

## INVESTIGATIONS OF WATERFOWL LEAD POISONING IN CALIFORNIA

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### Abstract.

The California Department of Fish and Game has been investigating waterfowl lead poisoning in California for the past three years. The availability of spent lead shot has been determined by collecting 661 sample plots from 18 waterfowl areas in California. To determine levels of ingested lead shot, gizzards were taken and examined from trapped, hunter and disease killed waterfowl. Of 14,768 gizzards examined, 982 (6.65%) contained one or more ingested lead pellets. Wingbones and tissue chemically analyzed for lead content have been little help in determining the actual effect of lead accumulation within the body. Raptors fed lead pellets to simulate acquiring spent shot from their prey were found to suffer no noticeable detrimental effects. During the three years of this study approximately 3,000 waterfowl have been necropsied. One hundred forty-five were diagnosed as lead poisoning.

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### INTRODUCTION

Waterfowl lead poisoning, resulting from ingested spent lead shot, has been known to occur since the late 1800's (Grinnell, 1894). Despite the relatively early discovery of this disease little field research had been done regarding the impact of plumbism on the waterfowl resource. In 1959 Frank C. Bellrose attempted to quantify lead poisoning as a mortality factor in waterfowl populations. According to his report, plumbism accounts for losses annually of 2-3% in the national waterfowl resource. California has been indicated as a state where the problem has the potential of being serious. It is the main wintering ground for the bulk of the birds in the Pacific Flyway (7-10 million) and hunting is concentrated on private clubs and public waterfowl management areas (Kozlik, 1977).

The California Department of Fish and Game has maintained disease surveillance and food habits investigation projects since the early 1940's. The Department supplied Bellrose with information during the 1940's and 1950's on California's lead poisoning situation. During this time the 2-3% loss projected by Bellrose's report was not found to exist.

Until recently, Bellrose had supplied the most comprehensive information on waterfowl lead poisoning for all areas in the United States.

Over the last three years the California Department of Fish and Game's Disease Section has amassed a far greater amount of information on California's lead poisoning situation than was gathered by Bellrose over the 15 years of his study.

## MATERIALS AND METHODS

Soil samples, to determine availability of spent lead shot, were taken from eighteen waterfowl areas in California.

Soil plot sites (1 meter x 1 meter x 10 centimeters) were picked and location to nearest landmarks were noted. A prefabricated steel measuring device one meter square and ten centimeters deep was placed into the soil with the top remaining flush with the surface. A square shovel was used to remove the soil which was placed in plastic lined burlap bags. Each bag was labeled and transported to the field station. The soil was then fluoroscopically examined and the pellets counted.

Marsh management practices were started at Grizzly Island WMA in an attempt to reduce the availability of lead shot to waterfowl.

Discing, prior to resampling, on Pond 17 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. The additional 20 tons of crushed rock was applied, one year later, in the same manner. Observations of hunter activity and waterfowl use of graveled areas was from temporary blind sites, using 8 x 40 binoculars, 20-60 power spotting scope and light intensifying scope. For hunter observations two observers separated by 50 feet were used to judge distances and waterfowl recovery (Rangefinder used was a Ranging-Rangematic 610).

Ingestion rates were determined by collecting gizzards from hunter and disease killed waterfowl at state, federal and private hunting areas. Gizzards were also collected as hunters left the areas. These were labeled as to area, species and date collected. Gizzards were then frozen and at the end of the season shipped to the Wildlife Disease Laboratory in Sacramento. Examination consisted of emptying the gizzard contents into a 500 ml beaker than 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 the examination.

Wingbones for lead analyses were removed from hunter, experimental 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 opened, 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 10 drops of redistilled  $\text{HNO}_3$  added, dried, then reashed at 450 degrees C for one hour and allowed to air cool. Five ml of 6N  $\text{HCl}$  were added and warmed to 80 degrees C. After cooling it was diluted with 10.0 ml deionized 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. Analysis of tissue were performed essentially this same way.

