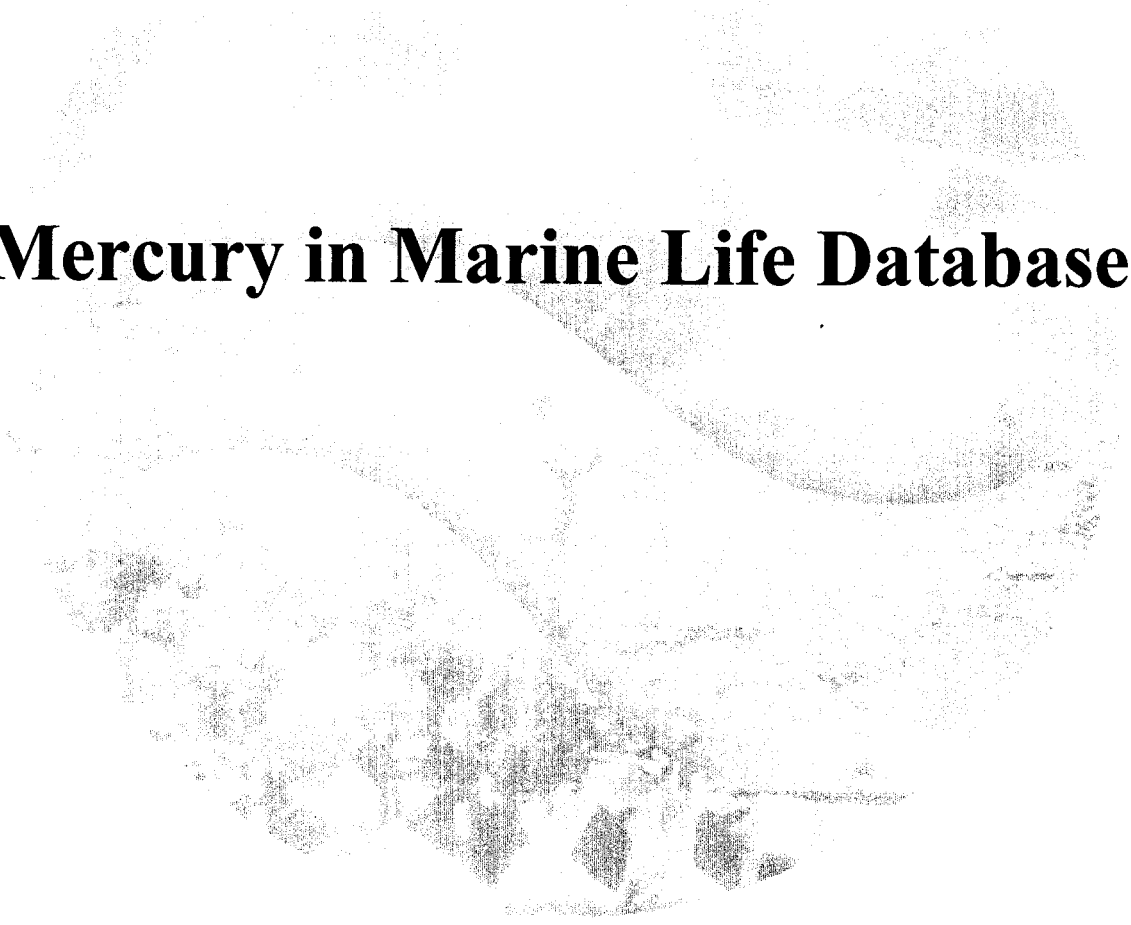
U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF WETLANDS, OCEANS, AND WATERSHEDS
OCEANS AND COASTAL PROTECTION DIVISION
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Mercury in Marine Life Database



Prepared by Pat Cunningham, William Cooter, and Elizabeth Sullivan
RTI International
Environmental Health and Safety Division
Research Triangle Park, NC 27709
April 30, 2003

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Larry Skinner	New York State Department of Environmental Conservation
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[1] RTI International is a trade name of the Research Triangle Institute.

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EXECUTIVE SUMMARY

PURPOSE AND OBJECTIVES

The U.S. Environmental Protection Agency (EPA) has long been concerned with mercury levels in fish and wildlife. EPA has taken federal regulatory actions to limit emissions to the air and discharges to waterbodies and has provided guidance and regulations on the management of hazardous wastes containing mercury. Most of the mercury tissue concentration data that EPA has used to make regulatory decisions, however, relate to mercury levels in freshwater fish species. The purpose of this Mercury in Marine Life Project is to organize information on estuarine and marine species so that EPA can better understand the extent of mercury monitoring and the level of mercury contamination in coastal estuarine and marine species.

The report presents five questions, the answers to which provide needed information with respect to the level of mercury contamination in marine life:

1. What is the extent of tissue monitoring in the Atlantic, Gulf of Mexico, and Pacific coastal regions for mercury contamination?

2. What are the levels of mercury contamination for key species sampled in federal, state, regional, and local programs?

3. What commercial and recreational fish and shellfish species are regularly harvested from U.S. waters and from each of the three coastal areas?

4. What species have the coastal states and the U.S. Food and Drug Administration (FDA) already recognized as potential health risks through the issuance of fish advisories?

5. What is the range of consumption rates for estuarine and marine fish identified in national market basket surveys, as well as in regional or state fish consumption surveys?

SCOPE AND QUALIFICATIONS

The scope of this study was defined by the EPA Oceans and Coastal Protection Division and included the following study parameters:

- The Mercury in Marine Life Project focuses on assessing the occurrence of mercury in estuarine and marine species typically harvested from U.S. coastal areas, but excludes freshwater species harvested from estuarine waters.

- Tissue monitoring data evaluated in this study are limited to samples collected and analyzed between 1990 and 2002.
- This study acquired, aggregated, and analyzed data sets from federal, regional, and state monitoring programs that provided data for estuarine and coastal waters of 24 states, the District of Columbia, and Puerto Rico, as well as for marine waters of three Canadian provinces (New Brunswick, Nova Scotia, and British Columbia). Although there is a high degree of confidence in the validity of each data set in the Mercury in Marine Life Database, no attempt was made to acknowledge or describe all associated uncertainties.
- All mercury tissue concentration values in this report and in the Mercury in Marine Life Database are reported as parts per million (ppm) mercury on a wet weight basis (equivalent to µg total mercury/g tissue wet weight)
- A correction factor of 0.2 was used to convert dry weight mercury concentrations to wet weight concentrations.
- Mercury tissue concentrations were screened against the 2001 EPA methylmercury criterion, which is 0.3 ppm methylmercury in fish tissue.
- In all analyses conducted, total mercury and methylmercury measurements were used as equivalent measures of methylmercury contamination in tissue samples.

METHODOLOGY

As part of the data acquisition process for this study, federal programs, regional assessments, and state data were aggregated into the Mercury and Marine Life Database. Federal programs contributing data included EPA's Environmental Monitoring and Assessment Program (EMAP), EPA's National Listing of Fish and Wildlife Advisory (NLFWA) database, EPA's Gulf of Mexico Program (GMP), EPA's National Estuary Program (NEP), and National Oceanic and Atmospheric Administration's (NOAA's) Mussel Watch Program. Regional assessments added data from the Gulf of Maine Gulfwatch Program, Puget Sound Ambient Monitoring Program, San Francisco Estuary Institute database, and the Delaware River Basin Commission database. State data included information for 24 U.S. coastal states, the District of Columbia, and Puerto Rico.

The Mercury in Marine Life Database is a locational database developed in Microsoft Access and designed on a geographic information system (GIS) platform. Several custom shapefiles were used to create the GIS layer for this project, including the following coverages: EPA NEP sites, EPA National Coastal Assessment (NCA) polygons, Mineral Management Service (MMS) maps of the Outer Continental Shelf (OCS), and NOAA open-water polygons from the Coastal Assessment Framework (CAF).

Filtering the database for records that met the study criteria and GIS mapping requirements (e.g., the data record had associated latitude and longitude values and was sampled on or after January 1, 1990) produced 14,893 records, collected at 3,310 mappable stations, representing samples from more than 270 different fish and shellfish species.

SUMMARY OF FINDINGS

Fish and Shellfish Species Regularly Harvested from U.S. Coastal Waters

This report provides information on the mean annual landings of commercial and recreational fish species for the most recent 3-year period (1998 to 2000) both nationally and for each coastal area so that species of commercial and recreational importance with regard to landings can be ranked. A 3-year period was selected to moderate individual-year differences in landings data. This ranking information, obtained from the National Marine Fisheries Service (NMFS) Web site, is used to determine whether existing monitoring efforts are currently sampling key species of economic importance to both the commercial and recreational fisheries. Table ES-1 presents a summary of the top five ranked commercial and recreational fish species/groups in the United States and for each of the three coastal areas.

Table ES-1. The Top Five Ranked Commercial and Recreational Species*

Region	Commercial Species	Recreational Species
All U.S. estuarine and marine waters	Walleye pollock Atlantic menhaden Pacific cod Pacific hake Pink salmon	Other tunas/mackerel Striped bass Dolphin Spotted seatrout Summer flounder
Atlantic coastal region	Atlantic menhaden Atlantic herring Blue crab American lobster Atlantic surf clam	Striped bass Other tuna/mackerel Summer flounder Bluefish Dolphin
Gulf of Mexico	Atlantic menhaden Brown shrimp White shrimp Blue crab American oyster	Spotted seatrout Red drum *Mycteroperca* groupers Red snapper Sheepshead
Pacific coastal region	Walleye pollock Pacific cod Pacific hake Pink salmon Sockeye salmon	Other fish Other tuna/mackerel Yellowtail Black rockfish Pacific barracuda

* Rankings are based on mean landings (pounds per year) averaged from 1998 to 2000 for the United States and for each of the three coastal areas.

Source: Based on the calculated national 1998–2000 combined landings for commercial and recreational fisheries (see Appendix A, Tables 1 and 5).

Fish and Shellfish Species Currently under Advisory for Mercury Contamination

According to EPA's NLFWA database, a total of 27 active state advisories that encompass estuarine or coastal marine waters are currently in effect. Of these 27 state advisories, 16 are waterbody-specific advisories (Table ES-2) and 11 are statewide advisories (Table ES-3) issued as a result of mercury contamination. Finfish species identified in more than one state's advisories include striped bass and king mackerel, and shellfish identified in more than one state's advisories include oysters, clams, mussels, and crabs. Statewide advisories are in effect for striped bass and bluefish (ME); tuna, tilefish, king mackerel, swordfish, and shark (MA); king mackerel (NC, GA, FL, AL, MS, LA, and TX); and sharks (FL). Current FDA advisories issued for pregnant women and women of childbearing age advise these groups to completely avoid consumption of four marine species—tilefish, shark, king mackerel, and swordfish. These women are encouraged, however, to eat other varieties of fish purchased in stores or obtained from friends and family members who are recreational or subsistence fishers.

Consumption Rates for Various Consumer Populations

Relatively few data are available on fish consumption rates for estuarine and marine fish and shellfish species compared with data available on consumption of freshwater species. Consumption survey studies have been conducted at both national and regional/state levels. Data are available on fish consumption rates for members of the general U.S. population by age group for the last several years. The results of recent (1994–1996 and 1998 combined) market basket studies suggest that the mean, 90th percentile, and 95th percentile per capita marine fish and shellfish consumption rates were 8.25, 29.20, and 55.80 g/d, respectively, for both sexes and all ages in the general population. In contrast to per capita data (which average consumption rates across the entire population of fish-eaters and nonfish-eaters), the consumption rate data derived from fish consumers in the general population show much higher mean, 90th percentile, and 95th percentile rates of 80.19, 168.88, and 207.57 g/d, respectively. Surprisingly, these data suggest that consumption rates of marine fish and shellfish among fish consumers in the general population are similar to rates among recreational and some subsistence populations.

Data from regional and state studies are more limited, especially for the Gulf coast region. Even when data are available for recreational and subsistence fishers, information on the body weights of the respondents is often not collected. As a result, consumption rates presented in units of grams of fish consumed per day cannot be converted to grams of fish consumed per kilogram of body weight per day (g/kg•d^{-1}) for comparison with consumption rates given in g/d. Current data on fish consumption rates, particularly from regional and state studies of both recreational and subsistence fishers, including Native Americans, is a critical data need. A better understanding of seafood consumption patterns and rates among all fish consumers, whether in the general population, recreational, or subsistence fishers, is of critical importance to support future public health risk assessments and risk management decisions related to the issuance of consumption advisories.

Table ES-2. Active Waterbody-Specific Fish Consumption Advisories in Effect for Mercury in U.S. Coastal Waters

State	Advisory Number	Geographic Extent of Advisory	Species	Population of Concern
DE	104190	St. Jones River: Silver Lake Dam to river mouth	All fish	RGP
DE	104174	Delaware River: PA/DE border to Chesapeake and Delaware Canal	All fish	NCGP
DE	104177	Lower Delaware River and Delaware Bay: Chesapeake and Delaware Canal to Delaware Bay Mouth	Striped bass	RGP
GA	4944	Terry Creek: St. Simons Estuary; South of Torras Causeway to Lanier Basin	Quahog clams, blue mussels, American oysters	NCGP
			Silver perch	RGP
GA	3327	Upper Turtle and Buffalo Rivers: St. Simons Estuary; Upriver of GA Hwy 303	Spotted sea trout, red drum, flounder, Atlantic croaker, and blue crabs	RGP
			American oysters, blue mussels, Quahog clams, and black drum	NCGP
GA	3329	Lower Turtle and South Brunswick Rivers: St. Simons Estuary; Channel Marker 9 downstream to Dubignon and Parsons Creeks	Quahog clams, American oysters, blue mussels	NCGP
			Blue crab, spotted sea trout, Atlantic croaker, and black drum	RGP
FL	3341	Indian River Lagoon - North	Ladyfish, crevalle jack	RGP
			Ladyfish, crevalle jack	RSP
FL	3345	Indian River Lagoon - South	Crevalle jack	RSP
			Crevalle jack	RGP
FL	3343	Florida Bay - Monroe County	Spotted sea trout, crevalle jack	RGP
			Spotted sea trout, crevalle jack	RSP
FL	3342	Florida Keys - Monroe County	Spotted sea trout, crevalle jack	RGP
			Spotted sea trout, crevalle jack	RSP
FL	3344	Tampa Bay	Ladyfish, Spanish mackerel, gafttopsail catfish, crevalle jack	RSP
			Ladyfish, Spanish mackerel, gafttopsail catfish, crevalle jack	RGP
FL	3340	Charlotte Harbor	Spotted sea trout, crevalle jack, Spanish mackerel	RSP
			Spotted sea trout, crevalle jack, Spanish mackerel	RGP
TX	851	Upper Lavaca Bay (area of the Bay inshore of a line beginning at the last point of land at the NE approach of the Causeway, then in a SW direction to Aquatic Life Marker A and B)	All fish and shellfish (crabs)	NKZ
CA	27	San Francisco Bay Delta Region	All fish except salmon, anchovy, herring, smelt	RSP
			All fish except salmon, anchovy, herring, smelt	RGP
WA	3339	Eagle Harbor - Bainbridge Island	All bottom fish and shellfish-bivalves and crabs	NCGP
AS	2120	Inner Pago Pago Harbor: Portion of inner bay between village and a line from Rainmaker Hotel to Trading Point	All fish and shellfish and fish (liver)	NCGP
			All fish and shellfish	CFB

RGP = Restricted-consumption advisory for the general population
RSP = Restricted-consumption advisory for sensitive populations, including pregnant women, nursing mothers, and young children
NCGP = No-consumption advisory for the general population
NCSP = No-consumption advisory for sensitive populations, including pregnant women, nursing mothers, and young children
NKZ = No kill zone—a waterbody where chemical contamination levels make it illegal to harvest, kill, or possess any species
CFB = Commercial fishing ban prohibits the commercial harvest and sale of fish or shellfish from the designated waterbody

Source: U.S. EPA (2002b), NLFWA database available at the U.S. EPA Office of Water (OW) Web site at http://www.epa.gov/waterscience/fish.

Table ES-3. Active Statewide Fish Consumption Advisories in Effect for Mercury in U.S. Coastal Waters

State	Advisory Number	Geographic Extent of Advisory	Species and Size Specifications (inches)	Population of Concern
ME	9986	Statewide: all coastal and estuarine waters	Striped bass, bluefish	RGP
			Striped bass	RSP
MA	9179	Statewide: all coastal and estuarine waters	Tuna, tilefish, king mackerel, swordfish, shark	NCSP
NC	104037	Statewide: all coastal and estuarine waters	King mackerel 33-39"	RGP
			King mackerel 33-39"	RSP
			King mackerel > 39"	NCGP
			King mackerel > 39"	NCSP
SC	104230	Statewide: all coastal and estuarine waters	King mackerel > 39"	NCSP
			King mackerel > 39"	NCGP
			King mackerel 33-39"	RGP
			King mackerel 33-39"	RSP
GA	104231	Statewide: all coastal and estuarine waters	King mackerel 33-39"	RSP
			King mackerel 33-39", Atlantic croaker, blue crab	RGP
			King mackerel > 39", black drum, American oysters, blue mussels, Quahog clams	NCGP
FL	3050	Statewide: all coastal and estuarine waters	Shark	RSP
			Shark	RGP
FL	4608	Statewide: all coastal and estuarine waters	King mackerel < 39" (fork length)	RGP
			King mackerel > 39" (fork length)	NCGP
			King mackerel 33-39" (fork length)	RSP
AL	4007	Statewide: Gulf coastal and estuarine waters	King mackerel > 39"	NCGP
			King mackerel < 39"	RGP
MS	4827	Statewide: Gulf coastal and estuarine waters	King mackerel > 39"	NCGP
			King mackerel 33-39"	RGP
LA	4621	Statewide: Gulf coast waters off all coastal parishes	King mackerel > 39"	NCSP
			King mackerel > 39"	NCGP
			King mackerel ≤ 39"	RSP
			King mackerel ≤ 39"	RGP
TX	4575	Statewide: all Gulf waters off the Texas coast	King mackerel > 43"	NCGP
			King mackerel 37-43"	RGP
			King mackerel 37-43"	RSP
			King mackerel < 37"	NR

RGP = Restricted-consumption advisory for the general population
RSP = Restricted-consumption advisory for sensitive populations, including pregnant women, nursing mothers, and young children
NCGP = No-consumption advisory for the general population
NCSP = No-consumption advisory for sensitive populations, including pregnant women, nursing mothers, and young children
NR = No restrictions on consumption of this species

Source: U.S. EPA (2002b). NLFWA database available at the U.S. EPA OW Web site at http://www.epa.gov/waterscience/fish.

Extent of Mercury Tissue Monitoring in the U.S. Coastal Waters

An initial review of the data demonstrates little temporal consistency for (1) station visitations, (2) number of samples collected at a station, and (3) species and size classes collected in each sample, over the evaluated time period. A review of the number of samples collected at each station over the timeframe of the study (1990–2002) confirms that at 40 to 48 percent of the stations in each coastal area (almost 48%, 42%, and 40% in the Atlantic, Gulf, and Pacific, respectively), only one sample was collected over the past 12-year period. However, multiple samples were collected at most stations in each coastal area. This variability is expected given the different objectives of the various monitoring programs from which the data were derived. The data analysis did not attempt to evaluate temporal trends across the mercury data, but rather focused on the extent of mercury contamination in individual species.

An analysis of monitoring station locations in coastal areas revealed a lack of consistent geographic coverage in tissue monitoring for most species analyzed in this study, with the exception of species evaluated as part of the Mussel Watch Project under NOAA's National Status and Trends (NS&T) Program. On the Atlantic and Gulf coasts, the American oyster (also known as the Eastern oyster) has been widely monitored, whereas in the northeast Atlantic coast and on the Pacific coast, the blue mussel is the indicator species that has been most widely monitored. In addition, these species have been widely monitored both spatially (at established stations) and temporally over a long period of time because this monitoring program has been in effect for nearly 20 years. Although the location of monitoring stations in coastal areas seems to be widespread, many of the sampling stations are part of NOAA's Mussel Watch Program. Sampling of finfish species is not as widespread, because fish monitoring programs are typically conducted under the jurisdiction of individual states, each with a different sampling strategy and spatial coverage.

More than 90 percent of all monitoring since 1990 has occurred in coastal estuaries and the territorial sea—areas within state jurisdictional waters—while little monitoring of species has occurred in offshore waters of the OCS or the Exclusive Economic Zone (EEZ). The largest number of sites sampled that fell outside the boundaries of the territorial sea were in the Gulf of Mexico, where samples were collected at 45 stations outside the territorial sea (Table ES-4). Although 58 stations in the Atlantic region were outside the U.S. territorial sea, many of these stations were in near-coastal waters of Canada within the Gulf of Maine. More monitoring data were compiled from federal, regional, state, and local sources for the Gulf coast area than for the Atlantic or Pacific coasts. Overall, mercury data sets for the Pacific coast were less available than for the other two regions; however, this may have been a function of the data acquisition process.

Table ES-4. Spatial Distribution of Monitoring Stations Where High-Resolution Site Information (Latitude/Longitude) Is Available

Coastal Region	Number of Monitoring Stations within the Territorial Sea[a]	Number of Monitoring Stations Outside the Territorial Sea[a]	Total Number of Mappable Monitoring Stations[a]	Total Number of Monitoring Stations
Atlantic	1,125	58	1,183	1,254
Gulf	1,439	45	1,484	1,736
Pacific	627	16	643	676

[a] Monitoring stations defined by latitude/longitude coordinates

Occurrence of Mercury in Fish and Shellfish of the U.S. Coastal Waters

Mercury tissue concentrations were available for many of the recreational species in all coastal areas, but were less available for commercial species. Many commercial species that are harvested in deep water over the OCS or in the EEZ require specialized sampling gear that may not be readily available to state monitoring programs. In addition, because state jurisdiction typically ends at the margin of the territorial sea, states are more likely to concentrate their fish monitoring efforts in estuarine and near-shore coastal marine waters of the territorial sea within their jurisdiction that would typically be fished by recreational fishers. Because of this, the analysis of mercury tissue concentrations centered on the recreational species most likely to be caught by recreational and subsistence fishers in near-shore waters (Figures ES-1 through ES-3). Tissue monitoring data were analyzed for mercury primarily by species and/or by groups because bioaccumulative patterns are species-dependent and the potential health risks from mercury in seafood are managed at the species level. In some cases, specific groups of species were aggregated to conform to the groups identified by NMFS recreational fish landings data.

Despite this fact, the data analysis revealed that there are also many recreational species ranked among the top 25 recreational species for which little or no data are available. For example, in the Atlantic region, little or no mercury data are available for 12 of the 25 highest-ranking recreational species/groups, including other tuna/mackerel, dolphin, Atlantic cod, scup, black sea bass, Atlantic mackerel, tautog, little tunny/Atlantic bonita, kingfish, winter flounder, and greater amberjack. In the Gulf of Mexico, little or no mercury data are available for 11 of the 25 highest-ranking recreational species/groups, including black grouper, scamp grouper, dolphin, pinfish, white grunt, other tuna/mackerel, greater amberjack, little tunny/Atlantic bonita, and blue runner. In the Pacific region, little or no data are available for 21 of the 25 highest-ranking recreational species/groups, including other tuna/mackerel, yellowtail, black rockfish, Pacific barracuda, lingcod, California halibut, barred sea bass, blue rockfish, kelp bass, yellowtail rockfish, sturgeon, striped bass, dolphin, bocaccio, barred surfperch, California scorpionfish, canary rockfish, cabezon, copper rockfish, dogfish sharks, California sheephead, and other sharks. Obtaining data for some of these high-

ranking recreational species is critical for ascertaining the level of mercury contamination and potential human health concerns, especially with regard to consumption of fish caught by recreational and subsistence fishers who typically consume larger amounts of fish than the general population.

The median and mean mercury concentrations, as well as the number of samples in the database for the 10 most-harvested recreational species or groups in each of the three coastal areas, are shown in Figures ES-1 through ES-3. Figure ES-1 shows that the median and mean mercury concentrations for king mackerel and bluefish in the Atlantic coastal region exceed the EPA methylmercury criterion. For the Gulf of Mexico, the median mercury concentrations for king mackerel, sand seatrout, and Spanish mackerel all exceed the EPA criterion. The mean mercury tissue concentrations for spotted sea trout, red drum, *Mycteroperca* groupers, king mackerel, sand seatrout, Spanish mackerel, and black drum all exceed the EPA methylmercury criterion. For the Pacific coastal region, much less data on the levels of mercury in various species were acquired for the Mercury in Marine Life Database. For some groups of the most popular finfish, species were aggregated at the family or group level for comparison as limited samples (less than 50 samples were available in the database for individual species). For the Pacific coastal region, the median mercury concentrations for lingcod and striped bass exceed the EPA criterion. The mean mercury tissue concentrations for lingcod, other rockfish, and striped bass all exceed the EPA methylmercury criterion.

DATA TO BE ADDED

This report provides a brief summary of additional data sets that were acquired but not included in the Mercury in Marine Life Database for several reasons (e.g., appropriate metadata were not available). It also briefly describes data sets that may be of future interest to EPA, which include federal, state, and tribal monitoring data; describes additional work on the review of 120 peer-reviewed journal articles; and describes work on providing trophic level and feeding guild assignments for all species in the Mercury and Marine Life Database.

CONTACT INFORMATION

Questions about the Mercury in Marine Life Database may be directed to Debora Martin, Air/Water Coordinator, EPA Office of Wetlands, Oceans, and Watersheds (martin.debora@epa.gov; phone: 202-566-1243).

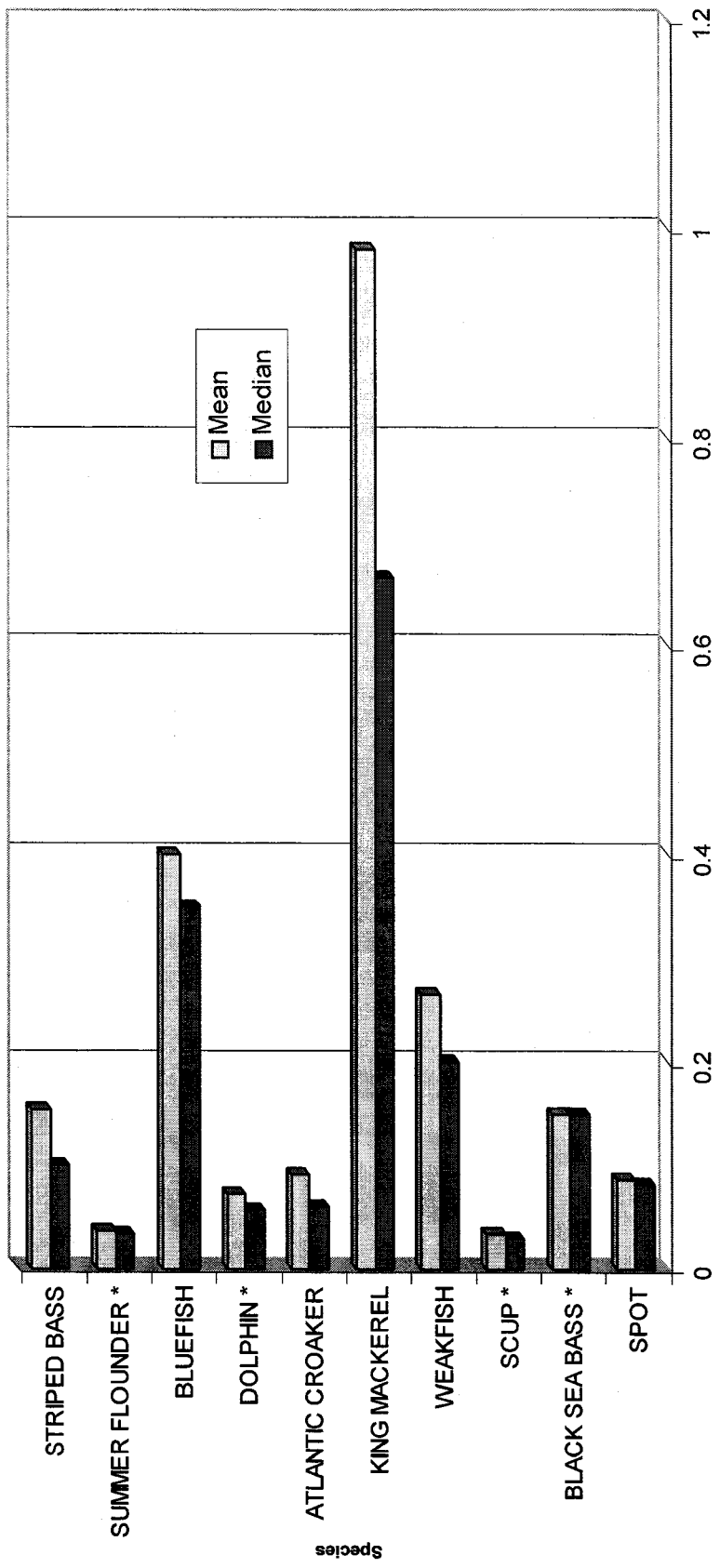

Figure ES-1. Mercury concentrations in the top 10 recreational species in the Atlantic Ocean.

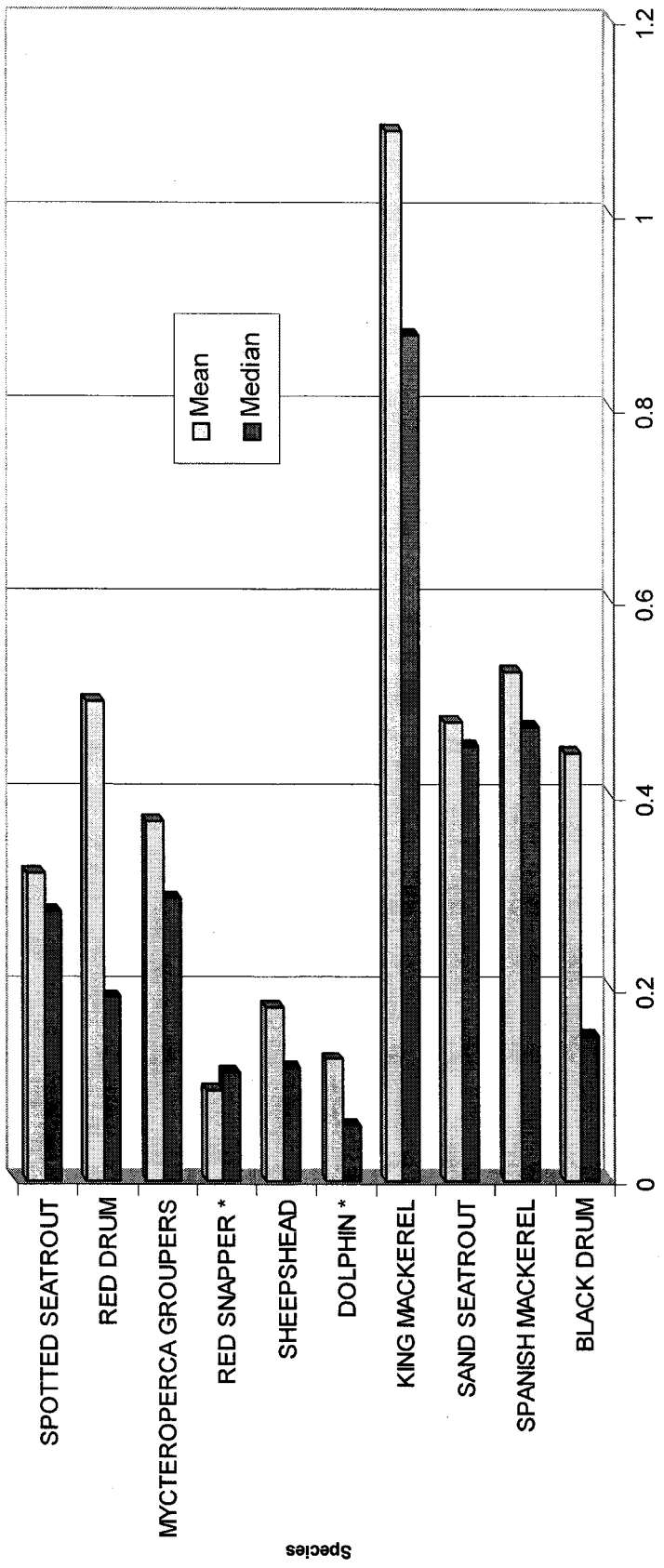

Figure ES-2. Mercury concentrations in the top 10 recreational species in the Gulf of Mexico.

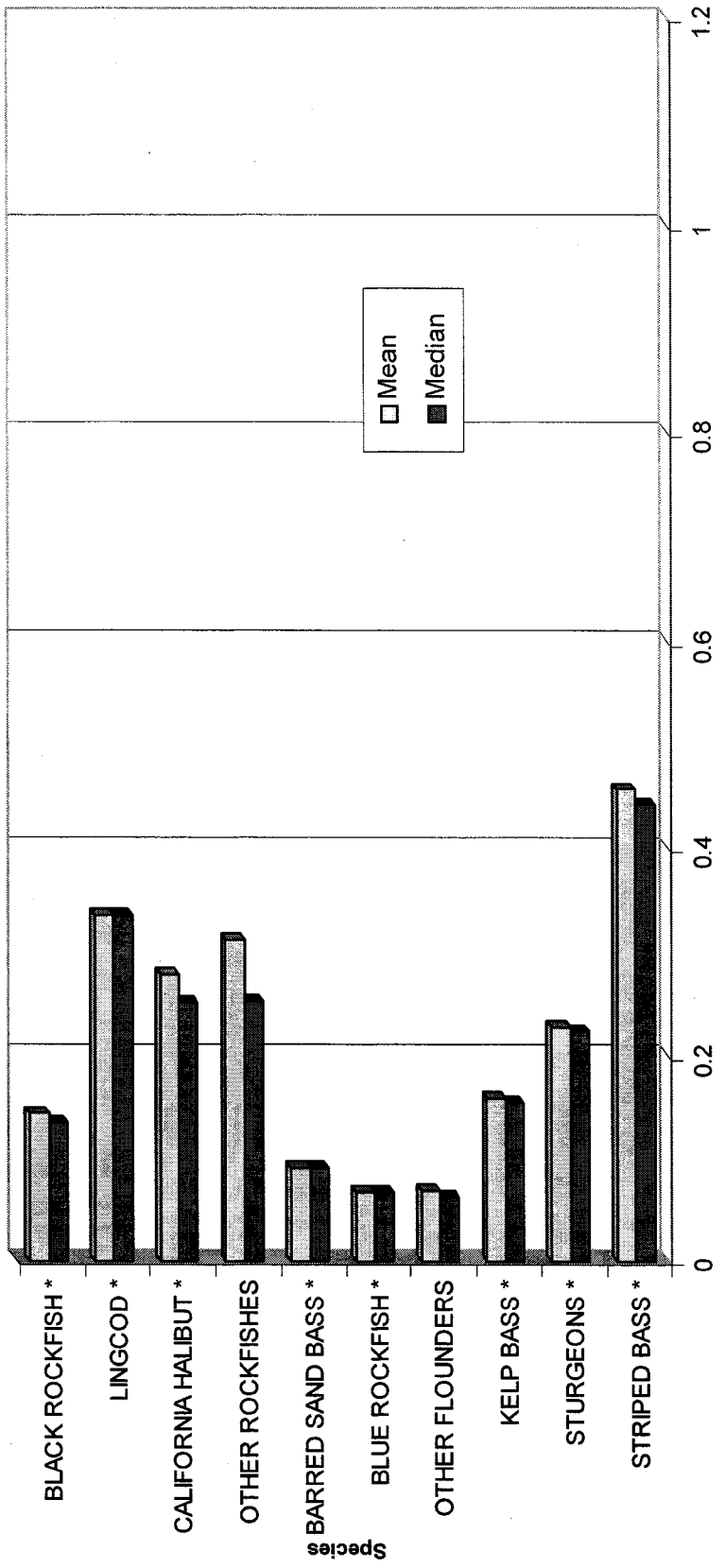

Figure ES-3. Mercury concentrations in the top 10 recreational species in the Pacific Ocean.

SECTION 1.0

INTRODUCTION

1.1 PURPOSE

The U.S. Environmental Protection Agency (EPA) has long been concerned with mercury levels in fish and wildlife (Kuehl et al., 1994; U.S. EPA, 1992a, 1992b, 1997b, 1999). EPA has taken federal regulatory action to limit mercury emissions to the air from various sources and has developed water quality criteria to limit the inputs of mercury directly to waterbodies. In addition, the Agency's waste programs have provided guidance and regulations on the management of hazardous wastes that contain mercury. EPA hopes that, eventually, these measures will reduce the concentrations of mercury in fish and wildlife. Most of the mercury tissue concentration data that EPA has used to make these decisions relate to freshwater fish species.

The purpose of the Mercury in Marine Life Project is to organize information on estuarine and marine species so that EPA can better understand both the extent of monitoring for mercury and level of mercury contamination in the biota of coastal environments.

This report follows a similar report commissioned by the Gulf of Mexico Program (GMP), entitled *A Survey of the Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico* (Ache et al., 2000), which provided detailed information on the occurrence of mercury in the fishery resources of the Gulf of Mexico. This Gulf of Mexico Program report assessed freshwater species collected in estuarine areas, as well as estuarine and marine species. The current study builds on that report, expanding the scope to include all marine waters (Atlantic, Gulf of Mexico, and Pacific) of the United States, but excludes data on freshwater species collected in estuarine areas. The current Mercury in Marine Life Study can serve as a resource for environmental, fish and wildlife, and public health managers in the United States. To facilitate further EPA analysis of these data, the Mercury in Marine Life Database, prepared to support this report, is available in a Microsoft Access file developed using a geographic information system (GIS) platform.

This study does not evaluate or make any conclusions about mercury-associated human health risks from the consumption of fish and shellfish harvested from the estuarine and marine waters of the United States. The public health significance of mercury in seafood is determined by several factors, including the

- Chemical form of mercury present, tissue mercury concentration, and toxicity of the mercury compound in a particular seafood,

- Consumption rate and frequency of exposure of individuals consuming the seafood, and
- Level of risk that regulatory agencies are willing to accept regarding the protection of public health (Fortner et al., 1997).

The primary focus of the Mercury in Marine Life Report is to document the mercury concentrations present in various estuarine and marine fish and shellfish and other wildlife species nationwide; these concentrations constitute only one component of the data that are required for the public health risk assessment process.

1.2 THE RELATION BETWEEN MERCURY FISH CONSUMPTION ADVISORIES AND THE CLEAN WATER ACT'S SECTION 303(d) PROCESS

1.2.1 Characteristics of State and Federal Fish Consumption Advisories Involving Mercury

States have primary responsibility for protecting residents from the health risks of consuming contaminated noncommercially caught fish and shellfish; they do this by issuing consumption advisories or guidelines. State public health agencies may use slightly different criteria and processes to issue advisories, and the mercury concentrations used in issuing advisories may be different from those used to open or close commercial fisheries. EPA has worked with state public health agencies to incorporate in their advisory systems risk-based approaches that take into account EPA national human health criteria, as well as EPA-recommended strategies for sample collection and analysis. Consumption advisories are typically issued for the general population, including recreational and subsistence fishers, as well as for sensitive subpopulations, such as pregnant women, nursing mothers, and children. These advisories inform the public that high concentrations of chemical contaminants, such as mercury, have been found in local fish and shellfish; they also include recommendations to limit or avoid consumption of certain species from specific waterbodies or waterbody types (U.S. EPA, 2002a,b).

EPA has recently updated its national water quality criterion for methylmercury (U.S. EPA, 2001b). The new criterion is based on methylmercury levels in fish tissues rather than a specific concentration in ambient water. Although states can refine EPA's recommendations, the suggested default criterion for sensitive populations is 0.3 mg methylmercury/kg fish (ppm in tissue) based on a total fish and shellfish consumption-weighted rate of no more that 0.0175 kg fish/d. States are in the process of adopting the new EPA-recommended criterion and methods into their EPA-approved water quality standards. At present, however, several types of approaches to developing water quality standards are used in different states.

While state public health agencies have primary responsibility for issuing advisories for noncommercial fisheries, the safety of seafood sold in interstate commerce is under the jurisdiction of the U.S. Food and Drug Administration (FDA), which has issued an action level (1 ppm) for concentrations of methylmercury in fish and shellfish. The FDA works with state regulators and with

such federal agencies as the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) when commercial fish, caught and sold locally, are found to contain methylmercury levels exceeding this action level. The FDA has stated that the average concentration of methylmercury for commercially important species, most of which are marine in origin, is less than 0.3 ppm (U.S. FDA, 1995). During the 1990s, the FDA felt that consumption advice was unnecessary for the top 10 seafood species, making up about 80 percent of the seafood market, because these species—canned tuna, shrimp, pollock, salmon, cod, catfish, clams, flatfish, crabs, and scallops—typically contain less than 0.2 ppm methylmercury (U.S. FDA, 2001c), based on the FDA's analysis of available evidence, and few people were deemed likely to eat more than the suggested weekly limit of fish (2.2 pounds) for this level of methylmercury contamination (U.S. FDA, 1995). In 2001, in an updated consumer advisory, FDA advised pregnant women and women of childbearing age who may become pregnant on the hazards of consuming certain kinds of marine fish—shark, swordfish, king mackerel, and tilefish. FDA recommended that these groups of women not eat these four species of fish, but rather consume up to 12 oz. per week of a variety of other fish, including shellfish, canned fish, and smaller ocean or farm-raised fish (U.S. FDA, 2001a,b). In 2002, the FDA initiated a review of its overall public health strategy for regulation of mercury in commercial seafood (U.S. FDA, 2002).

In addition to the FDA national consumption advice that covers marine fish, EPA has also issued a national advisory for methylmercury in freshwater fish for sensitive populations, including women who are pregnant or may become pregnant, nursing mothers, and young children. EPA advises members of these sensitive populations to limit consumption of freshwater fish caught by family and friends to one meal per week. For adults, one meal is 6 oz. of cooked fish or 8 oz. of uncooked fish; for a young child, one meal is 2 oz. of cooked fish or 3 oz. of uncooked fish. The EPA advisory also recommends that these sensitive groups follow the FDA advice on methylmercury for coastal and ocean fish caught by family and friends (U.S. EPA, 2001a). This EPA advice is available at the following URLs: http://www.epa.gov/waterscience/fishadvice/advice.html and http://www.epa.gov/waterscience/fishadvice/factsheet.html. Although the FDA and EPA provide separate advice for marine and freshwater species, respectively, this separate advice should not be interpreted as being mutually exclusive. Members of these sensitive populations should keep the total level of methlymercury contributed by all fish they eat (whether marine, estuarine, or freshwater) at a low level in their body. For example, if in a given week, a woman consumes 12 oz. of cooked marine fish from a store or restaurant, then she should not eat fish caught by family or friends during that same week. Fish is a good source of protein, and adequate protein is necessary for a baby or child's healthy development. To keep the level of methylmercury at a low level in the body, EPA recommends that if fish (marine, estuarine, or freshwater) caught by family and friends are a primary source of protein, women should try substituting a variety of other foods (e.g., meat, poultry, eggs, or dairy products) that are high in protein, but that are typically lower in methylmercury (U.S. EPA, 2001a).

1.2.2 The Clean Water Act Total Maximum Daily Load Process

The quality of the nation's waters is protected in large measure through the development of pollution control strategies by the states. These strategies are constructed in cooperation with a broad array of stakeholders and are designed to achieve water quality standards established for the nation's rivers, lakes, estuaries, and coastal waters. Section 303 of the federal Clean Water Act (CWA) establishes the water quality standards and total maximum daily load (TMDL) programs implemented by EPA and state water quality management agencies. The TMDL process is an important tool in the Comprehensive Water Quality Management Programs under Title III of the CWA, as illustrated in Figure 1-1.

Section 303(d) specifies that states will list segments of rivers, streams, lakes, reservoirs, and estuaries or other waters not meeting the appropriate water quality standards. Water quality standards are set by the states, and these standards identify uses for each waterbody—for example, drinking water supply, primary contact recreation (swimming), secondary contact recreation (boating), and aquatic life support (fishing)—and the scientific criteria to support that use. The resulting 303(d) list then serves as the inventory of water quality problems. States must develop TMDLs for those waterbodies not meeting the relevant water quality standards. A TMDL identifies the maximum amount of a pollutant (wasteload allocation [WLA] or load allocation [LA]) that a waterbody can receive and still meet water quality standards. EPA has issued guidance on approaches to adapt

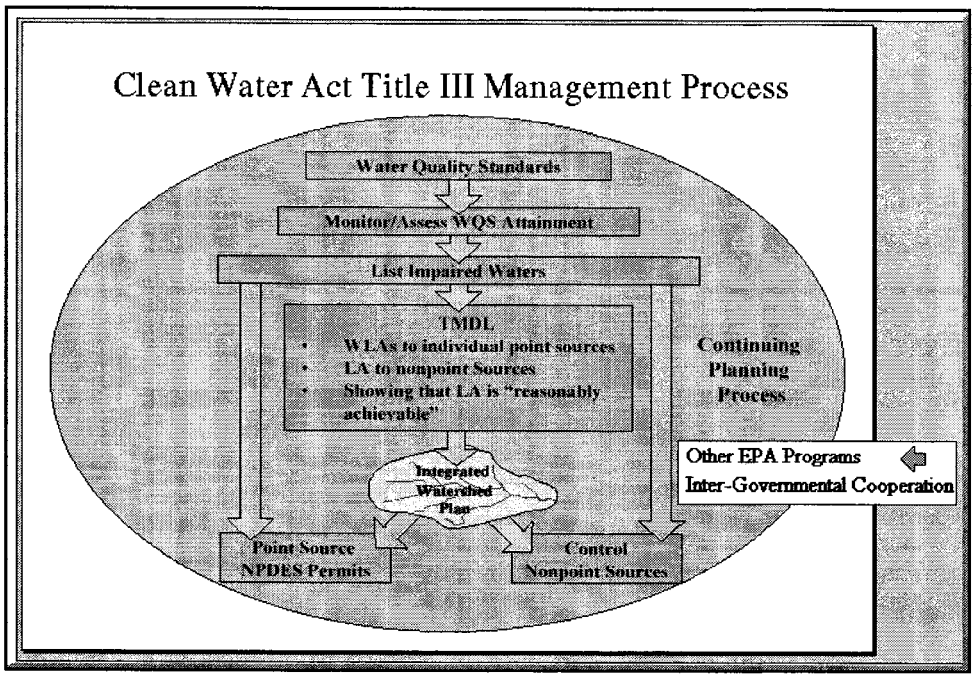

Figure 1-1. The TMDL process as a tool in CWA Comprehensive Water Quality Management Programs. Source: Sutfin (2002)

the information content in state fish consumption advisories to make decisions for 303(d) listings (Grubbs and Wayland, 2000). EPA recommends that a state, territory, or authorized tribe include on its Section 303(d) list, at a minimum, specific waters where a fish or shellfish consumption advisory demonstrates nonattainment of water quality standards (e.g., the advisory or classification is based on tissue data, the data are from the specific waterbody in question, and the risk assessment parameters of the advisory or classification are cumulatively equal to or less protective than those in the water quality standards). When listing waters based on a fish advisory, EPA suggests that common migratory waters of the monitored species should also be listed (Grubbs and Wayland, 2000).

Because 303(d) listing decisions and TMDLs are based on state water quality standards, this process applies only to those waters of a state that are inland fresh waters, such as rivers and lakes, and coastal waters that fall within the limits of the territorial sea. The territorial sea, with certain exceptions, includes those waters within 3 nautical (geographic) miles of the coastal shoreline (or baseline). Most freshwater-influenced estuaries fall within the state jurisdictional boundaries of the territorial sea. Other marine and oceanic waters fall outside the 3 nautical mile limit. EPA and other federal agencies have jurisdictions that extend into the ocean at least to a set of internationally sanctioned boundaries associated with the Exclusive Economic Zone (EEZ) and the limits of the Outer Continental Shelf (OCS). Figure 1-2 illustrates several of these jurisdictional limits as they apply to coastal waters.

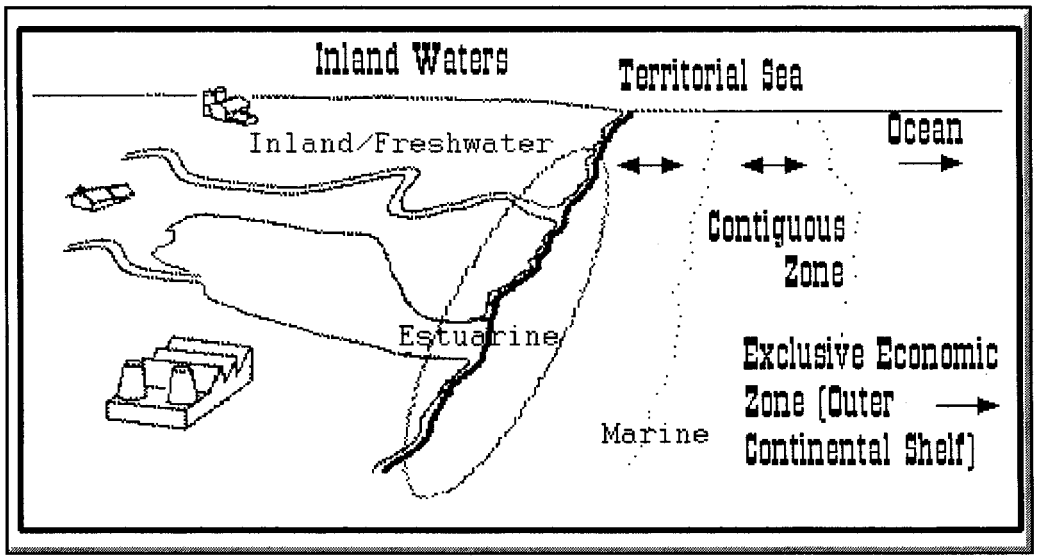

Figure 1-2. Jurisdictional limits involving coastal waters.
Source: U.S. EPA (1994)

1.3 REPORT ORGANIZATION

The Mercury in Marine Life Report is structured to address several questions, the answers to which provide basic information about the occurrence and extent of mercury contamination in U.S. estuarine and marine fishery resources and potential for health risks to consumers. These questions include

1. What is the extent of estuarine/marine species mercury tissue monitoring in the Atlantic, Gulf of Mexico, and Pacific coastal areas?
2. What are the levels of mercury contamination (median, mean, and maximum) for selected species sampled in federal, regional, and state programs?
3. What fish and shellfish species are regularly harvested both commercially and recreationally from all U.S. waters and individually from the waters of the Atlantic, Gulf of Mexico, and Pacific coastal areas?
4. What specific fish and shellfish species in coastal waters have the coastal states and/or FDA recognized as potential human health risks, through the issuance of consumption advisories or bans for mercury?
5. What is the range of consumption rates of estuarine and marine fish and shellfish identified in both national market basket studies and regional or state consumption surveys for the general population, as well as for populations of recreational and subsistence fishers?

