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Fish and Wildlife Issues Related to the Use of Lead Fishing Gear

by Pat Michael

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Executive Summary

There is growing concern about the amount of lead that is deposited into our environment by various means. Federal laws have addressed what appear to be the most common pathways. The manufacture of paint with high levels of lead was banned in 1978, and leaded gasoline was banned in the mid-1980s. But problems persist, and a recent New York Times article (January 17, 2006) states that about 25% of our nation's children are still exposed to lead in their homes and more than 400,000 each year are found to have amounts of lead in their bodies that are hazardous to normal mental and physical development. Workers in the metals trades are still at risk – as recently as 1998, over 320,000 workers in the U.S. were exposed to lead (Needleman, 2004). Another more recent area of concern is the lead deposited into the environment from hunters and fishers in the form of lead shot and lead fishing tackle.

This paper looks at the possible environmental effects of this metal, focusing on lost fishing tackle. Although many different species of birds, reptiles, and small mammals are known to have died from ingesting lead, studies have shown that birds are very susceptible to lead poisoning because the grinding action of their gizzards releases the toxic metal directly into their bloodstream. Loons are the birds most likely to ingest lead fishing tackle, and one lead sinker or lead jig can kill a loon. Several countries have enacted laws banning or limiting the use of lead fishing tackle. Several U.S. states also have passed laws, often based limiting the use of small lead sinkers or jigs that are more likely to be swallowed.

Introduction

This paper is intended to provide a broad overview on the subject of lead. It includes basic information about lead as an element, and a short history of how it has been used by man for many centuries. It discusses the detrimental effects that lead can have to both humans and wildlife, and the main pathways by which lead enters humans and animals. It lists major federal laws regulating the use of lead in paint, plumbing and gasoline that have been enacted to stop the deposit of lead into the water, air and soil. It also discusses the effects that shot and lead fishing gear can have on different species of fish and wildlife, and laws enacted regarding their use. Because this paper is produced primarily for use within the fish program, special emphasis is placed on the effects of lead fishing gear on wildlife, particularly loons, the species shown to be most susceptible to ingesting lead fishing tackle. This paper includes a summary of laws enacted by other countries and other states within our country limiting the use of lead fishing gear and some of the reasons behind the restrictions. This information will aid managers when they need to make decisions on the use or limitations on the use of lead fishing tackle.

Chemical Properties of Lead

Lead is a naturally occurring element, a normal constituent of the earth's crust. Trace amounts occur naturally in soil, plants and water, and if it is left undisturbed, lead is nearly immobile. However, once mined and transformed by man into products that are dispersed throughout the environment, lead becomes very toxic. Solely as a result of man's actions, lead has become the most widely distributed toxic metal in the world (Needleman, 1999). Lead is a heavy metal. It is soft and malleable and has a relatively low melting point. Most heavy metals are extremely toxic because, as ions or in certain compounds, they can be taken into the body, where they tend to combine with and inhibit the functioning of particular enzymes. Lead is not biodegradable – it accumulates where deposited. Lead is generally resistant to corrosion but will dissolve in weakly acidic water (low pH).

Lead Poisoning

Lead is absorbed into animals mainly via the gastro-intestinal tract or the respiratory tract, although some organic lead compounds can also be absorbed through the skin. Lead initially attaches to red blood cells and is eventually concentrated in the bones, blood, brain, kidneys, and liver. It stays in the blood for several months, and can be stored in the bones and teeth for decades. Lead poisoning can cause permanent damage to the brain and nervous system, digestive organs, kidneys, heart and reproductive organs. In its acute form, lead poisoning can cause paralysis, coma and death. In chronic lead poisoning, very small amounts of lead can

interfere with the brain development in a human fetus or cause a miscarriage or premature birth. Children are more susceptible than adults. Very low blood lead levels in children may cause no distinctive clinical symptoms, but the effects of childhood lead poisoning on intellectual and neurobehavioral functioning are measurable and may persist for life (Reigert et al, Needleman 2004, Eisler 1988).

Historical uses of Lead

Lead was known and widely used by ancient civilizations. A lead statue discovered in Turkey dates from 6500 BC. In Egypt between 5000 and 7000 B.C., lead was used for glazing pottery, solder, ornaments, fishing net weights, anchors, caulking, coins and cooking utensils, cosmetics, and as a wine sweetener. It has long been used in metal alloys (with zinc and copper to make brass, and with tin to make pewter).

In Roman times, lead was used in the vast network of pipes that kept Rome and provincial cities supplied with water. Our word "plumbing" comes from the Latin word for lead, *plumbum.*

History of Lead Poisoning

Although Romans were aware that lead could cause serious problems, including madness and death, they were extremely fond of its uses. Reasoning that limiting the exposure of the ruling classes would limit their risk, jobs like mining and smelting lead were reserved for slaves. What the upper class did not realize was that everyday low-level exposure to lead gave them chronic lead poisoning, rather than the acute form prevalent among the lowest classes. Many modern scholars think that the result was the slow poisoning of this great empire. Lead contained in the food and wine ingested by the Roman elite likely contributed to the epidemics of gout and sterility among males, and the high rate of infertility and stillbirths among the women. The degenerate emperors that followed Caligula and Nero are conspicuous examples of the mental incompetence that was probably another result of chronic lead poisoning (Lewis, 1985).

A few references to lead's harmful effects were recorded by the ancient Greek and later Roman physicians. There are written accounts of lead toxicity in Egyptian papyrus scrolls, which indicate that lead compounds were often used for homicidal purposes (Hernberg, 2000).

The first "modern" clinical description of lead poisoning can be said to date from the 1839 publication of Tanquerel des Planches, in Paris, in which he described the clinical course of 1,207 persons with lead colic and the types of work that exposed them to lead (Hernberg, 2000).

More than 800 of the cases were in painters or workers involved in the manufacture of white or red lead pigments.

During the Industrial Revolution, work in smelters and factories put many people in the United States into close contact with lead, causing major health problems and sometimes death. But, with the general poor health of the population, the medical community did not recognize lead poisoning as a disease nor establish guidelines for diagnosis, treatment or prevention. Even today, chronic lead poisoning often goes undiagnosed, especially in developing countries, where many sources have not been eliminated. In their 2003 Lead Review, the Nordic Council of Ministers reported that of 52 African nations, only two had any unleaded gasoline available.

In Europe, the general health hazards of lead in paint were recognized earlier than in the U.S. Awareness of the hazards was reflected in advertising of the period: Figure 1 depicts an advertisement appearing in England in 1897 emphasizing the nonpoisonous nature of Aspinall's Enamel paint, in contrast with toxic leaded paint.

Figure 1. Advertisement for Aspinall's enamel, which appeared in the Diamond Jubilee issue of the *Illustrated London News*, 1897. Note that it is not made with lead, is not toxic, and represents 60 years of progress. The latter probably refers to the work of Tanquerel des Planches in Paris in the 1830s. He published his famous treatise, "Les Maladies de Plumbe" in 1839. Note that Aspinall's enamel could be purchased in 1897 in Paris, London, and New York.

In the 1890s, clinical reports of lead poisoning were documented at a children's hospital in Australia. The source of lead was not a factory, but the white lead paint on the porch railings of the children's homes, baking in the hot sun, and flaking off onto the porches where is was accessed by the children. Although there was a lot of resistance from the business community, Australia passed the first lead paint prevention act in 1920. In 1914 the first American case of lead-paint poisoning was described in a 5-year-old boy, but the U.S did not enact laws concerning this source of lead poisoning until much later (see below). In the 1920s, tetraethyl lead was added to gasoline, dispersing it through the air and into soils, especially along roadways. Water-borne lead from lead pipes in areas with acidic water is another common source of lead poisoning in humans.

