



North Carolina Fish Consumption Advisory Process Manual

HOW TO COLLECT CONTAMINANT DATA ON FISH AND
INFORM FUTURE FISH CONSUMPTION ADVISORIES

Duke
UNIVERSITY

SUPERFUND
Research Center

early life exposures, later life consequences

OAKLAND
UNIVERSITY™

North Carolina Fish Consumption Advisory Process Manual

HOW TO COLLECT CONTAMINANT DATA ON FISH AND INFORM
FUTURE FISH CONSUMPTION ADVISORIES

SEPTEMBER 2022

Mozhgon Rajae
Samuel Cohen
Elizabeth Shapiro-Garza
Chiara Klein

ACKNOWLEDGEMENTS

We would like to acknowledge all the many partner organizations and individuals, and their vital role in making our work on subsistence fish consumption possible. A special thanks to Cape Fear River Watch, New Hanover County NAACP, New Hanover County Department of Health, the Wake Forest School of Medicine, and the Duke University Environmental Law & Policy Clinic who initiated this work, and to those who have joined and sustained it, including the North Carolina Coastal Federation, Veronica Carter, Deborah Dicks-Maxwell, Dean Neff, Keith Rhodes, Madi Polera, Catherine Kastleman, and Bryan Luukinen. We are also deeply indebted to all those from the North Carolina Wildlife Resources Commission and Department of Marine Fisheries who offered their time and expertise in collecting fish tissue samples and at the North Carolina Department of Health and Human Services who conducted the health risk assessment that led to the setting of new consumption advisories on the lower Cape Fear River.

Funding

The Duke University Superfund Research Center's Community Engagement Core is supported through the National Institute of Environmental Health Sciences Superfund Research Program P42 Multiproject Center Grant program, grant number [P42ES010356](#).

Attribution

Please cite this work as follows:

Rajae, Mozgon, Samuel Cohen, Elizabeth Shapiro-Garza, and Chiara Klein. 2022. *North Carolina Fish Consumption Advisory Process Manual: How to Collect Contaminant Data on Fish and Inform Future Fish Consumption Advisories*. Duke University Superfund Research Center and Oakland University.

Cover photos: screenshots from the 'Eating safe fish from the Cape Fear River, NC – Stop, Check, and Enjoy!' YouTube [video](#), created by Hendy Street Productions.

Goal and Purpose

Local health departments and non-governmental organizations can play a part in the fish consumption advisory setting process, and this manual is designed to help interested groups get started.

The process for setting fish consumption advisories in North Carolina is complex. This manual provides a high-level overview of the advisory setting process: 1) initial planning, 2) sample collection and transport, 3) testing samples, and 4) risk assessment.

This manual also references more detailed documents covering each of these topics and necessary quality assurance/quality control practices.

The figure below shows the overall process for setting and disseminating fish consumption advisories in North Carolina, with the government agencies that are involved in the different steps. This manual will help you work with state agencies to collect fish samples, test samples for contaminants, and collaborate with the NC Department of Health and Human Services (DHHS) to analyze this data and inform fish consumption advisories.

The following diagram shows the overall process to set a new fish consumption advisory along with the government agencies that are involved. This manual will help you collect fish tissue data (in consultation with NC Department of Environmental Quality when appropriate) and work with DHHS to set new advisories.