The first two questions are the primary focus of data collection efforts undertaken for this report. A brief description of the information discussed in each section of the report is presented below.

Section 1 reviews the purpose of the Mercury in Marine Life Study, the organization of the report, and the key components and qualifications of the study, including the study area, species selection, and study period.

Section 2 begins with a brief description of the federal, regional, and state programs that provided electronic data for compilation into the Mercury in Marine Life Database. The Mercury in Marine Life Database includes mercury tissue monitoring data from five federal agencies/programs, four regional studies, and several state toxic monitoring programs (inclusive of data for Puerto Rico). It also includes data from Canadian waters for the Gulf of Maine Mussel Watch Program and the Puget Sound Ambient Monitoring Program from along the coast of British Columbia. This section also describes a database containing information on the concentration of mercury in tissues of terrestrial vertebrates that was not aggregated with the Mercury in Marine Life Database, but that is available as a separate data file. This data file is a subset of the Contaminant Exposure and Effects -Terrestrial Vertebrates (CEE-TV) database prepared by Barnett Rattner of the U.S. Geological Survey (USGS) Patuxent Wildlife Research Center in Laurel, MD. Section 2 also presents the methodology for developing the Mercury in Marine Life Database and the associated GIS-based mapping capabilities and addresses issues of data quality (precision, accuracy, and comparability), consistency in reporting mercury measurements (e.g., dry to wet weight conversion assumptions, methylmercury vs. total mercury considerations), and methods used for handling values below the detection limits of analytical methods and for mercury values reported as zero.

Section 3 describes preliminary results of an analysis of data in the Mercury in Marine Life Database and includes maps of mercury monitoring sites and data

tables for mercury concentrations in the 25 most-harvested recreational species and key commercial shellfish in the Atlantic, Gulf of Mexico, and Pacific coastal areas and summary information from the USGS CEE-TV database for terrestrial vertebrate species collected in estuarine watersheds.

Section 4 provides a summary of additional electronic files of mercury monitoring data that may be added to the Mercury in Marine Life Database during 2003. Some of the data sets were unavailable for aggregation into the database at the required time because data collection activities were ongoing or because the data required additional quality control (QC) checks performed by the data proprietor before being released to EPA. This section also provides a discussion of procedures used to identify, acquire, and archive more than 120 papers from the scientific literature.

Section 5 documents all literature used in the preparation of this report.

The last three questions listed above provide important ancillary information needed to evaluate the problem of mercury contamination in marine life and its potential health impacts to humans; these questions are addressed in separate appendices.

Appendix A provides information on landings of both the commercial and the recreational species that are regularly harvested from marine waters. This appendix presents a perspective on recent mean commercial and recreational fishery landings by species, averaged over the most recent 3 years for which data are available (1998–2000). It also provides the user with a quantitative sense of the magnitude and importance of both kinds of fisheries in the three coastal regions of the United States (Atlantic, Gulf of Mexico, and Pacific).

Appendix B presents a current overview of active fish consumption advisories and bans nationwide issued by the FDA or states for mercury. This appendix also defines the types of advisories issued by states and the difference in risk management approaches used by the states for mercury contamination that have led to both waterbody-specific and statewide advisories in coastal marine waters.

Appendix C summarizes the results of national, regional, and state fish consumption surveys related to marine and estuarine fish and shellfish. Because public health risk management of mercury in fishery resources is generally conducted at the species level, an understanding of (1) important recreational and commercial species and (2) seafood consumption patterns gleaned from both national market basket approaches and state surveys of recreational and/or subsistences fishers is also essential. These data are part of the information needed by risk assessors and risk managers to determine the potential health risks associated with consumption of mercury-contaminated fish and shellfish by various members of the general population, as well as by recreational and subsistence fishers. It is the latter two populations that are of special concern because they typically consume much greater amounts of fish and shellfish than members of the general U.S. population (Harris and Harper, 1997; U.S. EPA, 2000a,b,c).

Appendices D through J provide data that are important when thinking about the impact of mercury on marine species and on human health and describe various procedures used in the development of the Mercury in Marine Life Database. Appendix D describes the methodology used for developing GIS coverages; Appendix E provides a data dictionary for the database; Appendix F explains search procedures used for identifying scientific literature for this report; Appendix G describes the frequency of sampling at stations aggregated into the database; Appendix H provides summary statistics on mercury concentrations in all species; Appendix I lists identified literature citations; and Appendix J describes procedures for making trophic level and feeding guild assignments.

1.4 KEY COMPONENTS AND CRITERIA FOR THE MERCURY IN MARINE LIFE DATABASE STUDY

This report provides a summary of existing electronic data on the extent of monitoring for mercury in marine and estuarine species in the Atlantic, Gulf of Mexico, and Pacific coastal waters of the United States. It is intended as a national resource on mercury in marine life, and EPA hopes that it will foster a better understanding of potential mercury problems in the waters of the United States and facilitate greater communication between researchers and risk managers with similar regional or state mercury problems in their coastal waters. This study does not assess mercury-associated human health risks resulting from the consumption of estuarine and marine fish and shellfish harvested from U.S. coastal waters, but does provide information on the consumption rate of the general population and various subpopulations of fish consumers (Appendix C).

To be included in this study, data had to meet certain criteria related to study area, species selection, and study period. These criteria in turn had an effect on how existing data sets were aggregated into the database, how the database was analyzed, and how the mercury maps and data analyses contained in this report were produced.

1.4.1 Study Area

The Mercury in Marine Life study area consists of all marine waters of the United States and U.S. territory of Puerto Rico, including numerous estuarine watersheds and near-coastal areas. The study area also includes some Canadian waters, such as the Gulf of Maine and Georgia Basin-Puget Sound area of British Columbia. A screening process was applied to available tissue monitoring data to ensure that selection of information from the original monitoring stations was from estuarine and marine waters. In general, where the information was collected in Canadian waters, monitoring stations could be associated with a specific province. For most stations, the state data element provided enough information to relate the station to a major coastal area: the Atlantic (including the Florida Straits area), the Gulf of Mexico, or the Pacific. Where the original data source provided robust estimates of latitude and longitude locations, GIS analyses were performed to make a variety of georeferencing assignments, which are stored in a spatial location information table in the Mercury in Marine Life Database. These GIS analyses were based on a series of spatial custom

shapefiles constructed following EPA Office of Water (OW) procedures developed for the Reach Address Database (RAD). The custom shapefiles assist in filtering estuarine and marine monitoring site information. Appendix D provides a brief description of the GIS data products and custom shapefiles use in the Mercury in Marine Life Database.

1.4.2 Species Selection

Fish and shellfish species are found in a variety of habitats in the coastal estuaries and adjacent marine waters of the United States (e.g., black drum in bays, sheepshead around piers, weakfish and spotted seatrout in shallow coastal areas behind barrier islands, and king mackerel and dolphin in offshore waters). Mercury has been found to accumulate in fish and shellfish species living in each of these ecological habitats. Because the focus of the Mercury in Marine Life Study is on the estuarine and marine environments, this study concentrates solely on the concentrations of mercury in those recreationally and commercially harvested species from coastal areas. However, because EPA directed that only estuarine and marine species were to be analyzed in this study, all data on freshwater species that were harvested from estuarine areas were excluded from the Mercury in Marine Life Database analysis.

A species was determined to be strictly freshwater in nature or estuarine/marine based on the categorizations presented in the American Fisheries Society (AFS) Special Publication 20, *Common and Scientific Names of Fishes from the United States and Canada* (AFS, 1991). For shellfish species, various NOAA publications and national taxonomic guides served as references to assist in identifying estuarine and marine shellfish species (Abbott, 1974; Czapla et al., 1991; Emmett et al., 1991; Hoese et al., 1977; Jury et al., 1994; Monaco et al., 1989; Monaco et al., 1990; National Audubon Society, 1983; Nelson et al., 1991; Nelson et al., 1992; Migdalski and Fitcher, 1983; Pattillo et al., 1997; Stone et al., 1994; Williams et al., 1990).

1.4.3 Study Period

Over the past 10 years, both coastal states and federal agencies have begun more intensive and comprehensive tissue monitoring programs in coastal areas. Tissue monitoring data evaluated in this study were limited to samples collected from 1990 to 2001. This study period was selected to eliminate extreme variations in sampling procedures, processing, and chemical analysis methods (which underwent major changes in the late 1980s), yet allow for inclusion of the largest body of data that can provide an indication of the current status of mercury contamination to our nation's waters.

SECTION 2.0

METHODOLOGY

Since 1990, several federal agencies and many coastal states have regularly collected and analyzed fish and shellfish tissue samples for mercury contamination from estuarine and marine coastal waters. Several regional studies associated with the EPA's National Estuary Program (NEP) also have evaluated mercury concentrations in fish and shellfish tissue in specific coastal estuaries. For the Mercury in Marine Life Study, we identified and acquired many of these data sets and analyzed them for the occurrence of mercury in fish and shellfish tissue on a national and coastwide basis. Advancements in analytical techniques and QC procedures for detecting mercury in environmental samples have improved greatly since the late 1980s. These improvements have resulted in a significant lowering of the detection limits for mercury analysis to a point where comparability between data analyzed during that period (pre-1990) and the current data collection period (1990 to 2001) could be questionable. Because of this, EPA decided at the outset of this study that the timeframe for the collected data sets should be limited to data collected after January 1, 1990.

The purpose of this section is to provide a detailed description of the methodology used to identify, acquire, and analyze the Mercury in Marine Life data from federal, regional, state, and local sources. The process involved a number of discrete activities, including identification, acquisition, and archiving of existing electronic data sets; compilation of data sets into the Mercury in Marine Life Database; assessment of all database entries for compliance with selected study criteria (e.g., study area, species selection, collection date); and development of data analysis procedures and GIS mapping methodology.

The Mercury in Marine Life Database is a relational database implemented in Microsoft Access 2000. Appendix E provides documentation on the tables and table data elements in the Mercury in Marine Life Database, including an entity relationship diagram (ERD) that shows the relations among data tables and lookup tables. GIS procedures and mapping methodology are detailed in Appendix D.

All of the electronic data files described below were obtained prior to October 2002 unless otherwise noted. The reader should note that the analysis of data described in this report was performed only on data aggregated into the Mercury in Marine Life Database by October 2002. Additional data files have since been added to the database, but these data were not included in the analysis described in the current report. Additional data files that may be obtained by EPA during 2003 and aggregated into the Mercury in Marine Life Database are described in Section 4.

2.1 MONITORING PROGRAMS PROVIDING MERCURY DATA FOR FISH AND SHELLFISH SPECIES

EPA identified electronic data sets of mercury residue data using the following search methods: (1) a computerized literature search was conducted to identify peer-review studies published from 1990 to 2002 (see Appendix F for additional details); (2) an Internet search was conducted on mercury contamination in fish and shellfish species using major search engines. In addition to this Internet search, Web sites of all major federal agencies that might potentially have collected marine monitoring data were searched, including all EPA NEP sites; and (3) telephone calls or e-mail requests for additional information were made to several federal agency programs, including the EPA Fish Contamination Program, EPA Environmental Monitoring and Assessment Program (EMAP), EPA GMP, and NOAA's Mussel Watch Program, and to regional programs, such as the EPA National Estuary Programs in each state, the Gulf of Maine Gulfwatch Program, Delaware River Basin Commission (DRBC), Puget Sound Ambient Monitoring Program (PSAMP), and San Francisco Estuary Institute (SFEI) Regional Monitoring Program. Since the EPA's Fish Contamination Program provided the initial data files for each coastal state currently available through 2001 in the National Listing of Fish and Wildlife Advisory (NLFWA) database, most current state data were available. Some water quality monitoring and/or public health department staff in coastal states were also contacted directly to ensure that all current information had been obtained. Data collection efforts were designed to identify and acquire only the most appropriate data sets for inclusion in the Mercury in Marine Life Database. A brief description of each identified data set and source aggregated into the Mercury in Marine Life Database is presented in the following subsections:

- Federal programs
- Regional assessments
- State monitoring programs.

2.1.1 Federal Programs

EPA National Listing of Fish and Wildlife Advisories (NLFWA) Database
The NLFWA database is the national repository of information on fish and wildlife advisories issued by U.S. states, territories, the District of Columbia, and Native American tribal organizations. Beginning in 1997, the NLFWA developed the capability to archive information on chemical contaminant residues in fish and wildlife tissues. This tissue data repository archives monitoring data provided by the states that is used in the risk assessment process. Data contained in the NLFWA database were collected by the various states using a wide variety of sampling procedures and monitoring strategies. Both individual and composite sample results are included.

This information is currently available to the public on the EPA Web site at http://www.epa.gov/waterscience/fish. Although most of the data contained in the NLFWA database relate to freshwater species, there are also data on estuarine and marine fish and shellfish, as well as some wildlife information. Only estuarine

and marine data were imported into the Mercury in Marine Life Database. Additional information on the NLFWA can be found in the 2001 Fish Advisory Fact Sheet (U.S. EPA, 2002a), which is available for downloading from the Web site. NLFWA samples and stations in the Mercury in Marine Life Database are denoted with the prefix "NLFWA-".

Contact: Jeffrey Bigler, EPA Office of Science and Technology
Phone: 202-566-0389
E-mail: bigler.jeff@epa.gov
Web site: http://www.epa.gov/waterscience/fish

EPA Environmental Monitoring and Assessment Program (EMAP)
EMAP is an EPA research program designed to monitor and assess status and trends of national ecological resources. To answer broad-scale questions on environmental conditions, EMAP and its partners have collected estuarine and coastal data from hundreds of stations along the coasts of the continental United States. EMAP's National Coastal Assessment includes all the estuarine and coastal sampling done by EMAP beginning in 1990. This includes the sampling done in the biogeographic provinces, as well as data from the Regional EMAP studies done by EPA Regional Offices. These data can be retrieved from EPA's Web site at http://www.epa.gov/emap. EMAP coastal data for the Pacific coast, Alaska, and Hawaii were not available in time to be included in the database.

To add EMAP data to the Mercury in Marine Life Database, tissue data files and metadata files for each available state were downloaded from the EMAP Web site and reformatted to fit the Mercury in Marine Life Database design. A total of 170 samples from 138 different sites were added to the Mercury in Marine Life Database (EMAP data from Gulf states were added separately through the Gulf of Mexico Program database). Size data (length and weight) were not available. Most of the samples were composites; however, the number of fish per composite was not specified. Visit the EPA Web site for additional metadata and specific sample collection and analysis methods used by EMAP. EMAP samples and stations in the Mercury in Marine Life Database are denoted with the prefix "EMAP-".

Contact: Kevin Summers, U.S. EPA Environmental Effects Research Laboratory, Gulf Breeze, Florida
Phone: 850-934-9244
E-mail: Summer.Kevin@epa.gov
Web site: http://www.epa.gov/emap

NOAA National Status and Trends (NS&T) Program–Mussel Watch Project
Since 1986, NOAA's Mussel Watch Project has monitored chemical contaminants in mussels and oysters. Mussel Watch sites are selected to be representative of large coastal areas and to avoid small-scale patches of contamination. For this reason, its data can be used to compare contaminant concentrations across space and time to determine which coastal regions are at greatest risk in terms of degradation of environmental quality. Several species of bivalves are collected: blue mussels (*Mytilus edulis*) from the U.S. North Atlantic, blue mussels (*Mytilus*

edulis) and California mussels (*Mytilus californianus*) from the Pacific coast, American oysters (*Crassostrea virginica*) from the South Atlantic and the Gulf of Mexico, smooth-edge jewelbox (*Chama sinuosa*) from the Florida Keys, Caribbean oyster (*Crassostrea rhizophorae*) from Puerto Rico, and tropical oysters (*Ostrea sandwichensis*) from Hawaii. The bivalves are dredged or hand-collected from intertidal to shallow subtidal zones. All samples are composited: each mussel composite contains 30 individuals, and each oyster composite contains 20 individuals. For additional metadata and specific sample collection and analysis methods, refer to the Mussel Watch Web site (http://nsandt.noaa.gov/data_dexcription_mw.htm) and the references listed below.

For the Mercury in Marine Life Database, the Mussel Watch data file was downloaded from the Web site and reformatted to fit the Mercury in Marine Life Database design. A total of 1,701 samples from 242 sites were added to the Mercury in Marine Life Database, including a small number of sites available for Alaska, Hawaii, and Puerto Rico. All mercury results were given in dry weight, so a conversion factor of 0.2 was used to convert these results to wet weight for comparison with other data sources. This was the correction factor used for the Gulf of Mexico Program data analysis based on the recommendation of Thomas O'Connor (Ache et al., 2000). Mussel Watch samples and stations in the Mercury in Marine Life Database are denoted with the prefix "MW-".

Contact: Gunnar Lauenstein, NOAA
Phone: 301-713-3028 ext. 152
E-mail: Gunner.Lauenstein@noaa.gov
Web site: http://nsandt.noaa.gov/data_description_mw.htm

References:

O'Connor, T.P. 1998. Mussel Watch Results from 1986 to 1996. *Marine Pollution Bulletin*, 37(1–2):14–19.

O'Connor, T.P. 2002. National distribution of chemical concentrations in mussels and oysters. *Marine Environmental Research* 53:117–143.

EPA Gulf of Mexico Program (GMP)

In March 1999, EPA's GMP was asked to provide more detailed information on the occurrence of mercury in the fishery resources of the Gulf of Mexico. The result was a large database and associated report presenting all relevant data and characterizing the mercury issue and the methodologies and results of all regional monitoring and management efforts. The GMP database includes tissue residue data from the five Gulf states, Gulf-wide assessments performed by the NMFS, estuary-level assessments performed by state and federal agencies and programs, and some data from studies in peer-reviewed scientific journals. The GMP database includes many freshwater species and sampling locations, although only the marine and estuarine species and stations were incorporated into the Mercury in Marine Life Database. For additional information on the data used to compile the GMP and the methods used by those data sources, refer to

the following Web site, where the database and final report are available for downloading: http://mo.cr.usgs.gov/gmp/hg.cfm. GMP samples and stations in the Mercury in Marine Life Database are denoted with the prefix "GULF-".

Contact: Fred Kopfler, U.S. EPA Region 4 Gulf of Mexico Program Office, Stennis Space Center, MS
Phone: 228-688-2712
E-mail: kopfler.frederick@epa.gov

Reference:

Ache, B.W., J.D. Boyle, and C.E. Morse. 2000. *A Survey of the Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico.* EPA Gulf of Mexico Program Final Report; available at http://mo.cr.usgs.gov/gmp/hg.cfm.

National Estuary Program (NEP)–Sarasota Bay, FL
The Sarasota Bay NEP provided a CD-ROM with available mercury data for shellfish (clams and oysters) summarized in a PDF report (see Dixon et al., 1993). These data were hand entered into a database and then formatted to fit the Mercury in Marine Life Database design. A total of 20 samples from 20 sites from the Sarasota NEP were entered into the Mercury in Marine Life Database. For complete information on methods used by the NEP to collect and analyze its data, refer to Dixon et al. (1993). Sarasota Bay NEP samples and stations in the Mercury in Marine Life Database are denoted with the prefix "NEP-SARASOTA-".

Contact: Gary Raulerson, Sarasota Bay National Estuary Program
1550 Thompson Parkway; Sarasota, FL
Phone: 941-359-5841
E-mail: Gary_Raulerson@ci.sarasota.fl.us

Reference:

Dixon, L.K., J.M. Sprinkel, N.J. Blake, G.E. Rodrick, and R.H. Pierce. 1993. "Bivalved Shellfish Contaminant Assessment." Sarasota Bay National Estuary Program. Mote Marine Laboratory Technical Report No. 244. 206 pp.

2.1.2 Regional Assessments

Gulf of Maine Council, Gulfwatch Program
Gulfwatch is a program administered by the Gulf of Maine Council in which the blue mussel (*Mytilus edulis*) is used as an indicator for habitat exposure to organic and inorganic contaminants. Gulfwatch mercury data from 1991 to 1995 are available on the council's Web site. All relevant data were downloaded and reformatted to the Mercury in Marine Life Database design. Only samples marked as "indigenous" were included in the Mercury in Marine Life Database, because other samples had been caged or transported for experimental reasons. Also, all dates were listed in the Mercury in Marine Life Database as 07/01/YYYY because Gulfwatch provided only information on the year of collection, and the Mercury in Marine Life Database requires month, day, and year. This date was selected to

represent the midpoint in the summer sampling season (May to August). All of the sample mercury values were reported on a dry weight basis and were converted to wet weight using a conversion factor of 0.2. A total of 288 samples from 58 stations were included in the Mercury in Marine Life Database from this source. A few of the Gulfwatch sites are located in Canadian waters. For more information on the sampling and analysis methods used by Gulfwatch, refer to the council's Web site at http://www.gulfofmaine.org/index.html. Gulfwatch samples and stations in the Mercury in Marine Life Database are denoted with the prefix "GOMAINE-".

Contact: Steve Jones, Manager of the Gulfwatch Program
Phone: 603-862-2175
E-mail: shj@cisunix.unh.edu

Reference:

Chase, M.E., S.H. Jones, P. Hennigar, et al. 2001. Gulfwatch: Monitoring spatial and temporal patterns of trace metals and organic contaminants in the Gulf of Maine (1991-1997) with the blue mussel *(Mytilus edulis L.). Marine Pollution Bulletin* 42(6):491–505.

Puget Sound Ambient Monitoring Program (PSAMP)
The PSAMP brings together local, state, and federal agencies to assess trends in environmental quality in the Puget Sound. Information from the program is used to evaluate the effectiveness of the management plan and set priorities. The PSAMP data set represents data collected by the Washington Department of Fish and Wildlife for the PSAMP program from 1989 to 1999. Data were obtained via e-mail, and appropriate samples were added to the database. A total of 1,242 samples from 443 stations were added to the final database. PSAMP samples and stations in the Mercury in Marine Life Database are denoted with the prefix "PSAMP-".

Contact: Sandra O'Neill, Washington Department of Fish and Wildlife
Phone: 360-902-2843
Web site: http://www.wa.gov/puget_sound/Programs/PSAMP.htm

Reference:

West, J.E., S.M. O'Neill, G.R. Lippert, and S.R. Quinnell. 2002. *Toxic contaminants in marine and anadromous fish from Puget Sound, Washington: Results from the Puget Sound Ambient Monitoring Program Fish Component, 1989–1999.* Olympia, WA, Washington Department of Fish and Wildlife.

San Francisco Estuary Institute (SFEI)
The SFEI Regional Monitoring Program for Trace Substances monitors contaminant concentrations in fish and shellfish tissue in the San Francisco Bay and Delta, together known as the San Francisco Estuary. The program is designed to obtain data describing the concentration of toxic trace elements and organic contaminants. Data from the SFEI program were obtained from the

organization's Web site (http://www.sfei.org) and reformatted to fit the Mercury in Marine Life Database design. The 282 samples from 31 sites were added to the database from this source. SFEI samples and stations in the Mercury in Marine Life Database are denoted with the prefix "SFEI-".

Contact: Jay Davis, San Francisco Estuary Institute
Phone: 510-746-7368
E-mail: jay@sfei.org
Web site: www.sfei.org

References:

Davis, J.A., M.D. May, S.E. Wainwright, R. Fairey, et al. 1999. *Persistent toxic chemicals of human health concern in fish from San Francisco Bay and the Sacramento River, CA.* Available at www.sfei.org/rmp/posters/fishcontam/fish_contamination_99.htm.

Davis, J.A., M.D. May, G. Ichikawa, and D. Crane. 2000. *Contaminant concentrations in fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River – 1998.* Available at www.sfei.org/cmr/deltafish/dfc.pdf.

Delaware River Basin Commission (DRBC; added after October 2002)
The DRBC files were prepared under agreement between the DRBC and the Delaware Department of Natural Resources and Environmental Control (DNREC). This compilation includes all readily available and existing chemical residue data for fish and shellfish samples collected from the Delaware Estuary. Although the compilation focuses primarily on samples collected from the tidal waters between Trenton, NJ, and the mouth of the Delaware Bay, data are also presented for many nontidal waters that drain to the tidal Delaware Estuary. Data from Delaware, Pennsylvania, New York, and New Jersey were downloaded from the DRBC Web site at http://www.state.nj.us/drbc/fishtiss.htm, and 42 samples from 28 sites were added to the Mercury in Marine Life Database. Samples and stations from this data set are denoted with the prefix "DRBC-" in the final database.

Contact: Thomas Fikslin, Delaware River Basin Commission
Phone: 609-883-9500 ext. 253
E-mail: tfikslin2drbc.state.nj.us

2.1.3 State Monitoring Programs

In the past, many coastal states provided mercury data to EPA's NLFWA database; thus, the NLFWA database served as the basis for state-collected data in the Mercury in Marine Life Database. However, recent data were not available for every state, and a number of coastal states had few or no data in the NLFWA. States with few or no recent data in the NLFWA were contacted to determine the availability of mercury monitoring data for estuarine and marine species. A summary of the data obtained for each coastal state from all available sources by sampling year is shown in Table 2-1. Additional data sets acquired directly from

Table 2-1. Data Presented by State and Year in the Mercury in Marine Life Database

STATE	90	91	92	93	94	95	96	97	98	99	00	01
AK	X	X	X	X		X		X				
AL	X	X	X	X	X		X		X	X		
CA	X	X	X	X	X	X	X	X	X	X	X	
CT	X	X	X	X	X	X	X		X			
DC	X	X	X									
DE	X/O	X	X	X	X	X/O	X	X/O	X/O			
FL	X	X	X	X	X	X	X	X	X	X	X	
GA	X	X	X	X	X	X	X	X/O	O	O		O
HI	X	X	X		X		X		X			
LA	X	X	X	X	X	X	X	X	X	X	X	X
MA	X	X	X	X	X	X	X	X	X	X	X	
MD	X	X	X	X	X	X		X	X		X	
ME	X	X	X	X	X	X	X	X	O	O		O
MS	X	X	X	X	X	X	X	X	X	X		
NC	X	X	X	X	X	X	X	X	X	X		
NH	X	X	X	X	X	X					X	
NJ	X	X	X	X/O	X/O	X	X	X/O	X/O			
NY	X	X	X	X/O	X/O	X	X	X/O	X			
OR	X	X	X	X	X	X	X	X	X			
PA				O	O			O				
PR			X	X	X		X		X			
RI	X	X	X	X	X	X	X	X				
SC	X	X	X	X	X	X	X	X	X			
TX	X	X	X	X	X	X	X	X	X	X	X	
VA	X	X	X	X	X	X	X	X	X			
WA	X	X	X	X	X	X	X	X	X	X	X	X

Key: X = added prior to October 2002; O= added after October 2002

the states that were included in the Mercury in Marine Life Database are described below.

California Toxic Substances Monitoring Program (TSMP)
The TSMP provided 148 samples from 66 sites for the Mercury in Marine Life Database. The TSMP was initiated in 1976 by the California State Water Resources Control Board (SWRCB) to provide auniform statewide approach for the detection and evaluation of toxic substances in fresh, estuarine, and marine waters. The TSMP primarily targets waterbodies with known or suspected impaired water quality and is not intended to provide an overall water quality assessment. The California Department of Fish and Game (DFG) carries out the statewide TSMP for the SWRCB by collecting and analyzing samples. For more information about the TSMP data, refer to the SWRCB Web site or contact the organization directly.

Contact: Del Rasmussen, SWRCB, Division of Water Quality
Phone: 916-657-0916
Web site: http://www.swrcb.ca.gov/programs/smw/index.html

California EPA
The California EPA Office of Environmental Health Hazard Assessment also sent a data set that they use for health risk assessment. This data set provided 281 samples from 116 different sites along the California coast.

Contact: Robert K. Brodberg, CA EPA Office of Environmental Health Hazard Assessment
Phone: 916-323-4763
E-mail: rbrodber@oehha.ca.gov

New Jersey
In 1998, New Jersey's Patrick Center for Environmental Research (PCER) initiated a study of concentrations of polychlorinated biphenyls (PCBs), pesticides, and mercury in fish in New Jersey waters. This study was a follow-up to earlier studies focusing on mercury in freshwater fish. In 2000, this project was amended to include additional samples of marine fish and shellfish. The state of New Jersey has used this information for health risk assessment. Mercury data from this study were obtained from the state and added to the Mercury in Marine Life Database. Information on detection limits and latitude/longitude coordinates was not available. All samples were fillets; however, it is not known whether samples were composite or individual fish samples. A date of 07/01/1988, was used for all samples because specific dates were not provided. This date was selected to represent the midpoint in the summer sampling season (May to August). The 173 samples from 44 sites were added to the Mercury in Marine Life Database from this source.

Contact: Bruce Ruppel, New Jersey Dept. of Environmental Protection
Phone: 609-984-6548
E-mail: Bruce.Ruppel@dep.state.nj.us

Georgia (added after October 2002)
In October 2002, the state of Georgia submitted its final database, which included samples taken from 1997 through 2001. This data set included 354 samples from eight new sampling stations, which were added to the Mercury in Marine Life Database. Some samples were taken at existing sites already documented in the database (for instance, from the NLFWA database).

Contact: Randy Manning, Georgia Department of Natural Resources
Phone: 706-369-6376
E-mail: randy_manning@mail.dnr.state.ga.us

New York–Long Island Sound Study (added after October 2002)
Fish tissue residue data were collected by the New York Department of Environmental Conservation in Long Island Sound from 1975 to 1996. These data were downloaded from the EPA Region 1 Web site in August; however, the downloaded material did not contain sufficient metadata (specifically, a key to the species codes was not available). The missing metadata were received in late October 2002, and 437 samples from 120 sites were added to the Mercury in Marine Life Database. Based on the latitude /longitude coordinates, it was determined that some of the samples were taken in the New Jersey portion of New York Harbor. Latitude/longitude coordinates were not available for half of all sampling stations; therefore, the state waters (New York or New Jersey) from which the sample was collected are not definitely known for all samples.

Contact: Larry Skinner, New York State Department of Environmental Conservation
Phone: 518-402-8969
E-mail: lxskinne@gw.dec.state.ny.us
Web site: http://www.epa.gov/region01/eco/lis/data.htm

Maine (added after October 2002)
RTI obtained data from the Maine Department of Environmental Protection in December 2002. The 202 samples from 19 stations were added to the Mercury in Marine Life Database with the prefix "ME-". Latitude/longitude coordinates were not available for any of the sample sites. The state noted that it is currently working on obtaining coordinates for its sampling sites.

Contact: Barry Mower, Maine Department of Environmental Protection
Phone: 207-287-7777
E-mail: barry.f.mower@state.me.us

Florida (added after October 2002)
Originally, Florida provided data that were added to the Mercury in Marine Life Database prior to October 2002. However, because the state did not provide the sampling date for each sample, only the samples from stations that could be identified as not being duplicates of samples from GMP stations were added (the GMP database includes data from the same Florida source for earlier years). Florida did send date information after the initial cutoff date for adding data to the Mercury in Marine Life Database. These data were re-verified, and with the newly

obtained date information, additional samples could be added to the database. Overall, 214 samples from Florida were added. Latitude/longitude coordinates were not available for new sampling locations; however, in many cases, the samples were collected at sites already in the Mercury in Marine Life Database from the NLFWA or GMP projects, and coordinates were available for many of those stations.

Contact: George Henderson, Florida Fish and Wildlife Conservation Commission
Phone: 727-896-8626
E-mail: George.Henderson@fwc.state.fl.us

2.2 USGS PROGRAM PROVIDING MERCURY DATA FOR TERRESTRIAL VERTEBRATE SPECIES COLLECTED IN ESTUARINE WATERSHEDS

Acquisition of data sets for inclusion in the Mercury in Marine Life Database began in June 2002. During the data acquisition process, a USGS database, entitled *Contaminant Exposure and Effects - Terrestrial Vertebrates* (CEE-TV), developed by Barnett Rattner of the USGS Patuxent Wildlife Research Center, was identified. This database contained summary information (e.g., means or medians) extracted from the scientific literature on contaminant concentrations in the tissues of terrestrial vertebrates collected in estuarine watersheds nationwide. Dr. Rattner provided a subset of the database containing only information concerning mercury concentrations. Summary information included species, collection data, site coordinates, estuary name, hydrologic unit code, sample matrix, mercury concentration, biomarker and bioindicator responses, and reference source. Because of the summary nature of data aggregated in the CEE-TV mercury database, RTI did not aggregate the information into the Mercury in Marine Life Database, but created a separate data file for this information.

The CEE-TV mercury data files contain mercury tissue concentration information for amphibians, reptiles, birds, and mammals living in estuarine watersheds nationwide. Most mercury data values are presented on a wet weight basis; some are presented on a dry weight basis; and for some values, no information on wet weight or dry weight is provided. For the purpose of this report, only those data values that are provided on a wet weight basis were used in the analysis because appropriate dry weight conversion factors were not readily available for all of the different tissue types (matrices) analyzed in the database.

Contact: Barnett A. Rattner, USGS Patuxent Wildlife Research Center
Phone: 301-497-5671
E-mail: Barnett_Rattner@usgs.gov

Reference:

Rattner, B.A., J.L. Pearson, N.H. Golden, J.B. Cohen, R.M. Erwin, and M.A. Ottinger. 2000. Contaminant exposure and effects – Terrestrial vertebrates database: Trends and data gaps for Atlantic coastal estuaries. *Envirnonmental Monitoring and Assessment* 63:131–142.

2.3 DATA QUALITY CONSIDERATIONS

All data presented in this report were generously provided to the EPA's Office of Wetlands, Oceans, and Watersheds by various federal, regional, and state agencies or private organizations. The providers of these data sets aggregated for analysis in the Mercury in Marine Life Database are the primary data proprietors for their respective monitoring studies. Data quality considerations germane to this study include precision, accuracy, and comparability of mercury measurements in the Mercury in Marine Life Database. The quality of the data provided were assumed to be good; however, no attempt was made to describe all uncertainties associated with the individual data sets aggregated into the Mercury in Marine Life Database. For more information on the specific methods or QC procedures followed by the different data proprietors, their contact information, references, and Internet sites have been provided wherever possible. The primary goal of the Mercury in Marine Life Study was to identify appropriate monitoring data to address the questions enumerated in Section 1 of this document. RTI was not involved in the collection of any field data and must rely on the QC procedures the data proprietors used to ensure the precision, accuracy, and comparability of the measurements. If there were any doubts about the integrity of data in any of the data files, these data were not included in the Mercury in Marine Life Database.

2.3.1 Precision of Mercury Measurements

The precision of each unique mercury measurement contained in the Mercury in Marine Life Database is preserved as reported in the original data proprietor's source data set. The Mercury in Marine Life Database and GIS software used in compiling and analyzing the data allow the user to specify only the number of places to the right of the decimal point, and not the number of significant figures, for mean determinations and other mathematical calculations. Therefore, an inconsistent number of significant figures appear in this report and in the mercury occurrence maps and tables. Because current method detection limits (MDLs) for mercury analysis in fish and shellfish tissue range to 0.001 ppm (U.S. EPA, 2000b,c), to be conservative, the reader should evaluate all mercury values in this report assuming three significant figures.

2.3.2 Accuracy of Mercury Measurements

The accuracy of each unique mercury measurement is a measure of the closeness of the reported value to the true value (e.g., a certified reference standard). For mercury measurements contained in the Mercury in Marine Life Database, the accuracy of a measurement is preserved as reported in the original data proprietor's source data set. It was assumed that all laboratories used certified standard reference materials (SRM) to calibrate their analytical equipment to ensure accuracy of the resulting analytical measurements; however, the frequency with which the SRM were used to check the accuracy of the measurements could not be verified within the scope of this study.

2.3.3 Data Comparability

All data sets acquired for the Mercury in Marine Life Database were aggregated to enable a nationwide or coastwide analysis of mercury tissue contamination in various fish and shellfish species. Given differences in the field collection procedures, laboratory methods used (including the analytical methods, method detection limits as well as the differences in application of laboratory QC samples and use of standard reference materials), obtaining comparable analytical values for mercury in tissue is difficult to ascertain. Direct comparisons of analytical values generated by these different monitoring programs could be ensured only by evaluation of all programs using performance-based standards. To ensure absolute confidence in the comparability of the different laboratory data sets, a review of laboratory blanks and SRM data, as well as an evaluation of laboratory method detection limits, would be necessary. RTI determined that this information would have to be collected from the laboratory used by each of the data proprietors, an effort that was outside the scope of work for this project.

2.4 ASSUMPTIONS USED FOR REPORTING MERCURY MEASUREMENTS

2.4.1 Wet Versus Dry Weight Measurements

In this report and in the Mercury in Marine Life Database, all tissue mercury residue values are reported as parts per million (ppm) wet weight, which is equivalent to µg mercury/g tissue wet weight. Where mercury concentrations were reported in the original data set as dry weights, these values are maintained in the Mercury in Marine Life Database RESULTS_RAW table. All data analyses, however, were conducted by transforming dry weight values to wet weight values using a conversion factor of 0.2 (e.g., wet weight concentration = dry weight concentration x 0.2), as was recommended by Thomas O'Connor (NOAA) for the GMP report (Ache et al., 2000). Although other dry to wet weight conversion factors have been used for some shellfish species (Kawaguchi et al., 1999; O'Connor and Beliaeff, 1996), a conversion factor of 0.2 was used regardless of species and was taken to represent a reasonable approximation of the wet weight mercury concentration. Transformed values are reported in the RESULTS table of the Mercury in Marine Life Database.

2.4.2 Methylmercury Versus Total Mercury Measurements

Methylmercury is the predominant chemical form of mercury present in fish and shellfish that poses the greatest public health risk via consumption of seafood (NAS, 2000; Tollefson, 1989; U.S. EPA, 1997a; and WHO, 1990). It was assumed that all data sets aggregated into the Mercury in Marine Life Database reported values as total mercury (primarily because the cost of methylmercury analysis is two to three times higher than the cost for total mercury analysis). Only a few values were noted as methylmercury by the data providers, and those values were excluded for ease of comparison because total mercury values were also available for the same samples.

Because the methylmercury to total mercury ratio generally approaches unity in muscle tissue of top-level food chain predator fish, it is generally accepted that total mercury levels in fish tissue are reliable indicators of methylmercury concentrations (Bloom, 1992; Hueter et al., 1995; Kannan et al., 1998; Lasorsa and Allen-Gil, 1995). In their study of fish from south Florida estuaries, Kannan et al. (1998) reported that methylmercury contributed 83 percent of the total mercury concentration in fish muscle (average of all species) and that methylmercury concentrations were directly proportional to total mercury concentrations; however, the individual methylmercury to total mercury ratios ranged from 20 to 124 percent depending on the species. Many studies have also reported that mercury concentrations are directly related to the age of a fish or shellfish, with larger (older) individuals typically exhibiting higher mercury tissue levels than smaller (younger) individuals within the same species (Hueter et al., 1995). In addition, the ratio of methylmercury to total mercury in fish tissue typically increases as the fish ages.

A summary of methylmercury to total mercury ratios in muscle tissue reported for estuarine and marine fish worldwide is shown in Table 2-2. Although the mean ratios for many of the top-level predatory species approach unity, there is considerable variability in the range of values found for some species, and the ratio can be significantly lower than unity. The percentage of methylmercury in fish muscle tissue appears to be dependent on several factors, including fish species, size or weight class, age, feeding habits, position in the food chain, and site-specific considerations to which the fish is exposed (e.g., the form of mercury) (Hueter et al., 1995; Kannan et al., 1998; Lasorsa and Allen-Gil, 1995).

In contrast to this ratio of methylmercury to total mercury concentration in finfish, several studies have reported that the ratio of methylmercury to total mercury in bivalve molluscs and other invertebrate species is much lower. Lasorsa and Allen-Gil (1995) reported methylmercury to total mercury percentages of 15 to 80 percent for the blue mussel (*Mytilus edulis*). Kawaguchi et al. (1999) reported that, on average, only about 50 percent of the total mercury in oysters was methylmercury.

2.4.3 Mercury Concentration Values below the Method Detection Limit

Some mercury residue values in the Mercury in Marine Life Database are reported as below the MDL. When the data proprietor provided an MDL value for the data set, the values below the MDL were evaluated and analyzed as representing ½ MDL. This is a moderately conservative procedure with respect to using either a value of zero or the value of the MDL in all calculations for values below the MDL and is the method prescribed by the EPA OW in Volume 1 of the *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* (U.S. EPA, 2000b). In many cases, a value was reported for mercury, with a symbol or code for "below detection limit." It was assumed that these values represented the actual detection limit. Samples below the detection limit are noted in the RESULTS_RAW table of the Mercury in Marine Life Database. Values in the RESULTS table have been transformed based on the ½ MDL rule, where appropriate.

Table 2-2. Summary of Methylmercury/Total Mercury Ratios Reported in Muscle Tissue of Various Estuarine and Marine Fish

Source	Ecosystem and Location	Fish Species	MethylHg/ Total Hg Ratio Mean (range)
Bloom (1992)	Marine fish were either collected from Puget Sound or purchased from fish markets, but were of Alaskan origin except for blue marlin and swordfish; Washington, USA	Lingcod (*Ophiodon elongatus*)	94%
		Chinook salmon (*Oncorhynchus tshawytscha*)	105%
		Blue marlin (*Makaira nigricans*)	95%
		Striped seaperch (*Embiotoca lateralis*)	86%
		Dover sole (*Microstomus pacificus*)	98%
		Sablefish (*Anoplopoma fimbria*)	112%
		Swordfish (*Xiphias gladius*)	100%
		English sole (*Pleuronectes vetulus*)	95%
Zhang et al. (2001)	Salmon were collected returning to spawn in four rivers (Yukon, Kuskokwim, Nushagak, and Kvichak Rivers); Alaska, USA	Chum salmon (*Oncorhynchus keta*)	(76-81%)
		Coho salmon (*Oncorhynchus kisutch*)	(67-87%)
		Chinook salmon (*Oncorhynchus tshawytscha*)	(72-85%)
		Sockeye salmon (*Oncorhynchus nerka*)	(65-79 %)
Kannan et al. (1998)	Estuarine species; south Florida coast, USA	Hardhead catfish (*Arius felis*)	(63-124%)
		White grunt (*Haemulon plumieri*)	(100-103%)
		Gafftopsail catfish (*Bagre marinus*)	(20-96%)
		Sand seatrout (*Cynoscion arenarius*)	85%
		Sand perch (*Dipectrum formosum*)	(83-100%)
		Pinfish (*Lagodon rhomboides*)	(63-86%)
		Lane snapper (*Lutjanus synagris*)	(92-103%)
		Spot (*Leiostomus xanthurus*)	(54-93%)
		Pigfish (*Orthopristis chrysoptera*)	79%
Francesconi and Lenanton (1992)	Princess Royal Harbor, a marine bay polluted by superphosphate plant effluents; western Australia	Mean (range) of all species	96% (88-107%)
		Cobbler	>96
		Blue-spotted flathead	>94
		King George whiting	>95
		Australian herring	>95
		Brown spotted wrasse	>95
		Six-spined leatherjacket	>95
Andersen and Depledge (1997)	Marine species; coastal waters of the Azores	Albacore tuna (*Thunnus alalunga*)	92% (86-97%)
		Skipjack tuna (*Euthynnus pelamis*)	94% (82-100%)
		White seabream - 1993 data	89% (71-100%)
		White seabream - 1994 data	91% (86-99%)
		Scabbard fish	80% (63-93%)
		Forkbeard	86% (67-99%)
		Rockfish	86% (76-91%)
		Red mullet	89% (81-100%)
		Horse mackerel	83% (70-100%)
		Grey mullet	91% (77-100%)
		Blackspot seabream	90% (86-94%)
		Conger	84% (73-93%)
		Spotted moray	75%
		Common seabream	87%

(continued)

Table 2-2. (continued)

Source	Ecosystem and Location	Fish Species	MethylHg/ Total Hg Ratio mean (range)
Joiris et al. (1997)	Marine demersal species; Greenland and Barents Sea, North Atlantic	Long rough dab (*Hippoglossoides platessoides*) Greenland halibut (*Reinhardtius hippoglossoides*) Halibut (*Hippoglossus hippoglossus*) Starry ray (*Raja radiata*) Atlantic cod (*Gadus morhua*) Plaice (*Pleuronectes platessa*)	(3 ≥ 100%) (1-53%) (24 ≥ 100%) 4% (6-57%) (43-100%)
Storelli et al. (2002a)	Shark species; Mediterranean Sea, Italy	Blackmouth dogfish (*Galeus melastomus*) Small spotted shark (*Scyliorhinus canicula*) Kitefin shark (*Dalatias licha*) Gulper shark (*Centrophorus granulosus*) Longnose spurdog (*Squalus blainvillei*) Velvet belly (*Etmopterus spinax*) Smoothhound (*Mustelus mustelus*) Sharpnose sevengill (*Heptranchias perlo*) Hammerhead (*Sphyrna zygaena*)	(43-100%) (77-90%) (78-95%) (89-97%) (81-98%) (86-100%) (69-80%) (86-100%) 88%
Storelli et al. (2002b)	Tuna species; Mediterranean Sea, Italy	Albacore (*Thunnus alalunga*) Bluefin tuna (*Thunnus thynnus*)	91% (77-100%) 91% (75-100%)
Storelli et al. (2003)	Six marine fish species; Mediterranean Sea, Italy	Long nose skate Thornback ray Winter skate Starry ray Blue whiting Striped mullet	100% 100% 100% 98% 96% 95%

2.4.4 Mercury Concentration Values Reported as Zero

Some mercury residue values in the Mercury in Marine Life Database were reported by the data proprietors as zero ppm. These samples were excluded from analyses; if these values represent less than the MDL, the value ½ MDL could not be determined because detection limits were rarely given. This is a very rare occurrence in the Mercury in Marine Life Database, accounting for only a small number of records.

SECTION 3.0

SUMMARY OF FINDINGS

This section of the report presents the results of an evaluation of the extent of mercury monitoring in estuarine and marine waters nationwide and the occurrence of mercury contamination in our nation's fisheries resources based on currently available monitoring data in the Mercury in Marine Life Database. The analysis concentrated on recreational fish species because sampling data were not available for many of the commercial fishery species. Appendices A, B, and C present associated information developed for this report, including an analysis and ranking of commercial and recreational fishery landings, a summary of the types of fish advisories that have been issued at the federal and state levels to protect the consumer from the health effects of mercury-contaminated fish and shellfish, and reviews of consumption rates of seafood for the general population and for various subpopulations.

The Mercury in Marine Life Database is a compilation of data sets acquired from five federal programs, four regional assessments, and numerous state programs, representing a wide range of monitoring methods and objectives. Some samples were collected to support ecological community monitoring objectives, others were collected to support public health risk assessments, and still others were collected to support long-term trend analysis objectives. In addition, some samples were collected as part of unbiased sampling plans using random station selection, whereas other sampling plans were targeted to ascertain mercury contaminant levels at sites of known contamination. Depending on the monitoring resources available to the different programs and the monitoring objectives, some geographic areas were sampled routinely for a given species or a variety of species over an extensive period of time; other areas were sampled infrequently or on a one-time basis only; and some areas were not sampled at all. The number of samples collected at each station over the evaluated timeframe of the study period (1990–2001) is shown in Appendix G for the three coastal areas. These figures confirm that at 40 to 48 percent of the sites in each coastal area (almost 48%, 42%, and 40% in the Atlantic, Gulf, and Pacific, respectively) only one sample was collected over the timeframe of the current study period. However, multiple samples were collected at most sites in each coastal area. The various monitoring programs also used different types of samples; some programs used composite samples, others collected and analyzed individual specimens, and others did not provide information on the type of samples collected. Interpretation of the results of this report should be tempered by the reader's recognition of these basic differences in monitoring objectives and sampling design; however, these monitoring study differences do not preclude analysis of the data sets compiled for the purpose of this study.

3.1 EXTENT OF COASTAL MONITORING

The extent of coastal monitoring reported in the current report is based on an analysis of the Mercury in Marine Life Database as it existed in October 2002. Several data sets have been added to the original version of the Mercury in Marine Life Database since that time; however, summary statistics for these additional data are not reported here.

3.1.1 Atlantic Coast

In the Mercury in Marine Life Database (Version 1, October 2002), there are 4,990 data entries for the Atlantic coastal area. These data were collected from a total of 1,254 distinct stations; however, discrete locational information (latitude/longitude) was not available for some of these stations (Table 3-1). In the Atlantic coastal region, data were available from the Gulf of Maine south to the Florida Keys (Figure 3-1). Almost all of the monitoring in the Atlantic region, however, was confined to the territorial sea or localized in major estuaries, such as Massachusetts Bay, (MA), Long Island Sound (CT/NY), Delaware Bay (DE), Albemarle and Pamlico Sounds (NC), and Indian River Bay (FL). Of the 1,183 mappable monitoring stations, 1,125 stations (95%) are within the territorial sea, and 58 stations (5%) are outside the boundaries of the territorial sea.

