three spring-summer field seasons (Table 6). This was done in cooperation with staff from The Wildlife Trust (S. Elbin and F. Koontz), who had a research grant from U.S. Fish and Wildlife Service, and with staff from the New York City Department of Environmental Protection (C. Nadareski), who assisted at Muscoot Reservoir.

Table 6. Capture locations of mute swans fitted with satellite-tracked GPS transmitters.

Location	Region	2004	2006	2007
Rondout Creek	mid Hudson Valley	1	4	-
Lake Meahagh	lower Hudson Valley	-	2	-
Rockland Lake	lower Hudson Valley	-	2	-
Muscoot Reservoir	lower Hudson Valley	-	-	2
Nissequogue River	N shore - central LI	-	1	-
Stony Brook Harbor	N shore - central LI	-	2	-
Peconic River	Peconic Bay, eastern LI	-	-	3
Forge River	Moriches Bay, eastern LI	1	-	-

In all cases, swans were caught with a catch-pole on the water from a motorboat, or on land by baiting with food to the shore. All birds were marked with a numbered plastic neck collar and a USFWS leg band (as described earlier) in addition to a backpack satellite transmitter. We used several different transmitter models, but most were 70-gm solar-powered transmitters (Model PTT-100, Microwave Telemetry, Columbia, MD) that recorded GPS locations of the swans every hour for 9-12 months, with accuracy of 14.5 m east-west and 18.5 m north-south. Two swans tagged in 2004 had 150-gm battery-powered units. Each transmitter was attached to a bird with either a 9-mm Teflon ribbon (battery style) or a 3-mm (1/8") shock cord (solar-powered) backpack style harness. Individual swans were tracked for up to 12 months or until they stopped transmitting signals. When we were able to recover a radio from a dead swan or by recapturing a live radio-tagged swan a year later, we re-deployed radios the following year, in all but one case on a different bird.

We had mixed success with the satellite transmitters. We received essentially no data from two radios deployed in August 2006 and we suspect that both came off the birds soon after release, as both were seen alive many months later. Three more radios were out of service by December, so those provided no information on seasonal movements in response to winter weather conditions. One was a confirmed mortality, whereas fate of the other two was unknown. Six other radios transmitted location data into February, and four of those were confirmed dead soon after. We received data through the following spring (April or later) for only seven of the 18 birds tagged with satellite transmitters.

Movement data from the 13 swans whose radios transmitted into mid-winter was consistent with our neck-collar observation data. Nine swans, including all of the Long Island birds, were never located more than 20 km (12 mi) from their summer capture location. GPS location data revealed no overland movements in excess of 2 km (1.4 mi), and no swans were known to have moved between the north and south shore of Long Island or Peconic Bay. One swan banded on the Hudson River near Kingston moved about 80 km south to near Croton, where it remained on the river until the last transmission in February. Three other swans, all banded in the Hudson Valley (at Rondout, Rockland Lake and Lake Meahagh), moved south during winter 2007 to near Barnegat Bay on the central coast of New Jersey, and their movements followed open water all the way. One of those three died in New Jersey a month later, and the other two returned to New York in late March and late June, respectively. In contrast, none of the birds tagged in 2007 moved out of their banding region during winter 2008, when weather conditions were somewhat milder.

We were unable to use the satellite transmitter location data to assess habitat use as we had planned. The limited movements exhibited by tagged swans, the small number of birds that provided good location data, and lack of SAV maps for many areas all contributed to this outcome. However, location data for the swan that moved from Rondout Creek to Croton illustrated some of the challenges involved. During the last two weeks of September 2004, this swan remained close to its capture location south of Rondout Creek. Based on the SAV map for this area, most of the swan's locations were dominated by water chestnut (*Trapa natans*), despite the apparent presence of wild celery beds close by. We do not know if the maps were still accurate in 2004 and we do not know whether swans were feeding on the water chestnut or other plants that may have existed there. After this swan moved south to Croton in late September, it was most often located in a tidal cove where SAV beds were known to be present but not mapped. When this swan was on the main river channel, about half of the locations were over SAV beds and half were over un-vegetated bottom or deeper water. Until more extensive and current maps of SAV are available, more labor intensive field work would be necessary to classify location data for satellite-tagged swans. This was beyond the scope of our project.

