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CONTAMINANTS SURVEY OF
LA SAL VIEJA, WILLACY COUNTY
TEXAS,

by

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ABSTRACT

Organochlorine, trace element, and petroleum hydrocarbon contaminants were examined in sediments from two hypersaline lakes comprising the La Sal Vieja complex in Willacy County, Texas, and from sediment and biota in a slightly brackish drain nearby. One of the lakes, East Lake, has been impacted by considerable oil and gas production, and this was reflected in moderately higher levels of most contaminants in sediments. Polynuclear aromatic hydrocarbons were detected at low levels in sediment samples, and high levels of chromium, copper, nickel, zinc, and breakdown products of organochlorine pesticides (up to 1.4 ppm wet weight DDE) were detected in fish samples from the Salt Drain nearby. The high DDE levels may pose a threat of eggshell thinning in fish eating birds. Periodic monitoring of heavy metal and DDE levels in fish is recommended.

INTRODUCTION

La Sal Vieja is comprised of two natural salt lakes, East and West lakes. This area has been identified by the U.S. Fish and Wildlife Service (Service), Texas Parks and Wildlife Department, the World Wildlife Fund, and other organizations as a unique ecosystem of national significance. The Service ranked La Sal Vieja and the surrounding brushlands as fourth among 100 nationally significant fish and wildlife habitats. The lakes provide feeding and resting habitat for a great variety of wintering birds; Christmas bird counts since 1959 have documented 88 species using the lakes, including 41 species of waterfowl, 11 species of herons and egrets, 16 species of shore birds, 8 species of gulls and terns, and 3 birds of prey. The federally listed endangered bald eagle and peregrine falcon have been frequently observed at the lakes, in addition to sightings of the endangered ocelot and jaguarundi in the brush habitat surrounding the lakes. Furthermore, several tracts of land on the lakes are now part of the Lower Rio Grande National Wildlife Refuge.

Both lakes have been threatened by contaminants. Brine water from two producing oil and gas wells was discharged into East lake for several years, and West lake was at one tune slated to receive effluent from a proposed paper mill. Runoff from intense agricultural practices in this area poses additional contaminant threats to the system. Both lakes are closed basin systems in an area of high evaporation, a situation favoring concentration of contaminants. Salinities vary somewhat with precipitation, but are always very high. The only macroscopic fauna that live in the lake waters are brine shrimp, Artemia sp..

This study was intended to provide baseline contaminants data for West Lake, and to elucidate the extent of contamination in East Lake and the adjacent Salt Drain.

METHODS AND MATERIALS

Following a period of extended drought, the La Sal Vieja area brine lakes of Willacy County in south Texas (Figure 1) were sampled in early June 1989. The brine lakes were at or near saturation with a salinity of 240 ppt recorded for West Lake. East Lake consisted of 10-15 cm of water on top of a hard salt pan 5-8 cm thick, while West Lake had a water depth of 30-150 cm with a thin salt layer on the bottom. Sediment samples were collected with an Eckmann dredge from ten sites in both East and West Lakes, and one sample was collected from the Salt Drain. Using the top 2 inches of sediment, composites from three grab samples were collected. Random samples were taken in West Lake, and in East Lake sample sites were selected near the edge at the perimeter of the salt crust, with the exception of two samples taken from beneath the crust after chiseling through the salt layer. Three composite fish samples (Gulf killifish, sailfin and Amazon mollies) were collected from the Salt Drain with dip nets and minnow traps. Sample jars and lid liners were chemically cleaned with acid and organic solvents according to U.S. Environmental Protection Agency procedures (EPA 1982). Sediment samples were analyzed for trace elements, PCBs, organochlorines, organophosphate and carbamate pesticides, and polynuclear aromatic hydrocarbons (PAHs). Biota samples were analyzed for trace elements, organochlorines, and PCBs. Trace elements were analyzed at Hazleton Laboratories of America, Inc. Inductively coupled plasma atomic emission spectroscopy was used to determine most of the trace elements. Arsenic and selenium were determined by graphite furnace atomic absorption spectroscopy, and cold vapor atomic absorption spectroscopy was used to determine mercury concentrations. Blanks, duplicates, spiked samples, and standards were used for quality control and quality assurance (QA/QC), and the results monitored by personnel of the Service's Patuxent Analytical Control Facility (Patuxent). Organochlorines, PCBs, and PAHs were analyzed at the Mississippi State Chemical Laboratory. Organochlorines and PCBs were analyzed by column electron capture chromatography, and PAHs were quantified by capillary, flame ionization gas chromatography, and fluorescence HPLC. Blanks, duplicates, spiked samples, and standards were used for QA/QC, which was monitored by Patuxent. Organophosphates and carbamates were analyzed using gas chromatography at Patuxent. Elements and compounds analyzed in this study are presented in Table 1, and detection limits are shown in Table 2.