The history of man's use of lead can be tracked in ice core data from Greenland. The ice sheets are made of snow that falls to earth, carrying with it chemicals, metals, dust and radioactive fallout. Data from the cores indicate that large-scale pollution started about 2500 years ago from the smelting and mining of lead and silver during the Greek and Roman eras. Lead concentrations in the ice cores fell after the decline of the Roman Empire and did not surpass Roman levels until the start of the Industrial Revolution. In the twentieth century, lead concentrations rose to 200 times the pre-Greek and Roman levels. Since the passage of the Clean Air Act in 1970, concentrations have begun to fall (Nadis,1997).

U.S. Environmental Laws

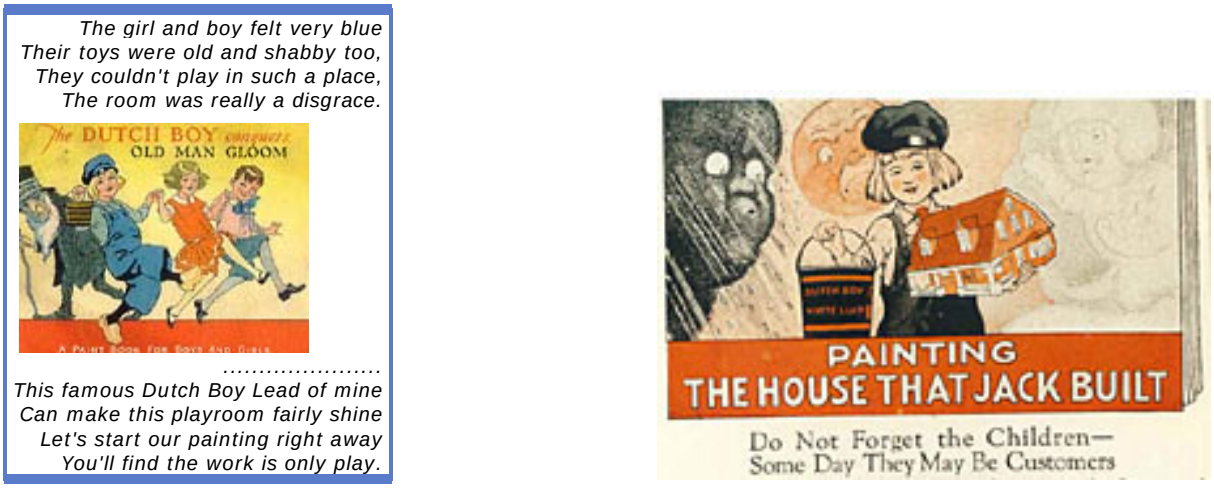


Figure 2. Examples of advertisements from companies promoting the use of lead-based paints in children's rooms and schoolrooms in the 1920's. Source: Cincinnati Children's Hospital Medical Center – History of Lead Advertising.

In the United States, the Department of Health first set a drinking water standard for lead in 1925. In 1974, Congress passed the Safe Drinking Water Act, which requires the Environmental Protection Agency to set nationwide regulations on primary drinking water contaminants. New amendments to the act in 1986 banned the use of materials containing lead in public water supplies and in home plumbing systems, and standards were tightened in 1991. The manufacture of paint with high levels of lead for interior and exterior surfaces, toys and furniture was banned in 1978. Leaded gasoline was finally banned in the mid-1980s.

Despite federal legislation, and a growing awareness of the consequences of exposure to even small amounts of lead, problems persist. Workers in the metals trades are still at risk – as recently as 1998, over 320,000 workers in the U.S. were exposed to lead (Needleman, 2004). A recent article in the New York Times (January 17, 2006) states that about 25% of our nation's children are still exposed to lead in their homes and more than 400,000 each year are found to have amounts of lead in their bodies that are hazardous to normal mental and physical development. Ten micrograms per deciliter of blood is the current acceptable standard for humans– it has been steadily lowered since 1969, when 60 micrograms per deciliter was considered to be safe. Some studies have shown that half of this level of lead can inflict notable damage to a child's cognitive abilities. The most recent information is even more disturbing. Blood levels as low as 2 mg/dl have been linked to higher rates of Attention Deficit Hyperactivity Disorder in U.S. Children (Braun et al 2006). There really is no safe threshold for lead. Any amount in the bloodstream is a potential hazard, particularly to a developing child (Brody, 2006). Exposure to lead has more recently been linked to antisocial behaviors as well as lowered IQ scores. Needleman et al (2002) note that adjudicated delinquents were four times more likely to have bone lead concentrations >25 ppm than controls. Nevin (2000) found that, in the United States, "Long-term trends in paint and gasoline lead exposure are also strongly associated with subsequent trends in murder rates going back to 1900."

Lead in the Environment

What happens to lead shot or fishing tackle that is deposited into the environment? Lead can infiltrate the soil and water, and eventually be taken up by aquatic invertebrates and plants.

Much of the work on lead shot deposits has been done on firing ranges. Ma et al (2000) looked at lead concentrations in the soil of six different shooting ranges in Florida. They found total lead concentrations from a few hundred to tens of thousands ppm for both rifle/pistol ranges and shotgun shooting ranges. Chen and Daroub (2002) studied a firing range in central Florida and found that the high accumulation of lead at the site would easily qualify it as a hazardous waste disposal site. Even after removing the lead bullets by sieving, the soil that remained was highly contaminated with lead. The lead concentration was highest in the first 10 cm of soil, but a

relatively high concentration was also found in the leached horizon (11-30 cm). A strong correlation was reported between the soil pH and the concentration of lead. This was also true in a 1999 study at a shooting range in Denmark. Lead pellets deposited onto soils are not chemically or environmentally inert, although tens or hundreds of years may be required for total breakdown and dissolution of the pellets. Close proximity of these contaminated sites to groundwater sources increases the chances of lead mobility and transport from the sites. Cao et al (2003) sampled soil and water at several shooting ranges in Florida. They found that the rate of oxidation of lead bullets was variable at the different sites. Some anion ligands, especially phosphate, carbonate, and sulfide seemed to be effective in controlling lead solubility because they formed less soluble compounds, resulting in low lead concentrations in water. They also noted that iron and aluminum oxides, clay and organic matter do not form chemical compounds with lead, but do decrease its mobility.

DiFrancisco et al (2003) state that about 2 billion lead pellets are deposited into the environment worldwide each year (hunting and recreational shooting combined). They note that this metal will take between 100 and 300 years to degrade and disappear, depending on soil conditions and the climate. Lead particles become more rapidly degraded when the soil or water is acidic or has a high concentration of dissolved oxygen.

Jacks et al (2001) reported on lead emissions from large fishing sinkers lost in a Swedish river. Sinkers placed in rapidly flowing water and recovered later showed substantial weight loss. Sinkers exposed at the mouth of a river where brackish water sometimes entered showed extensive corrosion. Although there was no evident effect to the stream water of lead emission from the dissolution of the sinkers, the dissolved lead probably ended up in marine or brackish water sediments in the sea. Because of the large amount of lead deposited yearly in the rivers tested, the authors urged the use of alternatives to lead sinkers in the river fisheries.

In general, under neutral or basic pH in streams or lakes, lead oxidation products are mostly insoluble. However, the presence of sand in the stream sediment can erode the crust of the pellet (or sinker) and release particles of lead compounds into the water. The more acidic the pH of the water, the more likely the dissolution and mobility of these compounds. In Washington, high lakes and streams on the west side of the state usually have a pH of less than 7 (acidic), meaning that solid lead and other metals are more easily mobilized. Minimum pH tends to occur during snow melt runoff (Michael D. Swain, personal communication).

Plants grown in soils with high lead concentration can pick up lead from the soil. Most of the lead is concentrated in the roots, but some is transported to the above ground biomass. This has important implications if grasses around high concentration areas such as shooting ranges are mowed, then recycled. Lead released from this plant biomass may be more easily available to

other plants. The above ground vegetation may also be eaten by animals, potentially exposing them to lead (Cao et al 2003).

Why are Lead Shot and Lead Fishing Tackle a Problem?

A large amount of lead shot and lead fishing tackle is deposited into the environment every year through three main pathways: firing ranges, hunting, and lost or discarded fishing tackle.

