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# Lead Poisoning in Maine's Common Loons: Examining Biological and Social Dimensions

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# LEAD POISONING IN MAINE'S COMMON LOONS:

# EXAMINING BIOLOGICAL AND SOCIAL SYSTEMS


By

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A THESIS

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Thesis Advisor: Dr. Sandra de Urioste-Stone

An Abstract of the Thesis Presented
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Lead poisoning from ingested fishing tackle is a well-documented conservation concern for adult common loons in the Northeastern United States. To mitigate this issue, the state of Maine began implementing restrictions on lead tackle use in 2002, with new legislation added in 2016 and 2017. In addition to legislative action there have been various non-regulatory strategies employed in Maine to help raise awareness, such as the *Fish Lead Free* campaign. Human behavior is the root cause of lead fishing tackle in aquatic environments, and also can determine the success of legislative and educational efforts. Measuring underlying factors that influence behaviors, such as values and trust, can help predict the efficacy of these efforts. We developed the following interdisciplinary study with two overarching goals: (1) to document the number of common loon adult mortalities resulting from lead poisoning; and (2) to measure factors that influence the risk perceptions of Maine regarding lead fishing tackle toxicity.

We conducted necropsies on 480 adult common loons recovered in Maine between 1990 and 2016. Direct, anthropogenic causes of death accounted for 53% of all adult common loons necropsied. Overall, the main known cause of death in these loons was lead poisoning (25.2%) followed by trauma (20.6%). Analyses of causes of death determined that lead-related deaths decreased and trauma-related deaths increased over time. In addition, we surveyed 280 Maine residents in order to determine the psychological determinants of risk perceptions regarding lead fishing tackle toxicity. We found that risk perceptions were positively influenced by biospheric values and negatively influenced by social trust. Biospheric values, social trust, and risk perceptions were significantly different between Maine Consumptive and Non-Consumptive recreationists responding to our survey. The thesis concludes with a convergence of our findings from both biological and social science components. We found that lead mortality in adult common loons is decreasing, and anglers reported using lead fishing tackle less frequently over the last five years. The majority (75%) reported they never or almost never used lead fishing tackle in 2016, with the primary reason indicated for reducing lead tackle use was common loon conservation. Our work highlights the need for transdisciplinary studies to fully understand complex conservation issues.

# DEDICATION

This thesis is dedicated to my parents, Michael and Vicki Hafford, and my husband, Logan MacDonald. Family is everything.

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# INTRODUCTION

## 1.1. Common Loons and Lead Fishing Tackle

In New England, the leading cause of death in adult common loons is lead poisoning from the ingestion of fishing tackle (Pokras, 2009). Lead ingestion by waterbirds has been documented since the 1800's (Grinnell, 1894) and has been reported in a wide variety of bird species (Blus, 1999; Grand 1998; Locke and Thomas, 1996; Cade, 2007; Wobeser, 1997). The hazard of fishing tackle to common loons was first discovered in the late 1980s (Pokras and Chafel, 1992; Sidor et al, 2003). Several studies have shown that common loons regularly ingest fishing tackle. Many necropsied carcasses have tackle remnants in digestive tracts, as well as elevated lead levels in their tissues (Daoust et al., 1998; Pokras and Chafel, 1992; Pokras et al., 1992; Poppenga et al., 1992; Stone and Okoniewski, 2001; Pokras et al., 2009). A recent study demonstrated that lead poisoning in New Hampshire's breeding common loons is reducing the population growth rate (Grade et al, 2018). A comprehensive necropsy study conducted by Sidor et al (2003) demonstrated that elevated blood, fluid and/or tissue lead levels are only observed when lead tackle is present in common loon carcasses.

Because of their feeding habits, common loons are particularly susceptible to toxicity from lead fishing tackle. Loons ingest several small stones (gastroliths) from the lakebed and store them in their muscular gizzard, presumably to help grind up food (McIntyre and Barr, 1997). Criteria for gastrolith selection are unknown, but may include size, shape, mass, texture, or taste (Pokras et al, 2009). Cadavers necropsied by Pokras et al. (2009) demonstrated that gastrolith dimensions fall between 1-25mm. Many sinkers and jigs also fall under this size class. Tackle lost or left behind on the lake floor may be ingested as mistaken gastroliths, but loons may also unintentionally ingest lead by eating fish with attached fishing gear. Some anglers will break the line with a fish attached or leave in hooks that are set deeply (Cooke et al., 2001). If an angler is only fishing for sport, fish are released back into the water and can make easy targets for predators (Cooke et al., 2001). Grade et al. (2018) found that in New Hampshire, lead tackle mortalities peak in July and August, coinciding with peak fishing activity of the lakes studied. Their findings suggest that the majority of loons obtain lead tackle from live fish, rather than from a reservoir of lost tackle from the lake bed (Grade et al., 2018). This timing suggests a close relationship between fishing activity and lead tackle mortalities.

As piscivores, loons are expected to have a lower stomach pH than herbivorous waterfowl (Sidor et al., 2003) which would lead to a more rapid absorption of lead in the gastrointestinal tract. Absorption is also aided by the grinding action of the gizzard (Marn et al., 1988; Locke and Thomas, 1996; Vyas et al., 2001). Once lead is absorbed into the bloodstream, its toxicological effects are widespread. The central nervous and hematopoietic systems are directly affected, resulting in biochemical, histopathological, neurological, and reproductive impacts (Eisler, 1988; Scheuhammer and Norris, 1996; Rattner et al., 2008; Franson and Pain, 2011). Characteristic signs of chronic toxicosis in wild birds are emaciation, lack of coordination, anorexia, vocalization changes, and “wing droop” (Haig et al., 2014). However, poisoning may occur rapidly with the animal lacking any outward signs of illness (Locke and Thomas, 1996). Common loons that die from lead toxicity generally have better body condition and are of heavier weight than loons dying of other causes. This indicates that loons typically die quickly after the ingestion of lead (Sidor et al., 2003).

**1.2. Study Area: Common Loons in Maine**

Maine, located in the northeast United States, has over 17.8 million acres of forest land and is the most heavily forested state in the nation (McWilliams et al, 2005). Freshwater lakes and ponds cover more than a million acres (Maine Department of Environmental Protection, 2018). The State of Maine supports the second largest breeding common loon population found in the U.S. - only Minnesota has more. Studies conducted by the Maine Audubon Society and the Maine Department of Inland Fisheries and Wildlife estimate 4,100 individual adult loons statewide, or 1,700 territorial pairs (Evers et al., 2010). Breeding common loons are also found in other northern states including Washington, Idaho, Montana, Michigan, Minnesota, Wisconsin, New York, New Hampshire, and Massachusetts, but the vast majority (over 94%) are found in Alaska and Canada (Evers et al., 2010).

During the summer breeding season, loons reside in freshwater lakes and ponds with a very specific set of characteristics. Loons prefer clear, deep waters and require an abundance of prey (McIntyre and Barr, 1983). Being primarily piscivorous, loons will spend most of their time on lakes and ponds that have high numbers of fish. Maine loons are relatively large, with a typical adult weighing between 2,780-5,400 grams (Evers et al., 2010), and have high nutritional requirements: daily fish intake by an adult can measure approximately 960 g; a family with two chicks can consume upwards of 423 kg in one breeding cycle (Barr, 1986). The presence of small invertebrates is also very important. Leeches and small crustaceans, for example, are often fed to chicks (Alvo et al., 1988) and adults will also consume them opportunistically (McIntyre and Barr, 1997). Nesting pairs will also seek out areas that have islands, coves, and hummocks available for nesting very close to the shore (Evers et al., 2010), or a small island if available (McIntyre, 1988). Nesting pairs occupy three different types of territories: multi-lake, where birds visit more than one small lake or pond in order to meet their nutritional needs; single-lake, where there is only one pair of breeding loons present; or shared-lake, where there is more than one breeding pair present on a single lake (Piper et al., 1997).

Lakes and ponds that have healthy fish populations are desirable locations not only for loons, but for human anglers as well. Fishing is a popular recreation activity in Maine; in 2013 an estimated 258,774 people participated in freshwater fishing in the state (Maine Office of Tourism and the Maine Department of Inland Fisheries and Wildlife, 2014). The timing of the loons' breeding season overlaps with peak freshwater fishing activity (Grade et al., 2017), and this can cause conflict between freshwater anglers and common loons. Since Maine is one of the few areas in the United States where breeding adults are observed (Evers et al., 2010), there have been both outreach and legislative efforts put forth in order to protect them from lead poisoning from fishing tackle.

### 1.3. Maine Legislative Efforts to Protect Common Loons from Lead Fishing Tackle Toxicity

The State of Maine began implementing lead tackle legislation in 2002, banning the sale of lead sinkers weighing 0.5oz or less. In 2013, Maine banned the sale and use of lead sinkers weighing 1oz or less, or measuring 2 ½ inches or less. Sinkers make up nearly half of the lead objects found in New England’s common loons, but these laws do not account for jigs, which constitute approximately 19% of lead tackle found in gizzards (Pokras et al., 2009).

To further reduce lead tackle mortalities, Maine passed *Legislative Document No. 730: An Act to Protect Maine's Loons by Banning Lead Sinkers and Jigs* on February 28, 2013. This act recently imposed size class restrictions on lead jigs in addition to sinkers:

- 2016: Ban sale of bare lead jigs weighing 1oz or less, or measuring 2 ½ inches or less
- 2017: Ban use of bare lead jigs weighing 1oz or less, or measuring 2 ½ inches or less

(source: www.mainlegislature.org)

It is worth noting that a "bare lead jig" as defined by the legislation, is "an unpainted jig". This language allows for jigs covered in a layer of paint to be permitted. How well paint protects against lead absorption after being ground in a loon gizzard and saturated with digestive acids has not yet been determined, although studies are currently ongoing. However, to date no jigs with paint remaining have ever been recovered from a loon gizzard (Pokras, pers comm, 2018).

Regulations implemented to reduce common loon mortalities are not always effective. In New Hampshire, after restrictions were implemented, studies showed that initially mortalities were reduced, but later began to increase (Vogel, 2013). Grade (2011) found that 45% of lead objects found in common loons necropsied were illegal sinkers, which demonstrated a lack of awareness or compliance among anglers. There are anglers who may be unaware of the laws or may not believe that lead causes actual harm (Pokras and Kneeland, 2008). Lead is also the most inexpensive material used to make fishing tackle and has a long history of use. Anglers may also believe that lead free tackle, such as tungsten or steel, does not perform as well or is too costly (Pokras and Kneeland, 2008). These are just some of the reasons why anglers may be deliberately choosing to use lead tackle, regardless of the law.

### 1.4. Maine Outreach Efforts to Protect Common Loons from Lead Fishing Tackle Toxicity

L.D. 730 passed in 2013 but did not begin to go into effect until 2016, and this timing allowed for educational outreach to occur prior to enforcement of the legislation. Most notable is the *Fish Lead Free* campaign, which is a cooperative partnership between the Maine Department of Inland Fisheries and Wildlife, Maine Audubon, Maine B.A.S.S. Nation, Maine Lakes Society, and the Sportsman's Alliance of Maine (www.fishleadfree.org). The primary goals of this outreach initiative have been to provide anglers information about the impacts of lead fishing tackle on wildlife and to inform them of the upcoming legislation. The website also lists information on where to buy lead free tackle, how to safely dispose of lead tackle, and information about lead tackle exchanges and events. In addition to public presentations, brochures, and online presence for *Fish Lead Free*, the cause has been highlighted in numerous newspaper articles and press releases.

### 1.5. Risk Perceptions

Attitudes are positive or negative responses toward people, groups, policies, or other objects (Slovic, 1992), and attitudes can affect a person's intention and actual behavior (Ajzen and Fishbein, 1980). Since human behavior is the root cause of lead in freshwater environments from fishing tackle, understanding these behaviors can facilitate more targeted communication initiatives (Teel, 2008). Theories from social psychology can be useful in understanding the factors that are the basis of human behavior. We chose a modified version of the Climate Change Risk Perceptions Model (CCRPM) developed by van der Linden (2015) to explore Maine resident risk perceptions about lead fishing tackle toxicity and the threat to common loon conservation.

While risk is defined as the actual odds or probability of an unfavorable outcome (Vogt, 1999), risk *perceptions* are a subjective, mental construct (van der Linden, 2015). Risk perceptions refer to individual judgements about the severity of the risk based on their knowledge and feelings about an issue (Slovic, 2000; Siegrist et al., 2005; Paek and Hove, 2017). The CCRPM framework combines several different social-psychological constructs that predict risk perceptions (van der Linden, 2015). In addition to climate change, risk perception models have been widely used to describe other natural Social-Ecological System topics such as nature-based tourism (De Urioste-Stone et al., 2016), metallic mineral mining (Zheng et al., 2015), and wildlife diseases (Needham and Vaske, 2008). Factors found to influence belief in or skepticism to an environmental issue may include gender, age, race, political affiliation, level of education, or socio-economic status (van der Linden, 2015; Mase et al., 2015). As van der Linden (2015) demonstrated, risk perceptions are also shaped by other factors such as cognitive dimensions, experiential processes, personal experience, and socio-cultural influences. Trust in the information sources was also added to our framework (see Figure 1). In studying climate change risk perceptions, Mase, et al. (2015) found that individuals rely on information sources that they trust.

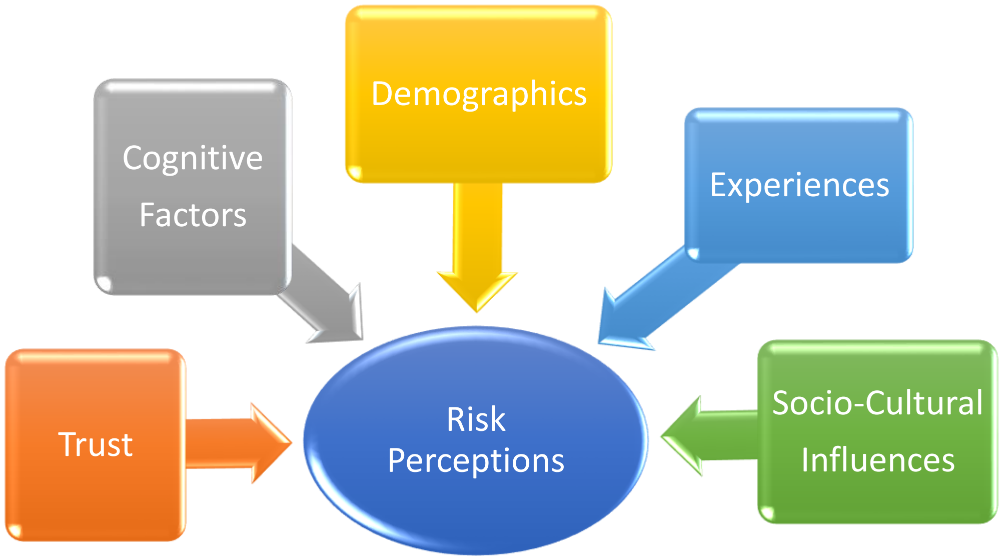


**Figure 1**: Risk Perceptions model.
(van der Linden, 2015 with information from Mase et al, 2015)

Understanding risk perceptions and angler attitudes is crucial for effective communication and outreach, and for potential behavior changes. At times, outreach may be preferred over regulatory measures for altering behavior because it retains one's freedom of choice (Ross-Winslow and Teel, 2011). For example, we may assume that some hunters and anglers use non-lead products only in areas where there are regulations, but through effective communication these individuals might resolve to use lead-free products outside of regulated areas as well (Ross-Winslow and Teel, 2011).

The Risk Perceptions model provided a theoretical framework to structure our research, questionnaire, and analysis. Risk perceptions measured how participants perceived the threat of lead fishing tackle (to common loons, wildlife, and humans). Following is a description of the theoretical constructs in our model that may determine risk.

