Characterization of Potential Adverse Health Effects Associated with Consuming Fish from

Trinity River

Dallas, Ellis, Henderson, Kaufman, Navarro, and Tarrant Counties, Texas

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INTRODUCTION

Since 1990, 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 Interstate Highway (IH) 20 Bridge southeast of Dallas) have been closed to the harvesting of fish. The Texas Department of Health (TDH)[a] issued Aquatic Life Order Number 2 (AL-2) on January 4, 1990, prohibiting possession of fish from this stretch of the river because fish samples contained chlordane, an organochlorine insecticide that posed a significant public health issue.[1] In 1996, the Texas Natural Resource Conservation Commission (TNRCC)[b] listed these segments of the Trinity River on the State of Texas Clean Water Act Section 303(d) List of impaired waters for not supporting the designated fish consumption use due to chlordane contamination.[2] In 1998, the TNRCC requested that the TDH reassess the possession ban issued in 1990. This survey examined fish samples from several sites along the Trinity River between Fort Worth and Dallas; an assessment that supported the continuation of AL-2 due to the presence of polychlorinated biphenyls (PCBs) at concentrations exceeding TDH health-based guidelines. The results of this survey also showed that chlordane concentrations in fish from this portion of the Trinity River were of less concern, in part due to decreases in concentration and to changes in the knowledge of the toxicity of chlordane. In 2000 and 2001, the TDH re-examined fish from stretches of the Trinity previously investigated as well as areas up- and downstream of the area delineated by AL-2. The 2000 and 2001 surveys revealed the presence of PCBs at concentration exceeding health-based guidelines in fish further downstream from the original area closed to the harvesting of fish. Because of these findings, TDH issued Advisory 25 (ADV-25) on September 13, 2002 recommending no consumption of gar species from Texas State Highway (SH) 34 downstream to its confluence with the discharge canal of Cedar Creek Reservoir.[3] Subsequently, on September 27, 2002 TDH issued Aquatic Life Order Number 14 (AL-14), extending the Trinity River prohibited area to include waters of the Trinity River from the Seventh Street bridge in Fort Worth downstream to the SH 34.[4] The Texas Commission on Environmental Quality (TCEQ) requested the present survey of the Trinity River as a five-year follow-up study under the Total Maximum Daily Load (TMDL) program for previously adopted TMDLs.

Description of the Trinity River

Four principal forks form the Trinity River in north central Texas: the Clear Fork, the West Fork, the Elm Fork, and the East Fork.[5] The Clear Fork originates east of Weatherford, Texas in Parker County and flows southeast and then northeast merging with the West Fork in Fort Worth, Texas. The West Fork, the longest fork of the four forks, rises in southeastern Archer County flowing southeasterly through Jack, Wise, and Tarrant Counties joining the main stem of the Trinity River in Dallas County. The Elm Fork originates in eastern Montague County and flows southeast through Cooke and Denton Counties to its confluence with the West Fork in Dallas County forming the main stem of the Trinity River west of downtown Dallas in central Dallas County. The East Fork originates in Cooke County and flows south through Collin and Kaufman Counties, merging with the main stem at the Kaufman-Ellis County line. The Trinity River flows

[a] Now the Department of State Health Services (DSHS)
[b] Now the Texas Commission on Environmental Quality (TCEQ)

423 miles from the confluence of the Elm and West Forks to Trinity Bay along the Texas coast, making it the longest river having its entire course in Texas. The Trinity River Basin total drainage area is 17,969 square miles including 21 reservoirs and all or part of 37 counties. Major reservoirs in the basin include Lake Bridgeport, Eagle Mountain Lake, and Lake Worth on the West Fork; Lake Weatherford and Benbrook Lake on the Clear Fork; Ray Roberts Lake and Lewisville Lake on the Elm Fork; Lavon Lake and Lake Ray Hubbard on the East Fork; and Lake Livingston on the main stem of the Trinity River. In addition, 11 major reservoirs exist on smaller tributaries, mostly in the Dallas-Fort Worth metropolitan area.

The Trinity River in the Dallas-Fort Worth metropolitan area is highly urbanized. Urban development has led to the alteration of the riverbed for flood control, primarily through the use of levees and channelization. The Trinity River is also impounded throughout the Dallas-Fort Worth metropolitan area to hold flood waters and provide a source for municipal and industrial water. This stretch of the Trinity River provides many public access points for river recreation.[6] The Trinity River between Dallas and Lake Livingston has rolling topography and is a narrow, slow-moving, meandering river with steep muddy banks.[5,7] Soils in the region are deep to shallow clay, clay loam, and sandy loam that support elms, sycamores, willows, oaks, junipers, mesquites, and grasses. This long stretch of the Trinity River provides limited recreational access. The Trinity River downstream of Lake Livingston is gently rolling to flat terrain with wide, shallow stream channels. Clay and sandy loams predominate and support water-tolerant hardwoods, conifers, and grasses. Recreational access is also limited in the lower Trinity River basin.

Demographics of Dallas, Ellis, Henderson, Kaufman, Navarro, and Tarrant Counties Surrounding the Area of the Trinity River

The Trinity River flows through the Dallas-Fort Worth-Arlington metropolitan area, locally referred to as the "The Metroplex". The Metroplex is the largest metropolitan area in the state of Texas and the fourth largest in the United States.[8] In 2008, according to the United States Census Bureau's (USCB) estimate, the 12 county Dallas-Fort Worth-Arlington metropolitan area has a population near 6,300,006.[8] The USCB also reported that the Dallas-Fort Worth-Arlington metropolitan area is the fastest growing metropolitan area in the United States, which gained 1,138,476 residents from April 1, 2000 to July 1, 2008.[8] The Metroplex covers approximately 9,286 square miles; an area larger than the combined U.S. states of Connecticut and Rhode Island.

Subsistence Fishing in the Trinity River

The United States Environmental Protection Agency (USEPA) suggests that, along with ethnic characteristics and cultural practices of an area's population, the poverty rate could contribute to the rate of subsistence fishing in an area.[9] The DSHS finds, in concert with the USEPA, that it is important to consider subsistence fishing to occur at any water body because subsistence fishers (as well as recreational anglers and certain tribal and ethnic groups) usually consume more locally caught fish than the general population. These groups sometimes harvest fish or shellfish from the same water body over many years to supplement caloric and protein intake. People who routinely eat chemically contaminated fish or shellfish from a water body – or those who eat large quantities of fish from the same waters – could unknowingly increase their risk of adverse health effects from that consumption. The EPA suggests that states assume that at least 10% of licensed fishers in any area are subsistence fishers. Subsistence fishing, while not explicitly documented by the DSHS, likely does occur. The DSHS assumes the rate of subsistence fishing to be similar to that estimated by the USEPA.[9]

The TMDL Program at the TCEQ and the Relationship between the TMDL Program and Consumption Advisories or Possession Bans Issued by the DSHS

The Texas Commission on Environmental Quality (TCEQ) enforces federal and state laws that promote judicious use of water bodies under state jurisdiction and protects state-controlled water bodies from pollution. Pursuant to the federal Clean Water Act, Section 303(d),[10] all states must establish a "total maximum daily load" (TMDL) for each pollutant contributing to the impairment of a water body for one or more designated uses. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and non-point sources. TMDLs incorporate margins of safety to ensure the usability of the water body for all designated purposes. States, territories, and tribes define the uses for a specific water body (e.g., drinking water, contact recreation, aquatic life support) along with the scientific criteria designated to support each specified use.[7]

Fish consumption is a recognized use for many waters. A water body is impaired if fish from that water body contain contaminants that make those fish unfit for human consumption or if consumption of those contaminants potentially could harm human health. Although a water body and its aquatic life may clear toxicants over time with removal of the source(s), it is often necessary to institute some type of remediation such as those devised by the TCEQ. Thus, whenever the DSHS issues a fish consumption advisory or prohibits possession of environmentally contaminated fish, the TCEQ automatically places the water body on its current draft 303(d) List.[7] The TCEQ is responsible for confirming the impairment and , if necessary, the TMDL program, then prepares a TMDL for each contaminant present at concentrations that, if consumed, would be capable of negatively affecting human health. After approval of the TMDL, the stakeholders in the watershed prepare an Implementation Plan for each contaminant. These plans are designed to facilitate the rehabilitation of the water body over time. Successful remediation should result in return of the water body to conditions compatible with all stated uses, including consumption of fish from the water body. When the DSHS lifts a consumption advisory or possession ban, people may once again keep and consume fish from the water body. If fish in a water body are contaminated, one of the several items on an Implementation Plan for a water body on a state's 303(d) list consists of the periodic reassessment of contaminant levels in resident fish.

METHODS

Fish Sampling, Preparation, and Analysis

The DSHS Seafood and Aquatic Life Group (SALG) collects and analyzes edible fish from the state's public waters to evaluate potential risks to the health of people consuming contaminated fish or shellfish. Fish tissue sampling follows standard operating procedures from the DSHS

Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual.[11] The SALG bases its sampling and analysis protocols, in part, on procedures recommended by the USEPA in that agency's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1.*[12] Advice and direction are also received from the legislatively mandated *State of Texas Toxic Substances Coordinating Committee (TSCC) Fish Sampling Advisory Subcommittee (FSAS).*[13] Samples usually represent species, trophic levels, and legal-sized specimens available for consumption from a water body. When practical, the DSHS collects samples from two or more sites within a water body to better characterize geographical distributions of contaminants.

Fish Sampling Methods and Description of the Trinity River 2008 Sample Set

In June and July 2008, SALG staff collected 130 fish samples from the Trinity River. Risk assessors used data from these fish to assess the potential for adverse human health outcomes from consuming fish from this river.

Twelve sites were assigned to provide spatial coverage of the study area (see Figure 1 for approximate locations). Site 1 was located at West Rosedale Street, Site 2 near the Purcey Drain, Site 3 at Beach Street, Site 4 at Beltline Road, Site 5 downstream of SH Loop 12, Site 6 at Westmoreland Road, Site 7 at Commerce Street, Site 8 at South Loop SH 12, Site 9 at Dowdy Ferry Road, Site 10 at SH 34, Site 11 at Farm-to-Market (FM) 85, and Site 12 at SH 31. Species collected represent distinct ecological groups (i.e. predators) that have some potential to bioaccumulate chemical contaminants, have a wide geographic distribution, are of local recreational fishing value, and/or that anglers and their families commonly consume. The 130 fish collected from the Trinity River represented all species targeted for collection from this water body. Table 1 lists species sampled, the sample number of each species collected, and the length and weight (in metric units) of each sample from each collection site. Fish species for the 2008 Trinity River project are listed in descending order by number of each species collected: smallmouth buffalo (23), channel catfish (21), blue catfish (20), longnose gar (13), common carp (12), flathead catfish (11), freshwater drum (10), largemouth bass (10), white bass (4), spotted bass (3), spotted gar (3).

The SALG set gill nets in the late afternoon at each of the sample sites and fished those sites overnight. The gill nets were set in locations to maximize available cover and habitat. Staff retrieved captured fishes from the gill nets in the early morning hours, retaining only fish pre-selected as target samples. Staff immediately stored retrieved samples on wet ice in large coolers to ensure interim preservation, returning live fish culled from the catch to the water body.

The SALG utilized a boat-mounted electrofisher to collect fish. The SALG staff conducted electrofishing activities during daylight hours using pulsed direct current (Smith Root 2.5 and 5.0 GPP electrofishing system settings: 4.0-6.0 amps, 60 pulses per second [pps], low range, 300-500 volts, 40-50% duty cycle and 1.0-2.0 amps, 15 pps, low range, 300-500 volts, 50% duty cycle [catfish species]) to stun fish that crossed the electric field in the water in front of the boat. Staff used dip nets over the bow of the boat to retrieve stunned fish, netting only fish pre-selected as target samples. Staff immediately stored retrieved samples on wet ice in large coolers to enhance tissue preservation.

Collection of catfish species using the boat-mounted electrofisher and gill nets proved a difficult task at two samples sites: Site 4 Trinity River at Belt Line Road and Site 8 Trinity River at South Loop SH 12. To maximize catfish species sampling efficiency, the SALG team also set trot lines baited with cut smallmouth buffalo collected in the gill net sets. The trot lines were set and baited during daylight hours targeting various types of habitat at each site and retrieved 1-2 hours later.

SALG staff processed fish onsite at the Trinity River**.** Staff weighed each sample to the nearest gram (g) on an electronic scale and measured total length (tip of nose to tip of tail fin) to the nearest millimeter (mm). After weighing and measuring a fish, staff used a cutting board covered with aluminum foil and a fillet knife to prepare two skin-off fillets from each fish. The foil was changed and the knife cleaned with distilled water after each sample was processed. The team wrapped fillet(s) in two layers of fresh aluminum foil, placed in an unused, clean, pre-labeled plastic freezer bag, and stored on wet ice in an insulated chest until further processing. The SALG staff transported tissue samples on wet ice to their Austin, Texas, headquarters, where the samples were stored temporarily at -5° Fahrenheit (-20° Celsius) in a locked freezer. The freezer key is accessible only to authorized SALG staff members to ensure the chain of custody remains intact while samples are in the possession of agency staff. The week following the collection trip, the SALG staff delivered the frozen fish tissue samples to the Geochemical and Environmental Research Group (GERG) Laboratory, Texas A&M University, College Station, Texas, for contaminant analysis.

Analytical Laboratory Information

Upon arrival of the samples at the laboratory, GERG personnel notified the SALG of receipt of the 130 Trinity River samples and recorded the condition of each sample along with its DSHS identification number.

Using established USEPA methods, the GERG laboratory analyzed fish fillets from the Trinity River for inorganic and organic contaminants commonly identified in polluted environmental media. Analyses included seven metals (arsenic, cadmium, copper, lead, total mercury, selenium, and zinc), 123 semivolatile organic compounds (SVOCs), 70 volatile organic compounds (VOCs), 34 pesticides, 209 polychlorinated biphenyl (PCB) congeners, and 17 polychlorinated dibenzofurans and/or dibenzo-*p*- dioxins (PCDFs/PCDDs) congeners. The laboratory analyzed all 130 samples for mercury, pesticides and PCBs. A subset of 26 samples was selected for metals and PCDFs/PCDDs analyses and a subset of 18 samples was selected for SVOC and VOC analyses.[14]

<u>Explanatory Details of Specific Analyses</u>

<u>Arsenic</u>

The GERG laboratory analyzed 26 fish for total (inorganic arsenic + organic arsenic = total arsenic) arsenic. Although the proportions of each form of arsenic may differ among fish species, under different water conditions, and, perhaps, with other variables, the literature suggests that well over 90% of arsenic in fish is likely organic arsenic – a form of arsenic that is virtually nontoxic to humans.[15] DSHS, taking a conservative approach, estimates 10% of the total arsenic in any fish is inorganic arsenic, deriving estimates of inorganic arsenic concentration in each fish by multiplying reported total arsenic concentration in the sample by a factor of 0.1.[15]

Mercury

Nearly all mercury in upper trophic level fish three years of age or older is methylmercury.[16] Thus, the total mercury concentration in a fish of legal size for possession in Texas serves well as a surrogate for methylmercury concentration. Because methylmercury analyses are difficult to perform accurately and are more expensive than total mercury analyses, the USEPA recommends that states determine total mercury concentration in a fish and that – to protect human health – states conservatively assume that all reported mercury in fish or shellfish is methylmercury. The GERG laboratory thus analyzed fish tissues for total mercury. In its risk characterizations, DSHS compares mercury concentrations in tissues to a comparison value derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL) for methylmercury (in these risk characterizations, the DSHS may interchangeably utilize the terms "mercury," "methylmercury," or "organic mercury" to refer to methylmercury in fish).[17]

Polychlorinated Biphenyls (PCBs)

For PCBs, the USEPA suggests that each state measures congeners of PCBs in fish and shellfish rather than homologs or Aroclors® because the USEPA considers congener analysis the most sensitive technique for detecting PCBs in environmental media.[14] Although only about 130 PCB congeners were routinely present in PCB mixtures manufactured and commonly used in the United States, the GERG laboratory analyzes and reports the presence and concentrations of all 209 possible PCB congeners. From the congener analyses, the laboratory also computes and reports concentrations of PCB homologs and of Aroclor® mixtures. Despite the USEPA's suggestion that the states utilize PCB congeners rather than Aroclors® or homologs for toxicity estimates, the toxicity literature does not reflect state-of-the-art laboratory science. To accommodate this inconsistency, the DSHS utilizes recommendations from the National Oceanic and Atmospheric Administration (NOAA),[18] from McFarland and Clarke,[19] and from the USEPA's guidance documents for assessing contaminants in fish and shellfish[12, 14] to address PCB congeners in fish and shellfish samples, selecting the 43 congeners encompassed by the McFarland and Clark and the NOAA articles. The referenced authors chose to use congeners that were relatively abundant in the environment, were likely to occur in aquatic life, and were most likely – as projected from structure –activity relationships – to show assessable toxicity.[18, 19] SALG risk assessors summed the 43 congeners to derive "total" PCB concentration in each sample.[18,19] SALG risk assessors then averaged the summed congeners within each group (e.g., fish species, sample site, or combination of species and site) to derive a mean PCB concentration for each group.

