Spring 2000

Deposition and uptake availability of lead shot for waterfowl at Honeybee Pond within the Overton Wildlife Management Area, Nevada, USA

Jason Eckberg

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Deposition and uptake availability of lead shot for waterfowl at Honeybee pond within the

Overton Wildlife Management area, Nevada, USA

A Thesis submitted in partial satisfaction of the requirement for the

degree of Bachelor of Science

in

Environmental Studies

University of Nevada Las Vegas

by

Jason Eckberg

Spring 2000

Thesis Advisor: Dr. Darren Divine
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ABSTRACT

Lead shot has been banned for hunting waterfowl since 1974, but lead poisoning continues to be a major problem in many waterfowl habitats. In December of 1999, soil samples were collected from the Honeybee pond at the Overton Wildlife Management area to determine the lead pellet concentration and the availability of lead shot to waterfowl. There were no shot pellets recovered from the thirty-one samples taken from the pond. Based on this information waterfowl do not appear to be exposed to lead in the pond areas at OWMA.

INTRODUCTION/BACKGROUND

HISTORY OF LEAD SHOT USE

Lead poisoning kills an estimated 1.5 to 3 million waterfowl each year (Bellrose, 1959, 1975). The main cause of lead poisoning in waterfowl comes from the ingestion of spent lead shotgun pellets. In a study by Bellrose in 1959, he suggested the use of iron shot in waterfowl hunting to reduce the risk of poisoning. This practice was not made into law until 1974, when the U.S. Fish and Wildlife Service (USFWS) made it illegal to use lead shot when hunting waterfowl (United States Fish and Wildlife Service, 1974).

Despite advances in waterfowl hunting regulations, the numbers of waterfowl dying each year from lead poisoning has not decreased from the range of 1.5 to 3 million a year. This is assumed to be because of continued lead shot deposition from the hunting
of other birds in the same or proximate location as waterfowl or existing sites from previous activity.

In a 1¼-ounce, 2¾ inch 12 gauge shotgun shell there are approximately 280 No. 6 lead shot pellets (Flint, 1998). Basing on the average, six shells are fired for each bird shot resulting in 1400 lead pellets being deposited for each bird shot. An estimated 5442 metric tons of lead shot is deposited in the United States every year (Schranck and Dollahon, 1975), and this spent shot can stay in the environment for up to 3 years (Flint, 1998).

SHOT ALTERNATIVES

Since the 1974 ban on lead shot in waterfowl hunting there has been a continued attempt to create an alternative (non-toxic) shot that works as well as lead. According to hunters, none have done so (Environment Canada, 1998). Lead is heavily preferred by hunters because of its long history, superior ballistic properties, and relatively low cost.

The main shot alternatives to lead include steel, bismuth/tin, and tungsten/polymer, with steel shot being the most common of the three in North America (Environment Canada, 1998). Opponents of steel shot say that the lighter/harder pellets would result in an increase in crippling losses (those loses that resulted from the bird being shot, but dying from indirect causes such as blood loss, inability to feed, etc.); however, this has not been the case. In a study by the USFWS in 1986, the office concluded, “currently available steel shotshell ammunition is an effective alternative to that containing lead shot, and the large scale use of steel shot will not result in inordinate crippling losses of waterfowl” (USFWS, 1986).
Bismuth/tin and tungsten/polymer shot are about 86% as dense as lead, compared to only about 70% for steel (Environment Canada, 1998). This results in shot patterns similar to lead, and an "instant" kill of the bird as opposed to crippling the bird which was one complaint by hunters for steel shot. The main opposition by hunters is that it is much more expensive than lead. The raw material for tungsten costs about $10.72 U.S./kg in the 1980's and early 90's compared to the lead at approximately $0.40-$0.80 U.S./kg in the same time period (Environment Canada, 1998). This equates to the hunter paying $8.00 for a box of lead shot would have to pay approximately $80.00 for the same amount of tungsten shot.