Although monitoring in coastal areas seems to be widespread, many of the sampling stations shown are part of NOAA's Mussel Watch Program, which monitors mercury concentrations in bivalve molluscs, primarily the blue mussel and American oyster, on the Atlantic coast. Sampling for finfish species is not as widespread because it is typically an activity performed by the individual states.

Table 3-1. Spatial Distribution of Monitoring Stations Where High-Resolution Site Information (Latitude/Longitude) Is Available

Coastal Region	Number of Monitoring Stations within the Territorial Sea[a]	Number of Monitoring Stations Outside the Territorial Sea[a]	Total Number of Mappable Monitoring Stations[a]	Total Number of Monitoring Stations
Atlantic	1,125	58	1,183	1,254
Gulf	1,439	45	1,484	1,736
Pacific	627	16	643	676

[a] Monitoring stations defined by latitude/longitude coordinates

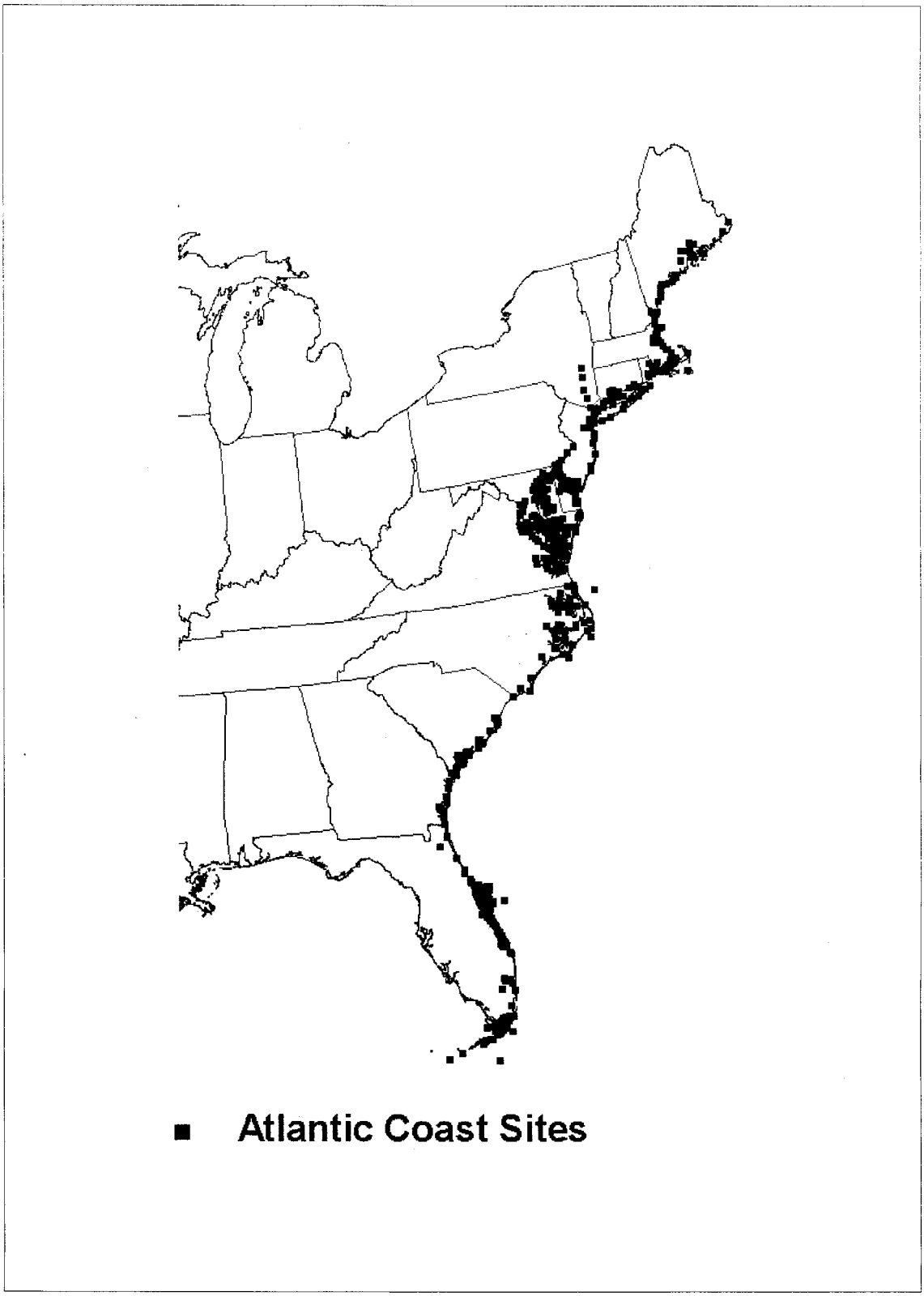

Figure 3-1. Sampling station locations in the Atlantic coast region.

3.1.2 Gulf Coast

In comparison to the Atlantic coast, there were almost 45 percent more data entries (7,224) in the Mercury in Marine Life Database for the Gulf coastal area. These data were collected from a total of 1,736 distinct stations (Table 3-1). Data were available from the Florida Keys to the Gulf coast of Texas at the U.S.-Mexican border (Figure 3-2). Just as they were for the Atlantic region, monitoring sites were primarily confined to the estuaries and territorial sea, with only a few extending out to include areas in the OCS and EEZ. Relatively extensive sampling was conducted in several major NEP estuaries, including Charlotte Harbor and Tampa Bay (FL), Mobile Bay (AL), Barataria and Terrebonne Bays (LA), and Galveston and Corpus Christi Bays (TX). Of the 1,484 mappable monitoring stations, 1,439 stations (97%) are within the territorial sea, and 45 stations (3%) are outside the boundaries of the territorial sea.

Although monitoring in coastal areas seems to be widespread, many of the sampling stations shown are part of NOAA's Mussel Watch Program, which monitors mercury concentrations in bivalve molluscs, primarily the American oyster, on the Gulf coast. Sampling for finfish species is not as widespread because it is typically performed by the individual states. The large number of data entries acquired for the Gulf of Mexico region was facilitated by a previous study by Ache et al. (2000), who had done extensive work in compiling existing monitoring information for this coastal area.

3.1.3 Pacific Coast

The smallest amount of mercury tissue data in the Mercury in Marine Life Database was available for the Pacific region. There were only 2,579 data entries collected from a total of 676 distinct stations (Table 3-1). Data were available from the U.S.-Mexican border north to Puget Sound and for a number of stations in Alaska and Hawaii (Figure 3-3). Almost all of the monitoring in the Pacific region, however, was confined to the territorial sea or localized in major estuaries, such as the San Franscico Bay (CA) or in Puget Sound (WA). Of the 643 mappable monitoring stations, 627 stations (98%) are within the territorial sea, and 16 stations (2%) are outside the boundaries of the territorial sea.

Although monitoring in the Pacific coastal areas seems to be relatively widespread, many of the sampling stations are part of NOAA's Mussel Watch Program, which monitors mercury concentrations in bivalve molluscs, primarily the blue mussel, California mussel, and the Pacific oyster, on the Pacific coast. Sampling for finfish species is not as widespread because it is typically performed by the individual states. Much of the mercury sampling that has been done on the West Coast has been concentrated primarily in the two major estuaries, San Francisco Bay and Puget Sound.

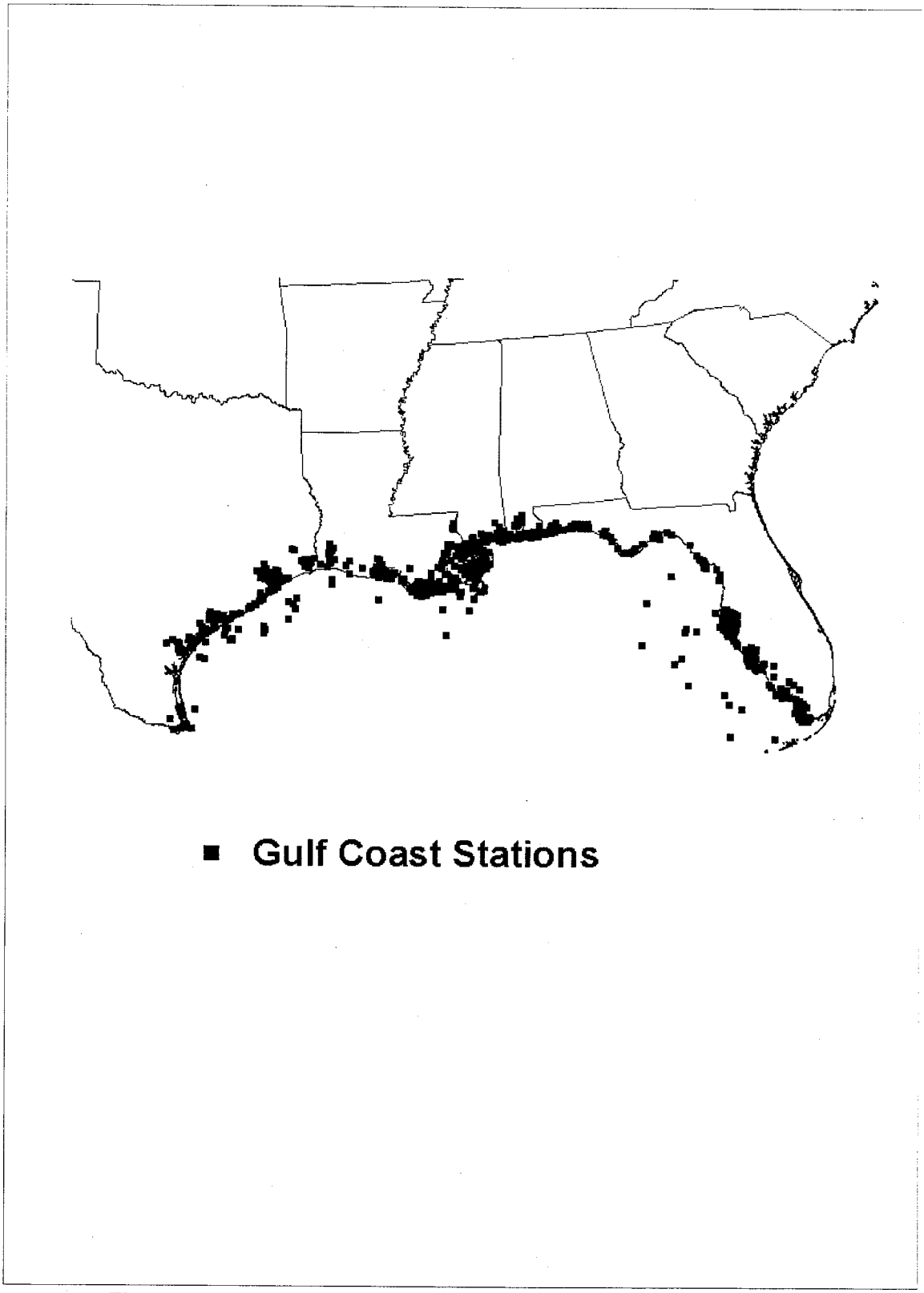

Figure 3-2. Sampling station locations in the Gulf coast region.

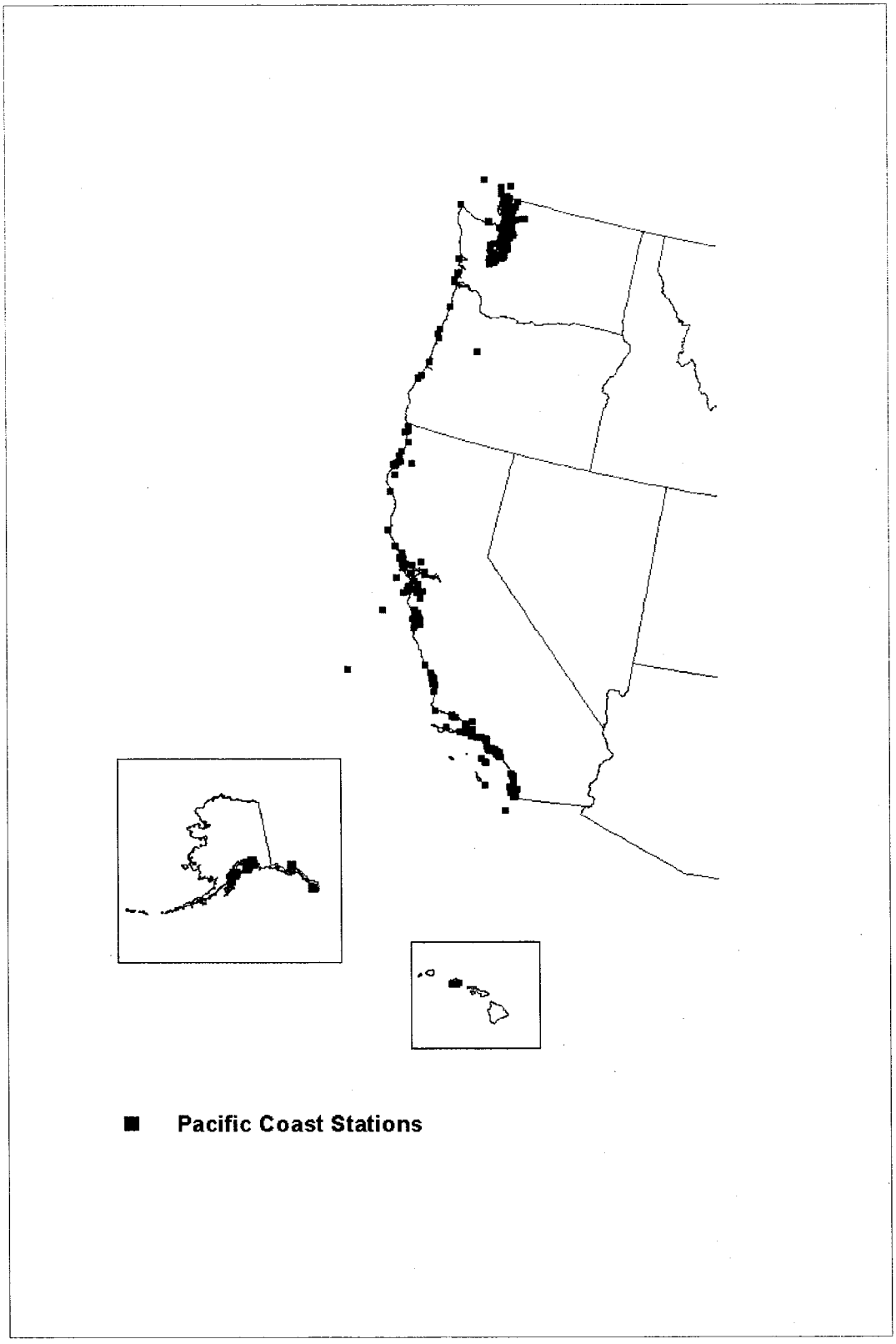

Figure 3-3. Sampling station locations in the Pacific coast region.

3.2 OCCURRENCE OF MERCURY IN IMPORTANT RECREATIONAL SPECIES

Mercury is a common element found widely in edible tissues of many of the estuarine and marine fish and shellfish harvested from the coastal waters of the United States. Tables 3-2 through 3-5 present the distribution of median, mean, and maximum mercury concentrations for the 25 most-harvested recreational species/groups analyzed in this study, as well as important commercially harvested shellfish species. For 20 of the 75 species/groups in the Atlantic, Gulf of Mexico, and Pacific regions (combined), the median mercury concentration exceeded the EPA water quality criterion for methylmercury in fish tissue (0.3 ppm).

Because data were available for a greater number of recreationally harvested species than for commercial species, the following assessment of the occurrence of mercury is presented only for the 25 most highly ranked recreationally harvested species in each of the three coastal regions. Because statistics on recreational landings of shellfish are not part of the NMFS fishery survey, these species were not included in the analysis; however, levels of mercury in several of the more important commercial shellfish species are also discussed. Statistics are provided on the median, mean, and maximum concentration of mercury observed for key recreational species for each coastal region, including the number of samples present in the Mercury in Marine Life Database. Statistics on mercury concentrations for all species are provided in Appendix H.

The EPA methylmercury criterion value is given in ppm methylmercury, whereas the tissue concentration values available in the Mercury in Marine Life Database are reported in ppm of total mercury. As was shown in Table 2-2, although the ratio of methylmercury to total mercury is often greater than 90 percent for some species, particularly among older and large individuals in populations of top level predatory species, this ratio is highly variable in other species. For the purpose of this analysis and to be conservative with respect to assessment of the potential human health risks of mercury, it is assumed that all of the mercury present in fish and shellfish tissue is present as the more toxic methylmercury.

3.2.1 Atlantic Coast

In the Atlantic region, mercury tissue concentrations were reported for 129 separate fish and shellfish species. The median, mean, and maximum total mercury concentration for eight, nine, and 15 Atlantic species, respectively, exceeded the EPA methylmercury criterion (Table 3-2). The median mercury concentration for blackfin tuna (1.162 ppm), little tunny (0.946 ppm), king mackerel (0.665 ppm), sharks (0.610 ppm), greater amberjack (0.463 ppm), spotted seatrout (0.440 ppm), bluefish (0.350 ppm), and Spanish mackerel (0.343 ppm) exceeded the EPA methylmercury criterion of 0.3 ppm in fish tissue. The median mercury concentration for blackfin tuna also exceeded the FDA action level (1.0 ppm), although this value represented only one sample. Maximum mercury concentrations for 15 species exceeded the EPA methylmercury criteria, and eight of those species also exceeded the FDA action level.

Table 3-2. Total Mercury Concentrations for the 25 Most-Harvested Recreational Species in the Atlantic Coast Fishery

Rank	Species	Median mercury concentration (ppm)	Mean mercury concentration[1] (ppm)	Maximum mercury concentration [2] (ppm)	Number of samples in MML Database
1	Striped bass	0.100	0.154	**0.840**	215
2	Other tunas/mackerels [3]				
	blackfin tuna	**1.162**	**1.162**	**1.162**	1
	cero	0.150	0.188	0.264	3
3	Summer flounder	0.033	0.036	0.110	34
4	Bluefish	**0.350**	**0.401**	**1.600**	174
5	Dolphins	0.056	0.072	0.191	14
6	Atlantic croaker	0.060	0.090	**0.550**	58
7	King mackerel	**0.665**	**0.979**	**3.500**	118
8	Weakfish	0.200	0.265	**0.840**	61
9	Atlantic cod	ND	ND	ND	ND
10	Other fishes	NA	NA	NA	NA
11	Scup	0.029	0.033	0.072	10
12	Black sea bass	0.150	0.150	0.160	2
13	Atlantic mackerel	ND	ND	ND	ND
14	Tautog	ND	ND	ND	ND
15	Spot	0.081	0.086	**0.360**	93
16	Little tunny	**0.946**	**1.178**	**2.150**	5
	Atlantic bonito	ND	ND	ND	ND
17	Spotted seatrout	**0.440**	**0.538**	**2.500**	373
18	Sharks	**0.610**	**0.808**	**6.900**	396
19	Sheepshead	0.150	0.186	**0.490**	53
20	Kingfishes	0.076	0.080	0.240	19
21	Red drum	0.170	**0.311**	**2.700**	234
22	Spanish mackerel	**0.343**	**0.371**	**1.000**	73
23	Winter flounder	0.013	0.026	0.090	9
24	Black drum	0.160	0.178	**0.850**	60
25	Greater amberjack	**0.463**	**0.508**	**0.990**	7

[1] The mean mercury concentration is the mean of all samples for the species or group
[2] The maximum mercury concentration is the maximum concentration of all samples
[3] Mercury concentrations for these two species were listed separately because of the difference in mean mercury concentrations reported

Note: Although it has been shown that levels of total mercury/methylmercury are not 1:1 for all finfish species, to be conservative of human health concerns, all total mercury values are assumed to represent equivalent concentrations of methylmercury. All mercury values shown in bold exceed the EPA water quality criterion for methylmercury (0.3 ppm)
ND=No data available for this species
NA=Not applicable, as category "other fishes" is imprecise

Table 3-3. Total Mercury Tissue Concentrations in Various Shellfish Species

Atlantic Coast

Rank[1]	Species	Median mercury concentration (ppm)	Mean mercury concentration[2] (ppm)	Maximum mercury concentration[3] (ppm)	Number of samples in MML Database
63	Blue mussel	0.044	0.061	**0.500**	641
42	American oyster	0.020	0.036	0.250	453
3	Blue crab	0.170	**0.432**	**3.680**	86

Gulf of Mexico

Rank[1]	Species	Median mercury concentration (ppm)	Mean mercury concentration[2] (ppm)	Maximum mercury concentration[3] (ppm)	Number of samples in MML Database
5	American oyster	0.042	0.080	**0.720**	1,634
4	Blue crab	0.060	0.141	**2.650**	239

Pacific Coast

Rank[1]	Species	Median mercury concentration (ppm)	Mean mercury concentration[2] (ppm)	Maximum mercury concentration[3] (ppm)	Number of samples in MML Database
82	Blue mussel	0.018	0.025	0.200	340
175	California mussel	0.051	0.055	**0.387**	93
40	Pacific oyster	0.054	0.056	0.144	64

[1] The rank is based on the annual weight of commercial fishery landings for the species for the appropriate coastal region (see Appendix A, Attachment 1, Tables 2 through 4).
[2] The mean mercury concentration is the mean of all samples.
[3] The maximum mercury concentration is the maximum concentration of all samples.
Note: Although it has been shown that levels of total mercury/methylmercury are not 1:1 for all finfish species, to be conservative of human health concerns, all total mercury values are assumed to represent equivalent concentrations of methylmercury. All mercury values shown in bold exceed the EPA water quality criterion for methylmercury (0.3 ppm)

Table 3-4. Total Mercury Concentrations for the 25 Most-Harvested Recreational Species in the Gulf Coast Fishery

Rank	Species	Median Mercury Concentration (ppm)	Mean mercury concentration (ppm)	Maximum mercury concentration (ppm)	Number of Samples in MML
1	Spotted seatrout	0.280	**0.320**	**1.500**	546
2	Red drum	0.191	**0.497**	**4.620**	590
3	*Mycteroperca* groupers	0.293	**0.373**	**1.400**	94
	black grouper	**0.940**	**0.907**	**1.400**	7
	scamp grouper	0.280	0.285	**0.590**	24
4	Red snapper	0.112	0.093	0.159	13
5	Sheepshead	0.117	0.180	**1.730**	224
6	Dolphins	0.057	0.126	**0.490**	29
7	King mackerel	**0.875**	**1.085**	**4.470**	385
8	Sand seatrout	**0.450**	**0.475**	**1.200**	99
9	Spanish mackerel	**0.470**	**0.527**	**2.900**	204
10	Black drum	0.150	**0.443**	**6.620**	233
11	Other fishes	NA	NA	NA	NA
12	Mullets	0.031	0.063	**0.780**	87
13	Pinfishes	0.150	0.131	0.170	6
14	*Epinephelus* groupers	0.034	**0.560**	**3.300**	94
15	White grunt	0.230	0.230	0.270	2
16	Other tunas/mackerels	**1.040**	**0.767**	**1.100**	5
17	Gray snapper	0.160	0.185	**0.620**	159
18	Greater amberjack	**0.490**	**0.541**	**1.100**	24
19	Kingfishes	0.150	0.197	**0.780**	66
20	Sharks	**0.510**	**0.704**	**5.400**	178
21	Southern flounder	0.058	0.128	**1.700**	146
22	Saltwater catfishes	0.106	0.244	**1.800**	359
	hardhead catfish	0.099	0.167	**1.631**	190
	gafftopsail catfish	0.220	**0.354**	**1.800**	153
23	Little tunny	**0.964**	**0.964**	**0.964**	1
	Atlantic bonito	ND	ND	ND	ND
24	Blue runner	0.180	0.180	0.180	1
25	Crevalle jack	**0.496**	**0.612**	**1.800**	102

[1] The mean mercury concentration is the mean of all samples for the species or group
[2] The maximum mercury concentration is the maximum concentration of all samples
Note: Although it has been shown that levels of total mercury/methylmercury are not 1:1 for all finfish species, to be conservative of human health concerns, all total mercury values are assumed to represent equivalent concentrations of methylmercury. All mercury values shown in bold exceed the EPA water quality criterion for methylmercury (0.3 ppm)
ND=No data available for this species
NA=Not applicable, as category "other fishes" is imprecise

Table 3-5. Total Mercury Concentrations for the 25 Most-Harvested Recreational Species in the Pacific Coast Fishery

Rank	Species	Median Mercury Concentration (ppm)	Mean Mercury Concentration[1] (ppm)	Maximum Mercury Concentration[2] (ppm)	Number of Samples in MML
1	Other tunas/mackerels	ND	ND	ND	ND
2	Yellowtail	ND	ND	ND	ND
3	Black rockfish	0.136	0.144	0.231	3
4	Pacific barracuda	ND	ND	ND	ND
5	Lingcod	**0.334**	**0.334**	**0.334**	**1**
6	California halibut	0.251	0.277	**0.470**	11
7	Other rockfishes	0.252	**0.311**	**1.440**	280
8	Barred sand bass	0.091	0.091	0.161	2
9	Blue rockfish	0.068	0.068	0.116	4
10	Other flounders	0.062	0.069	**0.470**	330
11	Kelp bass	0.155	0.159	0.244	6
12	Yellowtail rockfish	ND	ND	ND	ND
13	Sturgeons	0.223	0.227	**0.354**	9
14	Striped bass	**0.442**	**0.457**	**0.895**	**26**
15	Other croakers	0.089	0.120	**0.344**	54
16	Dolphins	ND	ND	ND	ND
17	Bocaccio	ND	ND	ND	ND
18	Barred surfperch	0.044	0.066	0.161	26
19	California scorpionfish	0.050	0.050	0.050	2
20	Canary rockfish	ND	ND	ND	ND
21	Cabezon	ND	ND	ND	ND
22	Copper rockfish	0.100	0.165	**0.690**	28
23	Dogfish sharks	ND	ND	ND	ND
24	California sheephead	0.169	0.168	0.209	6
25	Sharks	**0.845**	**0.803**	**1.705**	35

[1] The mean mercury concentration is the mean of all samples for the species or group
[2] The maximum mercury concentration is the maximum concentration of all samples
Note: OTHER FISHES was the number 1 ranked recreational group and was deleted from the list as too general a category so that the sharks could be included as the 25th ranked recreational fisheries group.

Note: Although it has been shown that levels of total mercury/methylmercury are not 1:1 for all finfish species, to be conservative of human health concerns, all total mercury values are assumed to represent equivalent concentrations of methylmercury. All mercury values shown in bold exceed the EPA water quality criterion for methylmercury (0.3 ppm)
ND=No data available for this species or group
NA=Not applicable as category "other fishes" is imprecise

Although mercury tissue concentration values were very numerous (100 or more values in the database) for six species and moderately numerous (20 to 99 values in the database) for seven species, values for nine species were scarce (1 to19 values in the database). Along the Atlantic coast, only minimal data were available for dolphin (14 records), scup (10 records), winter flounder (9 records), black sea bass (2 records), and tuna (1 record). No data were available for four species among the 25 most-harvested Atlantic species. These species included Atlantic cod, Atlantic mackerel, Atlantic bonito, and tautog.

With respect to Atlantic shellfish species, data in the Mercury in Marine Life Database were available primarily for the blue mussel, American oyster, and blue crab. The median, mean, and maximum mercury tissue concentrations reported for the Atlantic coastal region are shown in Table 3-3. Bivalve molluscs typically exhibited much lower mercury concentrations than fish species because they typically consume phytoplankton and zooplankton that are lower on the food chain. Mercury concentrations were highest for the blue crab (mean exceeded the EPA criterion and the maximum exceeded the FDA action level), which is a scavenger that often feeds on dead fish and other invertebrates. Little or no information on mercury concentrations was available for several highly ranked commercial shellfish species, including American lobsters, Atlantic surf clams, longfin squid, ocean quahog, northern shortfin squid, sea scallops, white shrimp, and quahog clams (hard clams) (see Appendix A, Attachment 1, Table 2).

3.2.2 Gulf Coast

In the Gulf of Mexico, mercury tissue concentrations were reported for 108 separate fish and shellfish species. The median, mean, and maximum total mercury concentration for nine, 15, and 24 species, respectively, exceeded the EPA methylmercury criterion (Table 3-4). The median mercury concentration for other tuna/mackerel (1.040 ppm), little tunny (0.964 ppm), black grouper (0.940 ppm), king mackerel (0.875 ppm), sharks (0.510 ppm), crevalle jack (0.496 ppm), greater amberjack (0.490 ppm), sand seatrout (0.450 ppm), and Spanish mackerel (0.470 ppm) exceeded the EPA methylmercury criterion of 0.3 ppm in fish tissue. The median mercury concentration for other tuna/mackerel also exceeded the FDA action level, although this value represented only five samples. Maximum mercury concentrations for 24 species exceeded the EPA methylmercury criteria, and 18 of those species exceeded the FDA action level.

Although mercury tissue concentration values were very numerous (100 or more values in the database) for 13 species and moderately numerous (20 to 99 values in the database) for eight species, values for seven species were scarce (1 to19 values in the database). Along the Gulf coast, only minimal data were available for dolphin (29 records), red snapper (13 records), pinfish (6 records), black grouper (5 records), other tuna and mackerel (5 records), white grunt (2 records), scamp grouper (2 records), little tunny (1 record), and blue runner (1 record). No data were available for one species among the 25 most-harvested Atlantic species, Atlantic bonito.

With respect to Gulf coast shellfish species, data in the Mercury in Marine Life Database were available primarily for the American oyster and blue crab. The median, mean, and maximum mercury tissue concentrations reported for the Gulf coastal region are shown in Table 3-3. Bivalve molluscs typically exhibited much lower mercury concentrations than fish species because they typically consume phytoplankton and zooplankton that are lower on the food chain. Mercury concentrations were highest (as they were in the Atlantic) for the blue crab (maximum concentration exceeded the FDA action level), which is a scavenger that often feeds on dead fish and other invertebrates. Little or no information on mercury concentrations was available for several highly ranked commercial shellfish species, including white, brown and pink shrimp; Florida stone crabs; Caribbean spiny lobsters; and rock shrimp (see Appendix A, Attachment 1, Table 3).

3.2.3 Pacific Coast

In the Pacific region, mercury tissue concentrations were reported for only 91 separate fish and shellfish species. The median, mean, and maximum total mercury concentration for three, four, and nine species, respectively, exceeded the EPA methylmercury criterion (Table 3-5). The median mercury concentration for sharks (0.845 ppm), striped bass (0.442 ppm), and lingcod (0.334 ppm) exceeded the EPA methylmercury criterion of 0.3 ppm in fish tissue. The median mercury concentration did not exceed the FDA action level for any species or group. Maximum mercury concentrations for nine species exceeded the EPA methylmercury criterion and for two species/groups (other rockfish and sharks) exceeded the FDA action level. Although there is much less monitoring data available for the Pacific, the level of mercury contamination in Pacific coast species appears to be slightly lower overall than the level in the Atlantic and Gulf coast recreational fisheries species.

Mercury tissue concentration values were very numerous (100 or more values in the database) for only two species and moderately numerous (20 to 99 values in the database) for five species; values for nine species were scarce (1 to19 values in the database). Along the Pacific coast, only minimal data were available for California halibut (11 records), kelp bass (6 records), California sheephead (6), blue rockfish (4 records), sturgeon (9 records), black rockfish (3 records), barred sand bass (2 records), California scorpionfish (2 records), and lingcod (1 record), In addition, there are no data records for nine species, including yellowtail, other tuna/mackerel, Pacific barracuda, yellowtail rockfish, dolphin, bocaccio, canary rockfish, cabezon, and dogfish sharks. Much less monitoring data were available for species in the Pacific coast region than for either the Atlantic coast or Gulf of Mexico.

With respect to Pacific shellfish species, data in the Mercury in Marine Life Database were available primarily for the blue mussel, California mussel, and Pacific oyster. The median, mean, and maximum mercury tissue concentrations reported for the Pacific coastal region are shown in Table 3-3. All these bivalve molluscs exhibited much lower mercury concentrations than fish species because they typically consume phytoplankton and zooplankton that are lower on the food

chain, although the maximum concentration exceeded the EPA criterion for California mussels. Little or no information on mercury concentrations was available for several highly ranked commercial shellfish species, including California market squid, snow crab, Dungeness crab, and ocean shrimp (see Appendix A, Attachment 1, Table 4).

3.2.4 Conclusions

There is no consistent geographic coverage in tissue monitoring for the majority of the species/species-groups analyzed in this study. The American oyster on the Atlantic and Gulf coasts and the blue mussel on the Atlantic and Pacific coasts, monitored through the federal NOAA Mussel Watch Program, are the exceptions.

Overall, the species that rank highest in average annual recreational fisheries landings in the various coastal regions are monitored for mercury by one or more states within the species geographic range. However, there are several high-ranking recreational species for which little or no sampling has been conducted as part of any federal, regional, or state program since January 1990. Acquisition of additional mercury monitoring data for these undermonitored or unmonitored species is a critical data need.

3.3 OCCURRENCE OF MERCURY IN TERRESTRIAL VERTEBRATES

This section reviews information on the tissue concentrations of terrestrial vertebrates inhabiting estuarine watersheds throughout the United States. During the data acquisition phase of the Mercury in Marine Life Project, Barnett Rattner of the USGS Patuxent Wildlife Research Center in Laurel, MD, provided his CEE-TV database. Although this database has not yet been aggregated into the Mercury in Marine Life Database, a preliminary analysis of CEE-TV data is presented at this time. In general, in each of the vertebrate classes, the species exhibiting the highest mercury tissue concentrations are top-level fish-eating carnivores, while more omnivorous species (consuming fish and inverbrates) and herbivorous (plant-eating) species generally have lower mercury tissue concentrations.

The CEE-TV database contains information on mercury tissue concentrations collected from terrestrial organisms that lived in estuarine watersheds, including amphibians, reptiles, birds, and mammals. Mercury concentrations are reported in this database as wet weight or dry weight, or the method was not specified. Because of this, we chose to use only the data that reported mercury on a wet weight basis because dry to wet weight conversion factors were not available for all tissue types reported. The summary findings are presented in Table 3-6.

3.3.1 Amphibians

Although data for one amphibian were reported in the CEE-TV database, the mercury tissue concentration was not given in units of wet weight.

3.3.2 Reptiles

Mercury concentrations were available for five reptilian species, including the American alligator, American crocodile, cottonmouth, diamondback water snake, and a turtle, the red-eared slider (Table 3-6). Mercury concentrations reported for these species included concentrations in the liver, muscles, blood, kidneys, heart tissue, and eggs. Although mercury concentrations were reported for several tissue types for some species, values for each tissue type were available for only one species, except for blood concentrations for which three species were sampled. Unfortunately, few comparisons among the different species can be drawn from the limited data available. The highest mercury concentration overall was observed in the liver of the American alligator (21.26 ppm). This species is a top-level predator that feeds primarily on fish, other alligators, and a variety of birds.

3.3.3 Birds

Mercury concentration data reported on a wet weight basis were available for 22 species of birds covering a wide array of feeding strategies. The largest amount of data was available for concentrations of mercury in eggs (11 species) and liver tissue (10 species). Egg concentrations were highest in bald eagles (0.63 ppm), Caspian terns (0.61 ppm), and herring gulls (0.34 ppm) and were lowest in great blue herons (0.09 ppm), snowy egrets (0.07 ppm) and tree swallows (0.07 ppm). Mean liver tissue mercury concentrations were highest in the double-crested cormorants (24 ppm), common loon (15.51 ppm), wood stork (10.68 ppm) and the bald eagle (5.65 ppm), which are almost exclusively fish eaters. Mean mercury liver concentrations were lowest in the American crow (0.06 ppm), osprey (0.21 ppm), and the red- tailed hawk (0.38 ppm), which are typically more omnivorous species.

3.3.4 Mammals

Mercury concentration data reported on a wet weight basis were available for eight species of mammals covering a wide array of feeding strategies (Table 3-6). Mean mercury concentrations in liver tissue were available for all but one species, mink. Liver concentrations were highest in the Northern fur seal (26.7 ppm), Florida panther (18.12 ppm), raccoon (11.03 ppm), and the bearded seal (9.4 ppm). The Northern fur seal and bearded seal are omnivorous marine species consuming both fish and invertebrates; the Florida panther is a carnivorous predator species of small mammals, birds, and occasionally alligators; and the raccoon is an omnivorous predator of fish, small crustaceans, and bird and reptile eggs. At the other end of the mercury concentration spectrum, bobcat (0.96 ppm) and river otter (2.81 ppm) exhibited the lowest mercury liver concentrations for the mammalian species represented. These two species are carnivores of terrestrial rodents and birds, and fish and shellfish, respectively.

Table 3-6. Mercury Concentrations in Wildlife Sampled from Estuarine Watersheds

		Mean Mercury Concentration by Sample Type (all units µg/g ww)								
Class	**Species**	**Liver**	**Muscle**	**Blood**	**Kidney**	**Heart**	**Egg**	**Hair**	**Feather**	**Brain**
Reptiles	American alligator	21.26	0.84		13.72	1.30				0.77
	American crocodile						0.04			
	Cottonmouth			0.01						
	Diamondback water snake			0.10						
	Red-eared slider			0.02						
Birds	American crow	0.06								
	Arctic tern						0.11			
	Bald eagle	5.65					0.63			0.80
	Black-crowned night-heron			0.10					0.96	
	Caspian tern						0.61			
	Common loon	15.51		0.75					5.44	
	Double-crested cormorant	24.00			7.10					1.60
	Emperor goose			0.05						
	Great black-backed gull	1.37	0.72		1.24	0.89				
	Great blue heron						0.09			
	Great egret			1.00					12.35	
	Great white heron								8.20	
	Herring gull	0.84	0.38		0.47	0.40	0.34			
	Laughing gull	0.48	0.14		0.45	0.27				
	Osprey	0.21					0.16			
	Peregrine falcon						0.19			
	Red-tailed hawk	0.38								
	Roseate tern						1.17			
	Snowy egret						0.07			
	Tree swallow						0.07			
	Tricolored heron						0.14			
	Wood stork	10.68								
Mammals	Bearded seal	9.40								
	Bobcat	0.96								
	Florida panther	18.12	1.26	0.43	2.95			23.69		0.94
	Mink							12.36		
	Northern fur seal	26.70	0.36		0.98					
	Raccoon	11.03	0.93							
	Ringed seal	5.20								
	River otter	2.81								

Source: Rattner, B. 2002. Contaminant Exposure and Effects-Terrestrial Vertebrates Database. USGS Patuxent Wildlife Research Center, Laurel, MD.

SECTION 4.0

DATA TO BE ADDED TO THE DATABASE

4.1 ADDITIONAL DATA SETS AVAILABLE FOR INCLUSION IN THE DATABASE

During the early part of this project, RTI identified a number of electronic data sets that contained residue data appropriate for inclusion in the Mercury in Marine Life Database. However, several sources of data either were received too late to be included in the August 2002 version of the database or did not have sufficient background information supplied by the data proprietor. Also, for some sources, the sampling effort or QC checks of the data could not be conducted until after August 2002. A brief summary of the data in these categories is provided below (entering these new data may change summary results for all coastal areas, but especially in the Pacific coastal areas where few data were available in the original version of the database).

4.1.1 Data Sets That Could Not Be Included in the Database

RTI began acquiring data sets in June 2002 for inclusion in the Mercury in Marine Life Database. No data sets received after August 15, 2002, were included in the original version of the database. Data sets received between August 15 and December 31 were aggregated into the second version of the database (April 2003), and these data sets are identified in Section 2. The following data sets have not been included in the database to date:

Naval Facility Monitoring Study in New Hampshire
The Naval facility in Portsmouth, NH, collected fish tissue residue data for two separate studies. One data set was collected from 1991 to 1993; the other, from 1999 to 2001. RTI received the data on August 12, 2002. Data integrity problems inherent in the data sets prevented RTI from adding these data to the database by the August 15 cutoff date. The Navy was contacted with questions and responded by saying it would try to resolve the issues. To date, it has not responded. RTI believes that, given additional time to work with the Navy, the issues can be resolved for at least for some of these data.

Contact: Frederick J. Evans, PE, Remedial Project Manager
Phone: 610-595-0567 ext. 159
E-mail: evansfj@efane.navfac.navy.mil

State of Rhode Island
Rhode Island sent a data set in June 2002; however, most of the data were for freshwater fish species. Data included only the species code, length, and mercury concentration. There was no information provided on site location or sample type.

Because of the lack of site information (latitude/longitude), RTI could not tell if any of the sites were located in estuarine or marine waters. However, it does appear that most site names identified the sampling location as being in ponds and lakes. It is not likely that any of these data are for estuarine species. It may be productive to contact the state again and determine if any data are available for marine or estuarine species.

Contact: Bob Vanderslice
Phone: 401-222-3424
E-mail: bobv@doh.state.ri.us

State of Virginia
The data set sent by Virginia appeared to be almost entirely freshwater data. Followup with the state needs to be conducted to determine if it has collected any additional estuarine or marine samples in recent years.

Contact: Khizar Wasti
Phone: 804-786-1763
E-mail: kwasti@vdh.state.va.us

4.1.2 Data Sets of Future Interest

During several telephone calls and e-mail communications with federal, regional, and state staff, RTI identified several studies that were in progress but for which the resulting data were not yet available. The following sources could provide data for inclusion in the Mercury in Marine Life Database in the near future:

State of Hawaii Mercury Study
The state of Hawaii has recently conducted a study of mercury in 12 marine finfish species from the waters surrounding the Hawaiian Islands. The species selected are popular among Hawaiian consumers. This study was in the laboratory analysis phase, and QC checks of the data still needed to be performed by the data proprietor for some data sets. The data sets should be available by mid-2003.

Contact: Barbara Brooks, Hawaii Department of Health
Phone: 808-586-4249
E-mail: bbrooks@eha.health.state.hi.us

State of Alaska
The state of Alaska is currently in the process of designing a database containing information on the levels of various environmental contaminants in freshwater and marine fish, as well as marine mammals consumed by recreational and subsistence populations. Data sets should be available by mid-2003.

Contact: Bob Gerlach, Alaska Department of Environmental Conservation
Phone: 907-269-7635
E-mail: bob_gerlach@envircon.state.ak.us

State of California–Study of the Southern California Bight Area
The Southern California Bight data set, which will likely be available in mid-2003, contains mercury monitoring information for southern California coastal areas. The proprietor of the data was involved in intensive quality assurance (QA)/QC of the data set that would ultimately be submitted to the California Department of Health. This is one of the few studies that monitored mercury concentrations in the marine life of southern California; much of the previous monitoring was directed at PCBs, dioxins, and other organochlorine pesticides. This data set will be very important for expanding the limited monitoring information that is available for the Pacific coast states.

Contact: Robert Brodberg, California EPA, Office of Environmental Health Hazard Assessment
Phone: 916-323-4763
E-mail: rbrodber@oehha.ca.gov

U.S. EPA National Coastal Assessment (Coastal 2000)
The Coastal 2000 data set will not be available until mid-2003. The proprietor of the data was involved in intensive QA/QC of the data set in the fall of 2002. This data set will contain mercury monitoring information for all coasts of the United States, including Alaska, Hawaii, and Puerto Rico, and its addition to the Mercury in Marine Life Database will be very important for expanding the limited monitoring information that is available on mercury concentration for the Pacific coast states.

Contact: Kevin Summers, EPA Gulf Breeze Laboratory
Phone: 850-934-9244
E-mail: summers.kevin@epa.gov

NOAA's National Status and Trends (NS&T) Program–Benthic Surveillance Project
As part of NOAA's NS&T Program, the National Benthic Surveillance Project (NBSP) was conducted between 1984 and 1993 and regularly determined the levels of contaminant chemicals in benthic sediments and in the stomach contents, liver, and bile tissues of selected bottomfish, as well as the associated prevalence of pathological lesions (e.g., fin erosion and liver tumors) in these fish. The NBSP collected and analyzed sediment and bottomfish samples from about 100 coastal sites throughout the United States, including estuaries, bays, and near-shore marine areas of the East, Gulf, and West coasts, as well as from Alaska. Samples were collected from March through September annually from 1984 to 1986 and biannually from 1987 to 1993. The database is available at http://nsandt.noaa.gov/data_description_bs.htm.

The NBSP was designed to assess and document the status of long-term trends in the environmental quality of the nation's coastal and estuarine waters and was a cooperative effort between the NMFS and the Coastal Monitoring and Bioeffects Assessment Division (CMBAD) of NOAA's National Ocean Services (NOS). The specific objectives of NBSP included the

- Measurement of concentrations of chemical contaminants in sediment and in species of bottom-dwelling fish at selected sites in urban and nonurban embayments
- Determination of the prevalence of diseases in these same fish species
- Exploration of associations between contaminant concentrations in tissue and sediment and between contaminant concentrations in tissue and sediment and fish disease
- Evaluation of spatial and temporal trends of contaminant concentrations and fish diseases.

Contact: Jawed Hameedi
Phone: 301-713-3034 ext. 170
email: Jaweed.Hameedi@noaa.gov

Wampanog Tribal Study of Mercury in Marine Fish
The Wampanog tribe is collecting data on mercury contamination in marine species off Martha's Vineyard, MA. This data set will not be available until mid-2003.

Contact: Jeff Day, Tribal Enforcement Officer
Phone: 508-645-9265
E-mail: ranger@wampanoagtribe.net

Passomaquoddy Tribal Study of Mercury in Marine Fish
The Passomaquoddy tribal group in Maine has been collecting data on mercury levels in estuarine and marine fish and shellfish.

Contact: Marvin Cling, Tribal Environmental Department
Phone: 207-853-2600 ext. 234
E-mail: Marvin@Wabanaki.com

NOAA Database for Sea Mammals and Sea Turtles
The NOAA NMFS program assesses contaminant levels in sea mammals and sea turtles. Further investigation is warranted to clarify whether data could be shared on mercury tissue analyses from stranded sea mammals (dolphins, whales, seals etc.) and from dead sea turtles. Information may also be available for analyses of mercury in scrapings from scutes (scales on outer carapace) and, possibly, blood samples collected from live turtles.

Contact: Janet Whaley NOAA Fisheries, Office of Protected Resources
Phone: 301-713-2322 ext. 170
E-mail: Janet.Whaley@noaa.gov

4.2 FUTURE REVIEW OF RETRIEVED PEER-REVIEWED LITERATURE

As part of the search to identify appropriate electronic data sets, RTI conducted an electronic literature search of major publications that have appeared in the peer-reviewed scientific literature over the past 10 years. More than 120 journal articles, book chapters, and reports were retrieved in hard copy for review. The articles focused on the bioaccumulation of mercury in marine life, including fish and shellfish species, sea birds, marine mammals, and sea turtles worldwide. In addition, several articles were retrieved that dealt with consumption of marine fish and shellfish or other marine life by various consumer populations. Although resources did not permit review of these articles at this time, a listing of the papers retrieved is presented in Appendix I.

Future work on these peer-reviewed journal articles could include incorporating data from them with data already aggregated in the USGS CEE-TV database files.

4.3 TROPHIC LEVEL AND FEEDING GUILD ASSIGNMENTS

Trophic level and feeding guild information help to characterize each species' potential exposure to mercury contamination. Because mercury bioaccumulates in fish, species at higher trophic levels and those that prey primarily on other fish generally have higher tissue levels of mercury. As part of this study, RTI developed a procedure for defining trophic levels and feeding strategies (see Appendix J). In the Mercury in Marine Life Database, more than 300 species of fish and shellfish were identified, and currently about 40 percent have been assigned a trophic level and feeding strategy. Resources did not permit assigning all of these species trophic level and feeding strategy designations for inclusion in the database.

SECTION 5

LITERATURE CITED

Abbott, R.T. 1974. *American Seashells—The Marine Molluscs of the Atlantic and Pacific Coasts of North America.* 2nd Edition. New York: Van Nostrand Reinhold Company.

Ache, B.W., J.D. Boyle, and C.E. Morse. 2000. *A Survey of the Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico.* Prepared by Battelle for the U.S. EPA Gulf of Mexico Program, Stennis Space Center, MS, January.

AFS (American Fisheries Society). 1991. *Common and Scientific Names of Fishes from the United States and Canada.* American Fisheries Society Special Publication 20. Fifth Edition. Bethesda, MD.

Anderson, J.L., and M.H. Depledge. 1997. A survey of total mercury and methylmercury in edible fish and invertebrates from Azorean waters. *Marine Environmental Research* 44(3):331–350.

Bloom, N.S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. *Can. J. Fish. Aquat. Sci.* 49(5):1010–1017.

Chase, M.E., S.H. Jones, P. Hennigar, et al. 2001. Gulfwatch: Monitoring spatial and temporal patterns of trace metals and organic contaminants in the Gulf of Maine (1991–1997) with the blue mussel, *Mytilus edulis L. Marine Pollution Bulletin* 42(6):491–505.

Czapla, T.C., M.E. Pattillo, D.M. Nelson, and M.E. Monaco. 1991. *Distribution and Abundance of Fishes and Invertebrates in Central Gulf of Mexico Estuaries.* ELMR Report No. 7. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.

Davis, J.A., M.D. May, S.E. Wainwright, R. Fairey, et al. 1999. Persistent toxic chemicals of human health concern in fish from San Francisco Bay and the Sacramento River, CA. Available at www.sfei.org/rmp/posters/fishcontam/fish_contamination_99.htm.

