

# INVESTIGATIONS OF WATERFOWL LEAD POISONING IN CALIFORNIA

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**Abstract.** The California Department of Fish and Game has been investigating four major aspects of waterfowl lead poisoning. Randomly selected soil samples taken from four locations were examined to determine availability of lead pellets. These have shown a range of 0-188 pellets per plot for one hundred twenty, one meter square by ten centimeter deep, plots. To determine levels of ingested lead shot, gizzards were taken from trapped, hunter and disease killed birds. Of 3,799 gizzards examined, 294 (7.74%) contained ingested lead pellets. Wingbone and tissue samples chemically analyzed for lead content have been of no help in differentiating sources of lead in waterfowl. In wingbone samples of seemingly alike immature ducks, values ranged from <1-871 ppm per sample. Actual confirmed mortality for the last two years has been approximately 150 waterfowl. Estimated mortality statewide has been 2,000.

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## INTRODUCTION

Since the late 1800s lead shot ingestion has been indicated as a mortality factor in waterfowl (Grinnell 1894). Despite this, little field research has been done regarding availability of spent shot or the number of birds actually succumbing to lead poisoning (plumbism).

Bellrose (1959) published the most comprehensive work to date on lead poisoning in waterfowl. He reported plumbism as a mortality factor in 2-3% of the national waterfowl population. California which winters up to 10 million waterfowl annually (R. LeDonne, pers. commun.) and has hunting concentrated on private clubs and public waterfowl management areas, has been indicated as a lead poisoning problem area. Using Bellrose's figures and logic California could lose 200,000-300,000 waterfowl annually to lead poisoning. In other words, each one of California's 22 waterfowl areas would have to lose 100 waterfowl daily from lead poisoning during the four month wintering period to reach these estimated losses.

## MATERIALS AND METHODS

Soil sampling areas were selected on the basis that they were currently heavily hunted or sites where waterfowl lead poisoning has occurred.

Plot sites (1 m<sup>2</sup> x 10 cm deep) were randomly picked and samples marked by a measuring device made of 1/2 inch reinforcing bar. A square shovel marked at 10 cm was used to excavate the sample. Once placed in plastic lined burlap bags the sample was transported to the Field Station in Sacramento for examination. The clods were broken up and soil placed in a container eight inches across, 2-3 inches deep. Fluoroscopic examination was performed using a Radifluor 360 (5 ma, 120 kilovolts).

Discing, prior to resampling, on Pond 17 Grizzly Island Wildlife Management Area (WMA) was accomplished using four passes on each of six, 700 yard long, eight feet wide, 10 inches deep strips. Resampling was performed in the same manner as the original but within the disced strips.

Approximately 60 cubic yards of crushed basalt road gravel were spread in fifteen strips 3-5 inches deep, eight feet wide and approximately 50 feet long.

Observations of waterfowl use of the graveled areas was from a parked vehicle and temporary blinds. Optics used included 8 x 40 binoculars, 20-60 power spotting scope and a starlite scope.

Waterfowl gizzards, used for determining ingested lead shot levels were collected from birds trapped in a modified Ohio funnel trap, and from hunter and disease killed birds. Removed gizzards were labeled, bagged and taken to the Field Station. Examination consisted of emptying the gizzard contents into a 500 ml beaker then floating off vegetative matter leaving only the grit to be fluoroscoped. Detected shot was removed to determine if it was lead or steel and to what degree it had been worn. Gizzard walls were examined for wounds if unusually large or faceted shot was found. Checking the gizzards for signs that lead shot may recently have been present (heavy bile staining, sluffing of inner walls, muscle atrophy and/or impaction) completed examination.

Wingbones for lead analyses were removed from trapped, hunter and disease killed birds by severing the proximal end of the humerus then sealing the wings in a plastic bag. Skin, feathers and muscle were removed from the radius and ulna of the left wing. These bones were cracked open, placed on acid treated filter paper to absorb runoff of marrow and lipid material then autoclaved at 120 degrees C for 20 minutes. The radius and ulna were then ground to a powder, dried and weighed to 0.5 grams. This sample was then ashed at 450 degrees C, cooled, had ten drops of redistilled HNO<sub>3</sub> added, dried, then reashed at 450 degrees C for one hour and allowed to air cool. Five ml of 6N HCl were added and warmed to 80 degrees C. After cooling it was diluted with 10.0 ml dionized water placed in a Teflon test tube and shaken. Actual analysis was by burning in a Varian Techtron Model 1200 Atomic Absorption Spectrophotometer with background corrector. Results were given to the nearest mg/kg.

As a measure to determine actual waterfowl mortality due to lead poisoning we advised State and Federal wildlife personnel on waterfowl areas to ship waterfowl to our laboratory that was suspected of being lead poisoned.

