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Environmental Contamination and Toxicology

Mercury in Tissues of Selected Estuarine Fishes from Minimally Impacted Bays of Coastal Texas

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Recognizing a need for baseline contaminant data for coastal resources, Texas Parks and Wildlife Department (TPWD) entered into a multi-year cooperative effort with the Coastal Conservation Association (CCA) to sample selected minimally impacted (reference) areas. Efforts were made to sample recreational species that would offer comparative data with other existing databases on coastal contaminants. This paper addresses mercury data obtained during this study.

Mercury is a toxic contaminant of concern because of its persistence, biomagnification, and bioaccumulation through the food chain (USEPA 1995). Since mercury bioaccumulates, concentrations in fish tissues have resulted in consumption advisories and closures due to human health risks. These have resulted from mercury deposition by long-range transport such as the coast-wide advisories for consumption (TDH 2003) of King mackerel (*Scomberomorus cavalla*), as well as deposition by point source releases (Francesconi and Lenanton 1992; Sager 2002; TDH 2003). Mercury's persistence in the environment and continued releases can result in such problems existing for many years (Francesconi et al. 1997; Sager 2002).

Background (or reference area) mercury concentrations in fisheries resources is important for determining when mercury concentrations are becoming elevated in environmental impact or ecological risk assessments. The information is also important for setting goals for, and determining the success of, remedial and restoration plans.

MATERIALS AND METHODS

This paper considers data from South Bay, Redfish Bay, Espiritu Santo Bay, Christmas Bay, and Keith Lake (Fig. 1). These sites were selected as minimally impacted sites to offer reference data. These bays are considered minimally impacted because they have few wastewater discharges, good water quality (TNRCC 1996), wetland and/or submerged aquatic vegetation, and are important sites for recreational fishing activities.

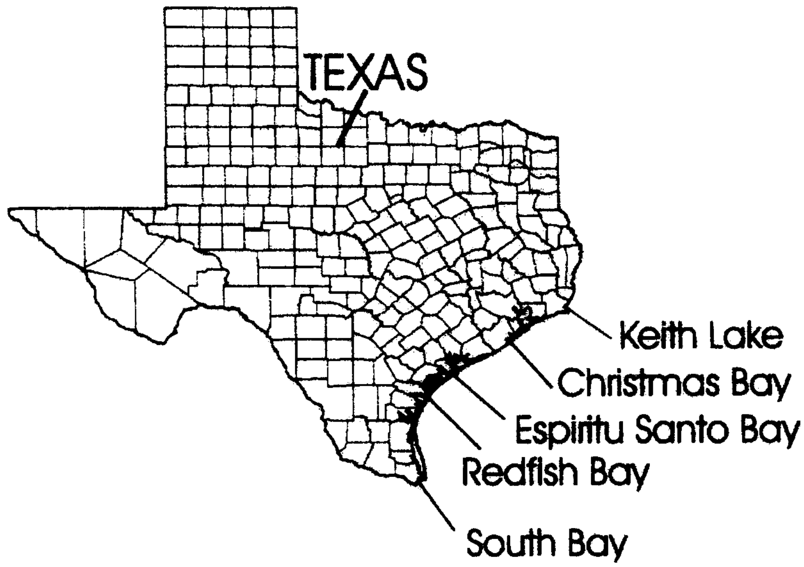


Figure 1. General location of Texas estuarine systems sampled.

CCA volunteers and TPWD staff members collected fishes over 5 years. Freshly collected fish were transported to a site where they were individually weighed (in grams), measured (total length in millimeters), and axial muscle tissue (and livers when practical) was taken for analysis. All samples were transported on ice to a laboratory freezer (within 12 hours) where they were stored at -20°C until analyzed.

Axial muscle tissues were analyzed for the top predator fish species spotted seatrout, *Cynoscion nebulosus*; red drum, *Sciaenops ocellatus*; and southern flounder, *Paralichthys lethostigma*, both muscle and liver samples were collected from South Bay, Espiritu Santo Bay, and Keith Lake. Samples were digested (in sulfuric acid, nitric acid, and potassium permanganate in a hot water bath with hydroxylamine hydrochloride and stannous chloride added after digestion) and analyzed using published methods (USEPA 1991) for total mercury by Cold Vapor Atomic Absorption Spectrophotometry. Reference Material Standards comparisons and other normal laboratory quality control procedures were employed to ensure accurate results.

