

2.5 Consumption of Fish and Shellfish

Many coastal and fresh water environments are contaminated with a variety of toxic substances. Of particular concern are mercury, DDT, and PCBs because they persist in the environment and bioaccumulate in the food chain. Though PCBs and DDT are no longer manufactured or distributed in the U.S., they persist in historical deposits in watersheds and near-shore sediments. These deposits continue to provide an active source for contaminating fish and shellfish. Mercury can come from several sources, including industrial releases, abandoned mines, the burning of fossil fuels for electric power generation, and natural sources such as weathering of rock and volcanoes.

Persistent chemicals enter the food chain when they are ingested by bottom-dwelling (benthic) organisms. Benthic organisms are eaten by smaller fish, which in turn are eaten by larger fish, which may be consumed by humans or wildlife. Levels of PCBs and DDTs are a concern in bottom-feeding fish and shellfish, as well as in higher-level predators. Mercury is concentrated particularly in larger and longer-lived predators, such as large-mouth bass, tunas, swordfish, and some sharks. Concentrations of all these compounds, especially in larger fish, can reach levels that are harmful to humans. To protect human health, state and local officials monitor levels of these compounds in fish and shellfish, and issue advisories when tissue concentrations exceed threshold levels. Typically, a fish or shellfish advisory will suggest that intake of a particular species be limited, especially for those at higher risk of health effects such as children, pregnant women, and nursing mothers.

Three questions have been posed concerning consumption of fish and shellfish:

- What is the condition of waters that support consumption of fish and shellfish?
- What are contaminants in fish and shellfish, and where do they originate?
- What human health effects are associated with consuming contaminated fish and shellfish?

Sections 2.5.1, 2.5.2, and 2.5.3, respectively, discuss these questions and, where available, the indicators that are used to help answer these questions.

2.5.1 What is the condition of waters that support consumption of fish and shellfish?

Indicators

Percentage of river miles and lake acres with fish consumption advisories
 Contaminants in fresh water fish
 Number of watersheds exceeding health-based national water quality criteria for mercury and PCBs in fish tissue

Three indicators, presented on the following pages, are available to help answer this question:

- Percentage of river miles and lake acres with fish consumption advisories.
- Contaminants in fresh water fish.
- Number of watersheds exceeding health-based national water quality criteria for mercury and PCBs in fish tissue.

The first indicator describes the extent of fish advisories, such as closed fisheries and/or restricted fish consumption. Fish advisories are issued by state or local authorities when levels of contaminants in monitored fish exceed threshold levels. These advisories, which are widespread across the U.S., limit or restrict consumption of contaminated species. Mercury, dioxin, PCBs, DDT, and chlordane are responsible for many of these advisories (EPA, OW, May 2002a). Increases in the number of advisories over the years may reflect increased monitoring, increased contamination, and in some cases, more stringent health standards.

The second indicator examines the number of contaminants in fish tissue from samples across the nation. This indicator shows that more than 90 percent of sampled fish had at least one contaminant and more than half had at least five.

The third indicator compares average fish tissue concentrations of mercury and PCBs across watersheds to human-health based water quality criteria. This analysis showed that more than 30 percent of the watersheds for which there are data exceed mercury criteria. These watersheds are predominantly located in eastern coastal states, New England, and the lower portion of the Mississippi River watershed.

For all three indicators, data are based on fish tissue data collected by state or local government agencies, which tend to focus primarily on areas where these agencies believe there may be contaminated fish. This bias may result in inaccurate estimates of the extent of contamination.

Coastal Fish

For coastal fish, insufficient data on the edible portion of these fish are available to provide a national indicator. However, examination of fish tissue collected in coastal waters of the eastern U.S. and Gulf of Mexico shows that compounds of concern were present at levels above EPA's threshold for issuing an advisory.

Shellfish

No national indicators are available for shellfish. However, as discussed below, data are available on the extent of shellfish waters that were classified as harvest-limited or harvest-prohibited from 1966 to 1995. These data show a steady decrease over this time period in the extent of waters classified as harvest-limited or harvest-prohibited. Still, as of 1995, harvesting was limited in 31 percent of shellfish waters and prohibited in 13 percent (NOAA, 1997). The predominant causes of closures are both human and non-human coliform bacteria.

