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Consumption Surveys For Fish And Shellfish

A Review And Analysis Of Survey Methods

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SUMMARY

Although several studies have demonstrated that fish and shellfish consumption rates differ both regionally and within specific subpopulations, most States do not have available sufficient data to calculate local consumption rates or to identify special populations at risk. Examples of these special populations are recreational and subsistence anglers and members of their households–in particular, women of child-bearing age, children, and the elderly–who frequently consume fish obtained from contaminated sites. This report was designed as a critical assessment of fish tissue consumption rate survey approaches and methods and their applicability for estimating consumption rates in recreational and subsistence fishing populations. Additional information is provided to assist Federal and State agencies in developing appropriate surveys to answer questions and resolve issues related to the fish consumption rates of special populations.

Five approaches to obtaining fish consumption data were reviewed: (1) recalled information collected by telephone; (2) recalled information collected by in-person (face-to-face) interviews; (3) recalled information requested on self-administered mailed questionnaires; (4) diaries maintained by anglers; and (5) on-site creel censuses. The effectiveness of the approach used to obtain adequate information for fish consumption rate calculations varied with the objective(s) of the survey. For example, creel censuses usually failed to collect data on consumption. Many surveys combined two or more approaches in order to maximize the number of respondents or validate the information obtained. Several studies addressed actual contaminant exposures through physical examinations and measurement of blood serum levels of contaminants, while others investigated risk perception and compliance with fish consumption advisories and bans by the targeted anglers.

Five elements common to all surveys have been identified, and specific methodological details are provided to help solve problems that may be encountered when undertaking a fish consumption survey. (1) Survey design must address the purpose for which the survey is to be conducted, the resources available for carrying it out, including time and funding available, and the approach to be used. (2) Survey participants should be identified from a pool of subsistence or recreational anglers, and the method by which the sample is selected may vary depending on the approach that will be used to collect the data and how the data will be analyzed. (3) The information to be collected should examine sociodemographic factors that may influence fish consumption rates, as well as those factors that are needed to calculate fish consumption rates, minimizing the number of assumptions that could compromise results. The survey length and complexity should be carefully considered in order to elicit maximum cooperation from respondents. (4) Appropriate quality assurance procedures need to be developed before beginning the survey, and quality control must be carefully monitored during the survey to ensure the validity of the data *before* statistical analyses are conducted. (5) Data processing procedures and statistical analyses should be performed to provide the desired information and correlations.

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I. INTRODUCTION

Concern over potential human health risks associated with chemically-contaminated fish and shellfish* has led many States to issue consumption advisories and bans in an effort to limit exposures to certain organic compounds and metals that may become concentrated in the tissues of these organisms. However, the processes and procedures by which States issue fish consumption advisories and bans have varied. In a recent effort to evaluate the fish advisory process in the States, the U.S. Environmental Protection Agency (EPA) provided a grant for the American Fisheries Society (AFS) to conduct a survey of State fish advisory practices (Cunningham et al., 1990). In the survey, State representatives were asked to describe their fish advisory process and procedures, to identify State concerns related to the advisory process, and to recommend actions that could be undertaken by the Federal government to improve the effectiveness of the advisories.

To follow up on the State recommendations for Federal action, EPA invited officials from State agencies to attend a Federal-State Forum on August 30, 1990, in Pittsburgh. Representatives of agencies from 27 States and the District of Columbia, as well as several Federal agencies, including EPA, the Food and Drug Administration (FDA), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (FWS), the Tennessee Valley Authority (TVA), and the Agency for Toxic Substances and Disease Registry (ATSDR) were present. The agenda for the Forum contained a list of the Federal action items identified in the AFS survey. Participants were asked to rank proposed Federal action items as short- or long-term priorities and to recommend other action items not previously identified in the survey. Each participant was also requested to submit the three action items that were most important to his/her program. The second most frequently requested short-term action item contributed by Forum participants was to conduct surveys/studies to assess the fish consumption rates of various subpopulations in different regions of the country (Southerland, 1991).

Fish consumption rates differ throughout the country and for specific subpopulations (e.g., Hu, 1985). The use of an "average" consumption rate for typical households, recreational anglers, and subsistence anglers may not

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*Hereafter, in this document, "fish" and "fishing" will include shellfish and shellfishing, except where specific surveys are discussed.

and subsistence anglers may not accurately reflect the local consumption rate in a particular subpopulation and may overestimate or underestimate the risk associated with the consumption of contaminated fish tissue by different members of households. Presently, most States do not have available sufficient data to calculate local consumption rates or identify special populations at risk. As a result, a variety of methods are used for estimating consumption rates when calculating risk associated with the consumption of chemically-contaminated fish tissue (USEPA, 1989). To further complicate the issue, recreational anglers may catch fish from contaminated sites for sport, but not consume them, while subsistence anglers may be obtaining a large proportion of their diet from contaminated resources because they cannot afford to purchase other foods. There are also commercial-type subsistence fishing operations, which obtain fish on a larger scale to provide these items to communities. The amount of time spent in these activities may vary depending on the weather and the state of the fishery (seasonal restrictions, for example).

Human exposures to chemical contaminants (e.g., dioxins or polychlorinated biphenyls from industrial sources, pesticides from nonpoint sources, or mercury from natural sources) through fish consumption are a function of the quantities of these foods consumed by humans as well as the ability of different species of fish to bioconcentrate the chemicals of concern. The EPA, FDA, National Marine Fisheries Service (NMFS/NOAA), and other organizations are responsible for monitoring the chemicals found in these organisms. A number of recent studies, however, have pointed out that the national surveys that are the basis for many human health risk assessments fail to target some of the potentially most high-risk populations, including recreational and subsistence anglers and their families.

Early studies of fish consumption provided only limited data (e.g., Nash, 1971; Hu, 1985). Although the number of fish meals was tallied, socioeconomic or demographic questions were usually limited and no distinction was made between recreationally (self-caught) and commercially harvested (including processed/canned) fish consumed. Furthermore, in these early studies there was usually no characterization of types of fish consumed (an exception was the National Marine Fisheries Service Survey 1973-74). Surveys were either specific to particular regions of the country or national in scope (nonspecific). Thus, while these databases did provide important information on consumers and frequency of consumption of various fish products, there was no effort to identify subsistence and recreational anglers obtaining their catches from polluted waters. Regionally specific data could not be used in consumption rate calculations for other areas of the country, (Rupp et al., 1980). Another review by SRI International (1980) found that the most reliable source of data on human fish consumption was the National Purchase Diary Fish Consumption Survey, a national questionnaire survey conducted during 1973-74 by NPD Research Inc. SRI performed additional

tabulations of the corrected data to obtain mean consumption rates for various demographic categories and fish species.

Wagstaff et al. (1986) examined three types of national studies: (1) commercial production data on landings, imports, and exports of food fish; (2) surveys of food (including fish) intake; and (3) surveys specific for fish intake. Commercial fish production data failed to include commercial freshwater fish, recreationally caught fish, or marine fish sold at roadside stands (see also report by SRI International, 1980; Kleiman, 1985). General food intake surveys were limited in scope, season, or demographic and socioeconomic data. Specific fish intake surveys, based on weekly diaries for periods up to a year, included all fish meals, whether caught or bought, but recreational catch information was sparse to nonexistent. Although estimates of per capita fish consumption based on these surveys were similar, Wagstaff et al. (1986) concluded that improved survey design and implementation of quality control in conducting, documenting, and reporting the results of such a survey were needed. Fisher (1988) reviewed nine early surveys and found that none of them provided the data needed to estimate usual or heavy fish intake or to examine recreationally-caught and consumed fish species. Hence, these surveys had only limited value in determining diet/health relationships or performing risk assessments associated with fish consumption. He noted, however, that because studies suggested an upward trend in per capita consumption, more recent and more detailed information was needed "either by expansion of currently planned nutrition surveys or by focused efforts to obtain such data from surveys on fish consumption."

Despite the numerous limitations of these early studies, calculations of fish consumption rates suggested that certain subpopulations, based on race, ethnic origin, age, sex, income, and residence, did consume more fish than other groups. More recent surveys of Michigan sport anglers and their families by West et al. (1989a,e) revealed that minorities from cities, rural Native Americans, and the elderly also caught and consumed more fish. Some recent surveys have attempted to link fish consumption rates to epidemiologic studies of health status (USEPA, 1984b) or body burden levels of contaminants (Fiore et al., 1989). These studies and observations of fishing activity at known chemically-contaminated sites (e.g., Puffer et al., 1982a,b; Belton et al., 1985; Smith and Enger, 1988; Smith and Thompson, 1989) indicated that more detailed surveys targeting subsistence and recreational anglers were warranted to improve calculations of fish consumption rates and risk assessments for specific subgroups (Table 1). Such information is important for determining the success of advisories and bans issued to reduce health risks from eating contaminated fish and/or of changing waterbody management policies to reduce or eliminate toxic chemical inputs.