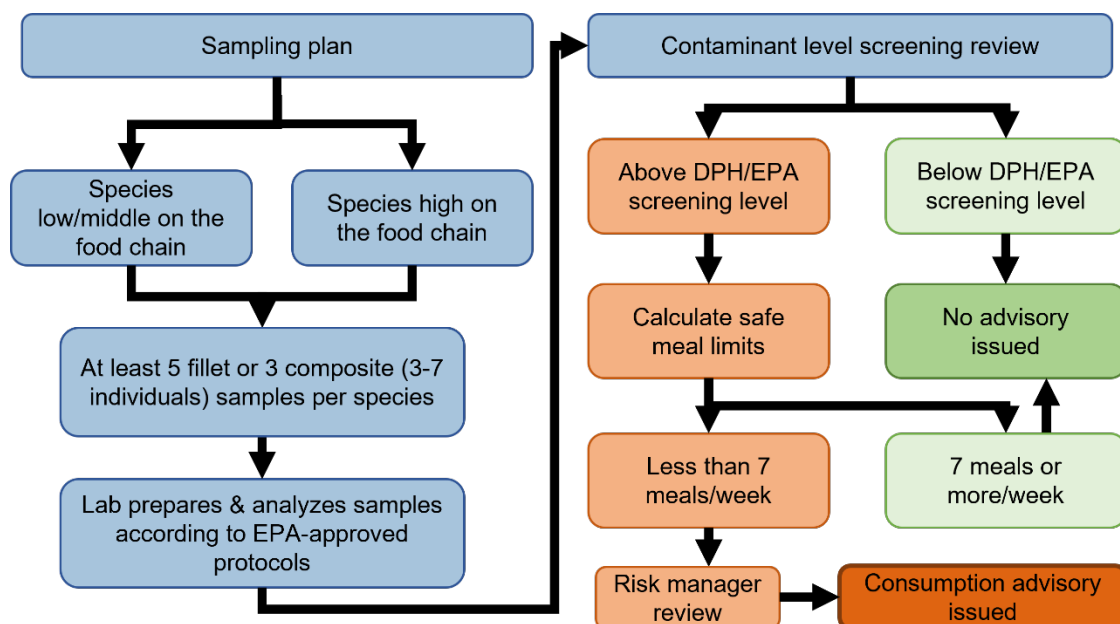


Initial Planning

In order to collect fish tissue samples for a given location, test them for specific contaminants, and submit those results to be considered for an advisory, you should work closely with officials from the NC Department of Environmental Quality (DEQ), the NC Wildlife Resources Commission (WRC), and the NC Division of Public Health's [Occupational and Environmental Epidemiology Branch](#) (OEEB), which is part of the [NC Department of Health and Human Services](#). The OEEB branch reviews and analyzes fish tissue data and develops a risk assessment based on that data (OEEB 2017).

Before you get started collecting fish, you will need to work with the OEEB Branch to make sure that your sampling plan is acceptable. This plan may include: 1) proposed sampling locations and species to collect at each location, 2) minimum required number of samples for each species or trophic level, 3) procedures for storing and transporting samples, and 4) lab testing protocols for specific contaminants. You should also consult DEQ to determine whether there is any overlap in current state-run sampling plans. DEQ can also be helpful for determining best options for storing, transporting, and testing samples. See page 2 of NC DENR (2013) for more information on sampling plans. Lastly, WRC may be able to help you determine which fish are most commonly caught, and when and where they are caught.

Fish and shellfish are identified and collected based on their *trophic level*. The trophic level is the position of a species within a food chain: in general, organisms that get energy directly from the sun are at the bottom, followed by animals that get energy by eating plants and other primary producers, and then by animals that eat other animals. Knowing the trophic level of a fish or shellfish is important since organisms with higher trophic levels are more likely to accumulate and magnify contaminants and pose a greater health risk (known as *biomagnification*). The WRC can assist with general information about various fish species, including trophic levels. The following figure provides an overview of the fish consumption advisory setting process in North Carolina. Have OEEB review your sampling plan before you begin the process.



Sample Collection and Transport

Where should I collect fish?

Where you choose to collect fish tissue samples is your decision, although you should work with the state agencies mentioned above to record locations in your sampling plan, as well as alternate locations if need be. Ideally, the locations you choose should be popular fishing locations, and/or near known or suspected contamination sources.

When should I collect fish?

In general, sample collection is not confined to specific times of year, although the Occupational and Environmental Epidemiology Branch (OEEB) recommends collecting during late summer or fall, which is when fish will typically have the maximum concentration of contaminants (NC DHHS 2019). For each species or trophic level selected in one location, all individual samples should be collected within one week. (Samples collected over a longer period of time may not be considered by the OEEB.)

Which fish should I collect?