Results are reported in µg/g on a wet weight basis. Statistics were calculated using the detection limit value for all results reported as less than the detection limits. Detection limits for samples from South Bay ranged from 0.05 to 0.20 µg/g depending on the sample batch. Detection limits for samples from Espiritu Santo Bay were all 0.13 µg/g. Detection limits for samples from Keith Lake were all 0.05 µg/g. Detection limits for samples from Christmas Bay ranged from 0.05 to 0.10 µg/g. Detection limits from Redfish Bay were all 0.04 µg/g.

RESULTS AND DISCUSSION

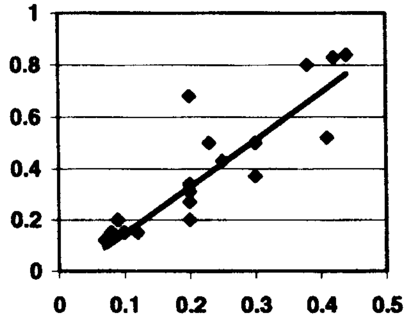
Mercury concentrations in fish muscle tissue were fairly consistent. Most results were near the detection limits. The detection limits for total mercury in fish tissue ranged from 0.04 to 0.2 μg/g (wet weight) during this study.

Table 1. Number of samples, means and value ranges of mercury tissue concentrations for each fish species and bay system sampled. Values are listed in the following order: number of samples followed by the mean on the first line and range of values on the second line. Values are given as μg/g (wet weight basis).

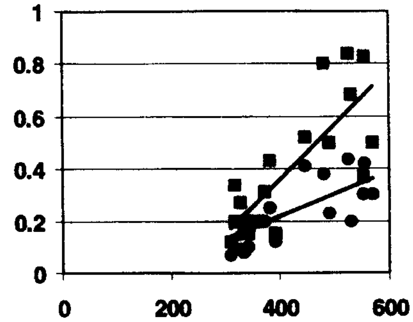
	South Bay	Redfish Bay	Espiritu Santo Bay	Christmas Bay	Keith Lake
Flounder					
Muscle	3; 0.2 <0.2-0.2	3; 0.08 0.07-0.1	11; 0.13 <0.13-0.15	14; 0.06 <0.05-0.08	6; 0.16 0.12-0.2
Liver	2; 0.2 <0.2-0.2	-	1; 0.13	-	3; 0.14 0.1-0.2
Spotted Seatrout					
Muscle	23; 0.24 <0.07-0.44	18; 0.16 0.07-0.32	28; 0.2 <0.13-0.61	15; 0.09 <0.05-0.1	36; 0.19 0.11-0.32
Liver	21; 0.38 <0.12-0.84	-	1; 0.14	-	12; 0.17 0.13-0.21
Red Drum					
Muscle	22; 0.18 <0.1-0.3	26; 0.11 <0.04-0.21	24; 0.22 <0.13-0.33	23; 0.1 <0.05-0.14	36; 0.25 0.1-0.59
Liver	22; 0.34 <0.1-0.59	-	1; 0.19	-	13; 0.23 0.07-0.63

Flounder had the lowest mean muscle concentrations (ranging from 0.06 to 0.16 μg/g – Table 1). Red drum and spotted seatrout had slightly higher mean concentrations (ranging from 0.1 to 0.25 and 0.09 to 0.24 μg/g, respectively). Although the variability in detection limits influenced the mean values from the different bay systems, mean muscle mercury concentrations for each species appeared higher for South Bay, Espiritu Santo Bay, and Keith Lake samples (Table 1). Since most of the mercury accumulated in the muscle tissue of fish is probably related to bioaccumulation through the food chain; the differences in concentrations among the species are related to the amount of exposure, age, and food habits of the specimen (Francesconi and Lenanton 1992; Post et al. 1996; Wiener and Spry 1996; Sager 2002). These results are similar to results from a contaminated site that indicated flounder had lower mercury levels than red drum and spotted seatrout due to differing exposure and food habits (Sager 2002).

