Declining Loon populations in New York State: Are humans to blame?

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EXECUTIVE SUMMARY

The common loon (*Gavia immer*), is listed as of special concern in New York State by the New York State Department of Environmental Conservation. In this case study our aim was to identify the most serious threats facing loon populations in New York and to identify feasible conservation solutions to help promote a population increase. Loon populations face a number of threats, such as predation, habitat loss, environmental pollutants, and disease. In this study we focused on human-caused threats considered most serious for New York State’s breeding population, currently estimated at <1000 individuals. Threats were identified as acid deposition, mercury contamination, botulism type E, lead poisoning and human development & recreation.

We carried out our research by reviewing literature, conducting phone interviews with stakeholders and representatives from governmental and non-governmental organizations. In order to understand perspectives of local residents we sent out surveys to 110 randomly selected residents of Northern New York, where the majority of the state’s loon population is found. We also surveyed existing related conservation programs and research projects in New York and nearby regions in order to identify potential solutions.

We used the knowledge gained from research, interviews and surveys to identify the most feasible as well as best conservation solutions to loon populations in New York State. All in all we have come to the conclusion of four best solutions in order to maintain healthy loon populations within the Adirondack Park: increase in education, expansion of citizen science, increased efforts for policy changes, and more protection for nesting loons. Ideally, we would like to see the implementation of all four solutions in order to achieve a goal of increased loon populations in the park, but regardless, the implementation of any of our best solutions would surely construct a positive change.
PROBLEM DEFINITION

The call of the common loon (\textit{Gavia immer}), evokes a feeling of pure, unspoiled wilderness as it echoes off a lake in the Adirondack State Park in Northern New York. It is a sound so inhuman that it reminds listeners that there are places in the world that are still untouched by man’s ever reaching grasp. Despite their charisma and the popularity of their image, common loons have not remained untouched by human development. To the contrary, loon populations have been severely impacted by anthropogenic activity over the past few centuries, particularly in the Northeastern United States. In New York State in particular, where loon populations are only recently beginning to stabilize, there are thought to be less than half as many loons as the region’s lakes are able to support (Schoch et al. 2015). In the following section we will describe common loon natural history as well as the status of common loons internationally, nationally, and in New York State. We will then outline threats that the species faces, expanding on those that most severely impact New York State populations.

\textbf{Common loon natural history}

Loons are large waterbirds that live on lakes and ponds in the northern hemisphere. While similar to other common waterbirds such as ducks and geese, they are classified separately and are more closely related to penguins and albatrosses (About loons 2015). Also known as “divers” in Eurasia, loons are members of the family \textit{Gaviidae} and the genus \textit{Gavia} (Common loon 2015). All five species of loons that exist globally are found in the United States and include: the common loon (\textit{Gavia immer}), yellow-billed loon (\textit{Gavia adamsii}), the red-throated loon (\textit{Gavia stellata}), the pacific loon (\textit{Gavia pacifica}) and the arctic loon (\textit{Gavia arctica}). Our focal species, the common loon, is the only of these species of loon present in New York State.
Loon pairs are generally believed to mate for life, often raising their young on the same lake they were born on, or nearby, and returning to the same lake year after year. A relatively long-lived species, loons don’t reach sexual maturity until 5-7 years of age. Their late sexual maturity, as well as their low clutch size of two eggs, gives them an inherently low reproductive rate (Common loon factsheet 2015). While they will opportunistically prey on small invertebrates and amphibians such as crayfish and frogs, loons are primarily piscivorous, with their diet made up almost entirely of fish. While legs set back far on their bodies to make them excellent divers, they make their mobility on land extremely limited. Awkward and unable to escape prey quickly out of water, loons always build their nest next to the water’s edge. To avoid land predators such as raccoons and coyotes, parents usually select nest sites near embankments or other difficult to reach shorelines (Common loon factsheet 2015).

Males and females work together both to build the nest and to watch over the eggs. The incubation period, which is roughly one month, is when chicks are most vulnerable; once hatched they are able to swim almost immediately and are moved to a separate nursery area within one day (Common loon factsheet 2015). Chicks spend several months with their parents learning to fish and building their diving stamina before fledging. This period is formative, and lakes must have a variety of suitable habitat for loons to choose them as breeding sites. Loons prefer lakes or ponds > 14 hectares will nest on somewhat developed water bodies. Although they prefer secluded spaces, loons must nest on lakes large enough for a long takeoff runway, as their heavy bodies make it hard for them to
takeoff. In addition, they require habitat variety, as deep water is used for fishing and shallow water is necessary for foraging and sheltering chicks (Common loon factsheet 2015). These requirements mean not every lake is suitable nest habitat. As loon habitat is limited to water, adult and juvenile loons must migrate to the ocean during winter months. During late fall loons begin to congregate on larger lakes, such as the Great Lakes in the Northeastern United States, migrating to coasts together in larger groups.

Distribution

While individual loon pairs will return to the same ponds and lakes year after year, their overall breeding range expands past the United States, including Canada, Iceland, Greenland, and parts of Eurasia (Common loon factsheet 2015; Fig. 1). In the later they are known as great Northern divers, leading the International Ornithological Committee to give them the name the great northern loon (Gill and Donsker 2015). Common loons breed across Canada, but their breeding range in the United States is limited to northern states, ranging from Alaska south to Montana and Minnesota in the West, Wisconsin and Michigan near the Great Lakes, throughout New York and New England in the East (Common loon factsheet 2015).

In New York State, our region of focus, Common loons are found breeding on lakes in the St. Lawrence River Valley and throughout the Adirondack State Park (Common loon factsheet 2015). The Adirondack State Park, established in 1892, is a 6.5 million acre protected area in Northern New York that encompasses roughly 3,000 lakes and ponds (Adirondack Regional Tourism Council; Fig. 3). While historically loons are believed to have bred across all
of New York State, the lakes in the Adirondacks are one of the few places their populations come close to representing historic densities.

Figure 3. Map depicting waterbodies in Northern New York and in the Adirondack State Park (light blue), and the designation of the Adirondack State Park (dark blue line).
Conservation status

While not listed as threatened internationally (IUCN Red List of Threatened Species 2014), common loon populations in the Northeastern United States have dropped below historic averages and are protected nationally by the Federal Migratory Bird Treaty and listed in New York State as of special concern (Fig. 4; Schoch et al. 2015; Common loon factsheet 2015).

Figure 4. Changing distribution of breeding common loons, 1875-2013; Biodiversity Research Institute (Adirondack Center for Loon Conservation 2015).

In New York State increased human development has been crowding out loons since people first began settling the area in earnest in the early nineteenth century, with development along lakeshores being the most significant impact. As mentioned, today their populations are limited to breeding primarily in the Adirondack State Park (Common loon factsheet 2015).

The majority of states across the Northeast conduct annual loon censuses, usually structured as a single day bird count once a year during the breeding season. In New York, the
count is organized by the Wildlife Conservation Society’s Adirondack Program and occurs at 8:00am on the third Saturday in July (Adirondacks 2015). In 2013 breeding loons with chicks or juveniles were observed on 52 (28%) of the 189 lakes that were sampled in the Adirondacks. In contrast, loons without young were observed on 95 of the sampled lakes (50%). Another 22% of observed lakes had no loons present at all (Adirondack Loon Census 2013). The overall population of loons in the Adirondacks is currently estimated at between 650-850 territorial pairs (Schoch et al. 2015). While historic loon populations in the region and across New York are not certain, most agree the population has stabilized and begun to increase some since last 20th century (Common loon factsheet 2015).

Historically, Populations are estimated to have been lowest in the 1960s and 1970s, when there were estimated to be < 200 breeding pairs in the Adirondacks (Schoch et al. 2015). In the 1980’s surveys carried out by the New York State Department of Environmental Conservation (DEC) showed loon populations starting to rise, at between 216-270 breeding pairs (Schoch et al. 2015). Despite this improvement, and the increase in today’s Adirondack loon population, the species is still struggling to regain territory in other regions of the state.

Of the lakes observed in the WCS census, almost all were located within the Adirondack State Park and Northern New York, so further studies are needed to determine their range across the entire state. However, examining these maps, showing results from loon censuses in 1985 and 2013, respectively, it is possible to notice that there are few loons outside the Adirondack State Park, even within Northern New York. This may be due to lack of suitable habitat, or other human threats.
Loon populations in other parts of the United States, but particularly in the Northeast, have also declined, leading to conservation statuses in several nearby states. In Vermont, loon populations dropped to only ~7 breeding pairs in the early 1980s, leading Vermont to classify them as endangered. Today they have begun to rebound to > 70 pairs and were removed from the state-wide endangered species list (Vermont Loon Conservation Project 2015; Table 1)

Table 1. Status and population estimate for loon populations in nearby regions

<table>
<thead>
<tr>
<th>Geographic Region</th>
<th>Current Conservation Status</th>
<th>Population estimate (adults)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>Special Concern</td>
<td>650-800 breeding pairs</td>
</tr>
<tr>
<td>Vermont</td>
<td>Not Threatened</td>
<td>200-300</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>Threatened</td>
<td>~500</td>
</tr>
<tr>
<td>North America</td>
<td>Not Listed</td>
<td>~621,000 individual adults</td>
</tr>
</tbody>
</table>

Sources: Schoch et al. 2015; NY DEC factsheet; NY Annual loon census 2013; US Geological Survey
Throughout the Northeast, and especially within the Adirondack Park, loons are well-loved as an icon of untouched wilderness. The passion that loons invoke makes them an ideal species to use to describe the importance of biodiversity and to gain support for conservation efforts. The popularity of loons and their position as top predator makes them an ideal indicator species when studying anthropogenic effects on ecosystems. Despite their popularity, most threats to loons are human-induced, as we will describe in the following section.

