

**Agency for Toxic  
Substances and  
Disease Registry**  
Division of Health Studies

Sheboygan River & Harbor  
Fid No. 460143200  
Folder No. \_\_\_\_\_

**FISH CONSUMPTION EXPOSURE ASSESSMENT STUDY  
SHEBOYGAN HARBOR AND RIVER**

**May 1998**



**DEPARTMENT OF HEALTH  
& HUMAN SERVICES**  
Agency for Toxic Substances  
and Disease Registry  
Atlanta, Georgia 30333

Additional copies of this report are available from:  
National Technical Information Services, Springfield, Virginia  
(800) 553-6847 or (703) 605-6565  
Request publication number PB98-136195

**FINAL REPORT PRINTED BY**  
**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES**  
**AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY**  
**ATLANTA, GEORGIA**

**FISH CONSUMPTION EXPOSURE ASSESSMENT STUDY**  
**SHEBOYGAN HARBOR AND RIVER**

**SUBMITTED BY**  
**WISCONSIN DEPARTMENT OF HEALTH AND SOCIAL SERVICES**  
**1414 EAST WASHINGTON AVENUE**  
**MADISON, WISCONSIN 53703-0309**

**May 1998**

---

This report was supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) trust fund provided to the Wisconsin Department of Health and Social Services under Grant Number H75/ATH580122 from the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document, presented in its entirety as submitted by the grantee, has not been revised or edited to conform with agency editorial guidance.

---

## **DISCLAIMER**

Mention of the name of any company or product does not constitute endorsement by the Agency for Toxic Substances and Disease Registry, or the U.S. Department of Health and Human Services or the Wisconsin Department of Health and Social Services.

## TABLE OF CONTENTS

	<u>Page</u>
DISCLAIMER .....	ii
LIST OF TABLES .....	v
LIST OF APPENDICES .....	vii
ABSTRACT .....	1
INTRODUCTION .....	3
BACKGROUND .....	3
HEALTH IMPLICATIONS OF POLYCHLORINATED BIPHENYL .....	4
AWARENESS OF FISH CONSUMPTION ADVISORIES .....	5
OBJECTIVES OF THE EXPOSURE INVESTIGATION .....	6
POTENTIALLY EXPOSED SHEBOYGAN SUBPOPULATIONS .....	6
METHODS .....	8
SURVEY DESIGN AND IMPLEMENTATION .....	8
INTERVIEWERS .....	11
HEALTH EDUCATION .....	11
DATA PROCESSING AND ANALYSIS .....	12
RESULTS .....	12
SHEBOYGAN RIVER ANGLERS .....	12
SHEBOYGAN WIC PARTICIPANTS .....	13
SHEBOYGAN HMONG .....	14
DISCUSSION .....	15
FISH CONSUMPTION .....	15
HEALTH ADVISORY AWARENESS .....	16
STUDY LIMITATIONS .....	16
CONCLUSIONS .....	19
RECOMMENDATIONS .....	21
REFERENCES .....	23
AUTHOR .....	25

ACKNOWLEDGMENTS ..... 25  
TABLES ..... 27  
APPENDICES ..... 35

## LIST OF TABLES

	<u>Page</u>
Table 1— Distribution of Annual Fish Meals Of Sheboygan Subpopulations April 1994 to March 1995 .....	29
Table 2— Most Frequently Fished Locations Sheboygan River Anglers April to November 1994 .....	29
Table 3— Type Sport-Caught Fish Meal by Source Summer & Fall Sheboygan River Anglers June to November 1994 .....	30
Table 4— Number and Type of Fish Meals Reported by Sheboygan WIC Participants Who Ate Fish During Week Prior to Completing Survey June-August, 1994 .....	30
Table 5— Number and Sources of Fish Meals Reported by Sheboygan WIC Participants Who Ate Fish During Week Prior to Completing Survey June-August, 1994 .....	31
Table 6— Source and Types of Fish Meals Reported By Sheboygan WIC Participants Who Ate Fish During Week Prior to Completing Survey June to August 1994 .....	31
Table 7— Awareness of Sheboygan Fish Consumption Advisory By Sheboygan WIC Participants Who Consumed $\geq$ 12 Annual Fish Meals June-August, 1994 .....	32
Table 8— Reported Sources of All Fish Meals by Sheboygan Hmong Respondents October 1994 to March 1995 .....	32
Table 9— Types of Fish Eaten by Sheboygan Hmong Respondents October 1994 to March 1995 .....	33
Table 10— All Fish Meals by Source Sheboygan Hmong Households Who Ate Fish During Week Prior to Completing Survey November 1994 to March 1995 .....	33

**LIST OF APPENDICES**

	<u>Page</u>
APPENDIX A— SHEBOYGAN AREA MAP .....	A-1
APPENDIX B— SURVEY TOOLS .....	B-1



## ABSTRACT

Several residents of Sheboygan, Wisconsin, reported eating fish from the Sheboygan River that were contaminated with polychlorinated biphenyls (PCBs). The Wisconsin Department of Health and Social Services conducted an exposure investigation to evaluate the extent of exposure to PCBs among three Sheboygan-area subpopulations. In 1994 and 1995, the Wisconsin Division of Health surveyed 67 Sheboygan river anglers, 106 Sheboygan Hmong households, and 435 participants of the Sheboygan WIC program about their fish consumption practices, particularly regarding fish caught from the Sheboygan River. Mean levels of fish consumption among the three subpopulations were comparable to amounts of fish eaten by other populations. Some households of each subpopulation regularly ate contaminated fish from the Sheboygan river. The awareness of the health-based fish consumption advisory was found to be similar with other Great Lakes populations, though there was a segment of each subpopulation who were unaware of the advisories. Hmong households who had recently arrived in Sheboygan had a significantly lower awareness of the fish consumption advisories than those who had lived there four or more years. The exposure investigation did not identify a substantial portion of the three Sheboygan-area subpopulations that eat the most heavily PCB-contaminated fish from the Sheboygan River.

## **INTRODUCTION**

The Wisconsin Department of Health and Social Services, Division of Health (DOH) initiated this investigation to evaluate if certain groups of people were eating amounts of PCB-contaminated fish from the Sheboygan River that may pose a threat to human health. The sediments of the lower 14 miles of the Sheboygan River and Sheboygan Harbor are highly contaminated with polychlorinated biphenyls (PCBs). Because PCBs tend to bioaccumulate in fish, the State of Wisconsin has determined it is unsafe to eat any resident species of fish from this part of the Sheboygan River. While sport fish consumption advisories have been in place for the Sheboygan River and Harbor since 1978, it is possible that some people ignore or are unaware of the advisories and eat significant amounts of PCB-contaminated fish from this location. This investigation was funded by a grant from the Agency for Toxic Substances and Disease Registry (ATSDR).

## **BACKGROUND**

The Sheboygan River drains a watershed of approximately 432 square miles before emptying into Lake Michigan at the City of Sheboygan. Sediment samples collected from this stretch of the river showed the presence of elevated levels of polychlorinated biphenyls (PCBs) and some heavy metals. Elevated levels of PCBs have also been detected in sport-caught fish and waterfowl which reside year-round in the lower 14 miles of the river and harbor.

In 1985, the lower 14 miles of the Sheboygan River and Harbor was proposed to be included on the National Priority List (NPL), the listing of national Superfund hazardous waste sites. In 1986, it was officially placed on the NPL.

ATSDR's Public Health Assessment for the Sheboygan River and Harbor identified this portion of the river "a public health hazard to people who frequently eat fish and waterfowl that reside in the river and harbor" [1]. The public health assessment recommended that efforts be mounted to identify people who might be frequent consumers of PCB-contaminated fish from the river and harbor. The report indicated that these frequent consumers might include Sheboygan River anglers, local women of childbearing age who rely on sportcaught fish from the river and harbor as a source of protein, and members of the Sheboygan Hmong community. Sheboygan area Hmong were identified in the public health assessment as possibly less aware of the fish consumption advisories because of cultural and communication barriers. The public health assessment recommended that follow-up activities include a PCB-contaminated fish consumption exposure investigation of frequent consumers.

Elevated levels of PCBs measured in fish from Sheboygan River and Harbor resulted in the State of Wisconsin issuing fish consumption advisories specific for this location, particularly for resident, non-migratory fish that live year-round in the river [2]. In 1992, fillets from Sheboygan River smallmouth bass had PCB concentrations ranging between 0.4 and 17 mg/kg [3], while composite samples of whole carp had PCB levels between 10.5 and 200 mg/kg. In contrast, PCB levels

measured in fillets from lake-run brown trout, taken from the Sheboygan River in 1985, were as high as 4 mg/kg. Typical PCB levels in fillets of Lake Michigan fish are 3 mg/kg for lake trout, 1.5 mg/kg for chinook salmon, 0.8 mg/kg for coho salmon, and PCB levels less than 0.2 mg/kg were measured in other Lake Michigan fish species, including yellow perch [1].

Federal toxicologic evaluations of PCBs provide a means for putting these contaminant levels into perspective. ATSDR established their chronic Minimal Risk Level<sup>1</sup> for PCBs at 0.00002 mg/kg/day. Thus, an adult eating two eight-ounce fillets per month of smallmouth bass in 1992 (with 17.0 mg/kg of PCBs) would have a PCB exposure of 0.0037 mg/kg/day, or 184 times greater than ATSDR's chronic Minimal Risk Level. The U.S. Environmental Protection Agency established the cancer slope factor<sup>2</sup> for polychlorinated biphenyls at 2.0 (mg/kg/day)<sup>1</sup>. An adult who ate similar two eight-ounce smallmouth bass fillets per month for fifteen years would have a high increased lifetime excess cancer risk (upper level estimate) equivalent to an excess of 66 liver cancers for every 1,000 such individuals exposed for a lifetime.

