Quantitative Risk Characterization

Trinity River

in

Tarrant, Dallas, Henderson and Navarro Counties, TX

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Prepared by

Texas Department of Health
Division of Seafood Safety
Division of Environmental Epidemiology and Toxicology

BACKGROUND AND STATEMENT OF ISSUES

Portions of the Clear Fork Trinity River, West Fork Trinity River, and the Trinity River in the Dallas-Fort Worth metropolitan area (from the Seventh Street Bridge in Fort Worth downstream to the I-20 Bridge southeast of Dallas) have been closed to the taking of fish since 1990. The Texas Department of Health (TDH) issued Aquatic Life Order-2 (AL-2) on January 4, 1990. AL-2 prohibits possession of fish from this stretch of the river. TDH issued AL-2 because fish samples from this stretch of the river contained chlordane, an organochlorine insecticide [1]. In response to a 1998 request from the Texas Natural Resource Conservation Commission (TNRCC; currently known as the Texas Commission on Environmental Quality or TCEQ), TDH again examined fish samples from several sites along the Trinity River between Fort Worth and Dallas, an assessment that supported continuation of the previously existing aquatic life order (AL-2). In addition to chlordane, the 1998 sample set contained polychlorinated biphenyls (PCBs). The existing aquatic life order was left in place after the 1998 survey. At the time, the TNRCC also placed those segments of the Trinity River covered by AL-2 on the state's 303(d) list of impaired waters. In 2000 and 2001, with funding from the TNRCC, the Texas Department of Health re-examined fish from stretches of the Trinity previously investigated as well as areas up- and downstream of the area currently covered by AL-2.

DISCUSSION

Collection and Chemical 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 that 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 for seven metals – arsenic, cadmium, copper, lead, mercury, selenium, and zinc – and for many volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, and polychlorinated biphenyls (PCBs: Aroclors 1016, 1221, 1224, 1232, 1248, 1254, 1260).

Description of the Trinity River 2000-2001 Sample Set

In 2000, the Seafood Safety Division (SSD) collected thirty samples along the Trinity River in the Dallas-Fort Worth metropolitan area. These sites were: (1) Clear Fork Trinity River downstream of Benbrook Lake; (2) Beach Street on the West Fork Trinity River; (3) upstream of the confluence of Elm Fork with West Fork Trinity River; (4) Trinity River downstream of Elm Fork; and (5) near the Dowdy Ferry Road Bridge. In 2001, the SSD collected nine fish from a rural area of the Trinity River near Seven Points, TX. Three of the sampling sites (Beach Street; upstream and downstream of the confluence of Elm Fork Trinity River) were within the AL-2 closure area. Three sample sites were outside the closure area. One site was upstream of the closure area: Clear Fork Trinity River in Fort Worth. Two sampling sites were downstream of

the closure area: (1) Dowdy Ferry Road Bridge 5.9 km downstream of Interstate Highway 20 (I-20) in Dallas County; and (2) on the border of Navarro and Henderson Counties near the town of Seven Points, about 140 km downstream of I-20. In 2000, the SSD collected fifteen smallmouth buffalo, six common carp, two flathead catfish, one channel catfish, three longnose gar, one alligator gar and two spotted gar from Clear Fork, West Fork, and the Trinity River. In 2001, the SSD collected six blue catfish, two longnose gar, and one alligator gar from the Seven Points site.

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.

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 [2]. 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), an acceptable lifetime risk level (ARL) of 1 excess cancer in 10,000 (1×10^{-4}) people exposed 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. 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. People who wish to minimize exposure to environmental contaminants in seafood are advised 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) [3]. 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. The hazard quotient (HQ) is the ratio of the estimated exposure dose of a contaminant to its RfD or MRL. 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 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 [4]. Unique childhood vulnerabilities may result from the fact that, at birth, most organs and body systems have not achieved structural or functional maturity, but continue 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 [4], 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 [4]. 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* [5] and USEPA's *National Agenda to Protect Children's Health from Environmental Threats* [4], 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 eat no more than twenty-four meals per year. Ideally, children should not eat such seafood more than twice per month.

Risk Characterization

Characterizing the Risk of Systemic (Noncancerous) Health Effects from Consumption of Contaminants in Fish Samples from the Trinity River

The hazard ratio for p,p'-DDE in common carp collected from Clear Fork Trinity River, upstream of the closure area, was less than 1. These carp contained no other identifiable contaminants. On the other hand, samples collected in 2000 from sites within the closure area contained PCBs, chlordane and/or other contaminants at concentrations that resulted in a hazard index of 7.8. This finding supports continuation of the ban on possession of fish from the closure area encompassed by AL-2.

