Biodiversity Research Institute And The Ricketts Conservation Foundation

Summary of Common Loon Productivity and Population Demographics for Massachusetts, 1975-2017

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SUMMARY OF COMMON LOON PRODUCTIVITY AND POPULATION DEMOGRAPHICS FOR MASSACHUSETTS, 1975-2017

SUBMITTED TO:

Andrew Vitz

Massachusetts Department of Fisheries and Wildlife

1 Rabbit Hill Road

Westborough, MA 01581

And

Dan Clark

Massachusetts Department of Conservation and Recreation

251 Causeway Street, #900

Boston, MA 02114

SUBMITTED BY:

David Evers, Vincent Spagnuolo, Lucas Savoy, Lee Attix, and Michelle Kneeland

Biodiversity Research Institute

276 Canco Road

Portland, Maine, USA 04103

(207-839-7600)

SUBMITTED ON:

7 February 2018

The mission of Biodiversity Research Institute is to assess emerging threats to wildlife and ecosystems through collaborative research, and to use scientific findings to advance environmental awareness and inform decision makers.

To obtain copies of this report contact:
Biodiversity Research Institute
276 Canco Road
Portland, ME 04103
(207) 839-7600 x221
David.evers@briloon.org
www.briloon.org

PROJECT FUNDING

Funding for this project has been generously provided by the Ricketts Conservation Foundation, which was formed to support the conservation of wildlife and natural resources, and the Massachusetts Department of Conservation and Recreation (DCR).

FRONT PHOTO CAPTION: Adult Common Loon (*Gavia immer*). Photo provided by Dan Poleschook and Ginger Gumm.

SUGGESTED CITATION: Evers, DC, V Spagnuolo, L Savoy, L Attix, and M Kneeland. 2018. Summary of Common Loon productivity and population demographics for Massachusetts, 1975-2017. Report # 2018-07. Biodiversity Research Institute, Portland, Maine.

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1.0 EXECUTIVE SUMMARY

From 2013 - 2017, Biodiversity Research Institute (BRI) while supported by a grant from the Ricketts Conservation Foundation (RCF), partnered with the Massachusetts Division of Fisheries and Wildlife (MassWildlife) and the Department of Conservation and Recreation (DCR), to assess the overall health and status of the Massachusetts Common Loon (*Gavia immer*) breeding population. The project was conducted through surveys, banding efforts, and nonlethal sampling of blood, feathers, and abandoned eggs. Data gathered during this five-year period were added to available historical data and compared to long-term data sets provided by the Loon Preservation Committee (LPC) in New Hampshire, and the Vermont Center for Ecostudies (VCE), allowing us to examine long-term population and productivity trends. Results published in this report were taken from data gathered by all five organizations.

Over the five-year period of 2013-2017, an average of 91 lakes were surveyed each year. Based on well-defined criteria for an established loon territory, the number of observed territorial pairs reached a peak of 45 pairs in 2015, before decreasing to 39 in 2017. During this five-year period, a total of 108 nest attempts were observed. From 56 successful nests, 133 chicks hatched and 98 survived to > 6 weeks of age – an age used as a proxy for fledging for modeling purposes. Average productivity in Massachusetts from 2013-2017 was 0.47 chicks surviving per territorial pair (CS/TP), which is just below the established threshold for maintaining a breeding population (0.48 CS/TP).

Analysis of long-term productivity data showed a declining trend in Massachusetts. The 20-year mean was 0.41 chicks surviving per territorial pair, and the most recent 10-year mean was 0.39 chicks per pair. By comparison, productivity in New Hampshire for these same periods was 0.48 (10-year), and 0.50 (20-year). In Vermont, long-term productivity was 0.72 (10-year), and 0.68 (20-year). The most recent 10- and 20-year trends in New Hampshire and

Vermont were slightly lower when compared to longer-term trends, but remained at, or above the 0.48 threshold, and well above the long-term productivity figures for Massachusetts.

Since artificial nesting platforms (rafts) were first utilized in Massachusetts in the early 1980s, nesting loons have benefited from their use. Pairs nesting on rafts (33% of nests) have had more success than pairs nesting on natural sites (67% of nests). Between 2013 and 2016, there were 36 nest attempts on rafts, and 31 were successful (86%), hatching 49 chicks. A total of 72 pairs nested naturally, and 25 were successful (35%) in hatching 37 chicks.

Banding efforts first occurred in 1999 and have continued annually through 2017. During the five year period of 2013-2017 a total of 47 loons were banded and 107 loons have been banded since 1999. Among Massachusetts breeding loons, we observed a higher rate of annual breeding site fidelity compared to other North American breeding populations. During 2013-2017, we observed a 92% fidelity rate (145 returns to a territory from a potential 158 possibilities) among adult loons. Male and female fidelity rates were the same (92%). Loon survival information from the Massachusetts banding data is limited, due in part to a relatively small number of individually marked loons statewide.

Massachusetts loon productivity and survivorship measures are needed to fulfill the U.S. Fish & Wildlife's (USFWS) Natural Resource Damage Assessment (NRDA) objectives including determining the number of loon years gained from proposed loon restoration actions following the 2003 Bouchard Barge 120 oil spill (B-120). Overall, the Massachusetts long-term (1983-2017) loon productivity rate (0.54 ± 0.37) exceeded the 0.48 threshold estimated to maintain a sustainable population. However, loon productivity rates over the past two decades have declined and now the average for the past 10 years (0.38 ± 0.13) falls below the sustainability threshold. Conversely, site fidelity of breeding adult loons is higher than rates found across New England and the Great Lakes (92% vs. 80%).

Key site-specific demographic parameters, such as productivity and survivorship, will be critical for confidently quantifying how different restoration efforts will ultimately meet the needs of NRDA projects, such as the B-120.

2.0 INTRODUCTION

As a result of human activities, breeding Common Loons (*Gavia immer*) in Massachusetts were extirpated early in the 20th century (Forbush 1925). In 1975, a single nesting pair was discovered on Quabbin Reservoir (Clark 1975; Blodget and Lyons 1988). Following the discovery of this nesting pair, MassWildlife initiated annual monitoring of loon breeding activity on Quabbin Reservoir. Since the early 1980s, DCR has conducted a loon monitoring and management program to annually record and protect the reproductive effort of loons on their water supply reservoirs; primarily Quabbin and Wachusett Reservoirs. More recently (2011-2017), MassWildlife, BRI, and others have conducted surveys on non-DCR waterbodies across the state with a focus on central Massachusetts. Common Loons are protected under the Federal Migratory Bird Treaty Act and are designated as a Species of Special Concern under the Massachusetts Endangered Species Act.

Since 1999, BRI has partnered with DCR in a long-term mercury (Hg) monitoring study on DCR water supply reservoirs, using the loon as an ecological indicator of water quality (Gray et al. 2017). Each season, BRI and DCR biologists visited loon territories containing pairs with young and captured adults and chicks in order to collect blood for Hg screening. Additionally, each captured adult was uniquely color-marked with plastic leg bands to facilitate subsequent monitoring of each loon's breeding history and associated Hg exposure and accumulation.

During 2013-2017, BRI biologists provided dedicated staff to support existing state agency loon survey efforts, while independently expanding state-wide surveys and color-marking efforts to help fill critical data gaps. Field research efforts emphasized broad survey coverage to assure a reasonable accounting of the current state loon pairs and productivity data. Additionally, specific information was collected for confirming annual adult survivorship, breeding site fidelity, and return rates of adults marked as juveniles, through the capture and marking of loons and subsequent band re-observations. These collaborative efforts have developed a more robust dataset and have documented the re-colonization of the Common Loon to Massachusetts in greater detail. Data gathered during the most recent five-year period enables us to summarize statewide loon reproductive success and draw comparisons to demographics in other state loon populations.

Understanding and quantifying loon life history parameters is a critical step in assessing the overall sustainability of their populations (Mitro et al. 2008; Grear et al. 2009). A quantitative approach is also useful in determining the scope and magnitude of conservation strategies needed to enhance populations of species impacted by anthropogenic catastrophes, such as oil spills (Sperduto et al. 2003).

In 2003, the Bouchard Barge 120 spill, which occurred in Buzzards Bay, caused the death of more than 500 Common Loons. The U.S. Fish and Wildlife Service, through the NRDA program, identified the Common Loon as one of the primary species requiring conservation efforts to restore bird years lost due to this oil spill (Table 1).

Table 1. Biological parameters used to calculate total loon-years gained per nest protected in North Cape Oil Spill restoration plan.

Demographic Parameters	*Measured or published data*
Productivity gain in protected area	0.22 (CS/TP)
Productivity of offspring	0.48 (CS/TP)
1st year survival rate	0.81
Adult survival rate	0.81 in year 2 0.81 in year 3 0.92 > 3 yrs
Average life expectancy of a newly hatched loon (discounted)	5.77
Average age at first breeding	6 yr
Maximum age	30 yr
Proportion of adult loons that maintain territories	0.80
Discount rate	0.03/yr
Number of nests needed to compensate for the NCOS loss	51
Loon years fledged/nest over 100-yr project life span	63

The following report provides a summary of the Massachusetts breeding Common Loon population, productivity, and survival data sets, and identifies the current data gaps in demographic parameters required for fulfilling NRDA's ecological parameters used to calculate total loon-years gained through conservation actions (e.g. the North Cape oil spill restoration plan; see Table 1).

