HEALTH CONSULTATION

Black Cypress Bayou, Texas

Cass County, TX

April 1, 1999

Prepared by

Texas Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

BACKGROUND AND STATEMENT OF ISSUES

The Texas Natural Resource Conservation Commission (TNRCC) requested that the Texas Department of Health (TDH) Seafood Safety Division (SSD) evaluate potential health risks associated with consumption of fish taken from Black Cypress Bayou. This request followed special studies conducted by TNRCC in 1998 that showed mercury in fish from Black Cypress Bayou exceeded the human health criterion for mercury in fresh water fish.

Black Cypress Bayou (known locally as Lake Pruitt) is located in semi-rural areas of Cass County in northeast Texas and is reached via Texas Highway 155. The bayou is 40 to 50 yards wide and is approximately 1.5 miles long, with a maximum depth of about 20 feet. The two towns closest to the bayou are Avinger, with a population of approximately 750, and Linden, with a population of about 2500 people. Avinger has a public boat ramp and people have been seen taking fish from the Bayou. Interviews with some of these fishers suggest that people fish regularly in Black Cypress Bayou and that they do eat the fish. For this assessment, fishing is assumed to be recreational, although some subsistence fishing may occur [1].

In September 1998, TDH collected 24 fish samples from Black Cypress Bayou. Samples consisted of two bigmouth buffalo, two black crappie, four bowfin, two common carp, five flathead catfish, four largemouth bass, one longnose gar, and four spotted gar. TDH analyzed edible tissue from 24 fish for mercury. Four fish were analyzed for volatile organic compounds (VOC's), semi-volatile organic compounds, pesticides, polychlorinated biphenyls, and metals (Table 1), as recommended by the United States Environmental Protection Agency (EPA) [2].

The four samples subjected to the full-scan procedures did not contain significant quantities of pesticides, semi-volatile organic compounds, or polychlorinated biphenyls. Two of the four samples contained acetone. Acetone was not evaluated in this document because it is both a naturally-occurring compound and a common laboratory contaminant. No other volatile organic compounds were detected in these samples.

Low concentrations of cadmium, lead, selenium, copper, and zinc were found in the four fish analyzed for these components (Table 2). Mercury levels in the 24 fish ranged from 0.241 mg/kg to 2.86 mg/kg and the concentrations varied with species (Table 3).

Table 1. Analytical scheme for samples collected from Black Cypress Bayou

Sample ID	Species	Analytes
BCB-1	Common Carp	Metals; VOC's; Semivolatile Organics; Pesticides; PCB's
BCB-2	Common Carp	Mercury
BCB-3, BCB-16	Largemouth Bass	Mercury
BCB-4, BCB-18	Black Crappie	Mercury
BCB-5	Flathead Catfish	Metals; VOC's; Semivolatile Organics; Pesticides; PCB's
BCB-6, BCB-7, BCB-8, BCB-17	Flathead Catfish	Mercury
BCB-9, BCB-10, BCB-21, BCB-22	Bowfin	Mercury
BCB-11	Longnose Gar	Mercury
BCB-12, BCB-13, BCB-23, BCB-24	Spotted Gar	Mercury
BCB-14, BCB-15	Largemouth Bass	Mercury
BCB-15	Largemouth Bass	Metals; VOC's; Semivolatiles; Pesticides; PCB's
BCB-19	Bigmouth Buffalo	Mercury
BCB-20	Bigmouth Buffalo	Metals; VOC's; Semivolatiles; Pesticides; PCB's

Table 2. Common metals in tissues of fish from Black Cypress Bayou: Comparison with Public Health Assessment Comparison Values (HAC's)

Metal	# Samples Affected	Average Conc. (mg/kg)	Range	HAC Value (mg/kg)	Basis[3]*	HAC Value Exceeded
Cadmium (Cd)	3/4	0.007	0.0018-0.014	0.467	ATSDR Chronic MRL (0.0002 mg/kg/day)	no
Copper (Cu)	1/4	0.103	0.0-0.41	------	Not Available	------
Lead (Pb)	1/4	0.0045	0.0-0.018	------	Not Available	------
Selenium (Se)	4/4	0.329	0.205-0.570	11.67	ATSDR Chronic MRL (0.005 mg/kg/day)	no
Zinc (Zn)	4/4	4.7123	2.89-5.88	700	ATSDR Chronic MRL (0.3 mg/kg/day)	no

*HAC values are derived from ATSDRs MRL's or EPAs RfD's for noncarcinogens such as these and assume a body weight of 70 kg and a consumption rate of 30 grams per day.

