

Ambio

Electronic Supplementary Material

This supplementary material has not been peer reviewed.

Title: **Lead Poisoning from Ingestion of Fishing Gear: A Review**

Table S1

This review of voluntary and legislative efforts with voluntary and legislative efforts is presented side by side for each jurisdiction to make the comparison of these approaches clearer. Jurisdictions that have tried both voluntary and legislative approaches are presented first and in order of the implementation date of the first action. Jurisdictions that have used only voluntary approaches are summarized in the latter part of the table.

Table S1: Comparison of Voluntary and Legislative Approaches

Jurisdiction & Program	Voluntary / Educational Programs			Legislative Intervention Restricting Import, Sale and/or Use		
	Dates	Features	Program Effectiveness	Date(s)	Features	Program Effectiveness
<p>UK</p> <p>Concern for swan population declines resulting in codes of practice and then a legislative ban.</p>	1982 to 1987	<p>Educational outreach</p> <p>Voluntary codes of practice introduced in the UK in 1982 encouraging the safe use and disposal of lead fishing gear.</p> <p>Non-lead alternatives increasingly marketed 1984-1985</p>	<p>Partially successful</p> <p>Lead ingestion continued to be the biggest single cause of mute swan mortality; 20% to 40% of swan mortality confirmed to be due to lead poisoning prior to full implementation of the ban (Sears and Hunt 1991; Brown et al., 1992). In some areas with high densities of lost weights, mortality due to fishing weight ingestion in 1983-85 accounted for up to 94% of deaths (Sears 1988)</p> <p>Precipitous decline of mute swan populations in areas with heavy angling pressure continued.</p>	1987	<p>Importation and sale ban on lead weights 0.06-28.36 g;</p> <p>Bylaws prohibiting <u>use</u> of lead weights (England and Wales)</p>	<p>Significant progress but not complete</p> <p>Lower lead poisoning rates for swans following implementation of the ban observed particularly in areas with high human activity/angling pressure, e.g., lead poisoning cases fell by 70% in the Thames Valley following the ban (1984 vs 1988) (Sears and Hunt, 1991).</p> <p>Lower lead poisoning rates for swans following the ban confirmed by MacDonald (1990), Kirby et al., (1994), Pennycott (1999), Perrins et al., (2002). However, lead mortality still observed, some of this being due to ingestion of lead gunshot.</p> <p><u>Conclusion:</u> Voluntary code of practice ineffective in achieving goal, legislative approach more effective. Coordinated action on lead ammunition would be required to further reduce wildlife mortality from lead ingestion.</p> <p>NOTE: there continue to be major problems with lead ingestion in swans from ammunition sources</p>
<p>Canada</p> <p>Voluntary Programs and Prohibition on the</p>	1995	Educational outreach and Lead tackle exchange programs	<p>Ineffective</p> <p>No appreciable drop in sales or uses of lead or</p>	1997	Restriction on product use based on	<p>Low effectiveness</p> <p>The market in Canada for fishing sinkers continues to be >99% lead, and jigs >90% lead (ECCC, 2018). The</p>

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use of lead sinkers and jigs in Canadian National Parks and Wildlife Areas (1997)		e.g., sinker exchanges through the Great Lakes 2000 program, the Ontario Ministry of the Environment's Bay of Quinte Remedial Action Plan's "Take a little lead out" program, and exchange programs run by ENGOs. Parks Canada has conducted educational campaigns and lead tackle exchanges in National Parks	reduced mortality due to lead ingestion resulted (ECCC, 2018) Lead poisoning from ingestion of lead sinkers or jigs accounts for 10–50% of recorded adult loon mortality, depending on the locations studied (Scheuhammer and Norris, 1995; Scheuhammer et al., 2003; Scheuhammer, 2009).		limited size range: < 50 g (1.76 oz) and limited geographical scope: National Parks and Wildlife Areas only ^{1,2}	total quantity of lead used for this purpose has remained unchanged over the last 20+ years at ~400-550 tonnes per year (Scheuhammer and Norris 1995; ECCC, 2018). The current restriction covers <1% of recreational anglers and <3% of Canada's land mass. <u>Conclusion:</u> Voluntary programs ineffective in achieving goal. Legislative approach ineffective if highly limited in geographical scope. Canadian Environmental Protection Act (CEPA) provides Environment and Climate Change Canada (ECCC) with the authority to restrict the manufacturing, import, sale and use of lead fishing tackle.
Denmark	Prior to 2001	Educational outreach	Ineffective Lead fishing tackle continued to dominate the market in Denmark prior to 2001. The total quantity of lead used for angling in Denmark in 2000 was estimated at 97-170 tonnes per year (Lassen et al., 2003), corresponding to 18-32 g/capita/year (European Commission, 2004).	2001-2002	Importation of many lead commodities banned in 2001 Ban on <u>sale</u> of all sizes of lead fishing tackle containing >100 ppm lead in 2002. Limited ban as does not cover possession or use. ³	Positive trend but not complete Overall the ban has reduced sales of lead fishing gear, but the ban has not been completely respected. Enforcement checks in 2012 found 40% of sampled fishing gear being sold in stores was in violation of the regulation and store owners were fined. Subsequent checks in 2013 found 25% of sampled fishing gear being sold in stores was in violation of the regulation. ⁴ Use and possession not covered under the regulation and older lead gear (prior to 2002), and gear sold more recently in violation of the ban, can continue to be used. <u>Conclusion:</u> Enforcement of regulatory restrictions essential to ensure effectiveness. Regulations that

