LEAD AND MERCURY IN LESSER SNOW GEESE WINTERING IN LOUISIANA

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Abstract: Wintering Lesser Snow Geese (*Chen caerulescens*) were analyzed for lead and mercury residues and lead shot ingestion. Lead shot ingestion paralleled assimilation of lead residues. Snow geese collected in rice-growing areas had significantly ($P < 0.01$) more lead residues than marsh area geese. This was attributed to different soil firmness, feeding habits, and hunting practices in the 2 areas. Recent deposits of lead apparently played a major role in lead shot ingestion because lead residues and shot ingestion were greatest during the hunting season. Mercury residues significantly ($P < 0.05$) declined over the wintering season.

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Southwest Louisiana's marshes and rice-growing areas are one of the most important wintering areas for Lesser Snow Geese and many other migratory birds in North America. The snow goose is an extremely important recreational species. Recent snow goose die-offs attributed to lead poisoning, and the impending switch from lead to steel shot for waterfowl hunting in portions of Louisiana prompted the initiation of a study on potential toxicants in Lesser Snow Geese. The heavy metals (lead and mercury) portion of the study is presented in this paper.

Historically, the snow goose in Louisiana wintered almost exclusively in remote coastal marshes, but in the late 1940's, they began expanding their normal wintering range to include rice farming lands north of the coastal marsh (Lynch 1975). Snow geese using rice-growing areas are obviously more closely exposed to agricultural chemicals and to hunting than snow geese in the coastal marsh which is less accessible and has approximately 150,000 ha in wildlife refuges.

Rice seed was formerly treated with a methyl mercury fungicide (Ceresan L) to protect against rice seedling blight, however the sale of rice treated with Ceresan L was banned after 1974 (Personal communication, R. Crawford, Environmental Protection Agency, February 1977).

Waterfowl hunting in Louisiana is traditional and important economically and recreationally. Many rice fields of southwest Louisiana have been subjected to heavy duck hunting pressure for decades, and the expanded range of the snow goose has contributed to increased hunting value and use of these areas. Heavy hunting pressure has led to deposition of large quantities of lead pellets on the firm soils of the rice-growing area, and has resulted in lead poisoning of snow geese in the past. Bellrose (1959) documented 3 die-offs of snow geese in the Mississippi flyway attributed to lead poisoning, 2 in Nebraska and 1 at Vinton, LA, a rice-growing area. Bateman (1975) reported that an estimated 2,000 snow geese were lost in a lead-poisoning outbreak in the rice lands north of Lacassine National wildlife Refuge in 1973. A. Brazda (unpublished report, U.S. Fish and Wildlife Service, 1977) noted that approximately 500 snow geese died of lead poisoning in December 1976, most of which were also in the vicinity of Lacassine National Wildlife Refuge (Personal communication, B. Brown, Manager, Lacassine National Wildlife Refuge, February 1977). Objectives of this study were: (1) to determine residue levels of mercury and lead in Lesser Snow Goose tissues from rice-growing and coastal marsh areas of Louisiana, and (2) to determine the incidence of lead shot ingestion by Lesser Snow Geese in Louisiana.

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METHODS

Study Area

This study was conducted in 5 parishes of southwest Louisiana (Fig. 1). Two general land types which are approximately separated by the Intracoastal Waterway occur in the

