The loon is a key biosentinel of aquatic integrity for lakes and near shore marine ecosystems across North America. Supported by a grant from the Ricketts Conservation Foundation, which first proposed the idea, Biodiversity Research Institute (BRI) has initiated the largest conservation study for the Common Loon. The goal is to strengthen breeding populations in their existing range and to restore loons to their former breeding range.

This work will advance our understanding of loon ecology and allow us to apply that knowledge to help restore the integrity of ecosystems where loons once thrived. BRI is working with Maine Audubon and the Maine Department of Inland Fisheries and Wildlife to achieve these goals.

Known for its rocky coastline, rolling mountains, and expansive forests, Maine is also home to approximately 2,600 water bodies that are larger than 10 acres in size. Across this landscape, an estimated 1,700 territorial pairs of Common Loons breed each summer. With their haunting calls and distinctive black and white plumage, loons are emblematic of the north woods in this state. While this population of loons is healthy, current environmental threats require continuous loon monitoring and public outreach efforts to ensure this trend is not reversed.
Status of the Breeding Common Loon Population in Maine

Distribution and Population Size
The Common Loon’s (*Gavia immer*) contemporary range likely followed the retreat of the glaciers about 11,700 years ago. They are historically reported to have bred as far south as northern New Jersey in the eastern United States. As human settlement increased throughout New England in the 1600’s and beyond, Maine loons were somewhat more protected from human disturbance due to their preference for more remote lakes. By the mid-1900s, however, Maine began to experience declines thought to be related to human disturbance (Cross 1979, Sawyer 1979). Human encroachment on nesting habitat can have numerous deleterious effects, such as adults flushing from their nest (Vermeer 1973, Titus and VanDruff 1981), which leaves eggs vulnerable to predation by bald eagles, American crows, and common ravens (Alvo 1981, Titus and VanDruff 1981, Alvo and Blancher 2001). Through time, however, some loons have acclimated to human activity and are able to successfully produce chicks on lakes with heavy recreational use.

Maine’s current population estimate of adult loons is 1,700 territorial pairs, which is equivalent to 3,400 breeding adults and 700 non-breeding but oversummering subadults and adults. This estimate is based on Maine Audubon’s ongoing monitoring and volunteer efforts in southern Maine coupled with random aerial surveys in northern Maine by the Maine Department of Inland Fisheries and Wildlife in the 1980s (Figure 1).

Movements
Loons migrate from their breeding lakes to the ocean in the late fall. Maine’s proximity to the ocean allows loons to remain on their breeding grounds much later into the fall than their mid-continent counterparts. Adults depart before juveniles, thus young birds arrive on the ocean without guidance, prior knowledge, or experience.

Band recoveries indicate that the majority of Maine loons overwinter along the coasts of Rhode Island, Massachusetts, New Hampshire, and Maine; however, a handful of individuals have been located further north or south along the Atlantic coastline (Figure 2).

**Figure 1**: Estimated loon population for the southern half of Maine, 1983-2014. Data provided by Maine Audubon.
Conservation Concerns

Threats to Maine’s breeding and wintering loon population include:

- Loss of breeding habitat from shore-line development
- Human disturbance, such as recreational boating activities
- Fishing line entanglement
- Water level fluctuations from dams and storms
- Lead toxicity from ingestion of lead fishing tackle
- Environmental mercury pollution and acid deposition
- Cyanobacteria outbreaks in lakes and the ocean
- Wintering hazards such as marine oil spills

A long-lived species, loons have relatively low fecundity and poor ability to colonize new areas, with young dispersing an average of only twelve miles from their natal lakes. As the Maine loon population expands, it is expected that there will be a corresponding increase in interspecific interactions, potentially limiting the numbers of breeding pairs. Understanding and quantifying the unpaired “floater” population of loons in the state will provide insight into these dynamics.

Figure 2. Migratory movements of Maine’s Common Loon population, 1996-2015. Movements of loons are based on recoveries and observations of individual Maine loons banded by BRI (n=39). Not shown on map are two recoveries: one in Carolina Beach, North Carolina, and one in Tignish Shore, Prince Edward Island. The “Translocation Site” indicates location of the rearing lake for chicks translocated from New York State and Maine.