3.0 OBJECTIVES

Assess the Massachusetts breeding loon population through:

1. Compiling and summarizing long-term loon breeding population and productivity data.
2. Comparing Massachusetts loon productivity and population data to neighboring New Hampshire and Vermont loon data sets.
3. Determining adult and juvenile loon survival rates for Massachusetts loons through band resight and recovery data.

4. Comparing loon survival rates in Massachusetts to previously reported data from New England and the Midwest.
5. Assessing the suitability of Massachusetts loon data sets for determining the number of loon years lost during the oil spill and using NRDA's parameters of productivity and survival.

4.0 METHODS

4.1 Long-term Common Loon Reproductive Monitoring

Lakes, ponds, and reservoirs were surveyed regularly throughout the loon breeding season (May – August) to identify territorial loon pairs, nesting pairs, and chicks surviving to fledge. Methodologies followed standardized protocols developed by the LPC (Taylor and Vogel 2000). We calculated loon productivity as the number of loon chicks surviving to fledge (>6 weeks of age) (CS) per territorial pair (TP), as described in Evers et al. (2008).

We merged long-term loon productivity data (1975-2017) provided by MassWildlife, DCR, and Spagnuolo (2012; 2014) with BRI's 5-year loon productivity results (2013-2017). The combined data set was then compared to similar long-term loon productivity data for New Hampshire (LPC, unpubl. data) and Vermont (Hanson and Buck 2017).

4.2 Capture and Color Marking Breeding Loons

Color marking individual loons combined with annual tracking to confirm their presence / absence allowed us to closely monitor demographic parameters (i.e., site fidelity, seasonal movements, and adult and juvenile survival). Loon pairs brooding young were targeted for capture utilizing a well-established night-lighting and dip-net technique from a boat (Evers 2001). Each captured adult loon was weighed, sexed, measured, uniquely color-banded, and sampled (blood and feathers) for Hg analysis.

4.3 Site Fidelity of Breeding Loons

Monitoring a marked population of breeding loons provides a valuable opportunity to understand the annual adult survivorship and breeding site fidelity of loons in Massachusetts. These parameters, coupled with loon reproductive benchmarks, are used to evaluate population growth and overall sustainability of the Massachusetts breeding loon population. Breeding site fidelity has been previously reported for loons in New England (Evers 2001, 2007) and the Midwest (Piper et al. 2000).

We determined the breeding site fidelity rates of loons in Massachusetts through the re-observation of color-marked adults during 2013-2017. We followed methodologies described in Evers (2001) and Piper et al. (2000).

4.4 Movements of Loons

Movement data collected from loons during their annual cycle provides wildlife resource managers varying resolutions of their movement ecology and habitat associations. Fine-scale movement data (e.g., satellite telemetry) for loons provides precise migration patterns and timing (Kenow et al. 2002, 2009, Paruk et al. 2014, 2015), linkages between breeding and wintering areas (Kenow et al. 2002, 2009, Paruk et al. 2014, 2015), and non-breeding habitat use (Paruk et al. 2015). Recoveries and re-observations of banded loons outside of their breeding lakes can broadly discern linkages between breeding and wintering areas (Paruk et al. 2015).

BRI maintains a comprehensive loon banding, re-observation, and recovery database. Demographic data (e.g., breeding site fidelity, survivorship) collected from various loon monitoring programs across North America are entered into the database after each field season. Band re-observations and recoveries of banded loons compiled from reports by the finder or the Bird Banding Laboratory are also recorded in the database. We queried our database for breeding loons captured and banded in Massachusetts which were encountered (resight or carcass recovery) outside of their breeding lakes to connect breeding locations to wintering areas.

4.5 Adult Survivorship

Annual adult survivorship has been estimated through modeling robust long-term data sets of marked populations from New England and Wisconsin (Mitro et al. 2008). We used these established loon survival rates and other demographic parameters to assess the sustainability of the Massachusetts loon population.

4.6 Juvenile Survivorship

Juvenile survival estimates are achieved through the banding of loon chicks on their natal lakes with subsequent monitoring to determine the proportion of adults banded as juveniles (ABJ) returning to the study area (≥ 3 years later), as described in Mitro et al. (2008) and Piper et al. (2012).

5.0 CURRENT STATUS OF THE MASSACHUSETTS LOON POPULATION

5.1 Status and Distribution of the Massachusetts Population, 2017

Since the recolonization of Common Loons to Massachusetts by a single breeding pair on Quabbin Reservoir in 1975, the state loon population has steadily increased (Spagnuolo 2014) to its 2017 level of 39 pairs on 17 lakes (Attix et al. 2017). The core loon breeding area remains within the north-central Massachusetts area, encompassing Quabbin Reservoir (20 pairs), Wachusett Reservoir (4 pairs), and other small lakes, ponds and reservoirs, mostly clustered in Worcester County (Attix et al. 2017) (Figure 1). Statewide survey efforts in 2017 focused on this core breeding population located in central Massachusetts, with additional surveys of other lakes and ponds across the state where loons have been observed in recent years (Appendix 1).

In examining the geographic distribution of territorial pairs in 2017, the trend of limited dispersal continued for this population. Thirty-seven of the 39 territorial pairs were found in

Worcester County (95%), one territorial pair in Essex County (Crystal Lake, Haverhill), and one territorial pair in Hampden County (Springfield Reservoir, Ludlow). A single pair has been observed on either Upper Reservoir or Buckley-Dunton Lake over the past decade in the Berkshires region, however a pair was not observed in that region in 2017. Other loon significant presence in the Berkshires region includes a successful nesting pair in 2014 on Benedict Pond (BRI unpubl. data) located just over the Massachusetts border in Connecticut and unconfirmed reports of a potential pair on Borden Brook Reservoir. Annual observations of unpaired adults on various lakes in the Berkshires, northeast MA, and central MA regions indicate there is a floater population that annually fluctuates in abundance and distribution; however, recent survey efforts have not been able to estimate numbers or exact locations of these birds.

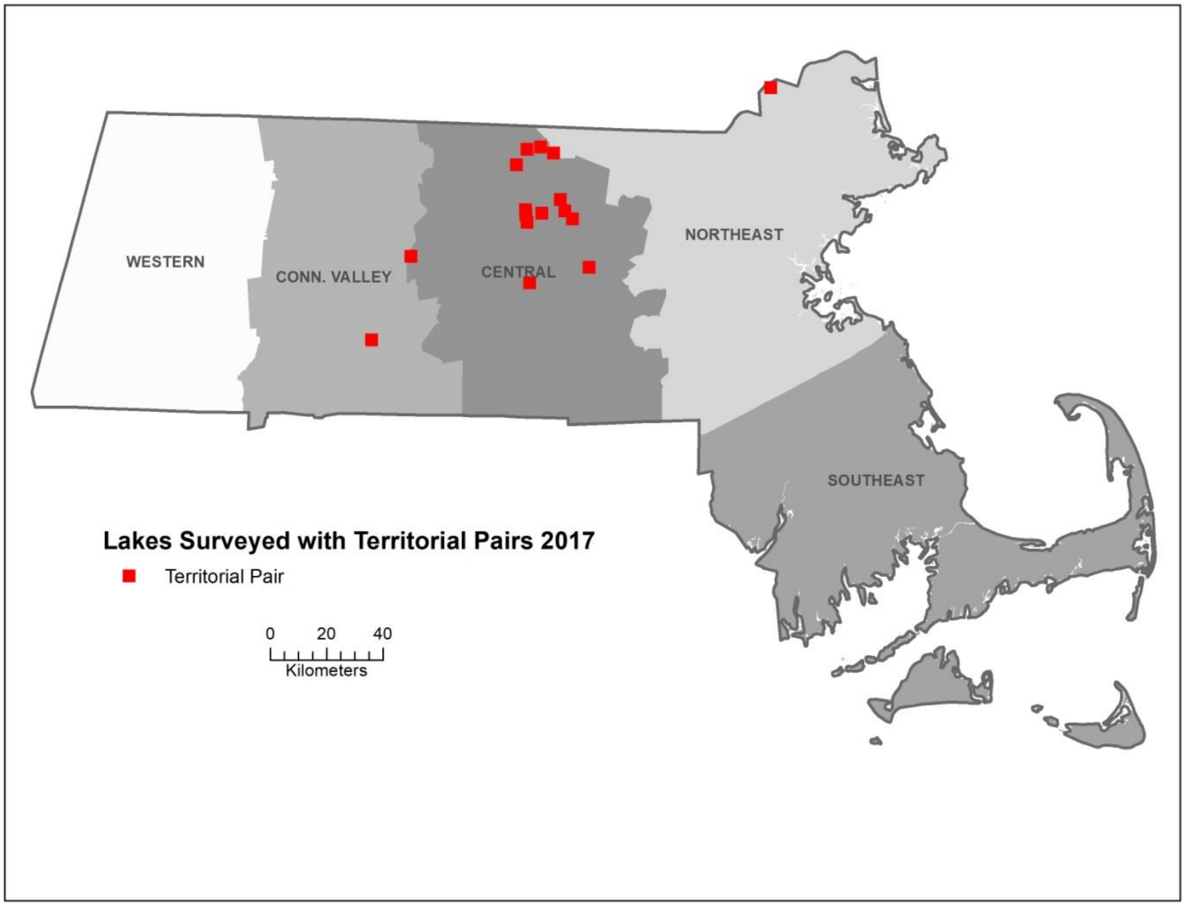

Figure 1: Massachusetts Common Loon Survey results, 2017.