INGESTION

There are two main reasons waterfowl ingest spent shot. First, the bird may incidentally pick up shot while looking for food (Sanderson and Bellrose, 1986). Secondly, and more commonly, the shot may be picked up along with gravel as grit to aid in the digestion process (Moore et al., 1998).

AVAILABILITY FACTORS

There are many factors that contribute to the availability of the lead shot to waterfowl in a lake or pond (USFWS, 1986). The first three factors are based in the hunter activities, the last three are based on natural occurrences, or possibly the pond construction. The most likely occurrence of uptake would occur in is the combination of one or more of these factors (Bellrose 1959). The first factor is the amount of lead shot deposited in the area. The second factor is the frequency of shooting in the hunting area. With an increase of deposits into the area, the possibility of uptake increases also.
Third, the chance that a bird will ingest the shot pellets increases when those areas are along a major migration pattern, specifically rest/feeding areas.

A fourth factor is the feeding habits of the waterfowl in question. Dabbling ducks feed on plants and invertebrates in the water column or on the surface of the bottom, this makes their level of exposure relatively low. Diving ducks on the other hand may dig 10 to 12cm for tubers, and canvasbacks and other diving ducks can dig equally deep for clams, thus substantially increasing the risk of lead uptake and exposure. Geese and swans can dig up to 38cm for tubers and clams, exposing deposits from many years earlier, making their chance of exposure the highest of these three categories.

A fifth factor is water depth of the lake or pond. If the water is very deep, it will be more difficult or perhaps impossible for birds to reach the bottom and ingest lead shot. On the contrary, if the water is very shallow then it might be easier for the birds to reach the bottom, and the availability of lead shot uptake increases.

A sixth factor is the type of sediment on the bottom of the lake or pond. If the bottom is hard the shot will tend to remain on top, and thus more accessible for the birds. Where the bottom is soft or mucky, the shot is likely to sink downward or be buried in the sediment, which could be out of reach of the bird.

POISONING

The ingested lead pellets are dissolved by the acid and grinding motion in the gizzard along with other grit substances and food. Lead is first distributed to the red blood cells which carries it to various soft tissue, such as the liver, kidney, and nervous system (Hartup, 1996). Lead poisoning is not inevitable after ingestion because there are many factors that determine lethality. The birds diet is the most important of these
Deposition and uptake availability of lead shot... Eckberg 9

factors. The intake of protein, calcium, and phosphorus reduces lead poisoning (Sanderson and Bellrose, 1986). The volume of food and the rate it is absorbed and digested is also important in the reduction of lead absorption. Also the more active the calcium metabolism of the bird the more likely the lead will be excreted, consequently breeding mothers and young birds have a higher resistance to lead (Sanderson and Bellrose, 1986). Lead may also redistribute to the bone and become biologically inactive.

Lead poisoning in waterfowl comes in two forms, acute lead poisoning, and chronic lead poisoning. Acute lead poisoning occurs after a bird has ingested a very large number of shot (40-300). Death occurs usually 1-3 days later, without any noticeable signs of sickness, such as dramatic loss of weight. Chronic lead poisoning is the more common of the two, usually occurring after a bird has ingested 1-15 pellets (more often just 1 or 2) and can last from 2 to 3 weeks and results in death (USFWS 1986). Lead poisoning is not a contagious disease.

NEVADA-OWMA

Studies of these risks associated with lead shot deposits are limited in Southern Nevada, and more specifically the Overton Wildlife Management Area (OWMA). The OWMA is located along the pacific flyway migratory route and is approximately 80 miles from the city of Las Vegas. This study will attempt to determine the potential for exposure and uptake by waterfowl by looking at the availability factors listed earlier.