Using only a few PCB congeners to determine total PCB concentrations could underestimate PCB levels in fish tissue. Nonetheless, the method complies with expert recommendations on evaluation of PCBs in fish or shellfish. Therefore, SALG risk assessors compare average PCB concentrations of the 43 congeners with health assessment comparison (HAC) values derived from information on PCB mixtures held in the USEPA's Integrated Risk Information System (IRIS) database.[20] IRIS currently contains systemic toxicity information for five Aroclor® mixtures: Aroclors® 1016, 1242, 1248, 1254, and 1260. IRIS does not contain all information for all mixtures. For instance, only one other reference dose (RfD) occurs in IRIS – the one derived for Aroclor 1016, a commercial mixture produced in the latter years of commercial production of PCBs in the United States. Aroclor 1016 was a fraction of Aroclor 1254 that was supposedly devoid of dibenzofurans, in contrast to Aroclor 1254.[21] Systemic toxicity estimates in the present document reflect comparisons derived from the USEPA's RfD for Aroclor 1254 because Aroclor 1254 contains many of the 43 congeners selected by McFarland and Clark and NOAA, and because, as of yet, IRIS does not contain information on the systemic toxicity of individual PCB congeners.

For assessment of cancer risk from exposure to PCBs, the SALG uses the USEPA's highest slope factor of 2.0 per mg/kg/day to calculate the probability of lifetime excess cancer risk from PCB ingestion. The SALG based its decision to use the most restrictive slope factor available for PCBs on factors such as food chain exposure; the presence of dioxin-like, tumor-promoting, or persistent congeners; and the likelihood of early-life exposure.[22]

Calculation of Toxicity Equivalent Quotients (TEQs) for Dioxins

PCDDs/PCDFs are families of aromatic chemicals containing one to eight chlorine atoms. The molecular structures differ not only with respect to the number of chlorines on the molecule, but also with the positions of those chlorines on the carbons atoms of the molecule. The number and positions of the chlorines on the dibenzofuran or dibenzo-*p*-dioxin nucleus directly affects the toxicity of the various congeners. Toxicity increases as the number of chlorines increases to four chlorines, then decreases with increasing numbers of chlorine atoms - up to a maximum of eight. With respect to the position of chlorines on the dibenzo-*p*-dioxin/dibenzofuran nucleus, it appears that those congeners with chlorine substitutions in the 2, 3, 7, and 8 positions are more toxic than congeners with chlorine substitutions in other positions. To illustrate, the most toxic of PCDDs is 2,3,7,8–tetrachlorodibenzo-*p*-dioxin (2,3,7,8–TCDD), a 4-chlorine molecule having one chlorine substituted for hydrogen at each of the 2, 3, 7, and 8 carbon positions on the dibenzo-*p*-dioxin. To gain some measure of toxic equivalence, 2,3,7,8–TCDD – assigned a toxicity equivalency factor (TEF) of 1.0 – is the standard against which other congeners are measured. Other congeners are given weighting factors or TEFs of 1.0 or less based on experiments comparing the toxicity of the congener relative to that of 2,3,7,8-TCDD.[23, 24] Using this technique, risk assessors from the DSHS converted PCDF or PCDD congeners in each tissue sample from the present survey to TEQs by multiplying each congener's concentration by its TEF, producing a dose roughly equivalent in toxicity to that of the same dose of 2,3,7,8-TCDD. The total TEQ for any sample is the sum of the TEQs for each of the congeners in the sample, calculated according to the following formula.[25]

$$\text{Total TEQs} = \sum_{i=1}^{n}(\text{CI x TEF})$$

CI = concentration of a given congener

TEF = toxicity equivalence factor for the given congener
n = # of congeners
i = initial congener
$\sum$ = sum

Derivation and Application of Health-Based Assessment Comparison Values for Systemic Effects (HAC_{nonca}) of Consumed Chemical Contaminants

The effects of exposure to any hazardous substance depend, among other factors, on the dose, the route of exposure, the duration of exposure, the manner in which the exposure occurs, the genetic makeup, personal traits, habits of the exposed, or the presence of other chemicals.[26] People who regularly consume contaminated fish or shellfish conceivably suffer repeated low-dose exposures to contaminants in fish or shellfish over extended periods (episodic exposures to low doses). Such exposures are unlikely to result in acute toxicity but may increase risk of subtle, chronic, and/or delayed adverse health effects that may include cancer, benign tumors, birth defects, infertility, blood disorders, brain damage, peripheral nerve damage, lung disease, and kidney disease.[26]

If diverse species of fish or shellfish are available, the SALG presumes that people eat a variety of species from a water body. Further, SALG risk assessors assume that most fish species are mobile. SALG risk assessors may combine data from different fish species, blue crab, and/or sampling sites within a water body to evaluate mean contaminant concentrations of toxicants in all samples as a whole. This approach intuitively reflects consumers' likely exposure over time to contaminants in fish or shellfish from any water body but may not reflect the reality of exposure at a specific water body or a single point in time. The DSHS reserves the right to project risks associated with ingestion of individual species of fish or shellfish from separate collection sites within a water body or at higher than average concentrations (e.g. the upper 95 percent confidence limit on the mean). The SALG derives confidence intervals from Monte Carlo simulations using software developed by a DSHS medical epidemiologist.[27] The SALG evaluates contaminants in fish or shellfish by comparing the mean or the 95% upper confidence limit on the mean concentration of a contaminant to its HAC value (in mg/kg) for non-cancer or cancer endpoints.

In deriving HAC values for systemic (HAC_{nonca}) effects, the SALG assumes a standard adult weighs 70 kilograms and consumes 30 grams of fish or shellfish per day (about one 8-ounce meal per week) and uses the USEPA's RfD[28] or the ATSDR's chronic oral MRLs.[29] The USEPA defines an RfD as

> *An estimate of a daily oral exposure for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.*[30]

The USEPA also states that the RfD

> *… is derived from a BMDL* (benchmark dose lower confidence limit)*, a NOAEL* (no observed adverse effect level)*, a LOAEL* (lowest observed adverse effect level)*, or*

another suitable point of departure, with uncertainty/variability factors applied to reflect limitations of the data used. [Durations include acute, short-term, subchronic, and chronic and are defined individually in this glossary] and *RfDs are generally reserved for health effects thought to have a threshold or a low dose limit for producing effects.*[30]

The ATSDR uses a similar technique to derive its MRLs.[29] The DSHS divides the estimated daily dose derived from the measured concentration in fish tissue by the contaminant's RfD or MRL to derive a hazard quotient (HQ). The USEPA defines a HQ as

…the ratio of the estimated exposure dose of a contaminant (mg/kg/day) to the contaminant's RfD or MRL (mg/kg/day).[31]

Note that, according to the USEPA, a linear increase in the HQ for a toxicant does not imply a linear increase in the likelihood or severity of systemic adverse effects. Thus, a HQ of 4.0 does not mean the concentration in the dose will be four times as toxic as that same substance would be if the HQ were equal to 1.0. A HQ of 4.0 also does not imply that adverse events will occur four times as often as if the HQ for the substance in question were 1.0. Rather, the USEPA suggests that a HQ or a hazard index (HI) – defined as the sum of HQs for contaminants to which an individual is exposed simultaneously – that computes to less than 1.0 should be interpreted as "no cause for concern" whereas a HQ or HI greater than 1.0 "should indicate some cause for concern."

The SALG does not utilize HQs to determine the likelihood of occurrence of adverse systemic health effects. Instead, in a manner similar to the USEPA's decision process, the SALG may utilize computed HQs as a qualitative measurement. Qualitatively, HQs less than 1.0 are unlikely to be an issue while HQs greater than 1.0 might suggest a regulatory action to ensure protection of public health. Similarly, risk assessors at the DSHS may utilize a HQ to determine the need for further study of a water body's fauna. Notwithstanding the above discussion, the oral RfD derived by the USEPA represents chronic consumption. Thus, regularly eating fish containing a toxic chemical, the HQ of which is less than 1.0 is unlikely to cause adverse systemic health effects, whereas routine consumption of fish or shellfish in which the HQ exceeds 1.0 represents a qualitatively unacceptable increase in the likelihood of systemic adverse health outcomes.

Although the DSHS utilizes chemical specific RfDs when possible, if an RfD is not available for a contaminant, the USEPA advises risk assessors to consider evaluating the contaminant by comparing it to the published RfD (or the MRL) of a contaminant of similar molecular structure or one with a similar mode or mechanism of action. For instance, Aroclor® 1260 has no RfD, so the DSHS uses the reference dose for Aroclor 1254 to assess the likelihood of systemic (noncarcinogenic) effects of Aroclor 1260.[28]

In developing oral RfDs and MRLs, federal scientists review the extant literature to devise NOAELs, LOAELs, or benchmark doses (BMDs) from experimental studies. Uncertainty factors are then utilized to minimize potential systemic adverse health effects in people who are exposed through consumption of contaminated materials by accounting for certain conditions that may be undetermined by the experimental data. These include extrapolation from animals to humans (interspecies variability), intra-human variability, use of a subchronic study rather than a chronic study to determine the NOAEL, LOAEL, or BMD, and database insufficiencies.[28,30] Vulnerable groups such as women who are pregnant or lactating, women who may become pregnant, infants, children, people with chronic illnesses, those with compromised immune systems, the elderly, or those who consume exceptionally large servings are considered sensitive populations by risk assessors and USEPA and also receive special consideration in calculation of a RfD.[30, 32]

The primary method for assessing the toxicity of component-based mixtures of chemicals in environmental media is the HI. The USEPA recommends HI methodology for groups of toxicologically similar chemicals or chemicals that affect the same target organ. The HI for the toxic effects of a chemical mixture on a single target organ is actually a simulated HQ calculated as if the mixture were a single chemical. The default procedure for calculating the HI for the exposure mixture is to add the hazard quotients (the ratio of the external exposure dose to the RfD) for all the mixture's component chemicals that affect the same target organ, e.g., the liver. The toxicity of a particular mixture on the liver represented by the HI should approximate the toxicity that would have occurred were the observed effects caused by a higher dose of a single toxicant (additive effects). The components to be included in the HI calculation are any chemical components of the mixture that show the effect described by the HI, regardless of the critical effect from which the RfD came. Assessors should calculate a separate HI for each toxic effect.

Because the RfD is derived for the critical effect (the "toxic effect occurring at the lowest dose of a chemical"), a HI computed from HQs based on the RfDs for the separate chemicals may be overly conservative. That is, using RfDs to calculate HIs may exaggerate health risks from consumption of specific mixtures for which no experimentally derived information is available.

The USEPA states that

> *the HI is a quantitative decision aid that requires toxicity values as well as exposure estimates. When each organ-specific HI for a mixture is less than one and all relevant effects have been considered in the assessment, the exposure being assessed for potential systemic toxicity should be interpreted as unlikely to result in significant toxicity.*

And

> *When any effect-specific HI exceeds one, concern exists over potential toxicity. As more HIs for different effects exceed one, the potential for human toxicity also increases.*

Thus,

> *Concern should increase as the number of effect-specific HI's exceeding one increases. As a larger number of effect-specific HIs exceed one, concern over potential toxicity should also increase. As with HQs, this potential for risk is not the same as probabilistic risk; a doubling of the HI does not necessarily indicate a doubling of toxic risk.*

Derivation and Application of Health-Based Assessment Comparison Values for Application to the Carcinogenic Effects (HAC_{ca}) of Consumed Chemical Contaminants

The DSHS calculates cancer-risk comparison values (HAC_{ca}) from the USEPA's chemical-specific cancer potency factors (CPFs), also known as cancer slope factors (CSFs), derived through mathematical modeling from carcinogenicity studies. For carcinogenic outcomes, the DSHS calculates a theoretical lifetime excess risk of cancer for specific exposure scenarios for carcinogens, using a standard 70-kg body weight and assuming an adult consumes 30 grams of edible tissue per day. The SALG risk assessors incorporate two additional factors into determinations of theoretical lifetime excess cancer risk: (1) an acceptable lifetime risk level (ARL) [30] of one excess cancer case in 10,000 persons whose average daily exposure is equivalent and (2) daily exposure for 30 years, a modification of the 70-year lifetime exposure assumed by the USEPA. Comparison values used to assess the probability of cancer do not contain "uncertainty" factors. However, conclusions drawn from probability determinations infer substantial safety margins for all people by virtue of the models utilized to derive the slope factors (cancer potency factors) used in calculating the HAC_{ca}.

Because the calculated comparison values (HAC values) are conservative, exceeding a HAC value does not necessarily mean adverse health effects will occur. The perceived strict demarcation between acceptable and unacceptable exposures or risks is primarily a tool used by risk managers along with other information to make decisions about the degree of risk incurred by those who consume contaminated fish or shellfish. Moreover, comparison values for adverse health effects do not represent sharp dividing lines (obvious demarcations) between safe and unsafe exposures. For example, the DSHS considers it unacceptable when consumption of four or fewer meals per month of contaminated fish or shellfish would result in exposure to contaminant(s) in excess of a HAC value or other measure of risk. The DSHS also advises people who wish to minimize exposure to contaminants in fish or shellfish to eat a variety of fish and/or shellfish and to limit consumption of those species most likely to contain toxic contaminants. The DSHS aims to protect vulnerable subpopulations with its consumption advice, assuming that advice protective of vulnerable subgroups will also protect the general population from potential adverse health effects associated with consumption of contaminated fish or shellfish.

Children's Health Considerations

The DSHS recognizes that fetuses, infants, and children may be uniquely susceptible to the effects of toxic chemicals and suggests that exceptional susceptibilities demand special attention. [33, 34] Windows of special vulnerability (known as "critical developmental periods") exist during development. Critical periods occur particularly during early gestation (weeks 0 through 8) but can occur at any time during development (pregnancy, infancy, childhood, or adolescence) – times when toxicants can impair or alter the structure or function of susceptible systems.[35] Unique early sensitivities may exist after birth because organs and body systems are structurally or functionally immature at birth, continuing to develop throughout infancy, childhood, and adolescence. Developmental variables may influence the mechanisms or rates of absorption, metabolism, storage, or excretion of toxicants. Any of these factors could alter the concentration of biologically effective toxicant at the target organ(s) or could modulate target organ response to the toxicant. Children's exposures to toxicants may be more extensive than adults' exposures because children consume more food and liquids in proportion to their body weights than adults consume. Infants can ingest toxicants through breast milk, an exposure pathway that often goes unrecognized. Nonetheless, the advantages of breastfeeding outweigh the probability of significant exposure to infants through breast milk and women are encouraged to continue breastfeeding and to limit exposure of their infants by limiting intake of the contaminated foodstuff. Children may experience effects at a lower exposure dose than might adults because children's organs may be more sensitive to the effects of toxicants. Stated differently, children's systems could respond more extensively or with greater severity to a given dose than would an adult organ exposed to an equivalent dose of a toxicant. Children could be more prone to developing certain cancers from chemical exposures than are adults.[36] In any case, if a chemical or a class of chemicals is observed to be, or is thought to be, more toxic to fetuses, infants, or children, the constants (e.g., RfD, MRL, or CPF) are usually modified further to assure the immature systems' potentially greater susceptibilities are not perturbed.[28] Additionally, in accordance with the ATSDR's *Child Health Initiative*[37] and the USEPA's *National Agenda to Protect Children's Health from Environmental Threats,*[38] the DSHS further seeks to protect children from the possible negative effects of toxicants in fish by suggesting that this potentially sensitive subgroup consume smaller quantities of contaminated fish or shellfish than adults consume. Thus, DSHS recommends that children weighing 35 kg or less and/or who are 11 years of age or younger limit exposure to contaminants in fish or shellfish by eating no more than four ounces per meal of the contaminated species. The DSHS also recommends that consumers spread these meals over time. For instance, if the DSHS issues consumption advice that recommends consumption of no more than two meals per month of a contaminated species, those children should eat no more than 24 meals of the contaminated fish or shellfish per year and should not eat such fish or shellfish more than twice per month.

Data Analysis and Statistical Methods

The SALG risk assessors imported Excel© files into SPSS® statistical software, version 13.0 installed on IBM-compatible microcomputers (Dell, Inc) and used SPSS® to generate descriptive statistics (mean, standard deviation, median, minimum and maximum concentrations, and range) on measured compounds in each species from each sample site.[39] In computing descriptive statistics, SALG risk assessors utilized ½ the reporting limit (RL) for analytes designated as not detected (ND) or estimated (J-values)[c]. PCDFs/PCDDs descriptive statistics are calculated using estimated concentrations (J-values) and assuming zero for PCDFs/PCDDs designated as ND.[d] The change in methodology for computing PCDFs/PCDDS descriptive statistics is due to the

[c] *"J-value" is standard laboratory nomenclature for analyte concentrations that are detected and reported below the reporting limit (<RL). The reported concentration is considered an estimate, quantitation of which may be suspect and may not be reproducible. The DSHS treats J-Values as "not detected" in its statistical analyses of a sample set.*

[d] *The SALG risk assessors' rationale for computing PCDFs/PCDDs descriptive statistics using the aforementioned method is based on the proximity of the laboratory reporting limits and the health assessment comparison value for PCDFs/PCDDs. Thus, applying the standard SALG method utilizing ½ the reporting limit for analytes designated as not detected (ND) or estimated (J) will likely overestimate the PCDFs/PCDDs fish tissue concentration.*

proximity of the reporting limits to the HAC value. Assuming ½ the RL for PCDFs/PCDDs designated as ND or J-values would unnecessarily overestimate the concentration of PCDFs/PCDDs in each fish tissue sample. The SALG used the descriptive statistics from the above calculations to generate the present report. The SALG employed Microsoft Excel® spreadsheets to generate figures, to compute HAC_{nonca} and HAC_{ca} values for contaminants, and to calculate HQs, HIs, cancer risk probabilities, and meal consumption limits for fish from the Trinity River.[40] When lead concentrations in fish or shellfish are high, SALG risk assessors may utilize the EPA's Interactive Environmental Uptake Bio-Kinetic (IEUBK) model to determine whether consumption of lead-contaminated fish could cause a child's blood lead (PbB) level to exceed the Centers for Disease Control and Prevention's (CDC) lead concentration of concern in children's blood (10 mcg/dL).[41,42]

RESULTS

The GERG laboratory completed analyses and electronically transmitted the results of the Trinity River samples collected in summer 2008 to the SALG on May 27, 2009. The laboratory reported the analytical results for metals, pesticides, PCBs, PCDFs/PCDDs, SVOCs, and VOCs.