Data on shellfish waters come from the National Oceanic and Atmospheric Administration (NOAA), which records areas that are closed to shellfishing or are subjected to restricted or conditional harvesting. NOAA obtains its data from coastal states, which identify, survey, and classify shellfish-growing waters according to National Sanitary Survey Program (NSSP) guidelines (FDA, 1993). Classification status is based on sanitary surveys of water quality and shoreline surveys of pollution sources. Individual shellfish-growing areas are classified either as approved for harvest or as one of four harvest-limited categories: conditionally approved, restricted, conditionally restricted, and prohibited.

All identified shellfish-growing waters must be classified as prohibited unless sanitary surveys indicate that water quality meets specific NSSP standards for the other categories. Harvesting is permissible in approved areas year-round. The conditionally approved and conditionally restricted categories are for voluntary use by states when a predictable pollution event such as seasonal population, heavy rainfall, or fluctuating discharges from local sewage plants affects the suitability of an area for harvest. Most shellfish harvest restrictions are made based on the concentration of fecal coliform bacteria in shellfish. This organism is not directly harmful to humans, but typically is associated with human sewage and with organic wastes from livestock and wildlife.

The *National Shellfish Register* provides a record of the acreage of all classified shellfish-growing waters in the conterminous U.S. The Register was first published in 1966 to meet the need for summary information on the status and extent of the nation's commercial shellfish-growing areas. Since the publication of the first *Register*, the acreage of classified shellfish-growing waters has increased more than two-fold from 10 million acres to more than 21 million acres (Houser and Silva, 1966; FDA, 1971; EPA, OE, 1975; DOC and HHS, 1985; NOAA, 1991; NOAA, 1997), primarily due to an expanding consumer demand for shellfish.

Since 1966, the percentage of all classified waters approved for harvest has decreased 10 percent. However, data compiled for the 1995 *Register*, the last available compilation, suggest significant improvements. For example, the overall percent of harvest-limited waters decreased from a high of 42 percent in 1985 to 31 percent in 1995. The percent of prohibited waters also decreased from a high of 26 percent in 1974 to 13 percent in 1995—the lowest percentage recorded.

Indicator

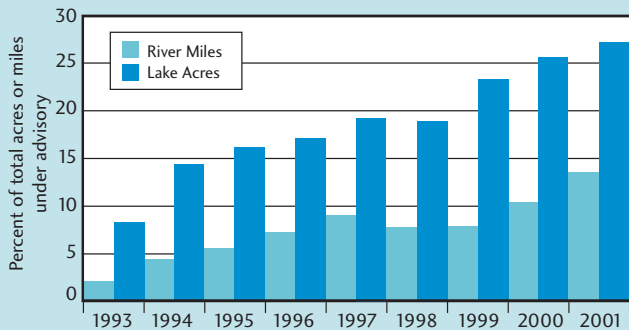
Percent of river miles and lake acres under fish consumption advisories - Category 2

State and local governments protect people from possible risks of eating contaminated fish by monitoring local waters and issuing fish advisories when contaminant levels are unsafe. A consumption advisory may recommend that people limit or avoid eating certain species of fish caught from certain lakes, rivers, or coastal waters. Advisories are often very specific. They may apply to specific water types (such as lakes), or they might include recommendations for specific groups (such as pregnant women or children). Advisories apply to locally caught fish or wildlife as well as fish purchased in stores and restaurants. EPA has compiled these advisory data into the National Listing of Fish and Wildlife Advisories (NLFWA) database, which lists, among other things, the species and size of fish or wildlife under advisory, the chemical contaminants covered by the advisory, the location and surface area of the waterbody under advisory, and the population subject to the advisory.

What the Data Show

Exhibit 2-33 shows the percent of the nation's river miles and lake acres under advisory for the years 1993 to 2001. Note that the Great Lakes and their connecting waters are considered separately from other waters and are not included in the calculations of total lake acres or river miles. Except for 1998, the percentage increased continuously during this 8-year period. Approximately 79,119 lakes (11,277,276 lake acres) and 485,205 river miles were under advisory in 2001, compared to 14,962 lakes and 74,505 river miles under advisory in 1993. Note that the increase in the total size of waters under advisory is due in part to increased monitoring for chemical contaminants in fish and wildlife tissue

Exhibit 2-33: Trends in percentage of river miles and lake acres under fish consumption advisory, 1993-2001



Coverage: all 50 states

Source: EPA, Office of Water. Update: National Listing of Fish and Wildlife Advisories. May 2002.

and the states' increasing use of statewide advisories. Currently, the 2,618 advisories in the national listing represent almost 28 percent of the nation's total lake acreage and 14 percent of the nation's total river miles.

