QUANTITATIVE RISK CHARACTERIZATION

Nueces Bay
Nueces County, TX

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Seafood Safety Division
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BACKGROUND AND STATEMENT OF THE ISSUES

The Corpus Christi Bay system comprises over 124,700 acres along the central Texas coast. Nueces Bay (19,518 acres) is a part of the Corpus Christi Bay system. The mouth of the Nueces River empties into Nueces Bay just north of Corpus Christi at the San Patricio county line. Most of Nueces Bay is located in the San Antonio-Nueces coastal basin with a small portion in the Nueces-Rio Grande coastal basin. Nueces Bay is shallow and poorly flushed (average depth: two- to three feet over broad mud flats and scattered oyster reefs), which is characteristic of most coastal bend estuaries. The Corpus Christi Bay system exchanges water with the Gulf of Mexico through Aransas Pass [1]. The 2000 population of the Corpus Christi, Texas, metropolitan statistical area (MSA) was over 380,000, of whom more than 277,000 live in the city of Corpus Christi [2]. Several industrial plants and refineries are located near or adjacent to Nueces Bay and to the Dona Park residential neighborhood. Among these is Encycle Texas, Inc. This large hydrometallurgical complex, a subsidiary of the American Smelting and Refining Company (ASARCO), is adjacent to the south side of Nueces Bay. Encycle Texas, Inc. recovers and sells (recycles) nickel, copper, cobalt, tin, zinc, lead, gold, and silver. From 1942 to 1985, ASARCO operated a zinc refinery at this location [3].

Dona Park is a residential neighborhood lying south of the turning basin of the Port of Corpus Christi. Residents of Dona Park have numerous health complaints and attribute these health problems to contamination from the former ASARCO site, to releases from nearby refinery stacks and to large piles of coke along the canal to the north of Encycle [3]. There have been reports of releases into the bay. In March 1994, the Texas Natural Resources Conservation Commission (TNRCC, now the Texas Commission on Environmental Quality; TCEQ) reported contamination of neighborhood soils with cadmium and zinc. In August 1994, the Texas Department of Health (TDH) examined fish, crabs, and oysters from Nueces Bay in response to Dona Park residents' concerns for the safety of consuming seafood from Nueces Bay. Oysters from the 1994 samples contained high concentrations of zinc (range: 2294-2482 ppm) [3]. In January 1995, under authority of Chapter 436 of the Texas Health and Safety Code [4], TDH closed Nueces Bay to the harvesting of oysters [5]. Pursuant to that TDH action, the TCEQ (then TNRCC) classified Nueces Bay as "impaired" and placed it on the Texas 303 (d) list [6]. In 2002, with funding from the General Land Office, TDH reassessed the potential for health risks from consumption of contaminated seafood taken from Nueces Bay. This report is the culmination of that reassessment.

METHODS

Sampling and Analysis

Collection and Analysis of Seafood Samples

To evaluate potential health risks to recreational and subsistence fishers who consume environmentally contaminated seafood, the Texas Department of Health (TDH) collects and analyzes samples of edible seafood tissues from the state's public waters; these samples are designed to represent the species, trophic levels and legal-sized specimens available for consumption. When practical, TDH collects samples from several sites within a water body to characterize the geographical distribution of contaminants. The TDH laboratory utilizes established methodology to analyze edible fillets (skin off) of fish and edible meats of shellfish (crab and oyster) for seven metals – arsenic, cadmium, copper, lead, total mercury[1], selenium, and zinc – and for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs: Aroclors 1016, 1221, 1224, 1232, 1248, 1254, and 1260).

