Perspectives on Lead, Fish, and Wildlife

A List of Introductory Resources Compiled and Maintained by the Association of Fish and Wildlife Agencies' Lead Working Group

The Association of Fish and Wildlife Agencies maintains this page as a free resource to members of the fish and wildlife management community who are looking for introductory scientific information describing the complex interactions between lead and fish, wildlife, and their habitats. Lead (chemical symbol Pb) is the heaviest non-radioactive element and has been used historically for a wide range of household and industrial applications.

Lead has long been a popular metal for fishing equipment and ammunition, due to its abundance, heaviness, low cost, malleability, and low melting point. However, concerns about the toxicity of lead to humans and other species have led to the phase-out of this metal from many of its former uses in broader human society. The continued use of lead in wildlife and fisheries management is an active area of discussion and debate.

The Association and its Fish and Wildlife Health Committee have established the Lead Working Group in order to facilitate dialogue and information-sharing among interested parties. The references provided here represent a diversity of scientific perspectives regarding the use of lead in fish and wildlife management in the United States. We appreciate the input from members of the Lead Working Group, The Wildlife Society, and the American Fisheries Society in the development of this page.

Overview Documents and Websites

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. The Wildlife Society and American Fisheries Society, Bethesda, MD.

U. S. Geological Survey, National Wildlife Health Center
Known and Potential Impacts of Lead on Wildlife

U.S. National Park Service, Pinnacles National Park, California
Lead and Wildlife

Watson, R. T., M. Fuller, M. Pokras, and W. G. Hunt (Eds.). 2008. Ingestion of Lead from Spent Ammunition: Implications for Wildlife and Humans. The Peregrine Fund, Boise, Idaho, USA.

World Forum on the Future of Sport Shooting Activities. 2005. Sport Shooting and the Environment: Sustainable use of lead ammunition. Proceedings of the World Symposium on Lead Ammunition September 9 -10, 2004. World Forum on the Future of Sport Shooting Activities, Rome, Italy.

Biological and Ecological Studies

Overview

Eisler, R. 1988. Lead Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. Contaminant Hazard Reviews, U. S. Fish and Wildlife Service, Patuxent Wildlife Research Center, Laurel, MD.

Haig, S. M., J. D'Elia, C. Eagles-Smith, J. M. Fair, J. Gervais, G. Herring, J. W. Rivers, and J. H. Schulz. 2014. The persistent problem of lead poisoning in birds from ammunition and fishing tackle. The Condor 116:408–428.

Lahner, L. L., J. C. Franson, D. Bradley, P. Haeussler, P. O'Sullivan, R. Friedman, A. Till, D. Bradley, J. Trop, and B. L. Burton. 2009. Lead Poisoning in Wild Birds. US Department of the Interior, US Geological Survey.

Lead Isotope Studies: An Introduction

Scheuhammer, A. M., and D. M. Templeton. 1998. Use of stable isotope ratios to distinguish sources of lead exposure in wild birds. Ecotoxicology 7(1):37-52.

Buttigieg, G. A., M. E. Baker, J. Ruiz, and M. B. Denton. 2003. Lead isotope ratio determination for the forensic analysis of military small arms projectiles. Analytical Chemistry 75:5022-5029.

California Condors

Kelly, T. R., J. Grantham, D. George, A. Welch, J. Brandt, L. J. Burnett, K. J. Sorenson, M. Johnson, R. Poppenga, D. Moen, J. Rasico, J. W. Rivers, C. Battistone, and C. K. Johnson. 2014. Spatiotemporal Patterns and Risk Factors for Lead Exposure in Endangered California Condors during 15 Years of Reintroduction. Conservation Biology 28:1721–1730.

See also the section on ***Scientific Discussion and Debate*** below for several widely-cited publications on condors.

Waterfowl

Bellrose, F. C. 1959. Lead poisoning as a mortality factor in waterfowl populations. Illinois Natural History Survey Bulletin; v. 027, no. 03.

Blus, L., C. Henny, D. Hoffman, L. Sileo, and D. Audet. 1999. Persistence of high lead concentrations and associated effects in tundra swans captured near a mining and smelting complex in Northern Idaho. Ecotoxicology 8:125-132.

Demendi, M., and S. A. Petrie. 2006. Shot Ingestion in Scaup on the Lower Great Lakes After Nontoxic Shot Regulations in Canada. Wildlife Society Bulletin 34:1101–1106.

Franson, J. C., S. P. Hansen, T. E. Creekmore, C. J. Brand, D. C. Evers, A. E. Duerr, and S. DeStefano. 2003. Lead fishing weights and other fishing tackle in selected waterbirds. Waterbirds 26:345–352.

Pokras, M. A., and R. Chafel. 1992. Lead toxicosis from ingested fishing sinkers in adult common loons (*Gavia immer*) in New England. Journal of Zoo and Wildlife Medicine 23(1):92–97.

Large Mammals

Rogers, T. A., B. Bedrosian, J. Graham, and K. R. Foresman. 2012. Lead exposure in large carnivores in the greater Yellowstone ecosystem. The Journal of Wildlife Management 76:575–582.