As mentioned above, a huge amount of lead is deposited into the soil at military, commercial, and private firing ranges. Acidic soil, wetlands, and "acid rain" can dissolve the lead shot, releasing it into the sediment where it can be taken into plants, or enter groundwater and surface water.

Hunters, especially waterfowl hunters (before various laws were enacted requiring the use of non-lead shot), have deposited a large amount of lead into the environment each year. In their Occasional Paper #88, "A Review of the Environmental Impacts of Lead Shotshell Ammunition and Lead Fishing Weights in Canada" (Scheuhammer and Norris 1995), the Canadian Wildlife Service estimates that between 1988 and 1993 the average annual discharge of lead shot in Canada by hunters of waterfowl, upland birds and small game was about 2000 metric tons per year. This does not include target shooting. In a 1988 report "Lead Hazards to Fish, Wildlife, and Invertebrates, a Synoptic Review" put out by the USFWS (Eisler,1988), it was estimated that U.S. hunters deposited some 6000 metric tons of lead shot annually into lakes, ponds, and estuaries.

In Canada, it is estimated that some 500 tons of lost or discarded fishing weights and jigs are deposited into the environment each year. This represents up to 14% of all non-recoverable lead releases in Canada (Scheuhammer, et al 2003).

What Kinds of Wildlife do Lead Shot and Fishing Tackle Affect?

In the past, lead poisoning in wildlife, especially birds, has been associated with the ingestion of spent lead shot from hunting. More recently, lead poisoning, especially in birds such as the common loon, has been associated with lost or discarded lead fishing sinkers or lead jigs.

In birds, lead tackle or shot can become lodged in the gizzard, where the grinding action and the presence of digestive acids release ionic lead into the upper digestive tract, and from there into the bloodstream and throughout the body. There are two types of lead poisoning in birds, acute

and chronic. Acute toxicity can kill a bird within a few days. The chronic form can take weeks. Within a few days after ingesting lead, birds show behavioral changes, such as accidents when trying to land. They may hold their head and neck in an unnatural position. Other symptoms include listlessness, vomiting, and greenish staining at the vent from diarrhea, as the digestive system shuts down. Often, birds cannot fly (and later cannot walk) due to progressive paralysis of wings and legs, making them easy prey (Sanderson and Bellrose, 1986). As birds become emaciated, they become light in weight and develop a "hatchet breast" appearance where the breastbone becomes very prominent as the fat disappears from the undersurface of their skin. Many have impactions of the digestive system and a prominent gall bladder (Friend and Franson 1999). Sensitivity varies between bird species, and is somewhat dependant on diet, but in most instances one or two lead pellets or a single fishing weight can kill a bird (Eisler, 1988; Nordic Council of Ministers, 2003; and Sanderson and Bellrose, 1986). A definitive diagnosis of lead poisoning as a cause of death should be based on pathological and toxicological findings as well as clinical signs and field observations. This usually includes high lead values in kidney or liver samples or elevated levels of certain blood enzymes and presence of lead in the digestive tract, in addition to some of the field and clinical observations mentioned above (Friend and Franson 1999).

Lead shot and lead fishing tackle are more likely to have deleterious effects on birds, particularly ducks, swans and loons, than on other wildlife because of their feeding habits. Species like the mallard and pintail that mostly feed in shallow water and sift through bottom sediments to find food are especially vulnerable (Eisler,1988). Kraege, 2001 notes that the bills of waterfowl are morphologically adapted to feed in wetland bottoms and strain the sediments for seeds or invertebrates. They may even deliberately select small lead shot as grit, used in their gizzards to aid in grinding their food. Twiss and Thomas (1998) report the deaths of at least 6 species of waterbirds in Canada after ingesting one or more lead fishing-weights, with the common loon being the species most often affected. Scheuhammer et al (2003) state that "Virtually all species of piscivorous birds, as well as species that feed in nearshore soils and sediments, are at risk of lead poisoning from inadvertent consumption of lost or discarded lead sinkers."

Although loons are the animals most often affected by ingesting lead tackle, lead poisoning from ingested fishing gear has been documented in many other species, including the laughing gull, herring gull, whistling swan, mute swan, trumpeter swan, American black ducks, wood ducks, redheads, scaups, scoters, Canada Geese great blue heron, snowy egret, white ibis, common merganser, red-breasted merganser, double-crested cormorant, green heron, white and brown pelicans, painted turtle, and snapping turtle (Scheuhammer et al 2003).

Meharg et al (2002) report that a population of white storks that fed in an area contaminated by spillage of metal sludge containing high levels of lead and other toxicants and a low pH had an

elevated level of genetic damage to their offspring even though blood levels of lead taken 16 days after the accident did not show elevated metal levels. Isotopic analysis of lead in the stork chick's blood shows that it came from the spill. There has been an elevated incidence of leg and bill deformities in these birds, according to unpublished data.

Lead poisoning has also been noted in small mammals (raccoons) and in raptors, probably from ingesting lead while devouring their prey. Acute lead poisoning has been documented in golden and bald eagles, peregrine falcons, osprey, coopers hawks, sharp-shinned hawks, and northern goshawks. Fisher et al (2006) list 59 terrestrial bird species that have been documented to have ingested lead or suffered from lead poisoning including nine species listed as "Globally Threatened" or "Near Threatened" by Birdlife International.

In "Lead: a health hazard for eagles and other wildlife," the Raptor Center at the University of Minnesota reported lead poisoning in 138 of 650 eagles treated by the center between 1980 and 1996. Since 1996, an average of 25% of the bald eagles admitted each year had toxic levels of lead in their blood. Because lead shot for waterfowl was banned in 1991, and because the majority of the lead-poisoned eagles are admitted during big game hunting seasons, they theorized that the source of ongoing lead poisoning in eagles is lead shot from big game and lead jigs and sinkers used in fishing.

In the mid-1980s, shrapnel from rifle and shotgun slugs in the flesh of deer and elk was found to be a source or mortality to California condors. Today, lead poisoning continues to be one of the most challenging problems to the reintroduction of free-flying condors. In "Condors and Lead" Arizona Fish and Game lists lead poisoning as the leading cause of death in condors in their reintroduction program, with 8 confirmed and 2 suspected deaths, the most recent in March of 2006, despite trapping and testing the birds twice a year to test their blood for lead. The June 19 and 30, 2006 news releases from Pinnacles National Monument note that 10 of 11 condors that fed on the carcasses of squirrels shot outside the Monument with lead ammunition were captured and tested for lead. Four juveniles showed elevated blood levels of lead more than a week after the incident was reported. The birds were not captured soon enough after the ingestion for veterinarians to surgically remove the lead fragments. Daily shots of calcium EDTA can be administered to "collect" the lead in the blood and help the birds excrete it from their systems but, at last report, blood levels were not high enough to merit this emergency measure.

Loons and Lead Fishing Tackle

Common loons are the bird most often mentioned when people express concerns over the use of lead fishing tackle.

Loons probably ingest lead sinkers in several ways. Sinkers found in dead loons are sometimes associated with hooks and lines. In such cases, loons may have keyed in on live fish used for bait and ingested the fishing gear directly from anglers. Loons are primarily piscivorous, and can ingest fish or baitfish that have broken free from anglers, but still contain fishing tackle. Loons also may simply pick up lead sinkers or jigs when they are sifting through the sediment looking for invertebrates or gathering "pebbles" from the sediment to use in their crop to grind their food (Pokras and Chafel 1992). Sidor et al (2003) state that most of the loons found dead in New England from 1987-2000 had relatively high body weights compared to other causes of mortality, indicating a quick death from acute toxicosis. Other studies (Daoust et al 1998) have shown a more chronic form of lead poisoning with the victims found in generally poor body condition. Birds in this study were collected along the shores of freshwater lakes, the Atlantic Ocean or the Gulf of St. Lawrence. It is theorized that these chronically lead poisoned birds can't catch and digest prey or preen and waterproof their plumage, and often beach themselves when they are too weak to swim.