Evidence of the loon’s ability to acclimate suggests that with forethought and understanding both people and loons can adapt and live together.

In addition to color bands, satellite transmitter tags help us track loon movements.
The Rangeley Lakes study is the longest running monitoring effort of a uniquely color-marked loon population in North America. Shoreline nest placement and the loon’s limited mobility on land make loon nests vulnerable to failure caused by water level fluctuations. Due to this sensitivity, the U.S. Fish and Wildlife Service (USFWS), Maine Department of Inland Fisheries and Wildlife, and Maine Department of Environmental Protection identified the Common Loon as a species to be monitored in connection with the Federal Energy Regulatory Commission (FERC) relicensing of reservoirs.

**Project Overview**

Current efforts characterize and monitor the demographics of the breeding population, environmental exposure and effects of mercury and lead, incidence of diseases (e.g. avian influenza), and ecological impacts from reservoir operations.

**Productivity: Rafts versus Natural Nests**
Loons prefer to nest on islands as they provide a safeguard against egg predation. Nesting platforms or rafts artificially provide this benefit and also protect against nest flooding or water level drops (see page 6). Analysis of reproductive success and raft use show these platforms can provide compensation for loss of productivity (DeSorbo et al. 2007). BRI biologists use nearly 80 artificial nesting islands (rafts) as the primary management tool in compensating for the impacts of water level fluctuations on nesting loons (Figure 3).

**Overall Study Goals**
- Maintain nearly 80 artificial nesting rafts for Common Loons on reservoirs in Rangeley Lakes region and monitor egg laying rates, hatching success, and fledging success
- Capture and color-band adult and juvenile loons (557 loons from this area were banded between 1994 and 2015)
- Monitor breeding territories on a weekly basis for overall breeding success, site fidelity, and individual performance of uniquely color-banded adult loons
- Determine local and long-distance movements of breeding loons
- Develop a long-term baseline for methylmercury availability and monitor the relationship of mercury body burdens and effects of mercury on physiology, behavior, productivity, and survival

*Figure 3. Proportion of successful nesting attempts (at least one chick hatched) from nests built on rafts versus natural sites on Richardson, Aziscohos, Flagstaff, and Mooselookmeguntic reservoirs, 1987-2015.*
Common Loon Territories in the Rangeley Lakes Region of Maine

Site Fidelity in Western Maine

Common Loons have strong breeding site fidelity, meaning they return to the same lakes to breed each year. Larger lakes are often broken up into numerous territories, which are areas of the lake the loon utilizes and defends.

More than 200 territorial pairs of loons are annually monitored in the Rangeley Lakes Region. Surveys began in 1993, fully covering the area in 2000 (Figure 4).

Researchers have also maintained a major, parallel effort to color band adult and juvenile loons each year. Re-observation of color-banded individuals provides good insight into site and pair fidelity (Figure 5), local movements, migratory paths, and wintering areas.

Figure 4. Location of 166 Common Loon territories in Maine. This does not include territories monitored by Loon Preservation Committee in New Hampshire that are considered to be part of the long-term monitoring effort.

Figure 5. Male (n = 106) versus female (n = 181) site fidelity in Rangeley Lakes region of Maine, 1994-2013.
Artificial Nesting Rafts as a Conservation Management Tool

Federal Energy Regulatory Commission
The Federal Energy Regulatory Commission (FERC) oversees the licensing of dams in the United States and issues new licenses every 20 or more years. The renewal of FERC licenses in the past decade has taken place within the context of negotiated settlement agreements arrived at by the dam licensees, state and federal agencies, and nongovernmental organizations. The International Joint Commission (IJC) plays a similar role to FERC for reservoirs that cross the U.S./Canadian border; Canada does not have a legal entity that corresponds to FERC.

