Bull. Environ. Contam. Toxicol. (1985) 34:295–300

Bulletin of Environmental Contamination and Toxicology

Bird Use and Heavy Metal Accumulation in Waterbirds at Dredge Disposal Impoundments, Corpus Christi, Texas

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The disposal of dredged material resulting from the creation and maintenance of navigation waterways and harbors has become a matter of national concern. In recent years, the search for new energy reserves in bays and estuaries has increased dramatically, thereby compounding the problem of what to do with dredged material. There are several alternatives for disposal of dredged material including (1) piling the material in mounds adjacent to the dredged site thereby creating man-made islands; (2) hauling or piping the material to mainland dump sites; and (3) impounding areas along the shoreline and pumping the material to these open impoundments. We studied sites resulting from the latter method of dredge disposal.

Often the shorelines of bays and estuaries around port cities are lined with industrial complexes including refineries, chemical plants, and smelting facilities. Usually the waters and sediments of these impacted bays are contaminated with heavy metals and other toxic substances introduced by industrial dumping. One such area is Corpus Christi Bay at Corpus Christi, Texas, where high concentrations of cadmium and zinc residues are found in bay sediments (Holmes et al. 1974).

During 1979-80, several large impoundments (dredge-pits) on the south shore of Nueces Bay, Corpus Christi, Texas, were filled with sediments from dredging operations. Waterbirds were observed using these impounded areas as feeding and resting sites. White et al. (1980) found that shorebirds collected from undeveloped areas in Nueces Bay in 1976-77 before the impoundments were built had high selenium and cadmium concentrations in their tissues. Thus, through the food web, waterbirds utilizing dredge disposal impoundments may be exposed to even higher concentrations of certain heavy metals. Our goal was to determine the extent to which aquatic birds use dredge-pits and to determine the accumulation of selected heavy metals in their tissues compared to non-industrialized areas.

MATERIALS AND METHODS

We conducted approximate biweekly mid-morning waterbird censuses

at three dredge-pits on the industrialized south shore of Nueces Bay, Corpus Christi, Texas (27°52'N, 97°30'W), during May 1981 - July 1982. Censuses were usually conducted during mid-morning hours. All birds were identified to species, counted, and their activities (resting or feeding) noted. Samples of three aquatic bird species were collected using steel shot at various times from the pits and from control sites at Port Mansfield (26°14'N, 97°18'W) and Powderhorn Lake (28°29'N, 96°36'W), Texas, to be analyzed for selected metals. In addition, a sediment sample from each dredge-pit was collected for heavy metal analysis.

Livers and kidneys of birds were removed and shipped frozen along with sediments to the Patuxent Wildlife Research Center for metal analyses. Tissues and sediments were analyzed for lead, zinc, cadmium, and selenium as described by Haseltine et al. (1981) and for mercury following Monk (1961) and Hatch and Ott (1968). The lower limit of reportable residues was: 2.0 ppm lead, 0.2 ppm zinc, 0.3 ppm cadmium, 0.02 ppm mercury, and 0.1 ppm selenium.

RESULTS AND DISCUSSION

We observed 56 species of birds feeding in one or more of the dredge-pits. Most were seen infrequently. Nine species were present more than 20% of the total census periods (Table 1). Use of the dredge-pits by most species was seasonal, for example, ducks and peeps were there only in fall-winter, whereas stilts and egrets were seen only in spring-summer. Also, the average number of birds present per census period was highly variable among species, ranging from 1 to 225 (Table 1).

We began our biweekly censuses in May 1981, about a year after the impoundments were filled with dredged material. Initially, the pits were unused by birds, but after several months a layer of water collected on top of the sediments and birds began to use the areas as feeding sites following the establishment of sufficient food organisms. By August 1982, all the water in the pits had evaporated or drained off, subsequently birds abandoned the areas. Thus, the impoundments at Nueces Bay were attractive to birds as feeding sites only as long as water was available (about 1 1/2 years).

Elemental concentrations in the three sediment samples analyzed were quite variable among samples. Geometric means and ranges (ppm, wet weight) of the elements were: lead, 49.2 ppm (37.5-58.3 ppm); zinc, 847.6 ppm (330.3-2343.9 ppm); cadmium, 7.5 (2.7-19.9 ppm); mercury, 0.5 ppm (0.4-0.7 ppm); and selenium, 2.3 ppm (1.1-8.4 ppm).

Elemental concentrations in tissues of birds collected at the dredge-pits and control sites are shown in Table 2. Geometric mean concentrations of lead, zinc, cadmium, and mercury in tissues were much less than levels detected in impoundment sediments. Moreover, residues were no higher (ANOVA, $p > 0.05$) in birds collected at the impoundments than in those from control sites. In

Table 1. Bird use of dredge-pits at Nueces Bay, Corpus Christi, Texas; species listed used the areas mainly as feeding sites. Calculations based on 25 biweekly censuses during 1981-82.

Species	Mean/Count[1]	% Occurrence[2]	Season
Great Blue Heron (Ardea herodias)	6	36	Year-round
Snowy Egret (Egretta thula)	19	43	Spring-Summer
Tricolored Heron (Egretta tricolor)	1	34	Spring-Summer
Green-winged Teal (Anas crecca)	162	24	Winter
Northern Shoveler (Anas clypeata)	154	37	Fall-Winter
Black-necked Stilt (Himantopus mexicanus)	14	62	Spring-Summer
American Avocet (Recurvirostra americana)	125	37	Fall-Winter
Willet (Catoptrophorus semipalmatus)	4	24	Year-round
Peeps (Calidris spp.)	225	47	Fall-Winter

[1]Mean based on number of counts when birds present, not total counts.