10.0 IMPACTS ON SUBMERGED AQUATIC VEGETATION (SAV)

Many studies have shown that foraging and uprooting by mute swans can reduce the density or biomass of SAV beds that are important for many native fish and wildlife species by as much as 95% or more (Cobb and Harlan 1980, Conover and Kania 1994, Maryland DNR 2001, Allin and Husband 2003, Tatu et al. 2006). However, we wanted to document the extent to which this was occurring in New York, through field studies conducted in 2005. We selected four locations, including a freshwater site (north end of Irondequoit Bay in Rochester), two brackish water sites (mouth of Annsville Creek near Peekskill, and East Pond at Jamaica Bay in Queens), and a saltwater site (Forge River at Moriches Bay, Long Island). All four sites were chosen based on the presence of ≥ 20 swans throughout most of the year in 2004. We tried to avoid locations with territorial pairs of swans since their effects on vegetation were expected to be much less than those of congregations of molting mute swans during the summer growing season.

Despite our plans, field studies were completed at only two of the four sites we selected (Jamaica Bay and Irondequoit Bay). At the Hudson River site, we discovered that the sampling area (selected by the constant presence of swans during earlier visits) was virtually devoid of vegetation, even inside the exclosures, and swans did not utilize the area during the study period. The Forge River site was set up and sampled initially, but a phenomenon occurred during June 2005 that affected water quality and vegetation throughout the area. During this period, the water took on a milky appearance and a strong, foul odor was detected. Water quality testing found the water to be anoxic with coliform bacteria levels typical of stressed waters. Aquatic vegetation died back and a number of dead crabs and fishes were observed. We decided not to sample vegetation after that point, and other DEC staff planned to investigate the cause of this phenomenon.

Physical exclosures were used to determine the impact of mute swans on SAV in the two remaining study areas. The exclosures were floating 1.8-m x 1.8-m x 0.6-m tall (6-ft x 6-ft x 2-ft) frames constructed of 1.9-cm (0.75-in) diameter PVC piping and covered on all sides with 3.8-cm^2 (1.5-in^2) mesh polyurethane deer fencing (Fig. 7).

Exclosures were fenced on all sides but not on top to minimize any shading effect on plant growth. Floatation was achieved by attaching Styrofoam pool noodles to opposite sides on the bottom of each exclosure. Four 3.4-m (11-ft) plastic coated, aluminum garden stakes were placed at the corners of each exclosure to hold them in place. The aluminum stakes were placed on the inside of the exclosure, allowing it to move up and down with changing water levels. Stakes were driven approximately 1 m into the substrate to ensure stability.

Within each exclosure, a 1.2-m x 1.2-m (4-ft x 4-ft) sampling grid, comprised of 64 15-cm^2 sampling blocks was used to sample vegetation. A portable sampling frame was constructed of wood (3.2 cm x 3.2 cm x 1.2 m or 1.25 in x 1.25 in x 4 ft). Aluminum wire was strung across the frame at 15-cm intervals to create a grid pattern with 64 potential sampling locations. The sampling grid was placed in the center of each exclosure, attached to two opposite exclosure stakes with chains of a set length, creating a 0.3-m (1-ft) buffer between the grid and the sides of the exclosure (Fig. 8). The buffer served to eliminate any impacts of swans feeding around the perimeter or disturbance by personnel sampling from outside the exclosure.

Figure 7. A typical exclosure used to document impacts of mute swans on submerged aquatic vegetation at Irondequoit Bay, New York.

Figure 8. K. Clarke preparing to collect SAV samples from a swan exclosure at Jamaica Bay, July 2005.

Each study site hosted four exclosures and four "control" plots. All exclosures and control plots were located in waters 0.5-1.0-m deep (at mean low tide, where applicable). Exclosures were randomly located by selecting points from a 200-m x 200-m grid pattern covering each study area. Each exclosure had a corresponding control plot located approximately 30 m in a random direction, marked with a single garden stake. Sampling of control plots was similar to sampling inside the exclosures, with placement of one corner of the sampling frame 2 m from the control stake, and the opposite corner attached to a second garden stake located due south of the control stake. This process was repeated for each control plot, each time they were sampled, to ensure that locations of the control plots was as consistent as possible without erecting any structure that might affect foraging by swans.