**Threats to loon populations**

As with any wild animal, populations of common loons across the United States fluctuate in size for a variety of reasons. This is partly because the success of each individual depends on its ability to survive in its environment long enough to reproduce and rear its young to adulthood. However, human development in the last few centuries has severely decreased historic loon populations, as outlined above. Today, while loon populations are stable and beginning to increase across the United States, they face new challenges that make survival difficult. As loons prefer to nest in quiet, undisturbed habitat, lakeshore development continues to be a challenge for them. Additionally, loons are impacted by environmental pollutants such as mercury, acid deposition, lead, and oil spills at migration sites. Populations that migrate through the Great Lakes are also significantly impacted by Botulism type E outbreaks. Drastic changes in water level due to dams can make nests vulnerable to flooding and/or nest predation, and loons can get caught in abandoned fishing line (Schoch et al. 2015).
There are many components that threaten the common loon nationally and internationally however, for our focus we will expand upon the four major threats to common loons in the Adirondack region of New York which include mercury contamination, acid deposition, lead poisoning, and human disturbance (Fig. 6). In addition, we will describe Botulism type E, as it is a disease the impacts New York State loons that migrate through the Great Lakes.
Mercury contamination

Since its first documentation in 1865, mercury poisoning has been an issue for humans and animals alike (Barrett 2005). Mercury can be introduced into surface and groundwater by runoff, industrial waste, leaks, spills and precipitation from polluted air (NYSDEC 2015). Mercury pollution is of concern because once mercury reaches groundwater, it is converted by bacteria (in both the soil and water) into methylmercury. Methylmercury is readily taken up by aquatic organisms and is then transferred through the food chain through the process of bioaccumulation. More simply put, methylmercury dissolved in the water is taken up by invertebrates, which are then preyed upon by fish and small amphibians. These fish and amphibians are then eaten by loons, and the concentration of mercury is then at its highest on the food chain (Fig. 7). As a top predator species (although not an apex predator), loon populations are extremely susceptible to the bioaccumulation of mercury, ingesting these smaller organisms and taking the mercury into their systems. When concentrated, mercury is extremely toxic, hampering the neurological functions of organisms that take it up (Schreiber interview 2015**; USGS 2014). Recent studies have shown increased levels of methylmercury in aquatic ecosystems to be correlated with decreases in the success of common loon reproduction (Schoch et al. 2014; Kenow et al. 2008). Since pre-industrial times, mercury concentrations in the environment have increased by three times due to increases in anthropogenic acts (Evers et al. 2014; Fig. 8).
While further studies are needed to fully assess the impact of mercury on loon physiology, some research is beginning to suggest that mercury causes loons to experience “oxidative stress” and can impact neurological functions (Schoch et al. 2014). In one study, common loon eggs were gathered and raised on three degrees of Hg dietary treatments, and the chicks were then
reared and exposed to methylmercury in the form of a daily capsule (Kenow et al. 2008). Blood was sampled from each individual’s jugular at seven occasions throughout the experiment to determine concentrations of methylmercury in the specimens’ blood (Kenow et al. 2008). After 105 days all individuals were euthanized and brain, liver, bone marrow, spleen and kidneys were analyzed (Kenow et al. 2008). The results showed that there was no significant genetic damage in common loon chicks from dietary Hg (Kenow et al. 2008). The results did indicate that chicks exposed to $\geq 0.4 \, \mu g \, Hg/g$ have compromised immune systems, however there were no seen effects on survival or growth at this level of exposure (Kenow et al. 2008). The effects of mercury were seen in the brain and liver tissue. Overall, this was not a perfect experiment and 49% of the chicks experienced a disease common in captive rearing called aspergillosis (Kenow et al. 2008).

Another study conducted in the Adirondack State Park from 1998-2007 found that lower mercury levels were related to the long-term success of loon reproduction (Schoch et al. 2014). Acidity in lakes was also found to correspond to mercury levels in common loons, with loons with higher blood mercury concentrations found in more acidic lakes (Schoch et al. 2014). Additionally, loons with the highest internal mercury concentrations were found to have fledged the lowest numbers of chicks, indicating the mercury levels limit reproductive success (Schoch et al. 2014). While it is understood that mercury limits the ability of loon pairs to reproduce, it is not yet clear which stage of reproduction mercury is affecting (Schoch, personal communication$^1$). While it is known that methylmercury can pass from a female organism to the egg (Schoch, personal communication$^2$), further studies are needed to determine to what degree this occurs in common loons. It is possible that reproductive success is limited by both increased

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$^1$ Personal Interview, 13 April 2015  
$^2$ Personal Interview, 13 April 2015
mercury concentrations in eggs, and high levels of mercury in the bodies of the parents (Schoch interview 2015**). High levels of mercury in the blood of adult loons is also thought to decrease rearing success by causing parents to become less attentive to the young (Schoch et al. 2014).

While mercury pollution is an issue throughout the Adirondacks, the amount of mercury that loons are exposed to varies in accordance with lake chemistry and geographic location. As shown by Schoch et al., lakes with low pH (<6.5) have been found to be home to loons with the highest concentrations of blood mercury. The impact that methylmercury has on loons can range from reduced productivity in nesting, hatching and chick success to behavioral changes (Schoch et al. 2014). Because loons are sexually dimorphic, with males being larger than females, some scientists have hypothesized that the impact of mercury would differ between sexes (Mitro et al. 2006 and Schoch et al. 2014).

Reducing the release of methylmercury into the environment will not only help protect biodiversity, it will help ensure the health of future human populations as well. Fishing is a popular hobby among locals and visitors in the Adirondack Park as well as throughout the North Country. If mercury levels of fish within the Adirondack Park increase, this favored pastime is potentially at stake. If people feel that they can no longer harvest fish safe enough to consume, the art of fishing and the popularity of the sport could decline leading to less economic growth in the region as well as a devaluing of the natural world. As of 2008 there were already 84 water bodies that had fish consumption advisories in New York State (Shea 2008).

While common loons are not currently endangered and there is not an immediate risk of extinction in their native range, their listing as special concern in New York state shows that populations are not at carrying capacity. Although the loon population within the Adirondack State Park is well-monitored—and while their population is not declining—the effects of mercury
pollution are increasingly evident. More studies are needed, but it is clear that mercury contamination is an issue that needs to be addressed in order to protect both loons and other New York wildlife.

**Acid deposition**

The high level of mercury contamination that reaches the Adirondack Park through acid rain places common loons and other wildlife in this region of particular concern when compared to national populations. Acid precipitation coming down in the form of rain, snow, sleet or hail causes immense damage to the lakes in New York State (Shea 2008). Documentation of acid rain has been around for centuries, but not until the 1970’s did research on the damages of acid rain actually come into effect (Evers 2014). Acid rain is formed by the combination of sulfur dioxide, nitrogen oxides, ammonia and moisture within the atmosphere (Shea 2008). This results in the production of both sulfuric and nitric acids. Acid rain is tied heavily with mercury pollution in the atmosphere created by coal-powered plants, large-scale factories and car emissions (Shea 2008). Much of the acid rain in New York State comes from emissions produced within the Midwest region (Shea 2008) but recently we have seen a large portion of emissions falling as acid rain from China as well (Simonin, personal communication³). Although sulfur dioxide and nitrous oxide levels have decreased since their peaks in 1973 and 1990 respectively (Shea 2008), reductions still need to continue for the Adirondack lakes and wildlife to remain healthy.

Since all of New York State is affected by acid rain deposition, the lakes within the Adirondack region have suffered tremendously. This is because of the low buffering capacity that the rock deposits have around the lakes themselves (Shea 2008). The Adirondack Park

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³ Personal Interview, 4 May 2015
consists mainly of hard metamorphic and igneous rock, both of which have a low acid neutralizing capacity (Shea 2008). The acid neutralizing capacity refers to the water’s ability to buffer the acid present and revert itself back to normal, tolerable pH levels. We also discovered that 26% of the lakes within the park are not able to lower their acidic levels to a somewhat tolerable range, and around 70% of the lakes within the park have the potential to be too acidic during certain times of the year (Shea 2008).

Lower pH levels due to increased acid rain deposition also affects loon reproductive success (Evers 2014). Fledging success was found to be very unlikely when lake pH ranged anywhere from 4.0-4.3 and high chick mortality rates were consistent on lakes with pH levels between 4.4-5.8 (Evers 2014).

