

QUANTITATIVE RISK CHARACTERIZATION

Lake Ratcliff

Houston County, TEXAS

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Prepared by

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BACKGROUND AND STATEMENT OF ISSUES

A 1999 survey of fish from Lake Ratcliff by the Texas Parks and Wildlife Department (TPWD) detected mercury in largemouth bass at concentrations that exceeded TDH health-based guidelines for exposure to this toxicant [1]. Consequently, the Texas Natural Resource Conservation Commission (TNRCC) requested that the Texas Department of Health (TDH) evaluate fish commonly consumed from Lake Ratcliff for potential public health hazards. Inorganic mercury in the environment is transformed by bacteria to methylmercury, an organic mercury compound that accumulates in seafood and is toxic to humans. Consumption of contaminated fish is thought to be the main source of exposure to methylmercury. The developing nervous system is exceptionally susceptible to the toxic effects of methylmercury. Consequently, regular consumption of fish containing high concentrations of methylmercury by infants and young children (up to and including 35 kg in weight and up to and including 11 years of age), or by pregnant or lactating women is of special concern.

Lake Ratcliff, located in Houston County within the borders of the Davy Crockett National Forest, is a picturesque 45 surface-acre reservoir impounded in 1936 by the Civilian Conservation Corps. The lake was once a log pond and water source for the Central Coal and Coke Company sawmill. It is currently administered by the United States Forest Service. Public access facilities that include fishing piers and a boat ramp are available at Lake Ratcliff [3]. Bass, bream, and catfish are the predominant fish species in this reservoir [4]. Recreational fishing is common and subsistence fishing may occur at the lake.

DISCUSSION

Sample Collection and Data 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.

Description of the Lake Ratcliff Sample Set

The Seafood Safety Division collected seventeen fish samples from Lake Ratcliff in July 2000 (one blue catfish, one river carpsucker, five channel catfish, and ten largemouth bass). All catfish samples met minimum legal size requirements. Six largemouth bass were smaller than the minimum legal length of 16 inches [4]. The TDH laboratory analyzed edible fillets (skin off) of the single blue catfish and one largemouth 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). Edible fillets from the other fifteen fish were analyzed for mercury.

Analytical Results

The blue catfish and the largemouth bass screened for volatile organic compounds (VOCs) contained carbon disulfide, a compound that may be generated during post-harvest tissue necrosis or that may be the result of laboratory contamination. One sample contained a small amount of acetone. Acetone is a common laboratory or field contaminant. Because carbon disulfide and acetone are unlikely environmental contaminants, this health consultation does not further address these compounds. The laboratory reported no other volatile organic compounds (VOCs) in samples tested for VOCs. No SVOCs, pesticides, or PCBs were detected in samples tested for those contaminants. Copper, lead, selenium, and zinc were identified in the fish analyzed for these metals (results not shown). The measured concentrations of these elements did not exceed TDH guidelines for protection of public health. Mercury was present in fifteen fish collected from Lake Ratcliff: ten largemouth bass; three channel catfish; one river carpsucker; and one blue catfish (Table 1).

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. Although TDH routinely evaluates contaminants across species or locations within a specific water body, the agency also may examine the risks associated with ingestion of individual species from each collection site.

TDH evaluates chemical contaminants in fish by comparing average contaminant concentrations with health-based assessment comparison (HAC) values (in mg contaminant per kg edible tissue or mg/kg) for non-cancer and cancer endpoints. TDH uses the U.S. Environmental Protection Agency's oral reference doses (RfDs) or the Agency for Toxic Substances and Disease Registry's (ATSDR) chronic oral minimal risk levels (MRLs) to derive HAC values for evaluating systemic (noncancerous) adverse health effects (HAC_{nonca}). TDH also 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) to calculate all HAC values. RfDs are estimates of long-term daily exposures that are not likely to cause adverse noncancerous (systemic) health effects even if exposure occurs over a lifetime [5]. Since MRLs and RfDs are similar concepts, the numbers from both agencies may be identical. However, in some instances, the RfD may differ from the MRL because scientific judgment or interpretation can vary between regulatory agencies. The cancer risk comparison values (HAC_{ca}) that TDH uses to assess carcinogenic potential from consumption of seafood containing carcinogenic chemicals are based on the USEPA's chemical-specific cancer slope factors (SFs), an acceptable lifetime risk level (ARL) of 1 excess cancer in 10,000 (1×10^{-4}) people exposed and an exposure period of 30 years.