For reference, Table 1 contains the total number of samples collected. Tables 2a through 2d present the results of metals analyses. Tables 3a through 3j contain summary results of pesticides analyses, while tables 4a and 4f summarize the PCB analyses. This paper does not display SVOC and VOC data because these contaminants were not present at concentrations of interest in fish collected from the Trinity River during the described sampling trip. Unless otherwise stated, table summaries present the number of samples containing a specific toxicant/number tested, the mean concentration ± 1 standard deviation (68% of samples should fall within one standard deviation of the arithmetic mean in a sample from a normally-distributed population), and, in parentheses under the mean and standard deviation, the minimum and the maximum detected concentrations. Those who prefer to use the range may derive this statistic by subtracting the minimum concentration of a given toxicant from its maximum concentration. In the tables, results may be reported as ND, BDL (below detection limit), or as measured concentrations greater than or equal to the contaminant reporting limit (RL). According to the laboratory's quality control/quality assurance materials, results reported as "BDL" rely upon the laboratory's method detection limit (MDL) or its RL. The MDL is the minimum concentration of an analyte that be reported with 99% confidence that the analyte concentration is greater than zero, while the RL is the concentration of an analyte reliably achieved within specified limits of precision and accuracy during routine analyses. Contaminant concentrations reported below the RL are qualified as "J-values" in the data report.[43]

Inorganic Contaminants

<u>Arsenic, Cadmium, Copper, Lead, Selenium, and Zinc</u>

A subset of 26 samples was selected from the 130 samples collected from the Trinity River for metals analyses. The 26 samples comprised seven of 11 fish species collected from the Trinity River for this survey. All 26 fish tissue samples from the Trinity River contained some level of copper, selenium, and zinc (Tables 2a- 2d).

Three of the metalloids analyzed are essential trace elements: copper, selenium, and zinc. All 26 fish tissue samples contained copper (Table 2b). The mean copper concentration in fish sampled from the Trinity River was 0.135±0.062 mg/kg. Blue catfish had the highest average concentration of copper (0.219±0.120 mg/kg). All fish tissue samples assayed also contained selenium (Table 2d). The mean selenium concentration in fish tissue samples from the Trinity River was 0.243±0.117 mg/kg (Table 2d). Selenium concentrations in fish from the Trinity River ranged from 0.095 to 0.474 mg/kg. All samples examined also contained zinc (Table 2d). The average zinc concentration in fish from the Trinity River was 4.374 mg/kg with a standard deviation of ±3.591 mg/kg. Zinc in fish from the Trinity River ranged from 0.572 to 19.033 mg/kg (Table 2d).

The SALG evaluated three toxic metalloids having no known human physiological function (arsenic, cadmium, and lead) in the samples collected from the Trinity River. Twenty-five of 26 fish assayed contained arsenic ranging from ND to 0.318 mg/kg (Table 2a). No fish from the Trinity River contained cadmium (Table 2b). Three of 26 fish examined contained lead at estimated concentrations below the RL (Table 2c).

Mercury

All 130 Trinity River fish samples collected were selected for mercury analysis (Table 2c). All fish samples analyzed contained mercury ranging from BDL to 0.742 mg/kg (Table 2c). Largemouth bass contained the highest average mercury concentration (0.479 ± 0.102 mg/kg). A spotted bass – weighing 1.3 pounds and measuring 14.1 inches – contained the highest mercury concentration of all samples (0.742 mg/kg), a value greater than three standard deviations above the mean for combined species (0.243±0.152 mg/kg).

Organic Contaminants

Pesticides

The GERG laboratory analyzed all fish for 34 pesticides. All 130 samples contained low concentrations of chlordane, 4,4'-DDE, and 4,4'-DDD (Tables 3c, 3g, and 3i). Chlordane concentrations ranged from 0.003 to 0.299 mg/kg in Trinity River fish (Table 3c). The mean 4,4'-DDE and 4,4'-DDD concentrations in fish were 0.039±0.046 mg/kg and 0.005±0.006 mg/kg, respectively (Table 3g and 3i). One hundred twenty four of 130 samples assayed contained dieldrin (Table 3d). Dieldrin concentrations in fish ranged from ND to 0.090 mg/kg. The mean dieldrin concentration in fish was 0.016±0.017 mg/kg (Table 3d). Low concentrations of hexachlorobenzene, heptachlor epoxide, pentachloroanisole, mirex, 2,4'-DDD, and 4,4'-DDT were reported in most of the 130 fish samples assayed (Tables 3a, 3b, 3e, 3f, 3h, and 3j). Low concentrations of pentachlorobenzene, chloropyrifos, 2,4'-DDE, 2,4'-DDT, endosulfan I, and endosulfan II were reported in some of the 130 fish samples evaluated (data not presented).

Trace[e] quantities of 1,2,3,4-tetrachlorobenzene, 1,2,4,5-tetrachlorobenzene, endosulfan sulfate, and methoxychlor were present in some fish samples (data not presented).

PCBs

The present study marks the first instance in which the SALG required analysis of fish tissue samples from the Trinity River for PCB congeners rather than Aroclors®. Thus, it is important that readers do not attempt to make direct comparisons between PCB concentrations in this report and Aroclor® concentrations from previous studies of the Trinity River.

All 130 fish tissue samples assayed contained concentrations of one or more PCB congeners (Tables 4a through 4e). No fish sample contained all PCB congeners (data not shown). Across all sites and species, PCB concentrations in fish ranged from 0.023 mg/kg (spotted bass) to 1.301 mg/kg (longnose gar; Table 4e). Ten of 11 fish species evaluated had mean PCB congener concentrations that exceeded the DSHS HAC_{nonca} for PCBs (0.047 mg/kg; Table 4e). Longnose gar contained the highest mean concentration of PCBs (0.397±0.316 mg/kg) and spotted bass contained the lowest mean concentration of PCBs (0.040±0.028 mg/kg). The other nine fish species assayed had mean PCB concentrations that ranged from 0.067 mg/kg (largemouth bass) to 0.357 mg/kg (spotted gar; Table 4e). The mean PCB concentration in all 130 fish tissue samples examined was 0.185±0.200 mg/kg (Table 4e).

The SALG risk assessors condensed the 12 original collection sites into two composite sites based on previous recommended consumption guidance. Composite Site 1 consists of the original collection sites 1 through 10 (N = 107) within the Trinity River prohibited area from the seventh street bridge in Fort Worth, Texas downstream to the State Highway (SH) 34 bridge. Composite Site 2 consists of the original collection sites 11 and 12 (N = 23). Site 11 is within the Trinity River advisory area from the SH 34 bridge downstream to the discharge canal of Cedar Creek Reservoir and site 12 is approximately 12 river-miles downstream of the Cedar Creek Reservoir discharge canal. The mean PCB concentration for combined species at the Composite Site 1 (Prohibited Area) was 0.197±0.212 mg/kg (Table 4f) while, at Composite Site 2 (Advisory Area) the mean PCB concentration was 0.129±0.114 mg/kg (Table 4f). An independent-samples T test confirmed that the mean fish tissue PCB concentration in fish from Composite Site 1 (Prohibited Area) was not statistically different from the mean concentration in fish collected from Composite Site 2 (Advisory Area; $t = 1.687$; $df = 128$; $P = 0.094$).

Although discussed in different ways from summary data tables showing the data geographically separated, the SALG used the data from all combined sample sites to recommend advisory or regulatory action to protect public health along the Trinity River as described in the current risk characterization.

PCDFs/PCDDs

[e] *Trace: in analytical chemistry, a trace is an extremely small amount of a chemical compound, one present in a sample at a concentration below a standard limit. Trace quantities may be designated with the "less than" (<) sign or may also be represented by the alpha character "J" – called a "J-value" defining the concentration of a substance as near zero or one that is detected at a low level but that is not guaranteed quantitatively replicable.*

The GERG laboratory analyzed a subset of 26 fish tissue samples for 17 of the 210 possible PCDF/PCDD (135 PCDFs + 75 PCDDs) congeners from the Trinity River. The congeners examined consist of 10 PCDFs and 7 PCDDs that contain chlorine substitutions in, at a minimum, the 2, 3, 7, and 8 positions on the dibenzofuran or dibenzo-*p*-dioxin nucleus and are the only congeners reported to pose dioxin-like adverse human health effects.[44] Although 12 of the 209 PCB congeners – those often referred to as "coplanar PCBs," meaning the molecule can assume a flat configuration with both phenyl rings in the same plane – may also have dioxin-like toxicity, the SALG does not assess PCBs for dioxin-like qualities because the dioxin-like behavior has been less extensively evaluated. Tables 5a through 5d contain site and species-specific summary statistics for PCDFs/PCDDs in fish collected from the Trinity River. Before generating summary statistics for PCDFs/PCDDs, the SALG risk assessors converted the reported concentration of each PCDF or PCDD congener reported present in a tissue sample to a concentration equivalent in toxicity to that of 2,3,7,8-TCDD (a TEQ concentration - expressed as pg/g or ng/kg). All 26 fish tissue samples contained at least one of the 17 congeners assayed (minimum – to – maximum concentration after conversion: 0.003-12.751 pg/g; Table 5a–5c). No samples contained all 17 congeners (data not shown). Smallmouth buffalo contained the highest mean TEQ concentration (5.115±4.150 pg/g; Table 5c). The mean PCDFs/PCDDs concentration in all 130 fish tissue samples assayed was 2.642±2.795 mg/kg (Table 5c).

SVOCs

A subset of 18 samples was selected from the 130 samples collected from the Trinity River for SVOC analyses. A trace concentration of bis(2-ethylhexyl) phthalate (BEHP or di-(2-ethylhexyl)phthalate or DEHP was present in one of 26 fish samples assayed (data not presented). The laboratory detected no other SVOCs in fish collected from the Trinity River.

VOCs

The GERG laboratory reported the 18 fish tissue samples selected for analysis from the Trinity River to contain quantifiable concentrations >RL of one or more VOCs: acetone, carbon disulfide, methylene chloride, trichlorofluoromethane, toluene, 4-isopropyl toluene, 1,2,3-trichlorobenzene, and naphthalene (data not presented). Trace quantities of most VOCs were also present in one or more fish tissue samples assayed from the Trinity River (data not presented). The *Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Control/Assurance Manual* contains a complete list of the 70 VOCs selected for analysis.[11] Numerous VOCs were also identified in one or more of the procedural blanks, indicating the possibility that these compounds were introduced during sample preparation. VOC concentrations <RL are difficult to interpret due to their uncertainty and may represent a false positive. The presence of many VOCs at concentrations <RL may be the result of incomplete removal of the calibration standard from the adsorbent trap, so they are observed in the blank. VOC analytical methodology requires that VOCs be thermally released from the adsorbent trap, transferred to the gas chromatograph (GC), and into the GC/mass spectrometer (MS) for quantification.

DISCUSSION

Risk Characterization

Because variability and uncertainty are inherent to quantitative assessment of risk, the calculated risks of adverse health outcomes from exposure to toxicants can be orders of magnitude above or below actual risks. Variability in calculated and in actual risk may depend upon factors such as the use of animal instead of human studies, use of subchronic rather than chronic studies, interspecies variability, intra-species variability, and database insufficiency. Since most factors used to calculate comparison values result from experimental studies conducted in the laboratory on nonhuman subjects, variability and uncertainty might arise from the study chosen as the "critical" one, the species/strain of animal used in the critical study, the target organ selected as the "critical organ," exposure periods, exposure route, doses, or uncontrolled variations in other conditions.[28] Despite such limitations, risk assessors must calculate parameters to represent potential toxicity to humans who consume contaminants in fish and other environmental media. The DSHS calculated risk parameters for systemic and cancerous endpoints in those who would consume fish from the Trinity River. Conclusions and recommendations predicated upon the stated goal of the DSHS to protect human health follow the discussion of the relevance of findings to risk. Meal consumption calculations are integral to the SALG's risk characterizations and are used by DSHS risk managers to determine whether consumption advice or regulatory actions might be necessary to protect human health from adverse effects of consuming toxicants in fish from Texas waters.

Characterization of Systemic (Noncancerous) Health Effects from Consumption of Fish from the Trinity River

PCBs and PCDF/PCDDs were observed in fish from the Trinity River that equaled or exceeded their respective HAC_{nonca} (Tables 4a–5c). One (spotted bass) of 130 fish samples assayed contained mercury exceeding the HAC_{nonca} for mercury (0.700 mg/kg; Table 2c). Mean mercury concentrations of the 11 fish species evaluated and the *all fish combined* mean concentration did not exceed the mercury HAC_{nonca} value nor did the HQs exceed 1.0. No species of fish collected from the Trinity River contained any other inorganic or organic contaminants at concentrations that equaled or exceeded the DSHS guidelines for protection of human health or would likely cause systemic risk to human health from consumption of fish from the Trinity River. Potential systemic health risks related to the consumption of fish from the Trinity River containing inorganic and organic contaminants (other than PCBs and PCDFs/PCDDs) are not of public health concern. Consequently, this risk characterization concentrates on assessing the likelihood of adverse health outcomes that could occur from consumption of Trinity River PCB and PCDF/PCDD-contaminated fish. Tables 6a through 6e provide HQs for PCBs in each species of fish by sample site and the recommended weekly consumption rate for each species. Tables 7a through 7b provide HIs for PCBs and PCDFs/PCDDs in each species of fish collected from the Trinity River and the recommended weekly consumption rate for each species.

PCBs

All fish collected from the Trinity River in 2008 contained PCBs (Tables 4a–4e). Eighty-four percent of all samples (N = 130) analyzed contained PCB concentrations that equaled or exceeded the HAC_{nonca} for PCBs (0.047 mg/kg). Mean PCB concentrations for 10 of 11 species assayed exceeded the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4e and 6e). The *all fish* *combined* mean PCB concentration (0.185 mg/kg) exceeded the HAC_{nonca} for PCBs or a HQ of 1.0 (Tables 4e and 6e) representing a potential systemic health risk related to the consumption of fish from the Trinity River. The *all fish combined* mean PCB concentrations for each of the 12 samples sites also exceeded the HAC_{nonca} for PCBs (Tables 4a–4e) or a HQ of 1.0 (Tables 6a–6e).

Meal consumption calculations may be useful for decisions about consumption advice or regulatory actions. The SALG risk assessors calculated the number of 8-ounce meals of fish from the Trinity River that healthy adults could consume by sample site and species without significant risk of adverse systemic effects assuming that PCBs were the only contaminant contributing potential health risks (Table 6a–6e). The SALG estimated this group could consume 0.2 (8-ounce) meals per week of fish containing PCBs (Table 6e), suggesting that fish from the Trinity River contain PCBs at concentrations that could result in adverse effects on human health and that people should not consume fish from the Trinity River within the study area. The developing nervous system of the human fetus may be especially susceptible to these effects.

<u>PCDFs/PCDDs</u>

All fish collected from the Trinity River in 2008 contained PCDFs/PCDDs (Table 5a–5c). Fifty percent of all samples (N = 26) analyzed contained PCDFs/PCDDs concentrations that equaled or exceeded the HAC_{nonca} for PCDFs/PCDDs (2.33 pg/g). The mean PCDFs/PCDDs concentration for smallmouth buffalo assayed exceeded the HAC_{nonca} for PCDFs/PCDDs or a HQ of 1.0 (Tables 5c and 7b) representing a potential systemic health risk related to the consumption of smallmouth buffalo from the Trinity River. The single freshwater drum and longnose gar samples also contained PCDFs/PCDDs that exceeded the HAC_{nonca} for PCDFs/PCDDs. The *all fish combined* mean PCDFs/PCDDs concentration (2.642 pg/g) exceeded the HAC_{nonca} for PCDFs/PCDDs (Table 5c) and exceed the DSHS guidelines for protection of human health (Table 7c).

The SALG risk assessors calculated the number of 8-ounce meals of fish from the Trinity River that healthy adults could consume by species without significant risk of adverse systemic effects assuming that PCDFs/PCDDs were the only contaminant contributing potential health risks (Table 7a–7c). The SALG estimated this group could consume 0.8 (8-ounce) meals per week of fish containing PCDFs/PCDDs (Table 7c), suggesting that fish from the Trinity River contain PCDFs/PCDDs at concentrations that could result in adverse effects on human health and that people should limit their consumption of fish from the Trinity River within the study area. The developing nervous system of the human fetus may be especially susceptible to these effects.