1. National Parks of Canada Fishing Regulations: http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._1120/

2. Wildlife Area Regulations: http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.,_c._1609/

3. Danish lead fishing gear regulation: <https://www.retsinformation.dk/Forms/R0710.aspx?id=126138>

4. Report on lead fishing gear sales in Denmark: <https://mst.dk/service/nyheder/nyhedsarkiv/2014/maj/miljoestyrelsen-paa-jagt-efter-bly-i-fiskegrej/>

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						cover importation, sale, possession and use (rather than sale only) would be expected to be more effective and allow enforcement activities throughout the supply chain.
US	1989 -	Educational Outreach, exchange programs by US states. No federal program.	Ineffective Assessment of educational outreach and voluntary programs in various US states indicate that these voluntary approaches alone are inadequate.	1995	US Fish and Wildlife Service bans lead sinker use in 12 National Wildlife Refuges with habitat used by loons. US National Park Service (NPS) bans most lead fishing gear in Yellowstone & Glacier National Parks	Low The limited geographical scope of the restriction limits the effectiveness of the instrument at the national level. The majority of sinkers and jigs sold in the US continue to be made of lead. Attempts to extend the ban on lead sinkers and jigs beyond this limited scope in 1994, 2010, 2012 (under TSCA (1976) and 2017 (by Executive Order) failed or were revoked. NPS has expressed intent to prohibit all uses of lead in US national parks under its authority, see National Park Service Organic Act (16 U.S.C. 1 2 3, and 4 -- Aug 25, 1916 -- and subsequent amendments).
New Hampshire (US) Loon Preservation Committee (LPC) public education programs and ‘Get the lead out’ campaign by New Hampshire Fish and Game and US Fish and Wildlife Service (US)	1989-2018	Educational outreach (including brochures, posters, presentations, innumerable contacts with anglers) Exchange programs: > 40,000 lead sinkers were collected from anglers in state parks and fishing stores in 1 year in New Hampshire and Vermont (1999-2000)	Ineffective During the period 1989-2012 nearly half (48.6%; 123 of 253) of collected adult Common Loon mortalities resulted from lead toxicosis from ingested lead fishing tackle (Grade et al., 2018) The timing of lead tackle mortalities which	2000 2005	Restriction on use of lead sinkers weighing ≤1oz and jigs <1in in length on lakes and ponds in 2000 Restriction extended to uses on rivers and streams, all freshwater	Some initial progress but remains TBD overall LPC analysis comparing pre- and post-restriction periods (1989-1999 vs. 2000-2011) found that the rate of lead fishing tackle mortalities in New Hampshire loons fell subsequent to these restrictions; however, this reduction was not large enough to protect the loon population, and from 2006-2011 rates of lead tackle mortalities began to rise again. Between 2000 and 2011, legal-sized jigs (longer than 1 inch) comprised 52% of the tackle found inside New Hampshire loons that died from lead tackle ingestion; ⁵ hence, legislation was passed in 2013 to include the sale and use of all lead jigs weighing 1oz or less, regardless of length, which took effect June 1, 2016.