Ideally, you will collect fish species that are commonly consumed by people who fish or by those who receive fish caught from that given water body. However, it is sometimes difficult to collect samples of a specific species, so OEEB does allow for collection of “surrogate species,” although they must be from the same trophic level (OEEB 2017). You can do a preliminary search of fish species characteristics and trophic level through the [NC Wildlife Resources Commission](#) and [FishBase](#), a database of fish species. Your decision may also be influenced by the [current fish consumption advisories](#) in North Carolina. Check to see if there are any advisories in your area. If they exist, when were they published? Which contaminants do they concern? What are the data gaps that you can fill? The [DEQ's record](#) of previous fish tissue testing may also be helpful (NC DEQ 2021a). Which fish were sampled from the water body in question? How long ago were they sampled?

At minimum, fish from two different trophic levels must be collected at a given location. The number of required trophic levels depends on site-specific conditions and is determined by OEEB.

How many samples do I need to collect for a specific species or trophic level at one location?

There are two types of samples: fillet and composite. Generally, fillet samples can be gathered from larger, higher trophic level fish, while composite samples may be necessary for smaller fish.

The minimum number of samples per trophic level for a given location are either:

- 5 fillet samples, each from a separate individual fish
- 3 composite samples, each consisting of tissue from 3 to 7 individual fish of the same species

Each composite sample should only contain fish from a single species, but multiple species can be collected across composite samples to represent a single trophic level.

Are there specific methods I must follow when collecting samples?

It is important that your methods for sample collection, storage, and documentation conform with what is agreed to in the sample plan, otherwise your samples may not be considered for new fish consumption advisories. Please see pages 2 - 6 and Appendix B of *NC DENR (2013)* for a more detailed description of the State of North Carolina's standard methods for sample collection, shipment and handling, skinning and filleting, and proper documentation.

Fish samples are primarily collected by personnel from the DEQ's Department of Water Resources and the NC Wildlife Resources Commission, although commercial fishermen and private individuals may assist with collecting fish as long as all protocols are followed. A fish tissue survey form that includes fish sample quality, site conditions, water quality, and other observations (Appendix B of NC DENR 2013) is required for each site where fish are collected. The finalized sampling plan should include the required number of samples per location.

Sample handling varies depending on the contaminant analyzed. Samples analyzed for metals should be placed in plastic polyethylene bags, while samples analyzed for organic chemicals should have large spines trimmed and wrapped whole in unused aluminum foil (dull side against the skin of the fish or shellfish) and then all aluminum foil-wrapped samples of the same species should be placed in a polyethylene bag. All sample bags should be sealed and labeled with the species, date, time, site name, and collector name(s). Bagged fish samples should be transported to a laboratory on ice (ideally chilled at 4°C, not frozen) within 24 hours of sample collection.

Once at a laboratory, personnel will inspect fish for abnormalities or tissue damage, and record the wet weight, total length, and species name. Equipment used in analyses should follow protocols to ensure that no contamination occurs. Sample preparation practices may depend on the type of contaminant that you would like to measure. For example, for testing of metals, fillet samples of scaleless fish such as catfish should be skinned, while all other fish should be scaled with the skin left on. For organic compounds like PCBs or dioxins, you may be asked to keep the entire fish for sampling. See Figure 1 of *NC DENR (2013)* for a diagram of the NC DENR's procedure for filleting a fish. Fillet and composite samples are ground and uniformly mixed (homogenized) before analysis to ensure that all parts of the sample have the same amount of the contaminant. Each homogenized sample should have at least 100 grams of fish tissue, although this minimum is not required if the threshold cannot be met. Ensure that all proper quality assurance and control procedures will be followed and recorded by laboratory personnel.

Testing Samples

Which contaminants should I test for?

It is your decision which contaminants you test for in fish. In general, the Occupational and Environmental Epidemiology Branch (OEEB) performs risk assessments for mercury and other metals, PCBs, and dioxins, although data on other compounds like polycyclic aromatic hydrocarbons (PAHs) can also be considered. You may want to look at the past [DEQ fish tissue sampling](#) record for your target location to get a sense of previous sampling efforts (NCDEQ 2021a). It may also be worth examining [state](#) and [national](#) maps of potential contamination sources or NPDES discharge points to get a sense if there are any potential contaminants that you might be overlooking (NCDEQ 2021b, EPA 2022).