### **HEALTH IMPLICATIONS OF POLYCHLORINATED BIPHENYL EXPOSURE**

Polychlorinated biphenyls (PCBs) are a mixture of certain chlorinated biphenyl molecules, which are fat-soluble. Once released into an aquatic ecosystem PCBs accumulate in sediments and bioconcentrate at the top of the food chain, particularly in fish. In the past, PCBs were widely used in the manufacture of many industrial and commercial products, most notably fluids used in transformers, capacitors, and hydraulics. The manufacturing of PCBs was halted in 1977. Since then levels measured in the environment and human tissue and fluids have decreased. PCBs are persistent because they are not readily broken down by environmental factors, however less chlorinated PCBs are susceptible to anaerobic biodegradation in aquatic settings.

Most available information about the adverse human health effects from PCBs is based on high levels of exposure in occupational settings. Workers exposed to PCBs can have irritated nasal passages and lungs, and are known to develop skin rashes and chloracne. Some studies of laboratory rats indicate that ingesting PCBs can cause damage to the liver, stomach and thyroid gland. Ingesting PCBs might increase the incidence of certain types of cancer. While there is inconclusive evidence that PCBs cause cancer in humans, studies of laboratory animals show that mixtures of certain PCBs cause liver cancer in rats. PCBs may also cause stomach cancer in rats [4].

Eating contaminated sport-caught fish is thought to be the largest single environmental source of human exposure to PCBs [5]. In several studies, self-reported fish consumption was found to be associated with PCB body burden levels, as determined by human serum analysis. The amount of

---

<sup>1</sup> Minimal Risk Level: an estimate of the daily human exposure to or dose of a chemical that is likely to be without an appreciable risk of deleterious, noncancerous effects over a specified duration of exposure.

<sup>2</sup> Cancer Slope Factor: the lifetime probability that a cancer causing chemical will cause cancer at a dose of 1.0 mg/kg/day.

sport-caught fish eaten by Wisconsin anglers was found to be positively correlated with PCB blood serum levels [6]. Self-reported consumption of Lake Michigan fish by women was shown to be positively correlated with detectable PCB blood serum levels [8].

The development of infants and children may be adversely affected by *in utero* and lactational exposure, however the evidence is not conclusive. Intrauterine PCB exposure was found in one study to be associated later in life with an increased number of infections, such as colds, influenza, otitis media, and fevers [9]. The newborns of women who self-reported they regularly ate PCB-contaminated fish during pregnancy were found to have smaller head circumferences than the newborns of women who did not eat such fish [10]. Four-year old children who were exposed *in utero* to PCBs weighed less and had poorer short-term memory functions than those not exposed [11]. Breastfeeding infants and children may continue to be exposed to PCBs in breastmilk, which has been suggested as a principal source of childhood exposure to PCBs [12]. While Jacobson previously reported in the 1990 study that larger quantities of PCBs are transferred to infants via breastmilk than are transferred placentally to unborn children, nursing exposure to PCBs was unrelated to cognitive performance.

#### **AWARENESS OF FISH CONSUMPTION ADVISORIES**

Despite regular updates to the fish consumption advisories, a substantial portion of people apparently do not adhere to these advisories. In a 1985 study 85% of Lake Michigan and Lake Superior anglers reported they were aware of the fish consumption advisory, and 57% of all anglers reported following the advisory [6]. An unpublished report by Tilden, et al., found 65.3% of Wisconsin sportcaught fish eaters reported they were aware of the fish consumption advisory [7]. Tilden estimated that residents of the Great Lakes typically consume 28.8 median total fish meals each year, with those who eat Great Lakes sport fish consuming 34.8 median fish meals per year. Tilden also found that self-reported awareness of fish consumption advisories was low among women (39.1%), non-whites (22.1%), those without a high school education (33.7%), and individuals less than 35 years old (46.9%).

In 1991, Wisconsin Department of Natural Resources (WDNR) creel census clerks surveyed 52 Sheboygan River and Harbor anglers about their fish consumption. Twelve anglers reported eating one or more fish meals per week, with three (25%) indicating they did not follow the fish advisories. However, no information was collected about the amounts or specific types of fish typically eaten.

Informal contacts and surveys of anglers along the Sheboygan River and Harbor indicate most do not eat species of fish with high levels of PCBs, however some anglers continue to eat PCB-affected fish caught from the Sheboygan River and Harbor. In May 1993, seven Sheboygan River anglers were interviewed by DOH. All anglers were familiar with the consumption advisory, yet one indicated he would eat any fish he could catch. During fall 1993 and spring 1994, another investigation interviewed 227 anglers at locations along the lower Sheboygan River and Harbor, unfortunately anglers were not surveyed about their awareness of the fish consumption advisories [13]. Fifty-one percent of the fall anglers and 71% of the spring anglers said they typically

ate fish from the Sheboygan River and Harbor. For anglers who said they ate fish from the Sheboygan River during the previous year, 12.9% and 24.7% of fall and spring anglers, respectively, said their households ate resident fish species from the river. Approximately one-fifth of interviewed anglers had fish in their possession at the time of the interview, however anglers were not questioned about their awareness of the fish consumption advisory. While non-resident, migratory fish were the most commonly possessed species of fish, resident species comprised 5% and 11% of the fish possessed by fall and spring anglers, respectively. Sheboygan River anglers were not surveyed during summer months, when there are few migratory fish in the river and only resident species are present.

People may continue to fish the Sheboygan River and not be exposed to high levels of PCBs. Anglers who practice catch-and-release would avoid eating fish from the river. During the spring and fall many anglers seek lake-run salmonid species (salmon and trout) that migrate up the Sheboygan River. These non-resident fish have much lower PCB levels than those fish that live in the river the year-round. Smaller sizes of Lake Michigan-run coho and chinook salmon (less than 26 and 21 inches respectively) pose the lowest health risk. Women and children are advised to not eat larger salmon or any trout caught from the harbor and river. Anglers are advised to avoid chinook salmon over 32 inches and all other species of fish from the river [2]. Some other species found in the harbor, such as yellow perch, are considered safer because of lower PCB levels. In the summer, people are often seen fishing for yellow perch along the harbor side of the Sheboygan breakwater.

#### **OBJECTIVES OF THE EXPOSURE INVESTIGATION**

The objectives of this exposure investigation were as follows.

1. Identify anglers who regularly fish the Sheboygan River and Harbor, and who frequently eat fish (two or more times per week).
2. Characterize the fish consumption practices of anglers who fish in the Sheboygan River and Harbor.
3. Characterize fish consumption practices of participants of the Sheboygan County Special Supplemental Nutrition Program for Women, Infants and Children (WIC), particularly regarding Sheboygan River fish with elevated levels of PCBs.
4. Characterize fishing practices and fish consumption habits of Hmong households located within Sheboygan County, particularly regarding Sheboygan River fish with elevated levels of PCBs.

#### **POTENTIALLY EXPOSED SHEBOYGAN SUBPOPULATIONS**

Three Sheboygan subpopulations were targeted for this investigation - anglers who fish the Sheboygan River, participants of the Sheboygan WIC Program, and members of the Sheboygan Hmong community. The Public Health Assessment for the Sheboygan River and Harbor [1]

recommended a follow-up investigation of these three Sheboygan subpopulations to evaluate their exposure to PCBs in sport-caught fish from the river.

### *Sheboygan River Anglers*

Sheboygan River anglers were selected because they are the primary source of sport-caught fish from the Sheboygan River and are the most likely to eat these fish. Anglers consume quantities of fish that exceed the number of fish meals typically eaten by the general population [14]. While most Sheboygan River anglers previously encountered reported they do not eat PCB-contaminated sport-caught fish from the Sheboygan River, some continue to do so. Surveying Sheboygan River anglers would characterize those with the greatest access to sport-caught fish from the Sheboygan River and provide insight about the amount and types of fish they eat.

### *Sheboygan WIC Participants*

Participants of the Sheboygan WIC Program (Supplemental Nutrition Program for Women, Infants, and Children) were selected because they may be exposed to PCBs from resident fish they eat that come from the Sheboygan Harbor and River. WIC participants may be less aware of fish consumption advisories than others, since women have a lower awareness of fish consumption advisories than men [15], particularly those from low-income households [16]. To qualify for the WIC program participants must qualify as low income (below 185% of the federal poverty level), which may result in an increased reliance on sport-caught fish as a source of dietary protein [17]. Additionally, the health status of WIC participants may cause them to be more susceptible to the effects of PCB exposure. As well as meeting low-income requirements, eligible WIC participants must be nutritionally "at risk"<sup>3</sup>. Young children are adversely affected by PCBs, and those with a nutritional risk factor could have a heightened sensitivity to the adverse effects of a significant PCB exposure. Children may have an increased risk of adverse health effects if their mothers ate PCB-contaminated fish before and during pregnancy. Infants exposed in utero to PCBs may experience more frequent illnesses, developmental and growth problems. Shortened gestation, resulting in lower birth weights, was found in the newborns of women who were exposed to PCBs during pregnancy.

