LAKE ERIE

LAKEWIDE MANAGEMENT PLAN

Lake Erie Lakewide Management Plan (LaMP) Technical Report Series

Impairment Assessment of Beneficial Uses: Tainting of Fish and Wildlife Flavor

Lauren Lambert
1997

Lake Erie LaMP Technical Report No. 3

Technical Report 3

Tainting of Fish & Wildlife Flavor

Prepared for the Lake Erie LaMP
Preliminary Beneficial Use Impairment Assessment

by Lauren Lambert
February 6, 1997

NOTE TO THE READER:

This technical report was prepared as one component of Stage 1, or "Problem Definition," for the Lake Erie LaMP. This report provides detailed technical and background information that provides the basis for the impairment conclusions recorded in the Lake Erie LaMP *Status Report*.

This document has been extensively reviewed by the government agencies that are partnering to produce the LaMP, outside experts, and the Lake Erie LaMP Public Forum, a group of approximately of 80 citizen volunteers. This review was designed to answer two questions:

- Is the document technically sound and defensible?
- Do the reviewers agree with the document conclusions and format?

In its present form, this report has been revised to address the comments received during that review process, and there is majority agreement with the impairment conclusions presented.

3.1 Listing Criteria

According to the International Joint Commission (IJC), tainting of fish and wildlife flavor occurs when ambient water quality standards, objectives, or guidelines, for the anthropogenic substance(s) known to cause tainting, are being exceeded or survey results have identified tainting of fish or wildlife flavor (IJC, 1989).

3.2 Scope of the Assessment

The scope of the Lake Erie LaMP beneficial use impairment assessment (BUIA) includes open lake waters, nearshore areas, river mouths and embayments, and the lake effect zone of Lake Erie tributaries. The lake effect zone is defined as that zone where the waters of the lake and the tributary river are mixed. In the case of the Detroit River, there is no lake effect zone. Thus, Detroit River impairments in the Lake Erie LaMP will be evaluated on a case by case basis, and, will be included where relevant to potential impacts in Lake Erie.

This assessment examines all existing regional or jurisdictional standards or criteria and any available survey results, which address tainting of fish and wildlife.

3.3 Summary of Jurisdictional Fish Tainting Criteria

Most Lake Erie jurisdictions have regulations specifying that waters of that jurisdiction are required to be free from substances that cause taste and odor problems or nuisances. The degree to which these general standards specifically address fish tainting (versus other types of taste and odor problems) varies. Only one Lake Erie jurisdiction (Canada) has specific ambient water quality standards that address fish tainting in Lake Erie. Two Lake Erie jurisdictions (Canada and Michigan) have protocols in place to test and evaluate fish tainting, once it has been noted.

Binational

Annex 1 of the Great Lakes Water Quality Agreement (GLWQA) contains specific water quality use objectives for the Great Lakes. Two of these objectives (I.B.1.b and I.C.4) relate to tainting in general. Specifically, the GLWQA states that: 1) "oil and petrochemicals should not be present in concentrations that can be detected by odor or that can cause tainting of edible aquatic organisms; and 2) substances entering the water as the result of human activity that cause tainting of edible aquatic organisms should not be present in concentrations which will lower the acceptability of these organisms as determined by organoleptic tests" (IJC, 1988).

Canadian Federal

Canadian regulations address fish tainting in relation to ambient water quality and the quality of commercial fish products processed for export.

The Canadian Water Quality Guidelines contain a requirement that total phenols should not exceed 1ug/l of total phenols to prevent tainting of fish flesh (Canadian Council of Resource and Environment Ministers, 1987).

The Canadian Federal Department of Fisheries & Oceans (DFO), Inspection Branch, has responsibility for insuring that fish and fish products processed in Canada for export are in compliance with the Federal Fish Inspection Act and Regulations. All fish processing facilities must be federally registered to export fish. As a condition of registration, each processing facility must have a Quality Management Program (QMP) in place.

A QMP identifies standards for plant construction, sanitary operating procedures for equipment, and product safety, quality, and identity. DFO audits the effectiveness of a plant s QMP at regular intervals. Frequency and rate of inspection varies from every two weeks to every two months, dependent upon the compliance rating of the processor. Part of DFO s QMP audit involves product inspection. Two representative samples of products processed in the operation are withdrawn and inspected for compliance analysis.

Two aspects of the compliance analysis are relevant to fish tainting: a) sensory analysis of taint, decomposition, and/or unwholesomeness, which includes a standardized evaluation of the odors associated with the product, and b) laboratory analysis of the edible portion of the fish, if the sensory analysis suggests contamination of a chemical nature (e.g. petroleum products, phenols, and metallic, or muddy flavors) (Hendzel, 1996).

Based on DFO s inspections, there are no problems with fish tainting from Lake Erie commercial fish processed in Canada (Gushue, 1996, personal communication).

U. S. EPA

As part of developing ambient water quality criteria for chlorinated phenols, U.S. EPA has reported on what is known about these chemicals in terms of their ability to cause tainting in aquatic organisms. Detailed study results are shown in Table 3.1 below. These thresholds are not water quality standards.

"Chlorinated phenols have been shown to impair the flavor of freshwater fish flesh at concentrations much lower than those at which it has a toxic effect (Shumway and Palensky, 1973) . . . Rainbow trout were exposed for 48 hours to a range of concentrations of five different chlorinated phenols, and a panel of 15 judges scored the flavor of the cooked and coded fish samples on an increasing impairment scale of 0 to 6.

The results were then plotted against exposure concentrations and graphically interpreted to arrive at an estimate of the highest concentration which would not impair the flavor of the flesh. The resulting estimates for five different compounds ranged from 23 ug/l for 2,5-chloro-phenol to 84 ug/l for 2,3-dichlorophenol" (U.S. EPA, 1980 a).

For 2,4-dichlorophenol, "flavor impairment studies (Shumway and Palensky, 1973) showed that flesh tainting occurred when 2, 4-dichlorophenol concentrations ranging from 0.4 ug/l to 14 ug/l, depending on the species of fish tested, were exceeded" (U.S. EPA, 1980 b).