Some of the contaminants you choose to measure may come in different forms. For example, if you are testing for arsenic (As), OEEB prefers that inorganic arsenic be measured in *addition* to total arsenic, because the inorganic form is more toxic. Testing for organic methylmercury (MeHg) in addition to total mercury is also preferred, as methylmercury is the most toxic form of the metal. If you are concerned about hexavalent chromium (Cr(VI)), keep in mind that there are not currently dependable methods to quantify Cr(VI) in fish tissue. You will likely need to test for total chromium content until effective protocols are developed. To get a more accurate and complete picture of Cr(VI) levels in fish, you could consider also analyzing sediment and water samples for total chromium and Cr(VI). This environmental sampling can inform what fraction or proportion of total Cr might be assumed to be Cr(VI).

OEEB does have built-in assumptions to extrapolate from data on total chromium, mercury and arsenic. These assumptions are discussed in the *Risk Assessment* section.

Where should I get my samples tested? Which analytical testing methods should I use?

Samples should be tested at NC DHHS [Division of Public Health](#)-approved laboratories, using EPA-approved analytical methods. Not all contaminants that you might want to test for have EPA-approved methods, and in these cases, OEEB will decide on acceptable methods and laboratories to carry out testing. Confirm that your selected laboratory can and will follow the approved protocols, report quantification limits, and follow quality assurance and control protocols and reporting. The method quantification limit (MQL) for each analyzed contaminant must be reported.

Risk Assessment and Issuing Advisories

How should I prepare results?

Once testing of fish tissue is complete, you can submit a summary of these results to the Occupational and Environmental Epidemiology Branch (OEEB) of the Division of Public Health (DPH) along with any supporting documents to help verify that proper sample handling and lab practices were used. OEEB asks for editable spreadsheets of data and summary tables that include specific samples and any detected contaminants, along with average concentrations by contaminant and fish species (OEEB 2017). If you collected samples from multiple locations, then organizing by location is necessary.

What are screening levels? How can I use them?

Fish consumption screening levels (SLs) are a risk threshold that allows public health professionals to quickly determine whether contaminant levels found in fish tissue might pose a health risk to people who eat fish. These screening levels are calculated for non-cancer and/or cancer health effects, based on toxicity values from the U.S. EPA's [Regional Screening Level \(RSL\)](#) table.¹ If the average contaminant concentration for a given species or trophic level at one location exceeds the screening level for either cancer or non-cancer effects, OEEB will conduct further evaluations and make recommendations to risk managers at the DPH. Screening levels are used only for this determination, not for regulatory purposes.

To be most health protective, the screening levels calculated by NC DPH are based on a subsistence fish consumer eating the fish every day over the course of a lifetime. These screening levels are based on formulas that can be found in appendix B of OEEB's 2017 SOP document (OEEB 2017). You can calculate these values on your own, but you should also confirm with OEEB that they are using the same values.

When comparing average contaminant concentrations with screening levels or meal limits (see next section), you should keep in mind the following assumptions OEEB makes about contaminants (OEEB 2017):

- All total mercury measured in fish tissue is assumed to be methylmercury
- If only total arsenic data is available, then 10% of total arsenic is assumed to be inorganic arsenic
- All total chromium measured in fish tissue is assumed to be hexavalent chromium

¹ Use the most up to date summary [RSL table](#) with a target hazard quotient (THQ) of 1.0 and a target cancer risk of 1E-06. As of November 17, 2021, here is the most up to date version, from May 2021: <https://semspub.epa.gov/work/HQ/400750.pdf>. For non-cancer effects, use the reference dose (RfD), and for cancer effects use the cancer slope factor (SFO).

If the average contaminant concentration for a given species exceeds either the cancer or non-cancer screening level, then the next step in the risk assessment process is to calculate meal limits.

What are meal limits?

Meal limits are recommendations for the maximum number of meals (or servings) of a given fish per week or month, based on the fish tissue contaminant data and associated health risks. You can think of meal limits as transforming your fish tissue data into practical advice for people who eat fish. In addition to limits for the general public, some advisories may include meal limits for more vulnerable subpopulations like children under 15 years old, pregnant and nursing people, and those who may become pregnant.² Formulas to calculate meal limits can be found in Appendix C of OEEB's 2017 SOP document (OEEB 2017). Meal limits are calculated based on the fish tissue contaminant concentration, an average body weight, daily fish consumption, meal portion size, chemical loss factors for organic chemicals, and standardly accepted contaminant exposures that are considered safe throughout a lifetime for cancer and non-cancer effects.