At the OWMA, the migratory game bird season in 1999 was from Nov. 6 1999-Jan.22, 2000, duck hunting season will started on Oct. 9, and goose season started on Nov. 20 (NDOW, 1999). Migratory waterfowl found in southern Nevada include; various types of dabbling and diving ducks, mergansers, coots and moorhens (gallinules),
common snipes, Canada and white-fronted geese, snow geese and Ross' geese, and Tundra swan.

Nevada Division of Wildlife (NDOW) is expecting 84 million waterfowl in the 1999-2000 season, to pass through the United States, 10 million less than last year's record of 94 million (NDOW 1999). The U.S. Fish and Wildlife Service predicts that a record 105 million ducks will be heading south from Canada and Alaska.

This study will concentrate on the Honeybee pond area at the OWMA which has blinds #1-3, and those species that are affected by the deposition of lead into that pond. However, it should be stated that the pond is not in an isolated area and those actions that affect the species in the pond are similar if not equally effective as those on the dry land surrounding it (Appendix 1). It is hypothesized that the lead shot levels at Honeybee pond at OWMA will be significantly higher than those areas in similar studies reviewed in the literature that have been proven to have a lead deposition/poisoning problem.

**LITERATURE REVIEW**

In a very influential study of the effects of lead shot and waterfowl F. Bellrose (1959), he wrote about the amount of lead in the sediment in areas all over North America (Table 1). He found that in areas that had large hunting activities using lead shot, there was a high incidence of lead poisoning. Among 2,184 gizzards containing lead shot, 64.7% contained one pellet, 14.9% contained two pellets, and 7.4% contained more than six pellets. This study was done in the late 1950's, and lead levels are believed to have increased since then up to 1974 when lead shot was banned for waterfowl hunting (Sanderson and Bellrose 1986).
Frank Bellrose came up with five availability factors to determine the chance that waterfowl may ingest lead. The factors are (1) shooting intensity, or amount of shot on the bottom, (2) firmness of bottom material, (3) size of shot pellets involved, (4) depth of the water, and (5) ice cover.

In a study by Esslinger and Klimstra (1983) sediment samples were taken to determine the amount of lead on a hunting area in southern Illinois. Soil samples were collected March-April 1977 to obtain evidence of shot deposition following the 1976-1977 hunting season. Samples were collected within a ring around each of the blinds, the ring measuring 81-135 m. Ten samples were taken from the ring around each of the twenty blinds. The top 2.5cm of soil was skimmed off and placed in a plastic bag. The samples were washed through a #10 U.S. standard sieve to recover shot.

Fifty of the 200 soil samples taken in the spring yielded 1-85 lead shot (203 total) producing an estimated 109,789 pellets/ha. Twenty-five of the 200 samples collected in the fall of 1977 had 1-3 lead shot resulting in 15,068 pellets/ha.
Table 1. -Number of lead shot pellets per square foot and per acre found in samples of the bottom soils of various lakes and marshes used extensively by waterfowl in North America reproduced from Bellrose (1959).

