Contaminant Level of Fishes in Several Coastal Bend Estuaries: Screening Investigation

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Technical Report

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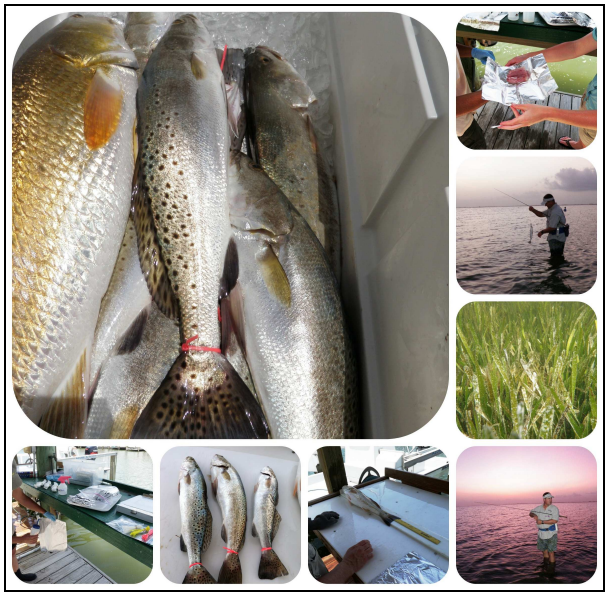

Table of Contents

List of Tables

List of Figures

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Contaminant Level of Fishes in Several Coastal Bend Estuaries: Screening Investigation

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Executive Summary

Recreational fisheries represent a $1.7 billion/year industry to Texas, with over 1.2 million saltwater anglers in 2006. The majority of these anglers consume their catch. In July 2008, the Texas Department of State Health Services (TDSHS) issued a fish consumption advisory in Galveston Bay, Texas due to elevated levels of polychlorinated biphenyls (PCBs), polychlorinated dibenzodioxins (PCDDs), and polychlorinated dibenxofurans (PCDFs) in spotted seatrout and all catfish species. This advisory is alarming, as there is very little information on the contaminant levels for routinely consumed fishes captured by commercial and recreational anglers in the Coastal Bend region of Texas. Thus, the goal of this study was to quantify contaminant loads (mercury, PCBs, and PCDDs/PCDFs) in black drum (*Pogonias cromis*), spotted seatrout (*Cynoscion nebulosus*), and red drum commonly referred to as redfish (*Sciaenops ocellatus*) fish tissues from the Laguna Madre, Corpus Christi, and Aransas Bay complexes.

Total Mercury

We analyzed a total of 49 fish for total mercury analysis and found generally low concentration levels among all bays and species. However, the 5 fish collected from the surf zone had a mean concentration (mean = 1.02 mg/kg ± 0.18 SE) above the reported 0.7 mg/kg threshold level set by the TDSHS, and was significantly greater than all other bays. We also found a significant relationship between total length and total mercury concentration showing increased contaminant level with larger specimens.

Total PCB and PCDD/PCDF

We collected a total of 36 fish for total PCB and PCDD/PCDF analyses and found generally low concentrations of total PCBs and PCDDs/PCDFs among all bays and species. There was no statistical difference in concentration among bays or species for either contaminant; however, one fish (sample number 23, 915 mm TL redfish) had a concentration of total PCBs (2.631 mg/kg) approximately 50 times higher than the reported 0.047 mg/kg threshold set by the TDSHS. No PCDDs/PCDFs were detected for any fish except for the same oversized redfish. This fish had a total PCDF/PCDD concentration of 8.4 pg/g, which is above the 2.33 pg/g threshold set by the TDSHS. These data show that there is a need for further investigation to better understand if large, oversize redfish have high concentrations of PCBs and PCDDs/PCDFs as we were only able to test 1 fish. It is critical to understand because of the popularity of angling for redfish, and local anglers routinely retain this species for consumption. If these large, recreationally-targeted fish have high concentrations of mercury, PCBs, and PCDDs/PCDFs, the TDSHS may need to consider issuing consumption advisory.

Introduction

Recreational fisheries represent a $1.7 billion/year industry to Texas, with over 1.2 million saltwater anglers in 2006. The most commonly recreationally caught and consumed estuarine species in Texas are spotted seatrout (*Cynoscion nebulosus*), red drum commonly referred to as redfish (*Sciaenops ocellatus*), and black drum (*Pogonias cromis*). Because these recreationally-caught fish are consumed by the local population, there have been concerns about possible contaminants found in their tissues. Common contaminants that can pose human health risks include methylmercury (mercury), polychlorinated biphenyls (PCBs), polychlorinated dibenzodioxins (PCDDs), and polychlorinated dibenxofurans (PCDFs). These contaminants can persist in the environment and have been shown to bioaccumulate in fish tissue because they attach to lipids in tissues and metabolize slowly. When the rate of ingestion exceeds the rate of elimination then compounds accumulate within the organism leading to bioaccumulation (Domingo and Bocio 2007).

Consumption of contaminated fish has been a major source of human exposure to mercury, PCBs and PCDDs/PCDFs worldwide (Hites et al. 2004, Adams and Onorato 2005, Domingo and Bocio 2007). Approximately 10,000 tons of mercury naturally occur in the atmosphere with anthropogenic activities contributing an additional 20,000 tons/year. The most prevalent anthropogenic source is coal smoke released into the air from coal-fired plants. This mercury eventually makes its way into the marine environment, where it is microbiologically transformed into methyl mercury (Sager 2002, Zahir et al. 2005). Methyl mercury ingestion in humans is a health hazard and can lead to various problems as the compound can penetrate the blood-brain barrier resulting in damage to the central nervous system; this is most evident in developing fetuses. The development of organs and nerves is greatly impacted by this exposure and can lead to developmental problems in young children (Sager 2002, Chien et al. 2010). PCBs were produced in large quantities from industrial processes such as coolants in electric transformers and are considered persistent organic pollutants (POPs) (Dorea 2008). These compounds can affect the cardiovascular system, liver, and skin. They are considered probable carcinogens in humans and can pass through the placenta and effect the development of fetuses. PCBs can also pass through breast milk and may affect the development of infants and young children (Harris and Jones 2008). PCDDs and PCDFs can disrupt the immune, nervous, endocrine, and reproductive systems and are known carcinogens (WHO 2010). PCDDs/PCDFs are produced through human activities such as metal smelting, the combustion of chlorine containing compounds, refining, and chemical manufacturing. The compounds are typically released into the atmosphere where they are then deposited on soil and aquatic environments thus entering the food chain (Zhang et al. 2009).

