TECHNICAL REVIEW OF THE SOURCES AND IMPLICATIONS OF LEAD AMMUNITION AND FISHING TACKLE ON NATURAL RESOURCES

BARNETT A. RATTNER[1], J. CHRISTIAN FRANSON[2], STEVEN R. SHEFFIELD[3], CHRIS I. GODDARD[4], NANCY J. LEONARD[5], DOUGLAS STANG[6] AND PAUL J. WINGATE[7]

[1]*US Geological Survey, Patuxent Wildlife Research Center, Beltsville Laboratory c/o BARC-East, Building 308, 10300 Baltimore Avenue, Beltsville, MD 20705, USA.*
E-mail: Barnett_Rattner@usgs.gov

[2]*US Geological Survey, National Wildlife Health Center, 6006 Schroeder Road, Madison, WI 53711-6223, USA.*

[3]*Department of Natural Sciences, Bowie State University, 4000 Jericho Road, Bowie, Maryland 20715 and College of Natural Resources, Virginia Polytechnic Institute and State University, National Capital Region – Northern Virginia Center, 7054 Haycock Road, Falls Church, VA 22043, USA.*

[4]*Great Lakes Fishery Commission, 2100 Commonwealth Boulevard, Suite 100, Ann Arbor, MI 48105-1563, USA.*

[5]*Michigan State University, Center for Systems Integration and Sustainability, Department of Fisheries and Wildlife, 115 Manly Miles Building, 405 South Harrison, East Lansing, MI 48823-5243, USA.*

[6] *Bureau of Fisheries, New York State Department of Environmental Conservation, 625 Broadway, Albany, NY 12233-4753, USA.*

[7]*Minnesota Department of Natural Resources, 500 Lafayette Road, St. Paul, MN 55155-4020, USA.*

EXTENDED ABSTRACT.—A technical review of lead sources that originate from hunting, shooting sports, and fishing activities (Rattner et al. 2008) was undertaken to provide background information for the preparation of policy statements by the American Fisheries Society and The Wildlife Society. Lead is a naturally occurring metal in the environment. In biological systems, it is a nonessential metal with no functional or beneficial role at the molecular and cellular levels of organization. Its use in ammunition and fishing tackle dates back hundreds to thousands of years, respectively. Realization of the hazards of lead shot to waterfowl can be traced to the late 1870s, while the hazards of lead fishing sinkers to birds became well-recognized in the 1970s with lead poisoning of swans in Britain. By the 1980s, Britain and some jurisdictions within the United States and Canada began placing restrictions on the use of lead shot and fishing sinkers.

Large quantities of lead ammunition and fishing tackle are produced annually. Estimates of lost fishing tackle are much less than the quantity of spent ammunition at waterfowl hunting areas and target ranges. Nonetheless, lost fishing tackle poses a toxicological threat to some waterbird species. Lead from spent ammunition and lost fishing tackle is not readily released into aquatic and terrestrial systems under most environmental conditions. Lead

artifacts can be relatively stable and intact for decades to centuries. Nevertheless, under some environmental conditions (e.g., soft acidic water, acidic soil), lead can weather and be mobilized from such artifacts, yielding free dissolved lead, precipitates, and chemical species that complex with inorganic and organic matter. Dissolved, complex species and particulate lead can be adsorbed onto or incorporated into the surface of plants. In soil and sediment, various forms of lead can become adsorbed, taken up by tissues, and entrained in the digestive tract of invertebrates. Lead that is released from artifacts can evoke a range of biochemical, physiological, and behavioral effects in some species and life stages of invertebrates, fish, amphibians, and terrestrial vertebrates and can exceed criteria for protecting some biota (e.g., water quality criteria for invertebrates). Lead in soil, adsorbed or incorporated into food items, and fragments emanating from shooting ranges can ultimately result in elevated tissue concentrations in birds and small mammals and cause hematological changes and pathological lesions. For anthropogenic activities such as mining and smelting, lead concentrated in sediments (lead in silt, fine particulates, and pore water) can also be lethal to aquatic invertebrates, fish and waterbirds.