<table>
<thead>
<tr>
<th>State</th>
<th>Area</th>
<th>Year and season:</th>
<th>Number of pellets per square foot</th>
<th>Number of pellets per acre:</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>Sacramento Valley</td>
<td>1939,1940</td>
<td>60</td>
<td>19,602</td>
</tr>
<tr>
<td></td>
<td>North Bay, San Francisco...</td>
<td>Springs</td>
<td>120</td>
<td>33,977</td>
</tr>
<tr>
<td></td>
<td>Delta</td>
<td>80</td>
<td>0.20</td>
<td>8,712</td>
</tr>
<tr>
<td></td>
<td>South Bay, San Francisco</td>
<td>240</td>
<td>0.79</td>
<td>34,412</td>
</tr>
<tr>
<td></td>
<td>San Joaquin Valley</td>
<td>120</td>
<td>1.37</td>
<td>59,677</td>
</tr>
<tr>
<td></td>
<td>South Coast</td>
<td>40</td>
<td>0.48</td>
<td>20,908</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Lakes on Carlos Avery</td>
<td>1939-1940</td>
<td>10</td>
<td>17,859</td>
</tr>
<tr>
<td></td>
<td>Refuge Winter</td>
<td></td>
<td>0.41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lakes adjacent to Carlos</td>
<td></td>
<td>94</td>
<td>16,117</td>
</tr>
<tr>
<td></td>
<td>Avery Refuge</td>
<td></td>
<td>53</td>
<td>23,955</td>
</tr>
<tr>
<td></td>
<td>Rice Lake</td>
<td></td>
<td>36</td>
<td>64,032</td>
</tr>
<tr>
<td></td>
<td>Heron Lake</td>
<td></td>
<td>249</td>
<td>6,098</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>Lake Puckaway</td>
<td>1949</td>
<td>100</td>
<td>118,048</td>
</tr>
<tr>
<td></td>
<td>Clans Lake Winter</td>
<td>67</td>
<td>2.71</td>
<td>46,174</td>
</tr>
<tr>
<td></td>
<td>Horicon Marsh</td>
<td>53</td>
<td>0.08</td>
<td>3,485</td>
</tr>
<tr>
<td>Manitoba</td>
<td>Portage Creek, Delta Marsh</td>
<td>1950</td>
<td>186</td>
<td>50,965</td>
</tr>
<tr>
<td></td>
<td>Cadham Point, Delta Marsh</td>
<td>Summer</td>
<td>195</td>
<td>16,988</td>
</tr>
<tr>
<td>Michigan</td>
<td>Saginaw Bay</td>
<td>?</td>
<td>45</td>
<td>11,761</td>
</tr>
<tr>
<td></td>
<td>Maumee Bay</td>
<td>?</td>
<td>200</td>
<td>11,761</td>
</tr>
<tr>
<td>Indiana</td>
<td>Willow Slough</td>
<td>1956</td>
<td>14</td>
<td>40,511</td>
</tr>
<tr>
<td></td>
<td>Spring, Fall</td>
<td>14</td>
<td>1.07</td>
<td>46,609</td>
</tr>
<tr>
<td>Illinois</td>
<td>Moscow Bay</td>
<td>Summer</td>
<td>60</td>
<td>1,742</td>
</tr>
</tbody>
</table>
In a study of the lead shot incidence in Merrymeeting Bay, Maine by Longcore, Corr, and Spencer (1982), results were calculated by soil samples and gizzard examinations. They took sediment samples between the split waterfowl season in late October 1976. They took 40 Ekman dredge samples along eight arbitrarily placed 91.4 m transects. These samples revealed a density of 43.055 lead shot/ha. Ninety-four lead shot pellets were found in 180 dredge samples from the vegetated tidal flats of the bay. The mean number of shot/ha for all shot combined was 99,932 (59,541-140,324; 95% CL). They examined 1,246 waterfowl gizzards of ten species. Shot incidence average was 3.6% for all species combined for the 5 years (Table 2).

Table 2.-Incidence of ingested lead shot in waterfowl gizzards from Merrymeeting Bay, Maine, 1976-80.

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>GIZZARDS</th>
<th>N(%) WITH SHOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALLARD</td>
<td>164</td>
<td>5(3.0)</td>
</tr>
<tr>
<td>PINTAIL</td>
<td>42</td>
<td>1(2.4)</td>
</tr>
<tr>
<td>AMERICAN WIGEON</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>GREEN-WINGED TEAL</td>
<td>397</td>
<td>1(0.3)</td>
</tr>
<tr>
<td>GADWALL</td>
<td>111</td>
<td>2(1.8)</td>
</tr>
<tr>
<td>WOOD DUCK</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>RING-NECKED DUCK</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>LESSER SCAUP</td>
<td>5</td>
<td>1(20.0)</td>
</tr>
<tr>
<td>TOTALS</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1,246</td>
<td>43(3.6)</td>
</tr>
</tbody>
</table>
Schrank and Dollahon (1975) studied lead shot incidence on a New Mexico public hunting area. The study area consisted of 20.2 ha within the 40 ha unit heavily utilized by hunters. This area was flooded during late September, and depths ranged from 1-1.5 m. The area was gridded to form 15.2m squares. A table of 3-digit random numbers was used to select 200 sample sites. An open metal frame, 30.5cm square by 7.6 cm deep was used to collect soil samples. The frame was pushed into the soil and the soil inside was removed. From 1 to five pellets were recovered from 96 of the 163 soil samples. Based on this data the lead shot density was 98,985 pellets/ha. Samples containing lead were found in clay soils. Of the 66 samples without lead, 19 came from heavily vegetated area that were difficult to sample. Soils in 12 other samples not containing lead were classified as black ooze.