When live animals were received they were fluoroscoped and examined for emaciation and loss of muscular control. Dead animals were fluoroscoped then examined for emaciation, atrophy of liver and kidney, impaction of proventriculus and gizzard with undigested food and grit, sluffing, bile-stained gizzard inner walls, and ingested shot present in the gizzard. Depending on the degree to which ingested lead pellets were affecting the waterfowl one or more of the above signs were present.

## RESULTS

These results represent only a progress report on continuing investigations of waterfowl plumbism in California.

To determine availability of lead shot in soil 120 sample plots have been taken from four locations (Table 1).

Samples taken at Lower Klamath National Wildlife Refuge (NWR) averaged 18.12 pellets per plot for 60 samples.

Tule Lake NWR averaged 2.27 pellets for 11 samples.

A private duck club that has been hunted for over 40 years averaged 26.76 pellets for four samples.

Grizzly Island WMA averaged 115.36 pellets for 45 samples.

As indicated Grizzly Island had the greatest amount of available spent lead shot of all areas sampled. Considering this fact and reported lead poisoning losses on area 17 (477 acres), Grizzly Island was chosen as an area to attempt marsh management practices for reduction of available lead shot. Six lanes were disced within the area previously sampled. Resampling after discing and before flooding showed a decrease of 11.69% in pellets (Table 1). The disced area will again be sampled during the summer of 1977. Another aspect of marsh management was depositing gravel around the edge of the pond, as an alternate grit source. The strips were deposited along the perimeter so when the area was flooded portions of the gravel would be both in and out of the water.

Previous plumbism mortality on Grizzly Island WMA had been reported in September and October during the area's annual flooding. Pond 17 was observed twice weekly during this time to determine use of the graveled areas and to collect any sick or dead birds. Two carcasses and one sick bird were picked up. None of these birds contained ingested shot or showed signs or symptoms of plumbism. The sick bird recovered and was released within two weeks. All three birds were mature female pintails (Anas acuta). Observations of the graveled areas showed use during the day by 200-500 waterfowl, mostly ducks. After dusk the use increased to 2-3 thousand birds, with as many as 50 percent being whitefronted geese (Anser albifrons).

To determine the levels of ingested lead shot in waterfowl 3,799 gizzards were examined. These were collected from 1974-76 and had an overall 7.74 percent ingestion rate. Of these, 96 (2.53 percent) contained two or more ingested pellets (Table 2). The range of pellets found per gizzard was 0-736.

A total of 637 birds were trapped at Lower Klamath NWR and Gray Lodge WMA, 6.27 percent contained ingested lead pellets. Gizzards from hunter-killed birds were received from Lower Klamath, Colusa, Kern, Modoc and Imperial NWR and Gray Lodge WMA. Of the 1,081 gizzards received, 7.77 percent contained ingested lead pellets.

Disease killed birds were collected statewide, mainly during botulism and fowl cholera outbreaks (Table 3). The gizzards from 2,081 waterfowl revealed 8.16 percent had ingested lead pellets.

Chemical analysis of wingbones and tissue for accumulated lead levels have been completed on a total of 544 pintails, mallards (Anas platyrhynchos) and ringnecked pheasants (Phasianus colchicus).

Five hundred trapped or hunter-killed immature ducks from Lower Klamath NWR and Gray Lodge WMA were the first group of wingbones analyzed. One male

Table 1. Incidence of available spent lead shot found in soil samples 1 meter x 1 meter x 10 centimeters.

Area	Sub area	Number of plots	Average number of pellets/plot	Range	Approximate No. of available pellets/acre
Lower Klamath N.W.R.	White Lake Unit	7	6.57	0-22	26,595
"	Unit 1	9	29.33	15-58	118,712
"	Unit 4	6	20.83	2-52	84,313
"	Unit 6	12	2.25	0-7	9,106
"	Unit 8	25	25.80	4-60	104,413
"	Unit 12	1	1	1	4,047
Tule Lake N.W.R.	Frog Pond Unit	11	2.27	0-4	9,187
Yolo Bypass	Private Duck Club	4	26.75	15-39	108,257
Grizzly Is. W.M.A.	Pond No. 17	25	121.68	82-188	492,439
"	Pond No. 17 after discing	20	107.45	56-181	434,850

Table 2. Incidence of ingested lead shot in California waterfowl.