Most constants employed to calculate HAC values contain built-in margins of safety (uncertainty factors). Uncertainty factors are chosen to minimize the potential for systemic adverse health effects in those people – including sensitive subpopulations such as women of childbearing age, pregnant or lactating women, infants, children, the elderly, people who have chronic illnesses, or

those who consume exceptionally large quantities of fish or shellfish – who eat environmentally contaminated seafood. Therefore, adverse health effects are very unlikely to occur, even at concentrations approaching the HAC values. Moreover, health-based assessment comparison values do not represent a sharp dividing line between safe and unsafe exposures. The strict demarcation between acceptable and unacceptable exposures or risks is primarily a tool used by risk managers to assure protection of public health. TDH finds it unacceptable when consumption of four or fewer meals per month would result in exposures that exceed a HAC value or other measure of risk. People who wish to minimize exposure to environmental contaminants in seafood are advised to eat a variety of fish and shellfish and to limit consumption of those species that are most likely to contain environmental toxicants.

Addressing the Potential for Cumulative Effects

When multiple chemicals 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) [6].

Cumulative Systemic (Noncancerous) Effects

To evaluate the importance of possible cumulative [6] noncancerous (systemic) health effects, TDH calculates a hazard index (HI) for those contaminants with similar effects by summing the hazard quotients (HQ) previously calculated for each contaminant. The hazard quotient (HQ) is the ratio of the estimated exposure dose of a contaminant to its RfD or MRL. A HI of less than 1.0 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 imply 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 multiple carcinogens on excess lifetime cancer risk, TDH sums the risks calculated for each observed carcinogenic contaminant. 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 [7]. 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 [7]. 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 [7]. 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 than otherwise, thereby reflecting children's potentially greater susceptibility. Additionally, in accordance with ATSDR's *Child Health Initiative* [8] and USEPA's *National Agenda to Protect Children's Health from Environmental Threats* [7], 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 35 kg or less and/or who are aged eleven years or under eat no more than four ounces of chemically contaminated fish or shellfish per meal. The meals should also be spread out over time. For instance, if the consumption advice recommends eating no more than two meals per month, children should eat no more than one meal every two weeks.

Risk Characterization

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

Fifteen of seventeen fish taken from Lake Ratcliff in 2000 contained mercury (Table 1). Average mercury levels in the blue catfish (0.157 mg/kg), the river carpsucker (0.153 mg/kg), and channel catfish (0.094 mg/kg) did not exceed the HAC value for methylmercury. TDH examined four legal-size largemouth bass (16-20.5 inches) and six smaller bass (14-15.5 inches). As might be expected, largemouth bass, a predator species, contained higher concentrations of mercury than did other species. The average concentration of mercury in all largemouth bass was 0.775 mg/kg. Legal-size largemouth bass from this reservoir averaged 0.997 mg mercury/kg edible tissue. The hazard quotient (HQ) for mercury in all largemouth bass was 1.1, while that for legal-size bass was 1.42. TDH calculated that adults consuming three or more eight-ounce meals per month of legal-size largemouth bass from Lake Ratcliff could exceed the ATSDR's chronic oral minimal risk level (MRL) of 0.0003 mg methylmercury/kg-day, as could a 35 kg child consuming three or more four-ounce meals per month of largemouth bass of legal size. The HQ for mercury in species other than largemouth bass was 0.2, less than one-fifth that for legal-size largemouth bass. Consequently, consumption of blue and channel catfish and river carpsuckers should not present a significant hazard to health and people may continue to eat these species from Lake Ratcliff.

Characterizing the Risk of Cancer from Consumption of Contaminants in Fish from Lake Ratcliff

Few published reports exist of cancer in humans after exposure to methylmercury [2]. Although methylmercury has been associated with neoplastic changes in the kidneys of experimental animals, those changes generally occurred only at doses that caused significant systemic toxicity and were associated with alterations in structure or function classified as threshold effects [2]. Therefore, although the USEPA has determined that methylmercury is a possible human carcinogen (Group C) [2], it is likely that systemic (noncancer) effects would occur at methylmercury exposures much lower than those required for tumor formation. Long-term administration of methylmercury to experimental animals produces overt symptoms of neurotoxicity at daily doses an order of magnitude lower than those required to induce tumors in mice. Thus, the USEPA has deemed it inappropriate to derive a cancer slope factor for methylmercury. Consequently, it was unnecessary to assess carcinogenic risk from consuming mercury-contaminated fish from Lake Ratcliff.

