Minimizing Methylmercury Exposure in the Hmong Community from Sport-Caught Fish Consumption in Minnesota

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ABSTRACT

Due to increasing levels of mercury emissions throughout the world, there is an increased threat to the human population from methylmercury, a biomethylated derivative of mercury. Methylmercury is a dangerous neurotoxin that can have adverse effects on the central nervous system and behavioral centers of the brain. Humans can become exposed to methylmercury through consumption of contaminated fish from polluted waters. Many states, including Minnesota, use fish consumption advisories to warn the public of methylmercury exposure, but these advisories may not always reach at-risk segments of the population. The Hmong community in the Twin Cities consumes a high quantity of sport-caught fish for a variety of reasons, including a desire to maintain cultural identity, recreation, or economic necessity, even though fish consumption advisories warn against such actions. Four alternatives were considered to provide better protection to the Hmong community from methylmercury exposure – (1) continue the use of fish consumption advisories as developed by the Minnesota Department of Health (MDH), (2) alter the current program by reallocating advisory education efforts from state agencies to local governmental units and organizations, (3) impose a ban on the consumption of all fish from methylmercury-impaired waters in the Minneapolis/St. Paul metropolitan area, and (4) establish more Asian-specific food shelves in the Twin Cities area to provide food alternatives to sport-caught fish. Each of these alternatives were evaluated using six criteria – safety effectiveness, program awareness, social and cultural acceptability, administrative operability, program cost, and health benefit. This report concludes that efforts taken by the MDH in educating Hmong anglers have the promise of being effective in reducing methylmercury exposure from fish consumption. However, based on theories of risk perception and communication, more needs to be done at both the state and local level to effectively target this specific subpopulation in Minnesota.
INTRODUCTION

Human industrialization and subsequent mercury emissions, the majority originating from coal-fired power plants, have contributed to a public health problem throughout Minnesota. Over the past 40 years, the United States and Minnesota have attempted to reduce the amount of mercury in the environment through bans on the purposeful use of and the industrial emissions of mercury. Although these efforts have greatly reduced the amount of mercury in the environment, the problem continues to persist as other nations march toward industrialization (UNEP, 2002). Once released into the environment, mercury is transformed into methylmercury, a dangerous compound that can have adverse effects on the central nervous system and behavioral centers of the brain (NRC, 2000). Humans can be exposed to methylmercury through the consumption of fish which accumulate the compound in their muscular and fatty tissue. Segments of the population who consume fish at greater quantities are at a greater risk of methylmercury exposure. In the Minneapolis – St. Paul metropolitan area, one such segment is the Hmong community whose culture is rich in angling and fish consumption. There is evidence that Hmong may be consuming unsafe levels of methylmercury from sport-caught fish despite federal and state consumption advisories (Story, 1989; Hutchinson and Kraft, 1994; Dourson, 2002). The goal of this policy analysis is to perform a retrospective study of the current program to minimize methylmercury exposure in the Hmong community, and to analyze prospective alternatives that may provide increased protection to this community in Minnesota.

Environmental justice and risk communication literature provide foundations for this analysis. In recent decades there has been a move towards recognizing the adverse position that minorities and low-income segments of the population face regarding environmental contaminants. Writings from academics such as Robert Bullard have helped place environmental justice on the social agenda under the belief that all citizens have a basic right to live, work, and play in a clean and healthy environment (1990). Numerous studies, such as Berry (1972) and McCaull (1976), have shown that minorities and low-income groups are subjected to a disproportionately large amount of pollution in their neighborhoods. Over time, the environmental movement has seen a shift in strategy from participatory to power, where movements are based more on political lobbying and justice-based technical evaluation rather than protest marches (Schnailberg, 1980). Given this trend, an analysis such as this one is important not only in assessing the risk of methylmercury exposure to the Hmong community, but to ensure equitable safeguards are in place to protect all Minnesotans from methylmercury exposure.

To achieve this level of protection, proper risk communication must take place between risk messengers and receivers. The intent of risk communication is to supply lay people with the information they need to make informed independent judgments about health, safety, and the environment (Morgan et. al., 2002). To be effective, this information must come from a credible source, using receiver-centered
messages and channels in use by the audience (Knuth, 1990). The field of risk communication has matured to include input from diverse stakeholders and a focus on reaching susceptible populations (NRC, 1996). The Hmong community in Minnesota is an example of a susceptible population who may be subjected to higher exposures of methylmercury than the rest of the population. Because consuming fish is currently a choice in the Hmong community, it is particularly important that accurate and understandable information is available to community members. Opportunities for dialog and information exchange form the cornerstone of new approaches to risk communication (NRC, 1996). Policy options in this paper are evaluated in this context.

This analysis begins with a brief review of the origins and health impacts of methylmercury contamination, background on the Hmong community, and the reasons for their susceptibility to methylmercury exposure. The analysis continues by using evidence and theory from environmental justice and risk communication literature to evaluate four policy alternatives to mitigate risks from methylmercury exposure in the Hmong community.

MERCURY SOURCES

Methylmercury originates as mercury, a naturally occurring element in the earth’s crust which can become a toxic and persistent pollutant when released into the environment. Mercury can enter the environment naturally through events such as volcanic activity, forest fires, weathering of rocks and minerals, and evaporation from soil and water surfaces (EPA, 2006). Although these natural sources do add to the global mercury pool, the greatest contribution is from the anthropogenic sources such as the purposeful use of mercury and industrial processes.

Recent studies estimate that anthropogenic additions to the mercury pool have increased levels of mercury in the atmosphere by roughly a factor of three (Figure 1; UNEP, 2002). U.S. mercury emissions in 2000 totaled approximately 112 tons, representing approximately 3 to 5% of total world anthropogenic mercury emissions (EPA, 2006). Activities such as fossil fuel combustion, metal processing, mining, waste incineration, and the improper disposal of items containing mercury (such as thermometers, light bulbs, computers) are major anthropogenic sources of mercury. Coal combustion and waste incineration are the greatest anthropogenic sources, accounting for 87% of all U.S. emissions (EPA, 2001). Studies have shown increases in average deposition rates by a factor of 1.5 to 3 and deposition near industrial areas by a factor of 2 to 10 (Figure 1; UNEP, 2002). Total Mercury deposition in the U.S is estimated at approximately 144 tons per year, although only 17% of this deposition originates from American or Canadian sources (EPA, 2006). The origin of deposited mercury is a source of considerable controversy, and is the key scientific uncertainty in efforts to manage the risk from mercury exposure.
Mercury emission trends in Minnesota have been similar to those seen at the national level. The Minnesota Pollution Control Agency (MPCA) categorizes mercury emissions in the state under three categories: (1) emissions incidental to energy production, (2) emissions due to purposeful use, and (3) emissions due to material processing. The most recent data on mercury emissions in Minnesota show an annual rate of 3,637.5 pounds, with coal combustion being the greatest contributor at 1648.7 pounds (MPCA, 2004). Over half of the mercury emissions in the state are from energy production, with material processing (mainly from taconite) a distant second (Figure 2). Considering that mercury can travel great distances once in the atmosphere, annual mercury deposition rates from specific sources in Minnesota are difficult to measure. However, the MPCA estimates that of the mercury emitted by in-state sources, only 10% is deposited in Minnesota (MPCA, 2007). Therefore the problem of mercury deposition in Minnesota stretches beyond the state’s borders.
MERCURY REGULATIONS

The increasing threat of mercury in the environment has prompted federal and state agencies to regulate the release of mercury into the environment through bans on the purposeful use of mercury and regulation of industrial emissions. The earliest Federal mercury control efforts began in the mid-1900s by addressing occupational exposures to mercury. Beginning in the 18th century, mercury was a common ingredient used in hat making to separate animal fur from the pelt. The mercury-laced solution used in this process was highly toxic and hat makers began to develop psychological disorders related to mercury poisoning (inspiration for the phrase, “mad as a hatter”). Prompted by public health concerns, the U.S. Public Health Service banned mercury use in the felt industry in 1941 (Waldron, 1983).

Efforts to ban mercury would later expand to mercury use in all commercial products and industrial processes. The first step was the creation of a series of legislative acts to limit the amount of pollution (including mercury) in the nation’s air and water with passage of the Clean Air Act in 1963, the Safe Drinking Water Act in 1974, and the Clean Water Act in 1977 (EPA, 2008a). In the 1970s, the newly formed U.S. Environmental Protection Agency (EPA) oversaw the compliance of these regulations. By 1991, there were a total of nine regulations, bans, standards, or guidelines for mercury that had been developed by nine different federal agencies, including the Consumer Product Safety Commission, the Food and Drug Administration, the Occupational Safety and Health Administration, and the EPA (GAO, 1991). These series of regulations successfully lowered mercury emissions by 45% between 1990 and 2000, and decreased mercury use in products and processes by 83% from 1980 to 1997 (EPA, 2006).
success of this targeted approach to mercury reduction has meant that in 2000, coal fired power plants remained as the largest remaining emitter of mercury (Figure 3; EPA, 1999).