Table 3.1 Fish Flavor Impairment Thresholds Based on Exposure to Chlorinated Phenolics (USEPA, 1980 a, b, c)

Fish Species	Chemical	Duration of Exposure	Highest Estimated Concentration of Chemical That Will NOT Impair Flavor	Reference
Rainbow Trout ***Salmo gairdneri***	2-chlorophenol	48 hours	60 ug/l	Shumway & Palensky, 1973
Rainbow Trout ***Salmo gairdneri***	2,4-dichlorophenol	48 hours	1 ug/l	Shumway & Palensky, 1973
Rainbow Trout ***Salmo gairdneri***	4-chlorophenol	48 hours	45 ug/l	Shumway & Palensky, 1973
Rainbow Trout ***Salmo gairdneri***	2,3-dichlorophenol	48 hours	84 ug/l	Shumway & Palensky, 1973
Rainbow Trout ***Salmo gairdneri***	2,5-dichlorophenol	48 hours	23 ug/l	Shumway & Palensky, 1973
Rainbow Trout ***Salmo gairdneri***	2,6-dichlorophenol	48 hours	35 ug/l	Shumway & Palensky, 1973
Rainbow Trout ***Salmo gairdneri***	2,4,6-trichlorophenol	48 hours	52 ug/l	Shumway & Palensky, 1973
Bluegill ***Leopomis macrochirus***	2-chlorophenol	1 week	2,000 ug/l	Henderson, et al., 1960
Bluegill ***Leopomis macrochirus***	2,4-dichlorophenol	48 hours	14 ug/l	Shumway & Palensky, 1973
Largemouth bass ***Micropterus salmoides***	2,4-dichlorophenol	48 hours	0.4 ug/l	Shumway & Palensky, 1973

Michigan

Rule 55, Part 4 of the Michigan Water Quality Standards states that "the waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair. . . . . the palatability of fish as measured by test procedures approved by the Michigan Department of Environmental Quality." Michigan is unique among the Lake Erie jurisdictions in having a specific protocol in place for assessing sport fish tainting, once it has been reported. "Fish taste and odor studies may be conducted by Great Lakes and Environmental Assessment Section staff or required of a National Pollutant Discharge Elimination System (NPDES) applicant when it has been established that complaints of poor tasting fish from a particular water body are occurring with some regularity" (Michigan Department of Environmental Quality, 1990).
There have been some fish taste problems noted in Michigan tributaries to Lake Erie. Details are outlined in section 3.5, "Fish/Wildlife Tainting Surveys," of this report.

New York

Title 6, Chapter 10, Part 702.12 of the New York State Codes, Rules and Regulations addresses general procedures for deriving standards and guidance values based on tainting of aquatic food. This regulation states, "values based on aesthetic considerations, including but not limited to taste, odor and discoloration shall be based on an evaluation of the reported levels of the substance that affect the aesthetic quality of the fish flesh, aquatic life, wildlife or livestock that are consumed by humans and that acquire such flavor, odor or color because of habitation in, passage through, or ingestion of waters" (New York State Department of Environmental Conservation, 1992.)

New York has used this particular regulation to establish specific ambient water quality standards to address fish tainting in Lake Erie waters of New York, particularly for phenolics and chlorobenzenes. No complaints of impaired fish flavor in Lake Erie waters have been received by the New York State Department of Environmental Conservation (Lange, 1996).

Ohio

Ohio general water quality standards require that all surface waters of the state, including mixing zones, be "free from materials entering the waters as a result of human activity producing color, odor, or other conditions in such a degree as to create a nuisance" (Ohio EPA, 1985). No specific ambient water quality standards exist to address fish tainting.

Because fish tainting due to exposure to chlorinated phenolics has been documented in certain species (see Table 3.1), Ohio wastewater dischargers with phenolic permit limit violations were examined. However, phenolic violations are reported as total recoverable phenolics rather than chlorinated phenols. Therefore, it is not possible to analyze whether

phenolic discharges that exceed permit limits are likely to cause fish tainting.

Some problems with fish tainting were identified in the Cleveland nearshore area. Details are outlined in section 3.5 "Fish/Wildlife Tainting Surveys," of this report.

Ontario

In July, 1996, 10 provincial fisheries managers from the Ontario Ministry of Natural Resources were surveyed to determine if they had received complaints of fish tainting in Lake Erie during the 12 months prior. No occurrences of fish tainting were reported in Ontario waters of Lake Erie during this time period (Ryan, 1996).

Pennsylvania

Pennsylvania water quality standards for Lake Erie specify that phenols and other objectionable taste and odor producing substances should be substantially absent. Pennsylvania has historically conducted fish taste testing surveys annually. Most of this testing was done in the Pittsburgh area and all of it was done inland. Therefore, no fish taste testing results are available for Pennsylvania s Lake Erie shoreline (Burch, 1996).

3.4 Summary of Jurisdictional Criteria Used to Assess Tainting of Wildlife Flavor

No criteria have been established by any Lake Erie jurisdiction to measure tainting of wildlife flavor.

No complaints of impaired wildlife flavor in or near Lake Erie waters have been received by the Ohio Environmental Protection Agency, the Ohio Department of Natural Resources, the Michigan Department of Environmental Quality, the New York Department of Environmental Conservation, the Pennsylvania Department of Environmental Protection, or the Canadian Wildlife Service (Shieldcastle, 1995; Sweet, 1996; Draper; Burch, 1996; Robinson, 1996).

3.5 Fish/Wildlife Tainting Surveys

Limited survey results regarding fish tainting are available in relation to the Black, Detroit, Rouge, and Raisin River Areas of Concern (AOCs). In the case of the Black River, surveys of hunters were also conducted. A survey related to fish consumption habits was conducted in the Cuyahoga AOC, but also yielded some information about fish taste and odor.

Between October 1993 and January 1994, the Consortium for Health Assessment for Great Lakes Sports Fish Consumption conducted a study to investigate the associations between Great Lakes sports fish consumption and adverse reproductive outcomes. Although the focus of the study was on fish consumption habits, charter boat captain/spouses who were interviewed also talked about their general perceptions of the Lake Erie fishery and associated problems.