Davis, J.A., M.D. May, G. Ichikawa, and D. Crane. 2000. Contaminant Concentrations in Fish from the Sacramento-San Joaquin Delta and Lower San Joaquin River, 1998. Available at www.sfei.org/cmr/deltafish/dfc.pdf.

Dixon, L.K., J.M. Sprinkel, N.J. Blake, G.E. Rodrick, and R.H. Pierce. 1993. *Bivalved Shellfish Contaminant Assessment.* Sarasota Bay National Estuary Program. Mote Marine Laboratory Technical Report No. 244.

Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. *Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries. Volume II: Life History Summaries.* ELMR Report No. 8. Strategic Assessment Division, National Oceanic and Atmospheric Administration, Rockville, MD.

Fortner, A.R., D.K. Johnson, J.K. Bangerter, M.J. Balthis, P. Comar, J. DeVane, and T.C. Siewicki. 1997. *Chemical Contamination of Seafood from the Gulf of Mexico: A Report Characterizing Chemical Contamination in Gulf of Mexico Seafood and Describing a Functional System for Contaminant Data Retrieval* (GulfChem). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Charleston Laboratory. August.

Francesconi, K.A., and R.C. Lenanton. 1992. Mercury contamination in a semi-enclosed marine embayment: Organic and inorganic mercury content of biota, and factors influencing mercury levels in fish. *Marine Environmental Research* 33:189–212.

Grubbs, G.H., and R.H. Wayland. 2000. *Letter Guidance: Use of Fish and Shellfish Advisories and Classifications in 303(d) and 305(b) Listing Decisions.* Available at http://www.epa.gov/waterscience/library/wqstandards/shellfish.pdf. Accessed October 24, 2000.

Harris, S.G., and B.L. Harper. 1997. A Native American exposure scenario. *Risk Analysis* 17(6):789–795.

Hoese, H.D., R.H. Moore, and V.F. Sonnier. 1977. *Fishes of the Gulf of Mexico Texas, Louisiana, and Adjacent Waters.* College Station and London: Texas A&M University Press.

Hueter, R.E., W.G. Fong, G. Henderson, et al. 1995. Methylmercury concentration in shark muscle by species, size, and distribution of sharks in Florida Coastal waters. Pp. 893–899 in *Mercury as a Global Pollutant.* Pocella, D.B., and B. Wheatley (eds.). Proceedings of the Third International Conference, British Columbia, Canada, July 1994. Boston: Kluwer Academic Publishers.

Joiris, C.R., I.B. Ali, L. Holsbeek, M. Kanuya-Kinoti, and Y. Tekele-Michael. 1997. Total and organic mercury in Greenland and Barents Seas demersal fish. *Bulletin of Environmental Contamination and Toxicology* 58:101–107.

Jury, S.H., J.D. Field, S.L. Stone, D.M. Nelson, and M.E. Monaco. 1994. *Distribution and Abundance of Fishes and Invertebrates in North Atlantic Estuaries.* ELMR Rep. No. 13. National Oceanic and Atmospheric

Administration, National Ocean Services, Strategic Environmental Assessments Division, Silver Spring, MD.

Kannan, K., R.G. Smith, Jr., R.F. Lee, H.L. Windom, P.T. Heitmuller, J.M. Macauley, and J.K. Summers. 1998. Distribution of total mercury and methylmercury in water, sediment, and fish from south Florida estuaries. *Arch. Environ. Contam. Toxicol.* 34:109–118.

Kawaguchi, T., D. Porter, D. Bushek, and B. Jones. 1999. Mercury in the american oyster (*Crassostrea virginica*) in South Carolina, USA, and public health concerns. *Marine Pollution Bulletin* 38(4):324–327. Pergamon.

Kuehl, D.W., B. Butterworth, and P.J. Marquis. 1994. A national study of chemical residues in fish III: Study results. *Chemosphere* 29(3):523–535.

Lasorsa, B., and S. Allen-Gil. 1995. The methylmercury to total mercury ratio in selected marine, freshwater, and terrestrial organisms. *Water, Air, and Soil Pollution* 80:905–913.

Migdalski, E.C., and G.S. Fischer. 1983. *The Fresh and Salt Water Fishes of the World.* New York: Crown Publishers.

Monaco, M.E., D.M. Nelson, T.C. Czapla, and M.E. Pattillo. 1989. *Distribution and Abundance of Fishes and Invertebrates in Texas Estuaries.* ELMR Report No. 3. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.

Monaco, M.E., DM Nelson, R.L. Emmett, and S.A. Hinton. 1990. *Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries. Volume I: Data Summaries.* ELMR Report No. 4. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.

NAS (National Academy of Sciences). 2000. *Toxicological Effects of Methylmercury.* National Research Council, Washington, DC.

National Audubon Society. 1983. *The Audubon Society Field Guide to North American Fishes, Whales, and Dolphins.* New York: Alfred A. Knopf.

Nelson, D.M., M.E. Monaco, E.A. Irlandi, L.R. Settle, and L. Coston-Clements. 1991. *Distribution and Abundance of Fishes and Invertebrates in Southeast Estuaries.* ELMR Report No. 9. Strategic Assessment Division, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.

Nelson, D.M., et al. 1992. *Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries, Vol. 1: Data Summaries.* ELMR Rep. No. 10. National Oceanic and Atmospheric Administration, National Ocean Service, Strategic Environmental Assessments Division, Rockville, MD.

O'Connor, T.P. 1998. Mussel Watch results from 1986 to 1996. *Marine Pollution Bulletin* 37(1–2):14–19.

O'Connor, T.P. 2002. National distribution of chemical concentrations in mussels and oysters. *Marine Environmental Research* 53:117–143.

O'Connor, T.P., and B. Beliaeff. 1996. *Appendix to Recent Trends in Coastal Environmental Quality: Results from the Mussel Watch Project.* U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Coastal Monitoring and Bioeffects Division, Silver Spring, MD.

Pattillo, M.E., T.E. Czapla, D.M. Nelson, and M.E. Monaco. 1997. *Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries. Volume II: Species Life History Summaries.* ELMR Report No. 14. National Oceanic and Atmospheric Administration, National Ocean Service, Strategic Environmental Assessments Division, Silver Spring, MD.

Rattner, B.A., J.L. Pearson, N.H. Golden, J.B. Cohen, R.M. Erwin, and M.A. Ottinger. 2000. Contaminant exposure and effects–Terrestrial vertebrates database: Trends and data gaps for Atlantic Coast estuaries. *Monitoring and Assessment* 63:131–142.

Stone, S.L., T.A. Lowery, J.D. Field, C.D. Williams, D.M. Nelson, S.H. Jury, M.E. Monaco, and L. Andreasen. 1994. *Distribution and Abundance of Fishes and Invertebrates in Mid-Atlantic Estuaries.* ELMR Rep. No. 12. National Oceanic and Atmospheric Administration, National Ocean Service, Strategic Environmental Assessments Division, Silver Spring, MD.

Storelli, M.M., R. Giacominelli-Stuffler, and G.O. Marcotrigiano. 2002a. Mercury accumulation and speciation in muscle tissue of different species of sharks from Mediterranean Sea, Italy. *Bulletin of Environmental Contamination and Toxicology* 68:201–210.

Storelli, M.M., R. Giacominelli-Stuffler, and G.O. Marcotrigiano. 2002b. Total and methylmercury residues in tuna-fish from the Mediterranean Sea. *Food Additives and Contamination* 19(8):715–720.

Storelli, M.M., R. Giacominelli-Stuffler, and G.O. Marcotriiano. 2003. Total mercury and methylmercury content in edible fish from the Mediterranean Sea. *Journal of Food Protection* 66(2):300–303.

Sutfin, C. 2002. *Current TMDL Program and New Watershed Rule.* Presented at the Association of State and Interstate Water Quality Administrators Mid-Winter Meeting, March 10, Washington, DC.

Tollefson, L. 1989. Methylmercury in fish: Assessment of risk for U.S. consumers. In *The Risk Assessment of Environmental and Human Health Hazards: A Textbook of Case Studies.* Dennis J. Paustenback (ed.). New York: John Wiley & Sons.

U.S. EPA (Environmental Protection Agency). 1992a. *National Study of Chemical Residues in Fish.* Volume I. EPA-823/R-92-008a. Office of Science and Technology, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1992b. *National Study of Chemical Residues in Fish.* Volume II. EPA-823/R-92-008b. Office of Science and Technology, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1994. *Clean Water Act Section 403 Report to Congress: Phase II–Point Source Discharges Inside the Baseline.* EPA-842-R-94-001. Office of Water, Office of Wetlands, Oceans and Watersheds, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1997a. *Exposure Factors Handbook, Volume 2, Food Ingestion Factors.* EPA/600/P-95/002Fa. Office of Research and Development, Washington, DC.

U.S. EPA (Environmental Protection Agency). 1997b. *Mercury Study Report to Congress. Volume 1: Executive Summary.* EPA-452-R-97-003.

U.S. EPA (Environmental Protection Agency). 1999. *The National Survey of Mercury Concentrations in Fish–Database Summary 1990–1995.* EPA-823-R-99-014. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2000a. *Estimated Per Capita Fish Consumption in the United States.* EPA-821-R-00-025. Office of Science and Technology, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2000b. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories–Fish Sampling and Analysis.* Volume 1. 3rd Edition. EPA 823-B-00-007. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2000c. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories–Risk Assessment and Fish Consumption Limits.* Volume 2. 3rd Edition. EPA 823-B-00-008. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2001a. *EPA Consumption Advice Factsheet – National Advice on Mercury in Fish Caught by Family and*

Friends: For Women Who Are Pregnant or May Become Pregnant, Nursing Mothers, and Young Children. EPA-823-F-01-004. January.

U.S. EPA (Environmental Protection Agency). 2001b. *Water Quality Criterion for the Protection of Human Health: Methylmercury.* EPA-823-R-01-001, Office of Water/Office of Science and Technology, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2002a. *EPA Fact Sheet -Update: National Listing of Fish and Wildlife Advisories.* EPA-823-F-02-005. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2002b. *National Listing of Fish and Wildlife Advisory Database.* Accessed July 2002 at http://www.epa.gov/waterscience/fish. Office of Water, Washington, DC.

U.S. FDA (Food and Drug Administration). 1995. *Mercury in Fish: Cause for Concern?* Consumer advise article accessed January, 31, 2000, at http://vm.cfsan.fda.gov/~dms/ mercury.html. Revised May 1995.

U.S. FDA (Food and Drug Administration). 2001a. *An Important Message for Pregnant Women of Childbearing Age Who May Become Pregnant about the Risks of Mercury in Fish.* Accessed July 2002 at http://www.cfsgn.fda.gov/~dms/admetig.html. Revised March 2001.

U.S. FDA (Food and Drug Administration). 2001b. *FDA Announces Advisory on Methylmercury in Fish.* Accessed January 2003 at http://www.fda.gov/bbs/topics/ANSWERS/2001/ANS01065.html. January 2001. Revised March 9, 2001: Updated Consumer Advisory.

U.S. FDA (Food and Drug Administration). 2001c. *Mercury Levels in Seafood Apecies.* Accessed July 2002 at *Mercury Levels in Seafood Species.* http://www.cfsan.fda.gov/~frf/sea-mehg.html. Revised May 2001.

U.S. FDA (Food and Drug Administration). 2002. *FDA Announces Food Advisory Committee to Meet on Methylmercury in Seafood.* Accessed January 2003 at http://www.fda.gov/bbs/topics/ANSWERS/2002/ANS01141.html. March 1, 2002: Updated Consumer Advisory.

West, J.E., S.M. O'Neill, G.R. Lippert, and S.R. Quinnell. 2002. *Toxic Contaminants in Marine and Anadromous Fish from Puget Sound, Washington: Results from the Puget Sound Ambient Monitoring Program Fish Component, 1989–1999.* Washington Department of Fish and Wildlife, Olympia, WA.

WHO (World Health Organization). 1990. *Environmental Health Criteria 101: Methylmercury.* WHO: Geneva.

Williams, C.D., D.M. Nelson, M.E. Monaco, S.L. Stone, C. Iancu, L. Coston-Clements, L.R. Settle, and E.A. Irlandi. 1990. *Distribution and Abundance of Fishes and Invertebrates in Eastern Gulf of Mexico Estuaries.* ELMR Report No. 6. Strategic Assessment Branch, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Rockville, MD.

Zhang, X., A. S. Naidu, J.J. Kelley, S.C. Jewett, D. Dasher, and L.K. Duffy. 2001. Baseline concentrations of total mercury and methylmercury in salmon returning via the Bering Sea (1999–2000). *Marine Pollution Bulletin* 42(10):993–997.

APPENDIX A

COMMERCIAL AND RECREATIONAL FISHERY LANDINGS

APPENDIX A

COMMERCIAL AND RECREATIONAL FISHERY LANDINGS

Assessing the occurrence and extent of mercury contamination in the fishery resources of the United States, as well as of individual coastal areas (Atlantic, Gulf of Mexico, and Pacific), requires an understanding of the fish and shellfish species that are routinely harvested from these waters. This section reviews the commercial and recreation fishery landings for the United States on a national basis, as well as for each individual coastal area.

COMMERCIAL FISHERY LANDINGS

The commercial fishery landings data summarized in this section were obtained from the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Fisheries Statistics and Economics Division (FSED) Web site at http://www.st.nmfs.gov/st1/commercial/index.html. This Web site allows users to query the commercial fishery database and summarize domestic commercial landings in a number of formats. Domestic fishery landings represent those fish and shellfish that are landed and sold in the 50 states by U.S. fishermen: these landings do not include landings made in U.S. territories or by foreign fishermen. Also, these data represent landings from inshore saltwater and brackish waters and bays, state territorial seas, and the federal Exclusive Economic Zone (EEZ) only. Landings from freshwater areas are not included.

One important caveat to the annual commercial landings summary data presented at the NMFS Web site is that the NMFS reports only nonconfidential commercial landing statistics. Federal statutes prohibit public disclosure of landings information that would allow identification of the individual data contributors (seafood companies) and potentially put them at a competitive disadvantage. Although most of the summarized landings data are nonconfidential, whenever confidential commercial landings data occur, NMFS has combined these data with other landings data, and they are usually reported as "finfishes, (unc)" (unclassified) or "shellfishes, (unc)" (unclassified). Total landings by state include confidential data and are accurate, but landings data reported by individual species may, in some cases, be misleading as a result of data confidentiality considerations if only one seafood company accounts for all landings.

For commercial landings, a query of the online database was conducted for each of three years (1998, 1999, and 2000) by individual species for all U.S. waters, the Atlantic coast, Gulf of Mexico, and Pacific coast. Information on commercial landings for Alaska and Hawaii is included in the Pacific coast query. Commercial landings data for all species are reported in pounds (live weight), whereas

univalve and bivalve mollusc landings (clams, abalone, oysters, mussels, and scallops) are reported as pounds of meats (excluding shell weight).

For each commercial species, the 1998, 1999, and 2000 landings data were aggregated to produce a 3-year mean annual value for commercial landings. The complete results of the commercial fishery landings database queries are presented in Attachment 1 to this Appendix (Tables 1 through 4). As part of the averaging process, where data were not available for a particular year — indicated by NA in the raw data tables — landings were averaged only for years where data were available (e.g., 2-year average). Both fish and shellfish species are included in the commercial landings listing. Several species in the listing, such as menhaden, are not directly consumed by humans, but are harvested for use in animal feed.

National Statistics

Overall, there are 482 species or groups of fish and other marine species listed in the comprehensive commercial landings data presented in Attachment 1 (Tables 1 through 4) to this Appendix. Some of the species identified in these tables, however, are freshwater species that were harvested from estuarine areas. To identify commercially important species, freshwater species are noted in this national table and in the three regional tables (Tables 1 through 4 in Attachment 1); however, these species are not considered further as they do not meet the species selection criteria of the Mercury in Marine Life Study. Tables 1 through 4 in Attachment 1 present the species with the largest commercial landings for all U.S. coastal waters, as well as for each of the three coastal areas, ranked in descending order by average annual landings (in pounds) over the most recent 3-year period (1998–2000). Only the 17 species with mean annual landings exceeding 100 million pounds nationally are shown in Table A-1. The most predominant commercial species landed nationally include walleye pollock, Atlantic menhaden, Pacific cod, Pacific hake, and pink salmon. In addition, the commercial fishery landings of each coastal area are discussed separately in the subsections below.

On a national perspective, the Pacific coast commercial fishery represents the largest source of commercially harvested fish in the United States, accounting for 63 percent (5.88 billion pounds) of all mean landings nationwide averaged for 1998, 1999, and 2000. Landings for the Gulf coast and Atlantic coast represent 19 percent (1.79 billion pounds) and 18 percent (1.69 billion pounds), respectively (Figure A-1).

Very few data on the concentration of mercury in important commercial species are available from the federal, regional, and state programs that provided data sets to the Mercury in Marine Life Database because many of these monitoring programs have been limited to the collection of fish in estuarine and near-coastal waters of the territorial sea, whereas many of the most important commercial species are deepwater species that are often harvested with specialized, commercial sampling gear in waters outside the jurisdiction of monitoring programs of the states.

Table A-1. Species with Greater than 100 Million Pounds Average Annual Commercial Fisheries Landings in the United States (1998 to 2000)

Rank	Species	Mean Annual Landings (lbs)
1	Walleye pollock	2,561,783,276
2	Atlantic menhaden	1,817,969,068
3	Pacific cod	548,041,418
4	Pacific hake (Whiting)	485,748,404
5	Pink salmon	307,625,832
6	Blue crab	203,034,555
7	Sockeye salmon	193,753,663
8	Atlantic herring	170,437,356
9	California market squid	156,060,918
10	Yellowfin sole	152,594,692
11	Snow crab	152,080,416
12	Chum salmon	145,977,338
13	Brown shrimp	144,170,557
14	Pacific sardine	126,011,310
15	White shrimp	108,292,749
16	Atka mackerel	108,191,427
17	Kelp seaweed	107,406,567

Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/stl/commercial/index.html. Accessed July 2002.

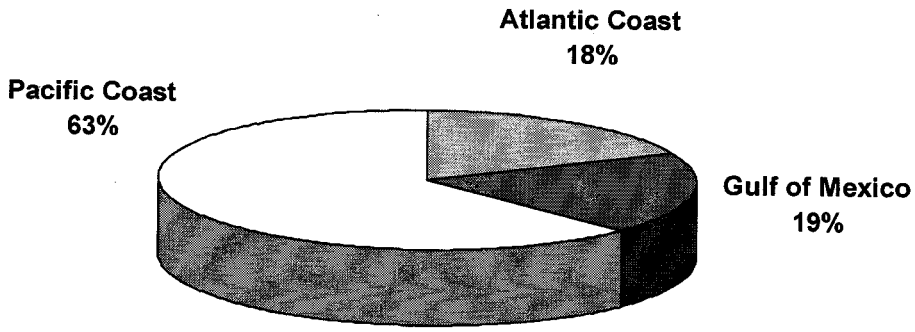

Figure A-1. Percentage of mean annual commercial fishery landings by coastal area for 1998 to 2000 (combined).

Atlantic Coast Statistics

For the Atlantic coast fishery, 297 separate species or groups are listed in the comprehensive commercial landing data presented in Table 2 (Attachment 1 to this Appendix). Of these, 42 species have mean annual landings exceeding 5 million pounds (Table A-2). The most predominant commercial species for the Atlantic coast include two finfish species—the Atlantic menhaden, and Atlantic herring—and three shellfish species—blue crabs, American lobster, and Atlantic surf clams. Although the Atlantic menhaden is an important commercial species, it is not typically consumed by humans and is harvested primarily for use in domestic animal feeds.

Of the 42 commercial species with landings exceeding 5 million pounds per year; mercury concentration data are available in the Mercury in Marine Life Database for only 10 of these species or groups. Mercury data and the number of samples in the database (in parentheses) are available in the Atlantic coastal region for only seven commercial finfish species—striped bass (216), bluefish (174), spot (95), weakfish (61), summer flounder (34), Atlantic croaker (30), and winter flounder (9)—and for three shellfish species—American oysters (471), blue crab (85), and white shrimp (16).

Gulf of Mexico Statistics

For the Gulf of Mexico fishery, 213 separate species or groups are listed in the comprehensive commercial landing data presented in Table 3 (Attachment 1 to this Appendix). Of these, only 14 species have mean annual landings exceeding 5 million pounds (Table A-3). The most predominant commercial species for the Gulf of Mexico include one finfish species—the Atlantic menhaden—and four shellfish species—brown shrimp, white shrimp, blue crabs, and American oysters.

Of the 14 commercial species with landings exceeding 5 million pounds per year; mercury concentration data are available in the Mercury in Marine Life Database for only seven of the species or groups. Mercury data and the number of samples in the database (in parentheses) are available in the Gulf of Mexico region for three commercial finfish species—black drum (233), striped mullet (56), and Atlantic menhaden (1)—and for four shellfish species—American oysters (1634), blue crab (239), white shrimp (16), and brown shrimp (14).

Pacific Coast Statistics

For the Pacific coast fishery, 184 separate species or groups are listed in the comprehensive commercial landing data presented in Table 4 (Attachment 1 to this Appendix). Of these, 43 species have mean annual landings exceeding 5 million pounds (Table A-4). The most predominant commercial species for the Pacific coast region include five finfish species—the walleye pollock, Pacific cod, Pacific hake, pink salmon, and sockeye salmon.

Table A-2. Species with Greater Than 5 Million Pounds Average Annual Commercial Fisheries Landings in the Atlantic (1998 to 2000)

Rank	Species	Mean Annual Landings (lbs)
1	Atlantic menhaden	508,956,857
2	Atlantic herring	170,437,356
3	Blue crab	135,242,532
4	American lobster	83,938,653
5	Atlantic surf clam	56,573,874
6	Goosefish	52,885,019
7	Catfishes, bullheads*	52,207,065
8	Longfin squid	40,382,222
9	Spiny dogfish shark	33,316,460
10	Ocean quahog clam	32,790,540
11	Silver hake	30,304,533
12	Skates	28,640,145
13	Atlantic croaker	26,245,433
14	Tilapias*	24,418,291
15	Atlantic cod	23,678,358
16	Northern shortfin squid	22,264,890
17	Sea scallop	22,119,859
18	Atlantic mackerel	21,925,336
19	White shrimp	15,831,212
20	Sea urchins	14,694,809
21	Gizzard shad freshwater	14,083,066
22	Winter flounder	11,292,377
23	Yellowtail flounder	10,968,642
24	Summer flounder	10,832,141
25	Pollock	10,450,218
26	Quahog clam	9,690,864
27	Other marine shrimp	9,479,670
28	Clams or Bivalves	8,264,565
29	American plaice	8,091,080
30	Bluefish	7,861,979
31	Sea cucumber	7,509,742
32	Haddock	7,338,422
33	Weakfish	6,905,367
34	Striped bass	6,687,757
35	Spot	6,586,086
36	General finfishes (unclassified)	6,485,107
37	White hake	5,860,200
38	Brown shrimp	5,762,936
39	Bait and animal food finfishes (unclassified)	5,452,535
40	Horseshoe crab	5,279,459
41	Hagfishes	5,081,494
42	American oyster	5,024,590

* Freshwater species
Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/stl/commercial/index.html. Accessed July 2002.

Table A-3. Species with Greater than 5 Million Pounds Average Annual Commercial Fisheries Landings in the Gulf of Mexico (1998 to 2000)

Rank	Species	Mean Annual Landings (lbs)
1	Atlantic menhaden	1,309,012,211
2	Brown shrimp	138,407,621
3	White shrimp	92,461,537
4	Blue crab	67,916,974
5	American oyster	23,008,475
6	Pink shrimp	17,167,683
7	Striped mullet (Liza)	17,052,274
8	Crayfishes or crawfishes*	11,865,525
9	Seabob shrimp	8,001,066
10	General finfishes (unclassified)	7,570,235
11	Florida stone crab (claws)	6,395,158
12	Red grouper	6,183,399
13	Caribbean spiny lobster	5,758,355
14	Black drum	5,117,483

* Freshwater species
Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/stl/commercial/index.html. Accessed July 2002.

Table A-4. Species with Greater than 5 Million Pounds Average Annual Commercial Fisheries Landings in the Pacific (1998 to 2000)

Rank	Species	Mean Annual Landings (lbs)
1	Walleye pollock	2,561,783,276
2	Pacific cod	548,041,418
3	Pacific hake (whiting)	485,748,404
4	Pink salmon	307,625,832
5	Sockeye salmon	193,753,663
6	California market squid	156,060,918
7	Yellowfin sole	152,594,692
8	Snow crab	152,080,416
9	Chum salmon	145,977,338
10	Pacific sardine	126,011,310
11	Atka mackerel	108,191,427
12	Kelp seaweed	107,406,567
13	Pacific herring	86,556,195
14	Pacific halibut	76,423,319
15	Sablefish	48,212,984
16	Rock sole	44,345,202
17	Pacific ocean perch rockfish	41,801,618
18	Dungeness crab	38,839,456
19	Chub mackerel	38,642,085

(continued)

Table 2-4. (continued)

Rank	Species	Mean Annual Landings (lbs)
20	Flathead sole	36,864,115
21	Coho salmon	33,086,176
22	Rockfishes	27,272,140
23	Albacore tuna	26,974,145
24	Arrowtooth flounder	26,778,021
25	Ocean shrimp	24,026,473
26	Dover sole	22,314,754
27	King crab	18,580,306
28	Flatfish	18,404,969
29	Sea urchins	17,030,945
30	Chinook salmon	15,440,234
31	Northern anchovy	13,760,807
32	General finfishes (unclassified)	12,125,728
33	Swordfish	11,310,647
34	Greenland halibut	10,596,264
35	Righteye flounders	10,569,499
36	Brine shrimp	10,448,119
37	Yellowfin tuna	9,875,336
38	Widow rockfish	9,208,657
39	Skipjack tuna	9,191,717
40	Pacific oyster	8,577,662
41	Bigeye tuna	6,576,701
42	Yellowtail rockfish	6,480,310
43	Sharks	5,324,395

Source: NOAA/NMFS/Fisheries Statistics and Economics Division at http://www.st.nmfs.gov/stl/commercial/index.html. Accessed July 2002.

Of the 43 commercial species with landings exceeding 5 million pounds per year; mercury concentration data are available in the Mercury in Marine Life Database for only 12 of the species or groups. Mercury data and the number of samples in the database (in parentheses) are available in the Pacific coastal region for 10 commercial finfish species—right-eyed flounder (532), rockfish (318), Pacific herring (131), coho salmon (157), chinook salmon (108), sharks (35), Pacific cod (29), Pacific halibut (11), sockeye salmon (9), and Pacific hake (1)—and for two shellfish species— Pacific oysters (64) and Dungeness crab (3).

RECREATIONAL LANDINGS

Recreational landings data summarized in this section were also obtained from the FSED Web site at http://www.st.nmfs.gov/st1/ recreational/index.html. For recreational landings, a query of the online database was conducted for 1998, 1999; and 2000 by individual species for all U.S. waters, the Atlantic coast, Gulf of Mexico, and Pacific coast. Information on recreational landings in the database are provided for all states (with the exception of Alaska, Hawaii, and Texas) and for Puerto Rico for 1998 to 2000 only. One year of data (2000) was also available

for the U.S. Virgin Islands. Recreational landings data are reported in pounds (live weight).

For recreational landings, NOAA's FSED conducts an annual marine recreational fisheries statistics survey, the purpose of which is to provide a reliable database for estimating the impact of recreational fishing on marine resources. To obtain the recreational landings data for this study, a query of this online database was conducted with the following specifications:

- All U.S. waters, Atlantic coast (excludes the west coast of Florida), Gulf of Mexico (excludes the east coast of Florida), and Pacific coast area
- Annual landings are reported in pounds by individual species for 1998, 1999, and 2000
- All modes of fishing (includes private, rental, and charter boats and catches from shore)
- All areas combined (includes inshore saltwater and brackish waters and bays, state territorial seas, and federal EEZ; but no freshwater areas are included)
- Total catch (Type A + B1 + B2), where Type A catch are fish that were landed whole, were brought back to the dock, and were available for identification by trained interviewers. Type A fish were also available for weighing and measuring. Type B1 catch are fish that were caught but used for bait, released dead, or given away (e.g., they were killed, but identification is by individual anglers), and Type B2 catch are fish that were caught, but released alive (identification is by individual anglers).

For each species, the 1998, 1999, and 2000 landings data were aggregated to produce a 3-year mean annual value for the recreational landings. The complete listing of species with the largest recreational landings for all U.S. coastal waters, as well as for each of three coastal areas, ranked in descending order by average annual landings (in pounds) over the most recent 3-year period (1998–2000) is presented in Tables 5 through 8 (Attachment 1 to this Appendix). As part of the averaging process, where data were not available for a particular year — indicated by NA in the raw data tables—landings were averaged only for those years where data were available (e.g., 2-year average).

Information on recreational landings is available for finfish species only and not for shellfish harvested recreationally. In addition, the raw data tables in Attachment 1 to this Appendix represent landings from inshore saltwater and brackish waters and bays, state territorial seas, and the federal EEZ only. Landings from freshwater areas are not included. Some of the species identified in these tables, however, are freshwater species that were harvested from estuarine areas. To identify recreationally important species, freshwater species are noted in these tables; however, these species are not included in the database or in the data analysis because they do not meet the species selection criteria of the Mercury in Marine Life Study (see Section 1.4.2).

National Recreational Statistics

Overall, 127 species or groups of fish and other marine species are listed in the comprehensive recreational landings data for the United States presented in Table 5 in Attachment 1 to this Appendix. The 44 species with mean annual landings exceeding 1 million pounds nationally are listed in Table A-5. The most predominant recreational species nationally include other tuna/mackerel, striped bass, dolphin, spotted seatrout, and summer flounder. Of these five species, mercury concentration data are available in the database in adequate numbers for only two species: striped bass and spotted seatrout. The recreational fishery landings of each coastal area are discussed separately in the subsections below.

On a national perspective, the Atlantic coast recreational fishery represents the largest source of recreationally harvested fish in the United States, accounting for 55 percent (122 million pounds) of all landings nationwide. Landings for the Gulf coast represent 31 percent (68 million pounds) of the recreationally harvested fish landed nationally. This is more than double the landings for the Pacific coast, which represent only 14 percent (31 million pounds) of the landings nationwide (Figure A-2). Note: Recreational fishery landings information is not available in the Gulf of Mexico for Texas and in the Pacific, for Alaska and Hawaii. These omissions are likely to significantly influence the percent contributions of recreational landings for each respective coastal area.

Table A-6 summarizes the number of recreational fishers living in both coastal and noncoastal counties within coastal states of the United States. The percentage of fishers engaged in marine recreational fishing in the Atlantic, Gulf of Mexico, and Pacific coastal states (Figure A-3) nationally, parallels the percent contribution of each coastal area to the total recreational landings nationwide. For example, 55 percent of all recreational fishers (in both coastal and noncoastal counties) live along the Atlantic coast; this figure closely parallels the 55 percent of recreational fishery landings that are contributed by Atlantic recreational landings. Percentages of recreational fishers by coastal area compared to the percentage of recreational fishery landings were 25 and 31 percent for the Gulf of Mexico and 20 and 14 percent for the Pacific coast, respectively. Percentages for the Gulf coast do not include the number of recreational fishers from Texas, and percentages for the Pacific coast do not include the number of recreational fishers from Alaska and Hawaii, for which data were unavailable. This missing data may have been partially responsible for the wider variation in percentages observed for the Gulf of Mexico and Pacific coast recreational fishers and the respective recreational landings.

Table A-5. Species with Greater Than 1 Million Pounds Average Annual Recreational Fisheries Landings in the United States (1998 to 2000)

Rank	Species	Average
1	Other tunas/mackerels	18,024,736
2	Striped bass	15,412,830
3	Dolphins	14,835,451
4	Spotted seatrout	13,255,255
5	Summer flounder	12,474,072
6	Red drum	12,062,630
7	Other fishes	11,000,970
8	Bluefish	10,778,200
9	Atlantic croaker	8,787,583
10	King mackerel	8,220,032
11	Sheepshead	4,870,212
12	*Mycteroperca* groupers[1]	4,853,738
13	Red snapper	4,175,885
14	Weakfish	3,781,065
15	Spanish mackerel	3,755,472
16	Atlantic cod	3,566,146
17	Black drum	3,289,300
18	Yellowtail	2,936,025
19	Other sharks	2,903,829
20	Black sea bass	2,895,608
21	Scup	2,734,688
22	Little tunny/Atlantic bonito	2,619,805
23	Mullets	2,597,273
24	Atlantic mackerel	2,551,761
25	Tautog	2,470,268
26	Sand seatrout	2,444,474
27	Black rockfish	2,296,647
28	Kingfishes	2,281,599
29	Spot	2,277,978
30	Pinfishes	2,073,596
31	Greater amberjack	1,954,268
32	Pacific barracuda	1,852,444
33	*Epinephelus* groupers[2]	1,597,094
34	Gray snapper	1,531,125
35	White grunt	1,471,910
36	Southern flounder	1,448,843
37	Crevalle jack	1,334,251
38	Lingcod	1,329,235
39	California halibut	1,268,619
40	Blue runner	1,237,373
41	Winter flounder	1,168,900
42	Barracudas	1,138,235
43	Other rockfishes	1,125,366
44	Barred sand bass	1,053,010

[1] *Mycteroperca* grouper include gag, scamp, yellowmouth grouper, yellow fin grouper, and black grouper.
[2] *Epinephelus* grouper include jewfish, rock hind, speckled hind, red hind, yellowedge grouper, red grouper, Warsaw grouper, snowy grouper, Nassau grouper, mutton hamlet, coney, and marbled grouper.
Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/st1/recreational/index.html. Accessed July 2002.

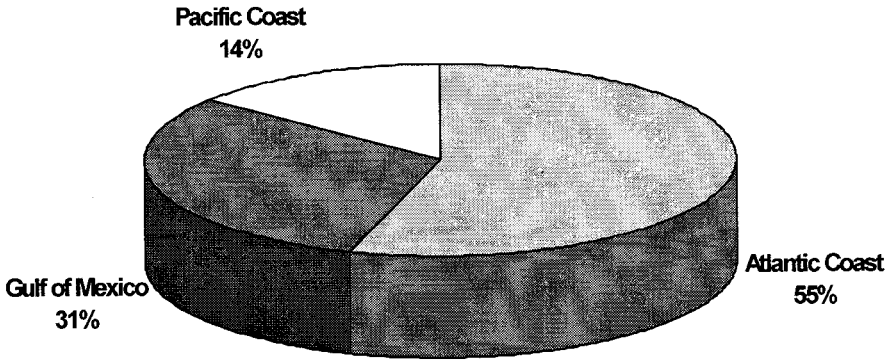

Figure A-2. Percentage of mean annual recreational fishery landings by coastal area for 1998 to 2000 (combined).

Table A-6. Average Number of Recreational Fishers Residing in Coastal and Noncoastal Counties by State: 1998, 1999, and 2000

State		Average	1998	1999	2000
Maine	Coastal	**117,831**	102,806	111,586	139,100
	Noncoastal	**15,288**	16,065	9,672	20,128
	Total in State	**133,119**	**118,871**	**121,258**	**159,228**
New Hampshire	Coastal	**62,852**	57,085	54,713	76,759
	Noncoastal	**8,800**	7,581	8,356	10,464
	Total in State	**71,653**	**64,666**	**63,069**	**87,223**
Massachusetts	Coastal	**357,891**	341,566	239,531	492,576
	Noncoastal	**70,995**	65,438	57,251	90,296
	Total in State	**428,886**	**407,004**	**296,782**	**582,872**
Rhode Island	Coastal	**104,978**	95,670	107,555	111,709
	Noncoastal	**0**	0	0	0
	Total in State	**104,978**	**95,670**	**107,555**	**111,709**
Connecticut	Coastal	**251,448**	290,105	242,716	221,523
	Noncoastal	**0**	0	0	0
	Total in State	**251,448**	**290,105**	**242,716**	**221,523**
New York	Coastal	**410,839**	426,974	336,748	468,794
	Noncoastal	**9,680**	6,252	10,912	11,877
	Total in State	**420,519**	**433,226**	**347,660**	**480,671**
New Jersey	Coastal	**478,984**	399,938	493,491	543,522
	Noncoastal	**25,229**	28,581	30,172	16,935
	Total in State	**504,213**	**428,519**	**523,663**	**560,457**
Delaware	Coastal	**84,582**	102,851	68,845	82,051
	Noncoastal	**0**	0	0	0
	Total in State	**84,582**	**102,851**	**68,845**	**82,051**
Maryland	Coastal	**422,424**	423,162	382,764	461,347
	Noncoastal	**40,453**	29,324	40,728	51,307
	Total in State	**462,877**	**452,486**	**423,492**	**512,654**
Virginia	Coastal	**332,956**	302,065	308,856	387,947
	Noncoastal	**57,196**	37,737	66,185	67,666
	Total in State	**390,152**	**339,802**	**375,041**	**455,613**
North Carolina	Coastal	**350,624**	312,246	324,091	415,535
	Noncoastal	**178,965**	143,355	164,398	229,143
	Total in State	**529,589**	**455,601**	**488,489**	**644,678**
South Carolina	Coastal	**153,011**	137,344	131,641	190,048
	Noncoastal	**72,015**	85,104	61,271	69,671
	Total in State	**225,026**	**222,448**	**192,912**	**259,719**
Georgia	Coastal	**72,485**	68,712	59,368	89,376
	Noncoastal	**48,345**	27,736	31,682	85,618
	Total in State	**120,831**	**96,448**	**91,050**	**174,994**

(continued)

Table A-6. (continued)

State		Average	1998	1999	2000
Florida [Altantic Coast]	Coastal	**1,135,699**	1,077,029	935,995	1,394,072
	Noncoastal	**0**	0	0	0
	Total in State	**1,135,699**	**1,077,029**	**935,995**	**1,394,072**
Florida [Gulf Coast]	Coastal	**1,383,717**	1,266,487	1,217,624	1,667,041
	Noncoastal	**0**	0	0	0
	Total in State	**1,383,717**	**1,266,487**	**1,217,624**	**1,667,041**
Florida	Coastal	**2,519,417**	2,343,517	2,153,620	3,061,113
	Noncoastal	**0**	0	0	0
	Total in State	**2,519,417**	**2,343,517**	**2,153,620**	**3,061,113**
Alabama	Coastal	**124,530**	101,444	131,265	140,881
	Noncoastal	**76,505**	56,089	91,990	81,435
	Total in State	**201,035**	**157,533**	**223,255**	**222,316**
Mississippi	Coastal	**105,973**	81,993	76,070	159,857
	Noncoastal	**25,599**	24,911	25,678	26,209
	Total in State	**131,573**	**106,904**	**101,748**	**186,066**
Louisiana	Coastal	**463,792**	434,040	409,175	548,160
	Noncoastal	**46,770**	41,095	33,115	66,101
	Total in State	**510,562**	**475,135**	**442,290**	**614,261**
Texas	Coastal	**NA**	NA	NA	NA
	Noncoastal	**NA**	NA	NA	NA
	Total in State	**NA**	**NA**	**NA**	**NA**
California	Coastal	**1,158,047**	1,098,573	956,349	1,419,219
	Noncoastal	**60,715**	64,663	53,088	64,395
	Total in State	**1,218,762**	**1,163,236**	**1,009,437**	**1,483,614**
Oregon	Coastal	**207,699**	168,332	183,509	271,257
	Noncoastal	**16,498**	12,692	13,650	23,153
	Total in State	**224,198**	**181,024**	**197,159**	**294,410**
Washington	Coastal	**359,074**	325,772	328,747	422,704
	Noncoastal	**25,338**	20,986	23,258	31,770
	Total in State	**384,412**	**346,758**	**352,005**	**454,474**
Alaska	Coastal	**NA**	NA	NA	NA
	Noncoastal	**NA**	NA	NA	NA
	Total in State	**NA**	**NA**	**NA**	**NA**
Hawaii	Coastal	**NA**	NA	NA	NA
	Noncoastal	**NA**	NA	NA	NA
	Total in State	**NA**	**NA**	**NA**	**NA**

NA – No information available
Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/st1/recreational/queries/participation/par_time_series.html. Accessed July 2002. Searched on year (1998 to 2000); Wave (ANNUAL); geographic area (UNITED STATES BY STATES)

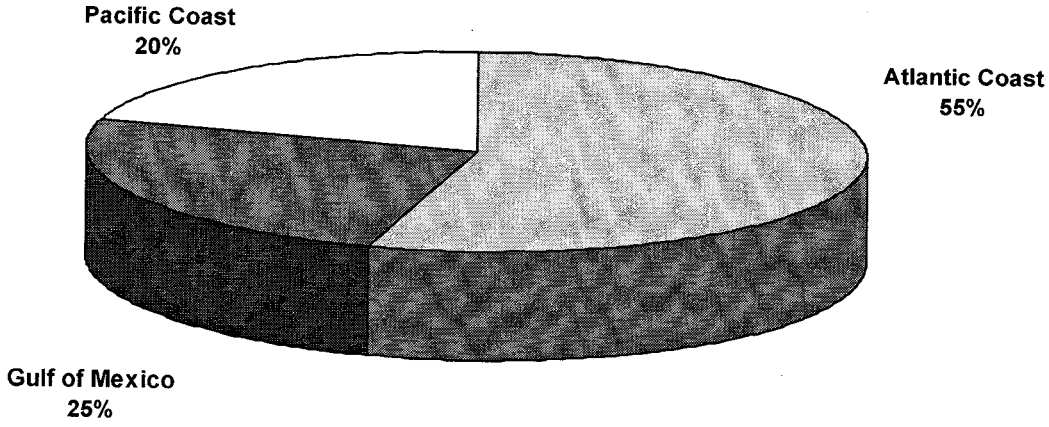

Figure A-3. Mean percentage of recreational fishers by coastal area for 1998 to 2000 (combined).

Atlantic Coast Statistics

Sixty-nine species or groups of fish and other marine species are listed in the comprehensive recreational landings data for the Atlantic coast presented in Table 6 (Attachment 1 to this Appendix). The 24 species with mean annual recreational landings exceeding 1 million pounds in the Atlantic coast fishery are listed in Table A-7. The most predominant recreational species in the Atlantic fishery include striped bass, other tuna/mackerel, summer flounder, bluefish, and dolphin.

Of the 24 species with recreational landings exceeding 1 million pounds per year; mercury concentration data are available in the Mercury in Marine Life Database for all but five species. Mercury data and the number of samples (in parentheses) are available for 19 finfish species: sharks (484), spotted seatrout (373), red drum (234), striped bass (216), bluefish (174), king mackerel (118), spot (95), Spanish mackerel (73), other tuna and mackerel (73), weakfish (61), sheepshead (53), summer flounder (34), Atlantic croaker (30), kingfish (19), dolphin (14), scup (10), winter flounder (9), little tunny (5), black sea bass (2). Shellfish species are not included in the NMFS recreational fishery landings data.

Gulf of Mexico Statistics

Sixty species or groups of fish and other marine species are listed in the comprehensive recreational landing data for the Gulf of Mexico presented in Table 7 (Attachment 1 to this Appendix). The 18 species with mean annual recreational landings exceeding 1 million pounds in the Gulf coast fishery are

Table A-7. Species with Greater Than 1 Million Pounds Average Annual Recreational Fisheries Landings in the Atlantic (1998 to 2000)

Rank	Species	Average
1	Striped bass	14,896,850
2	Other tunas/mackerels	12,488,906
3	Summer flounder	12,474,072
4	Bluefish	10,397,647
5	Dolphins	10,281,107
6	Atlantic croaker	8,308,521
7	King mackerel	5,010,102
8	Weakfish	3,781,065
9	Atlantic cod	3,566,146
10	Other fishes	2,766,503
11	Scup	2,734,688
12	Black sea bass	2,588,224
13	Atlantic mackerel	2,551,761
14	Tautog	2,470,268
15	Spot	2,271,880
16	Little tunny/Atlantic bonito	1,971,850
17	Spotted seatrout	1,907,617
18	Other sharks	1,891,765
19	Sheepshead	1,424,238
20	Kingfishes	1,394,042
21	Red drum	1,392,081
22	Spanish mackerel	1,336,676
23	Winter flounder	1,168,900
24	Black drum	1,050,560

Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/st1/recreational/index.html. Accessed July 2002.

listed in Table A-8. The most predominant recreational species in the Gulf fishery include spotted seatrout, red drum, *Mycteroperca* groupers (including gag, scamp, and black grouper), red snapper, and sheepshead.

Of the 18 species with recreational landings exceeding 1 million pounds per year; mercury concentration data are available in the Mercury in Marine Life Database for only nine of the species or groups. Mercury data and the number of samples (in parentheses) are available for nine finfish species: red drum (589), spotted seatrout (544), king mackerel (385), black drum (233), Spanish mackerel (204), sand seatrout (99), mullet (69), dolphin (29), and white grunt (2). Shellfish species are not included in the NMFS recreational fishery landings data.

Pacific Coast Statistics

Seventy-two species or groups of fish and other marine species are listed in the comprehensive recreational landing data for the Pacific coast presented in Table 8 (Attachment 1 to this Appendix). Only nine species had mean annual

Table A-8. Species with Greater Than 1 Million Pounds Average Annual Recreational Fisheries Landings in the Gulf of Mexico (1998 to 2000)

Rank	Species	Average
1	Spotted seatrout	11,347,637
2	Red drum	10,670,549
3	*Mycteroperca* groupers[1]	4,288,982
4	Red snapper	3,912,130
5	Sheepshead	3,445,974
6	Dolphins	3,315,379
7	King mackerel	3,192,296
8	Sand seatrout	2,442,777
9	Spanish mackerel	2,418,795
10	Black drum	2,238,741
11	Other fishes	1,900,964
12	Mullets	1,823,883
13	Pinfishes	1,569,240
14	*Epinephelus* groupers[2]	1,433,127
15	White grunt	1,345,618
16	Other tunas/mackerels	1,310,464
17	Gray snapper	1,062,464
18	Greater amberjack	1,050,636

[1] *Mycteroperca* grouper include gag, scamp, yellowmouth grouper, yellow fin grouper, and black grouper.
[2] *Epinephelus* grouper include jewfish, rock hind, speckled hind, red hind, yellowedge grouper, red grouper, Warsaw grouper, snowy grouper, Nassau grouper, mutton hamlet, coney, and marbled grouper.
Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/st1/recreational/index.html. Accessed July 2002.

recreational landings exceeding 1 million pounds in the Pacific coast fishery (Table A-9). The most predominant recreational species in the Pacific fishery include other fishes (unspecified species), other tunas/mackerel, yellowtail, black rockfish, and Pacific barracuda.

Table A-9. Species with Greater Than 1 Million Pounds Average Annual Recreational Fisheries Landings in the Pacific (1998 to 2000)

Rank	Species	Average
1	Other fishes	6,113,320
2	Other tunas/mackerels	4,117,996
3	Yellowtail	2,936,025
4	Black rockfish	2,296,647
5	Pacific barracuda	1,852,444
6	Lingcod	1,329,235
7	California halibut	1,268,619
8	Other rockfishes	1,125,366
9	Barred sand bass	1,053,010

Source: NOAA/NMFS/FSED at http://www.st.nmfs.gov/st1/recreational/index.html. Accessed July 2002.

Of the nine species with recreational landings exceeding 1 million pounds per year; mercury concentration data are available in the Mercury in Marine Life Database for only five of the species or groups. Mercury data and the number of samples (in parentheses) are available for five finfish: other rockfish (312), black rockfish (3), lingcod (1), barred sea bass (2), and California halibut (1). Shellfish species are not included in the NMFS recreational fishery landings data.

REFERENCES

NMFS (National Marine Fisheries Service). 2001a. *Commercial Fishery Landings*. National Marine Fisheries Service, Fisheries Statistics and Economics Division, Silver Spring, MD. Accessed July 2002 at http://www.st.nmfs.gov/st1/commercial/index.html.

NMFS (National Marine Fisheries Service). 2001b. *Recreational Fishery Landings*. National Marine Fisheries Service, Fisheries Statistics and Economics Division, Silver Spring, MD. Accessed July 2002 at http://www.st.nmfs.gov/st1/recreationall/queries/catch/snapshot.html.

