Appendix J

Malcolm Grant 2011/USFWS

Fencing exclosure to protect shorebirds from predators

Predator and Competitor Management Plan for Monomoy National Wildlife Refuge

Background and Introduction

Throughout North America, the presence of a single mammalian predator (e.g., coyote, skunk, and raccoon) or avian predator (e.g., great horned owl, black-crowned night-heron) at a nesting site can result in adult bird mortality, decrease or prevent reproductive success of nesting birds, or cause birds to abandon a nesting site entirely (Butchko and Small 1992, Kress and Hall 2004, Hall and Kress 2008, Nisbet and Welton 1984, USDA 2011). Depredation events and competition with other species for nesting space in one year can also limit the distribution and abundance of breeding birds in following years (USDA 2011, Nisbet 1975). Predator and competitor management on Monomoy refuge is essential to promoting and protecting rare and endangered beach nesting birds at this site, and has been incorporated into annual management plans for several decades. In 2000, the Service extended the *Monomoy National Wildlife Refuge Nesting Season Operating Procedure, Monitoring Protocols, and Competitor/Predator Management Plan, 1998-2000*, which was expiring, with the intent to revise and update the plan as part of the CCP process. This appendix fulfills that intent.

As presented in chapter 3, all proposed alternatives include an active and adaptive predator and competitor management program, but our preferred alternative is most inclusive and will provide the greatest level of protection and benefit for all species of conservation concern. The option to discontinue the management program was considered but eliminated due to the affirmative responsibility the Service has to protect federally listed threatened and endangered species and migratory birds. The rationale sections in alternative A, objectives 1.1 to 1.4, include information about the importance of predator management to promote nesting tern species (including federally listed roseate terns), piping plovers, and American oystercatchers. Discontinuing the predator management program would prevent us from meeting our productivity objectives for these and other high priority bird species.

Regardless of the alternative chosen, monitoring programs accompany all predator and competitor management actions; monitoring helps us evaluate the success of the management actions in meeting our objectives. The lessons we learn annually, and daily, are continually used to help us refine our future management efforts. We strive to use non-lethal methods of predator and competitor management whenever it is feasible and effective. Non-lethal methods at Monomoy refuge include, but are not limited to, predator exclosures (to protect piping plover nests from avian and mammalian predators), electric fences (to protect piping plover, least tern, and American oystercatcher nests from mammalian predators), human disturbance (to prevent gulls from nesting in tern habitat), and prescribed burning and herbicide application to improve habitat conditions for terns and deter competing laughing gulls. Often, non-lethal methods alone are not sufficient to reduce predation and competition, and lethal methods are necessary.

Although predation and competition can have a tremendous effect on beach-nesting birds, we recognize that changes in bird abundance, distribution, and reproductive success are often influenced by several other variables, including daily weather patterns, food resources, seasonal storm events, and human disturbance. We strive to manage the variables that are within our control (predator and competitor species, human disturbance) to help offset negative impacts of variables that are outside our control (weather, food resources). Monitoring programs are important, but even with careful monitoring it is sometimes difficult to make cause-effect connections between predator and competitor management efforts, and the birds' response. The collective effect of several influential variables, in addition to a lag effect of some variables, e.g., predation pressure this year can affect bird distribution in the following year, can prevent us from identifying the effect of any one variable in a given year.

However, there is a general inverse correlation on Monomoy refuge between the number of predators removed in a given year and the productivity of beach-nesting birds in that year. For example, in both 2007 and 2009, higher numbers of black-crowned night-herons, gulls, and coyote were lethally removed from the island, indicating these years were characterized by extreme predator pressure. In both years, piping plover and common tern productivity were below the threshold needed to maintain these populations and meet our biological objectives. Based on our experience and knowledge of the refuge and wildlife interactions, we believe piping plover and common tern productivity would have been lower had these predators not been removed.

The predator and competitor species discussed in this plan include all species that were addressed in the original plan, additional species that have since become prevalent on Monomoy refuge, and species that may become prevalent in the future. However, we recognize that additional species that we have not considered here may

be influential predator or competitor species in the future and may result in additional analysis to determine if management is warranted. In this appendix, we provide information about each predator and competitor species, including a summary of their population status, impacts to birds of conservation concern, proposed management techniques (lethal and non-lethal) for our most inclusive alternative presented in chapter 3 (proposed alternative), and impacts of management to targeted species. We encourage the reader to read the rationale sections in chapter 3, which additionally provide information about the role that predator and competitor species have played in limiting beach-nesting birds of conservation concern. A thorough analysis on the impacts of predator management to all avian and mammalian target predators included in this appendix has been previously discussed in an environmental assessment prepared by U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA APHIS), Wildlife Services, in March 2011. The environmental assessment was completed in cooperation with the U.S. Fish and Wildlife Service. We encourage the reader to review this document for more detailed information, and have noted throughout this appendix relevant page numbers in that document.

Species-specific Predator and Competitor Management

1. Eastern Coyote

Population Status:
Eastern coyotes were first documented in New England in the 1930s (Richens and Hugie 1974) and in western Massachusetts in the late 1950s (Pringle 1960). They are thought to have expanded to Cape Cod by the late 1970s (Way 2002).

Eastern coyotes are now well established throughout most of Massachusetts (except Nantucket and Martha's Vineyard) and the State's population has likely been stable at about 10,000 animals since the mid-2000s. When individuals die or are lethally removed, territories are quickly filled with new generations of coyotes. The territories can be taken over by transients, i.e., individuals that do not currently maintain a territory, or by a member of the family group. Eastern coyotes are classified as a furbearer species in Massachusetts with an established hunting season. The total number of eastern coyotes harvested Statewide, and from within the southeast district (which includes Cape Cod and the islands) is in table J.1. Beginning with the 2007/2008 hunting season, the Massachusetts Division of Fisheries and Wildlife expanded the eastern coyote hunting season by 5 weeks, and the number of eastern coyotes harvested more than doubled from the 2006/2007 season. The increase in harvest numbers reported in this year may also be attributed to the increase in check stations throughout the State in 2007/2008. The number of check stations has remained stable since the initial increase in 2007/2008. Harvest has been stable between 400 to 500 coyotes (with the exception of 09/10) for the last 5 seasons. Since the 2006/2007 season, the number of eastern coyotes harvested annually from the southeast district (which includes Cape Cod and the islands) has numbered more than 100, and it is likely that the number of eastern coyotes on Cape Cod has also stabilized since the mid-2000s (Hajduk-Conlee, personal communication 2013).

Table J.1. Eastern Coyote Harvests in Massachusetts 2002 to 2013.

Hunting Season	Total # Eastern Coyotes Harvested State-wide	# Eastern Coyotes Harvested in Southeast District (% of Total)
2002 / 2003	85	19 (22%)
2003 / 2004	176	57 (32%)
2004 / 2005	190	60 (32%)
2005 / 2006	188	79 (42%)
2006 / 2007	242	103 (42%)
2007 / 2008	532	203 (38%)
2008 / 2009	513	167 (33%)
2009 / 2010	599	164 (27%)
2010 / 2011	489	174 (36%)
2011 / 2012	449	117 (26%)
2012 / 2013	470	115 (24%)

Eastern coyote tracks were first observed on Monomoy refuge on South Monomoy Island in 1996. In 1997, 3 sets of tracks were documented together, suggesting the presence of more than one individual. One dead eastern coyote was found on the west shore of South Monomoy Island in July in 1997, and in 1998 eastern coyotes were confirmed to be denning on South Monomoy Island. Since that time, eastern coyotes have denned on the refuge nearly every year. Eastern coyote presence on the island increased in the mid-2000s and has remained high since then. One reason for the increased number of eastern coyotes on the refuge, beginning in 2005, was the proximity of neighboring South Beach. Due to cyclic movement of sand in the area, the tip of South Beach extended closer to the north end of South Monomoy in 2005. At that time, the crossing was only several hundred yards wide and easy for eastern coyotes to navigate. An eastern coyote was observed exiting the channel from South Beach to South Monomoy Island in 2005 by refuge staff, and on several occasions eastern coyote tracks were seen leading to the water's edge on both South Beach (Jedrey, personal communication 2013) and South Monomoy Island, indicating regular movement across this channel. As the flats surrounding the Monomoy Islands continued to expand, crossings also become possible at several additional locations during low tide. Eastern coyotes were seen crossing from North Monomoy Island to the north tip of South Monomoy Island on several occasions, and tracks seen throughout the season indicated that crossings occurred regularly between the two islands in 2005. Eastern coyotes were also likely crossing from Morris Island to North Monomoy Island at that time. By the fall of 2006, the channel between the tip of South Beach and South Monomoy Island filled in and formed a land bridge connecting South Monomoy to the mainland, providing easy access for eastern coyotes. This land bridge formation is still intact, but in February 2013 a blizzard caused a new break in South Beach approximately 3 miles north of the land bridge, effectively separating South Monomoy from the mainland once again. During the 2013 nesting season, we observed less coyote activity on South Monomoy as a result of this break. The sediment in and around this new channel is continually shifting and the break is not likely to be permanent. Although the width of the channel can be ¼ mile wide at high tide, one storm could cause the break to abruptly fill in and reconnect South Monomoy to the mainland, or it could gradually fill back in and cause a reconnection.

Impacts to Birds of Conservation Concern:
Coyotes have been widely documented as predators on least terns (Butchko and Small 1992, Krogh and Schweitzer 1999, Adrean and Jedrey 2007), piping plovers (Adrean and Jedrey 2007), common terns (USDA 2011, Kress and Hall 2004), and American oystercatchers (Schulte et al. 2010). Management has been implemented at many sites (USDA 2011, Butchko and Small 1992, Bent and Taygan 2010). On Monomoy refuge, eastern coyotes have been documented preying on all ground-nesting birds, including least and common terns, piping plovers, American oystercatchers, gulls, and waterfowl, as well as seals and other non-focal species such as Canada goose and voles. Eastern coyote presence on Cape Cod and southeastern Massachusetts nesting sites is frequent and has increased in the last 10 to 15 years (Adrean and Jedrey 2007, USDA 2011, Monomoy field season reports, Bent and Taygan 2010).

Coyotes are problematic to nesting birds for several reasons. They are nocturnal and easily move from nest to nest in dense nesting colonies, preying on eggs, chicks, and incubating adults. In addition to direct predation, eastern coyote presence in the colony at night elicits defense-attack responses by adult terns, leaving chicks vulnerable to other opportunistic predators and inclement weather (particularly cold and rain). When eastern coyotes successfully den, adults are motivated to hunt more to provide food for their pups. When pups are old enough to travel from the denning site, adults may take pups into nesting colonies to teach them how to hunt and kill. Therefore, in years when eastern coyotes successfully raise pups, there is likely to be greater loss at nearby nesting sites.

