Quantitative Risk Characterization

Fosdic Lake

Fort Worth, Tarrant County, TX

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BACKGROUND AND STATEMENT OF ISSUES

The Commissioner of Health for the State of Texas issued an aquatic life order on April 5, 1995 that closed Fosdic Lake in Fort Worth, Texas, to possession of fish [1]. Then commissioner, Dr. David Smith, took this action because fish collected from Fosdic Lake in 1994 contained Aroclor 1260, a mixture of polychlorinated biphenyls, as well as other pollutants, at levels that exceeded Texas Department of Health (TDH) guidelines current at that time. Although the closure order prohibits fishers from keeping fish taken from Fosdic Lake, recreational and subsistence fishing may still occur there. Subsistence fishers are particularly likely to consume their catches. Therefore, with a grant from the Texas Natural Resource Conservation Commission (TNRCC), the Seafood Safety Division at TDH undertook the task of reevaluating Fosdic Lake for potential health risks from eating fish from this reservoir.

Fosdic Lake, a very small (six surface-acres) urban storm-water retention pond in Oakland Lake Park, is located near the southwest corner of East Freeway (Interstate 30) and East Loop 820 off Oakland Boulevard near a heavily populated older residential area near downtown Fort Worth. Owned and operated by the city of Fort Worth, the retention pond receives nonpoint source runoff from the area. In previous years, Fosdic Lake has been stocked with several species of fish, including largemouth bass, white crappie, and channel catfish as a part of an urban fisheries program.

DISCUSSION

Sample Collection and Analysis

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

Description of Fosdic Lake Sample Set

Staff from the Fort Worth Department of Environmental Management (DEM) collected five largemouth bass from Fosdic Lake on 10/26/00. The TDH Seafood Safety Division collected another five largemouth bass on 3/6/01. Using USEPA-approved methods, the TDH laboratory analyzed edible fillets (skin off) of the ten bass for seven metals: arsenic, cadmium, copper, lead, mercury, selenium, and zinc; volatile organic compounds

(VOCs); semivolatile organic compounds (SVOCs); pesticides; and polychlorinated biphenyls (PCBs).

Derivation of Health-Based Assessment Comparison Values (HACs)

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

TDH evaluates chemical contaminants in fish by comparing average contaminant concentration with health-based assessment comparison (HAC) values (in mg contaminant per kg edible tissue or mg/kg) for non-cancer and cancer endpoints. Following approaches suggested by the United States Environmental Protection Agency (USEPA) in its *Guidance for assessing chemical contaminant data for use in fish advisories* [5], TDH has developed noncancer (HAC_{nonca}) and cancer (HAC_{ca}) comparison values. To derive HAC_{nonca} values, TDH uses oral reference doses (RfDs) from the USEPA or chronic oral minimal risk levels (MRLs) from the Agency for Toxic Substances and Disease Registry (ATSDR). RfDs are estimates of long-term (greater than three months) daily exposure doses that are considered unlikely to cause adverse noncancerous (systemic) health effects even if exposure occurs over a lifetime [4]. MRLs are similar to RfDs but may not be identical due to use of different assumptions or constants by the two agencies. TDH derives HAC_{ca} values from the USEPA's chemical-specific cancer slope factors (SFs) using an acceptable lifetime risk level (ARL) of 1 excess cancer in 10,000 (1×10^{-4}) people exposed and an exposure period of 30 years. For these derivations, TDH utilizes a standard adult body weight of 70 kilograms and assumes that adults consume 30 grams of fish per day (about one eight-ounce meal per week). TDH also utilizes tissue concentration of a contaminant to calculate a hazard quotient (HQ) for the contaminant. A hazard quotient is the ratio of the estimated exposure dose of a contaminant to its RfD or MRL. An HQ of less than 1.0 usually indicates that consumption of seafood containing an isolated contaminant will not present a significant hazard to human health.