When there is an increase in mercury pollution and acid rain deposition in a lake, the methylmercury formed is accumulated by fish in the polluted lake at a much faster rate (Shea 2008; Fig. 9). As how loons are piscivorous, the consumption of highly contaminated fish is detrimental to their health, as well as the health of their offspring. Acid rain is also a cause for lowered invertebrate and fish species richness and biomass in New York’s Adirondack Park (Evers 2014). Positive changes in these finding will only happen unless further reductions are obtained.
Lead poisoning

Since the 1980’s lead poisoning in New York State has had dramatic effects on loon populations, accounting for about 30% of all mortalities (NYSDEC 2015; Stone and Okoniewski 2001). Out of a nationwide waterbird study, loons had the highest amount (3.5%) of cases involving lead ingestion (Evers 2014). Lead sinkers are primarily used to help casting distance and rate of sinking while fishing, and, while small, can cause irreversible damage. Sinkers can be lost during such recreational activities by getting caught on rocks or other underwater obstructions (NYSDEC 2015). It is thought that loons are drawn to eat sinkers mistaking them for small pebbles (NYSDEC 2015). Loons ingest these small pebbles in order to help grind up
fish bones so they may be easily passed through their body without causing serious harm (NYSDEC 2015). Biologists also believe that more often than not, loons are drawn to the bait hooks attached to the sinkers, and accidently swallow both in the process of scavenging for food (NYSDEC 2015; Fig. 10).

Along with swallowing lead sinkers, loons are also prone to consume fishing line that is still tied to the sinkers, causing them to choke or wrap themselves in the line (Schoch 2013). Since loons are diving birds, accidental entanglement while diving for prey underwater is very common (Schoch 2013). If attention is not given immediately to a tangled or poisoned loon, permanent damage or death could be the end result (Schoch 2013).

Human disturbance

Although tourism can indirectly benefit loon conservation efforts, it can also hinder them by promoting new development in order to make room for increased tourism rates. The Adirondack Park Agency Land Use Law was passed in 1973 and states that natural resources within the park must be preserved. It also requires that any development within the park must be planned and executed carefully so as not to diminish the quality or “forever wild” aesthetic the park provides the public (Gibson and Plumley 2012).

Ceasing large scale development within the park has not proved an easy task. The Adirondack Park and Resort, spanning 6,235 acres of land, will include over 700 condos, 332 buildings and 15 miles of new roads, all within the heart of the Adirondack Park (Gibson and Plumley 2012). This type of development can pose a huge threat to loon populations, as the increase in tourism will cause an increase in human disturbance on loons during breeding
seasons. Not only will increased tourism be a direct result, but shoreline development included in this type of habitat degradation can result in decreased vegetation, shoreline erosion and reduced water quality (Evers 2014). Since loons are territorial and breed at the same lake year after year (Schoch 2013) increased occurrence of this type of development could harm the natural processes of loons within the park. If development such as this is continues to be allowed within the Adirondack Park, not only will we continue to destroy important habitat, but we will also displace wildlife such as loons.

Along with development, recreational pressures have also put stress on breeding loon populations, being one of the possible implications of their decline (Evers 2014). One of the main concerns in regards to recreational activities includes boating and jet skiing practices along the shorelines and in open waters (Evers 2014). If exposure to motorboats occurs frequently, it can slow down response times for loons to avoid the boats and jet skis, resulting in an increase in collision reports (Evers 2014). Increases in non-motorized activities pose a threat as well. Canoes and kayaks in particular are able to access the shallow waters of a lake which is where loons will nest and brood (Evers 2014). Disturbances such as these are extremely harmful to the early stages of nesting, as increased disturbance can cause loons to abandon their nests and eggs (Evers 2014).

**Botulism type E**

Although botulism has not been an issue within the Adirondack Park specifically, this bacteria is of concern in Lake Erie within New York State. Type E botulism (*Clostridium botulinum*) is a type of food poisoning that can affect animals who prey upon other organisms infected by the bacteria (NYSDEC 2015). It is a ubiquitous bacteria, but does not pose a threat to other organisms unless the environment is anoxic (depleted of dissolved oxygen) (McMillian,
personal communication⁴). Other factors are necessary to provide the perfect breeding ground for this bacteria, such as shallow lakes and decomposing matter (McMillian, personal communication⁵). Invasive species such as quagga mussels, zebra mussels and gobies may also be key in botulism breakouts (MPR 2013).

For example, in Lake Michigan loon mortalities reached several thousand numbers in the years 2010 and 2012 (MPR 2013). This number was tied to the massive amounts of invasive mussels and gobies in the lake. The mussels are able to filter out the water at such a quick rate that the water soon becomes clear enough for sunlight to penetrate the bottom of the lake (MPR 2013). This excess sunlight allows Cladophora algae to grow to extremes in short periods of time; causing algal mats begin to form (MPR 2013). As these mats grow thicker, the lower layers of them begin to decay and provide a breeding site for Clostridium botulinum. Invasive gobies that eat the contaminated algae matter soon begin to show signs of botulism such as slow movement in water (McMillian, personal communication⁶). This allows loons to consume the infected gobies more easily, resulting in death by botulism (McMillian, personal communication⁷).

This bacterium causes neurological damages as well as paralysis (NYSDEC 2015). This paralysis is commonly known as “rubbernecking” where the loons are no longer able to hold their heads up above the water, causing them to drown (McMillian, personal communication⁸).

⁴ Personal Interview, 30 April 2015
⁵ Personal Interview, 30 April 2015
⁶ Personal Interview, 30 April 2015
⁷ Personal Interview, 30 April 2015
⁸ Personal Interview, 30 April 2015
Other indicators that a loon may have botulism include a head-bobbing motion followed shortly by diaphragm paralysis (McMillian, personal communication\(^9\)).

Although mortalities caused by botulism have been seen for decades, they appear in sudden “booms” that last for a few years and stop abruptly (McMillian, personal communication\(^10\)). The first die-off occurred on Lake Michigan in 1963, and approximately 3,300 loons died (Ever 2014). Sporadic outbreaks had occurred in the 70’s and 80’s on Lake Michigan but had subsided until recently (McMillian, personal communication\(^11\)). Though the only area at risk for botulism in New York State is Lake Erie, it is important to keep this threat to loon populations in mind within the Adirondack Park, as quagga mussels and zebra mussels are invasive species in New York State (NYSDEC 2015). The presence of such invasives at a high rate may increase photosynthetic rates, creating algal mats that will decay at exponential rates and therefore allow for the presence of the botulism bacteria (McMillian, personal communication\(^12\)). The Biodiversity Research Institute is currently collaborating with the NYSDEC in order to determine loon populations that are most at risk within New York State in order to determine future population impacts (Evers 2014).

The threats to loon populations we have addressed are all anthropogenic. The impacts that our populations have on loons within the Adirondack Park have been threatening loons over the years. If issues such as these are seen consistently, we can expect to see a drop in loon populations. The continued use of coal-burning power plants, use of lead sinkers, and increased development within the Adirondack Park are all harmful to current loon populations. It is clear

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\(^9\) Personal Interview, 30 April 2015  
\(^10\) Personal Interview, 30 April 2015  
\(^11\) Personal Interview, 30 April 2015  
\(^12\) Personal Interview, 30 April 2015
that we as humans are the main deterrent to loon populations increasing not only within the Adirondacks, but in states such as New Hampshire, Vermont and Massachusetts as well.

Declines in loon populations are a concern not only because loons play a key role in the food web as top predators, but because they are an excellent indicator species of environmental pollution and habitat degradation. Loon populations have stopped decreasing over the last decade through conservation efforts and policy changes, but their populations are still lower than historic numbers. Continuing conservation efforts to protect loons is important to both boost their populations in the Adirondacks to a stable size and to promote awareness of the impacts of human development on the environment and the wildlife populations that depend on it.

Our topic encompasses understanding both the aquatic ecology of water bodies within the Adirondack region, the human-induced threats that loons face, as well as the presence of common loon populations prevalent within the area today. Threats to loons spark concern over the biodiversity within the Adirondack region. The loss of the common loon in Northern New York could very well mean the loss of many other aquatic bird species if nothing is done to lower present mercury levels/acid rain deposition, limit lead poisoning and slow down human development and recreational activities.
METHODS

We conducted this case study systematically, beginning with an overview of related literature and primary articles and then identifying and surveying stakeholders, special interest groups and representatives from the government. Most of the information and insight gained on our topic came from a multitude of scientific papers concerning each individual threat posed to loon populations. These papers covered populations in the Adirondack Park as well as within the Great Lakes region in both the United States and Canada. Special interest groups consulted included NGOs, Research institutions and individuals (Table 2).

In addition to our literature methodology, we interviewed staff members at St. Lawrence University, The University of Buffalo, the Wildlife Conservation Society (WCS), the Biodiversity Research Institute (BRI), the New York State Department of Environmental Conservation (NYSDEC) and the New York State Energy and Research Development Authority (NYSERDA). We identified our informants based on their educational background and general knowledge of mercury poisoning, lead poisoning, botulism as well as their knowledge on loon populations in the Adirondack Park.