Increased interest in recreational and environmental resources associated with these reservoirs, including breeding loons, has generated new considerations for reservoir management. Fluctuating water levels during the nesting season can have deleterious effects on loon nesting success. Increasing water levels easily inundate nests while lowering water levels strand nests, increasing the difficulty of incubation exchanges and enhancing predation.

In Voyageurs National Park’s Rainy, Namakan, and Kabetogama Lakes, a study from the 1980s found an average of 60 to 70 percent of loon nests failed due to water level fluctuations. Based on a BRI-led study, the IJC in 2000 instituted new water level management guidelines for these water bodies in order to minimize the impact on loon nesting success, which is a good example for similar situations in Maine (Windels et al. 2013).

For the past 20 years, the FERC relicensing process has also implemented reservoir management schemes that minimize impacts to nesting loons. The general guidelines recommend maintaining water levels within a 6-inch rise and 12-inch drop during the primary loon nesting period, or the implementation of artificial loon nesting rafts to enhance nesting success.

Aquatic birds, loons build their nests at the water’s edge. Typically, a 6-inch increase or a 12-inch decrease in the water level will likely cause significant nest loss. Fluctuations in natural lakes can vary widely depending on geographic and climate conditions.

Reservoirs can be managed so that water draw downs are timed to be sensitive to nesting and egg hatching. Rafts have proven to be an effective management tool in loon reproductive studies.
Case Study: Monitoring Loons on Mount Desert Island

A collaboration between BRI, Acadia National Park and the Somes-Meynell Wildlife Sanctuary, the Mount Desert Island Loon Monitoring Project began in 2002 to monitor the productivity and movement of the Common Loon population in this region. Color marked loons are tracked to gain specific information on territory boundaries and life history. Artificial nesting islands were floated in loon territories where nesting success was impacted by shoreline predation or water level fluctuations.

**Research and History**

On Mount Desert Island (MDI), 8 +/- 1 territorial pairs are annually present (range 9-11 pairs). Of these pairs, an average of 6 +/- 1 (range 3-8) nest. The average number of chicks hatched is 5 +/- 3 (range 2-10) with 2 +/- 2 of those chicks (range 1-3) surviving to fledge each season. Compared to BRI’s long-term study of breeding loon populations in the Rangeley Lakes Region, nesting frequency is normal (0.74 nests/pair versus Rangeley Lakes at 0.71) and the hatch rate is high (0.76 chicks/nest versus Rangeley Lakes at 0.51). However, chick survivorship is very low on MDI (0.26 versus 0.56). Therefore, overall productivity is low (0.29) and is not meeting the needs of a self-sustaining population (Figure 6). Immigrant loons are critical for maintaining a breeding population on MDI. Poor fledging rates could be reflective of numerous factors including increased human disturbance and predation, particularly from Bald Eagles (*Haliaeetus leucocephalus*).

![Productivity (Chicks Surviving Per Territorial)](image)

**Figure 6.** Overall productivity on for loon populations on Mount Desert Island, (2002-2014). Red line depicts the self-sustaining population level of 0.48 fledged young per territorial pair. Productivity in only two of the past 13 years is above this threshold. Data presented are jointly gathered with Somes-Meynell Wildlife Sanctuary (www.somesmeynell.org).

**Loon Breeding Populations in National Parks**

The National Park Service preserves the natural and cultural resources and values of the National Park system for the enjoyment, education, and inspiration of this and future generations.

The NPS manages 388 properties totalling 84 million acres that includes national parks, national seashores, national lakeshores, and national monuments.

Of the 59 national parks, only a few include suitable breeding habitat for the Common Loon. Six national parks with the largest breeding populations are identified on this map. Other parks where breeding loons are found are also identified.
Case Study: Monitoring Mercury in Common Loons

Loons are one of many species of avian piscivores that rely on fish as the dominant part of their diet. These birds are important bioindicators because of their obvious connection to aquatic ecosystems and their susceptibility to bioaccumulation of mercury as they feed at higher trophic levels.

Wildlife directly linked to the aquatic ecosystem have an increased risk of exposure to mercury versus species living independently of aquatic food webs because the conversion of mercury to methylmercury is enhanced in wet soils low in oxygen.