Black River Survey

In 1994 the Black River Study Group/Friends of the Black River at Oberlin College sent approximately 230 fish and hunter surveys to local fishing and hunting clubs for the Black River RAP. The purpose of the surveys were to interact with hunters and fishermen active in the Black River watershed to determine: a) the nature and magnitude of their use of the resource; b) whether they have noticed taste and odor problems with their catches; and c) their perceptions of water use and water quality problems (Vidra, 1995).

Due to poor response to the written survey, a second phase of the project involved personal interviews with 29 people, 21 fishermen and 8 hunters.

All of the fishermen described the taste of the fish as good, although 4 people had problems with it depending on where it was caught. One person would not eat fish from Grafton north, due to the muddy taste. Grafton north is not located within the scope of the Lake Erie LaMP beneficial use impairment assessment.

Three of the 8 hunters hunt in areas within the scope of the Lake Erie LaMP beneficial use impairment assessment. Species eaten were deer, waterfowl, rabbit, pheasant, crow, and squirrel. Seven of the survey participants described the game's taste as good and one said it was fair (Barbour et. al., 1994).

Detroit River Survey

Fish tainting was evaluated in the Detroit River as part of the beneficial use impairment assessment for the Detroit River AOC. A preliminary fish flavor impairment study was conducted on walleye from the Trenton Channel of the Detroit River, on August 19, 1992. Compared to control walleye purchased from a seafood market, 4 of the 6 Trenton channel walleye evaluated were found to be taste impaired at the 95% level of significance ($p=0.05$) and three at the 99% level of significance ($p=0.01$). Comments from the panel members on the taste/odor of the Trenton Channel walleye included "petroleum taste," "earthy," "sewery," "musty/moldy," "chemical flavor," and "kerosene smell." (Michigan Department of Natural Resources, 1994).

Based on the results of the 1992 preliminary study, a follow-up study was conducted on August 4, 1993. The follow-up fish flavor impairment study compared walleye from two locations in the Detroit River---- the Trenton Channel and east of Grosse Ile, Lake St. Clair, and western Lake Erie to walleye from a control site in southern Lake Huron (see Figure 1, Appendix 3A for locations). This study was designed to: a) evaluate whether the flavor of walleye from select locations in the Detroit River, Lake St. Clair and Lake Erie was impaired compared to a local control population; and b) define the extent of any fish flavor impairment problems (MDNR, 1994). This summary will focus on the results from the Lake Erie fish samples.

Flavor impairment is defined as "a detectable flavor deterioration, between a test and control sample. Flavor tainting, off flavor, and undesirable flavor are considered synonyms" (ASTM D 3696 - 89). The flavor impairment study consisted of a panel tasting and rating the fish and statistical interpretation of the results (MDNR, 1994).

The taste/rating portion of the study involved 21 volunteer tasters who were instructed to rinse the mouth with diluted lemon juice before tasting any fish and between samples, chew and spit out the fish , but do not consume it, start by tasting the control fish, and rate each test fish before going on to the next. Tasters were asked to rate the fish on a scale from +3 (strong flavor enhancement) to -3 (strong flavor impairment). Tasters were also asked to include any comments they might have about the fish. In particular, they were asked to note if they detected an undesirable odor and to try to describe any flavor they might detect.

A statistical analysis was conducted which was designed to determine whether a difference existed between the samples and the control, the magnitude of that difference, and if that difference was statistically significant. Neither of the two walleye samples from Lake Erie were judged to be significantly impaired. However, one of them approached a level which would indicate statistically significant impairment.

Several factors limit the conclusions which can be drawn from this study including the small sample sizes from Lakes Erie and St. Clair, fish movement, the use of sample portions which included the lateral line, and variation in the results for the fish sampled by both panels (MDNR, 1994).

1993 Detroit Boat Show Angler Survey

An informal survey of 1224 anglers was conducted at the 1993 Detroit Boat show to obtain information on potential fish taste or odor problems in the Detroit River and several additional southeastern Michigan water bodies (including the Rouge and Raisin Rivers). 9.8% of the Detroit River anglers and 2.8% of the Raisin River anglers had noticed unusual taste or odor in fish they caught. A copy of the survey and the tabulated results is included in Appendix 3B (MDNR, 1994).

Cuyahoga River AOC Creel Survey

In 1993 the Cuyahoga RAP conducted a creel survey to gather information on human consumption of fish caught from the lower 45 miles of the Cuyahoga River and Cleveland lakefront area. The overall survey was designed to determine whether socio-demographic patterns exist among subsistence anglers and to evaluate anglers overall level of awareness of existing advisories and access to health related information. One of the survey questions asked about taste/odor of the fish as it relates to consumption. The purpose of the creel survey results was to combine them with information on contaminant levels in fish to identify anglers who may be at risk due to their fish consumption habits. A copy of the creel survey questions is found in Appendix 3C.

It should be noted that the 1993 creel survey was considered by the survey designers to be preliminary. It was fully anticipated that additional surveying would have to be done in order to control for other factors, such as season of sampling and survey design. For example, information is needed on whether people eating fish during the summer maintain those consumption rates during other seasons.

Nine sites were targeted for interviews with anglers. On average, each site was visited by the survey taker once a day. Anglers were very receptive to the survey, answering questions willingly. Of the nine interview sites, four were located on Lake Erie---- Edgewater State Park, Wildwood Park (adjacent to Euclid Beach), East 55th Street, and E. 72nd Street at Gordon Park.

Interview responses from 339 individuals were used for analysis. A majority of respondents (64%) said that they or someone else ate the fish they caught.

Thirty-four percent of the individuals surveyed exhibited characteristics of subsistence fishing. For this study, someone displaying characteristics of subsistence fishing was an individual who said: a) the fish caught was a primary source of their diet, or b) the fish caught was either somewhat or very important to their or somebody else's diet, or c) that six or more of their meals per month were prepared from the fish caught at the study site.

Subsistence anglers differed from anglers that don't eat the fish they catch (non-consumers) in the reasons why they don't eat fish. See Figure 6 in Appendix 3C for details. Of particular interest for this summary is that 18% of the subsistence anglers said they have noticed an unpleasant or unusual taste or odor when eating the fish they have caught locally (Cuyahoga River RAP, 1993). The types of fish caught and eaten by subsistence anglers in this study are summarized in Tables 3.2 and 3.3 below.