Cognitive factors refer to the information that people possess about an object (e.g. common loon) or an issue (e.g. the toxicity of lead). This information may or may not be accurate (Glickman et al., 2012). Previous studies show when people lack prior knowledge attitudes can change when given new information (Slovic et al., 1982). If a respondent was not aware of the issue of lead toxicity in loons or about Maine legislative efforts prior to completing the survey this could explain some inconsistencies with their responses (Morgan, 2017).

If people are unaware of the impacts of lead fishing tackle on wildlife this could suggest the need for more awareness outreach. One study targeting hunters, conducted in 2013 by the United States Fish and Wildlife Service, found that nearly half of dove hunters surveyed did not know that ingested lead shot would cause doves to die (Case et al., 2014). Such information is valuable to outreach organizations, because they can target their lead awareness outreach towards dove hunters, for example, rather than just focusing on hunters of large game or hunters as a whole.

Socio-demographics measure gender, income, education, and political affiliation. The relationship between gender and environmental concern has been extensively studied, with women being generally more concerned than men (Blocker and Eckberg, 1989; Mohai, 1992; Stern et al., 1993; O'Connor et al., 1999; Brody et al., 2008). Women, in general, also tend to "worry" more than men about a wide variety of risks (Weber, 2006). Research shows that this higher levels of environmental concern in females also leads to behavioral adjustments, much more so than in male populations (Hunter et al., 2004). Previous studies have found that a higher education may mean lower risk perceptions, perhaps due to a greater feeling of self-awareness and control (O'Connor et al., 1999). Political affiliation is another consistent predictor of risk perceptions, particularly in the field of climate change research, with liberals expressing more concern over climate change than conservatives (van der Linden, 2015). Other research studies conclude that minorities have higher risk perceptions than whites (Finucane et al., 2000).

Experiential processing: Experience with a hazard has long been identified with influencing risk perceptions (Tierney et al., 2001). When people experience an event they tend to develop strong attitudes which lead to behavioral changes (Heberlien, 2012). Personal experiences have been found to influence attitudes and behaviors in many contexts, including the use of seatbelts after experiencing a car accident, preparing for natural disasters after experiencing a weather-related event, implementing crime prevention efforts after being victimized by a crime, and reducing risk behaviors linked to health issues (Weinstein, 1989). These types of experiences are linked to emotions, which makes them more memorable and dominant when processing a risk (Lowenstein et al., 2001). Receiving information from direct, personal experiences – as opposed to second-hand, statistical descriptions – can impact a person's overall perceptions of risk (Hertwig et al., 2003; Weber, 2006). Having direct experiences with lead poisoning (i.e. witnessing a loon with lead poisoning) may elicit an emotional response. Feeling more concerned, or "worried" would therefore drive decisions to take action (Weber, 2006). Even low-probability events can cause greater concern than their probability warrants if they are experienced directly (Weber, 2006). Personal experience is also associated with heuristics, or mental shortcuts, which link them to stronger attitudes (Heberlien, 2012).

Socio-cultural Influences - Values: This construct measures the strength of our participants' value orientations. By incorporating works by Schwartz (1992), Stern et al. (1999), and DeGroot and Steg (2007), Van der Linden (2015) used three broad value scales to measure values in his CCRP model: altruistic (i.e. caring about others), egoistic (maximizing individual outcomes), and biospheric (caring for non-human nature and the biosphere itself). Research has shown that having an altruistic or biospheric “self-transcendent” viewpoint differs from an egoistic “self-enhancement” viewpoint when it comes to environmental beliefs and behaviors (De Groot and Steg, 2007). Altruistic and biospheric values are positively related to pro-environmental norms, and policy acceptability, while egoistic values appear to be negatively related to norms, and policy acceptability (Stern, 2000; Stern et al., 1995; Stern et al., 1999). This could be because acting pro-environmentally benefits others and the environment, but it is associated with high personal costs, such as spending more on environmentally friendly products (Steg et al., 2009). Specifically, an awareness of adverse consequences for a particular valued object (in this case, a common loon) activates personal norms, which in turn induce pro-environmental behaviors (Stern and Dietz, 1994).

Although influencing value orientations is very difficult, it is not entirely impossible. Since values are persistent over time, cultural value changes are expected to be very gradual – perhaps even taking generations (Fulton et al, 1996). But going beyond the superficial underpinnings of behavior, such as attitudes, and appealing to the deeper, more fundamental constructs of values, may result in stronger, more enduring behavioral changes (Jones et al, 2016). While research has shown connections between biospheric values and environmentally friendly behavioral intentions, attitudes, and actions (Steg and DeGroot, 2012), far less research has been devoted to the facilitation of these values in individuals (Martin and Czellar, 2017).

Trust: When information comes from a trusted source, it is less likely to be rejected (Mase, 2015). Shared thoughts, opinions, and values are thought to shape this trust (Siegrist et al., 2000). When people do not fully understand the complexities surrounding a risk they may rely on the opinions of experts. The experts they seek for information are those they find trustworthy (Siegrist and Cvetkovich, 2000). Trust is influenced by perceived similarity in goals, values, and opinions (Needham and Vaske, 2008). This perceived similarity frequently predicts social trust (Walls et al, 2004; Needham and Vaske, 2008). In turn, judgement of a risk may be more dependent on the opinions of trusted experts, rather than an evaluation of the risk itself (Siegrist and Cvetkovich, 2000). Therefore, social trust plays an important role in how people process a risk.

# CHAPTER 2

# MORTALITY IN MAINE'S ADULT COMMON LOONS (1990-2016)

## 2.1. Study Purpose

The use of lead fishing tackle has been a highly disputed topic among Maine residents for many years. State agencies, non-profits, and environmental research organizations have explored mitigation strategies to limit lead fishing tackle use, but implementation of these efforts is never without controversy. While the effects of lead fishing tackle on common loons are well documented, providing more information about mortality in Maine specifically (i.e. not just "The Northeast" or in nearby states such as New Hampshire) may help strengthen outreach efforts in the state. The last published document to include Maine common loon mortality data was in 2003 (Sidor et al., 2003), so continuing to document causes of death will be necessary as new legislation takes effect.

For nearly 30 years Dr. Mark Pokras (associate professor emeritus from the Cummings School of Veterinary Medicine at Tufts University), has examined and necropsied common loon cadavers found in the Northeast. In addition, data from other necropsy labs including the University of New Hampshire and the Biodiversity Research Institute have been added to this large dataset. The main goals of this study were to (1) analyze the long-term dataset to determine leading causes of death in Maine's adult common loons, and (2) document the number of common loon adult mortalities resulting from lead poisoning.

## 2.2. Methods

### 2.2.1. Necropsy Methods

From 1990-2016, common loon carcasses found in Maine were submitted to the Biodiversity Research Institute in Portland, Maine or the Wildlife Clinic at Tufts University in North Grafton, Massachusetts for post mortem examination. Loons were collected in the wild by state and federal wildlife biologists and game wardens, non-profit organizations, and volunteer community members. Moribund loons admitted to Avian Haven Wild Bird Rehabilitation Facility and other rescue agencies were humanely euthanized and also submitted as part of this study. Most loons were frozen after collection and thawed at the time of examination, but if a carcass could be delivered fresh it would be examined within 48 hours. During examination all birds were radiographed, weighed, photographed and classified as a chick, immature, or an adult. Only adults were used for analysis, since adult breeding loons are most impacted by lead poisoning (Pokras and Chafel, 1992; Sidor et al., 2003). Sex was determined by internal examination of gonads (Sidor et al., 2003).

Lead poisoning is often diagnosed by testing the blood, but this method is impractical after death because of clotting (Kornetsky et al., 2013). Searle et al. (1973) found that anodic stripping voltammetry (ASV) is suitable for testing a variety of body fluids, not just blood. "Tissue fluids" that pool in the body after death (which include a combination of unclotted blood, interstitial fluids, respiratory fluids and lymph) can be used with ASV, and this method is a cost-effective way to get reliable results (Kornetsky et al., 2013). During necropsy, tissue fluids tested with a LeadCare© II lead analyzer, which uses ASV technology. The analyzer has a reporting range of 3.3µg/dL-65µg/dL; anything below 3.3µg/dL will read at "LOW" and anything above 65µg/dL will read at "HI" www.leadcare2.com).

Lead tackle toxicosis was determined if two or more of the following five conditions were met: (1) tissue, blood, or body fluids were tested for lead and exceeded thresholds at which clinical signs of lead poisoning have been observed (Sidor et al., 2003, Franson and Pain, 2011); (2) the necropsy form reported the cause of death as lead toxicosis, indicated the presence of lead tackle in the gastrointestinal (GI) tract, or documented clinical pathology consistent with lead toxicosis; (3) one or more lead tackle object was removed from the loon's GI tract; (4) a radiograph showed a sinker or jig inside the loon's GI tract; and (5) the field mortality collection report noted signs consistent with lead toxicosis (Grade et al., 2018). A diagnosis of *suspected* lead toxicosis was made if only one of the five aforementioned conditions were met (Sidor et al., 2003).

Other main categories were "unspecified trauma" and "loon trauma". Loon trauma was diagnosed if the animal presented injuries consistent with a territorial dispute with another loon. Unspecified trauma was diagnosed if injuries were indicative of blunt force trauma, such as a boat strike. Fungal respiratory disease was only considered a primary cause of death in severe cases, with loons presenting fungal plaques in multiple airsacs and lungs. Likewise, parasitism was determined to be an ultimate cause of death only when infections were significant, associated with peritonitis or hemorrhage, with large numbers or organisms present in multiple sections of bowel or widespread in liver and pancreas. Non-lead fishing tackle deaths were also noted, such as ingestion of fishing gear with penetrating gastrointestinal wounds, or deaths related to entanglements with nets or fishing line (Sidor et al., 2003). Uncommon, miscellaneous deaths, such as hypothermia or osteomyelitis, were also noted. If cause of death could not be determined by gross necropsy, or if the cadaver was autolyzed, heavily scavenged, or otherwise in poor condition, the death was listed as Open or Unknown.

### 2.2.2. Statistical Methods

During data collection we recorded all necropsy data in Microsoft Excel or Google Sheets and uploaded final data frames into R statistical and graphics computing software (R Core Team, 2016). We used linear regression to model the percentage of leading causes of death over time, and used Akaike's Information Criterion (AIC) to determine the best fitting models. We used year as our independent variable and percentages of causes of death as the dependent variable. For example, during analysis of lead related deaths we began with *lm(Percent.Pb~Year)*, where "*Percent.Pb"* is the percentages of deaths attributed to lead, and *"Year"* is the year carcasses were recovered. We also created additional models to control for the total number of deaths per year and other causes of death. Regression results and AIC values are displayed in tables, while means and standard deviations are presented throughout the text. Results of statistical tests are considered significant at $\alpha = 0.05$.

## 2.3. Results

### 2.3.1. Carcass Recovery

Between 1990 and 2016, 480 adult common loons found in Maine were submitted for necropsy. An average of 17 (sd=7.65) loons were collected each year. Collection peaked between 2013-2016, with an average of 27 (sd=8.3) adult loons collected each year (Figure 2). A total of 56% (n=270) were males, 39% (n=187) were female, and 5% (n=23) were undetermined. In terms of location of recovery, 74% (n=351) were found in or near freshwater lakes, ponds, and rivers, 13% (n=62) were found on or near the ocean, 13% (n=64) were not specified, and less than 1% (n=3) were found in parking lots, roads, or fields. Carcasses were recovered during every month of the year, but 62% (n=298) of carcasses were retrieved during the summer months of June, July, and August (Figure 3).

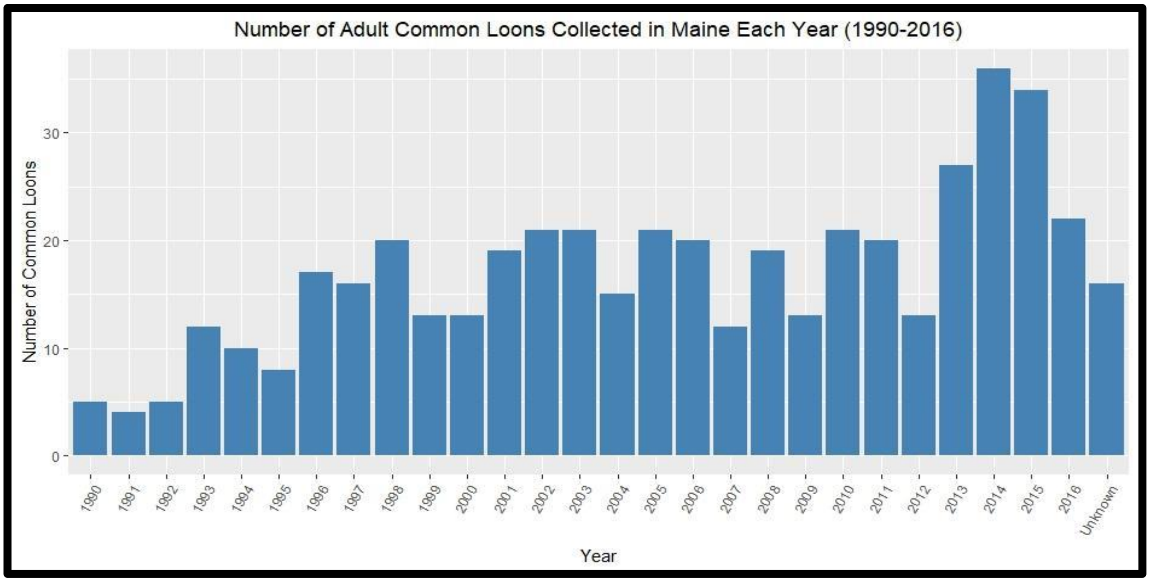


**Figure 2**: Number of adult common loon carcass recoveries each year (Maine, 1990-2016).

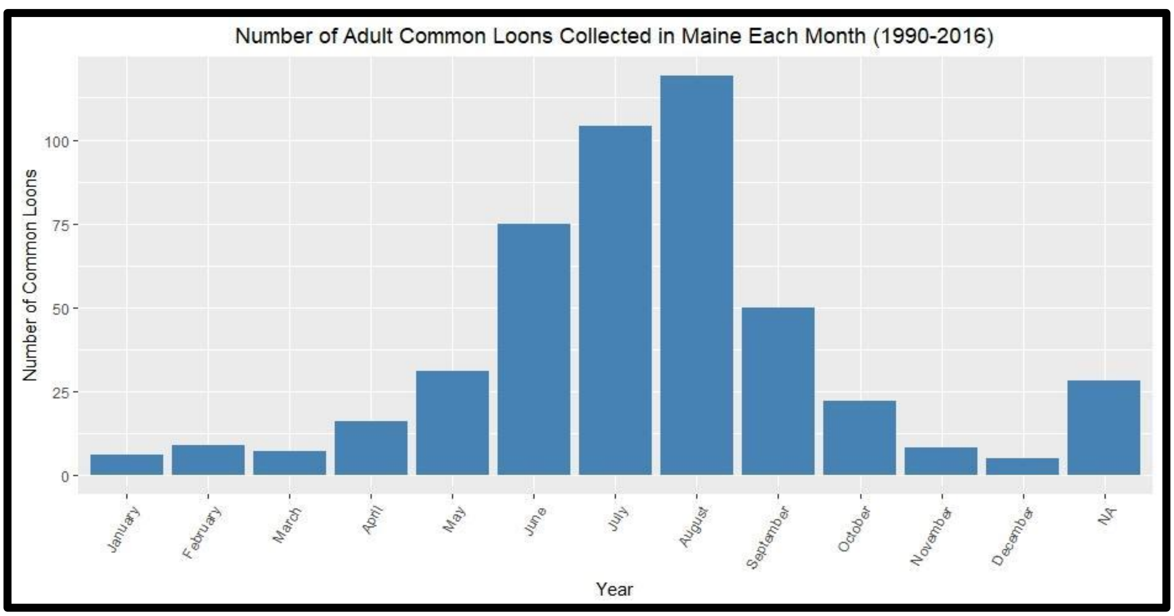


**Figure 3**: Within year timing of adult common loon carcass recoveries (Maine, 1990-2016).

### 2.3.2. Causes of Mortality

Table 1 shows all causes of death for adult common loons submitted for necropsy. The majority of birds (25.4%, n=122) were labeled as either Open or Unknown. Lead poisoning was the overall known leading cause of death during this time span (25.2%, n=121). Of these 121 cases, 109 were confirmed and 12 were suspected (Table 2). Lead poisoning remains the overall leading cause of death after removal of suspected cases. The second most common known cause of death is trauma, followed by fungal respiratory disease, fishing gear/net entanglements, and loon-related trauma. Direct anthropogenic known causes of death, including lead poisoning, entanglements, oil, gunshot, and trauma (assumed to be primarily from boat strikes) account for 53% (n=255) of deaths.