Exclosures and control plots were to be established in May 2005 and sampled three times each from June-September (approximately once per month). During each sampling period, four blocks in each exclosure and control plot were sampled, providing a total of 32 samples (16 exclosure samples and 16 control samples) from each site per visit. The exception to this was during July sampling at Jamaica Bay, when only three sites were sampled ($n = 24$). The other site was not sampled because the exclosure and control point were located in the territory of a breeding swan pair that excluded all other swans from the area. The exclosure and control point were moved at that time to a nearby location outside the territory of the breeding swans.

For each block sampled, a plastic sampling tube (15-cm x 15-cm x 50-cm tall) was lowered vertically onto the substrate, and all rooted vegetation within the tube was removed by hand, placed in a mesh laundry bag and allowed to drain. Each sample was then transferred to a small brown paper bag and oven dried at approximately 43^{o} C for ≥ 72 hrs. Once dried, the samples were weighed in the bags with a digital scale and dry weights were recorded to the nearest 0.01 g. Mean dry weights of dried vegetation masses were calculated for exclosures and controls. Samples of vegetation were also collected and pressed from each site for species identification, but species composition of SAV collected was not determined or available for this report.

A total of 184 SAV samples (92 from exclosures, 92 from control plots) were collected during the 2005 field season. The Irondequoit Bay site had no rooted aquatic vegetation visible when sampling plots were set up in May. In all subsequent visits (June, July, September) exclosures contained significantly more SAV than controls (Table 7). The Jamaica Bay site was set up on July 7, after the growing season had begun. However, preliminary SAV sampling at the time of setup (including the plot pair relocated away from a breeding pair) suggested that there was no difference in mean vegetation masses between the exclosures and controls (Table 7).

In our study, areas exposed to swan foraging had 70-80% less biomass of SAV compared to the exclosures (Table 7) after less than one full growing season. However, longer term studies would be needed to measure the full impact of mute swan foraging, since areas that were heavily denuded by swans in prior years may have had too little time (or seed source) to revegetate to their full potential. The ecological impact of SAV removal by mute swans, which are year-round residents of most areas, is likely greater than that of migratory waterfowl that are not present during the growing season (Badzinski et al. 2006).

Table 7. Mean (SE) dry weights in g of submerged aquatic vegetation (SAV) collected from mute swan exclosures and control plots at two study areas in New York, 2005.

Area / Sample date	n	Exclosures	Control plots	% difference
Irondequoit Bay				
April 29 (set up)	na	na	na	na
June 30	16	3.67 (1.04)	0.70 (0.33)	-81%
July 29	16	5.21 (0.56)	0.87 (0.23)	-83%
September 5	16	2.16 (0.36)	0.51 (0.17)	-76%
total	48	3.68 (0.44)	0.69 (0.14)	-81%
Jamaica Bay				
July 7 (set up)	16	2.76 (0.82)	3.24 (1.12)	+17%
August 5	12	3.36 (0.96)	0.99 (0.46)	-71%
September 21	16	0.20 (0.14) [1]	-0.22 (0.05)[1]	na[1]
total	28	1.56 (0.51)	0.30 (0.23)	na[1]

[1] Samples collected in September at Jamaica Bay had so little vegetation that mean weights from exclosures and control plots were within the measurement error for weights of sampling bags.

11.0 INTERACTIONS WITH OTHER WATERFOWL

Mute swans are known to behave aggressively towards other birds, especially other waterfowl during the nesting and brood-rearing periods (Kania and Smith 1986, Allin et al. 1987, Ciaranca et al. 1997). In extreme cases, mute swans may attack and kill ducklings, goslings or other small water birds (Stone and Marsters 1970, Virginia DGIF 2012). More often their aggression may simply displace or deter other birds from the swans' territories, preventing use of valuable or preferred wetland habitats by native species (Allin et al. 1987, Ciaranca et al. 1997). In other cases, there is little evidence that other waterfowl species are affected by or avoided areas near swans (Willey 1968, O'Brien and Askins 1985, Conover and Kania 1994, Gayet et al. 2011).

The extent of aggression by mute swans varies widely among individuals and the intensity varies seasonally. In general, only breeding (paired) adult swans are aggressive, especially male swans defending their nesting territories or cygnets. Interspecific aggression reaches a peak during the breeding and brood-rearing season, but territorial behavior can also occur in winter (Scott 1984).