Table 3. Concentrations of mercury detected in each species of fish from Black Cypress Bayou

Species	# Samples(	Average Concentration	Range (mg/kg)‡
Bigmouth Buffalo	2	0.341	0.242, 0.440
Black Crappie	2	0.355	0.285, 0.424
Bowfin	4	1.670	0.508-2.860
Common Carp	2	0.397	0.452, 0.341
Flathead Catfish	5	1.182	0.871-1.630
Largemouth Bass	4	1.190	1.060-1.910
Longnose Gar	1	0.981	------
Spotted Gar	4	1.303	1.170-1.380

*All samples were taken from waters under the Hwy. 155 Bridge near Avinger, TX, TNRCC Station # 10246.
‡ Range given when more than two samples of a single species were collected. Otherwise, individual data points are listed.

DISCUSSION

Health Assessment Comparison Values

To assess the potential health risks associated with metals other than mercury, TDH compared contaminant concentrations with health assessment comparison (HAC) values (see Table 2). HAC values are media-specific contaminant concentrations used to screen contaminants that may require additional scrutiny. HAC values for noncarcinogens such as the metals listed in Table 2 are based on the EPA's reference doses (RfDs) or on the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk levels (MRLs). RfDs and MRLs are estimates of daily exposures to a contaminant that are unlikely to cause adverse noncancer health effects over a lifetime. Exceeding a HAC value does not imply that a contaminant represents a public health threat, but suggests that the contaminant warrants further evaluation.

Metals other than Methylmercury

Neither zinc, cadmium, nor selenium exceeded their respective HAC values. Only one sample contained lead (Table 2). Although there are no HAC values for inorganic lead, TDH used EPA's Integrated Uptake Biokinetic Model (IEUBK) for lead to estimate the potential impact that chronic ingestion of fish containing lead would have on children's blood lead levels. With fish accounting for 50% of the total daily meat consumption, the model predicts that daily ingestion of fish containing lead at the concentration detected in the one sample would result in a 0.1 µg/dL increase in the geometric mean blood lead level for children zero to 84 months of age. Based on this information and the fact that finfish do not significantly bioaccumulate inorganic lead, TDH concluded that detection of lead in a single sample of fish from Black Cypress Bayou does not pose a hazard to public health.

Methylmercury (MeHg)Toxicity

Mercury is a naturally-occurring element found throughout the environment. The mercury in air, water, and soil is primarily inorganic in nature. Under favorable conditions, microorganisms in the water convert inorganic mercury in the water to organic mercury, predominantly methylmercury. Fish may then absorb this contaminant from the water. Many species of fish concentrate methylmercury and store it in edible tissues. Older and larger predatory fish are likely to contain higher concentrations of mercury than do younger or smaller fish or nonpredatory species.

The neurologic effects resulting from ingestion of methylmercury are well documented. Adults poisoned with methylmercury have complained of tingling of the skin, hearing and memory loss, trouble walking, and depression. Clinical signs of toxicity may include ataxia, tremor, hearing loss, and difficulty with speech. In adults, chronic exposure to methylmercury may cause permanent central nervous system damage [4].

Young children and fetuses are especially vulnerable to methylmercury, which may be carried to an infant through breast milk or to the fetus through the placenta. Neurological defects in children range from delayed mental and physical development to a severe syndrome similar to cerebral palsy, depending on extent of exposure [4]. The developing nervous system is the critical target organ for MeHg toxicity. Currently, considerable controversy exists over the exposure levels at which adverse effects on the immature nervous system occur. Nonetheless, the effects of MeHg on the very young have been observed in both nonfish-eating and fish-eating populations. Summaries of the most important of these studies and a description of benchmark dose methodology follow.

Benchmark Dose Methodology

In the past, acceptable human exposure limits to chemicals have been established through manipulation of a "No Observable Adverse Effects Level" (NOAEL). Problems stemming from this approach to human exposure limits led to development of a benchmark dose method for creating these limits [5]. A benchmark dose (BMD) is one that corresponds to a specific detrimental change in response. Typically, the benchmark dose is a dose that results in a change of 10% or more in the response rate because a 10% change in the rate of response is statistically more stable than is a smaller change. In this model, after establishing a BMD, a computer-generated statistical lower bound (BMDL - 95% lower limit on the BMD) is used to construct appropriate exposure limits.