5.2 Productivity Summary, 2017

During the 2017 field season, 99 lakes were surveyed statewide. Thirty-nine territorial pairs were recorded on 17 different lakes. Loons were observed on 42 of the 99 lakes surveyed (Appendix 1). Of the 39 pairs, 33 nested, and 19 successful nests hatched 26 chicks; 16 survived to fledge. This yielded a nesting frequency (NP/TP) of 0.85, a hatching success (CH/NP) of 0.79 young per nest, and chick survival (CS/CH) of 0.62. Productivity statewide was 0.41 chicks surviving per territorial pair (Table 2).

Table 2. Common Loon Population and Productivity in Massachusetts, 2017.

Population		*Reproductive Rate*	
Territorial Pairs (TP)	39	Nesting Frequency (NP/TP)	0.85
Nesting Pairs (NP)	33	Hatching Success (CH/NP)	0.79
Chicks Hatched (CH)	26	Chick Survivorship (CS/CH)	0.62
Chicks Surviving (CS)	16	Overall Productivity (CS/TP)	0.41

6.0 MASSACHUSETTS LONG-TERM LOON MONITORING (1975-2017) AND NEW HAMPSHIRE & VERMONT COMPARISONS

6.1 Long-term Population Summary

The re-colonization of loons to Massachusetts is assessed annually through observation of the number of territorial pairs and the number of occupied lakes. Since re-colonization was first confirmed in 1975 there has been a general increasing trend in the number of territorial pairs.

Examining data from increased survey efforts that began in 2011, the number of loon pairs in the state peaked in 2015, before declining in 2016, and again in 2017. This modest decline over the last two years may be attributable to fluctuations in pair stability and previously observed year-to-year localized fluctuations in productivity. These fluctuations have also been observed throughout the breeding range in New England (BRI unpubl data, LPC unpubl data). Since 2007, growth in the number of territorial pairs has significantly outpaced the growth of occupied lakes (Figure 2). This reflects a large increase in territorial pairs on Quabbin Reservoir from 2007-2017 relative to pairs occupying new lakes.

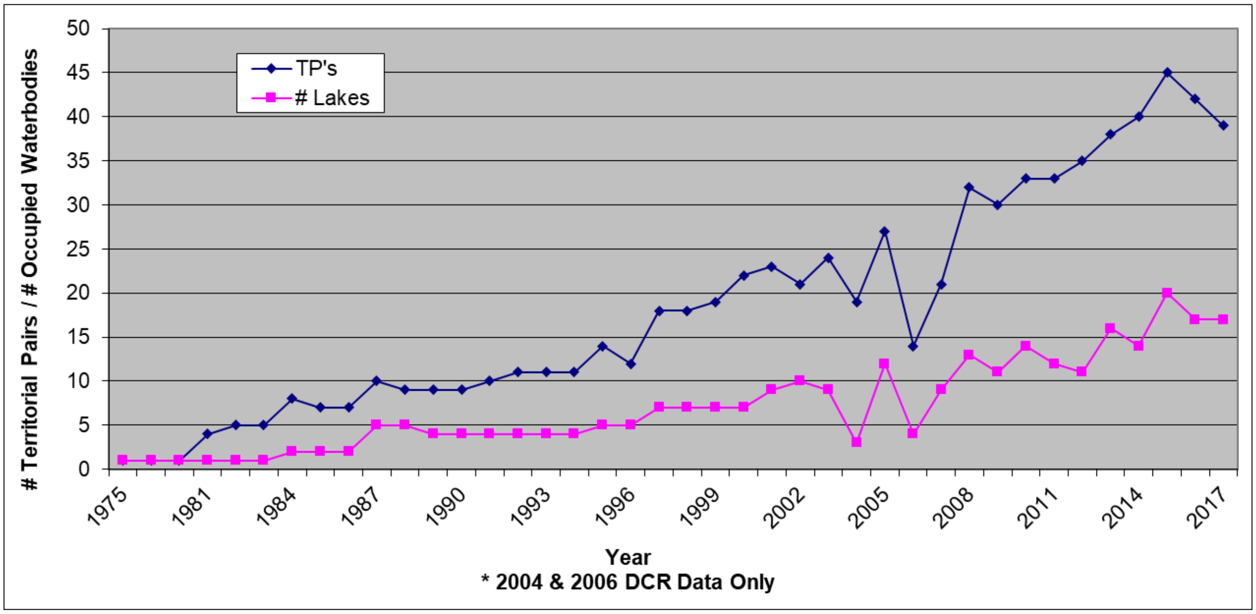

Figure 2. Trends in territorial pairs and lakes occupied in Massachusetts, 1975-2017.

6.2 Long-term Productivity Summary

Long-term productivity is the best indicator of population integrity because it represents the availability of offspring into the breeding pool for a species. Comparisons to neighboring state loon reproductive parameters, aid state and federal agencies and other stakeholders to effectively manage breeding populations of loons.

Productivity is calculated by dividing the number of chicks surviving by the number of territorial pairs (CS/TP) observed in a population or study area. Analysis of long-term data across different populations (Evers 2007; Mitro et al. 2008) showed a stable loon population requires pairs to fledge approximately one chick every other year (0.48 CS/TP). Productivity from 1983-2017 averaged 0.54 +/- 0.37 (CS/TP). In this time period, productivity reached its highest level in 1988 (1.00) and was lowest in 1983 (0.00) (Figure 3).

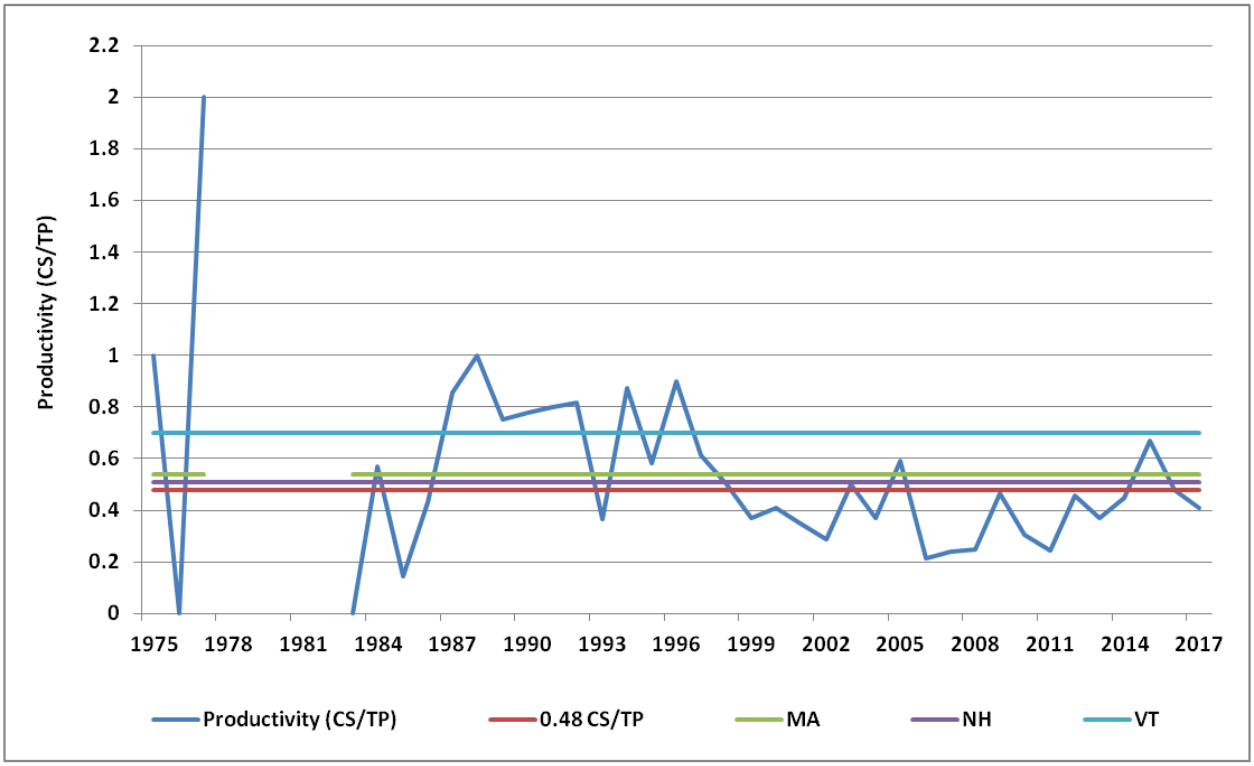

Figure 3. Productivity (CS/TP) of loons breeding in Massachusetts, 1975-1977 and 1983-2017, with comparison to average productivity for New Hampshire and Vermont (1975-2017). Loon data for Massachusetts was not available for 1978-1982.