Because the river is currently closed to possession of fish between the 7th Street Bridge in Fort Worth and the I-20 Bridge in southeast Dallas County, TDH concentrated the present hazard analyses on the two sites downstream of the closure area of the river. Samples collected from the Dowdy Ferry Road Bridge site contained Aroclor 1260 – a mixture of polychlorinated biphenyls (PCBs) that contains approximately 60% chlorine. The average concentration of this contaminant exceeded the HAC_{nonca} value (Table 1, Table 2) derived from the EPA's RfD for Aroclor 1254 – a mixture of structurally similar PCBs containing approximately 54% chlorine. TDH assumes, for hazard assessments of PCBs, that the systemic effects of Aroclor 1260 are similar to those of Aroclor 1254 [6]. The average concentration of PCBs in fish collected from the Dowdy Ferry Road site resulted in a hazard ratio of 9.9, approximately 10 times the HAC_{nonca} value for Aroclor 1254. TDH calculated that an adult regularly consuming more than one eight-ounce meal of fish every two months from this site would exceed the HAC_{nonca} for Aroclor 1254

(Table 1, Table 3). Children who regularly consume more than one four-ounce meal every two months would similarly exceed the HAC_{nonca} for Aroclor 1254. Chlordane and p,p'-DDE –other contaminants observed in some fish from this area of the Trinity – did not exceed their respective HAC_{nonca} values. However, a hazard index was calculated for this site to determine the cumulative systemic effects of all observed contaminants. The calculated hazard index for the Dowdy Ferry Road site was 10.8.

Gar species collected from the area near Seven Points, TX, contained Aroclor 1260 at concentrations averaging 4.6 times the HAC_{nonca} for Aroclor 1254 (Table 1, Table 2). Thus, people consuming one meal per month of gar species from this sampling site would exceed the HAC_{nonca} for Aroclor 1254 (Table 3). On the other hand, the blue catfish collected near Seven Points contained only very low concentrations of p,p'-DDE (data not shown). The reason these "fatty" bottom-feeding blue catfish, ranging in weight from one to ten pounds, were free of PCBs is unknown. Chlordane and p,p'-DDE were also detected in gar species from the Seven Points sampling site, but neither contaminant exceeded its HAC_{nonca} value. Again, although the concentrations of chlordane and DDE in the gar species would not have resulted in public health action, these contaminants did contribute to the hazard index for gar from the Seven Points site (4.8).

Characterizing the Risk of Cancer from Consumption of Contaminants in Trinity River Fish Samples

Common carp collected from Clear Fork Trinity River upstream of the closure area contained no contaminants at concentrations exceeding their respective HAC_{ca} values. Fish taken from the Trinity River between the 7th Street Bridge in Fort Worth and the site at Seven Points, TX, contained PCBs in excess of the HAC_{ca} for PCBs. Because the river is closed to possession of fish from the 7th Street Bridge in Fort Worth to the I-20 Bridge in southeast Dallas county, TDH focused the present assessment on the sites downstream of the closure area: the Dowdy Ferry Road Bridge and Seven Points, TX sites. Samples of several species from the Dowdy Ferry Road Bridge site contained PCBs at an average concentration that exceeded the HAC_{ca} for PCBs (Table 1). Some samples from this site also contained low levels of chlordane and/or p,p'-DDE which would not, of themselves, have resulted in public health action. However, these contaminants did contribute to the overall cancer risk (Table 3). Frequent consumption of fish from the Dowdy Ferry Road area could increase the lifetime risk of cancer by as much as one excess cancer in 5200 people exposed to the contaminants (Table 3). TDH interprets this as a low to moderate increase in the risk of cancer. Gar species from the Seven Points sample site contained Aroclor 1254, p,p'-DDE, and/or chlordane at concentrations resulting in a cancer risk to those who consume these species of one excess cancer in approximately 11,000 people, an estimated risk that does not exceed the level used by TDH to protect public health. Qualitatively, this level of calculated risk would be interpreted as no apparent to a low increase in the lifetime risk of cancer. Conversely, consumption of blue catfish from the Seven Points area is unlikely to increase the lifetime excess risk of cancer (risk was calculated at approximately one excess cancer in 3,800,000 exposed persons).

CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

Based on results of the present risk characterization of data from fish collected from the Clear Fork Trinity River, West Fork Trinity River and the Trinity River, TDH concludes that:

1. Consumption of fish from the current closure area ordered by AL-2 **continues to pose a public health hazard**.

2. Consumption of fish from the Trinity River near the Dowdy Ferry Road Bridge **poses a public health hazard.**

3. Consumption of gar species from the Trinity River near Seven Points, TX **poses a public health hazard.**

4. Consumption of fish from the Trinity River between the Dowdy Ferry Road Bridge site and the Seven Points area **poses an indeterminate public health hazard** because the agency has only limited data with which to characterize this long stretch of the Trinity River. Additional sampling is necessary to clarify this question.

5. Consumption of common carp from the Clear Fork Trinity River upstream of the 7th Street Bridge in Fort Worth, TX, **poses no apparent public health hazard**. However, additional sampling that encompasses other species from this portion of the Clear Fork Trinity River would enable TDH to better characterize the risk to public health from consumption of contaminated fish from this stretch of the Trinity River.

RECOMMENDATIONS

TDH risk managers have established certain criteria, based, in part, on recommendations from the USEPA [7], for issuing fish consumption advisories. When the risk characterization confirms that consumption of four or fewer meals per month would result in exposures that exceed TDH health-based risk 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. Based on the results of this characterization of chemical contaminant data from fish from the Trinity River between Fort Worth, TX and Seven Points, TX, the Seafood Safety Division (SSD) and the Environmental Epidemiology and Toxicology Division (EE&TD) at the Texas Department of Health (TDH) recommend that:

1. TDH extends the Trinity River closure order (AL-2) downstream from the I-20 Bridge in Dallas County to the Texas State Highway 34 bridge spanning the river between Kaufmann County and Ellis County. Extension of AL-2 to include this stretch of the Trinity River should effectively protect those people who fish along this stretch of the river from the potential health effects associated with eating contaminated fish from this water body.

2. TDH issues consumption advice for all species of gar taken from the Trinity River from the crossing at Texas State Highway 34 downstream to its confluence with the Cedar Creek Reservoir discharge canal on the border of Henderson and Navarro Counties below the Seven Points sample site. TDH should advise that people not consume any species of gar from this stretch of the Trinity River.

3. TDH collects additional samples of fish species from the Clear Fork Trinity River and from the Trinity River between the Dowdy Ferry Road Bridge and the river's confluence with the Cedar Creek Reservoir drainage canal to better characterize the types of contaminants and degree of contamination of species commonly consumed from this area. TDH should also collect fish samples from the Trinity River downstream of the Cedar Creek Reservoir drainage canal to further characterize contamination in fish downstream of the current study area.

PUBLIC HEALTH ACTION PLAN

TDH fish consumption advisories and bans are published in a booklet that is available to the public through the TDH Seafood Safety Division: (512-719-0215). This information is also posted on the Internet at URL: http://www.tdh.state.tx.us/bfds/ssd, which is updated regularly. 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 Natural Resource Conservation Commission (TNRCC: URL: http://www.tnrcc.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 [8] that is 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. Concentration (mg/kg) of polychlorinated biphenyls (PCBs) in fish collected in 2000 or 2001 from sites along the Trinity River in Tarrant, Dallas, or Henderson/Navarro counties.

Sample Site	# Detected (# Analyzed)	Average Concentration (min-max)*	Health-based Assessment Comparison Value† (HAC)	Basis for Comparison Value
Clear Fork Upstream of 7th Street Bridge	0 (5)	Not Detected	**0.047**	EPA/ATSDR chronic oral RfD/MRL-Aroclor 1254: 0.00002 mg/kg/day
West Fork at Beach Street§	5 (5)	**0.911** (0.150-3.27)		
West Fork Upstream of Elm Fork§	2 (5)	**0.074** (nd-0.182)		
Trinity River Downstream of Elm Fork§	0 (4)	Not Detected		
Dowdy Ferry Road Bridge	9 (11)	**0.461** (nd-1.900)	0.271	EPA slope factor for PCBs: 2 $(mg/kg/day)^{-1}$
Seven Points, TX				
Gar species	2 (3)	**0.215** (nd-0.544)		
Blue catfish	0 (6)	Not Detected		

***** *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 $1x10^{-4}$.*

‡ *nd-not detected at concentrations above the laboratory reporting limit*

§ *The current closure order, AL-2 encompasses these areas*

Table 2. Average concentration (in mg/kg with minimum-maximum) of polychlorinated biphenyls (PCBs) in each species of fish collected in 2000 or 2001 from the Trinity River between Fort Worth, TX, and Seven Points, TX.