Data Analysis

Minimum and maximum values were determined for all analytes found above detection limits. Trace element data is presented in parts per million (ppm) on a dry weight basis, and all other data are presented as ppm wet weight.

RESULTS AND DISCUSSION

ORGANOCHLORINE PESTICIDES

Half of the sediments analyzed for organochlorines had detectable levels (>0.01 ppm wet weight) of p,p'-DDE, the most persistent DDT homolog. These samples were equally distributed from both East and West Lakes. No other organochlorines were detected in sediment. This is comparable to a study by Gamble et al. (1988) which found DDE in 74% of sediment samples from the Lower Rio Grande Valley (LRGV), with a geometric mean of 0.02 ppm dry weight.

Chlordane, DDE, and DDD were detected in all three fish samples from the Salt Drain (Table 3). The most persistent DDT homolog, p,p'-DDE, was detected at the highest levels (1.2 - 1.4 ppm wet weight), in a range that may be of concern for some eggshell thinning in eagles (U.S. Fish and Wildlife Service 1986). These levels are well above the National Contaminant Biomonitoring Program (NCBP) geometric mean of 0.19 ppm in whole fish from throughout the United States in 1984 (Schmitt et al. 1990). In 1986, p,p'-DDE median concentrations of 0.38 ppm (range of .036 to 9.9 ppm wet weight) were found in fish samples from the LRGV (Wells et al. 1988). Another study in the same area in 1985-86 by Gamble et al. (1988) found a geometric mean for 33 fish samples of 0.55 ppm DDE (range 0.02-9.90 ppm wet weight). A Gulf killifish sample from Laguna Atascosa National Wildlife Refuge (NWR) had a level of 0.38 DDE (Wells et al. 1988), considerably lower than the 1.2 ppm found in the same species during the current study. In the Burgentine Lake area of Aransas NWR, Maurer et al. (1989) found DDE in two of four sailfin molly samples with levels of 0.33 and 0.12 ppm wet weight. These are much lower levels than those found in this study in the same species, but the Aransas NWR is not surrounded by as intensive agriculture as the LRGV. Levels of DDE in the Salt Drain are clearly elevated.

Concentrations of p,p'-DDD ranged from 0.035 ppm in Gulf killifish to 0.06 ppm in both sailfin and Amazon mollies. This closely matches the NCBP geometric mean of 0.06 ppm for this organochlorine in 1984 (Schmitt et al. 1990), but is higher than the median DDD concentration of 0.022 ppm found in a variety of fish from the LRGV (Wells et al. 1988), and moderately elevated compared to 0.03 ppm (geometric mean) found by Gamble et al. (1988) in the same area. Two of four sailfin mollies from the Burgentine Lake area of Aransas NWR had detectable (0.01 and 0.06 ppm) of DDD (Maurer et al. 1989), which was lower than the 0.06 ppm found in the same species in this study.

Chlordane levels in fish of 0.1 - 0.3 ppm were well below the NCBP geometric mean (0.11 ppm) for total chlordane. Only à-chlordane (cis-chlordane) was detected in this study (Table 3). Chlordane was detected at levels below the FDA Action Level for animal feed of 0.1 ppm (Irwin 1988). In their studies on fish in the vicinity,

Gamble et al. (1988) found chlordane derivatives in only about 10% of samples, and no chlordane was detected by Wells et al. (1988). The source of the organochlorines detected in this study is likely from historic use of DDT and related pesticides in this
area of intense agriculture.