Loon productivity data provided by the LPC of New Hampshire, and VCE for a time period similar to the data available for Massachusetts provide solid benchmarks for demographic comparisons. During 1976-2017, New Hampshire's productivity was 0.51 +/- 0.08, and Vermont's was 0.70 +/- 0.12. Massachusetts' mean reproductive rate of 0.54 +/- 0.37 is slightly above New Hampshire's long-term average rate of 0.51 +/- 0.08, but below Vermont's long-term average of 0.70 +/- 0.12 (Figure 4).

Massachusetts' productivity over the past 20 years has declined. The 20-year mean is 0.41 +/- 0.13, and the 10-year mean is 0.38 +/- 0.13. In 14 of the last 20 years, the productivity rate has been below 0.48. These recent low productivity rates are well below both New Hampshire and

Vermont 10- and 20-year means (Table 3). Average productivity for the past 20 years (0.41 +/- 0.13 CS/TP) is below self-sustaining level of 0.48 CS/TP (Evers 2007; Mitro et al. 2008).

Table 3. Annual Productivity for Massachusetts, New Hampshire, and Vermont 1997-2017*.

YEAR	CS/TP - MA	CS/TP - NH	CS/TP - VT
1997	0.61	0.47	0.68
1998	0.50	0.30	0.75
1999	0.37	0.48	0.86
2000	0.41	0.59	0.92
2001	0.35	0.53	0.96
2002	0.29	0.59	0.68
2003	0.50	0.67	0.70
2004	0.37	0.61	0.69
2005	0.59	0.55	0.79
2006	0.21	0.48	0.73
2007	0.24	0.46	0.68
2008	0.25	0.39	0.64
2009	0.47	0.41	0.82
2010	0.30	0.47	0.76
2011	0.24	0.55	0.61
2012	0.46	0.48	0.64
2013	0.37	0.42	0.67
2014	0.45	0.53	0.56
2015	0.67	0.60	0.62
2016	0.48	0.50	0.68
2017	0.41	0.43	0.78
20 YEAR MEAN	**0.41 +/- 0.13**	**0.50 +/- 0.086**	**0.72 +/- 0.10**
10 YEAR MEAN	**0.38 +/- 0.13**	**0.48 +/- 0.065**	**0.68 +/- 0.079**

* Below 0.48 population sustainability threshold; * At or above 0.48 sustainability threshold.

7.0 LONG-TERM DEMOGRAPHIC SUMMARY

7.1 Capture and Color-Banding Loons

Since 1999, BRI has worked collaboratively with DCR and MassWildlife to band both adult and juvenile loons in Massachusetts. During this 19-year period, a total of 107 breeding adults (93) and juvenile (14) loons have been captured and color-marked (Table 4 & Appendix 2). Color-marking individuals enables us to distinguish between neighboring pairs, properly delineate territorial boundaries and common feeding areas, and allows more accurate surveys by eliminating incidences of double-counting individuals or pairs. Banding also provides information on inter- and intra- seasonal movements, between-year territory fidelity, mate switching, estimated minimum survival, individual behavior, and loon social dynamics (Evers 2001), and links local breeding populations to key winter habitat. Color-marking juveniles has provided biologists in previous studies with information on loon recruitment rates, dispersal distances, natal site fidelity, and year of first reproduction. These parameters are necessary components for modeling population trends. Many of these findings can then be related to monitoring findings, productivity, and other demographic parameters.

Table 4. Summary of banded loons in Massachusetts 1999-2017.

	Male	Female	Juvenile	Adult (unk[1])	Totals
DCR Waterbodies					
Quabbin Reservoir	26	27	3	1	**58**
Hycrest Reservoir	2	2	-	-	**4**
Paradise Pond	1	1	5	-	**7**
Wachusett Reservoir	6	5	4	-	**16**
DCR Totals	**35**	**37**	**12**	**1**	**85**
Non DCR Waterbodies	8	9	2	3	**22**
State-wide Totals	**43**	**46**	**14**	**4**	**107**

[1]Gender could not be determined.

A marked loon population in conjunction with annual re-observations provides a tool to detect and explain population trends and abnormalities. If a catastrophic event on wintering grounds caused mortality of a significant portion of the Massachusetts population, it could be detected the following year when banded individuals did not return. Findings by Evers (2001) indicate that mate switches, which would be initiated by such an event, could reduce a loon's likelihood to nest by as much as 83%, thereby affecting annual productivity totals.

7.2 Annual Breeding Site Fidelity

Common Loons have been well studied across North America, particularly in the Northeast. From long-term data across different populations, Evers (2007) showed for a Common Loon population to remain stable, a pair needs to fledge approximately one chick every other year (0.48 chicks surviving/territorial pair). Dispersal distances of individuals are extremely limited and therefore loons are poor colonizers of new habitat and slow in recolonizing formerly occupied habitat. Banded juvenile loons returning to freshwater lakes for the first time as adults, show an average dispersal of 13 km from their natal lakes; however dispersal upwards of 92 km has been documented (Evers et al. 2010). Adult loon inter-seasonal movements are much more limited with an average of 4 km and no records of dispersal beyond 20 km (Evers et al. 2010). Females are more likely to disperse farther than males and new territories are more likely to be established near former territories. Across North America, both sexes exhibit a high degree of territory fidelity with 80% of males and 82% of females returning to the same lake or territory in successive years (Evers 2007).

Among Massachusetts loons, we observed a higher rate of annual breeding site fidelity compared to other North American breeding populations. During 2013-2017, there was a 92% fidelity rate (145 returns to a territory from a potential 158 possibilities) among adult loons with male and female territory fidelity rates being identical (92%).

7.3 Movements of Loons

The color-marking and subsequent tracking of loons in Massachusetts has confirmed numerous cases of adults switching territories on Quabbin and Wachusett Reservoirs as well as adults switching lakes on non-DCR waterbodies. Additionally, recoveries and re-observations of color-banded loons outside of their breeding lakes (e.g., coastal wintering locations) provide linkages between breeding and non-breeding areas utilized by loons throughout their annual cycle.

A total of nine loons banded in Massachusetts have been recovered and reported deceased. Of those recoveries, three individuals (3% of the banded population) were recovered outside of the breeding area and breeding season. A female loon banded on Quabbin Reservoir in 2014 was found dead near Wellfleet, Cape Cod, Massachusetts in April of 2015 and a female banded on Quabbin Reservoir in 2010 was recovered in Nantucket Sound, Massachusetts in April 2013. A male banded on Wachusett Reservoir in 2015 was recovered dead in the Sakonnet River, Rhode Island (between Narragansett Bay and Buzzards Bay) in December 2017. Similar percentages of banded loons recovered outside their breeding areas have been documented for Maine (4%), New Hampshire (5%), New York (3%), and Vermont (6%) (Table 5).

Table 5. The total number of Common Loons banded, percentage of overall recoveries, and winter location recovery/re-observations by state.

Banding location	# of loons banded	# band recoveries	% banded loons recovered	% band recoveries on wintering locations
MA	102	9	9%	(3) 3%
ME	974	94	10%	(40) 4%
NH	501	64	13%	(23) 5%
NY	457	46	10%	(12) 3%
VT	52	6	12%	(3) 6%

On wintering grounds, Common Loons appear to maintain a small wintering home range and also appear to return to the same wintering area in consecutive seasons (Paruk et al. 2015). Recovery data from breeding loons banded in New England and New York and recovered on wintering areas ranged from coastal Canada to Florida. Coastal Maine (35%) and Cape Cod, Massachusetts (36%) accounted for 71% of all wintering areas and was followed by the mid-

Atlantic (10%; New Jersey to North Carolina), southern New England (8%; Connecticut and Rhode Island), Long Island, New York (6%), and coastal New Hampshire (4%) (Table 6). One loon banded in Maine was recovered near Prince Edward Island, Canada and another loon banded in New York was re-sighted alive in Florida.

Table 6. Total numbers, percentages, and locations of Common Loons recovered or re-observed on wintering areas (coastal), 1993-2017.

	Recovery Location							
Banding location	**Canada**	**ME**	**MA[1]**	**NH**	**CT/RI**	**LI[2]**	**Mid[3]**	**FL**
ME	1	17	14	3	1	2	2	
MA			2		1			
NH		11	10		2			
NY			1		2	2	6	1
VT			2			1		
Totals	**1 (1%)**	**28 (35%)**	**29 (36%)**	**3 (4%)**	**6 (8%)**	**5 (6%)**	**8 (10%)**	**1 (1%)**

[1]Massachusetts: areas of coastal Massachusetts
[2] Long Island: areas surrounding the New York coastlines of Long Island.
[3]Mid-Atlantic: areas ranging from New Jersey south to North Carolina.