Species	Total Fluoroscoped	Number w/ingested shot	% of total w/ingested shot	Number w/ingested shot		% of total w/ingested shot	
				1 shot	2+ shot	1 shot	2+ shot
Mallard	1298	94	7.24	75	19	5.78	1.46
Pintail	1015	115	11.33	72	43	7.09	4.24
Widgeon	263	7	2.66	5	2	1.90	.76
Shoveler	163	2	1.23	2	--	1.23	--
Green wing Teal	94	0	--	--	--	--	--
Godwall	68	2	2.94	2	--	2.94	--
Diving Ducks	169	9	5.33	6	3	3.55	1.76
Geese	396	32	8.08	25	7	6.31	1.77
Swans	333	33	9.91	11	22	3.30	6.61
Total	3799	294	7.74	198	96	5.21	2.53

Table 3. Comparison of trapped, hunter killed and disease killed waterfowl ingestion rates.

Species	No.	Trapped		Hunter Killed		Disease Killed			
		No. w/ingested shot	%	No.	%	No.	%		
Mallard	335	25	7.46	228	17	7.45	735	52	7.07
Pintail	302	15	4.96	453	62	13.68	260	38	14.61
Other	---	--	----	360	4	1.11	228	7	3.07
Puddle Ducks									
Diving Ducks	---	--	----	24	1	4.00	145	8	5.51
Geese	---	--	----	16	0	0	380	32	8.42
Swans	---	--	----	---	--	----	333	33	9.91
Total	637	40	6.27	1081	84	7.77	2081	170	8.16

mallard was omitted during analysis and will not be accounted for. A summary of the results follows.

Mallards - 99 samples

Pintails - 400 samples

Considering the total sample the mean was 15.7 ppm lead/bone with an overall range of <1-871 ppm (Tables 4 and 5).

Of the total sample 31 (6.21 percent) birds contained ingested shot. Samples from these birds ranged from <1-324 ppm with a mean of 53.8 ppm lead/bird. For those 468 without ingested shot the range was <1-871 with a mean of 13.2 ppm lead/bird.

During September and October 1975, 26 lead poisoned waterfowl from Grizzly Island WMA were collected. Wingbones, kidney, liver and breast muscle samples were taken for analysis. The 25 pintail and one mallard contained from 2 to 33 well, worn ingested pellets each (Table 6).

In the fall of 1976 18 pheasants were collected from Grizzly Island WMA in the same area waterfowl had died of lead poisoning in 1975. Wingbones and breast muscle samples were taken to better define background lead levels.

Wingbone lead level results ranged from 1.6-868 ppm, the average being 161 ppm. Six were under 10 ppm, seven were over 100 ppm. Breast muscle levels ranged from 0.5-1.8 ppm. Thirteen of these breast samples were 0.5 ppm while two were above 1.0 ppm. Two of the birds did contain one ingested shot each. These birds had 2.2 ppm and 868 ppm lead in their wingbones. No birds showed signs of plumbism.

Records at the California Department of Fish and Game's Disease Section show 86 necropsied waterfowl being diagnosed as succumbing to lead poisoning (Table 7). This covers a two-year period and 1,471 necropsied waterfowl. There have been two confirmed lead poisoning "die-offs" within the past two years. One occurred 10 miles south of Bakersfield on a private duck club in Kern County during December 1974-January 1975. The other was at Grizzly Island WMA during September-October 1975. Field personnel at both locations placed losses at approximately 100 waterfowl.

Estimated yearly losses were obtained during December 1976 from 14 National Wildlife Refuges and 8 State Wildlife Management Areas. These losses were totaled to be approximately 5,000 waterfowl statewide. Tule Lake/Lower Klamath NWR collectively reported their estimated losses at 4,000 waterfowl. The California Department of Fish and Game's Disease Section has placed estimated mortality for 1976 at 2,000 waterfowl statewide based on laboratory reports, confirmed and reported lead poisoning mortality.

Confirmed plumbism losses reported for 1974-76 from the 22 wildlife areas amounted to 150 waterfowl.

#### DISCUSSION

Just over two years ago when these investigations began, current information on the effects of lead poisoning in California's waterfowl was practically nonexistent. Our figures today are still estimates, especially concerning mortality, but are now based on two years of intense study to reliably quantify the impact of lead on the waterfowl resource.

Ideas concerning just what aspect to study have changed considerably. Up to a year ago wingbones were being collected, analyzed and results compared. This was done to try to find a pattern to link lead shot ingestion to lead accumulation within the body. We could not find this correlation.

Table 5. Parts per million lead for 499 mallards and pintails analyzed for lead/bone levels.

	Mallards	Pintails
Average ppm lead overall	20.77	14.45
Number and % with ingested shot	5, 5.05%	26, 6.50%
Average ppm lead samples with ingested shot	4.0	65.92
Range in ppm	1-7	1-324
Average ppm lead of sample w/out ingested shot	21.67	10.87
Range in ppm	1-439	1-871
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Number of birds from Lower Klamath	51	85
Average ppm/bird	20.86	2.91
Range in ppm	1-277	1-24
Number with ingested shot and %	2, 3.92%	2, 2.35%
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Number of birds from Gray Lodge	48	315
Average ppm/bird	20.68	18.35
Range in ppm	1-439	1-871
Number with ingested shot and %	6.25%	24, 7.61%
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% of overall sample the ingested shot birds accounted for	1.00%	5.21%

Table 4. Ranges ppm and species of 499 mallards and pintails analyzed for lead/bone levels.