Eastern coyotes have been the most prevalent mammalian predator on the refuge during the last 12 years, and in most years refuge staff document them depredating on terns, piping plovers, and American oystercatchers. The extent of depredation varies from year to year, however, the result in some years is significant nest loss and lowered productivity. For example, in 2002 and 2009, consistent eastern coyote depredation resulted in extensive nest loss and lowered reproductive success to nesting common terns (USFWS 2003, USFWS 2012). In most years since 1998, eastern coyotes also attempted to den on the refuge (USFWS annual field season activities reports from 1998 to present) and adult eastern coyotes have taken mobile pups hunting in the tern colony (Koch 2012 personal observation). Similarly, although not quantitatively monitored, eastern coyotes frequently prey on least tern eggs and chicks, and in some years, eastern coyote tracks are regularly seen traversing least tern nesting areas (USFWS 2012a). Eastern coyotes have been effective predators on piping plovers as well, and

were responsible for predating four plover nests (of nine lost nests for which cause of loss could be identified) in 2009 (USFWS 2012) and at least nine plover nests (the most common known cause of nest loss) in 2011 (USFWS unpublished data). Quantifying the total loss of productivity from eastern coyotes can be difficult because often no evidence of take is left behind; therefore, the observed loss is generally an underestimate of the actual loss. Coyote stomach dissection gives a general sense, however, of how catastrophic eastern coyotes can be to productivity on Monomoy refuge. For example, an eastern coyote stomach collected in 2006 contained 69 common tern chicks, likely representing one night of feeding (USFWS unpublished data.). In 2009, two coyote stomachs collectively contained 75 common tern chicks (USFWS 2012). Similarly, stomach dissection of an eastern coyote removed from another nesting site in Massachusetts in June 2010 revealed 3.4 pounds of tern chicks, which equates to 50 to 100 chicks taken in one night of hunting (USDA 2011). Eastern coyotes can frequent the tern colony dozens of nights in a season, and the number of chicks lost can quickly add up (USFWS field season reports 2001 to current).

In general, productivity of piping plovers and common terns has decreased over time, as more eastern coyotes have been observed in and around the nesting areas (USFWS field season reports). In most years, the number of eastern coyotes lethally removed from the refuge is generally positively correlated with the degree of predator pressure (table J.2); the higher the predator pressure, the lower the productivity. Therefore, it is likely if eastern coyotes were not removed from the refuge in these years, productivity would have been further suppressed.

In addition to the impact coyotes have on nesting piping plovers, American oystercatchers, and terns, they may be responsible for the precipitous decline in nesting herring and great black-backed gulls on South Monomoy in recent years. Chapter 2 contains details of nest counts of herring and great black-backed gulls through the 1900s. In recent years, complete counts of nesting gulls have been conducted on North Monomoy Island in 2000 and 2007. South Monomoy was surveyed using aerial photography in 2000, and was surveyed using a stratified random-sample transect method in 2007. In 2000, 1,609 herring gull nests and 1,018 great black-backedgull nests were counted on North Monomoy Island, but the aerial photography for South Monomoy was never full analyzed (Koch, personal communication 2013). In 2007, 1,245 herring gull nests and 683 great black-backed gull nests were counted on North Monomoy Island (USFWS 2009b), and 1,088 herring gull nests and 2,490 great black-backed gull nests were estimated on South Monomoy (Koch, personal communication 2013), for a total refugewide count of 2,333 herring gull nests and 3,173 great black-backed gull nests. In 2013, a gull census was conducted on both North Monomoy Island and South Monomoy, using the same methodology as in 2007. Data compilation is still ongoing but preliminary numbers for North Monomoy Island are 1,180 herring gull nests and 995 great black-backed gull nests. On South Monomoy, no herring gull nests were observed on transects, and the total number of great black-backed gull nests islandwide likely numbered less than 100 (Iaquinto, personal communication 2013). This sharp decline in nesting gulls on South Monomoy did not occur on North Monomoy Island, suggesting the cause was specific to South Monomoy. It also coincides with the connection of South Monomoy to South Beach, and increased presence of coyotes on South Monomoy. Evidence of coyotes preying on herring and great black-backed gulls on Monomoy refuge has been frequently observed, but not systematically documented (Koch and Iaquinto, personal communication 2013).

Current and Future Management Techniques:
The refuge employs a variety of non-lethal and lethal techniques to minimize eastern coyote depredation. Non-lethal techniques are only effective in some circumstances, and include the use of electric fencing (to protect least tern, American oystercatcher, and piping plover eggs) and individual nest exclosures (to protect piping plover eggs). These methods can also be effective in deterring other predators, and are explained in more detail in the Non-lethal Methods Common to Many Predators section of this plan.

Beginning in 1998, focused lethal eastern coyote management has been conducted annually to prevent establishment on the refuge and minimize depredation on nesting birds. We have adopted a zero tolerance policy for eastern coyotes on South Monomoy and North Monomoy Islands during the nesting season because of the impact they can have on nesting birds. Service staff or contractors shoot eastern coyotes that are present on South Monomoy or North Monomoy Island from April through August. They are not managed in other months of the year because they don't present a threat to refuge resources outside the bird nesting season. Eastern coyotes may be shot while opportunistically observed traversing the refuge, or located with the use of dogs trained

specifically to hunt coyotes. Efforts to remove eastern coyotes are especially important in the early spring to increase the chances that adults do not raise young successfully on the refuge. Any young that are found during the bird nesting season are also shot.

A total of 189 eastern coyotes (adults and pups) have been lethally removed (mostly from South Monomoy, except pups in 2009) between 1998 and 2012 as part of the predator management program (table J.2).

Table J.2. Annual Eastern Coyote Management and Bird Productivity on Monomoy NWR (1998 to 2012).

Year	# Adult Eastern Coyotes Removed	# Pups Removed	Total Piping Plover Nests Lost (% of Total Lost to Known Causes) to Eastern Coyotes	Total American Oystercatcher Nests Lost (% of Total Lost to Known Causes) to Eastern Coyotes	Common Tern Productivity
1996	0	0	0	0	1.50
1997	0	0	0	0	1.70
1998	1 female	0*	2 (15%)	No data	1.83
1999	1 female	0*	0	No data	1.61
2000	2 males	8	0	No data	1.85
2001	1 unknown	12	0	No data	1.20
2002	0	10	3 (12%)	1 (25%)	0.70
2003	4 females, 2 males	0	5 (19%)	9 (26%)	1.26
2004	11 females, 6 males	3	7 (41%)	7 (30%)	1.59
2005	1 female, 4 males	0	0	7 (18%)	1.41
2006	2 females, 6 males, 1 unknown	0	3 (33%)	2 (20%)	0.96
2007	5 females, 10 males	4	4 (44%)	5 (45%)	0.70
2008	7 females, 12 males	0	4 (18%)	4 (24%)	1.12
2009	9 females, 16 males, 1 unknown	4	4 (44%)	4 (44%)	0.35
2010	5 females, 6 males, 1 unknown	7	0 (0%)	5 (50%)	1.25
2011	3 females, 7 males, 1 unknown	2	10 (71%)	5 (36%)	1.28
2012	2 females, 5 males	7	8 (33%)	2 (12%)	1.38
Total	132	57			

**Although no pups were removed in these years, coyotes were confirmed to have pups on South Monomoy Island.*

In most years, even with an adaptive management approach, we are not able to remove all coyotes. Our level of success at removing coyotes varies depending on weather, funding, and availability of experienced personnel.

Impacts of Management to Eastern Coyote Population:
Given the Statewide estimated population of 10,000 eastern coyotes and the likely population stabilization since the mid-2000s (Hajduk-Conlee, personal communication 2013), it is not likely that the removal of 189 adults from Monomoy refuge in the last 15 years is impacting the local population any more than the annual hunting pressures. Between 2002 and 2012, 3,463 eastern coyotes have been harvested in Massachusetts through the regulated harvest seasons. During this timeframe, 164 eastern coyotes were lethally removed from Monomoy refuge, representing less than 5 percent of the total State harvest. Additionally, the maximum removed in any one year was 30 coyotes (2009); this represents 0.3 percent of the total eastern coyote population. Therefore, lethal removal on Monomoy refuge is not impacting the overall State population.

It is possible that more eastern coyotes will be removed from Monomoy refuge annually in future years. Even if 50 eastern coyotes are removed in a given year, it is still less than 1 percent of the State's population. The fact that the State has not set a limit on the number of eastern coyotes that may be taken during the State-regulated harvest seasons additionally suggests that the species is not at risk for overharvesting (USDA 2011).

2. Other Mammalian Predators Including Gray Fox, Red Fox, Virginia Opossum, Raccoon, Red Fox, Striped Skunk, Long-tailed Weasel, Short-tailed Weasel, River Otter, Mink, and Fisher

Population Status:
There are no population estimates for furbearer species (other than coyotes) in Massachusetts, but all populations are considered to be stable. The Massachusetts Division of Fisheries and Game establishes harvest seasons for red fox, gray fox, opossum, raccoon, striped skunk, weasels, mink, and river otter. Harvested gray fox, red fox, mink, and river otter are required to be reported to a check station so the State has harvest information for all animals that were taken by permit or salvage (road kill). Total harvests for the last 3 seasons are listed in table J.3 below.

Table J.3. Harvest Information for Furbearer Species in Massachusetts from 2010 to 2013.

	Gray Fox	Red Fox	Virginia Opossum	Raccoon	Striped Skunk	Weasels	River Otter	Mink
2010/2011	49	55	74	237	12	6	79	35
2011/2012	38	42	43	287	15	9	88	38
2012/2013	57	47	not yet compiled	not yet compiled	not yet compiled	not yet compiled	156	50

Impacts to Birds of Conservation Concern:
Small mammals can be a risk to beach nesting adult birds as well as their chicks and eggs (USDA 2011, Kress and Hall 2004, USFWS 1988, USFWS 1996). All the refuge focal bird species are potentially at risk from small mammal predation. Many small mammals, including opossum, are opportunistic feeders, and eggs are considered a basic part of their omnivorous diet (Burt 1976). Mammals are also often active during the night when they are less visible to incubating adults. Given their powerful sense of smell, small mammals can find nests in the dark and often take out a series of nests in one night.

It is possible that as South Monomoy grows due to sand deposition, mammalian predator populations on the island may also increase. Access to the island had become easier for land- based mammalian predators since the connection to South Beach in November 2006 and an increase had been seen in mammal activity on South Monomoy. However, the recent separation of South Beach from the mainland (refer to the Eastern Coyote section) may help reduce mammalian predation pressures on Monomoy refuge.