Non-Fish Eating Population

Marsh *et al.* [6] described developmental neurological abnormalities in 81 Iraqi infants whose mothers ate bread made grain treated with a fumigant containing MeHg. Infants exposed to higher levels of MeHg (as measured by mercury concentration in mothers' hair) were older when they began to walk and talk than were infants exposed to less MeHg. The EPA characterized a BMD from these data by grouping the data into several categories, collapsing each of the three outcomes into a dichotomous variable for each child and defining an overall dichotomous measure of health outcomes (a child's development was abnormal if he were judged "abnormal" in any one of the three outcome variables: walking, talking, or abnormal neurological scores). Using the lower 95% confidence level for an increase of 10% +in the incidence of

developmental abnormalities, the BMDL was estimated to be around 11 mg of mercury per kg of hair. Previously published pharmacokinetic data were used to convert the benchmark dose (maternal hair mercury level of 11 mg/kg) to an estimated total daily dietary intake of 65 µg methylmercury. From this dose, the EPA calculated a daily intake NOAEL of 1.1 µg MeHg/kg/day (65 µg/day) 60 kg body weight). The EPA applied an uncertainty factor of 10 to establish a reference dose (RfD) of 0.1 ug/kg day^{-1} [5].

After independently analyzing the Iraqi childhood lead exposure data, the World Health Organization (WHO) suggested that a maternal hair mercury concentration of 10 to 20 mg/kg may be associated with a 5% risk for developmental effects [7]. The statistical best estimate for the population threshold (NOAEL) was 10 mg/kg of methylmercury in hair, with 95% confidence limits of zero to 13.6 mg/kg. For a pregnant woman, this corresponds to an estimated daily intake of approximately 0.9 µg MeHg/kg-body weight.

Fish Eating Populations

The research community has expressed concern that data from consumption of contaminated bread were used to set acceptable daily exposure to methylmercury from consumption of fish. Since many reports exist of effects on humans exposed to methylmercury from eating fish, some have suggested that these studies may be more appropriate for use in establishing benchmark doses for fish consumption. The most widely cited reports are of fish-eating populations in the Republic of the Seychelles [8, 9, 10, 11], the Faeroe Islands [12, 13], and New Zealand [14, 15]. These studies have not consistently confirmed an association between low-dose methylmercury exposure and developmental neurological effects. For instance, the Seychelles studies have not shown such an association. On the other hand, the Faeroe Island studies have revealed a correlation between MeHg exposure and developmental abnormalities. However, in the Faeroe Island studies, dose-response relationships are obscure. Studies of New Zealand children exposed to MeHg through consumption of seafood showed a dose-related increase in developmental abnormalities with increasing exposure to MeHg. Despite the inconsistencies of these studies, researchers have used the data to derive critical toxicity values for pre- and post-natal exposure to MeHg.

In its *Mercury -Draft for Public Comment (Update)- Toxicological Profile* [16], the ATSDR derived a NOAEL from Seychelles Island data. These data reflect several generations of human exposure to MeHg through consumption of fish. Investigators examined children at 29 months of age for neurobehavioral deficits [9]. Mercury concentrations in maternal hair segments corresponding to pregnancy ranged from 0.5 to 26.7 mg/kg, with a median level of 5.9 mg/kg. The ATSDR designated the median mercury concentration as a NOAEL.

Davidson *et al.* [10] examined the Seychelles cohort when the children were sixty-six months old for age-appropriate outcomes. At that time, average maternal hair total Hg was 6.8 mg/kg and the average child's hair total Hg level was 6.5 mg/kg. At five and one-half years of age, none of the children suffered adverse effects associated with either pre- or post-natal MeHg exposure. Conversely, Axtell *et al.* [11] reported that children who were exposed prenatally to MeHg experienced a very slight (less than one day) delay in the age at which they walked as mercury levels increased from zero to seven mg/kg. No effect was seen at higher exposure levels, making

it difficult to show a cause and effect relationship. Prenatal exposure to MeHg did not affect the age at which the children began to talk. Recently, the benchmark dose method was used to examine a wide range of neurological endpoints reported in the Seychelles study [17]. This analysis set the 95% lower bound confidence limit on the 10% benchmark dose (NOAEL) at a maternal hair mercury concentration of 21 mg/kg.