Most constants employed to calculate HAC_{nonca} values contain built-in margins of safety (uncertainty factors). Uncertainty factors are based on scientific judgment and are chosen to minimize the potential for adverse health effects in those people – including sensitive subgroups: e.g., pregnant women, infants, children, the elderly, people with chronic illnesses, or those who consume large amounts of fish or shellfish – who eat environmentally contaminated seafood. The cancer slope factors (SFs) from which HAC_{ca} values are derived are also designed to ensure a wide margin of safety. Furthermore, health-based assessment comparison values (HAC values) are not meant to represent a sharp dividing line between safe and unsafe exposures. The strict demarcation

between acceptable and unacceptable exposures or risks is a tool used by risk managers to assure protection of public health. TDH finds it unacceptable when consumption of four or fewer meals per month would result in exposures that exceed a HAC value or other measure of risk. TDH further advises people who wish to minimize exposure to environmental contaminants in seafood to eat a variety of fish and shellfish and to limit consumption of those species that are likely to contain environmental toxicants.

Addressing the Potential for Cumulative Effects

When multiple chemicals similarly affecting a target organ or having the same mechanism of action are found simultaneously in seafood samples, TDH assumes that potential adverse systemic or carcinogenic effects are cumulative (i.e., additive) [7].

Cumulative Systemic (Noncancerous) Effects

The Texas Department of Health Seafood Safety Division (SSD) evaluates potential cumulative noncancerous (systemic) health effects from simultaneous consumption of multiple chemicals in environmentally contaminated seafood by calculating a hazard index (HI) for those contaminants with similar effects. To calculate a HI for multiple contaminants, the TDH first calculates a hazard quotient for each compound identified in samples from the water body. To derive the HI, TDH sums the hazard quotients (HQ) for each contaminant. A HI of less than 1.0 usually indicates that no significant hazard is present for the observed combination of contaminants at the observed concentrations. On the other hand, while a HI greater than 1.0 may indicate some level of hazard, it does not mean that exposure to the contaminants at these doses will result in adverse health effects. Nonetheless, finding an HI that exceeds 1.0 may prompt the agency to consider some public health intervention strategy.

Cumulative Carcinogenic Effects

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

Addressing Children's Unique Vulnerabilities

TDH recognizes that fetuses, infants, and children may be uniquely susceptible to the effects of toxic chemicals and that any such vulnerabilities demand special attention. Windows of vulnerability (i.e., critical periods) exist during development. These critical periods are particularly evident during early gestation, but may also appear throughout pregnancy, infancy, childhood, and adolescence – indeed, at any time during development, when toxicants can permanently impair or alter the structure or function of vulnerable systems [8]. Unique childhood vulnerabilities may result because, at birth,

most organs and body systems have not achieved structural or functional maturity, but continue to develop throughout childhood and adolescence. Because of these structural and functional differences, children can differ from adults in absorption, metabolism, storage, and excretion of toxicants, any of which could result in higher biologically effective doses at the target organ(s). Children's exposures to toxicants may be more extensive than those of adults because children consume more food and liquids in proportion to their body weight than do adults [8]. Children can also ingest toxicants through breast milk – often unrecognized as an exposure pathway. They may also experience toxic effects at a lower exposure dose than adults due to differences in target organ sensitivity. Stated differently, children could respond more severely than would adults to an equivalent exposure dose [8]. Children may also be more prone to developing certain cancers from chemical exposures than are adults. If a chemical – or a class of chemicals – is shown to be more toxic to children than to adults, the RfD or MRL will be commensurately lower to reflect children's potentially greater susceptibility. Additionally, in accordance with ATSDR's *Child Health Initiative* [9] and USEPA's *National Agenda to Protect Children's Health from Environmental Threats* [8], TDH further seeks to protect children from the potential effects of toxicants in fish or shellfish by suggesting that this sensitive group consume smaller quantities of environmentally-contaminated fish or shellfish than adults. Therefore, TDH routinely recommends that children who weigh 35 kg or less and/or who are eleven years of age or under, eat no more than four ounces of contaminated seafood per meal. TDH also suggests that consumers spread out the recommended number of meals over time. For instance, if the consumption advice recommends eating no more than two meals per month, children consuming seafood from the affected water body should eat no more than one meal every two weeks.