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ATTACHMENT 1

ANNUAL COMMERCIAL FISHERY LANDINGS

Table 1. Annual Commercial Fisheries Landings by Species in the United States: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
1	Pollock, Walleye	2,561,783,276	2,752,656,486	2,325,889,086	2,606,804,256
2	Menhaden, Atlantic	1,817,969,068	1,704,272,214	1,989,068,311	1,760,566,678
3	Cod, Pacific	548,041,418	589,627,072	523,992,044	530,505,138
4	Hake, Pacific (Whiting)	485,748,404	509,485,583	492,607,111	455,152,518
5	Salmon, Pink	307,625,832	332,584,704	382,091,420	208,201,372
6	Crab, Blue	203,034,555	217,509,051	213,047,726	178,546,889
7	Salmon, Sockeye	193,753,663	128,740,064	244,347,916	208,173,008
8	Herring, Atlantic	170,437,356	180,478,712	175,004,814	155,828,543
9	Squid, California Market	156,060,918	6,381,235	201,762,173	260,039,345
10	Sole, Yellowfin	152,594,692	178,238,532	125,287,225	154,258,320
11	Crab, Snow	152,080,416	240,433,650	182,997,046	32,810,551
12	Salmon, Chum	145,977,338	131,596,077	143,994,758	162,341,179
13	Shrimp, Brown	144,170,557	130,333,397	137,007,872	165,170,401
14	Sardine, Pacific	126,011,310	95,486,141	132,560,094	149,987,695
15	Shrimp, White	108,292,749	98,587,689	103,368,155	122,922,404
16	Atka Mackerel	108,191,427	112,870,724	113,395,523	98,308,034
17	Seaweed, Kelp	107,406,567	55,836,200	173,983,500	92,400,000
18	Herring, Pacific	86,556,195	92,297,762	91,157,668	76,213,154
19	Lobster, American	83,938,653	80,092,672	87,420,414	84,302,874
20	Halibut, Pacific	76,423,319	75,589,329	79,298,783	74,381,845
21	Clam, Atlantic Surf	56,573,874	50,289,422	55,084,005	64,348,195
22	Goosefish	52,885,240	57,857,883	55,137,529	45,660,307
23	Sablefish	48,212,984	46,556,918	48,347,552	49,734,482
24	Sole, Rock	44,345,202	34,468,887	37,901,558	60,665,160
25	Catfishes and Bullheads	42,349,230	5,849,919	76,167,103	45,030,667
26	Rockfish, Pacific Ocean Perch	41,801,618	39,742,643	45,952,661	39,709,549
27	Squid, Longfin	40,382,222	42,224,390	42,811,807	36,110,469
28	Crab, Dungeness	38,839,456	34,307,924	44,017,481	38,192,963
29	Mackerel, Chub	38,715,716	47,560,482	20,018,883	48,567,782
30	Sole, Flathead	36,864,115	43,166,120	31,566,041	35,860,185
31	Shark, Spiny Dogfish	34,707,049	46,765,066	34,935,458	22,420,622
32	Salmon, Coho	33,090,375	36,148,501	29,254,437	33,868,187
33	Clam, Ocean Quahog	32,790,540	35,663,390	34,292,680	28,415,550
34	Skates	32,423,928	34,564,398	29,471,337	33,236,050
35	Sea Urchins	31,725,753	30,135,855	33,903,775	31,137,630
36	Hake, Silver	30,304,533	32,978,751	31,086,023	26,848,826
37	Oyster, Eastern	28,033,065	26,255,801	29,139,901	28,703,493
38	Tuna, Albacore	27,323,608	33,799,171	25,723,560	22,448,093
39	Rockfishes	27,272,140	24,017,216	31,267,198	26,532,006
40	Flounder, Arrowtooth	26,778,021	11,781,503	27,017,400	41,535,159
41	Croaker, Atlantic	26,362,716	25,427,599	26,865,727	26,794,822
42	Finfishes (Unclassified General)	26,181,069	26,578,918	18,514,954	33,449,336
43	Shrimp, Ocean	24,026,473	10,659,197	28,437,541	32,982,681
44	Cod, Atlantic	23,678,358	24,520,373	21,444,855	25,069,845
45	Scallop, Sea	22,791,362	12,961,008	22,747,960	32,665,119

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
46	Sole, Dover	22,314,754	22,160,225	23,957,534	20,826,503
47	Squid, Northern Shortfin	22,264,890	51,030,244	6,870,106	8,894,321
48	Mackerel, Atlantic	21,925,336	27,254,402	26,226,266	12,295,341
49	Mullet, Striped (Liza)	20,608,259	19,604,225	21,761,449	20,459,104
50	Flatfish	19,769,454	12,143,792	29,474,366	17,690,203
51	Tilapias	19,168,199	282,633	41,020,278	16,201,685
52	Crab, King	18,580,306	23,722,868	16,919,934	15,098,115
53	Shrimp, Pink	17,784,930	27,651,110	13,382,141	12,321,540
54	Swordfish	16,383,116	15,062,294	16,432,309	17,654,745
55	Tuna, Yellowfin	16,001,860	21,381,947	12,823,892	13,799,742
56	Salmon, Chinook	15,936,112	16,265,371	15,342,356	16,200,608
57	Anchovy, Northern	13,760,807	3,491,304	11,709,286	26,081,830
58	Shrimp, Marine, Other	12,938,641	17,409,638	11,592,801	9,813,483
59	Shad, Gizzard	12,324,043	2,845,668	23,055,984	11,070,478
60	Whitefish, Lake	11,926,572	12,517,134	11,801,807	11,460,774
61	Crayfishes or Crawfishes	11,865,525	21,977,681	13,226,019	392,875
62	Flounder, Winter	11,292,377	10,787,074	10,260,857	12,829,199
63	Flounder, Yellowtail	10,968,642	7,865,369	9,768,178	15,272,380
64	Flounder, Summer	10,832,141	10,992,953	10,496,250	11,007,219
65	Halibut, Greenland	10,596,303	18,120,495	30,466	13,637,947
66	Flounders, Righteye	10,569,499	10,569,499	NR	NR
67	Pollock	10,450,218	12,308,385	10,129,202	8,913,066
68	Shrimp, Brine	10,448,119	5,908,357	3,689,915	21,746,084
69	Clam, Quahog	10,294,836	9,668,050	9,517,265	11,699,193
70	Tuna, Skipjack	9,242,904	14,025,619	10,323,254	3,379,839
71	Rockfish, Widow	9,208,657	9,754,758	9,306,992	8,564,222
72	Sea Cucumber	8,725,061	6,601,868	8,826,846	10,746,469
73	Oyster, Pacific	8,577,662	7,408,252	8,684,140	9,640,594
74	Clams or Bivalves	8,526,386	8,393,794	8,539,976	8,645,389
75	Sharks	8,197,633	10,858,230	8,576,405	5,158,263
76	Plaice, American	8,091,080	8,075,408	6,909,439	9,288,392
77	Shrimp, Seabob	8,003,075	8,295,380	8,061,946	7,651,899
78	Bluefish	7,945,258	8,309,788	7,448,955	8,077,032
79	Tuna, Bigeye	7,805,755	8,678,225	7,743,933	6,995,106
80	Haddock	7,338,422	6,255,788	6,936,644	8,822,833
81	Shrimp, Rock	7,107,515	10,150,271	3,907,388	7,264,885
82	Weakfish	6,905,611	8,425,203	6,908,090	5,383,539
83	Bass, Striped	6,687,757	6,714,150	6,431,177	6,917,943
84	Spot	6,686,697	7,418,335	5,698,673	6,943,083
85	Finfishes (Unclassified Bait and Animal Food)	6,632,564	6,260,346	6,668,478	6,968,868
86	Crab, Florida Stone Claws	6,504,966	7,074,388	5,536,674	6,903,837
87	Grouper, Red	6,484,439	4,979,812	7,337,941	7,135,564
88	Rockfish, Yellowtail	6,480,310	6,363,512	6,070,774	7,006,643
89	Lobster, Caribbean Spiny	6,460,898	5,955,132	7,672,257	5,755,306
90	Shellfish	6,432,018	1,687,956	13,734,701	3,873,397
91	Hake, White	5,860,200	5,217,587	5,784,458	6,578,554

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
92	Mackerel, King and Cero	5,491,322	5,767,641	5,801,410	4,904,914
93	Hagfishes	5,416,756	3,210,888	5,919,198	7,120,183
94	Crab, Horseshoe	5,378,095	6,835,305	5,542,506	3,756,475
95	Drum, Black	5,350,907	4,601,340	5,423,457	6,027,925
96	Squids	5,298,344	3,296,775	1,294,332	11,303,925
97	Snapper, Red	5,268,142	5,094,097	5,354,539	5,355,789
98	Butterfish	4,820,573	5,576,795	5,135,306	3,749,618
99	Crabs	4,793,384	2,536,041	4,440,344	7,403,767
100	Flounder, Witch	4,715,978	4,089,882	4,681,887	5,376,166
101	Tuna, Bluefin	4,202,424	6,652,233	2,779,341	3,175,699
102	Thornyhead, Longspine	4,110,655	4,955,620	3,869,011	3,507,334
103	Crab, Blue, Peeler	3,918,475	4,070,122	3,705,168	3,980,134
104	Scups or Porgies	3,669,683	4,510,730	3,622,662	2,875,658
105	Sole, Petrale	3,566,728	3,226,584	3,303,294	4,170,307
106	Jack Mackerel	3,531,916	3,917,214	3,480,737	3,197,798
107	Mackerel, Spanish	3,496,703	3,527,016	3,290,429	3,672,663
108	Catfish, Blue	3,470,288	2,230,802	3,979,374	4,200,687
109	Sheepshead	3,443,763	3,044,681	3,827,422	3,459,186
110	Sea Bass, Black	3,425,978	3,273,942	3,609,283	3,394,708
111	Chubs	3,374,970	4,595,847	3,362,122	2,166,941
112	Flounder, Flukes	3,373,351	3,961,893	2,938,528	3,219,632
113	Crab, Atlantic Rock	3,301,337	3,007,821	2,866,451	4,029,739
114	Herring, Atlantic Thread	3,293,120	3,591,214	3,530,397	2,757,748
115	Hake, Red	3,286,709	2,961,194	3,434,528	3,464,405
116	Buffalofishes	3,274,403	2,114,985	4,884,473	2,823,752
117	Sole, Rex	3,271,820	7,313,481	1,300,915	1,201,063
118	Shrimp, Penaeid	3,260,038	3,656,720	3,085,295	3,038,099
119	Finfishes, Freshwater, Other	3,237,570	NR	2,529,835	3,945,305
120	Gag	3,081,863	3,632,328	2,894,140	2,719,120
121	Crab, Deepsea Red	3,081,634	2,129,775	1,862,360	5,252,766
122	Crab, Jonah	2,876,838	2,767,159	3,411,340	2,452,015
123	Mussel, Blue	2,863,360	3,112,750	2,211,379	3,265,952
124	Sole, English	2,731,591	3,151,704	2,512,572	2,530,496
125	Clam, Softshell	2,724,323	2,815,377	2,689,565	2,668,026
126	Snapper, Vermilion	2,687,510	2,451,270	2,821,236	2,790,025
127	Snails (Conchs)	2,445,102	2,056,428	3,232,193	2,046,684
128	Tilefish	2,441,279	3,278,325	1,916,548	2,128,964
129	Shad, American	2,401,412	3,300,200	1,798,182	2,105,855
130	Perch, White	2,373,356	2,126,996	2,299,517	2,693,556
131	Ladyfish	2,252,030	2,162,088	4,243,844	350,158
132	Crab, Southern Tanner	2,178,844	2,684,986	2,165,478	1,686,069
133	Catfish, Channel	2,146,499	2,526,844	2,068,975	1,843,678
134	Carp, Common	2,137,519	2,355,223	2,479,643	1,577,692
135	Rockfish, Chilipepper	2,072,427	3,164,937	2,054,585	997,760
136	Thornyhead, Shortspine	2,039,305	2,694,908	1,881,436	1,541,572
137	Scallop, Calico	2,035,865	2,396,511	3,571,876	139,208

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
138	Finfishes (Unclassified for Food)	1,940,360	2,200,933	1,870,888	1,749,259
139	Shrimp, Atlantic & Gulf, Roughneck	1,736,963	4,250,088	446,154	514,647
140	Flounder, Pacific, Sanddab	1,712,215	1,712,215	NR	NR
141	Shark, Sandbar	1,689,648	1,357,422	1,739,197	1,972,324
142	Snapper, Yellowtail	1,636,505	1,523,954	1,837,169	1,548,392
143	Clam, Pacific Geoduck	1,535,252	1,447,558	1,593,587	1,564,610
144	King Whiting	1,480,930	1,242,089	1,634,810	1,565,891
145	Rockfish, Canary	1,409,620	2,595,778	1,495,891	137,192
146	Drum, Freshwater	1,387,498	1,261,484	1,629,553	1,271,456
147	Rockfish, Splitnose	1,348,561	3,277,679	521,212	246,791
148	Eel, American	1,343,124	1,016,769	1,470,579	1,542,023
149	Crab, Blue, Soft and Peeler	1,334,556	513,305	1,770,312	1,720,051
150	Alewife	1,307,976	1,335,555	1,401,669	1,186,703
151	Grenadiers	1,290,689	2,214,074	964,134	693,858
152	Lingcod	1,281,192	2,089,381	1,374,535	379,660
153	Crab, Blue, Soft	1,271,735	2,134,086	728,641	952,478
154	Shark, Blacktip	1,256,100	464,467	1,687,092	1,616,740
155	Amberjack, Greater	1,229,243	1,293,751	1,198,926	1,195,052
156	Perch, Yellow	1,217,642	1,219,348	1,184,423	1,249,156
157	Sardine, Spanish	1,178,336	1,131,906	1,042,664	1,360,439
158	Shark, Smooth Dogfish	1,167,160	1,099,802	1,331,251	1,070,427
159	Trout, Lake	1,151,867	1,103,170	1,089,157	1,263,273
160	Halibut, California	1,133,798	1,204,012	1,333,418	863,963
161	Shrimp, Pacific Rock	1,132,953	435,931	1,394,174	1,568,755
162	Dolphin	1,098,598	926,907	1,221,567	1,147,320
163	Rockfish, Darkblotched	1,069,349	2,003,060	712,412	492,576
164	Crab, Red Rock	1,054,413	1,276,653	793,602	1,092,984
165	Grouper, Yellowedge	1,025,153	720,539	1,084,582	1,270,339
166	Ballyhoo	1,023,665	1,265,508	869,485	936,002
167	Bonito, Pacific	935,683	2,519,343	191,292	96,413
168	Shark, Dogfish	889,354	2,064,543	401,725	201,795
169	Smelts	857,456	832,771	735,398	1,004,199
170	Jack, Crevalle	840,073	956,403	855,494	708,321
171	Shark, Thresher	808,921	840,546	828,942	757,275
172	Shad, American Roe	798,014	949,071	589,936	855,034
173	Smelt, Rainbow	769,184	708,260	722,317	876,974
174	Scads	768,539	1,120,860	598,003	586,753
175	Clam, Manila	759,655	690,486	746,043	842,436
176	Jellyfish	748,824	748,824	NR	NR
177	Grunts	747,056	669,702	693,040	878,425
178	Redfish or Ocean Perch	728,617	706,524	778,019	701,309
179	Tuna, Little Tunny	715,595	660,642	1,013,996	472,146
180	Flounder, Windowpane	702,247	1,148,306	366,640	591,794
181	Seatrout, Spotted	664,560	588,991	835,332	569,358
182	Pompano, Florida	648,033	826,917	533,005	584,176
183	Lobster, California Spiny	646,245	738,159	493,987	706,590

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
184	Gars	638,642	510,190	780,314	625,421
185	Rockfish, Black	636,576	1,180,695	398,249	330,783
186	Shrimp, Spot	629,770	826,720	614,214	448,375
187	Seaweed, Irish Moss	616,658	1,550,133	178,470	121,371
188	Shrimp, Royal Red	614,735	395,048	602,339	846,819
189	Mullet, White	588,782	519,630	602,661	644,056
190	Scamp	588,473	537,078	706,304	522,036
191	Herring, Lake or Cisco	571,869	625,583	527,495	562,528
192	Cusk	567,712	780,365	507,522	415,248
193	Rockfish, Bank	558,639	1,324,061	136,910	214,947
194	Wolffish, Atlantic	553,756	651,559	567,848	441,860
195	Grouper, Snowy	529,314	434,552	581,676	571,715
196	Crab, Deepsea Golden	528,893	424,795	245,272	916,611
197	Amberjack	496,756	544,940	450,344	494,984
198	Suckers	470,056	655,431	624,121	130,615
199	Mojarras	457,233	430,233	434,424	507,042
200	Rockfish, Yelloweye	451,748	1,127,247	208,433	19,563
201	Sturgeon, White	447,707	519,755	368,893	454,473
202	Catfish, Flathead	447,352	883,313	286,790	171,953
203	Runner, Blue	445,923	601,618	452,500	283,650
204	Bloodworms	444,840	492,615	514,717	327,189
205	Leatherjackets	433,771	593,167	421,820	286,325
206	Shark, Shortfin Mako	409,998	528,348	340,501	361,145
207	Grouper, Black	406,962	323,779	316,167	580,939
208	Flounder, Starry	389,533	572,458	309,946	286,194
209	Snapper, Gray	369,825	405,156	348,332	355,987
210	Cabezon	365,000	433,594	335,993	325,414
211	Tunas	364,291	231,813	366,029	495,032
212	Drum, Red	363,024	338,042	427,676	323,353
213	Rockfish, Bocaccio	356,815	660,518	342,754	67,172
214	Tuna, Black Skipjack	353,354	509,362	197,346	NR
215	Spearfishes	346,334	296,000	472,000	271,001
216	Shark, Finetooth	335,589	370,740	352,159	283,867
217	Trout, Rainbow	328,769	398,687	262,893	324,728
218	Herring, Pacific, Roe on Kelp	314,992	232,957	521,211	190,807
219	Cobia	295,608	329,481	309,513	247,829
220	Rockfish, Blackgill	285,793	512,755	140,713	203,911
221	Snappers	283,478	168,096	349,460	332,877
222	Bass, White	279,905	365,718	239,789	234,207
223	Quillback	279,704	248,796	328,749	261,566
224	Snapper, Mutton	265,966	353,862	246,174	197,861
225	Shark, Atlantic Sharpnose	264,028	317,742	279,371	194,972
226	Tautog	236,636	254,426	209,140	246,342
227	Sponge, Grass	235,096	262,041	243,475	199,771
228	Wahoo	232,144	240,798	248,792	206,843
229	Sponge, Yellow	229,587	222,869	240,014	225,878

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
230	Sole, Sand	220,534	228,437	256,380	176,784
231	Tilefish, Blueline	220,212	219,935	206,444	234,258
232	Rockfish, Silvergray	212,591	429,854	204,724	3,195
233	Seabass, White	212,412	159,725	248,764	228,746
234	Porgy, Red	200,472	343,147	173,901	84,368
235	Scad, Bigeye	199,145	163,770	176,659	257,006
236	Sheephead, California	188,707	262,563	129,767	173,792
237	Octopus	182,030	444,828	54,695	46,568
238	Salmon, Pacific	176,147	299,324	103,309	125,809
239	Sandworms	176,012	167,600	242,320	118,117
240	Barracuda, Pacific	170,335	131,148	202,747	177,109
241	Seatrout, Sand	168,213	126,800	210,620	167,220
242	Rockfish, Greenstriped	167,611	374,625	106,438	21,770
243	Shark, Blacknose	167,165	141,285	118,310	241,901
244	Mackerel, King	166,647	NR	250,431	82,863
245	Croaker, Pacific White	166,064	142,491	162,719	192,981
246	Escolar	163,120	152,268	173,927	163,164
247	Rockfish, Starry	158,354	461,534	12,277	1,251
248	Bonito, Atlantic	156,557	179,022	183,894	106,756
249	Harvestfish	150,336	133,847	141,272	175,888
250	Whitefish, Round	147,809	205,383	134,460	103,585
251	Sponge, Sheepswool	147,236	132,752	145,126	163,829
252	Barracudas	144,290	180,033	127,013	125,825
253	Yellowtail	142,121	247,670	66,839	111,855
254	Grouper, Warsaw	139,861	87,529	188,772	143,281
255	Rockfish, Vermilion	139,250	284,291	101,055	32,404
256	Snapper, Silk	138,499	106,987	99,605	208,906
257	Jacks	136,812	157,547	131,328	121,561
258	Herring, Sea	133,010	133,010	NR	NR
259	Shark, Soupfin	130,059	119,341	164,548	106,288
260	Rockfish, Sharpchin	127,520	242,432	116,809	23,318
261	Shad, American Buck	119,427	153,190	88,548	116,542
262	Shad, Hickory	117,767	105,752	136,564	110,985
263	Shark, Dusky	115,043	52,682	90,848	201,599
264	Spadefishes	114,564	84,819	118,590	140,283
265	Groupers	109,317	135,151	114,827	77,974
266	Rockfish, Redstripe	108,718	244,207	73,547	8,401
267	Periwinkles	107,423	89,771	118,087	114,411
268	Rockfish, Redbanded	106,632	178,503	68,049	73,344
269	Tuna, Blackfin	102,052	115,036	111,784	79,336
270	Rockfish, Brown	97,869	101,912	115,285	76,409
271	Rockfish, Copper	94,162	137,185	107,040	38,261
272	Scorpionfishes	92,181	125,523	96,641	54,379
273	Sculpins	91,874	132,731	3,259	139,633
274	Jack, Almaco	91,276	52,734	118,607	102,488
275	Shark, Pacific Angel	90,818	NR	106,780	74,856

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
276	Eel, Conger	90,693	99,622	82,870	89,586
277	Triggerfish, Gray	89,408	NR	96,675	82,140
278	Puffers	87,914	63,120	103,312	97,310
279	Mullets	86,872	NR	77,666	96,077
280	Crab, Green	85,771	190,269	30,835	36,208
281	Clam, Pacific Littleneck	85,025	96,856	89,752	68,468
282	Rockfish, Blue	81,677	129,806	70,848	44,377
283	Penaeid Shrimp	80,702	97,991	84,797	59,317
284	Rockfish, Gopher	79,721	78,901	86,003	74,258
285	Rockfish, China	76,882	119,929	69,729	40,989
286	Hogfish	72,690	69,124	75,063	73,882
287	Rockfish, Grass	72,689	95,187	59,331	63,550
288	Pinfish	71,755	43,458	79,732	92,074
289	Sponges	71,716	55,805	67,499	91,845
290	Oilfish	70,354	40,849	70,525	99,689
291	Dory, American John	69,772	106,960	41,641	60,714
292	Searobins	69,114	70,363	84,779	52,201
293	Porgy, Knobbed	65,556	62,129	71,644	62,894
294	Snapper, Lane	61,882	54,649	68,559	62,437
295	Rockfish, Greenspotted	61,473	127,165	45,348	11,905
296	Turtle, Snapping	61,225	53,088	55,636	74,951
297	Flyingfishes	60,612	77,885	NR	43,338
298	Surfperches	59,828	73,781	49,419	56,285
299	Rockfish, Yellowmouth	59,399	87,329	68,134	22,734
300	Cutlassfish, Atlantic	57,748	26,362	43,198	103,685
301	Shark, Hammerhead	56,144	76,737	71,687	20,007
302	Clam, Atlantic Jackknife	55,824	38,796	50,017	78,659
303	Hind, Speckled	55,755	51,148	51,089	65,028
304	Carps and Minnows	55,506	26,875	69,455	70,187
305	Scallop, Bay	55,096	104,897	35,433	24,957
306	Herring, Round	54,513	15,487	NR	93,539
307	Permit	54,209	93,927	38,609	30,090
308	Rockfish, Black-and-Yellow	51,912	55,576	55,515	44,644
309	Sturgeon, Green	51,667	38,850	36,752	79,400
310	Rockfish, Aurora	51,378	77,662	59,113	17,359
311	Rudderfish, Banded	50,385	43,619	48,489	59,047
312	Silversides	46,610	52,432	54,653	32,744
313	Snapper, Black	44,749	NR	45,922	43,576
314	Oyster, European Flat	43,990	53,773	44,564	33,634
315	Rockfish, Stripetail	42,481	94,793	22,517	10,132
316	Burbot	41,940	53,800	28,468	43,553
317	Bowfin	41,882	44,728	55,203	25,714
318	Pigfish	41,270	43,178	41,654	38,978
319	Hake, Atlantic, Red/White	40,982	43,074	29,926	49,945
320	Turtles	40,834	NR	25,139	56,529
321	Pout, Ocean	39,912	38,632	40,457	40,646

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
322	Shrimp, Ghost	39,276	38,515	40,882	38,432
323	Crab, Snow/Tanner	38,740	NR	NR	38,740
324	Amberjack, Lesser	38,628	30,320	38,498	47,066
325	Rosefish, Blackbelly	37,754	43,236	56,037	13,989
326	Carp, Grass	37,599	28,740	47,137	36,919
327	Rockfish, Shortbelly	36,913	46,860	19,371	44,508
328	Snapper, Queen	32,558	30,722	28,495	38,456
329	Pinfish, Spottail	32,289	24,870	40,633	31,365
330	Shark, Leopard	31,108	32,723	31,492	29,110
331	Mollusks	30,737	37,816	27,653	26,741
332	Moonfish, Atlantic	30,198	23,223	28,883	38,488
333	Shark, Lemon	29,318	24,577	31,795	31,581
334	Goatfishes	26,668	26,668	NR	NR
335	Squid, Jumbo	26,528	NR	26,528	NR
336	Rays	25,859	22,460	3,480	51,638
337	Clam, Butter	25,719	19,061	23,004	35,093
338	Hind, Red	25,687	23,911	27,350	25,799
339	Brotula, Bearded	24,895	24,326	29,762	20,598
340	Hind, Rock	24,820	20,030	27,418	27,012
341	Herrings	24,725	19,040	23,159	31,976
342	Skippers	24,384	32,779	18,125	22,248
343	Halibut, Atlantic	22,760	18,549	25,343	24,389
344	Smelt, Eulachon	21,463	12,060	23,325	29,004
345	Shark, Bull	20,799	9,931	34,018	18,447
346	Shrimp, Blue Mud	20,772	23,205	16,421	22,690
347	Rockfish, Cowcod	19,742	35,300	18,061	5,866
348	Mackerel, Frigate	19,719	2,989	36,485	19,682
349	Goldfish	18,952	21,277	14,854	20,726
350	Hake, Offshore Silver	18,836	11,654	26,018	NR
351	Jack, Bar	18,464	3,681	30,193	21,517
352	Cockle, Nuttall	17,612	8,927	16,926	26,984
353	Shark, Bigeye Thresher	15,381	23,967	12,081	10,095
354	Black Driftfish	15,352	NR	14,841	15,863
355	Lobster, Slipper	15,035	23,342	11,165	10,597
356	Scup	14,567	14,567	NR	NR
357	Rockfish, Speckled	14,011	30,090	9,197	2,747
358	Finfishes, Marine, Other	13,022	164	30,465	8,436
359	Margate	12,995	16,993	11,356	10,635
360	Shark, Tiger	12,980	13,959	14,775	10,206
361	Shark, Porbeagle	12,789	27,118	7,429	3,819
362	Shark, Silky	12,517	18,925	6,968	11,657
363	Sea Chubs	12,235	NR	6,902	17,568
364	Shrimp, Freshwater	12,219	NR	12,219	NR
365	Sea Catfishes	11,525	6,464	11,243	16,867
366	Clam, Pacific Razor	11,463	3,088	213	31,089
367	Finfishes, Groundfishes, Other	11,358	NR	22,714	2

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
368	Thresher Sharks	11,299	3,969	22,776	7,151
369	Grunt, White	11,263	NR	10,795	11,730
370	Clam, Arc, Blood	11,245	17,455	12,888	3,392
371	Tripletail	10,648	7,877	10,532	13,534
372	Shark, Bonnethead	10,633	17,833	3,432	NR
373	Dealfish	9,507	1,234	3,226	24,060
374	Frogs	9,502	12,322	6,681	NR
375	Walleye	9,380	13,605	5,284	9,250
376	Pompano, African	9,173	8,260	7,254	12,006
377	Rockfish, Pinkrose	9,069	9,069	NR	NR
378	Tilefish, Goldface	8,517	1,228	14,514	9,810
379	Sea Raven	8,493	7,136	10,658	7,684
380	Sole, Curlfin	8,187	17,037	5,835	1,689
381	Crappie	8,003	6,635	8,485	8,889
382	Snapper, Cubera	7,262	9,261	7,533	4,993
383	Lookdown	7,257	4,218	5,086	12,468
384	Rockfish, Kelp	7,248	11,209	6,966	3,570
385	Cunner	7,245	6,536	8,501	6,698
386	Eels	7,028	11,616	4,724	4,744
387	Barrelfish	6,860	3,684	9,377	7,519
388	Rockfish, Olive	6,619	12,093	5,337	2,426
389	Grouper, Marbled	6,612	13,350	4,376	2,111
390	Turtle, Soft-shell	6,386	NR	6,433	6,339
391	Surgeonfishes	6,373	NR	6,373	NR
392	Mussels, Freshwater	6,205	NR	6,205	NR
393	Wreckfish	6,185	12,358	11	NR
394	Grouper, Yellowfin	6,059	1,160	7,859	9,158
395	Rockfish, Greenblotched	5,829	12,999	3,359	1,130
396	Shark, Longfin Mako	5,668	6,178	4,605	6,220
397	Sea Bass, Giant	5,393	6,497	5,186	4,495
398	Toadfishes	5,093	8,073	4,448	2,759
399	Scallops	5,049	7,106	293	7,748
400	Rockfish, Rosy	4,894	10,921	3,270	492
401	Porgy, Jolthead	4,810	3,146	4,941	6,343
402	Shark, Spinner	4,138	83	NR	8,192
403	Wolf-eel	3,903	4,824	3,400	3,486
404	Oyster, Olympia	3,716	3,712	3,706	3,729
405	Sole, Butter	3,385	7,879	1,108	1,168
406	Creole-fish	3,354	2,333	4,115	3,613
407	Shark, Blue	3,327	6,064	2,195	1,721
408	Bigeye	3,207	3,339	2,740	3,543
409	Snapper, Blackfin	3,161	2,738	4,113	2,631
410	Porgy, Whitebone	3,076	NR	4,457	1,694
411	Rockfish, Flag	2,912	6,936	1,306	494
412	Rockfish, Bronzespotted	2,820	2,475	5,369	617
413	Parrotfishes	2,636	4,615	2,100	1,194

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
414	Squirrelfishes	2,484	2,501	2,963	1,989
415	Clam, Pacific, Gaper	2,420	2,824	2,983	1,452
416	Anchovies	2,348	4,625	70	NR
417	Wenchman	2,171	NR	3,624	717
418	Rockfish, Treefish	2,157	571	2,040	3,859
419	Mantis Shrimps	2,105	2,465	556	3,295
420	Opah	1,928	1,660	2,345	1,780
421	Triggerfish, Ocean	1,875	NR	1,875	NR
422	Grouper, Misty	1,872	NR	845	2,899
423	Sunfishes	1,774	756	800	3,766
424	Seaweeds	1,711	NR	NR	1,711
425	Runner, Rainbow	1,710	809	3,960	360
426	Scad, Rough	1,629	NR	1,629	NR
427	Corals	1,439	30	2,848	NR
428	Snapper, Dog	1,348	2,226	977	841
429	Graysby	1,333	2,728	305	966
430	Bass, Rock	1,332	190	1,626	2,181
431	Skate, Big	1,257	NR	1,257	NR
432	Launces	1,209	1,855	1,483	290
433	Gunnels	1,151	NR	1,677	625
434	Seaweed, Rockweed	1,112	NR	NR	1,112
435	Rockfish, Swordspine	1,037	NR	295	1,778
436	Bass, Longtail	946	538	1,279	1,021
437	Echinoderm	934	880	921	1,000
438	Snapper Caribbean Red	903	NR	NR	903
439	Tilefish, Sand	893	1,019	1,264	396
440	Grouper, Yellowmouth	837	NR	837	NR
441	Marlin, White	798	NR	798	NR
442	Sea Bass, Rock	768	706	1,085	512
443	Shark, Makos	745	NR	NR	745
444	Rockfish, Squarespot	697	2,051	23	17
445	Sand Perch	646	918	650	370
446	Queenfish	635	NR	399	871
447	Shark, Sand Tiger	589	84	320	1,364
448	Finfishes, Pelagic, Other	428	NR	86	769
449	Eels, Snake	412	NR	NR	412
450	Mussel, California	305	340	365	210
451	Rockfish, Pink	305	NR	561	49
452	Scorpionfish, Spinycheek	286	286	NR	NR
453	Clam, California Jackknife	266	306	300	193
454	Drums	243	NR	432	54
455	Jack, Black	226	NR	321	130
456	Prickleback, Monkeyface	216	225	175	248
457	Sturgeons	186	353	118	86
458	Jack, Horse-eye	151	132	138	183
459	Skate, California	141	NR	141	NR

(continued)

Table 1. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
460	Turtle, Terrapin	131	343	2	47
461	Butterflyfishes	124	NR	124	NR
462	Sea Bass, Bank	116	116	NR	NR
463	Snapper, Mahogany	98	NR	98	NR
464	Lamprey, Sea	96	96	NR	NR
465	Shark, Atlantic Angel	86	NR	NR	86
466	Roughy, Big	70	NR	NR	70
467	Tarpon	68	126	29	50
468	Rockfish, Chameleon	67	18	174	8
469	Crab, Cancer	62	30	93	NR
470	Lumpfish	58	66	81	28
471	Ratfish Spotted	56	94	17	NR
472	Finfishes (Unclassified Spawning Finfish)	52	NR	60	44
473	Eel, Morays	51	51	NR	NR
474	Shark, Nurse	51	10	11	132
475	Spanish Flag	31	30	31	NR
476	Snapper, Schoolmaster	26	NR	42	10
477	Rockfish, Honeycomb	18	NR	18	NR
478	Shark, Bignose	15	NR	15	NR
479	Argentines	10	NR	10	NR
480	Hogchoker	5	NR	5	NR
481	Needlefish, Atlantic	2	NR	3	1
482	Starfish	2	NR	NR	2

"Annual Commercial Fishery Landing by Species – National: 1998–2000"

Source: http://www.st.nmfs.gov/st1/commercial/index.html
Accessed in July 2002

Searched on:
Years: 1998–2000
Species: ALL SPECIES individually
State: All States

Table 2. Annual Commercial Fisheries Landings by Species in the Atlantic: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
1	Menhaden, Atlantic	508,956,857	611,602,033	458,581,558	456,686,980
2	Herring, Atlantic	170,437,356	180,478,712	175,004,814	155,828,543
3	Crab, Blue	135,242,532	150,206,705	144,651,958	110,868,932
4	Lobster, American	83,938,653	80,092,672	87,420,414	84,302,874
5	Clam, Atlantic Surf	56,573,874	50,289,422	55,084,005	64,348,195
6	Goosefish	52,885,019	57,857,883	55,136,868	45,660,307
7	Catfishes and Bullheads	52,207,065	4,981,204	95,749,287	55,890,705
8	Squid, Longfin	40,382,222	42,224,390	42,811,807	36,110,469
9	Shark, Spiny Dogfish	33,316,460	45,492,042	33,555,195	20,902,143
10	Clam, Ocean Quahog	32,790,540	35,663,390	34,292,680	28,415,550
11	Hake, Silver	30,304,533	32,978,751	31,086,023	26,848,826
12	Skates	28,640,145	30,728,282	25,787,885	29,404,267
13	Croaker, Atlantic	26,245,433	25,314,711	26,732,123	26,689,464
14	Tilapias	24,418,291	3,565	52,593,131	20,658,176
15	Cod, Atlantic	23,678,358	24,520,373	21,444,855	25,069,845
16	Squid, Northern Shortfin	22,264,890	51,030,244	6,870,106	8,894,321
17	Scallop, Sea	22,119,859	12,126,370	22,078,272	32,154,934
18	Mackerel, Atlantic	21,925,336	27,254,402	26,226,266	12,295,341
19	Shrimp, White	15,831,212	14,035,497	18,693,815	14,764,324
20	Sea Urchins	14,694,809	15,461,810	15,723,795	12,898,821
21	Shad, Gizzard	14,083,066	2,458,192	26,771,206	13,019,800
22	Flounder, Winter	11,292,377	10,787,074	10,260,857	12,829,199
23	Flounder, Yellowtail	10,968,642	7,865,369	9,768,178	15,272,380
24	Flounder, Summer	10,832,141	10,992,953	10,496,250	11,007,219
25	Pollock	10,450,218	12,308,385	10,129,202	8,913,066
26	Clam, Quahog	9,690,864	9,123,674	8,795,289	11,153,629
27	Shrimp, Marine, Other	9,479,670	13,711,625	8,118,017	6,609,369
28	Clams or Bivalves	8,264,565	7,994,276	8,164,129	8,635,289
29	Plaice, American	8,091,080	8,075,408	6,909,439	9,288,392
30	Bluefish	7,861,979	8,253,047	7,349,141	7,983,750
31	Sea Cucumber	7,509,742	5,304,749	7,724,174	9,500,304
32	Haddock	7,338,422	6,255,788	6,936,644	8,822,833
33	Weakfish	6,905,367	8,424,725	6,907,836	5,383,539
34	Bass, Striped	6,687,757	6,714,150	6,431,177	6,917,943
35	Spot	6,586,086	7,293,919	5,589,213	6,875,127
36	Finfishes (Unclassified General)	6,485,107	5,654,213	2,291,364	11,509,743
37	Hake, White	5,860,200	5,217,587	5,784,458	6,578,554
38	Shrimp, Brown	5,762,936	2,281,197	5,780,411	9,227,200
39	Finfishes (Unclassified Bait and Animal Food)	5,452,535	5,373,872	5,433,731	5,550,002
40	Crab, Horseshoe	5,279,459	6,835,305	5,246,598	3,756,475
41	Hagfishes	5,081,494	3,191,277	5,251,648	6,801,556
42	Oyster, Eastern	5,024,590	5,707,276	5,208,208	4,158,286
43	Flounder, Witch	4,715,978	4,089,882	4,681,887	5,376,166
44	Crabs	4,527,026	2,118,399	4,133,510	7,329,169

(continued)

Table 2. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
45	Squids	4,355,888	1,211,519	676,235	11,179,911
46	Finfishes, Freshwater, Other	4,094,546	NR	3,183,750	5,005,341
47	Butterfish	4,072,560	4,337,290	4,625,135	3,255,256
48	Swordfish	4,024,482	3,678,565	4,142,317	4,252,565
49	Shellfish	3,920,719	223,253	9,663,376	1,875,529
50	Crab, Blue, Peeler	3,653,419	4,070,122	3,454,716	3,435,418
51	Shrimp, Rock	3,636,571	2,200,641	2,276,406	6,432,667
52	Mullet, Striped (Liza)	3,555,985	3,931,934	2,679,577	4,056,444
53	Scups or Porgies	3,397,603	4,181,348	3,342,111	2,669,349
54	Flounder, Flukes	3,373,351	3,961,893	2,938,528	3,219,632
55	Crab, Atlantic Rock	3,301,337	3,007,821	2,866,451	4,029,739
56	Hake, Red	3,286,709	2,961,194	3,434,528	3,464,405
57	Sea Bass, Black	3,255,819	3,152,535	3,463,015	3,151,908
58	Mackerel, King and Cero	3,130,182	3,249,226	3,198,794	2,942,525
59	Crab, Deepsea Red	3,081,634	2,129,775	1,862,360	5,252,766
60	Crab, Jonah	2,876,838	2,767,159	3,411,340	2,452,015
61	Clam, Softshell	2,724,171	2,815,026	2,689,565	2,667,923
62	Mackerel, Spanish	2,653,137	3,056,966	2,327,462	2,574,984
63	Mussel, Blue	2,493,580	2,816,700	1,825,288	2,838,752
64	Snails (Conchs)	2,443,713	2,053,766	3,230,689	2,046,684
65	Tuna, Bluefin	2,319,900	2,289,565	2,266,963	2,403,173
66	Perch, White	2,199,389	1,860,769	2,179,282	2,558,115
67	Tilefish	2,076,912	2,978,156	1,551,015	1,701,566
68	Tuna, Yellowfin	1,687,930	1,355,654	1,555,445	2,152,691
69	Eel, American	1,398,387	1,016,745	1,601,326	1,577,091
70	Sharks	1,342,606	1,238,127	1,466,143	1,323,549
71	Alewife	1,285,029	1,331,720	1,351,686	1,171,680
72	Crab, Blue, Soft	1,224,127	2,134,086	642,703	895,591
73	King Whiting	1,191,425	954,149	1,378,405	1,241,721
74	Tuna, Bigeye	1,182,559	1,241,914	1,532,079	773,684
75	Shark, Smooth Dogfish	1,167,160	1,099,802	1,331,251	1,070,427
76	Crab, Blue, Soft and Peeler	1,148,662	242,739	1,645,421	1,557,827
77	Shark, Sandbar	1,022,249	715,831	1,215,185	1,135,730
78	Snapper, Vermilion	993,758	715,752	888,796	1,376,727
79	Shark, Dogfish	888,310	2,064,543	398,591	201,795
80	Shad, American	835,433	1,073,730	729,274	703,295
81	Shad, American Roe	798,014	949,071	589,936	855,034
82	Redfish or Ocean Perch	728,617	706,524	778,019	701,309
83	Flounder, Windowpane	702,247	1,148,306	366,640	591,794
84	Gag	690,432	855,205	681,522	534,568
85	Flatfish	655,247	1,035,291	459,402	471,047
86	Shrimp, Pink	617,247	540,164	681,842	629,736
87	Seaweed, Irish Moss	616,658	1,550,133	178,470	121,371
88	Lobster, Caribbean Spiny	609,528	537,642	704,169	586,772
89	Scallop, Calico	593,856	93,402	1,548,958	139,208
90	Herring, Atlantic Thread	577,712	881,110	840,389	11,637
91	Cusk	567,632	780,125	507,522	415,248

(continued)

Table 2. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
92	Dolphin	563,535	504,423	609,299	576,882
93	Wolffish, Atlantic	553,756	651,559	567,848	441,860
94	Seatrout, Spotted	514,367	393,746	686,699	462,657
95	Finfishes (Unclassified for Food)	464,431	758,092	332,526	302,675
96	Bloodworms	444,840	492,615	514,717	327,189
97	Tuna, Little Tunny	429,450	433,252	502,651	352,447
98	Mullet, White	418,680	417,491	474,069	364,481
99	Amberjack, Greater	399,803	519,641	321,460	358,309
100	Grouper, Snowy	344,982	297,609	400,198	337,138
101	Tuna, Albacore	343,174	418,095	391,750	219,678
102	Shark, Finetooth	335,589	370,740	352,159	283,867
103	Scamp	327,498	281,964	404,587	295,943
104	Drum, Red	325,073	302,475	387,474	285,269
105	Leatherjackets	313,608	425,332	300,334	215,159
106	Ballyhoo	307,657	433,695	282,503	206,774
107	Carp, Common	302,420	446,679	296,479	164,101
108	Grouper, Red	301,040	299,454	321,501	282,165
109	Crab, Deepsea Golden	297,218	175,785	245,272	470,598
110	Jack, Crevalle	276,051	290,345	294,771	243,038
111	Perch, Yellow	275,133	223,540	329,853	272,007
112	Amberjack	272,065	281,709	257,411	277,076
113	Shark, Atlantic Sharpnose	262,875	314,999	279,371	194,256
114	Tautog	236,636	254,426	209,140	246,342
115	Sardine, Spanish	236,208	331,074	371,591	5,960
116	Sheepshead	234,207	213,452	189,693	299,476
117	Drum, Black	233,425	134,648	335,142	230,484
118	Mojarras	212,970	192,156	196,502	250,252
119	Shark, Blacktip	211,884	205,544	180,848	249,259
120	Runner, Blue	184,611	234,676	183,646	135,512
121	Shrimp, Royal Red	183,001	78,549	161,738	308,716
122	Grunts	181,529	194,645	180,474	169,469
123	Shark, Shortfin Mako	180,462	218,900	166,524	155,961
124	Sandworms	176,012	167,600	242,320	118,117
125	Pompano, Florida	158,426	243,526	109,705	122,047
126	Tunas	155,410	76,596	98,795	290,840
127	Bonito, Atlantic	154,858	179,022	180,879	104,673
128	Harvestfish	150,336	133,847	141,272	175,888
129	Shark, Blacknose	148,405	117,891	107,219	220,104
130	Barracudas	138,022	178,029	115,976	120,062
131	Porgy, Red	135,782	279,181	111,338	16,826
132	Herring, Sea	133,010	133,010	NR	NR
133	Shark, Thresher	120,038	134,599	119,750	105,765
134	Shad, American Buck	119,427	153,190	88,548	116,542
135	Shad, Hickory	117,767	105,752	136,564	110,985
136	Snapper, Yellowtail	116,166	126,550	118,746	103,201
137	Cobia	114,569	126,201	118,328	99,179
138	Crab, Florida Stone Claws	109,808	110,379	90,966	128,079

(continued)

Table 2. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
139	Periwinkles	107,423	89,771	118,087	114,411
140	Shark, Dusky	106,941	41,609	77,616	201,599
141	Tilefish, Blueline	102,629	89,839	107,613	110,434
142	Snapper, Red	92,958	87,126	91,542	100,207
143	Eel, Conger	89,681	98,715	81,499	88,829
144	Crab, Green	85,771	190,269	30,835	36,208
145	Spadefishes	83,392	75,582	85,052	89,541
146	Penaeid Shrimp	80,702	97,991	84,797	59,317
147	Puffers	79,230	53,156	95,394	89,140
148	Scads	70,174	116,452	93,779	291
149	Dory, American John	69,772	106,960	41,641	60,714
150	Searobins	69,114	70,363	84,779	52,201
151	Snapper, Gray	63,504	77,834	58,338	54,339
152	Wahoo	61,228	60,793	74,503	48,387
153	Snapper, Mutton	60,040	80,369	64,044	35,707
154	Clam, Atlantic Jackknife	55,824	38,796	50,017	78,659
155	Scallop, Bay	55,096	104,897	35,433	24,957
156	Tuna, Skipjack	50,003	52,810	92,503	4,697
157	Silversides	46,610	52,432	54,653	32,744
158	Turtles	45,241	NR	NR	45,241
159	Shark, Hammerhead	44,427	56,977	56,298	20,007
160	Pinfish	43,107	13,886	52,722	62,713
161	Pigfish	41,270	43,178	41,654	38,978
162	Porgy, Knobbed	40,835	42,809	44,181	35,516
163	Pout, Ocean	39,912	38,632	40,457	40,646
164	Turtle, Snapping	37,650	40,682	20,816	51,453
165	Jacks	37,628	59,525	34,948	18,410
166	Rosefish, Blackbelly	37,333	43,236	56,018	12,746
167	Jack, Almaco	37,229	6,680	59,887	45,121
168	Hogfish	34,168	33,042	38,172	31,290
169	Scad, Bigeye	33,682	41,946	38,026	21,074
170	Hake, Atlantic, Red/White	32,853	41,109	19,201	38,249
171	Pinfish, Spottail	32,289	24,870	40,633	31,365
172	Moonfish, Atlantic	30,172	23,223	28,804	38,488
173	Rudderfish, Banded	29,469	28,607	25,401	34,400
174	Tuna, Blackfin	28,780	34,900	32,699	18,741
175	Grouper, Black	24,582	28,448	18,658	26,640
176	Oyster, European Flat	24,437	29,136	25,855	18,320
177	Skippers	24,384	32,779	18,125	22,248
178	Carps and Minnows	24,365	21,538	23,583	27,975
179	Hind, Rock	23,054	16,800	26,215	26,147
180	Halibut, Atlantic	22,760	18,549	25,343	24,389
181	Groupers	22,585	20,709	25,974	21,073
182	Octopus	21,640	24,468	21,093	19,358
183	Mackerel, Chub	20,969	40,219	6,443	16,246
184	Gars	20,400	20,770	19,252	21,179
185	Mackerel, Frigate	19,719	2,989	36,485	19,682

(continued)

Table 2. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
186	Escolar	19,190	20,919	14,922	21,730
187	Hake, Offshore Silver	18,836	11,654	26,018	NR
188	Grouper, Yellowedge	18,597	8,553	9,824	37,414
189	Shark, Bonnethead	17,833	17,833	NR	NR
190	Cutlassfish, Atlantic	17,181	4,775	27,338	19,431
191	Hind, Red	16,600	19,314	16,691	13,795
192	Ladyfish	16,224	22,745	17,033	8,894
193	Scup	14,567	14,567	NR	NR
194	Shark, Porbeagle	12,789	27,118	7,429	3,819
195	Sea Chubs	12,235	NR	6,902	17,568
196	Shark, Tiger	11,758	11,935	14,775	8,564
197	Grunt, White	11,263	NR	10,795	11,730
198	Clam, Arc, Blood	11,245	17,455	12,888	3,392
199	Dealfish	9,507	1,234	3,226	24,060
200	Sea Raven	8,493	7,136	10,658	7,684
201	Oilfish	8,318	7,965	5,518	11,471
202	Pompano, African	7,933	7,402	5,198	11,198
203	Cunner	7,245	6,536	8,501	6,698
204	Shark, Silky	7,163	13,771	6,968	751
205	Sponges	6,953	NR	NR	6,953
206	Snapper, Lane	6,744	8,114	6,298	5,821
207	Tripletail	6,625	6,531	4,976	8,368
208	Lookdown	6,394	4,218	5,013	9,951
209	Wreckfish	6,185	12,358	11	NR
210	Shrimp, Seabob	6,027	NR	6,027	NR
211	Burbot	5,837	176	9,139	8,195
212	Crappie	5,552	5,316	4,975	6,364
213	Toadfishes	5,093	8,073	4,448	2,759
214	Shark, Bull	4,762	7,025	6,492	768
215	Snapper, Silk	4,645	2,209	7,042	4,684
216	Snapper, Cubera	4,604	6,346	3,659	3,808
217	Surgeonfishes	4,464	NR	4,464	NR
218	Eels	4,282	6,362	3,929	2,556
219	Shark, Lemon	3,608	NR	6,798	418
220	Amberjack, Lesser	3,440	3,537	2,703	4,080
221	Permit	2,692	3,205	1,694	3,178
222	Suckers	2,565	245	4,867	2,583
223	Rays	2,559	NR	2,559	NR
224	Snappers	2,479	3,289	2,056	2,092
225	Lobster, Slipper	2,435	3,694	738	2,872
226	Anchovies	2,348	4,625	70	NR
227	Parrotfishes	2,151	4,207	1,433	813
228	Mantis Shrimps	2,105	2,465	556	3,295
229	Whitefish, Lake	2,070	NR	3,469	670
230	Bigeye	2,047	2,154	1,420	2,567
231	Sunfishes	1,774	756	800	3,766
232	Bowfin	1,741	1,487	1,172	2,565