The lower limit of concern for eggshell thinning in bald eagles is 0.5 ppm (U.S. Fish and Wildlife Service 1986). Some concern for eggshell thinning in eagles and other fish eating birds is therefore warranted. However, assessing the levels of contaminants in food in only one area used by migratory species can be misleading because of the highly lipotrophic nature of organochlorines; harmful levels acquired on other areas may mask lesser effects of contaminants obtained locally (King et al. 1991).

ORGANOPHOSPHATE AND CARBAMATE PESTICIDES

Neither organophosphate nor carbamate pesticides were found above detection limits of 0.5 and 1.0 ppm, respectively, for any of the sediment samples in this study.

TRACE ELEMENTS

Eighteen of 22 trace elements were found above detection limits in sediment. Antimony, molybdenum, silver, and tin were the only elements not found above detection limits, although selenium was found in only two sediment samples. The mean and range for selected trace elements in sediment are presented in Table 4 and are compared to geochemical baselines for minor elements in soils in the western United States (Shacklett and Boernaen 1984). Arsenic, silver, lead, cadmium, beryllium, and antimony were not detected in any of the three biota samples analyzed. Data from selected trace elements in biota are presented in Table 3. Trace element concentrations in biota are compared, in the main text, to NCBP data from diverse fish species sampled throughout the U.S. in 1984 (Schmitt and Brumbaugh 1990). Except where specified, such as for comparisons to NCBP data, all trace element data from this study are presented in parts per million (ppm) dry weight.

Arsenic

Arsenic was detected in all sediment samples with arithmetic means of 9.29 and 6.25 ppm recorded for East and West Lakes, respectively, with 24 ppm detected in the Salt Drain. This is modestly elevated for the Lower Rio Grande Valley, and is most likely due to concentration of salts and agricultural runoff containing arsenicals from cotton fields. Even at this elevated level, no particular concern is warranted (Eisler 1988). Levels were below detection in all samples of fish from the Salt Drain, as might be expected because of the low bioaccumulation potential of arsenic.

Boron

Extremely high levels of boron, with a maximum of 559 ppm, were detected in sediments from both salt lakes (arithmetic means of 248.3 and 269 ppm dry weight for East and West Lakes, respectively). Even the level of 37.3 ppm from the Salt Drain is extremely elevated as compared to a geometric mean of 1.5 ppm for a wide range of samples in the LRGV (Gamble et al. 1988). However, these high levels of boron are most likely associated with the hypersalinity of this system as opposed to contaminants per se. Boron levels in seawater (ñ 35ø%) range from 4.5 to 5.5 ppm (Eisler 1990), and concentrations increase at higher salinities (Liddicoat et al. 1983).

Naturally elevated boron levels are usually associated with marine sediments (Eisler 1990). Postglacial marine sediments had levels as high as 500 ppm dry weight (Ahl and Jonsson 1972). Anthropogenic sources of boron are associated with coal fired power plants, mine drainage, municipal wastes (borax detergents) and agricultural drainage. Only the latter activity has any input to this system, and its relative contribution of boron is probably insignificant. Boron levels of 1.99-3.85 ppm dry weight (0.51 to 1.05 ppm wet weight) were detected in fish sampled from the Salt Drain. This is comparable to values of 0.5 to 4.4 ppm wet weight of boron in sockeye salmon tissues (Thompson et al. 1976). Sheepshead minnows (Cyprinidon variegatus) from the Texas coastal area all had equal or higher boron concentrations despite being from less boron-rich environments (Gamble et al. 1988, Maurer et al. 1989, Robertson et al. 1991, and Wells et al. 1988). Based on the above information, boron is not a contaminant of great concern in this system.

Cadmium

Cadmium was detected in less than 20% of sediment samples and was undetected in biota samples in this study. Sediment levels, where above detection limit, ranged from 0.34-0.85 ppm.

Chromium

Chromium was detected in all sediment samples, and averaged 12.01 ppm in East Lake and 6.71 ppm in West Lake. The higher levels in East Lake can likely be attributed to the oil and gas exploration activities occurring there. A significant portion of the 65,000 tons of chromium compounds used annually in exploratory oil drilling enters the environment through discharge of used drilling muds (Eisler 1986).