Satellite telemetry data collected from 12 breeding loons in New York (Kenow et al. 2002) generally identified similar wintering locations to band recovery data. Nine satellite marked loons from New York wintered in coastal areas of Cape Cod, Rhode Island, Connecticut, and New Jersey. Among band recovery data, 67% (8/12) of the loons banded in New York shared similar wintering areas as the satellite marked birds. The remaining four satellite marked loons were recovered in coastal Delaware, Virginia, North Carolina, and Florida. Wintering data were also collected by satellite telemetry from six breeding loons from Maine (n=1; Kenow et al. 2002) (n=5; Paruk et al. 2015). The wintering areas ranged from coastal Maine to Chesapeake Bay with the majority wintering in Maine and Cape Cod (67%; 4/6). Similarly, band recovery data from Maine breeding loons ranged from Prince Edward Island, Canada to North Carolina, with the majority recovered in coastal Maine and Cape Cod (78%; 31/40).

Satellite telemetry data and band recovery/re-observation occurrences complimented each other in outlining loon wintering ranges on the Atlantic coast. Limited wintering period band recoveries of Massachusetts breeding loons appear related to the total number of loons banded statewide. The recovery rate of banded loons from Massachusetts (9%) is similar to rates among other New England and New York breeding populations (10-13%).

7.4 Adult Loon Survival

A comprehensive study combining New England and Midwest loon data reported an adult Common Loon survival rate of 0.92 (n=776) (Mitro et al. 2008). Population studies utilizing band recovery data of Arctic Loons (*Gavia arctica*) (Nilsson 1977) and satellite telemetry of Red-throated Loons (*Gavia stellata*) (Schmutz 2014) determined slightly lower adult survival rates, 0.89 and 0.84, respectively. Overall, loon survival rates appear relatively high and static, which is similar to the life histories for most long-lived sea bird species (Schmutz 2009). Due to the small number of loon recoveries (n=9), we were unable to confidently calculate the Massachusetts loon survival rates. Given the high rate (92%) of adult loon breeding site fidelity and low number of observed mortalities, we expect Massachusetts adult loon survival rates to be sustainable and similar or exceeding 0.92, as calculated in Mitro et al. (2008).

7.5 Juvenile Loon Survival

Multiple studies have quantified juvenile Common Loon survival rates and resulted in similar estimates. Mitro et al. (2008) modeled the rate of juvenile loons surviving to return as adults to be 45% based on combined recoveries of banded juveniles from New England and Wisconsin (n=450) during 1993-2001. Similarly, Piper et al. (2012) reported banded juvenile loon survivorship to adulthood was 46% in Wisconsin during 1992-2009 (n = 381).

As part of DCR and BRI's annual mercury monitoring effort, we emphasized the capture and sampling of adult loons for use as aquatic bio-indicators. As a result, few juvenile loons have been captured and banded. During 1999-2017, a total of 14 juvenile loons were banded in Massachusetts. Of those 14 individuals, one juvenile (7%) has been documented as returning as an adult banded as a juvenile (ABJ). This male loon was banded on Wachusett Reservoir in

2001 as a chick, and returned to his natal lake to breed successfully in 2007at six years of age. He was last resighted in 2016 in the Wood Island territory of Wachusett Reservoir. A nest camera confirmed he was one of three different males who copulated with the same banded female occupying the territory; all attempts were unsuccessful.

Additionally, an ABJ was observed on Mare Meadow Reservoir in 2013. Through band re-observations and recaptures, we identified the loon as originally banded on Squam Lake, NH in 2001. Confirming her bands each year since 2013, we were able to determine she switched lakes in 2016, moving from Mare Meadow Reservoir in Westminster to Bickford Pond in Westminster/Hubbardston. She returned this location in 2017, and successfully bred, hatching two chicks, and fledging one. Her dispersal of approximately 135 km from her natal lake far exceeds the historical average dispersal distance of 13 km (Evers 2007). A more recent study in Wisconsin reported 100% juvenile loon dispersal >25-30km (Piper et al. 2012). The latter study occurred in Wisconsin in an area with high densities of lakes and loon pairs which may have caused a larger dispersal distance of ABJ's seeking a breeding lake.

As part of the loon chick relocation project (2015-2017), 24 chicks have been translocated to southeastern Massachusetts from Maine and New York natal lakes. Each juvenile loon was banded and either captive-reared then released or direct released onto lakes in the Assawompset Pond Complex. Progress updates from this study can be found in a separate BRI report (Kneeland et al. 2018).

7.6 Other Loon Reproductive and Demographic Parameters

Use of Nesting Rafts

Analysis of Massachusetts loon management efforts confirms that rafts continue to be an important conservation tool for aiding the success rate of nesting loon pairs who utilize them (Desorbo et al. 2007, Spagnuolo 2012, Attix et al. 2017). DCR first introduced rafts in the 1980s on Quabbin and Wachusett Reservoirs. Data from these reservoirs over the last five years (2013-2017) indicates nest attempts on rafts were far more successful (86%), versus natural nest attempts (35%). Over this same period, pairs nesting on rafts hatched 49 (57%) of the 86 chicks hatched, while pairs nesting naturally hatched a total of 37 (43%) of the 86 chicks hatched (Table 7).

Table 7. Comparative Loon Nesting Summary of Raft Nests vs. Natural Nests, Quabbin and Wachusett Reservoirs, 2013 -2017.

Raft Nests	***2013-2017***	***Natural Nests***	***2013-2017***
Number of Nest Attempts	36	Number of Nest Attempts	72
Number of Successful Nest Attempts	31	Number of Successful Nest Attempts	25
Success Rate	***86%***	***Success Rate***	***35%***
Chicks Hatched from Rafts	49	Chicks Hatched from Natural Sites	37
Total Chicks Hatched	86	Total Chicks Hatched	86
Percentage of Total Chicks Hatched	***57%***	***Percentage of Total Chicks Hatched***	***43%***

<u>Loon Longevity Records</u>

The known maximum longevity of a wild Common Loon is a female banded as a breeding adult (≥ 6 years of age) in New Hampshire in 1993 and re-sighted annually through the 2017 breeding season (≥ 30 years of age) (BRI unpubl. data). In Massachusetts, the oldest known loon is a female banded as a breeding adult (≥6 years of age) on Wachusett Reservoir in 2000 (≥ 23 years of age). Several other older loons from Massachusetts ranging in age ≥ 20-22 years are currently returning each season (Table 8).

Table 8. Adult loons from Massachusetts re-sighted in 2017 and originally banded in 2000-2003.

Band Number	Capture Date	Age	Sex	Original Lake	Original Territory	Current Lake	Current Territory
0898-06410	7/27/2000	ATY	F	Wachusett Reservoir	Crescent	Wachusett Reservoir	Wood Island
0649-08831	7/5/2001	ATY	M	Hycrest	Hycrest	Hycrest	Hycrest
0938-15236	7/25/2001	ATY	F	Quabbin Reservoir	Boat Area 2	Quabbin Reservoir	Boat Area 2
0938-15377	7/25/2001	ATY	M	Quabbin Reservoir	Russ Mountain	Quabbin Reservoir	Russ Mountain
0938-15264	7/8/2002	ATY	M	Wampanoag	Wampanoag	Wampanoag	Wampanoag
0938-15315	7/23/2002	ATY	F	Quabbin Reservoir	Boat Area 3	Quabbin Reservoir	Den Hill
0938-30821	7/28/2003	ATY	F	Paradise Pond	Paradise Pond	Haynes Reservoir	Haynes Reservoir
0938-30900	7/28/2003	ATY	M	Paradise Pond	Paradise Pond	Wachusett Lake	Wachusett Lake
0938-30810	7/20/2003	ATY	F	Quabbin Reservoir	Target	Quabbin Reservoir	Target

Age of First Breeding

A comprehensive loon demographic study in the Midwest reported loons first return to breeding lakes as adults at 3-5 years of age, but were not observed paired and securing a breeding territory (Evers et al. 1997). Common Loons secure a breeding territory on average at 6 years of age (range 4-11 yrs) (Evers et al. 1997 McIntyre and Barr, 1997; Evers et al. 2000; Evers, 2007; Mitro et al., 2008; Grear et al., 2009). The ABJ from Massachusetts was first observed on a breeding lake and paired at age six, complimenting findings from Evers et al. (1997).

Unpaired Adults (loons not mated in a territory)

Population counts for Common Loons in New Hampshire and Vermont include overall estimates, including both breeding pairs and unpaired adults; defined as breeding age adults not mated in a territory. Time and staffing limitations in Massachusetts have not allowed an accurate estimate of non-breeding adult numbers; however, on average 19% of the adult population is unpaired annually in New Hampshire (LPC unpubl. data).

8.0 DISCUSSION

Territorial loon pairs in Massachusetts have generally increased since 1975, however their rate of recolonization have been more gradual than the recovering loon populations in New Hampshire (Spagnuolo 2014) and Vermont (Hanson and Buck 2017).

Several factors have likely contributed to the differences between the three loon populations. Unlike Massachusetts, the New Hampshire and Vermont loon populations were never extirpated. Having reached a historical low of 67 territorial pairs statewide in 1975, New Hampshire's loon population currently holds 296 pairs (J. Cooley pers. comm.). Similarly, Vermont's loon population supported 12 pairs in 1983 and has steadily increased to 117 pairs in 2016 (Hanson and Buck 2017).

