# HEALTH CONSULTATION

Lake Kimball, Texas

Hardin and Tyler Counties

March 1998

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 Lake Kimball. This request followed special studies conducted by TNRCC in 1998 that showed mercury in fish from Lake Kimball exceeded the human health criterion for mercury in freshwater fish.

Lake Kimball is a small man-made lake found 35 miles northwest of Beaumont off Highway 69 in Hardin and Tyler counties. The lake provides recreational fishing facilities for Wildwood Resort City, a community of 900 to1200 residents. Although the development began as a retirement settlement, people of all ages now live there. The community supports a bass club with approximately 100 recreational fishers who regularly take and eat fish from the lake. Other people also sporadically take and eat fish from the lake.

In September 1998, TDH collected 24 fish from Lake Kimball consisting of two flathead catfish, one channel catfish, fifteen largemouth bass, two spotted gar, and four white crappie. Two fish (one flathead catfish and one largemouth bass) were collected 1/4 mile upstream of the dam. Twenty-two fish were collected from around the dam. TDH analyzed all 24 fish for mercury. Four fish from around the dam were analyzed for pesticides, semi-volatile, and volatile organic chemicals (VOC's), polychlorinated biphenyls (PCB's), and metals as recommended by the United States Environmental Protection Agency (EPA) [1].

The four samples subjected to full-scan analysis did not contain significant quantities of pesticides, semi-volatile compounds, or PCB's. Two of the four samples contained acetone. Acetone is added to samples during analysis. This common laboratory contaminant was not, therefore, considered in this assessment. One sample contained 1,2,4- and 1,3,5-trimethylbenzene at levels that do not pose a risk to human health (20 µg/kg). Metals other than mercury were found at low concentrations (below levels of health concern) in the four fish analyzed for these components. Mercury concentrations in the 24 fish varied with the species and ranged from 0.235 mg/kg to 2.49 mg/kg (Table 1). Because of the small number of fish and probable variability in consumption patterns, mercury concentrations across species were combined for this analysis.

| Table 1. Concentrations of mercury in different species of fish from Lake Kimball, Texas* | | | |
|---|---|---|---|
| **Species** | **#Samples** | **Average Concentration (mg/kg)** | **Range (mg/kg)** |
| Flathead Catfish | 2 | 0.93 | 0.67-1.20 |
| Channel Catfish | 1 | 1.30 | -- |
| Largemouth Bass | 15 | 1.19 | 0.675-1.68 |
| Spotted Gar | 2 | 2.12 | 1.75 - 2.49 |
| White Crappie | 4 | 0.51 | 0.24 - 0.76 |

*samples collected September 1998

# DISCUSSION

### 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.

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 [2]. The developing nervous system currently is considered 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.

<u>Benchmark Dose Methodology</u>

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 limiting human exposure have led to development of the benchmark dose method for creating these limits [3]. A benchmark dose (BMD) is a dose that corresponds to a specific detrimental change in response. Usually, the benchmark dose is a dose that results in a change of 10% or more in the response rate. A 10% change is more statistically stable than is a smaller change in response rates. In this model, the statistical lower bound (BMDL - 95% lower limit on the BMD), generated by a computer program, is used as a guideline for constructing appropriate human exposure limits.

Non-Fish Eating Population

Marsh *et al.* [4] 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 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 BMD was estimated to be around 11 mg of mercury per kg 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$^{-1}$ [3].

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 hair may be associated with a 5% increase in risk of developmental abnormalities [5]. 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 eating fish. However, many reports exist of effects on humans exposed to methylmercury through consumption of fish. The most widely cited reports are of fish-eating populations in the Republic of the Seychelles [6,7, 8, 9], the Faeroe Islands [10, 11], and New Zealand [12, 13]. These studies have not consistently confirmed a relationship between low-dose methylmercury exposure and developmental neurological effects. For instance, the Seychelle Island 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* [14], the Agency for Toxic Substances and Disease Registry (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. Mercury concentrations in maternal hair segments corresponding to the period of 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.* [7] 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. On the other hand, Axtell *et al.* [9] reported that children with prenatal exposure 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, ICF Kaiser [15] used the benchmark dose method to examine a wide range of neurological endpoints reported in the Seychelles study. Based on this analysis, the 95% lower bound confidence limit on the 10% benchmark dose (NOAEL) was equivalent to a maternal hair concentration of 21 mg/kg.

Grandjean *et al.* [10, 11] 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, determining 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 [12, 13]. Analysis of these data using multiple regression analyses of actual hair mercury levels revealed no such association [16] but 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 was considerably higher than the 11 mg/kg established as the benchmark dose using the Iraqi data. However, 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 (.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 to calculate the upper limit of consumption of fish that should result in no significant toxicity in the most sensitive subpopulation, women of childbearing age, and, by inference, their fetuses. By inference, protection of this subpopulation should extend protection from the adverse effects of methylmercury to children and adults who consume fish from Lake Kimball.