Figure 3: U.S. Emissions of Human-Caused Mercury (EPA, 1999)

Recently the EPA has attempted to address mercury emissions for coal combustion by issuing the Clean Air Mercury Rule (CAMR) in 2005. The CAMR would permanently cap mercury emissions from coal plants (EPA, 2008b). As written, the CAMR would create a cap-and-trade system between states and cap nationwide emission at 38 tons/year by 2010 (the level achieved as a co-benefit of emission controls required the proposed Clean Air Interstate Rule) and 15 tons per year by 2018. States would be responsible for administering the rule, and each state would be assigned a mercury budget. However, implementation of these rules has hit a roadblock. On February 8, 2008 in New Jersey v. EPA, the United States Court of Appeals for the District of Columbia Circuit invalidated the CAMR by ruling that the EPA violated statutes of the Clean Air Act (CAA) in its removal of coal-fired power plants from the listing under the CAA and placing them under CAMR. The suit, brought forth by fourteen states (including Minnesota) and several dozen Native American tribes, as well as public health and environmental groups, argued that by the placing the regulation of the coal-fired power plants under CAMR weakens mercury emission regulations which are currently in place under CAA. The court agreed, reversed the actions taken by EPA and invalidated the CAMR, thereby continuing the current state of mercury emissions regulation under the CAA.
The increase in mercury regulations in Minnesota has mirrored the efforts made at the federal level. Since the late 1980s state agencies, such as the MPCA, the Minnesota Department of Health (MDH), and the Minnesota Department of Natural Resources (DNR) have been working in concert with federal regulations while adopting their own forms of mercury regulation. Minnesota began by focusing on limiting mercury pollution from commercial use, such as requiring the removal of mercury-containing components in appliances (1992), banning the sale of toys and apparel containing mercury (1992, 1994, 2001), and prohibiting fluorescent lamp disposal (1994; Welch and Hansen, 2004). It is estimated these regulations have reduced mercury in Minnesota’s environment by 45% between 1990 and 1995 (Figure 4; MPCA, 2005). As is the case at the national level, the largest remaining source of mercury emissions in Minnesota is from coal-fired power plants.

![Figure 4: Mercury Air Emissions by Sector, 1990-2005 (MPCA, 2005).](image)

However, unlike the EPA, Minnesota has been able to successfully begin the process of regulating mercury emissions from coal combustion. After three months of intense debate and negotiations between the Minnesota Public Utilities Commission, environmental groups, and industry leaders, the Mercury
Emissions Reduction Act was passed unanimously by the Minnesota State Legislature and signed into law in May 2006. The Act focuses on the three largest plants in Minnesota whose electricity production is greater than 100 megawatts, and who collectively are responsible for 70% of Minnesota’s mercury emissions. These facilities are required to cut mercury emissions by 90% by 2014, based on a six-month emission rate baseline established in July 2007. When fully implemented, statewide mercury emissions will be cut by one-third or an estimated 1,200 pounds per year (MPCA, 2006). However, the MPCA (2004) estimates that 90% of the mercury deposited in Minnesota are from sources outside the state, meaning mercury deposition in Minnesota is a national, and increasingly, a global problem.

GLOBAL MERCURY SOURCES

Although the U.S and Minnesota have been able to remove some mercury from the environment, the threat of mercury contamination remains due the continual and increasing mercury emissions from international sources. Mercury emissions are a global problem as mercury particles can travel great distances once released into the atmosphere. Evidence for this global transport is evidenced by the discovery of mercury in the arctic, which can not attributable to natural or local sources (AMAP, 2004). Large emitters of mercury have risen over the past few decades as developing countries move toward industrialization (Figure 5). The EPA (2006) has estimated that 83% of the mercury deposited in the U.S. is from international sources, primarily in Asia and Africa.

Figure 5: Spatial distribution of anthropogenic mercury emissions in 2000 (Wilson, 2006).
Pacyna et. al. (2006) found that Asian nations were the world’s largest mercury emitters at 52% of world totals in 2000, with Africa a distant second at 18%. The report also shows that the three largest mercury-emitting countries in the world in 2000 (China, South Africa, and India) all hail from these continents. Mercury emissions in these regions continue to increase, while emissions have decreased in other industrialized continents such as North America and Europe (Figure 6). Although mercury emissions regulations have been successful on these continents, regulations in most developing countries are either not comprehensive, not enforced, or do not exist (UNEP, 2002). Until mercury emissions are reduced globally, mercury contamination will continue to be a concern in the U.S. and Minnesota.

**Figure 6: Change in global anthropogenic emissions of total mercury to the atmosphere from 1990-2000 (in tons, Pacyna et al., 2006).**

**METHYLMERCURY**

Human exposure to methylmercury from the increasing global pool is a function of both atmospheric processes affecting mercury deposition, and biological processes that transform mercury to methylmercury (Figure 7). The majority of atmospheric mercury is in the elemental form of Hg°. In this form, mercury will persist in the atmosphere until it becomes oxidized into a reactive form, Hg²⁺. This form is short-lived in the atmosphere because of its high water solubility, low volatility, and high reactivity. Therefore, it is easily taken up by rain or snow resulting in wet deposition, or absorption into other particulate matter that settle as dry deposition.
When this form of mercury is deposited into a body of water, the element is transformed yet again through a process called biomethylation to create the dangerous neurotoxin, methylmercury (CH$_3$Hg$^+$). Although methylation of mercury can take place through photochemical reactions, the majority of methylmercury is created through this biological process. Sulfate-reducing bacteria metabolize mercury to form methylmercury, which then bioaccumulates through the food chain. Bioaccumulation begins at the autotrophic level with these organisms absorbing and retaining methylmercury. These autotrophs are consumed by plankton, which are in turn consumed by invertebrates or herbivorous fish, such as trout and catfish. These fish are then consumed by piscivorous fish such as bass, walleye, and pike. Subsequently, these larger fish will carry greater amounts of methylmercury than other fish. Birds, mammals, and humans that consume these fish inherit this increased level of methylmercury.

**HEALTH AND METHYLMERCURY**

Methylmercury is an extremely toxic substance that can adversely affect multiple systems in the human body. In 2000, the National Research Council (NRC) released a comprehensive report on the health effects related to methylmercury exposure. The report found that the primary health effect from chronic low-level methylmercury exposure is impairment of neurological development in fetuses, infants, and children. Maternal fish consumption results in methylmercury exposure in the womb that can impair...
the brain and nervous system during development, which can result in disorders related to cognitive thinking, attention, memory, language, and spatial and fine motor skills. Typically, toxicological studies can only extrapolate human effects from animal studies; however the NRC report had the advantage of using low-dose chronic methylmercury exposure studies which occurred in human populations. One such case was in Minamata and Niigata, Japan where residents were exposed to methylmercury after consuming fish which resided in local surface waters contaminated with methylmercury (EPA, 1997).

As was shown in the Minamata and Niigata cases, the primary route of exposure for humans to methylmercury is through the consumption of fish contaminated with methylmercury. Since methylmercury is highly lipophilic compound, it easily passes through a fish’s digestive system and then resides and accumulates in the fat and muscle tissue. Methylmercury is able to persist in an organism due to its relatively long half-life and its difficulty in being purged from muscular tissue. Although trimming fat does remove a portion of methylmercury from a fish, it is impossible to remove the compound from muscular tissue and the compound is not destroyed or neutralized during cooking.

The degree to which methylmercury exposure is a public health risk in Minnesota has been debated in the literature. According to the EPA (2001), a typical U.S. consumer of fish (consumption of 10 g/day, or ¼ cup) is not at a significant risk from methylmercury exposure and a large change in consumption habits is unnecessary. However, given the rich tradition of fishing in Minnesota consumers of fish may not be considered typical. Additionally, methylmercury contamination of lakes and streams in Minnesota is widespread; 66% of Minnesota’s waters are impaired because of mercury contamination (MPCA, 2007). This poses a danger to children, women of childbearing age, and fishing-rich cultural groups which may consume large quantities of fish. One such cultural group is the Hmong community in the Twin Cities.

THE HMONG COMMUNITY

The Hmong are a segment of Minnesota’s population originally from nations within Southeast Asia. After facing years of isolation and persecution in Vietnam and Laos, 150 families immigrated to the U.S through the U.S. Refugee Program in 1976 (HAP, 2007). Sixty of these individuals were sponsored by the state of Minnesota and given assistance by churches and non-profits to establish residence in the Twin Cities. Since 1976, the Hmong population has grown dramatically. As of the last U.S Census in 2000, 41,800 Hmong were residing in Minnesota, but local community leaders believe this number could be as high as 70,000, with 97% of this population residing within the Twin Cities area (Hughes, 2001). Approximately 33% of the population live below the poverty line, a significant departure from the 8% in Minnesota (Pfeifer, 2003).
As the Hmong people immigrated to Minnesota, they brought with them their culture and social norms. One deep cultural tie is to angling and fish consumption. Studies have shown that Hmong chose to fish to maintain ethnic identity through consumption of a familiar food source (Story, 1989). Immigrant food consumption patterns are often resistant to change, so it is understandable why Hmong would choose to consume fish, even if they are told it could be hazardous to their health (Dourson, 2002). According to Hutchison and Kraft (1994), Hmong anglers in northern Wisconsin not only fish as a recreational activity, but also consumed 90% of all fish caught. The primary species consumed were white bass, a piscivorous fish known to carry methylmercury.

An additional consideration is that a third of the Hmong community in the Twin Cities lives below the poverty line. Research has shown that low-income segments of the population have higher fish consumption than the rest of the population because fish are can be easily acquired and is inexpensive (Dourson, 2002). Low-income individuals who are from a fishing-rich culture may turn to local angling for their primary food source if they are unable to purchase enough food.

When dealing with human exposure to harmful contaminants, society must wrestle with both preventing exposure, and treating any adverse medical effects related to this exposure. Although taking preventative steps and seeking medical treatment is common and second nature many Minnesotans, in the Hmong community, health care is viewed differently. In an examination of Hmong health care beliefs, Deinard & Dunnigan (1987) discovered that heath education, public health, and preventative medicine are rarely practiced in Hmong communities in the native lands. Instead of seeking treatment from trained physicians, many Hmong seek treatment administered by a shaman (spiritual healer), herbalists, or acupuncturists. Once in the United States, it has been found that many first generation members of the Hmong community are skeptical, distrusting of, and often resistant to the American health care system. To many Hmong, illness is related to soul loss or spiritual interactions, not bacteria, viruses, and chemical contaminants (Johnson, 2002). Therefore, Hmong may find it difficult to reconcile why someone who is feeling ill should be treated by a physician.