Characterization of Theoretical Lifetime Excess Cancer Risk from Consumption of Fish from the Trinity River

Dieldrin, PCBs, and PCDF/PCDDs were observed in fish from the Trinity River that equaled or exceeded their respective HAC_{ca} (Tables 3d; 4a–5c). Eleven percent of the total number of fish samples, representing at least one sample from five of 11 fish species, evaluated contained dieldrin concentrations that exceeded the DSHS HAC_{ca} for dieldrin (0.034 mg/kg; Table 3d). Mean dieldrin concentrations for individual fish species and *all fish combined* did not exceed the dieldrin HAC_{ca} value nor did the HQs exceed 1.0. No fish sample or fish species at any site contained any other inorganic or organic contaminants at concentrations that would likely increase the calculated excess lifetime risk of cancer from daily exposure for 30 years to these contaminants. Thus, exposure to inorganic or organic contaminants (other than PCBs and PCDFs/PCDDs) in fish is unlikely to increase the theoretical probability of cancer associated with consumption of fish from the Trinity River. Consequently, this risk characterization concentrates on assessing the theoretical probability of cancer that could occur from consumption of Trinity River PCB and PCDF/PCDD-contaminated fish.

PCBs

Tables 8a through 8f provide predicted excess cancer incidences calculated from mean concentrations of PCBs in each species of fish by sample site and the recommended weekly consumption rate for each species. The table contains the calculated probability of one excess cancer in a given number of people exposed to PCBs in the various fish species. Of the fish sampled from the Trinity River, the mean concentrations of PCBs in longnose gar, smallmouth buffalo, and spotted gar exceed a 1 in 10,000 calculated theoretical lifetime excess cancer risk (Table 8f). Longnose gar, smallmouth buffalo, and spotted gar contained PCBs at a concentration that might cause or contribute to cancer in people who regularly consume these species from the Trinity River. Although other species from the Trinity River do not contain PCBs at levels that pose a carcinogenic risk, blue catfish, channel catfish, common carp, flathead catfish, freshwater drum, largemouth bass, and white bass do contain these contaminants at concentrations already judged to pose a risk to health from systemic adverse health outcomes from long-term, low-level consumption of PCBs.

PCDFs/PCDDs

The conclusions from this data should be tempered by the fact that a 26-sample subset of the 130 fish samples was assayed for PCDFs/PCDDs representing only seven of 11 fish species examined for the study. Tables 9a through 9b provide predicted excess cancer incidences calculated from mean concentrations of PCDFs/PCDDs in each species of fish collected from the Trinity River and the recommended weekly consumption rate for each species. The table contains the calculated probability of one excess cancer in a given number of people exposed to PCDFs/PCDDs in the various fish species. Of the fish sampled from the Trinity River, the concentration of PCDFs/PCDDs in a single longnose gar and the mean concentration in smallmouth buffalo (N =6) exceeds a 1 in 10,000 calculated theoretical lifetime excess cancer risk (Table 9b). Longnose gar and smallmouth buffalo contained PCDFs/PCDDs at a concentration that might cause or contribute to cancer in people who regularly consume these species from the Trinity River. Although other species from the Trinity River do not contain PCDFs/PCDDs at levels that pose a carcinogenic risk, channel catfish and freshwater drum do contain these contaminants at concentrations already judged to pose a risk to health from systemic adverse health outcomes from long-term, low-level consumption of PCDFs/PCDDs.

Characterization of Calculated Cumulative Systemic Health Effects and of Cumulative Excess Lifetime Cancer Risk from Consumption of Fish from Clear Creek

Cumulative adverse health effects may be of concern if people are exposed simultaneously to more than one contaminant in one environmental medium (e.g., fish) or in multiple media (multiple media are not discussed in this report because the SALG has no way of knowing the toxicants to which people may be exposed through other media).

Cumulative Systemic Health Effects

In the present risk characterization, risk assessors observed various combinations of metals, pesticides, VOCs, SVOCs, PCBs, and PCDFs/PCDDs in samples collected from the Trinity River. Although it is possible that exposure to combinations of observed contaminants could potentially increase damage to one or more organ systems, the individual metalloids did not affect the same target organ, had different mode/mechanism of action, or the constant SALG utilizes to quantify toxic effects (RfDs, MRLs, or CPFs) was not available.[45] Therefore, SALG risk assessors did not calculate cumulative effects for metals. HIs for combined pesticides, VOCs and/or SVOCs– many of which do affect the same target organ (for instance, the liver) or do act by the same mode or mechanism – were generally far lower than 1.0 indicating that consuming fish from the Trinity River containing various combinations of pesticides, VOCs, and/or SVOCs is unlikely to result in cumulative systemic toxicity.[46]

Consuming fish that contain both PCBs and PCDFs/PCDDs (Tables 4e and 5c) may additively increase toxicity. Tables 7a and 7b clearly indicate that the greater portion of potential systemic toxicity from consuming fish from the Trinity River would come from eating PCBs. Thus, consumption of fish from the length of the Trinity River surveyed for the present study – which could contain both contaminants – could increase the likelihood of systemic adverse health effects.

Although using hazard index methodology to determine cumulative effects of toxicants is common, risk assessors advise caution if the toxic endpoint is not the same and/or does not utilize the critical effect of each toxicant because assessing cumulative noncarcinogenic effects estimated by hazard quotient/hazard index methodology may overestimate the cumulative toxicity of the combined toxicants.[46] The critical organs or critical effects of PCBs and of PCDFs/PCDDs used to derive an RfD or an MRL for these contaminants are different. Research suggests, however, that both are developmental toxicants, affecting function of the reproductive organs as well as in utero development.[47] Thus, if one knew the RfDs for developmental effects, the RfDs for those effects could be used to calculate cumulative risk more accurately. This information is unavailable for PCDFs/PCDDs, so the SALG utilized the HQs from the RfD for critical effects for each toxicant to estimate the cumulative toxicity of consuming low-level concentrations of PCBs and PCDFs/PCDDs in fish from the Trinity River. Cumulative effects derived from adding HQs for the two toxicants (Tables 7a and 7b) may therefore over or underestimate effect size to an unknown extent.

Cumulative Carcinogenicity

In most assessments of cancer risk from environmental exposures to mixtures of contaminants, researchers consider any increase in neoplastic activity, whether cancerous or benign or in one or more organs to be cumulative, no matter the mode or mechanism of action of the contaminant. In this assessment, risk assessors added the calculated carcinogenic risks of consuming PCDFs/PCDDs in each species to that of the corresponding risk of excess cancers from eating PCBs in each species (Tables 9a and 9b). In all instances, when the effects of PCDFs/PCDDs are added to those of PCBs, theoretical excess cancer risk is increased. This increase does raise the theoretical excess cancer risk to a level greater than 1 excess cancer in 10,000 equivalently exposed people for channel catfish, freshwater drum, longnose gar, smallmouth buffalo, and *all fish combined*. Singly, the effects of PCBs or PCDFs/PCDDs increase the theoretical excess cancer risk to a level greater than 1 excess cancer in 10,000 equivalently exposed people for longnose gar and smallmouth buffalo.

CONCLUSIONS

SALG risk assessors prepare risk characterizations to determine public health hazards from consumption of fish and shellfish harvested from Texas water bodies by recreational or subsistence fishers. If necessary, SALG may suggest strategies for reducing risk to the health of those who may eat contaminated fish or seafood to risk managers at DSHS, including the Texas Commissioner of Health.

This study addressed the public health implications of consuming fish from the Trinity River, located in Dallas, Ellis, Henderson, Kaufman, Navarro, and Tarrant Counties, Texas. Risk assessors from the SALG conclude from the present characterization of potential adverse health effects from consuming fish from the Trinity River

1. That all species of fish collected from the Trinity River in 2008 contain PCBs at concentrations exceeding the PCB HAC_{nonca}. Regular or long-term consumption of fish from the Trinity River may result in adverse systemic health outcomes. Consuming fish from the Trinity River **poses an apparent hazard to human health.**

2. That channel catfish, flathead catfish, freshwater drum, longnose gar, and smallmouth buffalo contain PCDFs/PCDDs at concentrations exceeding the PCDFs/PCDDs $HAC_{nonca.}$ Regular or long-term consumption of these fish from the Trinity River may result in adverse systemic health outcomes. Consuming fish from the Trinity River **poses an apparent hazard to human health.**

3. That longnose gar, smallmouth buffalo, and spotted gar contain PCBs at concentrations exceeding the PCB HAC_{ca}. Regular or long-term consumption of these fish from the Trinity River may increase the risk of cancer in people eating these fish.

4. That longnose gar and smallmouth buffalo contain PCDFs/PCDDs at concentrations exceeding the PCDFs/PCDDs $HAC_{ca.}$ Regular or long-term consumption of these fish from the Trinity River may increase the risk of cancer in people eating these fish.

5. That consumption of multiple inorganic and organic contaminants in fish does not significantly increase the likelihood of systemic or carcinogenic health risk above that of PCBs and/or PCDFs/PCDDs observed in fish from the Trinity River.

RECOMMENDATIONS

Risk managers at the DSHS have established criteria for issuing fish consumption advisories based on approaches suggested by the USEPA.[12, 14, 48] Risk managers at the DSHS may decide to take some action to protect public health if a risk characterization confirms that people can eat four, or fewer meals per month (adults: eight ounces per meal; children: four ounces per meal) of fish or shellfish from a water body under investigation. Risk management recommendations may be in the form of consumption advice or a ban on possession of fish from the affected water body. Fish or shellfish possession bans are enforceable under subchapter D of the Texas Health and Safety Code, part 436.061(a).[49] Declarations of prohibited harvesting areas are enforceable under the Texas Health and Safety Code, Subchapter D, parts 436.091 and 436.101.[49] DSHS consumption advice carries no penalty for noncompliance. Consumption advisories, instead, inform the public of potential health hazards associated with consuming contaminated fish or shellfish from Texas waters. With this information, members of the public can make informed decisions about whether and/or how much – contaminated fish or shellfish they wish to consume. The SALG concludes from this risk characterization that consuming fish from the Trinity River **poses an apparent hazard to public health.** Therefore, SALG risk assessors recommend

1. That pregnant women, women who may become pregnant, women who are nursing an infant, and children 12 years of age or under or who weigh less than 75 pounds should not eat any species of fish from the Trinity River between West Rosedale Street in Fort Worth, Texas and SH 31.

2. That adult men and women past childbearing should not eat any species of fish from the Trinity River between West Rosedale Street in Fort Worth, Texas and SH 31.

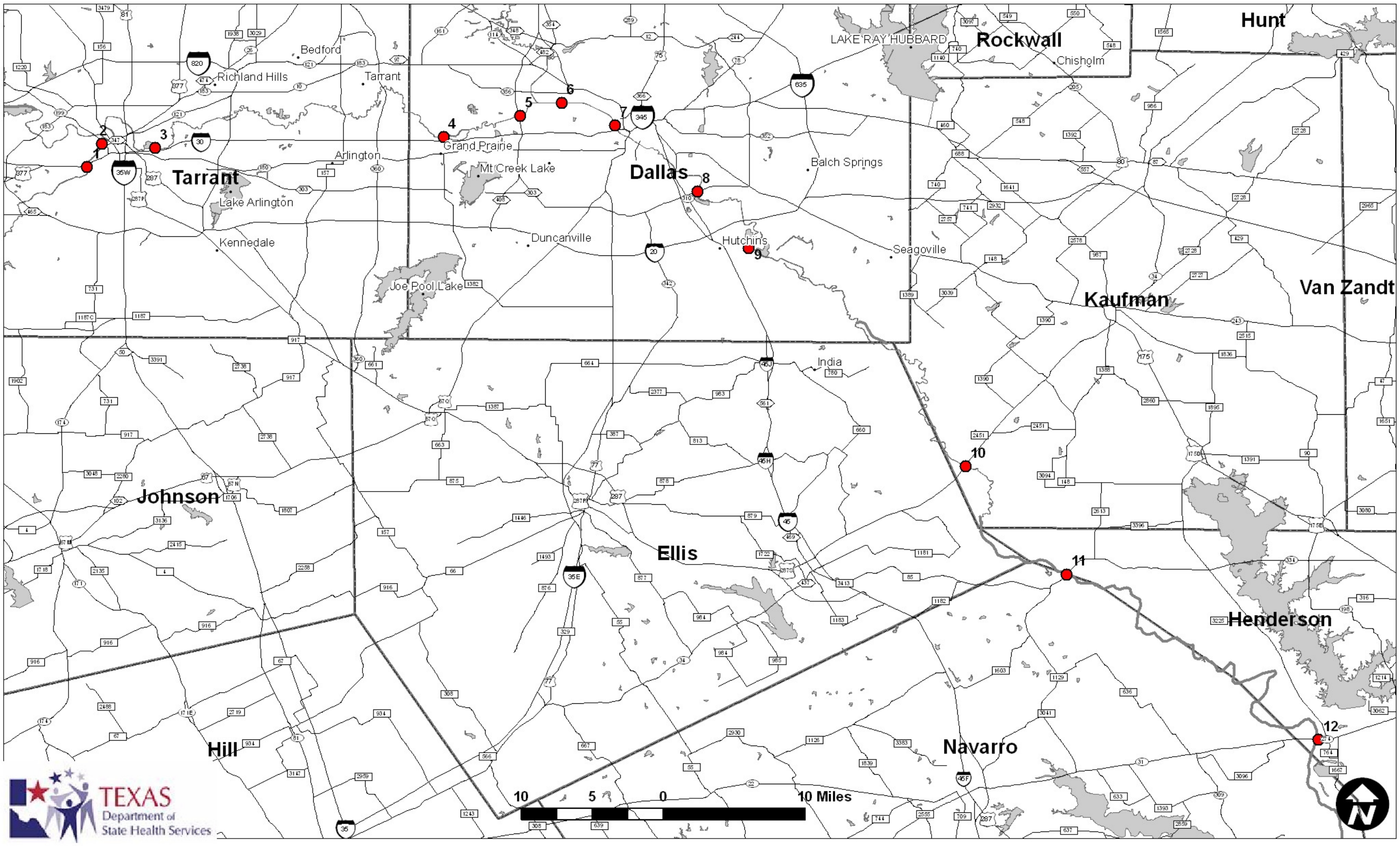
3. That as resources become available, the DSHS should continue to monitor fish from the Trinity River in the Dallas-Fort Worth metropolitan area for changes or trends in contaminants or contaminant concentrations that would necessitate a change in consumption advice and also complete a comprehensive fish tissue contaminant study of the entire Trinity River from Dallas-Fort Worth to Trinity Bay.

PUBLIC HEALTH ACTION PLAN

Communication to the public of new and continuing possession bans or consumption advisories, or the removal of either, is essential to effective management of risk from consuming contaminated fish. In fulfillment of the responsibility for communication, the Texas Department of State Health Services (DSHS) takes several steps. The agency publishes fish consumption advisories and bans in a booklet available to the public through the Seafood and Aquatic Life Group (SALG). To receive the booklet and/or the data, please contact the SALG at 1-512-834-

6757.[50] The SALG also posts the most current information about advisories, bans, and the removal of either on the internet at http://www.dshs.state.tx.us/seafood. The SALG regularly updates this Web site. The DSHS also provides USEPA (http://epa.gov/waterscience/fish/advisories/), the TCEQ (http://www.tceq.state.tx.us), and the Texas Parks and Wildlife Department (TPWD) (http://www.tpwd.state.tx.us) with information on all consumption advisories and possession bans. Each year, the TPWD informs the fishing and hunting public of consumption advisories and fishing bans on it's Web site and in an official hunting and fishing regulations booklet available at many state parks and at all establishments selling Texas fishing licenses.[51] Readers may direct questions about the scientific information or recommendations in this risk characterization to the SALG at 512-834-6757 or may find the information at the SALG's Web site (http://www.dshs.state.tx.us/seafood). Secondarily, one may address inquiries to the Environmental and Injury Epidemiology and Toxicology Branch of the Department of State Health Services (512-458-7269). The USEPA's IRIS Web site (http://www.epa.gov/iris/) contains information on environmental contaminants found in food and environmental media. The Agency for Toxic Substances and Disease Registry (ATSDR), Division of Toxicology (888-42-ATSDR or 888-422-8737) or the ATSDR's Web site (http://www.atsdr.cde.gov) supplies brief information via ToxFAQs.™ ToxFAQs™ are available on the ATSDR Web site in either English (http://www.atsdr.cdc.gov/toxfaq.html) or Spanish (http://www.atsdr.cdc.gov/es/toxfaqs/es _toxfaqs.html). The ATSDR also publishes more in-depth reviews of many toxic substances in its *Toxicological Profiles* (ToxProfiles™). To request a copy of the ToxProfiles™ CD-ROM, PHS, or ToxFAQs™ call 1-800-CDC-INFO (800-232-4636) or email a request to cdcinfo@cdc.gov.

Figure 1. Trinity River Sample Sites



TABLES

Table 1. Fish samples collected from the Trinity River from June 2008 through July 2008. Sample number, species, length, and weight were recorded for each sample.