Table 3.2 Types of Fish Caught By Subsistence Anglers in Cuyahoga Area of Concern
(Cuyahoga River RAP, 1993)

Type of Fish	Percentage of Subsistence Anglers Who Caught Fish Type Frequently
Freshwater Drum	84%
White Perch	50%
Rock Bass	50%
White Bass	50%
Yellow Perch	33%
Bluegill	25%
Catfish	19%
Carp	13%
Walleye	10%
Small Mouth Bass	10%
Crappie	10%
Shad	10%

Table 3.3 Types of Fish Consumed by Subsistence Anglers in the Cuyahoga River AOC
(Cuyahoga River RAP, 1993)

Fish Type and Frequency of Fish Consumption in Decreasing Order	Percentage of Subsistence Anglers Who Consumed at Least One Fillet in the Month Previous to the Survey
White Perch	25% or more
Yellow Perch	25% or more
White Bass	25% or more
Catfish	25% or more
Bluegill	25 % or more
Rock Bass	25% or more
Freshwater Drum	20%
Walleye	18%
Small Mouth Bass	17%
Large Mouth Bass, Crappie, Carp or Shad	10% or less

Great Lakes Charter Boat Captain Health Study

The Consortium for the Health Assessment for Great Lakes Sports Fish Consumption is a cooperative effort between the State Health Departments of Wisconsin, Illinois, Indiana, Michigan, and Ohio. The main objective of the Consortium is to investigate the association between Great Lakes sports fish consumption and adverse reproductive outcomes. Charter boat captains on the Great Lakes were selected as the study group because the accessibility of fish to them is greater than to almost any other group in the five state region (Vidra, 1995).

The Lorain County Health Department in Ohio is overseeing a majority of the field work on Lake Erie. There are approximately 1200 charter boat captains in Ohio. Approximately 200 participants were selected from this group, including 36 control participants who did not consume Lake Erie fish. Survey participants were interviewed personally and shared their perceptions on all aspects of the Lake Erie fishery. Although participants were not specifically asked about fish tainting, it is worth noting that none of the participants mentioned fish tainting as a problem (Boddy, 1995).

3.6 Impairment Conclusions

The IJC listing criteria state that a tainting impairment occurs when ambient water quality standards, objectives, or guidelines, for the anthropogenic substance(s) known to cause tainting are being exceeded or survey results have identified tainting of fish or wildlife flavor.

With the exception of Canada, none of the Lake Erie jurisdictions have specific ambient standards to address fish tainting in Lake Erie. Therefore, to apply the IJC listing criteria to assessment of fish tainting in Lake Erie, it was necessary to rely almost solely on survey results, most of which did not address fish tainting alone. In terms of tainting survey results, data on Lake Erie fish and wildlife tainting is extremely limited. If the IJC listing criteria are interpreted literally, any survey results that identify tainting would point to impairment. However, for the survey data which does exist, its use in assessing impairment, per the IJC listing criteria, is further limited by the following.

No criteria exist for the evaluation of wildlife tainting.

Only the Black River survey included wildlife consumers.

The only survey that **focused** on fish tainting was the Detroit River survey.

All survey results were based on fish caught in Lake Erie tributaries, harbor and/or shoreline areas. No data is available for fish caught in open lake waters.

In the case of survey respondents from the River Raisin, it is not clear from the responses whether they were addressing fish taste and odor problems in the lake effect zone of the River Raisin. It is possible that they were addressing problems in the headwater areas.

Survey respondents were asked to identify taste and odor problems noted, but not all of the survey results distinguished between taste and odor problems reported.

Survey questions were quite general and were therefore subject to a wide variety of interpretations by the survey respondents.

With the exception of the Detroit River survey, survey data collected was exclusively dependent on the willingness of fishermen/hunters to respond to the questions asked.

Based on statistical analysis of fish flavor sampling results from the Detroit River Survey, fish tainting problems in the Detroit River do not impact Lake Erie fish at a statistically significant level. It is not clear whether River Raisin survey respondents were referring to taste and odor problems within the lake effect zone of the river. Therefore, survey responses that identify taste and odor problems in fish that were caught within the geographic scope of the Lake Erie LaMP are limited to the Cleveland lakefront area. However, the general nature of the survey questions asked during the Cuyahoga Creel Survey do not allow us to be sure that taste and odor problems identified by respondents equate with a tainting impairment in Lake Erie fish.

For example, the Cuyahoga Creel survey respondents were asked two questions:

A) Have you ever noticed an unpleasant or unusual taste or odor when eating fish you have caught locally?

B) Tell me whether the following factors are very important, somewhat important, or not important as reasons why you don t eat the fish that you catch? Potential responses included: pollution in water, taste/odor of the fish, don t catch the right kind of fish, like to catch and release, don t like to eat fish, don t need to eat fish I catch, and knowledge of the fish advisory.

Question A could be interpreted to mean that the survey respondent was being asked to identify taste or odor problems for any time during their fishing history on Lake Erie. This could mean that a taste problem from 20 years ago was identified during the survey. Similarly, answering that taste and odor of the fish are a reason for not eating the fish, in response to Question B, could mean that they didn't like the taste of a particular local fish species that they had tried eating in the past.

In summary, based on available information, taste and odor problems with fish have been identified in relation to only one geographic location that is clearly within the scope of the Lake Erie LaMP--- the Cleveland lakefront area. For this location, available information does not provide the detail necessary to draw a tainting impairment conclusion. However, fish tainting is easily detected by a fish consumer. This, coupled with the fact that government agencies have not received any recent Lake Erie fish tainting complaints, indicates that there does not seem to be a fish tainting problem present in Lake Erie. Therefore, given the "weight of evidence" against fish tainting (no complaints), there is no impairment due to fish tainting within the geographic scope of the Lake Erie LaMP.

No criteria exist for assessment of wildlife tainting. The Lake Erie LaMP is not aware of any complaints about wildlife flavor in and around Lake Erie. Therefore, based on available information, it appears that wildlife flavor tainting is not an impairment in and near Lake Erie.