⁵ LPC: <http://www.loon.org/ingested-lead-tackle.php>

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		and anglers received free steel sinkers in return (Haig et al., 2014) Educational outreach continued post-ban to support regulatory restrictions	peaked in July and August, suggest that loons obtain the majority of lead tackle from current fishing activity rather than from a reservoir of lead tackle on lake bottoms (Grade et al., 2018)	2006 2016	Ban extended to sales of lead sinkers weighing ≤ 1 oz and jigs < 1 in in length Ban on use and sale extended to all sinkers and jigs weighing ≤ 1 oz (28.35 g), regardless of length	It is too early to assess the effectiveness of the additional restrictions on jigs that were introduced in 2016. <u>Conclusions:</u> To increase effectiveness bans should cover all sizes that are typically ingested or ban the use of lead in all terminal tackle used for recreational fishing. Ban should be on sale and use with enforcement otherwise anglers will continue to use stocks of lead sinkers/jigs and may buy from other states where lead sinkers are not banned. NH trying to combat use of old supplies by tackle buy-back program. Recently, Lead tackle buy-back program introduced (providing a \$10 incentive for 1oz or more, in 2018) – effectiveness of buy-back approach to be determined.
Maine (US)	1997 2013-2016	Law passed to collect funds to educate the public on ways to minimize the threat to loons and other bird species from discarded or lost lead sinkers and lures. <i>Fish Lead Free</i> ⁶ educational outreach campaign to support legislative bans coming into force in 2016/2017	Low effectiveness for education alone. Long term mortality data for Maine's common loons show that, between 1990-2002, ~35% of documented deaths on average were due to lead poisoning (see Fig 1) and, prior to implementation of the ban, lead poisoning was consistently the leading single known cause of death (see Fig 2).	2002 2013 2016	2002 ban on <u>sales</u> of lead sinkers weighing ≤ 0.5 oz. Ban expanded to <u>sale and use</u> of lead sinkers weighing ≤ 1 oz or measuring ≤ 2.5 " in length Ban expanded to <u>sales</u> of bare (unpainted) lead jigs weighing ≤ 1 oz or measuring ≤ 2.5 "	Positive trend but not completely effective thus far Lead related deaths of Maine's common loons have decreased over time (1990-2016; see Fig 1), indicating a positive trend. Prior to the implementation of the 2002 limited ban (1990-2002), lead poisoning was the overall leading recorded cause of death of common loons (responsible for 52 of 163 (31.9%) of deaths on average). From 2003-2016, lead poisoning was documented to be responsible for 63 of 295 (21.4%) of common loon deaths. In 2009, trauma replaced lead poisoning as the leading known cause of death (see Fig 2). It is too early to assess the effectiveness of the additional restrictions on jigs that were introduced in 2016/17, although it should be noted that the law excluded coated jigs based on the erroneous assumption that coatings could limit lead exposure and toxicity (see USFWS, 1986).

⁶ Lead Free Fish Program run by ENGOs that operate in Maine, Massachusetts, New Hampshire, New York and Vermont: www.leadfishfree.org

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				2017	Ban expanded to <u>use</u> of bare lead jigs weighing ≤ 1 oz or measuring ≤ 2.5 " (Sept 2017)	
Washington State (US)	1996-2011	Educational outreach; exchange programs Including educational programs, on-site education efforts, brochures, talks, magazine articles, TV interviews	May be effective (small sample size) Long term population decline of common loons observed in Washington during 1985-2008 period. From 1999-2010, 33% of known causes of adult Common Loon deaths were from lead toxicosis (Poleschook and Gumm, 2009)	2011	Ban on the use of lead sinkers and jigs ≤ 1.5 inches in length at 12 Common Loon breeding lakes. Strong enforcement element (including arrests for violations)	Early indications of effectiveness In the 15-years immediately preceding the ban (1996-2010), 8 of 21 (38%) of documented adult loon mortalities resulted from lead poisoning, whereas no lead mortalities have been recorded since 2011. Nine breeding seasons have passed since the legislation took effect, it appears that restricting the use of lead-free fishing tackle on Common Loon nesting lakes has been effective to date in Washington. This is thought to be due, in large part, to the legislation, but also to other factors, such as public acceptance statewide of using lead-free tackle alternatives, educated public on not casting in the direction of Common Loons, better recovery of spent line and tackle, and for other non-apparent factors. Some arrests have been made for those caught using lead tackle, increasing incentives for others not to use lead tackle. <u>Conclusions:</u> A sizable portion of anglers given on-site education about the toxicity of lead fishing tackle indicated that they would change in the future but only when an actual ban was in place (Poleschook and Gumm, 2009), indicating the importance of an approach that combines legislation with education. The strong law enforcement of the ban appears to be a key element in its success to date.
New York (US)	2004	Educational program started in 2004 to support implementation of regulatory restrictions. Included distribution of educational	Ineffective Educational program established to support regulatory program. See comments under Legislative Program Effectiveness.	2004 2007	Ban on <u>retail sales</u> of lead sinkers weighing $\leq 1/2$ ounce. Ban expanded to <u>use</u> of lead	Ineffective From 1972-1999, lead poisoning accounted for 21% of the mortality cases; and, from 2000-2017, lead poisoning accounted for 19% of mortality cases, indicating the current program has been ineffective. Note that the current ban only extends to sinkers weighing ≤ 0.5 oz, whereas the majority of