Sample Number	Species	Length (mm)	Weight (g)
Site 1 Trinity River at West Rosedale Street			
TRR14	Largemouth bass	485	1686
TRR15	Largemouth bass	451	1135
TRR16	Largemouth bass	433	1310
TRR17	Largemouth bass	435	1352
TRR18	Largemouth bass	422	1173
TRR20	Channel catfish	439	775
TRR21	Freshwater drum	560	3162
TRR22	Flathead catfish	850	8618
TRR23	Common carp	635	3900
TRR24	Common carp	580	2680
Site 2 Trinity River at Purcey Drain			
TRR1	Smallmouth buffalo	835	14969
TRR2	Smallmouth buffalo	692	7260
TRR3	Largemouth bass	521	1857
TRR4	Largemouth bass	468	1445
TRR5	Largemouth bass	480	1585
TRR8	White bass	378	801
TRR9	Freshwater drum	569	3441
TRR10	Freshwater drum	355	638
TRR12	Common carp	581	3095
TRR13	Common carp	575	2549
TRR52	Channel catfish	551	1051
TRR53	Channel catfish	426	802
Site 3 Trinity River at Beach Street			
TRR25	Largemouth bass	497	1913
TRR28	Largemouth bass	458	1535
TRR36	Smallmouth buffalo	570	3180
TRR37	Smallmouth buffalo	515	2224
TRR38	Freshwater drum	495	1674
TRR39	Freshwater drum	515	1922
TRR43	Channel catfish	651	2671
TRR44	Channel catfish	545	1732
TRR47	White bass	402	1027
TRR48	White bass	342	562
TRR50	Common carp	566	2240
TRR51	Common carp	515	1545

Table 1 Continued. Fish samples collected from the Trinity River from June 2008 through July 2008. Sample number, species, length, and weight were recorded for each sample.			
Sample Number	**Species**	**Length (mm)**	**Weight (g)**
Site 4 Trinity River at Belt Line Road			
TRR90	Common carp	540	2248
TRR91	Common carp	575	2968
TRR92	Smallmouth buffalo	540	2731
TRR93	Smallmouth buffalo	531	2762
TRR94	Smallmouth buffalo	500	2475
TRR95	Smallmouth buffalo	490	2497
TRR96	Smallmouth buffalo	490	2021
TRR118	Channel catfish	547	1456
TRR119	Channel catfish	553	1675
Site 5 Trinity River at SH Loop 12			
TRR70	Spotted bass	359	606
TRR71	Channel catfish	452	769
TRR72	Channel catfish	405	578
TRR73	Channel catfish	417	603
TRR74	Channel catfish	410	535
TRR75	Channel catfish	427	616
TRR76	Flathead catfish	640	2955
TRR77	Freshwater drum	450	1385
TRR78	Common carp	607	3321
TRR79	Smallmouth buffalo	550	2979
Site 6 Trinity River at Westmoreland Road			
TRR55	Channel catfish	590	1700
TRR56	Channel catfish	555	1661
TRR60	Flathead catfish	680	3619
TRR61	Freshwater drum	420	1480
TRR62	Freshwater drum	498	2106
TRR63	Spotted bass	338	589
TRR64	Spotted bass	317	401
TRR65	White bass	377	667
TRR66	Smallmouth buffalo	595	3474
TRR67	Smallmouth buffalo	575	3955
TRR68	Longnose gar	882	2503
TRR69	Longnose gar	1010	2830
Site 7 Trinity River at Commerce Street			
TRR80	Freshwater drum	383	4293
TRR81	Channel catfish	332	330
TRR82	Channel catfish	385	445

Table 1 Continued. Fish samples collected from the Trinity River from June 2008 through July 2008. Sample number, species, length, and weight were recorded for each sample.

Sample Number	Species	Length (mm)	Weight (g)
Continued Site 7 Trinity River at Commerce Street			
TRR83	Channel catfish	477	960
TRR84	Channel catfish	360	427
TRR85	Channel catfish	365	394
TRR86	Flathead catfish	472	1039
TRR87	Smallmouth buffalo	740	7889
TRR88	Smallmouth buffalo	620	5382
TRR89	Longnose gar	1030	3697
Site 8 Trinity River at SH Loop 12 (South)			
TRR97	Smallmouth buffalo	540	2584
TRR99	Smallmouth buffalo	513	2483
TRR100	Common carp	540	2480
TRR101	Common carp	415	1153
TRR104	Longnose gar	799	1409
TRR105	Longnose gar	773	1555
TRR106	Spotted gar	625	1162
TRR120	Flathead catfish	1040	14061
TRR121	Channel catfish	550	1788
TRR123	Channel catfish	500	1326
Site 9 Trinity River at Dowdy Ferry Road			
TRR107	Blue catfish	620	3548
TRR108	Blue catfish	831	6750
TRR109	Blue catfish	785	6328
TRR110	Smallmouth buffalo	560	3192
TRR111	Smallmouth buffalo	589	3468
TRR113	Common carp	567	2341
TRR114	Longnose gar	931	2266
TRR115	Longnose gar	850	2234
TRR116	Spotted gar	741	1707
TRR117	Spotted gar	729	1871
Site 10 Trinity River at SH 34			
TRR140	Blue catfish	663	2961
TRR141	Blue catfish	610	2047
TRR143	Blue catfish	640	2781
TRR144	Blue catfish	685	3034
TRR145	Blue catfish	595	2174
TRR146	Blue catfish	573	1770
TRR147	Flathead catfish	750	5848
TRR148	Flathead catfish	684	3477

Table 1 Continued. Fish samples collected from the Trinity River from June 2008 through July 2008. Sample number, species, length, and weight were recorded for each sample.			
Sample Number	**Species**	**Length (mm)**	**Weight (g)**
Continued Site 10 Trinity River at SH 34			
TRR149	Freshwater drum	415	1192
TRR150	Smallmouth buffalo	650	5388
TRR151	Smallmouth buffalo	568	3635
TRR152	Longnose gar	925	2482
Site 11 Trinity River at FM 85			
TRR153	Blue catfish	637	2436
TRR154	Blue catfish	920	7475
TRR155	Blue catfish	663	2782
TRR156	Blue catfish	686	3049
TRR157	Blue catfish	655	2799
TRR160	Flathead catfish	627	2513
TRR161	Flathead catfish	755	5275
TRR162	Smallmouth buffalo	577	3807
TRR163	Longnose gar	901	2520
TRR164	Longnose gar	895	2734
TRR165	Longnose gar	1030	2629
Site 12 Trinity River at SH 31			
TRR127	Blue catfish	460	949
TRR129	Blue catfish	515	1265
TRR130	Blue catfish	541	1370
TRR131	Blue catfish	507	1320
TRR132	Blue catfish	508	1240
TRR133	Blue catfish	517	1218
TRR134	Flathead catfish	627	3190
TRR135	Flathead catfish	478	1181
TRR136	Smallmouth buffalo	585	3621
TRR137	Smallmouth buffalo	532	3344
TRR138	Longnose gar	1080	4720
TRR139	Longnose gar	839	2057

Table 2a. Arsenic (mg/kg) in fish collected from the Trinity River, 2008.

Species	#Detected/ # Sampled	Total Arsenic Mean Concentration ± S.D. (Min-Max)	Inorganic Arsenic Mean Concentration[f]	Health Assessment Comparison Value (mg/kg)[g]	Basis for Comparison Value
Blue catfish	3/3	0.047±0.020 (0.032-0.070)	0.005	0.7 0.362	EPA chronic oral RfD for Inorganic arsenic: 0.0003 mg/kg–day EPA oral slope factor for inorganic arsenic: 1.5 per mg/kg–day
Channel catfish	8/8	0.106±0.067 (0.042-0.263)	0.011		
Flathead catfish	4/5	0.031±0.017 (ND[h]-0.056)	0.003		
Freshwater drum	1/1	0.318	0.032		
Largemouth bass	1/1	0.202	0.020		
Longnose gar	2/2	0.072±0.030 (0.051-0.093)	0.007		
Smallmouth buffalo	6/6	0.161±0.045 (0.104-0.222)	0.016		
All fish combined	25/26	0.107±0.079 (ND-0.318)	0.011		

[f] *Most arsenic in fish and shellfish occurs as organic arsenic, considered virtually nontoxic. For risk assessment calculations, DSHS assumes that total arsenic is composed of 10% inorganic arsenic in fish and shellfish tissues.*

[g] *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 $1x10^{-4}$.*

[h] *ND: "Not Detected" was used to indicate that a compound was not present in a sample at a level greater than the reporting limit.*

Table 2b. Inorganic contaminants (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected/ # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Cadmium				
Blue catfish	0/3	ND	0.47	ATSDR chronic oral MRL: 0.0002 mg/kg–day
Channel catfish	0/8	ND		
Flathead catfish	0/5	ND		
Freshwater drum	0/1	ND		
Largemouth bass	0/1	ND		
Longnose gar	0/2	ND		
Smallmouth buffalo	0/6	ND		
All fish combined	0/26	ND		
Copper				
Blue catfish	3/3	0.219±0.120 (0.101-0.340)	333	National Academy of Science Upper Limit: 0.143 mg/kg–day
Channel catfish	8/8	0.151±0.043 (0.093-0.211)		
Flathead catfish	5/5	0.093±0.215 (0.074-0.130)		
Freshwater drum	1/1	0.150		
Largemouth bass	1/1	0.083		
Longnose gar	2/2	BDL[i]		
Smallmouth buffalo	6/6	0.143±0.026 (0.096-0.169)		
All fish combined	26/26	0.135±0.062 (BDL-0.340)		

[i] *BDL: "Below Detection Limit" – Concentrations were reported as less than the laboratory's reporting limit ("J" values). In some instances, a "J" value was used to denote the discernable presence in a sample of a contaminant at concentrations estimated as different from the sample blank.*

Table 2c. Inorganic contaminants (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected/ # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Lead				
Blue catfish	0/3	ND	NA	EPA IEUBKwin32 Version 1.1 Build 9
Channel catfish	1/8	0.039±0.005 (ND-BDL)		
Flathead catfish	0/5	ND		
Freshwater drum	0/1	ND		
Largemouth bass	0/1	ND		
Longnose gar	1/2	0.048±0.004 (ND-BDL)		
Smallmouth buffalo	1/6	0.053±0.016 (ND-BDL)		
All fish combined	3/26	0.044±0.011 (ND-BDL)		
Mercury				
Blue catfish	20/20	0.214±0.106 (0.110-0.521)	0.7	ATSDR chronic oral MRL: 0.0003 mg/kg–day
Channel catfish	21/21	0.104±0.080 (BDL-0.352)		
Common carp	12/12	0.093±0.039 (BDL-0.161)		
Flathead catfish	11/11	0.332±0.109 (0.219-0.598)		
Freshwater drum	10/10	0.292±0.182 (BDL-0.643)		
Largemouth bass	10/10	0.479±0.102 (0.365-0.694)		
Longnose gar	13/13	0.309±0.101 (0.132-0.505)		
Smallmouth buffalo	23/23	0.230±0.100 (0.107-0.494)		
Spotted bass	3/3	0.463±0.244 (0.294-**0.742**)		
Spotted gar	3/3	0.192±0.012 (0.181-0.205)		
White bass	4/4	0.347±0.084 (0.231-0.422)		
All fish combined	130/130	0.243±0.152 (BDL-**0.742**)		

Table 2d. Inorganic contaminants (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected/ # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Selenium				
Blue catfish	3/3	0.174±0.029 (0.140-0.192)	6	EPA chronic oral RfD: 0 .005 mg/kg–day ATSDR chronic oral MRL: 0.005 mg/kg–day NAS UL: 0.400 mg/day (0.005 mg/kg–day) RfD or MRL/2: (0.005 mg/kg –day/2= 0.0025 mg/kg–day) to account for other sources of selenium in the diet
Channel catfish	8/8	0.201±0.110 (0.095-0.435)		
Flathead catfish	5/5	0.166±0.051 (0.112-0.245)		
Freshwater drum	1/1	0.246		
Largemouth bass	1/1	0.252		
Longnose gar	2/2	0.205±0.028 (0.185-0.224)		
Smallmouth buffalo	6/6	0.408±0.065 (0.317-0.474)		
All fish combined	26/26	0.243±0.117 (0.095-0.474)		
Zinc				
Blue catfish	3/3	5.830±3.234 (2.542-9.008)	700	EPA chronic oral RfD: 0.3 mg/kg–day
Channel catfish	8/8	5.268±1.469 (3.485-7.913)		
Flathead catfish	5/5	2.968±0.461 (2.375-3.565)		
Freshwater drum	1/1	3.357		
Largemouth bass	1/1	3.287		
Longnose gar	2/2	10.212±12.475 (1.391-19.033)		
Smallmouth buffalo	6/6	2.033±0.898 (0.572-3.126)		
All fish combined	26/26	4.374±3.591 (0.572-19.033)		

Table 3a. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Hexachlorobenzene				
Blue catfish	17/20	0.0004±0.0004 (ND-0.002)	1.867 0.340	EPA chronic oral RfD: 0.0008 mg/kg–day EPA slope factor: 16 per mg/kg-day
Channel catfish	20/21	0.0004±0.0004 (ND-0.002)		
Common carp	11/12	0.0003±0.0001 (ND-0.0005)		
Flathead catfish	5/11	0.0003±0.0001 (ND-0.0005)		
Freshwater drum	10/10	0.0008±0.0007 (ND-0.003)		
Largemouth bass	6/10	0.0002±0.00001 (ND-0.0003)		
Longnose gar	7/13	0.001±0.001 (ND-0.005)		
Smallmouth buffalo	21/23	0.001±0.001 (ND-0.005)		
Spotted bass	3/3	BDL		
Spotted gar	3/3	0.0007±0.0001 (0.0006-0.0008)		
White bass	4/4	0.0004±0.0003 (BDL-0.0009)		
All fish combined	107/130	0.0006±0.0008 (ND-0.005)		

Table 3b. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Heptachlor Epoxide				
Blue catfish	19/20	0.002±0.001 (ND-0.006)	0.03 0.06	EPA chronic oral RfD: 0.000013 mg/kg–day EPA slope factor: 9.1 per mg/kg-day
Channel catfish	19/21	0.001±0.001 (ND-0.005)		
Common carp	11/12	0.0009±0.0006 (ND-0.002)		
Flathead catfish	9/11	0.0009±0.0006 (ND-0.002)		
Freshwater drum	10/10	0.004±0.004 (0.001-0.013)		
Largemouth bass	5/10	0.0003±0.00008 (ND-0.0005)		
Longnose gar	13/13	0.004±0.002 (0.002-0.008)		
Smallmouth buffalo	23/23	0.004±0.003 (0.0005-0.010)		
Spotted bass	3/3	BDL		
Spotted gar	3/3	0.003±0.0001 (0.003-0.003)		
White bass	4/4	0.001±0.0006 (0.0006-0.002)		
All fish combined	119/130	0.002±0.001 (ND-0.005)		

Table 3c. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Chlordane				
Blue catfish	20/20	0.057±0.054 (0.009-0.264)	1.167 1.553	EPAchronic oral RfD: 0.0005 mg/kg–day EPA slope factor 0.35 per mg/kg–day
Channel catfish	21/21	0.050±0.063 (0.005-0.299)		
Common carp	12/12	0.030±0.022 (0.003-0.059)		
Flathead catfish	11/11	0.036±0.027 (0.010-0.087)		
Freshwater drum	10/10	0.105±0.077 (0.028-0.251)		
Largemouth bass	10/10	0.019±0.008 (0.006-0.032)		
Longnose gar	13/13	0.099±0.056 (0.031-0.191)		
Smallmouth buffalo	23/23	0.082±0.060 (0.016-0.220)		
Spotted bass	3/3	0.006-0.005 (0.003-0.012)		
Spotted gar	3/3	0.070±0.022 (0.045-0.083)		
White bass	4/4	0.090±0.057 (0.040-0.171)		
All fish combined	130/130	0.061±0.058 (0.003-0.299)		

Table 3d. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Dieldrin				
Blue catfish	20/20	0.018±0.017 (0.003-**0.076**)	0.117 0.034	EPAchronic oral RfD: 0.00005 mg/kg–day EPA slope factor 16 per mg/kg–day
Channel catfish	20/21	0.010±0.011 (ND-**0.039**)		
Common carp	11/12	0.009±0.009 (ND-0.033)		
Flathead catfish	10/11	0.007±0.005 (ND-0.014)		
Freshwater drum	10/10	0.028±0.021 (0.009-**0.081**)		
Largemouth bass	9/10	0.002±0.002 (ND-0.006)		
Longnose gar	13/13	0.028±0.012 (0.016-**0.058**)		
Smallmouth buffalo	21/23	0.025±0.023 (ND-**0.090**)		
Spotted bass	3/3	0.002±0.0007 (0.001-0.003)		
Spotted gar	3/3	0.023±0.002 (0.021-0.025)		
White bass	4/4	0.014±0.006 (0.006-0.018)		
All fish combined	124/130	0.016±0.017 (ND-**0.090**)		