[2]Proportion of total counts that birds were present.

contrast, selenium was higher (ANOVA, $p < 0.05$) in birds collected at the dredge-pits than at control sites in all instances (Table 2). Further, mean concentrations of selenium in birds collected at dredge-pits were similar to concentrations detected in pit sediments.

Lead, zinc, cadmium, and mercury did not accumulate to elevated levels in aquatic birds using the dredge-pits when compared to birds from undeveloped areas. The levels of these metals detected in birds were considered to be low, and far below known-effect levels in other avian species (Fimreite 1974; Gasaway and Buss

Table 2. Heavy metal and selenium concentrations (ppm, wet weight) in aquatic bird tissues. Livers were analyzed for Pb, Zn, Cd, and Hg; kidneys were analyzed for Se.

Species	Location	Date	n	Pb	Zn	Cd	Hg	Se
American Avocet	Control Site	11/81	10	0.8[1] (4)[2] ND[3]-5.6[4]	31 (10) 18-46	0.7 (10) 0.3-1.6	0.1 (10) 0.02-0.3	2.0[a] (10) 1.3-2.6
	Dredge-Pits	10/81	5	1.3 (2) ND-6.2	30 (5) 27-33	0.4 (5) 0.1-0.6	0.1 (5) 0.07-0.2	2.9[b] (5) 2.2-3.7
		2/82	5	0.1 (4) ND-0.2	29 (5) 20-34	0.3 (5) 0.2-0.6	0.1 (5) 0.05-0.3	2.5[b] (5) 2.2-3.0
Black-necked Stilt	Control Site	6/82	5	0.2 (1) ND-0.8	29 (5) 21-43	0.3 (5) 0.2-0.6	0.1 (5) 0.1-0.2	1.7[a] (5) 1.2-2.3
	Dredge-Pits	11/81	5	0.1 (2) 0.1-0.5	48 (5) 23-126	0.4 (4) 0.2-0.9	0.1 (5) 0.06-0.2	2.2[b] (5) 1.3-3.1
		5/82	5	0.03 (4) ND-0.2	27 (5) 22-37	0.4 (5) 0.2-0.5	0.1 (5) 0.07-0.2	2.8[b] (5) 1.4-6.2

Table 2 (Continued).

Species	Location	Date	n	Pb	Zn	Cd	Hg	Se
Green-winged Teal	Control Site	11/81	4	ND	31 (4) 20-54	0.2 (4) 0.1-0.3	0.01 (1) ND-0.03	0.8[a] (4) 0.7-1.1
	Dredge-Pits	1/82	5	0.03 (1) ND-0.14	34 (5) 23-55	0.3 (4) 0.1-0.5	ND	1.3[b] (5) 1.0-1.5

[1]Geometric mean, ppm wet weight.

[2]Number of samples with detectable residues.

[3]ND = not detected.

[4]Range.

[ab]Geometric means with different superscripts significantly different ($p < 0.05$).

1972; Longcore et al. 1974; White et al. 1978). However, selenium in some birds from dredge-pits was within the range known to cause reproductive impairment in chickens (Ort and Latshaw 1978). It is unknown whether these elevated selenium levels adversely affect wild aquatic birds.

Acknowledgements. We thank Martha Gay and Barnett Rattner for critical reviews of the manuscript. Christine Mitchell provided technical assistance, and Deborah Holman and Patricia McDonald typed the manuscript drafts.

REFERENCES

Fimreite N (1974) Mercury contamination of aquatic birds in northwestern Ontario. J Wildl Manage 38:120-131

Gasaway WC, Buss IO (1972) Zinc toxicity in the mallard duck. J Wildl Manage 36:1107-1117

Haseltine SD, Heinz GH, Reichel WL, Moore JF (1981) Organochlorine and metal residues of waterfowl nesting on islands in Lake Michigan off Door County, Wisonsin, 1977-78. Pestic Monit J 15: 90-97

Hatch WR, Ott WL (1968) Determination of sub-microgram quantities of mercury by atomic absorption spectrophotometry. Anal Chem 40:2085-2087

Holmes CW, Slade EA, McLerran CJ (1974) Migration and redistribution of zinc and cadmium in marine estuarine system. Environ Sci Technol 8:255-259

Longcore JR, Locke LN, Bagley GE, Andrews R (1974) Significance of lead residues in mallard tissues. Spec Sci Rep, Wildl No 182, Washington DC

Monk HE (1961) Recommended methods of analysis of pesticide residues in food stuffs. Report by the joint mercury residues panel. Analyst 86:608-614

Ort JF, Latshaw JD (1978) The toxic level of sodium selenite in the diet of laying chickens. J Nutr 108:1114-1120

White DH, Finley MT, Ferrell JF (1978) Histopathologic effects of dietary cadmium on kidneys and testes of mallard ducks. J Toxicol Environ Health 4:551-558

White DH, King KA, Prouty RM (1980) Significance of organochlorine and heavy metal residues in wintering shorebirds at Corpus Christi, Texas, 1976-77. Pestic Monit J 14:58-63

Received July 10, 1984; accepted August 1, 1984