When Hmong chose to be treated by a physician, many are faced with both language and cultural barriers. In regards to language, Johnson (2002) found there are few terms in the Hmong language that directly translate medical physiology and anatomy. The result is physicians must often use non-direct and confusing terms to communicate medical issues to a patient. The cultural barriers faced by some Hmong patients are even greater. Uba (1992) discovered that within the Hmong culture is the belief that one’s life span is predetermined and that pain and suffering is an inevitable part of life. Because of this belief, in addition to the feeling uncertain of American physicians, Hmong may only seek treatment when symptoms have become severe. In many circumstances, by this time there is nothing modern medicine
can do to treat the illness and the patient either continues to suffer or eventually dies. The family of the patient is left to conclude that American medicine is ineffective and some cases harmful.

For those who do seek initial treatment, many patients are faced with accepting treatments that contradict cultural beliefs. For example, Hmong people believe that blood is the life force of a body, and that removing blood weakens the overall health of an individual. Many Hmong patients are extremely resistant to the drawing of blood for medical tests, believing that once withdrawn, cannot be replaced (Deinard and Dunnigan, 1987). Hmong patients have also been resistant to taking prescribed medications. According to Johnson (2002), for many patients, their closest experience with medication is either herbal remedies or opium. When patients do take a prescribed medication, they sometimes encounter a drug that does not provide adequate relief or has negative side effects. Patients will then discontinue use of the medication, but fail to notify their physician of their decision out of fear of being rude. These negative experiences are shared within the Hmong community to reinforce distrust in the American health care system (Johnson, 2002).

Many health care facilities have attempted to bridge these cultural divides through increased education and interpreters. In the past these attempts have had minimal success. Deinard and Dunnigan (1987) found that even when faced with understandable educational materials, patients remain skeptical. Interpreters have been helpful in relaying information between patient and physician, but often times they are caught in the middle of relaying a physician’s orders and being seen as an advocate to the patient.

Thus far the discussion has involved Hmong who have the means and access to medical care. Given that a large portion of the Hmong community in Minnesota lives below the poverty line, an equally large population may exist who cannot afford health care and are without health insurance. It is likely that many members in the Hmong community will either under-use or not seek treatment for illnesses that are attributed to methylmercury exposure. Because of these barriers faced between physicians and Hmong patients, there needs to be an even greater emphasis on preventing methylmercury exposure.

**RISK COMMUNICATION**

In order for prevention to take place, the risk of fish consumption must be clearly communicated to the target audience. Risk communication is defined as communication intended to supply people with the information they need to make informed independent judgments about health, safety, and the environment (Morgan et. al., 2002). Modeling risk communication has been done for a variety of risks and social environments, including sport-fishery management in regards to angler knowledge and behavior toward chemical contaminant hazards. Knuth (1990) described one such model as a process involving risk messengers communicating through message channels and filters to receivers, who in turn decide how the message should influence their behavior or attitudes. The model, illustrated in Figure 8, can be
influenced by variables at each stage of the process, which can affect the degree to which an angler is making an informed decision about consuming fish.

According to Knuth (1990), the risk communication process begins with risk messengers – the source and/or communicator of risk information. How a message is received and interpreted from a messenger is directly related to the perceived credibility of the messenger by the receiver. If the messenger is not considered credible, the receiver will likely not fully consider and respond to the message. Risk messenger credibility can be influenced by the operational objective of the messenger, the channels of communication, and message itself. This can lead to unintended messages being communicated along with intended messages. As messages move along channels, they also encounter filters in terms of personal, societal, and/or cultural influences, which can distort the message. At the end of the process, the message is conveyed to an audience who in turn decides whether to alter his or her opinions and behavior. A change in audience behavior is related to the congruence between the communicated and filtered message, and the needs, abilities, and values of the target audience. Fish consumption advisory programs, the methods of communication, and the influences on Hmong fish consumption behavior can also be framed in this way.
ANALYSIS METHODS

Methods used for this policy analysis are taken from the writings of Bardach (2005) and Patton and Sawicki (1993) by selecting policy alternatives to current policies and then evaluating each alternative with a set of evaluation criteria. For this policy analysis, four alternatives were evaluated that could potentially reduce methylmercury exposure to Hmong anglers in the Twin Cities. These alternatives were chosen after performing a literature review on programs used in other parts of the country, as discussed below and in the results. The first alternative considered was the baseline alternative to continue the use of fish consumption advisories developed by the Minnesota Department of Health (MDH). Each state in the nation has the responsibility and authority to protect its citizens, and one is through the use of fish consumption advisories. These advisories provide specific advice on either the limitation or restriction of fish consumed from a given lake or stream. All but one state in the contiguous United States (Wyoming) use fish consumption advisories to warn the public about exposure to mercury or other toxins (EPA, 2007). The second alternative is to augment the baseline reallocating the responsibility for public education regarding fish consumption advisories from the state level to local governmental units and organizations. Currently, the vast majority of public education efforts reside with state agencies, primarily with the MDH. However, there are examples of other education efforts performed by local organizations in other states. One such example which is used in this report is the efforts made by the Fox River Environment and Diet Study (FRIENDS) in northern Wisconsin.

The third alternative is to impose a ban on the consumption of all fish from contaminated waters in the Minneapolis/St. Paul metropolitan area, essentially removing the source of human methylmercury exposure. Several states throughout the country have used fishing and consumption bans to protect anglers from contaminated fish. One such example is the Texas Parks and Wildlife Department, which currently enforces a consumption ban on all fish species from five separate water bodies due to environment contaminants (TPWD, 2008). Rationale for the fourth alternative, which could be used in conjunction with any of the alternatives, is to establish more Asian-specific food shelves in the metropolitan area. These shelves would be stocked with Asian food items that can be distributed to lower income segments of the Hmong population as an alternative to locally caught fish.

Six evaluation criteria were used to analyze these four alternatives. The criteria used for this analysis were selected to evaluate the health and social effectiveness of each alternative. The first criterion is safety effectiveness in regards to whether the alternative minimizes human exposure to methylmercury from fish consumption. This will be measured by fish consumption rates of Hmong anglers in the Twin Cities. The second criterion is program awareness by those in the Hmong community who consume fish. Social and cultural acceptability is the third criterion, which measures the level of congruence between...
the alternative and the Hmong culture. Limited data for this criterion exists however, so the evaluation will be conducted using published literature of the Hmong culture. Fourth will be administrative operability, which assesses which governmental, private, or public institutions are currently in place to assist in the implementation of an alternative, and how feasible it is for these entities to do so.

The fifth criterion is program cost which is a quantitative measurement of program implementation costs. Costs are estimated using the 2007 budget figures supplied by the Department of Finance.\(^1\) The total program cost of Minnesota’s fish advisory program is not explicitly documented by the state. Therefore costs will be estimated based on the portion of each department’s budget that contributes to the advisory program. The sixth and final criterion is health care benefits associated with a reduction in methylmercury exposure and related illnesses. Quantifying the level of health savings from reducing methylmercury exposure is difficult to accomplish due to uncertainties in cause and effect linkages. Schenck (2005) was able to quantify health benefits related to a decrease in neurological deficiencies in developing children and in the incidence of myocardial infarction in adults after the implementation of a variety of mercury emission reduction strategies from coal-fired power plants. One of the scenarios tested in the report closely matches the current state of mercury emissions regulation at both the federal and state level. The benefits associated with this scenario will be used as a baseline of benefits for this report. Any derivation from this value will be done in a qualitative manner, based on the effectiveness of the alternative in increasing fish consumption advisory awareness and reducing methylmercury exposure.

To evaluate these criteria, data was gathered from multiple informal interviews during past nine months with state and local government employees, non-profit institutions, and academic researchers to extrapolate conclusions through benefit transfer methods. These methods are used to estimate impacts by transferring available information from studies already completed in another location and/or context. Literature on risk communication, environmental justice, and public engagement were reviewed to assist in the theoretical analyses of case studies.

**ANALYSIS AND RESULTS**

In order to frame the alternatives in this report and conduct a systematic analysis, a mental models approach was taken as described by Morgan et. al. (2002). The purpose behind this approach is to identify interactions of beliefs and behaviors, and how these interactions influence individual choices. By doing so, decision-makers gain a greater understanding of how an individual makes choices when faced with a behavior involving risk. According to Morgan, these interactions can be illustrated through the use of an influence diagram, which consists of connections between uncertain circumstances and “states of

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\(^1\) 2007 budget figures were used because the 2008 budget is still being finalized by Governor and the State Legislature.
the world.” The influence diagram for methylmercury exposure from fish consumption in the Hmong community is illustrated in Figure 9. Ovals (methylmercury exposure and toxicity) represent uncertain circumstances and the rectangles represent behaviors by the Hmong community that influence these circumstances. Altering any one of these behaviors or actions can have a positive or negative influence on methylmercury exposure and toxicity. Therefore, this is where alternatives analyzed in this report are centered. The location of each alternative is indicated by the orange shadow.

**Figure 9: Influence diagram for methylmercury exposure from fish consumption in the Hmong community.**

Alternative 1: Continue the use of fish consumption advisories

*Background*

The fish consumption advisory program in Minnesota is instituted through the cooperation of three state agencies – the MPCA, DNR, and the MDH. The MPCA is responsible for developing state water standards and monitoring water quality, while the DNR enforces fishing regulations and assists with analyzing fish for contaminants. The MDH develops guidelines for safe fish consumption and publishes state-wide and site-specific advisories for both the general population and sensitive sub-populations (children and women of child-bearing age). The MDH has been issuing consumption advice...
since the 1970s and began formally publishing advisories in 1983. These advisories are available in both
print (Figure 10) and online at the MDH website translated in English and Spanish. Literature has been
translated to Hmong, but is only available upon request.