Guitart et al. (1994) studied lead in sediments at the Ebro Delta in Spain. Lead shot concentration in sediments was measured at two different zones of the Ebro Delta: the Buda island coastal lagoon and some rice fields. The sampling areas were selected as representatives of two important wild bird habitats of the Ebro Delta. Sampling depth was 20cm, and the samples were washed through sieves of 2mm mesh size.

The lead shot concentration in the Buda Island lagoon and the rice fields was as follows: At Buda Island in the summer of 1991, there were 221 sampling points with a concentration of 282,184 pellets/ha. At Buda Island in the spring of 1992, there were 106 sampling points with a concentration of 544,748 pellets/ha. In the rice fields in the spring of 1992, there were 96 sampling points with a concentration of 60,149 pellets/ha. This has a mean concentration of 297,590 pellets/ha.
From gizzard, liver and kidney analysis researchers found that 25.64% of mallards examined were suffering from some degree lead poisoning.

Despite a brief mention in the 1959 study by Bellrose, there has been little to no study of the lead shot deposition rates and availability factors in Nevada. This was changed by Gerstenberger and Divine (in press 1999) when they studied the lead deposition and distribution rates in Nevada. One hundred and twenty-two samples were collected from the Overton Wildlife Management Area (OWMA) in the spring of 1998 and 1999. The OWMA lies directly on the pacific flyway used by waterfowl during migration. In 1998 36 samples were taken in one field by taking a 15 cm x 15cm x 15cm soil sample every 150 m along a transect. Eighteen samples were taken from another two other fields. In 1999, fifty samples were taken from a fourth field. Samples were taken back to the laboratory and ran through soil sieves of decreasing sized sieves ranging from 1.25cm to 600μm. Seventy-one gizzards from hunter-harvested waterfowl were collected throughout the 1998-99 hunting season which ran from November 1, 1998 to January 16, 1999.

The lead concentrations in the four fields that soil sampling were done are as follows, 862,275 pellets/ha, 107,642 pellets/ha, 2,691 pellets/ha, and 649,085 pellets/ha. Of the seventy-one gizzards collected, eight (11%) showed the presence of shot, with 5.6% of the shot consisting of lead.

The synthesis of the studies mentioned in this section will be used to examine the possibility of exposure posed to waterfowl at Honeybee Pond, Overton, Nevada. The amount of lead in each of the studies is combined and shown in Table 3. The results from Bellrose (1959) were converted from pellets/acre to pellets per hectare.
Table 3. Mean pellets per hectare in 11 areas from six studies