Description of Nueces Bay Sample Set

In February 2002 and again in July and August 2002, the Seafood Safety Division collected, in total, forty samples from six sites within Nueces Bay [9]. The attached map of Nueces Bay (Appendix) shows the sample collection sites. Four sites were relatively close to sites sampled in 1994: Gum Hollow, Portland Cove, the Nueces Causeway site, and a point near the Central Power and Light (CPL) cooling water outfall (1994 samples were taken from the vicinity of Rincon Point, east of the 2002 site nearest the CPL site). TDH also analyzed samples from Avery Point near the CPL plant and from Whites Point near the mouth of the Nueces River. Gum Hollow yielded one southern flounder and two blue crab composite samples. Portland Cove samples consisted of six composite blue crab samples, two spotted seatrout, and one southern flounder. The Nueces Causeway site yielded seven composite oyster samples, one black drum, and one red drum. From the site nearest CPL, the crew collected five composite oyster samples and one composite blue crab sample. The SSD collected two sheepshead from a site near Avery Point. Four black drum, one composite sand trout, one spotted seatrout, three red drum and two sheepshead were collected from Whites Point. With the exception of one nineteen-inch red drum from the Nueces Causeway site, all finfish collected were of legal size for possession according to Texas Parks and Wildlife Department (TPWD) regulations [10].

Statistical Analyses

TDH calculated average concentrations, standard deviations, median concentrations, minimum and maximum concentrations, and ranges for each species on IBM-compatible microcomputers using SPSS software [11]. Inferential statistics were not performed on these data. TDH calculated hazard quotients (HQs) and allowable meals with Microsoft Excel [12]. All samples were included in the analyses.

Derivation of Health-Based Assessment Comparison Values (HACs)

Generally, people who regularly eat contaminated seafood are exposed to low concentrations of contaminants over an extended time. This pattern of exposure seldom results in acute toxicity but may increase the risk of subtle, delayed or chronic adverse health effects. Presuming that people eat a variety of fish, TDH routinely evaluates average contaminant concentrations across species and locations within a specific water body since this approach best reflects the likely exposure pattern of consumers over time. However, the agency also may examine the risks associated with ingestion of individual species of fish or shellfish from individual collection sites.

[1]Nearly 100% of the mercury in upper trophic-level fish over three years of age is methylmercury [7]. Total mercury is a conservative surrogate for methylmercury concentration in fish and shellfish. Because of the higher cost of methylmercury analyses, the USEPA recommends that states determine total mercury concentrations in fish and that – to be most protective of human health – states assume that all mercury in fish or shellfish is methylmercury. Thus, the Texas Department of Health (TDH) analyzes fish and shellfish tissues for total mercury, which includes that found as methylmercury and as inorganic mercury. In its risk characterizations, TDH compares total mercury concentrations in tissues to a comparison value derived from the ATSDR's minimal risk level for methylmercury [8]. TDH may utilize the terms "mercury" and "methylmercury" interchangeably to refer to methylmercury in fish.

TDH evaluates chemical contaminants in fish by comparing average contaminant concentrations with health-based assessment comparison (HAC) values (in mg contaminant per kg edible tissue or mg/kg) for non-cancer and cancer endpoints. To calculate the associated HAC values for both carcinogenic and systemic effects, TDH assumes that a standard adult weighs 70 kilograms and that adults consume 30 grams of fish per day (about one eight-ounce meal per week). TDH uses the U.S. Environmental Protection Agency's (USEPA) oral reference doses (RfDs) or the Agency for Toxic Substances and Disease Registry's (ATSDR) chronic oral minimal risk levels (MRLs) to derive HAC values for evaluating systemic (noncancerous) adverse health effects (HAC_{nonca}). RfDs are estimates of long-term daily exposures that are not likely to cause adverse noncancerous (systemic) health effects even if exposure occurs over a lifetime [13]. Since MRLs and RfDs are similar concepts, the numbers from both agencies may be identical. However, in some instances, the RfD may differ from the MRL because scientific judgment or interpretation can vary between regulatory agencies. The cancer risk comparison values (HAC_{ca}) that TDH uses to assess carcinogenic potential from consumption of seafood containing carcinogenic chemicals are based on the USEPA's chemical-specific cancer slope factors (SFs) [13], an acceptable lifetime risk level (ARL) of 1 excess cancer in 10,000 (1×10^{-4}) persons equally exposed to the toxicant and an exposure period of 30 years.