Long-term comprehensive loon management practices in New Hampshire and Vermont have also accelerated the growth of their loon populations. In 1975, LPC was formed in New Hampshire over the concern for the rapidly declining number of loon pairs within the state. LPC began constructing and introducing rafts, roping off loon nest sites (exclosures), and implementing signage and other forms of outreach to educate residents and recreationists on breeding loon. Over 40 years later, loon studies demonstrating the effectiveness of rafts in enhancing loon reproductive success (Desorbo et al. 2007) have confirmed LPC's early management actions. Protecting nesting and brooding loons through exclosures and educational signage also appear beneficial to overall loon reproductive success (LPC unpub. data; Spagnuolo 2012; Hanson and Buck 2017).

The first loon raft in Massachusetts was deployed in the early 1980s, and gradual introductions of additional rafts over the time, culminated in a raft management program of 22 rafts floated as of 2017. Nesting exclosures and signage have been rarely used in Massachusetts with only Paradise Pond benefiting from ropes and signs in 2003 and 2005.

An assessment of Massachusetts waterbodies for the potential to support additional loon pairs determined suitable habitat is abundant and could support 295 pairs state-wide if anthropogenic impacts are mitigated (e.g. human disturbance of nest sites and brooding areas, loss of nesting habitat due to shoreline development, etc.). This carrying capacity estimate adapted from methods developed by LPC and BRI, excluded Cape Cod, the islands of Nantucket and Martha's Vineyard, and lakes within large city limits, all of which are not likely to support loon dispersal and colonization (Spagnuolo 2014).

Loon survival data from the Massachusetts datasets are limited. Only eight banded loons have been recovered and one ABJ documented from loons banded in Massachusetts. Previous studies have reported a 0.92 survival rate for Common Loons from New England and Wisconsin (Mitro et al. 2008). Massachusetts loon pairs have a high rate of fidelity to breeding lakes (92%) and survival rates would likely be similar to findings in Mitro et al. (2008).

Loon productivity and survivorship measures are needed to fulfill NRDA's objectives of determining the number of loon years lost as a result of instances of high loon mortality documented during the B-120 oil spill. Overall, the long-term (1983-2017) productivity (0.54 ± 0.37 CS/TP) for Massachusetts exceeds the 0.48 threshold required to maintain a sustainable population (Evers 2007); However, loon productivity rates over the past two decades have steadily declined, resulting in 10-year (0.38 ± 0.13) and 20-year (0.41 ± 0.13) averages falling below the sustainability threshold. These periods of low productivity have been driven by the number of territorial pairs exceeding the number of chicks fledged annually. This trend can be partially be attributed to newly colonized lakes and newly formed territories exhibiting poor productivity early on in occupation by a pair(s) (Spagnuolo 2012, Spagnuolo 2014), and sometimes experiencing poor productivity for extended periods.

9.0 FURTHER NEEDS

Monitoring and banding efforts have allowed a detailed examination and understanding of the Massachusetts breeding loon population's demographics and natural history as well as comparisons and benchmarking with neighboring state populations. Additional data is required to more fully understand the biological parameters used in NRDA's calculations for loon-years gained through conservation actions resulting from the B-120 oil spill. These knowledge gaps and recommendations to address them are presented in the following sections.

Adult and Juvenile Survivorship and Breeding Site Fidelity

The monitoring of banded breeding loons in Massachusetts should continue during the breeding season. The annual count of returning loons and their associated reproductive outcomes will allow the refinement of the demographic parameters required to model loon years lost due to oil spills.

Translocated Loon Chick Return Rates & Dispersal

Documenting the successful fledging, returning, and breeding of translocated loon chicks is important for guiding restoration plans aiming to utilize translocation methods as part of an effort to restore loon years lost. Translocated chicks have fledged from both captive rearing and direct release approaches; however, their successful return as adults has yet to be documented. Monitoring of southeastern Massachusetts, as part of the continued state-wide monitoring effort, to re-sight returning loons translocated to Massachusetts should be conducted in 2018 onward. If returned translocated loons are discovered, they should be followed to document habitat use, movements, and any territorial behavior.

Wintering Range and Winter Site Fidelity

Few wintering band resights and recoveries have occurred for Massachusetts loons due to the small number of banded loons and difficulty of obtaining these data points. In order to increase the understanding of this aspect of the population's natural history, satellite telemetry tracking devices (PTT - Platform Transmitter Terminal) or new implantable cell tower transmitters (CTTs) should be deployed on male Massachusetts loons. Data obtained from this effort would provide insight into migration timing and pathways, wintering locations, and winter home range. Alternatively, the geolocator approach to investigating wintering loons requires recovery of the devices in subsequent breeding seasons and the resulting location data lacks precision (100+ km spread in data points).

Massachusetts Habitat Assessment and Carrying Capacity

Prior to extirpation, loons occupied a large part of Massachusetts, but have only recolonized a small portion of their former range in the state. Carrying capacity estimates by Spagnuolo (2014) reported quality breeding habitat across the state as well as the potential for 295 territorial pairs. This effort could be revised and refined to better understand the potential population gains from loon restoration efforts in targeted areas (i.e., southeastern Massachusetts and the Berkshires regions).

Comparison of NRDA-related demographic factors

Based on parameters measured used by the NRDA process for determining the injury to Common Loons during the North Cape Oil Spill (Sperduto et al. 2003), we compared the data collected in Massachusetts with the data used by the trustees (Table 9). Minor differences in the demographic parameters can play significant roles in changing the ultimate injury that is calculated.

In this report, we describe the reproductive success of the loon breeding population in Massachusetts since re-occupancy in 1975 (42 years). For the first 20 or so years of recovery (until the late 1990s), productivity (i.e., chicks surviving/territorial pair; CS/TP) exceeded the 0.48 CS/TP stable population threshold, which was responsible for a growing population. However, for the past 10 years, it is well under – 0.38 CS/TP (Tables 3 and 9). Another parameter that differed in Massachusetts is the proportion of adult loons that maintain territories (i.e., breeding territory site fidelity) – 92% vs. 80% (Table 9). This is likely because overall adult survivorship is higher than other areas and/or there are lower intrusion rates from conspecifics without territories (likely the latter).

Improving the resolution on the current knowledge about breeding and wintering loon populations in Massachusetts that are of interest to governmental agencies is needed for several demographic parameters.

Table 9. NRDA demographic parameters used to calculate total loon-years gained with known Massachusetts-specific data compared to those data used for the North Cape Oil Spill*.

NRDA demographic parameters of interest	Massachusetts-specific data (from this report)	North Cape Oil Spill data (Sperduto et al. 2002)
Productivity of offspring (CS/TP) – for past 10 years	0.38	0.48
1st year survival rate	unknown	0.81
Adult survival rate	0.81 in year 2 0.81 in year 3 0.92 > 3 yrs	0.81 in year 2 0.81 in year 3 0.92 > 3 yrs
Average life expectancy of a newly hatched loon (discounted)	5.77	5.77
Average age at first breeding	6 yr	6 yr
Maximum age	30 yr	30 yr
Proportion of adult loons that maintain territories	0.92	0.80

*Demographic parameters are shaded when they differ.

10.0 ACKNOWLEDGMENTS

Biodiversity Research Institute gratefully acknowledges the support of the Ricketts Conservation Foundation for funding the *Restore the Call* initiative which spanned the 5-year period 2013-2017. We thank Drew Vitz, Bridget McAlice, and Tom French of MassWildlife as well as Dan Clark, Jillian Whitney, Ken MacKenzie, and Kiana Koenen of MADCR for their support of our efforts, providing data, and their contributions to the study of Common Loons in Massachusetts. We would also like to thank John Cooley of LPC and Eric Hanson of VCE for providing data and insight for the comparisons of these state populations. We also thank all the BRI seasonal biologists and other surveyors for helping collect the data for this report.

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Appendix 1. Massachusetts Common Loon lake occupancy and productivity summary, 2017.

Lake Name	Town	Territory Name	Territorial Pair	Nesting Pair	Chicks Hatched	Chicks Surviving	Lakes w/ Loons
Ashby Reservoir	Ashby	Ashby	0	0	0	0	
Ashland Reservoir	Ashland	Ashland	0	0	0	0	
Asnacomet Pond	Hubbardston	Asnacomet	0	0	0	0	1
Assawompset Pond	Lakeville/Middleborough	Assawompset	0	0	0	0	1
Bickford Pond	Hubbardston/Princeton	Bickford	1	1	2	1	1
Big Pond	Otis	Big Pond	0	0	0	0	
Billington Sea	Plymouth	Billington Sea	0	0	0	0	
Buckley-Dunton Lake	Becket	Buckley-Dunton	0	0	0	0	1
Chauncy Lake	Westborough	Chauncy	0	0	0	0	
Chebacco Lake	Essex/Hamilton	Essex	0	0	0	0	
Cheshire North Reservoir	Cheshire	Cheshire North	0	0	0	0	
Cheshire South Reservoir	Cheshire	Cheshire South	0	0	0	0	
Cleveland Brook Reservoir	Hinsdale	Cleveland Brook	0	0	0	0	1
Crocker Pond	Westminster	Crocker Pond	0	0	0	0	
Crystal Lake	Gardner	Crystal Lake - Gardner	0	0	0	0	1
Crystal Lake	Haverhill	Crystal Lake - Haverhill	1	1	1	0	1
E. Waushacum Pond	Sterling	E. Waushacum	0	0	0	0	
East Brimfield Lake/Long Pond	E. Brimfield	East Brimfield	0	0	0	0	
Fallbrook Reservoir	Leominster	Fallbrook	1	0	0	0	1
Farm Pond	Framingham	Farm Pond	0	0	0	0	1*
Federal Pond	Carver	Federal	0	0	0	0	
Fitchburg Reservoir	Ashby	Fitchburg	1	1	0	0	1