EPA recognizes that studies of fish consumption patterns need to be conducted to update current information and to focus on potentially high-risk geographical or cultural populations. To address this need, EPA has

TABLE 1. ISSUES AND INFORMATION REQUIREMENTS FOR FISH CONSUMPTION SURVEYS

Sociodemographic Characteristics of Angler:

- Age
- Occupation/employment status
- Income level
- Education level attained
- Number of household members
- Race/ethnic group, sex, age, height, and weight of the fisherman and each household member
- Pregnancy/lactation status of women in the household
- Language spoken at home
- City of residence

Fishing Activities:

- Location(s) of fishing activities (specific sites, type of waterbody)
- Distance(s) of fishing activities from principal residence
- Seasonal and temporal distribution of fishing activities (total number of days per season, which months of the year, for each location)
- Fishing effort (hours/outing, hours/day, outings/month, days/month)
- Purpose for fishing (consumption, sport only: catch and return, etc.)
- Mode of fishing (nets, traps, hook and line, etc.; pier, shore, private boat, charter boat, SCUBA)
- Type of fish captured (general category such as bottomfish, flatfish; or identified to species or group of species)
- Numbers of fish captured per outing by species
- Size ranges of fish captured (minimum and maximum weights and lengths by species)
- How the fish were disposed of (released, consumed by household, sold , given away)
- How long involved in fishing activities and consuming self-caught fish (new to sport or years

TABLE 1. Continued

Preparation and Consumption Patterns:

- Portions of fish consumed (may vary with the species)
- How the fish were prepared for eating (skinned, fillet, steak, shucked, etc.)
- How fish were cooked (baked, fried, steamed, etc.)
- Amounts (weight) of wild-caught fish eaten per meal/day/week/month for each person in household
- Special cultural/ethnic practices in fish consumption and preservation
- Consumption of fish purchased in supermarkets, fish markets, or roadside stands; purchased at the dock; or obtained by bartering (amounts, frequency)
- Consumption of other aquatic organisms, waterfowl, or wildlife that may have consumed fish from same sites (amounts, frequency)
- Fish frozen or preserved and eaten throughout the year or eaten only when fresh
- Participation in food assistance program
- Source of home water supply
- Voluntary risk patterns (smoking, drinking)

Fish Consumption Advisory Awareness and Understanding:

- Has the angler heard, from announced fishing bans or posted notices, of the possible contamination of fish by chemical or biologic agents in areas where presently fishing or where planning to fish?
- If the answer to the previous question is yes, has it affected his/her fishing activities, fish preparation methods, or consumption patterns?
- What, if anything, would stop the angler from eating the fish that he/she has caught?
- Did the angler ever get sick from eating self-caught/self-prepared fish or shellfish?
- Did the angler ever observe any abnormalities, internal or external, in captured fish? If so, were the fish consumed, thrown out, or given away?

implemented a three-phased approach for assisting the States in estimating fish tissue consumption rates in potentially high-risk populations. This approach includes the following steps:

- Review and critically evaluate existing fish tissue consumption rate survey methods and determine their applicability for estimating consumption rates in recreational and subsistence fishing populations.
- Conduct a workshop for the States presenting the results of the review and critical evaluation of fish tissue consumption survey methods.
- Provide direct support to the States in conducting fish tissue consumption surveys, targeting recreational and subsistence anglers.

This document was prepared to meet the first step in this process. Existing literature concerning fish tissue consumption was reviewed, and selected surveys were evaluated to identify approaches (recall vs. diary vs. creel census) and methods for survey design and analysis. The purpose of this report is to assess the attributes and shortcomings of these approaches and to explore the underlying methods involved in designing and conducting fish consumption surveys. The report also discusses the types of questions that need to be answered if we are to understand fish consumption patterns in high-risk populations (Table 1). It does not, however, recommend a specific protocol for use by the States. The methods, approaches, and questions chosen will depend on the goals, objectives, and situations of the particular State and may also vary for the high-risk subpopulation to be investigated. Therefore, a variety of options and guidelines for designing and executing surveys is presented. This document is intended to assist Federal and State agencies in revising surveys so that the types of information needed for valid statistical analyses to adequately address human health risks in subsistence and recreational anglers and their families can be collected efficiently and cost-effectively. Survey professionals from government, academia, and/or private industry should also be consulted to ensure a successful survey.

II. SURVEY APPROACHES

A variety of approaches has been used in attempts to develop appropriate estimates of fish consumption rates. Fisher (1988) examined techniques for obtaining data for a "national" sample of individuals and for samples of subpopulations that might be more frequent fish consumers. He noted that the complex problem of estimating fish consumption for possible assessment of diet/health relationships and risks associated with the use of fish as food required consideration of the following:

- Sociodemographic characteristics of consumers;
- Geographic and seasonal variations in consumption;
- Species of fish and geographic origin of species consumed;
- Parts of fish consumed; and
- Quantities consumed.

The approaches to collecting data on fish consumption were categorized as follows:

- Indirect - data collected on food disappearance into marketing channels or households (the unit of observation) and
- Direct - data collected on actual food use or food consumed by a variety of methods (i.e., the household or individual intake is the variable measured).

Indirect techniques were usually deemed unsuitable for small-scale studies and did not allow for correction of waste or individual intakes. Direct techniques, such as food diaries or records, weighed intake, dietary recall, food frequency, and duplicate portion studies, provided individual consumption data but were more labor-intensive in both data gathering and analysis. More information on the attributes and limitations of direct approaches to quantification of daily consumption by individuals was provided in Anderson (1986).

Five different approaches to conducting surveys of subsistence and recreational anglers were identified during this review of recent fish consumption surveys. In this section, each approach will be described and the advantages and disadvantages presented. Four categories of information needs similar to those listed above by Fisher (1988) have been compiled and are presented in Table 1. These categories include questions that need to be answered or issues that need to be resolved in order to be able to calculate fish consumption rates for special populations. The questions were derived from recent

fishing/shellfishing surveys and comments from representatives of Federal and State agencies and other organizations. Although the types of data on sociodemographic characteristics, fishing activities, preparation and consumption patterns, and fish advisory awareness and understanding will be discussed in more detail below, the ability of each approach to adequately address these information needs will be examined in this section, in particular:

- Can the approach assess region-specific (rather than national) consumption rates?
- Can the approach target and identify specific subpopulations of concern (i.e., subsistence and recreational anglers)?

The use of any particular approach will depend on the specific objectives of the study and the questions asked, as well as other factors. These will be discussed further in Chapter III, Important Method Considerations.

Recall - Telephone Survey

The telephone survey recall approach consists of making contact with respondents by telephone and asking questions to elicit information on current or recent fishing trips and fish consumption. The answers are recorded directly on preprinted questionnaires, usually by interviewers working from one central location under the supervision of an experienced researcher. Although this approach "is rapidly becoming the principal method of collecting survey data in research situations where probing or in-depth exploration of the issues is not required" (USEPA, 1984a), interestingly, none of the surveys reviewed relied exclusively on data collected by telephone interviews. Instead, these surveys combined this technique with either on-site personal interviews or mailed questionnaires. A comparison study of different protocols examined by USEPA (1984a) found that a telephone interview based on a written questionnaire previously mailed to the respondent was the most effective approach because the respondent had time to review the questions and survey information. Often, the telephone was used to gather information on non-response bias or to confirm, adjust, or add to data collected in the field (see West, 1989b; National Marine Fisheries Service, 1991). Telephone surveys may minimize recall bias and achieve a better overall response than mail surveys because the personal contact involved may encourage the respondent's participation and jog his/her memory.

Telephone surveys may be appropriate for collecting certain types of information where long-term recall or familiarity with certain facts is not required (such as species names of fish caught/consumed). SRI International (1980) found that a 7-day recall period could be quite inaccurate; however, West et

al. (1989b) observed that a 7-day recall period was as accurate as 1-day recall (see discussion under "Recall - Mail Survey"). Fisher (1988) found that single-day, 24-hr recalls could be used to estimate mean intakes of population groups if the days were distributed throughout the year and if the survey population were large enough. Although large numbers of respondents could often be reached at a cost savings over personal interviews (e.g., the National Marine Fisheries Service studies), the types of information that could be reliably collected by this approach were limited. For example, anglers may not divulge their fishing sites or give accurate answers to certain sociodemographic questions. To maintain cooperation, each interview lasted no longer than 10 minutes and therefore the questions were few (although other successful telephone surveys have used longer interviews). Hence, the surveys examined in this review usually relied on other approaches as their primary means of gathering data.

A number of problems were found in the use of telephone surveys, including difficulty in scheduling to make contact with selected respondents, absence of respondents at time of calling, unlisted numbers, and lack of a phone. The last could be a problem when trying to include low-income, suspected subsistence, anglers in the sample. Wendt (1986) observed that low-income anglers consumed more freshwater fish than those with higher incomes. List-assisted dialing, in which respondents were identified from lists of licensed anglers or participants in fishing tournaments, or other such preselected lists, was considered to be better than random-digit dialing techniques (see Brown, 1981, for an example of the latter) because specific populations of anglers could be more easily identified. Computer-assisted survey techniques (e.g., Computer Assisted Telephone Interviewing or CATI, USEPA, 1984a) may be more efficient and less prone to errors made when transferring written data to computers since printed questionnaires are not used and the information is directly entered into the computer during the interview. If extensive narrative questioning is the basis of the survey, however, the use of CATI could compromise data collection. Verification of the information given is important and could require much additional work.

Advantages:

- The telephone survey can assess region-specific consumption rates, depending on how the respondents are selected, i.e., determined by residence or proximity to a particular waterbody.
- This approach can target and identify specific subpopulations of concern when these populations can be preselected on some basis or when specific limiting questions are included on the surveys.
- This approach is generally less expensive (by approximately one-half) and less time-consuming than personal interviews (since less training of

interviewers is required and travel costs are not necessary), so large numbers of respondents may be contacted (see USEPA, 1984a).