An experiment was conducted to determine raptor susceptibility to ingested spent lead pellets acquired from their prey. Three red-tailed hawks (Buteo jamaicensis) were fed lead shot in portions of meat. Each hawk was dosed twice weekly with from 2 to 6 pellets per dosage. Pellets were imbedded in small pieces of venison and force-fed to the hawks. Birds were fluoroscoped before each feeding to determine if any pellets were being retained from previous feedings. After twelve weeks all three birds were euthanized with 1 cc Euthanol intracardially. Wingbone and tissue samples were sent to Nimbus Water Pollution Control Laboratory for lead content analysis.

Waterfowl plumbism mortality was determined by advising all state and federal wildlife field personnel on waterfowl areas to ship all sick or dead individual animals to our laboratory. A representative sample of a die-off, especially those suspected of being lead poisoned, should be sent when large numbers of birds die. All waterfowl received are, fluoroscoped, examined for emaciation, atrophy of liver, heart and kidneys, impaction of proventriculus and gizzard with undigested food and grit, sluffing and bile staining of the gizzard mucosa, bile stained vent and finally 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.

Pick up procedures to collect all waterfowl dead, injured or sick on Delevan NWR included the use of an airboat, two trained retrievers, two 4-wheel drive vehicles and ten personnel.

The procedures for setting up waterfowl mortality transects were as follows.

Each waterfowl area will establish two transect areas, one within a hunting area the other on a nonhunting area. Transects will be run only on ponded areas. Approximately 10 percent of an area's water units should be included in the transect areas. That is, 10 percent of the ponded area open to hunting and 10 percent of the ponded area closed to hunting for a total of 10 percent of all ponded areas.

Transects should be run along levees and cross dikes of ponded units. Searches should be conducted on foot, motorized vehicles would be acceptable only if all birds are sure to be found. Dogs can and should be used if at all possible. The transects must be run in the same manner each time. Choose only areas in which consistent sampling methods can be used for the duration of this study. All birds, regardless of condition, must be picked up, including readily catchable sick or crippled birds.

Each bird picked up should be recorded by area, date and species. Accession numbers should accompany all birds sent to the laboratories for examination. Assession number should include area, transect and bird number (i.e., H.L. - 2-15, would be the accession number for the fifteenth bird picked up from transect 2 on Honey Lake WMA).

The laboratories will report findings of their diagnostic work to the wildlife areas for each sample sent. Each WMA will prepare a final report, before May 1, 1978, to the Department of Fish and Game Laboratory which will consolidate individual station reports.

Only birds in a freshly dead state should be submitted for examination. Samples are to be enclosed in plastic bags and placed in a waterproof container with ice. If immediate shipment is not possible refrigeration up to 48 hours after death is required, with freezing preferable only after 48 hours.

There will be two pick up days per week until October 24, 1977 when thereafter this

will be reduced to one.

Specific instructions were supplied to each waterfowl area regarding what days the transects would be run, and the number of samples to be sent to California Department of Fish and Game Disease Laboratory and the U.S. Fish and Wildlife Service Wildlife Health Laboratory at Madison.

## RESULTS

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

To determine availability of spent lead shot in soil 661 sample plots have been taken from 18 waterfowl areas (Tables I and II).

The areas sampled ranged from a low at Modoc NWR (no pellets were found in these samples) to a high at Grizzly Island's Pond 17 (115.2 pellets/plot). Considering this and reported lead poisoning losses on Pond 17, during September and October 1975 of approximately 100 waterfowl, Grizzly Island was chosen as an area to attempt marsh management practices for reduction of available spent lead shot. Six lanes were disced within the area previously sampled. Resampling after discing and before flooding showed a decrease of 11.69 percent in available pellets (Table II). The disced area was again sampled after flooding to measure any further reduction of pellets, at this time the samples have not yet been examined. Another aspect of marsh management was depositing gravel around the edge of the pond as an alternate grit source. Approximately 60 cubic yards were deposited during the summer of 1976 and an additional 20 tons during August 1977 to replenish what had been used. To date no known plumbism has occurred on Pond 17 since October 1975.