Table 3e. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Pentachloroanisole				
Blue catfish	18/20	0.002±0.002 (ND-0.007)	N/A	Not Available
Channel catfish	20/21	0.002±0.001 (ND-0.004)		
Common carp	11/12	0.0007±0.0007 (ND-0.002)		
Flathead catfish	5/11	0.0005±0.0006 (ND-0.002)		
Freshwater drum	10/10	0.003±0.003 (BDL-0.011)		
Largemouth bass	0/10	ND		
Longnose gar	8/13	0.002±0.002 (ND-0.005)		
Smallmouth buffalo	22/23	0.004±0.003 (ND-0.011)		
Spotted bass	3/3	BDL		
Spotted gar	3/3	0.002±0.0003 (0.001-0.002)		
White bass	4/4	0.0009±0.001 (BDL-0.002)		
All fish combined	104/130	0.002±0.002 (ND-0.011)		

Table 3f. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Mirex				
Blue catfish	19/20	0.001±0.001 (ND-0.004)	0.467	EPA chronic oral RfD: 0.0002 mg/kg–day
Channel catfish	20/21	0.002±0.003 (ND-0.016)		
Common carp	4/12	BDL		
Flathead catfish	9/11	0.0007±0.0006 (ND-0.002)		
Freshwater drum	7/10	0.0008±0.0007 (ND-0.002)		
Largemouth bass	0/10	ND		
Longnose gar	10/13	0.004±0.005 (ND-0.017)		
Smallmouth buffalo	20/23	0.002±0.002 (ND-0.008)		
Spotted bass	3/3	0.0005±0.0003 (BDL-0.0008)		
Spotted gar	2/3	0.0009±0.0006 (ND-0.001)		
White bass	3/4	0.0006±0.0005 (ND-0.001)		
All fish combined	97/130	0.001±0.002 (ND-0.017)		

Table 3g. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
4,4′-DDE				
Blue catfish	20/20	0.038±0.043 (0.012-0.173)	1.167 1.599	EPAchronic oral RfD: 0.0005 mg/kg–day EPA slope factor 0.34 per mg/kg–day
Channel catfish	21/21	0.026±0.034 (0.003-0.138)		
Common carp	12/12	0.016±0.012 (0.002-0.034)		
Flathead catfish	11/11	0.019±0.013 (0.005-0.043)		
Freshwater drum	10/10	0.037±0.039 (0.006-0.134)		
Largemouth bass	10/10	0.013±0.007 (0.004-0.026)		
Longnose gar	13/13	0.110±0.067 (0.040-0.235)		
Smallmouth buffalo	23/23	0.046±0.043 (0.009-0.160)		
Spotted bass	3/3	0.003±0.003 (0.001-0.006)		
Spotted gar	3/3	0.081±0.027 (0.054-0.108)		
White bass	4/4	0.038±0.033 (0.019-0.087)		
All fish combined	130/130	0.039±0.046 (0.001-0.235)		

Table 3h. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
2,4′-DDD				
Blue catfish	20/20	0.001±0.001 (BDL-0.006)	1.167 1.599	EPA chronic oral RfD: 0.0005 mg/kg–day EPA slope factor 0.34 per mg/kg - day
Channel catfish	21/21	0.0009±0.001 (BDL-0.003)		
Common carp	10/12	0.002±0.004 (ND-0.015)		
Flathead catfish	8/11	0.0004±0.0003 (ND-0.0009)		
Freshwater drum	10/10	0.002±0.001 (BDL-0.005)		
Largemouth bass	5/10	0.0002±0.00001 (ND-0.0003)		
Longnose gar	13/13	0.002±0.0006 (0.001-0.003)		
Smallmouth buffalo	22/23	0.002±0.002 (ND-0.005)		
Spotted bass	3/3	BDL		
Spotted gar	3/3	0.002±0.0005 (0.001-0.002)		
White bass	4/4	0.0008±0.0004 (BDL-0.001)		
All fish combined	119/130	0.001±0.002 (ND-0.015)		

Table 3i. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
4,4′-DDD				
Blue catfish	20/20	0.003±0.003 (0.0007-0.012)	1.167 1.599	EPA chronic oral RfD: 0.0005 mg/kg–day EPA slope factor 0.34 per mg/kg - day
Channel catfish	21/21	0.005±0.008 (BDL-0.034)		
Common carp	12/12	0.004±0.006 (BDL-0.024)		
Flathead catfish	11/11	0.002±0.001 (0.0005-0.005)		
Freshwater drum	10/10	0.008±0.008 (0.002-0.026)		
Largemouth bass	10/10	0.002±0.001 (BDL-0.004)		
Longnose gar	13/13	0.009±0.004 (0.003-0.015)		
Smallmouth buffalo	23/23	0.006±0.005 (0.001-0.018)		
Spotted bass	3/3	0.0003±0.0001 (BDL-0.0005)		
Spotted gar	3/3	0.006±0.002 (0.004-0.008)		
White bass	4/4	0.008±0.008 (0.003-0.020)		
All fish combined	130/130	0.005±0.006 (BDL-0.034)		

Table 3j. Pesticides (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
4,4′-DDT				
Blue catfish	7/20	0.0004±0.0004 (ND-0.002)	1.167 1.599	EPA chronic oral RfD: 0.0005 mg/kg–day EPA slope factor 0.34 per mg/kg - day
Channel catfish	19/21	0.001±0.002 (ND-0.006)		
Common carp	4/12	0.0007-0.0009 (ND-0.003)		
Flathead catfish	2/11	0.0003-0.0003 (ND-0.001)		
Freshwater drum	9/10	0.003±0.003 (ND-0.008)		
Largemouth bass	8/10	0.0006±0.0003 (ND-0.001)		
Longnose gar	9/13	0.001±0.001 (ND-0.004)		
Smallmouth buffalo	13/23	0.003±0.004 (ND-0.013)		
Spotted bass	1/3	BDL		
Spotted gar	2/3	0.001±0.0009 (ND-0.002)		
White bass	4/4	0.004±0.003 (0.001-0.008)		
All fish combined	78/130	0.001±0.002 (ND-0.013)		

Table 4a. PCBs (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Site 1 Trinity River at West Rosedale Street				
Channel catfish	1/1	**0.117**[j]	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	2/2	**0.064**±0.0003 (**0.0636**-**0.0639**)		
Flathead catfish	1/1	**0.079**		
Freshwater drum	1/1	**0.128**		
Largemouth bass	5/5	0.033±0.011 (0.025-**0.052**)		
All fish combined	10/10	**0.062**±0.037 (0.025-**0.128**)		
Site 2 Trinity River at Purcey Drain				
Channel catfish	2/2	**0.121**±0.043 (**0.090**-**0.151**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	2/2	**0.197**±0.077 (**0.142**-**0.251**)		
Freshwater drum	2/2	**0.048**±0.022 (0.033-**0.064**)		
Largemouth bass	3/3	**0.089**±0.034 (**0.050**-**0.109**)		
Smallmouth buffalo	2/2	**0.105**±0.047 (**0.072**-**0.138**)		
White bass	1/1	**0.120**		
All fish combined	12/12	**0.111**±0.058 (0.033-**0.251**)		
Site 3 Trinity River at Beach Street				
Channel catfish	2/2	**0.488**±0.354 (**0.238**-**0.738**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	2/2	**0.063**±0.045 (0.032-**0.096**)		
Freshwater drum	2/2	**0.509**±0.098 (**0.440**-**0.579**)		
Largemouth bass	2/2	**0.116**±0.020 (**0.102**-**0.130**)		
Smallmouth buffalo	2/2	**0.336**±0.015 (**0.326**-**0.347**)		
White bass	2/2	**0.316**±0.290 (**0.111**-**0.521**)		
All fish combined	12/12	**0.305**±0.226 (**0.032**-**0.738**)		

[j] ***Emboldened numbers*** *indicate the concentration of a contaminant exceeded a DSHS HAC value.*

Table 4b. PCBs (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Site 4 Trinity River at Belt Line Road				
Channel catfish	2/2	**0.095**±0.031 (**0.073**-**0.117**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	2/2	**0.131**±0.020 (**0.117**-**0.145**)		
Smallmouth buffalo	5/5	**0.234**±0.092 (**0.172**-**0.395**)		
All fish combined	9/9	**0.180**±0.093 (**0.073**-**0.395**)		
Site 5 Trinity River at SH Loop 12				
Channel catfish	5/5	**0.065**±0.019 (0.035-**0.083**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	1/1	**0.067**		
Flathead catfish	1/1	**0.053**		
Freshwater drum	1/1	**0.069**		
Smallmouth buffalo	1/1	**0.118**		
Spotted bass	1/1	0.023		
All fish combined	10/10	**0.066**±0.026 (0.023-**0.118**)		
Site 6 Trinity River at Westmoreland Road				
Channel catfish	2/2	**0.118**±0.088 (**0.056**-**0.180**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Flathead catfish	1/1	**0.213**		
Freshwater drum	2/2	**0.215**±0.046 (**0.183**-**0.247**)		
Longnose gar	2/2	**0.933**±0.520 (**0.566**-**1.301**)		
Smallmouth buffalo	2/2	**0.256**±0.218 (**0.102**-**0.410**)		
Spotted bass	2/2	**0.048**±0.033 (0.025-**0.072**)		
White bass	1/1	**0.215**		
All fish combined	12/12	**0.297**±0.351 (0.025-**1.301**)		

Table 4c. PCBs (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Site 7 Trinity River at Commerce Street				
Channel catfish	5/5	**0.087**±0.026 (**0.057**-**0.115**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Flathead catfish	1/1	**0.097**		
Freshwater drum	1/1	**0.563**		
Longnose gar	1/1	**0.544**		
Smallmouth buffalo	2/2	**0.488**±0.166 (**0.371**-**0.605**)		
All fish combined	10/10	**0.262**±0.232 (**0.057**-**0.605**)		
Site 8 Trinity River at SH Loop 12 (South)				
Channel catfish	2/2	**0.055**±0.003 (**0.053**-**0.057**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	2/2	0.036±0.002 (0.034-0.037)		
Flathead catfish	1/1	**0.219**		
Longnose gar	2/2	**0.203**±0.056 (**0.163**-**0.243**)		
Smallmouth buffalo	2/2	**0.823**±0.544 (**0.439**-**1.207**)		
Spotted gar	1/1	**0.442**		
All fish combined	10/10	**0.289**±0.357 (0.034-**1.207**)		
Site 9 Trinity River at Dowdy Ferry Road				
Blue catfish	3/3	**0.210**±0.020 (**0.187**-**0.226**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Common carp	1/1	0.025		
Longnose gar	2/2	**0.434**±0.184 (**0.305**-**0.564**)		
Smallmouth buffalo	2/2	**0.128**±0.053 (**0.091**-**0.166**)		
Spotted gar	2/2	**0.315**±0.111 (**0.237**-**0.394**)		
All fish combined	10/10	**0.241**±0.153 (0.025-**0.564**)		

Table 4d. PCBs (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Site 10 Trinity River at SH 34				
Blue catfish	6/6	**0.115**±0.047 (**0.075**-**0.196**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Flathead catfish	2/2	**0.155**±0.084 (**0.095**-**0.214**)		
Freshwater drum	1/1	**0.152**		
Longnose gar	1/1	**0.187**		
Smallmouth buffalo	2/2	**0.171**±0.037 (**0.145**-**0.197**)		
All fish combined	12/12	**0.140**±0.051 (**0.075**-**0.214**)		
Site 11 Trinity River at FM 85				
Blue catfish	5/5	**0.145**±0.069 (**0.065**-**0.235**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Flathead catfish	2/2	**0.076**±0.044 (0.045-**0.107**)		
Longnose gar	3/3	**0.224**±0.056 (**0.169**-**0.281**)		
Smallmouth buffalo	1/1	0.042		
All fish combined	11/11	**0.145**±0.081 (0.042-**0.281**)		
Site 12 Trinity River at SH 31				
Blue catfish	6/6	**0.052**±0.017 (0.041-**0.085**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Flathead catfish	2/2	0.039±0.0002 (0.0385-0.0389)		
Longnose gar	2/2	**0.308**±0.241 (**0.138**-**0.479**)		
Smallmouth buffalo	2/2	**0.181**±0.194 (0.044-**0.318**)		
All fish combined	12/12	**0.114**±0.140 (0.039-**0.479**)		

Table 4e. PCBs (mg/kg) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
All Trinity River Sample Sites				
Blue catfish	20/20	**0.118**±0.068 (0.041-**0.235**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Channel catfish	21/21	**0.125**±0.148 (0.035-**0.738**)		
Common carp	12/12	**0.089**±0.066 (0.025-**0.251**)		
Flathead catfish	11/11	**0.109**±0.072 (0.039-**0.219**)		
Freshwater drum	10/10	**0.246**±0.207 (0.033-**0.579**)		
Largemouth bass	10/10	**0.067**±0.041 (0.025-**0.130**)		
Longnose gar	13/13	**0.397**±0.316 (**0.138**-**1.301**)		
Smallmouth buffalo	23/23	**0.274**±0.250 (0.042-**1.207**)		
Spotted bass	3/3	0.040±0.028 (0.023-**0.072**)		
Spotted gar	3/3	**0.357**±0.107 (**0.237**-**0.442**)		
White bass	4/4	**0.242**±0.192 (**0.111**-**0.521**)		
All fish combined	130/130	**0.185**±0.200 (0.023-**1.301**)		

Table 4f. PCBs (mg/kg) in fish collected in 2008 from Composite Site 1 (Trinity River-Prohibited Area) and Composite Site 2 (Trinity River-Advisory Area).			
# Detected / # Sampled	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Composite Site 1 (Trinity River-Prohibited Area consisting of sites 1 through 10)			
107/107	**0.197**±0.212 (0.023-**1.301**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day
Composite Site 2 (Trinity River-Advisory Area consisting of sites 11 and 12)			
23/23	**0.129**±0.114 (0.039-**0.479**)	0.047 0.272	EPA chronic oral RfD: 0.00002 mg/kg–day EPA slope factor: 2.0 per mg/kg–day

Table 5a. PCDFs/PCDDs toxicity equivalent concentrations (TEQ; pg/g) in fish collected from the Trinity River, 2008.

Species	# Detected / # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (pg/g)	Basis for Comparison Value
Site 1 Trinity River at West Rosedale Street				
Channel catfish	1/1	0.421	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Flathead catfish	1/1	0.003		
All fish combined	2/2	0.212±0.296 (0.003-0.421)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 2 Trinity River at Purcey Drain				
Channel catfish	1/1	**3.008**		
Freshwater drum	1/1	**2.912**	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Largemouth bass	1/1	1.527		
Smallmouth buffalo	1/1	**12.751**	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
All fish combined	4/4	**5.050**±5.179 (1.527-**12.751**)		
Site 3 Trinity River at Beach Street				
Channel catfish	1/1	**2.582**	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Smallmouth buffalo	1/1	0.645		
All fish combined	3/3	1.614±1.370 (0.645-2.582)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 4 Trinity River at Belt Line Road				
Channel catfish	1/1	**5.790**	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Smallmouth buffalo	1/1	**6.297**		
All fish combined	2/2	**6.044**±0.359 (**5.790-6.297**)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 5 Trinity River at SH Loop 12				
Channel catfish	1/1	0.983	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Flathead catfish	1/1	**3.172**		
All fish combined	2/2	2.078±1.548 (0.983-**3.172**)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day

Table 5b. PCDFs/PCDDs toxicity equivalent concentrations (TEQ; pg/g) in fish collected from the Trinity River, 2008.

Species	# Detected / # Sampled	Mean Concentration ± S.D. (Min-Max)	Health Assessment Comparison Value (pg/g)	Basis for Comparison Value
Site 6 Trinity River at Westmoreland Road				
Channel catfish	1/1	0.462	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Smallmouth buffalo	1/1	**3.951**		
All fish combined	2/2	2.207±2.467 (0.462-**3.951**)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 7 Trinity River at Commerce Street				
Channel catfish	1/1	0.699	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Smallmouth buffalo	1/1	**3.548**		
All fish combined	2/2	2.124±2.015 (0.699-**3.548**)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 8 Trinity River at SH Loop 12 (South)				
Channel catfish	1/1	0.427	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Flathead catfish	1/1	0.455		
All fish combined	2/2	0.441±0.020 (0.427-0.455)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 9 Trinity River at Dowdy Ferry Road				
Blue catfish	1/1	0.925	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Smallmouth buffalo	1/1	**3.497**		
All fish combined	2/2	2.211±1.819 (0.925-**3.497**)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 10 Trinity River at SH 34				
Blue catfish	1/1	0.692	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Flathead catfish	1/1	**2.600**		
All fish combined	2/2	1.646±1.349 (0.692-**2.600**)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Site 11 Trinity River at FM 85				
Blue Catfish	1/1	2.110	2.33	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day
Flathead catfish	1/1	2.315		
All fish combined	2/2	2.213±0.145 (2.110-2.315)	3.49	EPA slope factor: 1.56 x 10^{5} per mg/kg/day

Table 5c. PCDFs/PCDDs toxicity equivalent concentrations (TEQ; pg/g) in fish collected from the Trinity River, 2008.				
Species	**# Detected / # Sampled**	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (pg/g)**	**Basis for Comparison Value**
Site 12 Trinity River at SH 31				
Blue catfish	1/1	0.333	2.33 3.49	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Longnose gar	1/1	**6.578**		
All fish combined	2/2	**3.456**±4.416 (0.333-**6.578**)		
All Trinity River Sampling Sites				
Blue catfish	4/4	1.015±0.770 (0.333-2.110)	2.33 3.49	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Channel catfish	8/8	1.797±1.907 (0.421-**5.790**)		
Flathead catfish	5/5	1.709±1.395 (0.003-**3.172**)		
Freshwater drum	1/1	**2.912**		
Largemouth bass	1/1	1.527		
Longnose gar	1/1	**6.578**		
Smallmouth buffalo	6/6	**5.115**±4.150 (0.645-**12.751**)		
All fish combined	26/26	**2.642**±2.795 (0.003-**12.751**)		

Table 5d. PCDFs/PCDDs toxicity equivalent concentrations (TEQ; pg/g) in fish collected in 2008 from Composite Site 1 (Trinity River-Prohibited Area) and Composite Site 2 (Trinity River-Advisory Area).			
# Detected / # Sampled	**Mean Concentration ± S.D. (Min-Max)**	**Health Assessment Comparison Value (mg/kg)**	**Basis for Comparison Value**
Composite Site 1 (Trinity River-Prohibited Area consisting of sites 1 through 10)			
22/22	**2.607**±1.164 (0.003-**12.751**)	2.33 3.49	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day EPA slope factor: 1.56 x 10^{5} per mg/kg/day
Composite Site 2 (Trinity River-Advisory Area consisting of sites 11 and 12)			
4/4	**2.834**±2.650 (0.333-**6.578**)	2.33 3.49	ATSDR chronic oral MRL: 1.0 x 10^{-9} mg/kg/day EPA slope factor: 1.56 x 10^{5} per mg/kg/day

Table 6a. Hazard quotients (HQs) for PCBs in fish collected from the Trinity River in 2008. Table 6a also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.