To determine the number of meals a person could consume without exceeding this upper limit of allowable consumption, TDH used two concentrations of mercury: the arithmetic average of mercury in the fish from Lake Kimball and the 95$^{th}$ percentile of that arithmetic average. The 95$^{th}$ percentile of the arithmetic average is a value that, when calculated repeatedly for randomly drawn subsets of site-specific data, will equal or exceed the true average 95 percent of the time.

TDH estimated the 95$^{th}$ percentile by defining the distribution of mercury in the fish from Lake Kimball 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 950$^{th}$ rank ordered average was defined as the 95$^{th}$ percentile. The arithmetic average is most representative of the concentration that a person might consume over time. However, the 95$^{th}$ percentile of the average provided a conservative estimate of the average concentration and is useful to account for sampling variability, differences in consumption, and suspected seasonal variations in fish tissue concentrations of chemicals. Figure 1 shows the relationship between the sample distribution, the arithmetic average, and the 95$^{th}$ percentile of the arithmetic average.

Using the arithmetic average, TDH estimated that a 70 kg adult could consume approximately two eight-ounce meals each month, while children (body weight 15-35 kg) could consume no more than one to two and one-half four-ounce meals per month of fish from Lake Kimball before exceeding the maximum allowable daily intake (Table 2).

Using the 95$^{th}$ percentile of the arithmetic average, TDH estimated that adults weighing between 50 to 100 kg could consume approximately one and one-half to three eight-ounce meals each month, while children (body weight 15-35 kg) could consume no more than one to two four-ounce meals per month of Lake Kimball fish before exceeding the maximum allowable daily intake.

**Table 2. Recommended Limitations on Long-Term Fish Consumption by Body Weigh**

**Estimates based on an average mercury level of 01.14 mg/kg and a 95th percentile mean of 1.39 mg/kg in the 24 fish samples collected from Lake Kimball**

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

| Body Weight (kg) | Age Range (years) | Maximum Allowable Daily Consumption (μg/day) | Number of meals per month that may be consumed without exceeding the maximum allowable daily intake. | |
|---|---|---|---|---|
| | | | Arithmetic Average 1.14 mg/kg | 95th Percentile of Arithmetic Average 1.39 mg/kg |
| Child: average meal size = 4 ounces | | | | |
| 15 | 3 to 6 | 4.5 | 1 | <1 |
| 35 | 10 to 11 | 10.5 | 2.5 | 2 |
| Adult: average meal size = 8 ounces | | | | |
| 50 | | 15 | 1.8 | 1.4 |
| 60 | | 18 | 2.1 | 1.7 |
| 70 | | 21 | 2.5 | 2 |
| 80 | | 24 | 2.8 | 2 |
| 90 | | 27 | 3.2 | 2.6 |
| 100 | | 30 | 3.5 | 3 |

## ATSDR's Child Health Initiative

The TDH has prepared this consultation under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). TDH has included the following information following ATSDR's Child Health Initiative [17].

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. 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. Children are, also, smaller, a factor that results in higher exposure doses per kilogram of body weight. 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 Lake Kimball 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 this type of exposure [18, 19].

## CONCLUSIONS

1. The 24 fish collected from Lake Kimball 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 eight-ounce meals per month of fish from Lake Kimball 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 age 10 to 11 years of age (body weight <35 kg) who consume more than two four-ounce meals per month of fish from Lake Kimball would exceed the maximum allowable daily intake for mercury.

3. 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 Lake Kimball is warranted.

## RECOMMENDATIONS AND PUBLIC HEALTH ACTION PLAN

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

   a.. Children (ages 3-11 years) should not consume more than two (2) four-ounce meals per month of fish taken from Lake Kimball.

   12 Adults should consume no more than two (2) eight-ounce meals per month of fish taken from Lake Kimball.

2. This health consultation has been provided to the TDH Seafood Safety Division.

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## PREPARERS OF THE REPORT

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

Lisa Williams, M.S.
Toxicologist
Health Risk Assessment and Toxicology Program

John F. Villanacci, Ph.D.
Co-Director
Environmental Epidemiology and Toxicology Division
Director
Health Risk Assessment and Toxicology Program

## ATSDR REGIONAL REPRESENTATIVE

George Pettigrew, P.E.
Senior Regional Representative
ATSDR - Region 6

## ATSDR TECHNICAL PROJECT OFFICER

Alan W. Yarbrough
Environmental Health Scientist
Division of Health Assessment and Consultation
Superfund Site Assessment Branch

## CERTIFICATION

This Health Consultation was prepared by the Texas Department of Health under the 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.

Technical Project Officer, SPS, SSAB, DHAC, ATSDR

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

Chief, State Programs Section, SSAB, DHAC, ATSDR