In July 2008, the Texas Department of State Health Services (TDSHS) issued a fish consumption advisory in Galveston Bay, Texas due to elevated levels of PCDDs, PCDFs, and PCBs in spotted seatrout and all catfish species (TDSHS 2008). This advisory is alarming, as there is little information on the contaminant levels from routinely consumed fishes in the Corpus Christi, Texas area. The only recent research

done in the Corpus Christi area was by the Center for Coastal Studies (CCS) at Texas A&M University-Corpus Christi (TAMUCC) in 2004 and targeted catfish and pinfish. However, these samples were collected via trawls, and did not specifically target legal-size recreational fishes that are commonly consumed. Thus, the goal of this study was to quantify the contaminants (mercury, PCBs, and PCDDs/PCDFs) found in legal size black drum, spotted seatrout, and redfish fish tissues from the Laguna Madre, Corpus Christi, and Aransas Bay complexes. This project was designed with conversations among TDSHS staff so that the data from this project may be recognized as valid if contaminate levels exceed unsafe thresholds.

Methods

Study area description

Aransas Bay is a positive primary bay located along the south Texas coast. Aransas Bay has a maximum depth of 3.1 m (Britton and Morton 1989), a surface area of 539 km^2 and a mean salinity of 15 ppt (USEPA 1999). Freshwater inflow into Aransas Bay is supplied by the Aransas and Mission Rivers and also by Copano Creek, and is connected to the Gulf of Mexico by Aransas Pass (Britton and Morton 1989). Corpus Christi Bay is a positive primary bay located south of Aransas Bay and is the largest bay in the Corpus Christi Bay system. Corpus Christi Bay has a maximum depth of 3.1 m (Britton and Morton 1989), a surface area of 497 km^2, and a mean salinity of 22 ppt (USEPA 1999). Freshwater inflow is from the Nueces River and Oso Creek. Directly south of Corpus Christi Bay is the Laguna Madre, a negative bar-built estuary divided by the Rio Grande Delta to form two separate lagoons (upper and lower): the Laguna Madre of Texas, USA, to the north and Laguna Madre de Tamaulipas, Mexico, to the south. Collectively, these lagoons make up the largest of five hypersaline systems in the world (Javor 1989). Laguna Madre of Texas is the southernmost major semi-enclosed coastal body of water in Texas, extending from Corpus Christi Bay to the Brazos-Santiago Pass near the mouth of the Rio Grande River, encompassing 1550 km^2 with an average depth of slightly less than 1 m (Britton and Morton 1989). The Laguna Madre of Texas is divided further into the upper Laguna Madre and the lower Laguna Madre by a land-bridge extending from Padre Island to the mainland (Tunnell 2002). The Laguna Madre of Texas is a hypersaline system because freshwater inputs are minimal and connections to the Gulf of Mexico are few and with only Packery Channel and Port Mansfield Channel. However, the primary reason is that evaporation exceeds precipitation, sometimes by a factor of two to three (Tunnell 2002). Salinities in the upper Laguna Madre are typically 40 ppt, but historically have reached 100 ppt (Quammen and Onuf 1993) (Fig.1).

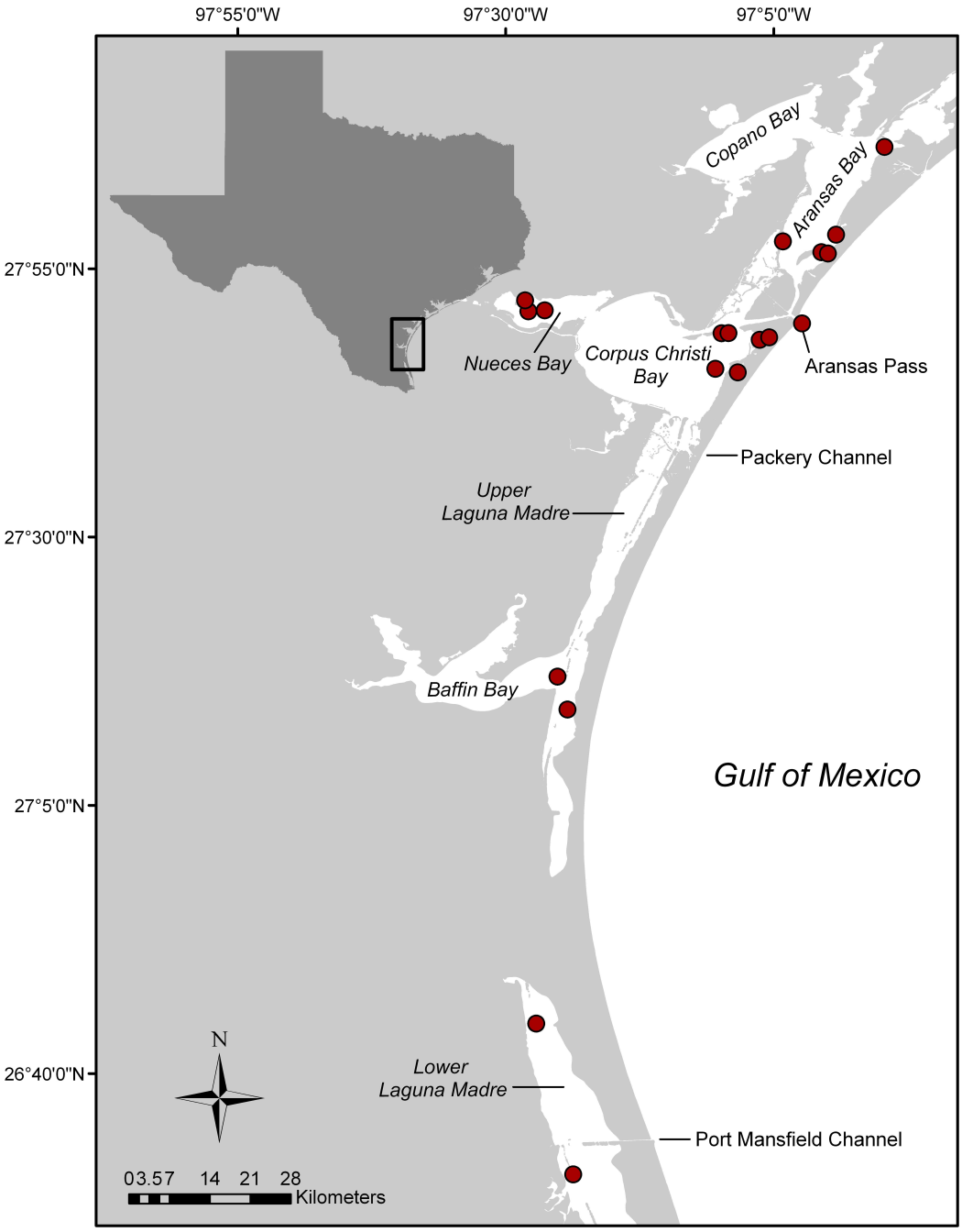

Figure 1. Study map representing the sampling locations for fish collected throughout the study period from June - September 2010.