Most constants employed to calculate HAC values contain built-in margins of safety (uncertainty factors). Uncertainty factors are chosen to minimize the potential for systemic adverse health effects in those people – including sensitive subpopulations such as women of childbearing age, pregnant or lactating women, infants, children, the elderly, people who have chronic illnesses, or those who consume exceptionally large quantities of fish or shellfish – who eat environmentally contaminated seafood [14]. Therefore, adverse health effects are very unlikely to occur, even at concentrations approaching the HAC values. Moreover, health-based assessment comparison values do not represent a sharp dividing line between safe and unsafe exposures. The strict demarcation between acceptable and unacceptable exposures or risks is primarily a tool used by risk managers to assure protection of public health. TDH finds it unacceptable when consumption of four or fewer meals per month would result in exposures that exceed a HAC value or other measure of risk. TDH advises people who wish to minimize their exposure to environmental contaminants in seafood to eat a variety of fish and shellfish and to limit consumption of those species that are most likely to contain environmental toxicants.

Addressing the Potential for Cumulative Effects

When multiple chemicals that affect the same organ or that have the same mechanism of action exist together in one or more samples from a water body, the standard assumption is that potential adverse health effects are cumulative (additive) [14]. Therefore, TDH conservatively assumes that each time people eat seafood from an affected water body, they will be exposed to all of the chemicals and, further, that any potential adverse systemic or carcinogenic effects from any of the contaminants will be cumulative (i.e., additive).

Cumulative Systemic (Noncancerous) Effects

To evaluate the importance of possible cumulative systemic (noncancerous) health effects from consumption of contaminants with similar toxicity profiles, TDH calculates a hazard index (HI) by summing the hazard quotients (HQ) previously calculated for each contaminant [15]. The hazard quotient (HQ) is the ratio of the estimated exposure dose of a contaminant to its RfD or MRL [15]. A HI of less than 1.0 may suggest that no significant hazard is present for the observed combination of contaminants at the observed concentrations. While a HI that exceeds 1.0 may indicate some level of hazard, it does not imply that exposure to the contaminants at observed concentrations will result in adverse health effects. Nonetheless, finding an HI that exceeds 1.0 may prompt the agency to consider some public health intervention strategy.

Cumulative Carcinogenic Effects

To estimate the potential additive effects of multiple carcinogens on excess lifetime cancer risk, TDH sums the risks calculated for each carcinogenic contaminant observed in a sample set. TDH recommends limiting consumption of seafood containing multiple carcinogenic chemicals to quantities that would result in an estimated combined theoretical excess lifetime cancer risk of not more than 1 extra cancer in 10,000 persons so exposed.

Addressing Children's Unique Vulnerabilities

TDH recognizes that fetuses, infants, and children may be uniquely susceptible to the effects of toxic chemicals and that any such vulnerabilities demand special attention. Windows of vulnerability (i.e., critical periods) exist during development. These critical periods are particularly evident during early gestation, but may also appear throughout pregnancy, infancy, childhood, and adolescence – indeed, at any time during development, when toxicants can permanently impair or alter the structure or function of vulnerable systems [16]. Unique childhood vulnerabilities may result from the fact that, at birth, most organs and body systems have not achieved structural or functional maturity, continuing to develop throughout childhood and adolescence. Because of these structural and functional differences, children may differ from adults in absorption, metabolism, storage, and excretion of toxicants, any one of which factors could increase the concentration of biologically effective toxicant at the target organ(s). Children's exposures to toxicants may be more extensive than adult's exposures because children consume more food and liquids in proportion to their body weight than do adults [16], a factor that also may increase the concentration of toxicant at the target. Children can ingest toxicants through breast milk – often unrecognized as an exposure pathway. They may also experience toxic effects at a lower exposure dose than adults due to differences in target organ sensitivity. Stated differently, children could respond more severely than would adults to an equivalent exposure dose [16]. Children may also be more prone to developing certain cancers from chemical exposures than are adults. If a chemical – or a class of chemicals – is shown to be more toxic to children than to adults, the RfD or MRL will be commensurately lower to reflect children's potentially greater susceptibility. Additionally, in accordance with ATSDR's *Child Health Initiative* [17] and USEPA's *National Agenda to Protect Children's Health from Environmental Threats* [16], TDH seeks to further protect children from the potential effects of toxicants in fish and shellfish by suggesting that this sensitive group consume smaller quantities of environmentally contaminated seafood than adults. Therefore, TDH routinely recommends that children who weigh 35 kg or less and/or who are eleven years of age or younger eat no more than four ounces of chemically contaminated fish or shellfish per meal. TDH also recommends that consumers spread these meals out over time. For instance, if the consumption advice recommends eating no more than two meals per month, children consuming fish or shellfish from the affected water body should consume no more than twenty-four meals per year. Ideally, children should not eat such seafood more than twice per month.