Loons are relatively long lived (one wild bird returned to breeding grounds for 9 years – some sources estimate a lifespan of up to 30 years) and slow to mature, not breeding until they at least 4 years old. Females lay only one clutch a year of 1-3 (usually 2) eggs (Kirschbaum, K. and R. Rodriguez, 2002, McIntyre, J.W. and J.F. Barr 1997). Both parents incubate the eggs, feed the young, and protect them from predators for the first 3-4 months of life, so the loss of a breeding adult is likely to cause the loss of the young of the year as well.

The study most often cited to justify regulations against the use of lead fishing tackle is "Mortality of Common Loons in New England 1987-2000" (Sidor, et al. 2003). This study of 522 loons found dead in New England between 1987 and 2000 showed that in breeding adult loons, confirmed and suspected lead toxicosis from ingested fishing weights accounted for almost half of all adult mortality. A diagnosis of lead toxicosis was made when the concentration of lead in the liver was over 6 ppm by weight along with either a lead object found in the digestive tract, or clinical, gross, or histologic signs of lead toxicosis. Scheuhammer and Norris (1995) state: "In North American freshwater environments where sport angling activity and loon populations co-occur, lead poisoning from ingestion of small (<50 g) lead sinkers or jigs can account for 10-50% of recorded adult loon mortality, depending on the location studied."

Stone and Okoniewski (2001) examined 105 common loons found dead in New York over a 17-year period. The two top causes of death were Aspergillosis, an infection caused by a fungus (23%), and the ingestion of lead fishing weights or jigs (21%). Most of the 21 birds with lead tackle in their digestive tract had one lure, except for one loon with 3 sinkers. The heaviest sinker was 9.5 g (.33 oz) and measured 16.7 mm (.66 in) in length. The largest jig weighed 4.5 g (.16 oz). Many were accompanied by related tackle, such as swivels, hooks, and line.

Franson et al (2003) examined over 2000 waterbirds between 1995 and 1999 from 25 states (although almost half were from Florida and California). Bird carcasses for necropsies were collected from the field during disease mortality events, from those that died at rehabilitation centers, and sandhill cranes and tundra swans shot by hunters. Live birds were also radiographed and blood and liver samples collected to test for lead. Brown pelicans and common loons were the species where the most lead tackle occurred. Of 311 loons collected, 11 (3.5%) were found with ingested lead fishing gear. Of 365 brown pelicans, 10 (2.7%) were found with lead fishing gear. A black-crowned night heron and a double-crested cormorant were also found with ingested lead tackle. Types of lead fishing tackle found included split shot, jigs, and several different shapes of sinkers. The size of tackle found ranged from split shot 7mm (.28 in) in the longest dimension to pyramid and bell-shaped sinkers 39 mm (1.5 in) long. The weight of lead fishing gear retrieved ranged from 0.6 g to 78.2 g (02 oz to 2.76 oz).

In another study Franson et al (2001) sieved the stomach contents of common loons recovered in New York to examine the dimensions of stones used for grit. The greatest percentage of retrieved stones were retained in sieves with mesh sizes between 4.75 and 8.0 mm (.19 and .31 in). They also found that the median longest dimension of stones recovered measured 12.5 mm (.49 in) in loons from New England, compared to only 10.7 mm (.42 in) for those from the southeast, and the northern loons also had a greater mass of stones than their southern counterparts.

Scheuhammer and Norris (1995) state that “We judge that banning the sale and use of lead sinkers and jigs under 2 cm in all directions and under 50 g in mass would virtually eliminate the risk of lead poisoning in Common Loons and other fish-eating birds.” “There is no effective treatment for acute or chronic lead poisoning in loons, and a single lead sinker or jig can kill a loon.” (Sidor et al 2003). “Its black and white. One hundred percent of the animals that ingest lead fishing gear die of lead poisoning, while those lucky enough to avoid this stuff do not” says Dr Mark Pokras, Wildlife Clinic Director at Tufts University School of Veterinary Medicine (Nadis 2001).

Figure 3. Lead fishing gear taken from the stomachs of dead loons. New York State Department of Environmental Conservation website http://www.dec.state.ny.us/website/dfwmr/habitat/loons.html.

Laws Concerning Lead Shot

In the U.S. a ban on the use of lead shot for hunting waterfowl was phased in starting with the 1987-88 hunting season. The ban became nationwide in 1991. Nontoxic shot regulations apply only to waterfowl, defined as the family Anatidae (ducks, geese, [including brandt], and swans) and coots. Nontoxic shot is defined as any shot type that does not cause sickness and death when ingested by migratory birds. Many U.S. Fish and Wildlife refuges require the use of nontoxic shot for all bird hunting.

Several states (Washington among them) have adopted additional rules about the use of lead shot. In Washington it is unlawful to possess shot other than nontoxic shot for any purpose in several wildlife areas, when hunting for game birds or game animals in several pheasant release sites and the Dungeness Recreation Area. These regulations were put into effect after soil sampling showed high densities of lead pellets in the top levels of the soil at several sites (Kraege 2001).

In Canada, hunters may not use lead shot for hunting waterfowl and most other migratory game birds within 200 meters of a watercourse or water body. England, Wales, Scotland, and Ireland are among other countries that have adopted similar regulations. However, monitoring in England by their Department for Environment, Food, and Rural Affairs showed that in 2002, 2/3 of the ducks sampled at game dealers had been shot with lead. A major review of regulations and increased monitoring of the current rules is expected in 2006 (British Association for Shooting and Conservation 2005).

Laws Concerning Lead Fishing Tackle

International

Great Britain

After experimenting with a voluntary effort to reduce the use of leaded fishing tackle, Great Britain implemented a ban on the use of lead fishing weights weighing from .06 g to 28.35 g (1 ounce) in 1987 because of widespread mortality in mute swans. The number of cases of lead poisoning in swans in the Thames Valley fell by 70% in the two years following the ban (Friend and Franson 1999). Although the precipitous decline of mute swans was reversed, Kelly and Kelly (2004) report that many birds still show elevated blood lead levels and many swans are still dying from injuries caused by lost or discarded fishing tackle (mostly hooks and pieces of fishing line).

Denmark

In 2001, Denmark banned the importation of many commodities containing lead. Since December 2002, it has not been legal to use lead in fishing tackle in Denmark.

Canada

Canada prohibited the use of lead sinkers and jigs weighing less than 50 g (1.76 oz) or 2 cm (.79 in) on their longest axis in all of its National Parks and Wildlife Areas in 1997.

A ban in other areas was proposed by an Environment Minister in January 2005, and a discussion paper was circulated that included a proposed ban on the import, manufacture and sale of lead sinkers less than 50 g and 2 cm in length (Fishing Lead Free: A Regulatory Proposal). This proposal was met with a huge amount of opposition from tackle manufacturers and sportfishing groups. Their main criticism was lack of consultation with the industry and that the proposal was based on misinterpreted statistics and "junk science." In their response to the proposal, the Canadian Sport Fishing Industry Association asserts there is insufficient data to warrant a widespread ban on lead fishing tackle. On a population level, they assert, lead fishing tackle is not limiting loon populations in Canada. (Response to "Fishing Lead Free: A Regulatory Proposal").

A new Canadian Environmental Minister is now in place and is directing a more cautious approach to the problem. As a first step, he directed the agency to address the "junk science" claim by holding a science symposium. The symposium was held in October 2005, and was successful in the sense that a working relationship was developed with the Sportfishing Industry Association. Other key opponents, most notably the Ontario Federation of Anglers and Hunters, refused to work with the rest of the group and are opposed to any sort of partnership with the government (Garry Donaldson, personal communication).

United States (Federal)

The USFWS has banned the use of lead sinkers in 13 wildlife refuges containing habitat used by loons, and in Yellowstone National Park.