Field collections

Black drum, spotted seatrout, and redfish were collected from the Laguna Madre, Corpus Christi, and Aransas Bay complexes from June - September 2010. Four fish of each species were collected from each bay complex of legal size for a total of 36 fish analyzed for total mercury, total PCBs, and total PCDDs/PCDFs. Nearly all (99%) the mercury found in fish tissue is in the methylmercury form; therefore, total mercury was assessed in fish tissues (Bloom 1992). Thirteen additional fish were collected for total mercury analyses from Nueces Bay, the Lower Laguna Madre, and from the surf zone (Fig. 1). All fish collected were legal size in accordance with Texas Parks and Wildlife Department (TPWD) regulations, with the exception of 5 redfish that were >711 mm total length (TL) and were collected in the surf zone near Port Aransas, Texas. Fish were collected with rod and reel using artificial and live bait. After fish were caught, they were placed on ice until processed, which was no longer than 24-h post capture. We also measured air temperature (℃), water temperatu re (℃), salinity (ppt), and dissolved oxygen (mg/L); however, there were some instances when we were unable to record these variables. To supplement missing field recordings, we used physical data from the Texas Coastal Ocean Observation Network (TCOON) when available.

The total length (TL) of each fish was measured (mm) and sex was recorded. Fish were rinsed with freshwater and then placed on a foil-covered cutting board. Each fish was filleted on the left-side and dorsal epaxial white muscle tissue (> 20 g) was placed on a sheet of pre-combusted aluminum foil (450℃ for 4-h). A clean knife was used for each individual fish. Knives were cleaned by rinsing with methanol followed by de-ionized water and allowed to air dry. Fish tissue was then wrapped in 2 more pieces of pre-combusted foil to ensure no contamination. An identification tag indicating the sample identification number, date/time of sample, bay sampled, species name, and sampling location was placed between the second and the third foil pieces. The foil-wrapped sample was then placed in a plastic bag labeled with the same information and placed in a -20° C freezer until they were shipped to the Geochemical & Environmental Research Group (GERG) for analysis. Samples were in the freezer for no more than 4 months. For shipment to GERG, samples were placed in a Styrofoam ice chest, placed on dry ice, and shipped overnight. At GERG samples were tested for total mercury (Sweet 2008, Sweet 2009), total PCBs (Qian, 1998, Sericano 2002), and total PCDDs/PCDFs (Qian 1998, Sericano 2009).

Statistical analysis

Differences in contaminant concentrations among species and bays were analyzed using two-way analysis of variance (ANOVA, $\alpha = 0.05$) and with contaminant concentration (total mercury, total PCBs, or total PCDDs/PCDFs) as the dependent variable and bay and species as the independent variables using SAS 9.1. Total PCB concentration is expressed as the sum of the 10 PCB chlorination levels and the total PCDD/PCDF concentration is expressed as the sum of 17 polychlorosubstituted furans and dioxins congeners. The distribution of the residuals were analyzed using the UNIVARIATE procedure and data were transformed ($\log_{10}$ (x+1)), to ensure homogeneity of variance and normality of the residuals. Mean differences in contaminant concentrations among bays or species were further analyzed using

Tukey's HSD (α = 0.05). Relationships between the size of fish and concentration of contaminants were examined using analysis of covariance (ANCOVA, α = 0.05) in SAS 9.1. Species was the independent variable and length the covariate, with contaminant concentration the dependent variable.

Results

Physical parameters

The physical parameters were fairly consistent throughout the study period. Air temperature ranged from 28.2 ℃ (June 2010) to 42.1 ℃ (August 2010) with some small differences among the bays. The water temperature had less variability throughout the study period and ranged from 26.4 ℃ (September 201 0) to 33.3 ℃ (July 2010) with few differences among bays. There were only slight differences in dissolved oxygen between Aransas Bay (4.9 mg/l ± 0.4 SE) and the Upper Laguna Madre (6.8 mg/l ± 1.7 SE). Salinity had the highest amount of variability, with low salinities found in Nueces Bay (13.7) compared to all other bays that ranged from 30.7 to 36.7.

Total Mercury

A total of 49 fish were analyzed for total mercury (Appendix 1). Fish ranged in size from 383 mm TL to 1018 mm TL. Redfish were generally larger than both spotted seatrout and black drum, and were the only species collected in the surf (Table 2). Black drum were not collected in either the Lower Laguna Madre or the surf, and spotted seatrout were collected in all locations but the surf. The oversize redfish that were collected in the surf were only analyzed for total mercury. We examined differences in concentration of total mercury and found low concentration levels among all bays and species. There was no interaction between species and bay for total mercury, indicating that mercury concentrations were similar among bays for each species (Table 2, Table 3). There was no significant difference in mean concentration of mercury in trout (mean = 0.30 mg/kg ± 0.04 SE), redfish (mean = 0.463 mg/kg ± 0.10 SE), or black drum (mean = 0.15 mg/kg ± 0.03 SE) (Table 2, Fig. 2); however, fish from the surf zone (mean = 1.02 mg/kg ± 0.18 SE) had a mean concentration above the reported threshold level of 0.7 mg/kg by the TDSHS, and was significantly higher than all the other bays (Table 2, Fig. 3). Nueces Bay (mean = 0.47 mg/kg ± 0.06 SE) and the Lower Laguna Madre (mean = 0.41 mg/kg ± 0.06 SE) had similar mean total mercury concentrations and were higher than the Upper Laguna Madre (mean = 0.19 mg/kg ± 0.03 SE), Corpus Christi Bay (mean = 0.141 mg/kg ± 0.03 SE), and Aransas Bay (mean = 0.11 mg/kg ± 0.01 SE), but all were below the TDSHS threshold level (Table 2, Fig. 3). We also extracted the otoliths from the 5 redfish collected from the surf to determine age, and found their mean age was 20 years ± 4.8 SE (Appendix 1).

Table 1. Mean size, standard error (SE), and total catch (N) of spotted seatrout, redfish, and black drum collected. A dash (-) indicates no catch.

	Spotted Seatrout			Redfish			Black drum		
BAY SYSTEM	Mean	SE	N	Mean	SE	N	Mean	SE	N
Aransas Bay	446	(20.5)	4	570	(18.7)	4	445	(30.1)	4
Corpus Christi Bay	505	(26.6)	2	713	(58.2)	2	598	(30.5)	2
Nueces Bay	468	(21.7)	4	577	(33.1)	4	450	(66.5)	2
Upper Laguna Madre	458	(33.6)	4	597	(22.8)	4	495	(7.0)	4
Lower Laguna Madre	483	(38.1)	4	-	-	0	-	-	0
Surf	-	-	0	945	(37.1)	5	-	-	0

Table 2. Analysis of variance (ANOVA) table for total mercury (A), total PCBs (B), and total PCDD/PCDFs of fish collected from various bays along the south Texas coast. Bay (N=6 for total mercury and N=4 for total PCBs and PCDDs/PCDFs) and species (N=3) were independent variables. An * indicates that the ANOVA probability value was significant at the 0.05 level.

A.

SOURCE	*df*	Sum of Squares	Mean Square	F Value	P Value
TOTAL MERCURY					
Bay	5	0.232	0.046	23.320	< 0.001 *
Species	2	0.008	0.004	2.330	0.112
Bay x Species	6	0.011	0.002	1.070	0.399
Residual	35	0.062	0.002		

B.

SOURCE	*df*	Sum of Squares	Mean Square	F Value	P Value
TOTAL PCBS					
Bay	3	0.044	0.015	2.270	0.106
Species	2	0.034	0.017	2.600	0.095
Bay x Species	6	0.086	0.014	2.210	0.078
Residual	24	0.156	0.007		

C.