RESULTS

Chemical Analyses

The Seafood Safety Division (SSD) received the analytical results of the Nueces Bay samples from the TDH laboratory in late October 2002. After entering field and laboratory data and assessing those entries for accuracy, the SSD toxicologist conducted statistical analyses on the data and interpreted the results to produce the present report.

Organic contaminants were conspicuous by their general absence from fish and shellfish collected from Nueces Bay during 2002 (data not shown). One sample contained chlordane and p,p'-DDE at concentrations near the reporting limits for these compounds while another contained p,p-DDE, again at a concentration near the reporting limit (data not shown). One spotted seatrout, collected from near Whites Point, contained 0.170 mg/kg of Aroclor 1260. The average concentration of Aroclor 1260 in spotted seatrout was 0.057 mg/kg (n=3), while Aroclor in all finfish from Nueces Bay was 0.009 mg/kg (n=19). Oysters collected in February 2002 contained small, but measurable quantities of pyridine, as did blue crab composites – all collected in August 2002 (data not shown). Oysters collected in the summer months did not contain pyridine.

Samples from Nueces Bay contained various inorganic or metalloid contaminants (Table 1). Selenium and zinc were present in all samples, arsenic in twenty-nine samples, cadmium in thirty samples. Copper was present in thirty-six of forty samples, while mercury was observed in twenty-three samples. Only oysters were consistently free of measurable concentrations of mercury. Visual inspection of the data also revealed that only oysters (n=12) contained measurable quantities of lead (Table 1).

The average concentration of zinc in fish, blue crab and oyster tissue samples was 2 mg/kg, 45 mg/kg and 1000 mg/kg, respectively (Table 1). Oysters were collected from two sites: a site on the north side of the Nueces Bay causeway and a site near the Central Power and Light (CPL) cooling water outfall. Zinc in oysters from the site nearest CPL averaged 1486 mg/kg, while oysters from the causeway site averaged 770 mg zinc/kg edible tissue.

Statistical Analyses

Mean concentrations, minimum and maximum concentrations and the number of samples of each species at each site that contained metalloid contaminants are presented in Table 1. TDH utilized average concentrations of contaminants to calculate theoretical risk values for the present risk characterization.

DISCUSSION

Risk Characterization

Characterizing the Risk of Systemic (Noncancerous) Health Effects from Consumption of Nueces Bay Fish and Shellfish

Organic compounds

Organic contaminants were not prominent in samples from Nueces Bay. Of nineteen finfish samples, one – a spotted seatrout collected off Whites Point – contained PCBs consistent with Aroclor 1260 (data not shown). PCBs – of which Aroclor® is a brand – can cause immune suppression and other systemic adverse health effects [18]. The average concentration of Aroclor 1260 in spotted seatrout (0.057 mg/kg) was slightly greater than that of the HAC_{nonca} value for Aroclor 1254 (0.047 mg/kg), the systemic toxicity of which is likely comparable to that of Aroclor 1260. The Aroclor concentration averaged across all fish species (.009 mg/kg) was well below the HAC_{nonca} for this substance. Spotted seatrout are very popular game fish; for retention (presumably for consumption), spotted seatrout must be at least 15 inches in length [10]. Based upon three samples, only one of which contained Aroclor 1260, people who consume spotted seatrout exclusively could perhaps have some increased risk of systemic effects from the presence of PCBs in this species. However, the sample size for this species is too small for an accurate assessment of the risk of adverse health outcomes from consuming spotted seatrout from Nueces Bay that contain PCBs. Moreover, those who consume a diet consisting of varied species of finfish from Nueces Bay should not encounter increased risk of adverse health outcomes from PCBs. Chlordane and DDE did not approach the HAC_{nonca} for those compounds and are, thus, of no toxicologic importance.