Canada geese (*Branta canadensis*) are often a target of aggressive attacks by mute swans (Conover and Kania 1994). With this in mind, some people have released mute swan pairs or placed mute swan decoys onto ponds and lakes where local-nesting or "resident" Canada geese are a problem, with the hope that the geese would be deterred from using these areas. However, these tactics have not been proven to be effective at reducing nuisance goose problems.

Mute swans are not always aggressive towards other birds within their nesting territory, and some breeding pairs may allow other waterfowl to nest within a few meters of an active nest. Mallards (*Anas platyrhynchos*), wood ducks (*Aix sponsa*), geese, and in rare instances, other mute swans have been observed nesting in close proximity to active mute swan nests (Willey and Halla 1972, Conover and Kania 1994, Maryland DNR 2001).

In this study, we attempted to document the frequency and outcomes of aggressive behavior by mute swans towards native wetland birds. We recorded behavioral observations for breeding mute swans during systematic observation periods from late April to mid July 2005 and from late April to mid June 2006. Observations were initiated at random during the course of other field activities, to reduce the likelihood that any individual or pair was chosen to be observed based on the likelihood of aggression occurring. Observations were made from a distance and location that we believed would not affect behavior of the swans being monitored.

Only one breeding pair or individual swan was monitored during each observation period, and observation periods were initiated only when other waterfowl were present (i.e., within ~100 m of the swans being observed), including other breeding or non-breeding swans. Therefore, each observation period produced one or more "encounters" for analysis. For example, if there were both mallards and Canada geese present during an observation period, that was recorded as one encounter with Canada geese and one encounter with mallards. Other waterfowl were deemed present only when they could be seen in the area of the swans being observed without the use of binoculars. Observation periods ended when the other waterfowl left the vicinity of the breeding swans, when the swans being observed moved out of sight, or at least 20 minutes had elapsed.

Only chasing and physical attacks were recorded as aggressive behaviors. Each aggressive behavior noted within an observation period was recorded as a separate "aggressive event". For each aggressive event, we recorded duration (to nearest minute), targeted species, approximate distance to the target when aggression occurred, and response of the targeted birds. Thus, there could be multiple aggressive events within each encounter. When a swan continuously pursued a single individual or group of waterfowl for a period of time, it was recorded as a single event over that period of time. In addition to aggressive events, the total numbers and species of any other waterfowl present and their closest proximity to the swans being observed without the occurrence of aggression were recorded.

We completed 54 observation periods at 33 locations during the two breeding seasons (total = 1,560 min, range = 2−60 min, $\bar{x}$ = 29 min). We observed aggressive behavior by swans at 14 (42%) of the 33 locations where observations were made, despite spending an average of less than 30 min observing individual birds or breeding pairs. A total of 42 aggressive events (chases or attacks) were noted, with 15 events documented at one location. Canada geese were most often the target of aggressive behavior, with ducks and other mute swans targeted less often. However, the proportion of encounters that resulted in aggression was highest for other mute swans and Canada geese (75% and 68%, respectively), and much lower for mallards and wood ducks (14% and 0%, respectively) (Table 8).

Aggressive events usually caused the affected waterfowl to move away from the aggressive swans, but rarely caused birds to leave a water body entirely. We observed eight encounters with duck broods, but only one resulted in an aggressive response. As expected, there seemed to be great individual variation in response of mute swans to the presence of other waterfowl.

Table 8. Number of avian encounters with mute swans during 54 observation periods at 33 locations in New York during April - July, 2005 and 2006.

Species Encountered	Encounters	Aggressive	% Aggressive	Non-aggressive	Non-aggressive w/in 50 m
Mute Swan	4	3	75	1	1
Canada Goose	50	34	68	16	8
Mallard	21	3	14	18	13
Wood Duck	3	0	0	3	2
Egret	2	2	100	0	0
Total	80	42	53	38	24

Distances between swans and targets of aggressive behavior at the start of aggression were estimated for 20 of 22 aggressive events observed in 2005. Seven (35%) aggressive events were initiated with the targeted individuals ≥ 50 m away, six (30%) occurred with the targets 10-50 m away, and seven (35%) began with the targets <10 m away. Comparable data were not collected in 2006.