In addition to the NLFWA data, much information is available on the advisory status of our nation's waters. EPA and FDA issued a national mercury advisory in January 2001 recommending that women of childbearing age and young children limit their consumption of fish (<<http://www.epa.gov/waterscience/fish>>).

Many great waters of the U.S. are currently under fish advisories for a variety of pollutants. The great waters include the Great Lakes, Lake Champlain, the Chesapeake Bay, 20 National Estuary Program (NEP) sites, and 14 National Estuarine Research Reserve System (NERRS) sites.

- All of the Great Lakes and their connecting waters are under advisory.
- Lake Champlain is under advisory for PCBs and mercury.
- Although the Chesapeake Bay is not under any advisories, the Potomac, James, Back, and Anacostia Rivers, which connect to it, are all under PCB advisories.
- Baltimore Harbor, which also connects to the Chesapeake Bay, is under advisory for chlordane and PCB contamination in fish and blue crabs.
- Many of the major estuaries listed in the NEP and/or designated as NERRS sites are under fish and/or shellfish advisories for multiple chemical contaminants. Sixty-five percent of the total number of NEP, NERRS, and combined sites are under fish consumption advisories. Seventeen sites have no current fish consumption advisories.

Several states have issued fish advisories for all of their coastal waters. An estimated 71 percent of the coastline of the conterminous 48 states currently is under advisory. This includes 92 percent of the Atlantic coast and 100 percent of the gulf coast. The Atlantic coastal advisories have been issued for a wide variety of chemical contaminants, including mercury, PCBs, dioxins, and cadmium. All of the gulf coast advisories have been issued for mercury, although other contaminants may also be present. No Pacific coast state has issued a statewide advisory for any of its coastal waters, although several local areas along the Pacific coast are under advisory.

Indicator Gaps and Limitations

Currently, fish consumption advisories are being used as a way of informing the public of risks associated with eating contaminated

Indicator Percent of river miles and lake acres under fish consumption advisories - Category 2 (continued)

fish in certain waterbodies. Advisories are based on fish tissue monitoring data collected by states and are largely focused on areas where states know fishing occurs or suspect contamination. Criteria used to issue advisories vary among states, with some having more stringent criteria and more robust advisory programs than others.

Due to the large range in geographic size of lake acres and river miles affected by chemical contaminants that may be contained under a single advisory, the number of advisories is not as accurate a measure of the contamination as geographic extent. As a result, information is now provided on total lake acres and river miles where advisories are currently in effect. A large-scale fish tissue study is underway and will help identify waters that

require further monitoring to determine whether advisories are necessary.

This indicator is based on fish tissue monitoring data collected by the states. It does not provide unbiased geographical coverage, and it is largely focused on areas where states know fishing occurs or suspect contamination problems. At present, 43 states issued risk-based advisories.

Data Source

Fish advisory indicator data are from the National Listing of Fish and Wildlife Advisories program. (See Appendix B, page B-17, for more information.)

Indicator Contaminants in fresh water fish - Category 2

From 1992 to 1998, fish samples were collected from 223 stream sites in the U.S. Geological Survey's (USGS) National Water Quality Assessment (NAWQA) program. Tissue composites from whole fish were analyzed for PCBs, organochlorine pesticides, and trace elements. These contaminants may harm organisms directly or by affecting their reproduction, and they may make fish unsuitable for consumption by humans. These data were compiled for the entire U.S.

What the Data Show

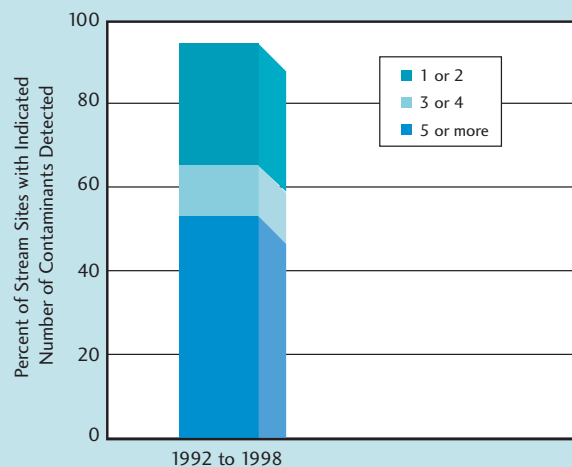
More than 90 percent of sampled fish had at least one contaminant detected and about half of the fish tested had at least five contaminants at detectable levels (Exhibit 2-34) (The Heinz Center, 2002). All fish tested from the Great Lakes had five or more detected contaminants.