When the island first became isolated from the mainland, the Service removed red fox. Mammal sightings were rare through the 1980s (long-tailed weasel in 1983, Norway rats in 1985, raccoon in 1986). Red fox, Virginia opossum, raccoon, striped skunk, and river otter have all been periodically noted on the refuge since 2000. A red fox washed up on the north tip of South Monomoy in 2007, but evidence of live red fox on the island has not been documented in recent years. Virginia opossums were seen or confirmed as present most years between 2007 and 2012, though predation on beach-nesting birds was only confirmed in 2008 and 2009. In 2008, nine adult Virginia opossums were lethally removed, including four females with young. The stomachs of two of the opossums removed contained eggshells (USFWS 2009c). In 2009, one Virginia opossum was lethally removed from the tern colony. Its stomach contained eggshells and yolk. Three additional animals were found dead during this year (USFWS 2012). Raccoons were first seen on the island in recent years in 2005 when a dead animal washed up. A second animal was lethally removed this year (USFWS 2009a). From 2007 to 2009, four more animals washed up dead on the refuge but evidence of live animals (tracks) weren't documented again until 2010 and 2011 (USFWS 2009b, USFWS 2009c, USWFS 2012, USFWS unpublished data). Tracks and a raccoon carcass were observed on South Beach near the South Monomoy connection in 2012 (Iaquinto, personal communication 2013). Striped skunks were first seen on the refuge in 2000, and one animal was lethally removed. In 2001, a striped skunk was

shot and removed from the refuge. In 2011 skunk tracks were seen near the lighthouse, but no predation was observed (USFWS unpublished data). Evidence of river otter (mostly tracks) has been documented in 2005, 2007, 2009, 2011 and 2012, (USFWS 2009a, USFWS 2009b, USFWS 2012, USFWS unpublished data) and although they are a suspected predator, this has not been confirmed. Lastly, in 2009 three predated common terns were examined by the National Wildlife Health Center. Puncture wounds on all three terns indicated a canine bite, and the spacing suggested the predator was mink, fisher, or river otter (Organ, personal communication 2011). Gray fox and long- and short-tailed weasels have not been documented on the refuge in recent years of monitoring.

Current and Future Management Techniques:
Since small mammals have not been prevalent predators on the refuge in most years, efforts to remove them have been infrequent and focused. Personnel are prepared to shoot small mammals when observed during night stints in the same manner as described for coyotes and black-crowned night-herons. Signs of depredation and presence in the tern colony and around beach nesting bird areas are recorded when observed.

Several non-lethal techniques are also effective at reducing small mammal depredation on eggs, including the use of electric fencing (to protect least tern, American oystercatcher, and piping plover eggs) and individual nest exclosures (to protect piping plover eggs). These methods can be effective at deterring several predators under some circumstances, and are explained in more detail in the non-lethal section of this plan.

Preparedness for managing mammalian predators will continue and mammalian predators will be removed when appropriate. We will also continue to document impacts from mammalian predators.

Impacts of Management to Target Mammalian Predators:
Although there are no current State population estimates for any furbearer species (other than coyotes) in Massachusetts, all are considered stable, and most do not have harvest limits during the harvest seasons, suggesting they are not at risk for overharvesting (USDA 2011). Since 2000, only two striped skunk, one raccoon, and ten adult Virginia opossums have been lethally removed from the refuge and this certainly has had no impact on the State's populations.

The environmental assessment prepared by USDA APHIS in 2011 includes an effects analysis of their management actions for all small mammal predators, including Virginia opossum (pages 50 and 51), red fox (pages 54 to 56), gray fox (pages 56 to 58), raccoons (pages 58 to 60), fisher (pages 60 and 61), short-tailed weasel (pages 61 and 62), long-tailed weasel (pages 62 and 63), mink (pages 63 and 64), and striped skunk (pages 64 to 66). Because population estimates are not available for these species, APHIS estimated conservative populations based on typical species densities and amount of available habitat. They calculated the maximum of each species that they would lethally take as part of their annual management actions, and calculated the percentage of the total population that maximum take represents. For fisher and mink, maximum lethal take was compared to recent harvest numbers, instead of an estimated statewide population. This is presented in table J.4.

Table J.4. Estimates of Predator Populations and Harvest (APHIS 2011).

	Virginia Opossum	Red Fox	Gray Fox	Raccoon	Fisher	Short-tailed Weasel	Long-tailed Weasel	Mink	Striped Skunk
Most Conservative Population Estimate*	5,100 to 79,200	10,200	12,200	7,900	1,707	20,580	17,640	149	32,500
Maximum Annual Take	50	50	50	50	50	50	50	15	50
Percent of Total Population**	0.1 to 1	0.5	0.4	0.6	11.7	0.3	0.3	10	0.2

** Total harvest from 2006 to 2009 for fisher and mink*
*** Percent of total harvest from 2006 to 2009 for fisher and mink*

Mammalian predator pressure may increase in future years, resulting in higher lethal take of mammals from the refuge. While we can't predict how many predators we are likely to remove, annual take will almost certainly be below the maximum annual take in the table above, and well below 1 percent of the total population.

3. Black-crowned Night-Heron

Population Status:
Throughout the Commonwealth of Massachusetts, colonies of nesting black-crowned night-herons have generally been declining and becoming more widely dispersed, although increases have been observed in some years. Black-crowned night-herons declined from an estimated 3,300 to 3,600 pairs in 1955 through the early 1970s. Although they increased to nearly 2,000 pairs in 1977 (Erwin 1978, Erwin and Korschgen 1979), only 973 pairs were counted during a coastwide survey in 1984 (Andrews 1990). Coastwide surveys were repeated from 1994 to 1995 and 2006 to 2008, and a 45 percent decline was documented between these two surveys, with only 781 pairs counted at 14 sites most recently (Melvin 2010a). Statewide surveys of black-crowned night-herons were conducted in 2013, but survey results have not yet been compiled.

The number of nesting black-crowned night-herons on Monomoy NWR increased from 12 pairs in 1980 to 200 pairs in 1987. In most years since 1996, when annual surveys were initiated, between 150 and 250 black-crowned night-herons have nested on Monomoy refuge (see table J.5). Monomoy NWR is an important nesting site in Massachusetts and was one of only 14 nesting sites in 2008, with about 20 percent of the State's nesting total (Melvin 2010a).

Impacts to Birds of Conservation Concern:
Black-crowned night-herons are also nocturnal predators and will prey on eggs and chicks, especially beginning in late June when tern chicks are hatching and many young chicks are present. Black-crowned night-herons may also teach their young to hunt in tern colonies and we often observe juvenile black-crowned night-herons feeding in the tern colony at Monomoy refuge (USFWS 2003a, 2009d, 2007a, 2007b). Night-heron predation has been documented at other tern nesting sites as well (Collins 1970, Hunter and Morris 1976, Kress and Hall 2004), and because individual night-herons are likely specialist predators, removing these specialized individuals can significantly improve tern productivity (Hall and Kress 2008).

Black-crowned night-herons were significant predators of tern eggs in 1982, 1984 (Fitch and Folger 1983, Fitch 1985), and 1985 to 1987 (Humphrey, personal communication as in USFWS 1988). For several years in the late 1970s and early 1980s, Massachusetts Audubon Society tern biologists and Service employees held State and Federal permits to shoot individual night-herons identified as tern predators.

In 1997, removal of predatory black-crowned night-herons resumed (table J.5) due to the impact they were having on the newly established tern colony. The extent of black-crowned night-heron presence in the tern colony has varied among years, but was most extensive in 2002, 2003, and 2004. During these years, black-crowned night-herons were present in the tern colony more than 20 nights each year (table J.5). This is probably an underestimate, as visibility was often limited by weather, failed night vision equipment, dense vegetation, and the overall size and expanse of the colony. Often more than one black-crowned night-heron was in the colony on one night (USFWS 2003, USFWS 2007a, USFWS 2007b). In 2002, four black-crowned night-herons were removed on one night (USFWS 2003). Extensive egg and chick loss was documented in 2002 to 2004 (table J.5); however, the numbers of eggs and chicks taken likely represents a minimum because terns may clear their nesting area of depredated egg shells before they are checked by staff, and chicks, especially the very young, are often eaten whole. Black-crowned night-herons were dissected after removal and tern chicks were often found in the digestive tracts, with a maximum of seven chicks found in one black-crowned night-heron (2004).

Table J.5. Black-crowned Night-Heron Predation and Removal in Monomoy NWR Tern Colony (1996 to 2012).

Year	Nights in the Tern Colony	Minimum Total Eggs and Chicks Depredated	Adults Removed	Juveniles Removed	Total Nesting Black-crowned Night-herons	% of Total Adult Birds Removed
1996	0	0	0	0	460	0
1997	9	0	4	0	450	0.9
1998	0	0	0	0	364	0
1999	11	9	0	0	386	0
2000	0	0	0	0	382	0
2001	0	0	0	0	414	0
2002	36	210	7	3	498	1.4
2003	30	254	3	1	482	0.6
2004	22	404	8	1	400	2.0
2005	11	10	2	0	334	0.6
2006	4	45	0	0	316	0
2007	9	169	1	1	278	0.4
2008	6	29	0	0	300	0
2009	10	117	3	0	216	1.4
2010	1	8	0	0	296	0
2011	3	12	0	0	no data	0
2012	1	21	0	0	326	0

In addition to predation on common tern chicks and eggs, black-crowned night-herons have been documented on Monomoy refuge depredating eggs of laughing gulls, black skimmers, and American oystercatchers (USFWS 2007b), as well as an American oystercatcher chick (USFWS 2009b).

Current and Future Management Techniques:
Black-crowned night-herons observed predating in the tern colony or on other beach nesting species of conservation concern will be shot. Black-crowned night-herons observed flying over the tern colony or walking near the tern colony and not disturbing terns are not considered predatory and are not targeted (Megyesi 1997). Black-crowned night-heron removal generally occurs from dusk to dawn. Total number of black-crowned night-herons removed annually is in table J.5. No management actions will be taken to discourage nesting black-crowned night-herons, with the exception of removal of woody vegetation that is on the perimeter or within the tern nesting colony.

Impacts of Management to Black-crowned Night-Heron Population:
We recognize the importance of maintaining nesting habitat and protecting black-crowned night-herons on Monomoy NWR, given the relative importance of this site and especially the likely future loss of additional sites due to sea level rise, shoreline erosion, and increasing pressure for development and human recreation. Table J.5 includes a tally of the black-crowned night-herons removed from the tern colony annually, the total number of nesting birds (pairs x 2), and the percentage of adult birds that were lethally removed. Even during the years of the most intense predator pressure and lethal removal, no more than 2 percent of the total of nesting adults was removed in any one given year, and this is unlikely to impact the local nesting population or the Statewide population. The decline in nesting black-crowned night-herons beginning in 2005 may be attributed to eastern coyote predation on South Monomoy; wading birds have shifted from nesting primarily on South Monomoy Island to nesting almost solely on North Monomoy Island. Eastern coyotes are frequently seen resting in the woody vegetation that had been used as nesting habitat by black-crowned night-herons (Iaquinto, personal communication).