In their 1994 response to a citizen's proposal to require labels or warnings on lead fishing sinkers stating that the products are toxic to wildlife, the Environmental Protection Agency (EPA) proposed a ban on the manufacture, processing, and distribution of lead and zinc sinkers for use in the U.S. The EPA estimated that the proposed rule would prevent an estimated 450 million lead and zinc-containing sinkers from being produced each year, and from potentially entering the environment. The economic impact (purchase price of sinkers) was estimated to be less than $4.00 for the average angler per year. They estimated that approximately 4.7 million birds could be potentially saved by the proposed regulation. A bill was introduced into the 1994 Legislature containing these restrictions, but was not passed into law.

United States (Individual State Actions)

New Hampshire

On January 1, 2000, New Hampshire became the first state to ban the use of lead sinkers of one ounce (28.35 g) or less and lead jigs less than one inch (2.54 cm) long on freshwater lakes and ponds. Violators are subject to a maximum fine of $250. A later law, which became effective January 1, 2005, extended the ban to rivers and streams (effectively all waters of the state), and on January 1, 2006 it became illegal to sell these lead sinkers or jigs statewide.

According to New Hampshire Fish and Game personnel (Stephen G. Perry, personal communication), Fish and Game wardens have been performing random checks on anglers. Unless the disregard of the rule is blatant, anglers are educated on the rule and the reasons behind it, rather than fined. Most anglers, even bass anglers who commonly use lead-headed jigs, have made the switch to other materials. Although the bans for use and sale of lead tackle in New Hampshire and other states are opposed by the American Sportfishing Association, most local sportfishing groups, who were not involved in the legislative process, have not shown much strong opposition.

Some of the smaller retail outlets for fishing gear were unhappy with the rule banning the sale of small lead tackle. Larger chain stores were not affected as much because they could transfer stock to stores in other states where it was still legal. Some questions about the sale of this gear remain to be answered, though, and have been referred to the NH Attorney General's office. Among these is the legality of mail order or internet sales – can a company based in New

Hampshire sell small lead weights or lead jigs to an angler with an address outside the state (Stephen G. Perry, personal communication)?

Maine

In September 1997, the state of Maine passed a law allowing the commissioner of Inland Fisheries and Wildlife to accept money, goods, or services donated to the department for the purpose of educating the public on ways to minimize the threat to loons and other bird species from discarded or lost lead sinkers and lures. In 1999, a new law banned the sale of small lead sinkers (weighing .5 oz (14.17 g) or less), beginning January 1, 2002. A sinker was defined as "a device that is designed to be attached to a fishing line and intended to sink the line. It does not include artificial lures, weighted line, weighted flies or jig heads".

During the legislative process, testimony against the bills was mostly from members of the Bass Anglers Sportsmens' Society (BASS) and people associated with youth fishing programs. They had raised money and given out thousands of dollars of fishing gear to kids over the last few years and were concerned that some of this gear would become illegal if the bill passed.

Minnesota

The state of Minnesota has not adopted rules restricting the use of lead fishing tackle, but has taken an educational approach to the problem. The information shown below in Figure 4 is printed in the 2006 Minnesota Fishing Regulations, published by the Department of Natural Resources.

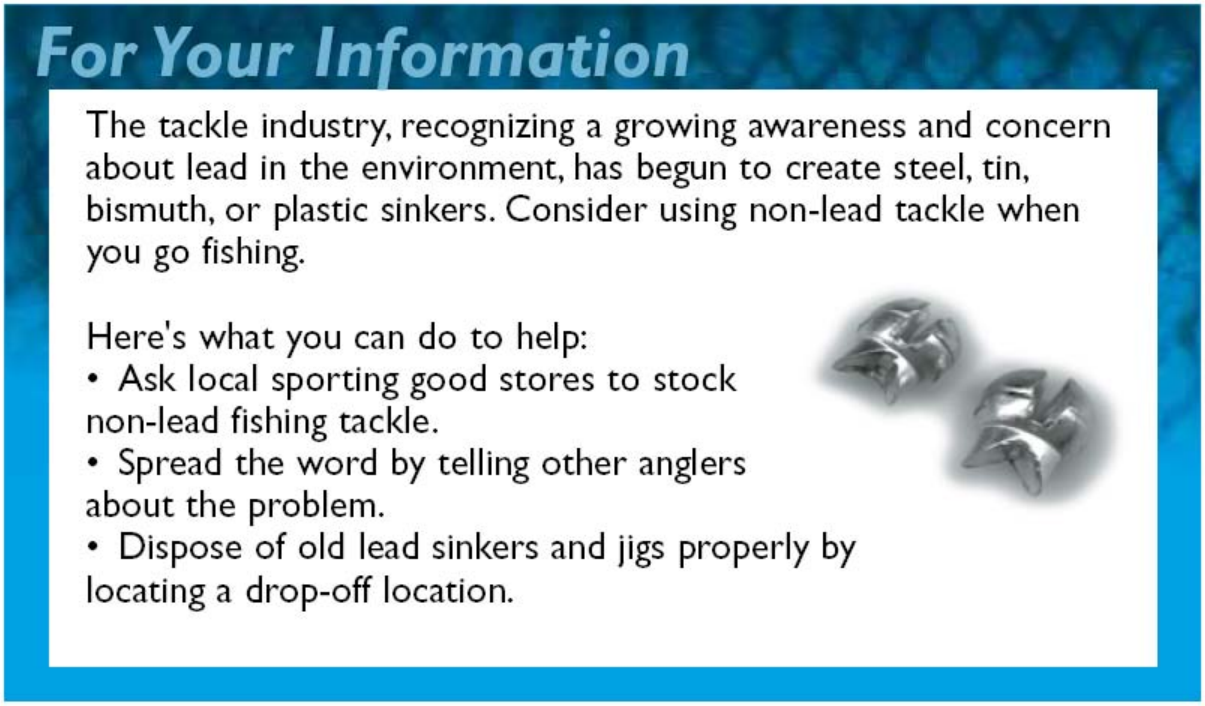
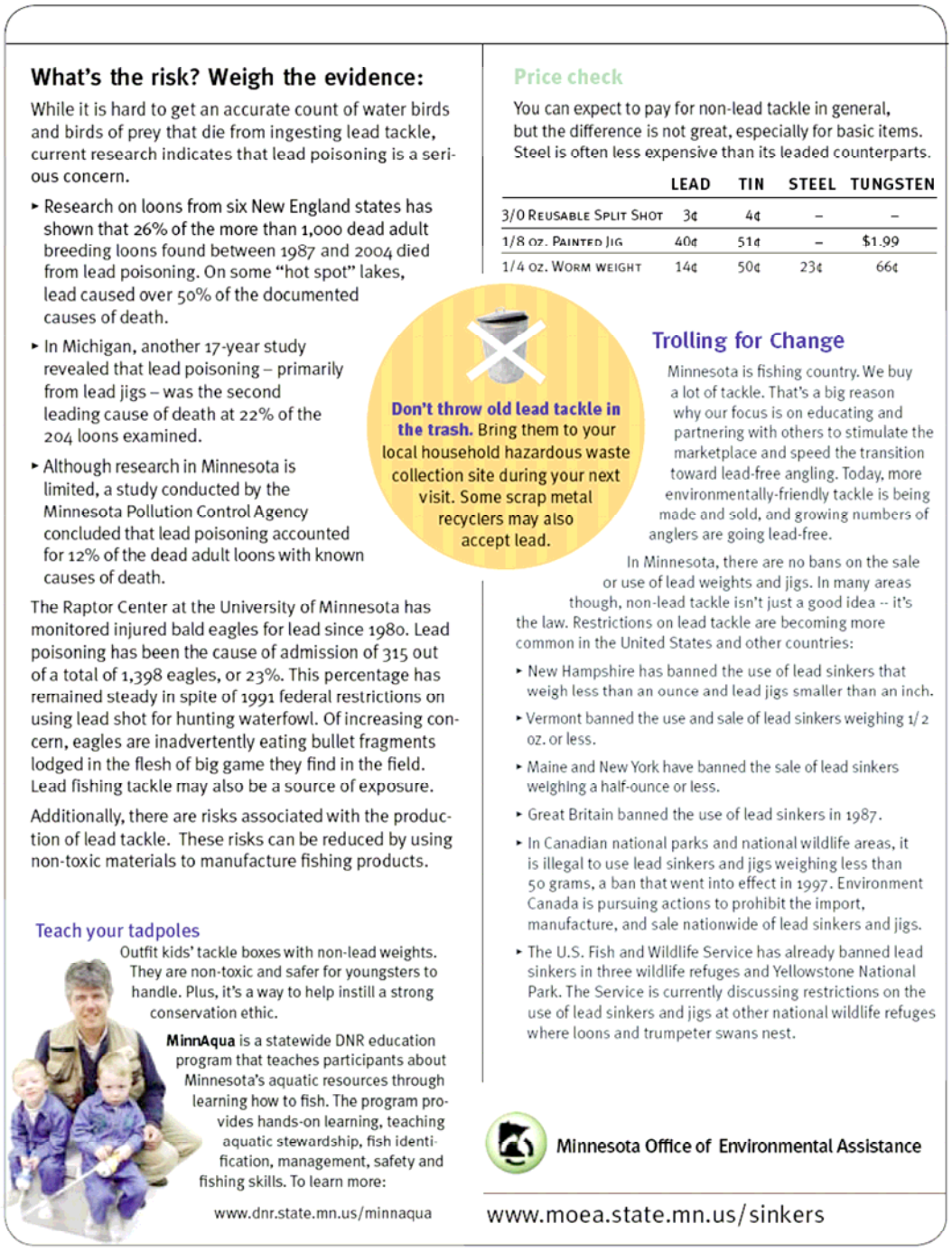