**Table 1**: Causes of adult common loon mortality (Maine, 1990-2016).

| Cause of Death | Number of Cases | % of Total Cases |
|---|---|---|
| Open/Unknown | 122 | 25.4 |
| Lead Poisoning | 121 | 25.2 |
| Trauma | 99 | 20.6 |
| Fungal Respiratory Disease | 55 | 11.5 |
| Fishing Gear/Entanglement | 26 | 5.4 |
| Loon Trauma | 12 | 2.5 |
| Gunshot | 8 | 1.7 |
| Parasitism | 7 | 1.5 |
| Infection | 7 | 1.5 |
| Emaciation/Starvation | 6 | 1.3 |
| Drowning | 3 | <1 |
| Iced In | 2 | <1 |

**Table 1 (continued):** Causes of adult common loon mortality (Maine, 1990-2016).

| Cause of Death | Number of Cases | % of Total Cases |
|---|---|---|
| Egg Bound | 2 | <1 |
| Chronic Disease | 2 | <1 |
| Foreign Body | 1 | <1 |
| GI Obstruction | 1 | <1 |
| Hypothermia | 1 | <1 |
| Oil | 1 | <1 |
| Osteomyelitis | 1 | <1 |
| Road Crash | 1 | <1 |
| Steatitis | 1 | <1 |
| Tubing | 1 | <1 |
| **TOTAL** | **480** | |

**Table 2**: Lead poisoning cases (Maine, 1990-2016).

| Cause of Death | Number of Cases | % of Total Lead Poisoning Cases |
|---|---|---|
| Lead Poisoning, Confirmed | 109 | 90 |
| Lead Poisoning, Suspected | 12 | 10 |
| **Total** | 121 | |

### 2.3.3. Gender Differences

Table 3 shows main causes of death broken down by gender. A much higher percentage of adult male loons died from lead poisoning, which is consistent with findings in other states such as New Hampshire (Grade et al, 2018). We also found a higher percentage of male birds succumbed to fungal respiratory disease than females. Both females and males engage in territorial disputes (Paruk, 1999; Piper et al, 2008), and in Maine more females than males died from loon related injuries.

**Table 3**: Top five causes of death for adult common loons (Maine, 1990-2016).

| **Cause of Death** | **Number of Cases** | **% Males** | **% Females** | **% Undetermined Sex** |
|---|---|---|---|---|
| Lead Poisoning | 121 | 70 (n=85) | 26 (n=31) | 4 (n=5) |
| Trauma | 99 | 56 (n=55) | 42 (n=42) | 2 (n=2) |
| Fungal Respiratory Disease | 55 | 62 (n=34) | 33 (n=18) | 5 (n=3) |
| Fishing Gear/ Entanglement | 26 | 46 (n=12) | 50 (n=13) | 4 (n=1) |
| Loon Trauma | 12 | 33 (n=4) | 67 (n=8) | 0 (n=0) |
| All Causes | 480 | 56 (n=270) | 39 (n=87) | 5 (n=23) |

### 2.3.4. Within Year Timing and Location of Lead Mortalities

Table 4 and Figure 4 show the total number of birds collected each month between 1990-2016. This also shows how many of those birds had confirmed or suspected lead poisoning, and the percentage of lead-related deaths per month. The highest number of lead poisoned carcasses were found in the summer months of June, July, and August, and this is also the period when more birds were collected overall. The highest percentages of lead related deaths were found during migration seasons, either early spring (March) or late fall and early winter (October, November and December).

**Table 4**: Percentage of lead deaths per month (Maine, 1990-2016). Lead deaths documented without a known month of recovery (n=27) were omitted.

| Month | Number of Total Deaths | Number of Lead Deaths | % Lead Deaths per Month |
|---|---|---|---|
| January | 6 | 1 | 17 |
| February | 8 | 1 | 13 |
| March | 7 | 3 | 43 |
| April | 16 | 0 | 0 |
| May | 31 | 5 | 16 |
| June | 75 | 10 | 13 |
| July | 105 | 21 | 20 |
| August | 119 | 44 | 37 |
| September | 50 | 15 | 30 |
| October | 23 | 9 | 39 |
| November | 8 | 4 | 50 |
| December | 5 | 2 | 40 |

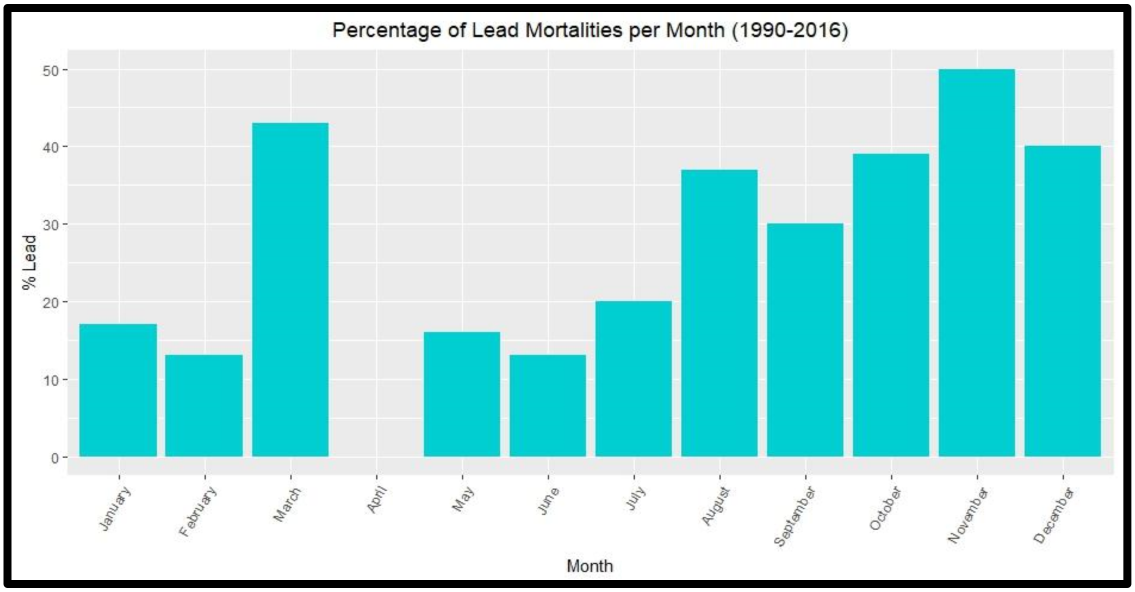


**Figure 4**: Percent of lead mortalities per month, adult common loons (Maine, 1990-2016).

Figure 5 shows known locations where lead poisoned loons were found in Maine from 1990-2016. A total of 79% (n=96) of lead poisoned birds (confirmed and suspected) were found inland, 4% (n=5) were found on or near the ocean, and 17% (n=20) were from unknown locations.  Carcasses were primarily recovered in the lower half of the state, and lead poisoned carcasses were evenly distributed throughout recovery areas.

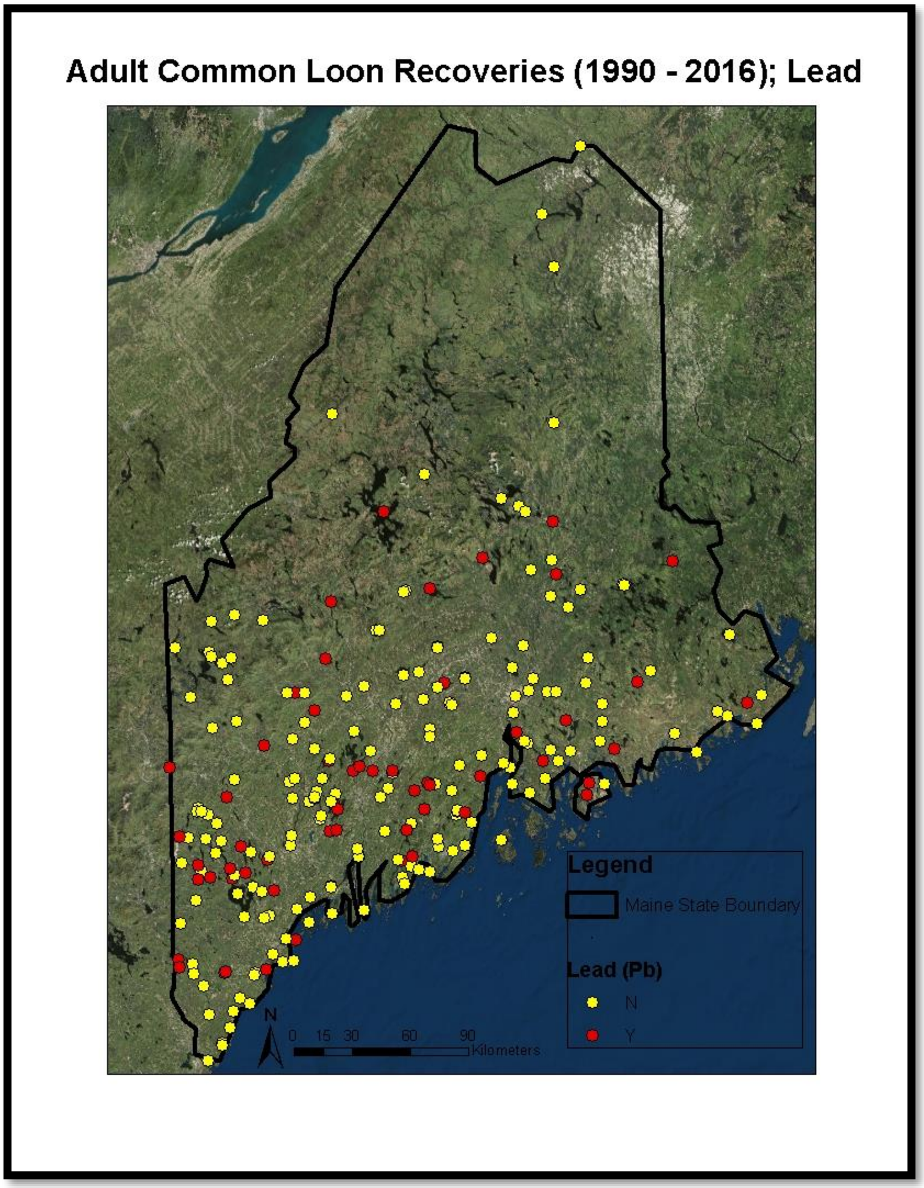


**Figure 5**: Carcass recovery locations of adult common loons (Maine, 1990-2016). Lead related deaths are highlighted in red, all others in yellow.

### 2.3.5. Long Term Trends in Leading Causes of Death

Figures 6-8 illustrate trends in the lead and trauma related deaths over time. Figure 6 demonstrates how lead related deaths have decreased over time, while Figure 7 shows a sharp increase in trauma deaths beginning in the early to mid-2000's. Figure 8 illustrates how trauma replaced lead poisoning as the leading cause of death in 2009 and has consistently been the leading cause of death since 2011. Also represented are deaths related to fungal respiratory disease, the third leading cause of death.

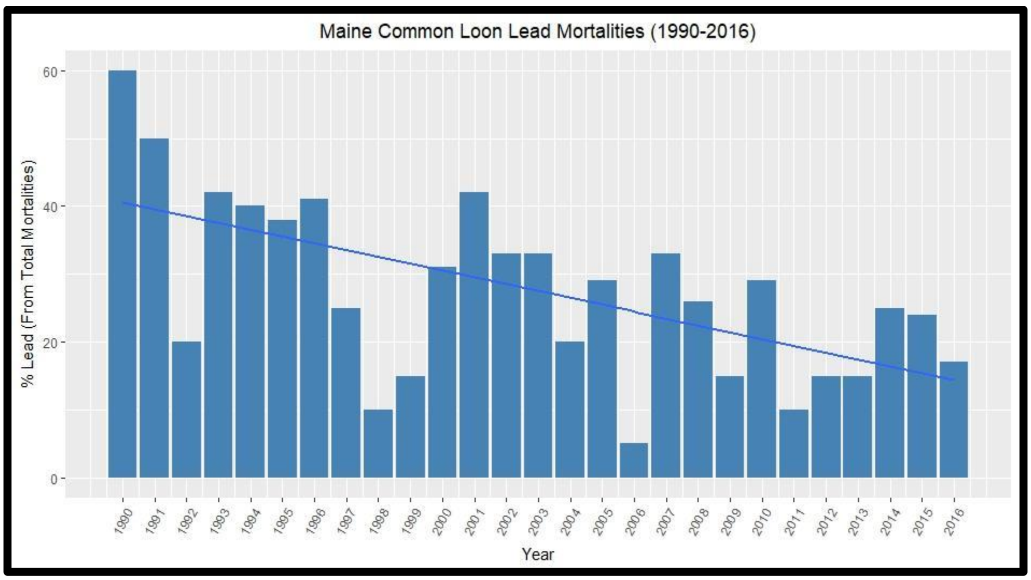


**Figure 6**: Long term trend in lead related deaths (Maine, 1990-2016), indicating these deaths are decreasing over time.

Table 5 shows regression results and AIC values regarding lead related deaths over time. There is a significant linear relationship between lead related deaths with each year of this study ($p=0.0008636$) and this model accounts for 36.4% of variance ($r^2=0.364$).

**Table 5**: Lead regression results. All regression models and resulting p-values, multiple $r^2$ values, and AIC values when models were tested against each other.

| Model | p-value | Multiple $r^2$ | AIC |
|---|---|---|---|
| lm(Percent.Pb~Year) | 0.000863 | 0.364 | 208.7303 |
| lm(Percent.Pb~Year +Total.Deaths) | 0.003965 | 0.3692 | 210.5075 |
| lm(Percent.Pb~Year +Total.Deaths+Percent.FRD) | 0.01054 | 0.380 | 212.0317 |
| lm(Percent.Pb~Year+Total.Deaths +Percent.FRD+Percent.Trauma) | 0.02671 | 0.3806 | 214.0178 |

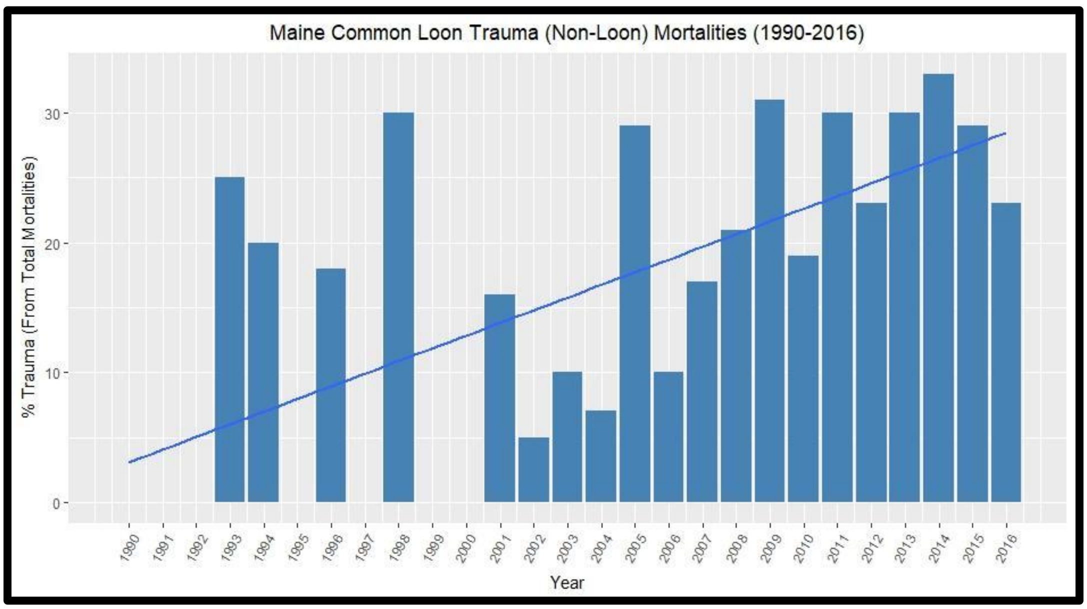


**Figure 7**: Long term trend in trauma related deaths (Maine, 1990-2016). This indicates an increase in these deaths in recent years.