Mercury can have adverse effects on all aspects of avian ecology, including survival, reproduction, immune response, and endocrine response.

BRI annually samples mercury levels in tissue from Common Loons from sites across their North American breeding and wintering ranges. To date, 2,589 adult and 1,053 hatch year birds (plus 785 recaptures) have been tested for mercury (in blood, feathers, and eggs), creating one of the world's most robust data sets for mercury in loons.

Mercury samples have been collected from more than 40 water bodies in the Rangeley Lakes region of Maine since 1994 (n=509), allowing for the unique ability to track environmental mercury loads in this region over time (Figure 7).

**Figure 7.** Common Loon adult blood mercury levels in the Rangeley Lakes region, 1994-2014. Values are expressed in Female Loon Units (FLU) which converts a male to a female blood Hg level to allow for side-by-side comparison. Significant adverse reproductive effects from mercury occur at >3.0 FLU (ppm) (Evers et al. 2008).

This simple version of the mercury cycle illustrates how mercury enters and moves through an ecosystem. Sources of mercury in New England are varied. Coal-fired power plants (particularly those in the Ohio River Valley) are a major source of air emissions. Recent reductions in air emissions from incinerators have proven effective in rapidly reducing mercury in loons and fish (Evers et al. 2007). Water-borne sources in Maine are still not fully known.
Common Loon Demographics Across North America

Much is known about the demographics of the Common Loon based on a 29-year monitoring program of color-marked individuals from across North America (n>5,000) and associated movement studies using satellite telemetry (n>50 individuals) by Biodiversity Research Institute (BRI).

For example, on average, individual loons produce 5-10 fledged young over a lifetime. This is based on a model using known national rates for fecundity of 0.24 fledged young per breeding female (or 0.48 fledged young per territorial pair), average first year breeding at 6 years of age, 3-year-old survivorship of 48 percent, 3-20 year old annual survivorship of 92 percent, and 20-30 year old annual survivorship of 85 percent.

Models developed by BRI in conjunction with the U.S. Environmental Protection Agency and the U.S. Fish and Wildlife Service indicate that a long-term average of 0.48 fledged young per territorial pair is needed for a sustainable loon population. Typically around 18-20 percent of the summer adult population represents individuals that may be over-summering, but not attempting to breed (i.e., 3-5 year olds).

Common Loons are poor colonizers; adults disperse an average of 1-2 miles from their previous breeding territory and fledged young disperse an average of 12 miles (although the record is just over 100 miles; Evers et al 2010).

Restore the Call Loon Conservation Study

Following the success in Minnesota in 2014 and 2015 (seven chicks released each year), BRI researchers translocated seven loon chicks from New York lakes to Massachusetts during the late summer months of 2015. This work, part of the Restore the Call loon conservation study initiated in 2013, is now involving (as of 2016) Maine in collaboration with Maine Department of Inland Fisheries and Wildlife and Maine Audubon. For more information, visit: www.briloon.org/restorethecall.
The Importance of Suitable Lake Habitat for Loons

Protection of loon breeding habitat is critical to maintaining the integrity of loon populations and avoiding increased degradation of suitable breeding habitat. Because of its status at the top of the food web, high visibility to people, limited dispersal ability, and relatively slow replacement rate, the loon is widely used as an indicator species for tracking aquatic integrity (Evers 2006).

Human Disturbance Affects Loons

Human recreational activity has high potential to affect breeding Common Loons. High levels of boat-related disturbance can cause formerly occupied territories to be less attractive to potential new pairs. In some instances, wakes from passing boats can erode nesting habitat and flood existing nests. Additionally, when incubating loons are flushed from a nest by humans, the eggs are left vulnerable to predators and chilling, and therefore may fail to hatch. Human activity may also discourage the birds from getting back on the nest, especially if disturbed during the first week of incubation.