Figure 4. Information in Minnesota Fishing Regulations.

The flyer reproduced below (Figure 5) is an example of the educational information distributed by the Minnesota Office of Environmental Assistance.

Figure 5. Educational brochure from Minnesota Dept of Environmental Assistance.



What's the risk? Weigh the evidence:

While it is hard to get an accurate count of water birds and birds of prey that die from ingesting lead tackle, current research indicates that lead poisoning is a serious concern.

- Research on loons from six New England states has shown that 26% of the more than 1,000 dead adult breeding loons found between 1987 and 2004 died from lead poisoning. On some "hot spot" lakes, lead caused over 50% of the documented causes of death.
- In Michigan, another 17-year study revealed that lead poisoning – primarily from lead jigs – was the second leading cause of death at 22% of the 204 loons examined.
- Although research in Minnesota is limited, a study conducted by the Minnesota Pollution Control Agency concluded that lead poisoning accounted for 12% of the dead adult loons with known causes of death.

The Raptor Center at the University of Minnesota has monitored injured bald eagles for lead since 1980. Lead poisoning has been the cause of admission of 315 out of a total of 1,398 eagles, or 23%. This percentage has remained steady in spite of 1991 federal restrictions on using lead shot for hunting waterfowl. Of increasing concern, eagles are inadvertently eating bullet fragments lodged in the flesh of big game they find in the field. Lead fishing tackle may also be a source of exposure.

Additionally, there are risks associated with the production of lead tackle. These risks can be reduced by using non-toxic materials to manufacture fishing products.

Teach your tadpoles

Outfit kids' tackle boxes with non-lead weights. They are non-toxic and safer for youngsters to handle. Plus, it's a way to help instill a strong conservation ethic.

MinnAqua is a statewide DNR education program that teaches participants about Minnesota's aquatic resources through learning how to fish. The program provides hands-on learning, teaching aquatic stewardship, fish identification, management, safety and fishing skills. To learn more:

www.dnr.state.mn.us/minnaqua

Price check

You can expect to pay for non-lead tackle in general, but the difference is not great, especially for basic items. Steel is often less expensive than its leaded counterparts.

	LEAD	TIN	STEEL	TUNGSTEN
3/0 Reusable Split Shot	3¢	4¢	–	–
1/8 oz. Painted Jig	40¢	51¢	–	$1.99
1/4 oz. Worm weight	14¢	50¢	23¢	66¢

Don't throw old lead tackle in the trash. Bring them to your local household hazardous waste collection site during your next visit. Some scrap metal recyclers may also accept lead.

Trolling for Change

Minnesota is fishing country. We buy a lot of tackle. That's a big reason why our focus is on educating and partnering with others to stimulate the marketplace and speed the transition toward lead-free angling. Today, more environmentally-friendly tackle is being made and sold, and growing numbers of anglers are going lead-free.

In Minnesota, there are no bans on the sale or use of lead weights and jigs. In many areas though, non-lead tackle isn't just a good idea -- it's the law. Restrictions on lead tackle are becoming more common in the United States and other countries:

- New Hampshire has banned the use of lead sinkers that weigh less than an ounce and lead jigs smaller than an inch.
- Vermont banned the use and sale of lead sinkers weighing 1/2 oz. or less.
- Maine and New York have banned the sale of lead sinkers weighing a half-ounce or less.
- Great Britain banned the use of lead sinkers in 1987.
- In Canadian national parks and national wildlife areas, it is illegal to use lead sinkers and jigs weighing less than 50 grams, a ban that went into effect in 1997. Environment Canada is pursuing actions to prohibit the import, manufacture, and sale nationwide of lead sinkers and jigs.
- The U.S. Fish and Wildlife Service has already banned lead sinkers in three wildlife refuges and Yellowstone National Park. The Service is currently discussing restrictions on the use of lead sinkers and jigs at other national wildlife refuges where loons and trumpeter swans nest.

Minnesota Office of Environmental Assistance

www.moea.state.mn.us/sinkers

Figure 5. (continued)

Source: http://www.moea.state.mn.us/pulbications/sinkers.pdf

New York

As of May 7, 2004, it is unlawful to sell "at retail" lead fishing sinkers weighing ½ ounce (14.17 g) or less. A sinker is defined as a device designed to be attached to a fishing line and intended to sink the line. It does not include artificial lures, weighted line, weighted flies, or jig heads. "Sell at retail" is defined as the sale to any person in the state for any purpose other than resale. Fish and Wildlife staff from New York report that this regulation was championed by the loon lobby in Adirondack Park, which successfully lobbied the state legislature. The original proposal was more restrictive, but input from marine constituents and the agency reduced the scope of the ban to only sinkers under ½ ounce. The ban on sale, rather than use, allowed anglers to transition from lead sinkers to lead-free alternatives. The challenge was to get the word out to smaller retailers (large chain stores were easy to contact). The primary tool used was press releases, information in the regulations guide, and signs posted at license sales agents. The Adirondack Cooperative Loon Program sponsored a Lead Sinker Exchange Program. Overall, there was little resistance to the regulation, and sporting goods stores are now stocking small non-lead sinkers. Figure 6 (below) is an example of some of the educational materials distributed.

Figure 6. See how difficult it is to distinguish split shot from pebbles.

Can you tell the difference? Search the photo on the left for the eight lead sinkers (split shot). See answers in photo on the right. Images courtesy of Jim Clayton- Photographer at NY Department of Environmental Conservation.

Vermont

Vermont is an example of a state with a very thorough program to address the problem of lead fishing tackle. As directed by their legislature, the Vermont Fish and Wildlife Commission has taken several actions to help educate anglers about lead tackle and its effect on wildlife, as well as working to encourage anglers to be aware of and use lead-free tackle.

In 2004 the Vermont Legislature passed H.516, An Act Relating to a Prohibition Against the Use and Sale of Lead Sinkers. The new legislation, supported by the Vermont Federation of Sportsmen's Clubs and the National Wildlife Federation, contained three sections that took effect on three different dates. Staff of the Vermont Fish and Wildlife Commission report little opposition to the rules from either sportfishers or retailers. The three sections were:

Sec 3. Lead Sinkers; Public Education Program; Appropriation
This section took effect July 1, 2004. It directed the Commissioner of Fish and Wildlife to develop and carry out a public education program designed to alert the public to the threat that lead fishing tackle can pose to wildlife, and also a program to provide Vermont anglers lead-free fishing sinkers in exchange for leaded sinkers. The commissioner was to report back to the legislature on January 15, 2006 on expenditures for the programs. A sum of $25,000 was appropriated from the state's general fund to develop the education program.