<table>
<thead>
<tr>
<th>Authors, Date</th>
<th>Area</th>
<th>Mean Pellets/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerstenberger and Divine, 1999</td>
<td>OWMA, Nevada</td>
<td>405,423</td>
</tr>
<tr>
<td>Guitart et al., 1994</td>
<td>Ebro Delta, Spain</td>
<td>297,590</td>
</tr>
<tr>
<td>Schranck and Dollahon, 1975</td>
<td>New Mexico</td>
<td>98,985</td>
</tr>
<tr>
<td>Longcore et al., 1982</td>
<td>Merrymeeting Bay, Maine</td>
<td>99,932</td>
</tr>
<tr>
<td>Esslinger and Klimstra, 1983</td>
<td>S. Illinois</td>
<td>109,789</td>
</tr>
<tr>
<td>Bellrose, 1959</td>
<td>California</td>
<td>11,710</td>
</tr>
<tr>
<td>Bellrose, 1959</td>
<td>Minnesota</td>
<td>12,222</td>
</tr>
<tr>
<td>Bellrose, 1959</td>
<td>Manitoba</td>
<td>13,750</td>
</tr>
<tr>
<td>Bellrose, 1959</td>
<td>Michigan</td>
<td>4,759</td>
</tr>
<tr>
<td>Bellrose, 1959</td>
<td>Indiana</td>
<td>17,628</td>
</tr>
<tr>
<td>Bellrose, 1959</td>
<td>Illinois</td>
<td>352</td>
</tr>
</tbody>
</table>
MATERIALS AND METHODS

Transects were delineated at Honeybee Pond (Figure 1), using the hunting blinds and the boat docking bridge as visual markers. Soil samples were taken using an Ekman dredge. The dredge samples approximately 0.052 m² to a depth of < 10cm.

Figure 1. Map of transects one and two on Honeybee pond, Nevada.

Samples were taken every twenty paces, approximately 20m, along each transect starting at the bridge. This resulted in 18 samples along transect 1 and 13 samples along transect 2. The samples were put in labeled plastic bags for future use/identification and taken back to the laboratory.

The soil samples were diluted with water and passed through decreasing sizes of sieves, from 1.25 cm down to 600μm. Recovered shot was put into labeled bags and the shot type identified. Second, transect records were analyzed to determine if there is any
concentration of shot and/or lead in particular parts of the pond. Third, the lead levels were compared to the amount of non-lead shot.

The concentration level per hectare was compared to the results of various other studies around the world in similar hunting areas (Table 3). Statistical comparisons were done between the various data sets. This allowed for the conclusions of whether the Honeybee pond has a higher or lower risk level for lead poisoning in waterfowl.

During the soil sampling, approximate measures of other availability factors were done. This included water depth, soil types, location of the pond, vegetation levels, and blind location. These were done by using physical or visual observations during the soil sampling.

Questions were asked via telephone to Keith Brose, Wildlife Technician III at Overton Wildlife Management Area, about the hunter statistics, harvest statistics, and Management area and Honeybee pond information (Appendix 1).
RESULTS

Of the 31 samples taken at Honeybee pond, zero contained lead shot pellets, and zero contained non-toxic shot pellets. No statistical analysis could be done between shot types or between locations.

The depth of the water along the transects ranged from approximately 0.5m to 1.5m. The depth of the sediment ranged from approximately 0.1m to 0.3m. The sediment type would be classified as soft thick clay.

Honeybee pond is at the northern most point of the Overton Wildlife Management Area (OWMA), which lies upon the Pacific Flyway.

The following are the results from the questionnaire given to Keith Brose via telephone of NDOW (Personal Communication, March 1, 2000)(Appendix 1).

1. The Honeybee pond is a man-made pond.
2. Overton Wildlife Management Area has been in operation since 1953.
3. In the past fifteen years Honeybee pond has been drained twice. In 1996, it was drained for work on cattails, and in 1987 for repairs due to flooding.
4. Due to the alkalinity of the water, steel shot will start to oxidize almost immediately, less than 24 hours.
5. Some quail hunters also use the Honeybee pond area for hunting.
6. There were 1550 hunters at OWMA in the 1999-2000 waterfowl hunting season.
7. In the 1999-2000 season at blind #1 there were 24 days of hunting, 34 ducks were harvested and 2 geese for an average of 1.5/day. At blind #2 there were 19 days of hunting, 46 ducks were harvested for an average of 2.4/day. At blind #3 there were 9 days of hunting with 2 ducks being harvested for an average of 2.4/day.
8. In the six years that Keith has been working at OWMA, there have been no incidences of hunters being caught using lead shot.