- A high rate of success for completing interviews is likely, although the sucess rate is 5 percent lower than that for personal interviews (USEPA, 1984a) because of lack of personal contact.
- Sensitive information may be obtained more easily than with other approaches.
- This approach provides immediate responses to questions, so analyses may be completed more quickly.

Disadvantages:

- Interviewers cannot reach people who do not have phones or those with unlisted numbers.
- Interviews may need to be limited in scope and length, so the number of questions must be carefully chosen.
- It is difficult to verify information given.

To Solve These Problems:

- Use telephone interviews only as a follow-up to collecting information by other approaches.
- Use other approaches to contact low-income people.
- Use random-digit dialing to reach those with unlisted numbers (USEPA, 1984a), although considerably more effort may be required to reach members of the target population.
- Have one very specific objective for the survey, such as fishing activities *or* fish consumption patterns, to limit the number of questions.
- Carefully design the survey to examine specific subpopulations and carefully prepare the questions to be asked to obtain optimal responses and to serve as self-checks on information given.
- Use combined mail/telephone techniques to provide questions and visual aids or other information prior to contact.

Recall - Mail Survey

A number of surveys used self-administered mailed questionnaires to obtain information from recreational anglers. As noted by USEPA (1984a), these mail surveys are best for collecting detailed technical data, especially if the respondents need to think about the questions or consult their records. The types of information ranged from simple creel census harvest/angler use data (Swanson and Stephenson, 1982) to more detailed data on fish meals consumed by the household and methods of cooking. The Wisconsin survey

(Fiore et al., 1989) additionally obtained blood samples for chemical analyses from some of the respondents who agreed to participate in a follow-up study. A mail survey by Diana (1989) investigated behavioral groupings that indicated compliance with fish consumption advisories and respondents' knowledge of the fish contaminant situation. The available sample population for mail fish consumption surveys was most often identified from records of anglers holding State fishing licenses and was sometimes geographically stratified to target those anglers nearest waterbodies of concern (e.g., the Great Lakes, coastal counties, specific rivers). The actual costs associated with this method will vary with the length of the survey and number of questionnaires sent, the number of reminders, and the type of follow-up performed.

Success rates for the return of completed questionnaires varied widely. SRI International (1980) considered an 80 percent response rate to be acceptable, but many surveys fell far short of this goal. Cox, et al., (1987) distributed three sets of questionnaires with the *Guide to Eating Ontario Sport Fish.* In 1978, questionnaires were sent randomly to people who had requested a guide in response to newspaper advertising and 876 (44%) responses were received. In 1983 and 1986, the questionnaire was included in the back of the guide, and 807 and 1483 responses were received, respectively. The most recent mailing in 1989 included 100,000 questionnaires placed in the book, but only 913 responses were received (Cox et al., 1990). This response rate indicated that other methods, including providing incentives or contacting nonrespondents, would be necessary to improve the sample size (C. Cox, Ministry of the Environment, Toronto, Canada, personal communication). However, direct mail questionnaires were much more effective than the insert questionnaires in the guide. Questionnaires were mailed to Great Lakes salmon anglers using randomly-selected names from fishing derby entry forms, together with an informative covering letter and postage-paid return envelope. The return rates for three mail-outs (600–800 names each) were 65.6 percent, 67.3 percent, and 71.8 percent (Cox and Johnson, 1990). Questionnaires sent to a 10 percent random sample of Arizona's resident 1980 Class A and F license holders with a postage-prepaid return envelope resulted in only a 35 percent return rate (Swanson and Stephenson, 1982). Most of the other surveys reviewed for this report had higher return rates, but they required relatively more money and time and included advance letters, stamped return envelopes, reminder letters or postcards, a second mailing of the survey to nonresponders and, finally, follow-up telephone calls to check on non-response bias. A variation of this technique, known as the "Dillman Method" (Dillman, 1978), in which advance notices and several reminders are also mailed, increased the response rates up to 47–64 percent (Fiore et al., 1989; Connelly et al., 1990; West, 1989a; Chem-Risk, 1991a). Babbie (1973) reported greater success when the survey questionnaire was either personally delivered to the respondent or picked up later.

The information collected in the mail survey approach is typically based on recall periods of days to months, up to 1 year (Fiore et al., 1989). Thus, these surveys are all subject to problems of longer term recall accuracy. West et al. (1989b) examined several possible modes for conducting their survey and concluded that of the the 1-day recall, 7-day recall, or 7-day diary record, the 7-day recall would be best. The 7-day recall proved to be as accurate as the 1-day recall when determining group means and was more representative of fluctuations over time. They noted, however, that this time period could be subject to "telescoping," in which respondents tend to include events from a longer time frame than is called for. West et al. (1989b) used the "bounded recall" technique to minimize telescoping by first having respondents mark out in a one-week calendar the meals at which fish were eaten before providing detailed consumption information. The ChemRisk (1991a) study noted that in addition to the length of the recall period (up to 1 year in this survey), the self-reporting nature of the mailed questionnaire survey, social desirability of the sport (prestige bias), importance of fishing to the individual, and frequency of fishing trips also contributed to overestimates of consumption. Avid anglers were more successful and therefore consumed more; consequently, 10 percent of the anglers consumed 90 percent of the fish in that study.

The mailed questionnaire surveys did target recreational anglers but usually did not specifically examine the occurrence of subsistence fishing (except to include questions from which analysts might infer subsistence fishing, such as income levels). Only a few studies linked specific waterbodies to the consumption of fish from those waterbodies (e.g., ChemRisk, 1991a; see also Connelly et al., 1990, which targeted Lake Ontario fish consumption; other Great Lakes examined by Fiore et al., 1989; West et al., 1989b). The information collected to calculate fish consumption rates varied in complexity and ease of analysis, but certain assumptions needed to be made to cover recall bias identified from follow-up surveys.

Advantages:

- Mail surveys can assess region-specific consumption rates, depending on how the respondents are selected (obtaining addresses from license applications, fishing tournament entries, etc.).
- This approach can target and identify specific subpopulations of concern when these populations can be preselected on some basis or when specific limiting questions are included on the surveys.
- This approach is the least costly since no interviewers are required except for obtaining follow-up information. Large numbers of respondents may be contacted over a broad area (see USEPA, 1984a).
- Respondents are most likely to provide honest answers and fewer "socially-desirable" responses (USEPA, 1984a).

- Complex technical data may be obtained because the respondent can take time to consider the questions asked and consult other sources if necessary.
- The survey may cover more types of questions, so more than one objective may be evaluated.

Disadvantages:

- Mail surveys cannot reach people who lack mailing addresses, such as migrant workers. If addresses are obtained from specific sources, such as licensed anglers, the survey will miss unlicensed anglers and others possibly at high risk from fish consumption.
- Questions must be carefully designed to compensate for the lack of social interaction provided by telephone or personal interviews and must provide adequate instructions to elicit satisfactory responses and motivate the respondents to cooperate (USEPA, 1984a).
- Questions need to be limited in scope and complexity, preferably requiring only short answers or checking off multiple choices, to maintain cooperation by the respondent.
- Voluntary mail surveys require substantial follow-up efforts or incentives to achieve reasonable response rates (either by conducting telephone interviews or by offering the respondents the choice of phoning in their answers).
- A mail survey is likely to produce a higher number of inaccurate and incomplete responses because it lacks the personal contact provided by other approaches to instruct and motivate (USEPA, 1984a).
- This type of survey may miss respondents who are illiterate, who have difficulty understanding the questions, or who cannot read the language in which the questions are written.

To Solve These Problems:

- Use mail surveys in conjunction with telephone interviews or other approaches to check on non-response and recall biases.
- Increase the return success rate by sending out several waves of follow-up reminders, conducting follow-up telephone interviews, offering respondents the choice of phoning in their answers, personally picking up the completed questionnaires, or using incentives.
- Use other approaches, such as personal interviews, to contact low-income people or subsistence anglers, or those who cannot fill out the questionnaires because of literacy problems or language differences.

- Carefully design the survey to examine specific subpopulations, and carefully prepare the questions to be asked to obtain optimal responses and to serve as self-checks on information given (see USEPA, 1984a).
- Carefully plan and pretest the questions to be answered to minimize the length of recall time required.
- See Babbie (1973) for more information on how to conduct self-administered questionnaire surveys.

Recall - Personal Interview

Personal interviews were conducted in a variety of surveys to obtain information ranging from angler use to fish consumption patterns. The interviews occurred at known fishing sites (which personnel had to cover up to 18 hours per day to contact early morning and late evening anglers) or at home. Home interviewees were selected from samples of licensed anglers identified by State fish and game departments, or households located near fishing locations (Wolfe and Walker, 1987). Subsistence anglers were also specifically identified because they were participating in special programs, such as that conducted by the Expanded Food and Nutrition Education Program of Cornell University Cooperative Extension Service (Wendt, 1986). In all cases, the respondents were asked a fixed set of questions and the answers were recorded on the questionnaires.

Although the questions in most on-site interviews were limited to those of a creel census nature (see "Creel Census" below), a few interviews collected data for fish consumption rates. Three surveys were conducted in the Puget Sound area (McCallum, 1985; Landolt et al., 1985, 1987). The Landolt et al. studies targeted shoreside anglers and boating anglers as they returned to boat ramps. Over 4,000 shoreside angler interviews were conducted during the first year, but only 437 boating anglers were interviewed the second year. Landolt et al. noted that the latter interviews produced fewer cooperative respondents (only 83 percent), and the anglers either refused to give the exact sites of their fishing activities or only vaguely identified them. The McCallum study interviewed all anglers, crabbers, and clammers from one end of the beach or pier to the other end at specific sites throughout the year. The survey was advertised at local marinas and bait shops to aid in eliciting cooperation from respondents.