Figure 10: Excerpt from literature published and distributed by the MDH describing
Minnesota’s fish consumption advisories (MDH, 2006).

The goal of the fish consumption advisory program is not to reduce overall fish consumption, but
to educate anglers about which fish are safe to eat, at a given quantity and frequency (McCann, 2007).
For example, the general population is advised to limit consumption of most fish from Lake Calhoun in
Minneapolis to once per week, while children and women who are or plan to become pregnant should
limit consumption to once per month (MDH, 2007a). Minnesota currently has advisories listed online for
every lake and river in the state (Figure 11). Minnesota has the greatest number of advisories in the
nation (1,069 in 2006), which includes all waters within the metropolitan area (EPA, 2007).
In 1996, Pamela Shubat of the MDH published a report on efforts by the department to outreach to the Hmong community regarding state fish consumption advisories (Shubat et al., 1996). According to the report, the department received anecdotal evidence that Hmong anglers who were catching and consuming fish were unaware of fishing regulations or advisories. In order to determine the reason for this communication gap, the MDH took a two step approach by first speaking with community groups and state agencies, and second, surveying a selected segment of the Hmong population.

In the first approach, the authors interviewed a variety of community groups and state agencies familiar with the Hmong community. The interviewees included social services, park officials, environmental groups, the DNR, and primary care physicians. Those interviewed were asked to provide...
their own personal perspectives on the issue, including Hmong fishing and consumption habits. Responses included:

- Hmong anglers enjoyed fishing and often felt obliged to eat what they caught.
- Anglers many times caught more fish than recommended by MDH guidelines.
- The idea of water pollution and fish contamination is new to the Hmong community.
- Preventative care is rarely used by Southeast Asians and many distrust the health care system in this country.
- The most effective communication strategy is community-based personal interactions.

The second approach used by the authors was to interview a segment of the Hmong community. The process began by screening 59 individuals with a Hmong interviewer trained by the DNR. Of this group, 30 were selected for final interviews based on their declaration of consuming fish caught from the Mississippi River. The majority of respondents were men (79%), ages 17-88. Each individual was asked a series of open-ended questions about their fishing activities, species of fish caught and consumed, meal frequency, knowledge of contaminated areas, and how they found this information. Respondents were not asked to estimate the size of their meals. Results of the surveys found that the respondents ate an average of 3 fish meals per month (range of 0.5 – 12.0), which is near or exceeds the specific fish consumption advisory for the Mississippi River. However, the authors noted that respondents used non-official names for lakes and rivers and the name of the fish consumed was not always known. Therefore it is difficult to pinpoint the species and location of fish consumed. In regards to the advisory program itself, respondents preferred information conveyed in person and had little interest in written material. The authors did not publish answers to questions regarding respondent’s knowledge of the fish consumption advisory program, and the authors concede that the survey sample may not be representative of the population given the respondents were primarily males who fished frequently along the Mississippi River.

The report concluded with steps the MDH will take in educating the Hmong community about fish consumption hazards. One method was to create a video, produced and aired by local television channel, KTCI, which discussed the fish consumption advisory program and how anglers can reduce exposure to contaminants. The MDH also published translated written material which was widely distributed through local parks, bait shops, food stores, the DNR, and health care providers, as well as conducted two workshops with community members.

The MDH also stated in its report that signs warning anglers of the consumption advisory were placed at major fishing sites in Minnesota. However, in trying to locate a sign for this study, none were
along the Mississippi River, a popular fishing location. On April 14, 2008, six fishing areas and boat launches along the Mississippi River were visited to evaluate the signs in place. The sites included Anoka County Riverfront Regional Park, Hidden Falls/Crosby Farm Regional Park, Lilydale Park, Harriet Island, South St. Paul boat launch, and Lions Levee Park. Signage regarding fish consumption advisories was not found at any one of the six locations. According to a representative from the DNR, signs have been posted at smaller Twin Cities lakes, but admitted none exist along the Mississippi River.3

Currently the MDH is attempting to implement some of the findings of 1996 MDH report. (Shubat et. al., 1996). Pat McCann, an environmental scientist with the MDH who oversees the department’s fish consumption advisory program stated that the program is engaged in outreach programs with the St. Paul-Ramsey County Department of Public Health and collaborative groups like Emergency and Community Health Outreach (ECHO).4

Safety Effectiveness

In this paper, consumption rates of sport-caught fish were used to measure the level of efficacy of Minnesota’s fish consumption advisory program in reducing methylmercury exposure in the Hmong community. However, it was difficult to quantify these rates due the lack of specific data on fish consumption rates of the Hmong community in the Twin Cities or throughout Minnesota since 1996. According to those interviewed at the MDH, Minneapolis Park and Recreation Board (MPRB), and the St. Paul-Ramsey County Department of Public Health, there has not been a comprehensive survey of Hmong anglers in Minnesota.5 The only data collected by any of these groups are questions embedded in the DNR’s creel surveys of anglers in Minnesota. The MDH is currently attempting to compile this data.6 Because this type of data has not been collected for the Hmong population in the Twin Cities, this paper uses fish consumption survey data of anglers from the upper Midwest and of Asian anglers from other states.

One of the initial surveys conducted of fish consumption habits was performed by the Great Lakes Sport Fish Consortium of fish consumers in eight Great Lake states (Tilden et. al., 1997). 8,078 individuals were surveyed in Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin through random telephone interviews. Only 22% of respondents were listed other than “White”. Of the total surveyed, 679 (8.4%) reported eating sport-caught in the Great Lakes over the past

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3 Email correspondence, April 29, 2008.
4 Personal conversation: Pat McCann, Environmental Scientist, MDH, April 8, 2008.
5 Interviewees included Pat McCann, Environmental Scientist, MDH (April 8, 2008); Tracey Nordstrom, Vice President and District #4 Commissioner, Minneapolis Park and Recreation Board (November 20, 2007); Mary Elizabeth Berglund, Supervisor, Community Involvement Unit, St. Paul-Ramsey County Department of Public Health (April 11, 2008).
6 Personal conversation: Pat McCann, Environmental Scientist, MDH, April 8, 2008.
year (1993-1994), consuming a median of 34.8 sport fish meals a year. 67 were from Minnesota and 50 were classified other than White.\textsuperscript{7} When broken down into just sport-fish consumers, the median number of sport-fish meals consumed per year was 6.4 for Whites and 9.8 for non-Whites.\textsuperscript{8} Data was not supplied for consumption rates of all Minnesotans in the report.

The Consortium performed a duplicate survey eight years later with the same eight states (Imm et. al., 2005). In this iteration, 4,106 individuals were interviewed (in 2001-2002) – 510 from Minnesota and 302 were classified under race as “Other/unknown” (neither White nor Black). Of the total sampled, 7.3% reported consuming sport-caught fish over the past year, consuming an average of 53 sport-fish meals per year. When broken down into just sport-fish consumers, the median number of sport-fish meals consumed per year was 13.0.\textsuperscript{9} Imm et. al. went one step further in this study by extrapolating consumption results to entire populations. Under this weighted method, the results show that 22% reported eating sport-caught fish over the past year. When broken down by state and race, 44% of Minnesotans and 15% of those classified as “Other/unknown” reported consuming sport-caught fish. The authors concluded that these consumption levels are similar to those reported in the 1993-1994 study, and likely to comply with most Great Lakes fish consumption advisories.

These two studies show that fish consumption rates in the upper Midwestern states may not have changed much between 1993 and 2002. It is difficult to conclude what this means in terms of the safety effectiveness of fish consumption advisories. Although consumption rates have remained level, there were still respondents surveyed who stated they consumed sport-caught fish over 100 times a year (Imm et. al., 2005). The authors claim that the consumption rates found in both surveys are likely to comply with most fish consumption advisories in the states surveyed. Considering that many advisories are based on location and fish species, data of which were not collected in either survey, it is difficult to make this conclusion for Minnesota anglers and accurately determine the level of methylmercury exposure.

A more definitive survey of fish consumption was performed by the Energy and Environment Research Center in 2001 (Benson and Crocker, 2001). In a questionnaire to 988 households in Minnesota, family members were asked estimate their fish consumption habits in 2000. The study found that average consumption rates ranged from 1.4-15.1 g/day, with the upper-level rate (95\textsuperscript{th} percentile) ranging from 41.5-73.6 g/day. These numbers exceed the consumption rate of 10 g/day recommended by the EPA (2001). However, the survey did not determine the rates of consumption of commercial vs. sport-caught fish. The survey only found that one-third of fish consumption was from sport-caught fish, but that this rate varied throughout the year.

\textsuperscript{7} Tilden et. al. did not list the total number of survey respondents from Minnesota in the report.
\textsuperscript{8} Tilden et. al. did not consider this a statistical difference due to the low sample size of non-White respondents (n=50).
\textsuperscript{9} Imm et. al. did not list a consumption rate of sport-fish consumers classified racially as “Other/unknown”.
These studies have done an adequate job of quantifying consumption rates, but they lack a quantitative measure of fish consumption from methylmercury-impaired waters for the Hmong community. Although there has not been a study on Hmong consumption rates in Minnesota, there have been studies done on this culture, and Asians in general, in other states. Burger (2002) in studying fish and crab consumption from the Newark Bay Complex in New York and New Jersey found that Asians had greater average monthly fish consumption than other ethnicities. Anderson et. al. (2004) reported in a telephone survey of 3015 women across twelve states (including Minnesota), found that Asian women had the highest percentage of sport-fish consumption (39%) of any racial group studied. Lastly, Silver et. al. (2007) surveyed low-income women at a Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinic in California to characterize commercial and sport fish consumption patterns. The authors interviewed 500 women, 21 of which were Hmong. The results showed that 10 of the 21 Hmong (48%) stated they consumed sport-caught fish within the last 30 days. Of these 10, 5 individuals reported consuming fish above the joint FDA/EPA advisory limit for pregnant women, nursing mothers, or young children (FDA & EPA, 2004). The authors concede these numbers could be higher if compared to local advisory limits which tend to be stricter than federal recommendations.