### *Sheboygan Hmong Community*

The Sheboygan Hmong community was selected because Hmong households may eat fish more frequently than the general population and several factors may result in a lower awareness of the fish consumption advisories. One study reported that 60% of Hmong living in Green Bay, Wisconsin, fish and regularly eat sport-caught fish, and that Green Bay Hmong are twice as likely to fish as the general population [18]. Another study [19] reported that 27.5% of Sheboygan Hmong residents eat fish at least once per week, with some indicating they were unaware that certain fish from the Sheboygan River posed a health hazard.

---

<sup>3</sup> WIC nutritional risk is determined by a clinical assessment of hematologic, anthropometric, medical and dietary factors.

A lower awareness of the fish advisories by Hmong may be partially attributed to language and cultural barriers. Many Hmong households are low-income, and may disregard fish advisories because sport-caught fish provide a low-cost source of protein. The lack of access to automobiles and boats may cause some Hmong anglers to rely heavily on nearby stretches of the Sheboygan River as a fish source. Additionally, many Sheboygan Hmong are recent migrants to Sheboygan and may be less aware of the fish consumption advisories than other residents. DOH planned to interview a 25% randomly selected sample of the approximately 400 Hmong households within Sheboygan County to obtain specific information about their angling and fish consumption practices.

## **METHODS**

### **SURVEY DESIGN AND IMPLEMENTATION**

A separate survey tool was designed, for interviews or self-administered questionnaires, to collect fish consumption information from each of the three targeted Sheboygan subpopulations. Each subpopulation was surveyed about the number of fish meals consumed by each member in their household, the sources of the fish meals, types of fish they consumed, and their self-reported awareness of the health-based fish consumption advisories.

#### ***Sheboygan River Anglers***

All anglers encountered along the lower Sheboygan River and Harbor were interviewed about their sport-fish consumption by WDNR creel clerks during the 1994 spring, summer, and fall creel surveys. The WDNR annually conducts a creel survey to collect information about sport fishing pressure and harvests in Wisconsin waters, that helps direct state fishery and stocking programs. The creel census is a statistically designed and validated survey that provides WDNR with information on Great Lakes fishing pressure, projected catch and harvest data, and size data on fish caught [20]. Angler's responses to WDNR creel census clerks are thought to be more accurate than reports to WDNR wardens because creel census surveys serve a non-regulatory function, creel clerks maintain a low-profile and non-enforcement role, and angler anonymity is maintained because the clerk does not inquire about the identity of the angler or ask for a valid fishing license. Following WDNR creel survey protocol, creel clerks conduct angler counts at specific locations at randomly selected times and, when an angler has finished fishing, they interview anglers about their fishing success and collect data of fish kept by the angler. However, the creel census does not typically gather information from anglers about their fish consumption practices. During the 1994 fishing season WDNR creel clerks expanded their interviews of Sheboygan River anglers to include questions about their fish consumption and awareness of the advisory.

The supplemental fish consumption survey was designed to collect information from anglers about: the number of sport-caught fish meals eaten per month; the types of fish caught; the location on the Sheboygan River where the angler catches fish; and the angler's awareness of the health-based fish consumption advisory. The final draft survey tool was developed and pretested during the spring

interviews of Sheboygan River anglers. Pretest results found the questionnaire design did not collect meal-specific information about the type and source of each fish meal consumed. The survey was modified to include a table that would allow the interviewer to record details of the source and type of fish for each fish meal reported. This table was adapted for use with the WIC and Hmong survey tools.

Creel clerks interviewed anglers about their fish consumption practices once per season; spring, summer, or fall. To avoid a repeat interview with an angler during the same season, creel clerks first asked each angler if they were previously interviewed during the current fishing season about their fish consumption. The interview was discontinued if the angler indicated they were previously interviewed. Anglers not previously interviewed were next asked if their household consumed fish. If an angler responded their household did not eat fish, the interview was discontinued. Anglers who reported their household ate fish were then asked to estimate the number of sport-caught fish meals consumed per month, the species of sport-caught fish consumed and the source of these fish. The creel clerk then recorded on the survey information about the angler's household (number of individuals, ages, and sex), and the angler's awareness of the fish consumption advisory.

There were 67 individual anglers interviewed on the Sheboygan River between April 3, 1994, and October 22, 1994, with 20 Spring anglers interviewed between April and May, 17 Summer anglers interviewed between June and August, and 30 Fall anglers interviewed between September and November. For the 20 Spring anglers, 17 reported that fish was eaten in their household and 3 reported no one in their household ate fish. Interviewers contacted 1 angler twice during the Spring season, but the second interview was suspended when the angler reported providing a previous Spring interview. For the 17 Summer anglers, 15 reported that fish was eaten in their household and 2 anglers reported no one in their household ate fish. Interviewers contacted 1 angler twice during the Summer season, but the second interview was suspended when the angler reported providing a previous Summer interview. All 30 Fall anglers interviewed reported that fish was eaten in their household. For the 3 Spring anglers and 2 Summer anglers who reported that no one in their household ate fish, once they identified their household non-fish consumption status, no additional questions were asked and the interview was terminated by the creel clerk.

### *Sheboygan WIC Households*

Sheboygan WIC participants were surveyed during visits to WIC certification clinics between May and August 1994 about their household's fish consumption practices. The WIC participants surveyed during these four summer months were anticipated to be a representative sample of Sheboygan WIC participants. Enrolled WIC program participants must be re-certified and return to the clinic every six months (except participating pregnant women need to be certified only once). During the summer of 1994, the Sheboygan WIC Program had a caseload of 1,500 participants. WIC participants, their parents, or legal guardians completed the WIC Fish-Consumption Questionnaire while enrolling at their first WIC visit or during a recertification visit. It should be noted that the WIC program allows most participants to return for a visit four times per year.



The WIC questionnaire was issued by a WIC clerk during a participant's certification/re-certification visit. The fish consumption survey was self-administered in a waiting room where participants stopped after the intake encounter and before proceeding to the next step of the visit. WIC participants were informed by the WIC clerk that responding to the survey was not mandatory nor required to maintain their eligibility in the WIC Program. The WIC clerk asked participants about the number of fish meals their household ate in the past 12 months. If the participant reported eating less than 12 fish meals per year the clerk recorded the number of meals and terminated the survey. Participants who ate 12 or more fish meals per year were issued the survey form. The participant then completed the self-administered portion of the survey. They responded to questions about: a) the number of fish meals consumed by a participant's household; b) the source of each fish meal; c) what types of fish were usually eaten; d) how each household's fish meals were prepared; and e) the respondent's awareness of the health-based fish consumption advisory for Lake Michigan and the Sheboygan River. After the survey was completed and returned, the WIC clerk reviewed the form for completeness, and checked the number of fish meals reported for the previous week. If the participant's household consumed any fish meals during the previous week, the clerk interviewed the participant and completed the table on the survey with specific information for each fish meal eaten.

Between May 23, 1994, and August 17, 1994, 435 Sheboygan County WIC consecutive participants received a self-administered survey at 41 WIC certification clinics, at the central office of the Sheboygan Human Services Agency, in Sheboygan. Of these 435 participants who received the questionnaire, 388 (89.2%) participants provided an answer to the first question regarding the number of fish meals eaten and 47 (10.8%) participants returned the survey without responding to the first question.

### ***Sheboygan Hmong Households***

One-quarter of an estimated 400 Sheboygan Hmong households were originally planned to be randomly selected and surveyed during the summer of 1994 about their fish consumption practices. The Sheboygan Hmong Mutual Assistance Association was approached to obtain their membership list from which to randomly select homes to be interviewed. The association reported there were an estimated 400 Hmong households in the Sheboygan area, but they declined DOH's request to use this membership mailing list and to provide specific information about the characteristics of the Sheboygan Hmong Community.

As a fall-back measure, a list of 168 Hmong households was generated from all Hmong surnames listed in the 1994 Sheboygan telephone book. Each household on the list was assigned a unique random number and sorted sequentially by the random number. The list was then divided into thirds, with each interviewer receiving a list of 56 households to be contacted. The interviewers then contacted homes during the fall of 1994, in the order households appeared on the list, to request an interview. If they were unable to contact a household member and arrange an interview, the interviewer proceeded to contact the next home on the list. Interviewers could make several efforts to re-contact these homes at a later date in order to arrange an interview. Interviews were conducted

between October 1994 and March 1995. Interviewers conducted the interview in either Hmong or English, based on the language preference of household. Surveys were available in both Hmong or English.

At the beginning of the interview the member of the Hmong household who agreed to be surveyed was asked about the length of time lived in Sheboygan, other places they have lived, the age and sex of every household member, the number of children in the household who were born in Sheboygan, and their familiarity with the fish consumption advisory for the Sheboygan River. Respondents of households where 12 or more fish meals were consumed per year were asked about the type and source of the fish they eat. The interview was discontinued for households that ate fewer than 12 fish meals per year. The survey collected information about: a) the number of fish meals the household typically consumed; b) the number of fish meals consumed the week prior to the interview; c) where the fish typically came from; d) what types of fish they ate; e) how fish meals were usually prepared; and f) the interviewee's awareness of health advisories affecting fish from the Sheboygan River. The survey was administered to the study participant usually in their home.

Between October 21, 1995, and March 8, 1995, members of 106 Sheboygan Hmong households were interviewed about their fish consumption practices. These 106 households comprise 63.1 percent of the 168 households that were contacted by interviewers, and approximately 26.5 percent of the estimated 400 Hmong households in the Sheboygan area. We are unable to determine to what extent these 106 are representative of all Sheboygan area Hmong households because comparative information about the larger Sheboygan Hmong community is not available.