Despite the frequency of aggressive behavior observed, we may not have documented the full impact that mute swans may have on other waterfowl species. We recorded observations only when other waterfowl entered areas where mute swans had already established territories. Our observations began well after swans had established territories, so we had no way to know whether other waterfowl were avoiding areas occupied by mute swans, as there would be no encounters to observe. It seems unlikely that ducks would remain in an area where they were repeatedly chased or attacked by swans, and we would have expected ducks to be present at any habitat that was suitable for swans. Such avoidance could occur annually or have some lasting effect over a period of years. Geese may be more tolerant of such behaviors because of their larger body size or better defensive capabilities than ducks.

12. INTERACTIONS WITH OTHER BIRDS

Reports from two other states suggested that mute swans could adversely impact wetland birds other than waterfowl. In Maryland, a large molting flock of 600-1,000 mute swans caused abandonment of a colonial bird nesting colony in Chesapeake Bay; at least four species were affected, including least terns (*Sterna antillarum*) and black skimmers (*Rynchops niger*), both of which are state-threatened species. These birds nested on oyster shell bars and beaches that were used by swans as loafing sites (Therres and Brinker 2004). In Michigan, an increase in the mute swan population from two adults in 1980 to 100 in 1988 in a Lake St. Claire marsh corresponded with a sharp decline in numbers of breeding black terns (*Chlidonias niger)*, although the mechanism involved was unknown; the black tern is a species of conservation concern in North America (Shuford 1999).

The potential impact of mute swans on black terns was of concern to DEC because the latter is a State-listed endangered species in New York. Black terns nest primarily in marshes around Lake Ontario, and their numbers have declined significantly since the mid 1990s (I. Mazzochi, DEC, unpublished data). This decline occurred concurrent with the establishment and rapid growth of a feral mute swan population in the Lake Ontario region, and we were not aware of any locations where the two species co-existed.

Black terns nest in loose colonies on floating vegetation or other platforms, including artificial nesting platforms (Shealer et al. 2006). Breeding male mute swans will often construct a false nest, or loaf, on any available surface after the active nest is finished. To test the hypothesis that mute swans may interfere with nesting by black terns, we conducted an experiment using artificial nest platforms in two emergent marsh complexes connected to Lake Ontario.

In May 2006, we installed 20 tern nesting platforms at Braddock Bay in Monroe County. Thirty pairs of black terns nested in Monroe County (28 in the Braddock Bay area) in 1994, but almost none have nested there since 2001 (Table 9). The cause for this sudden decline is unknown, but mute swans began nesting in that area in the mid 1990s, and at least 17 pairs of mute swans nested in Monroe County (10 or more in Braddock Bay) during 2004-2006. Platforms were placed 15-215 m from active swan nests in early May, before the peak period of tern nesting.

Table 9. Number of black tern nesting pairs in two areas of New York State, 1991-2010, where nesting platforms were deployed in this study (source: I. Mazzochi, DEC, unpublished data).

	1991	1994	1998	2001	2004	2007	2010
Monroe County	16	30	16	2	0	0	0
Dexter Marsh	49	20	15	17	13	20	2

We also placed 20 tern nesting platforms in Dexter Marsh in Jefferson County. Dexter Marsh was considered a "control" site, since it had no mute swans nesting and an active nesting colony of black terns. Twenty pairs of black terns nested in Dexter Marsh in 1994, and numbers there have remained relatively stable at 13-20 per year through 2007 (Table 9). Since there were no swan nests in this area, we installed nest platforms in the vicinity of the known tern nesting area, primarily to confirm that terns would utilize them.

We visited the nest platforms at both areas bi-weekly through June, and again in early August, to document any use by black terns or mute swans. However, our results were inconclusive because DEC staff removed many of the swans nesting at Braddock Bay after we installed the platforms, and no black terns were ever observed in the area. We did observe one mute swan brood in the area, but they did not use or disturb the platforms. The adult male swan in this group had established a loafing site prior to the typical nesting season of black terns, so this may be why the platforms were not used by swans. At Dexter Marsh, two of the 20 platforms we installed were used by nesting black terns, but no mute swans were in the area. Thus it remains uncertain whether swans have contributed to the decline of black terns in New York, but further investigation is warranted.