Lake Name	Town	Territory Name	Territorial Pair	Nesting Pair	Chicks Hatched	Chicks Surviving	Lakes w/ Loons
Ft. Meadow Reservoir	Marlborough	Ft. Meadow	0	0	0	0	
Goose/Upper Goose	Tyringham	Goose	0	0	0	0	
Great Herring Pond	Cedarville	Great Herring	0	0	0	0	
Great Pond	S. Weymouth	Great Pond - W	0	0	0	0	
Great Quittacas	Lakeville	Great Quittacas	0	0	0	0	1
Great Sandy Bottom Lk	Bryantville	Great Sandy Bottom	0	0	0	0	
Greenwater Pond	Becket	Greenwater	0	0	0	0	
Haggetts Pond	Andover	Haggetts	0	0	0	0	
Halfway Pond	Plymouth	Halfway Pond	0	0	0	0	
Haynes Reservoir	Leominster	Haynes	1	0	0	0	1
Heywood Reservoir	Leominster/Sterling	Heywood	0	0	0	0	
Hopkinton Reservoir	Hopkinton	Hopkinton	0	0	0	0	
Hycrest Pond	E. Princeton	Hycrest	1	1	2	2	1
Kendall Reservoir	Holden	Kendall	0	0	0	0	
Kenoza Lake	Haverhill	Kenoza	0	0	0	0	1*
Lake Buel	Monterey	Buel	0	0	0	0	
Lake Cochichewick	Essex/Hamilton	Cochichewick	0	0	0	0	1*
Lake Garfield	Monterey	Lake Garfield	0	0	0	0	
Lake Mattawa	Orange	Mattawa	0	0	0	0	
Lake Nippenicket	W. Bridgewater	Nippenicket	0	0	0	0	
Lake Pearl	Wrentham	Pearl	0	0	0	0	1
Lake Rico	Taunton	Rico	0	0	0	0	
Lake Waban	Wellesley	Waban	0	0	0	0	
Laurel Lake	Lee	Laurel Lake	0	0	0	0	
Leverett Pond	Leverett	Leverett	0	0	0	0	

Lake Name	Town	Territory Name	Territorial Pair	Nesting Pair	Chicks Hatched	Chicks Surviving	Lakes w/ Loons
Little Quittacas	Lakeville/Rochester	Little Quittacas	0	0	0	0	
Littleville Lake	Chester	Littleville	0	0	0	0	
Lower Naukeag	Ashburnham	Lower Naukeag	0	0	0	0	1*
Mare Meadow Reservoir	Westminster/Hubbardston	Mare Meadow	1	0	0	0	1
Mare Meadow Reservoir - N	Westminster/Hubbardston	Mare Meadow - N	1	1	0	0	1
Mascuppic Lake	Tyngsborough	Mascuppic	0	0	0	0	
Massapoag Lake	Sharon	Massapoag Lake	0	0	0	0	
Meetinghouse Pond	Westminster	Meetinghouse	0	0	0	0	1
Monponsett Pond	Monponsett	Monponsett	0	0	0	0	
Moosehorn	Hubbardston	Moosehorn	0	0	0	0	1
Nagog Pond	Acton	Nagog	0	0	0	0	
Norwich Pond	Huntington	Norwich	0	0	0	0	
Notown Reservoir	Leominster	Notown	1	1	0	0	1
Noyes Pond	Tolland	Noyes	0	0	0	0	
O'Loughlin	New Salem	O'Loughlin	0	0	0	0	1
Onota	Pittsfield	Onota	0	0	0	0	1
Otis Reservoir	Otis/Tolland/Blandford	Otis	0	0	0	0	1
Paradise Pond	Princeton	Paradise	0	0	0	0	1
Pelham Lake	Rowe	Pelham	0	0	0	0	
Pine Hill Reservoir	Rutland	Pine Hill	1	1	1	1	1
Plainfield Pond	Plainfield	Plainfield	0	0	0	0	
Pocksha Pond	Middleborough	Pocksha	0	0	0	0	1
Ponkapoag Pond	N. Randolph	Ponkapoag	0	0	0	0	
Pontoosuc	Pittsfield	Pontoosuc	0	0	0	0	
Pottapaug	New Salem	Pottapaug	0	0	0	0	

Lake Name	Town	Territory Name	Territorial Pair	Nesting Pair	Chicks Hatched	Chicks Surviving	Lakes w/ Loons
Putnamville Reservoir	Danvers	Putnamville	0	0	0	0	
Quabbin Reservoir	New Salem	Boat Area 2	1	1	2	1	1
Quabbin Reservoir	New Salem	Hamilton W./Moosehorn	1	1	2	1	
Quabbin Reservoir	Petersham	Moore - Eagle Tree	1	1	1	1	
Quabbin Reservoir	Petersham	Moore - Pipe	1	1	0	0	
Quabbin Reservoir	New Salem	Hop Brook	1	0	0	0	
Quabbin Reservoir	New Salem	Russ Mountain	1	1	0	0	
Quabbin Reservoir	New Salem	Target Island	1	1	1	1	
Quabbin Reservoir	New Salem	Townline	1	1	0	0	
Quabbin Reservoir	Hardwick	Boat Area 3	1	1	0	0	
Quabbin Reservoir	Hardwick	Den Hill	1	1	0	0	
Quabbin Reservoir	Petersham	Graves Landing	1	1	0	0	
Quabbin Reservoir	Petersham	Townsend	1	1	0	0	
Quabbin Reservoir	Petersham	Fever Brook	1	1	1	1	
Quabbin Reservoir	Petersham	Gulf Brook	0	0	0	0	
Quabbin Reservoir	Hardwick	Parker Island	1	0	0	0	
Quabbin Reservoir	New Salem	Prescott	1	1	1	1	
Quabbin Reservoir	Pelham/New Salem	West Arm	1	1	1	1	
Quabbin Reservoir	Petersham	Purgee Brook	1	1	0	0	
Quabbin Reservoir	Petersham	Phragmites	1	0	0	0	
Quabbin Reservoir	Belchertown	Boat Area 1	1	1	0	0	
Quabbin Reservoir	New Salem	Sandbar	1	1	1	1	
Quabbin Reservoir	Petersham	Carrick	0	0	0	0	
Quabbin Reservoir	Petersham	Dragonfly	0	0	0	0	

Lake Name	Town	Territory Name	Territorial Pair	Nesting Pair	Chicks Hatched	Chicks Surviving	Lakes w/ Loons
Quaboag Pond	Brooksfield	Quaboag	0	0	0	0	1*
Quinapoxet Reservoir	Holden/Princeton	Quinapoxet	0	0	0	0	1
Richmond Pond	Richmond	Richmond	0	0	0	0	
Sampson Pond	S. Carver	Sampson	0	0	0	0	
Shaw Pond	Becket/Berkshire Hills	Shaw	0	0	0	0	
Snipatuit Pond	Rochester	Snipituit	0	0	0	0	
Springfield Reservoir	Ludlow	Springfield	1	1	1	1	1
Stockbridge Bowl	Stockbridge	Stockbridge	0	0	0	0	1
Stodge Meadow	Ashburnham	Stodge Meadow	1	1	2	1	1
Sudbury Reservoir	Marlborough/Southborough	Sudbury	0	0	0	0	1
Sunset Lake	Ashburnham	Sunset	0	0	0	0	1
Thousand Acre Swamp	New Marlborough	Thousand Acre	0	0	0	0	
Tully Lake	Royalston	Tully	0	0	0	0	
Upper Naukeag	Ashburnham	Upper Naukeag	1	1	0	0	1
Upper Reservoir	Lee	Upper Reservoir	0	0	0	0	1
W. Waushacum Pond	Sterling	W. Waushacum	0	0	0	0	
Wachusett Lake	Westminster	Wachusett Lake	1	1	2	0	1
Wachusett Reservoir	Boylston	South Bay	1	1	?	1	1
Wachusett Reservoir	Clinton	Cemetery	0	0	0	0	
Wachusett Reservoir	Sterling	Crescent Island	1	1	1	0	
Wachusett Reservoir	Boylston	Hastings Cove	1	1	2	1	
Wachusett Reservoir	Boylston	Wood Island	1	1	0	0	
Wampanoag	Gardner	Wampanoag	1	1	2	0	1
Wenham Lake	Wenham	Wenham	0	0	0	0	
Whitehall Reservoir	Woodville	Whitehall	0	0	0	0	

Lake Name	Town	Territory Name	Territorial Pair	Nesting Pair	Chicks Hatched	Chicks Surviving	Lakes w/ Loons
Willet Pond	Norwood	Willet	0	0	0	0	
Windsor Pond	Windsor	Windsor	0	0	0	0	
Wyola	Shutesbury	Wyola	0	0	0	0	
Yokum Pond	Becket	Yokum	0	0	0	0	
		Totals	**39**	**33**	**26**	**16**	**42**

*unconfirmed citizen data

Appendix 2. List of breeding loons banded in Massachusetts, 1999-2017.