There is evidence documenting ingestion of spent shot and bullets, lost fishing sinkers and tackle, and related fragments by reptiles, birds, and mammals. Ingestion of some of these elemental lead artifacts can be accompanied by a range of effects (molecular to behavioral) in individuals and potentially even population-level consequences in some species (e.g., waterfowl, eagles, condors). Fish can ingest sinkers, jigs, and hooks, but unlike higher vertebrates, fatality seems to be related to injury, blood loss, exposure to air and exhaustion rather than lead toxicosis. There are no data demonstrating the ingestion of spent shot or bullets by invertebrates, fish or amphibians. Numerous reports in the medical literature describe accidental or purposeful ingestion of lead fragments in humans. Lead shot and sinkers can be retained in the appendix and digestive tract, and in some instances (particularly in children) lead artifacts are surgically removed to minimize exposure and adverse effects. Lead poisoning related to spent ammunition and lost fishing tackle has been most studied in avian species, and at least two studies indicate that the ban on the use of lead shot for hunting waterfowl and coots in North America has been successful in reducing lead exposure in waterfowl. Nonetheless, other species including upland game (e.g., doves, quail) and scavengers (e.g., vultures, eagles) continue to be exposed, and in some instances populations (e.g., California Condor, *Gymnogyps californianus*) may be at risk. Accordingly, many states have instituted restrictions on the use of lead ammunition to minimize effects to upland game birds and scavengers. The hazard of ingested lead sinkers and fishing tackle is well documented in swans and loons, and restrictions on the sale and use of lead weights have been instituted in the United Kingdom, Canada, numerous other countries, and several states in the United States to minimize effects on these and other species. There are only limited data on lead ingestion at shooting ranges by terrestrial vertebrates, and reproductive rates and estimation of population parameters of wildlife at these sites have not been adequately investigated. The hazards of spent ammunition and lost fishing gear to fish populations are unknown, but suspected to be minimal.

There has been an extensive effort in the development, efficacy testing, and regulation of alternatives to lead shot for hunting waterfowl and coots. Environmentally safe alternatives have been approved and currently are available in North America and elsewhere. Environmentally safe (non-lead) alternatives for some other types of hunting (e.g., shot for some upland birds, bullets for large game) and for target shooting are more recent developments, but use of these alternatives is not widespread. Many substitutes for lead fishing tackle have entered the marketplace in recent years. Some, but not all lead-substitute metals in fishing tackle have been previously deemed safe if ingested by waterfowl and some other birds and mammals. Less is known about the potential hazard of these alternatives to lower vertebrates.

The overall understanding of the hazards of lead used in shot, bullets, and fishing tackle would benefit from research generating toxicological and environmental chemistry data, and monitoring and modeling of exposure and effects. Those of highest priority include:

(1) broad scale monitoring on the incidence of lead poisoning in wildlife in countries where the extent of the problem is poorly documented or unknown, (2) data on the prevalence of lead poisoning related to fishing tackle in reptiles and aquatic birds, (3) information on the weathering, dissolution and long-term fate of lead fragments, and bioavailability of lead, in various aquatic and terrestrial ecosystems, (4) the hazards of spent ammunition and mobilized lead to wildlife at or near shooting ranges, and (5) evaluation of the results of regulations restricting the use of lead ammunition and fishing tackle on exposure and health of biota in various ecosystems.

The American Fisheries Society and The Wildlife Society seek to prepare position statements on the continued use of lead in ammunition and fishing tackle. There are at least three position options. Namely, the introduction of lead into the environment from hunting, shooting sports and fishing activities (1) is adequately regulated and the toxicological consequences of ingestion of lead are currently considered acceptable, (2) could be restricted in locations where lead poses an unacceptable hazard to biota and their supporting habitat, or (3) could be phased out with a goal of complete elimination. The leadership of both the American Fisheries Society and The Wildlife Society could interact with various entities to disseminate information about hazards and toxic effects of lead ammunition and tackle, as well as the availability and ecological benefits of safe alternatives. *Received 11 June 2008, accepted 28 July 2008*.

RATTNER, B. A., J. C. FRANSON, S. R. SHEFFIELD, C. I. GODDARD, N. J. LEONARD, D. STANG, AND P. J. WINGATE. 2009. Technical review of the sources and implications of lead ammunition and fishing tackle on natural resources. Extended abstract *in* R. T. Watson, M. Fuller, M. Pokras, and W. G. Hunt (Eds.). Ingestion of Lead from Spent Ammunition: Implications for Wildlife and Humans. The Peregrine Fund, Boise, Idaho, USA. DOI 10.4080/ilsa.2009.0106

Key words: Ammunition, fishing, hunting, lead, shooting, sinkers, wildlife.

LITERATURE CITED

RATTNER, B. A., J. C. FRANSON, S. R. SHEFFIELD, C. I. GODDARD, N. J. LEONARD, D. STANG, AND P. J. WINGATE. 2008. Sources and Implications of Lead Ammunition and Fishing Tackle on Natural Resources. Technical Review 08-01, The American Fisheries Society, The Wildlife Society, Bethesda, Maryland, USA.