Results also show that there is a significant linear relationship between trauma related deaths with each year of this study (Table 6). The best fitting model includes total deaths as a covariate (p=0.00055896) and accounts for 46.19% of variance ($r^2$=0.4619).

**Table 6**: Trauma regression results. All regression models and resulting p-values, multiple $r^2$ values, and AIC values when models were tested against each other.

| Model | p-value | Multiple $r^2$ | AIC |
|---|---|---|---|
| lm(Percent.Trauma~Year) | 0.0002654 | 0.4186 | 201.1097 |
| lm(Percent.Trauma~Year +Total.Deaths) | 0.0005896 | 0.4619 | 201.0190 |
| lm(Percent.Trauma~Year +Total.Deaths+Percent.FRD) | 0.002194 | 0.4632 | 202.9524 |
| lm(Percent.Trauma~Year+Total.Deaths +Percent.FRD+Percent.Pb) | 0.006466 | 0.4635 | 204.9386 |

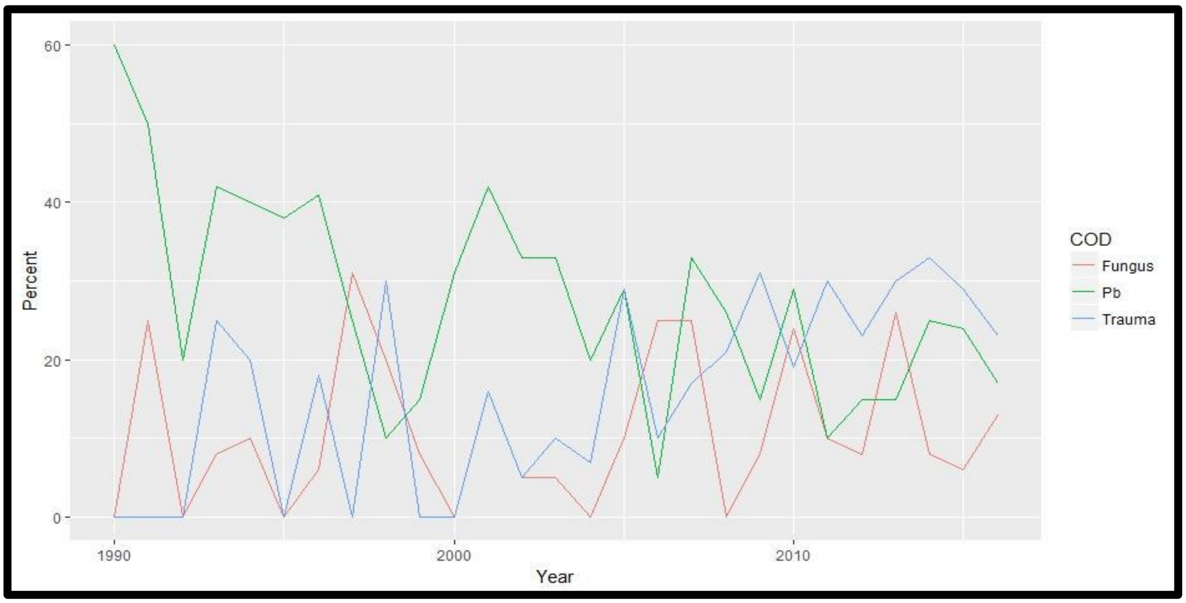


**Figure 8**: Line graph of leading causes of mortality (Maine, 1990-2016). This illustrates how non-loon trauma deaths (in blue) have surpassed lead poisonings (in green) as the leading cause of mortality in Maine's adult common loons. Fungal respiratory disease trends are in red.

## 2.4. Discussion

### 2.4.1. Leading Causes of Death

Lead poisoning was the overall leading known cause of death in Maine's adult common loons necropsied for this study, followed by trauma (not including trauma resulting from territorial disputes between loons) and fungal respiratory disease. However, trauma related deaths were the leading cause of death between 2011-2016, first surpassing lead poisoning in 2009. Generally, trauma deaths have increased relative to lead related deaths over time. Fungal respiratory disease related deaths were variable over the years, peaking in 1997.

Categorizing trauma cases can prove difficult. Cases diagnosed as "Loon Trauma" were confirmed by a characteristic puncture wound typically found in the sternal area (Sidor et al., 2003). Boat related trauma was often characterized by lumbar and hip wounds, consistent with a boat propeller strike, which likely occur as a loon attempts to swim or dive away from an oncoming boat (Pokras, pers. comm, 2018). Other diagnoses relied on eyewitness accounts, including written testimony accompanying necropsy forms, which helped determine causes of death. There are examples of carcasses being immediately recovered by volunteers who witnessed the death occur, including those involving boat strikes. Without characteristic wounds or eyewitness accounts, however, discussion regarding *how* a trauma occurred is speculative. Such uncertainty in the data underscores the need for continued long-term monitoring, and caution should be used when interpreting trauma-related deaths. The authors recommend a more thorough examination of historical forms and notes from earlier necropsies in order to classify trauma cases into more precise categories. However, this study shows that trauma is a threat to adult common loons in Maine, and future conservation and management efforts should consider trauma as an emerging conservation issue.

Over the period prior to the implementation of the 2002 limited ban (1990-2002) lead poisoning was the overall leading cause of death of common loons, responsible for approximately 35% of deaths on average. Over the period 2003-2016 which follows the 2002 ban, and that spans the introduction of *Fish Lead Free* outreach in 2013, lead poisoning was found to be responsible for approximately 20% of common loon deaths. While it is still too early to assess the effectiveness of additional restrictions from 2016 and 2017, it appears that outreach and legislative measures are having an impact on reducing lead related deaths.

Legislation limiting lead tackle use has proven effective in other parts of the world as well. Following a ban on lead weights in the United Kingdom, lead deaths in mute swans decreased by over 70% in the Thames Valley in the 1980s (Sears and Hunt, 1991). However, in other parts of America such as New Hampshire, lead poisoning in breeding common loons is having a population-level effect (Grade et al, 2017) despite legislation limiting lead tackle use. The authors support the continuation of long-term data collection and continued conservation of common loons, particularly as new legislation goes into effect and also as new threats emerge.

### 2.4.2. Recovery Rates

Rates of reporting and carcass recovery for all of Maine were not consistent, as most loons were recovered in the southern half of the state (Figure 2). Southern Maine hosts the majority of the state's anglers (Maine Office of Tourism and the Maine Department of Inland Fisheries and Wildlife, 2014) and houses more than 40% of the state's population (U.S. Census Bureau, 2010). Anthropogenic causes of death will be higher where there is more human-wildlife interaction, and which may mean higher rates of reporting (Deem et al, 1998). This can explain why over half of the birds necropsied were found to have died from anthropogenic causes.

When data collection began, public concerns about common loon conservation and lead fishing tackle toxicity were relatively new (Pokras, pers. comm, 2018). Since carcass reporting and recovery is reliant on volunteers, state biologists, and conservation organizations, this lack of awareness could explain low recovery rates for this time period. While recovery rates generally increased over time, there was over a 100% increase between 2012 and 2013 (from thirteen birds to twenty-seven), and the highest number of birds were recovered in 2014 (Figure 1). A possible explanation for this increase is the outreach effort and public awareness resulting from the *Fish Lead Free* initiative, which began soon after the passage of LD 730 in the spring of 2013 (Gallo, pers. comm, 2018).

## 2.5. Study Limitations

### 2.5.1. Carcass Condition

Carcasses were often found days after death, eliminating many possibilities for diagnosis. If tissues are significantly autolyzed more subtle causes of deaths become more difficult to diagnose, and significant traumatic injuries may be given more weight (Sidor et al, 2003). Necropsy labs are located in southern Maine, New Hampshire, and Massachusetts, so fresh cadavers were often put on ice and stored until they could be transported for analysis. Freezing and thawing causes cells to lyse, eliminating the possibility of histopathological analysis (Sidor et al, 2003).

### 2.5.2. Determination of Causes of Death

Data were analyzed based on primary diagnoses, and underlying causes of death (e.g. toxicity leading to immunosuppression leading to a fungal respiratory disease) could not be determined. For example, a loon weakened from advanced fungal respiratory disease may be more susceptible to boat strikes. In addition, some causes of death may have been underreported, particularly during the early years of the study. For example, biologists and veterinarians conducting necropsies were not aware of the significance of “Loon Trauma”. These deaths may have been classified as simply “Trauma” (Pokras, pers. comm, 2018).

### 2.5.3. Salt Water Carcasses

This study included adult common loons found on the Maine coast in salt water environments. Loons will reside on the ocean during the winter months when freshwater lakes and ponds freeze over (Evers et al, 2010). Carcass recovery on the ocean is even more opportunistic than in freshwater, and it is likely that many more birds die on the ocean that what is documented. Loons dying on the ocean are less likely to wash ashore than those dying on freshwater (Forsell, 1999). Breeding Maine loons have been documented to live on the Maine coast for the winter, but others are known to travel as far south as New Jersey or Maryland (Paruk et al, 2015). Because of this, we are unable to determine if loons recovered on the ocean in the winter are Maine breeders. It is also possible that birds recovered from the ocean in spring and fall were migrating birds that did not breed in Maine. Therefore, it is nearly impossible to determine if birds recovered on the ocean with lead poisoning (n=5) ingested lead fishing tackle from a Maine lake.

# CHAPTER 3

# LEAD POISONING IN COMMON LOONS: THE INFLUENCE OF TRUST AND VALUES ON MAINE RESIDENT RISK PERCEPTIONS

## 3.1. Study Purpose

Lead poisoning of common loons is a concern in the state of Maine. There is a demonstrable need to understand the beliefs and attitudes in a diverse array of stakeholders in order to inform more targeted outreach initiatives with regards to lead tackle. This project is the first to address risk perceptions among Maine outdoor recreationists with regards to lead toxicity in the state. Analysis of risk perceptions and values among recreation groups may provide a greater understanding of *why* common loon poisoning remains an ongoing issue in Maine, and the results may assist outreach efforts in the future.

Our main hypotheses were as follows:

H1: Respondents who have high biospheric values will have higher risk perceptions.

H2: Respondents who have high social trust will have lower risk perceptions.

H3: There will be significant differences between outdoor recreation groups regarding biospheric values, trust, and risk perceptions.

## 3.2. Research Design and Data Collection

Data for this article were drawn from a study designed to develop a greater understanding of Maine resident risk perceptions regarding lead fishing tackle toxicity and common loon conservation. An online survey was used to collect data on recreation activity, risk perceptions associated with lead fishing tackle toxicity, socio-demographics, trust, and values from a sample of Maine residents. Survey development and implementation followed Dillman's Tailored Design method, which was used to reduce measurement, non-response, and coverage errors (Dillman et al, 2014). We requested input from stakeholders in the development and pre-testing of the survey instrument; key stakeholders included members of Maine Audubon, B.A.S.S. Nation of Maine, the Maine Department of Inland Fisheries and Wildlife, and experienced anglers.

The survey instrument was pre-tested (N=15), and changes were made based on feedback. For the official launch of the online survey, a total of 2,500 Maine resident addresses were purchased from InfoUSA in the spring of 2016. Addresses were randomly selected and included residents from all regions of the state. Residents were sent postcard invitations to participate in the online survey hosted by Qualtrics survey software. Residents received up to two mail reminders to increase response rates and reduce non-response bias. To increase further response rate, participants were offered an opportunity to enter in a raffle to win one of three gift cards upon completion of the questionnaire (Dillman et al, 2014). The raffle was not connected to responses.

Initial survey invitations were mailed to the 2,500 addresses randomly selected on October 31, 2016. Non-respondents were mailed a postcard reminder on November 15, 2016. This was followed by a third and final reminder letter on January 24, 2017. The final reminder letter was sent after the holidays to avoid low response but was still sent within an appropriate time frame (Dillman, 2014). Of the 2,500 initial letters sent, 290 were returned as undeliverable and removed from the response rate calculations. The survey was closed on March 1, 2017. A total of 280 Maine residents participated in this survey, which resulted in an overall survey response rate of 13%.

### 3.3. Measures and Indicators

Our survey was constructed of four distinct sections; Section 1 asked respondents to select the types of outdoor recreation activities in which they participate: freshwater fishing, open water fishing, hunting, wildlife viewing, or none of the above. Section 2 asked questions on fishing activity (frequency, regions, seasonality) and type of fishing gear used. These questions were derived from questions used in a previous angler survey (Leszek, 2005) in New Hampshire. Section 3 included questions on the use of lead tackle, risk perceptions (modified from van der Linden 2015) regarding the use of lead tackle, trust in information sources, and values. In order to capture the full meaning and richness of each construct in our model, we used multiple-item indicators (i.e. multiple questions) to measure each construct (Vaske, 2008). The last section asked demographic questions (gender, age, education, household income, residency, and ethnicity).

Risk Perceptions: A seven- point Likert-scale, ranging from *strongly agree* to *strongly disagree* was used to measure respondents' levels of concern with five statements regarding lead toxicity and common loon health. We also included statements regarding lead tackle use and human health.

Trust: A seven-point Likert-scale, ranging from *strongly distrust* to *strongly trust*, was used to ask participants how much they trusted a number of agencies, organizations, and groups as sources of information about the use of lead fishing tackle.

Values: We created a biospheric value scale by using confirmatory factor analysis (Furr and Bacharach, 2014) to measure a seven-point Likert-scale, indicating the level of importance (from *opposed to my values* to *quite important*). These were presented as "guiding principles" in our respondent's lives (van der Linden, 2015).

**3.4. Statistical Analyses**

We conducted statistical analyses for the survey using the Statistical Package for the Social Sciences (SPSS). Questionnaire items were tested for normality using Shapiro-Wilkes tests and were found to be non-normal. After conducting descriptive statistical analyses we used non-parametric Kruskall-Wallis Tests to explore differences between variables (van der Linden, 2015).

We conducted principal component factor analyses with a varimax rotation to explore constructs and validate scales (Vaske, 2008). The Kaiser-Meyer-Olkin's measure was calculated to measure sampling adequacy, and if the value was above 0.6 we determined that factor analysis was adequate (Aldrich and Cunningham, 2016). We created new scales based on these findings and calculated a Chronbach's alpha to test internal validity of scales and was acceptable when above 0.6 (Vaske, 2008). Linear regression analysis was used to determine the significance of predictor variables and the amount of variance in risk perception explained by the aforementioned constructs (van der Linden, 2015). To test for potential differences between respondents in trust, risk perceptions, and values, survey participants were grouped into one of three outdoor recreation categories. Resident categories included: Consumptive (those who fish and/or hunt) recreationists, Non-Consumptive (those who only selected wildlife viewing) recreationists, Mixed (those who select hunting and/or fishing as well as wildlife viewing) recreationists, and Non-Recreationists (those who did not select any outdoor recreation activity).

## 3.5. Results

### 3.5.1. Understanding Our Participants: Demographics

To understand the characteristics of our respondents and assess any biases, we present general demographic data in Table 7. Survey respondent demographics are compared to 2010 Maine census data and 2016 Maine voter registration demographics, when applicable (Morgan, 2017). More females (56.9 %) participated in our survey than males (43.1%), and the average age of our participants was 53.8 years (as a requirement, all participants were 18 years or older). While the average Maine resident earned $49,331 (in 2010) the majority of participants (71.7%) reported earning $50,000 or more. Survey participants were more educated (53.4% have a Bachelor’s degree or higher) as compared to the general Maine population (28.4% have a Bachelor’s degree or higher). Participants identifying as Democrats mirrored closely to that of the Maine population (35.1% survey participants and 32% in the Maine population) but we had more participants identify as Independent (41.3% survey participants vs. 36% Maine population) and fewer identifying as Republican (19.4% survey participants vs. 27% Maine population).