Smith and Enger (1988) conducted 703 interviews at fishing sites along the Tittabawassee River in Michigan. Although fishing bans had been announced because of contamination with dioxins, the survey found that fishing effort had increased as the result of the successful restocking of the river with walleye. Only 2.7 percent of the anglers interviewed said that they were fishing for food, but the authors suspected that this was not an accurate percentage. This particular survey relied on long-term (up to 1 year) recall of the anglers' fish consumption habits and did not target the actual catch of

the day. Despite recall bias and the fact that weather conditions prohibited fishing in some parts of the river later in the summer (suggesting that this was not the best representation of the normal fishing effort and catch there), the study did target a specific local population where chemical exposure through fish consumption was of concern.

Other types of personal interviews were conducted at home. The Nationwide Food Consumption Surveys (1977-78, 1987-88), conducted by the U.S. Department of Agriculture (USDA), used a list of foods to assist the household respondent in recalling the kind, form, quantity, and cost (if purchased) of foods used at home during the previous 7 days. The interviewer also obtained information on those characteristics that might be related to food consumption (demographic and socioeconomic data). The interviewer then recorded the preceding day's food intake for each eligible household member present and instructed each individual to record his or her intake for the day of the interview and the next day. This procedure provided three consecutive days of dietary information. The interviewer returned to pick up the records, and each household received $1 for each record returned (up to $10 per household). Data were collected throughout the week. Respondents were contacted in advance to participate in the survey. The 1977-78 survey included 15,000 households and 38,000 individuals. The Continuing Survey of Food Intakes by Individuals, also conducted by the USDA, asked individuals to provide from 1 day to 6 days of dietary data at intervals of 2 months over a 1-year period (see, for example, USDA, 1985b, 1986b). The first day's data were collected by personal interview, with subsequent data collected by telephone interview. Unfortunately, these studies did not target consumers of recreationally-caught fish, and the consumption of potentially contaminated fish could not be determined from the questions administered.

The U.S. Department of Health and Human Services (USDHHS, 1989) survey of fishing patterns and contaminant exposure in Lake Coeur d'Alene, Idaho, included personal interviews with 299 households, using recall periods of up to 1 month. In another study, Wendt (1986) targeted low-income freshwater fish consumption by carrying out personal interviews with respondents identified as participants in the Expanded Food and Nutrition Education Program at Cornell University. She found that these interviews required the presence of aides to serve as go-betweens or to keep children entertained during the 30-minute interview. They did, however, yield interesting information on the fish consumption patterns of the participants. While the on-site interviews could collect information on the species of fish caught and consumed, household interviews suffered from the inability of the respondents to identify species of fish and to assess recall bias. Both on-site and household interviews encountered literacy (understanding) and language barriers.

Advantages:

- Personal interviews can assess region-specific consumption rates by targeting the waterbody or residence of the respondent.
- This approach can also identify specific subpopulations of concern by obtaining data from known contaminated fishing/shellfishing sites or by using specific programs to identify potential respondents.
- Personal interviews can provide first-hand observations of the respondents and the interview sites.
- Literacy and language barriers may be more easily overcome using this approach.
- Recall bias can be minimized by providing appropriate visual aids (for portion or meal size) or basing the survey on the fish caught at the time of the interview.
- This approach has a high rate of success for completing interviews because of personal contact. Interviewers also can clarify confusing questions or neutrally probe for answers.
- Verification of information may be easy, especially if data collected are based on the actual catch of the day. It is also relatively easy to use special techniques such as visual aids and probing.

Disadvantages:

- The number and complexity of survey questions may need to be limited so that surveys can be performed quickly, depending on the respondents' availability and interest.
- Personal interviews are the most costly approach, requiring the coordination, hiring, training, and close supervision of interviewers and field staff at more than one location, as well as additional paperwork to control the fieldwork and processing operations (USEPA, 1984a).

To Solve These Problems:

- Conduct the survey in different languages (or use bilingual interviewers or translation assistance from other family members or associates) and provide visual aids such as fish models to assist in obtaining information from the respondents. McCallum (1985) cited problems with questions on the parts of the catch eaten, fishing frequency, and how the fish were prepared for eating.
- Use the "clustering" technique to limit the number of sites or group the residences where interviews will be held, thus reducing costs.

- Carefully prepare the survey questions to minimize the length of the survey yet provide the precise information needed to achieve the objectives.
- Provide adequate training (including practice interviews) and supervision of interviewers throughout the survey.
- See Babbie (1973) or other survey methodology texts for more information on how to conduct interviews for surveys.

Diary

While complete food consumption diaries have been used in general nutrition surveys (e.g., USDA, 1983a,b), none of the fish consumption surveys examined for this report employed this approach for obtaining data. Block (1982) found that diary methods were subject to selective forgetting or lapses in diary keeping even after only a few days, and it was difficult to get respondents committed to the project, especially if no personal contact was involved. However, Fisher (1988) noted that such records, kept at home for periods of days to months, can provide reliable data on patterns of food intake. This approach does require respondent literacy, and the act of keeping records itself may affect dietary practices, so there is a need to analyze for changes that may occur in motivation of the subject or changes in food records (Fisher, 1988). West et al. (1989b) observed that earlier studies have shown that the most valid and accurate studies of fish consumption have been diary studies involving repeated personal contact with the study subjects (e.g., Humphrey, 1976, 1983). Such contact probably maximized motivation and minimized alterations in diet and recording by the respondents. Diary records may provide sound information for examining fish consumption patterns if the survey is carefully designed and monitored.

Advantages:

- The diary approach can assess region-specific consumption rates if respondents are selected appropriately.
- Diaries can provide data over long periods of time for particular subpopulations of concern if such subpopulations have been appropriately preselected.
- This approach is less expensive than personal interviews.
- The diary approach can be used with persons inaccessible by telephone.
- Large numbers of respondents may be included.
- This approach results in minimal recall bias, although other potential sources of error or alterations in record-keeping may occur.

Disadvantages:

- Interviewers must be trained to teach the respondents how to complete the diary.
- Using the diary approach requires respondent literacy, a high degree of motivation, and constant monitoring to maintain consistency in the data collected.
- The act of keeping records can affect dietary practices.

To Solve These Problems:

- Combine the diary approach with other approaches (such as personal interviews) to provide additional, in-depth, or longer term information on fish consumption patterns.

Creel Census

The creel census approach is used by fishery managers to obtain harvest data collected on-site, from single anglers (hook and line, castnet, clam rake, etc.) or from larger scale commercial-type operations (trawl, gill nets, etc.) that obtain fish for a specific community. This information is then used to make management decisions for optimal utilization of the resource. For example, a number of creel censuses have been done in Georgia, such as Scott (1981), Hottell et al. (1983), Schmitt and Hornsby (1985), Fowler and Holder (1987), and Spencer (1987). These on-site interviews examined the species fished for, species caught, weight caught, method, bait, origin, and type of fishing (boat, bank, dock, bridge), but did not include questions on fish consumption or sociodemographic data. These surveys also did not distinguish whether the fish caught were going to be consumed, given away, sold, or released. Other surveys of this type include Mullis (1989), who obtained data on angler effort associated with striped bass fishing on the Roanoke River, and Ranthum (1975), who recorded lengths and weights of species of fish caught. ChemRisk (1991a) found that creel censuses were often used to estimate angler use and fish harvest from specific waterbodies, but noted that because individual anglers may fish in more than one location, such a survey might not completely characterize the total freshwater fish harvest or consumption for anglers and others sharing their catch.

Diverse time periods have been selected for creel census interviews. Ranthum sampled two consecutive census days, with a varied schedule (7 to 11 am, 11 am to 3 pm, or 3 to 7 pm) for on-site interviews during the 2-month study period. The Wisconsin series of creel censuses (e.g., Thuemler, 1981; Heizer 1986,1988; Schumacher, 1987) used a stratified random sampling schedule for 2-hour periods. Counts of anglers present on the lake were made at 2-hour intervals from 7:00 a.m. to 7:00 p.m., with a final count at 8:00

p.m. Between counts, anglers were interviewed to determine the number, length, and species of fish caught and the angler's residence. More censuses were scheduled for weekend days and holidays and for the entire opening weekend of the fishing season. Fifty percent of the remaining weekend periods and 30 percent of the weekday periods were sampled, with an equal amount of effort given to each month and each hourly time period. Brown (1981) looked at recreational shrimping along the Gulf coast by allocating most interviews to the opening days of the seasons for brown and white shrimp, with the remainder of the interviews taking place on weekend days. Chandler and Brown (1978) examined potential problems that might be encountered while collecting marine recreational fishing and shellfishing harvest data for the Atlantic and Gulf coasts. They noted that the selection of fishing sites and times with the highest levels of fishing activity was best for obtaining the maximum number of interviews that needed to be conducted.

Five creel census surveys that attempted to obtain direct information on the fish consumption patterns and habits of recreational and subsistence anglers were conducted. An early study by Pierce et al. (1981) sampled fishing and shellfishing effort at four subareas around Commencement Bay in Washington State that were suspected of having potentially hazardous seafood. The on-site interviews were followed by telephone surveys to determine whether the fish that were caught that day had been eaten and how they had been prepared. The study suffered from problems in changes of sampling sites and the number of survey days during the study, but did provide data on fish consumption patterns for the area.