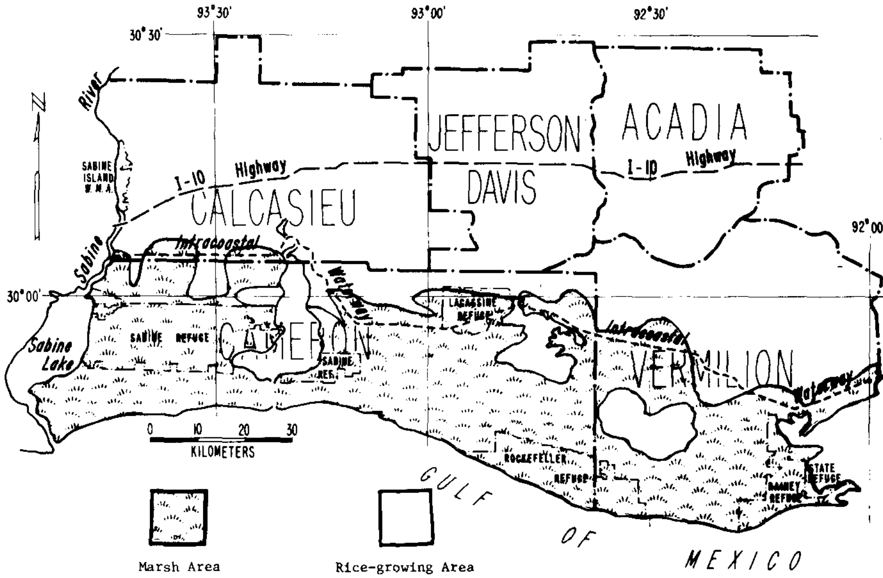

Fig. 1. The southwest Louisiana study area, and areas within it classified as rice and marsh.

study area, coastal prairie and coastal marsh. The coastal prairie, approximately 673,000 ha, was originally a tall grass prairie with meandering tree and shrub lined bayous, but is now primarily a rice-growing area. Soils in this area have a silt loam or silty clay surface and clay or silty clay subsoils, and a firm consistency when moist. (Lytle 1968). Some of the common genera and species of plants in the coastal prairie are: alligatorweed (*Alternanthera philoxeroides*), eastern baccharis (*Baccharis halimifolia*), Walter's millet (*Echinochloa walteri*), water hyacinth (*Eichornia crassipes*), spikerush (*Eleocharis* spp.), yankee weed (*Eupatorium capillifolium*), fimbristylis (*Fimbristylis mileacea*), panicum (*Panicum* spp.), smartweed (*Polygonum* spp.) and sagittaria (*Sagittaria* spp.).

The approximate size of the coastal marsh or Chenier Plain of southwest Louisiana is 513,500 ha. Soils are generally classified as peats, mucks, or clays with brown peats and black mucks occupying level and shallow concave areas. These may contain 30 to 85 percent organic matter and may be 0.3 to 3.65 m or more thick (Lytle 1968). Some of the major plant species of the coastal marsh are: marshhay cordgrass (*Spartina patens*), maidencane (*Panicum hemitomon*), oystergrass (*Spartina alterniflora*), saltgrass (*Distichlis spicata*), black rush (*Juncus roemerianus*), roseau (*Phragmites communis*), bulltongue (*Saggitaria falcata*), spikerush (*Eleocharis* spp.), and alligatorweed. Prevalent species of open water areas are: widgeongrass (*Ruppia maritima*), duckweed (*Lemna minor*), Eurasian watermilfoil (*Myriophyllum spicatum*), muskgrass (*Chara vulgaris*), coontail (*Ceratophyllum demersum*), and dwarf spikerush (*Eleocharis parvula*) (Chabreck 1972).

Study Material-Collection

Snow geese were collected during 3 periods: (1) post migration, fall (October and November), (2) winter (December, January, and to the end of the hunting season, 8 February 1976), and (3) pre-spring, spring migration (February and March). Ten to 18 snow geese were collected in each period from both rice-growing and marsh areas, and classified by age and sex. Age was determined by plumage characters (Bellrose 1974) and gonad size. Sex was determined by cloacal examination and confirmed internally by presence of ovaries or testes. Twelve geese were collected in Missouri in spring and examined for lead pellet ingestion, and 9 of these geese were analyzed for lead and mercury residues.

In addition to whole birds collected by the above system, snow goose gizzards were collected to determine lead pellet ingestion levels. Gizzards were obtained from professional waterfowl pluckers, waterfowl hunters, snow geese confiscated after game law violations, and those collected for residue analysis.

Tissue Handling and Analysis

Immediately after collection geese were wrapped in aluminum foil and kept cool in ice chests in the field and transported to the laboratory for tissue extraction. Tissues collected for analysis were one unbroken wing, liver, and stomach (esophagus, proventriculus, and gizzard). Livers were wrapped in aluminum foil and stored in a labeled plastic bag, along with a wing and stomach from each goose, in a freezer.

An ocular estimate of fat reserves was made on each snow goose when tissues were collected. Each goose was assigned a value of 1, 2, 3, or 4 with 1 = none to poor fat reserves, 2 = fair, 3 = good, and 4 = excellent.