In addition, we felt it was also important to gather perspectives of the common loon as an icon of wilderness from local people. We interviewed employees the following stores within the Adirondack region: the Adirondack Store, Adirondack Trading Co., Critters, and Adirondack Reflections (Table 3). In order to further understand how methylmercury is physiologically distributed in loons we spoke with Dr. Alexander Schreiber, a physiology professor who has done previous work with the impact of mercury on amphibians. We conducted another informal interview with Dr. Baldwin at St. Lawrence University, a professor who focuses on marine biology and limnology, in order to discuss his personal experience with speaking to Adirondack
locals about mercury poisoning and their possible exposure through eating the fish they catch. Baldwin has studied least terns and cormorants’ (a similar species to the common loon) exposure to mercury in the St. Lawrence River.

To better understand the opinions of stakeholders within the Adirondack Park region, we compiled and sent out a survey by mail in order to gauge the knowledge our stakeholders had on current loon populations in the region as well as the effects that mercury has on loon population levels. We used Geographic Information Systems (ArcGIS 10.2.2) provided by the GIS lab at St. Lawrence University to randomly select 110 addresses within the Adirondack and Northern New York region. The survey instrument and methods (Appendix A) were approved by the St. Lawrence University Institutional Review Board (#123-456) and sent on 30 March 2015. We received and analyzed 14 surveys (Table D).

Table 2. Individual stakeholders interviewed.

<table>
<thead>
<tr>
<th>Person Interviewed</th>
<th>Affiliation</th>
<th>Area of Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Alex Schreiber</td>
<td>St. Lawrence University</td>
<td>Physiology; impacts of mercury on amphibians</td>
</tr>
<tr>
<td>Dr. Brad Baldwin</td>
<td>St. Lawrence University</td>
<td>Marine Biology/Limnology; freshwater research in and around Adirondack Park</td>
</tr>
<tr>
<td>Zoe Smith</td>
<td>The Wildlife Conservation Society (WCS)</td>
<td>Adirondack Landscape Coordinator</td>
</tr>
<tr>
<td>Dr. Nina Schoch</td>
<td>Biodiversity Research Institute (BRI)</td>
<td>Coordinator of the BRI’s Adirondack Center for Loon Conservation</td>
</tr>
<tr>
<td>Dr. Amy McMillan</td>
<td>University of Buffalo</td>
<td>Associate professor of biology; population and conservation genetics and type E botulism effects</td>
</tr>
<tr>
<td>Howard Simonin</td>
<td>New York State Department of Environmental Conservation (NYSDEC)</td>
<td>mercury pollution within NYS</td>
</tr>
<tr>
<td>Greg Lampman</td>
<td>New York State Energy and Research Department Authority (NYSERDA)</td>
<td>Senior Project Manager, Environmental Research</td>
</tr>
</tbody>
</table>
IDENTIFICATION OF STAKEHOLDERS

Stakeholders play an important role in regards to issues surrounding declining loon populations. Without the involvement of stakeholders, there becomes a loss of intrinsic value on nature as well as for the conservation of nature. Intrinsic value is defined as a value created by humans that any being, organism or life form has in itself; it is valued for exactly what it is, rather than what it can provide for humans. For our case study, we have identified stakeholders as humans and non-human. For human stakeholders we examined New York State residents, local businesses owners, people from native cultures and both governmental and non-governmental organizations, for non-human we looked at the issue from the perspective of both common loons and other forms of wildlife.

Human

Humans may remain the largest group of stakeholders identified in this study. This is not only because of the many threats we pose to Adirondack loon populations, but also because we as humans are also at the root of solving this problem. Our actions resulting in mercury and lead poisoning as well as increased development put humans as one of the key stakeholders in our argument.

New York State Residents

We must also consider that through our actions, we are not only harming the future of the Adirondack wildlife and environment, but our own future as well. Acid rain deposition and mercury pollution don’t just impact wildlife, and certainly not just the common loon. Mercury exposure can have extremely serious effects on human health. While human systems are able to handle low levels of mercury in the blood, prolonged exposure can be harmful. According to the Environmental Protection Agency, pregnant women should be particularly careful, as ingesting
high levels of mercury has been shown to lead to impaired neurological development in infants and children (EPA 2015). One study found that roughly 75,000 newborns born every year are at risk of experiencing birth defects such as learning disabilities due to exposure to methylmercury during development (Martin et al. 2012; EPA 2015). This exposure can result from the consumption of methylmercury by pregnant women when eating fish and shellfish (Martin et al. 2012; EPA 2015).

With high enough exposure, adult men and women can experience negative effects from mercury exposure, which often manifests itself as difficulty seeing, numbness in the hands and feet, coordination impairment, and difficulty speaking, hearing, and walking (EPA 2015). As clean water is becoming an increasingly valuable commodity, the impact of mercury on human drinking water is of particular concern. However, while the above impacts of mercury should be considered, it is important to note that currently, mercury is not as much a life-threatening risk for humans as it is for loons. That said, it is important to limit consumption of top-predator fish species and safely dispose of products containing mercury.

In addition to its possible impacts on human health, mercury contamination is a human concern because of its connection to acid rain and the widespread influence of human pollution. Acid rain impacts humans because it degrades the environment, which people depend on for a variety of things, such as clean air and water, recreation, and food. The contamination of mercury and acid rain into the environment is a complex issue that impacts all New York State residents.

As mentioned, mercury in water is a public health concern and therefore pollutant levels are of interest to anyone using water that may be contaminated. Additionally, citizens living in
regions with common loon populations are also stakeholders of this issue because changes in loon populations will impact them directly. For example, if loons stop nesting on a particular lake due to pollution, residents of that town may experience negative economic impacts when tourists choose to go to a different location where they can still see loons. Residents of the same community may be impacted in other ways, such as personal disappointment in not seeing loons themselves, or being concerned about environmental toxins in their nearby lakes. Results from our survey indicated that most residents within the Adirondacks had seen a loon recently in their area each year.

When reviewing survey results, very few people agreed that loon health was in decline due to mercury pollution, indicating the lack of knowledge on this issue in the Adirondack Park (Table 7). However, the majority of people who took our surveys indicated that loons were not stable or healthy in their area (Table 7) again showing the importance of humans as stakeholders in this issue. In addition, very few people expressed that mercury pollution was a problem in their area. Yet, the majority of respondents said mercury was a threat to fish in their area (Table 7). This shows the lack of awareness that many people within the area may have about the actual effects that mercury pollution has on loons in the environment. Of the items containing mercury we listed on our survey the majority of people indicated that improper disposal of batteries and coal-burning power plants were the most significant contributors to mercury pollution (Table 10). It is evident that the problem of mercury pollution is evident, but not necessarily on the scale that we would like to see. How mercury affects fish vs loons vs the environment in general is not well known from what we could gain from our surveys. These results show the importance we have as human stakeholders in changing these results so we are better able to lower mercury pollution in our future.
There are still people, however, who truly care about nature for its intrinsic value and would be saddened to see loons and other Adirondack species go extinct because of environmental degradation. Loons have a majesty that invokes passion in many people, allowing them to connect to the idea of American wilderness and beauty. A decline in loon populations would therefore have a direct impact on the happiness of those individuals.

Table 3. Survey results: Participant age demographics (n=14).

<table>
<thead>
<tr>
<th>Participants Age</th>
<th>18-25</th>
<th>26-35</th>
<th>36-45</th>
<th>46-55</th>
<th>Over 55</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>14.3%</td>
<td>21.4%</td>
<td>14.3%</td>
<td>50%</td>
</tr>
</tbody>
</table>

Table 4. Survey results: Participant gender demographics (n=14).

<table>
<thead>
<tr>
<th>Participants Gender</th>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>57.1%</td>
<td>42.9%</td>
</tr>
</tbody>
</table>

Table 5. Survey results: Success of participant’s abilities to correctly identify a common loon when provided with pictures of loons alongside other waterbirds (n=14).

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Both Correct</th>
<th>Only Close up</th>
<th>Only Flying</th>
<th>One right, One wrong</th>
<th>One right, multiple wrong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photo Identification</td>
<td>28.6%</td>
<td>42.9%</td>
<td>0%</td>
<td>14.3%</td>
<td>14.3%</td>
</tr>
</tbody>
</table>
Table 6. Survey results: Participant response to time spent seeing loons (n=14).

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Never</th>
<th>Rarely</th>
<th>Somewhat</th>
<th>Frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you see loons in your community?</td>
<td>14.3%</td>
<td>35.7%</td>
<td>50%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 7. Survey results: Participant responses to questions regarding time spent in nature and the environmental impacts of mercury (n=14).