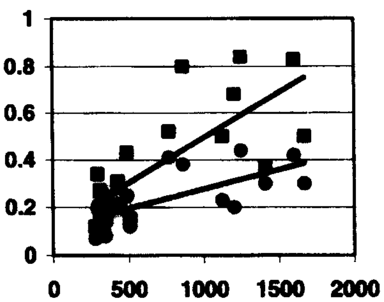
These results indicate that recreational estuarine fish species in minimally impacted areas along the Texas coast have mean mercury concentrations in



a) μg/g in liver (y axis) vs. muscle



b) μg/g in tissue (y axis) vs. length (mm)



c) μg/g in tissue (y axis) vs. weight (g)

Figure 2. Linear regressions for mercury (μg/g, wet wt.) in muscle and liver tissues of spotted seatrout from South Bay: a) significant regression of muscle vs liver concentrations (P=0.00001, Liver=-0.0372+1.825(Muscle)), b) significant regressions for liver (■) and muscle (●) concentrations compared to fish length (mm) (P=0.00001, Liver = -0.4638 + 0.00206(Length); P=0.0002, Muscle = -0.1225 + 0.000856(Length)), and c) significant regressions for liver and muscle concentrations compared to fish weight (g) (P=0.0005, Muscle = 0.1147 + 0.000162(Weight); P=0.00001, Liver = 0.1099 + 0.000385(Weight).

muscle tissues ranging from 0.05 to 0.25 μg/g.

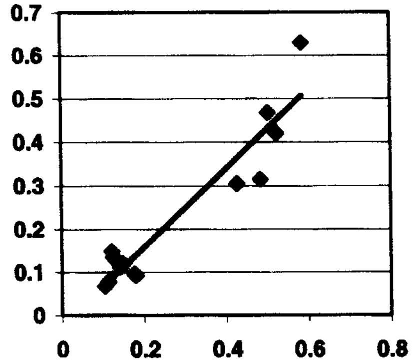
Similar mercury concentrations were shown in a study on Galveston Bay resources for the National Estuary Program (GBNEP 1992). When examining data for the same fish species collected in this study the Galveston Bay study indicated that red drum, spotted seatrout, and southern flounder had mercury concentrations normally below 0.25 μg/g with an average near 0.1 μg/g. Generally, southern flounder had the lowest concentrations of mercury with values less than 0.1 μg/g.

In South Bay, Espiritu Santo Bay, and Keith Lake it was possible to sample liver tissue in addition to muscle tissue. For Espiritu Santo Bay, liver composite samples were analyzed. For South Bay and Keith Lake, it was possible to sample liver tissues from individuals so more detailed comparisons could be conducted.

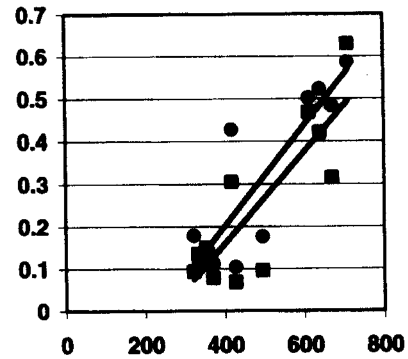
Mercury concentrations found in liver samples from red drum, spotted seatrout, and flounder (Table 1) were also lowest in flounder and generally higher for all three species in South Bay. Results comparing mercury concentrations in muscle to liver tissues were inconsistent. South Bay mean mercury concentrations in livers are higher than, or equal to, those in muscle tissue.

However, Espiritu Santo Bay and Keith Lake mercury concentrations in liver tissue were lower than, or equal to, concentrations in muscle tissue (Table 1). These results may be influenced by the varying detection limits. However, other studies have shown similar inconsistencies in the distribution of mercury accumulating among organs (Goldstein et al. 1996). This may reflect that at sites with low ambient mercury levels mercury bioaccumulation may not be above a level at which mercury becomes preferentially sequestered in liver tissue. The results may indicate that fishes from South Bay have more individuals above this sequestering point, while fishes from the other sites are below this point of discernable preferential accumulation.