Puffer et al. (1982a) examined the consumption of potentially hazardous marine fish and shellfish from 12 sites in the Los Angeles area known to be both fished and polluted. Teams of two surveyors conducted 1,059 interviews with anglers on different days of the week and at different times (61 percent of interviews were held during the week, 39 percent on weekends, for a total of 400 site visits). Incentives for cooperation included fishing maps, copies of regulations, and/or recipes sent following the interviews. Photographs were frequently taken to ensure the correct taxonomic identification of the fish caught, to document site conditions, and to confirm sport anglers' counts. Initially, the surveyors recorded the number of anglers present at a site and their sex, race, and approximate age. Then only those anglers who had actually caught fish were interviewed (if more than 20 had caught fish, a systematic sampling approach was used), resulting in a bias toward frequent anglers. The more successful the fishing, the more frequently the fisherman was inclined to fish. The information necessary for accurate fish consumption rate calculations was weak, and there were problems with having to change sites during the study because of weather, sewage overflows, and chemical disposal problems. However, the study did indicate

a need to assess health risks to consumers at specific sites and for specific subpopulations.

Belton et al. (1985) examined fishing effort at sites known to be chemically contaminated and where specific fishing bans had been instituted along the Raritan River and other sites in New Jersey. An interesting aspect of this study was that the interviewers initially conducted only visual observations and informal interviews at the six sites (cross-cultural anthropological field-work techniques) because they were concerned that this population of anglers might be leery of formal surveys and distrustful of outsiders. Later, a subsample of the fishing population was selected to answer the questionnaire by personal interview at the site. A monetary incentive of $10 was provided for those who agreed to participate in a long-term study. Although the questionnaire was fairly thorough and easy to interpret, the data collected for fish consumption rate calculations were incomplete. The questionnaire included no questions on size of portions consumed per meal or species. Assumptions were made to allow such calculations, but data from other studies were used to evaluate the health risks involved.

Kleinschmidt Associates (1989) examined the fish consumption patterns of anglers from two areas on the Androscoggin River in New Hampshire. The areas chosen were the relatively pristine section of the river north of Berlin to the Errol Dam near the Maine-New Hampshire border and the river below the James River Corporation's paper mill at Berlin. The New Hampshire Division of Public Health Service had issued a fish consumption advisory for that portion of the river downstream from Berlin. While spending approximately equal periods of time in each area on three weekends in August, the interviewers were able to find only three anglers fishing in the lower area, resulting in 5.26 hours per initiated interview there, compared to 66 interviews in the upper area taking approximately 0.3 hour per interview. Interviewees in the lower area did not consume the fish they caught there because of health/safety concerns. The report concluded that the fish consumption advisory had been effective. The consumption data collected were based on recall of how often the anglers ate fish from the particular section of the river (per week or month) and an average estimate of the meal size (in number of 8- to 10-inch fish). These data were easy to obtain, but the ambiguous nature of some of the questions makes calculations of fish consumption rates impossible.

Finally, a study was conducted to estimate consumption rates of selected chemicals from contaminated fish caught in San Diego Bay (San Diego County Department of Health Services, 1990). The survey protocol was based on that of Landolt et al., (1985) and questions covered species, weight, and length of fish caught and eaten by Bay anglers and others in their households, demographics of the angler population, and characterization of fish consumption rates and patterns. Interviews were obtained from 369

anglers at popular pier and shoreline fishing sites and boat launches over a one-year period, but only 59 interviews (representing 195 potential consumers) contained all of the data for calculating individual consumption rates. As in the Landolt et al., (1987) study, samples of fish (obtained separately) were analyzed for chemical contaminants and these data were used to estimate various subpopulation exposures and potential risks of adverse health effects.

Advantages:

- The creel census approach, as a personal interview approach, can assess region-specific consumption rates by targeting specific waterbodies.
- This approach can also identify specific subpopulations at high risk by obtaining data from actual anglers at known contaminated fishing/shellfishing sites.
- Creel censuses can provide first-hand observations of the respondents, their fishing activities, and the interview sites.
- Recall bias can be minimized by providing appropriate visual aids (for portion or meal size) and by basing the survey on the fish caught at the time of the interview.
- The rate of success for completing interviews is high because of personal contact.
- Verification of information may be easy, especially if data collected are based on the actual catch of the day. It is also relatively easy to obtain sensitive information and to use special techniques such as visual aids and probing.
- When the appropriate questions are included, this type of survey can more accurately assess fishing behavior by anglers, fish species can be more accurately identified to species, and important information on consumption rates and characteristics of the anglers can be easily obtained and verified.

Disadvantages:

- The number and complexity of survey questions must be limited so that surveys can be performed quickly.
- Interviewers may encounter language barriers.
- Creel censuses are costly because they require the coordination, hiring, training, and close supervision of interviewers and field staff for quality control, as well as additional paperwork to control the fieldwork and processing operations.

To Solve These Problems:

- As may be done for personal interviews, conduct the creel census in different languages.
- Provide visual aids to increase the response rates while minimizing the level of effort and time needed to conduct the interviews.
- Use the "clustering" technique to hold down costs by limiting the number of sites where interviews will be held. Try to select sites where there will be more respondents over longer periods of time or at different seasons in order to limit the time needed to "search" for respondents at a site.
- Carefully prepare the survey questions to minimize the length of the survey and the time needed to conduct each interview yet still provide the precise information needed to meet the objectives.

III. IMPORTANT METHOD CONSIDERATIONS

Fisher (1988) noted that, with regard to fish consumption surveys, two considerations were important in using available data or in designing approaches to collecting data: (1) the methodology used to collect data and (2) the population sampling techniques. He explained that the former was more complex because the dietary data collection method selected would depend on both the population surveyed and the purpose for deriving the estimate. Population sampling techniques are important in surveying population subsets that preferentially consume fish because representativeness becomes important in statistical analyses. Fisher (1988) further stated that since fish, as a food item, has unique attributes, any of the approaches taken to collect these data will have inherent advantages and disadvantages in regard to determining preferential fish consumption.

Many of the recent surveys examined for this report used more than one approach to obtain information. For example, a simple on-site creel census might be combined with a telephone interview to include additional characteristics of the fishing population and to determine whether the catch was consumed. Or, a questionnaire mail survey might ask for general fish consumption information and then include a table to be filled in asking for more specific fish consumption data over a period of several days. Other surveys have combined mailed surveys with follow-up telephone surveys to check on non-response bias or to obtain more complete information. Springer (1990) used several different types of questionnaires and either mailed surveys or conducted personal interviews, depending on the target audience (the former for recreational anglers, fisheries and health care experts, and the latter for migrant workers and low-income individuals) to investigate risk communication theories and the effectiveness of fish advisories and bans. More than one approach may need to be used to make the survey as informative and useful as possible for the desired objective. The choice of approach will also depend on the characteristics of the target population, data requirements, obligation to reply, target response rate, time available, and funds available (USEPA, 1984a). Highlights of the five approaches examined in Chapter II are presented in Table 2.

All approaches, however, share a number of common elements including design, selection of respondents, information to be sought, quality assurance procedures, and statistical analyses. For the purposes of this document, the most important criteria for preparing a fish consumption survey are the following:

- Thoroughness;
- Applicability to subpopulations of concern;

Table 2. Comparison of different approaches to conducting fish consumption surveys.

	Telephone Survey	Mail Survey	Personal Interview	Diary Record	Creel Census
Can assess region-specific consumption rates	yes[a]	yes[a]	yes	yes[a]	yes
Can target and identify specific subpopulations of concern	yes[b]	yes[b]	yes	yes[b]	yes
Allows first-hand observations of respondents and fishing locations	no	no	yes	no	yes
Provides immediate answers to questions	yes	no	yes	no	yes
Easy to verify information given	no	no	yes	yes	yes
Can be used where illiteracy may be encountered	yes	no	yes	no	yes
Success rate for completed, accurate interviews	high	low	high	moderate	high
Relative cost per interview	$$$$	$	$$$$$	$$$	$$

[a]Depends on how respondents are selected.
[b]Depends on how these subpopulations are identified.

- Scientific/analytical validity;
- Ease in interpreting results;
- Reasonableness of assumptions made; and
- Sufficient data to evaluate potential risks.

This section addresses various elements of survey design and analysis that must be considered prior to undertaking a survey to estimate fish consumption rates. Additional information and references can be found in Babbie (1973), Dillman (1978), and USEPA (1983,1984a). These resources also recommend discussing the survey plans with qualified, experienced survey research consultants and statisticians who can provide answers to questions that may arise while planning the survey. This step should ensure that the design will meet the particular survey objectives and adequately sample the populations of concern.

Survey Design

Fisher (1988) noted that the primary factors controlling the selection of a strategy to obtain the desired data were (1) the purposes for which an estimate of usual or preferentially high fish intake is sought and (2) the resources available to obtain such an estimate. Because of these factors, no one strategy may fulfill all possible needs for such data, yet each survey may be quite complex in its own right. He emphasized that the purpose of the survey must be narrowly defined and tailored to address the identified needs, such as whether the survey was to be used for diet/health concerns or risk assessment.