4. Laughing Gull

Population Status:
The laughing gull is primarily a southern nesting species, though sporadic colonies have existed in the Northeast (Nisbet 1971). Laughing gulls are abundant throughout their breeding range with 202,646 breeding pairs (MANEM 2006). Similar to terns and other colonial nesting waterbird species, northern laughing gull populations were almost completely extirpated in the late 1800s by the millenary trade before coming under the protection of the Migratory Bird Treaty Act of 1918 (USFWS 2008, Veit and Petersen 1993). Nesting numbers in Massachusetts immediately began to increase following the passage of the Act reaching a peak in the 1940s (Nisbet 1971), especially on Muskeget Island where approximately 20,000 pairs nested. After reaching this peak, the laughing gull population slowly declined due to the direct competition with larger gulls that were also seeing population increases (Nisbet 1971). Laughing gulls on Muskeget Island were completely wiped out in June 1972 by Hurricane Agnes (Nisbet 1976). Laughing gulls, perhaps displaced from Muskeget, first colonized Monomoy refuge in 1971 and succeeded in establishing a colony adjacent to and within the tern colony at the northern-most tip of the refuge.

Laughing gull numbers rose steadily on the refuge during the 1970s to a peak of 1,000 pairs in 1981 (USFWS 1988), but then declined and eventually stopped nesting by the mid-1990s (USFWS 1996b). This was most likely the result of continued expansion of the herring and great black-backed gull populations, which encroached on tern and laughing gull nesting areas (USFWS 1996b, USFWS unpublished reports 1985 to 1994). As the decline on Monomoy began laughing gulls were reported to be nesting with terns (Melvin 2010) on New Island in Eastham by Hecker (956 pairs in 1990) (Veit and Petersen 1993). This colony collapsed in 2001 and 2002 as the natural westward migration of Nauset Spit created a landbridge that allowed mammalian predators easier access at low tide to the nesting area (Melvin 2010). This incident at New Island was similar to what was documented after the attachment of South Beach to South Monomoy Island in 2006 (see section 1.). With the collapse of the New Island colony, increased nest destruction to prevent large gulls from nesting on Monomoy, and the beginning of lethal removal of adult herring and great black-backed gulls that began in 1996 on the refuge, the Monomoy population of laughing gulls again increased and by 2002 had reached 1,106 pairs (USFWS 2003a). The numbers of pairs on the refuge continued to increase to a high of 1,498 pairs in 2007 (figure J.1) (USFWS 2009e). Between 2002 and 2007, Monomoy refuge was the only nesting site for laughing gulls in Massachusetts. Laughing gulls began nesting on Plymouth Beach in Plymouth in 2007, two years after nest destruction began on Monomoy, and have continued to nest there since (Mostello, personal communication 2009 to 2012; Kerin McCall, personal communication 2013). No management to prevent nesting of laughing gulls has been implemented on Plymouth Beach (McCall, personal communication 2013).

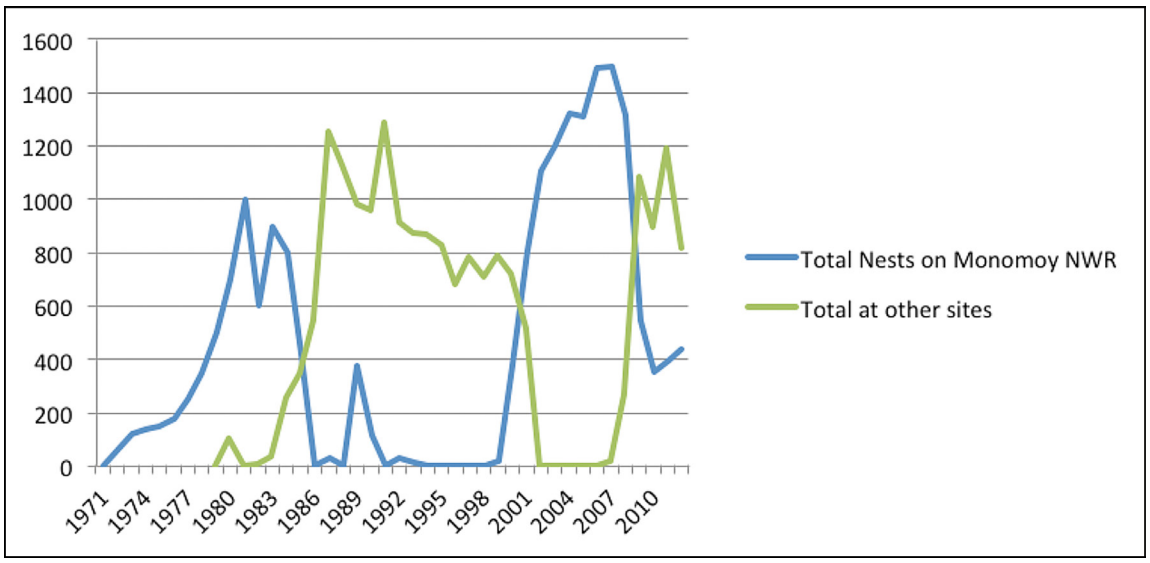

Figure J.1. Number of Nesting Laughing Gulls Counted on Monomoy National Wildlife Refuge vs. State of Massachusetts

The most recent compilation of the species as a whole in Birds of North America (Burger 1996) suggests that laughing gulls have steadily increased rangewide between 1966 and 1994.

Impacts to Birds of Conservation Concern:
The rapid increase in nesting laughing gulls on Monomoy refuge in the early 2000s resulted in direct competition with common and roseate terns for available nesting habitat, and increased rates of kleptoparasitism were documented. High densities of nesting laughing gulls within or on the immediate edge of the common tern colony increase the chances for interspecific interactions during the nesting season (harassment or direct predation). In addition, individual nesting laughing gulls that are pioneering nesting sites within the common tern colony are of concern because these pioneers may attract other prospecting laughing gulls to these areas (USFWS 2012). Laughing gulls have been documented preying on common tern chicks and eggs most years they have been present within the nesting colony on Monomoy. Eastern Egg Rock, Petit Manan Island, and Matinicus Rock in the Gulf of Maine have all reported that laughing gull predation on common, Arctic, and roseate tern eggs and chicks has directly reduced productivity rates in the terns (USFWS 2008). Documentation of this predation is likely underestimated since the events happen quickly and can be difficult to see within the dense vegetation in which laughing gulls nest.

In addition to displacing nesting terns by occupying their habitat and directly preying on tern eggs and chicks, laughing gulls frequently steal fish from terns returning to the colony from feeding; this is referred to as kleptoparasitism. Kleptoparasitism of tern by laughing gulls has been documented on the refuge extensively. Systematic recording of kleptoparasitism began in 2001, when this behavior was increasingly seen within the tern colony. Efforts increased from 68 hours in 2005 to more than 100 hours in 2008 to achieve a more accurate snapshot of laughing gull and common tern interactions. Between 2001 and 2012, a total of 859 hours has been spent documenting 15,022 attempts of laughing gulls to steal fish from terns. During each kleptoparasitism event, the maximum number of laughing gulls involved in a pursuit, victor, time, and location were recorded. Overall in the surveys conducted on Monomoy since 2001, laughing gulls were successful in stealing the fish from the tern between 32 and 57 percent of the time (USFWS unpublished and annual reports 2002 to 2013, and Johnson 2003). A study to monitor the effects of laughing gull kleptoparasitism rates on the seabird colony conducted on Matinicus Rock (Bishop unpublished data 1996 as in USFWS 2008) found that laughing gulls were successful in 38.5 percent of their attempts to steal fish from terns. A similar study conducted on Eastern Egg Rock by the National Audubon Society (NAS) found that groups of gulls were successful 44 percent of the time in their attempts to steal food from terns (NAS unpublished data 2006 as in USFWS 2008). Kleptoparasitism decreases food deliveries from tern adults to chicks, therefore decreasing the growth rate of tern chicks and overall increasing energetic demands on adults; this has the potential to reduce overall productivity in the tern colony (USFWS 2008).

Current and Future Management Techniques:
Each year on Monomoy refuge, laughing gulls are censused in conjunction with the annual tern census. Due to the increasing population of laughing gulls within the tern colony on South Monomoy Island, in 2004 we conducted a prescribed burn in the nesting area. A combination of prescribed fire and herbicide was used to create more suitable habitat for terns and discourage laughing gull nesting. The laughing gull population continued to rise. In 2004, there had only been a few instances of documented common tern chick depredation by laughing gulls, however, as the number of gulls increased annually, the instances of depredation increased as well as instances of kleptoparasitism. The refuge proposed and gained permission from the State to destroy laughing gull nests to keep the population managed at about 1,000 to 1,100 pairs beginning in the 2005 field season. Laughing gull nests and eggs (not chicks) were destroyed in late June and early July in areas where they were encroaching on tern nesting habitat within the nesting area on South Monomoy. Nonlethal management of laughing gulls was initiated for the first time in 2005 (USFWS 2009a) and was continued annually through 2009. Laughing gull nesting numbers were immediately reduced due to the nest destruction activities. When numbers were at a low of 355 pairs in 2010 (USFWS unpublished data), nest destruction was discontinued mid-season since the population was well below 1,100 pairs. Although nest destruction has not been conducted in recent years, if the laughing gull pair numbers increase beyond 1,000, it will be resumed to maintain a low population. See Figure J.2 for a comparison of nesting numbers to the number of nests destroyed between 2004 and 2012. In 2009 and 2012, subsequent burns were performed to continue to manage the colony habitat to promote a mosaic of sand and grass that is more favorable to terns and less favorable to laughing gulls. Vegetation within the tern colony and numbers of nesting laughing gulls will be monitored in the future to determine the management actions that are most successful at creating habitat for nesting terns.

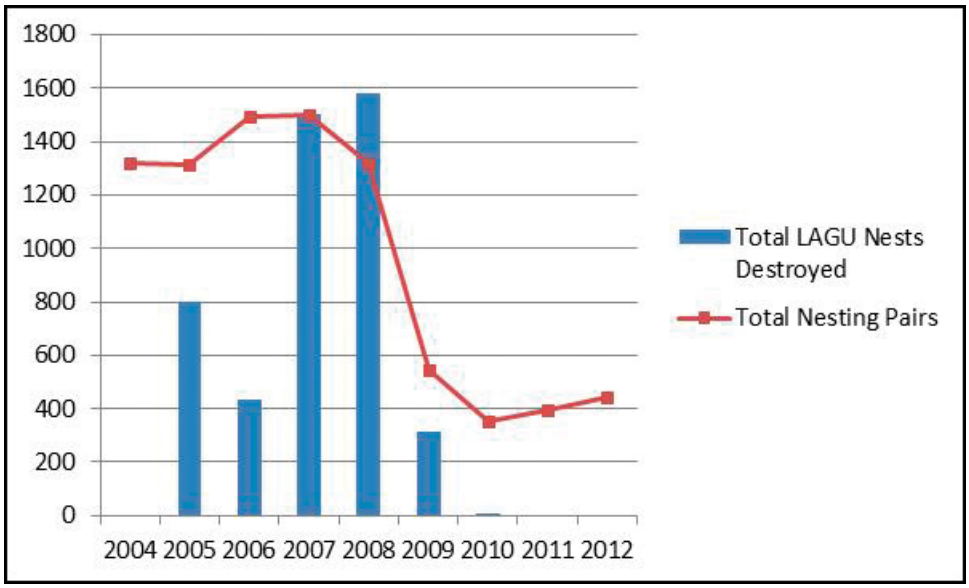

Figure J.2. Laughing Gull Nests Destroyed Between 2006 and 2012. (No nests were destroyed in 2004, 2011, or 2012.)