PPM	No. of Birds	%	PPM	No. of Birds	%
<1	155	31.06	1 or less	235	47.09
1	80	16.03			
2-9	138	27.65	2-19	183	36.67
10-19	45	9.01			
20-99	67	13.43	20+	81	16.23
100+	14	2.81			

418 birds are <20 ppm 83.77%

Table 7. Laboratory reports of lead poisoning occurrence in California waterfowl.

Date	Species	Location
1/7/74	Imm. Whistling Swan, female	Yolo Bypass N. of I 80
1/29/74	4 Whistling Swans	Sacramento N.W.R.
6/13/74	2 Imm. Mallards	Kern N.W.R.
12/24/74	2 Pintail	Buena Vista Lake, Kern Co.
12/30/74	Pintail 10 male, 6 female	Buena Vista Lake, Kern Co.
1/9/75	1 Snow goose	Gray Lodge W.M.A.
1/9/75	1 Whistling Swan	Venice Island & Delta Vic.
1/13/75	1 Mallard, male	Colusa N.W.R.
1/14/75	4 male Pintail, 2 female	Buena Vista Lake
1/16/75	1 Mallard	Sutter N.W.R.
1/16/75	1 Pintail	Sutter N.W.R.
1/29/75	6 male Pintail, 2 female	Buena Vista Lake
4/18/75	Scaup 3 male, 2 female	Upper Klamath Lake
4/18/75	Bufflehead 1 male, 1 female	Hank's Pond
9/23/75	1 Mallard, 13 Pintails	Grizzly Island W.M.A.
12/22/75	1 Snow goose, 1 Pintail	Sacramento N.W.R.
Picked up in Oct. 75	7 Pintails	Grizzly Island W.M.A.
3/3/76	1 Mallard	Merced N.W.R.
4/29/76	3 Pintails	Tule Lake, Lower Klamath N.W.R.
7/30/76	1 American Avocet	Honey Lake W.M.A.
12/13/76	1 Snow goose Imm.	Delevan N.W.R.
12/17/76	2 Snow geese	Sacramento N.W.R.
12/23/76	2 Snow geese	Sacramento N.W.R.
12/27/76	1 Snow goose	Sacramento N.W.R.
12/30/76	1 Mallard, female	Delevan N.W.R.

Table 6. Summary of Grizzly Island W.M.A. lead poisoned waterfowl wingbone and tissue analyzed.

Tissue analyzed	Range of lead level in ppm	Average lead level in ppm
Wingbone	51-340	105
Kidney	55-810	268
Liver	22-280	173
Breast muscle dry weight	0.99-5.2	3

All breast muscle samples are below Public Health guideline for lead on a fresh weight basis.

Emphasis is now being placed on more practical aspects dealing with, quantifying the amount of available lead shot in waterfowl areas, ingestion rates by waterfowl and a stressed emphasis on confirmed mortality.

Soil samples will be collected from all California waterfowl areas and National Wildlife Refuges within the Pacific Flyway. These samples will be sent to the Department's Disease Section for examination. Area 17 on Grizzly Island WMA, where marsh management practices of discing and placing grit were tried, will be resampled. The desired results will be a greater reduction of available shot in the disced areas after flooding and evidence of extensive use of the graveled areas by waterfowl. If these methods prove successful they would have great value for relieving a lead poisoning "hot spot" on an immediate but limited area basis.

Estimating lead poisoning mortality in waterfowl is extremely difficult. Normally birds are not lost in a "die-off" type situation where hundreds or thousands die and are easily noticed. Plumbism occurs most often as an occasional phenomena where the animal ingests lead pellets, becomes affected, slowly deteriorates, usually hides and then may die. Again this next year, as in the last two, waterfowl area personnel will be asked to report all lead poisoning losses. Finding the individual mortality will be stressed in order to account for losses that may otherwise go unnoticed. Any birds found dying from unknown causes should be sent to the California Department of Fish and Game's Disease section.

Ongoing and future research will be aimed at gathering more and better data to make intelligent decisions concerning the management of California's waterfowl resources.

#### REFERENCES

- Grinnell, G.B. 1894. Lead poisoning. Forest and Stream 42(6):117-118.
- Bellrose, F.C. 1959. Lead poisoning as a mortality factor in waterfowl populations. Ill. Nat. Hist. Survey Bull. 27:3.