## **INTERVIEWERS**

Three WDNR creel clerks, who were responsible for the Sheboygan River, were trained to administer the supplemental questionnaire. One WIC clerk was hired and trained to administer the WIC fish consumption questionnaire. Three Hmong interviewers were recruited through contacts with the Sheboygan County Health Department, and trained to administer the questionnaire to the Hmong subpopulation.

## **HEALTH EDUCATION**

At the end of each interview or survey, interviewees received health education information about ways to minimize their exposure to contaminants in sport-caught fish. The packet included WDNR's *Health Guide for People Who Eat Sport Fish from Wisconsin's Waters* [2], an information card summarizing the health-based fish consumption advisory for the Sheboygan River and Lake Michigan (English and Hmong), and a WDNR fish identification poster. For persons contacted through WIC, the packet also included information about cleaning fish. Each Hmong household received a color map of the Sheboygan area that identifies nearby lakes or rivers that have fish known to be unsafe. These health education activities were in accordance with ATSDR's Health Activities Recommendation Panel, resulting from their review of the Public Health Assessment for the Sheboygan Harbor and River.

## **DATA PROCESSING AND ANALYSIS**

Data collected from surveys and interviews were entered in three separate data files using CDC's Epi-Info, version 6. Descriptive statistics were performed using Epi-Info's Analysis component to describe the distribution, median, and mean of responses, particularly the level of fish consumption and the awareness of the fish consumption advisory. Logistic regression was conducted using SAS to examine the association, for the Hmong subpopulation, between awareness of the health-based fish consumption advisory and the length of residency in Sheboygan.

## **RESULTS**

A total of 561 individuals were surveyed to determine the fish consumption habits of the three subpopulations in the Sheboygan area: 67 Sheboygan River anglers; members of 106 Hmong households; and 388 WIC participants. Table 1 summarizes the annual mean and median fish meals eaten by each subpopulation.

### **SHEBOYGAN RIVER ANGLERS**

A total of 67 Sheboygan River anglers were interviewed. These anglers were predominantly male (85.2% male, 7.4% female, and 7.4% unknown) and white (86.6% White, 6.0% Black, 0.0% Asian, and 7.4% unknown), with a mean age of 39.4 years, and lived in a mean household size of 2.8 individuals. Creel clerks did not record information about the interviews that were discontinued when anglers reported they either did not eat fish or if they were previously interviewed during the current fishing season.

The mean annual fish meals consumed by the 67 surveyed Sheboygan River anglers was 26.0 (median of 24), with the number of meals ranging from 12 to 120. The anglers fished an average of 8.2 times per month and 76.2% of these anglers were aware of the fish advisory. During the summer and fall fishing seasons, rainbow trout was reported the most frequently eaten fish (24.8%), although during the spring season yellow perch was the most frequently eaten fish (50.0%). Lake Michigan was the location most frequently fished by Sheboygan River anglers interviewed during the spring (47.4%), but the Sheboygan River was fished most frequently by summer and fall anglers (47.2% and 37.7%, respectively) (Table 2).

During the summer and fall fishing seasons, 37 of a total of 111 fish meals reported by 47 Sheboygan anglers were identified as originating from the Sheboygan River or Harbor. Of these 37 Sheboygan fish meals, only 1 was a resident species (bass) (Table 3). One angler interviewed in July reported eating a fish meal of smallmouth bass from the Sheboygan River and was unaware of the fish consumption advisory. Resident species, which live their entire life in the Sheboygan River, have been found with higher PCB concentrations than migratory salmonids that spend much of their life cycle in Lake Michigan. No other summer or fall anglers reported eating resident fish from the Sheboygan River or Harbor and salmonid species comprised all of the remaining 36 fish meals. There were 6

spring anglers who indicated they frequently fished the Sheboygan River. All of these spring anglers typically ate either salmon or trout, with one angler eating yellow perch.

### **SHEBOYGAN WIC PARTICIPANTS**

The survey was issued to 435 WIC participants, with 388 participants responding to the first question about the number of fish meals they recently ate and 47 participants returning the survey with the first questions unanswered, with the survey disregarded for the 47 participants who did not respond to the first question. These 388 WIC participants were overwhelmingly women (95.1% female, 4.1% male, and 0.8% unknown), mostly White (65.0% White, 22.7% Asian/Pacific Islander, 8.5% Hispanic, 0.7% Black, 0.3% American Indian, and 2.8% unknown), and were from a mean household size of 4.7 individuals. For the 388 WIC respondents, 79 (18.2%) consumed less than 12 fish meals over the past twelve months, and the survey was discontinued for these individuals. The remaining 309 respondents (71.0%) estimated they consumed 12 or more fish meals in the past twelve months.

The 388 WIC participants consumed of 34.8 mean and 24 median fish meals per year (ranging 0 to 300 annual fish meals), with 309 participants, who completed the full survey, consuming 12 or more fish meals in the past year, for 42.7 mean annual fish meals. For those who consumed 12 or more fish meals in the past year, 27.5% previously ate Lake Michigan fish, 59.2% never ate Lake Michigan fish, and 13.3% were not sure about consuming fish from Lake Michigan. These 309 respondents consumed less fish from the Sheboygan River and Harbor than Lake Michigan, with 11.3% reporting they consumed fish from the Sheboygan River or Sheboygan Harbor, 79.0% never eating fish from the river or harbor, and 9.7% were not sure.

There were 160 WIC participants who ate at least one fish meal the week prior to being surveyed and they reported eating 72.8 annual mean fish meals (11.0 annual mean sportcaught fish meals). The four most frequently eaten types of fish were not sportcaught, with tuna accounting for 33.8% of total fish meals (Table 4). The most common source of fish, 72.9%, was from a store (Table 5).

Of those 309 WIC respondents who ate 12 or more annual fish meals, 11.3% reported they had consumed fish from the Sheboygan River or Sheboygan Harbor. Of the 35 respondents who reported consuming fish from the Sheboygan River or Harbor, 15 said they ate a fish meal at least once per week. Of the 35 Sheboygan fish consumers, 22 reported eating at least one fish meal in the week prior to completing the survey. Twelve of these respondents ate 2.9 mean fish meals per week (152 meals per year), and 2 of the 22 Sheboygan fish eaters said that a previous week's fish meal came from the Sheboygan River or Harbor (Table F). One respondent ate a meal of trout that came from the Sheboygan River, while the other was not sure about the type of fish that they ate.

Overall, 44.7% of WIC participants, who ate 12 or more annual fish meals (n=309), were aware of the fish advisory for the Sheboygan River and Harbor (Table 7). A slightly higher level of fish advisory awareness (51.4%) was observed for the 35 WIC participants who eat Sheboygan River

fish. For the WIC participants who ate fish from Lake Michigan during the previous week (n=85), 48.2% reported they were aware of the advisory. Of the WIC participants who ate fish the week prior to being surveyed (n=202), 48.8% were aware of the Sheboygan River fish advisory.

## **SHEBOYGAN HMONG**

The 106 interviewed Hmong respondents reported their households consumed a estimated 2,290 fish meals during the previous year, for 21.6 annual mean and 12 median fish meals (ranging from 0 to 208 annual fish meals) (Table 1). For these households, 5.7% (6 of the 106 respondents) reported they did not eat any fish meals during the previous year, 28.3% ate between 1 and 11 fish meals per year, 52.8% households ate between 12 and 51 fish meals per year, and 13.2% ate 52 or more fish meals per year. One household estimated eating 208 fish meals per year, the highest annual level of consumption observed in this study. These individuals reported their mean households size was 6.8 individuals.

Fifty-one Hmong respondents reported they ate sport-caught fish meals, for an annual 25.7 mean and 18 median sport-caught fish meals. There were 18 different sources of fish cited by the 100 Hmong respondents that ate fish, with Lakes Winnebago (48.2%) and Michigan (17.8%) the most frequently cited sources. Fish obtained from stores and restaurants were cited as the third and fourth most common sources of meals (18.8%) (Table 8). These 100 respondents described eating 18 different species of fish, with whitebass and smelt as the first and second most frequently eaten species (Table 9).

For the 100 households that consumed fish, 18 households ate at least one fish meal during the previous week. These 18 households accounted for a total of 27 fish meals consumed during the previous week (Table 10), with 20 of the fish meals coming from a store and 7 being sport-caught.

Three individuals reported they eat fish from the Sheboygan River or Harbor. None reported eating fish during the week prior to the interview. Two of these households estimated eating fish 12 and 18 times per year. The third household reported eating an estimated 104 fish meals per year. One of these two households reported not being aware of the Sheboygan River fish advisory. The types of fish eaten by these three households were chinook salmon and whitebass.

For the 106 Hmong interviewees, 46.2% self-reported awareness of the Sheboygan River fish consumption advisory. There were gender differences for self-reported awareness of the fish consumption advisory. Hmong women had the highest awareness of the fish consumption advisory (59.4%), compared to 35.0% when only men were interviewed, and 30.7% when men and women interviewed together. This difference between Hmong women and men was not statistically significant ( $p=0.05$ ).

For the 106 Hmong interviewees, 54.7% lived in Sheboygan less than four years, with an overall average of 4.8 years in Sheboygan. Logistic regression analysis showed those families who lived in Sheboygan four or more years are 3.5 times more likely to be aware of the fish advisory than families who have lived in Sheboygan less than four years (95% CI 1.85<x<6.62). The relative risk

(odds ratio) of claiming to be aware of the advisory increases by a factor of 1.32 for each additional year of residence in the Sheboygan area (95% CI 1.15<x<1.53).