Grandjean *et al.* [12, 13] studied people from the Faeroe Islands, another population with the potential for high MeHg exposures from eating fish. Results of a questionnaire given to adults on the island showed a daily consumption of 72 grams of fish, 12 grams of whale muscle, and seven grams of whale blubber. The most common fish eaten contained an average of 0.07 mg/kg mercury, while whale muscle contained more than 3 mg/kg, about half of which was MeHg. The authors reported that a maternal hair level of 10 mg/kg or less was associated with subtle effects on neurological development. However, these authors did not adjust for exposure to polychlorinated biphenyls, another known neurotoxicant found in fish and whale products eaten by the islanders. Thus, deciding whether the effects observed at maternal hair levels below 10 mg/kg were the result of prenatal exposure to MeHg is not possible.

Unlike the Faeroe Islands study, data from the New Zealand study do provide quantitative dose-response information. The original reports of analyses of these data using categories of maternal hair mercury showed a correlation between prenatal exposure to high mercury levels and poorer performance on psychological and developmental tests [14, 15]. These data were analyzed using multiple regression techniques, no such association was revealed [18]. However, the scores of a single child whose mother's hair mercury level during pregnancy was almost four times that of the other mothers (86 mg/kg) strongly influenced the results. When benchmark dose methods were applied to data containing this child's scores, the BMDL was between 17 and 24 mg/kg of mercury in hair. This dose is considerably higher than the 11-mg/kg benchmark dose established with the Iraqi data. When this child's data was omitted, BMDL's ranged from 7.4 to 10 mg/kg, a dose that is consistent with that established by EPA using the data from Iraqi children. However, because this child's scores are not statistically-provable outliers, omitting them from the analyses may not be appropriate.

Risk Assessment

The above-summarized studies confirm that maternal hair mercury levels during pregnancy adequately represent prenatal exposure to MeHg. Taking a weight of evidence approach to these data, TDH applied an uncertainty factor of 3 (three) to the dietary intake dose (0.0009 mg/kg/day) derived from EPA's benchmark dose in hair (11 mg/kg), primarily to account for variability in the human population, particularly variation in the biological half-life of MeHg and differences in the blood-to-hair ratios used to extrapolate a daily dose from hair concentrations. Thus, TDH calculated a "Maximum Allowable Daily Intake" of 0.0003 mg/kg/day for mercury. TDH used the allowable daily intake to calculate the upper limit of consumption of fish that should result in no significant toxicity to the most sensitive subpopulation, women of childbearing age and their fetuses. By inference, protection of this subpopulation should extend protection from the adverse health effects of methylmercury to children and adults who consume fish from Black Cypress Bayou.

To determine the number of meals a person could consume without exceeding the allowable daily intake, TDH used two concentrations of mercury calculated from the individual mercury levels in the 24 samples from Black Cypress Bayou. These were the arithmetic average and the 95th percentile of the arithmetic average. The 95th percentile of the average is a value that, when calculated repeatedly for randomly drawn subsets of site-specific data, equals or exceeds the true average 95 percent of the time. The small within-species sample sizes and probable variability in species-specific consumption patterns precluded conclusions about exposure by species.

TDH estimated the 95th percentile by defining the distribution of mercury in the fish from Black Cypress Bayou and then randomly drawing 1,000 samples of 24 fish from that distribution. Averages were obtained for each of the 1,000 samples and the 950th rank ordered average was defined as the 95th percentile [22, 23]. The arithmetic average is most representative of the concentration that a person might consume over time. On the other hand, the 95th percentile of the average provides a more conservative estimate of the average mercury concentration.

Employing the arithmetic average, TDH estimated that a 70-kg adult could consume approximately three eight-ounce meals per month, while children (body weight 15-35 kg) could consume no more than one to three four-ounce meals per month of fish from Black Cypress Bayou (depending on age and size) before exceeding the maximum allowable daily intake (Table 4).

Using the 95th percentile of the arithmetic average, TDH estimated that adults weighing between 50 and 100 kg could consume between one and three eight-ounce meals per month and children weighing 15-35 kg could eat no more than two four-ounce meals per month of fish from Black Cypress Bayou before exceeding the maximum allowable daily intake (Table 4).