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Uncertain</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I spend a lot of time outside and frequently visit local lakes and waterways</td>
<td>7.14%</td>
<td>7.14%</td>
<td>0%</td>
<td>42.9%</td>
<td>42.9%</td>
</tr>
<tr>
<td>I have seen loon(s) within the last year on water bodies near my home.</td>
<td>14.9%</td>
<td>7.14%</td>
<td>7.14%</td>
<td>42.9%</td>
<td>28.6%</td>
</tr>
<tr>
<td>Loon populations in the surrounding lakes and ponds are stable and healthy.</td>
<td>14.9%</td>
<td>64.3%</td>
<td>7.14%</td>
<td>14.9%</td>
<td>0%</td>
</tr>
<tr>
<td>A decline in common loon populations would have negative economic effects in my community.</td>
<td>0%</td>
<td>7.14%</td>
<td>35.7%</td>
<td>35.7%</td>
<td>21.4%</td>
</tr>
<tr>
<td>A decline in common loon populations would have negative environmental effects in my community.</td>
<td>0%</td>
<td>0%</td>
<td>35.7%</td>
<td>42.9%</td>
<td>21.4%</td>
</tr>
<tr>
<td>I have a basic understanding of the ways in which mercury is introduced into aquatic systems.</td>
<td>0%</td>
<td>21.4%</td>
<td>21.4%</td>
<td>42.9%</td>
<td>14.9%</td>
</tr>
<tr>
<td>Mercury pollution is an issue in my area.</td>
<td>0%</td>
<td>0%</td>
<td>78.6%</td>
<td>0%</td>
<td>21.4%</td>
</tr>
<tr>
<td>Mercury pollution a serious threat to common loon populations.</td>
<td>0%</td>
<td>0%</td>
<td>35.7%</td>
<td>42.9%</td>
<td>21.4%</td>
</tr>
<tr>
<td>I consider fish a regular part of my diet.</td>
<td>0%</td>
<td>42.9%</td>
<td>7.14%</td>
<td>28.6%</td>
<td>21.4%</td>
</tr>
</tbody>
</table>
I often source my fish locally. | 0% | 64.3% | 7.14% | 14.9% | 14.9%  
Fishing is a pastime/hobby of mine. | 21.4% | 14.9% | 0% | 50% | 14.9%  
Mercury pollution is a threat to fish populations. | 0% | 0% | 7.14% | 50% | 42.9%  

Table 8. Survey results: Participant responses regarding attempts to reduce human impact (n=14).

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Very</th>
<th>Often</th>
<th>Sometimes</th>
<th>Rarely</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>I safely dispose of CFL bulbs</td>
<td>35.7%</td>
<td>42.9%</td>
<td>7.14%</td>
<td>7.14%</td>
<td>7.14%</td>
</tr>
<tr>
<td>I drive a fuel efficient car or try to carpool when possible</td>
<td>21.4%</td>
<td>35.7%</td>
<td>14.3%</td>
<td>7.14%</td>
<td>21.4%</td>
</tr>
<tr>
<td>I use/support renewable energies</td>
<td>28.6%</td>
<td>42.9%</td>
<td>14.3%</td>
<td>14.3%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table 9. Survey results: Participant responses inquiring as to which items contain mercury (n=14).

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>All</th>
<th>Household batteries</th>
<th>Automobile pollution</th>
<th>CFL lightbulbs</th>
<th>Old thermometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>The following items contain mercury:</td>
<td>42.9%</td>
<td>71.4%</td>
<td>42.9%</td>
<td>64.3%</td>
<td>92.9%</td>
</tr>
</tbody>
</table>

*participants who said “all of the above” were counted for both their actual answer as well as each individual item.
Table 10. Survey results: Participant response to where mercury contamination is the highest (n=14).

<table>
<thead>
<tr>
<th>QUESTION</th>
<th>Improper disposal of batteries</th>
<th>Auto pollution</th>
<th>Coal power plants</th>
<th>All of the above</th>
<th>None of the above</th>
</tr>
</thead>
<tbody>
<tr>
<td>I consider _______ to be the most significant contribution to mercury pollution.</td>
<td>64.3%</td>
<td>42.9%</td>
<td>50%</td>
<td>42.9%</td>
<td>14.3%</td>
</tr>
</tbody>
</table>

*participants who said “all of the above” were counted for both their actual answer as well as each individual item

Businesses owners and tourists

Lake Placid, located in the central, being a tourism hotspot, may prove to be a loon crazed epicenter important to our vision of the importance of loons to the Adirondack region. Common loons are a well-loved species around the United States, and the populations in the Adirondack region help to boost the economy in the area by promoting more tourism. Tourists who recreate on lakes and in wild places impacted by pollution are stakeholders in this issue as well, as increases in mercury in the environment from acid rain and automobile exhaust may impact their experience and their likelihood to return. In turn, this will then impact local residents in regard to the tourism industry, as mentioned, altering local economies.

After conducting phone interviews with store owners in Lake Placid, a small town in the central Adirondacks, we found that store workers/owners unanimously find the common loon to be a popular seller among locals and tourists. However, there were mixed reviews on whether or
not those we interviewed thought that a decrease in the loon population would affect sales. One person said that a decline in loons had the potential to increase sales, but also mentioned that loons are going to be a “hot seller” no matter what. Another said that they projected that sales would fall if there were less loons in the area. Other stores did not see how a decrease would affect their businesses at all. The responses were curious and could be a result of the current stable populations of loons in the Adirondacks. They are indeed an animal of Least Concern on the IUCN RedList, however if they were listed differently, perhaps those we interviewed would be more concerned with sales.

Additionally, human social and economic systems are affected by environmental degradation when considering impacts on business, particularly tourism. If regions that depend on tourism to boost, or even support, the economy, experience loss in biodiversity they will likely see a corresponding decrease in tourism, as tourists elect to travel to other, more pristine locations instead. While we may hope that people will be motivated to conserve wildlife for its intrinsic value, it is likely that some will be more motivated by the very real economic implications of pollution.
Table 3. Store owners interviewed, with responses.

<table>
<thead>
<tr>
<th>Place of Business/Interviewee</th>
<th>Merchandise Offered:</th>
<th>Is loon merchandise a popular sell?</th>
<th>Estimated impact of loon decline:</th>
<th>Is the common loon an important image?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adirondack Store: Jon Prime (store manager)</td>
<td>Framed prints, Christmas ornaments, carved loons, loon tune, pillows, door mats and cd loon music</td>
<td>CD music, framed prints are popular</td>
<td>Increase business, “loon merchandise is always going to sell”</td>
<td>Yes</td>
</tr>
<tr>
<td>Adirondack Trading Company: Linda (store manager)</td>
<td>Shirts notepads mugs postcards “all sorts of things”</td>
<td>Very popular</td>
<td>Would not affect business, people would still love the image of the loon and buy the merchandise</td>
<td>Yes “loons are well liked”</td>
</tr>
<tr>
<td>Adirondack Reflections: Anonymous</td>
<td>Mugs, shirts, etc.</td>
<td>Yes</td>
<td>Loon sales are plentiful, but if loon populations were to decline it would harm sales</td>
<td>Very much so</td>
</tr>
<tr>
<td>Lake Placid store that requested to remain Anonymous</td>
<td>Stuffed loons that when you squeeze them they make a loon call</td>
<td>Yes</td>
<td>Didn’t see how that would affect business</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Traditional cultures

We also recognize that loons are not only extremely popular and well-loved today, but have been so for thousands of years. The common loon is native to the United States, and plays important roles in much of Native American folklore across the country. In some myths, loons voices help heal people who are unwell, while in others loons are said to have magical powers
that help to create the very earth itself. Still other tales believe that Native American flutes were inspired by the heart-wrenching call of the loon (Read 2015). Native American culture provides a unique stakeholder, as their appreciation for loons holds sentimental and medicinal value.

**Special interest groups**

For the purpose of this study we considered all special interest groups to be individuals or organizations (non-governmental) who were working on common loon conservation or involved in researching or solving one of the threats we identified as facing New York State loon populations. To we reached out to staff members at St. Lawrence University, University of Buffalo, the Wildlife Conservation Society (WCS), the Biodiversity Research Institute (BRI), and the New York State Energy and Research Development Authority (NYSERDA) in order to build our understandings of their roles as stakeholders.

The two special interest groups that we identified as having the strongest role in current common loon conservation in New York State were The Wildlife Conservation Society’s Adirondack Program and The Biodiversity Research Institute’s Adirondack Center for Loon Conservation. The Wildlife Conservation Society’s Adirondack Program is a non-profit, non-governmental organization started in 1895 and based out of New York City (About Us 2015). Their Adirondack Program is based out of Saranac Lake in the Adirondack State Park and focuses on research and environmental education in the region. On the research side, WCS organizes the NY Annual Loon Census Survey, which, as mentioned earlier takes place every summer on the third Saturday in July at 8:00am. The survey has gone on since 2001, involving over 500 volunteer citizen scientists overall and surveying >200 lakes each year (Adirondack Loon Census, 2013). Currently, results from the project show that the Adirondack loon
population is relatively stable at roughly 800 mated pairs, with a total of around 2,000 individuals (Adirondack Loon Census 2013).