All blue crabs (blue crab samples were collected in August 2002) and oysters collected during February 2002 contained pyridine in concentrations below guidelines for human health. Oysters collected during late summer 2002 did not contain this substance. TDH has previously determined that small quantities of pyridine occur naturally in crabs and oysters under some conditions and that low concentrations of pyridine are of no toxicological significance [19].

Inorganic or metalloid contaminants

Of the seven metallic contaminants analyzed in these samples, only zinc in oysters from Nueces Bay exceeded the HAC_{nonca} value (700 mg/kg). In small doses, zinc is an essential nutrient. The recommended daily allowance (RDA) for zinc ranges from 5 mg (infants) to 15 mg (adult males). Thus, too little zinc in the diet can lead to health problems, including reproductive difficulties [20]. However, too much zinc in the diet can also be harmful to health. Regular or long-term consumption of zinc or zinc compounds can cause a loss of copper from the body, which, in consequence, leads to a copper deficiency anemia [18]. Copper deficiency is associated with depressed levels of the copper-containing, low molecular-weight cytoplasmic protein, superoxide dismutase [18]. The USEPA bases the reference dose for zinc upon depressed levels of this enzyme, which is a more sensitive indicator of copper deficiency than is a change in serum copper concentration [18]. High zinc intake can also reduce HDL-cholesterol and increase LDL-cholesterol through an interaction of zinc with copper metabolism [18].

Consumption of foods containing very high levels of zinc may cause acute health effects including dehydration, electrolyte imbalance, abdominal pain, nausea, vomiting, lethargy, dizziness, and lack of muscular coordination. Available data suggests that 500 to 1,000 milligrams or more of zinc may be ingested daily without acute adverse effects. A single oral dose of more than ten grams of zinc may produce gastrointestinal distress, including nausea, vomiting, and diarrhea [18]. The highest zinc concentration observed in Nueces Bay oysters was 2300 mg/kg, a concentration that would result in consumption of about 522 mg of zinc in an eight-ounce meal of oysters. Thus, although conceivable, it is unlikely that most people who eat eight-ounce meals of oysters from Nueces Bay would experience GI upset. However, it is possible that some sensitive individuals could experience acute adverse effects from consuming these oysters.

On the other hand, the USEPA and the Agency for Toxic Substances and Disease Registry (ATSDR) suggest that a 70-kg adult generally should not regularly consume more than 21 mg zinc per day. Calculations indicate that a 70-kg adult who eats eight ounces of oysters/day containing zinc at the maximum concentration observed in these samples would exceed the RfD and/or the chronic oral minimum risk level (MRL; 0.3 mg/kg/day) by a factor of 25. Since chronic ingestion of high levels of zinc depletes copper from the body, regular or long-term consumption of oysters from Nueces Bay could cause chronic toxicity, the most prominent sign of which might be anemia associated with a decrease in the copper-transport protein ceruloplasmin and the resultant decrease in serum copper concentration [18].

Although all crab and oyster samples and some fish samples contained arsenic, the concentrations were below the HAC_{nonca} value for this element. Moreover, most arsenic in fish and shellfish is an organic form of the element (i.e., “fish arsenic,”) that is virtually nontoxic. Arsenic in fish, crabs, or oysters from Nueces Bay should not therefore be a public health concern [20]. Mercury levels in fish and crabs were also well below the HAC_{nonca} for this contaminant and should not constitute a threat to public health. The lead present in oysters from Nueces Bay would not materially increase blood lead concentrations in children who might eat oysters from this water body were these oysters available for consumption [22].