Stomachs were examined for lead pellets. Gizzards were first examined for pellet holes in order to prevent possible confusion between lead pellets eaten by snow geese and pellets penetrating the gizzard from shooting. The stomach was then cut open with a scalpel and the contents were scraped into a porcelain pan. Any material left in the gizzard was flushed into the pan with a stream of water from a wash bottle. The gizzard lining and its folds were then examined for embedded or hidden pellets. Finally, stomach contents in the porcelain pan were carefully examined for lead, and the number of pellets recorded.

Mercury and lead residues were analyzed in liver and wing bones, respectively. Tissues were analyzed by contract laboratories of the Patuxent Wildlife Research Center. The Environmental Trace Substances Research Center in Columbia, MO analyzed snow goose livers for mercury by the cold vapor technique described by Uthe et al. (1970). The WARF Institute, Madison, WI, analyzed lead residues in wing bones by the Extraction of Chelate: A.O.A.C. (25.065-25.070) (1975) Second Edition.

The Department of Experimental Statistics at Louisiana State University guided the authors in experimental design of the research and in analysis of data. Correlations among variables were determined. Data were also analyzed by a least squares analysis of variance to evaluate differences between means of the levels of the various effects studied, period, sex, age, and area with 3 levels of period, 2 of sex, 2 of age, and 2 of area. Period, sex, age, and area interactions were also evaluated. Means were adjusted because sample sizes differed.

RESULTS AND DISCUSSION

Eighty Louisiana wintering snow geese were analyzed for lead and 76 for mercury (Table 1). Nine spring migrating geese from the Schell-Osage Wildlife Area in west-central Missouri were analyzed for lead. Lead and mercury residues were found in all tissues analyzed.

Table 1. Residues of lead in wing bones and mercury in livers of Lesser Snow Geese 1975-1976.

Heavy metal	*Sample size*	*Mean (ppm)*	*Range (ppm)*
Lead			
Louisiana sample	80	8.763	0.5 - 92.8
Missouri sample	9	5.977	1.0 - 15.0
Mercury	76	0.037	0.006 - 0.196

Lead Residues and Lead Shot Ingestion

A highly significant difference ($P < 0.01$) in lead residues in wing bones was found between marsh and rice area geese.

Snow geese from the rice-growing area averaged 13.0 ppm lead while marsh area geese averaged 4.8 ppm. No other significant differences were found. Lead ingestion rates also support the hypothesis of greater availability of lead to snow geese in the rice-growing area. The incidence of lead shot ingestion in snow geese in the rice area was 10.0 percent (21 of 209). Snow geese from the marsh had a lead shot ingestion rate of 3.7 percent (9 of 241).

A firm soil substrate has been implicated as a contributor to increased lead ingestion in waterfowl by several authors (Anderson 1975, Bateman 1975, Bellrose 1959, Bishop 1972, Bachman and Low 1973, Smith, unpublished report, Oregon Wildlife Commission 1974, Trainer and Hunt 1965). Differences in settling rates for lead shot in various sediment types are prounounced, and very important in determining the availability of lead shot to feeding waterfowl (U.S. FWS 1974). Coastal prairie soils of the rice-growing area are firm (Lytle 1968) and are capable of holding lead pellets near the surface for long periods of time (Bateman 1975). Firm soils and heavy hunting pressure in some fields point to the rice-growing area as a lead poisoning problem area which has been demonstrated by recent records of die-offs. The peat and muck soils of the coastal marsh on the other hand, may not constitute as great a problem because they probably do not retain lead pellets near the surface as long.

Different habits of snow geese while in marsh and rice areas and different hunting practices in these areas may influence lead ingestion. Feeding near blinds where recent lead shot deposits are greatest is probably less likely to occur in marsh areas than in rice areas. Most snow goose harvest in the marsh is incidental to duck hunting, which is normally done near open water. Snow geese are taken predominantly by attracting them into shotgun range or pass shooting them as they travel to and from feeding and resting areas in the marsh. Hunting in the rice area on the other hand, usually takes place in a feeding area where returning snow geese could ingest lead at some later date. Most feeding in the marsh—grubbing for roots rhizomes, seeds, and tubers—is done on burned areas, which would probably make lead ingestion likely if large amounts of lead were present. Newly burned marsh areas are attractive to snow geese, and as new areas are burned, snow geese tend to move to those areas to feed. The lack of hunting pressure on feeding areas and periodic movement to new feeding areas probably helps to minimize lead shot availability.