Since differences in preferred species, availability, access, length of fishing season, and cultural heritage greatly influence freshwater fish consumption in a particular region (ChemRisk, 1991a), these factors must also be examined when planning a survey. The period of data collection is important. Will most of the subsistence and recreational anglers be active during the summer months only or during the entire open season for a particular fish? If information is required for an entire year, can recall be depended upon to provide the answers or should a year-long continuing survey be conducted? The level of literacy of potential respondents should also be estimated. Will the respondent be able to understand the written or spoken questions? The types of questions should be prepared and tested with respect to simplicity and clarity, as well as their ability to elicit the desired information. Language barriers may also exist, further limiting the amount of data that may be gathered from important constituencies. Thus, surveys may need to be conducted using more than one approach or in more than one language to adequately cover all of the subsistence and recreational anglers in a particular area.

Another general consideration for survey design is the level of detail required. Although extensive information may be desired for some programs, longer surveys will require more time and resources for the conduct of the survey and analysis of the data. Furthermore, increased length and complexity of the survey design may limit the cooperativeness of respondents, resulting in inadequate or incomplete data that are ultimately useless. All of the surveys reviewed for this report experienced problems in getting participants to cooperate and complete the questionnaire materials. To improve participation rates, some of the surveys provided incentives, such as lapel pins, maps, additional information in brochures, copies of the survey results, and/or cash. (The relative effectiveness of the incentives was not reported.) Other surveys limited the number of questions but consequently lost valuable information that would have been helpful for fish consumption rate calculations.

The approach taken to collect the data will affect the cost of the survey. As a general guideline, personal interviews cost at least twice as much and take twice as long as telephone interviews. Both of these methods are more costly than a mail survey (USEPA, 1983). However, if personal interviews are clustered at specific locations to maximize the number of respondents to obtain the fish consumption rates of recreational/subsistence anglers, less time and effort will be involved than if the same number of respondents who fished at those specific sites had to be culled from extensive telephone or mail surveys of the general population or licensed anglers. Some flexibility in the survey design may be required to accommodate any problems that may be encountered.

Few of the surveys reviewed for this report include information on level of effort, length of time to conduct the survey, and/or costs. Limited data were obtained by contacting the individual or agency responsible for the surveys (see Appendix). Costs and levels of effort ranged widely depending on the type of survey and its extent. Some surveys were conducted by volunteers or graduate students or were conducted as part of normal in-house responsibilities. Hence, it would be difficult to determine a meaningful "average" cost per survey. As noted by West (1989a), inadequate resources may prevent the researcher from obtaining statistically valid sample sizes. Therefore, it is important to have a clear understanding of the amount of funding and number of personnel available in order to achieve the best balance of resources for the desired survey. This analysis should determine work that can be done in-house versus work that must be done by outside consultants or volunteers, as well as other pertinent factors that may affect the costs.

The survey design should specify the following (see USEPA, 1983 for more information):

- The objectives of the survey, clearly stated in terms of the kinds of information to be collected, the problems to be solved, the hypotheses to be tested, and the key survey variables. For example, what are the minimum questions that need to be answered? What hypotheses will be tested–consumption rates related to income, ethnic group, or frequency of fishing, etc.? Each of the key survey variables and the specific data to be collected to meet the stated objectives must then be defined.
- The population to be surveyed and the extent of coverage (e.g., regional, site-specific, recreational anglers, subsistence fishermen, minority anglers).
- Identification of respondents by probability sampling. This means that every unit (e.g., person/household) has a known, non-zero chance of being included in the sample, thus allowing for statistically valid inferences about the entire population the sample is designed to represent.
- The required level of precision, specified in terms of sampling error–that is, the difference between the values and statistics that would have been obtained had all the members of the target population been surveyed and the values and statistics that were obtained from the sample population. This level will depend on the survey purpose, intended use of the data, level of effort, and available funds. Nonsampling errors, such as random, deliberate, wrong or unintentional replies and systematic one-sided errors or biases, must also be considered.
- The target response rate, defined as the ratio of the number of completed interviews to the total number of eligible units in the sample. As noted above, a 75 percent response rate is acceptable for an in-person or telephone survey, but a mail survey may receive less than a 40 percent response unless telephone calls or personal visits can raise the initial response rate

Recommendation:

Follow-up activities should be included with whatever approach is selected to ensure an appropriate response rate, check for non-response bias, and confirm data.

Selection of Respondents

Various methods have been used to select the anglers to be interviewed, (the sampling frame) depending on the approach to be taken to obtain the data. The sample may consist only of anglers or may include members of their households. (USEPA, 1983). Some national surveys have used random-digit dialing to obtain their samples. However, recreational or subsistence

anglers might not be captured by this technique. On the regional or local level, lists of sport fishing license holders may be used to obtain stratified samples based on a particular type of license or geographic reference, such as counties located close to the waterbody in question. Intercept or on-site interview approaches may attempt to question everyone, interview only those who have caught fish at the time (non-uniform), or randomly select anglers to be questioned. The Georgia creel censuses used non-uniform probability sampling, interviewing anglers on a predetermined basis up to a certain number required for statistical validity. The number of interviews needed was based on preliminary surveys, and these numbers were readjusted every 6 months to reflect possible changes in the fishing population. Depending on the objectives of the survey, other strategies may be required to obtain samples of recreational and subsistence anglers.

Sample selection must be carefully planned to achieve the numbers necessary for statistical validity. Final sample size will depend on the level of precision required for the estimates. The Bureau of Census may be consulted to obtain information about total population and/or subpopulation numbers present in a particular area. The Bureau can provide breakouts by age, sex, and/or ethnicity, for a cost. Then probability tables can be generated to determine the minimum numbers of respondents required. This technique can also be used to select subsamples of licensees or other designated groups. Sample stratification in the Bureau of Census design also allows for sampling procedures that are self-weighted. Additional respondents may need to be added to the pool to provide sufficient numbers if there are problems in obtaining the interviews (e.g., loss of questionnaires in the mail, non-responders, language barriers, etc.). Babbie (1973) contains detailed information on the selection of a survey population, probability sampling theory, and sampling distributions.

Recommendation:

It is essential to work with a statistician prior to initiation of the study to ensure that appropriate and representative sample sizes of the population to be examined are obtained by the technique that is selected.

Information Sought

The type of data to be collected will depend on the purposes of the study, as well as the complexity and length of the survey (single or multiple seasons, multi-year) to be conducted. Some of the surveys reviewed for this document were designed to collect information for purposes other than measuring fish consumption and therefore did not ask the "right" questions (e.g., creel censuses). Many assumptions must be made to obtain estimates of fish

consumption in these cases, and errors of overestimation or underestimation may be large. Questions on sociodemographic characteristics, fishing/shellfishing activities, preparation and consumption patterns, and awareness of fish advisories and bans can all contribute data that may be used to analyze fish consumption rates. Examples of questions that need to be answered or issues that need to be resolved for fish consumption rate determinations are presented in Table 1.

Sociodemographic variables such as age, community type, educational level of head of household or respondent, ethnic origin or race, family size and composition, geographic region, income, occupation of head of household, and religion may influence patterns of intake. Current employment status may affect the amount of time spent in fishing/shellfishing activities and the amounts of these foods consumed. However, this type of information may be difficult to obtain or controversial (for example, income level, race, ethnic group, language spoken at home, religion). Thus, including sociodemographic questions may decrease the number of successful interviews or completed questionnaires.

Although the residence of anglers may indicate that they are fishing at potentially contaminated waterbodies, it is more important to determine whether there is a possible contaminant exposure problem at the particular fishing site(s). Other information on fishing activities, such as distance from residence and mode of fishing, may be irrelevant for some surveys but may provide important data for others, depending on the objectives of the study.

Accurate identification of the type and amount of fish caught and consumed is important. Levels of contamination vary with the preferred habitat of the organism, its trophic level (for example, bottom-feeding versus planktivore), and its lipid content, as well as the waterbody. Pictures of the fish may need to be taken for verification if identification in the field is impossible. The level of detail required for fishing activities may also be difficult to obtain, especially since anglers often keep their fishing spots secret. Providing visual aids such as maps of fishing areas may produce more accurate information from respondents when recalling the location(s) of fishing activities. Persons involved in illegal sales of fish from contaminated sites would probably refrain from answering these questions.

Actual amounts of fish consumed need to be determined as accurately as possible. Silverman (1990) noted that "data on average meal size is glaringly absent..." from most studies. Pictures or models of portion sizes may be provided to aid in estimating the size of fish portions consumed (although it should be noted that this may vary with the species involved). West et al. (1989b) included pictures of an 8-ounce steak and fillet portion on a normal size plate for comparison, then estimated "more" as 10 ounces and "less" as 5 ounces for their survey. This 8-ounce portion size was derived from

restaurant surveys and the USDA (1983a,b) study. Cox et al. (1990) found that 8 ounces was the portion most commonly reported. These and other product identifiers can be used to provide the level of detail required in the answers. The survey should also specify whether the amounts eaten are to be determined for the angler only or for all household members.

Other information that may be useful in examining consumption patterns and levels of exposure to potentially contaminated fish includes the following:

- Whether a part of or the whole animal is eaten: for fish, muscle only, skin, head, entrails, broth; for shellfish, muscle, hepatopancreas, entrails.
- Method(s) of preparation (raw, dried, canned, smoked, steamed, boiled, baked, fried, stewed, marinated, barbecued; or whole, fillet, skin removed, etc.); accompaniments used in preparation (butter, lemon/lime juice, tomato sauce, garlic, etc.).
- Other types of aquatic organisms consumed from the same site(s) such as snapping turtles, frogs, sea cucumbers, sea urchins, squid, algae or other vegetation, etc. (quantities, frequency consumed).
- Whether fish are also consumed from other sources (market, restaurant, or gifts).