Loons, Lead, and Line

Loons and other wildlife occasionally eat a fish that still has fishing tackle and/or line attached after an angler’s line breaks. Unfortunately, this can detrimentally impact a loon who swallows a piece of lead fishing tackle or gets tangled in the line dangling from the fish. Lead is poisonous to animals when swallowed, as it breaks down in the acidic fluids in the stomach where it is absorbed, affecting the bird’s behavior and organ function, including the gastrointestinal and neurologic systems. A loon that accidentally ingests lead fishing tackle or gets tangled in fishing line will suffer and potentially die over the course of two to three weeks.

The Impact of Coastal Oil Spills

On April 27, 2003, the Bouchard Barge 120 (B120) struck ground near Cape Cod Canal. Between 22,000 and 98,000 gallons of No. 6 fuel oil spilled into Buzzards Bay (U.S. Coast Guard 2003; Hall 2003). This event occurred during migration of several bird species including the Common Loon. Approximately 200 dead or moribund loons were collected and a rapid field assessment was coordinated by the U.S. Fish and Wildlife Service (USFWS) through the Loon Preservation Committee (LPC) and BRI, to document the range and fate of dispersing individuals (Taylor et al. 2004).

In a precedent-setting 10-year restoration effort for the North Cape Oil Spill in Rhode Island, BRI worked with the U.S. Fish and Wildlife Service to identify and purchase best lake shoreline properties for mitigation. We then monitored the protected loon pairs on a weekly basis (for two to six years). This long-term approach was helpful in replacing most of the loon years lost (adult loons that died from the spill as well as their lost future progeny). This strategy is worth repeating in the event of future spills.

Water Quality Affects Loons

Loons breed in a wide variety of freshwater aquatic habitats, however, they prefer lakes larger than 60 acres with clear water, an abundance of small fish, numerous small islands, and an irregular shoreline that creates coves. Lake size and configuration, as well as undisturbed shoreline, are important determinants for loon density. Water quality is an important habitat feature for breeding loon success; loons are visual predators, therefore clear water is crucial for foraging efficiency.
Actions Needed for Maintaining Sustainable Loon Populations

Evidence of the loon’s ability to acclimate suggests that properly designed conservation efforts can be beneficial in many instances (Evers 2007). Over the years, BRI’s research has found the following actions to be successful or have potential for success:

**Monitoring**
A critical component of monitoring is to determine the cause of nest failure or chick loss. Standardized survey methods are used to collect data about the number of territorial pairs, nesting pairs, location of nests, chicks hatched, and chicks surviving beyond six weeks of age. BRI and Maine Audubon conduct such surveys in focused areas throughout Maine each summer.

**Research**
Research efforts track individual loons statewide. Through capture and banding, BRI biologists can determine mercury and lead body burdens. Research is conducted with the assistance of Maine Inland Fisheries & Wildlife.

**Outreach**
A variety of interactive outreach techniques, including exhibits, dioramas, school curricula, social media, and communication pieces (e.g. brochures, videos, and slide presentations, which can be available online), are utilized to create greater awareness of the presence and requirements of loons.

**Fish Lead-Free**
Lead poisoning resulting from the ingestion of lead sinkers and lead-headed jigs is the primary cause of mortality in adult loons in Maine (Gallo 2013). Loons ingest lead when they consume fish that are hooked with lead tackle (and broken line) or when they pick up lead sinkers from lake bottoms mistaking them for gravel which is used to grind up their food. The use of alternative fishing tackle made from non-toxic materials such as tin, steel, or ceramic can help to directly eliminate this threat to loons.

**Restoration and Management Plans**
Baseline data is utilized to create territory-specific restoration and management plans. Plans should include compensation measures for (1) the loss of nests by water level fluctuations or predation (i.e., nest platforms); (2) loss of nests/chicks from human disturbance (i.e., temporary closures); (3) adverse impacts from changes in prey or predator populations, such as Bald Eagles; and (4) the loss of territorial pairs (i.e., translocating loon chicks).

*Long-term monitoring of loons provides valuable information about their reproductive success, habitat utilization, and behavioral ecology.*
Literature Cited


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Editing/Production: Deborah McKew
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