In an attempt to determine why Area 17 had such a high amount of available spent lead shot, six days were spent during the 1976-77 waterfowl season observing hunters (Table III). For the 39 shoot days this study covered, it is estimated that 15,500 shots were fired over the observed pond within Area 17 (~125 acres).

To determine the levels of ingested lead shot in California waterfowl 14,768 gizzards were examined. These gizzards were collected on 26+ waterfowl areas (Table V) from 1974-January 1978 and had an overall ingestion rate of 6.65 percent. The range of pellets found per gizzard was 0-756.

Chemical analysis of wingbones and tissue for accumulated lead levels have been completed on a total of 544 pintails (Anas acuta), 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 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.

Of the total sample 31 (6.21%) birds contained ingested shot. Samples from these

Table I. Waterfowl areas in California sampled for available spent lead shot.

Waterfowl Area	Number of plots taken (m <sup>2</sup> x10cm)	Mean Pellets/plot
Yolo Bypass	4	26.75
Lower Klamath N.W.R.	85	15.92
Tule Lake N.W.R.	11	2.27
San Luis N.W.R.	48	36.98
Humboldt Bay N.W.R.	10	46.30
Salton Sea N.W.R.	7	41.00
Sacramento N.W.R.	16	44.25
Colusa N.W.R.	11	6.82
Sutter N.W.R.	6	39.17
Delevan N.W.R.	8	9.50
Modoc N.W.R.	10	0
Kern N.W.R.	115	16.90
Grizzly Island W.M.A.	45	115.02
Grizzly Island W.M.A.	35	*
Los Banos W.M.A.	50	*
Volta W.M.A.	50	*
Mendota W.M.A.	50	*
Gray Lodge W.M.A.	50	*
Honey Lake W.M.A.	50	*
Total:	661	

\* - Examination of these samples has not been computed at this time.

Table II. Incidence of available spent lead shot found in soil samples 1 meter x 1 meter x 10 centimeters taken from California waterfowl areas.

Area	Sub Area	Number of plots	Ave. Number of pellets/plot	Range	Approx. Number of available pellets/acre
Lower Klamath N.W.R.	White Lake Unit	7	6.57	0-22	26,500
"	" Unit 1	9	29.33	15-58	118,700
"	" Unit 4	6	20.83	2-52	84,300
"	" Unit 6	12	2.25	0-7	9,100
"	" Unit 7	25	9.8	2-23	39,600
"	" Unit 8	25	25.80	4-60	104,400
"	" Unit 12	1	1	1	4,000
Tule Lake N.W.R.	Frog Pond	11	2.27	0-4	9,100
Yolo Bypass	Private Duck Club	4	26.75	15-39	108,200
Grizzly Island W.M.A.	Pond 17	25	121.68	82-188	492,400
"	" Pond 17 After Discing	20	107.45	56-181	434,800
San Luis N.W.R.	Moffet Field	20	29.95	1-68	121,200
"	" Big Lake	15	60.93	6-175	246,600
"	" West Marsh	5	14.0	1-34	56,600
"	" Loaf Lake	5	27.0	17-42	109,300
"	" South Marsh	3	19.0	8-38	76,900
Humboldt Bay N.W.R.	-	10	46.3	17-80	187,400
Salton Sea N.W.R.	-	7	41.0	34-60	165,900
Sacramento N.W.R.	Tract B	4	24.5	10-30	99,100
"	" Pool 11	6	74.0	41-109	299,500
"	" Tract 22	6	27.67	10-56	111,900
Colusa N.W.R.	-	10	1.1	0-5	4,400
"	" Y.C.C.	1	64		259,000
Sutter N.W.R.	-	6	39.17	9-83	158,500
Delevan N.W.R.	Tract 27	8	9.5	1-23	38,400
Modoc N.W.R.	-	10	0	0	0
Kern N.W.R.	-	115	16.9	1-79	68,400