13.0 CONFLICTS WITH HUMAN INTERESTS

In addition to potential impacts on native plants and wildlife, mute swans can conflict with human interests in other ways, including degradation of waters used for drinking, swimming or shellfishing, and direct threats to human health or safety (Willey and Halla 1972, Scott and the Wildfowl Trust 1972, Chasko 1986). The environmental effects of swans are not easily perceived by the general public, so complaints about these impacts are relatively uncommon. DEC staff typically receive less than a dozen calls per year from citizens who are either concerned about potential impacts of swans on other wildlife or who have experienced some sort of threatening encounter with one or more swans defending a territory. In many cases, one aggressive swan attacking people can generate numerous calls and letters to DEC, often followed by contentious public debate about what to do with the offending birds, and local media coverage of the situation.

Mute swans are large, conspicuous birds and have little fear of humans. They are easily observed by the public and offer a chance for people to come in close contact with wildlife. Swans are widely regarded as symbols of royalty and romance, dating back to their association with royalty in Great Britain (Scott and the Wildfowl Trust 1972, Kear 1990). As such, and because they are still relatively uncommon in most areas of New York, many people enjoy seeing these birds in local parks, marinas, waterfront properties, and nearby lakes, bays, and other natural areas. However, most people do not realize that mute swans are a non-native, invasive species, and most are not aware of the concerns that waterfowl managers have about free-ranging mute swan populations.

In some cases, mute swans can be very aggressive towards humans, as they can be towards other waterfowl, in defense of active nests or cygnets (Willey and Halla 1972). In spring, nesting mute swans can be very aggressive to humans who come too close to their territory. Such aggression typically involves swans rapidly approaching on the water or in flight, in a threatening attack on anyone who has entered a defended territory. Attacks on personal watercraft (e.g., jet skis) or non-motorized boats (e.g., canoes or kayaks), and intimidating approaches toward people on land (e.g., people fishing along shore or wherever people routinely feed swans), occur almost every year (Rhode Island DEM 2006, Animal People Online 2012). Aside from direct physical injuries, aggressive mute swans can affect human use of properties where people are excluded from nesting areas by swans defending their territories. These situations all pose potentially dangerous results, especially for small children, and as the mute swan population grows, so will the occurrence of these encounters.

Fecal coliform (bacterial) loading of surface waters from swan feces may be significant. Unlike Canada geese, which are 100 times more abundant than swans in New York, swans normally defecate in the water rather than on land, so their potential impacts on water quality occur with far less public awareness or outcry. Swans are about twice the size of resident Canada geese (i.e., approximately 20-25 pounds compared to 10-12 pounds, on average), so it is likely that a mute swan deposits substantially more fecal matter per bird than a Canada goose.

A study in Maryland found that tundra swans excreted almost 100 times more fecal coliform bacteria per bird than Canada geese (Hussong et al. 1979). If microbial loading from mute swans is similar to tundra swans, then a relatively small number of swans could contribute as much as 100 or more geese. Impacts of bacterial contamination as well as nutrient loading from swan feces are difficult to assess and sort out from other potential avian or anthropogenic sources. This impact may of particular concern when swans congregate in sensitive areas (e.g., water supplies, beaches, or shellfishing areas) (Maryland DNR 2001).

We tried to determine whether there was any association of fecal coliform bacteria levels with presence or abundance of mute swans. We did this by collecting water samples in various marine waters around Long Island during summer 2006 and noting the numbers of swans within about 200 m at the time of sampling. Where possible, we intentionally sampled locations where swans were present or absent, and no sampling was done within 48 hr after significant rainfall events. Water samples were examined by DEC's Bureau of Marine Resources microbiology laboratory to determine the "most probable number" of fecal coliform bacteria (FC MPN) per 100 ml. We collected up to seven samples from each of nine water bodies, with each sample location separated by at least 100 m. There was no clear correlation between individual sample results and number of swans at the sample location. However, there was a tendency for water bodies where the most swans were observed to have higher FC counts than water bodies where no swans were observed at the time of sampling (Table 10).

Table 10. Results of fecal coliform (FC, "most probable number" per 100 ml of water) sampling in various marine waters around Long Island, New York, summer 2006 and number of swans observed near sample locations.