Indicator Gaps and Limitations

The sites sampled are representative of a wide range of stream sizes, types, and land uses broadly distributed across the U.S., but they do not represent a probability sample, so confidence bounds on the estimates could not be calculated (Gilliom, et al., 2002; The Heinz Center, 2002).

Fish tissue concentration data are derived from composites of whole fish and not from edible portions alone. Thus it is not possible to compare tissue concentrations to aquatic or human health

Exhibit 2-34: Occurrence of contaminants in stream fish, 1992-1998



Coverage: lower 48 states.

Note: Partial indicator data: freshwater stream fish only.

Source: The Heinz Center. *The State of the Nation's Ecosystems*. 2002. Data from the U.S. Geological Survey.

Indicator Contaminants in fresh water fish - Category 2 (continued)

guidelines. These data do, however, indicate organism exposure to measured chemicals.

Data Source

Data for this indicator came from the U.S. Geological Survey's National Water Quality Assessment Program as compiled for The Heinz Center (2002). (See Appendix B, page B-17, for more information.)

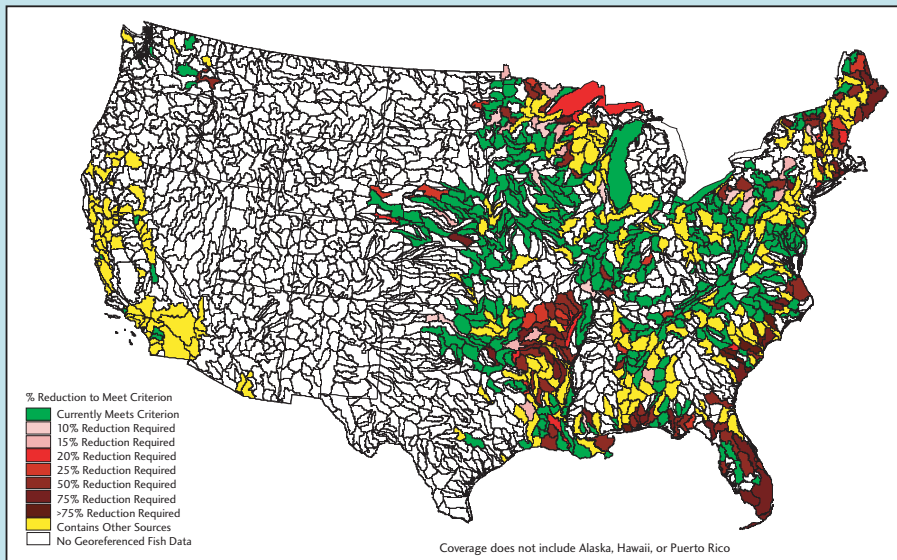
Indicator Number of watersheds exceeding health-based national water quality criteria for mercury and PCBs in fish tissue - Category 2

For this indicator, fish tissue concentrations of each chemical in the NLFWA database were averaged across 8-digit hydrologic unit code (HUC) watersheds. The average concentration was then compared to fish- tissue based criteria for mercury and PCBs. The average fish tissue concentration is for all monitored species, fillet samples only (whole fish samples were omitted from the analysis as these are not recommended for use in assessing human health

impact). Thus, the average is meant to represent the potential exposure concentration for persons consuming fish from typically frequented local lakes, streams, and rivers.

The mercury criterion used in this comparison was the national fish-tissue-based criterion. The PCBs criterion was based on the fish tissue levels used to derive the current national health-based water concentration criteria. Criteria exceedances can be interpreted as meaning that the watershed, on average, is not meeting maximum tissue contaminant levels designed to be protective of human health.

Exhibit 2-35: Watersheds with fish tissue concentrations exceeding health-based national water quality criteria for mercury, 2001



States currently use water column concentration-based mercury water quality standards and would need to adopt fish tissue-based target levels in order to use this approach for mercury Total Maximum Daily Loads. Additional reductions would be required to meet EPA national and most state fish advisory levels, which are often set below the methyl-mercury criterion.