(continued)

Table 2. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
233	Margate	1,736	2,330	1,342	1,537
234	Seaweeds	1,711	NR	NR	1,711
235	Opah	1,695	1,660	1,646	1,780
236	Grouper, Yellowfin	1,657	863	2,009	2,099
237	Scad, Rough	1,629	NR	1,629	NR
238	Shark, Longfin Mako	1,608	3,110	1,185	528
239	Seatrout, Sand	1,551	972	668	3,012
240	Squirrelfishes	1,547	1,704	1,516	1,421
241	Shark, Blue	1,543	NR	1,543	NR
242	Graysby	1,292	2,728	273	876
243	Snapper, Queen	1,223	NR	NR	1,223
244	Mullets	1,220	NR	NR	1,220
245	Launces	1,209	1,855	1,483	290
246	Gunnels	1,151	NR	1,677	625
247	Tilefish, Sand	1,135	1,005	1,264	NR
248	Seaweed, Rockweed	1,112	NR	NR	1,112
249	Marlin, White	798	NR	798	NR
250	Shark, Makos	745	NR	NR	745
251	Sand Perch	646	918	650	370
252	Jack, Bar	640	403	796	721
253	Drum, Freshwater	638	NR	598	677
254	Hind, Speckled	612	1,325	306	206
255	Shark, Sand Tiger	589	84	320	1,364
256	Snapper, Dog	491	850	131	NR
257	Finfishes, Pelagic, Other	428	NR	86	769
258	Porgy, Jolthead	344	396	231	406
259	Grouper, Warsaw	328	270	NR	385
260	Walleye	323	NR	417	229
261	Smelt, Rainbow	320	247	113	601
262	Scorpionfishes	316	417	264	267
263	Sculpins	308	NR	308	NR
264	Sea Bass, Rock	301	NR	301	NR
265	Barrelfish	262	NR	95	428
266	Brotula, Bearded	247	247	NR	NR
267	Drums	243	NR	432	54
268	Bass, Rock	233	NR	NR	233
269	Scallops	195	NR	NR	195
270	Sturgeons	186	353	118	86
271	Turtle, Terrapin	131	343	2	47
272	Butterflyfishes	124	NR	124	NR
273	Bass, White	105	NR	113	96
274	Snapper, Mahogany	98	NR	98	NR
275	Lamprey, Sea	96	96	NR	NR
276	Shark, Atlantic Angel	86	NR	NR	86
277	Shark, Spinner	83	83	NR	NR
278	Jack, Horse-eye	73	73	NR	NR
279	Roughy, Big	70	NR	NR	70

(continued)

Table 2. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
280	Tarpon	68	126	29	50
281	Crab, Cancer	62	30	93	NR
282	Lumpfish	58	66	81	28
283	Finfishes (Unclassified Spawn)	52	NR	60	44
284	Shark, Nurse	51	10	11	132
285	Eel, Morays	51	51	NR	NR
286	Snapper, Schoolmaster	42	NR	42	NR
287	Halibut, Greenland	39	33	44	39
288	Snapper, Blackfin	32	32	NR	NR
289	Shark, Bigeye Thresher	29	NR	29	NR
290	Grenadiers	23	NR	NR	23
291	Salmon, Pacific	20	20	NR	NR
292	Shark, Bignose	15	NR	15	NR
293	Argentines	10	NR	10	NR
294	Hogchoker	5	NR	5	NR
295	Needlefish, Atlantic	2	NR	3	1
296	Finfishes, Groundfishes, Other	2	NR	NR	2
297	Starfish	2	NR	NR	2

"Annual Commercial Fishery Landing by Species – Atlantic: 1998, 1999, 2000"
File Name: Comm_Atlantic.xls

Source: http://www.st.nmfs.gov/st1/commercial/index.html
Accessed in July 2002

Searched on:
Years: 1998–2000
Species: ALL SPECIES individually
State: Atlantic

Table 3. Annual Commercial Fisheries Landings by Species in the Gulf: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
1	Menhaden, Atlantic	1,309,012,211	1,092,670,181	1,530,486,753	1,303,879,698
2	Shrimp, Brown	138,407,621	128,052,200	131,227,461	155,943,201
3	Shrimp, White	92,461,537	84,552,192	84,674,340	108,158,080
4	Crab, Blue	67,916,974	67,302,346	68,447,018	68,001,559
5	Oyster, Eastern	23,008,475	20,548,525	23,931,693	24,545,207
6	Shrimp, Pink	17,167,683	27,110,946	12,700,299	11,691,804
7	Mullet, Striped (Liza)	17,052,274	15,672,291	19,081,872	16,402,660
8	Crayfishes or Crawfishes	11,865,525	21,977,681	13,226,019	392,875
9	Shrimp, Seabob	8,001,066	8,295,380	8,055,919	7,651,899
10	Finfishes (Unclassified General)	7,570,235	8,385,554	7,771,008	6,554,143
11	Crab, Florida Stone Claws	6,395,158	6,964,009	5,445,708	6,775,758
12	Grouper, Red	6,183,399	4,680,358	7,016,440	6,853,399
13	Lobster, Caribbean Spiny	5,758,355	5,291,490	6,825,436	5,158,140
14	Drum, Black	5,117,483	4,466,692	5,088,315	5,797,441
15	Snapper, Red	4,790,791	4,660,971	4,876,635	4,834,767
16	Tuna, Yellowfin	4,438,594	3,784,786	5,222,949	4,308,048
17	Shrimp, Rock	3,470,943	7,949,630	1,630,982	832,218
18	Catfish, Blue	3,470,288	2,230,802	3,979,374	4,200,687
19	Shrimp, Marine, Other	3,403,662	3,552,013	3,455,746	3,203,228
20	Sheepshead	3,209,556	2,831,229	3,637,729	3,159,710
21	Buffalofishes	2,938,028	1,701,526	4,572,870	2,539,687
22	Herring, Atlantic Thread	2,715,408	2,710,104	2,690,008	2,746,111
23	Gag	2,391,431	2,777,123	2,212,618	2,184,552
24	Mackerel, King and Cero	2,361,140	2,518,415	2,602,616	1,962,389
25	Ladyfish	2,235,806	2,139,343	4,226,811	341,264
26	Scallop, Calico	2,163,014	2,303,109	2,022,918	NR
27	Catfish, Channel	2,146,499	2,526,844	2,068,975	1,843,678
28	Shrimp, Atlantic and Gulf Roughneck	1,736,963	4,250,088	446,154	514,647
29	Snapper, Vermilion	1,693,752	1,735,518	1,932,440	1,413,298
30	Sharks	1,530,631	3,333,438	749,668	508,787
31	Snapper, Yellowtail	1,520,339	1,397,404	1,718,423	1,445,191
32	Finfishes (Unclassified for Food)	1,475,929	1,442,841	1,538,362	1,446,584
33	Shad, American	1,234,354	1,869,580	715,725	1,117,758
34	Finfishes (Unclassified Bait and Animal Food)	1,180,029	886,474	1,234,747	1,418,866
35	Shad, Gizzard	1,075,613	NR	1,474,850	676,376
36	Swordfish	1,047,987	1,125,454	986,618	1,031,888
37	Shark, Blacktip	1,044,216	258,923	1,506,244	1,367,481
38	Grouper, Yellowedge	1,006,556	711,986	1,074,758	1,232,925
39	Sardine, Spanish	942,128	800,832	671,073	1,354,479
40	Mackerel, Spanish	843,565	470,050	962,967	1,097,679
41	Amberjack, Greater	829,440	774,110	877,466	836,743
42	Shellfish	769,389	78,290	1,766,653	463,224
43	Jellyfish	748,824	748,824	NR	NR
44	Butterfish	748,013	1,239,505	510,171	494,362

(continued)

Table 3. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
45	Ballyhoo	716,008	831,813	586,982	729,228
46	Flatfish	709,238	646,979	786,118	694,618
47	Scads	698,365	1,004,408	504,224	586,462
48	Shark, Sandbar	667,399	641,591	524,012	836,594
49	Gars	618,118	489,330	760,783	604,242
50	Drum, Freshwater	611,400	469,255	999,269	365,677
51	Clam, Quahog	603,972	544,376	721,976	545,564
52	Grunts	565,526	475,057	512,566	708,956
53	Jack, Crevalle	564,021	666,058	560,723	465,283
54	Dolphin	535,063	422,484	612,268	570,438
55	Pompano, Florida	489,607	583,391	423,300	462,129
56	Catfish, Flathead	447,352	883,313	286,790	171,953
57	Shrimp, Royal Red	431,734	316,499	440,601	538,103
58	Crab, Blue, Peeler	397,584	NR	250,452	544,716
59	Grouper, Black	382,380	295,331	297,509	554,299
60	Tilefish	364,367	300,169	365,533	427,398
61	Crab, Deepsea Golden	347,512	249,010	NR	446,013
62	Snapper, Gray	306,321	327,322	289,994	301,648
63	Crab, Horseshoe	295,908	NR	295,908	NR
64	King Whiting	289,505	287,940	256,405	324,170
65	Tuna, Little Tunny	286,145	227,390	511,345	119,699
66	Scups or Porgies	272,081	329,382	280,551	206,309
67	Runner, Blue	261,311	366,942	268,854	148,138
68	Scamp	260,975	255,114	301,717	226,093
69	Mojarras	244,263	238,077	237,922	256,790
70	Sponge, Grass	235,096	262,041	243,475	199,771
71	Sponge, Yellow	229,587	222,869	240,014	225,878
72	Amberjack	224,691	263,231	192,933	217,908
73	Snapper, Mutton	205,926	273,493	182,130	162,154
74	Crab, Blue, Soft and Peeler	185,894	270,566	124,891	162,224
75	Grouper, Snowy	184,333	136,943	181,478	234,577
76	Cobia	181,038	203,280	191,185	148,650
77	Tilapias	173,861	279,068	113,229	129,287
78	Wahoo	170,917	180,005	174,289	158,456
79	Sea Bass, Black	170,158	121,407	146,268	242,800
80	Mullet, White	170,102	102,139	128,592	279,575
81	Seatrout, Sand	166,663	125,828	209,952	164,208
82	Mackerel, King	166,647	NR	250,431	82,863
83	Scad, Bigeye	165,463	121,824	138,633	235,932
84	Seatrout, Spotted	150,193	195,245	148,633	106,701
85	Sponge, Sheepswool	147,236	132,752	145,126	163,829
86	Squids	146,514	215,403	113,654	110,485
87	Escolar	143,929	131,349	159,005	141,434
88	Grouper, Warsaw	139,642	87,259	188,772	142,896
89	Snapper, Silk	133,854	104,778	92,563	204,222
90	Carp, Common	121,193	103,794	194,398	65,387

(continued)

Table 3. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
91	Catfishes and Bullheads	120,345	142,680	106,908	111,446
92	Leatherjackets	120,162	167,835	121,486	71,166
93	Tilefish, Blueline	117,584	130,096	98,831	123,824
94	Croaker, Atlantic	117,283	112,888	133,604	105,358
95	Spot	100,611	124,416	109,460	67,956
96	Jacks	99,184	98,022	96,380	103,151
97	Triggerfish, Gray	89,408	NR	96,675	82,140
98	Groupers	86,732	114,442	88,853	56,901
99	Mullets	86,262	NR	77,666	94,857
100	Bluefish	83,279	56,741	99,814	93,282
101	Mackerel, Chub	78,992	90,319	67,665	NR
102	Tuna, Blackfin	73,272	80,136	79,085	60,595
103	Crab, Blue, Soft	71,413	NR	85,938	56,887
104	Sponges	69,399	55,805	67,499	84,892
105	Porgy, Red	64,690	63,966	62,563	67,542
106	Oilfish	62,036	32,884	65,007	88,218
107	Tuna, Bluefin	61,751	29,739	79,585	75,929
108	Flyingfishes	60,612	77,885	NR	43,338
109	Hind, Speckled	55,143	49,823	50,783	64,822
110	Snapper, Lane	55,137	46,535	62,261	56,616
111	Jack, Almaco	54,047	46,054	58,720	57,367
112	Shark, Shortfin Mako	52,773	92,389	36,058	29,872
113	Permit	51,516	90,722	36,915	26,912
114	Tuna, Bigeye	46,495	29,311	59,657	50,516
115	Snapper, Black	44,749	NR	45,922	43,576
116	Cutlassfish, Atlantic	40,567	21,587	15,860	84,254
117	Bowfin	40,140	43,241	54,031	23,149
118	Hogfish	38,522	36,082	36,891	42,592
119	Drum, Red	37,951	35,567	40,202	38,084
120	Carp, Grass	37,599	28,740	47,137	36,919
121	Amberjack, Lesser	35,188	26,783	35,795	42,986
122	Snapper, Queen	32,150	30,722	28,495	37,233
123	Spadefishes	31,172	9,237	33,538	50,742
124	Carps and Minnows	31,140	5,337	45,872	42,212
125	Pinfish	28,648	29,572	27,010	29,361
126	Shark, Lemon	26,912	24,577	24,997	31,163
127	Goatfishes	26,668	26,668	NR	NR
128	Rays	25,006	22,460	921	51,638
129	Brotula, Bearded	24,813	24,079	29,762	20,598
130	Herrings	24,725	19,040	23,159	31,976
131	Porgy, Knobbed	24,720	19,320	27,463	27,378
132	Turtle, Snapping	23,575	12,406	34,820	23,498
133	Turtles	23,221	NR	25,139	21,302
134	Rudderfish, Banded	20,916	15,012	23,088	24,647
135	Snappers	18,784	44,807	7,606	3,940
136	Shark, Blacknose	18,761	23,394	11,091	21,797

(continued)

Table 3. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
137	Octopus	17,841	22,602	14,436	16,486
138	Jack, Bar	17,824	3,278	29,397	20,796
139	Shark, Hammerhead	17,575	19,760	15,389	NR
140	Shark, Bull	16,037	2,906	27,526	17,679
141	Black Driftfish	15,352	NR	14,841	15,863
142	Finfishes, Marine, Other	13,022	164	30,465	8,436
143	Lobster, Slipper	12,600	19,648	10,427	7,725
144	Shrimp, Freshwater	12,219	NR	12,219	NR
145	Shark, Dusky	12,153	11,073	13,232	NR
146	Sea Catfishes	11,525	6,464	11,243	16,867
147	Scorpionfishes	11,415	12,039	9,452	12,754
148	Margate	11,258	14,663	10,014	9,098
149	Suckers	11,081	11,081	NR	NR
150	Frogs	9,502	12,322	6,681	NR
151	Hind, Red	9,087	4,597	10,659	12,004
152	Puffers	8,684	9,964	7,918	8,170
153	Tilefish, Goldface	8,517	1,228	14,514	9,810
154	Shark, Spinner	8,192	NR	NR	8,192
155	Hake, Atlantic, Red/White	8,129	1,965	10,725	11,696
156	Shark, Silky	8,030	5,154	NR	10,906
157	Barrelfish	6,686	3,684	9,282	7,091
158	Grouper, Marbled	6,612	13,350	4,376	2,111
159	Turtle, Soft-shell	6,386	NR	6,433	6,339
160	Tuna, Albacore	6,289	5,838	5,289	7,740
161	Barracudas	6,268	2,004	11,037	5,763
162	Mussels, Freshwater	6,205	NR	6,205	NR
163	Tunas	5,797	12,627	200	4,565
164	Porgy, Jolthead	4,466	2,750	4,710	5,937
165	Grouper, Yellowfin	4,402	297	5,850	7,059
166	Shark, Longfin Mako	4,060	3,068	3,420	5,692
167	Tripletail	4,023	1,346	5,556	5,166
168	Shark, Bonnethead	3,432	NR	3,432	NR
169	Creole-fish	3,354	2,333	4,115	3,613
170	Snapper, Blackfin	3,150	2,706	4,113	2,631
171	Porgy, Whitebone	3,076	NR	4,457	1,694
172	Snapper, Cubera	2,658	2,915	3,874	1,185
173	Bonito, Atlantic	2,549	NR	3,015	2,083
174	Wenchman	2,171	NR	3,624	717
175	Shark, Thresher	2,095	2,168	3,627	491
176	Snails (Conchs)	2,051	2,598	1,504	NR
177	Surgeonfishes	1,909	NR	1,909	NR
178	Triggerfish, Ocean	1,875	NR	1,875	NR
179	Grouper, Misty	1,872	NR	845	2,899
180	Shark, Tiger	1,833	2,024	NR	1,642
181	Hind, Rock	1,766	3,230	1,203	865
182	Shark, Atlantic Sharpnose	1,730	2,743	NR	716

(continued)

Table 3. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
183	Runner, Rainbow	1,710	809	3,960	360
184	Lookdown	1,295	NR	73	2,517
185	Pompano, African	1,241	858	2,056	808
186	Tuna, Skipjack	1,184	1,053	837	1,661
187	Bigeye	1,160	1,185	1,320	976
188	Snapper, Dog	1,021	1,376	846	841
189	Eel, Conger	1,012	907	1,371	757
190	Bass, Longtail	946	538	1,279	1,021
191	Squirrelfishes	937	797	1,447	568
192	Snapper Caribbean Red	903	NR	NR	903
193	Grouper, Yellowmouth	837	NR	837	NR
194	Opah	699	NR	699	NR
195	Sea Bass, Rock	667	706	784	512
196	Goosefish	661	NR	661	NR
197	Rosefish, Blackbelly	631	NR	19	1,243
198	Parrotfishes	485	408	667	381
199	Eels, Snake	412	NR	NR	412
200	Weakfish	366	478	254	NR
201	Eels	290	477	206	186
202	Scorpionfish, Spinycheek	286	286	NR	NR
203	Eel, American	256	24	487	NR
204	Cusk	240	240	NR	NR
205	Jack, Black	226	NR	321	130
206	Chubs	205	NR	328	82
207	Tilefish, Sand	205	14	NR	396
208	Jack, Horse-eye	127	59	138	183
209	Sea Bass, Bank	116	116	NR	NR
210	Moonfish, Atlantic	79	NR	79	NR
211	Graysby	61	NR	32	90
212	Spanish Flag	31	30	31	NR
213	Snapper, Schoolmaster	10	NR	NR	10

"Annual Commercial Fishery Landing by Species – Gulf: 1998, 1999, 2000"
File Name: Comm_Gulf.xls

Source: http://www.st.nmfs.gov/st1/commercial/index.html
Accessed in July 2002

Searched on:
Years: 1998–2000
Species: ALL SPECIES individually
State: Gulf

Table 4. Annual Commercial Fisheries Landings by Species in the Pacific: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
1	Pollock, Walleye	2,561,783,276	2,752,656,486	2,325,889,086	2,606,804,256
2	Cod, Pacific	548,041,418	589,627,072	523,992,044	530,505,138
3	Hake, Pacific (Whiting)	485,748,404	509,485,583	492,607,111	455,152,518
4	Salmon, Pink	307,625,832	332,584,704	382,091,420	208,201,372
5	Salmon, Sockeye	193,753,663	128,740,064	244,347,916	208,173,008
6	Squid, California Market	156,060,918	6,381,235	201,762,173	260,039,345
7	Sole, Yellowfin	152,594,692	178,238,532	125,287,225	154,258,320
8	Crab, Snow	152,080,416	240,433,650	182,997,046	32,810,551
9	Salmon, Chum	145,977,338	131,596,077	143,994,758	162,341,179
10	Sardine, Pacific	126,011,310	95,486,141	132,560,094	149,987,695
11	Atka Mackerel	108,191,427	112,870,724	113,395,523	98,308,034
12	Seaweed, Kelp	107,406,567	55,836,200	173,983,500	92,400,000
13	Herring, Pacific	86,556,195	92,297,762	91,157,668	76,213,154
14	Halibut, Pacific	76,423,319	75,589,329	79,298,783	74,381,845
15	Sablefish	48,212,984	46,556,918	48,347,552	49,734,482
16	Sole, Rock	44,345,202	34,468,887	37,901,558	60,665,160
17	Rockfish, Pacific Ocean Perch	41,801,618	39,742,643	45,952,661	39,709,549
18	Crab, Dungeness	38,839,456	34,307,924	44,017,481	38,192,963
19	Mackerel, Chub	38,642,085	47,429,944	19,944,775	48,551,536
20	Sole, Flathead	36,864,115	43,166,120	31,566,041	35,860,185
21	Salmon, Coho	33,086,176	36,148,501	29,251,015	33,859,011
22	Rockfishes	27,272,140	24,017,216	31,267,198	26,532,006
23	Tuna, Albacore	26,974,145	33,375,238	25,326,521	22,220,675
24	Flounder, Arrowtooth	26,778,021	11,781,503	27,017,400	41,535,159
25	Shrimp, Ocean	24,026,473	10,659,197	28,437,541	32,982,681
26	Sole, Dover	22,314,754	22,160,225	23,957,534	20,826,503
27	Crab, King	18,580,306	23,722,868	16,919,934	15,098,115
28	Flatfish	18,404,969	10,461,522	28,228,846	16,524,538
29	Sea Urchins	17,030,945	14,674,045	18,179,980	18,238,809
30	Salmon, Chinook	15,440,234	15,679,648	15,133,681	15,507,374
31	Anchovy, Northern	13,760,807	3,491,304	11,709,286	26,081,830
32	Finfishes (Unclassified General)	12,125,728	12,539,151	8,452,582	15,385,450
33	Swordfish	11,310,647	10,258,275	11,303,374	12,370,292
34	Halibut, Greenland	10,596,264	18,120,462	30,422	13,637,908
35	Flounders, Righteye	10,569,499	10,569,499	NR	NR
36	Shrimp, Brine	10,448,119	5,908,357	3,689,915	21,746,084
37	Tuna, Yellowfin	9,875,336	16,241,507	6,045,498	7,339,003
38	Rockfish, Widow	9,208,657	9,754,758	9,306,992	8,564,222
39	Tuna, Skipjack	9,191,717	13,971,756	10,229,914	3,373,481
40	Oyster, Pacific	8,577,662	7,408,252	8,684,140	9,640,594
41	Tuna, Bigeye	6,576,701	7,407,000	6,152,197	6,170,906
42	Rockfish, Yellowtail	6,480,310	6,363,512	6,070,774	7,006,643
43	Sharks	5,324,395	6,286,665	6,360,594	3,325,927
44	Thornyhead, Longspine	4,110,655	4,955,620	3,869,011	3,507,334

(continued)

Table 4. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
45	Skates	3,783,784	3,836,116	3,683,452	3,831,783
46	Sole, Petrale	3,566,728	3,226,584	3,303,294	4,170,307
47	Jack Mackerel	3,531,916	3,917,214	3,480,737	3,197,798
48	Sole, Rex	3,271,820	7,313,481	1,300,915	1,201,063
49	Shrimp, Penaeid	3,260,038	3,656,720	3,085,295	3,038,099
50	Sole, English	2,731,591	3,151,704	2,512,572	2,530,496
51	Crab, Southern Tanner	2,178,844	2,684,986	2,165,478	1,686,069
52	Rockfish, Chilipepper	2,072,427	3,164,937	2,054,585	997,760
53	Thornyhead, Shortspine	2,039,305	2,694,908	1,881,436	1,541,572
54	Tuna, Bluefin	1,820,773	4,332,929	432,793	696,597
55	Shellfish	1,741,910	1,386,413	2,304,672	1,534,644
56	Flounder, Pacific, Sanddab	1,712,215	1,712,215	NR	NR
57	Clam, Pacific Geoduck	1,535,252	1,447,558	1,593,587	1,564,610
58	Rockfish, Canary	1,409,620	2,595,778	1,495,891	137,192
59	Shark, Spiny Dogfish	1,390,589	1,273,024	1,380,263	1,518,479
60	Rockfish, Splitnose	1,348,561	3,277,679	521,212	246,791
61	Grenadiers	1,290,681	2,214,074	964,134	693,835
62	Lingcod	1,281,192	2,089,381	1,374,535	379,660
63	Sea Cucumber	1,215,319	1,297,119	1,102,672	1,246,165
64	Halibut, California	1,133,798	1,204,012	1,333,418	863,963
65	Shrimp, Pacific Rock	1,132,953	435,931	1,394,174	1,568,755
66	Rockfish, Darkblotched	1,069,349	2,003,060	712,412	492,576
67	Crab, Red Rock	1,054,413	1,276,653	793,602	1,092,984
68	Bonito, Pacific	935,683	2,519,343	191,292	96,413
69	Smelts	857,456	832,771	735,398	1,004,199
70	Squids	795,942	1,869,853	504,443	13,529
71	Clam, Manila	759,655	690,486	746,043	842,436
72	Shark, Thresher	686,788	703,779	705,565	651,019
73	Scallop, Sea	671,504	834,638	669,688	510,185
74	Lobster, California Spiny	646,245	738,159	493,987	706,590
75	Rockfish, Black	636,576	1,180,695	398,249	330,783
76	Shrimp, Spot	629,770	826,720	614,214	448,375
77	Rockfish, Bank	558,639	1,324,061	136,910	214,947
78	Rockfish, Yelloweye	451,748	1,127,247	208,433	19,563
79	Sturgeon, White	447,707	519,755	368,893	454,473
80	Flounder, Starry	389,533	572,458	309,946	286,194
81	Snapper, Red	384,392	346,000	386,362	420,815
82	Mussel, Blue	369,780	296,050	386,091	427,200
83	Cabezon	365,000	433,594	335,993	325,414
84	Rockfish, Bocaccio	356,815	660,518	342,754	67,172
85	Tuna, Black Skipjack	353,354	509,362	197,346	NR
86	Spearfishes	346,334	296,000	472,000	271,001
87	Hagfishes	335,263	19,611	667,550	318,627
88	Shad, American	331,625	356,890	353,183	284,802
89	Trout, Rainbow	328,769	398,687	262,893	324,728
90	Herring, Pacific, Roe on Kelp	314,992	232,957	521,211	190,807

(continued)

Table 4. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
91	Rockfish, Blackgill	285,793	512,755	140,713	203,911
92	Crabs	266,358	417,642	306,834	74,598
93	Snappers	262,214	120,000	339,798	326,845
94	Clams or Bivalves	261,822	399,518	375,847	10,100
95	Sole, Sand	220,534	228,437	256,380	176,784
96	Rockfish, Silvergray	212,591	429,854	204,724	3,195
97	Seabass, White	212,412	159,725	248,764	228,746
98	Tunas	203,084	142,590	267,034	199,627
99	Sheephead, California	188,707	262,563	129,767	173,792
100	Shark, Shortfin Mako	176,763	217,059	137,919	175,312
101	Salmon, Pacific	176,141	299,304	103,309	125,809
102	Barracuda, Pacific	170,335	131,148	202,747	177,109
103	Rockfish, Greenstriped	167,611	374,625	106,438	21,770
104	Croaker, Pacific White	166,064	142,491	162,719	192,981
105	Rockfish, Starry	158,354	461,534	12,277	1,251
106	Octopus	142,549	397,758	19,166	10,724
107	Yellowtail	142,121	247,670	66,839	111,855
108	Rockfish, Vermilion	139,250	284,291	101,055	32,404
109	Shark, Soupfin	130,059	119,341	164,548	106,288
110	Rockfish, Sharpchin	127,520	242,432	116,809	23,318
111	Rockfish, Redstripe	108,718	244,207	73,547	8,401
112	Rockfish, Redbanded	106,632	178,503	68,049	73,344
113	Rockfish, Brown	97,869	101,912	115,285	76,409
114	Rockfish, Copper	94,162	137,185	107,040	38,261
115	Lobster, Caribbean Spiny	93,015	126,000	142,652	10,394
116	Sculpins	91,772	132,731	2,951	139,633
117	Shark, Pacific Angel	90,818	NR	106,780	74,856
118	Clam, Pacific Littleneck	85,025	96,856	89,752	68,468
119	Rockfish, Blue	81,677	129,806	70,848	44,377
120	Scorpionfishes	80,450	113,067	86,925	41,358
121	Rockfish, Gopher	79,721	78,901	86,003	74,258
122	Rockfish, China	76,882	119,929	69,729	40,989
123	Rockfish, Grass	72,689	95,187	59,331	63,550
124	Rockfish, Greenspotted	61,473	127,165	45,348	11,905
125	Surfperches	59,828	73,781	49,419	56,285
126	Rockfish, Yellowmouth	59,399	87,329	68,134	22,734
127	Shrimp, Marine, Other	55,308	146,000	19,038	886
128	Herring, Round	54,513	15,487	NR	93,539
129	Finfishes, Freshwater, Other	52,924	NR	53,585	52,262
130	Rockfish, Black-and-Yellow	51,912	55,576	55,515	44,644
131	Sturgeon, Green	51,667	38,850	36,752	79,400
132	Rockfish, Aurora	51,378	77,662	59,113	17,359
133	Rockfish, Stripetail	42,481	94,793	22,517	10,132
134	Shrimp, Ghost	39,276	38,515	40,882	38,432
135	Crab, Snow/Tanner	38,740	NR	NR	38,740
136	Rockfish, Shortbelly	36,913	46,860	19,371	44,508

(continued)

Table 4. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
137	Shark, Leopard	31,108	32,723	31,492	29,110
138	Mollusks	30,737	37,816	27,653	26,741
139	Squid, Jumbo	26,528	NR	26,528	NR
140	Clam, Butter	25,719	19,061	23,004	35,093
141	Finfishes, Groundfishes, Other	22,714	NR	22,714	NR
142	Smelt, Eulachon	21,463	12,060	23,325	29,004
143	Shrimp, Blue Mud	20,772	23,205	16,421	22,690
144	Rockfish, Cowcod	19,742	35,300	18,061	5,866
145	Oyster, European Flat	19,553	24,637	18,709	15,314
146	Cockle, Nuttall	17,612	8,927	16,926	26,984
147	Shark, Bigeye Thresher	15,371	23,967	12,052	10,095
148	Rockfish, Speckled	14,011	30,090	9,197	2,747
149	Clam, Pacific Razor	11,463	3,088	213	31,089
150	Thresher Sharks	11,299	3,969	22,776	7,151
151	Rockfish, Pinkrose	9,069	9,069	NR	NR
152	Sole, Curlfin	8,187	17,037	5,835	1,689
153	Rockfish, Kelp	7,248	11,209	6,966	3,570
154	Rockfish, Olive	6,619	12,093	5,337	2,426
155	Rockfish, Greenblotched	5,829	12,999	3,359	1,130
156	Sea Bass, Giant	5,393	6,497	5,186	4,495
157	Scallops	4,984	7,106	293	7,553
158	Rockfish, Rosy	4,894	10,921	3,270	492
159	Wolf-eel	3,903	4,824	3,400	3,486
160	Oyster, Olympia	3,716	3,712	3,706	3,729
161	Sole, Butter	3,385	7,879	1,108	1,168
162	Shark, Dogfish	3,134	NR	3,134	NR
163	Rockfish, Flag	2,912	6,936	1,306	494
164	Rockfish, Bronzespotted	2,820	2,475	5,369	617
165	Shark, Blue	2,812	6,064	652	1,721
166	Eels	2,456	4,777	589	2,002
167	Clam, Pacific, Gaper	2,420	2,824	2,983	1,452
168	Rockfish, Treefish	2,157	571	2,040	3,859
169	Corals	1,439	30	2,848	NR
170	Skate, Big	1,257	NR	1,257	NR
171	Rockfish, Swordspine	1,037	NR	295	1,778
172	Echinoderm	934	880	921	1,000
173	Rockfish, Squarespot	697	2,051	23	17
174	Queenfish	635	NR	399	871
175	Mussel, California	305	340	365	210
176	Rockfish, Pink	305	NR	561	49
177	Clam, California Jackknife	266	306	300	193
178	Clam, Softshell	227	351	NR	103
179	Prickleback, Monkeyface	216	225	175	248
180	Skate, California	141	NR	141	NR
181	Rockfish, Chameleon	67	18	174	8
182	Snails (Conchs)	64	64	NR	NR

(continued)

Table 4. (continued)

Rank	Species	Mean Annual Landings (lbs)	1998 Landings (lbs)	1999 Landings (lbs)	2000 Landings (lbs)
183	Ratfish Spotted	56	94	17	NR
184	Rockfish, Honeycomb	18	NR	18	NR

"Annual Commercial Fishery Landing by Species – Pacific: 1998, 1999, 2000"
File Name: Comm_Pacific.xls

Source: http://www.st.nmfs.gov/st1/commercial/index.html
Accessed in July 2002

Searched on:
Years: 1998–2000
Species: ALL SPECIES individually
State: Pacific

ATTACHMENT 1

ANNUAL RECREATIONAL FISHERY LANDINGS

Table 5. Annual Recreational Fisheries Landings by Species in the United States: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
1	Other Tunas/Mackerels	18,024,736	13,936,344	17,597,115	22,540,748
2	Striped Bass	15,412,830	13,462,747	14,413,066	18,362,676
3	Dolphins	14,835,451	12,124,418	13,426,514	18,955,420
4	Spotted Seatrout	13,255,255	9,544,392	13,549,461	16,671,913
5	Summer Flounder	12,474,072	12,522,897	8,384,766	16,514,553
6	Red Drum	12,062,630	9,849,577	10,478,113	15,860,199
7	Other Fishes	11,000,970	8,836,059	9,856,207	14,310,645
8	Bluefish	10,778,200	12,777,709	8,612,089	10,944,801
9	Atlantic Croaker	8,787,583	8,213,332	7,630,482	10,518,936
10	King Mackerel	8,220,032	8,721,243	7,157,670	8,781,184
11	Sheepshead	4,870,212	4,403,823	4,790,296	5,416,517
12	*Mycteroperca* Groupers	4,853,738	4,493,808	4,596,551	5,470,856
13	Red Snapper	4,175,885	4,374,427	4,652,376	3,500,852
14	Weakfish	3,781,065	4,044,974	3,143,427	4,154,794
15	Spanish Mackerel	3,755,472	2,916,223	3,598,031	4,752,163
16	Atlantic Cod	3,566,146	2,967,187	2,599,633	5,131,617
17	Black Drum	3,289,300	2,794,319	2,012,559	5,061,023
18	Yellowtail	2,936,025	5,698,119	807,082	2,302,874
19	Other Sharks	2,903,829	2,665,641	2,790,550	3,255,295
20	Black Sea Bass	2,895,608	1,674,449	2,246,099	4,766,275
21	Scup	2,734,688	874,823	1,886,110	5,443,131
22	Little Tunny/Atlantic Bonito	2,619,805	2,913,646	2,633,661	2,312,107
23	Mullets	2,597,273	2,673,558	2,240,513	2,877,748
24	Atlantic Mackerel	2,551,761	1,520,083	2,943,372	3,191,829
25	Tautog	2,470,268	1,479,763	2,532,691	3,398,349
26	Sand Seatrout	2,444,474	1,815,462	2,833,411	2,684,550
27	Black Rockfish	2,296,647	2,459,315	1,706,374	2,724,253
28	Kingfishes	2,281,599	1,721,409	2,187,880	2,935,509
29	Spot	2,277,978	3,065,029	1,664,424	2,104,480
30	Pinfishes	2,073,596	2,268,260	1,532,309	2,420,219
31	Greater Amberjack	1,954,268	1,287,830	2,696,625	1,878,350
32	Pacific Barracuda	1,852,444	2,057,943	1,988,320	1,511,070
33	*Epinephelus* Groupers	1,597,094	994,460	1,404,906	2,391,916
34	Gray Snapper	1,531,125	1,409,482	1,345,522	1,838,370
35	White Grunt	1,471,910	1,253,450	1,381,195	1,781,085
36	Southern Flounder	1,448,843	1,221,981	1,456,374	1,668,175
37	Crevalle Jack	1,334,251	900,822	1,316,208	1,785,724
38	Lingcod	1,329,235	1,283,758	1,398,104	1,305,844
39	California Halibut	1,268,619	939,459	1,297,277	1,569,120
40	Blue Runner	1,237,373	1,227,810	749,802	1,734,507
41	Winter Flounder	1,168,900	717,765	768,056	2,020,880
42	Barracudas	1,138,235	1,162,135	1,192,065	1,060,505
43	Other Rockfishes	1,125,366	751,420	1,641,146	983,532
44	Barred Sand Bass	1,053,010	685,121	661,215	1,812,695
45	Saltwater Catfishes	876,794	885,259	654,343	1,090,781
46	Herrings	747,698	964,433	648,642	630,020
47	Triggerfishes/Filefishes	726,774	774,791	757,018	648,512
48	Blue Rockfish	717,974	859,596	711,823	582,504

(continued)

Table 5. (continued)

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
49	Florida Pompano	688,493	691,237	592,916	781,326
50	Other Flounders	680,369	858,641	675,844	506,621
51	Other Jacks	621,323	415,587	806,657	641,726
52	Kelp Bass	618,937	511,073	338,527	1,007,211
53	White Perch	577,206	614,402	425,955	691,261
54	Yellowtail Rockfish	564,594	446,784	718,215	528,784
55	Sturgeons	519,764	566,300	617,663	375,329
56	Freshwater Catfishes	500,180	778,111	343,439	378,991
57	Pollock	451,155	283,095	196,527	873,842
58	Other Croakers	450,140	221,282	499,159	629,978
59	Vermilion Snapper	428,099	353,001	540,674	390,622
60	Other Snappers	423,281	295,701	298,177	675,966
61	Yellowtail Snapper	366,985	437,265	325,935	337,754
62	Pigfish	353,669	336,900	356,953	367,154
63	Dogfish Sharks	328,516	545,700	123,222	316,625
64	Bocaccio	320,413	124,295	311,609	525,334
65	Other Grunts	268,234	313,344	299,786	191,573
66	Other Cods/hakes	250,723	153,696	120,927	477,545
67	Barred Surfperch	250,283	534,283	157,790	58,777
68	California Scorpionfish	250,164	185,259	297,039	268,194
69	Canary Rockfish	249,610	185,466	271,419	291,944
70	Gulf Flounder	245,346	227,270	229,212	279,557
71	Cabezon	237,971	293,573	208,635	211,706
72	Lane Snapper	235,045	229,854	181,379	293,902
73	Copper Rockfish	211,924	240,698	222,603	172,472
74	California Sheephead	189,098	152,715	182,506	232,074
75	Surf Smelt	175,349	357,262	28,307	140,479
76	Pacific Bonito	170,747	347,191	4,705	160,345
77	Skates/Rays	162,648	100,558	194,792	192,594
78	White Croaker	157,353	162,532	156,740	152,788
79	Sanddabs	154,930	99,101	81,647	284,041
80	Other Drum	146,230	98,215	211,911	128,563
81	Kelp Greenling	132,993	117,474	114,752	166,754
82	Other Wrasses	129,646	113,951	182,208	92,778
83	Jacksmelt	124,106	149,196	102,060	121,063
84	Brown Rockfish	123,146	91,914	148,623	128,901
85	Other Porgies	121,975	111,335	101,912	152,677
86	Gopher Rockfish	118,874	78,034	122,540	156,048
87	Widow Rockfish	107,413	97,756	77,968	146,516
88	Silver Perch	102,331	109,375	101,405	96,213
89	Olive Rockfish	100,065	110,133	75,977	114,084
90	Searobins	93,444	106,246	78,142	95,944
91	Redtail Surfperch	90,139	91,297	57,015	122,106
92	Striped Seaperch	87,136	179,104	38,786	43,517
93	Quillback Rockfish	81,538	96,645	77,584	70,386
94	Puffers	79,767	63,027	59,436	116,837
95	Red Porgy	79,308	76,317	86,654	74,952
96	Other Sea Basses	78,828	98,953	66,539	70,993
97	Greenspotted Rockfish	74,418	32,926	97,900	92,428

(continued)

Table 5. (continued)

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
98	Red Hake	73,145	143,698	59,063	16,673
99	Opaleye	58,386	72,256	49,169	53,733
100	Spotted Sand Bass	52,185	22,383	38,129	96,043
101	Other Surfperches	46,938	55,406	53,171	32,236
102	Halfmoon	46,206	14,936	40,834	82,849
103	Chilipepper Rockfish	44,364	18,087	10,959	104,046
104	Black Perch	41,624	61,746	26,764	36,363
105	Cunner	40,138	9,636	61,065	49,714
106	Pile Perch	27,898	48,742	20,267	14,685
107	Queenfish	21,148	10,115	18,062	35,267
108	Northern Anchovy	17,984	0	53,951	0
109	California Corbina	17,818	32,053	15,483	5,919
110	Walleye Surfperch	15,695	15,395	18,477	13,212
111	Silver Surfperch	15,053	11,916	29,403	3,840
112	Other Greenlings	14,372	7,350	NR	21,393
113	Sculpins	13,026	18,089	12,873	8,117
114	Starry Flounder	12,917	19,264	7,915	11,572
115	Eels	11,903	7,103	12,015	16,590
116	Rock Sole	11,531	12,793	7,006	14,793
117	Shiner Perch	7,101	3,794	4,821	12,687
118	White Seaperch	7,006	4,782	8,805	7,432
119	Other Silversides	4,271	3,373	6,821	2,619
120	Sablefishes	3,955	8,982	388	2,496
121	Other Temperate Basses	2,435	7,200	104	0
122	Pacific Hake	1,528	2,601	1,982	0
123	Other Sea Chubs	1,237	NR	2,275	198
124	Toadfishes	745	2,033	203	0
125	Pacific Tomcod	378	115	141	877
126	Pacific Cod	340	1,019	0	0
127	Other Smelts	126	NR	126	NR

"Annual Recreational Fisheries Landing by Species - National: 1998, 1999, 2000"
File Name: RecFish_Master.xls

Source:
http://www.st.nmfs.gov/st1/recreational/queries/catch/snapshot.html
Accessed in July 2002.
Searched on:
Year : From: 1998-2000
Wave : ANNUAL
Geographic Area: UNITED STATES
Fishing Mode : ALL MODES COMBINED
Fishing Area : ALL AREAS COMBINED
Type of Catch : TOTAL CATCH (TYPE A + B1 + B2)

Table 6. Annual Recreational Fisheries Landings by Species in the Atlantic: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
1	Striped Bass	14,896,850	12,918,883	13,990,791	17,780,875
2	Other Tunas/Mackerels	12,488,906	8,134,648	11,403,025	17,929,046
3	Summer Flounder	12,474,072	12,522,897	8,384,766	16,514,553
4	Bluefish	10,397,647	12,334,001	8,253,114	10,605,826
5	Dolphins	10,281,107	7,676,466	10,078,197	13,088,659
6	Atlantic Croaker	8,308,521	7,912,640	7,321,256	9,691,666
7	King Mackerel	5,010,102	4,788,510	4,262,327	5,979,468
8	Weakfish	3,781,065	4,044,974	3,143,427	4,154,794
9	Atlantic Cod	3,566,146	2,967,187	2,599,633	5,131,617
10	Other Fishes	2,766,503	2,412,968	2,713,783	3,172,759
11	Scup	2,734,688	874,823	1,886,110	5,443,131
12	Black Sea Bass	2,588,224	1,513,562	1,949,307	4,301,803
13	Atlantic Mackerel	2,551,761	1,520,083	2,943,372	3,191,829
14	Tautog	2,470,268	1,479,763	2,532,691	3,398,349
15	Spot	2,271,880	3,062,026	1,652,528	2,101,085
16	Little Tunny/Atlantic Bonito	1,971,850	2,231,512	1,950,672	1,733,367
17	Spotted Seatrout	1,907,617	1,288,245	2,472,499	1,962,107
18	Other Sharks	1,891,765	1,659,358	2,130,770	1,885,167
19	Sheepshead	1,424,238	932,455	1,283,437	2,056,821
20	Kingfishes	1,394,042	1,016,673	1,203,216	1,962,237
21	Red Drum	1,392,081	1,327,350	1,229,814	1,619,078
22	Spanish Mackerel	1,336,676	1,006,034	1,187,393	1,816,601
23	Winter Flounder	1,168,900	717,765	768,056	2,020,880
24	Black Drum	1,050,560	648,562	706,021	1,797,097
25	Greater Amberjack	894,278	437,419	1,405,067	840,349
26	Barracudas	839,890	825,786	1,031,870	662,013
27	Crevalle Jack	774,424	396,804	738,354	1,188,114
28	Mullets	758,440	1,243,304	438,250	593,767
29	Southern Flounder	691,758	654,228	609,515	811,531
30	Blue Runner	606,782	537,691	525,557	757,097
31	White Perch	577,206	614,402	425,955	691,261
32	*Mycteroperca* Groupers	564,758	348,133	704,908	641,232
33	Pinfishes	504,355	520,409	449,857	542,799
34	Gray Snapper	468,443	282,176	449,725	673,428
35	Pollock	451,155	283,095	196,527	873,842
36	Freshwater Catfishes	437,755	687,158	291,481	334,625
37	Florida Pompano	405,465	414,853	313,942	487,600
38	Other Jacks	296,076	144,816	493,769	249,642
39	Red Snapper	261,438	114,963	169,432	499,920
40	Other Cods/Hakes	250,463	152,918	120,927	477,545
41	Herrings	250,421	269,323	318,375	163,564
42	Saltwater Catfishes	225,107	259,107	115,872	300,341
43	Pigfish	216,709	198,509	188,268	263,350
44	Other Snappers	192,074	167,920	119,238	289,065
45	Triggerfishes/Filefishes	185,726	202,574	192,669	161,934
46	Vermilion Snapper	176,293	125,157	148,352	255,370
47	Other Grunts	166,594	147,805	197,473	154,503
48	*Epinephelus* Groupers	146,923	177,565	157,228	105,977

(continued)

Table 6. (continued)

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
49	Dogfish Sharks	128,577	135,323	43,880	206,529
50	White Grunt	125,069	158,537	133,455	83,215
51	Yellowtail Snapper	111,889	104,683	65,040	165,945
52	Searobins	93,404	106,246	78,021	95,944
53	Lane Snapper	75,648	39,696	61,019	126,229
54	Other Porgies	74,112	54,507	69,923	97,906
55	Red Hake	73,145	143,698	59,063	16,673
56	Puffers	71,059	57,937	49,339	105,902
57	Other Wrasses	51,662	37,421	81,083	36,482
58	Skates/Rays	47,775	35,230	92,917	15,179
59	Silver Perch	44,698	23,896	69,824	40,373
60	Cunner	40,138	9,636	61,065	49,714
61	Gulf Flounder	35,769	7,244	20,086	79,976
62	Other Drum	26,083	53,735	5,139	19,374
63	Red Porgy	18,829	11,706	36,032	8,748
64	Other Sea Basses	14,897	13,799	13,988	16,905
65	Eels	11,765	7,103	12,015	16,177
66	Other Flounders	7,826	12,346	7,403	3,730
67	Sand Seatrout	2,548	99	4,996	NR
68	Sculpins	1,329	2,513	1,475	0
69	Toadfishes	745	2,033	203	0

"Annual Recreational Landing by Species - Atlantic: 1998, 1999, 2000"
File name: Rec_Atlantic.xls
Source:
http://www.st.nmfs.gov/st1/recreational/queries/catch/snapshot.html
Accessed in July 2002.

Year : From: 1998 To: 2000
Wave : ANNUAL
Geographic Area: ATLANTIC COAST
Fishing Mode : ALL MODES COMBINED
Fishing Area : ALL AREAS COMBINED
Type of Catch : TOTAL CATCH (TYPE A + B1 + B2)

Table 7. Annual Recreational Fisheries Landings by Species in the Gulf of Mexico: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
1	Spotted Seatrout	11,347,637	8,256,145	11,076,962	14,709,805
2	Red Drum	10,670,549	8,522,230	9,248,297	14,241,121
3	*Mycteroperca* Groupers	4,288,982	4,145,675	3,891,644	4,829,626
4	Red Snapper	3,912,130	4,259,464	4,482,946	2,993,979
5	Sheepshead	3,445,974	3,471,368	3,506,859	3,359,696
6	Dolphins	3,315,379	4,246,097	3,334,876	2,365,165
7	King Mackerel	3,192,296	3,932,733	2,895,341	2,748,814
8	Sand Seatrout	2,442,777	1,815,365	2,828,416	2,684,550
9	Spanish Mackerel	2,418,795	1,910,189	2,410,635	2,935,562
10	Black Drum	2,238,741	2,145,757	1,306,539	3,263,926
11	Other Fishes	1,900,964	1,735,942	2,105,790	1,861,161
12	Mullets	1,823,883	1,426,266	1,802,261	2,243,121
13	Pinfishes	1,569,240	1,747,851	1,082,450	1,877,420
14	*Epinephelus* Groupers	1,433,127	816,895	1,247,678	2,234,807
15	White Grunt	1,345,618	1,094,912	1,247,740	1,694,202
16	Other Tunas/mackerels	1,310,464	1,686,925	1,690,816	553,652
17	Gray Snapper	1,062,464	1,127,305	895,797	1,164,289
18	Greater Amberjack	1,050,636	850,411	1,291,561	1,009,936
19	Kingfishes	887,557	704,736	984,665	973,271
20	Other Sharks	828,486	826,225	457,188	1,202,045
21	Southern Flounder	757,085	567,751	846,860	856,644
22	Saltwater Catfishes	651,688	626,153	538,471	790,439
23	Little Tunny/Atlantic Bonito	642,042	682,134	682,992	561,000
24	Blue Runner	629,868	690,119	224,245	975,240
25	Crevalle Jack	548,970	504,018	577,854	565,037
26	Triggerfishes/Filefishes	512,010	572,215	564,349	399,467
27	Atlantic Croaker	478,086	300,694	309,224	824,340
28	Herrings	383,993	482,086	289,272	380,620
29	Bluefish	380,554	443,709	358,977	338,975
30	Black Sea Bass	307,384	160,887	296,792	464,472
31	Other Jacks	303,407	263,981	293,664	352,577
32	Florida Pompano	282,455	276,384	278,974	292,006
33	Barracudas	254,472	336,349	160,195	266,873
34	Vermilion Snapper	250,459	227,843	392,322	131,211
35	Yellowtail Snapper	247,828	332,582	260,895	150,008
36	Gulf Flounder	209,577	220,026	209,126	199,580
37	Pigfish	136,960	138,392	168,685	103,804
38	Lane Snapper	130,451	190,158	120,360	80,834
39	Other Drum	119,424	44,482	206,772	107,018
40	Other Snappers	112,299	127,781	178,936	30,181
41	Other Grunts	90,344	165,539	102,313	3,181
42	Other Wrasses	75,429	74,923	100,049	51,316
43	Freshwater Catfishes	62,427	90,955	51,958	44,368
44	Red Porgy	60,479	64,610	50,622	66,204
45	Silver Perch	57,633	85,479	31,581	55,840
46	Other Sea Basses	53,456	82,507	52,150	25,712
47	Other Porgies	46,630	56,828	31,989	51,074
48	Skates/Rays	23,295	818	18,836	50,230

(continued)

Table 7. (continued)

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
49	Puffers	6,947	5,088	10,097	5,655
50	Spot	6,098	3,005	11,896	3,393
51	Other Temperate Basses	3,652	7,200	104	NR
52	Other Flounders	1,254	0	3,752	11
53	Dogfish Sharks	942	0	2,826	0
54	Striped Bass	903	443	1,590	675
55	Other Cods/Hakes	776	776	NR	NR
56	Eels	137	0	0	412
57	Searobins	40	0	121	0
58	Weakfish	0	0	NR	NR
59	Summer Flounder	0	0	NR	NR
60	Toadfishes	0	0	0	0

"Annual Recreational Landing by Species - Gulf of Mexico: 1998, 1999, 2000"
File name: Rec_Gulf.xls
Source:
http://www.st.nmfs.gov/st1/recreational/queries/catch/snapshot.html
Accessed in July 2002.