If calculated meal limits are less than 7 meals per week, then a fish consumption advisory will be issued. However, if the meal limit is 7 meals per week or greater, then no fish advisory will be issued. Next, we will talk about how meal limits are turned into actual fish consumption advisories.

How are meal limits turned into fish consumption advisories?

Keep in mind that meal limits are calculated for a specific fish species and contaminant, captured from a specific location, based on either cancer or non-cancer health effects. Generally, fish consumption advisories are issued for the contaminant that presents the greatest health risk, whether for cancer or non-cancer health effects. For example, if a 4 meal a week limit has been calculated for catfish caught from the Cape Fear River based on cancer effects of arsenic exposure, and a 2 meal a week limit has been calculated for catfish from the Cape Fear based on non-cancer effects of mercury, then an advisory will be issued recommending no more than 2 meals per week of catfish because of elevated mercury.

Current advisories may have more stringent meal limits compared to limits based on your recent sampling, and in this case new advisories will not be issued, even if your newly calculated meal limit is based on a different contaminant. For example, the statewide advisory for mercury recommends that the general public eat no more than 1 meal of catfish per week if it was caught south and east of Interstate 85 (DHHS also recommends that higher risk populations such as children under 15 or pregnant people not eat any catfish). If you sample catfish in the Cape Fear River and calculate a limit of 2 meals per week because of arsenic, the statewide mercury advisory of 1 meal per week will still stand, and no new advisory will be issued.

² See the statewide fish consumption advisory for mercury in North Carolina, which includes separate meal limits for more vulnerable populations: <https://epi.dph.ncdhhs.gov/oe/mercury/safefish.html>

What happens when fish consumption advisories are issued?

If fish consumption advisories are warranted, then NC DHHS should alert local health departments in the affected areas. DHHS will also post the advisory to its website. The NC Wildlife Resources Commission includes a list of all fish advisories in their annual "[NC Inland Fishing, Hunting and Trapping Regulations Digest](#)."

There is sample language for fish consumption advisories in Appendix E of OEEB's 2017 SOP document (OEEB 2017). Our [Fish Consumption Advisory Communication Toolkit](#), developed jointly with N.C. State's Center for Human Health and the Environment, details some best practices and provides some creative ways to communicate about these advisories.

Helpful Resources

OEEB (Occupational and Environmental Epidemiology Branch). Standard Operating Procedure: Fish Consumption Advisories

This [document](#) provides a fairly detailed overview of the fish consumption advisory process for North Carolina, from sample plan creation, to sample collection and testing, to risk assessment and advisory setting (OEEB 2017).

NC DENR. Standard Operating Procedures: Fish Tissue Assessments

This [document](#) goes into greater detail on procedures for sample plan creation, along with sample collection, transport, and testing. It also includes a helpful form that can be used in the field while collecting fish tissue samples (NC DENR 2013).

EPA. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 1: Fish Sampling and Analysis

This EPA [document](#) is the basis for how states should run their fish tissue sampling and assessment programs—both of the above resources reference this document. In addition to getting some additional background on how to choose fish species and contaminants, this document includes information on acceptable analytical laboratory testing methods (EPA 2000).

FishBase

A global open-sourced [database](#) of fin-fish species. Estimates of trophic levels per species are indicated for most species (usually underestimates based on models).

NC WRC. Wildlife Resources Commission

Fish commonly caught and/or consumed in NC are described by the NC WRC. Each description has information about regulations, management, and fishing tips. The [WRC website](#) is a good place to start learning about individual fish species.

Duke Superfund Research Center and N.C. State University's Center for Human Health and the Environment. Fish Consumption Advisory Communication Toolkit

An [online resource](#) detailing some best practices for communicating about health risks from contaminated fish and fish consumption advisories specifically.

Online databases, tools, and interactive maps

The following online resources can help you learn more about potential contamination sources near your water body of interest.