Characterizing the Risk of Cancer from Consumption of Nueces Bay Fish and Shellfish

Neither p,p’-DDE (observed in one fish and one composite crab sample), chlordane (in one composite crab sample), nor Aroclor 1260 (observed in one seatrout) in samples from Nueces Bay exceeded its respective HAC_{ca} value. Aroclor 1260, p,p’-DDE, and chlordane have been shown experimentally to cause tumors in animals [18]. In the worst case, if all fish from the bay contained 0.170 mg Aroclor 1260 per kg edible tissue, the probability of excess cancers after 30 years’ exposure would be about one in 16,000 persons equally exposed to this toxicant, a risk that does not exceed TDH guidelines for protection of public health (1 in 10,000). At an average concentration of 0.009 mg of Aroclor 1260 per kilogram of edible tissue (all finfish combined), the calculated lifetime excess cancer risk would be in the range of 1 in 300,000 people equally exposed to Aroclor 1260. Oysters contained no organic contaminants other than pyridine, a naturally occurring compound without toxicologic significance in the present circumstances; therefore, assessment of the carcinogenic potential of consumption of organics in oysters from Nueces Bay was unnecessary.

The USEPA classifies inorganic arsenic a human carcinogen (Class A) [18]. Arsenic concentrations in fish, crabs, or oysters from Nueces Bay, however, did not exceed the HAC_{ca} for inorganic arsenic. Assuming all arsenic in fish and shellfish from Nueces Bay to be inorganic arsenic (only about 5% of the arsenic in fish or shellfish is inorganic arsenic), TDH calculated the excess cancer risk from consuming oysters containing average concentration of this contaminant as approximately one in 49,000 equally exposed individuals. That calculated risk did not exceed TDH health guidelines for cancer from exposure to environmental toxicants in fish or shellfish 1 in 10,000). Moreover, since most arsenic in fish or shellfish is organic arsenic [22], the risk is likely very much lower. Cancer potency factors (slope factors) are not available for cadmium, lead, mercury, selenium, or zinc [18]. Thus, it is not possible to determine the probability of excess cancers from consuming these contaminants in fish or shellfish from Nueces Bay.

Overall, however, the likelihood is remote that one would observe elevations in the rate of cancers from consumption of fish, crabs or oysters from Nueces Bay that contain any one of the observed organic or metalloid contaminants (Table 2).

Characterizing the Likelihood of Cumulative Systemic Adverse Health Effects or Cancer from Consumption of Fish and Shellfish from Nueces Bay

Blue crabs from Nueces Bay contained no contaminants in excess of HAC_{nonca} or HAC_{ca} values. Of the finfish sampled, one spotted seatrout contained elevated PCB levels. That same specimen contained chlordane, albeit at a level near the detection limit (one blue crab also contained small quantities of p,p'-DDE and chlordane). All three organic contaminants observed in these samples affect liver structure or function in experimental animals [18]. Examination of the additive effects of these compounds did not suggest that cumulative systemic effects or cancer are likely from consumption of seafood containing combinations of these sporadically observed organic contaminants.

The metalloid contaminants observed in samples from Nueces Bay affect diverse organs or have different mechanisms of action. Since cumulative effects assessments assume similar mechanisms and/or overlapping target organs. Therefore, it is unnecessary to assess cumulative systemic effects for the metallic contaminants in fish, crabs, or oysters from Nueces Bay. TDH could not assess the carcinogenic potential of metallic contaminants other than inorganic arsenic because published slope factors for oral exposure to these contaminants are lacking. Thus, it was not possible to assess the probability of cumulative carcinogenicity for these substances.