Lead residues assimilated in juvenile snow geese demonstrate that greater amounts of lead are available in the rice-growing area than in the marsh area (Table 2). Residues

Table 2. High and low levels[a] of lead residues in rice versus marsh juvenile snow geese over the wintering season 1975-1976.

	Rice		*Marsh*	
	High level (ppm)	*Low level (ppm)*	*High level (ppm)*	*Low level (ppm)*
	10.2	0.6	7.1	0.6
	8.9	0.8		0.5
FALL		0.5		0.5
		0.5		0.5
		0.5		0.7
	5.0	0.9	11.2	0.6
	18.1			0.5
WINTER	12.0			0.5
	92.8			0.6
	1.9			1.0
	12.5	0.6	18.3	0.7
	4.0	1.0	1.9	0.7
SPRING	9.7			0.5
	12.2			0.8
	35.9			0.5
				0.5

[a]High range geese had greater than 1.0 ppm lead in the wing bone and low range geese had 1.0 ppm or less lead residues.

were divided into high (> 1.0 ppm) and low (< 1.0 ppm) levels of lead in wing bones (Table 2). In fall, the number of juvenile geese in the high and low range categories of marsh and rice areas are almost identical with low range geese predominating; however, in winter and spring in the rice area, 10 of 13 geese were classified as high range and in the marsh, 11 of 14 classified as low range.

Residues in juvenile snow geese are noteworthy because they could only have been assimilated in the 4 to 9 months since hatching, and there could be no residues from previous exposure to confuse interpretation of recent residue trends. Evidence indicates some carryover of lead stored in bones may have occurred, because fall residue means for adults were approximately 4-fold greater than juveniles (8.6 vs 2.3 ppm, respectively) (Table 3). Residue levels in adults were 1.6 ppm greater in winter and 2.6 ppm greater in spring than those in juveniles.

Table 3. Summary of lead residues in wing bones and percent lead injestion in Lesser Snow Geese by Period, Age, and Area.

	Marsh		*Rice*		*Period Totals*	
	X lead residue (n) (ppm)	*% with shot (n)*	*X lead residue (n) (ppm)*	*% with shot (n)*	*X lead residue (n) (ppm)*	*% with shot (n)*
			FALL			
AHY	4.2 (6)	0.0 (9)	13.5 (7)	0.0 (16)	8.6 (13)	0.0 (25)
HY	1.6 (6)	12.5 (8)	3.1 (7)	11.8 (17)	2.3 (13)	12.0 (25)
AHY+HY	3.2 (12)	6.0 (17)	7.7 (14)	6.0 (33)	5.5 (26)	6.0 (50)
			WINTER			
AHY	12.2 (7)	7.5 (93)	14.6 (5)	17.0 (47)	13.7 (12)	10.7 (140)
HY	2.4 (6)	0.0 (82)	21.8 (6)	11.7 (77)	12.1 (12)	5.6 (159)
AHY+HY	7.3 (13)	4.0 (175)	18.5 (11)	13.7 (124)	12.9 (24)	8.0 (299)
			SPRING			
AHY	5.3 (8)	3.0 (37)	15.1 (7)	6.0 (32)	9.8 (15)	4.3 (69)
HY	3.0 (8)	0.0 (12)	10.8 (7)	0.0 (20)	7.2 (15)	0.0 (32)
AHY+HY	4.1 (16)	2.0 (49)	13.9 (14)	3.8 (52)	8.5 (30)	3.0 (101)
			AREA TOTALS			
AHY	7.1 (21)	5.7 (139)	14.3 (19)	10.5 (95)	10.7 (40)	7.7 (234)
HY	2.6 (20)	1.0 (102)	11.8 (20)	9.6 (114)	7.2 (40)	5.5 (216)
AHY+HY	4.8 (41)	3.7 (241)	13.0 (39)	10.0 (209)	8.7 (80)	6.6 (450)

Another factor which may contribute to the difference in lead residues in snow geese of marsh and rice-growing areas is that Rockefeller Refuge, where marsh geese were collected, is not hunted. Snow geese commonly feed off the refuge and daily flights to and from the hunted marshes around the refuge were observed. Lead shot ingestion data, which paralleled lead residue data, involved gizzards collected primarily from waterfowl hunters on private land.

Mean lead residues in males and females were about equal (9.6 and 8.3 ppm, respectively).