As much as 225 tons of drilling mud may be used for a single 3,000 meter well (Carr et al. 1982). Chromium levels between 2.16 and 2.61 ppm (0.57-0.67 ppm dry weight) were detected in the three fish samples collected in the Salt Drain area. These are well below the 4.0 ppm level suggested by Eisler (1986) as indicative of chromium contamination. However Irwin (1988) suggests chromium levels of 0.8 ppm wet weight are definitely elevated.

Copper

All sediment samples contained traces of copper, with similar means of 5.65 and 5.54 ppm from East and West Lakes, respectively, and 17.8 ppm in the Salt Drain. Soil baseline means for the western states are somewhat higher (21 ppm; Shacklett and

Boernaen 1984), so copper levels in sediment do not appear to be elevated. However, copper levels in whole fish tissue were 3.12, 4.91 and 7.04 ppm dry weight. Although copper is an essential dietary element for some plants and animals, high levels are quite toxic. Copper acts synergistically with other contaminants such as ammonia, cadmium, mercury, and zinc, resulting in greater toxicity to fish (Herbert and Vandyke 1964). Although not quantified for this study, high ammonia concentrations are commonly associated with brine discharges. The lowest level of copper in whole fish tissues (0.8 ppm wet weight) exceeds the NCBP mean of 0.65 ppm wet weight, while the two higher levels (1.34 and 1.83 ppm wet weight) are well above the NCBP 85th percentile of 1.0 ppm wet weight (Schmitt and Brumbaugh 1990). However, levels in Cyprinidon variegatus from the surrounding area were higher, ranging from 15.0-16.7. ppm dry weight (Gamble et al 1988; Wells et al. 1988).

Lead

Lead was detected in most sediment samples, and mean levels detected were consistently between 3.14 and 4.07 ppm, well below soil baselines of 17 ppm (Shacklett and Boernaen 1984). Lead was not detected in fish tissue samples from this study.

Mercury

Although detected in nearly all sediment samples and slightly higher than means for soil baselines, levels of mercury were not particularly elevated, with 0.125 ppm the highest level detected in sediments. Fish from the Salt Drain area similarly had low levels of mercury, ranging from 0.150 to 0.242 ppm dry weight (0.039-0.062 wet weight), well below the NCBP mean of 0.10 ppm wet weight (Schmitt and Brumbaugh 1990).

Nickel

Nickel was detected in 14 of 21 sediment samples, with lowest levels in West Lake (3.95 ppm), slightly higher levels in East Lake (5.06 ppm) and somewhat higher levels in the Salt Drain (14.6 ppm). Nevertheless, all levels were below the soil baseline mean of 15 ppm for the Western U.S. (Shacklett and Boernaen 1984). Only one fish sample, Gulf killifish, had a detectable level of nickel at 3.71 ppm (0.95 ppm wet weight). This is within the level of about 3.75 ppm considered by the Panel on Nickel (1975) to be normal for aquatic organisms. Wet weight concentrations exceeding 0.9 ppm appear to be elevated in relation to unpolluted sites studied by the Service (Irwin 1988).

Selenium

This element was detected in only two sediment samples, one from West Lake (1.2 ppm) and from the Salt Drain (1.3). The detection level in this study, 0.5 ppm, was above the baseline for soils in western states (0.23 ppm; Shacklett and Boernaen 1984). Selenium was detected in all fish samples at levels between 0.78 and 1.54

ppm (0.2-0.4 ppm wet weight)5 below the NCBP mean of 0.42 ppm wet weight, so it appears unlikely that selenium levels are cause for concern in this area.

Zinc

Zinc was detected in all sediment samples, with the lowest levels in West Lake, increased levels in East Lake, and the highest levels found in the Salt Drain, with mean values of 24.7, 36.0 and 64.3 ppm respectively. These levels are within soil baseline ranges of 17 to 180 ppm and near the mean of 55 ppm, and therefore unlikely to be cause for alarm. Levels of zinc in fish tissue ranged from less than 60 ppm in the two species of mollies to 111.3 ppm dry weight (28.5 ppm wet weight) in Gulf killifish. Only the killifish value exceeds the NCBP geometric mean of 21.7 ppm, but remains below the 85th percentile level of 34.2 ppm wet weight. Zinc may have severe impacts to macroinvertebrates, particularly in conjunction with elevated levels of copper.