Conclusions and Public Health Implications

TDH toxicologists prepare quantitative risk characterizations to determine public health hazards from consumption of fish, crabs, and oysters harvested by recreational or subsistence fishers from Texas waters, and, if indicated, make risk management recommendations to the TDH Commissioner of Health. The results of this risk characterization suggest that regular or long-term consumption of oysters from Nueces Bay containing excess zinc could result in systemic adverse health effects, including anemia and changes in serum cholesterol profiles. Therefore, consumption of oysters from Nueces Bay constitutes a **public health hazard** due to excessively high zinc levels in this species. PCBs in spotted seatrout slightly exceed the HAC_{nonca} for Aroclor

1254. However, this sample is too small for an accurate assessment of the likelihood that consumption of a diet of fish from Nueces Bay consisting only of spotted seatrout would result in adverse health events. Therefore, consumption of spotted seatrout from this water body constitutes an **indeterminate public health hazard.** Consumption of blue crabs or finfish from Nueces Bay other than spotted seatrout poses **no apparent public health hazard.**

Recommendations

TDH risk managers have established certain criteria for issuing fish consumption advisories based on approaches suggested by the USEPA [23]. When a risk characterization confirms that consumption of four or fewer meals per month (adults: eight ounces per meal; children: four ounces per meal) would result in exposures to toxicants that exceed TDH health-based assessment guidelines, risk managers may wish to recommend that the Commissioner of Health issue consumption advice or ban possession of fish from the affected water body. Subchapter D of the Texas Health and Safety Code, part 436.061(a) considers a species of aquatic life adulterated if taken from an area declared prohibited for possession of that species by the director (commissioner of health). Part 436.061(b) (1) declares that molluscan shellfish or crabmeat is adulterated if it bears or contains a poisonous or deleterious substance that may render it injurious to health unless the substance is a naturally occurring substance and the quantity of the substance in the molluscan shellfish or crabmeat does not ordinarily render the substance injurious to health [4]. Based on the information utilized to characterize risks from consumption of fish and shellfish from Nueces Bay, the Seafood Safety Division (SSD) and the Environmental Epidemiology and Toxicology Division (EE&TD) of the Texas Department of Health (TDH), have determined that oysters taken from Nueces bay are adulterated with zinc and, therefore, these divisions recommend:

1. That TDH continues to list Nueces Bay as an area closed to the harvesting of oysters due to zinc contamination.

2. That TDH collects several more spotted seatrout specimens for analysis of PCBs to better characterize the prevalence of this contaminant in this species and, therefore, the risk associated with consumption of spotted seatrout from Nueces Bay.

3. That, as resources allow, TDH continues to monitor fish and shellfish from Nueces Bay for the presence of zinc and other contaminants.

Public Health Action Plan

TDH publishes fish consumption advisories and bans in a booklet available to the public through the Seafood Safety Division: (512-719-0215) [24]. The Seafood Safety Division (SSD) also posts this information on the Internet at URL: http://www.tdh.state.tx.us/bfds/ssd. The SSD regularly updates its web site. Some risk characterizations for water bodies surveyed by the Texas Department of Health may also be available from the Agency for Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/HAC/PHA/region6.html). The Texas Department of Health provides the U.S. Environmental Protection Agency (URL: http://fish.rti.org), the Texas Commission on Environmental Quality (TCEQ; URL: http://www.tceq.state.tx.us), and the Texas Parks and Wildlife Department (TPWD; URL: http://www.tpwd.state.tx.us) with information on all consumption advisories and bans on possession. Each year, the TPWD informs the fishing and hunting public of fishing bans in an official hunting and fishing regulations booklet [10], available at some state parks and at establishments that sell fishing licenses.

Readers may direct questions about the scientific information or recommendations in this risk characterization to the Seafood Safety Division (512-719-0215) or the Environmental Epidemiology and Toxicology Division (512-458-7269) at the Texas Department of Health. Toxicological information on a variety of environmental contaminants found in seafood and other environmental media may also be obtained from the Agency for Toxic Substances and Disease Registry (ATSDR), Division of Toxicology, by telephoning that agency at the toll free number (800-447-1544) or from the ATSDR website (URL: http://www.atsdr.cdc.gov).