Note: Watersheds highlighted yellow have "significant" mercury sources other than deposition, defined as where the total estimated load from Publicly Owned Treatment Works (POTWs) and pulp and paper mills is greater than 5% of estimated waterbody delivered mercury at a typical air deposition load (10 g/km²/yr) and/or where mercury cell chlor-alkali facilities, mercury mines, or significant past producer gold mines are present

Source: EPA, Office of Water. National Listing of Fish and Wildlife Advisories (NLFWA) Mercury Fish Tissue Database. June 2001.

What the Data Show

The data for mercury are a fairly good representation of conditions in the eastern U.S. and California. Of the 696 8-digit HUC watersheds with available data, 225 exceeded the mercury criterion (Exhibit 2-35). These are predominantly located in eastern coastal states, New England, and the lower portion of the Mississippi River watershed. Data for PCB concentrations are less available; 114 of 153 watersheds where data were available contained tissue above the criterion level (Exhibit 2-36).

Indicator

Number of watersheds exceeding health-based national water quality criteria for mercury and PCBs in fish tissue - Category 2 (continued)

Indicator Gaps and Limitations

Several limitations should be noted for this indicator:

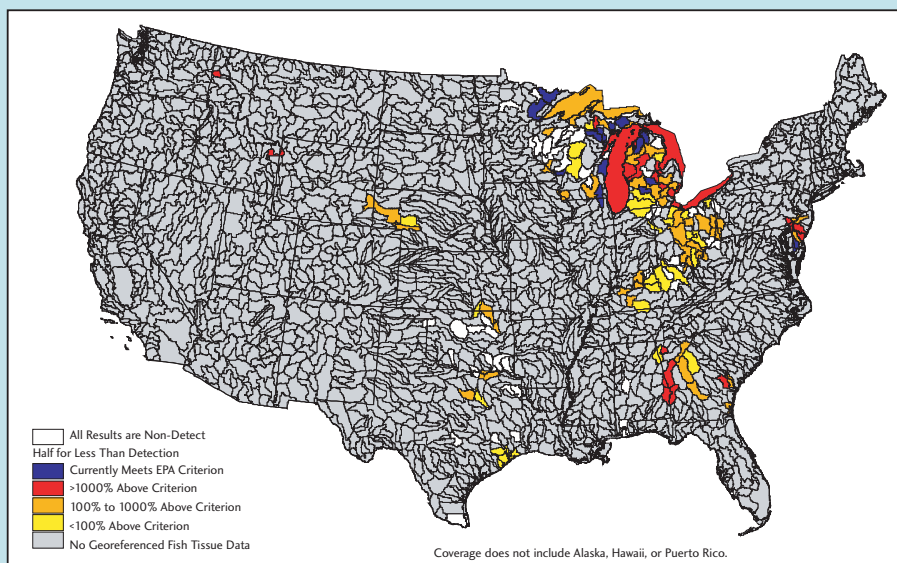
- The data were compiled based on voluntary contributions from individual states and have not undergone an independent quality assurance/quality control (QA/QC) review. Data quality is a function of the distinct programs for which the data were collected.
- Sampling by state agencies was not generally done on a statistical basis, but rather was targeted toward specific waterbodies and fish species. Some selection of sampling locations was based on fishing pressure and/or suspected elevated contaminant levels. For example, there appears to be a bias in the mercury data towards top predator or sport fish (of the top 10 most frequent species sampled, 83 percent are trophic level 4 species). This bias could potentially skew the average watershed concentration level to higher than actual exposure depending on real consumption patterns.
- Some states may not have reported tissue data when resultant concentrations were found to be below state fish advisory levels.
- Substantially more data are available for the years 1990 to 1995 than for more recent years.
- Spatial gaps in the data are readily apparent from the indicator maps. Since a large fraction (roughly two-thirds) of the database was not georeferenced (i.e., no latitude/longitude coordinates were created), those data could not be included in the indicator. Bias imposed by these missing data was not examined. Latitude/longitude coordinates will be assigned in a database update in the near future and can be incorporated in future indicators.
- The human health-based criteria of 0.3 ppm methylmercury that was used for comparison is considerably higher than the more recent federal advisory of 0.18 ppm for consumption of mercury-contaminated fish. State consumption advisories are typically at levels closer to the 0.18 ppm than to the 0.3 ppm level.
- Sampling patterns of state agencies are largely being directed toward areas of higher fishing pressure or based on suspected

elevated contaminant levels. Thus this indicator, which is based on generalizing from specific sampling locations to watershed averages, is expected to represent a somewhat conservative estimate of the average concentration in consumed fish in each respective area.