Table III. Chart for Hunter Observations on Grizzly Island WMA (Pond 17)

Groups	# of Hunters	Male	Female	Approx. Ages	Dog	Shots Fired	**	-**	# Birds Down	Recovered	Not Recovered	Date
I	2	2		30		40	32	8	13	10	3	10/23/76
II	3	3		10,45	X	96	36	60	19	11	8	
III	3	2	1	25,30	X	27	20	7	6	5	1	
IV	2	2		35		30	20	10	8	8		
V	1	1		30		7	3	4	1	1		11/3/76
VI	1	1		50	X	4	3	1	1	1		
VII	1	1		40		3	2	1	2	1	1	
VIII	2	2		30		10	7	3	2	1	1	
IX	2	2		40	X	11	10	1	2	2		
X	2	2		18,40		52	32	20	3	3		12/4/76
XI	1	1		30		6	6					
XII	1	1		25		34	16	18	2	1	1	
XIII	2	2		20		27	9	18	1	1		
XIV	2	1	1	25	X	6		6				
XV	1	1		25		12	2	10	1	1		
XVI	2	2		25,30		72	44	28	10	9	1	12/19/76
XVII	1	1		40	X	2	2		1	1		
XVIII	2	2		30		19	18	1	7	6	1	
XIX	1	1		50		38	19	19	6	6		
XX	1	1		50		20	3	17				12/29/76
XXI	2	2		15		6	6		1	1		
XXII	3	3		15,35		46	19	27	4	4		
XXIII	2	2		30		16	15	1	5	5		
XXIV	3	3		30	X	32	20	12	2	2		
XXV	1	1		40		7	3	4				
XXVI	1	1		50		39	14	25	2	2		
XXVII	2	2		18		41	32	9	2	2		1/8/77
XXVIII	2	2		30		16	11	5	3	3		
XXIX	2	2		25		7	2	5				
XXX	1	1		35		31	21	10	5	3	2	
XXXI	2	2		25		7	7		1	1		
XXXII	1	1		30		19	11	8	1	1		
Totals	55	53	2	30 Avr.	7	783	445	338	111	92	19	

\* indicates shots taken under 50 yds.      \*\* indicates shots taken over 50 yds.

Table IV. Incidence of ingested lead shot in California Waterfowl.

Species	Total Fluoroscoped	Number with Ingested shot	Percent with Ingested shot	Number with Ingested shot		Percent of Total with Ingested shot	
				1 shot	2+ shot	1 shot	2+ shot
Mallard	4412	304	6.89	241	63	5.47	1.42
Pintail	6249	529	8.46	344	185	5.50	2.96
Wigeon	440	7	1.59	5	2	1.14	.45
Gadwall	78	3	3.84	3	-	3.84	-
Teal	1309	2	.15	1	1	.07	.07
Shoveler	684	10	1.46	8	2	1.17	.29
Diving Ducks	291	18	6.18	11	7	3.78	2.40
Geese	272	76	7.82	56	20	5.76	2.06
Swans	333	33	9.91	11	22	3.30	6.61
Total	14,768	982	6.65	680	302	4.60	2.05