3.7 References

1. Ashtabula River Remedial Action Plan. December, 1991. Stage 1 Investigation Report.

2. ASTM Method "Standard Practice for Evaluating an Effluent for Flavor Impairment to Fish Flesh", D3696-89.

3. Barbour, Jenna, Crosson, A. & Moore, L. 1994. Black River RAP Watershed Use Survey. Black River RAP.

4. Black River RAP. April 1994. Stage 1 Report.

5. Boddy, Jim. November, 1995. Personal communication. Lorain County Health Department.

6. Burch, Kelly. 1996. Personal communication. Pennsylvania Department of Environmental Protection.

7. Canadian Council of Resource and Environment Ministers, Task Force on Water Quality Guidelines. 1987. Canadian Water Quality Guidelines, Chapter 3. Pp 3-33, to 3-34.

8. Cuyahoga River RAP. June, 1992. Stage 1 Report.

9. Cuyahoga River RAP. 1993. Creel Survey Report.

10. Department of Fisheries and Oceans. May 10, 1994. Service Standards. Inspection Branch.

11. Draper, Richard. 1996. Personal Communication. New York Department of

Environmental Conservation.

12. Enochs, Mark. June 3, 1996. Personal Communication. Ohio EPA, Division of Surface Water.

13. Gushue, Florence. March 13, 1996. Personal communication. Department of Fisheries and Oceans, Inspection Branch, Central & Arctic Region, Southern Area.

14. Hartig, J. H. And Law, Neely L. 1994 Progress in Great Lakes Remedial Action Plans, Implementing the Ecosystem Approach in Great Lakes Areas of Concern.

15. Hendzel, Marilyn. April 10, 1996. Personal communication. Department of Fisheries and Oceans, Inspection Branch, Central & Arctic Region.

16. IJC. 1988. Great Lakes Water Quality Agreement of 1978. pp. 40-42.

17. IJC. 1989. Proposed Listing/Delisting Criteria for Great Lakes Areas of Concern. Focus on International Joint Commission Activities. Volume 14, Issue 1, insert.

18. Lange, Bob. March 7, 1996. Personal communication. New York State Department of Environmental Conservation, Bureau of Fisheries, Division of Fish & Wildlife.

19. Maumee River RAP. April 1995. Status Report.

20. Michigan Department of Environmental Quality. June 21, 1990. Procedure #55, Fish Taste and Odor Studies. Great Lakes And Environmental Assessment Section, Surface Water Quality Division.

21. Michigan Department of Natural Resources. August 16, 1994. An Investigation of Fish Flavor Impairment in Walleye f rom the Detroit River, Lake St. Clair and Lake Erie. Surface Water Quality Division Staff Report.

22. New York State Department of Environmental Conservation. 1991. Water Quality Regulation, Surface Water and Groundwater Classifications and Standards, New York State Codes, Rules and Regulations, Title 6, Chapter X, Part 702.12.

23. NYSDEC. 1993. Water Quality Regulation, Surface Water and Groundwater Classifications and Standards, New York State Codes, Rules and Regulations, Title 6, Chapter X, Part 703.5.

24. Ohio EPA. April 4, 1985. State of Ohio Water Quality Standards, Ohio Administrative Code, Chapter 3725-1-04(C).

25. Ohio EPA. May 1, 1990. State of Ohio Water Quality Standards, Ohio Administrative

Code, Chapter 3725-1-07, p. 14.

26. Ohio EPA. 1989-1996. LEAPS Data. Division of Surface Water.

27. Presque Isle Bay Remedial Action Plan. 1992. Stage 1 Report.

28. Ricci, Laurie. March 1, 1996. Personal communication. Department of Fisheries & Oceans, Inspection Branch, Central & Arctic Region, Southern Area.

29. Robinson, Jeff. 1996. Personal Communication. Canadian Wildlife Service.

30. Ryan, Phil. 1996. Personal communication. Ontario Ministry of Natural Resources, Lake Erie Management Unit.

31. Shieldcastle, Mark. 1995. Personal communication. Ohio Department of Natural Resources, Division of Wildlife.

32. Shumway, D. L. and J. R. Palensky. 1973. Impairment of the Flavor of Fish by Water Pollutants. EPA-R3-73-010. USEPA. US Government Printing Office, Washington, D.C.

33. Sweet, Bob. 1996. Personal communication. Michigan Department of Environmental Quality.

34. USEPA. 1980 a. Ambient Water Quality Criteria for Chlorinated Phenols. Office of Water Regulations and Standards. EPA 440/5-80-032. Pp. B-4, B-6 to B-12.

35. USEPA. 1980 b. Ambient Water Quality Criteria for 2,4-dichlorophenol. Office of Water Regulations and Standards. EPA 440/5-80-042. Pp. B-4, B-7 to B-13.