In summary, there has been no formal all-encompassing study of Hmong fish consumption patterns in the Twin Cities or Minnesota. There have been a series of surveys of fish consumption in the general population of the upper Midwest, which show that consumption patterns have not increased or decreased while fish consumption advisories have been in place. Other studies have shown that Hmong and other Asian cultures may consume sport-caught fish at greater quantities (possibly above federal and state advisory limits) as compared to the rest of the population. However, given that these surveys did not collect data on fish location and species consumed, it is difficult to determine if fish consumption advisories are reducing methylmercury exposure.

Program Awareness

There has been no formal study of awareness with Minnesota’s fish consumption advisory program by the Hmong community. However, as with the case of the previous criterion, other studies have been done regarding advisory awareness in other states. Many of the studies examined in the previous criterion included questions on advisory awareness. The two telephone surveys conducted by the Great Lakes Fish Consortium both asked respondents questions on their level of awareness of fish consumption advisories within their respective states. The 1993-1994 study found that of the 671 of adults who consumed sport-

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10 Recommendations include, (1) do not eat Shark, Swordfish, King Mackerel, or Tilefish, and (2) eating up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury.
caught fish, 49.9% reported an awareness of consumption advisories (Tilden et al., 1997). Minnesotans reported an advisory awareness of 37.5%, and races other than White reported 22.1%. It was also found that awareness percent decreased with a decrease in education. Results from the study in 2001-2002 found awareness levels had not changed significantly (38%) from the previous study (Imm et al., 2005). Of those consumers who were aware of the consumption advisories, comparison of the two studies revealed a general increase in compliance with most components of the advisory. However, compliance with consumption frequency did not increase significantly (Table 1).

Table 1: Self-reported compliance with health advisory recommendations of Great Lakes sport fish consumers who heard of the advisory (Tilden et al., 1997; Imm et al., 2005).

<table>
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<tbody>
<tr>
<td></td>
<td>Men (%)</td>
<td>Women (%)</td>
<td>Men &amp; Women (%)</td>
<td></td>
</tr>
<tr>
<td>Cooking and Cleaning Methods</td>
<td>68.8</td>
<td>54.6</td>
<td>77</td>
<td></td>
</tr>
<tr>
<td>Consumption frequency</td>
<td>50.1</td>
<td>42.8</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Fish species and size</td>
<td>50.3</td>
<td>29.4</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Fishing locations</td>
<td>43.6</td>
<td>28.2</td>
<td>71</td>
<td></td>
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</tbody>
</table>

The additional fish consumption surveys considered previously illustrated similar results in regards to advisor awareness. In the study published by Anderson et al. (2004) of women in the upper Midwest, it was found that of the total number surveyed, 25% were aware of fish advisories. Asian women displayed the lowest level of awareness at 7%. Overall, minorities and those in lower income segments were less knowledgeable of fish consumption advisories. Knowledge of fish and methylmercury also varied between respondents. For those consumers eating more than two fish meals a week, the majority recognized that methylmercury can harm a developing child. However, the majority of respondents did not know that concentrations of methylmercury are greater in larger, piscivorous fish, and that methylmercury is concentrated in muscular tissue and cannot be removed from trimming fat from a fish. Silver et al. (2007) found similar results from Hmong women surveyed at a WIC clinic in California. Of the 21 Hmong women surveyed, 4 had a general awareness of the advisory, while only two had specific awareness. The study concluded that overall, those consumers with specific knowledge of consumption advisories did consume less fish.

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11 Imm et al. did not provide awareness percentages for anglers in Minnesota or for those racially classified as “Other/unknown”.
12 Imm et al. did not provide compliance with advisory recommendations by sex.
In summary, there has been no formal study of Hmong fish advisory awareness in the Twin Cities or Minnesota. There have been a series of surveys of advisory awareness in the general population of the upper Midwest, which show that awareness of and compliance to consumption advisories to be anywhere from 37-50%. Other studies have shown that Hmong and other Asian cultures have much lower levels of specific awareness of consumption advisories. However, one study did discover that those consumers with specific knowledge of consumption advisories did consume less fish, indicating that advisory programs can be effective.

**Social and Cultural Acceptance**

In general, the survey data revealed that anglers continued to consume fish in spite of consumption advisories that suggested otherwise. Although this behavior could be attributed to lack of awareness, it could also be attributed to a lack of acceptance. As previously stated, fishing and fish consumption is a deeply ingrained cultural behavior in the Hmong community (Story, 1989; Hutchinson and Kraft, 1994; Dourson, 2002). Additionally, some Hmong anglers may be torn between cultural norms and adhering to fish consumption advisories. In a survey of anglers of Southeast Asian descent in Rhode Island, Brown (2003) found that contamination was associated with visual deformities or poor taste and smell, and that most avoided fish for taste, not safety. The MDH and the DNR is currently performing outreach to the Hmong community to relay the importance of advisory compliance. Josee Cung, coordinator for the DNR’s Southeast Asian Outreach Program, has assisted the MDH in providing local education to strive for greater acceptance of fish consumption advisories.13

**Administrative Operability**

Creation and implementation of Minnesota’s fish consumption advisory program is through the cooperation of three state agencies. The MPCA is involved in water quality monitoring and determining the contaminant levels in Minnesota’s lakes and rivers. The DNR stocks, monitors, and maintains sport fish levels in the state. The department also conducts fish tissue sampling for contaminants and posts signs at all public water access points regarding all DNR fishing regulations. The MDH is responsible for setting the health standard used in the consumption advisory program based on tissue samples provided by the DNR. The MDH is also responsible for the majority of public education efforts regarding the program, which is currently implemented by one full-time employee at the MDH. There are others within state and local agencies that assist with education efforts when needed, but only on a minimal basis. The program is in place and thus feasible to administer. However, there is currently one employee at the state level fully involved in developing and implementing the program.

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13 Personal conversation: Josee Cung, Southeast Asian Outreach Program Coordinator, DNR, April 22, 2008.
Program Cost

According to the 2007 budget reports from the Department of Finance for each of the three state agencies involved, the annual cost of Minnesota’s fish consumption advisory program is estimated to be $176.3 million. The expenditure contribution from each agency is listed in Table 2. Considering that the budget for the advisory program is spread between three agencies and is not listed a discrete item in the state budget, these values are merely estimations. Values were determined by evaluating each agency’s budget and selecting programs that may impact or influence the advisory program. Because the programs selected within each agency perform tasks beyond the scope of just the advisory program, the overall calculation may be higher than the actual expenditure of the advisory program.14

<table>
<thead>
<tr>
<th>Department</th>
<th>Costs (millions $)</th>
<th>Expenditure Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPCA</td>
<td>52.7</td>
<td>Water quality monitoring</td>
</tr>
<tr>
<td>DNR</td>
<td>82.9 38.7</td>
<td>Fisheries maintenance</td>
</tr>
<tr>
<td>MDH</td>
<td>2 0.025</td>
<td>Staff payroll and support</td>
</tr>
<tr>
<td>TOTAL</td>
<td>176.325</td>
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</tr>
</tbody>
</table>

Health Care Benefits

According to Schenck (2005), minimizing exposure to methylmercury can result in a decrease in methylmercury-related illness and costs. Under this alternative, Minnesotans would see a health benefit assuming full awareness and compliance with the fish consumption advisory. However, it has been shown in fish consumption surveys discussed earlier that the level of awareness and compliance may be may not be optimal to provide a general health benefit to the state.

In summary, in this alternative, the MDH is currently using a variety of community outreach methods to inform the Hmong community of the risks of consuming fish from methylmercury-impaired waters. Given the lack of data on the effectiveness of the current advisory program, it is difficult to make

14 Employees at the MDH were contacted and asked to provide a better estimation of advisory program expenditures. Given the complexity of the program, an estimation could not be provided at this time.
a definitive judgment if the program is working. However, past fish consumption surveys of anglers in Minnesota and of anglers or Southeast Asian descent in other states find that advisory awareness and compliance can be generally low. Currently there are three state agencies and several local units assisting with implementation of the advisory program, however there is only a single individual devoted to the program full-time. The program currently costs the state approximately $176 million annually while providing marginal health benefits assuming that awareness and compliance levels reported by past surveys of Minnesotan anglers are accurate.

**Alternative 2: Shift responsibility regarding consumption education to local governmental units and organizations**

*Background*

This alternative explores an amendment to the current advisory program in which community education efforts would be removed from the MDH (the agency would retain control of setting health standards for the program) and placed within local units of government and community organizations. The current structure of Minnesota’s fish consumption advisory program and the vehicles established for effective communication of the threat from methylmercury have the potential for creating two problems that may interfere or invalidate messages to the Hmong community.

The first problem is the creation of a message, and the method used to deliver this message, that does not satisfy public needs and desires. Public engagement and participation are nothing new in the creation and implementation of fish consumption advisory programs. Numerous studies have shown that awareness and compliance to advisory programs can have positive outcomes when the public is involved early and often (Jardine, 2003; Judd et. al., 2005). In addition, framing risk communication strategies to address lay people’s mental models in an iterative fashion can lead to messages that have greater impact and address common misperceptions (Morgan et. al., 2002). The MDH has been involved in such outreach to the general public and the Hmong community through publications, public engagement, and workshops. However, given that the MDH is responsible for the health of the entire state and not a specific subpopulation within the state, organizations at the local level may have a greater sense of local consumer needs and desires, as well as the ability to address misperceptions from lay people’s mental models (Jardine, 2003; Morgan et. al., 2002).