On the education side, WCS’s Adirondack program works with school groups, provides information on their website, and holds events during the year to promote conservation. They present loon conservation as important because of the important role loons play both as indicators of environmental toxins and as an Adirondack icon - providing both cultural and economic value (Adirondacks 2015). WCS identifies the most serious threats to loons as toxins such as mercury and lead, nest disturbances, shoreline development, and fishing line entanglement. At their Adirondack Program they use the common loon as an umbrella species, telling its story to spread awareness and understanding of mercury pollution and acid deposition in the Adirondacks (Adirondacks 2015).

When we spoke to Zoe Smith, who joined WCS’s Adirondack program in 2000 as the Adirondacks Landscape Coordinator, she said that the most important roles WCS played were in research and education (Smith, personal communication13). She also described lead toxicity as one of the most severe threats facing loon populations and suggests that more work should go into removing lead sinkers from the environment and educating the public to avoid further contamination. On their website, WCS explains that >30% of Adirondack loon deaths each year are the result of abandoned lead fishing gear. They have created Lead Sinker Exchange program that is intended to limit amount of lead that gets released into lakes in the Adirondacks each year (Adirondacks 2015).

The Biodiversity Research Institute, based out of Portland, ME, runs the the Adirondack Center for Loon Conservation, another non-profit organization focused on conserving common

13 Personal Interview, 8 April 2015
loons in the Adirondacks. Like WCS, the Adirondack Center for Loon Conservation focuses both on research and education. Their research, organized by director D.V.M. Nina Schoch, is extensive, and they have recently published articles looking at mercury pollution in the region and its impact on loon physiology (Schoch 2014). BRI also helps WCS with New York Annual Loon Census and has banded 317 loons in the Adirondacks since 1998 (Adirondack Center for Loon Conservation 2015). Additionally, BRI contributes to environmental education efforts in the area by sending out their newsletter, *The Adirondack Tremolo*, organizing the Annual Loon Celebration, being held this year at the Lake Placid Center for the Arts on October 11, 2015. Furthermore, BRI tracks loons with geolocations and satellite transmitters, sets up cameras at nest sites to monitor chicks to assess reproductive success, and runs a program encouraging fishers to reduce the use of lead sinkers and recycle fishing line. BRI scientists attempt to protect loon nest sites by monitoring their locations and placing signs on boat launches to keep visitors away from sites. In an interview, Dr. Schoch said that she believes they are working hard, but that she would like to see more programs focusing on reducing lead poisoning (Schoch, personal communication14).

Both WCS and BRI have been working on common loon conservation in the Adirondacks for more than a decade and the two organizations have joined together to support long-term studies, creating the Loon Conservation Cooperative, allowing them to share resources and work together on larger projects.

14 Personal Interview, 13 April 2015
Governmental

As government agencies are placed with the role of protecting loons, and other species, and managing water quality and environmental toxins, they are also a very important stakeholder. To gain a perspective from this group we spoke with Greg Lampman, from the New York State Energy and Research Development Authority, and Howard Simonin, from the New York State Department of Environmental Conservation (NYSDEC).

Non-human

We would like to recognize the importance of non-human wildlife as stakeholders, including all wildlife directly or indirectly impacted by increasing acid rain and methylmercury levels in the environment, increased lead poisoning levels, as well as any and all wildlife that are harmed or threatened by human development and recreation. In particular we are considering the negative impact on common loons, but we recognize that acid rain deposition, mercury contamination as well as human development and recreation threaten the survival of other waterfowl and all other wildlife that relies on healthy ecosystems. In essence, the environment as a whole is also a stakeholder, as all threats posed to loons have the potential to change biodiversity levels present in the Adirondack ecosystem.
GOVERNMENTAL ISSUES

Air and Water Pollution Protection

Mercury is a naturally occurring element in the environment, but it can pose a potential danger to the development of humans and animals if accumulated through the food chain (DEC 2015). The high mercury levels that are present today in the Adirondacks region are largely due to coal burning powerplants in the mid-western United States and who are therefore responsible for the degradation of the natural environment in New York. The DEC and EPA however, have taken steps to respond to the threat and reality of environmental degradation through mercury and lead deposition. Monitoring and education have been their main vehicles for gaining support in restoration and raising awareness of these potential dangers to humans and wildlife.

The New York State of Department of Environmental Conservation has been monitoring levels of mercury in fish for the last 30 years (Simonin 2009). Since the passing of the Clean Water Act in 1970, and the establishment of fish monitoring since the late 1960’s, mercury levels appear to have decreased (Simonin 2009). Since that time however, continued efforts to monitor mercury levels have shifted focus from a statewide monitoring program, Statewide Toxic Substances Monitoring Program from 1976-1993, to investigation only pertaining to individual research (DEC 2015).

Under the Clean Air Act of 1990 lies Title IV otherwise known as the Acid Rain Act put in action in 1995, which requires emission reductions of sulfur dioxide (SO2) and nitrous oxides (NOx) (Acid Rain Program 2015). To effectively reduce SO2 emissions, a permanent cap is placed on electric generating units (EGUs) in the United States that cannot exceed 8.95 million tons (Acid Rain Program 2015). Coal-powered EGUs are managed to control release of NOx by a rate-based regulatory system (Acid Rain Program 2015). The Acid Rain Act has resulted in significant reductions in SO2 and NOx particularly in the years between 1989-1991 and 2010-
2012 there has been a 59% average decrease in the Mid-Atlantic, 59% decrease in the Midwest, 63% decrease in the North East and 56% decrease in the Southeast (Progress Reports, EPA 2015). During the same time frames, there has also been a reduction in acid deposition of SO2 by 59% in the Eastern United States (Progress Reports EPA 2015). Reductions in sulfur and nitrogen are important for improving the functionality of lakes and rivers to support a healthy ecosystem (Fig. 11; Progress Reports, EPA 2015). According to the 2012 Progress Report from the EPA, there was a 37% improvement in sulfur and nitrogen deposition from 2000-2002, but also a 27% combined deposition from 2010-2012 (Fig. 11; Progress Reports, EPA 2015).

In addition to Acid Rain Program, is the EPA Clean Air Interstate Rule (CAIR) helps to ensure that New York State meets and maintains emission congruent with regulations set by the National Ambient Air Quality Standards (NAAQS), authorized under the Clean Air Act of 1970, as well as mitigate interstate pollution of fine particulate pollution including sulfur dioxide and nitrogen oxides as well as ozone (Progress Reports EPA 2015). By setting limits for 26 states that contribute to downstate SO2 and NOx pollution, CAIR undertakes the responsibility to care for New York State and its neighbors (Progress Reports EPA 2015). CAIR and ARP combined have been successful in the EPA’s mission to decrease emissions in 2012 with a 68% decrease in SO2 emission and a 53% decrease in emissions from 2005 (Progress Reports EPA 2015). As an addition, CAIR has been changed to the Cross-State Air Pollution Rule that was put into place in January 2015 (Progress Reports EPA 2015).

Although there seems to be improvement in the amount of sulfur and nitrogen in the air and water in the eastern United States and an increase in the capacity of Adirondacks waterways to neutralize themselves as a result of acidification, fluctuating caps should continue to experience continuously strict regulation (Progress Reports, EPA 2015).

Figure 11. Estimated critical loads of combined sulfur and nitrogen deposition in 4,886 lakes and rivers with monitoring programs throughout the Appalachian Mountains and northern coastal plain for the years 2000-2002 and 2010-2012. Available from: http://www.epa.gov/airmarkets/progress/ARPCAIR12_02.html

Bird Protection International

The Migratory Bird Treaty Act 1918 in the United States was enacted in 1916 with Great Britain (otherwise Canada) in conjunction with the Migratory Bird Convention Act (MBCA)
passed in Canada in 1917 and updated in 1994 and 2005 to enforce legislation that protects the birds listed within (Migratory Birds Convention Act 1994, 2015). Under its 1994 installment, protection verbiage was expanded to include protecting and conserving migratory birds as populations and individuals as opposed to only the protection of migratory birds and their nests (Migratory Birds Convention Act 1994, 2015). With this revision, conservation is now acknowledged its own mechanism of protection (Migratory Birds Convention Act 1994, 2015). The MBCA forbids the possession of a migratory bird, nest or sell any such parts in Canada or within the economic zone of the country (Migratory Birds Convention Act 1994, 2015). In addition, the deposition of substances harmful to migratory birds are also illegal in any such area that a bird may land or enter unless authorized by the Canadian Shipping Act 2001 or by the Minister for scientific purposes (Migratory Birds Convention Act 1994, 2015).

**Recreation Restrictions**

One of the major threats to loons is the consumption of lead sinkers used as part of fishing practices. Because of such events, the state of New York has banned the use of lead sinkers that weigh less than half of an ounce and are less than an inch long (NYSDEC 2015). Other states, including New Hampshire and Maine (as well as parts of Canada) have put heavy restrictions on the sale and usage of lead sinkers under a certain size and/or weight (NYSDEC 2015).
DEVELOPMENT OF SOLUTIONS TO THE PROBLEM

As the issue of mercury contamination in waterways is a conservation concern that impacts a wide variety of stakeholders, it is important to attempt to solve it using a variety of solutions. With such a complicated environmental problem that has such far-reaching effects, no one universal solution will likely work. For this reason, we will explore several useful ways to address this problem.