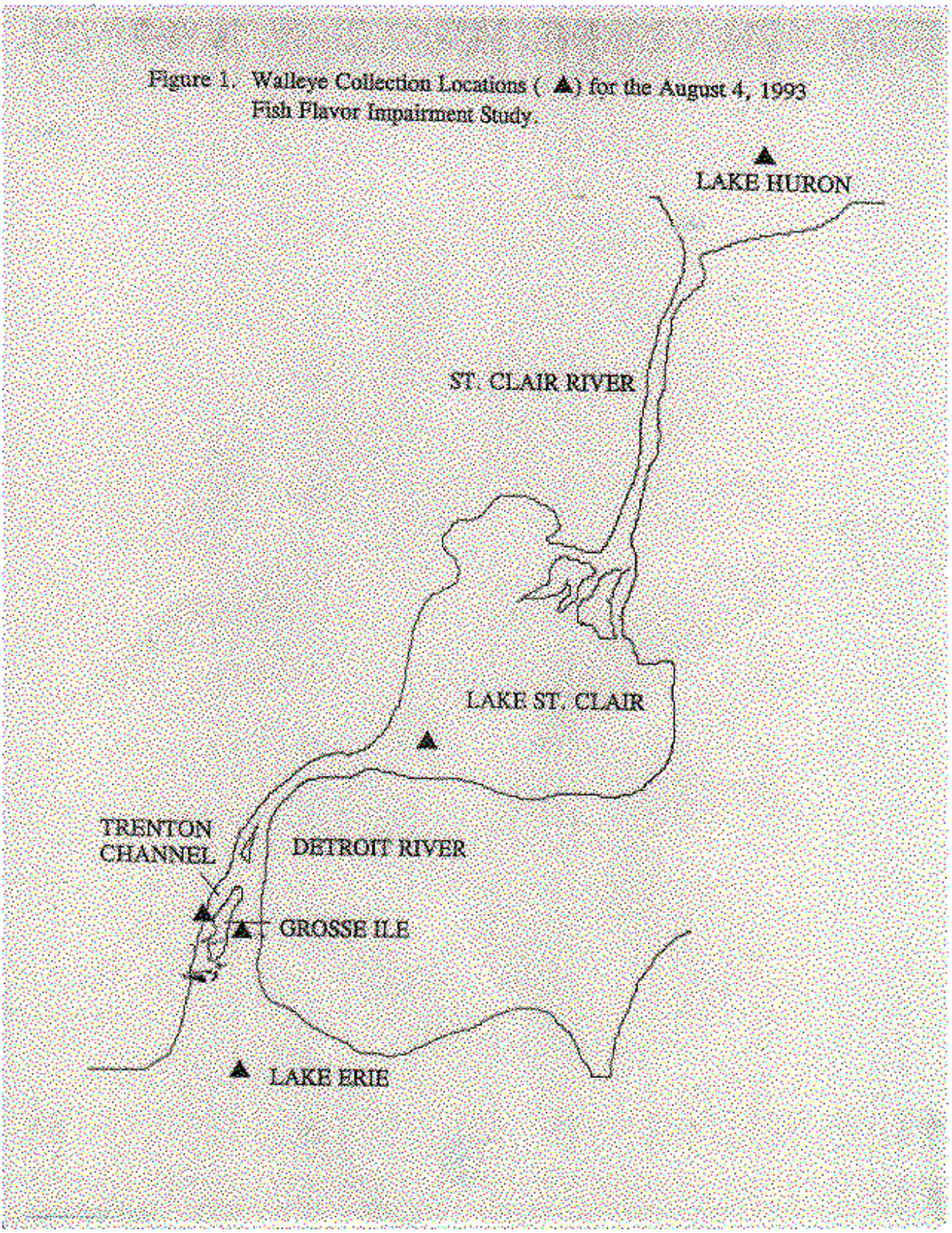
36. USEPA. 1980 c. Ambient Water Quality Criteria for 2-chlorophenol. Office of Water Regulations and Standards. EPA 440/5-80-034. Pp B-5 to B-10.

37. Vidra, Andy. November 7, 1995. Status of Research Activities in the Black River. Black River Remedial Action Plan Coordinating Committee, Black River Remedial Action Plan.

Appendix 3A

Detroit River/Lake Erie
Fish Flavor Impairment Study
Sample Source Locations
August 4, 1993

Figure 1. Walleye Collection Locations (▲) for the August 4, 1993 Fish Flavor Impairment Study.



Appendix 3B

1993 Detroit River Boat Show
Fishing Survey and Taste and Odor Problem Results

1993 DETROIT RIVER BOAT SHOW
FISHING SURVEY
SOUTHEAST MICHIGAN AREA

1. Did you fish the following Southeast Michigan areas last year? How many times?

	1-5	6-10	11-20	>20
Detroit River	☐	☐	☐	☐
St. Clair River	☐	☐	☐	☐
Lake St. Clair	☐	☐	☐	☐
Clinton River	☐	☐	☐	☐
Rouge River	☐	☐	☐	☐
Raisin River	☐	☐	☐	☐

2. What species of fish do you usually fish for?

☐ Walleye ☐ Northern Pike
☐ Freshwater Drum ☐ Small/Largemouth Bass
☐ White (Silver) Bass ☐ Panfish
☐ Catfish ☐ Perch
☐ Other _____

3. How many do you usually catch? _____

4. Do you eat your catch? ___ Always ___ Usually ___ Sometimes ___ Never

5. Compared to five years ago, are you eating more, less or the same amount of your catch?

6. Have you ever noticed an unusual taste or odor in any fish you have caught from these areas?

7. ___ No ___ Yes, where _____(Please be specific; Example: Belle Isle, Detroit River)

When: _____
Species: _____
Describe unusual taste/odor: _____

Thank you for your time. Please feel free to list additional comments or concerns on the back.

Table 2. Summary of an Informal Angler Survey for Fish Taste and Odor Problems Conducted at the 1993 Detroit Boat Show.

Fishing Location	Number of Respondents	Number of Respondents Reporting Fish Flavor or Odor Problems	
Detroit River	408	38	(9.3%)
St. Clair River	244	1	(0.4%)
Lake St. Clair	365	5	(1.4%)
Clinton River	68	0	
Rouge River	32	0	
Raisin River	107	3	(2.8%)
Totals	1,224	47*	

* An additional 9 respondents reported experiencing unusual taste or odor, but did not identify a waterbody or location.

1993 BOAT SHOW - FISHING SURVEY RESULTS
For Taste/Odor Problems

DETROIT RIVER (Total Responses = 408)

Positive Response

	Species	Date	Characteristics
DETROIT RIVER			
	Silver bass	Summer	Oily
	Walleye	Always	Oily
	--	--	Large fish-oily
	Walleye	3/4 years ago	Sulfur
	Silver bass	July	--
	Walleye	Spring	--
	Walleye	Spring '92	Yellow flesh, spoiled odor, skin sores
	Walleye	1989	Bad fishy taste
	Walleye	Summer	Bad
	--	--	Metallic
	Walleye	--	Bad taste, tumors
	Steelhead	Fall	Muddy water
	Walleye	July	--
	Walleye	June '92	--
	Walleye	Summer	Tart
	Bass, Perch	S, S, F	Metal
	Walleye	1992	>Muddy than usual
	Walleye	Spring	Oily
	Walleye	Summer	Muddy
Belle Isle	Perch, Bass	Late summer	Flat and oily taste
Belle Isle	Rock Bass	Summer '92	Bad taste
Bishop Park	Perch	--	Bad spoiled odor, tasted really fishy
Fighting Is.	Salmon	Early spring	Oily smell
Front St.	Bass, Catfish	8-10 years ago	Oily
Gross Isle	Walleye	Early summer	Oily
Lower River	Walleye, Crappie	Spring	Gasoline, strong oily taste
McClouth	Walleye	Last few years	Very fishy taste
Wyandotte	Silver Bass, Catfish	Summer --	Oily and bitter --
Zug Island	Walleye	Late summer	Heavy oily taste

TRENTON CHANNEL

Catfish	3 years ago	Oily
Walleye	Summer	Oily
Walleye	Aug./Sept.	Heavy oily taste and fishy
Walleye	Spring	Oil
Walleye	Sundays	Oil, oil slick
Walleye, White Bass	June	Bland tasting
Walleye	Spring '92	Chemical/salty

Total 38 = 9.3%

Oily Taste

Walleye	23
Bass	8
Catfish	3
Perch	3
Salmon	1
	38

Fishy or Bad Tasting

Total 17

Responses that did not indicate if catch was specifically from the Detroit River or from another river or lake.