The second problem that can arise involves communication conflicts due to the involvement of both the MDH and DNR in public education efforts. The involvement of two state agencies with differing objectives and areas of expertise can disrupt communication channels (Knuth, 1990). In Minnesota, the education portion of the advisory program involves interplay between two state agencies with divergent departmental missions – the MDH in public health prevention and the DNR in natural resource protection.
Local governments and community organizations that have smaller, defined missions may be better equipped to deliver effective messages to their citizenry.

To examine this alternative, the FRIENDS program will be used as a model of a local communication strategy. The FRIENDS program, that is primarily associated with the University of Illinois at Urbana-Champaign, is one of several Centers for Children’s Environmental Health Research funded by the EPA and the National Institute for Environmental Health Sciences (NIEHS). These centers are established to create community-based research programs with a focus on investigating the health effects of environmental contaminants in disadvantaged and underserved children. The FRIENDS program, which began to receive funding in 2001, is currently investigating the health effects of methylmercury, PCB, and polybrominated diphenyl ether (PDBEs) exposure from contaminated fish caught in the Fox River, Green Bay, and other waters in northeastern Wisconsin. In addition to this research, FRIENDS is also investigating community-based intervention and education strategies to reduce methylmercury and PCB exposure from fish consumption.

FRIENDS began to develop new outreach strategies for the Hmong community in northern Wisconsin after it was determined the awareness level of the program was low. According to Susan Schantz, Center Director and Principal Investigator for FRIENDS, focus groups were held with community members to determine the level of awareness. Similar to the results seen in fish consumption surveys described earlier, it was found that many Hmong anglers were not aware of the advisory program, knew little about fish and methylmercury, and did not receive literature about the program when obtaining a fishing license. As a result of these discussions, FRIENDS began a public education campaign to educate the public on the state’s advisory program and problems associated with methylmercury exposure.

The first step was to create advisory literature that was locally and culturally based. The aim of the project was not to replace the state’s fish consumption advisory program currently in place, but instead enhance and tailor the message to a local audience. Using the literature created by the Wisconsin Department of Health and Family Services (Figure 12), FRIENDS refined the publication to a more basic document that could be understood by anglers with minimal English proficiency (Figure 13). In addition to this advisory literature, FRIENDS have also published newsletters, held workshops, and developed an educational video featuring local citizens.

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15 Personal conversation: Susan Schantz, Center Director and Principal Investigator, FRIENDS, April 15, 2008.
Creation of a similar program in Minnesota could be done by an organization similar to FRIENDS or local units of government. In an interview with Tracey Nordstrom, Vice President of the Minneapolis Park and Recreation Board (MPRB), she described her organization as one well equipped to work with the public in the local areas.\textsuperscript{16} Many of the initiatives the MPRB works on are through local neighborhood associations. Local citizens are engaged in the decision making process, creating a greater level of access to local citizens. This sentiment was shared by Mary Elizabeth Berglund, Community Involvement Unit Supervisor at the St. Paul-Ramsey County Department of Public Health, stating that her department is also involved in partnership with the Department of Health and local groups and looking to provide more community-based services in the near future.\textsuperscript{17}

\textsuperscript{16} Personal conversation: Tracey Nordstrom, Vice President and District #4 Commissioner, Minneapolis Park and Recreation Board Department of Health. November 20, 2007.
\textsuperscript{17} Personal conversation: Mary Elizabeth Berglund, Community Involvement Unit Supervisor, Saint Paul-Ramsey Department of Public Health, Environmental Health, April 10, 2008.
Safety Effectiveness

A definitive answer to whether actions taken by the FRIENDS or similar community-based programs in reducing methylmercury exposure are not available at the time of this analysis. A survey of consumption rates of those in the Hmong community impacted by the efforts of FRIENDS has not been done, although may be conducted in the future. Additionally, the fish consumption surveys conducted by the Great Lakes Fish Consortium (which included Wisconsin) and other researchers were performed before education efforts began in 2005.

Program Awareness

In addition to not performing a survey of consumption rates, FRIENDS has not performed a quantitative measure of whether advisory awareness has increased in the Hmong community after implementation of their educational programs. However, according to those affiliated with the program, qualitatively there has been an increase in advisory and contaminant awareness, and all workshops have been well attended.

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18 Personal conversation: Susan Schantz, Center Director and Principal Investigator, FRIENDS, April 15, 2008.
19 Ibid.

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Figure 13: Wisconsin fish consumption advisory program literature published by FRIENDS (English and Hmong versions).
Social and Cultural Acceptance

Given that the messages regarding fish consumption advisories are originating from a known local source to the Hmong community, advisory compliance could increase. According to Knuth (1990), individuals are more likely to trust risk communication if it comes from a credible, unbiased source. Anglers in the Hmong community would likely have greater access to and knowledge of a local source, thereby resulting in a higher level of trust. However, given the deep rooted culture of fishing in the Hmong community, there could still be a level of non-compliance no matter the advisory information source.

Administrative Operability

In this alternative, the MPCA and DNR would continue their current roles under the fish consumption advisory program, as well as the MDH in regard to setting health standards for fish consumption. However, all public education would be reallocated to local units. As discussed previously, education and public engagement segments of the advisory program could reside within units such as the MPRB, St. Paul Parks and Recreation (SPPR), and Hennepin, Ramsey, and Dakota Counties with additional resources. Although the three counties listed do have departments of environmental health who would likely be responsible for public education, staff and resources may need to be increased. Staff and resources to implement this alternative do not exist at either the MPRB or SPPR and would need to be allocated to them.

Program Cost

Current expenditures of $176.3 million for the fish consumption advisory program for the three state agencies would remain as all three agencies will continue their involvement at their current capacities. The reduced responsibilities of the MDH should have a minimal impact on that department’s annual expenditures. To duplicate the FRIENDS program, the additional cost to a local unit of government or organization would be approximately $70,000 annually. These costs would include expenditures for educational materials ($25,000) and the annual salary and support for a full-time environmental educator ($45,000). Assuming the program would be placed in Hennepin, Ramsey, and Dakota Counties, as well as the MPRB and SPPR, the total cost to local units would be $350,000 annually. Additionally, there could be costs associated with stakeholder involvement as the program is put in place. To implement a FRIENDS-like program, stakeholders would need to be involved early and often through the use of focus.

20 According to Pat McCann, Environmental Scientist, MDH, the department budgets $25,000 annually to pay for education materials.
21 Estimates based on the starting salary of an environmental educator with at least three years experience.
groups and opinion surveys to co-develop an advisory strategy. According to Rowe and Frewer (2000), these methods require potentially high expenditures in the short-term.

**Health Care Benefits**

Similar to the previous alternative, the lack of quantitative data on the success of this alternative in providing awareness and promoting compliance makes it difficult to project health care benefits after implementing this alternative. However, based on the risk communication literature previously mentioned, centering education efforts at the local level could result in greater awareness and compliance as compared to the education efforts within a state agency (alternative 1). Therefore, health benefits from this alternative may be higher than the previous alternative.

In summary, this alternative continues the use of the fish consumption advisory program to educate Hmong anglers of the risk on consuming fish. The only modification will be that the origin of education efforts will come from local units and community groups rather than state agencies. An example of such efforts is the FRIENDS program in northern Wisconsin who recreated advisory literature tailored to their local population. Although such a program demonstrates possible success according to risk communication literature, qualitative data has not been collected to measure the effectiveness of such a program. Therefore it is difficult to state definitively the level of awareness and compliance for this alternative. Costs to implement this alternative would include additional costs on top of the cost of the fish consumption advisory program currently in place. Health benefits are difficult to assess given the lack of data on awareness and compliance for local programs, but could be greater than the previous alternative if advisory awareness and compliance were to increase.

**Alternative 3: Ban all consumption of fish from contaminated metropolitan waters**

**Background**

Under this alternative, all consumption of fish from any public body of water in the metropolitan area would be banned until contaminant levels improved to a level that fish consumption did not pose a public health risk. The fish consumption advisory program would remain in place for all other public waters not covered by the ban. Other states in the country have used selective consumption bans to keep anglers from consuming contaminated fish. One example is Texas, which currently has fish consumption bans in place on five public water bodies (TPWD, 2008). Possessing fish from any of these waters is considered a violation of state law and is enforced by the Texas Parks and Wildlife Department. In the case of this alternative, the DNR would be the primary enforcer of a ban through the use of conservation officers who would issue citations to any angler seen not practicing catch-and-release. Penalties from
these citations would include a fine and possible loss of the angler’s fishing license. In addition, signs would be posted at all water access points notifying the public of the ban. Consideration of this alternative is a departure from the previously stated alternatives which were voluntary advisories used to educate the public to make informed choices on whether to consume sport-caught fish. This alternative removes choice from the equation and relies on compliance to a law to protect the public from methylmercury contamination.

Safety Effectiveness

Since a ban would remove the primary source of methylmercury exposure to the Hmong community, it is expected that the risk of exposure would decrease to a minimal level. However, this assumes complete compliance with such a ban which cannot be guaranteed. In a study of anglers in New York and New Jersey, Burger (2002) found that people continued to catch and consume fish and crabs even though a consumption was ban in place. Reasons for this lack of compliance ranged from the need for food to angling being a popular recreational activity that people did not want to give up.

Program Awareness

Similar to fish consumption advisories, there is a lack of data on the level of awareness anglers have regarding a consumption ban. Considering the method of notification (ie. publications, online resources, signs at fishing areas) would be similar to those used by the advisory program, promoting complete awareness of a ban would encounter similar difficulties.