**Table 7**: Demographics of survey respondents.

| **Demographic Profile** | **Variable** | **Number (n)** | **Valid Percent** | **Census Data 2010 (%)** | **Voter Registration2016** |
|---|---|---|---|---|---|
| Gender n=248 | Female | 141 | 56.9 | 51 | |
| | Male | 107 | 43.1 | 49 | |
| Age n=246 | Mean | 53.8 yrs. | | | |
| Annual Household Income n=234 | $0-$25,000 | 19 | 8.1 | | |
| | $25,001-$50,000 | 47 | 20.1 | Median | |
| | $50,001-$75,000 | 55 | 23.5 | $49,331 | |
| | $75,001-$100,000 | 45 | 19.2 | | |
| | $100,001-$125,000 | 33 | 14.1 | | |
| | $125,001-$149,000 | 15 | 6.4 | | |
| | $150,000+ | 20 | 8.5 | | |
| Level of Education n=247 | High school or less | 59 | 23.9 | 41.3 | |
| | GED | 4 | 1.6 | | |
| | Associates Degree | 52 | 21.1 | 9.3 | |
| | Bachelor's Degree | 64 | 25.9 | 18.3 | |
| | Advanced Degree | 68 | 27.5 | 10.1 | |
| Political Affiliation n=242 | Democrat | 85 | 35.1 | | 32 |
| | Independent | 100 | 41.3 | | 36 |
| | Republican | 47 | 19.4 | | 27 |
| | Other* | 10 | 4.1 | | 5 |

*other political affiliations identified by survey respondents included "Green", and "Progressive")

### 3.5.2. Understanding our Participants: Outdoor Recreation Activity

Survey participants were placed into one of four categories based on the types of outdoor recreation activities they pursued. Table 8 shows how many respondents were assigned to the following categories: Consumptive (those who indicated they hunt and/or fish), Non-Consumptive (those who only selected wildlife viewing as an outdoor recreation activity), Mixed (those who hunt and/or fish in addition to wildlife viewing), or Non-Participatory (no outdoor recreation activity selected). The majority of our respondents either identified as Non-Consumptive (35.4%) or Mixed (39.3 %).

**Table 8**: Respondents by outdoor recreation activity.

| **Recreation Category** | **Frequency (n)** | **Percent (%)** |
|---|---|---|
| Consumptive | 32 | 11.4 |
| Non-Consumptive | 99 | 35.4 |
| Mixed | 110 | 39.3 |
| Non-Participatory | 39 | 13.9 |
| **TOTAL** | **280** | **100** |

There were significant gender differences between groups, with more males in the Consumptive and Mixed groups and more females in the Non-Consumptive and Non-Participatory groups ($p \leq 0.005$). There were significant differences between Non-Consumptive and Mixed groups regarding education, with the Non-Consumptive group reporting higher levels of education overall ($p<0.05$). There were significant differences between the Non-Consumptive and Mixed groups regarding political affiliation, with more Non-Consumptives identifying as

Democrats and Mixed group members identifying as Republicans ($p<0.005$). There were no significant income or age differences between any of the four groups.

### 3.5.3. Validation of Scales

Factor analysis demonstrated that the data were an appropriate fit for all three constructs: risk perceptions, trust, and values (Tables 9-11). Factor loadings ranged from 0.694 to 0.901 for risk perception. Principal component factor analysis (KMO=0.777) of trust in information sources yielded two reliable components. One component, which we called the Social Trust Scale, consisted of social groups such as fishing buddies, friends and family, and other anglers. The second component, Conservation/Biologist Trust Scale, consisted of biologists and conservation organizations. Factor loadings ranged from 0.683 to 0.847 for Social Trust and 0.603-0.75 for Conservation/Biologist trust. Reliability coefficients indicated acceptable internal consistency, with a risk perceptions Cronbach's Alpha of 0.861, social trust at 0.755, conservation/biologist trust at 0.649, and biospheric values at 0.937.

**Table 9**: Risk Perception scale. ($\alpha$=0.861)

| Variables | Mean | Standard Deviation | Factor Loading |
|---|---|---|---|
| Lead fishing tackle is safe for humans to handle. | 4.49 | 1.643 | 0.694 |
| Lead tackle covered in a layer of paint is safe. | 5.77 | 1.231 | 0.845 |
| A very small amount of lead will not harm humans | 5.18 | 1.619 | 0.829 |
| A very small amount of lead will not harm common loons. | 5.49 | 1.386 | 0.901 |
| The effects of lead fishing tackle on common loons has been exaggerated. | 5.15 | 1.472 | 0.777 |

**Table 10:** Trust scales. (Social Trust scale α=0.755; Conservation/Biologist Trust scale α=0.649)

| Variables | Mean | Standard Deviation | Factor Loading |
|---|---|---|---|
| **Social Trust scale** | | | |
| My Fishing Buddies | 4.45 | 1.156 | 0.804 |
| Experienced Anglers | 4.72 | 1.109 | 0.683 |
| Friends and Family | 4.87 | 1.184 | 0.847 |
| | | | |
| **Conservation/ Biologist Trust scale** | | | |
| Maine Department of Inland Fisheries and Wildlife Biologists | 5.84 | 1.079 | 0.603 |
| Non-Government Biologists | 5.34 | 1.178 | 0.633 |
| Conservation Organizations | 5.58 | 1.312 | 0.750 |

**Table 11:** Biospheric Values scale. (α=0.937)

| Variable | Mean | Standard Deviation | Factor Loading |
|---|---|---|---|
| **Biospheric scale** | | | n.a. |
| Preventing Pollution | 6.97 | 1.716 | n.a. |
| Protecting the Environment | 7.40 | 1.629 | n.a. |
| Respecting the Earth | 7.15 | 1.784 | n.a. |
| Unity with Nature | 6.69 | 1.908 | n.a. |

### 3.5.4. Regression Model

As predicted by Hypothesis 1, a negative relationship was observed between social trust and risk perceptions. Maine recreationists who have more trust in their fishing buddies, other anglers, or their friends and family for information about lead fishing tackle and common loons had lowered risk perceptions. As predicted by Hypothesis 2, a positive relationship was observed between biospheric value systems and risk perceptions. Maine residents who identified biospheric values as guiding principles in their lives had higher risk perceptions regarding lead fishing tackle toxicity. Table 12 shows the significance of each construct and the validity of the overall model.

**Table 12:** Risk Perception regression results.

| Independent Variables | Trust and Biospheric Values (β) |
|---|---|
| Trust in Fishing Buddies, Experienced Anglers, Friends and Family) | -0.119* |
| Biospheric Values | 0.494*** |
| $R^2$ | 0.262 |
| F statistic | 40.494 |
| df1, df2 | 2, 229 |

*p<0.05, ***p<0.001

### 3.5.5. Risk Perceptions, Social Trust, and Biospheric Values: Differences Between Groups

Hypothesis 3 was also confirmed, as there were significant differences between groups regarding risk perception, social trust, and biospheric value orientations. Most notable are the significant differences between Consumptive and Non-Consumptive groups for three constructs: risk perceptions ($p \leq 0.001$), social trust ($p<0.05$), and biospheric values ($p \leq 0.001$). Non-Consumptive and Mixed groups also had differences in social trust ($p \leq 0.001$ and biospheric values ($p<0.05$). Results are shown in Tables 13-15. There were no differences in conservation/biologist trust between groups.

**Table 13:** Risk Perception differences between outdoor recreation groups.

| GROUPS | p-value |
|---|---|
| Consumptive vs. Non-Consumptive | 0.000*** |
| Consumptive vs. Mixed | 0.054 |
| Consumptive vs. Non-Participatory | 0.805 |
| Non-Consumptive vs. Mixed | 0.126 |
| Non-Consumptive vs. Non-Participatory | 0.072 |

***p<0.001

**Table 14:** Social Trust differences between outdoor recreation groups.

| GROUPS | p-value |
|---|---|
| Consumptive vs. Non-Consumptive | 0.030* |
| Consumptive vs. Mixed | 1.000 |
| Consumptive vs. Non-Participatory | 0.079 |
| Non-Consumptive vs. Mixed | 0.000*** |
| Non-Consumptive vs. Non-Participatory | 1.000 |

*p<0.05; ***p<0.001

**Table 15:** Biospheric Values differences between outdoor recreation groups.

| GROUPS | p-value |
|---|---|
| Consumptive vs. Non-Consumptive | 0.000*** |
| Consumptive vs. Mixed | 0.135 |
| Consumptive vs. Non-Participatory | 0.342 |
| Non-Consumptive vs. Mixed | 0.021* |
| Non-Consumptive vs. Non-Participatory | 0.298 |

*p<0.05; ***p<0.001

## 3.6. Discussion

### 3.6.1. Non-Consumptive vs. Consumptive Groups

Our study found that our Non-Consumptive group, which had the highest risk perceptions, contained more female participants. The relationship between gender and environmental concern has been extensively studied, with women being generally more concerned than men (Blocker and Eckberg, 1989; Stern et al, 1993; Brody et al, 2008). Women, in general, also tend to “worry” more than men about a wide variety of risks (Weber, 2006).

Research reveals the higher levels of environmental concern in females also leads to behavioral changes (Hunter et al, 2004). Our Non-Consumptive group also had more individuals identifying as Democrats. Political affiliation is also known as a stable predictor of risk, with liberals expressing a higher level of environmental concern (van der Linden, 2015). This study found that having more education meant having higher risk perceptions regarding lead fishing tackle toxicity, which is also consistent with van der Linden's (2015) findings.

### 3.6.2. Trust

Consistent with the findings by Mase (2015), in this study scientists and researchers were the most trusted sources of information about lead fishing tackle. Our Conservation/Biologist trust scale was internally valid, but no differences were shown between our outdoor recreation groups. In other words, conservation organizations, the Maine Department of Inland Fisheries and Wildlife, and non-government biologists were trusted equally among our Consumptive, Non-Consumptive, Mixed, and Non-Participatory groups. However, our social trust scale - which included fishing buddies, experienced anglers, and friends and family - was more trusted by the Consumptive and Mixed groups than Non-Consumptive and Non-Participatory. Of course, those who do not participate in any fishing activities were not expected to be influenced by fishing buddies and other anglers. The more interesting finding is how this scale was found to negatively influence risk perceptions. Anglers who more highly trusted their friends, family, and other anglers as sources for information about lead fishing tackle and common loons perceived lower health risks associated with lead tackle.

### 3.6.3. Values

Our study found that increased risk perceptions regarding lead tackle toxicity were most strongly influenced by high biospheric values. Cultural theorists argue that values and worldviews play an important role in risk perception and behavior (Leiserowitz, 2006). Theory postulates that biospheric and altruistic values are particularly influential, are found to be at the core of environmental beliefs (Stern et al, 1999; Stern, 2000), and act as amplifiers with regards to risk (Slimak and Dietz, 2006). Our study also found significant differences in biospheric values between our Non-Consumptive and Consumptive groups, as well as between our Non-Consumptive and Mixed groups, with Non-Consumptives indicating higher biospheric values. Differences in value systems between Consumptive and Non-Consumptive groups have also been found in previous studies (Fulton et al, 1996; Daigle et al, 2002).

## 3.7. Management Implications

The Maine Department of Inland Fisheries and Wildlife was found to be the most trusted source for information about lead fishing tackle and common loon conservation. This agency has the potential to reach a broad audience with diverse environmental beliefs. Since the issue of lead poisoning in common loons is important to wildlife viewers, The Maine Department of Inland Fisheries and Wildlife should continue to foster positive relationships with Maine residents overall, not just those who hunt or fish. By understanding their constituents' diverse values, beliefs, attitudes, and goals, agencies can reflect these views and incorporate into policy, outreach, and management strategies. If constituents believe their views are shared with management agencies this will increase trust overall (Needham and Vaske, 2008). The challenge will be to address and incorporate different values held within the non-homogenous group of Maine residents, while developing outreach materials and strategies that target diverse values, expectations and behaviors.

Individuals influenced by the social trust construct (their fishing buddies, friends and family, other anglers) may require a different approach. Previous research has shown that "key influencers", like friends and family members, are known to influence decision making. Members of a social network influence a variety of decisions, including whether or not to join the military (see Kleycamp, 2006 for review), engage in certain agricultural practices (Conley and Udry, 2001) or purchase particular products (Godes and Mayzlin, 2004). Targeting specific, well-connected individuals to distribute information (via a process known as "social diffusion") is a well-known practice in marketing (Galeotti and Goyal, 2009) and may apply to our study as well. Since our social trust construct included *experienced anglers,* targeting anglers who write blogs or newspaper opinion pieces, or those with numerous "followers" on social media may be an effective strategy for the *Fish Lead Free* campaign. For anglers not influenced by media, targeting experienced anglers with more "in-person" contact with other anglers (e.g. fishing guides) may be more effective.

Values do not directly influence behaviors. Rather, they influence attitudes that lead to behavioral intentions, which may then lead to specific behaviors (Fulton et al, 1996). In other words, they act as "background" factors that influence behaviors by guiding attitudes and beliefs (Daigle et al, 2002). But unlike beliefs and attitudes, values are relatively consistent over the course of an individual's lifetime (Slimak and Dietz, 2006). Values are understood to form in childhood, take shape during adolescence, and remain stable throughout adult life (Jones et al, 2016). The deeply ingrained characteristics of values make them difficult to change (Fulton et al, 1996). Restructuring values might require a life-changing event, one that makes an individual rethink the fundamental principals that previously guided their entire life. For this reason, changes to values are unlikely to occur after education and informational campaigns often employed by agencies (Fulton et al, 1996). Rather than attempting to change environmental values, another strategy is to communicate messages differently. A current trend in climate change messaging, for example, is to identify the values of the target audience (even if those values are not biospheric) and promote messages that match those values. For example, it has become more common for climate change communicators to focus more on promoting the economic benefits of environmentally friendly behaviors, rather than the environmental ones (Corner et al, 2014) which appeal to those with higher egoistic values than biospheric values.

In the case of our study, it may be beneficial to focus on messages that appeal to egoistic and altruistc values in addition to biospheric. As the name implies, *LD 730: An Act to Protect Maine's Loons by Banning Sinkers and Jigs* was implemented because of concerns about lead poisoning in common loons, which is a wildlife conservation issue that may be most important to those with high biospheric values. Implementing message campaigns that focus on the human health hazards of lead, for example, might appeal to those expressing fewer concerns about common loon or wildlife health but who are more concerned about their own personal health or health of others. Values-based messaging also has the potential to overcome partisan, gender, and educational divides (Corner et al, 2014), which were found in our study as well.

### 3.8. Conclusions

Our findings indicate that trust and values are the most significant influencers of risk perceptions regarding lead fishing tackle toxicity. Our study also found that Maine residents identifying as Consumptive, Non-Consumptive, Mixed, and Non-Participatory showed key differences, and that messages concerning the hazards of lead fishing tackle need to be tailored for specific groups. With regards to anglers, targeting key influencers may help strengthen trust between anglers and the agencies promoting the *Fish Lead Free* campaign. Key influencers may include experienced anglers or “well-connected” anglers with a strong social media presence. Finally, understanding the values of the target audience is important, and framing messages to reflect those values may lead to more effective educational programs.

# CHAPTER 4

# OVERALL CONCLUSIONS

## 4.1. Biological and Social Science Convergence

This thesis used both biological science techniques and social science methods to better understand the issue of lead poisoning in Maine's common loons. By conducting common loon necropsies in the laboratory, and combining those findings with a long-term historical dataset, we were able to identify trends in mortality rates in Maine's adult common loons. We also used a social science survey to determine the risk perceptions of Maine residents regarding lead tackle toxicity. To our knowledge, this study is the first to combine both biological and social science findings in this context. This final chapter discusses four key findings and one future research opportunity resulting from this work.