Walleye	8/92	Pungent
	week late	Increased fish taste
Perch	Summer '91	Fishy taste
Walleye	June	Rotten, strong chemical taste
Smallmouth bass		Extremely strong fishy taste
Carp	August	Smelled bad
Walleye		Strong fish taste/odor
Walleye	1991	Mud taste, sores
Walleye	August	Off

Total 9

1993 BOAT SHOW - FISHING SURVEY RESULTS

For Taste/Odor Problems

ROUGE RIVER (Total Responses = 32)

Positive Response	Species	Date	Characteristics
	No reported incidence of unusual taste or odor.		

RAISIN RIVER (Total Responses = 107)

Positive Response	Species	Date	Characteristics
	Blue gill	1990	Acid odor
	Walleye	1991	Oily
	Bass, Perch	Mid-summer	Musky taste
Total	3 = 2.8%		

Appendix 3C

Cuyahoga River AOC Creel Survey
and
Reasons Why Anglers Don't Eat Some Kinds of Fish They Catch

Cuyahoga River AOC Creel Survey, 1993

1. In miles, how far from your residence did you travel here today? _____

2. And how did you get here today? _____

3. What is your primary purpose for fishing today?

_____ Relaxation	_____ To catch fish
_____ Recreation	_____ Other;
_____ Sport	specify _____

4. About how often do you fish?

_____ Every day/About every day	_____ About once every two weeks
_____ A few times a week	_____ About once a month
_____ About once a week	_____ Less than once a month

5. In the last two weeks, how many times have you gone fishing? _____

6. On the average, how many hours do you spend per fishing trip? _____

7. Is the fish that you catch used for food by you or somebody else? ____ Yes ____ No

IF ANGLER ANSWERS "YES" TO QUESTION 7, SKIP TO QUESTION 9.

8. Are the following factors very important, somewhat important, or not important as reasons why you do not eat the fish that you catch?

	Very Important	Somewhat Important	Not Important
Pollution in water	1	2	3
Taste/odor of the fish	1	2	3
Don't catch the right kind of fish	1	2	3
Size of the fish	1	2	3
Like to catch and release	1	2	3
Don't like to eat fish	1	2	3
Don't need to eat fish I catch	1	2	3
Knowledge of fish advisory	1	2	3

SKIP TO QUESTION 29

9. Is the fish you catch from here today or other days a primary source of food for you, your family, or others in your household? _____ Yes _____ No

10. Do you ever give away the fish you catch to people outside your household? _____ No
_____ Yes; specify amount _____

11. How important is the fish that you catch to your diet, your family's diet, or somebody else's diet?
_____ Very Important _____ Somewhat Important _____ Not Important

12. On the average, over the past year, how many of your meals per month were prepared from fish you caught here?

_____ 20 or more	_____ from 3 to 5
_____ from 11 to 19	_____ 1 or 2
_____ from 6 to 10	

13. Below are names of different kinds of fish. When you fish here, how often do you catch them?

1 = Frequently/almost every outing
2 = Often but not every outing
3 = Once in a while
4 = Never or almost never

Walleye	1	2	3	4	
Yellow perch		1	2	3	4
White perch		1	2	3	4
White bass		1	2	3	4
Freshwater drum/sheepshead		1	2	3	4
Catfish		1	2	3	4
Carp		1	2	3	4
Largemouth bass		1	2	3	4
Smallmouth bass		1	2	3	4
Rock bass		1	2	3	4
Panfish/bluegill		1	2	3	4
Crappie		1	2	3	4
Shad		1	2	3	4

IF ANGLER ANSWERS "NO" TO QUESTION 9, "NOT IMPORTANT" TO QUESTION 11, AND "FROM 3 TO 5" OR "1 OR 2" TO QUESTION 12, GO TO QUESTION 29

14. I m going to name the same fish. About how many fillets have you eaten of each in the last month?

Walleye	_____	Carp	_____
Yellow perch	_____	Largemouth bass	_____
White perch	_____	Smallmouth bass	_____
White bass	_____	Rock bass	_____
Freshwater drum/ sheepshead	_____	Panfish/bluegill	_____
		Crappie	_____
Catfish	_____	Shad	_____

15. Are there some kinds of fish you will not eat? _____ Yes _____ No

IF "NO," SKIP TO QUESTION 17

16. Tell me whether the following factors are very important, somewhat important, or not important as reasons why you do not eat the fish that you catch?

	Very Important	Somewhat Important	Not Important
Pollution in water	1	2	3
Taste/odor of the fish	1	2	3
Don't catch the right kind of fish	1	2	3
Size of the fish	1	2	3
Like to catch and release	1	2	3
Don't like to eat fish	1	2	3
Don't need to eat fish I catch	1	2	3
Knowledge of fish advisory	1	2	3

17. Do you skin the fish and remove fat before cooking? _____ Yes _____ No

18. Do you ever eat or cook any part of the fish other than the fillet? _____ No
_____ Yes; specify _____

19. How often do you use the following methods to cook the fish you catch?

1= frequently 3= occasionally
2= often 4= never

	Frequently	Often	Occasionally	Never
Pan-fry	1	2	3	4
Broil or grill	1	2	3	4
Bake	1	2	3	4
Steam or poach	1	2	3	4
Make soup or stew	1	2	3	4
Smoke	1	2	3	4
Other	1	2	3	4

specify _____

20. Have you ever noticed an unpleasant or unusual taste or odor when eating fish you have caught locally? _____ Yes _____ No