Impacts of Management to Laughing Gull Population:
Though laughing gull nest destruction on Monomoy has directly impacted the number of gulls nesting within our colony, the number of nesting laughing gulls in Massachusetts has steadily increased since the early 1990s. Plymouth Beach has seen increasing numbers of laughing gulls nesting in recent years, while Monomoy numbers have been low though we have not implemented any predator management to discourage nesting (Kerin McCall 2013). In areas where there is control of larger gulls like great black-backed gulls and herring gulls, it is likely that laughing gulls would out-compete terns for habitat and continue to increase as they did in the early 2000s before control was initiated on the refuge.

5. Great Black-backed and Herring Gull (Large Gulls)

Population Status:
Great black-backed and herring gulls are East Coast species, with herring gull being year-round residents of these areas. Historically both great black-backed and herring gulls have been expanding their range southward since the 1960s, at the expense of laughing gull populations (Pierotti and Good 1994, Good 1998). Both species are abundant throughout their breeding range with breeding pairs at 37,372 and 90,734 respectively (MANEM 2006).

In May and June of 2006 through 2008, a coastwide survey of nesting colonial waterbirds was completed in Massachusetts; 9,725 pairs of herring gulls were counted at 55 colonies and 9,054 pairs of great black-backed gulls were counted at 49 colonies (Melvin 2010). For both species of large gulls, North Monomoy Island and South Monomoy were listed as being two of the largest three colonies Statewide, with Muskeget Island being the second-largest nesting site for great black-backed gulls and Penikese Island being the third-largest nesting site for herring gulls. Herring gulls declined by 42.2 percent, from 15,812 to 9,143 pairs, between 1994 and 1995 and 2006 to 2008 surveys, based on comparable counts at 54 of 73 (74 percent) sites surveyed (Melvin 2010). Great black-backed gulls declined by 40.0 percent between 1994 and 1995 and 2006 to 2008, from 14,616 to 8,774 pairs, based on counts at 56 of 71 (79 percent) sites that were surveyed using comparable methods (Melvin 2010). This survey was replicated in 2013 and preliminary numbers suggest that the populations of herring and great black-backed gulls in the State have continued to decline (Melvin, personal communication 2013).

Herring gulls were first seen nesting on Monomoy Island in 1924 (Forbush 1925). The recent history of herring gull nesting on Monomoy NWR started with five pairs in 1963 (Kadlec and Drury 1968). The colony growth in

successive years was spectacular, with 75 pairs in 1964, 420 pairs in 1965, 1,000 pairs in 1966, 8,000 pairs in 1969, and more than 15,000 pairs in 1980; but in 1995 only 5,200 pairs of herring gulls were found on the refuge. This drop in herring gull numbers may be correlated to the closing of landfills and poor census methods used during the census in 1995. Great black-backed gulls moved onto Monomoy soon after the herring gulls did; there were 75 to 80 pairs in 1965 and 1966 and about 175 pairs in 1972. By 1980, the great black-backed population had reached 3,300 pairs and in 1995 had reached a total of 7,350 pairs, for a combined count of more than 13,000 pairs of the two large gull species (USFWS 1996b).

These counts (through the mid-1990s) are estimates however, and uncertainty and inconsistency in methodology among years reduces their reliability. In recent years, complete counts of nesting gulls have been conducted on North Monomoy Island in 2000 and 2007 (refer to table J.6) In 2000, South Monomoy was surveyed using aerial photography, and in 2007 it was surveyed using a stratified random-sample transect method. In 2000, 1,018 great black-backed gull nests and 1,609 herring gull nests were counted on North Monomoy Island, but the aerial photography for South Monomoy was never fully analyzed. In 2007, 1,245 herring gull nests and 683 great black-backed gull nests were counted on North Monomoy Island. An additional 1,088 herring gull nests and 2,490 great black-backed gull nests were estimated on South Monomoy, for a total refugewide count of 2,333 herring gull nests and 3,173 great black-backed gull nests.

Table J.6. Great Black-backed Gull and Herring Gull Nests Counted in Areas A and B During May Gull Censuses in 1996 to 2007* on South Monomoy.

Year	Great Black-backed Gull		Herring Gull		Empty		Total		
	Area A	Area B	Area A	Area B	Area A	Area B	Area A	Area B	Total
1996	307	652	544	178	859	322	1710	1152	2862
1997	78	356	26	51	262	147	366	554	920
1998	7	259	0	10	6	99	13	368	381
1999	2	195	0	35	1	98	3	328	331
2000	0	139	0	33	0	86	0	258	258
2001	3	115	0	28	3	55	6	198*	204*
2002	3	114	0	56	0	47	3	217	220
2003	1	79	0	32	0	47	1	158	159
2004	4	59	0	14	0	104	4	177	181
2005	0	39	0	18	0	61	0	118	118
2006	0	12	0	3	0	43	0	58	58
2007	0	13	0	5	0	17	0	35	35

**No gull census took place in 2008 through 2012.*

Gull census was again performed in 2013, concurrent with a regionwide effort to count all colonial nesting waterbird colonies. As stated in section 1, data compilation is still ongoing, but preliminary numbers for North Monomoy Island are 1,180 herring gull nests and 995 great black-backed gull nests. On South Monomoy, no herring gull nests were observed on transects, and great black-backed gull nests likely numbered fewer than 10 (Iaquinto, personal communication). This sharp decline in nesting gulls on South Monomoy did not occur on North Monomoy Island, suggesting the cause was specific to South Monomoy.

Impacts to Birds of Conservation Concern:
The overall increases in the northeastern populations of herring and great black-backed gulls have led to declines in tern populations (Cavanagh and Griffin 1993) through competition for nest sites and predation on chicks and eggs (Burger 1979, Morris and Hunter 1976). Herring and great black-backed gulls (large gulls) have been documented taking eggs, chicks, or fledglings from terns (Hatch 1970, Donehower et al. 2009, Kress and Hall

2004), oystercatchers (Schulte et al. 2010), and plovers (USFWS 1996) on Monomoy refuge (USFWS unpublished reports 1996 to 2013) and other locations in the Gulf of Maine where these species are present.

On Monomoy NWR, increases in nesting gulls were matched with precipitous declines in nesting terns. Common terns declined from a high of 4,000 pairs in 1970 to only hundreds of pairs by 1985. Roseate terns on Monomoy NWR declined from a high of 900 pairs in 1966 to fewer than 100 pairs in 1981 (USFWS 1996b). During most years from the early 1980s through 2000, no roseate terns nested. Further, predators (Nisbet and Welton 1984, Nisbet and Forster 1980), storm tides, and loss of habitat resulted in virtually zero productivity between 1980 and 1994 (Fitch 1985, USFWS unpublished reports 1985 to 1994).

Great black-backed gulls are both nocturnal (Nocera and Kress 1996) and diurnal predators in tern colonies. At Monomoy refuge we have observed them preying on eggs and chicks at night and during the day, as well as preying on fledged chicks and adults during the day as terns preen and stage on the sand flats. McNicholl (1973) suggested frequent tern mobbings of herring gulls may decrease common tern productivity by reducing time spent incubating, brooding, and guarding eggs and chicks. Herring gulls and northern harriers are generally only seen preying in the tern colony during the day. Herring gulls will prey on eggs and chicks, including large chicks, and northern harriers generally prey on fledged chicks or adults (USFWS unpublished reports 1996 to present).

Predator visits are monitored opportunistically throughout the season, and it is documented when large gulls enter and disturb the colony. Gull tracks in plover and oystercatcher nesting areas are documented as well. Gulls are considered predators when they are actively depredating nests or disturbing and being chased by terns or other birds. The following table reflects the interactions gulls have had in the colony since 1998 when data collection started, numbers of plover and oystercatcher nests taken by gulls, and the total number of herring and great black-backed gulls taken each year.

Table J.7. Large Gulls selectively removed from the Tern Colony on South Monomoy and Depredation by Gulls in these years 1998-2012

Year	# Great Black-backed Gulls Removed	# Herring Gulls Removed	Total Piping Plover Nests Lost (% of Total Lost to Known Causes) to Eastern Coyotes	Total American Oystercatcher Nests Lost (% of Total Lost to Known Causes)
1998	0	1	2 (15%)	nd
1999	0	0	2 (17%)	nd
2000	0	0	0	nd
2001	nd	nd	0	nd
2002	7	1	2 (8%)	0
2003	1	0	3 (12%)	6 (18%)
2004	3	0	2 (12%)	6 (26%)
2005	19	4	1 (6%)	7 (18%)
2006	12	0	0	0
2007	19	5	2 (22%)	0
2008	37	7	2 (9%)	3 (18%)
2009	0	0	1 (11%)	2 (22%)
2010	12	3	4 (57%)	4 (40%)
2011	0	0	0	1 (7%)
2012	0	0	3 (13%)	1 (6%)
Total	110	21	24 (11%)	30 (16%)

Though gulls directly impact nesting species on the refuge by consuming their chicks and eggs, a major factor for terns has been large gulls using habitat that would be preferred by terns. Once gulls were removed from nesting areas on South Monomoy during the initiation of the avian diversity project in 1996, habitat was available for terns to nest and they began nesting in this habitat in the same year. Gulls have predated plover and oystercatcher nests in most years, though they have caused only about 11 percent on average of the total nest loss. For piping plovers, 2010 was an outlier year, with exceptionally high productivity, so the percentage of nests taken by gulls is very high since very few nests were lost throughout the season (USFWS unpublished reports 1996 to present).

Current and Future Management Techniques:
In 1979, the Service made a preliminary effort to protect a large tern colony on North Monomoy Island (the only colony remaining on the refuge at that time) from encroaching herring and great black-backed gulls. Active gull nests were sprayed with an oil-formaldehyde mixture, which inhibits egg hatching, and at least 45 adult herring gulls were shot in a buffer zone adjacent to the nesting terns (USFWS 1988). In 1980, a more comprehensive program was initiated. In addition to targeting nesting gulls from a buffer zone around the terns, the plan called for the creation of a 130-acre alternate tern nesting area at a former colony site on South Monomoy using avicide DRC 1339 to lethally remove gulls from the area. The first of two planned annual avicide applications was administered in June 1980, and reduction in the number of nesting herring and great black-backed gulls was achieved. However, the avicide program was suspended after the first treatment due to the negative public reaction (USFWS 1988).

Subsequently, control efforts from 1980 to 1984 were focused on reducing the number of nesting gulls on North Monomoy Island only, using shooting, hazing devices, scarecrows, and nest destruction methods. While this program did prevent gulls from expanding their colony, it was unsuccessful in reducing gull populations (Lortie et al. 1985).