### 4.1.1. Trauma is now the leading cause of death in Maine's adult common loons – and Maine residents are concerned.

Analysis of our long-term common loon mortality dataset revealed that trauma is now the leading cause of death in adult common loons in Maine, surpassing lead related deaths in 2011. Our social science survey did not address trauma related deaths directly, but we did ask participants if they felt there were bigger threats to common loons than lead fishing tackle. Figure 1 shows the responses to the question, "To what extent do you agree with the statement 'There are bigger threats to Common Loons than fishing tackle'" and asked them to choose whether they strongly agree, agree, somewhat agree, are neutral, somewhat disagree, disagree, or strongly disagree.  Figure 9 illustrates the responses to this question and how the majority of respondents chose *somewhat agree, agree,* or *strongly agree.*

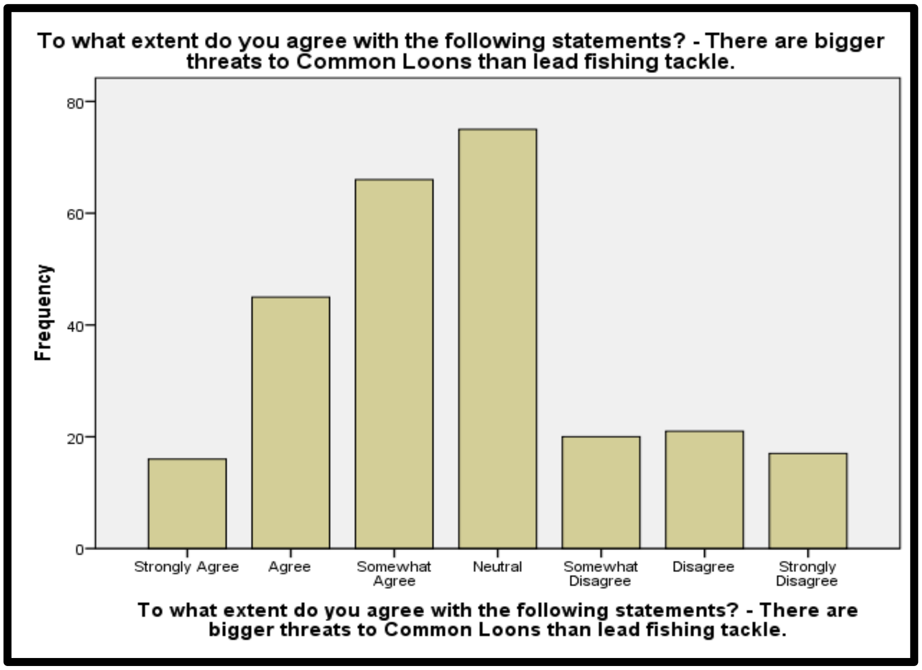


**Figure 9**: Responses to the question "To what extent to you agree with the statement? 'There are bigger threats to Common Loons than lead fishing tackle.'"

At the end of our survey we invited participants to provide written comments by stating "Please feel free to add any comments regarding the topics in this survey". This was not a requirement, and respondents were allowed to freely express themselves. Interestingly, some expressed concerns about the threat of boat strikes to common loons, even though boat strikes were never mentioned previously in the survey. The following comments came from older (55+) respondents identifying as females who participate in wildlife viewing activities. One participant also identified as a freshwater angler:

*"Motor boats and their wakes are dangerous to loons as well."*

Freshwater Angler/Wildlife Viewer, 55 year old female Windham, ME

*"I have witnessed boaters speeding on our lake (on 2 separate occasions) running directly at loons and striking and killing the common loon. It was heartbreaking…..Would like to see speed restrictions on lakes where there are loons in residence."*

Wildlife Viewer, 74 year old female Hampden, ME

*"We do not fish however, I feel that loons are also threatened by the boat traffic on lakes. I think speed limits should be set and adjusted for lakes of different sizes. Loon breeding is also threatened by boaters not observing the 200 foot rule regarding shoreline wakes."*

Wildlife Viewer, 68 year old female, North Yarmouth, ME

**4.1.2. Freshwater anglers are reducing their lead tackle use, and common loon lead-related deaths are declining.**

We asked participants identifying as freshwater anglers to indicate whether or not they used lead fishing tackle anytime during 2012, 2013, 2014, and 2015. They were also allowed to select "I don't remember" as an option. These years correspond to the time that they *Fish Lead Free* campaign was underway leading up to the implementation of legislation in 2016. Freshwater anglers reported using lead fishing tackle less often each year over the last five years, as indicated by more "No" responses over the four years (Figure 10). Figure 11 shows how the majority of respondents reported "never" using it in 2016, more so than any other year.

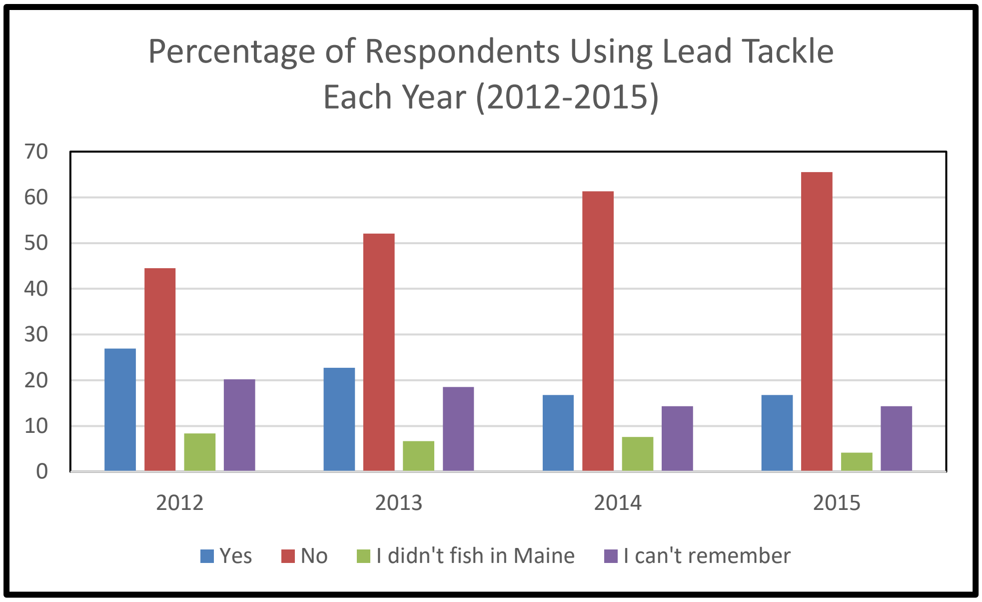


**Figure 10**: Percentage of respondents reporting if they fished with lead tackle for years 2012, 2013, 2014, and 2015.

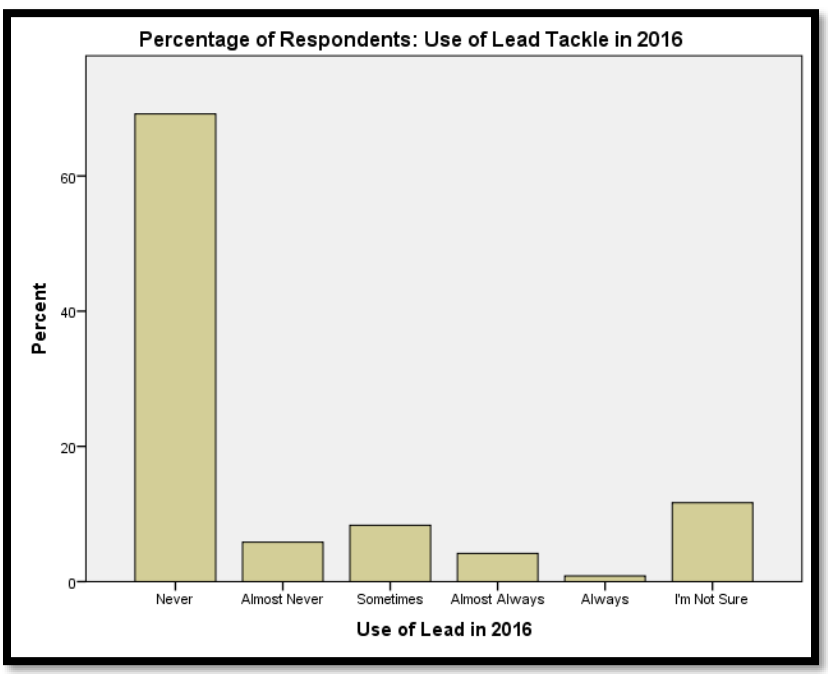


**Figure 11**: Percentage of respondents reporting the frequency of which they fished with lead tackle in the year 2016.

The *Fish Lead Free* campaign, which began after the 2013 passage of L.D. 730, may explain why anglers reported using less and less lead fishing tackle each year, even before 2016 legislative restrictions were in place. This indicates that anglers stopped using lead fishing tackle by choice, and not because of concerns about breaking the law. This supports work conducted by Ross-Winslow and Teel (2011), who demonstrated that effective communication may lead individuals to choose non-lead tackle and ammunition in areas without regulations.

**4.1.3. The main reason anglers do not use lead tackle is to protect common loons.**

We asked anglers to indicate reasons for using non-lead fishing tackle and rate their level of importance (very important, important, somewhat important, does not apply, or not at all important). Choices included: to protect common loons, to protect other wild birds (raptors, waterbirds, etc.), to protect my personal health, to protect the health of my family, because my fishing buddies use non-lead as well, the ability to participate in a tackle exchange program for free non-lead tackle, the ability to enter in a raffle or for a prize, the ability to support a local business, because I found affordable non-lead tackle, or because I found non-lead tackle that performs well.

Figure 12 shows the top responses to this question and illustrates the importance of common loon protection for switching to non-lead fishing tackle. The majority of respondents (24.6%) selected *very important*, which reflects a stronger attitude than the selection of *important* or *somewhat important.* Very few respondents (0.4%) selected *not at all important*. “To protect common loons” was the strongest response indicated by our participants overall.

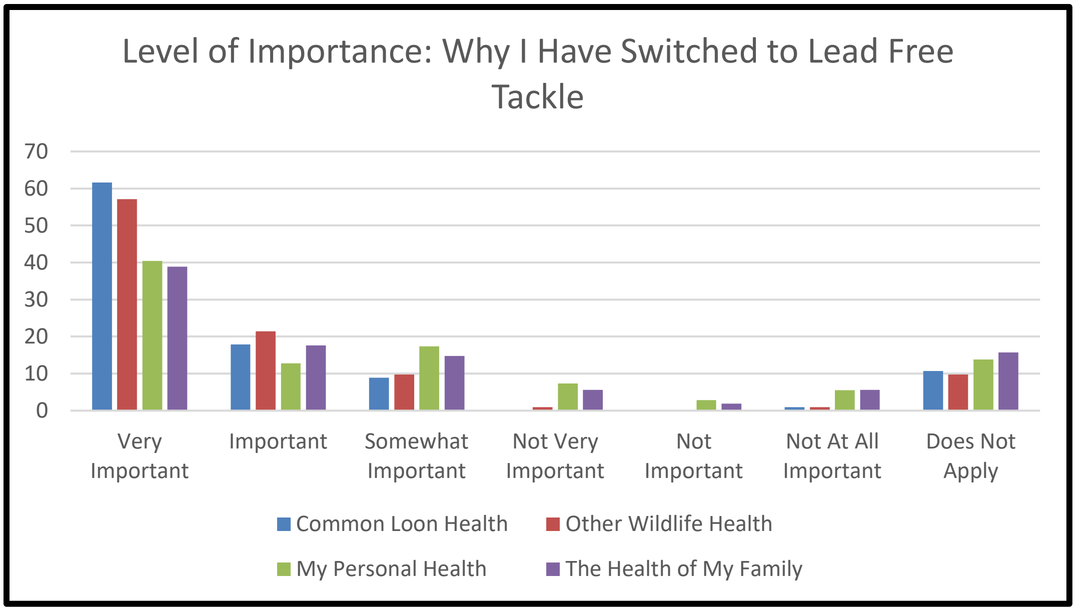


**Figure 12**: Responses to "If you currently use non-lead tackle, please indicate how each of the following factors influenced your decision: to protect common loons, to protect other wild birds, to protect my personal health, or to protect the health of my family."

Anglers also used the opportunity to express their appreciation of common loons and support of lead tackle restrictions in our comment section:

*"Seeing and hearing the loons make my fishing trip a joy!"*

Freshwater Angler/Wildlife Viewer, 65 year old male, Cumberland Center ME

*"I hope the results of this survey help you to build strategies that will gain support from diverse viewpoints to enact and enforce these protections for loons."*

Freshwater Angler/Wildlife Viewer 30 year old female, Cape Cottage ME

*"Good luck and I hope you succeed in saving the Maine Loon population. They are a great asset to have on the lakes and ponds of Maine."*

Freshwater Angler/Hunter/Wildlife Viewer, 68 year old male, West Enfield ME

*"Thank you for sending me the opportunity to help your study. Good luck to you and the Loons! They are a beautiful bird!"*

Fresh and Open Water Angler/Wildlife Viewer 50 year old female, Gray ME

*"I believe it is important to protect our wildlife. I support this 100%."*

Fresh and Open Water Angler/Wildlife Viewer 56 year old female, Lewiston ME

#### 4.1.4. Reaching anglers currently using lead fishing tackle may require a One Health approach.

We also asked anglers still using lead fishing tackle to indicate their willingness to replace their lead tackle. We offered the same choices as we did for those who have already switched to non-lead: to protect common loons, to protect other wild birds (raptors, waterfowl, etc), to protect my personal health, to protect the health of my family, if my fishing buddies did as well, to participate in a tackle exchange program, to enter in a raffle or for a prize, to support a local business, if I found affordable non-lead tackle, or if I found a better performing non-lead tackle. "To protect the health of my family" and "To protect my personal health" elicited the strongest attitudes (Figure 13), just ahead of "to protect common loons" and "to protect other wild birds".

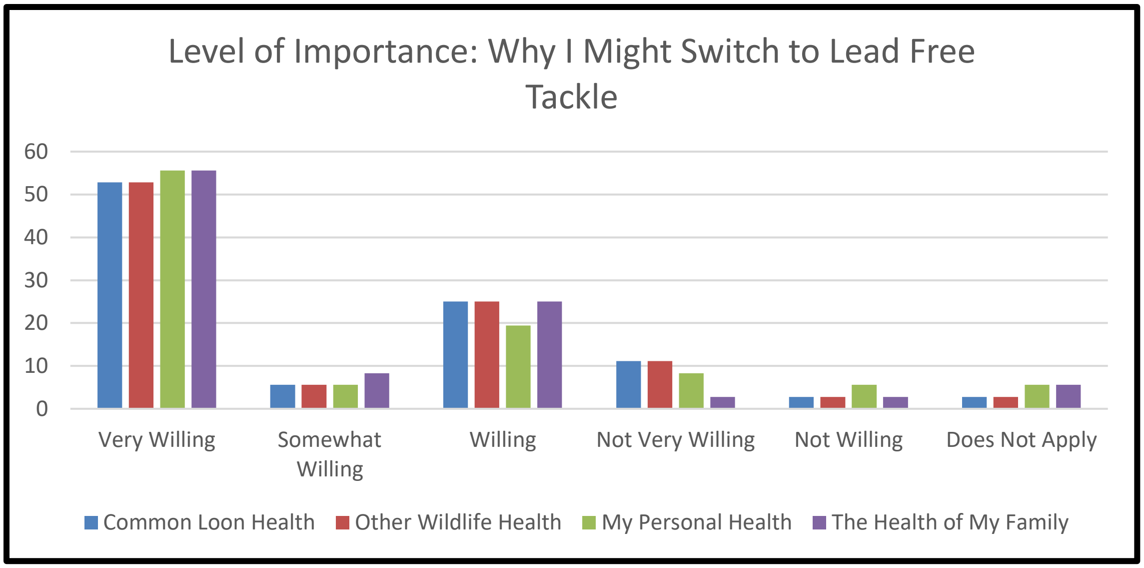


**Figure 13**: Responses to "If you currently use lead tackle, please indicate your willingness to replace your lead tackle for any of the following reasons: to protect common loons, to protect other wild birds, to protect my personal health, or to protect the health of my family".