Species	Number (N)	Hazard Quotient	Meals per Week
Site 1 Trinity River at West Rosedale Street			
Channel catfish	1	**2.5**[k]	**0.4**[l]
Common carp	2	**1.4**	**0.7**
Flathead catfish	1	**1.7**	**0.5**
Freshwater drum	1	**2.7**	**0.3**
Largemouth bass	5	0.7	1.3
All fish combined	10	**1.3**	**0.7**
Site 2 Trinity River at Purcey Drain			
Channel catfish	2	**2.6**	**0.4**
Common carp	2	**4.2**	**0.2**
Freshwater drum	2	**1.0**	**0.9**
Largemouth bass	3	**1.9**	**0.5**
Smallmouth buffalo	2	**2.2**	**0.4**
White bass	1	**2.6**	**0.4**
All fish combined	12	**2.4**	**0.4**
Site 3 Trinity River at Beach Street			
Channel catfish	2	**10.5**	**0.1**
Common carp	2	**1.4**	**0.7**
Freshwater drum	2	**10.9**	**0.1**
Largemouth bass	2	**2.5**	**0.4**
Smallmouth buffalo	2	**7.2**	**0.1**
White bass	2	**6.8**	**0.1**
All fish combined	12	**6.5**	**0.1**

[k] ***Emboldened numbers*** *denote the HQ for PCBs exceeds 1.0*
[l] ***Emboldened numbers*** *denote the calculated allowable meal consumption rate for an adult is less than one per week.*

Table 6b. Hazard quotients (HQs) for PCBs in fish collected from the Trinity River in 2008. Table 6b also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.			
Species	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Site 4 Trinity River at Belt Line Road			
Channel catfish	2	**2.0**	**0.5**
Common carp	2	**2.8**	**0.3**
Smallmouth buffalo	5	**5.0**	**0.2**
All fish combined	9	**3.9**	**0.2**
Site 5 Trinity River at SH Loop 12			
Channel catfish	5	**1.4**	**0.7**
Common carp	1	**1.4**	**0.6**
Flathead catfish	1	**1.1**	**0.8**
Freshwater drum	1	**1.5**	**0.6**
Smallmouth buffalo	1	**2.5**	**0.4**
Spotted bass	1	0.5	1.9
All fish combined	10	**1.4**	**0.7**
Site 6 Trinity River at Westmoreland Road			
Channel catfish	2	**2.5**	**0.4**
Flathead catfish	1	**4.6**	**0.2**
Freshwater drum	2	**4.6**	**0.2**
Longnose gar	2	**20.0**	**0.0**
Smallmouth buffalo	2	**5.5**	**0.2**
Spotted bass	2	**1.0**	**0.9**
White bass	1	**4.6**	**0.2**
All fish combined	12	**6.4**	**0.1**

Table 6c. Hazard quotients (HQs) for PCBs in fish collected from the Trinity River in 2008. Table 6c also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.			
Species	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Site 7 Trinity River at Commerce Street			
Channel catfish	5	**1.9**	**0.5**
Flathead catfish	1	**2.1**	**0.4**
Freshwater drum	1	**12.1**	**0.1**
Longnose gar	1	**11.7**	**0.1**
Smallmouth buffalo	2	**10.5**	**0.1**
All fish combined	10	**5.6**	**0.2**
Site 8 Trinity River at SH Loop (South)			
Channel catfish	2	**1.2**	**0.8**
Common carp	2	0.8	1.2
Flathead catfish	1	**4.7**	**0.2**
Longnose gar	2	**4.4**	**0.2**
Smallmouth buffalo	2	**17.6**	**0.1**
Spotted gar	1	**9.5**	**0.1**
All fish combined	10	**6.2**	**0.1**
Site 9 Trinity River at Dowdy Ferry Road			
Blue catfish	3	**4.5**	**0.2**
Common carp	1	0.5	1.8
Longnose gar	2	**9.3**	**0.1**
Smallmouth buffalo	2	**2.8**	**0.3**
Spotted gar	2	**6.8**	**0.1**
All fish combined	10	**5.2**	**0.2**

Table 6d. Hazard quotients (HQs) for PCBs in fish collected from the Trinity River in 2008. Table 6d also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.			
Species	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Site 10 Trinity River at SH 34			
Blue catfish	6	**2.5**	**0.4**
Flathead catfish	2	**3.3**	**0.3**
Freshwater drum	1	**3.3**	**0.3**
Longnose gar	1	**4.0**	**0.2**
Smallmouth buffalo	2	**3.7**	**0.3**
All fish combined	12	**3.0**	**0.3**
Site 11 Trinity River at FM 85			
Blue catfish	5	**3.1**	**0.3**
Flathead catfish	2	**1.6**	**0.6**
Longnose gar	3	**4.8**	**0.2**
Smallmouth buffalo	1	0.9	1.0
All fish combined	11	**3.1**	**0.3**
Site 12 Trinity River at SH 31			
Blue catfish	6	**1.1**	**0.8**
Flathead catfish	2	0.8	1.1
Longnose gar	2	**6.6**	**0.1**
Smallmouth buffalo	2	**3.9**	**0.2**
All fish combined	12	**2.4**	**0.4**

Table 6e. Hazard quotients (HQs) for PCBs in fish collected from the Trinity River in 2008. Table 6e also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.			
Species	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Composite Site 1 (Trinity River-Prohibited Area consisting of sites 1 through 10)			
All fish combined	107	**5.3**	**0.2**
Composite Site 2 (Trinity River-Advisory Area consisting of sites 11 and 12)			
All fish combined	23	**4.0**	**0.2**
Trinity River All Sampling Sites			
Blue catfish	20	**2.5**	**0.4**
Channel catfish	21	**2.7**	**0.3**
Common carp	12	**1.9**	**0.5**
Flathead catfish	11	**2.3**	**0.4**
Freshwater drum	10	**5.3**	**0.2**
Largemouth bass	10	**1.4**	**0.6**
Longnose gar	13	**8.5**	**0.1**
Smallmouth buffalo	23	**5.9**	**0.2**
Spotted bass	3	0.9	1.1
Spotted gar	3	**7.7**	**0.1**
White bass	4	**5.2**	**0.2**
All fish combined	130	**4.0**	**0.2**

Table 7a. Hazard quotients (HQs) and hazard indices (HIs) for PCDFs/PCDDs and/or PCBs in fish species collected in 2008 from the Trinity River. Table 7a also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[m]			
Species/Contaminant	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Blue catfish			
PCBs	20	**2.5**[n]	**0.4**[o]
PCDDs/PCDFs	4	0.4	2.1
Hazard Index (meals per week)		**3.0 (0.3)**	
Channel catfish			
PCBs	21	**2.7**	**0.3**
PCDDs/PCDFs	8	0.8	1.2
Hazard Index (meals per week)		**3.5 (0.3)**	
Common Carp			
PCBs	12	**1.9**	**0.5**
Flathead catfish			
PCBs	11	**2.3**	**0.4**
PCDDs/PCDFs	5	0.7	1.3
Hazard Index (meals per week)		**3.1 (0.3)**	
Freshwater drum			
PCBs	10	**5.3**	**0.2**
PCDDs/PCDFs	1	**1.2**	**0.7**
Hazard Index (meals per week)		**6.5 (0.1)**	
Largemouth bass			
PCBs	10	**1.4**	**0.6**
PCDDs/PCDFs	1	0.7	1.4
Hazard Index (meals per week)		**2.1 (0.4)**	

[m] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[n] ***Emboldened numbers** denote the HQ for PCBs exceeds 1.0*
[o] ***Emboldened numbers** denote the calculated allowable meal consumption rate for an adult is less than one per week.*

Table 7b. Hazard quotients (HQs) and hazard indices (HIs) for PCDFs/PCDDs and/or PCBs in fish species collected in 2008 from the Trinity River. Table 7b also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[p]			
Species/Contaminant	**Number (N)**	**Hazard Quotient**	**Meals per Week**
Longnose gar			
PCBs	13	**8.5**[q]	**0.1**[r]
PCDDs/PCDFs	1	**2.8**	**0.3**
Hazard Index (meals per week)		**11.3 (0.1)**	
Smallmouth buffalo			
PCBs	23	**5.9**	**0.2**
PCDDs/PCDFs	6	**2.2**	**0.4**
Hazard Index (meals per week)		**8.1 (0.1)**	
Spotted bass			
PCBs	3	0.9	1.1
Spotted gar			
PCBs	3	**7.7**	**0.1**
White bass			
PCBs	4	**5.2**	**0.2**
Composite Site 1 (Trinity River-Prohibited Area consisting of sites 1 through 10)			
PCBs	107	**4.2**	**0.2**
PCDDs/PCDFs	22	**1.1**	**0.8**
Hazard Index (meals per week)		**5.3 (0.2)**	
Composite Site 2 (Trinity River-Advisory Area consisting of sites 11 and 12)			
PCBs	23	**2.8**	**0.3**
PCDDs/PCDFs	4	**1.2**	**0.8**
Hazard Index (meals per week)		**4.0 (0.2)**	

[p] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[q] ***Emboldened numbers** denote the HQ for PCBs exceeds 1.0*
[r] ***Emboldened numbers** denote the calculated allowable meal consumption rate for an adult is less than one per week.*

Table 7c. Hazard quotients (HQs) and hazard indices (HIs) for PCDFs/PCDDs and PCBs in all fish species combined collected in 2008 from the Trinity River. Table 7c also provides suggested weekly eight-ounce meal consumption rates for 70-kg adults.[s]			
Species/Contaminant	**Number (N)**	**Hazard Quotient**	**Meals per Week**
All fish combined			
PCBs	130	**4.0**	**0.2**
PCDDs/PCDFs	26	**1.1**	**0.8**
Hazard Index (meals per week)		**5.1 (0.2)**	

[s] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*

Table 8a. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70-kg adults who regularly eat fish from the Trinity River over a 30-year period. [t]

Species	Number (N)	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	1 excess cancer per number of people exposed	
Site 1 Trinity River at West Rosedale Street				
Channel catfish	1	4.3E-05	23,357	2.2
Common carp	2	2.3E-05	42,698	3.9
Flathead catfish	1	2.9E-05	34,424	3.2
Freshwater drum	1	4.7E-05	21,229	2.0
Largemouth bass	5	1.2E-05	81,358	7.5
All fish combined	10	2.3E-05	44,001	4.1
Site 2 Trinity River at Purcey Drain				
Channel catfish	2	4.4E-05	22,564	2.1
Common carp	2	7.2E-05	13,843	1.3
Freshwater drum	2	1.8E-05	56,413	5.2
Largemouth bass	3	3.3E-05	30,604	2.8
Smallmouth buffalo	2	3.8E-05	25,995	2.4
White bass	1	4.4E-05	22,623	2.1
All fish combined	12	4.1E-05	24,604	2.3

[t] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*

Table 8b. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70-kg adults who regularly eat fish from the Trinity River over a 30-year period. [u]

Species	Number (N)	Theoretical Lifetime Excess Cancer Risk: Risk	Theoretical Lifetime Excess Cancer Risk: 1 excess cancer per number of people exposed	Meals per Week
Site 3 Trinity River at Beach Street				
Channel catfish	2	**1.8E-04**[v]	**5,576**	**0.5**[w]
Common carp	2	2.3E-05	42,588	3.9
Freshwater drum	2	**1.9E-04**	**5,343**	**0.5**
Largemouth bass	2	4.3E-05	23,408	2.2
Smallmouth buffalo	2	**1.2E-04**	**8,098**	**0.7**
White bass	2	**1.2E-04**	**8,620**	**0.8**
All fish combined	12	**1.1E-04**	**8,926**	**0.8**
Site 4 Trinity River at Belt Line Road				
Channel catfish	2	3.5E-05	28,655	2.6
Common carp	2	4.8E-05	20,736	1.9
Smallmouth buffalo	5	8.6E-05	11,624	1.1
All fish combined	9	6.6E-05	15,090	1.4
Site 5 Trinity River at SH Loop 12				
Channel catfish	5	2.4E-05	41,942	3.9
Common carp	1	2.4E-05	40,856	3.8
Flathead catfish	1	2.0E-05	50,959	4.7
Freshwater drum	1	2.5E-05	39,344	3.6
Smallmouth buffalo	1	4.3E-05	23,046	2.1
Spotted bass	1	8.5E-06	117,186	10.8
All fish combined	10	2.4E-05	41,554	3.8

[u] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[v] ***Emboldened numbers** denote calculated excess lifetime cancer risk after 30 years exposure is greater than $1x10^{-4}$.*
[w] ***Emboldened numbers** denote the calculated meal consumption rate for adults is less than one per week.*

Table 8c. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70-kg adults who regularly eat fish from the Trinity River over a 30-year period. [x]

Species	Number (N)	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	1 excess cancer per number of people exposed	
Site 6 Trinity River at Westmoreland Road				
Channel catfish	2	4.3E-05	23,065	2.1
Flathead catfish	1	7.8E-05	12,786	1.2
Freshwater drum	2	7.9E-05	12,656	1.2
Longnose gar	2	**3.4E-04**[y]	**2,917**	**0.3**[z]
Smallmouth buffalo	2	9.4E-05	10,634	1.0
Spotted bass	2	1.8E-05	56,297	5.2
White bass	1	7.9E-05	12,666	1.2
All fish combined	12	**1.1E-04**	**9,152**	**0.8**
Site 7 Trinity River at Commerce Street				
Channel catfish	5	3.2E-05	31,230	2.9
Flathead catfish	1	3.6E-05	28,154	2.6
Freshwater drum	1	**2.1E-04**	**4,834**	**0.4**
Longnose gar	1	**2.0E-04**	**5,002**	**0.5**
Smallmouth buffalo	2	**1.8E-04**	**5,576**	**0.5**
All fish combined	10	9.6E-05	10,405	1.0

[x] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[y] ***Emboldened numbers** denote calculated excess lifetime cancer risk after 30 years exposure is greater than $1x10^{-4}$.*
[z] ***Emboldened numbers** denote the calculated meal consumption rate for adults is less than one per week.*

Table 8d. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70-kg adults who regularly eat fish from the Trinity River over a 30-year period. [aa]				
Species	**Number (N)**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**1 excess cancer per number of people exposed**	
Site 8 Trinity River at SH Loop 12 (South)				
Channel catfish	2	2.0E-05	49,572	4.6
Common carp	2	1.3E-05	76,478	7.1
Flathead catfish	1	8.0E-05	12,430	1.1
Longnose gar	2	7.5E-05	13,403	1.2
Smallmouth buffalo	2	**3.0E-04**[bb]	**3,308**	**0.3**[cc]
Spotted gar	1	**1.6E-04**	**6,163**	**0.6**
All fish combined	10	**1.1E-04**	**9,407**	**0.9**
Site 9 Trinity River at Dowdy Ferry Road				
Blue catfish	3	7.7E-05	12,979	1.2
Common carp	1	9.1E-06	110,480	10.2
Longnose gar	2	**1.6E-04**	**6,265**	**0.6**
Smallmouth buffalo	2	4.7E-05	21,200	2.0
Spotted gar	2	**1.2E-04**	**8,634**	**0.8**
All fish combined	10	8.9E-05	11,295	1.0

[aa] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[bb] ***Emboldened numbers** denote calculated excess lifetime cancer risk after 30 years exposure is greater than $1x10^{-4}$.*
[cc] ***Emboldened numbers** denote the calculated meal consumption rate for adults is less than one per week.*