SOURCE	*df*	Sum of Squares	Mean Square	F Value	P Value
TOTAL PCDD/PCDF					
Bay	3	0.132	0.044	2.220	0.112
Species	2	0.105	0.053	2.670	0.090
Bay x Species	6	0.263	0.044	2.220	0.076
Residual	24	0.473	0.020		

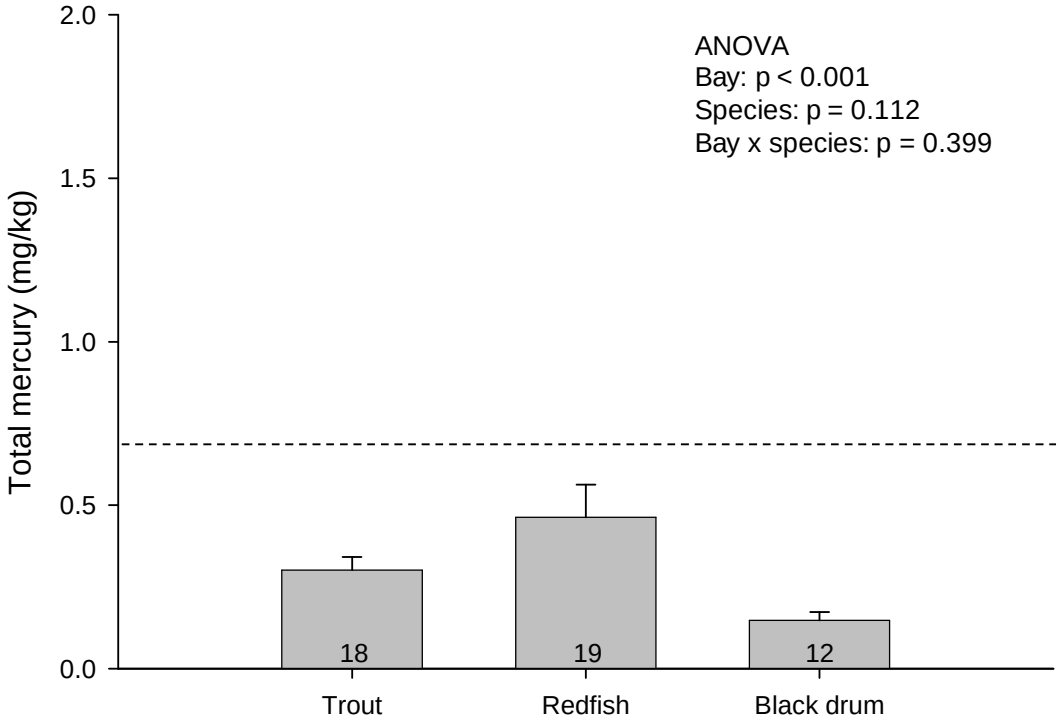

Figure 2. Mean total mercury for each species collected from all bays. Sample size (N) is indicated at the bottom of the bars. The dashed line indicates the 0.7 mg/kg threshold set by the Texas Department of State Health Services.

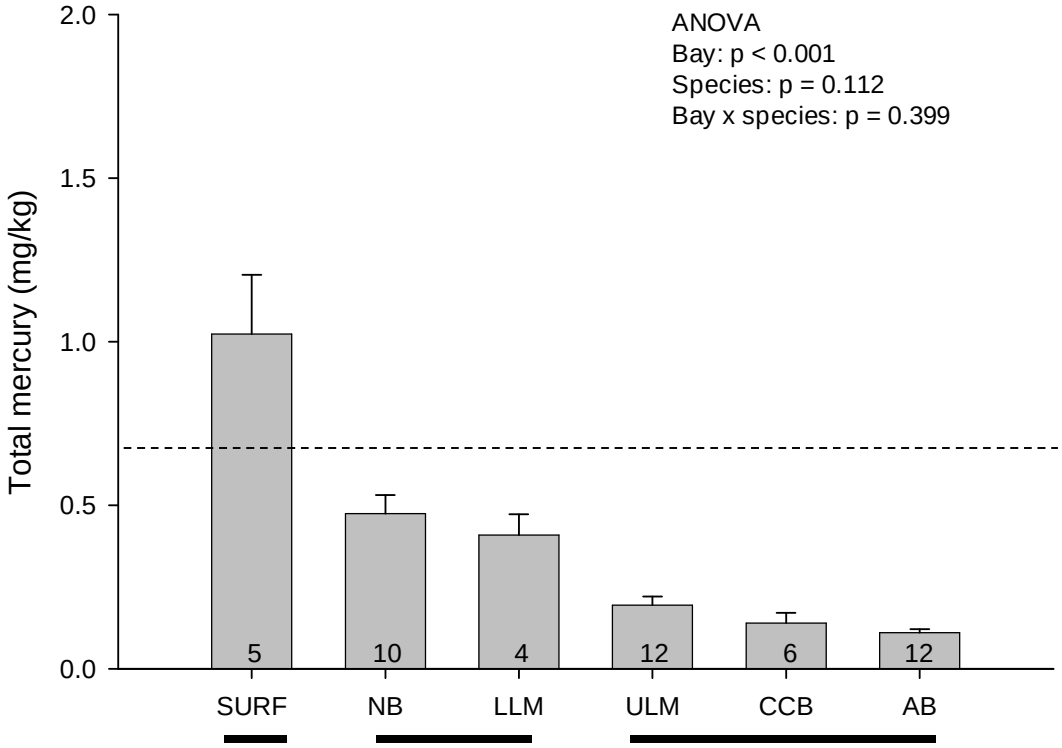

Figure 3. Mean total mercury for all species collected from each bay. Sample size (N) is indicated at the bottom of the bars. The dashed line indicates the 0.7 mg/kg threshold set by the Texas Department of State Health Services. SURF = surf zone, NB = Nueces Bay, LLM = Lower Laguna Madre, ULM = Upper Laguna Madre, CCB = Corpus Christi Bay, and AB = Aransas Bay.

Table 3. Contaminant means, standard error (SE), and total catch (N) for each species-bay combination. A dash (-) indicates no catch. ND = no detection.