Parameterizing solutions

Educational outreach may be one of the best methods of conserving loons and their habitat. In addition to the preservation of parks and reserves, the value people place on nature and more importantly, loons, may help to secure their future through the gain of intrinsic value. Loons are charismatic creatures that are easy to love because they are unique, charismatic and represent the spirit of the wilderness. One could also argue that the loon’s popularity stems from its position in culture. Although the loon predates upon fish and invertebrates, they do not pose a threat to livestock or peoples’ livelihoods like the wolf. The loon also apprehends a sense of wildness through its solitary ways, but not in an advanced or scary way. In this way, loons provide a comfortable way to access the idea of wilderness. Funding for such educational programs would be hard to attain, but our best options as of now would most likely have to come from the state of New York.

Identification and evaluation of potential solutions

With the number of threats now facing loon populations in the Adirondack, the possibilities for potential solutions increases considerably. Since all of the threats mentioned are human induced, the first step for any solution must begin with a change in people’s habits.
Limiting the usage of any item containing mercury, limiting the use of lead sinkers as well as recycling fishing line are all excellent options because there are alternatives there to lead available that are less harmful to loons when ingested. In addition, spreading awareness about proper recycling techniques and a notice of the location of town receptacles in the nearest location. Communities and schools could integrate a continuous biodiversity and local natural history course to their curriculum. With this, the DEC or EPA could be commissioned to help create a curriculum that can be taught early in primary education, but also a more cohesive curriculum that appeals to high school level students and incorporates the impact that harmful substances like lead and mercury can have on biodiversity. In order to capture the interest of educators, New York State could require achievement standards for the success of the local/natural science programs as well as mandate a yearly earth clean-up day throughout the state.

In addition to education programs in the private and public school district, citizen science programs that include students may also be effective and work in conjunction with classes, bringing the classroom outside into the natural environment. To a less involved degree, community clean-up projects along the shores of lakes and rivers could be most effective in removing fishing line and prevent loon entanglement as well as reduce possibly attached lead sinkers. Community recycling centers could also be set up for easy use and access so that residents may simply and safely dispose of their mercury containing items. Community members should be encouraged to get involved in their local government and speak to their local legislature to push for more strict laws.

The implementation of policy is also a potential effective method of protecting loons and their habitats. Policies that restrict sulfur dioxide and nitrous oxide pollution from both coal
burning and non-coal burning electric generating units are helpful in reducing acid rain in the Adirondacks. More strict additions to the Clean Air Act that further cap emission are helpful at the federal level and benefit multiple states.

Local level government like the DEC, New York Office of Parks, Recreation and Historic Preservation and EPA could further their programs with boat wash stations to improve use by visitors and provide educational material of invasive species. Restrictions such as increasing limitations on shoreline building would also help to reduce pollution in lakes and rivers and maintain vital loon nesting habitat on shore. In addition, “no-wake” zones and restricted recreation use in loon nesting areas are also possible solutions that preserve the natural nesting and laying process of the loons. Because loons are easily scared off their nests by the invasion of jet skis and paddle craft, loon nesting signs could be useful in order to educate and prevent people from coming close to nests, especially if signs were displayed as a buoy well before recreators encountered the nest as well as on shore. Although BRI practices these techniques in Maine, they could be expanded to New York and surrounding states.

Although there are annual loon censuses that occur in the north east every summer, it would be beneficial to monitor loon populations (breeding and nonbreeding) throughout the summer months in New Hampshire, Maine, Vermont and New York instead of just for one hour on the third Saturday in July and so perhaps encourage more citizen volunteers. As always, more research and monitoring of loon fecundity and successful reproduction would also be helpful in understanding the extent that acidic lakes contributes to loon infant mortality. With this, there should also be more communication between loon scientists in Vermont, New Hampshire, Maine and New York so that they could achieve data summaries of the north east region gather a more cohesive estimate of total loon populations and their health.
To improve loon numbers, reintroduction could also be a successful method for increasing loon numbers. Because loons are already native to much of the north eastern region, they may do well to be reintroduced to areas where they are lacking. Breeding programs could also be useful in increasing loon numbers and also mitigate the need for limited recreation areas if there is little to no reliance on nesting success.

**Identification of feasible solutions**

The most feasible solutions seem to be those that have government support, mostly state, and are not as costly. For example, loon reintroduction and captive breeding programs are expensive. In addition, loon chicks must learn feeding behaviors from their parents, which otherwise would be neglected in a breeding program. Along with funding complications, further research may be increasingly difficult to conduct especially if people are aware that the common loon population is of least concern.

On a less aggressive level however, educational outreach and citizen science is feasible for involving the community in simple projects that would inspire a passion to contribute to the wellbeing of the common loon. Forming citizen scientists would fuel a long term appreciation for the common loon, but also organisms that are connected to the loon in the food web. Citizen science can target a wide range of local community members in addition to students, which is more effective in spreading knowledge than just targeting one age group. Programs could be effective with independent organizations in partnership with state funding. Recycling efforts would also be a more feasible path because lessons on renewing, reusing and recycling have already infiltrated the school systems and are gaining momentum in communities. The expansion
of specific lead and mercury household contaminant recycling techniques would be an additional step in the right direction.

Although national legislation such as the Clean Air Act can influence businesses on a larger scale, the establishment of strict standards and caps is more difficult to achieve and less tangible for rural communities that are perhaps less involved with their state legislature or national government. In contrast, government involvement with the Adirondack Park Agency (APA) is a better adjusted level for those interested in local legislature. Encouraging attendance at planning commission meetings could be a simple informative way of community member to become aware of building and development plans in their area that could negatively impact the natural environment.

**Identification of best solutions**

All in all we have come to the conclusion of four best solutions in order to maintain healthy loon populations within the Adirondack Park: increase in education, expansion of citizen science, increased efforts for policy changes, and more protection for nesting loons. Ideally, we would like to see the implementation of all four solutions in order to achieve a goal of increased loon populations in the park, but regardless, the implementation of any of our best solutions would surely construct a positive change.

**Increased Education**

First, we propose increased educational efforts within both public and private schools in the State of New York. Educational efforts not only include those about loon populations in general, but also of the threats that they face today, specifically within the Adirondack Park. Education
about mercury and acid rain deposition in schools will create awareness to not only this problem on a local scale, but a global one as well. Much of this educational effort will have to come from support from the local communities who feel these efforts are necessary. With community support, we can achieve the goal of changing the curriculum of statewide schools.

We consider more education on the dangers of mercury in the classroom to be an important cause, seeing as how mercury is present in many items such as latex paint, home security systems, thermometers, light bulbs, plumbing, heating and cooling systems, sporting equipment, antiques and television sets (EPA). If any of these items are broken, the mercury escapes and it can evaporate into a toxic vapor that cannot be seen. Once this occurs, the real threat is when the mercury is disposed of and it is able to seep into the groundwater. More efforts geared towards this educational awareness are key in ensuring healthy future loon populations. Information about how to clean up mercury spills can be found at:

http://epa.gov/mercury/spills/index.htm#mercuryinhome

Citizen Science

Next, we believe that expanding monitoring programs for loon conservation should cover the entire state. Increasing popularity in citizen science can be seen for many conservation efforts nationwide; Earth Day for example. However, we believe that having more monitoring programs as well as expanding the programs already in place with the BRI and WCS would help bring awareness to the current status of loon populations. Increased participation in programs such as the annual loon census, as well as longer duration of the census would no doubt bring increased awareness to these majestic creatures. We also feel that a community of citizen
scientists across state borders would positively influence the results of annual census’ conducted, as we would then have a clearer idea of the number of loons within the Northeast region.

**Policy Changes**

We would also like to discuss the importance that community involvement has on loon populations in the Adirondack Park. As both educational and citizen science efforts increase, policy changes will then follow suit. With more community involvement and communication with local congressmen, we believe that changes in policy will happen more frequently and with more positive results. Policy changes that are geared toward limiting human development within the park will beget more of such changes.

**Protection of nesting loons**

Since programs geared toward the protection are already in effect, we propose that an increase in protection efforts through education, citizen science and policy change will ensure the safety of loon populations in the Adirondacks. The BRI currently does work involving the placement of signs to warn recreational visitors on lakes during loon breeding months as well as both verbal and written communication via pamphlets. Connecting to citizen science, we are also proposing more efforts to help build nest rafts for loons during their breeding months. These nests are important for loons for four reasons: 1) these rafts can adjust to water level changes easily, 2) loons are more easily able to get on to the nest rafts, 3) loons can easily dive into the waters to avoid airborne predators, and 4) reproductive success can increase due to the increased ease of the adult loon getting back on to the nest raft in order to protect their eggs.
EASE OF IMPLEMENTATION

Addressing the ease of implementation, we consider factors such as the affordability of our solutions, the consensus among communities to establish these solutions, possible fear of change that may come about during the process, as well as local communities respect for cultural values. With all of these factors a possibility in the hindering of our solutions, we realize that what we need in order to implement our solutions includes the involvement of stakeholders and be open with what our exact plans are for our solutions. As long as we are open and honest with our intentions throughout this entire process, we hope to mitigate any stigma that might be attached with our solutions. We also suggest that implementing a tourism tax within the Adirondack Park for nonlocals might also influence residents within the park to support our efforts.
IMPLEMENTATION PLAN

The first step to implement change (aka further protection and conservation of loons) is through education. From there, we hope that people will place value on the species and demonstrate their willingness to pay. The next step would be to enlist the help of local congressmen to create a goal. We want to create a connections between the communities and their congressmen, as well as connections between organizations working on loon conservation throughout the Northeast. These organizations include the Loon Conservation Cooperative and Restore the Call Project. People should be inspired to protect that which they love and to work together on different governmental levels for the sake of the preservation of nature and for human well-being. It’s for people's own good that they should protect loons.