Table 8e. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70-kg adults who regularly eat fish from the Trinity River over a 30-year period. [dd]				
Species	**Number (N)**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**1 excess cancer per number of people exposed**	
Site 10 Trinity River at SH 34				
Blue catfish	6	4.2E-05	23,756	2.2
Flathead catfish	2	5.7E-05	17,602	1.6
Freshwater drum	1	5.6E-05	17,895	1.7
Longnose gar	1	6.9E-05	14,538	1.3
Smallmouth buffalo	2	6.3E-05	15,939	1.5
All fish combined	12	5.1E-05	19,470	1.8
Site 11 Trinity River at FM 85				
Blue catfish	5	5.3E-05	18,762	1.7
Flathead catfish	2	2.8E-05	35,859	3.3
Longnose gar	3	8.2E-05	12,155	1.1
Smallmouth buffalo	1	1.5E-05	64,939	6.0
All fish combined	11	5.3E-05	18,820	1.7
Site 12 Trinity River at SH 31				
Blue catfish	6	1.9E-05	52,698	4.9
Flathead catfish	2	1.4E-05	70,342	6.5
Longnose gar	2	**1.1E-04**[ee]	**8,829**	**0.8**[ff]
Smallmouth buffalo	2	6.7E-05	15,017	1.4
All fish combined	12	4.2E-05	23,904	2.2

[dd] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[ee] ***Emboldened numbers*** *denote calculated excess lifetime cancer risk after 30 years exposure is greater than* $1x10^{-4}$.
[ff] ***Emboldened numbers*** *denote the calculated meal consumption rate for adults is less than one per week.*

Table 8f. Calculated theoretical lifetime excess cancer risk from consuming fish containing PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70-kg adults who regularly eat fish from the Trinity River over a 30-year period. [gg]

Species	Number (N)	Theoretical Lifetime Excess Cancer Risk		Meals per Week
		Risk	1 excess cancer per number of people exposed	
Trinity River All Sampling Sites				
Blue catfish	20	4.3E-05	23,147	2.1
Channel catfish	21	4.6E-05	21,732	2.0
Common carp	12	3.3E-05	30,426	2.8
Flathead catfish	11	4.0E-05	24,961	2.3
Freshwater drum	10	9.0E-05	11,073	1.0
Largemouth bass	10	2.4E-05	40,829	3.8
Longnose gar	13	**1.5E-04**[hh]	**6,856**	**0.6**[ii]
Smallmouth buffalo	23	**1.0E-04**	**9,926**	**0.9**
Spotted bass	3	1.5E-05	68,090	6.3
Spotted gar	3	**1.3E-04**	**7,616**	**0.7**
White bass	4	8.9E-05	11,262	1.0
All fish combined	130	6.8E-05	14,739	1.4

[gg] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[hh] ***Emboldened numbers** denote calculated excess lifetime cancer risk after 30 years exposure is greater than* $1x10^{-4}$.
[ii] ***Emboldened numbers** denote the calculated meal consumption rate for adults is less than one per week.*

Table 9a. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish containing PCDFs/PCDDs and PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70 kg adults who regularly eat fish from the Trinity River over a 30-year period.[jj]				
Species/Contaminant	**Number (N)**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**1 excess cancer per number of people exposed**	
Blue catfish				
PCBs	20	4.3E-05	23,147	2.1
PCDDs/PCDFs	4	2.9E-05	34,385	3.2
Cumulative Cancer Risk		7.2E-05	13,834	1.3
Channel catfish				
PCBs	21	4.6E-05	21,732	2.0
PCDDs/PCDFs	8	5.1E-05	19,427	1.8
Cumulative Cancer Risk		**9.7E-05**[kk]	**10,257**	**0.9**[ll]
Flathead catfish				
PCBs	11	4.0E-05	24,961	2.3
PCDDs/PCDFs	5	4.9E-05	20,421	1.9
Cumulative Cancer Risk		8.9E-05	11,232	1.0
Freshwater drum				
PCBs	10	9.0E-05	11,073	1.0
PCDDs/PCDFs	1	8.3E-05	11,985	1.1
Cumulative Cancer Risk		**1.7E-04**	**5,756**	**0.5**
Largemouth bass				
PCBs	10	2.4E-05	40,829	3.8
PCDDs/PCDFs	1	4.4E-05	22,855	2.1
Cumulative Cancer Risk		6.8E-05	14,653	1.4

[jj] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*
[kk] ***Emboldened numbers** denote calculated excess lifetime cancer risk after 30 years exposure is greater than $1x10^{-4}$.*
[ll] ***Emboldened numbers** denote the calculated meal consumption rate for adults is less than one per week.*

Table 9b. Calculated theoretical lifetime excess cumulative cancer risk from consuming fish containing PCDFs/PCDDs and PCBs collected in 2008 from the Trinity River and suggested consumption (8-ounce meals/week) for 70 kg adults who regularly eat fish from the Trinity River over a 30-year period.[mm]				
Species/Contaminant	**Number (N)**	**Theoretical Lifetime Excess Cancer Risk**		**Meals per Week**
		Risk	**1 excess cancer per number of people exposed**	
Longnose gar				
PCBs	13	**1.5E-04**[nn]	**6,856**	**0.6**[oo]
PCDDs/PCDFs	1	**1.9E-04**	**5,306**	**0.5**
Cumulative Cancer Risk		**3.3E-04**	**2,991**	**0.3**
Smallmouth buffalo				
PCBs	23	**1.0E-04**	**9,926**	**0.9**
PCDDs/PCDFs	6	**1.5E-04**	**6,823**	**0.6**
Cumulative Cancer Risk		**2.5E-04**	**4,044**	**0.4**
All fish combined				
PCBs	130	6.8E-05	14,739	1.4
PCDDs/PCDFs	26	7.6E-05	13,212	1.2
Cumulative Cancer Risk		**1.4E-04**	**6,967**	**0.6**

[mm] *DSHS assumes that children under the age of 12 years and/or those who weigh less than 35 kg eat 4-ounce meals.*

[nn] ***Emboldened numbers** denote calculated excess lifetime cancer risk after 30 years exposure is greater than $1x10^{-4}$.*

[oo] ***Emboldened numbers** denote the calculated meal consumption rate for adults is less than one per week.*

LITERATURE CITED

[1] [TDH] Texas Department of Health Aquatic Life Order Number 2 (AL-2) Trinity River, January 4, 1990. http://www.dshs.state.tx.us/seafood/PDF2/PossessionBansSigned/ActiveBans/AL-2_signed_TrinityR.pdf (Accessed July 2, 2009).

[2] [TNRCC] Texas Natural Resources Conservation Commission, State of Texas 1996 303(d) List. http://www.tceq.state.tx.us/assets/public/compliance/monops/water/96_303d.pdf (Accessed July 2, 2009).

[3] [TDH] Texas Department of Health Fish Consumption Advisory 25 (ADV-25) Trinity River, September 13, 2002. http://www.dshs.state.tx.us/seafood/PDF2/Active/ADV-25_signed_TrinityR.pdf (Accessed December 1, 2009)

[4] [TDH] Texas Department of Health Aquatic Life Order Number 14 (AL-14) Trinity River, September 27, 2002. http://www.dshs.state.tx.us/seafood/PDF2/PossessionBansSigned/ActiveBans/AL-14_signed_TrinityR.pdf (Accessed December 1, 2009).

[5] The Handbook of Texas Online, Trinity River, Texas. http://www.tshaonline.org/handbook/online/articles/TT/rnt2.html (Accessed December 1, 2009).

[6] [TPWD] Texas Parks and Wildlife Department. River Fishing in Dallas-Fort Worth. http://www.tpwd.state.tx.us/fishboat/fish/recreational/rivers/dfw_trinity.phtml (Accessed December 2, 2009).

[7] [TPWD] Texas Parks and Wildlife Department. An Analysis of Texas Waterways. A Report on the Physical Characteristics of Rivers, Streams, and Bayous in Texas. http://www.tpwd.state.tx.us/publications/pwdpubs/pwd_rp_t3200_1047/10_e_tx_trinity.phtml (Accessed December 2, 2009).

[8] [USCB] United States Census Bureau. Metropolitan and Micropolitan Statistical Area Population Estimates. http://www.census.gov/popest/metro/CBSA-est2008-annual.html (Accessed December 2, 2009).

[9] http://www.epa.gov/waterscience/316b/econbenefits/b6.pdf (accessed February 24, 2009).

[10] Clean Water Act. 33 USC 125 *et seq.* 40CFR part 131: Water Quality Standards.

[11] [DSHS] Texas Department of State Health Services, Seafood and Aquatic Life Group Survey Team Standard Operating Procedures and Quality Assurance/Quality Control Manual. Austin, Texas. 2007.

[12] [USEPA] United States Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories. Vol. 1, Fish sampling and analysis, 3rd ed. Washington D.C. 2000.

[13] [TSCC] Toxic Substances Coordinating Committee URL: http://www.tscc.state.tx.us/dshs.htm (Accessed February 24, 2009).

[14] [USEPA] United States Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories. Vol. 2, Risk assessment and fish consumption limits, 3rd ed. Washington D.C. 2000.

[15] [USDHHS] United States Department of Health & Human Services. Public Health Service. [ATSDR] Agency for Toxic Substances and Disease Registry. Toxicological profile for arsenic (update). Atlanta, GA. 2007.

[16] Clean Water Act. 33 USC 125 *et seq.* 40CFR part 131: Water Quality Standards.

[17] [USDHHS] United States Department of Health & Human Services. Public Health Service. [ATSDR] Agency for Toxic Substances and Disease Registry. Toxicological Profile for Mercury (update). Atlanta, GA: 1999 March.

[18] Lauenstein, G.G. & Cantillo, A.Y. 1993. Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Overview and Summary of Methods - Vol. I. NOAA Tech. Memo 71. NOAA/CMBAD/ORCA. Silver Spring, MD. 157pp. http://www.ccma.nos.noaa.gov/publications/tm71v1.pdf (Accessed February 24, 2009).

[19] McFarland, V.A. & Clarke, J.U. 1989. Environmental occurrence, abundance, and potential toxicity of polychlorinated biphenyl congeners: considerations for a congener-specific analysis. Environmental Health Perspectives. 81:225-239.

[20] [IRIS] Integrated Risk Information System, maintained by the USEPA. Polychlorinated biphenyls (PCBs) (CASRN 1336-36-3), Part II,B.3. Additional Comments (Carcinogenicity, Oral Exposure http://www.epa.gov/iris/subst/0294.htm (Accessed February 24, 2009).

[21] [IRIS] Integrated Risk Information System, maintained by the USEPA. Comparison of database information for RfDs on Aroclor® 1016, 1254, 1260 http://cfpub.epa.gov/ncea/iris/compare.cfm (Accessed on February 24, 2009).

[22] [USEPA] United States Environmental Protection Agency. Integrated Risk Information System (IRIS) for PCBs. http://www.epa.gov/ncea/iris/subst/0294.htm#quaoral (Accessed February 24, 2009).

[23] Van den Berg, M., L. Birnbaum, ATC Bosveld et al. Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ. Health Perspect. 106(12):775-792, 1998.

[24] The World Health Organization Project for the Re-evaluation of Human and Mammalian Toxic Equivalency Factors (TEFs) of Dioxins and Dioxin-Like Compounds web page. http://www.who.int/ipcs/assessment/tef_update/en/ (Accessed May 10, 2007).

[25] De Rosa, CT, D. Brown, R. Dhara et al. Dioxin and Dioxin-like Compounds in Soil, Part 1: ATSDR Interim Policy Guideline. Toxicol. Ind. Health. 13(6):759-768, 1997. http://www.atsdr.cdc.gov/dioxindt.html

[26] Casarett and Doull's Toxicology: The Basic Science of Poisons. 5th ed. Ed. CD Klaassen. Chapter 2, pp. 13-34. McGraw-Hill Health Professions Division, New York, NY, 1996.

[27] Beauchamp, Richard. 1999. Personal Communication. *Monte Carlo Simulations in Analysis of Fish Tissue Contaminant Concentrations and Probability of Toxicity.* Department of State Health Services, State of Texas.

[28] [USEPA] United States Environmental Protection Agency. Office of Research and Development, National Center for Environmental Assessment. Integrated risk information system (IRIS). Human Health Risk Assessments. Background Document 1A. 1993, March. http://www.epa.gov/iris/rfd.htm (Accessed February 24, 2009).

[29] [USDHHS] United States Department of Health & Human Services. Public Health Service. [ATSDR] Agency for Toxic Substances and Disease Registry. Minimal Risk Levels for Hazardous Substances. http://www.atsdr.cdc.gov/mrls/index.html (Accessed February 24, 2009).

[30] [USEPA] United States Environmental Protection Agency. Glossary of risk assessment-related terms. Washington, D.C.: 1999. http://www.epa.gov/NCEA/iris/help_gloss.htm (Accessed August 29, 2006).

[31] [USEPA] United States Environmental Protection Agency. Technology Transfer Network. National Air Toxics Assessment. Glossary of Key Terms. Washington, D.C.: 2002. http://www.epa.gov/ttn/atw/nata/gloss1.html (Accessed February 24, 2009).

[32] [USEPA] United States Environmental Protection Agency. Guidelines for Carcinogen Risk Assessment and Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Federal Register Notice posted April 7, 2005
.

[33] Thompson, KM. *Changes in Children's Exposure as a Function of Age and the Relevance of Age Definitions for Exposure and Health Risk Assessment*. MedGenMed. 6(3), 2004. http://www.medscape.com/viewarticle/480733. (Accessed February 24, 2009).

[34] University of Minnesota. Maternal and Child Health Program *Healthy Generations: Children's Special Vulnerability to Environmental Health Risks*. http://www.epi.umn.edu/mch/resources/hg/hg_enviro.pdf (Accessed February 24, 2009).

[35] Selevan, SG, CA Kimmel, P Mendola*. Identifying Critical Windows of Exposure for Children's Health.* Environmental Health Perspectives Volume 108, Supplement 3, June 2000.

[36] Schmidt, C.W. *Adjusting for Youth: Updated Cancer Risk Guidelines*. Environ. Health Perspectives. 111(13):A708-A710.

[37] [USDHHS] United States Department of Health & Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry (ATSDR). Office of Children's Health. Child health initiative. Atlanta Ga.: 1995.

[38] [USEPA] United States Environmental Protection Agency. Office of Research and Development (ORD). Strategy for research on environmental risks to children, Section 1.2. Washington D.C.: 2000.

[39] SPSS 13 for Windows©. Release 13.0.1. 12 December 2004. Copyright SPSS, Inc., 1989-2009. http://www.spss.com (Accessed February 24, 2009).

[40] Microsoft Corporation. Microsoft Excel®2000. Copyright© Microsoft Corporation 1985-1999.

[41] [CDC] Centers for Disease Control and Prevention Preventing Lead Poisoning in Young Children. Atlanta: CDC; 2005 http://www.cdc.gov/nceh/lead/publications/PrevLeadPoisoning.pdf (Accessed February 21, 2008).

[42] [CDC] Centers for Disease Control and Prevention. Interpreting and Managing Blood Lead Levels <10 mcg/dL in Children and Reducing Childhood Exposures to Lead. MMWR, Nov 2, 2007/ 56(RR08); 1-14; 16. http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5608al.htm ERRATUM MMWR November 30, 2007 / 56(47):1241-1242. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5647a4.htm

[43] Navy and Marine Corps Public Health Center. 2002. *Detection Limit and Reporting Limit Issues Related to Risk Assessments.* http://www-nehc.med.navy.mil/HHRA/guidancedocuments/issue/pdf/FDI.pdf (Accessed December 9, 2008).

[44] [NCEA] National Center for Environmental Assessment, Research and Development, United States Environmental Protection Agency. *Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds Part III: Integrated Summary and Risk Characterization for 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds* USEPA, Washington, D.C. December 2003 **DRAFT for PUBLIC REVIEW ONLY** http://www.epa.gov/NCEA/pdfs/dioxin/nas-review/pdfs/part3/dioxin_pt3_full_oct2004.pdf (Accessed April 7, 2008).

[45] [USEPA] United States Environmental Protection Agency Research and Development NCEA IRIS home Compare Iris Values. http://cfpub.epa.gov/ncea/iris/compare.cfm (Accessed March 27, 2008).

[46] [USEPA] United States Environmental Protection Agency. 2000e. "Supplementary Guidance for Conducting Health Risk Assessment of Chemical Mixtures." Risk Assessment Forum, Office of Research and Development. Washington, DC, EPA/630/R-00/002. http://www.epa.gov/ncea/raf/pdfs/chem_mix/chem_mix_08_2001.pdf. (Accessed March 27, 2008).

[47] Cumulative reproductive toxicity of PCBs and PCDFs/PCDDs in the developing organism.

[48] [USEPA] United States Environmental Protection Agency. Guidance for assessing chemical contaminant data for use in fish advisories. Vol. 3, Overview of Risk Management, Washington D.C. 1996.

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

[50] [DSHS] Department of State Health Services for the State of Texas. Fish Consumption Advisories and Bans. Seafood Safety Division. Austin, Texas: 2004.

[51] [TPWD] Texas Parks and Wildlife Department. 2007-2008 Outdoor Annual: hunting and fishing regulations. Ed. J. Jefferson. Texas Monthly Custom Publishing, a division of Texas Monthly, Inc. 2007.