Sec 2 10 V.S.A. Section 4614. Lead Sinkers; Sales Prohibited
This section took effect January 1, 2005 and reads:

"*It is unlawful to sell or offer for sale a lead sinker in the state of Vermont. In this section, "sinker" means any device which weighs one-half ounce or less and is attached to a fishing line for the purpose of sinking the line, and does not include other lead fishing-related items such as weighted fly line, lead-core fishing line, downrigger cannon balls, weighted flies, lures, spoons, or jig heads."*

Sec 1 10 V.S.A. Section 4604(g).
This section will take effect January 1, 2007 and reads:

"*A person shall not use a lead sinker for taking of fish in any state waters. In this section, "sinker" means any device which weighs one-half ounce or less and is attached to a fishing line for the purpose of sinking the line, and does not include other lead fishing-related items such as weighted fly line, lead-core fishing line, downrigger cannon balls, weighted flies, lures, spoons, or jig heads."*

To comply with Section 3 (Public Education Program) Vermont Fish and Wildlife Department did several things.

1. A full-page description of the issue, including workings of the new law, was placed in the Vermont Digest of Hunting, Fishing, and Trapping Laws, and in their Angler's Pocket Guide for 2005.
2. An educational poster was developed and placed on the Department's web site. Laminated versions of this poster will be placed at all Vermont public boating access areas and selected State parks before the beginning of the spring fishing season.
3. An enlarged version of the poster was used at the Yankee Classic Outdoor Sportsmen's show, and other similar public events.
4. A hunting/fishing license holder was designed and made available to license agents statewide, and at outdoor and sportsmen's shows. It includes a description of the new law, information about loons, and contact information telling where the public can learn more about the issues.

5. An information packet was mailed to all state game wardens, check-in stations, bait dealers, licensing agents, and selected State Parks (those with fishing opportunities). The packet included an educational poster, a list of manufacturers/suppliers of lead-free fishing tackle, some of the license holders described above, and information on where to properly dispose of lead sinkers.
6. A full-sized page and three smaller inserts were put into the 2006 Vermont Fish and Wildlife calendar describing the hazards of lead fishing tackle and the effects of the new law.
7. Lead-free fishing sample packets with educational tags were handed out at fishing clinics and educational programs, and were available to the public at Fish and Wildlife district offices, federal fish hatcheries, and selected Vermont State Parks.
8. Web pages linked to the Vermont Fish and Wildlife Homepage were developed featuring information on bald eagles, great blue herons, common loons, and Canada geese; 4 species of birds affected by lead sinker use; and detailing the new law designed to protect them. Other items on the web site include the educational poster, a copy of the lead-free tackle manufacturer list, links to other sites providing useful information about lead tackle, loons and lead, wildlife and lead, humans and lead, lead poisoning and disposal, the "Lets Get the Lead Out" brochure, and FAQ's about lead and the new law.
9. Prior to the opening of open water trout and salmon fishing seasons in April 2006 and 2007, paid advertising/Public Service Announcements will be placed on television and radio and in newspapers and magazines concerning the new laws and health impacts of lead on wildlife.

Mark Scott (2006) personal communication.

Figure 7. Lead Tackle Exchange Poster. Source: Tufts University Lead Sinker Program.

Massachusetts

On June 21, 2000, the Fisheries & Wildlife Board prohibited the use of all lead sinkers* for the taking of fish in Quabbin and Wachusett Reservoirs, the loons' primary habitat in the state. *Note: Lead sinkers do not include lead-fishing related items including, but not limited to, artificial lures, jigs, lead-core line, keel trolling weights, or weighted flies.

California

California requires manufacturers of lures that contain lead to print a warning on the packaging that reads "This product contains lead, a chemical known to the State of California to cause cancer and birth defects and other reproductive harm."

Loons in Washington

The worldwide population of loons is estimated at 500-700,000, with the majority of the population in Canada. In the U.S., the largest numbers are found in Minnesota and Alaska (McIntyre and Barr 1997). Breeding loons were found historically in small discontinuous groups, across the northwestern part of the U.S. A few records of nests exist from Oregon and California, but these populations have probably been extirpated for several decades. Idaho's small breeding population disappeared in the mid-1990s. Also in the 1990s, population trends were steady in Wyoming, but were unstable in Montana and Washington (Evers 2004). Figures 8 and 9 show more current distributions of breeding loons (Figure 8) and wintering loons (Figure 9).

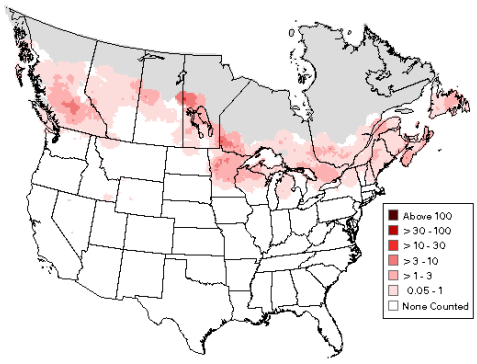


Figure 8. Common Loon Breeding Bird Survey
Map Source: Sauer, et al 2005.

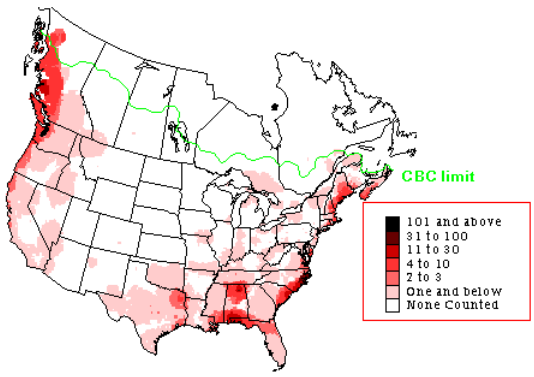


Figure 9. Common Loon Christmas Bird Count
Map Source: Sauer, et al 1996.

The loon is currently a rare breeder and a common migrant and wintering species in Washington. In the February 2000 WDFW status report for the common loon (Richardson et al 2000), it is noted that historic and current population levels are not well known, and most of the information available is from the past 15 years. What little historical information is available suggests that common loons were once a fairly common breeding species both east and west of the Cascades, but declined from 1890 to 1925 in most parts of Washington (and across most of the U.S.), probably as the result of shooting. Common loons are listed as a sensitive species in Washington. They have nested recently on lakes and reservoirs in Ferry, Okanogan, Douglas, Chelan, Whatcom, and King counties, with unconfirmed nesting reports from several other counties. Non-breeding loons are found on both salt- and freshwater during the summer, and in the winter primarily on coastal and inland marine waters, although a few winter on unfrozen lakes, rivers and reservoirs. Poleschook and Gumm (2006) note that there are currently about 12 territorial pairs of loons remaining in Washington. They breed in widely separated locations. Of the 31 historical breeding lakes in Washington, only 8 were used in 2005.

Washington's common loons primarily feed on fish, but crustaceans are an important part of their diet when fish are not plentiful or during murky water conditions when fish are hard to find. Loons sift through bottom sediments in search of these and swallow most of their prey underwater. Loons are highly territorial, especially when nesting.

Principal threats to loons include habitat loss and degradation from development or human disturbance, fluctuations in lake water levels, entanglement in fishing line, and mortality from ingesting fishing tackle. Loons are protected under both federal and state law from malicious harm, but neither law protects nesting habitat. In the past, the use of rotenone to eradicate non-desirable fish species was a threat to loons. Although fish (usually trout) are usually immediately re-planted in lakes following treatment, it can take years for the invertebrate population to rebound, or for smaller fish to reappear (Richardson et al 2000). WDFW's current program for rehabilitating lakes includes a screening for sensitive species (including loons) at the time a water is proposed for treatment with rotenone.