21. How many people in the following age categories live in your household, including yourself?

_____ 4 or less years old
_____ 5-17 years old
_____ 18-24 years old
_____ 25-44 years old
_____ 45-64 years old
_____ 64-74 years old
_____ 75 years or older

22. How many household members, by age, usually share in eating the fish you catch. Again, include yourself.

_____ 4 or less years old
_____ 5-17 years old
_____ 18-24 years old
_____ 25-44 years old
_____ 45-64 years old
_____ 64-74 years old
_____ 75 years or older

23. Is fish other than that caught by you prepared and eaten in your household?
_____ Yes _____ No

24. If yes, what is the source of this fish? Please be specific_____

25. Are any of the women in your household currently pregnant or nursing?
_____ Yes _____ No

26. Where do you and other members of your household ordinarily obtain your health care?

_____ Family doctor
_____ Neighborhood health center
_____ Urgent care health center
_____ Hospital
_____ Other
Specify _____

27. How do you primarily keep informed about health issues?

_____ Doctors or nurses
_____ Hospital or health center
_____ Television
_____ Magazines
_____ Newspapers
_____ Radio
_____ Word of mouth (friends/family)
_____ Government agencies
_____ Other
Please specify_____

28. How do you primarily keep informed about fishing?

_____ Bait shop
_____ Television
_____ Magazines
_____ Newspapers
_____ Radio
_____ Word of mouth (friends/family)
_____ Government agencies
_____ Other
Please specify_____

29. Were you aware of the current fish advisory about eating carp and channel catfish from Lake Erie?
_____ Yes _____ No

IF "NO," SKIP TO QUESTION 31.

30. If yes, where did you learn of it? _____

31. What other information about the health and safety of eating fish do you want from the State in the form of advisories? _____

32. Finally, we d like to obtain a little information about you.

In what year were you born? _____

33. Are you . . . (check ALL that apply)

____	Employed full-time	____	Retired
____	Employed part-time	____	Unemployed
____	Homemaker	____	Disabled
____	Student		

34. What is the highest level of school that you completed?

____ Did not graduate from high school
____ Completed high school or equivalent
____ Some college or vocational school
____ Completed college

35. What is your home zip code? _____

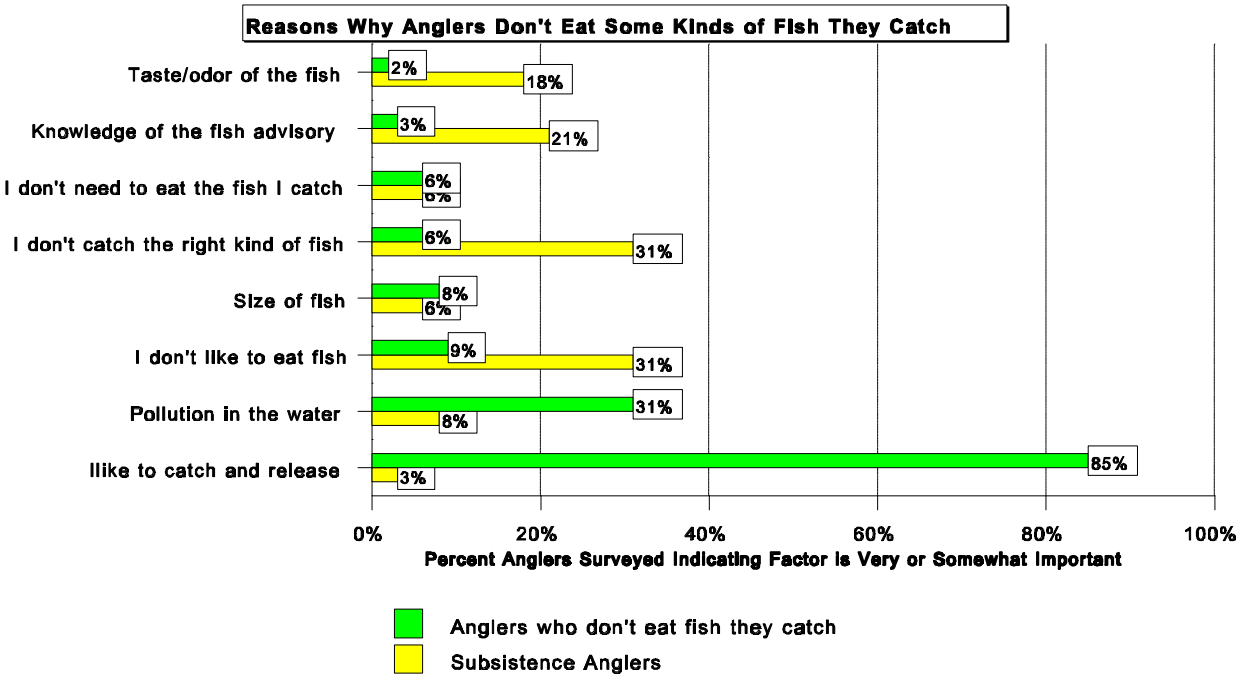
36. And, using the card, please give me the letter that represents your total household income last year?

_____	under $10,000	_____	$30,000 to $39,999
_____	$10,000 to $19,999	_____	$40,000 to $49,999
_____	$20,000 to $29,999	_____	$50,000 and more

37. Mark race or ethnicity of angler.

_____	Black or African-American	_____	Asian
_____	Hispanic	_____	White or Euro-American
_____	Other - specify_____		

38. Mark gender of angler. _____ Male _____ Female


Reasons Why Anglers Don't Eat Some Kinds of Fish They Catch
Taste/odor of the fish
2%
18%
Knowledge of the fish advisory
3%
21%
I don't need to eat the fish I catch
6%
I don't catch the right kind of fish
6%
31%
Size of fish
8%
6%
I don't like to eat fish
9%
31%
Pollution in the water
31%
8%
I like to catch and release
85%
3%
0%
20%
40%
60%
80%
100%
Percent Anglers Surveyed Indicating Factor is Very or Somewhat Important
Anglers who don't eat fish they catch
Subsistence Anglers