Analytical Results

Results of Chemical Analyses

Table 1 contains the principal analytical data from this survey. All fish contained one or more metallic components. Nine fish contained the chlorinated pesticide, chlordane. Four fish contained p,p'-DDE. Four samples contained acetone, a contaminant often related to laboratory contamination or to post-sampling tissue changes. No other VOCs, SVOCs, or pesticides were detected in these samples at concentrations above the reporting limits. None of the observed contaminants exceeded TDH's health-based guidelines for safe levels of contaminants in seafood.

Characterization of Risk

Characterizing the Risk of Systemic (Noncancerous) Health Effects from Consumption of Individual Contaminants in Fish from Fosdic Lake

Inorganic and organic contaminant concentrations in the ten largemouth bass from Fosdic Lake were below their respective noncancer HAC values (Table 1) suggesting that no

imminent hazard to health would occur from eating largemouth bass contaminated with any individual compound detected.

Characterizing Cumulative Noncancer Health Effects

The two organochlorine contaminants (chlordane and p,p'-DDE) observed in largemouth bass taken from Fosdic Lake in 2000 have adverse noncancerous effects on the livers of experimental animals [7]. Assuming these effects to be additive, TDH calculated a hazard index for largemouth bass. The HI for contaminants in this species was less than 1. Thus, consumption of largemouth bass from Fosdic Lake is unlikely to result in cumulative adverse noncancerous health effects. On the other hand, no other species were sampled for this risk assessment. Largemouth bass are predators, a species situated high on the food chain. Fatty species (e.g., catfish) that belong to lower trophic levels often contain higher concentrations of fat-soluble contaminants like chlordane and DDE. Further sampling of other fish species from Fosdic Lake would be needed to define the overall probability of systemic (noncancerous) health effects from consumption of multiple fish species from this pond.

Characterizing the Risk of Cancer from Consumption of Individual Contaminants in Fish from Fosdic Lake

The average concentration of each carcinogenic contaminant (chlordane; DDE) in largemouth bass from Fosdic Lake was below its respective cancer HAC value (Table 1). This suggests that an increase in the risk of cancer from exposure to individual contaminants is unlikely. However, TDH was unable to determine the theoretical excess lifetime risk of cancer from consuming fish species other than largemouth bass from this lake because no other species was analyzed for the present survey.

Characterizing the Cumulative Risk of Cancer from Consumption of Fish from Fosdic Lake

The USEPA classifies both chlordane and p,p'-DDE as probable human carcinogens (Group B2) [7]. Since people who eat fish from Fosdic Lake may be simultaneously exposed to both chemicals, carcinogenic effects should be considered cumulative (i.e., additive). TDH estimated cumulative cancer risk for persons exposed through eating largemouth bass from Fosdic Lake by summing the risks for these two carcinogenic contaminants. The cumulative risk from exposure to p,p-DDE and chlordane in largemouth bass from Fosdic Lake did not exceed TDH guidelines for protection of public health. Without representative samples of other species/trophic levels, however, TDH was unable to calculate a cumulative excess cancer risk that might occur from consuming fish species other than largemouth bass from Fosdic Lake.

CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

The Texas Department of Health concludes that regular consumption of largemouth bass taken from Fosdic Lake would not result in exposure doses exceeding TDH risk

management guidelines. Thus, consumption of largemouth bass from Fosdic Lake **does not pose a public health hazard**. Consumption of other species of fish from Fosdic Lake presents an **indeterminate health hazard** because of the lack of data. To assess these risks and to gain a perspective on overall risk of adverse health effects from consuming fish from this lake, TDH must collect and analyze other species that are available for consumption.