Maintenance of existing gull-free habitat between 1988 and 1992 was attempted through the destruction of gull nests and eggs. In 1993 and 1994, Migratory Bird Treaty Act permits were issued for the taking of herring and great black-backed gulls (using selective shooting) within a 210-acre area, with the objective of removing up to 5,000 birds (combined species total). Due to the fact that these gulls quickly adapt to stay beyond shooting range, this method resulted in an effective take of less than 1,500 birds in 1993 and less than 200 birds in 1994. Observations of large numbers of herring and great black-backed gulls nesting and loafing in the vicinity of less abundant nesting species prompted reconsideration of management alternatives following the 1994 field season (USFWS 1996b).

In accordance with tasks outlined in the Piping Plover Recovery Plan, Roseate Tern Recovery Plan, Endangered Species Act of 1973 and the goals of the National Wildlife Refuge System, which direct national wildlife refuge units to "preserve, restore, and enhance in their natural ecosystem (when practicable) all species of animals and plants that are endangered or threatened with becoming endangered," the Service proposed to strengthen ongoing efforts to manage habitat for nesting species on Monomoy NWR. The avian diversity project began in 1996, and a contiguous 169.5-acre area (67.7 ha) was chosen on the north end of South Monomoy (designated Areas A and B) to provide gull-free nesting habitat. An additional 175 acres immediately to the south of Area B was delineated as a control area, Area C (map 2.5) (USFWS 1996b).

The Service baited approximately 2,850 well-formed herring and great black-backed gull nests (both those with and without eggs) twice in this area in May 1996 using the avicide DRC 1339 (see USFWS 1996 for details). The avicide applications resulted in an almost 80 percent reduction in the number of territorial birds in Area A and a 50 percent reduction in Area B. The use of DRC 1339 on Monomoy NWR was later suspended after a public outcry when more than 600 of the birds died at freshwater roosting sites on the mainland rather than on South Monomoy. A total of 448 adult herring and great black-backed gulls were shot in the treatment area (map 2.5: Areas A and B; Megyesi 1996).

Monomoy National Wildlife Refuge - Comprehensive Conservation Plan
Gull Management Areas
Area A
Minimoy Island
Refuge Boundary
Area B
Area C
South Monomoy Island
Sources:
Refuge and Wilderness boundaries from USFWS.
Background image from the Town of Chatham, 2012
0
0.5
1
Miles
0
0.5
1
Kilometers
1:24,000
N
W
E
S

In 1997, nonlethal harassment, which involves discouraging territorial gulls from establishing territories and destroying any nests that are found, was used. Selective shooting took place in Area A when territorial gulls were discovered attending nests with eggs (refer to Megyesi 1997 for a complete description). Nonlethal harassment was performed in 1998, 1999, and 2000 in Areas A and B. Decline in nesting gulls has been documented in both of these areas. Area A experienced a decrease from 1,710 in 1996 to zero in 2000; Area B had 1,152 nesting gulls in 1996 and 258 in 2000 (USFWS 1996 and USFWS unpublished data).

Area A has been successfully maintained as a gull-free zone, while Area B has had minimal nesting. From 2001 to 2007, nest destruction and non-lethal harassment efforts were implemented each season to maintain low populations of herring and great black-backed gulls and prevent them from encroaching on the common and roseate tern colony. In 2008, these actions were deemed unnecessary due to the low numbers of gulls censused in Area B during the 2007 census, and non-lethal harassment only has been conducted sporadically since then to maintain Areas A as gull-free.

The start of the avian diversity project in 1996, when thousands of nesting great black-backed and herring gulls were removed from potential tern nesting areas, marked the beginning of nesting tern population increases that have been largely sustained for the last 15 years on Monomoy NWR. Nesting common terns increased from just a few hundred pairs in 1995 to more than 2,000 pairs in 1998 and more than 10,000 pairs by 2003. Maintaining gull-free areas for terns has also proven to be effective in restoring large numbers of nesting terns in Maine (Kress 1983, USFWS 2005b) and other Massachusetts sites (Blodget and Henze 1992).

Since the recent peak nesting years (2003 to 2006), numbers have fluctuated in response to habitat changes, predator pressures, and nesting habitat quality at other nearby sites. Monomoy NWR remains one of the most important common tern nesting sites in the State, and one of just a few sites that support roseate terns. However, the long term continued success of this project depends on a flexible adaptive management approach that incorporates annual management actions focused on habitat manipulations and management of predator and competitor species. We also carefully monitor habitat and birds' responses to the management actions, which leads to informed adaptations of strategies for the following year.

In recent years since regular gull harassments have been discontinued, the refuge has continued to closely monitor nesting gulls on the refuge and destroy nests that are placed in close proximity to nesting plovers, terns, and oystercatchers as soon as they are found. We have also continued to shoot predatory great black-backed and herring gulls that are actively preying on plover or oystercatcher eggs, chicks, or adults in the nesting area or actively preying on fledged chicks and adults on the adjacent staging flats (USFWS unpublished reports 1996 to present).

Impacts of Management to Great Black-backed and Herring Gull Population:
It is unlikely that management at Monomoy refuge has had a significant effect on the East Coast population of gulls, despite their recent decline locally. Massachusetts gulls have been declining in recent years for a variety of reasons; nest destruction and gull removal on the refuge has been very small compared to the size of the overall decline. As stated in section 1, evidence of coyotes preying on herring and great black-backed gulls on Monomoy refuge has been frequently observed, but not systematically documented (Koch and Iaquinto, personal communiction). This sharp decline in nesting gulls on South Monomoy did not occur on North Monomoy Island, suggesting the cause was specific to South Monomoy. It also coincides with the connection of South Monomoy to South Beach, and increased presence of coyotes on South Monomoy. It is likely that the most powerful force in the declining gull population on Monomoy in recent years may be eastern coyote depredation.

6. Great Horned Owl

Population Status:

Breeding Bird Atlas [1] (BBA) data for Massaschusetts shows great horned horned owls are likely increasing in the State as they take advantage of increasing surburban habitats and maturing forest (*http://www.massaudubon.org/StateoftheBirds/species_account.php?spc=GHOW*, MassAudubon 2011, Joan Walsh, personal communication July 2013). Great horned owls were detected[2] in 27 percent of the blocks (263 blocks) during Atlas 1(Petersen and Meservey 2003) and 42 percent of the blocks (435 blocks) during Atlas 2. After correcting for differences in block survey effort[3], it appears great horned owl presence has increased by about 40 percent (Walsh, personal communication July 2013). At the time of the first BBA, great horned owls were considered widespread but uncommon, and although they were common in the southern coastal regions, they were absent from the islands (Petersen and Meservey 2003). They are now considered to be fairly widespread (Walsh, personal communication July 2013), and are present on some of the islands (*http://www.pwrc.usgs.gov/bba/index.cfm?fa=explore.ResultsBySpecies*).

Great horned owls were first confirmed nesting on Monomoy NWR when a nest with owlets was found in 2000. Since that time, a pair has probably nested in some years on South Monomoy (adults are frequently seen on the south end of the island in the spring) but no census or nest searching has been conducted (Iaquinto, personal communication 2011). Great horned owls also nest on Morris Island (Iaquinto, personal communication).

Impacts to Birds of Conservation Concern:
Great horned owl has been the most sporadic of all the avian predators at Monomoy refuge in recent years, and most years there is very little evidence of their presence. However, in years when great horned owls are present at Monomoy refuge as well as at other tern colonies, complete abandonment of the tern colony until the following morning is often observed, leaving eggs and chicks exposed to inclement weather and other predators (Holt 1994, Fisk 1974, Nisbet and Welton 1984, Morris and Wiggins 1986). Additional consequences of nocturnal abandonment include prolonged incubation periods for chicks and sometimes inattentiveness to eggs during the day, which can leave them vulnerable to diurnal predators (Mostello 2007). The adult terns' decision to either abandon their nest and young or stay and attack a predator is likely based on the perceived risk of the predator to the adult itself. Owls are skilled at catching and preying on adult terns and large chicks, but have also been reported preying on small chicks (Nisbet and Welton 1984). Many other avian predators, however, are most likely to target eggs and smaller chicks (Collins 1970, Nisbet and Welton 1984, Shealer and Kress 1991, USFWS annual field season activities reports from 1996 to present). At Monomoy refuge we often observe nocturnal abandonment in conjunction with great horned owl presence, but we have also occasionally observed groups of terns attacking an owl that is present in the colony (Koch, personal communication 2012).

Great horned owls have been an influential predator on Monomoy refuge since the 1970s. A 1979 study of common tern nesting on Monomoy (Nisbet and Welton 1984) suggested that great horned owls were a major factor in tern nesting failure in the 1970s. The owls were responsible not only for direct predation on tern chicks but, more importantly, caused night desertion of the colony by adult terns, thereby exposing eggs and chicks to attacks by ants, predation by black-crowned night-herons, and chilling. Great horned owl visits ceased after 1983.

In more recent years and since active management for terns began in 1996, great horned owls were first observed preying in the tern colony on the north end of South Monomoy in 1999. In that year, they were documented in

[1] The first Massachusetts BBA was conducted from 1974 to 1979 and the second was conducted from 2007 to 2011. The entire state was divided into 1,134 blocks; 969 blocks were surveyed in Atlas 1 and 1,037 blocks were surveyed in Atlas 2 (Walsh, personal communication July 2013). Detailed information on the methodology and analyses can be found at *http://www.massaudubon.org/birdatlas/bbaportal/index.php*

[2] Detected birds include those classified as confirmed, probable, or possible breeders

[3] Some blocks were removed from analysis when calculating % change in block detection between survey windows because of differences in survey effort (Walsh personal communication July 2013)

the colony on 17 nights, took a minimum of 15 to 20 common tern adults, and caused nocturnal abandonment every night until the end of June (USFWS 2000). In 2000, great horned owls were documented in the tern colony early in the nesting season. As a result, the tern colony was abandoned every night from May 11 to June 14, at which point common tern chicks started nesting; for a total of 3 weeks there was full abandonment, and for 1 to 2 weeks there was partial abandonment. The decline in nesting roseate tern numbers observed in 2000 from 1999 is likely attributed to great horned owl presence in the colony during tern nest establishment (Koch, personal communication). In 2001, great horned owl was again present in the colony early in the season and nocturnal abandonment occurred throughout May and then again at the end of June, which resulted in the death of many small chicks. Great horned owl presence in the tern colony has been documented in most years since 2001, but in many years the impact was likely insignificant (USFWS annual field season activities reports from 2001to present). However, great horned owl caused repeated nocturnal abandonment in 2003 (USFWS 2007a) and 2009 (USFWS 2012). Direct loss of adults and chicks from great horned owls is not easy to quantify because carcasses are not always found, and it is often difficult to identify a kill resulting from great horned owls from that of other avian predators.

Current and Future Management Techniques:
Great horned owls have been frequently removed from other tern colonies in Maine where they are posing a threat (Kress and Hall 2004). In addition, "owl predation is unpredictable; an individual may return to the colony on successive nights, but may also be absent for two or more weeks before returning (Kress and Hall 2004). Several techniques were used in 1999 to 2001 on Monomoy refuge to try to capture great horned owls in the tern colony, but none were successful.