The fluctuations in lead residues over the wintering periods varied in a similar manner in both rice and marsh areas, with lead residues consistently higher in the rice-growing area. Residues were lowest in the fall when snow geese had been in Louisiana only a short time and the hunting season had not yet begun. Even at this time, residue levels in rice area geese (collected on and in the vicinity of Lacassine National Wildlife Refuge) were higher than those from marsh area geese. Residue levels were highest in winter in both areas. Residues in wing bones averaged 18.5 ppm in rice area geese and 7.3 ppm in marsh area geese. Ingestion of lead shot was also greatest in the winter. The percentage of geese that had ingested lead shot in winter was 13.7 (17 of 124) in the rice area and 4.0 percent (7 of 175) in the marsh. Higher lead pellet ingestion rates and lead residues in wing bones in winter indicate that lead availability and thus ingestion was greatest during the hunting season.

During spring, lead residues in wing bones declined to an average of 13.9 ppm in the rice area, and 4.1 ppm in the marsh. Lead shot had been ingested by about 4 percent of the geese from the rice area (2 of 52) and 2 percent (1 of 49) of those from the marsh area. Apparently lead was being ingested at a lower rate in spring than it was in the winter. Consequently less lead residue was being stored in wing bones, and some excretion of lead residues and lead pellets presumably took place. This could account for lower lead residues found in snow geese in the spring. Most of the geese that ingested lead shot had ingested one pellet (66.7%); the largest number of lead shot observed in a snow goose gizzard was 7.

Lead residues in wing bones and incidence of lead ingestion cannot be translated into mortality estimates because of the influence of diet at the time the pellets are consumed (Bellrose 1959 and U.S. Fish and Wildlife Service 1974). The diet of waterfowl in relation to lead dosage and its toxic effects have been studied by many authors and they agree that it is an important factor influencing morality (Jordon and Bellrose 1950, and 1951). Whole corn has been found to be one of the poorest diets in terms of influencing mortality of lead poisoned waterfwl (Grandy et al. 1968, Irby et al. 1967, and Jordan and Bellrose 1951. Selenium (a trace mineral that is deficient in corn) has been found to reduce mortality from lead poisoning in waterfowl when 1 ppm is added to a commercial ration or corn diet (U.S. Fish and Wildlife Service 1974). Soft green plants in the diet also reduce toxicity of lead to mallards (Jordan and Bellrose 1951). Apparently, nutritional properties and texture are the main factors that influence toxicity.

The diet of snow geese in the rice-growing area is dominated by waste rice grain until late December, when it shifts to rye grass (Linscombe 1971). The possibility of ingesting lead would be less for snow geese eating rye grass than for those eating rice. Snow geese generally feed on the above ground portions of rye grass, while rice grain is picked up off the soil surface or probed for in the soil where lead could easily be picked up. Rice grain is probably similar to corn in its effect on toxicity (West 1977). Die-offs of snow geese from lead poisoning, all of which have occurred during the hunting season in the rice-growing areas of Louisiana, are thus understandable.

The mean lead value in 9 snow geese collected in Missouri in spring (6.0 ppm) was slightly less than the mean for Louisiana snow geese in spring (8.8 ppm). Mean residue levels of adults in spring (9.2 ppm in Missouri v. 9.8 ppm in Louisiana) were approximately equal, while mean residues in juveniles were greater in Louisiana (4.3 ppm in Missouri and 7.2 ppm in Louisiana.) No lead pellets were found in 12 snow geese collected in Missouri.

Mercury

Mercury residues declined significantly ($P < 0.05$) in the wintering season (Fig. 2). The similar residue levels in geese from marsh and rice areas and the consistent decline in both areas indicate that mercury was probably assimilated before the geese arrived in Louisiana. Adult snow geese had only slightly higher residue levels than juveniles (0.04 vs. 0.03 ppm), indicating that most of the mercury was recently assimilated. Levels of mercury in male and female geese from rice and marsh areas were approximately equal in all 3 periods. Areas that snow geese use in Louisiana are apparently relatively "clean" of mercury residues.

Mercury residue levels in snow geese (Table 1) were below the levels usually associated with adverse effecs in other species. Fimreite et al. (1970) found that hen pheasants with 3 to 13 ppm methyl mercury in the liver had lowered hatching success. A diet containing 3 ppm mercury reduced reproductive success in mallards (Heinz 1974). Levels of mercury in muscle of pheasants that were experimentally killed by mercury ingestion ranged from 20 to 45 ppm (Selikoff 1971). Residue levels would probably have been higher in the liver than in the muscle of these pheasants (Swanson et al. 1972, and Vermeer and Armstrong 1972). The highest residue level found in a Louisiana snow goose liver (0.196 ppm) was well below the 0.5 ppm guideline of the U.S. Food and Drug Administration, for human consumption of fish and shellfish.