Polynuclear Aromatic Hydrocarbons

Sediment samples were analyzed for fourteen polynuclear aromatic hydrocarbon (PAH) compounds, and all but 2 (benzo(k)fluoranthrene and fluoranthrene) were detected in at least one sediment sample. Benzo-e-pyrene was detected at low levels in over 75% of sediment samples. Although sediments from East Lake had a higher incidence and level of detected PAHs, all were at levels of only 0.01-0.02 ppm wet weight, with the exception of a level of 0.1 ppm phenanthrene detected in a sediment sample from East Lake. This same sample had detectable levels of eight of 13 other PAHs. The presence of PAHs, albeit at low levels, can likely be attributed to oil and gas production in the area. The levels detected are not cause for concern because discharge of produced waters into this area is no longer permitted, thus further accumulation of PAHs in this area is not expected.

CONCLUSIONS

East Lake has higher levels of most trace elements than West Lake, probably due to the brine discharge it received from producing oil wells. Even so, most contaminants in the brine lakes are currently not at levels of concern except for arsenic, which should be monitored periodically in this area.

The Salt Drain, which has substantially lower salinities and therefore supports a resident fish population and has wider use by wildlife, has higher trace element levels, in general, than either of the brine lakes. This is likely to be as a result of receiving more agricultural and industrial drainage than either of the two lakes. Organochlorine values of over 1.2 ppm that were detected in prey items of fish-eating birds are of concern due to possible eggshell thinning problems. Although these levels are expected to gradually decline in the future, periodic sampling for DDE and heavy metals in biota from the Salt Drain is recommended.

Due to its importance as wildlife habitat, the unique nature of the area, and its vulnerability to pollution because it is a closed system, La Sal Vieja should not be considered as amenable to any type of development, nor as an area that can accommodate any type of effluent discharge.

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LITERATURE CITED

Ahl, T. and Jonsson. 1972. Boron in Swedish and Norwegian freshwaters. Ambio 1:66-70. From Eisler 1990.

Ahr, W.M. 1973. Long lived pollutants in sediments from the Laguna Atascosa National Wildlife Refuge, Texas. Geol. Soc. America Bull. 84:2511-2516.

Carr, R.S., W.L. McCullough and J.M. Neff. 1982. Bioavailability of chromium from a used chrome lignosulphonate drilling mud to five species of marine invertebrates. Mar. Environ. Res. 6:189-203.

Eisler, R. 1986. Chromium hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85/1.6, 60 pp.

Eisler, R. 1988. Arsenic hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85/1.12, 92 pp.

Eisler, R. 1990. Boron to hazards to fish, wildlife and invertebrates: a synoptic review. U.S. Fish Wildl. Serv. Biol. Rep. 85/1.2, 32 pp.

Gamble, L.R., G.A. Jackson and T.C. Maurer. 1988. Organochlorine, trace element, and petroleum hydrocarbon contaminants investigation of the Lower Rio Grande Valley, Texas, 1985-1986. U.S. Fish Wildl. Serv. Region 2 Contaminants Prog. Special Report, 34 pp.

Herbert, D.M. and J.M. Vandyke. 1964. The toxicity to fish of mixtures of poisons. Ann. Appl. Biol. 53:415-421.

Irwin, R.J. 1988. Impacts of toxic chemicals on Trinity River fish and wildlife. U.S. Fish Wildl. Serv. Region 2 Contaminants Prog. Special Report, 82 pp.

King, K.A., D.L. Baker, W.G. Kepner, and J.D. Krausmann. 1991. Contaminants in prey of bald eagles nesting in Arizona. U.S. Fish Wildl. Serv. Region 2 Contaminants Prog. Special Report, 16 pp.

Liddicoat, M.I., D.R. Turner and M. Whitfield. 1983. Conservative behavior of boron in the Tamar estuary. Estuarine Coastal Shelf Sci. 17:467-472. From Eisler 1990.

Maurer, T. C., L.R. Gamble and G.A. Jackson. 1989. Contaminants investigation of Burgentine Lake, Aransas National Wildlife Refuge, Texas. U.S. Fish Wildl. Serv. Region 2 Contaminants Prog. Special Report, 28 pp.