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		materials, press releases, information in the regulations guide, signs posted at license sales agents, announcements on radio and TV, in newspapers and magazines, and lead sinker exchange program.			sinkers weighing $\leq \frac{1}{2}$ oz. Supported with educational program	documented ingested objects were jigs: 46 jigs, 14 sinkers, and 7 other/unknown tackle. Overall, as the NH experience suggests, a more protective standard, including a ban on jigs, is necessary to reduce lead tackle mortality.
Massachusetts (US)	Pre-2000	Educational outreach by the Massachusetts Division of Fisheries and Wildlife included an angler education program consisting of newsletters, workshops, displays, and tackle loaner program	Ineffective No evidence of an appreciable drop in uses of lead or reduced mortality due to lead ingestion.	2000 2012	Ban on use of lead sinkers in 2 reservoirs Ban on use of lead sinkers and jigs weighing <1oz	Early data indicates ineffective but still a relatively new regulation Lead sinkers were initially prohibited only at certain reservoirs used by loons in Massachusetts (Quabbin and Wachusett). As of January 1, 2012, the Massachusetts Division of Fisheries and Wildlife, Fisheries and Wildlife Board prohibited 'the use of any lead fishing sinkers and lead jigs weighing less than 1 ounce in all inland waters (fresh water) of the Commonwealth'. ⁷ Lead tackle mortality accounted for 21% of adult mortality on freshwater prior to 2012 and 23% post-2012.
Vermont (US)	2004	Educational program. Commissioner of Fish and Wildlife implemented an education program to alert the public to the threat lead fishing tackle posed to wildlife and provided anglers lead-free fishing sinkers in exchange for leaded sinkers. The education program was designed	Moderately effective	2005 2007	Ban on <u>sale</u> of lead sinkers weighing $\leq \frac{1}{2}$ oz Ban expanded to <u>use</u> of lead sinkers weighing $\leq \frac{1}{2}$ oz	Indications of initial effectiveness but concern remains 1989-2006, 46.5% of documented mortalities (20 out of 43 total collected adult mortalities) were from lead tackle. From 2007-2018, this dropped to 18.1% (6 out of 33 total collected adult mortalities). Although mortality rates are lower following the ban the continued lead-related mortality rates (~18%) remain a concern. NOTE: significant growth in VT loon population since 2000.

⁷ <http://www.mass.gov/eea/agencies/dfg/dfw/hunting-fishing-wildlife-watching/fishing/loons-lead-sinkers-and-jigs.html>