9. In the six years that Keith has worked at OWMA, he has not found any birds suffering from lead poisoning.

10. During the 1999-2000 season there were 1385 ducks harvested at OWMA, 61 Canada goose (*Branta canadensis*), 19 Snow goose (*Chen caerulescens*), 4 Ross' goose (*Chen rossii*), 62 American coots (*Fulica americana*), and 2 swans were illegally harvested.

11. Waterfowl that can be commonly found and harvested at OWMA include:

- Canada goose (*Branta canadensis*)
- Snow goose (*Chen caerulescens*)
- Ross' goose (*Chen rossii*)
- Wood duck (*Aix sponsa*)
- Green-winged teal (*Anas crecca*)
- Mallard (*Anas platyrhynchos*)
- Northern Pintail (*Anas acuta*)
- Cinnamon teal (*Anas cyanoptera*)
- Northern shoveler (*Anas clypeata*)
- Gadwall (*Anas strepera*)
- American wigeon (*Anas americana*)
- Canvasback (*Aythya valisineria*)
- Redhead (*Aythya americana*)
- Lesser scaup (*Aythya collaris*)
- Ring-necked duck (*Aythya collaris*)
- Common Merganser (*Mergus merganser*)
- Bufflehead (*Bucephala albeola*)
- Ruddy duck (*Oxyura tachypterus*)
- American coot (*Fulica americana*)
DISCUSSION

HYPOTHESIS

The hypothesis that Honeybee pond has higher lead shot deposition levels than those studied in the literature has been proven false. There were no comparisons done because there was no shot found in any of the thirty-one samples.

AVAILABILITY FACTORS

No shot pellets were found, so no analysis could be done of this factor. It should be noted that there is some likelihood that there is some lead shot at the pond, because the area was in operation since 1953, 21 years before the ban on lead shot use.

There were 1,385 ducks harvested at OWMA in the 1999-2000 season. With 34 available blinds, this comes to an average of 40 ducks per blind. Blinds along the pond had 82 ducks harvested, blind #1 having 32, blind #2 had 46, and 2 ducks at blind #3. This comes to an average of 27 ducks per blind, well below the average for the entire area.

The OWMA lies along the pacific flyway, and is used as both a resting and feeding area for waterfowl.

The water depth ranged from 0.5m to 1.5m, so most waterfowl are able to dive to the sediment surface. Due to the sediment being very soft with a depth ranging from 0.1m to 0.3m, dabbling ducks have a relatively low chance of picking up the shot pellets because they feed off the surface and in the water column. Shot pellets that stay in the system will most likely sink to the bottom of the sediment. Diving ducks however have an increased chance of uptake. In some areas, the birds would be able to dive at least 1/3 of the way to the bottom and in other areas, they would be able to dive entirely to the
bottom. Geese and swans would have the highest probability of ingesting shot pellets while feeding. They would be able to dive entirely to the bottom in all areas of the pond.

In addition to feeding habits, it should be noted that very little vegetation was seen in the middle of the pond. The majority of the vegetation is along the perimeter of the pond. Therefore, most of the feeding and possible shot uptake will be along the perimeter as well.

EXPLANATION FOR NO SHOT RECOVERY

The main reason is the limited amount of hunting at the blinds along the pond (blinds 1-3) in the 1999-2000 waterfowl hunting season. There were 52 days of hunting along the pond with 82 ducks and 2 geese harvested in the 1999-2000 season. This comes to an average of 2.1 birds/day. If this limited success were not limited to one season, it would explain a minimal amount of shot deposition. However, success patterns for previous years are unknown.

Despite the fact that steel is the most common type of shot for waterfowl hunting, there was no steel shot recovered. From the questionnaire given to Keith Brose, it was learned that due to the high alkalinity of the pond water steel shot pellets will begin to oxidize in less than 24 hours.