Some participants commented on human health concerns, and also appeared to be less aware of common loon or other wildlife health concerns:

*"Thank you for bringing awareness to me and others about the dangers of lead. Often, when we think about lead, we think about it in terms of the paint and pipes in our homes, and not necessarily in products outside the home. Recently, there has been more attention paid to the inferior toys, etc imported from China. Now we need to think about animal safety too!"*

64 year old female, Portland, ME (no outdoor activities selected)

*"I am a Registered Nurse who has knowledge of lead poisoning, more in humans than animals and birds of course. I am in favor of sensible measures to protect wildlife, but against eco-crusaders who want to destroy legitimate sporting activities."*

Wildlife Viewer, 52 year old female, Oakland, ME

*"Your survey is interesting although I feel somewhat uneducated on this topic. As a former pediatric nurse working in an inner city hospital in the 70s and 80s, I treated children with lead poisoning who had elevated lead levels after exposure to lead paint. It was a grueling treatment for a child. The potential harm from lead exposure in people has been studied and accepted, but the science behind what it does to animals is not something about which I've heard much, but I imagine some of the same effects can be extrapolated from humans. I've been exposed to the very beautiful Loons when camping in Northern Maine. It is sad to think they can be sickened from lead exposure when there appears to be a viable solution i.e. banning lead based fishing products. It would be good to see more about this topic in the news."*

Wildlife Viewer, 64 year old female, Cape Elizabeth, ME

While these comments come from Maine residents who do not participate in fishing activities, they indicate a possible need to include human health concerns regarding lead tackle toxicity in outreach and communication efforts. This messaging has the potential to reach a broader audience, including those who have stronger altruistic and egoistic value systems than biospheric value systems. The concept of One Health could provide context for future messaging in order to address both human and wildlife health concerns. "One Health" evolved from Calvin Schwabe's advancement of the "one medicine" concept, which fully recognizes the interaction of humans and animals for nutrition, livelihood and health (Schwabe, 1984). One Health is now recognized by the World Health Organization and the Food and Agriculture Organization. One Health research provides links between veterinary medicine (domestic and wildlife) with human health, and may also reach outside clinical issues to include policy, economics, social science (Zinsstag et al., 2011). Framing messages to include both environmental and human health concerns has the potential to influence groups not concerned about wildlife health alone.

**4.2. Future Research Opportunity: Comparisons between Maine and other areas**

This study shows that Maine residents have responded to the issue of lead fishing tackle toxicity in common loons and are using less lead fishing tackle. This is partly due to respondents having strong biospheric values, which are very influential on risk perceptions. This could also be the result of the *Fish Lead Free* campaign and strong outreach programs. As evidence, lead-related deaths are decreasing in Maine's adult common loon populations.

However, in nearby New Hampshire, lead-related deaths are still a concern. A recent study by Grade et al. (2017) concluded that lead-related deaths have reduced the statewide population by 43%. The authors also concluded that loons are dying from current fishing activity, and not from ingestion of lead tackle left on lake beds (Grade et al., 2017). Other studies in New Hampshire suggest that lead-related deaths decrease soon after restrictions are in place, only to increase soon after (Vogel, 2005; Grade, 2011). This suggests there are barriers to compliance – but why? The state of New Hampshire also has a *Fish Lead Free* campaign and collaboration between state agencies and non-profit groups. Legislative and outreach efforts have also not been fully successful in Minnesota, Canada, and Sweden (Campbell, personal communication). However, there seems to have been more success in the United Kingdom (Friend and Franson, 1992). A study conducted in the Thames Valley, located in southeast England, showed that tundra swan deaths fell by 70% after a legislative ban on lead tackle (Sears and Hunt, 1991).

Using the risk perceptions framework from our study might be able to provide some insight. One unpublished study found that the majority of bass anglers in New Hampshire were influenced by social norms (Leszek, 2015), but no connection was made to perceptions of lead tackle toxicity risk. How would the New Hampshire fishing community rate their biospheric and egoistic values? Would those same anglers be more influenced by human health messaging? How do value systems in other countries, particularly those studying this topic, compare to Maine?

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# APPENDIX A

# SURVEY INSTRUMENT

Which of the following activities do you participate in the state of Maine? (Please select all that apply)

❑ Freshwater Fishing (2)
❑ Open water Fishing (ocean fishing) (3)
❑ Hunting (4)
❑ Wildlife Viewing (5)
❑ None of the above (6)

If Freshwater Fishing Is Not Selected, Then Skip To “To what extent do you agree with the ...

According to this map, roughly how many times per year do you fish in each Maine fishing region during the last two years?

| | Daily (1) | Every Few Days (2) | Weekly (3) | Every Few Weeks (4) | Monthly (5) | A Few Times Per Year (6) | Once A Year (7) | Never (8) |
|---|---|---|---|---|---|---|---|---|
| Region A (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Region B (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Region C (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Region D (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Region E (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Region F (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Region G (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

Please rate the average amount of time you freshwater fished during each of the following seasons:

| | Daily (1) | Every Few Days (2) | Weekly (3) | Every Few Weeks (4) | Monthly (5) | A Few Times per Year (6) | Once A Year (7) | Never (8) |
|---|---|---|---|---|---|---|---|---|
| Winter (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Spring (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Summer (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Fall (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

Approximately how many total days per year do you freshwater fish?

❍ Less than 20 (1)
❍ 20-40 (2)
❍ 41-60 (3)
❍ 61-100 (4)
❍ 101-150 (5)
❍ More than 150 (6)

Do you participate in freshwater fishing derbies?

❍ Yes (1)
❍ No (2)

Do you participate in freshwater fishing tournaments?

❍ Yes (1)
❍ No (2)

What type(s) of freshwater fish do you fish for? (Please select all that apply):

- ❑ Brook Trout (1)
- ❑ Brown Trout (2)
- ❑ Rainbow Trout (3)
- ❑ Lake Trout (Togue) (4)
- ❑ Smallmouth Bass (5)
- ❑ Largemouth Bass (6)
- ❑ Landlocked Salmon (7)
- ❑ White Perch (8)
- ❑ Yellow Perch (9)
- ❑ Northern Pike (10)
- ❑ Pickerel (11)
- ❑ Sunfish (12)
- ❑ Black Crappie (13)
- ❑ Alewife (14)
- ❑ Anything (15)
- ❑ Other (16) ____________________

What type(s) of fishing activities do you participate in? (Please select all that apply):

- ❑ Ice Fishing (1)
- ❑ Fly Fishing (2)
- ❑ Youth/Family Fishing (3)
- ❑ Bass Fishing (4)
- ❑ Live Bait Fishing (5)
- ❑ Other (6) ____________________

Where do you get most of your fishing tackle?

- ❑ Online (1)
- ❑ Local tackle shop (2)
- ❑ Large retailer (Wal-Mart, Cabela's, Bass Pro Shop) (3)
- ❑ Yard sales (4)
- ❑ Inherited from friends and family (5)
- ❑ I make my own tackle (6)
- ❑ Other (7) ____________________

Based on your experience, please indicate how well each of the following forms of tackle perform when fishing:

| | Extremely Well (1) | Very Well (2) | Moderately Well (3) | Slightly Well (4) | Not Well At All (5) | I Don't Know (6) |
|---|---|---|---|---|---|---|
| Tungsten (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Lead (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Stainless Steel (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Bismuth (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Tin (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Brass (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Natural Stone (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Other (8) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

Please indicate if you have used any lead freshwater fishing tackle during the following years:

| | Yes (1) | No (2) | I Didn't Fish In Maine That Year (3) | I Don't Remember (4) |
|---|---|---|---|---|
| 2015 (1) | ❍ | ❍ | ❍ | ❍ |
| 2014 (2) | ❍ | ❍ | ❍ | ❍ |
| 2013 (3) | ❍ | ❍ | ❍ | ❍ |
| 2012 (4) | ❍ | ❍ | ❍ | ❍ |

How often have you used freshwater lead fishing tackle during 2016?

❍ Never (1)
❍ Almost Never (2)
❍ Sometimes (3)
❍ Almost Always (4)
❍ Always (5)
❍ I'm Not Sure (6)

If Never Is Selected, Then Skip To “If you currently use only non-lead tackle...”

If you currently use lead tackle, please indicate your willingness to replace your lead tackle for any of the following reasons:

| | Very Willing (1) | Willing (5) | Somewhat Willing (2) | Not Very Willing (3) | Not Willing (6) | Not At All Willing (4) | Does Not Apply (7) |
|---|---|---|---|---|---|---|---|
| To protect Common Loons (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To protect other wild birds (raptors, waterbirds, etc) (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To protect my personal health. (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To protect the health of my family. (11) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| If my fishing buddies did as well (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To participate in a tackle exchange program (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To enter in a raffle or for a prize (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To support a local business (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| I found affordable non-lead tackle (8) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| I found a better performing non-lead tackle (9) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Other (10) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

If you currently use non-lead tackle, please indicate how each of the following factors influenced your decision:

| | Very Important (1) | Important (2) | Somewhat Important (3) | Not Very Important (4) | Not Important (5) | Not At All Important (8) | Does Not Apply (6) |
|---|---|---|---|---|---|---|---|
| To protect Common Loons (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To protect other wild birds (raptors, waterbirds, etc) (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To protect my personal health. (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| To protect the health of my family. (11) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Because my fishing buddies use non-lead as well (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| The ability to participate in a tackle exchange program for free non-lead tackle (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| The ability to exchange tackle to enter in a raffle or for a prize (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| The ability to support a local business (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| I found affordable non-lead tackle (8) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| I found non-lead tackle that performs well (9) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Other (10) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

To what extent do you agree with the following statements?

| | Strongly Agree (1) | Agree (2) | Somewhat Agree (3) | Neutral (4) | Somewhat Disagree (5) | Disagree (6) | Strongly Disagree (7) |
|---|---|---|---|---|---|---|---|
| Lead fishing tackle is safe for humans to handle. (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Common Loons that eat lead fishing tackle become very ill and/or die. (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| There are bigger threats to Common Loons than lead fishing tackle. (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| I understand the effects of lead fishing tackle on Common Loons. (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| The effects of lead fishing tackle on Common Loons have been exaggerated. (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Lead tackle covered in a layer of paint is safe. (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| A very small amount of lead will not harm | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Common Loons. (7) | | | | | | | |
| A very small amount of lead will not harm humans. (8) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Common Loon populations in Maine are healthy, so we do not need to worry about the impacts of lead fishing tackle. (9) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

To what extent would you agree with the following statements?

| | Strongly agree (1) | Agree (2) | Somewhat Agree (3) | Neutral (4) | Somewhat Disagree (5) | Disagree (6) | Strongly Disagree (7) |
|---|---|---|---|---|---|---|---|
| Lead free fishing tackle is too expensive. (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Lead free fishing tackle is difficult to find in my store (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Restrictions on lead mean less young people will fish in Maine (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Restrictions on lead would cause me to fish less often in Maine (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Restrictions on lead fishing tackle hurt Maine's economy (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| The effort to reduce lead fishing tackle in Maine is a tactic by environmental groups to eliminate fishing (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

Do you belong to any of the following organizations? (please select all that apply)

- ❑ B.A.S.S. Nation of Maine (1)
- ❑ Maine Audubon (2)
- ❑ National Rifle Association (3)
- ❑ Sierra Club (4)
- ❑ Sportsmen's Alliance of Maine (5)
- ❑ Trout Unlimited (6)
- ❑ Wildlife Society (7)
- ❑ North American Hunting Club (8)
- ❑ Ducks Unlimited (10)
- ❑ Other (11) ____________________

How much do you trust the following agencies, organizations, and groups as sources of information about using lead fishing tackle?

| | Strongly Distrust (1) | Distrust (2) | Somewhat Distrust (3) | Neutral (4) | Somewhat Trust (5) | Trust (6) | Strongly Trust (7) |
|---|---|---|---|---|---|---|---|
| My fishing buddies (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Maine Department of Fisheries and Wildlife Biologists (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Non-government Biologists (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Registered Maine Fishing Guides (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Conservation Organizations (Maine Audubon, World Wildlife Fund, etc) (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Fishing Organizations (B.A.S.S. Nation, Sportsmen's Alliance of Maine, etc) (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Outdoor Writers (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Fishing Tackle Manufacturers (8) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Experienced Anglers (9) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Friends and Family (10) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Other (11) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

How much information do you obtain from the following sources about wildlife?

| | A great deal (1) | A lot (2) | A moderate amount (3) | A little (4) | None at all (5) |
|---|---|---|---|---|---|
| Newspapers (1) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Fishing Magazines (2) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Radio (3) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Television (4) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Maine Department of Inland Fisheries and Wildlife (5) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Sporting Goods stores (6) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Registered Maine Guides (7) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Friends and Family (8) | ❍ | ❍ | ❍ | ❍ | ❍ |
| Other (9) | ❍ | ❍ | ❍ | ❍ | ❍ |

In this section, we would like to learn more about your direct experiences with Common Loons in Maine, as well as your personal experiences with lead poisoning.

How often do you encounter Common Loons while fishing in Maine?

- ❍ Always (100%) (1)
- ❍ Frequently (51-75%) (2)
- ❍ Commonly (26-50%) (3)
- ❍ Rarely (1-25%) (4)
- ❍ Never (0%) (5)

Do you own property on a lake?

- ❍ Yes (1)
- ❍ No (2)

If No Is Selected, Then Skip next question

If yes, do you see loons on your lake?

- ❍ Yes (1)
- ❍ No (2)

Please indicate if you have directly experienced the following:

| | Yes (1) | No (2) |
|---|---|---|
| I have witnessed a Common Loon with lead poisoning in person. (1) | ❍ | ❍ |
| I have witnessed a Common Loon with lead poisoning in a video. (2) | ❍ | ❍ |
| I have heard about Common Loons becoming ill from lead poisoning. (3) | ❍ | ❍ |
| I have heard about Common Loons dying from lead poisoning. (4) | ❍ | ❍ |

Please indicate if you have directly experienced the following:

| | Yes (1) | No (2) |
|---|---|---|
| I have witnessed an animal, other than a Common Loon, with lead poisoning in person. (1) | ❍ | ❍ |
| I have witnessed an animal, other than a Common Loon, with lead poisoning in a video. (2) | ❍ | ❍ |
| I have heard about an animal, other than a Common Loon, becoming ill from lead poisoning. (3) | ❍ | ❍ |
| I have heard about an animal, other than a Common Loon, dying from lead poisoning. (4) | ❍ | ❍ |

Please indicate if you have directly experienced the following:

| | Yes (1) | No (2) |
|---|---|---|
| I have heard about humans becoming ill from lead poisoning. (1) | ❍ | ❍ |
| I have heard about humans dying from lead poisoning. (2) | ❍ | ❍ |

For the following question, we would like to learn about your awareness and attitudes regarding the L.D. 730: An Act to Protect Maine's Loons. Lead sinkers weighing 1oz or less are already banned in Maine. Starting in September 2016, the sale of bare lead jigs will also be banned (weighing 1oz or less and 2 and 1/2 inches or less), followed by a ban on their use starting in September 2017.