Year : From: 1998 To: 2000
Wave : ANNUAL
Geographic Area: GULF OF MEXICO
Fishing Mode : ALL MODES COMBINED
Fishing Area : ALL AREAS COMBINED
Type of Catch : TOTAL CATCH (TYPE A + B1 + B2)

NOTE: A new method for estimating charter boat effort was implemented in the Gulf of Mexico region (Louisiana to West Florida) beginning in 2000. This change affects both the effort and catch estimates. The time series from 2000 and future years will not be completely comparable to earlier years.

Table 8. Annual Recreational Fisheries Landings by Species in the Pacific: Mean (1998–2000 Combined), 1998, 1999, and 2000

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
1	Other Fishes	6,113,320	4,687,152	5,036,636	8,616,172
2	Other Tunas/Mackerels	4,117,996	4,114,771	4,503,275	3,735,942
3	Yellowtail	2,936,025	5,698,119	807,082	2,302,874
4	Black Rockfish	2,296,647	2,459,315	1,706,374	2,724,253
5	Pacific Barracuda	1,852,444	2,057,943	1,988,320	1,511,070
6	Lingcod	1,329,235	1,283,758	1,398,104	1,305,844
7	California Halibut	1,268,619	939,459	1,297,277	1,569,120
8	Other Rockfishes	1,125,366	751,420	1,641,146	983,532
9	Barred Sand Bass	1,053,010	685,121	661,215	1,812,695
10	Blue Rockfish	717,974	859,596	711,823	582,504
11	Other Flounders	671,259	846,295	664,689	502,794
12	Kelp Bass	618,937	511,073	338,527	1,007,211
13	Yellowtail Rockfish	564,594	446,784	718,215	528,784
14	Sturgeons	519,764	566,300	617,663	375,329
15	Striped Bass	515,078	543,421	420,686	581,126
16	Other Croakers	450,140	221,282	499,159	629,978
17	Dolphins	375,244	201,855	13,439	910,438
18	Bocaccio	320,413	124,295	311,609	525,334
19	Barred Surfperch	250,283	534,283	157,790	58,777
20	California Scorpionfish	250,164	185,259	297,039	268,194
21	Canary Rockfish	249,610	185,466	271,419	291,944
22	Cabezon	237,971	293,573	208,635	211,706
23	Copper Rockfish	211,924	240,698	222,603	172,472
24	Dogfish Sharks	198,995	410,377	76,513	110,096
25	California Sheephead	189,098	152,715	182,506	232,074
26	Other Sharks	179,727	180,061	202,590	156,529
27	Surf Smelt	175,349	357,262	28,307	140,479
28	Pacific Bonito	170,747	347,191	4,705	160,345
29	White Croaker	157,353	162,532	156,740	152,788
30	Sanddabs	154,930	99,101	81,647	284,041
31	Kelp Greenling	132,993	117,474	114,752	166,754
32	Jacksmelt	124,106	149,196	102,060	121,063
33	Brown Rockfish	123,146	91,914	148,623	128,901
34	Gopher Rockfish	118,874	78,034	122,540	156,048
35	Widow Rockfish	107,413	97,756	77,968	146,516
36	Olive Rockfish	100,065	110,133	75,977	114,084
37	Herrings	91,675	213,024	40,992	21,010
38	Redtail Surfperch	90,139	91,297	57,015	122,106
39	Striped Seaperch	87,136	179,104	38,786	43,517
40	Skates/Rays	85,892	64,511	83,038	110,126
41	Quillback Rockfish	81,538	96,645	77,584	70,386
42	Greenspotted Rockfish	74,418	32,926	97,900	92,428
43	Opaleye	58,386	72,256	49,169	53,733
44	Spotted Sand Bass	52,185	22,383	38,129	96,043
45	Other Surfperches	46,938	55,406	53,171	32,236
46	Halfmoon	46,206	14,936	40,834	82,849
47	Chilipepper Rockfish	44,364	18,087	10,959	104,046
48	Black Perch	41,624	61,746	26,764	36,363

(continued)

Table 8. (continued)

Rank	Species	Average	1998 Weight (lbs)	1999 Weight (lbs)	2000 Weight (lbs)
49	Pile Perch	27,898	48,742	20,267	14,685
50	Queenfish	21,148	10,115	18,062	35,267
51	Northern Anchovy	17,984	0	53,951	0
52	California Corbina	17,818	32,053	15,483	5,919
53	Walleye Surfperch	15,695	15,395	18,477	13,212
54	Silver Surfperch	15,053	11,916	29,403	3,840
55	Starry Flounder	12,917	19,264	7,915	11,572
56	Mullets	11,889	3,990	0	31,676
57	Sculpins	11,698	15,578	11,398	8,117
58	Rock Sole	11,531	12,793	7,006	14,793
59	Other Greenlings	10,703	7,350	3,366	21,393
60	Other Jacks	10,434	6,790	19,224	5,289
61	Shiner Perch	7,101	3,794	4,821	12,687
62	White Seaperch	7,006	4,782	8,805	7,432
63	Other Silversides	4,271	3,373	6,821	2,619
64	Sablefishes	3,955	8,982	388	2,496
65	Other Sea Basses	2,332	2,648	401	3,946
66	Pacific Hake	1,528	2,601	1,982	0
67	Other Wrasses	1,348	1,607	1,076	1,362
68	Other Sea Chubs	1,237	NR	2,275	198
69	Pacific Tomcod	378	115	141	877
70	Pacific Cod	340	1,019	0	0
71	Other Drum	234	0	0	703
72	Other Smelts	126	NR	126	NR

"Annual Recreational Landing by Species - Pacific Coast: 1998, 1999, 2000"
File name: Rec_Pacific.xls
Source:
http://www.st.nmfs.gov/st1/recreational/queries/catch/snapshot.html
Accessed in July 2002.

Year : From: 1998 To: 2000
Wave : ANNUAL
Geographic Area: PACIFIC COAST
Fishing Mode : ALL MODES COMBINED
Fishing Area : ALL AREAS COMBINED
Type of Catch : TOTAL CATCH (TYPE A + B1 + B2)

APPENDIX B

FISH ADVISORIES FOR MERCURY IN ESTUARINE/ MARINE WATERS

APPENDIX B

CURRENT FISH ADVISORIES FOR MERCURY IN ESTUARINE/MARINE WATERS

AN OVERVIEW OF ACTIVE CONSUMPTION ADVISORIES FOR MERCURY

In the United States, fish consumption advisories are issued at both the federal and state levels in order to ensure that fish consumers are protected from the health risks associated with the consumption of chemically contaminated marine and estuarine fish and shellfish species. A federal advisory was issued in January 2001 by the U. S. Food and Drug Administration (FDA) for fish species transported in interstate commerce and sold in commercial markets nationwide (U.S. FDA, 2001a,b). In January 2001, the U.S. Environmental Protection Agency (EPA) also issued a national advisory for mercury in freshwater fish caught by family and friends specifically directed at women who are pregnant or may become pregnant, nursing mothers, and young children (U.S. EPA, 2001). This advisory warns sensitive populations (pregnant women, women who could become pregnant, nursing women, and young children) to restrict their consumption of freshwater fish caught by friends and family, as well as to follow the FDA advisory for consumption of marine fish.

In addition to these federal advisories, each state has jurisdiction in issuing fish consumption advisories to warn state residents about levels of chemical contaminants in fish or shellfish locally harvested from state waterbodies that may be of public health concern especially for recreational and subsistence fishers. These two fish-consuming groups typically eat larger quantities of fish and shellfish than members of the general population (U.S. EPA, 2000a,b).

Federal Advisory for Mercury in Commercial Marine Fish

The safety of seafood (fish and shellfish) sold in interstate commerce in commercial markets is under the jurisdiction of the FDA, which issues action levels for chemical contaminant concentrations in seafood and other food products. Currently, the FDA action level for methylmercury is 1 part per million (ppm), and seafood products found to exceed 1 ppm may be removed from the commercial market. The FDA works with state regulators and with such federal entities as the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS) when commercial fish, caught and sold locally, are found to contain methylmercury levels exceeding this action levels.

The FDA has stated that the average concentration of methylmercury for commercially important species, most of which are marine in origin, is less than 0.3 ppm (U.S. FDA, 1995). Table B-1 provides daily per capita consumption rates

Table B-1. Daily Average Per Capita Estimates of Fish Consumption for the U.S. Population for Commonly Consumed Estuarine and Marine Commercial Seafood Products

Species	Estimated mean grams/person/day consumption
Tuna	5.67438
Shrimp (estuarine)	1.78619
Cod	1.47609
Flatfish	1.24268
Salmon	0.99093
Perch (estuarine)	0.66494
Haddock	0.62219
Pollock	0.52906
Flatfish (estuarine)	0.50832
Crab	0.47567
Porgy	0.42587
Crab (estuarine)	0.40848
Ocean perch	0.39327
Clam	0.37982
Flounder (estuarine)	0.28559
Lobster	0.27563
Sea bass	0.26661
Scallop	0.26199
Oyster (estuarine)	0.18827
Swordfish	0.17903
Squid	0.14420
Sardine	0.13750
Pompano	0.12160
Mackerel	0.09866
Mullet (estuarine)	0.08958
Sole	0.08339
Croaker (estuarine)	0.06539
Whiting	0.06514
Mussels	0.03718
Smelt (estuarine)	0.0347
Herring (estuarine)	0.03408
Clam (estuarine)	0.03339
Halibut	0.03030
Shark	0.02385
Whitefish	0.00916
Snapper	0.00551
Octopus	0.00457
Anchovy (estuarine)	0.00304
Scallop (estuarine)	0.00297
Barracuda	0.00130
Abalone	0.00094
Scup (estuarine)	0.0005
Sturgeon (estuarine)	0.0004
Seafood	0.00043

Note: Data compiled from sample of 11,912 individuals in the U.S. population of 242,707,000 using 3-year combined survey weights.
Source: U.S. EPA (1997).

for some of the most consumed commercial seafood products. During the 1990s, the FDA felt that consumption advice was unnecessary for the top 10 seafood species, making up about 80 percent of the seafood market, because these species—canned tuna, shrimp, pollock, salmon, cod, catfish, clams, flatfish, crabs, and scallops—typically contain less than 0.2 ppm methylmercury based on the FDA's analysis of available evidence (Table B-2) and on the fact that few people in the general population were deemed likely to eat more than the suggested weekly limit of fish (2.2 pounds) for this level of methylmercury contamination (U.S. FDA, 1995).

In 2001, the FDA issued updated advice for sensitive populations (women who are pregnant or may become pregnant, nursing mothers, and young children) about the risks of mercury in four commercial marine fish species. This advice recommended that these sensitive populations not eat any of the following commercial species—shark, swordfish, king mackerel, and tilefish—because of high levels of mercury contamination in their tissues (U.S. FDA, 2001a,b,c). The FDA advice did suggest, however, that these sensitive populations could obtain comparable health benefits from eating fish species containing lower levels of mercury. Table B-3 presents the mean concentrations, range, and number of samples analyzed by the FDA in its analysis of the four most contaminated species it placed under advisory. This information is available on the FDA's Web site at the following URL: http://www.cfsan.fda.gov/~frf/sea-mehg.html.

Table B-2. FDA Listing of Commercial Fish and Shellfish Mercury Tissue Concentrations

Species	Mean (ppm)	Range (ppm)	No. of Samples
Grouper (*Mycteroperca*)[1]	0.43	0.05–1.35	64
Tuna (fresh or frozen)	0.32	ND–1.30	191
American lobster*	0.31	0.05–1.31	88
Grouper (*Epinephelus*)[2]	0.27	0.19–0.33	48
Halibut*	0.23	0.02–0.63	29
Sablefish*	0.22	ND–0.70	102
Pollock*	0.20	ND–0.78	107
Tuna (canned)*	0.17	ND–0.75	248
Blue crab*	0.17	0.02–0.50	94
Dungeness crab*	0.18	0.02–0.48	50
Tanner crab*	0.15	ND–0.38	55
King crab*	0.09	0.02–0.24	29
Scallop*	0.05	ND–0.22	66
Catfish*	0.07	ND–0.31	22
Salmon (fresh, frozen or canned)*	ND	ND–0.18	52
Oysters*	ND	ND–0.25	33
Shrimps*	ND	ND	22

[1] *Mycteroperca* grouper include gag, scamp, yellowmouth grouper, yellow fin grouper, and black grouper.
[2] *Epinephelus* grouper include jewfish, rock hind, speckled hind, red hind, yellowedge grouper, red grouper, Warsaw grouper, snowy grouper, Nassau grouper, mutton hamlet, coney, and marbled grouper.
* These fish and shellfish are among the most consumed of the domestic seafood market.

Source: U.S. FDA (2001c) from http://www.cfsan.fda.gov/~frf/sea-mehg.html. Accessed July 2002.

Table B-3. FDA Listing of Fish with the Highest Mercury Tissue Concentrations

Species	Mean (ppm)	Range (ppm)	No. of Samples
Tilefish	1.45	0.65–3.73	60
Swordfish*	1.00	0.10–3.22	598
Shark*	0.96	0.05–4.54	324
King mackerel	0.73	0.30–1.67	213

* These fish are among the most consumed of the domestic seafood market
Source: U.S. FDA (2001c) from http://www.cfsan.fda.gov/~frf/sea-mehg.html. Accessed July 2002.

Currently, the FDA is reviewing its overall public health strategy for regulation of mercury in commercial seafood (U.S. FDA, 2002). A comparison of the commercial landings for the four marine species currently under advisory and for tuna (species with the highest daily average per capita estimates of fish consumption for the U.S. population) is presented in Figure B-1. Figure B-1 shows that commercial tuna landings are more than 30 percent higher than landings for shark. Tuna and shark landings far exceed those for the other three species currently covered under the national mercury advisory: tilefish, king mackerel, and swordfish. Tuna, although not currently under advisory by the FDA, has been included in an advisory in at least one coastal state, Massachusetts (Table B-4). Table B-1 (daily per capita consumption rates for some of the most consumed commercial seafood products) shows that tuna is consumed at a rate almost 32 times higher than swordfish, more than 57 times higher than king mackerel, and more than 237 times higher than shark—species that are currently under the FDA mercury advisory.

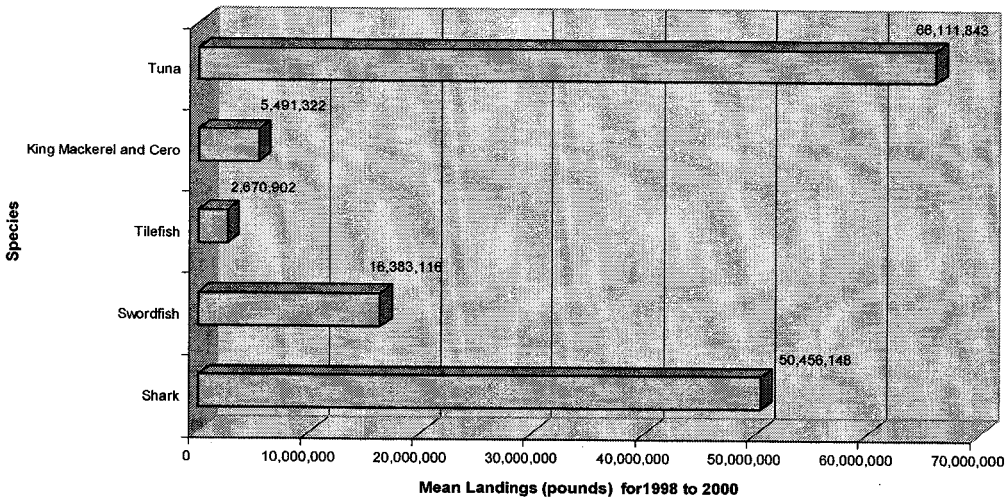


Figure B-1. Commercial landings (in pounds) of tuna as compared to four fish species currently listed under the FDA national mercury advisory or state commercial advisories.

Federal Advisory for Mercury in Freshwater Fish

In addition to the FDA national consumption advice that covers marine fish, EPA has also issued a national advisory for methylmercury in freshwater fish for sensitive populations, including women who are pregnant or may become pregnant, nursing mothers, and young children (U.S. EPA, 2001). EPA advises members of these sensitive populations to limit consumption of freshwater fish caught by family and friends to one meal per week. For adults, one meal is 6 oz. of cooked fish or 8 oz. of uncooked fish; for a young child, one meal is 2 oz. of cooked fish or 3 oz. of uncooked fish. The EPA advisory also recommends that these sensitive groups follow FDA advice on mercury for coastal and ocean fish caught by family and friends. This EPA advice currently is available at http://www.epa.gov/waterscience/fishadvice/advice.html and at http://www.epa.gov/waterscience/fishadvice/factsheet.html.

Although the FDA and EPA provide separate advice for marine and freshwater species, respectively, this separate advice should not be interpreted as being mutually exclusive. Members of these sensitive populations are advised to keep the total level of methlymercury contributed by all fish they eat (whether marine, estuarine, or freshwater) at a low level in their body. For example, if in a given week, a woman consumes 12 oz. of cooked marine fish from a store or restaurant, then she should not eat fish caught by family or friends during that same week. Fish is a good source of protein, and adequate protein is necessary for a baby or child's healthy development. To keep the level of methylmercury at a low level in the body, EPA recommends that if fish (marine, estuarine, or freshwater) caught by family and friends is a primary source of protein, individuals should try substituting a variety of other foods (e.g., meat, poultry, eggs, or dairy products) that are high in protein but that are typically lower in methylmercury.

State Advisories for Mercury in Locally Caught Marine and Estuarine Fish

States have the primary responsibility for protecting their residents from the health risks of consuming chemically contaminated locally caught (noncommercial) fish and shellfish; they do this by issuing fish consumption advisories. The 25 U.S. states that have coastal estuarine and marine waters within their state jurisdictions use slightly different criteria and processes to issue consumption advisories, and the mercury concentrations above which a fish consumption advisory is issued also differ among states (U.S. EPA, 2002).

Consumption advisories are issued for the general population, including recreational and subsistence fishers, as well as for members of sensitive populations, such as women who are pregnant or may become pregnant, nursing mothers, and young children. These advisories inform the public that high concentrations of chemical contaminants have been detected in locally caught fish and shellfish and include recommendations to limit (restrict or reduce) consumption to a specified number of meals over a specified time interval (e.g., meals per week) or to avoid consumption (no-consumption advisory) of certain species from specific waterbodies or waterbody types (U.S. EPA, 2002).

A consumption advisory is typically issued for a specific waterbody and defined geographic extent (e.g., a particular segment of an estuary or coastal marine area). Each consumption advisory also includes information that specifies the (1) fish or shellfish species of concern; (2) size or weight distinctions for that species, if available; and (3) the human population to which the advisory applies. States typically issue five major types of consumption advisories to protect both the general population and sensitive populations (U.S. EPA, 2002):

- No-consumption advisory for the general population (**NCGP**) is issued when chemical contaminant concentrations in fish or shellfish are high and pose a health risk to the general public.
- No-consumption advisory for a sensitive population (**NCSP**) is issued when contaminant concentrations are high and pose a health risk to sensitive populations, including pregnant women, nursing mothers, and young children.
- Restricted-consumption advisory for the general population (**RGP**) is issued by states for waterbodies where chemical contamination is less severe; this advisory recommends that members of the general population restrict their consumption of specific species (e.g., restrict the size of the fish they consume and/or the frequency and size of the meals they consume).
- Restricted-consumption advisory for sensitive populations (**RSP**) is issued by states for waterbodies where chemical contamination is less severe; this advisory recommends that members of sensitive populations restrict their consumption of specific species (e.g., restrict the size of the fish they consume and/or the frequency and size of the meals they consume).
- No-restriction **(NR)** advisory for all fishers is issued when chemical contaminant concentrations in fish or shellfish are relatively low, and therefore the state sets no restriction on their consumption.

In addition to consumption advisories, states may also issue commercial fishing bans (**CFB**), which prohibit the commercial harvest and sale of fish and shellfish from a designated waterbody and, by inference, the consumption of all species identified in the fishing ban from that waterbody. A waterbody can also be designated as a no kill zone (**NKZ**), where an elevated level of chemical contamination makes it illegal to harvest, kill, or possess any fish for the designated waterbody. This latter type of advice is currently issued only for coastal waters of the state of Texas and essentially warns residents that the fish are off limits for both personal consumption and commercial purposes.

The following section summarizes the active consumption advisories for mercury in marine and estuarine waters issued by the coastal states and other U.S. territory of American Samoa (AS). The source for this information is the 2002 National Listing of Fish and Wildlife Advisories (NLFWA) database, compiled by EPA's Office of Water, as part of the Agency's National Fish and Wildlife Contamination Program (U.S. EPA, 2002). The NLFWA database was accessed via the U.S. EPA Web site (http://www.epa.gov/waterscience/fish) in July 2002 and queried for active waterbody-specific advisories for mercury in estuarine waters and for statewide mercury advisories issued for coastal marine waters. A total of 26 active advisories are currently in effect for mercury in estuarine and marine areas. Of these 26 advisories, 16 are waterbody-specific mercury

advisories and 10 are statewide mercury advisories. Table B-4 contains a summary of these advisories listed geographically from Maine to Florida, west through the Gulf of Mexico, and north along the West Coast. These advisories are shown with respect to the geographic location of the states in each coastal area (Atlantic, Gulf of Mexico, and Pacific) to help show the extent of the mercury advisories in adjacent state jurisdictions along each coastline. Several states (NH, RI, CT, NY, NJ, MD, VA, OR, AK, HI) and four U.S. territories (Puerto Rico, U.S. Virgin Islands, Guam, and the Northern Marianas) currently have no coastal mercury advisories in effect.

Table B-4. Active Fish Consumption Advisories in Effect for Mercury in U.S. Coastal Waters

State	Advisory Number	Geographic Extent of Advisory	Species and Size Specifications (inches)	Population of Concern
ME	9986	Statewide: all coastal and estuarine waters	Striped bass	RGP
			Striped bass	RSP
			Bluefish	RGP
MA	9179	Statewide: all coastal and estuarine waters	Tuna	NCSP
			Tilefish	NCSP
			King mackerel	NCSP
			Swordfish	NCSP
			Shark	NCSP
DE	104190	St. Jones River: Silver Lake Dam to river mouth	All fish	RGP
DE	104174	Delaware River: PA/DE border to Chesapeake and Delaware Canal	All fish	NCGP
DE	104177	Lower Delaware River and Delaware Bay: Chesapeake and Delaware Canal to Delaware Bay mouth	Striped bass	RGP
NC	104037	Statewide: all coastal and estuarine waters	King mackerel 33-39"	RGP
			King mackerel 33-39"	RSP
			King mackerel > 39"	NCGP
			King mackerel > 39"	NCSP
SC	104230	Statewide: all coastal and estuarine waters	King mackerel > 39"	NCSP
			King mackerel > 39"	NCGP
			King mackerel 33-39"	RGP
			King mackerel 33-39"	RSP
GA	104231	Statewide: all coastal and estuarine waters	King mackerel 33-39"	RSP
			King mackerel 33-39"	RGP
			King mackerel > 39"	NCGP
GA	4944	Terry Creek: St. Simons Estuary; South of Torras Causeway to Lanier Basin	Shellfish, bivalves-Quahog clams	NCGP
			Shellfish, bivalves-Blue mussels	NCGP
			Shellfish, bivalves-American oysters	NCGP
			Silver perch	RGP

(continued)

Table B-4. (continued)

State	Advisory Number	Geographic Extent of Advisory	Species and Size Specifications (inches)	Population of Concern
GA	3327	Upper Turtle and Buffalo Rivers: St. Simons Estuary; Upriver of GA Hwy 303	Spotted sea trout	RGP
			Shellfish, crustacean-Blue crab	RGP
			Shellfish, bivalve-American oysters	NCGP
			Shellfish, bivalve-Blue mussels	NCGP
			Shellfish, bivalve-Quahog clams	NCGP
			Black drum	NCGP
			Red drum	RGP
			Flounder	RGP
			Atlantic croaker	RGP
GA	3329	Lower Turtle and South Brunswick Rivers: St. Simons Estuary; Channel Marker 9 downstream to Dubignon and Parsons Creeks	Shellfish, bivalve, Quahog clams	NCGP
			Shellfish, crustacean-Blue crab	RGP
			Shellfish, bivalve-American oysters	NCGP
			Spotted sea trout	RGP
			Shellfish, bivalve-Blue mussels	NCGP
			Atlantic croaker	RGP
			Black drum	RGP
FL	3341	Indian River Lagoon - North	Ladyfish	RGP
			Ladyfish	RSP
			Crevalle jack	RGP
			Crevalle jack	RSP
FL	3345	Indian River Lagoon - South	Crevalle jack	RSP
			Crevalle jack	RGP
FL	3343	Florida Bay - Monroe County	Spotted sea trout	RGP
			Spotted sea trout	RSP
			Crevalle jack	RSP
			Crevalle jack	RGP
FL	3342	Florida Keys - Monroe County	Spotted sea trout	RGP
			Spotted sea trout	RSP
			Crevalle jack	RGP
			Crevalle jack	RSP
FL	3344	Tampa Bay	Ladyfish	RSP
			Ladyfish	RGP
			Spanish mackerel	RSP
			Spanish mackerel	RGP
			Gafttopsail catfish	RGP
			Gafttopsail catfish	RSP
			Crevalle jack	RGP
			Crevalle jack	RSP
FL	3340	Charlotte Harbor	Spotted sea trout	RSP
			Spotted sea trout	RGP
			Crevalle jack	RGP
			Crevalle jack	RSP
			Spanish mackerel	RGP
			Spanish mackerel	RSP

(continued)

Table B-4. (continued)

State	Advisory Number	Geographic Extent of Advisory	Species and Size Specifications (inches)	Population of Concern
FL	3050	Statewide: all coastal and estuarine waters	Shark	RSP
			Shark	RGP
FL	4608	Statewide: all coastal and estuarine waters	King mackerel <39" (fork length)	RGP
			King mackerel > 39" (fork length)	NCGP
			King mackerel 33-39" (fork length)	RSP
AL	4007	Statewide: Gulf of Mexico coastal and estuarine waters	King mackerel > 39"	NCGP
			King mackerel < 39"	RGP
MS	4827	Statewide: Gulf of Mexico coastal and estuarine waters	King mackerel > 39"	NCGP
			King mackerel 33-39"	RGP
LA	4621	Statewide: Gulf of Mexico waters off all coastal parishes	King mackerel > 39"	NCSP
			King mackerel > 39"	NCGP
			King mackerel ≤ 39"	RSP
			King mackerel ≤ 39"	RGP
TX	4575	Statewide: Gulf Of Mexico - All waters off the Texas coast	King mackerel > 43"	NCGP
			King mackerel 37-43"	RGP
			King mackerel 37-43"	RSP
			King mackerel < 37"	NR
TX	851	Upper Lavaca Bay (Area Modified 01/13/2000, see Cox Bay - that area of Lavaca Bay inshore of a line beginning at the last point of land at the northeastern approach of the Lavaca Bay Causeway, then in a southwest direction to Aquatic Life Marker A to Aquatic Life Marker B)	Shellfish, crustacean, crabs	NKZ
			All fish	NKZ
CA	27	San Francisco Bay Delta Region	All fish except salmon, anchovy, herring, smelt	RSP
			All fish except salmon, anchovy, herring, smelt	RGP
WA	3339	Eagle Harbor - Bainbridge Island	Shellfish-bivalves	NCGP
			Shellfish, crustacean, crabs	NCGP
			All bottomfish	NCGP
AS	2120	Inner Pago Pago Harbor -Portion of inner bay between village and a line from Rainmaker Hotel to Trading Point	Shellfish	NCGP
			Shellfish	CFB
			All fish	NCGP
			All fish	CFB
			All fish (liver)	NCGP

RGP = Restricted-consumption advisory for the general population
RSP = Restricted-consumption advisory for sensitive populations, including pregnant women, nursing mothers, and young children
NCGP = No-consumption advisory for the general population
NCSP = No-consumption advisory for sensitive populations, including pregnant women, nursing mothers, and young children.
NR = No restrictions on consumption of this species
NKZ = No kill zone - a waterbody where chemical contamination levels make it illegal to harvest, kill, or possess any species
CFB = Commercial fishing ban prohibits the commercial harvest and sale of fish or shellfish from the designated waterbody

Source: U.S. EPA (2002) NLFWA database available at the U.S. EPA OW Web site at http://www.epa.gov/waterscience/fish. Accessed in July 2002.

TYPES OF STATE FISH CONSUMPTION ADVISORIES FOR MERCURY

This section generally describes the two types of fish consumption advisories typically used to inform state residents about levels of mercury in fish and shellfish that may be of human health concern. These include waterbody-specific advisories where contamination may be limited to a specific and well-defined geographic area and statewide advisories where large numbers of individuals of a certain species are found to have high tissue concentrations of mercury.

Waterbody-Specific Fish Consumption Advisories

Waterbody-specific advisories are typically issued for a relatively confined area of an estuary or for the estuary as a whole. This type of advisory is issued when levels of mercury contamination are detected in a high percentage of the population of a particular fish (or a specific size class of fish) or shellfish species of recreational value to state residents. In cases where contamination is pervasive in many fish and shellfish species, the states may choose to issue the advisory to cover all fish and/or shellfish species. Currently, waterbody-specific advisories for mercury have been issued for the following finfish species by the following states: striped bass (DE), silver perch (GA), spotted sea trout (GA, FL), black drum (GA), red drum (GA), Atlantic croaker (GA), ladyfish (FL), crevalle jack (FL), Spanish mackerel (FL), and gafftopsail catfish (FL). Waterbody-specific advisories for mercury have also been issued for several shellfish species, including quahog clams (GA), American oysters (GA), and blue mussels (GA). Several states have chosen to include all fish, or groups of fish or shellfish in their advisories. Waterbody-specific advisories of this type are currently in effect for all fish (DE, TX, AS); all fish except salmon, anchovy, herring, and smelt (CA); all bottomfish (WA); all flounder species (GA); all crabs, (TX, WA); all bivalves (WA); and all shellfish (AS).

Statewide Fish Consumption Advisories

Statewide fish consumption advisories are typically issued when levels of mercury contamination are detected in a high percentage of the population of a particular fish species (e.g., king mackerel) and over a wide geographic area of the state's marine coastal waters. These advisories typically include highly migratory predator species. Currently, statewide coastal marine advisories have been issued for seven predatory species or groups, including the king mackerel (MA, NC, SC, GA, FL, AL, MS, LA, TX), bluefish (ME), striped bass (ME), shark (MA, FL), tuna (MA), tilefish (MA), and swordfish (MA).

REFERENCES

U.S. EPA (Environmental Protection Agency). 1997. *Exposure Factors Handbook, Volume 2, Food Ingestion Factors.* EPA/600/P-95/002Fa. Office of Research and Development, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2000a. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories–Fish Sampling and Analysis.* Volume 1. 3rd Edition. EPA 823-B-00-007. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2000b. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories–Risk Assessment and Fish Consumption Limits.* Volume 2. 3rd Edition. EPA 823-B-00-008. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2001. *EPA Consumption Advice Factsheet – National Advice on Mercury in Fish Caught by Family and Friends: For Women Who Are Pregnant or May Become Pregnant, Nursing Mothers, and Young Children.* EPA-823-F-01-004. January.

U.S. EPA (Environmental Protection Agency). 2002. *National Listing of Fish and Wildlife Advisory Database.* Accessed July 2002 at http://www.epa.gov/waterscience/fish. Office of Water, Washington, DC.

U.S. FDA (Food and Drug Administration). 1995. *Mercury in Fish: Cause for Concern?* Consumer advise article accessed January, 31, 2000, at http://vm.cfsan.fda.gov/~dms/ mercury.html. Revised May 1995.

U.S. FDA (Food and Drug Administration). 2001a. *An Important Message for Pregnant Women of Childbearing Age Who May Become Pregnant About the Risks of Mercury in Fish.* Accessed July 2002 at http://www.cfsgn.fda.gov/~dms/admetig.html. Revised March 2001.

U.S. FDA (Food and Drug Administration). 2001b. *FDA Announces Advisory on Methylmercury in Fish.* Accessed January 2003 at http://www.fda.gov/bbs/topics/ANSWERS/2001/ANS01065.html. January 2001. Revised March 9, 2001: Updated Consumer Advisory.

U.S. FDA (Food and Drug Administration). 2001c. *Mercury Levels in Seafood Species.* Accessed July 2002 at http://www.cfsan.fda.gov/~frf/sea-mehg.html.

U.S. FDA (Food and Drug Administration). 2002. *FDA Announces Food Advisory Committee to Meet on Methylmercury in Seafood.* Accessed January 2003 at http://www.fda.gov/bbs/topics/ANSWERS/2002/ANS01141.html. March 1, 2002: Updated Consumer Advisory.

APPENDIX C

ESTUARINE AND MARINE FISH CONSUMPTION SURVEYS (1990–2001)

APPENDIX C

ESTUARINE AND MARINE FISH CONSUMPTION SURVEYS (1990–2001)

This section describes the results of estuarine and marine fish consumption surveys for the general population and for sport and subsistence fishers. Consumption rate data that are explicitly for estuarine and marine fish are very limited both nationally for the general U.S. population and regionally for various populations of fish consumers (e.g., ethnic populations or sport and subsistence fishers). Many consumption surveys provide freshwater, estuarine, and marine fish consumption rates as combined data. Fish and shellfish consumption rates may be presented as combined data or may be presented separately, making comparisons among studies infeasible. Only data from consumption surveys conducted from 1990 to the present are evaluated in this section. This timeframe was selected to be consistent with that defined for fish and shellfish monitoring data contained in the Mercury in Marine Life Database.

NATIONAL SURVEYS

Two federal agencies, the U.S. Department of Agriculture and the U.S. Department of Commerce/National Marine Fisheries Service (NMFS) have conducted fish consumption studies nationally to ascertain fish consumption rates for members of the general population. Table C-1 summarizes fish consumption data from these national studies. Consumption rates are reported as mean fish consumption (g/d) and as the 90^{th} and 95^{th} percentile values (g/d), where available. Most data are provided on a per capita basis (U.S. EPA, 2002b, also provided data on a consumer-only basis). The table also provides information on the age and gender of the population for which consumption rates are calculated. Information regarding the types of fish and food groups evaluated in the consumption surveys is also included with the consumption rate data. These distinctions include

- Inclusion of marine fish, estuarine fish, or both
- Inclusion of recreationally and/or commercially caught fish.
- Inclusion of finfish and/or shellfish.

Table C-2 summarizes the details of the survey methods used in these studies. The NMFS calculation of per capita consumption is based on a disappearance model, in which the total U.S. supply of fishery landings and imports is converted to edible weight, and decreases in supply (e.g., exports and inventories) are subtracted out. The remaining total is divided by the U.S. population (NMFS, 2002). In contrast, Jacobs et al. (1998) estimated consumption rates from the combined 1989, 1990, and 1991 Continuing Survey of Food Intake by Individuals (CSFII), which were based on a 3-day dietary recall interview of individuals surveyed in the 48 conterminous states; fish amounts considered the weight

Table C-1. Summary of National Fish Consumption Survey Data

Fisher Group	Data Source	Mean (g/d)	90th Percentile (g/d)	95th Percentile (g/d)	Gender/Age	Fish Type	Food Group
U.S. (per capita, 1990–2001)							
1995	NMFS, 2002	6.8			Both sexes, all ages	M only, C	F only
1996	NMFS, 2002	6.8			Both sexes, all ages	M only, C	F only
1997	NMFS, 2002	6.5			Both sexes, all ages	M only, C	F only
1998	NMFS, 2002	6.0			Both sexes, all ages	M only, C	F only
1999	NMFS, 2002	6.0			Both sexes, all ages	M only, C	F only
2000	NMFS, 2002	5.8			Both sexes, all ages	M only, C	F only
2001	NMFS, 2002	5.7			Both sexes, all ages	M only, C	F only
1995	NMFS, 2002	4.6			Both sexes, all ages	M only, C	S only
1996	NMFS, 2002	4.5			Both sexes, all ages	M only, C	S only
1997	NMFS, 2002	4.7			Both sexes, all ages	M only, C	S only
1998	NMFS, 2002	5.5			Both sexes, all ages	M only, C	S only
1999	NMFS, 2002	5.6			Both sexes, all ages	M only, C	S only
2000	NMFS, 2002	5.8			Both sexes, all ages	M only, C	S only
2001	NMFS, 2002	5.7			Both sexes, all ages	M only, C	S only
1990	NMFS, 2002	17.6			Both sexes, all ages	M only, C	F+S
1991	NMFS, 2002	17.5			Both sexes, all ages	M only, C	F+S
1992	NMFS, 2002	17.4			Both sexes, all ages	M only, C	F+S
1993	NMFS, 2002	17.6			Both sexes, all ages	M only, C	F+S
1994	NMFS, 2002	17.9			Both sexes, all ages	M only, C	F+S
1995	NMFS, 2002	17.6			Both sexes, all ages	M only, C	F+S
1996	NMFS, 2002	17.3			Both sexes, all ages	M only, C	F+S
1997	NMFS, 2002	17.0			Both sexes, all ages	M only, C	F+S
1998	NMFS, 2002	17.3			Both sexes, all ages	M only, C	F+S
1999	NMFS, 2002	17.8			Both sexes, all ages	M only, C	F+S
2000	NMFS, 2002	17.5			Both sexes, all ages	M only, C	F+S
2001	NMFS, 2002	17.0			Both sexes, all ages	M only, C	F+S
U.S. (per capita, 1989, 1990, 1991)							
	Jacobs et al., 1998	6.60	24.84	37.32	Female/14 or under	M only, C	F+S
	Jacobs et al., 1998	9.97	36.83	55.53	Female/15–44	M only, C	F+S
	Jacobs et al., 1998	12.59	42.92	63.85	Female/45 or older	M only, C	F+S
	Jacobs et al., 1998	10.10	36.97	55.54	Female/all ages	M only, C	F+S
	Jacobs et al., 1998	7.25	24.85	49.89	Male/14 or under	M only, C	F+S
	Jacobs et al., 1998	13.33	52.73	71.49	Male/15–44	M only, C	F+S
	Jacobs et al., 1998	13.32	50.39	64.51	Male/45 or older	M only, C	F+S

(continued)

Table C-1. (continued)

Fisher Group	Data Source	Mean (g/d)	90th Percentile (g/d)	95th Percentile (g/d)	Gender/Age	Fish Type	Food Group
	Jacobs et al., 1998	11.85	47.13	64.50	Male/all ages	M only, C	F+S
	Jacobs et al., 1998	6.93	24.88	42.07	Both sexes/14 or under	M only, C	F+S
	Jacobs et al., 1998	11.58	44.24	62.18	Both sexes/15–44	M only, C	F+S
	Jacobs et al., 1998	12.92	46.51	64.19	Both sexes/45 or older	M only, C	F+S
	Jacobs et al., 1998	10.94	39.51	59.62	Both sexes/all ages	M only, C	F+S
U.S. (per capita, 1994–1996, 1998)							
	U.S. EPA, 2002a	3.60	10.75	28.12	Female/14 or under	M only, C	F+S
	U.S. EPA, 2002a	7.03	27.90	48.06	Female/15–44	M only, C	F+S
	U.S. EPA, 2002a	10.87	41.98	63.28	Female/45 or older	M only, C	F+S
	U.S. EPA, 2002a	7.59	28.12	49.57	Female/all ages	M only, C	F+S
	U.S. EPA, 2002a	4.34	11.81	29.08	Male/14 or under	M only, C	F+S
	U.S. EPA, 2002a	9.41	36.62	72.81	Male/15–44	M only, C	F+S
	U.S. EPA, 2002a	11.85	47.05	71.44	Male/45 or older	M only, C	F+S
	U.S. EPA, 2002a	8.94	34.23	63.34	Male/all ages	M only, C	F+S
	U.S. EPA, 2002a	3.98	10.78	28.16	Both sexes/14 or under	M only, C	F+S
	U.S. EPA, 2002a	8.22	28.15	56.58	Both sexes/15–44	M only, C	F+S
	U.S. EPA, 2002a	11.31	42.73	65.14	Both sexes/45 or older	M only, C	F+S
	U.S. EPA, 2002a	8.25	29.20	55.80	Both sexes/all ages	M only, C	F+S
	U.S. EPA, 2002a	6.57	26.30	46.07	Both sexes/all ages	M only, C	F only
	U.S. EPA, 2002a	1.68	NA	NA	Both sexes/all ages	M only, C	S only
U.S. (consumer only, 1994–1996, 1998)							
	U.S. EPA, 2002a	48.72	98.09	135.87	Female/14 or under	M only, C	F+S
	U.S. EPA, 2002a	70.97	158.48	181.47	Female/15–44	M only, C	F+S

(continued)

Table C-1. (continued)

Fisher Group	Data Source	Mean (g/d)	90th Percentile (g/d)	95th Percentile (g/d)	Gender/Age	Fish Type	Food Group
	U.S. EPA, 2002a	82.26	153.34	203.45	Female/45 or older	M only, C	F+S
	U.S. EPA, 2002a	72.22	146.33	181.64	Female/all ages	M only, C	F+S
	U.S. EPA, 2002a	59.48	144.55	168.78	Male/14 or under	M only, C	F+S
	U.S. EPA, 2002a	99.08	186.07	232.50	Male/15–44	M only, C	F+S
	U.S. EPA, 2002a	89.98	179.83	224.37	Male/45 or older	M only, C	F+S
	U.S. EPA, 2002a	88.69	178.20	226.11	Male/all ages	M only, C	F+S
	U.S. EPA, 2002a	54.14	119.13	162.27	Both sexes/14 or under	M only, C	F+S
	U.S. EPA, 2002a	84.95	172.00	213.65	Both sexes/15–44	M only, C	F+S
	U.S. EPA, 2002a	85.82	168.44	218.69	Both sexes/45 or older	M only, C	F+S
	U.S. EPA, 2002a	80.19	168.88	207.57	Both sexes/all ages	M only, C	F+S

M = marine
E = estuarine
R = recreational
C = commercial
F = finfish
S = shellfish
NA = data not available

Table C-2. Description of National Fish Consumption Survey Parameters

Fisher Group	Data Source	Number Surveyed	Contact Method/Instrument	Catch vs. Consumption	Individual vs. Household
U.S. (per capita, 1990–2001)	NMFS, 2002	NA	Food disappearance into commercial market	Consumption	Individual
U.S. (per capita, 1989, 1990, 1991)	Jacobs et al., 1998	11,912	Interview of 3-day dietary recall	Consumption	Household
U.S. (per capita, 1994–96, 1998)	U.S. EPA, 2002a	20,607	Interview of 2-day dietary recall	Consumption	Household

NA = data not available

of fish as prepared (or "as consumed"). In a similar study, EPA (2002a) estimated per capita consumption rates of fish (as prepared or consumed) from the 1994–1996 and 1998 CSFII, which were based on a 2-day dietary recall interview of individuals surveyed in the 50 states and the District of Columbia.

In the NMFS study, the mean consumption rate of Americans in 2001 for commercial fresh or frozen marine finfish only, fresh or frozen marine shellfish only, and fresh, frozen, cured, or canned marine finfish and shellfish combined was 5.7, 5.7, and 17.0 g/d, respectively; cured and canned marine fishery products (not otherwise specified) accounted for 5.2 and 0.4 g/d, respectively (NMFS, 2002). Jacobs et al. (1998) reported a mean consumption rate of 10.94 g/d for commercial marine fish and shellfish combined, while EPA (2002a) reported a mean consumption rate of 8.25, 6.57, and 1.68 g/d for commercial marine fish and shellfish combined, finfish only, and shellfish only, respectively. EPA reported a 25 percent lower mean consumption rate than Jacobs et al. (1998) despite including Alaska and Hawaii; this discrepancy is difficult to explain. In addition, the CSFII data (Jacobs et al., 1998; U.S. EPA, 2002a) represent an almost 35 to 50 percent difference from the results reported by the NMFS (2002); however, differences in survey methods (dietary recall vs. food disappearance model) are likely responsible for this difference. Consumption rates for commercial marine finfish of 6.57 and 5.7 g/d for U.S. EPA (2002a) and NMFS (2002), respectively, are more similar; however, consumption rates for commercial marine shellfish varied greatly (1.68 and 5.7 g/d for U.S. EPA [2002a] and NMFS [2002], respectively). In contrast to per capita data (which average consumption rates across the entire population of fish-eaters and nonfish-eaters), consumer-only consumption rates are much higher (80.19 g/d) (U.S. EPA, 2002a). Surprisingly, these data suggest that consumption rates of marine fish and shellfish among fish consumers in the general population are similar to consumption rates for some recreational and subsistence populations.

For the purposes of risk assessment or risk management, the consumption rates derived from national surveys can provide a useful picture of the distribution of fish consumption for the general U.S. population. However, sport and subsistence fishers generally have higher consumption rates than the national rates and these rates can vary regionally, as well as among different fish-consuming populations within a region (U.S. EPA, 2000a, 2000b).

REGIONAL AND STATE SURVEYS

This section contains a summary of consumption data for sport and subsistence fishers from studies conducted in various geographic regions of the United States. There is wide variability in consumption patterns between sport fishers and subsistence fishers. Of the seven regional surveys reviewed, all but two were studies conducted of Pacific coast recreational or subsistence fisher populations. The only Atlantic coast studies involve New York/New Jersey harbor fishers and Florida fishers. Because the Florida study involved a statewide survey, responses for this study can also be included for the Gulf of Mexico region. Results of these regional and state surveys are summarized in Tables C-3 and C-4. The survey results are presented by coastal region.