## DISCUSSION

### FISH CONSUMPTION

The fish consumption behavior of the three Sheboygan subpopulations was similar to that found in a larger Great Lakes sport-fish consumption study conducted by Tilden, et al [7]. Sheboygan WIC and Hmong households reported eating 34.8 and 21.6 mean and 12 and 24 median annual fish meals, respectively, which are less than the 28.8 median annual fish meals eaten reported for 8,078 Great Lakes residents surveyed by telephone interviews. Store-bought fish comprised 73.8% of fish meals eaten by WIC households, which is above the 60.6% of non-self-caught fish meals eaten by Michigan licensed anglers [14]. Regarding the number of annual sport-caught fish meals, WIC households ate 11.0 mean and 12 median, Hmong households ate 25.7 mean and 18 median, and Sheboygan anglers ate 26.0 mean and 24 median, each less than the median 34.8 annual sport-caught fish meals reported for Great Lakes fish eaters by Tilden.

The majority of each subpopulation does not eat resident fish caught from the Sheboygan River. However, each subpopulation had one or two individuals who reported they ate resident fish from the river. Anglers reported that 37 of 111 fish meals came from the Sheboygan River and Harbor, with 36 fish meals of migratory species and one fish meal was bass, a resident species (Table 3). For WIC households there were 2 of 225 fish meals from the Sheboygan River, with one meal a lake-run species and the other meal an unknown species (Table 6). However, there were three WIC participants who said while their household did not eat fish from the Sheboygan River during the week prior to being surveyed, that they did occasionally eat resident fish from the Sheboygan River. Over 81 percent of fish meals consumed by WIC households were not sport-caught. No Hmong households reported eating a Sheboygan River fish meal during the week prior to being interviewed, but three households indicated they have eaten fish from the river in the past. Additionally, two Hmong households commented that they did eat crayfish and smaller, minnow-sized fish from the Sheboygan River. Hutchinson reported that the Sheboygan River was fished by 24.7% of surveyed Sheboygan Hmong households [19]. Additionally, the Sheboygan River was where 12.5% and 19.4% of Hmong households fished for smallmouth bass and carp species, respectively.

This investigation did not identify a substantial segment of the targeted subpopulations that are exposed to PCB-contaminated fish that reside in the Sheboygan River. Consequently, analysis of PCBs in biologic samples from members of the three targeted Sheboygan subpopulations would probably not yield new information about PCB body burdens and fish consumption. Less than one percent of each subpopulation is exposed to elevated levels of PCBs from eating sport-caught resident fish from the Sheboygan River. Additionally, the targeted subpopulations eat amounts of Lake Michigan fish that is similar to other Great Lakes populations that were investigated for their PCB body burdens and fish consumption. Fish from Lake Michigan comprised 46.9% of fish meals

consumed by anglers and 5.3% of fish consumed by WIC households, with no Hmong households eating fish from the Sheboygan River or Lake Michigan. Fiore found a mean PCB congener sum of 2.2  $\mu\text{g/L}$  for the 159 Wisconsin anglers who provided blood samples, with all surveyed 801 anglers consuming 19.8 mean annual sport-caught fish meals. Hovinga [21] surveyed 115 consumers of Great Lakes fish and found they eat 38.0 mean annual meals of sport caught fish, with a mean serum PCB concentration of 19.0  $\mu\text{g/L}$ . We estimate a comparable PCB exposure for Sheboygan River anglers, given they eat a similar annual average of sport-caught fish meals, and a lower PCB exposure for Sheboygan WIC participants and Sheboygan Hmong households. Furthermore, DOH is completing a five-year follow-up investigation of the cohort examined in the Fiore study. In addition, DOH is currently studying the PCB body burdens of Great Lakes charter boat captains, who consume Great Lakes sport-caught fish meals more frequently than the three targeted subpopulations in the current study. Consequently, there would be little additional benefit in evaluating the PCB body burdens of the three Sheboygan subpopulations.

### **HEALTH ADVISORY AWARENESS**

Each of the three Sheboygan subpopulations exhibited a degree of awareness of the fish consumption advisory that is comparable to other populations. Sheboygan River anglers had a 76.2% self-reported awareness of the fish consumption advisory, which is slightly less than the 85% awareness observed by Fiore in 1986 for licensed Wisconsin anglers [6]. The prevalence of self-reported advisory awareness measured for WIC participants (44.6%) and Hmong households (46.2%) is slightly less than the overall 49.9% awareness cited by Tilden for Great Lakes fish eaters [7]. However, over 95% of responding WIC participants were women and Tilden found that women have a lower advisory awareness (39.1%) than men (52.1%). Tilden also found that non-whites were less aware of fish consumption advisories than whites (22.1% and 52.1%, respectively). Gender and race factors could contribute to this lower awareness.

A sizable portion of each of these three subpopulations are unaware of the fish consumption advisories and are more likely to eat contaminated fish from the Sheboygan River. Consequently, there is a need for continued public education about the fish consumption advisories for both the Great Lakes and the Sheboygan River. Recently arrived Hmong families are particularly in need of such education, given their lower degree of awareness of the fish consumption advisories. Public health interventions to increase awareness of the fish consumption advisories should be targeted at subpopulations that are known or suspected of consuming PCB-contaminated fish.

### **STUDY LIMITATIONS**

#### ***Sheboygan Anglers***

There are several limitations with the investigation for Sheboygan River anglers. The modification of the survey design between the spring and summer 1994 fishing seasons allows only limited data comparisons. Because of the small number of anglers interviewed, it is difficult to generalize the results to the total subpopulation of Sheboygan River anglers. Of the 67 anglers interviewed, 5 reported that they did not eat fish and the interview was ended. The lack of

information about these 5 anglers decreases the confidence for generalizing the responses to all Sheboygan River anglers. However, the identification and selection of anglers for interviews was based on WDNR Creel Survey protocol [20], which was designed to obtain a representative sample of anglers encountered at a specified fishery.

Anglers were surveyed only about their monthly sportfish consumption, and information was not collected about their total fish consumption, which permitted limited comparisons with data collected from the Hmong and WIC subpopulations. The absence of this data may decrease the confidence in generalizing information from those interviewed to the entire population of Sheboygan River anglers.

### ***Sheboygan WIC Participants***

WIC participants completed the most of the survey by themselves, without the benefit of an interviewer. Findings may differ between self-administered questionnaires and interviewer-assisted surveys.

Interviews were discontinued for WIC participants who reported they ate less than 12 fish meals per year. As a result, the level of awareness of the fish consumption advisories is attributable only to WIC participants who said they consumed 12 or more annual fish meals. WIC participants who consumed less than 12 annual fish meals may have a dissimilar awareness of the fish consumption advisories than those who eat fish more frequently. WIC participants who consumed fewer annual fish meals could be practicing their greater knowledge of the fish consumption advisories.

### ***Hmong Households***

The Sheboygan Hmong community has been subjected to several communications efforts to bring to their attention the specifics of the fish consumption advisory, which makes it difficult to generalize results with other Midwest Hmong communities.

A self-reporting bias may have an unknown effect on the answers given by Hmong respondents. Concern was raised by Hmong interviewers and others familiar with the Hmong community, that Hmong respondents may alter their responses in order to match what they perceive an interviewer wishes to hear. Such a phenomena may possibly have been a factor with some of the 106 household interviews.

Many of the interviewed Hmong households stated they were previously interviewed for a very similar investigation during March 1994, and they had many unanswered questions about the previous and current survey. This previous survey contacted 125 Hmong homes in the Sheboygan area over a two-week period and was conducted by a sub-contractor of a corporation identified as potentially responsible for the contamination in the Sheboygan River. Little or no information about contaminated fish was provided during the previous investigation. Some of the previously interviewed



households commented that they thought the previous and ATSDR-funded surveys were affiliated. At these households, a large amount of time was required to answer additional questions.

Hmong surveys were conducted between October and March, when the least amount of sport-caught fish is consumed (during winter months Wisconsin lakes are frozen and ice fishing is not reported to be very popular with Hmong). This finding may have resulted in lower number of fish meals reported for the week prior to being surveyed. It may have also resulted in a lower estimate of annual fish meals, possibly due to recall bias. The 21.6 mean annual number of fish meals for Hmong households is lower than that observed for WIC participants and for sport-caught fish meals by anglers, and possibly reflects the time of year the survey was conducted.

The list of Hmong households that were surveyed was generated from the Sheboygan telephone directory, which may substantially limit the generalizability of these findings to all Sheboygan Hmong households. Sheboygan Hmong who are not listed in the telephone directory (either with unlisted numbers or households without a telephone) may have different fishing or fish consumption practices than those households who are listed in the directory. Several factors (e.g. economic) could result in increased fishing and fish consumption by a household. Recent immigrants to Sheboygan could be less likely to have a telephone, be less aware of the fish advisory, and might eat fish more frequently, particularly those caught from the Sheboygan River.

## CONCLUSIONS

1. The levels of fish meals consumed among each of the three Sheboygan subpopulations was comparable to that of other groups of fish consumers in the Great Lakes region.
2. For the majority of the three subpopulations, fish that reside in the Sheboygan River constitute a small proportion of the total fish meals eaten. Less than one percent of each of the three Sheboygan subpopulations regularly ate contaminated fish from the Sheboygan River and may have been exposed to PCBs at levels of health concern.
3. Each of the three Sheboygan subpopulations self-reported an awareness of the health-based fish consumption advisories similar to other Great Lakes populations.
4. Sizeable proportions of each subpopulation were unaware of the health-based fish consumption advisories.
5. While 46.2% of the Sheboygan Hmong community are aware of the Sheboygan River fish consumption advisory, those Hmong families who recently arrived in Sheboygan had a significantly lower awareness of the fish consumption advisory than those families who have been in Sheboygan four or more years.