Panel on Nickel. 1975. Nickel. Committee on Medical and Biological effects of Environmental Pollutants, National Research Council, National Academy of Sciences. Wash., D.C. 277 pp.

Robertson, S.M., T.W. Schultz, L.R. Gamble, and T.C. Maurer. 1991. Contaminants investigation of Aransas dredge spoil islands, Texas 1988-1989. U.S. Fish Wildl. Serv. Region 2 Contaminants Prog. Special Report, 29 pp.

Schmitt, C.J. and W.G. Brumbaugh. 1990. National contaminant biomonitoring program: concentrations of arsenic, cadmium, copper, lead, mercury, selenium, and zinc in U.S. freshwater fish, 1976-1984. Arch. Environ. Contam. Toxicol. 19:731-747.

Schmitt,.J., J.M. Zajicek, and P.H. Peterman. 1990. National Contaminant biomonitoring program: residues of organochlorine chemicals in U.S. freshwater fish, 1976-1984. Arch Environ. Contam. Toxicol. 19:748-781.

Thompson, J.A.J., J.C. Davis and R.E. Drew. 1976. Toxicity, uptake and survey studies of boron in the marine environment. Water Res. 10:869-875.

Wells, F.C., G.A. Jackson, and J. Rogers. 1988. Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Lower Rio Grande Valley and Laguna Atascosa National Wildlife Refuge, Texas, 1986-1987. U.S. Geological Survey, Water Resources Investigations Report 87-4277. 89 pp.

White, D.H., C.A. Mitchell, H.D. Kennedy, A.J. Krynitsky and M.A. Ribick. 1983. Elevated DDE and toxaphene residues in fishes and birds reflect local contamination in the Lower Rio Grande River Valley, Texas. Southwestern Naturalist. 28:325-333.

See Table/Figure

Figure 1. Location of the La Sal Vieja Study area in the Rio Grande Valley, Texas.

Table 1. Elements and compounds analyzed in sediment and biota from La Sal Vieja, Texas, 1989.

Elements	Organochlorines	Organophosphates[sup]1
Aluminum	à-BHC	Acephate
Antimony	á-BHC	Azinphos-methyl
Arsenic	ë-BHC	Chlorpyrifos
Barium	â-BHC	Coumaphos
Beryllium	Heptachlor epoxide	Demeton
Boron	HCB	Diazinon
Cadmium	Total PCBs	Dichlorvos
Chromium	alpha chlordane	Dichrotophos
Copper	gamma chlordane	Dimethoate
Iron	oxy chlordane	Disulfoton
Lead	trans nonachlor	Dursban
Magnesium	cis nonachlor	EPN
Manganese	Dieldrin	Ethoprop
Mercury	Endrin	Famphur

Molybdenum
Nickel
Selenium
Silver
Strontium
Thallium
Tin
Vanadium
Zinc

Mirex
o,p' - DDE
o,p' - DDD
o,p' - DDT
p,p' - DDE
p,p' - DDD
p,p' - DDT
Toxaphene

Fensulfothion
Fenthion
Malathion
Methamidophos
Methyl Parathion
Mevinphos
Monocrotophos
Parathion
Phorate
Terbufos
Trichlorfon

Aromatic Hydrocarbons[sup]1
Naphthalene
Fluorene
Phenanthrene
Anthracene
Fluoranthrene
Pyrene
Chrysene
1,2-Benzanthracene
Benzo(b)fluoranthrene
Benzo(k)fluoranthrene
Benzo(a)pyrene
Benzo(e)pyrene
1,2,5,6-dibenzanthracene
Benzo(g,h,i)perylene

Carbamates[sup]1
Aldicarb
Carbaryl
Carbofuran
Methiocarb
Methomyl
Oxamyl

[sup]1 Sediment only

Table 2. Nominal detection limits and analytical methods used in the analysis of sediment and biota samples collected from the La Sal Vieja, Texas, 1989.