RECOMMENDATIONS

TDH risk managers have established certain criteria for issuing fish consumption advisories. When the risk characterization confirms that consumption of four or fewer meals per month would result in exposures that exceed TDH health-based risk guidelines, risk managers may wish to recommend that the Commissioner of Health issue consumption advice or ban possession of fish from the affected water body. Based on a quantitative assessment of chemical contaminant data from largemouth bass from Fosdic Lake, TDH has determined that there is a negligible increase in the risk of systemic adverse health effects or cancer from consumption of largemouth bass from this water body. However, the present data are severely limited by the lack of other species from this reservoir. The contaminant pattern in largemouth bass, a predator, may not accurately reflect the true distribution of contaminants in fish from Fosdic Lake. Accordingly, the Seafood Safety Division (SSD) and the Environmental Epidemiology and Toxicology Division (EE&TD), Texas Department of Health (TDH), recommend that:

1. TDH takes **no** action on the aquatic life order for Fosdic Lake pending augmentation of the present sample with species of fish other than largemouth bass from this lake or until TDH receives confirmation that other species of fish are not present in this lake and, therefore, pose no hazard to public health because of unavailability.

2. TDH collects samples from Fosdic Lake representing available species/trophic levels other than largemouth bass.

PUBLIC HEALTH ACTION PLAN

TDH fish consumption advisories and bans are published in booklet form and are available through the TDH Seafood Safety Division: (512-719-0215). This information is also posted on the Internet at URL: http://www.tdh.state.tx.us/bfds/ssd, which is updated regularly. Some risk assessments for water bodies surveyed by the Texas Department of Health may also be available from the Agency for Toxic Substances and Disease Registry (http://www.atsdr.cdc.gov/HAC/PHA/region6.html). The Texas Department of Health provides all consumption advisory and ban information to the U.S. Environmental Protection Agency (URL: http://fish.rti.org), the Texas Natural Resource Conservation Commission (TNRCC; URL: http://www.tnrcc.state.tx.us) and the Texas Parks and Wildlife Department (TPWD; URL: http://www.tpwd.state.tx.us). Each year, the TPWD informs the fishing and hunting public of fishing bans in an official hunting and fishing

regulations booklet [4] that is available at some state parks and at establishments that sell fishing licenses.

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

Table 1. Average concentrations of contaminants (mg/kg) detected in largemouth bass taken from Fosdic Lake in 2000, 2001.

Contaminant	Number Affected/ Sampled	Average Concentration (Min-Max) *	Health-based Assessment Comparison Value † (mg/kg)	Basis for Comparison Value
Pesticides				
Chlordane	9/10	0.044 (nd‡-0.083)	1.2	USEPA chronic oral RfD: 0.0005 mg/kg/day
			1.6	USEPA slope factor: 0.35 per (mg/kg) –day
p,p'-DDE	4/10	0.0025 (nd-0.008)	1.2	USEPA RfD for p,p'-DDT: 0.0005 mg/kg/day
Metals				
Cadmium	2/10	0.001 (nd-0.007)	0.47	ATSDR chronic oral MRL: 0.0002 mg/kg/day
Copper	2/10	0.045(nd-0.23)	--------	Not Available
Mercury	10/10	0.247 (0.170-0.334)	0.7	ATSDR chronic oral MRL: 0.0003 mg/kg/day
Selenium	10/10	0.108 (0.074-0.183)	2.0	TDH Guideline
Zinc	10/10	4.5 (3.8-5.3)	700	ATSDR chronic oral MRL/USEPA chronic oral RfD: 0.3 mg/kg/day

** Minimum concentration to Maximum concentration (to calculate the range, subtract the minimum concentration from the maximum concentration).*

† Derived from the MRL or RfD for noncarcinogens or the USEPA slope factor for carcinogens; assumes a body weight of 70 kg, and a consumption rate of 30 grams per day, and assumes a 30-year exposure period for carcinogens and an excess lifetime cancer risk of $1x10^{-4}$.

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

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