	Total Mercury (mg/kg)			Total PCB (mg/kg)			Total PCDD/PCDF (pg/g)		
Bay	MEAN	SE	N	MEAN	SE	N	MEAN	SE	N
Aransas Bay									
Spotted seatrout	0.114	(0.009)	4	0.006	(0.003)	4	ND	ND	4
Redfish	0.090	(0.005)	4	0.000	(0.000)	4	ND	ND	4
Black drum	0.127	(0.031)	4	0.001	(0.000)	4	ND	ND	4
Corpus Christi Bay									
Spotted seatrout	0.220	(0.044)	2	0.011	(0.008)	2	ND	ND	2
Redfish	0.120	(0.046)	2	1.317	(1.314)	2	4.200	(4.200)	2
Black drum	0.080	(0.016)	2	0.001	(0.001)	2	ND	ND	2
Nueces Bay									
Spotted seatrout	0.462	(0.099)	4	0.005	(0.000)	2	ND	ND	2
Redfish	0.576	(0.069)	4	0.005	(0.002)	2	ND	ND	2
Black drum	0.298	(0.072)	2	0.010	(0.005)	2	ND	ND	2
Upper Laguna Madre									
Spotted seatrout	0.262	(0.035)	4	0.000	(0.000)	4	ND	ND	4
Redfish	0.193	(0.055)	4	0.001	(0.000)	4	ND	ND	4
Black drum	0.127	(0.024)	4	0.000	(0.000)	4	ND	ND	4
Lower Laguna Madre									
Spotted seatrout	0.409	(0.064)	4	-	-	-	-	-	-
Redfish	-	-	-	-	-	-	-	-	-
Black drum	-	-	-	-	-	-	-	-	-
Surf									
Spotted seatrout	-	-	-	-	-	-	-	-	-
Redfish	1.024	(0.181)	5	-	-	-	-	-	-
Black drum	-	-	-	-	-	-	-	-	-

We used ANCOVA to determine differences between the total length (TL mm) and total mercury concentration (mg/kg) among species from all bays. There was a significant relationship between TL and total mercury concentration ($F_{1,45}$ = 25.91; p < 0.001); however there was no significant interaction ($F_{2,43}$ = 3.09; p = 0.056) between length and species indicating that the slopes of the regression lines were not different among species. There was also no significant relationship between species (independent factor) ($F_{2,45}$ = 2.42; p = 0.100) indicating that length-mercury concentrations were not different among species (Fig. 4).

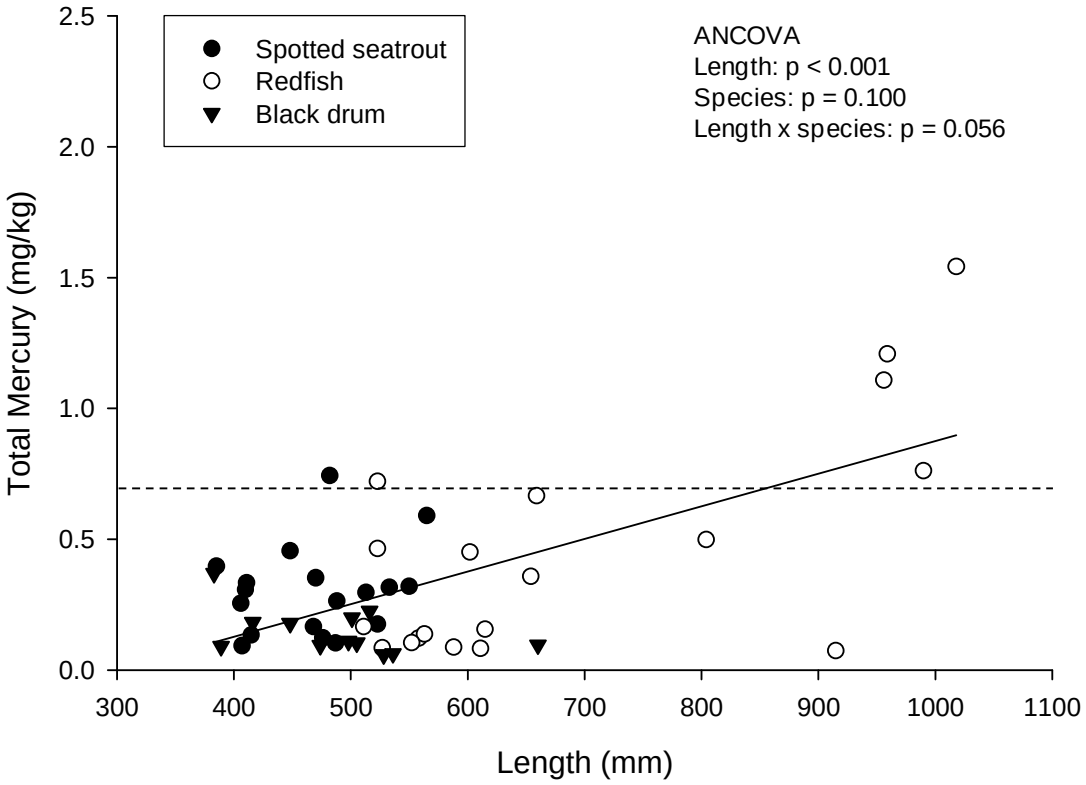

Figure 4. Relationship between the total length (mm) of each fish and total mercury concentration. ANCOVA results compare the slopes of the length-total mercury concentration relationship among species. The regression line shown is from the pooled length-total mercury concentration relationship among all species. Total mercury concentration = -0.3708 + 0.0012(length); N = 49; R^2 = 0.41; p < 0.001. The dashed line indicates the 0.7 mg/kg mercury threshold set by the Texas Department of State Health Services.

Total PCBs and PCDDs/PCDFs

We collected a total of 36 fish for total PCB and PCDD/PCDF analysis (Appendix 1). Fish used for this analysis were all of legal size, except for one large redfish (915 mm TL) collected from Corpus Christi Bay. We examined differences in concentration of total PCBs and PCDDs/PCDFs and found low concentration levels among all bays and species. There was no statistical difference in concentration among bays or species for both contaminants (Table 2, Table 3). However, one fish (sample number 23, 915 mm TL redfish) had a high concentration of total PCBs (2.631 mg/kg), which was approximately 50 times higher than the reported 0.047 mg/kg threshold set by the TDSHS (Fig. 5). We extracted the otoliths to determine age of this fish, and found it was approximately 7 years old. No PCDDs/PCDFs were detected for any of the fish analyzed, except for the same oversize redfish (sample number 23). This fish had a total PCDF/PCDD concentration of 8.4 pg/g (2,3,7,8-TCDF compound = 6.5 pg/g; 1,2,3,4,7,8,9-HpCDF compound = 1.9 pg/g), which is above the 2.33 pg/g threshold set by the TDSHS (Fig. 6).