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		to support the upcoming regulation				
Minnesota (US) 'Get the Lead Out'	2003-2013	Educational outreach; exchange programs (>200 exchanges; 50,000 packages of non-lead tackle distributed); displays at retail stores; media coverage.	Ineffective Increased awareness of the issue and greater availability of lead-free weights at retail stores resulted. However, no evidence of an appreciable drop in uses of lead. Creel surveys indicated that over 100,000 lead tackle items were lost in five water bodies in the 2004 season, totaling about one metric ton of lead (Radomsky et al., 2006). In 2013, the Minnesota Pollution Control Agency (MPCA) policy priorities included 'establish a pathway to measurably reduce the use of lead fishing tackle' (MPCA 2013)	N/a	N/a	n/a no legislated action yet During the 2002-03 session in Minnesota, the state Legislature considered banning the sale and use of lead tackle. But after a series of stakeholder discussions, the groups involved agreed that a better approach was to educate anglers about the alternatives to lead tackle and to offer opportunities to try out non-lead sinkers and jigs. The subsequent well-funded and extensive educational outreach program over more than 10 years failed despite the concerted and sustained educational efforts of all involved. It was concluded that education alone will not sufficiently reduce or eliminate avoidable loon deaths as a result of lead ingestion (LPC 2012)
California (US) The Safe Drinking Water and Toxic Enforcement Act of 1986 ("Prop 65")	2001	Labelling requirement: California required labelling of lead tackle, "This product contains lead, a chemical known to the State of California to cause cancer and birth defects and other reproductive harm."	Ineffective No evidence of a decline in sales or uses of lead in fishing terminal tackle due to labelling. Note that many lead sinkers/jigs sold in Canada carry this Prop 65 label and no reduction in lead sales/uses in Canada have been observed (ECCC, 2018)	N/a	N/a	n/a no legislative action on import/sales/uses yet California Department of Toxic Substances Control (DTSC) added lead fishing sinkers and jigs to the Department's Draft Priority Product Work Plan with a public comment period beginning in Sept 2014. DTSC released a draft of its Priority Product Work Plan in April 2015, which listed product types to be banned including lead fishing weights. On April 24, 2018, California Assembly Bill 2787 was introduced. The bill would outlaw the manufacture, sale and purchase of lead fishing weights that are under 50g. It was opposed by the sportfishing community. It was amended from an outright ban to a commitment to

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						study the issue. The sportfishing community still feels that the study called for is 'overly broad' and continues to oppose the amended bill. ⁸
Sweden	1995-2005	Educational outreach 15-year nationwide outreach effort to encourage the use of non-toxic fishing tackle involving the Swedish Angling Association and other fishing and industry partners.	Ineffective Quantity of lead used in non-commercial angling (200t/year) did not decrease over a period of ten years (1995-2005) despite information campaigns encouraging anglers to switch to non-lead alternatives (KEMI, 2007). Following outreach efforts, fishing tackle retailers stated that they did not intend to stop selling lead sinkers until legislation introduced (KEMI 2007).	N/a	N/a	n/a no legislative action yet <u>Conclusion:</u> The Swedish Chemicals Agency (KEMI) concluded that the voluntary phasing-out of lead in angling has been in progress for 15 years without adequate results having been achieved and stronger incentives are needed (KEMI, 2007). The Swedish Environmental Protection Agency and the Swedish Chemicals Agency therefore proposed that lead in angling tackle be restricted and proposed a 0.1% limit for lead concentration in fishing gear (KEMI, 2007).
Netherlands	2018	'Green Deal' developed between several ministries, water boards, environmental NGOs, and sports fishing organisations to eliminate the use of lead for sports fishing (May 22, 2018). Includes the promotion of lead-free alternatives.	TBD	n/a	n/a	n/a no legislative action yet

⁸ E.g. Update on California Lead Tackle Ban (June 2018) American Sportfishing Association, Policy Watch: <https://asafishing.org/update-on-california-lead-tackle-ban/>

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EU	1980's on	Educational outreach, exchange programs, voluntary codes of practice by some EU member states.	Ineffective European countries that have used voluntary approaches and assessed the effectiveness of these measures have found them inadequate (e.g., see examples from UK, Denmark, Sweden above, and ECHA 2018)	n/a	n/a	No legislation yet The European Parliament did not support a previous proposal for a ban on the use of lead sinkers, as proposed under the 2008 'Laperrouzze Report' (CEPHFS, 2008). This proposal was based on water quality considerations and not on the mortality of birds that might ingest lost fishing weights. 2018 Report by The European Chemicals Agency (ECHA) recommends restrictions on the marketing and use of lead fishing tackle, as well as lead ammunition, under the European Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (ECHA, 2018).

Appendix S1

Information on Lead-free Fishing Tackle

Environment Canada

<https://www.canada.ca/en/environment-climate-change/services/management-toxic-substances/list-canadian-environmental-protection-act/lead/using-more-lead-free-fishing-tackle.html>

Cummings School of Veterinary Medicine, Tufts University

<http://vet.tufts.edu/wildlife-medicine-program/research-2/lead-poisoning/>

Fish Lead Free

<https://fishleadfree.org>

Loon Preservation Committee

<http://www.loon.org/loon-lead-overview.php>

Minnesota Dept. of Natural Resources

<https://www.dnr.state.mn.us/eco/nongame/projects/leadout.html>