## RECOMMENDATIONS

1. Biologic sampling to characterize the PCB exposures of the three Sheboygan subpopulations, is not warranted because almost none of these subpopulations eat resident fish from the Sheboygan River and each subpopulation consumes amounts of non-Sheboygan fish similar to other Great Lakes populations, for whom biologic monitoring data is available.
2. Continuing education about the fish advisory is justified because some people are unaware of the advisories and several households continue to eat contaminated fish from the Sheboygan River.
3. A special education effort needs to be directed towards reaching Hmong families who recently arrived in Sheboygan because they are less aware of the health-based fish consumption advisories, particularly for the Sheboygan River.

## REFERENCES

1. Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Public Health Service, Department of Health and Human Services. Public Health Assessment for Sheboygan River and Harbor, Sheboygan County, Wisconsin. Public Comment Release. CERCLIS No. WID980996367. Atlanta, Georgia: ATSDR. April 29, 1994.
2. Wisconsin Department of Natural Resources. Important Health Information for People Eating Fish from Wisconsin Waters. PUB No. FH924 97. Madison, Wisconsin: WDNR. 1997.
3. Blasland and Bouck Engineers, PC. Alternative specific remedial investigation monthly progress reports: Sheboygan River and Harbor (1992-1994). Prepared for Foley and Lardner/Tecumseh Products Company. Syracuse, New York: Blasland and Bouck. 1994.
4. ATSDR. Toxicological Profile for Selected Polychlorinated Biphenyls. T.P.-92/16. Atlanta, Georgia: ATSDR. April 1993.
5. Humphrey, HD. Population Studies of PCBs in Michigan Residents. In: PCBs, Human and Environmental Hazards. (D'Itri FM, Kamrin, MA, eds). Ann Arbor, MI: Ann Arbor Science Publishers, 1983:299-310.
6. Fiore, BJ, Anderson, HA, Hanrahan, LP, Olson, LJ, and Sonzogni, WC. Sport fish Consumption and Body Burden Levels of Chlorinated Hydrocarbons: A Study of Wisconsin Anglers. Arch Environ Health, 44(2):82-88, March/April 1989.
7. Tilden JD, Hanrahan L, Anderson HA, Palit C, Olson J, and MacKenzie W. Health Advisories for Consumers of Great Lakes Sport Caught Fish: Is the Message Being Received? Environmental Health Perspectives, 105(12). December 1997.
8. Dar E, Kanarek MS, Anderson HA, and Sonzogni WC. Fish Consumption and Reproductive Outcomes in Green Bay, Wisconsin. Environ Res, 59:189-201, 1992.
9. Smith, JB. PCB Levels in Human Fluids: Sheboygan Case Study. Technical Report WI-SG-83-240. Madison, Wisconsin: University of Wisconsin Sea Grant Institute. 1984.
10. Fein GG, Jacobson JL, Jacobson SW, Schwartz PM, and Dowler JK. Prenatal Exposure to Polychlorinated Biphenyls: Effects on Birth Size Gestational Age. J Pediatr, 105(2): 315-320, August 1984.
11. Jacobson JL, Jacobson SW, and Humphrey HEB. Effects of In Utero Exposure to Polychlorinated Biphenyls and Related Contaminants on Cognitive Functioning in Young Children. J Pediatr, 116(1):38-45, January 1990.

12. Jacobson JL, Humphrey HEB, Jacobson SW, Schantz SL, Mullin MD, and Welch R. Determinants of Polychlorinated Biphenyls, Polybrominated Biphenyls, and Dichlorodiphenyl Trichloroethane Levels in the Sera of Young Children. *J Amer Public Health*, 79(10):1401-1404. October 1989.
13. Mead & Hunt, Inc. Fish Consumption Survey for the Sheboygan River, Sheboygan Wisconsin. Appendix B: Fall 1993. Appendix C: Spring 1994. Risk Assessment for the Sheboygan River, Sheboygan County, Wisconsin. Prepared by Environ Corporation for Tecumseh Products Company, Sheboygan Falls, Wisconsin. Princeton, NJ: Environ Corp. August 1995.
14. Murray DM and Burmaster DE. Estimated Distributions of Average Daily Consumption of Total and Self-Caught Fish for Adults in Michigan Angler Households. *Risk Anal*, 14(4):513-519, August 1994.
15. Connelly NA, Knuth BA, and Vena JE. New York State Angler Cohort Study: Health Advisory Knowledge and Related Attitudes and Behavior, With a Focus on Lake Ontario. Human Dimensions Research Unit, Department of Natural Resources, Cornell University. HDRU Series No. 93-9. Ithaca, New York: Cornell University. September 1993.
16. Tilden JD, et al. Great Lakes Fish Consumption: A Point-In-Time Survey. Unpublished Paper. July 1995.
17. Wisconsin WIC Program. Operational Manual for the Wisconsin WIC Program (Supplemental Nutritional Program for Women, Infants, and Children). State of Wisconsin, Department of Health and Social Services. Madison, Wisconsin: DHSS. March 1991.
18. Hutchison R and Kraft CE. Hmong Fishing Activity and Fish Consumption. *J Great Lakes Res*, 20(2):471-478, 1994.
19. Hutchison R. Fish Consumption by Hmong Households in Sheboygan Wisconsin. Appendix A: Risk Assessment for the Sheboygan River, Sheboygan County, Wisconsin. Prepared by Environ Corporation for Tecumseh Products Company, Sheboygan Falls, Wisconsin. Princeton, NJ: Environ Corp. August 1995.
20. Wisconsin Department of Natural Resources. A Manual for Creel Clerks and Contest Monitors. Undated Report.
21. Hovinga ME, Sowers M, and Humphrey HEB. Environmental Exposure and Lifestyle Predictors of Lead, PCB, and DDT Levels in Great Lakes Fish Eaters. *Arch Environ Health*, 48(2):98-104. March 1993.

## **AUTHOR**

Henry Nehls-Lowe, MPH  
Epidemiologist  
Health Hazard Evaluation Unit  
Bureau of Public Health  
Division of Health  
Wisconsin Department of Health & Social Services

## **ACKNOWLEDGMENTS**

The assistance and cooperation of many individuals and agencies were necessary in order to make this investigation possible. A special thanks to the WDNR Fisheries Management program for providing additional funding during 1994 that enabled the three-season creel census of the Sheboygan River. The author wishes to express his gratitude to: Jan Tjaden, Director of the Sheboygan County Human Services Agency; Jean Beinemann and Marilyn Voskuil, at the Sheboygan County WIC Program; Chao Yang, Chou Vang Yang, and Mailee Lee, Hmong Interpreters and Interviewers in Sheboygan; Candy Schrank and Jim Amrhein, Toxicologists with the WDNR Central Office; Brad Eggold, Fisheries Biologist at the WDNR Plymouth Field Office; John Tucker and Andrew Watkins, Creel Clerks at the WDNR Plymouth Field Office; and staff with the Health Hazard Evaluation Unit, Bureau of Public Health, Wisconsin Department of Health and Social Services. Betty Phifer was the Project Officer for this study from the U.S. Agency for Toxic Substances and Disease Registry.

**TABLES**

Table 1—Distribution of Annual Fish Meals Of Sheboygan Subpopulations  
April 1994 to March 1995

Subpopulation	Number in Group	Mean Annual Fish Meals	Median Annual Fish Meals
<b>All Fish Meals</b>			
Hmong	106	21.6	12
WIC Participants	388	34.8	24
<b>Sport-caught Fish Meals</b>			
Sheboygan River Anglers	67	26.0	24
Hmong	51	25.7	18
WIC Participants	160	11.0	12

Table 2—Most Frequently Fished Locations Sheboygan River Anglers  
April to November 1994

LOCATION	SEASON			TOTAL (n=67)
	SPRING (n=20)	SUMMER (n=17)	FALL (n=30)	
Sheboygan River	14.4%	47.2%	37.7%	39.5%
Sheboygan Harbor	4.1%	12.3%	18.0%	9.7%
Lake Michigan	47.4%	13.8%	13.1%	18.8%
Lake Winnebago	0.0%	7.1%	9.8%	4.4%
Other	34.1%	19.7%	21.3%	27.7%



Table 3—Type Sport-Caught Fish Meal by Source Summer & Fall Sheboygan River Anglers  
June to November 1994

(n=47)

FISH MEAL	SOURCE OF FISH				TOTAL
	Sheboygan River	Sheboygan Harbor	Lake Michigan	Other Locations	
Trout	19	8	6	8	41
Salmon	7	2	6	3	18
Walleye				11	11
Yellow Perch			2	7	9
Bass	1			9	10
Panfish				7	7
Other			1	14	15
TOTAL	27	10	15	59	111

Table 4—Number and Type of Fish Meals Reported by Sheboygan WIC Participants  
Who Ate Fish During Week Prior to Completing Survey June-August, 1994

(n=160)

Type of Fish Eaten	Number of Fish Meals	
Tuna	76	33.8%
Perch	23	10.2%
Haddock	14	6.2%
Cod	10	4.4%
Trout	10	4.4%
Smelt	8	3.6%
Bass	9	4.0%
Salmon	7	3.1%
White Bass	7	3.1%
Panfish	3	1.3%
Catfish	2	0.9%
Walleye	2	0.9%
Other	23	10.2%
Unspecified	27	12.0%
Not Sure	4	1.8%
TOTAL	225	