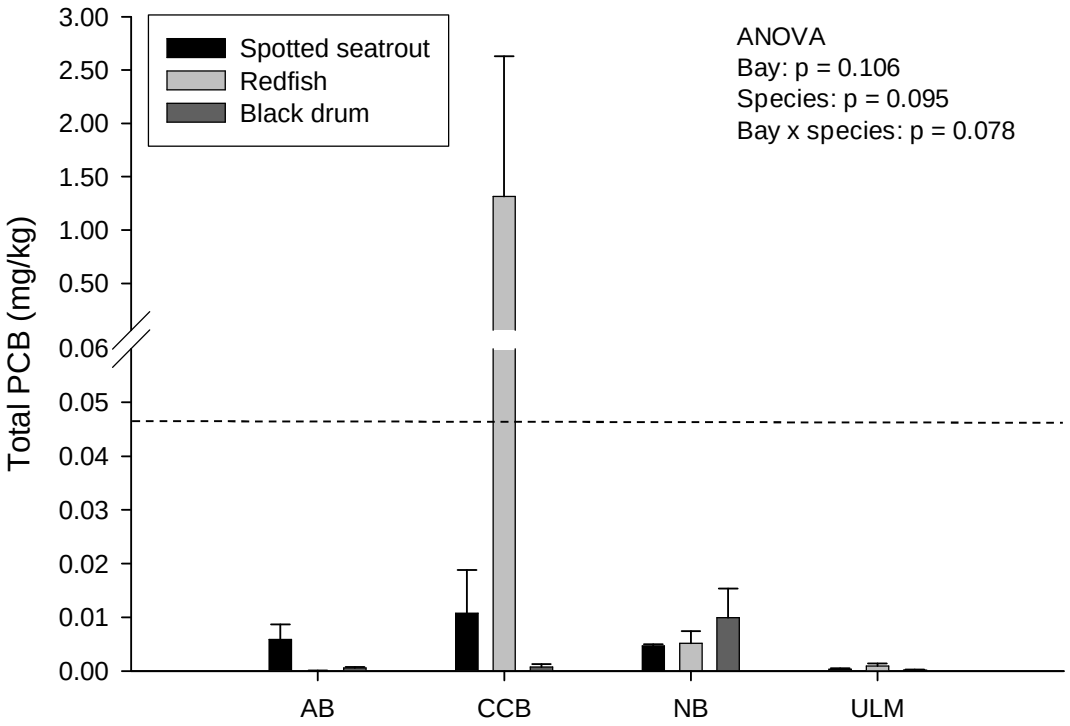

Figure 5. Mean total PCB concentrations for each bay and species. The dashed line indicates the 0.047 mg/kg threshold set by the Texas Department of State Health Services. AB = Aransas Bay, CCB = Corpus Christi Bay, NB = Nueces Bay, and ULM = Upper Laguna Madre.

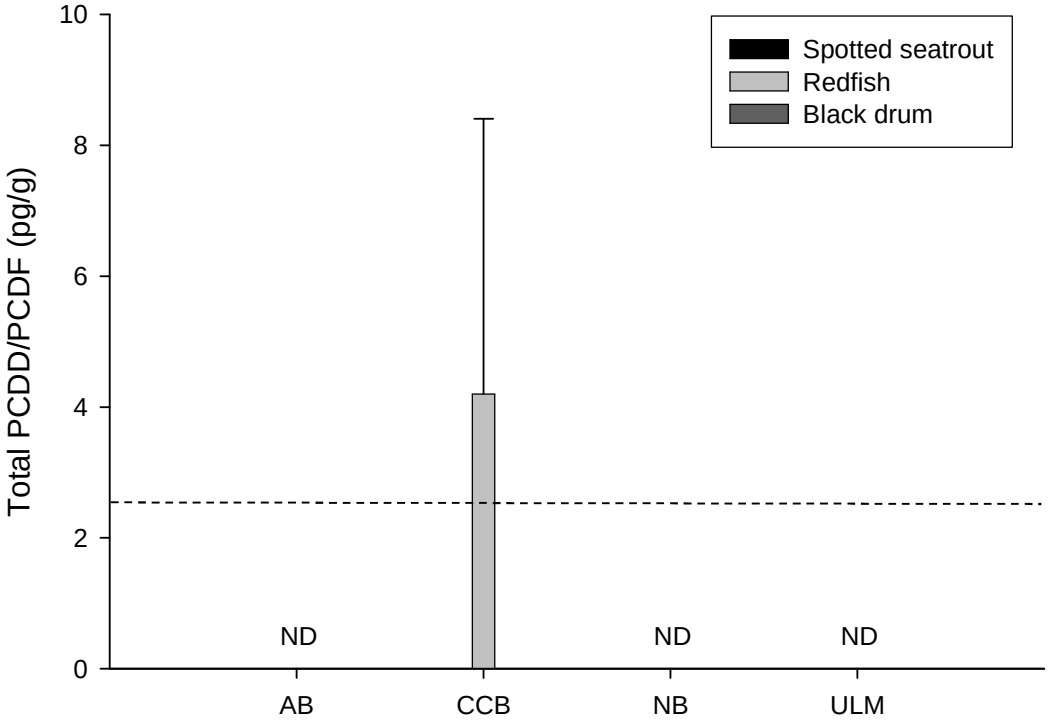

Figure 6. Mean total PCDD/PCDF concentrations for each bay and species. The dashed line indicates the 2.33 pg/g threshold set by the Texas Department of State Health Services. AB = Aransas Bay, CCB = Corpus Christi Bay, NB = Nueces Bay, and ULM = Upper Laguna Madre. ND = no detection of PCDD/PCDFs.

Because PCDDs/PCDFs were only detected in 1 fish, we were not able to run any further analyses. We used ANCOVA to determine differences between the total length (TL mm) and total PCB concentration (mg/kg) among species from all bays. Because the one redfish (sample #23) had an extremely high concentration of total PCBs compared to the remaining samples, it was excluded from the ANCOVA analysis. There was no significant relationship between TL and total PCB concentration ($F_{1,29}$ = 0.90; p = 0.350) and no significant interaction ($F_{2,29}$ = 0.36; p = 0.699) between length and species. There was also no significant relationship between species (independent factor) ($F_{1,29}$ = 2.42; p = 0.100) indicating that length-PCB concentrations were not different among species (Fig. 7).