Area	No. samples	$\bar{x}$ FC MPN	Range FC MPN	No. swans[1]
Moriches Bay	2	3	3	0
Reeves Bay	2	3	3 - 4	0
Seamans Creek	6	17	7 - 23	0
Forge River	5	19	3 - 43	0
Nissequogue River	6	103	9 - 240	0-17
Terrell River	6	137	9 - 460	0-190
Mt. Sinai Harbor	7	152	4 - 460	0-8
Peconic Bay	4	192	23 - 240	0-40
Mecox Bay	6	993	460 - 1100+	0-162

[1] No. swans is the range in number of swans observed within 200 m of each sample location.

New York State criteria for certified shellfish lands is a geometric mean FC MPN value of ≤ 14

MPN/100ml and an estimated 90th percentile MPN value of ≤ 49 FC MPN/100 ml, based on a minimum of 30 samples collected through a Systematic Random Sampling (SRS) strategy (per 6NYCRR Part 47 "Certification of Shellfish Lands" §47.3(a)(2)(iv)). If either of these values is exceeded, the area is generally classified as uncertified and closed to the harvest of shellfishing. Although our sampling did not follow the protocol for certification of shellfishing areas (e.g., the number of samples was insufficient), our results for all areas with mute swans present greatly exceeded the threshold values, whereas all areas without swans had FC levels near or below the thresholds for closure. This warrants further investigation where congregations of mute swans occur in certified shellfishing areas.

Despite these potential impacts, swans remain popular with the public. The news media often reflects this, publishing human interest stories about individual swans, their interactions with local people, or any discussion or proposal to manage these birds; often lacking is any distinction between free-ranging swans and those maintained in captivity (Appendix 1). During our study, we received >100 calls and emails reporting marked swan sightings, expressing concerns about effects of neck collars or failed nesting, and requesting further information about the research. To many people, these semi-domesticated birds offer an opportunity to observe and interact with wildlife. Supplemental feeding of mute swans and other waterfowl is common in New York, especially on Long Island, and management is often met with resistance.

14.0 MUTE SWAN MANAGEMENT IN NEW YORK

As noted earlier, mute swan management actions by DEC staff throughout this study were guided by a management policy developed in 1993. That policy authorized and encouraged mute swan population control efforts, especially by DFWMR staff, and it supported actions necessary to alleviate site-specific conflicts associated with these birds (DFWMR 1993).

Between 2005 and 2012, take of mute swan nests, eggs or adult birds occurred in most DEC regions, totaling more than 400 nests, nearly 2,500 eggs, and more than 500 adult swans or cygnets statewide (Tables 11 and 12). These totals include activities conducted by DEC and other cooperators such as USDA Wildlife Services; however, our data may be incomplete since annual activities were not routinely compiled after 2008. Eggs were typically punctured, oiled, or destroyed, and most take of adults was by shooting or hand capture and euthanasia.

The level of mute swan management that occurred during 2005-2012 likely helped slow the growth of mute swan populations in New York, but it was far less than would be needed to significantly reduce their overall numbers. Mute swans are long-lived birds, so many more adults would have to be removed from the population each year, combined with more extensive nest and egg destruction, to achieve a significant population reduction, as called for by the Atlantic Flyway management plan (AFC 2003). Removing breeding pairs during the nesting period would be useful because it would eliminate sexually mature adults and their potential offspring simultaneously. However, live capture and removal of large molting or winter congregations would be a much more efficient way to reduce the population and alleviate the most significant impacts quickly (Petrie and Francis 2003, Watola et al. 2003, Allin and Husband 2004, Hindman and Harvey 2004, Rhode Island DEM 2006, Ellis and Elphick 2007, Craves and Susko 2010, Meyer et al. 2012). In the absence of aggressive population management, mute swan numbers seem likely to increase in New York, as will the frequency and severity of conflicts caused by these birds.

Table 11. Management of mute swan nests and eggs in New York, by DEC Region, 2005 - 2012.