Table V. Summary Gizzard Data 1975-1977 Waterfowl Season

Area Samples Collected	Number of Gizzards	Number of Gizzards with Ingested Shot	
		Number	Percent
Honey Lake W.M.A.	54	5	9.25
Gray Lodge W.M.A.	1225	107	8.73
Grizzly Island W.M.A.	344	44	12.79
Joice Island W.M.A.	77	8	10.38
Volta W.M.A.	523	36	6.88
Los Banos W.M.A.	249	18	7.22
Mendota W.M.A.	669	68	10.16
Imperial W.M.A.	674	20	2.97
Colusa N.W.R.	414	36	8.69
Delevan N.W.R.	914	108	11.82
Sacramento N.W.R.	753	59	7.83
Sutter N.W.R.	359	13	3.62
Tule Lake N.W.R.	300	12	4.00
Lower Klamath N.W.R.	749	72	9.61
Modoc N.W.R.	178	3	1.68
Humboldt Bay N.W.R.	172	11	6.39
San Francisco Bay N.W.R.	230	7	3.04
San Pablo Bay N.W.R.	28	1	3.57
Kesterson N.W.R.	296	10	3.37
Merced N.W.R.	432	32	7.40
San Luis N.W.R.	375	14	3.73
Kern N.W.R.	200	16	8.00
Grasslands Water District	971	28	2.88
Butte Sink	1320	70	5.30
Ventura Co. Game Preserve	1305	35	2.68
Sacto-San Joaquin Delta	672	55	8.18
*Other areas	1285	94	7.31
Total	14,768	982	6.65

\* Gizzards submitted for examination from disease dieoffs state wide and private duck clubs.



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 twenty-five (25) pintail and one (1) mallard contained from 2 to 33 well worn ingested pellets each (Table VI).

In the fall of 1976 eighteen (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 found in waterfowl.

Wingbone lead level results ranged from 1.6-868 ppm, the average being 161 ppm. Six (6) were under 10 ppm, seven (7) were over 100 ppm. Breast muscle levels ranged from 0.5-1.8 ppm. Thirteen (13) 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.

The results of the raptor-lead tests can be found in Table VII. Upon necropsy no birds exhibited signs of plumbism or any other malady.

Actual mortality due to plumbism has been investigated by using necropsy records kept by the California Department of Fish and Game's Disease Section. During the three years of this study approximately 3,000 waterfowl have been sent to or collected by this section for necropsy purposes. One hundred forty-five of these were diagnosed as lead poisoning.

In an effort to quantify lead poisoning losses compared to other mortality factors a sweep was made January 24, 1977 on Delevan NWR to collect all available samples of dead, sick or injured waterfowl. Approximately 750 waterfowl were collected during this one day period, 300 were discarded before attempting diagnosis as being too decomposed or scavenged upon to examine. Delevan was picked due to the finding, at that time, that gizzards from their hunter killed waterfowl had the highest ingestion rate of any area in the state (Table VIII).

More recently increased waterfowl surveillance has been initiated on fourteen waterfowl areas in California. Each area has established waterfowl mortality transects which are run weekly. Since these transects have begun 1,316 waterfowl have been submitted for examination, 40 (3.04%) have been diagnosed as plumbism (Table IX). These transects will continue until the vast majority of California's migratory waterfowl have left the state for their northern breeding grounds.

There have been three confirmed lead poisoning "die-offs" within the past three years. One occurred 10 miles south of Bakersfield on a private duck club in Kern County during December 1974-January 1975. Another was at Grizzly Island WMA during September-October 1975. Field personnel at both locations placed losses at approximately 100 waterfowl. The third was at Lower Klamath NWR during December 1976 and January 1977 with a reported estimated loss of 4,000 waterfowl. This section believes that field estimate to be artificially high and the actual loss to be closer to 1,000 birds. Based on laboratory reports, confirmed lead poisoning mortality and waterfowl mortality transects estimated yearly waterfowl mortality due to plumbism is believed to be from 2,000-5,000 birds statewide.

Table VI. 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.

Table VII. Results of raptor - lead ingestion tests.

Red-tailed hawk no.	Dosage	Bone	Pb (mg/kg dry weight)		
			Flesh	Liver	Kidney
1	2*	22	1.3	6.0	7.7
2	4**	15	1.1	3.7	10
3	6***	18	1.2	5.6	8.2

\* = 2 pellets #6 lead shot twice weekly.

\*\* = 4 pellets #6 lead shot twice weekly.

\*\*\* = 6 pellets #6 lead shot twice weekly.

Dosing ended after 12-week period; euthanized June 25, 1976 - lcc Euthanol.