Lead-Free Alternatives Available Now

With the advent of new laws in several northeastern states that require anglers to use lead-free tackle, manufacturers have stepped up to the challenge, and retailers have begun to carry many more options for weights and jigs. Materials for these lead-free alternatives run the gamut from steel to bismuth, tungsten, and even granite (Duke 2005). Generally, the alternatives are more expensive than their lead counterparts, but not prohibitively so. (Example: in Cabela's on-line cataloge, a box of 24 ¼ ounce ultra steel egg sinkers is $2.99, the same sinkers in lead sell for $3.99 for 50). Several New England states have sponsored tackle exchange programs as a way to encourage anglers to trade their lead sinkers for lead-free gear. See Appendix 1 for a list of manufacturers and retailers of lead-free fishing tackle.

WDFW's Youth Fishing Program has totally switched to the use of lead-free tackle when providing fishing gear for kids at designated events.

Summary

- Lead is a naturally occurring element that can be toxic to most forms of life.
- Lead is not biodegradable and can accumulate in organisms and persist in bones and teeth for decades.
- Lead poisoning occurs in both acute and chronic forms. For humans, even a small exposure, especially for a child, can cause behavorial or cognitive changes.
- In the United States, laws have been adopted limiting lead content of water, paint, and gasoline.
- Ingestion of lead shot and lead fishing gear can cause lead poisoning in many species of wildlife.
- Because of their eating habits, lead poisoning is most common in waterbirds, but has also been reported in many other bird species including raptors, and in painted and snapping turtles and small mammals such as raccoons.
- In birds, lead is ground up in the gizzard, where it is dissolved by digestive acids releasing it into their bloodstream.
- Studies have shown that loons are very susceptible to lead poisoning, and one lead sinker or jig can kill a bird.
- Several countries have enacted laws limiting the use of lead shot, particularly for hunting waterfowl.
- Several countries and several U.S. states have enacted laws limiting the use of lead fishing tackle, mostly based on size.
- There is a growing list of manufacturers and retailers that offer lead-free fishing tackle at a reasonable price.

Appendix 1. Lead Tackle Alternatives

The following list of manufacturers and retailers of lead-free fishing tackle is borrowed from the Minnesota Office of Environmental Assistance web-site.
(**http://www.moea.state.mn.us/reduce/sinkers.cfm**.)

Lead-free Alternatives: Manufacturers and Retailers

Non-lead fishing tackle is not a novelty product. Ask for it at retailers and shops. In addition, you can go straight to these web sites of tackle manufacturers.

Ambush Lures | www.ambushlures.com
"Scented Polymer Matrix" non-toxic weights are made from densified plastic.
Bass Pro Shops | www.basspro-shops.com
Search their web site for "XPS" and "Excalibur" weights (tungsten), "Ultra Steel 2000," and "Sticky Weight" tungsten putty. New for 2004 are the "Lake Fork" tungsten jigs, Gremlin Green "bismuth worm sinkers," and "Safe-Sink" densified plastic worm weights.
Big Ten Tackle | www.bigtentackle.com
An online source for ceramic and steel sinkers.
BossTin | www.bosstin.com
Fishing weights made of tin, including split shot, stylers, swivel sinkers, and a variety of egg and bullet sinkers.
Bullet Weights | www.bulletweights.com
Alternative terminal tackle products including their line of "Ultra Steel" sinkers and interchangeable jigs, and tin split shot.
Cabela's | www.cabelas.com
This retailer carries many brands of "non-toxic fishing weights" in their online catalog.
Dr. Drop tungsten composite sinkers | http://drdropsinkers.com
Tungsten composite sinkers use exclusive "friction grip" allowing for fast attachment and retrieval. New for 2006, a "click and slide" weight, as well as traditional bullet and bell sinkers in several weights.
Envio-Weights | www.envio-weights.com
Nontoxic tackle made from reprocessed landfill steel and resin: Spinnerbaits, buzzbaits, jigs, lures, and weights of all kinds.
Enviroball 2000 | www.enviroball.com
Cast-iron downrigger weights come in extremely large sizes for primarily for saltwater and Great Lakes applications.
Flambeau Outdoors | www.flambeauoutdoors.com/fishing.html
New "Safe-Sink" worm weights and jig heads are made from a proprietary nontoxic plastic material with tungsten that promises the same specific gravity as lead.
GlowOptics | www.glowoptics.com
Luminescent jig heads made from hand-blown glass. Available for purchase through Internet and at stores throughout Minnesota and in other states. Call 763-689-4809 for location nearest you.

Gravity Fishing | www.gravityfishing.com
Heikkila sinker and jigs made from Tundra, a tungsten composite material. Available exclusively at Gander Mountain stores.
Hildebrandt Company | www.hildebrandt.net
Spinnerbaits, lures, and jigs made from pure tin or bismuth.
Islander Lures | www.islanderlures.com
Lead-free ice fishing and crappie jigs made of tin.
Jackfish Lures | www.jackfishlures.com
Jigs and sinkers made of bismuth.
Johns Freshwater Jigs | 412-351-2099
Pittsburg-based manufacturer of premium bismuth/tin jigs. Sold wholesale in large quantities, typically to tackle stores and distributors. To request a catalog, email bobsjigs@yahoo.com or call 412-351-2099.
Kanji International | www.tacklewarehouse.com/descpage-KTDS.html
Tungsten drop shot weights are more dense than lead, up to 50% smaller than their lead cousins of same weight. The smaller weight is marketed as more sensitive for detecting subtle bites in deep dropshot fishing.
Lake Fork Tackle | www.lakeforktackle.com/weights.htm
The "Mega-Weights" line features worm weights and barrel weights made from a tungsten-nickel alloy.
Lead Free Jig Heads | www.leadfreejigheads.com
On-line retailer of tin-bismuth alloy sinkers and jigs in a variety of styles.
Loon Outdoors | www.loonoutdoors.com/sinkets.html
The "Deep Soft Weight" (1 oz.) is made from tungsten.
Lucky Strike Bait Works Ltd. | www.luckystrikebaitworks.com
Jigs, jig heads, sinkers, and split-shot made from non-toxic bismuth and tin.
Northland Fishing Tackle | www.northlandtackle.com
The "Nature Jig" is cast from a nontoxic bismuth/tin alloy.
Outkast Tackle | http://outkasttackle.com
Bass jigs made of bismuth. Sold at several Twin Cities Gander Mountains stores and Pro-Tackle Imports (Burnsville), or purchase online.
PRADCO Outdoor Brands | www.lurenet.com
Excalibur series of tungsten barrel and line weights. Bullet-shaped YUM weights are made of tungsten and plastic and are porous in nature to absorb and hold scents. Find a dealer
Rocky Ledge Bass Tackle | www.rockyledge.com
Spinnerbaits, buzzbaits, and jigs made from pewter.
Tru-Tungsten | www.tru-tungsten.com
Lead-free weights and jigs made of 97% tungsten. Worm weights available a variety of colors, as well as convertible drop weights and jigs, buzzbaits, and spinnerbaits.
Unleaded Fishing Products | www.unleadedtackle.com
Products marketed as environmentally safe using a bismuth-tin alloy.
Water Gremlin | 800-328-1440
Since the early 1990s, this Minnesota tackle manufacturer has been marketing "Gremlin Green" tin split shot. A new line of bismuth tackle is now available in the teardrop-shaped Dipsy Swivel, egg, and bullet-shaped slip sinker styles.

Suppliers to Tackle Manufacturers

Du-Co Ceramics | www.du-co.com or 724-352-1511
Jigs and sinkers made from ceramic. Call Nick Norante for product information or becoming a distributor.
Ecomass | www.ecomass.com
Ecomass is a non-toxic polymer-metal composite with the same density as lead which can be molded into fishing weights and lures.
RTP Company | www.rtpcompany.com
Manufactures lead-free high gravity thermoplastics for terminal tackle and ammunition manufacturers.

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