	Nests (Eggs)								
	2005	2006	2007	2008	2009	2010	2011	2012	Total
Region 1	-	-	4 (21)	12 (72)	13 (73)	18 (69)	22 (150)	18 (75)	87 (460)
Region 2	-	-	-	-	17 (108)	-	21 (87)	12 (67)	50 (262)
Region 3	3 (17)	7 (46)	14 (70)	29 (249)	10 (114)	3 (25)	11 (60)	4 (27)	81 (608)
Region 4	-	-	-	-	-	-	-	-	-
Region 5	-	-	-	-	-	-	-	-	-
Region 6	-	1 (8)	-	-	-	-	-	1 (2)	2 (10)
Region 7	-	-	-	-	-	-	-	4 (39)	4 (39)
Region 8	13 (82)	33 (136)	30 (192)	48 (204)	47 (340)	-	22 (71)	13 (91)	206 (1,116)
Region 9	-	-	-	-	-	-	-	-	-
TOTAL	**16 (99)**	**41 (190)**	**48 (283)**	**89 (525)**	**87 (635)**	**21 (94)**	**76 (368)**	**52 (301)**	**430 (2,495)**

Table 12. Reported take of mute swans in New York, by DEC Region, 2005 - 2012.

	Adults or Cygnets								
	2005	2006	2007	2008	2009	2010	2011	2012	Total
Region 1	-	1	2	4	43	40	15	20	125
Region 2	-	-	-	-	-	-	-	12	12
Region 3	-	4	-	3	4	-	-	9	20
Region 4	-	-	-	-	-	-	-	2	2
Region 5	-	-	-	7	-	-	-	1	8
Region 6	3	19	13	13	5	-	9	31	93
Region 7	-	-	-	-	-	-	-	1	1
Region 8	1	26	33	49	48	-	41	61	259
Region 9	-	-	-	-	-	-	-	-	-
TOTAL	**4**	**50**	**48**	**76**	**100**	**40**	**65**	**137**	**520**

15.0 SUMMARY AND CONCLUSIONS

In response to long-standing concerns about the potential impacts of free-ranging mute swans in New York, DEC collaborated with the New York Cooperative Wildlife Research Unit at Cornell

University to conduct field studies of these birds in three regions of the state (Long Island, Hudson Valley and Lake Ontario). Over a four-year period (2004-2007), we collected new data on population parameters (productivity, survival and movements), vegetation impacts, and interactions with other bird species. We present those findings along with other available data on distribution, abundance, legal status, conflicts and management activities in New York from before, during, and after the field studies were done.

The mute swan is a non-native, invasive species in New York State. A free-ranging, breeding population of mute swans became established here in the early 1900s and grew to more than 2,500 birds statewide. The current population estimate is approximately 2,200 birds, with roughly 1,600 on Long Island, 400 in the Hudson Valley, and 200 around Lake Ontario. In recent years, the free-ranging swan population seems to have stabilized on Long Island, has apparently declined in the Hudson Valley, while growing very rapidly around Lake Ontario.

Despite current trends, mute swans in New York have high reproductive potential and high annual survival rates, both of which could lead to significant population growth and range expansion in the future. This is especially true across much of upstate New York, where an abundance of water bodies and wetlands provides extensive unoccupied habitat that could be colonized by mute swans. Mute swans in New York exhibit little or no tendency to migrate, so their potential impacts on fish and wildlife resources occur throughout the year, unlike migratory waterfowl that congregate primarily during fall and winter, outside of SAV growing and wildlife breeding seasons. Non-migratory mute swans will also be at risk of starvation during harsh winters, or they may become dependent on supplemental feeding by the public, contrary to sound waterfowl management. Requests for rescue or rehabilitation of starving swans are likely to increase if free-ranging populations continue to grow.

Many prior studies have documented the potential impacts of mute swans on submerged aquatic vegetation (SAV), other wildlife, and human activities. Our findings were consistent with those of others, including: 1) a significant reduction in SAV in areas where mute swans congregate; 2) frequent agonistic interactions between mute swans and other waterfowl, but no direct evidence of swans killing or precluding use of suitable habitats by other species; 3) possible conflicts between mute swans and endangered water birds (i.e., black tern); 4) an association of high coliform bacterial counts with presence of mute swans; and 5) occasional threatening behavior towards humans by individual swans. Aggressiveness of mute swans varies widely among individuals and the impacts of territorial pairs are very different from those of large flocks.

DEC has directed relatively little effort to control mute swans in New York since a management policy was adopted in 1993, and much more effort is needed to significantly reduce the free-ranging populations. From a biological perspective, mute swans can be relatively easy to manage, but from a sociological perspective, management is often controversial. Outreach based on this report and other studies should be used to inform policy makers and other stakeholders interested in the management of this species.

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