ELEMENT	BIOTA PPM (WET WT)	SEDIMENT PPM (WET WT)
SE[sup]1	0.1	0.1
HGý	0.025	0.025
AS[sup]1	0.1	0.1
AG[sup]3	0.5	2.5
AL[sup]3	1.0	5.0
BA[sup]3	0.5	2.5
BE[sup]3	0.05	0.25
B[sup]3	0.5	2.5
CD[sup]3	0.05	0.25
CR[sup]3	0.1	0.5
CU[sup]3	0.25	1.25
FE[sup]3	1.0	5.0
MG[sup]3	1.0	5.0
MN[sup]3	0.15	0.75
MO[sup]3	0.5	2.5
NI[sup]3	0.45	2.25
PB[sup]3	0.3	1.5
SN[sup]3	0.5	2.5
SR[sup]3	0.1	0.5
TL[sup]3	2.0	10.0

V[sup]3	0.5	2.5
ZN[sup]3	0.2	1.0

	BIOTA UG/G (WET WT)	SEDIMENT PPM (WET WT)
CARBAMATES	NA[sup]4	0.5
ORGANOPHOSPHATES	NA	1.0
ORGANOCHLORINES	0.01	0.01
TOXAPHENE	0.05	0.05
PCBs	0.05	0.05
POLYNUCLEAR AROMATIC HYDROCARBONS	NA	0.01

[SUP]1 Analysis by hydride generation atomic absorption

ý Analysis by cold vapor atomic absorption

[SUP]3 Analysis by ICP (Inductively coupled plasma emission spectroscopy) with acid extraction

[SUP]4 Not analyzed

Table 3. Levels of selected trace elements and organochlorine residues in composite samples of biota from the Salt Drain of La Sal Vieja, Texas, 1989.

	Gulf Killifish Fundulus grandis	Sailfin Molly Poecilia latipinna	Amazon Molly Poecilia formosa
TRACE ELEMENTS		ppm dry weight	
B	1.99	2.73	3.85
Cr	2.61	2.19	2.16
Cu	3.12	7.04	4.91
Hg	0.242	0.150	0.172
Ni	3.71	BDL	BDL
Se	0.78	1.54	1.1
Zn	113.3	58.8	59.7
ORGANOCHLORINE	RESIDUES	ppm wet wt	
p,p'DDE	1.2	1.4*	1.3*
o,p 'DDE	BDL	0.02	0.02
p,p' DDD	0.035	0.06	0.06
àchlordane	0.01	0.02	0.03

* Confirmed by GC/Mass Spectrometry

Table 4. Arithmetic means and ranges (in parenthesis) of selected elements in sediments (ppm dry weight) from East and West Lakes of La Sal Vieja, Texas, and comparative data from soil baselines.

Element	East Lake (n=10)	West Lake (n=10)	Salt Drain (n=1)	Soil Baselines[sup]1
As	9.29 (2.2-16.9) 10ý	6.25 (3.6-11.6) 10	24	5.5 (1.2-22)
B	248.3 (89.1-559) 10	269 (197-395) 10	37.3	23 (5.8-91)
Cd	-[sup]3 (0.34-0.38) 3	- (0.85) 1	BDL[sup]4	ND[sup]5
Cr	12.01 (2.98-20) 10	6.71 (2.89-10.7) 10	21	41 (8.5-200)
Cu	5.65 (1.83-9.84) 10	5.54 (3.95-9.15) 10	17.8	21 (4.9-90)
Pb	4.07 (0.9-7.95) 7	3.14 (1.3[sup]6-7.23) 6	3.24	17 (5.2-55)
Hg	0.0699 (.041-.113) 10	0.0763 (.02[sup]6-.125) 9	0.058	0.046 (.009-.25)
Ni	5.06 (1.22-13.4) 7	3.95 (1.75[sup]6-6.39) 6	14.6	15 (3.4-66)
Se	BDL	- (1.2) 1	1.3	0.23 (0.04-1.4)
Zn	36.0 (13.5-59.4) 10	24.7 (16.4-31.2) 10	64.3	55 (17-180)

1 Geometric means and expected 95% ranges for soils in the western U.S.. From Shacklett and Boernaen 1984.
2 Number of samples above detection limit.
3 Over 1/2 values below detection limit.
4 All values below detection limit.
5 No Data
6 Assigned value of 1/2 detection limit.