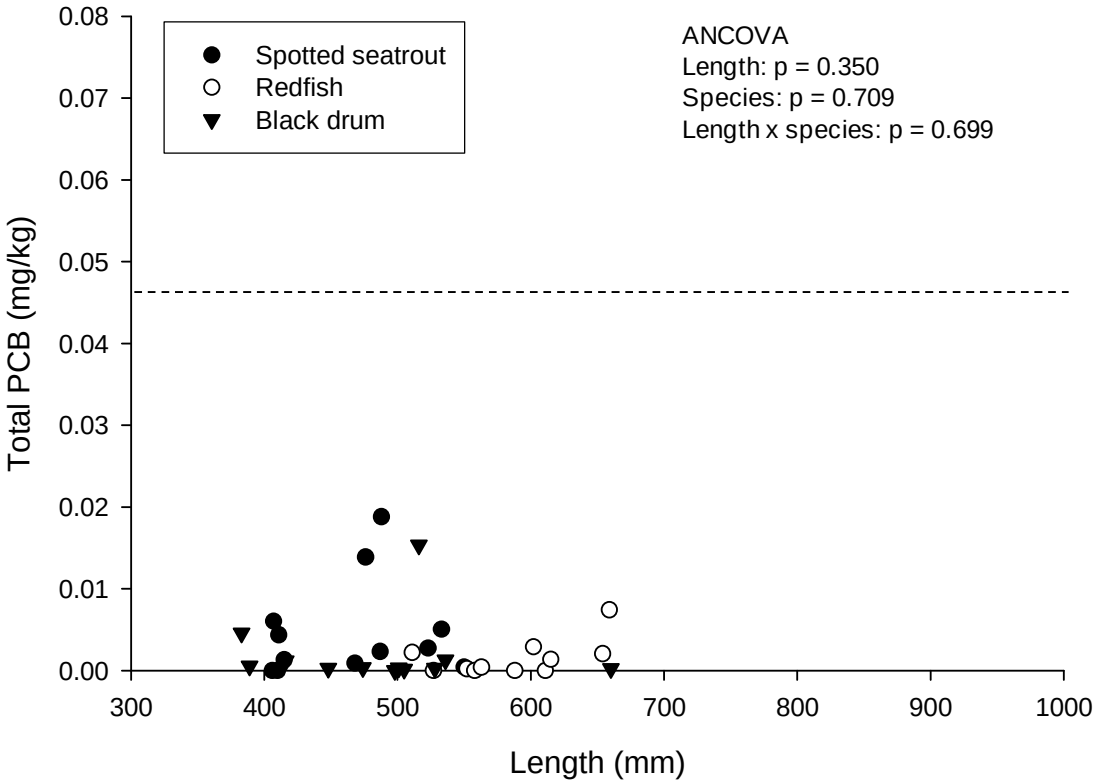

Figure 7. Relationship between the total length (mm) of each fish and total PCB concentration. ANCOVA results compare the slopes of the length-total PCB concentration relationship among species. The dashed line indicates the 0.047 mg/kg threshold set by the Texas Department of State Health Services.

Conclusions and Recommendations

This study was designed to provide preliminary information regarding the contaminant concentrations in muscle tissue of legal-sized sportfish in the Coastal Bend area of Texas. Overall, we found low levels of mercury, PCBs, and PCDDs/PCDFs in the majority of fish; however, a few fish showed high levels of some of these contaminants. These data show that there is a need for further investigation to determine how widespread these high concentrations may be in fish found in south Texas bays and coastal waters. This is particularly true for fish near the surf zone and large redfish.

Total Mercury

We collected 49 fish from South Texas bays and found generally low levels of mercury throughout all bays and among species. However, all the redfish collected from the surf near Port Aransas, Texas, had mean mercury concentrations that were well above the thresholds set by the TDSHS. Redfish are an estuarine dependent species where adults migrate from estuarine waters into the Gulf of Mexico to spawn near tidal inlets and passes so their larvae can migrate back into the estuarine nursery habitats (Weinstein 1979, Baltz et al. 1993, Kneib 1997). In Texas, anglers may keep 2 "oversize" (>711mm TL) redfish per angler per year (Texas Parks and Wildlife Department 2011). Because these redfish are so large, they yield many pounds of meat, which is why our findings are very concerning. We also found a relationship between fish size and mercury concentration, which further points to a need for more data on the mercury contamination of oversize redfish in Texas. Similar mercury studies have been conducted in Florida, where they found high mercury levels (≥ 1.5 mg/kg) in the majority of large adult redfish, greater than 670 mm standard length (SL), from Florida's offshore waters (Adams and Onorato 2005). However, recreational anglers in these areas are not allowed to keep redfish over 686 mm TL (Florida Fish and Wildlife Fish Conservation Commission 2011), and this has been an effective filter to prevent human consumption of these contaminated fish (Adams and Onorato 2005).

Only two other bays, Nueces Bay and the Lower Laguna Madre (LLM), had mercury concentrations near the TDSHS threshold level. Nueces Bay is very industrialized which may have contributed to the slightly higher mercury levels from fish collected in this area (Sager 2002, Zahir et al. 2005). On the other hand, elevated mercury levels in the LLM may be an artifact of only collecting spotted seatrout from this bay, although we did find mercury concentrations were similar among species in other bays.

Total PCBs and PCDDs/PCDFs

The persistent organic pollutants (POPs) found in the 36 fish collected for PCBs and PCDDs/PCDFs were generally very low in the majority of fish tissues. TDSHS issued an advisory for Trinity Bay and Upper Galveston Bay because these compounds were found in spotted seatrout and catfish tissues above safe thresholds (TDSHS 2008). We found that the majority of estuarine sportfish have very low, and often undetectable, concentrations of both PCBs and PCDDs/PCDFs. However, there was one oversize redfish caught that had extremely high levels both POPs analyzed, exceeding the thresholds set by TDSHS. Similar to the high levels of mercury found in the oversized redfish, this is alarming because these large redfish yield large quantities of meat and

are consumed by local residents. This redfish had PCB concentrations 50 times higher than the threshold set by the TDSHS. Because this concentration was so high, GERG laboratories repeated the test three times to ensure accuracy. All tests were similar, confirming that this fish did have extremely high levels of PCBs. However, conclusions from this data should be cautious because we were only able to analyze one redfish in this size class for these contaminants. We did not find a relationship between size and PCB concentration; however we did exclude the one oversized redfish from analysis and there was generally a small range of sizes for the remaining samples analyzed. To better determine this relationship, more samples of larger fish would be needed. We were able to determine the age of the oversized redfish and found this individual to be a fairly young (7 years old), since they routinely live approximately 50 years using a variety of habitats in estuaries and the Gulf of Mexico. Because POPs are known to bioaccumulate, it is surprising that this young redfish had such high levels of PCBs and PCDDs/PCDFs. It is uncertain what could have contributed to these high levels, and we highly recommend further investigations into these large, oversize, redfish that can be consumed by local anglers.

Currently there are no advisories for human consumption of spotted seatrout, redfish, or black drum in the Texas Coastal Bend area. We found that both spotted seatrout and black drum have very low levels of all contaminants analyzed, suggesting that no further investigations are currently needed for these species. However, our results show that there may be a need to expand this study by looking at contamination in large, oversized (>711 mm TL) redfish. These data showed mean mercury, total PCBs, and total PCDD/PCDF concentration levels over the TDSHS threshold levels, and suggest there is a need for further investigation. Unlike other Gulf regions, local anglers can keep and consume up to 2 redfish per year. If these large, recreationally-targeted fish have high concentrations of mercury, PCBs, and PCDDs/PCDFs, the TDSHS may need to consider issuing a consumption advisory.

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Appendix 1. Results for each individual fish analyzed for total mercury (Hg), PCBs, and/or PCDDs/PCDFs. A dash (-) indicates no data collected. F = Female, M = Male, U = Unknown.