The probable major source of the higher residues of mercury in snow geese in the fall is a seed treatment used on Canadian and United States cereal grains. Krapu et al. (1973) stated that fungicides containing methyl mercury have been used widely since the 1930's to treat cereal grain seeds prior to planting. Mercury seed dressing is primarily in the form of methyl mercury dicyandiamide which is more toxic to wildlife than other mercury formulations (Tucker and Crabtree 1970). Mercury levels were elevated in

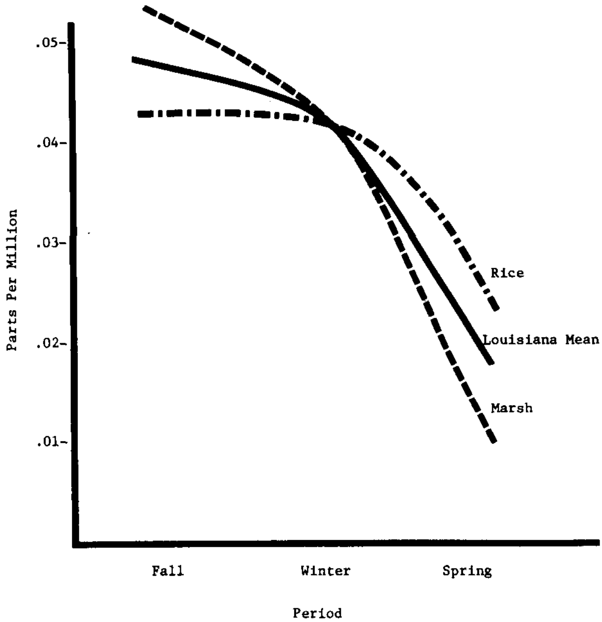

Fig. 2. Change in mean residue levels of mercury in livers of Lesser Snow Geese wintering in Louisiana 1975-1976.

pheasants collected in southern Alberta, Canada, where seed dressings are extensively used (Firmreite 1969). Gowen et al. (1976) reported that in an area where mercury had been used as a wheat seed treatment, mercury concentrations averaged 0.12 ppm in the soil and 0.29 ppm in grain. Mean residue levels of mercury in livers of female pintails collected in North Dakota in preplanting periods were 0.13 ppm and in postplanting periods 1.165 ppm (Krapu et al. 1973). In most years, few snow geese would be directly exposed to mercury-treated seed during the planting season, because planting takes place at about the time reproduction begins on the northern breeding grounds. They most likely assimilated the mercury during fall stopovers in areas where seed is treated, by ingestion of mercury in seeds, soil, and plants.

Fat Reserves

Changes in fat reserves probably stem from physiological responses to migration and the oncoming breeding season rather than from the effects of chemical residues. Mean fat reserves by period (on our scale of 1-4) were: 2.5 (fall), 2.6 (winter), 2.7 (spring), in Louisiana and 2.0 in Missouri. Correlations of fat reserves with lead and mercury residues were not significant.

Adults of both sexes (males 2.7 and females 2.8) had slightly greater average fat reserves than did juveniles (males 2.6 and females 2.5). Marsh and rice area snow geese had essentially the same mean fat reserves during the winter (2.6) and the spring (2.7).

CONCLUSIONS

Lesser snow geese using the rice-growing area ingested and assimilated greater amounts of lead than did snow geese using marsh areas.

Mercury was assimilated by snow geese primarily outside the Louisiana study area.

The intake of lead by snow geese wintering in Louisiana as reflected by lead shot in the gizzard and lead residues in wing bones, was greater during the hunting season than before or after it. This implies that the amount of lead ingested by snow geese is primarily a reflection of recent deposits of lead pellets. Outbreaks of lead poisoning in snow geese could possibly be eliminated by requiring that non-toxic shot be used in waterfowl hunting in the primary wintering area of snow geese north of the Intracoastal Waterway. An approximate northern boundary of this area recognizable to hunters would be Interstate 10 highway (Fig. 1).

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