Data Sources

The fish tissue indicator data are from the National Listing of Fish and Wildlife Advisories program. (See Appendix B, page B-18, for more information.)

Exhibit 2-36: Watersheds with fish tissue concentrations exceeding health-based national water quality criteria for polychlorinated biphenyls (PCBs), 2001



Note: Graphic was created for this report in ArcView using NLFWA data.
Source: EPA, Office of Water, National Listing of Fish and Wildlife Advisories (NLFWA). June 2001.

2.5.2 What are contaminants in fish and shellfish, and where do they originate?

Information is available to help answer this question in a general sense. Fish and shellfish can be contaminated by both chemical pollutants and pathogens. Chemical contaminants of greatest concern tend to be those that are toxic and persistent and that bioaccumulate. Contaminants with these properties that are common in fresh and coastal waters include:

- **DDT and PCBs.** The manufacture and use of these compounds have been banned in the U.S. However, deposits from past pollution persist in sediments and land-based sources, and these deposits continue to pollute watersheds. In addition, PCBs can be found in some products manufactured prior to the ban (e.g., electrical transformers).
- **Mercury.** This metal, a natural and highly toxic element, can now be detected (although in small amounts) in all waters. Sources of mercury include wastes from past mining practices and the burning of fossil fuels and wastes, which can create mercury emissions that settle on land and water. In water, bacteria convert mercury to methylmercury, a toxic compound that is absorbed by fish and accumulates in their tissue.

Biological threats to shellfish consumption include bacterial contamination from human and animal wastes and contamination from naturally occurring toxins that shellfish accumulate from consuming certain algae.

Some data are available on the sources of bacterial contamination. When state managers close or otherwise restrict a shellfish-growing area due to high levels of fecal coliform bacteria, they typically cite potential sources of that contamination. This information was collected for the 1990 and 1995 Shellfish Registers (NOAA, 1991; NOAA, 1997). In 1995, sources of shellfish contamination cited by reporting officials were (in decreasing order of frequency):

- Urban runoff (40 percent)
- Unidentified sources upstream of coastal watersheds (39 percent)
- Wildlife (38 percent)
- Individual wastewater treatment systems (e.g., septic tanks) (32 percent)
- Wastewater treatment plants (24 percent)
- Agricultural runoff (17 percent)
- Marinas (17 percent)
- Boating (13 percent)
- Industrial facilities (9 percent)
- Combined sewer overflows (7 percent)
- Direct discharges (4 percent)
- Feedlots (3 percent)

The 1990 Register reflects the same top five sources of pollution, although in slightly different order.

Marine biotoxins associated with “red tides” and other naturally occurring contaminants such as *Vibrio* species (a free-living marine and estuarine bacteria associated with stomach and intestinal disorders of varying intensity) can also cause temporary closures, although they are not usually regarded as a pollution source (Rippey, 1994; FDA, 1993).

At this time, insufficient data are available to develop national-level indicators about the type and origin of fish and shellfish contaminants.

2.5.3 What human health effects are associated with consuming contaminated fish and shellfish?

The health effects of consuming contaminated fish and shellfish depend on many factors, including the type of contaminant, its concentration in the organism, and how much contaminated fish or shellfish is consumed. Health effects include the following:

- Risk assessments show that exposure to sufficient levels of some contaminants in fish tissues may increase the risk of cancer
- Mercury, in sufficient quantities, is toxic—especially to the nervous system.
- Shellfish contaminated with fecal wastes can cause gastrointestinal illness and even death in individuals with compromised immune systems. Mollusks, mussels and whelks are the main shellfish that carry biotoxins causing common symptoms, such as irritation of the eyes, nose, throat, and tingling of the lips and tongue.

Advisories warn the public of these risks and suggest limits or outright bans on consuming some species in certain problem areas. Certain groups may be at higher risk for health effects from contaminated fish and shellfish. These include children, pregnant women, and nursing mothers, who may be more vulnerable to effects, and tribal, ethnic, and other populations that fish for subsistence and therefore consume more fish or shellfish.

At this time, insufficient data are available to develop indicators that can monitor, at the national level, the health effects of consuming contaminated fish and shellfish. Chapter 4, Human Health, provides more information on the human health impacts of contaminated fish.