Personnel have been prepared annually to shoot great horned owls that are actively preying in the tern colony (though this also hasn't been successful in recent years) at night, and will continue to be prepared. In 2002, the refuge began using triangular shaped "area closed" signs, instead of square or rectangular shaped signs, around the perimeter of the tern colony in an effort to reduce perching opportunities for hunting owls. We will continue to use these signs.

Impacts of Management to Great Horned Owl Population:
To date, no great horned owls have been removed from Monomoy refuge, so there has been no negative impact from our management actions to the great horned owl population. It is unlikely that more than three great horned owls would ever be removed in one year, so the anticipated impact of our management actions on the great horned owl population in the State is inconsequential.

7. Short-eared Owl

Population Status:
Short-eared owls are a State-endangered species and BBA data shows a strong decline between the two survey periods in Massachusetts. Short-eared owls were detected in 1 percdent of the blocks (13 blocks) during Atlas 1(Petersen and Meservey 2003) and less than 0.5 percent of the blocks (3 blocks) during Atlas 2. After correcting for differences in block survey effort, it appears short-eared owl presence has decreased by about 85 percent (Walsh, personal communication July 2013). At the time of the first BBA, short-eared owls were only documented breeding on Monomoy refuge, Martha's Vineyard, and Nantucket, Tuckernuck, and Muskeget Islands (Petersen and Meservey 2003). In 1985, 20 to 25 pairs of short-eared owls were estimated breeding at these sites and Pochet Marsh, Orleans (Veit and Petersen 1993). They did not nest at all in 2011 on Tuckernuck Island, which is the last known nesting site (*http://www.massaudubon.org/StateoftheBirds/species_account.php?spc=SEOW*) and have essentially been extirpated from the State (Walsh, personal communication July 2013). Short-eared owls only breed in three other states in the Northeast (New York, Pennsylvania, and Vermont), and incidences of short-eared owls there are even less than in Massachusetts (*http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/asio-flammeus.pdf*).

On Monomoy refuge, five pairs of short-eared owls nested in 1986 and two nesting pairs were confirmed in 1987. During this time, Monomoy's short-eared owls represented about one-quarter of the State's population. Holt and Melvin (1986) suspected that habitat loss and human disturbance have been the primary factors contributing to the decline of short-eared owl in Massachusetts. Short-eared owls are ground-nesters, and small mammals are

their major prey. Lortie et al. (1985) speculated that failure of short-eared owls to breed successfully on North Monomoy in 1983 and 1984 may be partially attributable to early season gull harassment efforts coinciding with owl nest site selection and courtship activities. Fitch (1985) reported that a late short-eared owl nesting attempt on North Monomoy Island in 1984 was abandoned, possibly due to its proximity to an access trail frequented by the public.

Impacts to Birds of Conservation Concern:
Short-eared owls can cause similar nocturnal disturbances in tern colonies as great horned owls. On Monomoy refuge, short-eared owls have been documented killing common tern adults and chicks and causing nocturnal abandonment, which led to prolonged incubation periods and chick mortality. "Night desertion allowed other predators and inclement weather to kill eggs, nestlings, and dispersed chicks incapable of flight." (Holt 1994). Short-eared owls have not been identified as a predator in recent years on Monomoy refuge.

Current and Future Management Techniques:
Because of the State-listed status of short-eared owls and likely extirpation from the State, we do not implement management of this species, nor do we actively discourage them from hunting in the common tern colony. Signs of depredation and presence in the colony are recorded when observed.

Impacts of Management to Short-eared Owl Population:
Short-eared owls are not actively managed on Monomoy refuge so there is no impact to their population.

8. Northern Harrier

Population Status:
BBA data for Massachusetts shows northern harriers are strongly increasing (Joan Walsh, personal communication July 2013). Northern harriers were detected in 4 percent of the blocks (36 blocks) during Atlas 1(Petersen and Meservey 2003) and 10 percent of the blocks (72 blocks) during Atlas 2. After correcting for differences in block survey effort, it appears northern harrier presence has increased by about 97 percent, or nearly doubled (Walsh, personal communication July 2013). However, northern harriers are a State-threatened species, and while BBA data shows a strong increase, their population is still at risk as open habitats are lost (*http://www.massaudubon.org/StateoftheBirds/species_account.php?spc=NOHA*).

Northern harriers have been nesting on Monomoy refuge since at least the mid 1980s when three nests were confirmed in 1985 and one nest confirmed in 1986 (USFWS 1988). In recent years, northern harriers have been observed nesting on the refuge: at least four nests in 1997, three nests in 1998, one nest in 1999, and three nests in 2000. The refuge has never been systematically searched for nesting northern harriers, but frequent observations of adults in most years suggest they are still nesting on the refuge (Iaquinto, personal communication).

Impacts to Birds of Conservation Concern:
Northern harriers have been active predators of piping plovers on Monomoy refuge and adjacent South Beach. In 2002, a northern harrier was most likely to blame for the death of an adult female plover in an exclosure (placed on piping plover nests to prevent nest predation) on the northeast tip of South Monomoy (USFWS 2003). In 2004, an adult female plover was found dead inside an exclosure with injuries consistent with those inflicted by a northern harrier in the same area (USFWS 2007b). Refuge staff removed exclosures on the northeast tip of South Monomoy following this event. Three adult piping plover mortalities due to avian predators were reported on South Beach during 2004 as well, although it was suspected that a peregrine falcon was the cause of at least one of these mortalities (Jedrey, personal communication 2004). None of the South Beach mortalities during 2004 were associated with exclosures. In addition, during 2001-2003, northern harriers were thought responsible for most of the 15 known plover fatalities at exclosed nests on South Beach (Melvin and Mostello 2002, 2003; Jedrey, personal communication 2004).

Northern harriers have also been active predators in the tern colony on Monomoy refuge and other sites (Burger and Gochfeld 1991). They likely nest within 1 mile of the Monomoy tern colony, and in most years, make frequent visits into the tern colony to hunt (Koch, personal communication, USFWS annual field season reports 1998 to present, and unpublished data). It is difficult to quantify the total number of chicks and adults taken by northern

harriers, but a minimum tally of loss is in table J.8 below.

Table J.8. Northern Harrier on Monomoy NWR Tern Colony.

Year	# Times Seen Hunting in the Colony (# Days)	# Tern Chicks Taken	# Adult Terns Taken
1998	15 (13)	>3	nd
1999	92 (33)	5	6
2000	nd	nd	nd
2001	nd	nd	nd
2002	87 (32)	27	4
2003	37 (24)	6	13
2004	40 (29)	11	9
2005	24 (nd)	1	3
2006	13 (nd)	13	2
2007	5 (5)	1	7
2008	21 (17)	3	1
2009	nd (5)	nd	nd
2010	nd (4)	nd	nd
2011	nd	0	0
2012	nd	0	0
Total		67	45

Current and Future Management Techniques:
Because of the State-listed status of northern harriers and concern for population stability in Massachusetts, we do not implement management of this species, nor do we actively discourage northern harriers from hunting in the common tern colony. Signs of depredation and presence in the colony are recorded when observed.

Impacts of Management to Northern Harrier Population:
Northern harriers are not actively managed on Monomoy refuge so there is no impact to their population.

9. American Kestrel, Merlin, and Peregrine Falcon

Population Status:
BBA data for Massachusetts shows American kestrels are strongly declining (Joan Walsh, pers. comm., July 2013). American kestrels were detected in 51 percent of the blocks (498 blocks) during Atlas 1 (Petersen and Meservey 2003) and 21 percent of the blocks (215 blocks) during Atlas 2. After correcting for differences in block survey effort, it appears American kestrel presence has decreased by about 62 percent (Walsh, personal communication July 2013).

BBA data for Massachusetts shows merlins are strongly declining (Joan Walsh, pers. comm., July 2013). Merlins were not detected during Atlas 1(Petersen and Meservey 2003) and were detected in 1 percent of the blocks (10 blocks) during Atlas 2. Merlins were detected in too few blocks to assign trend information (Walsh, personal communication July 2013).

Peregrine falcons are a State-endangered species and BBA data for Massachusetts shows their population is strongly increasing (Joan Walsh, pers. comm., July 2013). Peregrine falcons were not detected during Atlas 1 (Petersen and Meservey 2003) and were detected in 2 percent of the blocks (25 blocks) during Atlas 2 (Walsh, personal communication July 2013).

Impacts to Birds of Conservation Concern:

"Terns usually mob hawks such as buteos, accipiters and ospreys, driving them far from nesting islands. They are less likely to effectively defend against falcons. Peregrines, merlins, American kestrels, and an occasional gyrfalcon sometimes frequent tern colonies. Falcons can arrive at any time during the nesting season, but usually move on after a few days. While present, they can be extremely disruptive. For example, a single American kestrel killed more than 200 least terns over a 10-day period (J. Atwood, personal communication)" (Kress and Hall 2004). A peregrine falcon was also responsible for killing at least 36 roseate terns and 18 common terns on Bird Island in Massachusetts when it took up residence early in the nesting season (Nisbet 1992).

Current and Future Management Techniques:
Because of the State-listed status of peregrine falcon (State-listed endangered) and concern for population stability of American kestrel and merlin, we do not implement management of these species, nor do we actively discourage them from hunting in the common tern colony. Signs of depredation and presence in the colony are recorded when observed.

Impacts of Management to American Kestrel, Merlin, and Peregrine Falcon Populations:
American kestrels, merlins, and peregrine falcons are not actively managed on Monomoy refuge so there is no impact to their population.

10. American Crow, Fish Crow, and Common Grackle

Population Status:
In the U.S., American crow and fish crow have been protected by the Migratory Bird Treaty Act since 1971, but hunting is allowed in some locations. Individual states set hunting seasons (not to exceed 124 days) that exclude the nesting season (Clapp and Banks 1993). Crows are hunted on specific days in Massachusetts except during April 11 to June 30 (*www.mass.gov* 2013).

Massachusetts Audubon Society Breeding Bird Atlas (BBA2) data shows American crows are stable in Massachusetts (Walsh, personal communication July 2013). American crows were detected in 89 percent of the blocks (870 blocks) during Atlas 1 (Petersen and Meservey 2003) and 95 percent of the blocks (990 blocks) during Atlas 2. After correcting for differences in block survey effort, it appears American crow presence has increased by about 4 percent, or stayed relatively the same. Additionally, American crows are nearly ubiquitous in Massachusetts (Walsh, personal communication July 2013).

BBA2 data for Massachusetts shows fish crows are strongly increasing in Massachusetts (Walsh, personal communication July 2013). Fish crows were detected in 3 percent of the blocks (27 blocks) during Atlas 1 (Petersen and Meservey 2003) and 18 percent of the blocks (183 blocks) during Atlas 2. After correcting for differences in block survey effort, it appears fish crow presence has increased by about 530 percent (Walsh, personal communication July 2013).