Raptors/Scavengers

Bedrosian, B., D. Craighead, and R. Crandall. 2012. Lead Exposure in Bald Eagles from Big Game Hunting, the Continental Implications and Successful Mitigation Efforts. PLoS ONE 7:e51978.

Craighead, D., and B. Bedrosian. 2008. Blood Lead Levels of Common Ravens With Access to Big-Game Offal. Journal of Wildlife Management 72:240–245.

DeMent, S. H., J. J. Chisolm, J. C. Barber, and J. D. Strandberg. 1986. Lead exposure in an "urban" peregrine falcon and its avian prey. Journal of Wildlife Diseases 22:238-244.

Kelly, T. R., P. H. Bloom, S. G. Torres, Y. Z. Hernandez, R. H. Poppenga, W. M. Boyce, and C. K. Johnson. 2011. Impact of the California Lead Ammunition Ban on Reducing Lead Exposure in Golden Eagles and Turkey Vultures. PLoS ONE 6:e17656.

Doves/Ground-feeding birds

Bingham, R. J., R. T. Larsen, J. A. Bissonette, and J. O. Hall. 2015. Widespread ingestion of lead pellets by wild chukars in Northwestern Utah. Wildlife Society Bulletin 39:94–102.

Plautz, S. C., R. S. Halbrook, and D. W. Sparling. 2011. Lead shot ingestion by mourning doves on a disked field. The Journal of Wildlife Management 75:779–785.

Schulz, J. H., J. J. Millspaugh, B. E. Washburn, G. R. Wester, J. T. Lanigan III, and J. C. Franson. 2002. Spent-shot availability and ingestion on areas managed for mourning doves. Wildlife Society Bulletin 112–120.

Impacts on Effectiveness and Harvest Efficiency

Gremse, F., O. Krone, M. Thamm, F. Kiessling, R. H. Tolba, S. Rieger, and C. Gremse. 2014. Performance of Lead-Free versus Lead-Based Hunting Ammunition in Ballistic Soap. PLoS ONE 9:e102015.

Pierce, B. L., T. A. Roster, M. C. Frisbie, C. D. Mason, and J. A. Roberson. 2015. A comparison of lead and steel shot loads for harvesting mourning doves. Wildlife Society Bulletin 39:103–115.

Schulz, J. H., P. I. Padding, and J. J. Millspaugh. 2006. Will Mourning Dove Crippling Rates Increase With Nontoxic-Shot Regulations? Wildlife Society Bulletin 34:861–865.

Human Dimensions – Hunter/Angler Attitudes and Understanding

Chase, L., and M. J. Rabe. 2015. Reducing Lead on the Landscape: Anticipating Hunter Behavior in Absence of a Free Nonlead Ammunition Program. PLoS ONE 10:e0128355.

Thomas, V. G. 2003. Harmonizing Approval of Nontoxic Shot and Sinkers in North America. Wildlife Society Bulletin (1973-2006) 31:292–295.

U.S. Fish and Wildlife Service, Association of Fish & Wildlife Agencies, Oregon Department of Fish & Wildlife,. 2014. National Dove Hunter Survey 2013. National and Dove Management Unit Descriptive Statistics, DJ Case & Associates.

Shooting Ranges

Cao, X., L. Q. Ma, M. Chen, D. W. Hardison, and W. G. Harris. 2003. Weathering of lead bullets and their environmental effects at outdoor shooting ranges. Journal of Environmental Quality 32:526–534.

Vyas, N., J. Spann, G. Heinz, W. Beyer, J. Jaquette, and J. Mengelkoch. 2000. Lead poisoning of passerines at a trap and skeet range. Environmental Pollution 107:159–166.

Scientific Society Position Statements

American Fisheries Society
The Wildlife Society

Scientific Discussion and Debate

One of the key features of the scientific process is open debate and critical review of findings. Here are two widely-circulated papers on California condors, as well as two responses which critique these papers.

Church, M. E., R. Gwiazda, R. W. Risebrough, K. Sorenson, C. P. Chamberlain, S. Farry, W. Heinrich, B. A. Rideout, and D. R. Smith. 2006. Ammunition is the principal source of lead accumulated by California condors re-introduced to the wild. Environmental Science & Technology 40:6143–6150.

Finkelstein, M. E., D. F. Doak, D. George, J. Burnett, J. Brandt, M. Church, J. Grantham, and D. R. Smith. 2012. Lead poisoning and the deceptive recovery of the critically endangered California condor. Proceedings of the National Academy of Sciences 109:11449–11454.

Saba, D. 2008. Comment on "Ammunition is the Principal Source of Lead Accumulated by California Condors Re-Introduces to the Wild." Environmental Science and Technology. 42: 1807-1808.

Wright, T.D., R.K. Peddicord. 2007. Summary of science for ammunition as the source of lead in condors. *Prepared for* National Rifle Association Institute for Legislative Action, 11 pgs.