The future health of loons, aquatic wildlife, and our community members depends on how our relationship with the environment evolves. It is important to educate the public to help people understand the role biodiversity plays in keeping the environment strong by allowing it to adapt to future changes. Encouraging awareness of the threat environmental toxins such as mercury pose to biodiversity is an important part of developing that understanding. Therefore, our first recommendation when developing a conservation plan is to focus on how to best encourage the preservation biodiversity. Part of this well-rounded conservation approach will be to address the issue of mercury contamination through government policies on pollutants and educational outreach programs. The second part of our approach is to address concerns about loon population levels by surveying, monitoring nests, and developing programs to protect them and other wildlife. Monitoring progress of such efforts will be done by local scientists as well as citizen scientists in the surrounding areas.
Educational programs should be government funded at the state level and outsourced to scientists in order to make a curriculum that is encouraging, meets a learning standard and is relevant to students who live in the local area. We also hope to seek funding towards such educational programs through possible tourism taxes within the Adirondack Park for visiting guests.
CONCLUSIONS

Overall, within New York State (and more specifically the Adirondack Park) loon populations are stable. Although this may be the current case, their numbers are still lower than past populations. Throughout the entirety of our research we have come to two conclusions: 1) that human induced issues such as mercury pollution, lead poisoning, entanglement, botulism, climate change and development are the most common threats facing Adirondack loon populations today and 2) that only through education and the implementation of citizen science will Adirondack loons see a more healthy future. We hope to see the implementation of educational programs not only within New York State, but also in New Hampshire and Massachusetts, where loon populations are also lower than historical numbers.
ACKNOWLEDGMENTS

We would like to acknowledge Erika Barthelmess first and foremost, for her hard work and dedication to the Conservation Biology class of 2015. She has been unbelievably supportive and encouraging, and we are very grateful for her enthusiasm and patience. We would also like to thank all of our survey participants, shop owners in the Adirondack region, and the individuals we interviewed including: Dr. Nina Schoch from BRI, Zoe Smith from WCS, Greg Lampman from NYSERDA, Howard Simonin previously from the DEC, Dr. Brad Baldwin from St. Lawrence University and Dr. Alex Schreiber, also from St. Lawrence University. Of course, we would also like to express our gratitude for all of the common loons in the Adirondack Park, and we would like to thank them for their role in helping to raise awareness about mercury pollution. May they penguin dance on Adirondack lakes for years to come.
LITERATURE CITED


About Loons [Internet]. Moultonborough (NH): The Loon Preservation Committee (LPC); [cited 2015 May 6]. Available from: http://www.loon.org/about-loons.php


APPENDICES

Appendix A. Copy of survey instruments

Survey Questions

Below are a series of questions designed to assess your experience with the topic. Please respond by circling the appropriate answer:

1. I spend a lot of time outside and frequently visit local lakes and waterways.
   1 2 3 4 5
   Strongly Disagree Uncertain Agree Strongly Disagree Agree

2. Please circle all photos of the common loon:
3. I have seen loon(s) within the last year on water bodies near my home.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

4. Loon populations in the surrounding lakes and ponds are stable and healthy.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

5. A decline in common loon populations would have negative economic effects in my community.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

6. A decline in common loon populations would have negative environmental effects in my community.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

7. I have a basic understanding of the ways in which mercury is introduced into aquatic systems.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

8. Mercury pollution is an issue in my area.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree
9. Mercury pollution a serious threat to common loon populations.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

10. I consider fish a regular part of my diet.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

11. I often source my fish locally.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

12. Fishing is a pastime/hobby of mine.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

13. Mercury pollution is a threat to fish populations.

1 2 3 4 5
Strongly Disagree Uncertain Agree Strongly
Disagree Agree

Please respond by checking the appropriate statement:

The following items contain mercury:

☐ Household batteries
    Automobile pollution
CFL light bulbs
Old thermometers

I consider ________ to be the most significant contribution to mercury pollution:

Improper disposal of batteries
Automobile pollution
Coal-burning power plants
All of the above
None of the above

Which of the following actions do you take to limit your contribution to mercury pollution?
(Circle one)

I safely dispose of CFL bulbs  Very Often  Often  Sometimes  Rarely  Never

I drive a fuel efficient car or Very Often  Often  Sometimes  Rarely  Never
try to carpool when possible

I use/support renewable energies  Very Often  Often  Sometimes  Rarely  Never

What is your age?

• 18-25
• 26-35
• 36-45
• 46-55
• Over 55

Do you identify as:
• Male
• Female
• Other
• Prefer not to disclose

How often do you see loons in your community?

• Never
• Rarely
• Somewhat often
• Frequently

Feel free to share other comments or concerns below.

Thank you for your time.
Appendix B. Questions we asked Lake Placid store owners during phone interviews (n=6).

1. Do you still sell loon merchandise? If so what sorts of items and would you consider these popular items?
2. Do you consider loons an important image in the store ADK?
3. How do you think a decline of loon populations would impact your business/future sales?
4. Would you mind if your responses were used in our paper?
   a. name
   b. role in the store
   c. years worked there
   d. how long has the store been around
Appendix C. Contact info for Lake Placid store owners we interviewed by phone (n=5, 7 attempts).

<table>
<thead>
<tr>
<th>Store</th>
<th>Person</th>
<th>Contact Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adirondack Store</td>
<td>Jon Prime, manager</td>
<td>518-523-2646</td>
</tr>
<tr>
<td>Adirondack Trading Company</td>
<td>Linda, manager</td>
<td>518-523-4545</td>
</tr>
<tr>
<td></td>
<td>Worked there 25 years</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Store has been around for 30 years</td>
<td></td>
</tr>
<tr>
<td>High Peaks Gift Shop</td>
<td>No answer</td>
<td>518-523-2571</td>
</tr>
<tr>
<td></td>
<td>No answer again (4/8)</td>
<td></td>
</tr>
<tr>
<td>Adirondack Christmas Co.</td>
<td>Scott</td>
<td>(518) 523-8210</td>
</tr>
<tr>
<td>Adirondack Reflections</td>
<td>ANONYMOUS</td>
<td>(315) 357-4704</td>
</tr>
<tr>
<td></td>
<td>Store has been around for 15 years</td>
<td></td>
</tr>
<tr>
<td>Critters</td>
<td>ANONYMOUS (also preferred the store name to be anonymous as well)</td>
<td>(518) 523-1177</td>
</tr>
<tr>
<td>Finders’ Keepers</td>
<td>No answer</td>
<td>(315) 357-5116</td>
</tr>
<tr>
<td></td>
<td>No answer again (4/8)</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D. Contact info for all individuals interviewed by phone or skype, by date interviewed (n=7).

a. Dr. Alexander Schreiber  
Physiology professor, St. Lawrence University; Current research on methylmercury  
aschreiber@stlawu.edu  
Johnson Hall of Science 121  
(315) 229-5011 x5822  
Date interviewed: 27 Feb 2015

b. Dr. Brad Baldwin  
Biology professor, St. Lawrence University; freshwater research in and surrounding the Adirondacks  
bbaldwin@stlawu.edu  
Johnson Hall of Science 123  
(315) 229-5011 x5240  
Date interviewed: 2 March 2015

c. Zoe Smith: Adirondacks Landscape Coordinator of the Wildlife Conservation Society’s. Adirondack Program  
zsmith@wcs.org  
skype: zsmith_wcs  
Date interviewed: 8 April 2015

d. D.V.M. Nina Schoch  
Director of the Adirondack Center for Loon Conservation  
Biodiversity Research Institute (BRI)  
nina.schoch@briloon.org  
207-887-7160 x145  
Date interviewed: 13 April 2015
e. Dr. Amy McMillan: Associate Professor of Biology at Buffalo State University; currently researching population effects and mercury poisoning in Common Loons in North America
   (716) 878-3756
   MCMILLAM@buffalostate.edu
   Date interviewed: 30 April 2015

f. Greg Lampman
   Sr. Project Manager, Environmental Research
   NYS Energy Research and Department Authority (NYSERDA)
   gregory.lampman@nyserda.ny.gov
   518-862-1090 x3372
   Date interviewed: 24 April 2015

g. Howard Simonin
   Retired, New York State Department of Environmental Conservation
   Focus on mercury contamination and environmental pollutants
   315-865-6680
   Date interviewed: 4 May 2015