Characterizing the Likelihood of Cumulative Adverse Health Effects from Consumption of Fish from Lake Ratcliff

Mercury was the only contaminant in fish from Lake Ratcliff that exceeded its HAC value. No other toxicologically significant inorganic or organic contaminants were reported. Therefore, it was not necessary to evaluate samples from this reservoir for cumulative toxic effects.

CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

1. Based on average concentrations of mercury in largemouth bass of legal size from Lake Ratcliff, consumption of this fish species should be limited to less than three meals per month. Since TDH views it as unacceptable when consumption of four or fewer meals per month results in exposures that exceed a HAC value, TDH has determined that regular consumption of largemouth bass from Lake Ratcliff **poses a public health hazard**.
2. Based on observed mercury concentrations in blue catfish, channel catfish, and river carpsuckers from Lake Ratcliff, people may continue to eat these species from Lake Ratcliff without restriction (TDH defines unrestricted consumption as four or more meals per month).

RECOMMENDATIONS

TDH risk managers have established certain criteria for issuing fish consumption advisories based on approaches suggested by the USEPA [9]. When a risk characterization confirms that consumption of four or fewer meals per month (adults: eight ounces; children: four ounces) would result in exposures to toxicants that exceed TDH health-based assessment guidelines, risk managers may wish to recommend that the Commissioner of Health issue consumption advice or ban possession of fish from the affected water body. Based on this characterization of the adverse health effects that might be associated with regular consumption of fish from Lake

Ratcliff, the Seafood Safety Division (SSD) and the Environmental Epidemiology and Toxicology Division (EE&TD), Texas Department of Health (TDH), recommend that:

1. Adults – including pregnant women or those of childbearing potential – eat no more than one eight-ounce meal every two weeks (an average of two meals per month) of large-mouth bass from Lake Ratcliff.
2. Children eat no more than one four-ounce meal every two weeks (an average of two meals per month) of largemouth bass from Lake Ratcliff.
3. If resources permit, TDH continues to monitor mercury levels in fish from Lake Ratcliff.

PUBLIC HEALTH ACTION PLAN

TDH fish consumption advisories and bans are published in a booklet that is available to the public through the TDH Seafood Safety Division: (512-719-0215). This information is also posted on the Internet at URL: <http://www.tdh.state.tx.us/bfds/ssd>, which is updated regularly. Some risk characterizations for water bodies surveyed by the Texas Department of Health may also be available from the Agency for Toxic Substances and Disease Registry (<http://www.atsdr.cdc.gov/HAC/PHA/region6.html>). The Texas Department of Health provides 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 characterization to the Seafood Safety Division (512-719-0215) or the Environmental Epidemiology and Toxicology Division (512-458-7269) at the Texas Department of Health. Toxicological information on a variety of environmental contaminants 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).

Table 1. Mercury concentrations (mg/kg) in fish from Lake Ratcliff, July 2000.				
Species	Number Affected/ Number Sampled	Average Concentration (Min-Max) *	Health Assessment Comparison Value† †	Basis for Comparison Value
Blue catfish	1/1	0.157 (na [‡])	0.700 mg/kg	ATSDR MRL: 0.0003 mg/kg/day
River carpsucker	1/1	0.153 (na)		
Channel catfish	3/5	0.094 (nd [§] -0.134)		
Largemouth bass				
≥16 inches	4/4	0.997 (0.703-1.430)		
<16 inches	6/6	0.627 (0.495-0.891)		
All Largemouth bass	10/10	0.775 (0.495-1.430)		
All species	15/17	0.502 (nd-1.430)		

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

† Derived from the Minimal Risk Level for noncarcinogens; assumes a body weight of 70 kg, and a consumption rate of 30 grams per day.

‡ na: not applicable

§ nd: not detected at concentrations above the laboratory's reporting limit

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