Social and Cultural Acceptance

Considering the cultural interest of fishing within the Hmong community, both recreational and dietary, this alternative would likely have very low social acceptance. There are far too many Hmong anglers who consider fishing a way of life and a ban would be disruptive to their cultural norms. The reason behind such a low acceptance is related to the degree to which Hmong anglers see consuming fish as a right or a choice. A great deal of research has been done on risk perception over the past 20 years with the current belief that risk perception is a multidimensional process. Work by Slovic et. al. (1982) introduced the concept of risk perception from the view of the individual. An individual will act (such as consume a fish from a contaminated lake) in accordance to their perception of risk. This perception is based on factors such as whether the risk can be controlled, the trade-offs between benefits and risk of an activity, and the degree to which the impacts of risk are known and quantifiable (i.e. is there a possibility for a catastrophic event). Theses factors are influenced by both internal (i.e. personal experiences) and
external (i.e. media coverage) forces. Therefore, risk means different things to different people as people will disagree on the riskiness of hazards depending on controllability and the right to choose.

However, studies have shown that segments within a population can share similar levels of risk perception. This includes differences in risk perception between gender (men perceive risks to be smaller than women; Flynn, 1998) and socio-economic groups (poorer segments have a lower perception of risks; Sjöberg et. al., 2000). In regards to social and cultural groups, Kasperson et. al. (1988) described the concept of social amplification of risk where events pertaining to hazards interact with psychological, social, institutional, and cultural processes that can heighten or attenuate an individual’s perceptions of risk. In an extension of this thought, cultural groups can also have differing levels of risk perception based on the values and social context of that culture (Rohrmann, 2000). Behaviors based on these deeply held beliefs would be difficult to alter, even in the face of overwhelming evidence and awareness of risk (Slovic, 1982). Hmong anglers may have a level of distrust when it comes to warnings from a foreign and unknown source (Sjöberg et. al., 2000). Because of these reasons, Hmong anglers may choose to catch and consume fish in spite of the ban. Those who choose to consume fish may continue do so by either fishing in waters not covered by the ban or by choosing to violate the ban and continue to consume fish.

Implementation of this alternative means a shift from a voluntary advisory where anglers have choice to a situation where choice is removed through a legally enforceable ban. By removing choice, there is a violation of the ethical principle of autonomy which is rooted in the importance of individual freedom and choice. According to Beauchamp and Walters (1999), recognizing an autonomous individual to acknowledge capacities and perspectives, including the right to hold certain views, make certain choices, and take certain actions are based on personal values and beliefs. Respect for individual autonomy is to recognize individuals as “entitled to determine their own destiny, with due regard to their considered evaluations and view of the world.” In the case of the Hmong community, imposing a consumption ban removes decision-making from the individual, violating his or her autonomy, values, and beliefs.

Administrative Operability

Under this alternative, the three agencies currently involved in implementing the advisory program would remain, except in different capacities. In addition to its fish maintenance duties, the DNR would also be responsible for enforcing the consumption ban through the use of conservation officers. Given the large amount of shoreline and area of water in the proposed ban, additional officers may need to be hired to adequately enforce the regulation. The MPCA would continue its current role of developing state water quality standards and monitoring. The MDH would see a reduced role within the metropolitan area
as education efforts would no longer be needed. However, the department would continue its role in
advisory education throughout greater Minnesota. In addition, given the vast amount of lakes and rivers
within the metropolitan area, the task of enforcing such a ban is almost impractical.

Program Cost

Because the current fish consumption advisory program would remain in place under this alternative,
current costs to each state agency would remain with the exception of the DNR because of the need to
hire additional conservation officers to adequately enforce the ban. There are currently 19 conservation
officers stationed in the metropolitan area. Within the metropolitan area (Fridley, Brooklyn Center,
Minneapolis, St. Paul, Lilydale, Mendota, Mendota Heights, South St. Paul, West St. Paul, Newport,
Inver Grove Heights, St. Paul Park, and Grey Cloud Island Township), there are 41 lakes greater than 10
acres in size, as well as a 38 mile-stretch of the Mississippi River and less than 3 mile stretch of the
Minnesota River. In order to place an officer at each lake and four officers along the Mississippi and
Minnesota River, 26 additional officers would need to be hired. The average annual salary for a
conservation officer is $51,000, and the state could spend approximately $100,000 per officer annually in
resources (DNR, 2008). Therefore, the DNR would need an additional $3.9 million per year for
enforcement, on top of the $121.6 million per year it currently spends on fisheries maintenance and
protection. This brings the total cost of this alternative to approximately $180.5 million annually.

Health Care Benefits

Assuming complete compliance with the ban, Minnesota would see an increase in health benefits as
exposure to methylmercury and related illnesses are reduced. However as previously stated, it is
unreasonable to expect complete compliance due to social unacceptability. In addition, the removal of
fish from the diet could have unintended negative consequences because fish are a lean protein source,
rich in nutrients, and omega-3 fatty acids, which assist in the development of the eyes, brain and nervous
system in children (MDH, 2007b). Therefore, the actual heath benefit from implementing this alternative
may be no worse or no better than current conditions.

In summary, this alternative was evaluated as a way to remove the threat of methylmercury exposure
by instituting a consumption ban of public waters in the metropolitan area. Although this alternative has
promise in reducing methylmercury exposure, acceptability by the Hmong community would likely be
low, and the state would need a large increase in personnel and funding to implement and enforce a
consumption ban, while potentially seeing negligible health benefits.

22 Lake locations and calculations of lake size and river length performed using GIS from municipal, lake, and river
data acquired from the Metropolitan Council’s Data Finder website (http://www.datafinder.org/catalog/index.asp).
Alternative 4: Provide Asian-specific food shelves

Background

This alternative is being considered, not as a substitute to the previously mentioned alternatives, but instead, as an option to be considered in addition to alternatives 1-3. This option is meant to target a specific subpopulation within the Hmong community who may be at a specific risk of methylmercury exposure. Based on the 2000 U.S. Census, it was found that 33% of the Hmong population in Minnesota lives below the poverty line (Pfeifer, 2003). Because financial constraints limit food options, poorer segments of the population may see fishing as a food source more so than others within the same population (West 1992; Burger, 2002). The Hmong community has cultural ties to fishing and low-income segments of the population may turn to fishing as a food source to a greater degree than others in the Hmong community. This possible increased consumption rate poses a greater risk of methylmercury exposure. Data regarding fish consumption rates of low-income Hmong in Minnesota is not available and therefore this threat can only be supported by literature on the Hmong culture.

One way to minimize the risk to this specific segment is to offer more culturally-familiar options at local food shelves. This could be accomplished by expanding the food shelf program currently under operation by the Center for Asians and Pacific Islanders (CAPI). Beginning as a food shelf program in 1982, CAPI has since expanded its services to include employment assistance, skills training, English language programs, and refugee settlement services.

The CAPI food shelf program is the only program in Minnesota that caters to those of Asian-descent. The program, headquartered in Minneapolis, is only open to Hennepin County residents who register with the program. The food shelf is open three days a week and provides Asian foods such as varieties of noodles, fish sauce, bamboo shoots, rice, cooking oils, cereal, and canned goods, but does not provide fresh fish. Current estimates by CAPI find that the center serves 1,211 individuals or 280 households per month. This is approximately 26% of eligible clientele in the county as the program is only open to low-income residents of Hennepin County of Asian and Pacific descent. In order to serve the larger Hmong community in Ramsey County, the program will need to be expanded to this area.

In addition to providing food alternatives to sport-caught fish, this program could also serve as an outlet to provide education regarding fish consumption and methylmercury contamination. CAPI is currently engaged in providing health education services and could easily incorporate education materials developed by the MDH or a local organization such as FRIENDS in Wisconsin.

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23 According to the 2000 U.S. Census, approximately 13,924 Hmong live in Hennepin County, 4,595 of whom are considered low-income.
Safety Effectiveness

If the premise holds that low-income segments of the population eat more contaminated fish due to the lack of food sources, then this alternative could reduce methylmercury exposure. However, the CAPI program does not provide fresh fish or meat as one of their products. Because this alternative does not completely replace fish consumption, a reduction in methylmercury may not occur unless food shelves offered fresh fish free of contaminants.

Program Awareness & Social and Cultural Acceptance

Currently, approximately 26% of low-income Hmong in Hennepin County use the CAPI food shelf program each month. Because of the lack of specific data on the usage of the CAPI program, it is difficult to assign the reason for these rates to only program awareness or acceptability. Other barriers, such as location, transportation, or food shelf hours could also contribute to program usage rate. According to Nao Her, Food Shelf Coordinator for CAPI, the program is well attended each week, to the point that he believes that interest in food shelf would triple if expanded to St. Paul.

Administrative Operability

This alternative is a complement to the other alternatives in this report; therefore state agencies will continue its operations as outlined for a given alternative. The goal behind this alternative is to not alter the fish consumption advisory program, but instead offer an alternative food source to sport-caught fish for low-income segments of the Hmong population. Since there is only one Asian-specific food shelf in the Twin Cities which services only Hennepin County residents, another facility will need to be opened in Ramsey or Dakota County to service St. Paul residents. Given the limited resources of CAPI, this expansion may not occur without outside assistance.

Program Cost

Because the current fish consumption advisory program would remain in place under this alternative, current costs to each state agency would remain. Additional costs would come in the form of expanding the CAPI food shelf program to Ramsey County. CAPI currently allocates $36,000 annually for food purchases along with donations to serve approximately 14,500 individuals per year (1,211 per month). According to the census figures quoted earlier, around 23,000 Hmong are living under the poverty line. If the CAPI program was expanded to service all of these individuals, the cost of food would be

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25 Ibid.
26 Ibid.
approximately $57,040 annually (assuming comparable donation levels). In order to service individuals in St. Paul, a second location will need to be established. Currently, retail space in the Twin Cities is averaging $17.06 per square feet (Bizspace Twincities, 2008). Estimating that a food shelf, which provides food for approximately 300 people a week, would require 4,000 square feet of retail space, annual costs would be approximately $818,880. Other infrastructure costs, such as personnel, are difficult to estimate given that most of these costs are donated. Therefore, expanding the CAPI program to cover 23,000 individuals in two locations could be approximately $875,920 annually.