BBA2 data for Massachusetts shows common grackles are stable in Massachusetts (Walsh July 2013 personal communication). Common grackles were detected in 92 percent of the blocks (896 blocks) during Atlas 1(Petersen and Meservey 2003) and 95 percent of the blocks (984 blocks) during Atlas 2. After correcting for differences in block survey effort, it appears common grackle presence has increased by about 2 percent, or stayed relatively the same. Additionally, common grackles are nearly ubiquitous in Massachusetts (Walsh, personal communication July 2013).

A brood of crows was banded by June A. Chamberlain-Auger in 1992 on North Monomoy Island. In recent years, American crows were first recorded as being seen on South Monomoy Island in April 2003. American crows were seen early in the season in 2011, though little impact was documented and crows were not seen on the island through the season. 2012 was the first nesting season in which crows and grackles were documented taking piping plover nests. Fish crows have been heard on the refuge though no documentation of their presence exists and no predation is directly attributed to them. Common grackles have been common on the refuge for many years, as they nest in the freshwater wetlands surrounding the Monomoy Light, though there is no data to quantify this presence since surveys have not been done and predator visits have not been recorded for this species (Iaquinto, personal communication). Common grackles had been commonly seen feeding on dead seal carcasses on the

refuge beaches, especially on the southern end of South Monomoy (Iaquinto, personal communication). In 2013, a pair of American crows nested and hatched chicks just outside the main tern nesting area before being detected. Three additional crows were seen flying, perching, and walking around the island and many piping plover nests were lost to them.

Impacts to Birds of Conservation Concern:
Corvids are generally egg and nest predators; however, there are some examples of crows taking least tern chicks (Burger and Gochfeld 1991, Kress and Hall 2004). Corvids are intelligent predators that can learn to associate fencing or exclosures with nests of terns and plovers and are therefore attracted to nesting areas because they know there are potential meals there (Blodget and Melvin 1996). These species (American and fish crow) have earned a reputation for eating other birds' eggs and nestlings, and common grackles occasionally kill and consume adult birds (Verbeek and Caffrey 2002, Mcgowan 2001). Some sites, including Crane Beach and the Cape Cod National Seashore (CACO) have had issues with American crows learning to target piping plover nests that are in exclosures. Predators, especially crows and coyotes, have a significant impact on the reproductive success of piping plovers, least terns, and other shorebirds nesting at the national seashore (CACO fact sheet).

On Monomoy refuge, three lost piping plover nests were attributed to grackle depredation and one lost nest was attributed to crow depredation during the 2012 nesting season. None of these nests were exclosed. As of 26 July 2013, crow and grackle predation increased dramatically and became a serious problem. A total of 28 nests were either determined to be lost to or suspected to have been lost to American crow and common grackle on South Monomoy this year (12 nests determined predated by American crow, 4 nests determined predated by common grackle, 10 nests possibly predated by American crow, 2 nests possibly predated by common grackle). It was often difficult to determine the exact cause of the nest loss, but tracks were measured carefully. As with all predation on the refuge, unless it is witnessed, it is often difficult to tell what predator actually depredated the nest. A document compiled by refuge staff outlines how the cause of nest loss was identified. Tracks were often more difficult to distinguish based on length alone, as tracks made in sand appear enlarged after time and after rain and weather events. In general, most common grackle tracks measured 2 ¼ to 2 ½ inches long, while almost all American crow tracks measured above 2 ¾ inches in length. American crow tracks had very noticeable bulges at the toes.

In 2013, nests determined to be depredated by American crow occasionally had broken eggs or large egg fragments near or at the nest. Nests found depredated by common grackle did not exhibit this. In all cases of known or suspected American crow and common grackle predation, nests had significant amounts of yolk pieces in or near nest bowl. Yolk pieces were usually found dried and in clumps. In many cases of depredation, plover tracks were found surrounding the nest, replacing any sign of American crow or common grackle tracks within about 2 feet of nest. Because exclosures have been targeted at other sites by crows and grackles, the refuge staff was hesitant to use them this year to deal with this predation. Loss of adult plovers or making nests a target would be much worse than losing nests as crows and grackles found them opportunistically. Two false exclosures with fake wooden eggs in the center were erected in areas where grackles had been seen (lighthouse boat landing and plover beach). In both cases, grackle tracks were documented entering the exclosure and approaching the nest within. In one case, a fake egg was removed from the exclosure and later found on the beach approximately 40 feet from the exclosure. No evidence of grackles or crows were found surrounding the exclosures with actual plover nests, though these were not located in areas with lots of evidence of crow or grackles predation. More nests were not exclosed for a variety of reasons, including poor weather conditions that did not allow for exclosures to be erected and nests being located in areas that would be deemed as inappropriate for exclosure use. Data for the 2013 season is still in draft and should be considered preliminary.

Current and Future Management Techniques:
A common depredation order stands for the removal of any species of crows, grackles, and blackbirds when they are in direct competition with federally endangered species (50 CFR 21 Migratory Bird Permits § 21.43). In 2013, 4 adult American crows and 4 chicks were removed from South Monomoy Island. One pair of crows was found to be nesting in a shrub close to the common tern nesting area. The refuge plans to remove the small trees and

shrubs from this area before nesting season 2014 to discourage any future nesting in this area.

Crane Beach initiated a crow removal program in 2008 using toxicants to target individual crows foraging in piping plover nesting areas. False, open-topped exclosures were constructed in nesting areas and pre-baited with hard-boiled chicken eggs. Once the crows ate the eggs, USDA APHIS contractors baited the exclosures once more with hard-boiled chicken eggs laced with the DRC-1339. This is the same toxicant used for gull removal on Monomoy in the 1990s. Crow activity was monitored using point counts, and the program had an immediate and lasting effect on crow abundance and activity within the nesting areas (Crane Beach 2008 and 2009 annual report). While only three carcasses were recovered in 2008, it is estimated that the program removed at most 30 crows. The program is credited with significantly increasing piping plover nest success and chick survival at Crane Beach in 2008 and 2009 (Crane Beach 2008 and 2009 annual report).

If crow and grackle predation continues to be a problem for nesting piping plovers, terns, or oystercatchers, we will consider using toxicants and shooting to remove predatory American crows and grackles. If fish crows were deemed a predator on the refuge, they would be treated in the same way as American crows.

Impacts of Management to Crow Population:
Given the widespread distribution of American crows and common grackles in Massachusetts, and their stable population status, lethal removal of a small number of predatory individuals at Monomoy refuge would not have an impact on the overall population.

Non-lethal Methods Common to Many Predators

At Monomoy NWR, we have been utilizing a variety of non-lethal management techniques to reduce impacts of predator and competitor species during different times of the breeding season. A description of these techniques follows; we propose continuing to use all these methods under our preferred alternative.

1. Maintaining a Staffed Field Camp

"This is the primary technique for displacing small gull colonies (up to 300 pairs) that occupy islands of 2 ha (7 acres) or less. The technique is also useful for preventing gulls from reclaiming former breeding grounds up to 20 ha (49 acres), where lethal control has previously lowered gull numbers. The technique requires a team of resident stewards camping in a conspicuous location adjacent to tern habitat. For new restoration projects at well-established gull colonies, set up the field camp before egg laying begins (in Maine and New Hampshire, during the third week of April). After several years, the season may be pushed back to mid-May, but more breaking of gull eggs may be necessary. Daily visits by mainland-based stewards to large, well-established colonies (e.g., Bird and Ram Islands in Buzzards Bay) are sufficient to deter gull nesting, with occasional breaking of gull eggs. However, depending on proximity to the mainland, landing conditions and other logistic constraints can make daily visits more difficult than staffing resident camps." (Kress and Hall 2004).

Since 1998, refuge staff have maintained a field camp on South Monomoy adjacent to the tern colony for at least June and July, and sometimes from May to August. Maintaining a human presence on the island most of the time has successfully prevented nesting herring and great black-backed gulls from reestablishing territories in close proximity to tern nesting habitat. It has also greatly facilitated our ability to manage other predators and collect data about predator visits and impacts.

2. Using Rectangular Signs to Reduce Perching

Refuge staff noticed that great horned owls were perching on square and rectangular "Area Closed" and "Beach Closed" signs that were around the perimeter of the tern colony. In 2002 refuge staff began using triangular signs around the perimeter of the tern colony in an effort to eliminate perches for great horned owls. This technique has been successful, but great horned owls will also hunt from the ground, so this is not a complete solution. However, using these signs might reduce perching by other avian predators as well.

3. Habitat Management

Habitat management can be an effective method for controlling competitor species and minimizing risk of predators. For example, prescribed burning has been used at Monomoy refuge to reduce habitat suitability for nesting laughing gulls (a competitor species of terns), increase habitat for nesting terns, and reduce shrubby vegetation that provides shelter for mammalian predators.

4. Chick Shelters

Wooden tern chick shelters are placed throughout the tern colony, especially in areas devoid of natural vegetation, to provide additional shelter from weather and predators. Shelters are designed to minimize the chances that black-crowned night-herons can reach chicks, but their effectiveness at minimizing coyote depredation is uncertain.

5. Electric Fencing

Electric fencing has been successful on the refuge in flat, sparsely vegetated areas that are free of the risk of overwash. If the fence is placed in areas where it may be overwashed by salt water, electrical shorts may occur and destroy the fence for future electrified use. Erecting the fence in thick vegetation is very difficult and the vegetation needs to be trimmed, causing potential habitat damage, increased staff labor, and drawing more attention to the fenced area. Currently the energizers used at the refuge can only support fences of up to 12 panels or a circumference of 1,800 feet. When the fencing is used in areas with a varying elevation, predators can more easily breach the fence by jumping in from a higher area. This was observed on the refuge in both 2008 and 2009. For these reasons, enclosing the entire common and roseate tern colony is not practical. Nesting least terns and piping plovers have benefited from areas protected by electric fence on the refuge. However, electric fencing does not reduce avian predation.

6. Non-electric Fence

Funding provided by the National Fish and Wildlife Foundation in 2009 allowed us to test the effectiveness of 6-foot-tall non-electrified wire fencing on the refuge to protect American oystercatcher eggs and chicks from mammalian predators. The tall wire fencing was deemed impractical to set up in the field without causing considerable disturbance to the target nesting American oystercatchers and was discontinued.

7. Predator Exclosures on Piping Plover Nests

Studies have shown that predator exclosures can help minimize predation or reduce nest abandonment (Rimmer and Deblinger 1990, Vaske et al. 1994, Mabee and Estelle 2000), and they are actively being utilized on the refuge. Though exclosures are a useful tool, they may be inappropriate under certain conditions, including habitat that is too steep, highly vegetated, or susceptible to predators that may use exclosures to target nesting birds (refer to Blodget and Melvin 1996 for more information about appropriateness of use). All exclosures placed on the refuge are monitored frequently to ensure they are safely protecting the nests and birds within them and not putting the adults at risk. In some years, raptors have targeted adults on exclosed nests (see the Northern Harrier section), but exclosures are still an effective management tool when monitored carefully. However, exclosures only protect eggs, and do not provide protection for piping plover chicks, which leave the nest bowl soon after hatching.