Table 5—Number and Sources of Fish Meals Reported by Sheboygan WIC Participants Who Ate Fish During Week Prior to Completing Survey June-August, 1994

(n=160)

Source of Fish Meals	Number of Fish Meals	
Store	164	72.9%
Restaurant	20	8.9%
Lake Winnebago	13	5.8%
Lake Michigan	10	4.4%
Sheboygan River & Harbor	2	0.9%
Other Lake	5	2.2%
Other River	1	0.4%
Other Source	10	4.4%
<b>TOTAL</b>	<b>225</b>	

Table 6—Source and Types of Fish Meals Reported By Sheboygan WIC Participants Who Ate Fish During Week Prior to Completing Survey June to August 1994

(n=160)

FISH MEALS	SOURCE OF FISH					TOTAL
	Sheboygan River & Harbor	Lake Michigan	Lake Winnebago	Store	Other	
Trout	1	5		1	3	10
Salmon		2		4		6
Smelt		3		2	3	8
Bass			7		2	9
White Bass			6		1	7
Panfish					3	3
Tuna				76		76
Other	1			81	24	106
<b>TOTAL</b>	<b>2</b>	<b>10</b>	<b>13</b>	<b>164</b>	<b>36</b>	<b>225</b>

Table 7—Awareness of Sheboygan Fish Consumption Advisory By Sheboygan WIC Participants Who Consumed  $\geq$  12 Annual Fish Meals June-August, 1994

Respondent Category	Prevalence of Advisory Awareness	
WIC Respondents Consuming $\geq$ 12 Annual Fish Meals	44.7%	n=309
WIC Respondents Consuming $\geq$ 12 Annual Fish Meals and Ate Fish During Previous Week from any Source	48.8%	n=202
WIC Respondents Consuming $\geq$ 12 Annual Fish Meals and Ate Fish During Previous Week From Lake Michigan	48.2%	n=85
WIC Respondents Consuming $\geq$ 12 Annual Fish Meals and Ate Fish During Previous Week From Sheboygan River	51.4%	n=35

Table 8—Reported Sources of All Fish Meals by Sheboygan Hmong Respondents October 1994 to March 1995

(n=100)

Source of Fish Meals	Reported Frequency	
Lake Winnebago	92	48.2%
Lake Michigan	34	17.8%
Store	23	12.0%
Restaurant	13	6.8%
Two Rivers	6	3.1%
Sheboygan River	3	1.6%
Other Sources	15	20.4%
Not Sure	2	1.0%
No Response	3	1.6%
<b>TOTAL</b>	<b>191</b>	

Table 9—Types of Fish Eaten by Sheboygan Hmong Respondents  
October 1994 to March 1995

(n=100)

Type of Fish Meals	Reported Frequency	
White Bass	85	39.9%
Smelt	40	18.7%
Catfish	16	7.5%
Trout	9	4.2%
Bass	8	3.8%
Bullhead	7	3.3%
Salmon	4	1.9%
Carp	6	2.8%
Other	7	3.3%
Not Sure	29	13.6%
No Response	2	0.9%
<b>TOTAL</b>	<b>213</b>	

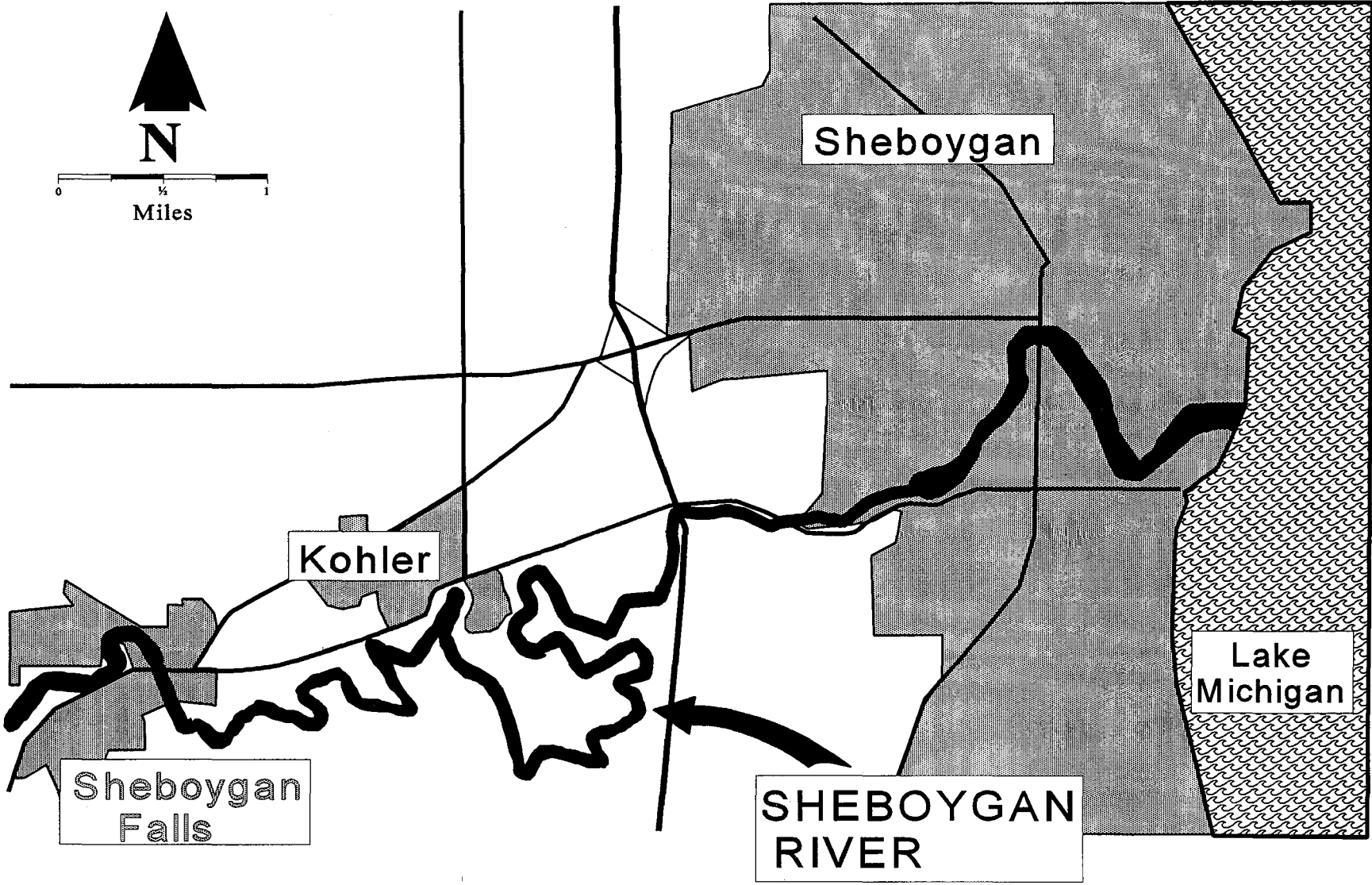
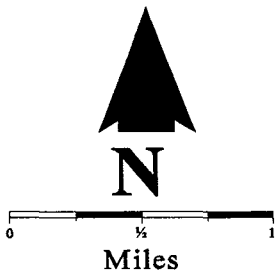
Table 10—All Fish Meals by Source Sheboygan Hmong Households Who  
Ate Fish During Week Prior to Completing Survey November 1994 to March 1995

(n=18)

FISH EATEN	SOURCE OF FISH		
	Lake Winnebago	Store	TOTAL
White Bass	7	7	14
Whitefish	0	5	5
Not Sure	0	8	8
<b>TOTAL</b>	<b>7</b>	<b>20</b>	<b>27</b>

**APPENDICES**

**Appendix A—Sheboygan Area Map**



A-3

MMDD				HHMM			
(Military Time)							

Have you been surveyed this FALL about eating fish by someone from the DNR?

- Yes - If yes, check box and discontinue survey.
- No - If no, continue with question "2" below.

Do you or your household eat fish?

- Yes - If yes, continue with "2b".
- No - If no, check box and discontinue survey.

If yes, about how many meals of SPORT-CAUGHT FISH do you eat per month?

\_\_\_\_\_ meals per month

Of these meals, what types of fish do you usually eat?

(Write in under the column, "NO. OF FISH MEALS", in the table below. Also, write in any fish eaten that are not already listed.)

Where do you usually catch each of these fish? (In the table below, by the type of fishes, write in number of meals per month, under the place fished.)

During the SUMMER, how often do you go usually go fishing each month?

\_\_\_\_\_ times per month

3 b. Where are the places you usually fish and how often do you fish there each month? (In the bottom row of the table, "How Often Do They Fish Here?", write in the number of times per month they fish at each of these places. This does not need to match the total number of fish meals caught from this place.)

4 a. How many people live in your household?

Age of Each Male: \_\_\_\_\_

Age of Each Female: \_\_\_\_\_

4 b. What is your age? \_\_\_\_\_

What is the angler's sex?  M  F

(Remember to ask if the angler is fishing with any other members of their HOUSEHOLD. If they are, then do not interview these other household members.)