Sample number	Bay	General location	Length (mm)	Sex	Total Hg (mg/kg)	Total PCB (mg/kg)	Total PCDD/PCDF (pg/g)	Age (years)
Spotted Seatrout (*Cynoscion nebulosus*)								
1	Upper Laguna Madre	Baffin	468	F	0.166	0.001	ND	-
2	Upper Laguna Madre	Baffin	550	F	0.320	0.000	ND	-
3	Upper Laguna Madre	Yarborough	410	F	0.307	ND	ND	-
4	Upper Laguna Madre	Yarborough	406	F	0.255	ND	ND	-
18	Aransas Bay	Sandbar at Allyns	415	U	0.135	0.001	ND	-
19	Aransas Bay	Sandbar at Allyns	407	U	0.093	0.006	ND	-
20	Aransas Bay	Tip of Mud Island	476	U	0.123	0.014	ND	-
22	Aransas Bay	Tip of Mud Island	487	F	0.104	0.002	ND	-
27	Corpus Christi Bay	Shamrock Island	488	F	0.264	0.019	ND	-
33	Corpus Christi Bay	South Pelican Island	523	F	0.175	0.003	ND	-
36	Lower Laguna Madre	S Spoils ICW	385	F	0.397	-	ND	-
37	Lower Laguna Madre	N Spoils ICW	470	M	0.353	-	ND	-
38	Lower Laguna Madre	N Spoils ICW	565	F	0.590	-	ND	-
39	Lower Laguna Madre	N Spoils ICW	513	F	0.296	-	ND	-
47	Nueces Bay	Cove	411	F	0.334	0.004	ND	-
50	Nueces Bay	Mid-Reef	533	F	0.316	0.005	ND	-
54	Nueces Bay	Mid-Reef	448	M	0.456	-	ND	-
57	Nueces Bay	Mid-Reef	482	M	0.743	-	ND	-

Appendix 1 continued.

Sample number	Bay	General location	Length (mm)	Sex	Total Hg (mg/kg)	Total PCB (mg/kg)	Total PCDD/PCDF (pg/g)	Age (years)
Red Drum (*Sciaenops ocellatus*)								
5	Upper Laguna Madre	Yarborough	615	F	0.156	0.001	ND	-
6	Upper Laguna Madre	Yarborough	654	F	0.358	0.002	ND	-
7	Upper Laguna Madre	Yarborough	558	F	0.122	0.000	ND	-
8	Upper Laguna Madre	Yarborough	563	F	0.138	0.000	ND	-
23	Corpus Christi Bay	Island Moorings Canal	915	F	0.074	2.631	8.4	7
26	Corpus Christi Bay	Shamrock Island	511	F	0.166	0.002	ND	-
41	Aransas Bay	South Mud Island	552	M	0.104	0.000	ND	-
42	Aransas Bay	Along Blind Pass	611	F	0.083	-	ND	-
43	Aransas Bay	Along Blind Pass	527	M	0.084	-	ND	-
44	Aransas Bay	Along Blind Pass	588	F	0.087	-	ND	-
48	Nueces Bay	Mid-Reef	659	F	0.666	0.007	ND	-
49	Nueces Bay	Cove	602	F	0.451	0.003	ND	-
55	Nueces Bay	Mid-Reef	523	F	0.721	-	ND	-
56	Nueces Bay	Mid-Reef	523	F	0.464	-	ND	-
59	Surf	Port A Jetties	804	M	0.498	-	ND	8
60	Surf	Port A Jetties	1018	M	1.542	-	ND	32
61	Surf	Port A Jetties	990	F	0.762	-	ND	26
62	Surf	Port A Jetties	959	M	1.208	-	ND	9
63	Surf	Port A Jetties	956	M	1.108	-	ND	25

Appendix 1 continued.

Sample number	Bay	General location	Length (mm)	Sex	Total Hg (mg/kg)	Total PCB (mg/kg)	Total PCDD/PCDF (pg/g)	Age (years)
Black Drum (*Pogonias cromis*)								
9	Upper Laguna Madre	Yarborough	498	M	0.110	-	ND	-
10	Upper Laguna Madre	Yarborough	474	F	0.094	0.000	ND	-
11	Upper Laguna Madre	Yarborough	501	F	0.200	0.000	ND	-
12	Upper Laguna Madre	Yarborough	505	F	0.104	0.000	ND	-
17	Aransas Bay	Sandbar at Allyns	528	U	0.059	0.000	ND	-
24	Corpus Christi Bay	Island Moorings Canal	536	M	0.063	0.001	ND	-
35	Corpus Christi Bay	Island Moorings Canal	660	F	0.096	0.000	ND	-
45	Nueces Bay	Mid-Reef Site 2	383	M	0.369	0.005	ND	-
46	Nueces Bay	Cove	516	F	0.226	0.015	ND	-
51	Aransas Bay	Trailer Island	416	M	0.182	0.001	ND	-
52	Aransas Bay	Spaulding Reef	448	M	0.178	0.000	ND	-
53	Aransas Bay	Spaulding Reef	389	M	0.090	0.001	ND	-

Appendix 2. PCB results for each fish analyzed by chlorination level. ND = no detection.

	PCB Chlorination (mg/kg)									
Sample number	1	2	3	4	5	6	7	8	9	10
1	ND	ND	ND	ND	0.43	0.29	0.19	ND	ND	ND
2	ND	ND	ND	ND	0.35	0.08	ND	ND	ND	ND
3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	ND	ND	ND	ND	ND	ND	1.37	ND	ND	ND
6	ND	ND	ND	0.15	0.58	0.92	0.40	ND	ND	ND
7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	ND	ND	ND	ND	0.22	0.09	0.08	ND	ND	ND
9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	ND	ND	ND	ND	0.25	0.10	ND	ND	ND	ND
11	ND	ND	ND	ND	0.22	0.10	ND	ND	ND	ND
12	ND	ND	ND	ND	0.06	0.09	ND	ND	ND	ND
17	ND	ND	ND	ND	0.17	0.10	ND	ND	ND	ND
18	ND	ND	ND	ND	0.76	0.40	0.15	ND	ND	ND
19	ND	ND	ND	ND	1.37	1.21	3.45	ND	ND	ND
20	ND	ND	ND	1.16	3.89	5.49	2.21	0.26	0.58	0.27
22	ND	ND	ND	ND	0.65	0.98	0.69	ND	ND	ND
23	ND	0.19	5.51	44.30	213.56	933.29	1150.00	217.92	61.79	4.44
24	ND	ND	ND	ND	0.15	0.50	0.65	ND	ND	ND
26	ND	ND	ND	ND	0.45	1.08	0.54	0.14	ND	ND
27	ND	ND	ND	1.92	4.19	6.67	4.46	0.92	0.38	0.27
33	ND	ND	ND	ND	0.79	1.14	0.55	ND	0.26	ND
35	ND	ND	ND	ND	0.12	0.11	ND	ND	ND	ND
41	ND	ND	ND	ND	0.14	0.08	ND	ND	ND	ND
42	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
43	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
44	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
45	ND	ND	ND	ND	1.18	2.27	1.14	ND	ND	ND
46	ND	ND	ND	0.61	2.57	6.08	5.02	0.77	0.29	ND
47	ND	ND	ND	ND	0.77	2.27	1.31	ND	ND	ND
48	ND	ND	ND	ND	0.85	3.30	2.70	0.33	0.24	ND
49	ND	ND	ND	ND	0.40	1.05	0.83	0.36	0.25	ND
50	ND	ND	ND	ND	0.76	1.77	1.79	0.55	0.17	ND
51	ND	ND	ND	ND	0.17	0.68	0.33	ND	ND	ND
52	ND	ND	ND	ND	0.06	0.23	ND	ND	ND	ND
53	ND	ND	ND	ND	0.10	0.31	0.16	ND	ND	ND