- [US EPA ECHO \(Enforcement and Compliance History Online\) Water Pollution Search](#)
- [US EPA EnviroAtlas](#)
- [US EPA TRI \(Toxic Release Inventory\) Tracker](#)
- [NC DEQ Division of Waste Management Site Locator Tool](#)

Glossary / Key terms

Composite sample - Fish tissue sample containing tissue from multiple fish of the same species. Composite samples are used more often with smaller species of fish. In North Carolina, these samples are derived from between 3 to 7 individual fish.

Fish consumption advisory - Warnings for people to either limit how much of a certain type of fish they eat, or avoid a fish entirely because it is unsafe to do so. Usually, these advisories are for specific species and specific water bodies due to the presence of a chemical contaminant. If the guidance does not say to avoid the fish outright, they will suggest the maximum number of meals to eat over a period of time, often a week or month. Sometimes, advisories have more stringent guidance for higher risk groups like children or pregnant people. These are health guidelines and are not enforceable. In North Carolina, the [Department of Health and Human Services](#) sets fish consumption advisories.

Meal limits - Recommendations for the maximum number of meals (or serving portions) of a given fish or shellfish over a period of time, often a week or month (in North Carolina, meal limits are per week). Meal limits transform fish tissue contaminant data and health risks into practical advice for people who eat fish.

Screening level - Fish consumption screening levels (SLs) are a risk threshold that allows public health professionals to quickly determine whether contaminant levels found in fish tissue might pose a health risk to people who eat fish. In North Carolina, screening levels are calculated for cancer and/or non-cancer effects, based on toxicity values from the U.S. EPA's [Regional Screening Level](#) (RSL) table. If the average contaminant concentration for a given species or trophic levels exceeds the screening level for either cancer or non-cancer effects, then OEEB will conduct further evaluations and make recommendations to risk managers at the DPH.

Trophic level - The position of a species within a food chain: in general, organisms that get energy directly from the sun are at the bottom, followed by animals that get energy by eating plants and other primary producers, next by animals that eat other animals. Higher trophic levels indicate organisms higher on the food chain (such as sharks, some catfish, falcons, etc.) and which are more likely to biomagnify certain chemicals. Lower trophic levels indicate organisms lower on the food chain (such as plants, algae, insects, rabbits, etc.).

Bioaccumulation - The increase in concentration of certain chemicals in a living organism over time. Bioaccumulation occurs when the rate of exposure to the chemical is greater than the rate it leaves the organism.

Biomagnification - The increase in concentration of certain chemicals in living organisms as you move up the food chain. For example, mercury levels are usually higher in fish that eat other fish, compared to fish that eat plants or smaller fish.

References

- EPA 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories. Volume 1: Fish Sampling and Analysis, Third Edition. EPA 823-B-00-007. USEPA Office of Water. 2000. <https://www.epa.gov/fish-tech/epa-guidance-developing-fish-advisories>
- EPA 2022. "Water Pollution Search". <https://echo.epa.gov/trends/loading-tool/water-pollution-search/>
- NC DENR 2013. Standard Operating Procedures: Fish Tissue Assessments. <https://sites.nicholas.duke.edu/superfund/files/2022/09/Fish-Tissue-SOP-Dec-30-2013.pdf>
- NC DEQ 2021a. "DWR Fish Tissue Monitoring Data." <https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/biological-assessment-branch/fish-tissue-data>
- NC DEQ 2021b. "Division of Waste Management Site Locator Tool." <https://deq.nc.gov/about/divisions/waste-management/science-data-and-reports/waste-management-gis-data-and-maps>
- NC DHHS 2019. "How Are Fish Consumption Advisories Developed?" Last updated December 17, 2019. <https://epi.dph.ncdhhs.gov/oeefish/howdeveloped.html>
- NC DHHS 2021. "Fish Consumption Advisories: Current Advisories for N.C." Last updated October 11, 2021. <https://epi.dph.ncdhhs.gov/oeefish/advisories.html>
- OEEB 2017. Occupational and Environmental Epidemiology Standard Operating Procedure: Fish Consumption Advisories. https://sites.nicholas.duke.edu/superfund/files/2022/09/Fish-Adv-SOP_FINAL-signed_8Feb2017.pdf