Lake	Territory	Sex	Date	Age
DCR:				
Quabbin Reservoir	Boat Area 1	F	7/5/2017	ATY
Quabbin Reservoir	Boat Area 2	F	7/25/2001	ATY
Quabbin Reservoir	Boat Area 2	M	7/25/2001	ATY
Quabbin Reservoir	Boat Area 2	U	7/25/2001	HY
Quabbin Reservoir	Boat Area 2	M	7/19/2005	ATY
Quabbin Reservoir	Boat Area 2	F	7/30/2008	ATY
Quabbin Reservoir	Boat Area 2	M	7/25/2014	ATY
Quabbin Reservoir	Boat Area 3	F	7/23/2002	ATY
Quabbin Reservoir	Boat Area 3	M	7/23/2002	ATY
Quabbin Reservoir	Boat Area 3	U	9/5/2015	HY
Quabbin Reservoir	Boat Area 3	F	8/1/2011	ATY
Quabbin Reservoir	Boat Area 3	M	7/8/2014	ATY
Quabbin Reservoir	Carrick Island	F	7/2/2010	ATY
Quabbin Reservoir	Carrick Island	M	7/2/2010	ATY
Quabbin Reservoir	Den Hill	M	7/26/2004	ATY
Quabbin Reservoir	Den Hill	F	7/27/2000	ATY
Quabbin Reservoir	Den Hill	F	7/29/2008	ATY
Quabbin Reservoir	Den Hill	F	7/13/2011	ATY
Quabbin Reservoir	Fever Brook	M	7/8/2009	ATY
Quabbin Reservoir	Fever Brook	M	7/8/2009	ATY
Quabbin Reservoir	Fever Brook	F	7/8/2014	ATY
Quabbin Reservoir	Fever Brook	F	7/7/2016	ATY
Quabbin Reservoir	Graves Landing	M	6/30/2014	ATY
Quabbin Reservoir	Hamilton West	F	7/28/2009	ATY

Lake	Territory	Sex	Date	Age
Quabbin Reservoir	Hamilton West	F	6/19/2014	ATY
Quabbin Reservoir	Hop Brook	F	7/25/2001	ATY
Quabbin Reservoir	Hop Brook	M	7/25/2001	ATY
Quabbin Reservoir	Hop Brook	M	7/8/2012	ATY
Quabbin Reservoir	Moore - Eagle Tree	F	6/29/2014	ATY
Quabbin Reservoir	Moore - Eagle Tree	M	6/30/2014	ATY
Quabbin Reservoir	Moore - Eagle Tree	F	7/25/2017	ATY
Quabbin Reservoir	Moore - Pipe	M	8/5/2015	ATY
Quabbin Reservoir	Moore - Pipe	F	8/5/2015	ATY
Quabbin Reservoir	Moosehorn Brook	M	7/11/2002	ATY
Quabbin Reservoir	Moosehorn Brook	F	7/11/2002	ATY
Quabbin Reservoir	Moosehorn Brook	M	7/30/2008	ATY
Quabbin Reservoir	Parker Hill/Island	F	8/18/1999	ATY
Quabbin Reservoir	Parker Hill/Island	M	7/19/2007	ATY
Quabbin Reservoir	Parker Hill/Island	F	7/9/2012	ATY
Quabbin Reservoir	Parker Hill/Island	F	7/13/2015	ATY
Quabbin Reservoir	Phragmites Island	M	7/8/2009	ATY
Quabbin Reservoir	Phragmites Island	F	7/8/2009	ATY
Quabbin Reservoir	Prescott Cove	F	7/19/2005	ATY
Quabbin Reservoir	Prescott Cove	M	7/19/2005	ATY
Quabbin Reservoir	Prescott Cove	M	7/26/2017	ATY
Quabbin Reservoir	Russ Mountain	F	7/27/2004	ATY
Quabbin Reservoir	Russ Mountain	M	7/27/2004	ATY
Quabbin Reservoir	Sandbar	F	8/5/2015	ATY
Quabbin Reservoir	Sandbar	M	8/5/2015	ATY
Quabbin Reservoir	Target Island	F	7/30/2003	ATY

Lake	Territory	Sex	Date	Age
Quabbin Reservoir	Target Island	M	7/30/2003	ATY
Quabbin Reservoir	Target Island	M	7/2/2008	ATY
Quabbin Reservoir	Target Island	U	8/26/2014	HY
Quabbin Reservoir	Townsend	M	7/20/2005	ATY
Quabbin Reservoir	Lone Pine Island/West Arm	U	8/18/1999	ATY
Quabbin Reservoir	Lone Pine Island/West Arm	F	7/28/2004	ATY
Quabbin Reservoir	Lone Pine Island/West Arm	M	7/24/2014	ATY
Quabbin Reservoir	Lone Pine Island/West Arm	F	7/24/2014	ATY
Total # banded on Quabbin Reservoir:				**58**
Wachusett Reservoir	Crescent Island	F	7/27/2000	ATY
Wachusett Reservoir	Crescent Island	M	7/27/2000	ATY
Wachusett Reservoir	Crescent Island	U	9/7/2010	HY
Wachusett Reservoir	Crescent Island	M	7/14/2015	ATY
Wachusett Reservoir	Hastings	M	7/23/2013	ATY
Wachusett Reservoir	South Bay	M	7/24/2001	ATY
Wachusett Reservoir	South Bay	U	7/24/2001	HY
Wachusett Reservoir	South Bay	U	7/23/2002	HY
Wachusett Reservoir	South Bay	F	7/18/2007	ATY
Wachusett Reservoir	South Bay	M	7/18/2007	ATY
Wachusett Reservoir	South Bay	F	6/30/2014	ATY
Wachusett Reservoir	South Bay	F	7/7/2016	ATY
Wachusett Reservoir	Wood Island	M	7/24/2001	ATY
Wachusett Reservoir	Wood Island	F	7/18/2005	ATY
Wachusett Reservoir	Wood Island	U	7/18/2007	HY
Wachusett Reservoir	Wood Island	F	7/13/2011	ATY
Total # banded on Wachusett Reservoir:				**16**

Lake	Territory	Sex	Date	Age
Hycrest Reservoir	Hycrest	F	7/5/2001	ATY
Hycrest Reservoir	Hycrest	M	7/5/2001	ATY
Hycrest Reservoir	Hycrest	F	7/23/2104	ATY
Hycrest Reservoir	Hycrest	M	7/23/2014	ATY
Total # banded on Hycrest Reservoir:				**4**
Paradise Lake	Paradise	F	7/28/2003	ATY
Paradise Lake	Paradise	M	7/28/2003	ATY
Paradise Lake	Paradise	U	7/28/2003	HY
Paradise Lake	Paradise	U	7/28/2003	HY
Paradise Lake	Paradise	U	7/28/2004	HY
Paradise Lake	Paradise	U	7/28/2004	HY
Paradise Lake	Paradise	U	7/27/2006	HY
Total # banded on Paradise Lake:				**7**
Total # banded on DCR lakes:				**85**
Non-DCR Lakes:				
Bickford Reservoir	Bickford	M	8/1/2012	ATY
Bickford Reservoir	Bickford	F	7/9/2013	ATY
Crystal Lake	Crystal	M	6/24/2014	ATY
Crystal Lake	Crystal	F	6/24/2014	ATY
Fitchburg Reservoir	Fitchburg	M	7/16/1999	ATY
Fitchburg Reservoir	Fitchburg	F	7/16/1999	ATY
Fitchburg Reservoir	Fitchburg	U	8/13/2001	HY
Fitchburg Reservoir	Fitchburg	F	8/13/2001	ATY
Fitchburg Reservoir	Fitchburg	M	7/8/2015	ATY
Mare Meadow Reservoir	Mare Meadow	M	7/24/2013	ATY
Mare Meadow Reservoir	Mare Meadow (Squam ABJ)	F	7/24/2013	ATY

Lake	Territory	Sex	Date	Age
Notown Reservoir	Notown	U	7/7/2015	ATY
Notown Reservoir	Notown	M	8/15/2013	ATY
Pine Hill Reservoir	Pine Hill	U	7/31/2014	HY
Stodge Meadow Pond	Stodge Meadow	F	8/1/2017	ATY
Stodge Meadow Pond	Stodge Meadow	M	8/1/2017	ATY
Upper Naukeag Reservoir	Upper Naukeag	U	7/29/2004	ATY
Wachusett Lake	Wachusett	F	7/8/2015	ATY
Wampanoag Lake	Wampanoag	F	7/24/2002	ATY
Wampanoag Lake	Wampanoag	M	7/24/2002	ATY
Wampanoag Lake	Wampanoag	F	8/17/2015	ATY
Winthrop Lake	Road Recovery	U	2/4/2016	ATY
Total # banded on non-DCR lakes:				**22**
`Grand total # banded in MA:				**107**