Table 4. Recommended Limitations on Long-Term Fish Consumption from Black Cypress Bayou

Estimates based on an average mercury level of 1.1 mg/kg and a 95th percentile of the arithmetic mean of 1.46 mg/kg in the 24 fish samples collected from Black Cypress Bayou

Chemical Name: **Mercury**
Population: **Adults and children**
Maximum Allowable Daily Intake: **0.0003 mg/kg body weight/day**
Reporting Limit: **2 Fg/g of tissue**

Risk-Based Consumption Limit (meals/month)				
Body Weight (kg)	Age Range (years)	Maximum Allowable Daily Intake (µg/day): (BW x 0.3 ug/kg/day)	Number of meals per month that may be consumed without exceeding the maximum allowable daily intake	
			Arithmetic Average 1.1 mg/kg	95th percentile of Arithmetic Average 1.46 mg/kg
Child: Average meal size = 4 ounces				
15	3 to 6	4.5	1	1
35	10 to 11	10.5	2.5 (10 oz/month)	2
Adult : Average meal size = 8 ounces				
50		15	2	1
60		18	2	2
70		21	2.5 (20 oz/month)	2
80		24	3	2
90		27	3	3
100		30	4	3

(When calculations resulted in fractions of meals, the number of meals was rounded to the nearest whole number according to generally-recognized rounding conventions.

ATSDR's Child Health Initiative

The TDH has prepared this consult under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). TDH has included the following information in accordance with ATSDR's Child Health Initiative [19].

ATSDR's Child Health Initiative recognizes that the unique vulnerabilities of infants and children demand special emphasis in communities faced with contamination of their water, soil, air, or food. Also, children are smaller, a factor that results in higher exposure doses per kilogram of body weight. It follows that children who consume fish contaminated with mercury are at greater risk for toxic effects than are adults who consume mercury-contaminated fish. Infants may be exposed by breast milk while fetuses may be exposed through transfer across the placenta. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most important, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care. TDH evaluated the upper limits of fish consumption that would result in no

significant risk to the fetus or to young children exposed after birth. TDH has determined that regular consumption of fish from Black Cypress Bayou at higher levels than the recommended consumption limits could pose a risk to the developing nervous system. Although human infants may be exposed to methylmercury through breast milk, evidence suggests that the benefits of breast feeding outweigh the risks associated with low level exposure to mercury through breast feeding [20, 21].

CONCLUSIONS

1. The 24 fish collected from Black Cypress Bayou contain mercury at levels that represent a public health hazard for persons consuming them.

2. An adult (body weight 70 kg) consuming more than two to two and one-half eight-ounce meals per month (20 ounces per month) of fish from Black Cypress Bayou would exceed the maximum allowable daily intake for mercury. A small child (age three to six years, body weight #15 kg) consuming more than one four-ounce meal per month would exceed the maximum allowable daily intake for mercury. Children 10 to 11 years of age (body weight #35 kg) who consume more than two to two and one-half four-ounce meals per month (10 ounces per month) of fish from this Bayou would exceed the maximum allowable daily intake for mercury.

   The TDH Seafood Safety Division has established criteria for issuing fish consumption advisories. For non-carcinogens like mercury, these criteria state that if consuming less than thirty grams of fish per day (about one eight-ounce meal per week) [1] exceeds the maximum allowable daily intake for a contaminant, a consumption advisory should be considered. The data in this health consultation suggest that a fish consumption advisory for Black Cypress Bayou is warranted.

RECOMMENDATIONS AND PUBLIC HEALTH ACTION PLAN

1. To protect the health and safety of people who might eat fish from this source, the Commissioner of the Texas Department of Health should consider issuing a fish consumption advisory for Black Cypress Bayou. The advisory should include the following guidelines:

   a. Children (ages 3-11 years) should not eat more than two four-ounce meals per month of fish taken from Black Cypress Bayou.

   12 Adults should consume no more than two eight-ounce meals per month of fish taken from Black Cypress Bayou.

2. This Health Consultation has been provided to the Division of Seafood Safety, Bureau of Food and Drug Safety.

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CERTIFICATION

This Health Consultation was prepared by the Texas Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the Health Consultation was initiated.

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The Division of Health Assessment and Consultation, ATSDR, has reviewed this Health Consultation and concurs with its findings.

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