Health Care Benefits

By providing access to a more diverse and healthy diet, one could expect an increase in health care savings related to a decrease in methylmercury exposure. However, since this alternative does not completely replace fish in a person’s diet, people could continue to consume locally-caught fish. Unless the food shelf program was to provide fresh fish, health care savings may remain at the baseline level.

To summarize, this alternative is considered as a complement to the other alternatives considered in this report. Because this alternative does not completely address fish consumption, Hmong anglers may choose to continue to consume sport-caught fish. The CAPI food shelf program is moderately attended in Hennepin County, but reasons for this attendance are difficult to assess. Because the CAPI program is only available to Hennepin County residents, a second program would need to be created which may be beyond CAPI’s current administrative abilities. Annual costs for additional location could double CAPI’s current food shelf budget, while only providing moderate health care benefits.

ALTERNATIVE EVALUATION

Based on the criteria chosen for this analysis, the alternatives were evaluated both qualitatively and quantitatively. Results of this evaluation are illustrated in Table 3. A qualitative assessment was performed for safety effectiveness, health benefits, and social and cultural acceptability. For each criterion (safety effectiveness and health benefits, and social and cultural acceptability and program awareness were joined because of similarities), each alternative was scored effective (likely to achieve goals), promising (has the potential to achieve goals), or problematic (not likely to achieve goals). This is similar to the policy evaluation scheme used by the international Millennium Ecosystem Assessment report (MEA, 2005). In some cases, alternatives were given multiple scores if outcomes are in question. Program cost is listed quantitatively as the total cost of implementation. Food shelf costs do not include costs of implementing other alternatives in conjunction. Administrative operability briefly outlines the level of difficulty in and resources needed for implementation.
Table 3: Criteria evaluation of each alternative.

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Safety Effectiveness &amp; Health Benefits</th>
<th>Social and Cultural Acceptance &amp; Program Awareness</th>
<th>Program Cost (estimated millions $)</th>
<th>Administrative Operability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effective</td>
<td>Promising</td>
<td>Problematic</td>
<td>Effective</td>
</tr>
<tr>
<td>Current FCA Program</td>
<td>Effective</td>
<td></td>
<td></td>
<td>Effective</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Local FCA Education</td>
<td>Effective</td>
<td></td>
<td>Problematic</td>
<td>Effective</td>
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<td></td>
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<tr>
<td>Fish Consumption Ban</td>
<td>Effective</td>
<td></td>
<td>Problematic</td>
<td>Effective</td>
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<td></td>
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<tr>
<td>Food Shelves</td>
<td>Effective</td>
<td></td>
<td>Problematic</td>
<td>Effective</td>
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When evaluating the four alternatives, alternative 2 (local advisory education) was rated the highest. This alternative scored high for safety effectiveness, health benefits, program awareness, and social and cultural acceptability. The cost of the implementing the alternative is similar to current advisory program costs, however local resources may need to be significantly increased. Alternative 1 (current advisory program) was also ranked highly, however there is a concern about the level of safety effectiveness and health benefits this alternative provides. Alternative 3 (fish consumption ban) was ranked the poorest because even though this action may be effective in limit methylmercury exposure, the action would have minimal social and cultural acceptability and would require additional resources and increased costs. Evaluation of alternative 4 (food shelves) confirmed that the program could be an effective complement to other alternatives, but would not be effective as a stand alone alternative.
RECOMMENDATIONS

Of the four alternatives evaluated in this report, three were scored similarly with respect to the selected criteria. Only the fish consumption ban alternative scored poorly and thus will not be recommended. The other three alternatives are therefore recommended to be established as positive steps in reducing methylmercury exposure to the Hmong community in the Twin Cities. Specifically, this report suggests the following actions.

Evaluate current fish consumption rates and advisory awareness of the Hmong community.

This report has revealed a large data gap regarding the overall effectiveness of the fish consumption advisory program in protecting the Hmong community from methylmercury exposure. Consumption and advisory awareness surveys have previously been conducted for Minnesotans in general, but none specifically for the Hmong population in the metropolitan area. Before implementing any of the alternatives discussed in this report, quantitative data (similar to data collected by the Great Lakes Fish Consortium) must be collected to determine if the Hmong community is aware of the current advisory program, accepts and understands the advisory, and to what degree alters their behavior. Data from this effort could then be used to determine what areas of the program need to be addressed.

The MDH should continue and augment partnerships with local governmental units and organizations to educate at-risk populations in Minnesota.

The MPCA, DNR, and MDH are the ideal agencies to monitor water quality, analyze fish for methylmercury, and set health guidelines for fish consumption due to their scientific expertise in their respective areas. The current methods used by the MDH and other state agencies in implementing and communicating risk of fish consumption scored relatively high in this report. The MDH has made great strides in partnering with local units in order to provide useful and culturally acceptable literature on methylmercury and fish consumption. However, those within MDH need to be cognizant of the limitations their agency has in communicating with local units and citizens. Research has shown that Hmong anglers may be distrustful of information from a foreign source (Sjöberg et. al., 2000). These individuals may be less likely to trust risk communication unless it originates from a credible, unbiased source (Knuth, 1990). The advisory program requests individuals to change their fish consumption habits because of methylmercury contamination, which cannot be detected by sight, smell, or taste. Understanding of contamination may be unknown to some Hmong anglers, who may continue to consume fish in accordance to cultural norms. Under the Knuth (1990) model, messages from the MDH regarding fish consumption may be altered or disregarded as it passes through cultural filters to receivers.
in the Hmong community. To minimize the effect of these filters, greater importance on local education must be used.

Local units of government and organizations should take on a greater role in direct education efforts of the advisory program. A model for this education effort is the FRIENDS program used for the Hmong population in northern Wisconsin. This organization took advisory information created by the Wisconsin Department of Health and Family Services, modified the message to conform to local cultural norms, and developed their own publications and workshops. However, implementing such a program would require a greater amount of resources from local units than what is currently being utilized. Funding may be available for such a program from NIEHS, the federal institution which currently funds the FRIENDS program.

*Effective angler education needs to be in place along all impaired public lakes and rivers in the metropolitan area.*

One of the prime locations to educate anglers of the risk of sport-caught fish consumption are the areas in which fishing takes place. This includes local fishing piers, shorelines, and boat launches. Using the Knuth (1990) model of risk communication, education along fishing and boating location would shorten the channel between messenger and receiver, possibly minimizing the effects of filters than may alter the message. Upon inspection of fishing locations and boat launches along the Mississippi River, there we no signs or literature available to alert anglers of the fish consumption advisory in general or for that specific river. The DNR claims that signs are present on small, local lakes, but admits none exist along the Mississippi River. This lack of education should be remedied by placing informational signs, translated in multiple languages, along all methylmercury-impaired public waters in the Twin Cities. According to Connelly and Knuth (1998), risk communication messages are most effective when text and graphics are used. An example of this format is used by the Wisconsin Department of Health and Family Services which could be used along metropolitan lakes and rivers (Figure 14).

*The MDH should revise the formats used to communicate advisory information.*

Currently the MDH uses a variety of formats to advise the public of fish consumption advisories. This includes brochures and online documentation. In general, the literature provided by the MDH conforms to formats shown to be effective in risk communication literature. Connelly and Knuth (1998)

*Figure 14: Fish consumption advisory sign developed by the Wisconsin Department of Health and Family Services (WDHFS, 2008).*
suggested documentation is effective when using text written in a simple sentence structure, using a cajoling tone, and interspersed with graphics. These communication formats are demonstrated in the main publication used by the MDH to educate the public (Figure 10). The MDH may want to consider adding a risk ladder (comparing the risk of eating fish to other common, everyday risks) to its publications, which have also been found to be effective in risk communication (Connelly and Knuth, 1998). Also, these publications are available online only in English and Spanish. Translated materials in other languages (including Hmong) should also be available online.
Effective use of risk communication strategies may not be the same however for online documentation regarding site-specific advisories. The method of symbols used to relay information on the consumption of a particular fish species and fish size can be confusing (Figure 11). The MDH may want to consider creating individual documents for each lake and river as opposed to a single document with multiple symbols and letters.

Although using the web can be quick and inexpensive format to deliver advisory information to the public, it should be noted that unless these materials are widely available in print (in documents or signs), segments of the population who do not have computer access could be kept from this information. In addition, online information is of little use when consumption decisions are made while fishing. The MDH must not become too dependent on online materials and must remember how the audience will use this information.

*Expand the CAPI food shelf program to serve residents of St. Paul.*

Although creation of this program should not be considered as a replacement to fish consumption advisories, this program could be effective in offering alternative foods to sport-caught fish. This could be especially important to low-income segments of the Hmong community. However, expansion of the CAPI program to St. Paul is likely beyond the financial capabilities of this organization and implementation of such a program may be long-term.

*Extend issues revealed in this report to other at-risk communities in Minnesota.*

While gathering information for this report, it was discovered that Hmong may not be the only culture in Minnesota with a higher level of susceptibility to methylmercury exposure from fish consumption. Much like the Hmong, Native Americans have a deep cultural connection to fishing and fish consumption (Roe, 2003). This connection may result in a higher rate of fish consumption than the general population, placing them at greater risk of methylmercury exposure. Preliminary data from the Indigenous Women’s Mercury Investigation (2006) found that Native Americans in northern Minnesota continue to consume fish at levels greater than recommended by the MDH. Communities such as these should also be considered when developing culturally-specific education literature in order to protect all Minnesotans from methylmercury.
LITERATURE CITED