5. Are you aware of the Wisconsin Health Advisory about eating fish that you catch?

- No  Yes

6. Some fish contain chemical contaminants. Certain fish from the Sheboygan River are known to have particularly high levels of PCBs. The Wisconsin Division of Health is investigating to discover if any people are eating these fish. The Division of Health will evaluate your answers to this questionnaire. If you are interested in receiving a written evaluation about the potential health consequences of your eating fish, please complete and mail in this card. All information will be kept confidential.

If interested, ask the angler to complete and mail in the card.

a. Have you surveyed this angler about eating fish on the Sheboygan River before this year?  Yes

b. What do you think is this angler's Race?  
 White  Black  Hispanic  Asian  Other \_\_\_\_\_

c. Comments:

	NO. OF FISH MEALS	Sheboygan River	Sheboygan Harbor & Pier	Milwaukee River	Lake Michigan	Lake Winnebago
Coho Salmon						
Chinook Salmon						
Brown Trout						
Rainbow Trout						
Sm/Lrg Mouth Bass						
Northern Pike						
Yellow Perch						
Walleye						
Whitebass						
Pan Fish/Bluegills						
How Often Do They Fish Here?						





In the LAST WEEK did you or your family eat fish at any meals? This includes fresh, canned, or frozen fish.

- Yes
- No (If no, please skip to question 9)
- I'm Not Sure / Don't Know

If yes, how many meals of fish did you eat in the last week? \_\_\_\_\_

How many of these fish meals came from a store? \_\_\_\_\_

How many of these fish meals were SPORT-CAUGHT (caught with a fishing pole)? \_\_\_\_\_

How many of these fish came from another source? \_\_\_\_\_

What was this source? \_\_\_\_\_

What kinds of fish did you eat during this past week? (*check all that apply*)

- |  |  |
|--|--|
| <input type="checkbox"/> Lake Trout              | <input type="checkbox"/> Perch                                 |
| <input type="checkbox"/> Brown Trout             | <input type="checkbox"/> Smelt                                 |
| <input type="checkbox"/> Rainbow Trout/Steelhead | <input type="checkbox"/> Walleye                               |
| <input type="checkbox"/> Trout: type not known   | <input type="checkbox"/> Bass (both Largemouth and Smallmouth) |
| <input type="checkbox"/> Chinook Salmon          | <input type="checkbox"/> Northern Pike                         |
| <input type="checkbox"/> Coho Salmon             | <input type="checkbox"/> Bluegill/Crappie/Panfish              |
| <input type="checkbox"/> Salmon: type not known  | <input type="checkbox"/> Store bought: type _____              |
| <input type="checkbox"/> Catfish                 | <input type="checkbox"/> Other _____                           |
| <input type="checkbox"/> Carp                    | <input type="checkbox"/> I'm Not Sure / Don't Know             |

Where did these fish come from? (*check all that apply*)

- Sheboygan River or Harbor
- Other River: \_\_\_\_\_
- Lake Michigan
- Lake Winnebago
- Other Lake: \_\_\_\_\_
- Store bought
- Restaurant
- Other Source: \_\_\_\_\_
- I'm Not Sure / Don't Know

Do you usually cook fish with the skin on or the skin off?

- skin off
- skin on

Do you usually cook fish whole, in steaks, fileted, or in some other way?

- whole
- steaks
- fileted
- other (please describe) \_\_\_\_\_

11. What method do you usually use to cook fish?

- fried
- baked
- grilled
- boiled
- smoked
- broiled
- other (please describe) \_\_\_\_\_

12. Are you aware of a Health Advisory about sport-caught fish from the Sheboygan River and Harbor?

- Yes
- No
- I'm Not Sure About It

*Thank you for answering these questions*

(please do not write below)

	NO. OF SPORT-FISH MEALS						
	Sheboygan River	Sheboygan Harbor & Pier	Milwaukee River	Lake Michigan	Lake Winnebago		
Coho Salmon							
Chinook Salmon							
Brown Trout							
Rainbow Trout							
Sm/Lrg Mouth Bass							
Northern Pike							
Yellow Perch							
Walleye							
Whitebass							
Pan Fish/Bluegills							

Hmong Survey - (English Version)

HOME NUMBER: \_\_\_\_\_

Hello, my name is \_\_\_\_\_. I am working for the Bureau of Public Health, Wisconsin Department Health & Social Services, to survey Hmong households in Sheboygan county about the fish they eat. We would appreciate your taking ten minutes to answer a few questions.

If you have any questions about this survey I will be more than happy to try to answer them.

**Postpone answering questions about the Sheboygan River fish advisory until you are done asking questions. If there are any questions the respondents seem to be uncomfortable with answering, remind them their answers will not be shared with anyone, but also then let them know that it is OK not to respond.)**

1. What year did you come to the United States?  
19\_\_\_\_
2. How many years have you lived in Sheboygan County?  
\_\_\_\_\_
3. In what other places in Wisconsin and the United States have you lived?  
\_\_\_\_\_
4. Please tell me the age of each member of your household and their sex.

Ages of Each Male: \_\_\_\_\_

Ages of Each Female: \_\_\_\_\_

5. Which of these household members were born in Sheboygan County?

**(Draw a CIRCLE around the AGE of each family member listed above who was BORN in Sheboygan county)**

6. Please tell me how often your family eats fish:

- My family NEVER eats fish (if "NEVER", then go to last page and end interview)
- My family eats \_\_\_\_\_ fish meals per week
- My family eats \_\_\_\_\_ fish meals per month
- My family eats \_\_\_\_\_ fish meals per year

7. How many people in the household do not eat fish? \_\_\_\_\_

8. Do you and your family ever eat fish caught by another person (a friend, neighbor, relative, etc)?

- Yes
- No
- I'm Not Sure / Don't Know

9. Tell me about all of the places where the fish that you eat comes from:

- Sheboygan River below Sheboygan Falls
- Sheboygan River above Sheboygan Falls
- Sheboygan Harbor or Pier
- Other River: \_\_\_\_\_
- Lake Michigan
- Lake Winnebago
- Other Lake: \_\_\_\_\_
- Store bought
- Restaurant
- Other Source: \_\_\_\_\_
- I'm Not Sure / Don't Know

List for me ALL of the types of fish your family ate in the last 12 months.

- |  |   |
|--|---|
| <input type="checkbox"/> Lake Trout                | <input type="checkbox"/> White Bass               |
| <input type="checkbox"/> Brown Trout               | <input type="checkbox"/> Bass (Lrg/Small Mouth)   |
| <input type="checkbox"/> Trout: type not known     | <input type="checkbox"/> Northern Pike            |
| <input type="checkbox"/> Rainbow Trout/Steelhead   | <input type="checkbox"/> Walleye                  |
| <input type="checkbox"/> Coho Salmon               | <input type="checkbox"/> Bluegill/Crappie/Panfish |
| <input type="checkbox"/> Chinook Salmon            | <input type="checkbox"/> Perch                    |
| <input type="checkbox"/> Salmon: type not known    | <input type="checkbox"/> Catfish                  |
| <input type="checkbox"/> Carp                      | <input type="checkbox"/> Smelt                    |
| <input type="checkbox"/> Other _____               | <input type="checkbox"/> Store bought: type _____ |
| <input type="checkbox"/> I'm Not Sure / Don't Know |   |

Do you usually cook fish with the skin on or the skin off?

- skin off  
 skin on

How do you usually prepare the fish for cooking, such as whole, in steaks, fileted, or in some other way?

- whole  
 steaks  
 fileted  
 other (please describe) \_\_\_\_\_

What method do you usually use to cook fish?

- fried  
 baked  
 grilled  
 boiled  
 smoked  
 broiled  
 other (please describe) \_\_\_\_\_

In the LAST WEEK did your family eat fish at any meals? This includes fresh, canned, or frozen fish.

- Yes  
 No ("**If "NO", then go to the last page and end the interview**")  
 I'm Not Sure / Don't Know

If yes, how many meals of fish did you eat in the last week? \_\_\_\_\_

How many of these fish meals came from a store? \_\_\_\_\_

Which store(s)? \_\_\_\_\_, \_\_\_\_\_

How many of these fish meals were SPORT-CAUGHT (caught with a fishing pole)? \_\_\_\_\_

How many of these fish came from some other source? \_\_\_\_\_

What was this source? \_\_\_\_\_

For each fish meal eaten in the past week, write the answers to the following questions into a single row of the below table.

15. For each fish meal eaten in the past week, what type of fish did you eat?
16. Where did this fish come from?
17. Did you cook it with the skin off or on?
18. How did you prepare this fish for cooking?
19. What method did you use to cook this fish?

Fish Type	Location						Preparation			Cooking								
	Number of FISH MEALS	Sheboygan River	Sheboygan Harbor & Pier	Milwaukee River	Lake Michigan	Lake Winnebago	Skin Off	Skin On	Whole Fish	Cut into Steaks	Fileted	Fried	Baked	Grilled	Boiled	Soup	Smoked	Broiled
White Bass																		

20. Are you aware of a Health Advisory about sport-caught fish from the Sheboygan River and Harbor?
- Yes
  - No
  - I'm Not Sure About It

Would you like to receive more information about this health advisory?

- Yes      **(If "YES", then give to them the fish advisory card)**
- No
- I'm Not Sure About It

What is the particular clinic, health center, doctor's office or other place that you usually go when you are sick or need advise about your health? \_\_\_\_\_

---

*When done asking you questions, are there any questions that YOU have of ME about this survey?*

**Answer all the questions you can. If you are unsure of or don't know the answer, write down the question now and tell the respondent we will get back to them with the answer)**

*Thank you for taking time to complete this survey.*