The next subject is the absence of tungsten or bismuth shot. It is assumed that the main reason for the absence of these shot types is that the amount of hunters using them is minimal because they are much more expensive than both steel and lead.

At the time that this study was done, lead shot had been banned for use when hunting waterfowl for 26 years. In addition, since OWMA has only been in operation from 1953 that would be only 21 years that lead shot could be legally used for waterfowl
hunting. This would lead to the assumption that there has been more non-toxic shot deposited than lead shot in the 47 years that OWMA has been in operation. The pond has also been drained twice in the past 15 years. This may have drained or at least moved some of the lead shot deposited before the 1974 ban.

**ALTERNATIVE EXPERIMENTAL PROCEDURES**

One change in the experiment would be to use different sampling patterns. First, hunter success and distribution of success should be used to model the pattern of sampling. Now we know that the majority of hunter success and activity occurred at blind #2 and second most at blind #1. Perhaps a better pattern of sampling would be semi-circles of gradually increasing distance from the blind locations going out to approximately 50-60m. This may accomplish two things. First, it would increase the amount of shot recovered in the samples. Second, it would be a better estimate of availability to waterfowl seeing that the majority of vegetation/feeding occurs along the perimeter of the pond.

**CONCLUSIONS/RECOMMENDATIONS**

Using the results of this study, there appears to be a significantly small or no availability of lead to waterfowl in the Honeybee pond. However, this is not to say that waterfowl do not have a risk of ingesting lead shot when visiting the OWMA. It is more likely that they pick it up in fields near the pond primarily used for dove hunting. Assuming that the OWMA is representative of other hunting areas across the country, it is important to note that the birds do not limit their feeding and grit consumption to those areas where they are hunted most prevalently.
This information can be useful to wildlife managers in hunting areas, as well as policy makers. The ban of the use of lead shot when hunting waterfowl is not the complete answer. There are still 1.5 to 3 million waterfowl dying from lead poisoning every year. One possible action could be to create or isolate feeding areas near the ponds. This area would have to have both food as well as gravel that can be used for grit, and no hunting allowed. This action wouldn’t have effects for a couple of years, but waterfowl often return to prime feeding areas while migrating every year.

Another action that could be done is to drain and clean pond areas. At the Honeybee pond, the pond was drained at least twice since the ban on lead shot. This action could have removed many of the lead pellets that were deposited prior to the 1974 ban. This will be difficult for many of the larger ponds, but it would only need to be done once. This may be an important step to limiting the amount of lead shot ingested from the sediment of the pond.

A third action would be for policy makers to ban the use of lead shot for all hunting activities in areas that lie along major flyways. This would eliminate any new deposition of lead to these areas. Combined with one or both of the previous actions, this may be the best way to minimize the amount of lead poisoning in waterfowl, while still allowing hunting activities to continue.
REFERENCES CITED


Appendix 1. – Map of Overton Wildlife Management Area.
Appendix 2. Questionnaire given to Keith Brose via telephone on March 1, 2000.

1. Is the Honeybee pond a natural, man-made, or man-altered pond? If man-altered, how so?
2. How many years has Overton Wildlife Management Area been in operation?, Honeybee pond?
3. Is the Honeybee pond drained or flooded at any time?
4. How long will it take steel shot pellets to oxidize in the water at Honeybee pond?
5. Is the Honeybee pond used by hunters for anything besides waterfowl?
6. How many hunters were at Overton Wildlife Management Area this season?, at blinds 1-3?
7. How successful were hunters at blinds 1-3 this season (number)?
8. Approximately how many hunters are caught per season using illegal lead shot for waterfowl at Overton Wildlife Management Area?
9. Have you found any waterfowl suffering from lead poisoning?, how many?
10. Approximately how many waterfowl have been harvested at Overton Wildlife Management Area?, how many total (population census)?
11. Do have a list of waterfowl found at Overton Wildlife Management Area that are legally harvested?