	COLLECTION SITE					
SPECIES	**Clear Fork Trinity River upstream of Benbrook Lake**	**West Fork Trinity River at Beach Street**	**West Fork Trinity River Upstream of Elm Fork**	**Trinity River Downstream of Elm Fork**	**Trinity River Near Dowdy Ferry Road**	**Trinity River Near Seven Points**
Gar species	Not Collected§	1.958 (0.645,3.27)	0.128 (na)	Not Collected	1.251 (0.154-1.900)	0.215 (nd-0.544)
Smallmouth buffalo	Not Collected	0.22 (0.15, 0.29)	0.061(nd-0.182)	Not Detected	0.169 (nd-0.630)	Not Collected
Blue catfish	Not Collected	Not Collected	Not Collected	Not Collected	Not Collected	Not Detected
Common carp	Not Detected	0.20 (na)	Not Collected	Not Collected	Not Collected	Not Collected
Channel catfish	Not Collected	Not Collected	Not Collected	Not Detected	Not Collected	Not Collected
Flathead catfish	Not Collected	Not Collected	Not Collected	Not Detected	0.130 (na)	Not Collected

§*Cells designating sites from which a specific species was not collected are designated as "Not Collected."*

Table 3. Hazard Indices and Allowable Meals for Fish containing PCBs, chlordane, and p,p'-DDE collected in 2000 and 2001 from the Trinity River Downstream of the I-20 Bridge in Dallas County.						
Dowdy Ferry Road Sampling Site						
Species	**Hazard Index**	**Meals/Month**	**Meals/Week**	**Cancer Risk***	**Meals/Month**	**Meals/Week**
All	**10.2**	**0.4**	0.1	**2e-4**	**2.1**	0.5
Seven Points Sampling Site						
All	**1.6**	**2.5**	0.6	3.3e-5	13.3	3.0
Gar species	**4.8**	**0.8**	0.2	9.02e-5	4.5	1.0
Blue catfish	0.004	1126	259	2.6e-7	1544	355

REFERENCES

1. [TDH] Texas Department of Health. Fish advisories and Bans, 2001. Information is available at http://www.tdh.state.tx.us/bfds/ssd/

2. [USEPA] U.S. Environmental Protection Agency. Glossary of risk assessment-related terms. Washington D.C.: 1994.

3. [USEPA] U.S. Environmental Protection Agency. Guidelines for the health risk assessment of chemical mixtures. Office of Research and Development. Washington, D.C.: 1986.

4. [USEPA] U.S. Environmental Protection Agency. Strategy for research on environmental risks to children, section 1.2. Office of Research and Development, Washington, D.C.: 2000.

5. [ATSDR] Agency for Toxic Substances and Disease Registry, Office of Children's Health. Child health initiative. Atlanta, Ga.: 1995.

6. [IRIS] Integrated risk information system (IRIS). Office of Research and Development, National Center for Environmental Assessment, 2001. Information available at URL: http://www.epa.gov/iris

7. [USEPA] U.S. Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories, Vol 2. Risk assessment and fish consumption limits, 3rd ed. Office of Science and Technology, Office of Water. Washington, D.C.: 2000. Information available at URL: http://www.epa.gov.

8. [TPWD] Texas Parks and Wildlife 2000-2001 Outdoor Annual: Official Hunting and Fishing Regulations. Emmis Communications Custom Publishing. Austin, TX: 2000.

REPORT PREPARED BY:

Texas Department of Health

Jerry Ann Ward, Ph.D.
Toxicologist
Seafood Safety Division
Bureau of Food and Drug Safety

Susan Bush, B.S.
Survey Branch Chief
Seafood Safety Division
Bureau of Food and Drug Safety

Eric Fonken, D.V.M., M.P.Aff.
Assistant Director
Seafood Safety Division
Bureau of Food and Drug Safety

Kirk Wiles, R.S.
Director
Seafood Safety Division
Bureau of Food and Drug Safety

Lisa Williams, M.S.
Toxicologist
Environmental Epidemiology and Toxicology Division
Bureau of Epidemiology