TABLES

Table 1. Inorganic Contaminants (mg/kg) in Fish and Shellfish from Nueces Bay, 2002

Contaminant	# Affected (# Sampled)	Average Concentration (mg/kg) (Min-Max) *	Health Assessment Comparison Value† (mg/kg)	Basis for Comparison Value
Arsenic‡				
Fish	8/19	0.013 (0.006-0.03)	0.7	EPA chronic oral MRL for INORGANIC arsenic: 0.0003 mg/kg/day‡
Blue crabs	9/9	0.031 (0.024-0.043)		
Oysters	12/12	0.074 (0.052-0.088)	0.362	EPA oral slope factor: 1.5 per mg/kg - day
Cadmium				
Fish	9/19	0.014 (0.002-0.09)	2.3	EPA Chronic Oral Reference Dose (RfD): 0.001 mg/kg -day
Blue crabs	9/9	0.158 (0.06-0.29)		
Oysters	12/12	1.023 (0.346-1.67)		
Copper			No Comparison Value	Not Available
Fish	15/19	0.4 (0.1-1.0)		
Blue crabs	9/9	7.9 (6.3-9.6)		
Oysters	12/12	46.1 (9.1-93.2)		
Lead				
Fish	0/19	Not Detected	0.6	EPA IEUBKwin**
Blue crabs	0/9	Not Detected	0.6	
Oysters	12/12	0.183 (.072-0.283)	0.6	
Mercury			0.7	ATSDR chronic oral Minimal Risk Level: 0.0003 mg/kg –day
Fish	15/19	0.195 (0.051-0.615)		
Blue crabs	8/9	0.121 (0.015-0.207)		
Oysters	0/12	0.042 (0.012-0.064)		
Selenium			2.0	TDH Guidelines
Fish	19/19	0.87 (0.5-1.5)		
Blue crabs	9/9	1.0 (0.71-1.5)		
Oysters	12/12	0.66 (0.29-1.05)		
Zinc			700	EPA chronic oral reference dose (RfD): 0.3 mg/kg –day
Fish	19/19	2.0 (0.8-3.5)		
Blue crabs	9/9	45 (39-53)		
Oysters	12/12	**1005** (479-2300)		

**Minimum concentration to maximum concentration (to calculate the range, subtract the minimum concentration from the maximum concentration).*
† Derived from the MRL or RfD for noncarcinogens or the USEPA slope factor for carcinogens; assumes a body weight of 70 kg, and a consumption rate of 30 grams per day, and assumes a 30-year exposure period for carcinogens and an excess lifetime cancer risk of $1x10^{-4}$.
‡Most arsenic in fish and shellfish occurs as organic arsenic, considered virtually nontoxic.
*** IEUBKwin: Integrated Exposure Uptake Biokinetic Model for Lead in Children, Windows version. EPA's biokinetic model accounts for exposure to all lead sources (diet, water, soil, air).*

Table 2. Hazard ratios (HRs) for zinc contamination and allowable meals for fish and shellfish collected from Nueces Bay in 2002.

Species	Hazard Ratio	Meals/Month	Meals/Week
Finfish	0.003	1424	328
Blue Crabs	0.06	62	14
Oysters	**1.44**	**2.8**	**0.6**

REFERENCES

1. [TPWD] Texas Parks and Wildlife. Exploring Texas. What's happening in the Corpus Christi Bay? Information available at URL: http://www.tpwd.state.tx.us/ex;ltx/eft/gulf/habitats/bays_corpuschristibayabout.htm

2. [USCB] United States Census Bureau. 2000 decennial census data. Washington, D.C.: 2001. Available at URL: http://www.census.gov

3. Texas Department of Health. Memorandum to GK Wiles from JF Villanacci concerning Nueces Bay and Port of Corpus Christi Seafood Sampling Data, January 12, 1995.

4. Texas Statutes: Health and Safety, Chapter 436, Subchapter D, § 436.011, §436.061 and others.

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Appendix
(Map of Nueces Bay)

Nueces Bay 2002 Sample Collection Sites