Table VIII. Dead Waterfowl Collection - Delevan N.W.R. 1/24/77

Species	Fowl Cholera	Crippling loss	Plumbism	Other or No diagnosis
Pintail	52	16	32	11
Mallard	5	4	2	3
Wigeon	37	25	1	13
Gadwall	1			
Shoveler	11	2		1
G.W. Teal	5	2	1	1
Diving Ducks	51	4		9
Geese	97	45	8	13
Total	259 - 57%	98 - 22%	44 - 10%	51 - 11%

None of the birds in the "No diagnosis" column contained ingested lead shot. Most birds were put there when upon examination they were found to contain severely decomposed viscera, no obvious malady could be found or another disease such as aspergillosis was diagnosed as the cause of death.

Table IX. Waterfowl Losses by Area-Waterfowl Mortality Transects

Month	Area	Fowl Cholera	Hunter Crippling Loss	Botulism	Plumbism	Other or No Diagnosis	Total
October 1977	Sacramento N.W.R.	1		38		13	52
"	San Francisco Bay N.W.R.			1		1	2
"	Tule Lake N.W.R.		4			4	8
"	Lower Klamath N.W.R.		4			1	5
"	Delevan N.W.R.		3	4		2	9
"	Kern N.W.R.		1				1
November 1977	Tule Lake N.W.R.	35	11			21	67
"	Lower Klamath N.W.R.	101	18		3	28	150
"	Sacramento N.W.R.	15	8			2	25
"	Delevan N.W.R.	31	9		3	18	61
"	San Francisco Bay N.W.R.					2	2
"	Sacto-San Joaquin Delta	1			1	2	4
December 1977	Tule Lake N.W.R.	17	6			5	28
"	Lower Klamath N.W.R.	4	6		1		11
"	Sacramento N.W.R.	22	11		7	11	51
"	Delevan N.W.R.	57	30		16	23	126
"	Merced N.W.R.					1	1
"	Los Banos W.M.A.	2	29			5	36
"	Mendota W.M.A.		2			3	5
"	Grizzly Island W.M.A.	17				3	20
"	San Francisco Bay N.W.R.					1	1
"	Kern N.W.R.		2				2
"	Sacto-San Joaquin Delta	312	16		2	25	355
January 1978	Tule Lake N.W.R.	9	5				14
"	Lower Klamath N.W.R.	1			2	1	4
"	Sacramento N.W.R.	7	6				13
"	Delevan N.W.R.	14	2			1	17
"	Los Banos W.M.A.	10	14			4	28
"	Mendota W.M.A.	2	13			6	21
"	Grizzly Island W.M.A.	26	7			5	38
"	Kern N.W.R.		4			1	5
"	Gray Lodge W.M.A.	1	3			1	5
"	Sacto-San Joaquin Delta	106	2		5	36	149
Total	All Areas	791	216	43	40	226	1316

## DISCUSSION

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

The importance of this study and its continuance is now even greater due to proposed implementation of steel shot in California. This move to steel shot has been questioned by both private organizations and state conservation agencies. At this time there is not sufficient data on the effects of lead on waterfowl or the actual benefits steel shot has had in areas where it has already been implemented. Until more of these questions can be answered steel shot will neither be wisely administered nor widely accepted in California.

Ideas concerning what aspects of plumbism to study has changed considerably over the last three years. Two years ago wingbones were being collected and analyzed in hopes of finding the relation between ingesting lead shot and lead accumulation in the body. This was abandoned when the numerous variables controlling the uptake of lead into the bones could not be separated, i.e. age, diet, size, unknown number of previous ingested pellets, lead contribution from other than ingesting lead pellets, etc.

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

New areas receiving attention by this study are, development of more precise and less time consuming techniques for diagnosis of plumbism in water fowl. To determine the effects of lead on wild birds, some will be trapped, banded and dosed with low levels of lead and band returns studied. Areas changing to steel shot will be monitored to determine changes in hunter harvest and attitudes. Waterfowl crippling, plumbism and lead ingestion rates will also be monitored on these areas.

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

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