Finally, the objectives of the survey may require an assessment of the awareness of health advisories and an understanding of contamination issues. Questions may address knowledge of fish consumption advisories or bans present in a particular fishing area and behavioral modifications resulting from these concerns. The impact of advisories may be reflected in changes in fishing locations and in the species, sizes, and parts of fish kept and consumed. If these issues are not addressed, biases may be introduced into the survey. Several surveys have also investigated links between diet and health. As noted by Fisher (1988), such studies may include questions on medical history, a physical examination for health status and clinical signs of deficiency or toxicity, food and nutrient intakes, body measurements, and hematological and biochemical tests (USEPA, 1984b; Fiore et al., 1989).

For any approach, requiring long-term recall may produce substantial bias in estimates of fish consumption and other variables. Although difficult to document, recall bias can be affected not only by anglers' attitudes toward their sport, their skill, and their investment in time and equipment, but also by the value of the fish to the family diet (P. Shubat, Minnesota Department of Health, Minneapolis, personal communication). Thompson and Hubert (1990) reported that anglers inflated the amount of time spent fishing. Other self-report surveys have documented overestimates of fishing statistics (see Westat, Inc., 1989, ChemRisk, 1991a).

Information requirements for the survey must be carefully planned based on the survey approach to be used. For example, food frequency recall approaches may need to include some probing questions to jog memories for consumption of fish meals over extended periods. Personal interviews and telephone surveys may also need such "neutral probing" to obtain complete, clear, relevant, and specific answers. Survey questions must be worded for understandability. The questions must then be pretested and revised as necessary *before* beginning the full survey. Actual phrasing of the questions is critical to obtaining usable data. For example, "How many fish did you eat?" will require assumptions on portion size, frequency of consumption, and preparation for cooking (whole, steak, fillet). Note that "preparation" of the fish may mean different things if the purpose is for cooking (scaled, filleted), for eating (pan fried, broiled), or for preservation (salted, smoked); this information, however, may provide acceptable data on portion sizes consumed or whether the preparation minimized exposure to contaminants.

It is equally important to ensure that the wording of the question will provide the correct data for evaluation, rather than give a vague or potentially uninterpretable response that becomes useless when calculations are to be made. The information to be collected may need to be modified depending on whether the survey will be answered directly by the respondent or through proxy. Conducting interviews in more than one language may also be necessary to reach the population of concern (for example, see Puffer et al., 1982a, and the National Marine Fisheries Service studies). Babbie (1973) discusses the construction and sequencing of questions in order to avoid many common pitfalls, as well as providing sufficiently clear instructions so the survey can be completed. He also suggests methods for conducting and evaluating pretests and pilot studies (see also Sudman and Bradburn, 1982).

Recommendation:

The selection and phasing of questions to meet the survey objectives is critical. Questions must ultimately be used only for the purposes intended and not stretched to try to fit other unrealistic purposes, thus introducing serious biases. The importance of consulting experts in nutrition and survey design and analysis cannot be overstressed.

Quality Assurance

Appropriate quality assurance procedures must be incorporated into both the planning and execution of the survey. The types of quality controls proposed will ultimately depend on the approach to be taken, but should include the following (USEPA, 1983):

- Validation of at least 10 percent of the interviews to verify that the interviews did take place and that information was accurately obtained and recorded.
- Manual checking of questionnaires for completeness and proper entry of answers.
- Checks on the manual coding operations and comparisons of results and error rates in interviews conducted by different interviewers.
- Verification of correct data entry; for example, by having all of the data entered twice and then compared.
- Computer edits to detect inadmissable and out-of-range values.

Other quality assurance considerations include the qualifications and training of interviewers. (Can they conduct interviews pleasantly and correctly? Can they identify the fish to species?) Close supervision should be provided throughout the survey to make sure that all data are entered and recorded on the forms correctly, all interviewers are performing similarly, and each interview session is conducted as the previous ones were conducted. Another technique is to use responses given in one category to check those in another, such as fishing history (catch rates, locations) vs. fish consumption (amounts, species). For mailed questionnaires, each questionnaire should be assigned an identifying number both at the time of delivery to the respondent and on completion or receipt. This procedure will allow monitoring of the number of questionnaires returned each day, as well as the cumulative total returned (Babbie, 1973), to help plan follow-up mailings and reminders.

Statistical Analyses

After the data have been collected, answers must be compiled and numerically analyzed. As emphasized above, it is essential to work with experienced statisticians during the design of the survey to ensure an adequate representation of the survey population. It is also important to conduct pretests and to ensure that test conditions, including the questions and instructions, are adequate for the purposes of the survey. Appropriate correlations cannot be made if the data are weak or missing.

Additional problems may be encountered when attempting to look at special subpopulations, such as those who eat fish frequently. The design of population surveys and sampling techniques for events and populations that are nonuniform or infrequent presents statistical issues that result in an additional series of trade-offs (Kalton and Anderson, 1986; Sudman et al., 1988). Fisher (1988) examined the case of looking for preferential fish consumers and noted that a larger total sample may be required. The recent ChemRisk (1991a) survey based the size of the population sample on the most constraining piece of data among the questions to be answered and

calculated the sample size required to ensure that the minimum number of replies needed for statistically valid results would be received. In this case, the inverse of the participation rates (percent anglers seeking to catch perch) for perch harvest from warmwater riverine fisheries was multiplied by the desired number of consumption observations for perch (believed to represent the rarest subpopulation to be encountered) and concluded that a minimum of 1,363 *completed* surveys would be required. ChemRisk (1991a) then estimated the percentage of undeliverable mailed surveys (10 percent), the percentage of those not answered due to changes in fishing status (10 percent), and the potential response rate of anglers who received the surveys (75 percent) and calculated a minimum sample size of 2,244 using the following equation:

$$T_s = \frac{Tr}{Pd_1 \times Pd_2 \times R}$$

where:

T_s = Total number of surveys sent,
Tr = Total required for a statistically valid sample size (1,363),
Pd_1 = Fraction of surveys deliverable as addressed (0.90),
Pd_2 = Fraction of 1989 licensed anglers who also purchased 1990 licenses or had changes in fishing status (0.90), and
R = Expected rate of response to delivered surveys (0.75).

ChemRisk mailed surveys to 2,500 anglers, selected from a pool of 2,953 names drawn randomly from the fishing license files to represent different resident categories and other special types.

Other statistical considerations include the accuracy of the responses that can be expected depending on the approach used to collect the data. For example, Carline (1972) found that harvest rates on the number of fish caught per day or per year were much higher than the catch rates determined by personal interviews of anglers. Swanson and Stephenson (1982) observed that the numbers of fish reported caught were often rounded off to 5, 10, 20, etc., indicating that biases and sources of error were greater for recall of angler harvests than of angler effort. The inaccuracy of respondents' memories is troublesome for recall, in addition to the inability of respondents to accurately identify fish species, confusion over the questionnaires, and frank exaggeration.

Additional checks may need to be made to examine non-response bias. West et al. (1989a) found that those who did not return surveys ate less fish, thereby resulting in a skewed calculation of consumption rates if the results were assumed to be accurate for the entire subpopulation originally sent the

questionnaires (see West et al., 1989c for calculation of nonresponse bias adjustment factor). Weighting techniques, based on demographic characteristics or other factors, may need to be applied to allow more accurate determinations of consumption rates for various subpopulations (e.g., Pao et al., 1982).

The final statistical calculations should be carefully planned and based solidly on the data collected in order to minimize assumptions that could compromise the results. For example, were the questions correctly phrased to elicit the number of fish meals per *angler* or per *household*? If the latter, were the members of the household enumerated, or must an *average* size household be assumed to determine the individual fish consumption rates? Can the data be used to calculate fish consumption by race or ethnic group, income, education, sex, or other factors that the survey may wish to test? A number of multivariate analyses may be used to compare differences in consumption rates for many factors. Detailed discussions on statistical analyses that may be used with survey data are presented in Babbie (1973). Whenever possible, these should be investigated and the appropriate information and numbers of responses should be planned *prior* to the collection of data.

Recommendations:

It is important to consider using data management protocols that will allow the data to be readily accessible. These include using standard formats, such as dBASE™ or Lotus®, standard statistical packages, and simple coding systems for ease in interpretation of the survey data.

A system for archiving the data (both paper and computer records) and ensuring future availability should also be determined prior to completion of the study, and this information should be included in the final report to aid other researchers on fish consumption.

IV. DISCUSSION

Wagstaff et al. (1986) noted that fish constitute the only class of foods subject to total governmental prohibition in large geographic areas of the United States for substantial time periods because of exposure to potentially hazardous environmental pollutants. Therefore, nutritionists, the medical community, marketing specialists, fishery resource managers, and ecosystem administrators would benefit from fish consumption databases that are "well-defined, validated, and accessible."

A variety of methods and approaches have been used in the fish consumption surveys presented in this report, but it appears that a thoroughly satisfactory survey remains to be conducted. Although the surveys may have been satisfactory for the objectives of the designers at the time, the goal of obtaining valid fish consumption rate data for high-risk subsistence anglers remains elusive. On-site interviews are more likely to reach subsistence/recreational anglers, who may not be licensed, but more detailed data may be obtained by diaries and written questionnaires. Many questions remain. Over what period of time must a survey be conducted (for one day, seasonally, or for one year)? What is the best approach for reaching the most anglers in a particular region? How have fish consumption bans and advisories affected the utilization of these resources and changed the public's perception of risks (see Reinert et al., 1991)? Silverman (1990) reviewed recent national and Great Lakes regional studies and noted the absence of detailed information about the public's consumption of sport fish. She also found that fish consumption had been partitioned into commercial vs. recreational portions that were not adequately covered in the surveys. Important information was missing on the sport fish consumption habits of the nonfishing public. Silverman (1990) described the West et al. (1989b) survey as one of the best of its type because fish consumption was reported based on demographic variables. However, other variables, such as fishing frequency, may prove necessary to our understanding of fish consumption rates.