Please indicate the extent to which you agree or disagree with the following statements:

| | Strongly Agree (1) | Agree (2) | Somewhat agree (3) | Neutral (4) | Somewhat disagree (5) | Disagree (6) | Strongly disagree (7) |
|---|---|---|---|---|---|---|---|
| Before this survey, I was aware of L.D. 730. (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| I support L.D. 730. (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| People I care about support L.D. 730. (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| I believe L.D. 730 will protect Common Loons. (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

We would like to learn more about what values are important to you.  For each value listed below, please rate the extent to which you consider it to be a guiding principal in your life.

| | Opposed to my values (1) | Not important (2) | Of little importance (3) | Somewhat important (4) | Important (5) | Slightly more than important (6) | Quite important (7) | Very important (8) | Of extreme importance (9) |
|---|---|---|---|---|---|---|---|---|---|
| Wealth (material possessions, money) (1) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Preventing Pollution (protecting natural resources) (2) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Peace (a world free of conflict) (3) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Protection of the environment (preserving nature) (4) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Social Power (control over others, dominance) (5) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Helpful (working for the welfare of others) (6) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Authority (the right to lead or command) (7) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Social Justice | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| (correcting injustice, care for the weak) (8) | | | | | | | | | |
| Respecting the earth (harmony with other species) (9) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Influential (having an impact on people and events) (10) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Unity with nature (fitting into nature) (11) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |
| Equality (equal opportunity for all) (12) | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ | ❍ |

In this final section, we would like to learn more about your background. Please remember that your answers to these questions, as well as all of the answers you provide in this questionnaire, will be completely anonymous.

What is your age?

What is your gender?

- ❍ Male (1)
- ❍ Female (2)
- ❍ Other (3)

What is the highest level of education that you have completed?

- 12th grade or less (1)
- High School (2)
- GED (3)
- Associate Degree (4)
- Bachelor's Degree (5)
- Advanced Degree (6)

What is your political affiliation?

- Democrat (1)
- Independent (2)
- Republican (3)
- Other (4) ____________________

What is your combined household income?

- $0-$25,000 (1)
- $25,001-50,000 (2)
- $50,001-75,000 (3)
- $75,001-100,000 (4)
- $100,001-125,000 (5)
- $125,000-149,000 (6)
- $150,000+ (7)

Which of the following best describes your residency in the state of Maine?

- Full-Time Resident (1)
- Seasonal Resident (at least 6 months per year) (2)

What is your state of Maine zip code?

With which race or ethnicity do you most closely identify yourself with?

- African-American (1)
- Asian-Pacific Islander (2)
- Hispanic (3)
- Native American (4)
- White (5)
- Other (6)
- Prefer not to answer (7)

Please feel free to add any comments regarding the topics in this survey:

# APPENDIX B

## MAIL INVITATION TO PARTICIPATE

Dear Maine Resident,

You are invited to participate in a research project being conducted by Brooke Hafford MacDonald, a master's student (M.S.) in Ecology and Environmental Sciences, at the University of Maine, Orono. Her faculty sponsor is Dr. Sandra De Urioste-Stone from the School of Forest Resources at the University of Maine, Orono. The purpose of the survey is to better understand your attitudes about lead fishing tackle, the new laws regarding lead tackle, and about Common Loon conservation.

Your address is one of only a small number that have been randomly selected to help in this study; we selected the address from a list provided by InfoUSA.

We would greatly appreciate if you would be willing to share your views. The survey should only take about 15-20 minutes to complete. You must be 18 years of age to participate. After completing the online survey you will have the option to be entered into a raffle to win one of three L.L. Bean gift cards. Survey responses will be anonymous. To learn more about this study and to take the survey, please follow the link below:

(Survey Link)

If you have any questions regarding the survey or this study, we would be happy to assist you. Please email or call us using the information given below.

Many Thanks!

Brooke Hafford MacDonald
M.S. Candidate

Ecology and Environmental Sciences
University of Maine
251 Nutting Hall
University of Maine
Orono, ME 04669-5755
brooke.hafford@maine.edu

Dr. Sandra de Urioste-Stone
Assistant Professor

School of Forest Resources
University of Maine
237 Nutting Hall
University of Maine
Orono, ME 04469-5755
sandra.de@maine.edu

# APPENDIX C

## INFORMED CONSENT

Dear Maine Resident,

You are invited to participate in a research project being conducted by Brooke Hafford MacDonald, a master's student (M.S.) in Ecology and Environmental Sciences at the University of Maine, Orono. Her faculty sponsor is Dr. Sandra De Urioste-Stone from the School of Forest Resources at the University of Maine, Orono. The main purpose of this research is to better understand your attitudes about lead fishing tackle, the new laws restricting lead tackle, and about Common Loon conservation. A primary goal is to learn how the recent L.D.730: *An Act to Protect Maine's Common Loons* (which bans the sale and use of bare lead jigs 1oz or less or up to 2.5 inches long) is perceived. You must be at least 18 years old to participate.

**<u>What will you be asked to do?</u>**

If you decide to participate, you will be asked to fill out the following questionnaire, which will take approximately 15-20 minutes. If you leave the survey early your responses will be saved and you may continue the survey later from the point where you left. You will receive up to two reminders.

**<u>Risks</u>**

Other than your time, there are no risks to participate in this study.

**<u>Benefits</u>**

While participation in this survey may have no direct benefit to you, the study will help us better understand views toward lead fishing tackle, the current legislation, and Common Loon conservation.

**<u>Compensation</u>**

At the end of the study, you will have the option of entering your address into a raffle to win one of three L.L. Bean gift cards. You will need to reach the end of the survey for your address to be entered. The raffle will not be connected to your survey responses.

**<u>Confidentiality</u>**

Survey data will be anonymous. Data will be kept in a password protected computer indefinitely.

**<u>Voluntary</u>**

Participation is voluntary. You may stop at any time or skip questions, but you must reach the end of the survey to enter the raffle. Starting the survey implies consent to participate.

**Contact Information**

If you have any questions about this study, you may contact Brooke Hafford MacDonald, M.S. Candidate, at brooke.hafford@maine.edu; or 251 Nutting Hall, University of Maine, Orono, ME 04469-5755.

You may also contact her academic sponsor, Dr. Sandra de Urioste-Stone at (207)581-2885; sandra.de@maine.edu; or 237 Nutting Hall, University of Maine, Orono, ME 04469-5755.

If you have any questions about your rights as a research participant, please contact Gayle Jones, Assistant to the University of Maine's Protection of Human Subjects Review Board, at 581-1498; or gayle.jones@umit.maine.edu.

**Thank you for taking the time to complete this questionnaire!**

# APPENDIX D

## POSTCARD REMINDER #1

Dear Maine Resident,

Recently, we sent you an invitation to participate in our important study about fishing in Maine. If you have already taken our survey, we appreciate your participation! If not, we hope that you will take this opportunity to respond so that we may better understand your attitudes and perceptions regarding lead fishing tackle and Common Loon conservation in Maine. Your address is one of only a small number that have been randomly selected to help in this study.

We are writing again because of the importance that your household's responses have for helping to get accurate results. Your participation is voluntary and your responses will be anonymous. You must be at least 18 years of age. If you choose to participate, you will have the option to enter our raffle to win one of three $50 L.L. Bean gift cards.

Please follow the link below to take the online survey, which will take you between 15-20 minutes to complete.

(Survey Link)

Many thanks!

Brooke Hafford MacDonald
M.S. Candidate

Ecology and Environmental Sciences
University of Maine
251 Nutting Hall
University of Maine
Orono, ME 04669-5755
brooke.hafford@maine.edu

Dr. Sandra de Urioste-Stone
Assistant Professor

School of Forest Resources
University of Maine
237 Nutting Hall
University of Maine
Orono, ME 04469-5755
sandra.de@maine.edu

# APPENDIX E

## POSTCARD REMINDER #2

Dear Maine Resident,

We still need your help!  Recently, we sent you an invitation to participate in our important study about lead fishing tackle and Common Loons in Maine. Your views matter greatly to us and are key to the success of this project.  Since you cannot be replaced, we wanted to offer you one last opportunity before we close the survey.

Below is the link to take the online survey, which will take you between 15-20 minutes to complete. Your participation is voluntary and your responses will be anonymous.  You must be at least 18 years old to participate.  After completing the survey you will have the opportunity to enter into a raffle for one of three **$50 L.L. Bean Gift Cards**.  Please use the survey link below:

(Survey Link)

Thank you in advance for your help with this important project!

Brooke Hafford MacDonald
M.S. Candidate

Ecology and Environmental Sciences
University of Maine
251 Nutting Hall
University of Maine
Orono, ME 04669-5755
brooke.hafford@maine.edu

Dr. Sandra de Urioste-Stone
Assistant Professor

School of Forest Resources
University of Maine
237 Nutting Hall
University of Maine
Orono, ME 04469-5755
sandra.de@maine.edu

# APPENDIX F

# IRB APPROVAL

**APPLICATION FOR APPROVAL OF RESEARCH WITH HUMAN SUBJECTS**

**Protection of Human Subjects Review Board, 418 Corbett Hall, 581-1498**

**(Type inside gray areas)**

**PRINCIPAL INVESTIGATOR:** Brooke Hafford MacDonald

**EMAIL:** brooke.hafford@maine.edu **TELEPHONE:** 207-266-7538

**CO-INVESTIGATOR(S):**

**FACULTY SPONSOR (Required if PI is a student):** Sandra de Urioste-Stone

**TITLE OF PROJECT:** Lead Exposure in Maine's Common Loons (*Gavia immer*): Examining Biological and Social Systems

**START DATE:** June, 2016 **PI DEPARTMENT:** Ecology and Environmental Sciences

**MAILING ADDRESS:** 251 Nutting Hall, University of Maine, Orono Maine 04469

**FUNDING AGENCY (if any):**

**STATUS OF PI:**

**FACULTY/STAFF/GRADUATE/UNDERGRADUATE** Graduate

**1. If PI is a student, is this research to be performed:**

- ☐ for an honors thesis/senior thesis/capstone?
- ☒ for a master's thesis?
- ☐ for a doctoral dissertation?
- ☐ for a course project?
- ☐ other (specify)

**2. Does this application modify a previously approved project? N (Y/N). If yes, please give assigned number (if known) of previously approved project:**

**3. Is an expedited review requested? N (Y/N).**

**Submitting the application indicates the principal investigator's agreement to abide by the responsibilities outlined in Section I.E. of the Policies and Procedures for the Protection of Human Subjects.**

**Faculty Sponsors are responsible for oversight of research conducted by their students. The Faculty Sponsor ensures that he/she has read the application and that the conduct of such research will be in accordance with the University of Maine's Policies and Procedures for the Protection of Human Subjects of Research. REMINDER: if the principal investigator is an undergraduate student, the Faculty Sponsor MUST submit the application to the IRB.**

**Email complete application to Gayle Jones (gayle.jones@umit.maine.edu)**

**Lead Exposure in Maine's Common Loons (*Gavia immer*):**

**Examining Social and Biological Systems**

## 1. Summary of the proposal:

In New England, the leading cause of death in adult Common Loons is lead poisoning (Sidor et al, 2003). Because of their feeding habits, these birds are particularly susceptible to toxicity from lead fishing tackle. Loons ingest and maintain small stones from the lakebed in their muscular gizzard, presumably to help grind up food. (McIntyre and Barr, 1997). Stones retrieved from necropsied carcasses generally have a diameter between 1-25mm, and many sinkers and jigs have diameters within this range (Pokras et al, 2009). These birds may also ingest lead by eating fish with tackle attached.

Lead has been documented as a common health hazard for over a century, with several hundred studies examining the impacts of lead on wildlife (Pettersen, 2009). There have been policy and outreach efforts to reduce lead poisoning resulting from fishing activities. One example is the *Fish Lead Free* project in Maine, a cooperative partnership between Maine Audubon, Maine Department of Inland Fisheries and Wildlife (IF&W), Sportsman's Alliance of Maine (SAM), BASS Nation, and the Maine Lakes Society. The state of Maine has also passed several laws, most recently L.D. No. 730: An Act to Protect Maine's Loons by Banning Lead Sinkers and Jigs on February 28, 2013. This law will impose size limits on lead jigs in addition to existing sinker laws and will be enacted in two stages: sales in 2016, and use in 2017 (source: mainelegislature.com). In spite of these outreach and policy instruments, there are still many anglers who argue against regulations, and it remains a controversial issue.

What is the level of knowledge and the current attitudes regarding the new legislation? The toxicity of lead? Conservation efforts surrounding Common Loons? We believe that understanding angler knowledge, attitudes, and behaviors surrounding this issue will be crucial for enhancing the effectiveness of communication and outreach efforts, and to inform future policy development and implementation.

Residents will be asked to participate in a self-administered online survey (Annex A). Demographic data will also be collected. Survey implementation will follow Dillman's Tailored Design method to reduce measurement, non-response, and coverage errors (Dillman et al, 2014). A total of 2,500 Maine residents will be randomly selected and invited to participate in the survey, but sample size may be modified in order to achieve a 5% margin of error with 95% confidence. Close ended questions and scales will be developed using previously tested and reliable items (Brenkert-Smith et al, 2013; Renn et al, 1992). Everyone will receive up to two reminders to increase response rate. The questionnaire will be pre-tested prior to initial data collection (Visser et al, 2000). All personnel will be trained by the supervisor before using data collection materials and before performing data entry procedures.

## 2. Personnel:

Principal Investigator (P.I.): Brooke Hafford MacDonald, M.S. Candidate, Ecology and Environmental Sciences, University of Maine, Orono, Maine, USA.

Ms. MacDonald will be collecting this data to contribute to her M.S. thesis research, which combines both biophysical as well as social science data, and focuses on lead toxicity in Common Loons due to fishing tackle. She is currently certified through the University of Maine to work with human subjects and has completed the human subjects training through the UMaine IRB.

Faculty Sponsor: Dr. Sandra De Urioste-Stone, Assistant Professor of Nature-based Tourism, School of Forest Resources, University of Maine, Orono, Maine, USA.

Dr. De Urioste-Stone has extensive experience in creating and interpreting scientific surveys both in the outdoor recreation field as well as other fields within the social sciences. While at the University of Idaho, she worked in cooperating with the National Park Service to implement and interpret data collected from visitors to US National Parks. Dr. De Urioste-Stone is currently certified through the University of Maine to work with human subjects and has completed the human subjects training through the UMaine IRB.

### 3. Participant Recruitment:

A mail survey will be distributed in order to assess angler awareness and attitudes regarding lead fishing tackle legislation, the toxicity of lead, and Common Loon conservation. The PI will send a letter to randomly selected Maine residents (2,500) from a list purchased from INFOUSA. The letter will invite them to take the online survey; anglers can voluntarily choose to take the survey from Qualtrics. Only addresses will be used for mailing/follow up purposes, and no names will be linked to the survey responses. The PI will send two follow up mailings to increase response rates (Annex D and Annex E). Participants will be over the age of 18.

### 4. Informed Consent:

All potential survey respondents will be provided with consent information before choosing to participate in the survey. At the beginning of the actual survey, participants will access written details that will describe what they would be asked to do in the survey, the risks they will be undertaking by participating, the benefits they might receive by participating, the procedures for maintaining their confidentiality, and the contact information of the PI of the research team. Participation in surveys will then imply consent to participate (see Annex C for details for the informed consent).

### 5. Confidentiality:

- Survey responses will be anonymous. Raffle information collected with not be connected to survey responses.
- All data will be downloaded to a password protected computer and kept indefinitely. Data will be deleted off Qualtrics in 2 years.

### 6. Risks to Participate:

In the judgement of the PI, there are no possibly physical, psychological, social, legal, economic, or other risks to the subjects, either immediate or long-term. The risk to human subjects is no greater than that of everyday living.

### 7. Benefits:

Individuals participating in the survey will not gain any direct benefit from participating in the study. Individuals may feel satisfied that their contribution to this survey may be helping to inform further discussions, decisions, and potential legislation regarding lead fishing tackle use in Maine.

### 8. Compensation:

At the end of the survey, participants will have the option of entering their address into a raffle to win one of three $50 L.L. Bean gift cards. Participants will need to reach the end of the survey and submit responses in order to be entered. The raffle will not be connected to survey responses.

## 9. Bibliography

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## BIOGRAPHY OF THE AUTHOR

Brooke Sandra MacDonald was born in Fort Kent, Maine. She graduated from Fort Kent Community High School in Fort Kent, Maine in 1999 and graduated with a B.A. from the College of the Atlantic in Bar Harbor, Maine in 2003. She is a candidate for a Master of Science degree in Ecology and Environmental Sciences from the University of Maine in December, 2018.