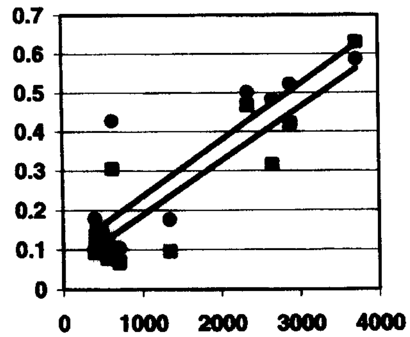
Linear regression analyses of mercury concentrations found in muscle or liver tissues versus the length or weight of the fish sampled were again inconsistent. No statistically significant regressions were found for Keith Lake spotted seatrout (n=12), even when comparing mercury concentrations found in liver versus muscle tissue. However, South Bay spotted seatrout (n=21) gave statistically highly significant results for all regression analyses (Fig. 2). The comparison of mercury in muscle tissues versus mercury in liver tissues gave a statistically significant regression (Fig. 2a) with liver concentrations being higher. The regression results for mercury in liver samples versus either the length or weight of the fish gave similar levels of significance (Figs. 2b and c). The mercury in muscle tissue versus the length or weight of the fish gave a slightly lower level of significance (Figs. 2b and c). These regression lines not only show the commonly reported situation of mercury accumulation increasing with age or size (length and weight), but also support the contention made earlier that mercury was preferentially accumulating in liver tissues for South Bay spotted seatrout. Results of linear regression analyses for red drum were similar to other species from South Bay. No statistically significant relationship between mercury in muscle and liver tissues and fish length or weight was indicated, but a highly significant regression (n=22, P=0.0001) was found when comparing mercury in liver and muscle. Mercury in liver was consistently higher than in muscle, with a regression equation of the liver concentration = 0.0107 + 1.8446(muscle concentration). For the three South Bay fish species there were significant relationships between mercury in muscle and liver tissues, with concentrations generally higher in liver tissues.



a) µg/g in liver (y axis) vs. muscle



b) µg/g in tissue (y axis) vs. length (mm)



c) µg/g in tissue (y axis) vs. weight (g)

Figure 3. Linear regressions for mercury (µg/g, wet wt.) in muscle and liver tissues of red drum from Keith Lake: a) significant regression of muscle vs liver concentrations (P=0.00001, Liver = -0.0219 + 0.9032(Muscle)), b) significant regressions for liver (■) and muscle (●) concentrations compared to fish length (mm) (P=0.0002, Liver = -0.2736 + 0.00108(Length); P=0.0001, Muscle = -0.2717 + 0.00118(Length)), and c) significant regressions for liver and muscle concentrations compared to fish weight (g) (P=0.0001, Muscle = 0.0902 + 0.000144(Weight); P=0.0001, Liver = 0.0494 + 0.000138(Weight).

Regression analyses for Keith Lake red drum with livers sampled (n=13) were statistically significant for all the analyses (Fig. 3). The comparison of mercury in liver versus muscle tissues (Fig. 3a) gave a highly significant result with the concentration in liver tissues almost equal to that in muscle. The other regression analyses gave highly significant results when comparing tissue concentrations to fish size or weight (Figs. 3b and c). While similar to South Bay spotted seatrout results, the results for Keith Lake red drum had regression lines for mercury in muscle and liver tissue that were nearly parallel (Figs. 3b and c). A somewhat higher level of mercury is indicated for muscle than for liver tissues and the difference did not substantially change as the fish got larger (or older). While these results show a higher bioaccumulation of mercury in older fish, the preferential accumulation of mercury in liver tissues is not indicated, unlike spotted seatrout in South Bay (Figs. 2b and c).

Mercury is commonly positively correlated with age, length, or weight for most fishes from sites with elevated mercury levels due to bioaccumulation and biomagnification (Francesconi and Lenanton 1992; USEPA 1995; Weiner and Spry 1996; Francesconi et al. 1997; Sager 2002). The inconsistent correlation of mercury concentrations with fish length and weight in this study may be a reflection of sampling minimally impacted sites. Low levels of bioaccumulation, regardless of fish size and age, may contribute to the lack of significance, or the lack of statistical significance may be a reflection of the low variability at ambient mercury concentrations. The lack of a correlation has been found in other studies where mercury concentrations are relatively low (Dixon and Jones 1994; Goldstein et al. 1996; Stafford and Haines 2001).

This study's results indicate that the mercury concentrations in important recreational fisheries resources are low in minimally impacted Texas coastal sites. Fisheries resources at certain Texas coastal sites have elevated concentrations of mercury from point sources (Lavaca Bay) and widespread dispersal patterns (TDH 2003), but mercury concentrations are not elevated in fisheries resources throughout the coast.

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