Clearly, additional efforts will be required to improve the survey methods and identify the best approach(es) to obtaining the desired data for fish consumption rates of subsistence and recreational anglers and special subpopulations of concern. For example, because most State fishery managers conduct creel census surveys routinely to assess resource use, additional public health-related questions could be included in the creel census to provide information needed for health officials. Other interagency and interdisciplinary cooperative ventures should be encouraged to reduce costs and effort. It is hoped that the information in this document will assist fisheries managers and health officials in designing and conducting surveys that will more accurately assess the fish consumption rates by various subpopulations in different regions of the country.

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APPENDIX

SUMMARY OF SURVEY METHODS INFORMATION

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Title of Survey	Type of Survey	Contact Address Phone No.	Level of Effort	Time	Cost	Comments
A Pretest of an Approach to Collection of Marine Recreational Fishing Data on the East and Gulf Coasts 1977	Creel census and telephone survey	The following information was given in K.A. Chandler and G.L. Brown, HSR-PR-78/1-C1, 25 January 1978, prepared for NMFS	6,077 telephone surveys, 1,644 fishermen interviewed at 3 locations to estimate sample sizes required and number of days	For a total of 18,800 fish to provide estimates of the proportional distribution of fish caught for an area (not to determine fish consumption rates), estimated 132 days to interview 3,003 fishermen in Rhode Island, 120 days for 3,087 interviews in South Carolina, 282 days to interview 6,373 in Texas	Telephone interviews: RI $1.50; SC $1.73; TX $1.68; cost for intercept interviews not given but average number of interviews per hr: RI 2.59; SC 2.29; TX 2.26; assumed 10 hrs of interviewing per day Cost for surveys in these 3 States estimated to be $333,236 (1979)	Noted cost per interview for surf fishermen may be higher
Fishing Effort and Harvest by Arizona's Licensed Resident Anglers 1980	Mail survey and creel census	Eric Swanson Arizona Game and Fish Department Phoenix, AZ (602) 942-3000 ext 608	Sent out 18,000 surveys (10% of registered fishermen); 33% response	About 9 months including set-up, data gathering and analysis	Funded through Federal aid	Ballpark estimates Have done subsequent surveys

SUMMARY OF SURVEY METHODS INFORMATION (continued)

Title of Survey	Type of Survey	Contact Address Phone No.	Level of Effort	Time	Cost	Comments
Commencement Bay Seafood Consumption Study 1981	Creel census	Doug Pierce Tacoma-Pierce County Health Department, Tacoma, WA (206) 591-5543	5 months in the field collecting data; 7 months writing report.	1 year	$25,000 primarily to pay contract staff	Cost does not include tissue analysis done by EPA
Fisheries Surveys: Altamaha River St. Mary's River 1982 1986	Creel census	Dan Holder Georgia Dept. Nat. Resources, Game & Fish Div. Atlanta, GA (912) 285-6094	10-month creel survey using college students, random samples	10-month or 12-month creel survey	$9,077 (based on $5.50/hr wage for surveys)	Ballpark estimates Have done subsequent surveys
A Study of Toxic Hazards to Urban Recreational Fishermen and Crabbers 1983	Personal interview and creel census	Bruce Ruppel NJ Dept. Environ. Protection, Trenton, NJ (609) 984-6548	87 interviews on-site	2 years for entire study	Estimate: $50,000, funded by the State	Also funds from Hudson River Foundation
Evaluation of Methods Used to Determine Potential Health Risks Associated with Organic Contaminants in the Great Lakes Basin 1983	Telephone and mail surveys	Given in report: USEPA Environmental Research Laboratory, Duluth, MN	Collected data by 3 different protocols, 587 respondents	About 2 years	About $21 per participant for each protocol, excluding data analysis	

SUMMARY OF SURVEY METHODS INFORMATION (continued)

Title of Survey	Type of Survey	Contact Address Phone No.	Level of Effort	Time	Cost	Comments
Recreational and Subsistence Catch and Consumption of Seafood from Three Urban Industrial Bays of Puget Sound 1983-1984	Personal interview and creel census	Mary McCallum Washington State Division of Health, Epidemiology Section, Seattle, WA (206) 753-5964	1643 interviews on-site	Data collection over a 12-month period, 2 years total	Grant - $100,000 for salary of supervisor	
Low Income Families' Consumption of Freshwater Fish Caught from New York State Waters. 1985	Personal interview	Marie Wendt KVRHA 122 State Street Augusta, ME 04330	40 personal interviews over a 2-week time frame	Data collection and analysis - 1 year	Graduate student thesis funded through Sea Grant	
Potential Toxicant Exposure Among Consumers of Recreationally Caught Fish from Urban Embayments of Puget Sound 1983-1987	Personal interview and creel census	Dr. Marsha Landolt, School of Fisheries, University of Washington Seattle, WA (206) 543-4270	1st year - 4,181 angler interviews; 2nd year - 437 interviews on-site at boat ramps	2 years	$207,000 (excluding indirect costs)	Significant portion of funds were for analytical chemistry; rest for data entry and analysis, salaries of interviewers, etc.
Study of Sport Fishing and Fish Consumption Habits and Body Burden Levels of PCBs, DDE, and Mercury of Wisconsin Anglers 1985	Mail survey	Beth Fiore Wisconsin Division of Health Madison, WI (608) 266-6914	1600 surveys mailed 801 returned	About 1 year	Estimate of $27,250	Phone follow-up to mail out 50% responded Cost does not include blood analyses for contaminants Would use two-tiered approach next time 1) Great Lakes 2) general

SUMMARY OF SURVEY METHODS INFORMATION (continued)

Title of Survey	Type of Survey	Contact Address Phone No.	Level of Effort	Time	Cost	Comments
Marine Recreational Fishery Statistics Survey. Atlantic and Gulf Coasts 1986 1987-1989	Creel census	Mark Holliday National Marine Fisheries Service, NOAA, Washington, DC (301) 427-2328	46,000 intercept interviews and 74,000 telephone interviews (1986)	Data collection 1 year - data ready for distribution within 4 months	Collaboration with 5 State agencies - $2,000,000	The 1987 - 1989 survey is now available Have done similar surveys for the Pacific coast
Relationship of Human Levels of Lead and Cadmium to the Consumption of Fish Caught on and around Lake Coeur d' Alene, Idaho 1986-1987	Personal interview or telephone survey	Mike Greenwell Agency for Toxic Substances and Disease Registry Public Health Service US Dept of Health & Human Service Atlanta, GA (404) 639-0700	299 households, follow-up study on 33 individuals	About 2 years	Done in-house	Done by Division of Health Studies, Sharon Campoluiu
A Survey of Attitudes and Fish Consumption of Anglers on the Lower Tittabawassee River, Michigan 1987	Creel census	John Hesse Michigan Department of Public Health, Lansing, MI (517) 335-8353 (8350)	5 interviewers conducted 703 interviews	4 months for surveys (1 May to 31 Aug)	$6,500	Follow-up telephone survey done by Michigan State University as part of a survey class
Angler Use and Harvest on Fox Lake, WI 1987	Creel census	James C. Congdon DNR Madison Wisconsin Bureau of Fisheries Mgmt Horicon County (414) 485-3003	1/2 FTE doing creel survey for entire fishing season (1 May-15 March, 11 1/2 mos	11 1/2 months	Funded with state funds	

SUMMARY OF SURVEY METHODS INFORMATION (continued)

Title of Survey	Type of Survey	Contact Address Phone No.	Level of Effort	Time	Cost	Comments
Michigan Sports Anglers Fish Consumption Survey 1988	Mail survey and telephone survey	Dr. Patrick West School of Natural Resources University of Michigan (313) 764-7206 (313) 763-2200	2,600 surveys mailed out 4 waves of mailings and follow-up phone calls for non-response bias	1 year	$30,000	
New York Statewide Angler Survey 1988	Mail survey	Dr. Nancy Connelly Cornell University NY State College of Agriculture and Life Sciences, Fernow Hall, Ithaca, NY (607) 255-2830	17,000 mailed out 3 follow-up mailings 200 telephone follow-ups for non-response bias 10,314 quest. returned	10 months, total time about 18 months	Funded by Dept. Environ. Conserv., Bureau of Fisheries, State of New York	
A Study of the Consumption Patterns of Great Lakes Salmon and Trout Anglers 1989	Mail survey	Chuck Cox Water Resources Branch, Ministry of the Environment, Toronto, CANADA (416) 323-4994	2100 surveys mailed out, 1427 returned (68% response)	4 months for data collection and analysis	$1,500 mailing costs, plus staff time for processing results	Very effective with proper cover letter, stamped return envelope, and multiple choice questionnaire. Also provide space for comments, so anglers may voice concerns.
Consumption of Freshwater Fish by Marine Anglers 1990	Mail survey	Ellen Elbert ChemRisk 1685 Congress St. Portland, ME (207) 744-0012	2,500 mailed out 1,612 returned	9 months	Client confidential	Revised draft report available