Table C-3 presents consumption rate data for sport and subsistence fishers and members of the general population for the Atlantic, Gulf of Mexico, and Pacific regions. The table lists mean fish and/or shellfish consumption in g/d and the 50th and 90th percentile of consumption (g/kg body weight•d^{-1}); however, these values

Table C-3. Summary of Regional and State Fish Consumption Survey Data

Fisher Group	Data Source	Mean (g/d)	50th Percentile (g/kg•d^{-1})	90th Percentile (g/kg•d^{-1})	Fish Type	Food Group	Population
Atlantic Coastal Region							
New York/New Jersey harbor fishers	May and Burger, 1996	52.8			E+M, R	F	Sport
New York/New Jersey harbor fishers	May and Burger, 1996	187			E+M, R	S	Sport
Florida	Degner et al., 1994	73.5			M, R+C	F	Gen
Florida	Degner et al., 1994	32.8			M, R+C	S	Gen
Gulf of Mexico Region							
Florida residents	Degner et al., 1994	73.5			M, R+C	F	Gen
Florida residents	Degner et al., 1994	32.8			M, R+C	S	Gen
Pacific Coastal Region							
Tulalip Island tribes, Puget Sound - WA	Toy et al., 1996		0.55 g/kg•d^{-1} all adults [converted to 53 g/d male and 34 g/d female] 0.08 g/kg•d^{-1} child		E+M, R+C	F+S	Sub
Squaxin Island tribes, Puget Sound - WA	Toy et al., 1996		0.52 g/kg•d^{-1} all adults [converted to 66 g/d male and 25 g/d female) 0.51 g/kg•d^{-1} child		E+M, R+C	F+S	Sub
Suquamish tribe, Puget Sound - WA	Suquamish tribe, 1999, as cited by Marien and Patrick, 2001			1.68	E+M, R	F (salmon)	Sub
Suquamish tribe, Puget Sound - WA	Suquamish tribe, 1999, as cited by Marien and Patrick, 2001			0.392	M, R	F (halibut, sole, rockfish, flounder, red snapper)	Sub
Suquamish tribe, Puget Sound - WA	The Suquamish Tribe, 1999 as cited by Marien and Patrick, 2001			0.346	M, R	F (tuna)	Sub
San Francisco Bay fishers - CA	CDHS and SFEI, 2001	14.0			E+M, R	F	Sport
Santa Monica Bay fishers - CA	SCCWRP and MBC, 1994; Allen et al., 1996	49.6			E+M, R	F	Sport
San Diego Bay fishers - CA	SDCDHS, 1990	31.2			E+M, R	F	Sport

M = marine
S = shellfish
E = estuarine
Sport = sport/recreational fishers
R = recreational
Sub = subsistence fishers
C = commercial
Gen = general population
F = finfish

Table C-4. Description of Regional and State Fish Consumption Survey Parameters

Fisher Group	Data Source	Number Surveyed	Contact Method/ Instrument	Catch vs. Consumption	Individual vs. Household	Data Available
Atlantic Coastal Region						
New York/ New Jersey harbor fishers	May and Burger, 1996	318	Intercept	Consumption	Individual	Age, sex, residence, occupation
Florida residents	Degner et al., 1994	8,000	7-day dietary recall	Consumption	Individual	Age, sex, ethnicity
Gulf of Mexico Region						
Florida state residents	Degner et al., 1994	8,000	7-day dietary recall	Consumption	Individual	Age, sex, ethnicity
Pacific Coastal Region						
Tulalip Island and Squaxin tribes, Puget Sound - WA	Toy et al., 1996	190	Interview	Consumption	Individual	Age, sex, income, tribe
Suquamish tribe, Puget Sound - WA	Suquamish tribe, 1999, as cited by Marien and Patrick, 2001	92	Interview	Consumption	Individual	Age, sex, income
San Francisco Bay fishers - CA	CDHS and SFEI, 2001	448	Recall	Consumption	Individual	Age, sex, ethnicity, income
Santa Monica Bay fishers - CA	SCCWRP and MBC, 1994; Allen et al., 1996	554	Creel/recall	Consumption	Individual	Age, sex, ethnicity, income
San Diego Bay fishers - CA	SDCDHS, 1990	59	Creel	Consumption	Individual	Ethnicity

Note: Readers may obtain more detailed information on fish consumption survey techniques from EPA's guidance document, entitled *Guidance for Conducting Fish and Wildlife Surveys* (U.S. EPA, 1998).

are estimates that are generally obtained by recall of the respondents and not strictly by log-keeping. In addition, surveys generally ask about the number of meals eaten in a given timeframe, but the size of these meals is generally imprecisely estimated. Information regarding the types of fish and food group eaten is included in the table with the consumption rate. These distinctions include

- Inclusion of marine fish, estuarine fish, or both
- Inclusion of sport and/or commercially caught fish
- Inclusion of finfish and/or shellfish.

Table C-3 also identifies the fish-consuming population as the general population, sport, or subsistence fishers. Survey methods used to collect the data reported in Table C-3 are listed in Table C-4. The methods of conducting fish consumption surveys and the reporting of information from these surveys may differ among studies, and many of the differences are highlighted in the survey methods tables.

Methods of averaging fish consumption information also differ among studies. Some studies average the consumption rates over all individuals, regardless of whether they ate fish (e.g., per capita studies), whereas other surveys average the information only for those individuals who reported eating fish (e.g., consumer-only

studies). When available, data by age or gender are presented. This can be important information when contaminants, such as methylmercury, have serious developmental effects (e.g., neurological) of particular concern to women of reproductive age and young children.

The largest number of regional and state consumption surveys for estuarine and marine species has been conducted for Pacific coast fish consumers, including both recreational and subsistence fishers, in several coastal areas of California and the Puget Sound area in Washington. Atlantic coast studies are limited to fishers in the New York/New Jersey harbor area and a Florida study that collected survey data from all Florida residents. This latter study can also provide information on Gulf coast consumption rates because Florida has both Atlantic and Gulf coast fisheries.

Mean consumption rates of recreationally caught estuarine and marine (combined) fish and shellfish (primarily crabs) reported were 52.8 g/d and 187 g/d, respectively in New York/New Jersey harbor fishers (May and Burger, 1996). Recreational fishers consumed an average of 330 g of fish per meal and an average of 4.8 fish meals per month, whereas crabbers consumed an average of 9.5 crabs per meal and an average of 3.7 crab meals per month. Much higher mean fish consumption rates (73.5 d/g) were reported in the state of Florida study based on information from the general population, although this rate included marine fish only, but did include both recreational and commercially purchased fish (Degner et al., 1994). In contrast to the New York/New Jersey study, a much lower mean consumption rate (32.8 g/d) was found in the Florida study for shellfish consumption, although the value represented only marine shellfish, but included both recreational and commercially purchased shellfish (Degner et al., 1994). Other than the state of Florida study, no other quantitative consumption surveys were located pertaining to Gulf coast fishers.

For the Pacific coast region, three studies of recreational fishers could be easily compared. These studies included fisher populations in San Francisco Bay, Santa Monica Bay, and San Diego Bay. Each of these studies reported a mean consumption rate based on consumption of estuarine and marine fish species caught by sport fishers. The mean consumption rates ranged from 14.0 (San Francisco Bay), to 31.2 g/d (San Diego Bay), and 49.6 g/d (Santa Monica Bay).

All of the studies conducted in the Puget Sound area of Washington surveyed members of three Native American tribes: the Tulalip Island tribe, the Squaxin Island tribe, and the Suquamish tribe. Results for all of the tribal surveys were reported as $g/kg \cdot d^{-1}$ rather than g/d of fish, although results for two tribes were also reported in g/d. Results suggest that consumption rates among subsistence fishers, even from the same area, can vary to some degree. For example, the 50^{th} percentile of consumption of estuarine and marine fish and shellfish obtained from both recreational fishing and commercially purchased seafood was reported to be 0.55 $g/kg \cdot d^{-1}$ for all adults (53 g/d for males and 34 g/d for females) and 0.08 $g/kg \cdot d^{-1}$ for children of the Tulalip Island tribe, but was 0.52 $g/kg \cdot d^{-1}$ for all adults (66 g/d for males and 25 g/d for females) and 0.51 $g/kg \cdot d^{-1}$ for children of the Squaxin Island tribes (Toy et al., 1996). In the Suquamish tribe, the 90^{th} percentile

consumption rate for estuarine and marine recreationally caught salmon was 1.68 g/kg•d^{-1}; for marine recreationally caught fish including halibut, sole, rockfish, flounder, and red snapper, the 90th percentile was 0.392 g/kg•d^{-1}; and for marine recreationally caught fish including only tuna, was 0.346 g/kg•d^{-1}. Almost 70 percent of the Suquamish tribe fish consumption rate (for the species evaluated in the study) was for salmon.

CONCLUSIONS

Current estimates of fish consumption for estuarine and marine species by the general population, as well as by recreational and subsistence fishers, is extremely limited. In addition, data reporting units are sometimes not comparable if body weight information of the respondents is not provided with consumption results. Fish consumption rates on a body weight basis (e.g., g/kg•d^{-1} rather than g/d) would provide more accurate exposure assessment information; incorrect body weight assumptions can result in under- or overestimations of exposure and risks posed by the consumption of contaminated fish and shellfish (Marien, 2002). The few studies available suggest that there can by sizeable differences in consumption rates even among individuals fishing in the same estuarine or marine waterbody. In addition, problems associated with reporting estuarine and marine fish combined in some studies, and reporting them separately in other studies precludes more detailed comparisons of the reviewed fish consumption data.

Acquiring current data on fish consumption rates from both national studies of the general population, but more importantly for recreational and subsistence fishers at the regional or state level, is a critical data need. A much better understanding of seafood consumption patterns is of major importance in order to provide information necessary to support future public health risk assessments and risk management decisions related to the issuance of fish consumption advisories.

REFERENCES

Allen, M.J., P.V. Velez, D.W. Diehl, S.E. McFadden, and M. Kelsh. 1996. Demographic variability in seafood consumption rates among recreational anglers of Santa Monica Bay, California, in 1991–1992. *Fishery Bulletin* 94:597–610.

CDHS (California Department of Health Services) and SFEI (San Francisco Estuary Institute). 2001. *Public Summary of the San Francisco Bay Seafood Consumption Study.* San Francisco Estuary Institute, Richmond, CA.

Degner, R.L., C.M. Adams, S.D. Moss, and S.K. Mack. 1994. *Per Capita Fish and Shellfish Consumption in Florida.* Submitted to Florida Department of Environmental Protection by the Florida Agricultural Market Research Center (FAMRC), University of Florida, Gainesville, FL.

Jacobs, H.L., H.D. Kahn, K.A. Stralka, and D. B. Phan. 1998. Estimates of per capita fish consumption in the U.S. based on the continuing survey of food intake by individuals (CSFII). *Risk Anal.* 18(3):283–291.

Marien, K., and G.M. Patrick. 2001. Exposure analysis of five fish-consuming populations for overexposure to methymercury. *Journal of Exposure Analysis and Environmental Epidemiology* 11(3):193–206.

Marien, K. 2002. The importance of weight-normalized exposure data when issuing fish advisories for protection of public health. *Environmental Health Perspectives* 110(7):671–677.

May, H., and J. Burger. 1996. Fishing in a polluted estuary: Fishing behavior, fish consumption, and potential risk. *Risk A*nalysis 16(4):459–471.

NMFS (National Marine Fisheries Service). 2002. *Fisheries of the United States*, 2001. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Silver Spring, MD. September 2002.

SCCWRP (Southern California Coastal Water Research Project) and MBC Applied Environmental Sciences. 1994. *Santa Monica Bay Seafood Consumption Study*. Final Report. Southern California Coastal Water Research Project and M.C. Applied Environmental Sciences. Westminister and Costa Mesa, CA. June.

SDCDHS (San Diego County Department of Health Services). 1990. *San Diego Bay Health Risk Study*: *An Evaluation of the Potential Risk to Human Health from Fish Caught and Consumed from San Diego Bay.* Environmental Health Services. San Diego County Department of Health Services. San Diego, CA. Document No. 25467. June.

Toy, K.A., N.L. Polissar, S. Liao, and G.D. Mittelstaedt. 1996. *A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region.* Tulalip Tribes, Department of Environment, Marysville, WA.

U.S. EPA (Environmental Protection Agency). 1998. *Guidance for Conducting Fish and Wildlife Surveys.* EPA-823-B-98-007, November. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2000a. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories–Fish Sampling and Analysis.* Volume 1. 3rd Edition. EPA 823-B-00-007. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2000b. *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories–Risk*

Assessment and Fish Consumption Limits. Volume 2. 3rd Edition. EPA 823-B-00-008. Office of Water, Washington, DC.

U.S. EPA (Environmental Protection Agency). 2002a. *Estimated Per Capita Fish Consumption in the United States.* Office of Water, Office of Science and Technology, Washington, DC. EPA-821-C-02-003. Available at http://www.epa.gov/waterscience/fish/consumption_report.pdf.

U.S. EPA (Environmental Protection Agency). 2002b. *National Listing of Fish and Wildlife Advisory Database.* Accessed July 2002 at http://www.epa.gov/waterscience/fish. Office of Water, Washington, DC.

APPENDIX D

DEVELOPMENT OF CUSTOM SHAPEFILES FOR THE MERCURY IN MARINE LIFE DATABASE STUDY AREA

APPENDIX D

DEVELOPMENT OF CUSTOM SHAPEFILES FOR THE MERCURY IN MARINE LIFE DATABASE STUDY AREA

LOCATIONAL INFORMATION IN THE MERCURY IN MARINE LIFE DATABASE

A spatial locations table in the Mercury in Marine Life Database has fields to store identification information (IDs) associated with the custom shapefiles for the Mineral Management Service (MMS) Outer Continental Shelf (OCS) areas for the Atlantic, Gulf of Mexico, and Pacific regions; U.S. Environmental Protection Agency (EPA) National Estuary Program (NEP); National Oceanic and Atmospheric Administration (NOAA) Coastal Assessment Framework (CAF); and EPA Office of Research and Development (ORD) National Coastal Assessment (NCA) polygons. This information, combined with the buffer zone and centerpoint custom shapefiles for the monitoring stations, provides a convenient way to assign monitoring stations to major coastal zones (Atlantic, Gulf of Mexico, and Pacific) and to characterize stations as falling either within or outside the territorial sea. These locational fields provide convenient ways to develop database queries involving geographic stratification (or filtering). The availability of the custom shapefiles also provides a set of powerful tools to present the results of database queries in maps.

This appendix discusses the various shapefiles that were obtained for monitoring sites, the OCS outside the territorial sea, NEP areas, NOAA's CAF, and EPA's NCA near-coastal areas.

Custom Shapefiles for Monitoring Sites

The Mercury in Marine Life Database (Version 1, developed October 2002) contains information from 3,689 monitoring stations. The agencies that developed the original data provided robust latitude and longitude coordinates for 3,323 of these stations. To convert the original station locational information into standard forms that can be readily applied to EPA Office of Water (OW) geodatabases, such as the Reach Address Database (RAD), a set of polygons was created using geographic information systems (GIS) buffering techniques representing 500 m zones around the original robust locations. The centerpoints of these buffer zone polygons were also developed as non-National Hydrography Dataset (NHD) custom shapefiles. The centerpoints are particularly useful for small-scale maps, where the shapes and the sizes of the plot symbols can be classified flexibly. Figure D-1 shows a map of the stations in the Mercury in Marine Life Database based on the custom shapefile centerpoints.

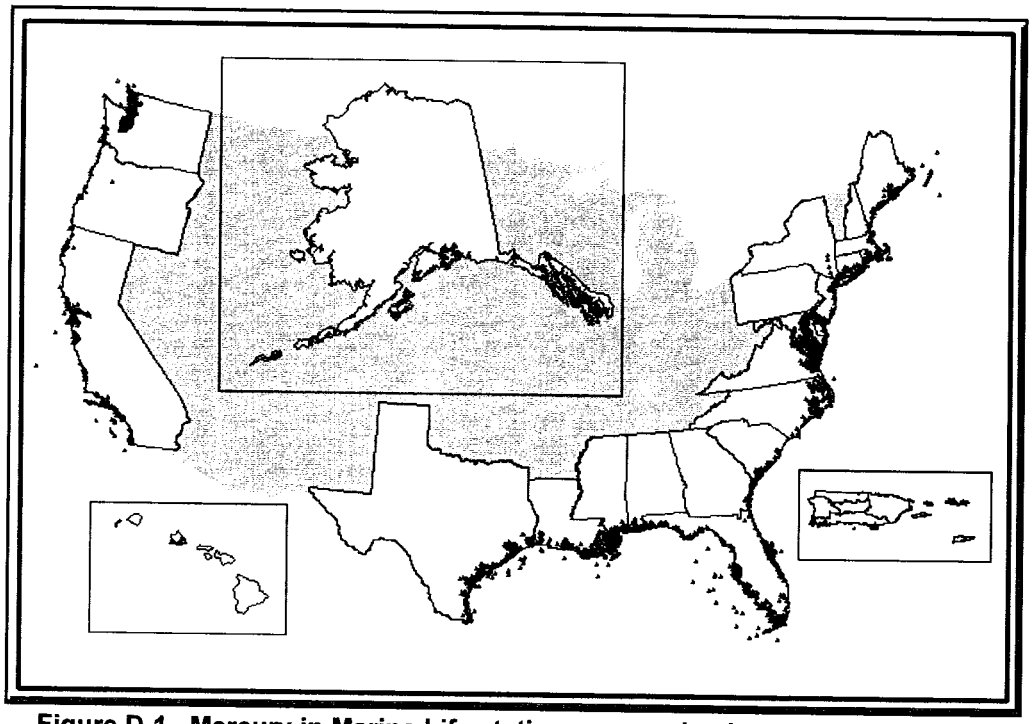


Figure D-1. Mercury in Marine Life stations mapped using custom shapefile centerpoints.

Note: The station counts will increase in the Version 2 database (January 2003) and Version 3 database (April 2003) because additional data sets were added.

Custom Shapefiles for the OCS outside the Territorial Sea

State jurisdictions focus primarily on the zone called the territorial sea. In most cases, states' seaward jurisdictional limits extend 3 nautical miles (approximately 3.3 statute miles) seaward of the coastal shoreline baseline from which the breadth of the territorial sea is measured. There are some exceptions to this 3-nautical-mile rule. Texas and the Gulf coast of Florida extend 3 marine leagues (approximately 10 nautical miles) seaward from the baseline from which the breadth of the territorial sea is measured. Louisiana extends 3 imperial nautical miles (imperial nautical mile = 6,080.2 feet) seaward of the baseline from which the breadth of the territorial sea is measured.

Federal jurisdiction is defined under accepted principles of international law. The seaward limit is defined as the farthest of 200 nautical miles seaward (the Exclusive Economic Zone [EEZ]) of the baseline from which the breadth of the territorial sea is measured or, if the continental shelf can be shown to exceed 200 nautical miles, a distance not greater than a line 100 nautical miles from the 2,500-meter isobath or a line 350 nautical miles from the baseline. The EEZ and the OCS extents may be reduced where foreign countries have claims. The

Florida Straits, for instance, show a reduced range to take account of the boundary claims of Cuba.

The Department of the Interior's MMS develops maps of the OCS. The OCS consists of the submerged lands, subsoil, and seabed lying between the seaward extent of the state jurisdiction and the seaward extent of federal jurisdiction. The continental shelf is the gently sloping undersea plain between a continent and the deep ocean floor. The United States OCS has been divided into four regions. These include the Gulf of Mexico OCS Region, the Atlantic OCS Region, the Pacific OCS Region, and the Alaska OCS Region. Each OCS region is divided further into areas. Custom shapefiles were developed for the OCS areas in the Atlantic, Gulf, and Pacific regions because these were zones where Mercury in Marine Life station data are available for sites beyond the territorial sea.

Figure D-2 shows the value of these MMS OCS GIS materials in helping to stratify the Mercury in Marine Life data into sites within the territorial sea and sites outside these focus areas of state jurisdiction. Of the 3,328 Mercury in Marine Life sites where robust latitude and longitude information is available in Version 1 of the database (October 2002), 3,201 of these sites (or 96%) fall within the territorial sea, and 127 (or 4%) fall outside the territorial sea. The Mercury in Marine Life data set also contains 23 sites that lie in Canadian waters (waters of British Columbia and the Gulf of Maine). For many fishery stocks, the major commercial fisheries are found outside the territorial sea. At the present time, additional tissue monitoring information collected from outside the territorial seas would be valuable, especially for many highly migratory species.

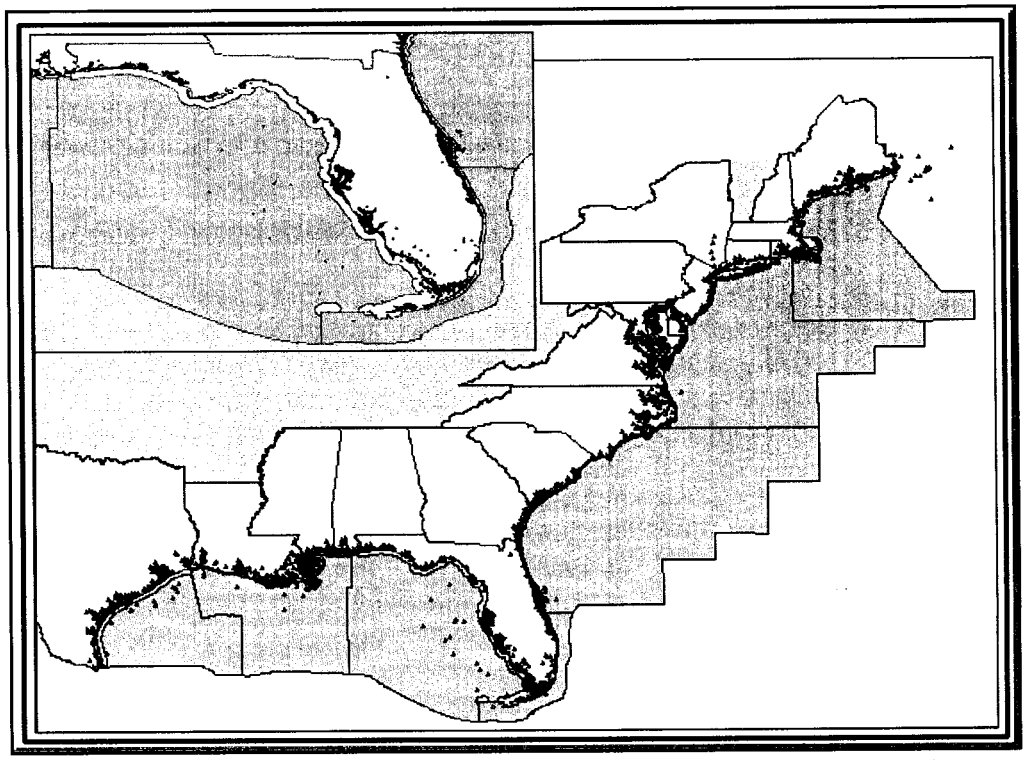


Figure D-2. Custom polygons for the OCS to map Mercury in Marine Life sites within and outside the territorial sea.

Custom Shapefiles for the National Estuary Program

The NEP had 28 programs with approved Comprehensive Conservation and Management Plans (CCMPs) by the end of fiscal year (FY) 2002. Figure D-3 shows the NEP study areas for these 28 NEP programs based on GIS materials developed by EPA's Oceans and Coastal Protection Division. These polygons can incorporate both open water areas and select portions of inland drainage areas.

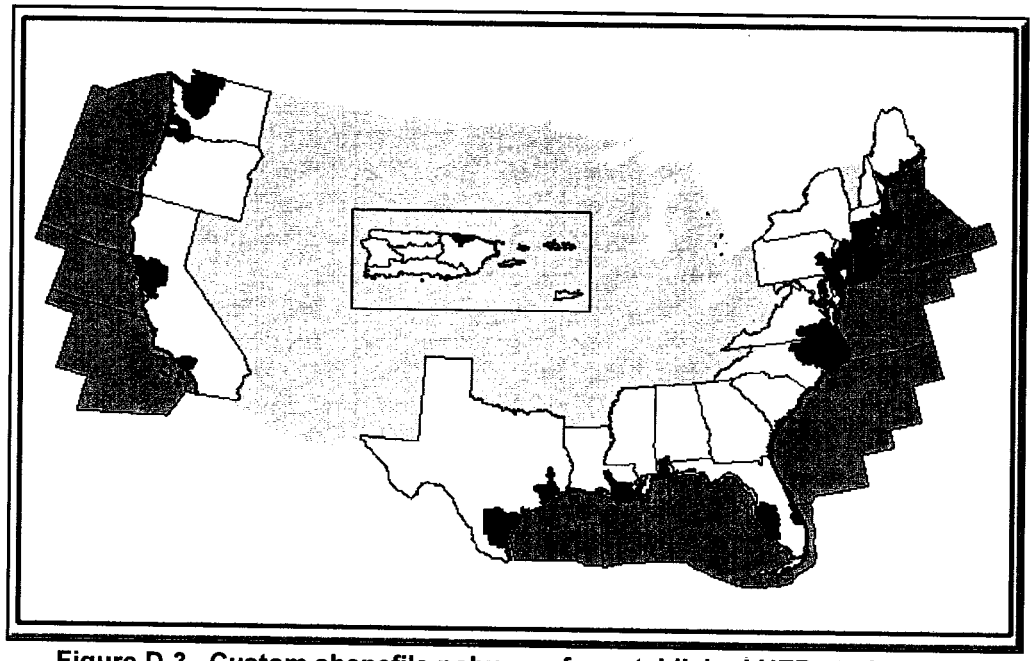


Figure D-3. Custom shapefile polygons for established NEP study areas.

Custom Shapefiles for the Coastal Assessment Framework

NOAA has developed a digital spatial framework called the Coastal Assessment Framework (CAF), which is also known as the Coastal Assessment and Data System (CA & DS). The CAF provides a consistently derived, watershed-based digital spatial framework for managers and data analysts to organize and present information on the nation's coastal resources. The open water polygons in the CAF system were converted to the non-NHD-based custom shapefile formats. Figure D-4 shows these CAF open-water polygons for the conterminous United States. Because there is no nationally consistent definition of an estuary or other near-coastal waterbodies, the NOAA CAF polygons can be helpful in relating monitoring stations to one well-defined set of digitized polygons.

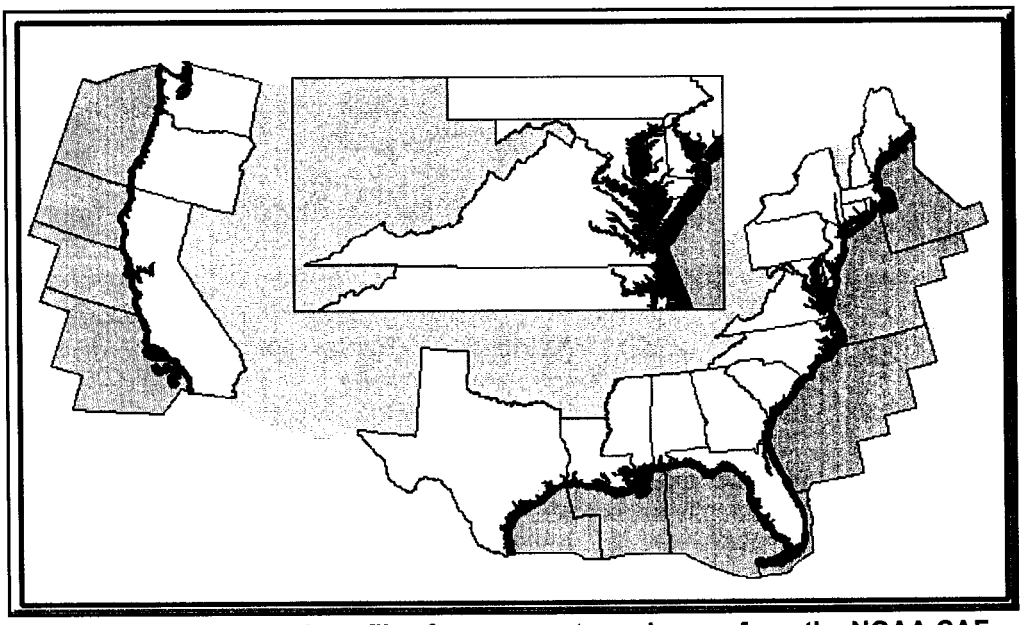


Figure D-4. Custom shapefiles for open water polygons from the NOAA CAF.

Custom Shapefiles for EPA National Coastal Assessment Near-Coastal Polygons

EPA ORD's Environmental Monitoring and Assessment Program (EMAP) led an initiative called Coastal 2000, which has subsequently been renamed the National Coastal Assessment (NCA). The NCA integrates previous EMAP coastal data collections and a set of ongoing efforts for which the monitoring results will become available starting in FY2003. Figure D-5 illustrates the estuarine and

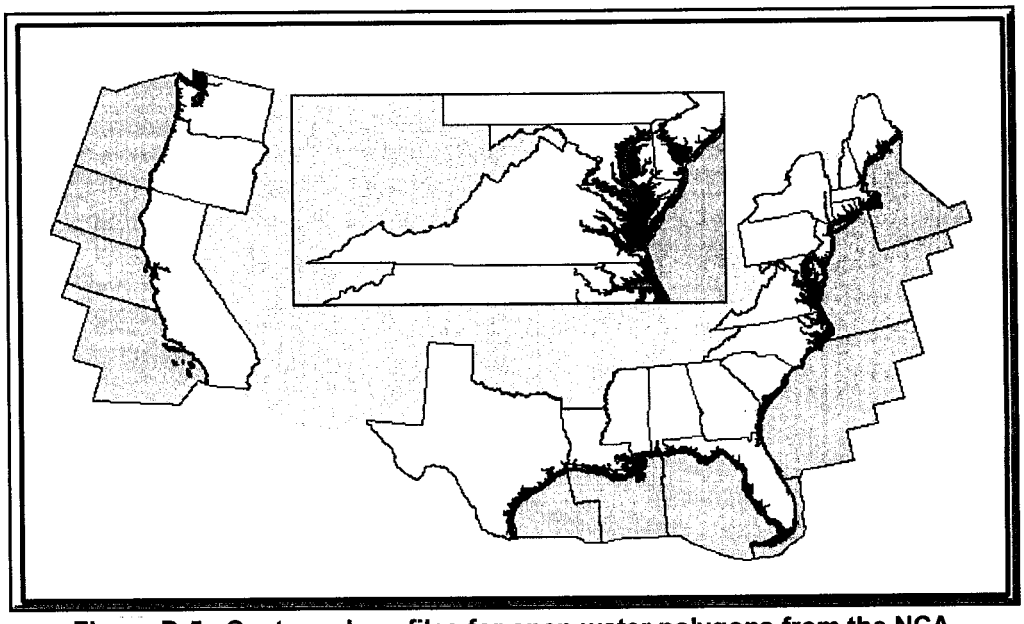


Figure D-5. Custom shapefiles for open-water polygons from the NCA.

near-coastal polygons defined for the NCA. Because there is no nationally consistent definition of an estuary or other near-coastal waterbodies, the ORD NCA polygons can be helpful in relating monitoring stations to one well-defined set of digitized polygons.

Custom Shapefile for Extended State Border Delineations

GIS techniques were applied in the development of the Mercury in Marine Life Database to ensure the accuracy of associating monitoring site locations with the correct state estuarine and coastal marine waters. In some cases, data developed by a state agency include some sites that fall within the coastal border waters of an adjacent state. One example occurs in the lower Hudson River Estuary and harbor area (New York/New Jersey Bight), where the monitoring agency from New York collects some samples at locations that technically fall within the jurisdictional coastal waters of New Jersey. For some EMAP or regional EMAP (REMAP) programs, samples collected in the Louisianan province would include sites falling not only in Louisiana, but also in such Gulf states as Mississippi or Alabama. In the Mercury in Marine Life Database, a data element with a state code assignment is intended to show the state jurisdictional waters where the monitoring information was collected — not necessarily the home state of the agency that was coordinating the data collection activities.

A special state polygon GIS coverage (the ST_EXT or "Extended State Border" shapefile) has been developed to support production work for EPA's RAD to automate the assignment of states to georeferenced entities. The ST_EXT state polygon boundaries extend to the approximate limits of the territorial sea and dissolve the complex geometries of coastal open-water features into a simple definition of the state administrative boundaries. GIS spatial join techniques were applied to populate state data element fields in the Mercury in Marine Life Database system where latitude/longitude information was available to identify a monitoring site. For a small number of sites falling either outside the limits of the territorial sea or in the waters of other countries (e.g., Canadian waters of the Gulf of Maine or Georgian Basin of British Columia), manual inspection was used to make these data element assignments. A copy of the ST_EXT shapefile is included in the most recent version (April 2003) of the Mercury in Marine Life Database CD-ROM containing all the GIS and database materials.

APPENDIX E

DATA DICTIONARY AND DATA ELEMENT DESCRIPTIONS FOR THE MERCURY IN MARINE LIFE DATABASE AND GIS CUSTOM SHAPEFILES

APPENDIX E

DATA DICTIONARY AND DATA ELEMENT DESCRIPTIONS FOR THE MERCURY IN MARINE LIFE DATABASE AND GIS CUSTOM SHAPEFILES

DATA DICTIONARY FOR THE MERCURY IN MARINE LIFE DATABASE DATA TABLES AND LOOKUP TABLES

The Mercury in Marine Life Database consists of a set of data tables and lookup tables. Relations are established between records of the data tables using primary keys. For some of the data tables, it is convenient to define lookup tables that store the range of data items that can appear in particular data fields. Figure E-1 shows an entity relationship diagram (ERD) that provides a standard format for summarizing the connections between the tables in a relational database. For instance, **HGSITE** and the **HGLOCATE** are data tables, where the data item **SITE_ID** is a primary database key (or index) to establish relations between the records of information in the two tables. The **LUT_SPECIES** table is a lookup table that provides a menu of different estuarine and marine species (common names, scientific names, and so forth) that can be entered in the **HGSAMPLE** data table. The data item **SpeciesID** is the foreign key to establish relations between records in the data table and the lookup table.

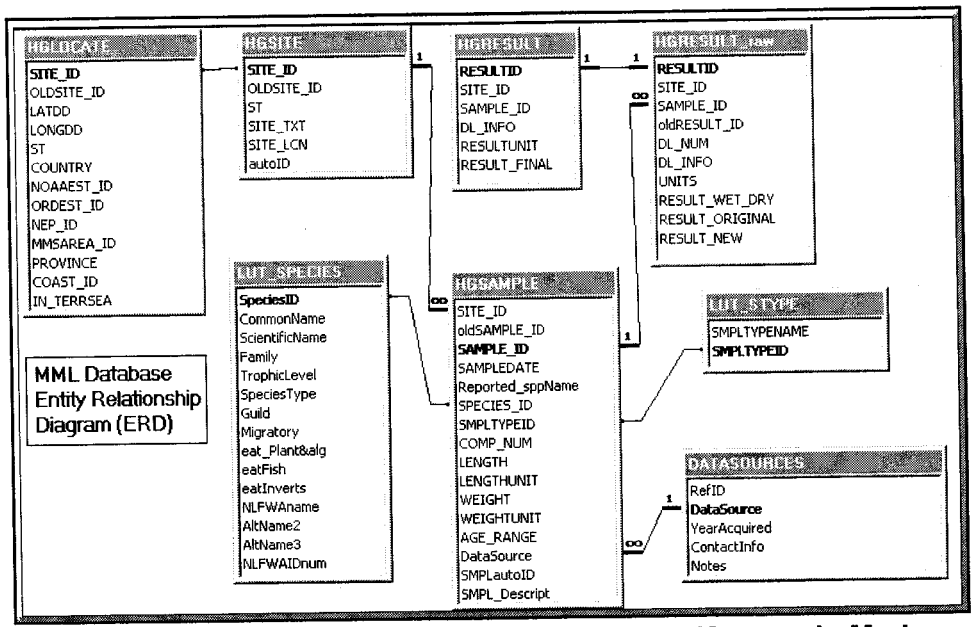


Figure E-1. Entity relationship diagram for the Mercury in Marine Life Database.

MERCURY IN MARINE LIFE DATA DICTIONARY

Data Tables

Table: HGSITE
Description: Site ID descriptor information

Field Name	Type	Size	Description
SITE_ID	Text	50	Database's site ID. Format ST_xxxxxxx
OLDSITE_ID	Text	40	Unique site ID -- based on ID in original database source
ST	Text	2	State (e.g., GA)
SITE_TXT	Text	40	Short caption describing the site/station
SITE_LCN	Text	80	More detailed site/station locational information
autoID	LInteger	4	

Table: HGLOCATE
Description: To store results of GIS analyses and for mapping using GIS custom shapefiles

Field Name	Type	Size	Description
SITE_ID	Text	50	database-assigned siteID
OLDSITE_ID	Text	40	Unique site ID -- based on ID in original database
LATDD	Double	8	decimal degrees (positive)
LONGDD	Double	8	decimal degrees (negative number for GIS mapping)
ST	Text	2	STATE or Canadian province
COUNTRY	Text	50	USA or CN (Canada)
NOAAEST_ID	Text	50	NOAA CAF open water polygons
ORDEST_ID	Text	50	ORD/EMAP National Coastal Assessment water polygons
NEP_ID	Text	50	National Estuary Program focus study area polygons
MMSAREA_ID	Text	50	MMS OCS coastal region/area polygons
PROVINCE	Text	10	EMAP biogeographical province name(e.g., Virginian)
COAST_ID	Text	10	Atlantic/Gulf/Pacific
IN_TERRSEA	Text	10	within the United States territorial sea (Y or N)

Table: HGRESULT
Description: Processed results. All in Wet Weight, detection limits addressed

Field Name	Type	Size	Description
RESULTID	Long Integer	4	Database key for a RESULT (Hg concentration in tissue) -- a machine generated sequence number
SITE_ID	Text	40	assigned site ID
SAMPLE_ID	Text	40	Assigned sample ID
DL_INFO	Text	50	Detection Limit information
RESULTUNIT	Text	10	units (e.g., ppb)
RESULT_FINAL	Double	8	calculated result concentration, all WW

Table: HGSAMPLE
Description: Sample info

Field Name	Type	Size	Description
SITE_ID	Text	40	Assigned site ID
oldSAMPLE_ID	Text	40	ID in original database source
SAMPLE_ID	Text	50	assigned sample ID; format ST_XXXX
SAMPLEDATE	Date	8	Y2K format such as YYYYMMDD
Reported_sppName	Text	255	name reported in original data source
SPECIES_ID	LInteger	4	assigned species ID number
SMPLTYPEID	Double	8	number from look-up table on sample types (e.g., singe fish --fillet -- skin off)
COMP_NUM	Double	8	number of organisms used for a composite sample (of the same genus/species)
LENGTH	Double	8	length of sample
LENGTHUNIT	Text	50	
WEIGHT	Double	8	weight of sample
WEIGHTUNIT	Text	50	
AGE_RANGE	Text	4	life stage
DataSource	Text	50	links to study/dataset source
SMPLautoID	LInteger	4	internally generated ID number
SMPL_Descript	Text	255	description in original source

Table: HGRESULT_raw
Description: results info as originally reported (ww/dw)

Field Name	Type	Size	Description
RESULTID	Linteger	4	Database key for a RESULT (Hg concentration in tissue) -- likely a machine generated sequence number
SITE_ID	Text	40	assigned site ID
SAMPLE_ID	Text	40	Assigned sample ID
oldRESULT_ID	Text	40	Unique result ID from original database
DL_NUM	Double	8	
DL_INFO	Text	50	Detection Limit information
UNITS	Text	10	units (e.g., ppb) for DL and results
RESULT_WET_DRY	Text	10	WET or DRY -- as reported in original data source
RESULT_ORIGINAL	Double	8	original tissue concentration information (including DL caveats)
RESULT_NEW	Double	8	result number corrected for DL (half of DL if below DL) and wet/dry conversion (resultx0.2 convert to wet). This goes into final HGResults table

Table: DATASOURCES
Description: Source of data (study or report)

Field Name	Type	Size	Description
RefID	Linteger	4	
DataSource	Text	255	Reference, or study providing data
YearAcquired	Date	8	Year data acquired and added to database
ContactInfo	Text	255	url; name of person; or other info
Notes	Memo		

Table: LUT_SPECIES
Description: Species look-up information for HGSAMPLE data table

Field Name	Type	Size	Description
SpeciesID	Linteger	4	
CommonName	Text	255	
ScientificName	Text	255	
Family	Text	255	
TrophicLevel	LInteger	4	
SpeciesType	Text	50	
Guild	Text	50	
Migratory	Text	50	
eat_Plant&alg	Boolean	1	
eatFish	Boolean	1	
eatInverts	Boolean	1	
NLFWAname	Text	255	
AltName2	Text	255	
AltName3	Text	255	
NLFWAIDnum	LInteger	4	

Table: LUT_STYPE
Description: Sample type (e.g., skin-off fillet) look-up information for HGSAMPLE data table

Field Name	Type	Size	Description
SMPLTYPENAME	Text	30	
SMPLTYPEID	Linteger	4	

GIS CUSTOM SHAPEFILES

Documentation on the attributing of the geographic information system (GIS), transactions table, and metadata table files for the non-National Hydrography Dataset (NHD) custom shapefiles can be found at the following Internet address: http://www.epa.gov/owow/monitoring/georef/training.html.

The document **NHDRIT_DATASTRUCTURE.PDF,** which can be downloaded from this Web site, provides a complete technical description for the ordinary U.S. Environmental Protection Agency (EPA) Reach Address Database (RAD)-compatible linear and point event tables. These special event tables provide precise locations relative to portions of the NHD. This document also provides technical documentation for custom (non-NHD-based) shapefiles. Custom point and polygon file sets were used for the Mercury in Marine Life Database GIS data layers. Figure E-2 shows the relations for the tables in these custom file sets and presents the attributes for a custom shapefile table.

The custom shapefiles contain an attribute field called ENTITY_ID. The contents of this field serve as a database key for a particular monitoring station or a custom polygon. These database keys are used by GIS software, and the IDs are stored

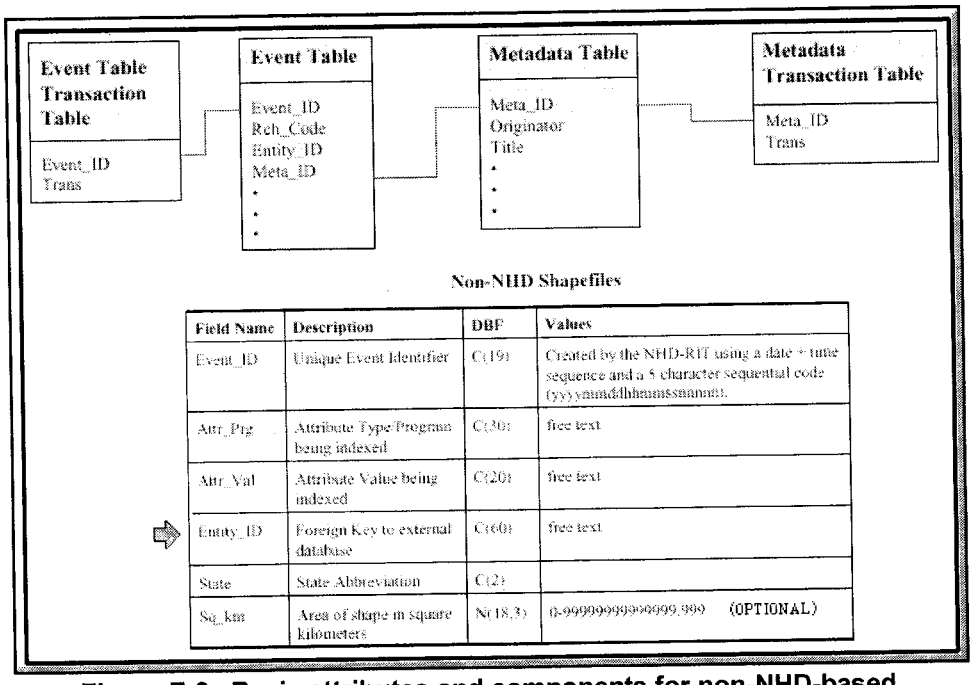


Figure E-2. Basic attributes and components for non-NHD-based custom shapefiles.

in appropriate fields in the Mercury in Marine Life Database HGLOCATE table. The ENTITY_ID attributes provide a link between the Mercury in Marine Life Database and GIS applications, such as Environmental Systems Research Institute's (ESRI's) ArcView, that can display the custom shapefile coverages and tap data tables or query tables from the Mercury in Marine Life Database. Typical records from the Mercury in Marine Life custom shapefile sets are included to illustrate the contents of the ENTITY-ID attribute field. The custom shapefiles contain two other fields, ATTR_PRG and ATTR_VAL, where information derived from the original parent GIS materials can be placed. For instance, in the custom polygons for the National Coastal Assessment (NCA), the ATTR_PRG field contains the name of the Environmental Monitoring and Assessment Program (EMAP) biographical province.

EXAMPLES OF MERCURY IN MARINE LIFE CUSTOM SHAPEFILE ATTRIBUTING

MML Site/Station Centerpoints

Event_id 2002082803575600014
Attr_prg PACIFIC
Attr_val
Entity_id CA-1070-10
State CA
Meta_id 200208280401060000

MMS Polygons

Event_id 2002082911203100002
Attr_prg PACIFIC - MMS OCS
Attr_val
Entity_id MPC1
State
Meta_id 200208291123330000

EMAP/ORD NCA Polygons

Event_id 2002082804551701581
Attr_prg EMAP_Louisianian
Attr_val Calcasieu Lake
Entity_id EMAP_9122
State LA
Meta_id 200208280502510000

NOAA CAF Polygons

Event_id 2002082803500272
Att_prg NOAA CAF
Attr_val Saco Bay
Entity_id N110x E 01060003 water
State
Meta_id 2002080449400000

NEP Polygons

Event_id 2002082805135900005
Attr_prg NEP
Attr_val
Entity_id Puget Sound NEP
State WA
Meta_id 200208280521530000

APPENDIX F

SEARCH PROCEDURES FOR IDENTIFYING SCIENTIFIC LITERATURE FOR THE MERCURY IN MARINE LIFE PROJECT

APPENDIX F

SEARCH PROCEDURES FOR IDENTIFYING SCIENTIFIC LITERATURE FOR THE MERCURY IN MARINE LIFE PROJECT

PROCEDURE

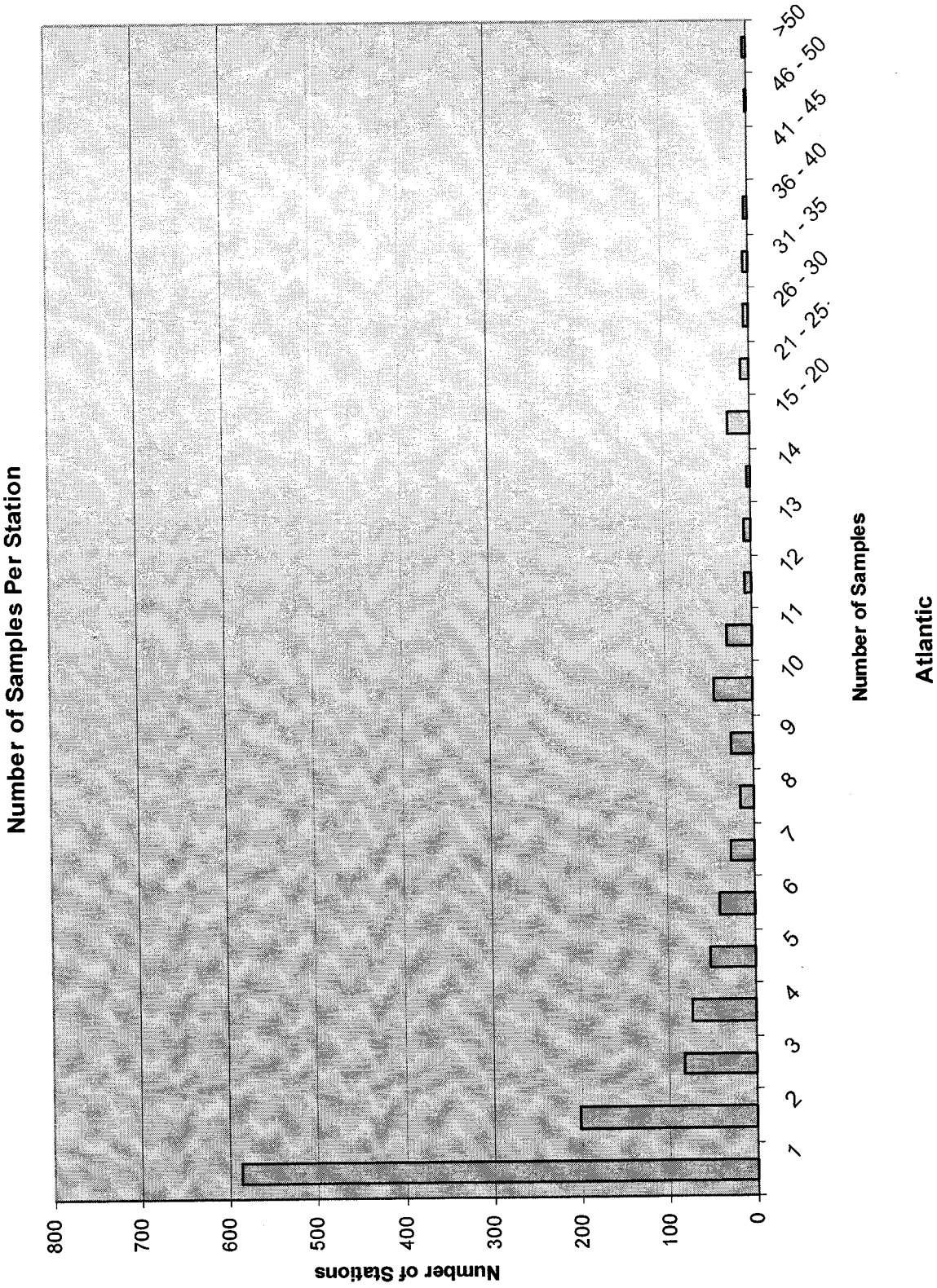
RTI conducted a search of major scientific journals using the database search engines *Medline*, *Toxline*, *Enviroline*, *Aquatic Sciences and Fisheries Abstracts*, *Environmental Bibliography*, *Pollution Abstracts*, *Food Science and Technology Abstracts*, and *Biological Abstracts*. This search identified major journals likely to have publications that deal with fish and wildlife contaminant data and articles related to the human health risks of chemical contaminants in fish, including consumption patterns and rates for human populations of fish consumer. The searches included, but were not limited to, the following journals:

Ambio
Aquatic Toxicology
Archives of Environmental Contamination and Toxicology
Archives of Environmental Toxicology
Bulletin of Environmental Contamination and Toxicology
Canadian Journal of Fisheries and Aquatic Science
Chemosphere
Environmental Contamination and Toxicology
Environmental Health Perspectives
Environmental Pollution
Environmental Research
Environmental Science and Technology
Estuaries
Fisheries
Food Chemistry
Food Technology
Journal of Agriculture and Food Chemistry
Marine Biology
Marine Environmental Research
Pesticides Monitoring Journal
Reviews in Environmental Contamination and Toxicology
Risk Analysis
Science
Science of the Total Environment
Toxicology and Environmental Health
Transactions of the North American Wildlife National Resources Council
Water Resources

RTI staff identified appropriate journal articles or abstracts published in English from the database search and then retrieved the complete journal article. Each article was then copied and archived for later review. Copies of each of the archived journal articles were delivered to U.S. Environmental Protection Agency (EPA) Work Assignment Manager Debora Martin at the completion of the project.

APPENDIX G

PROFILE OF THE NUMBER OF SAMPLES COLLECTED BY STATION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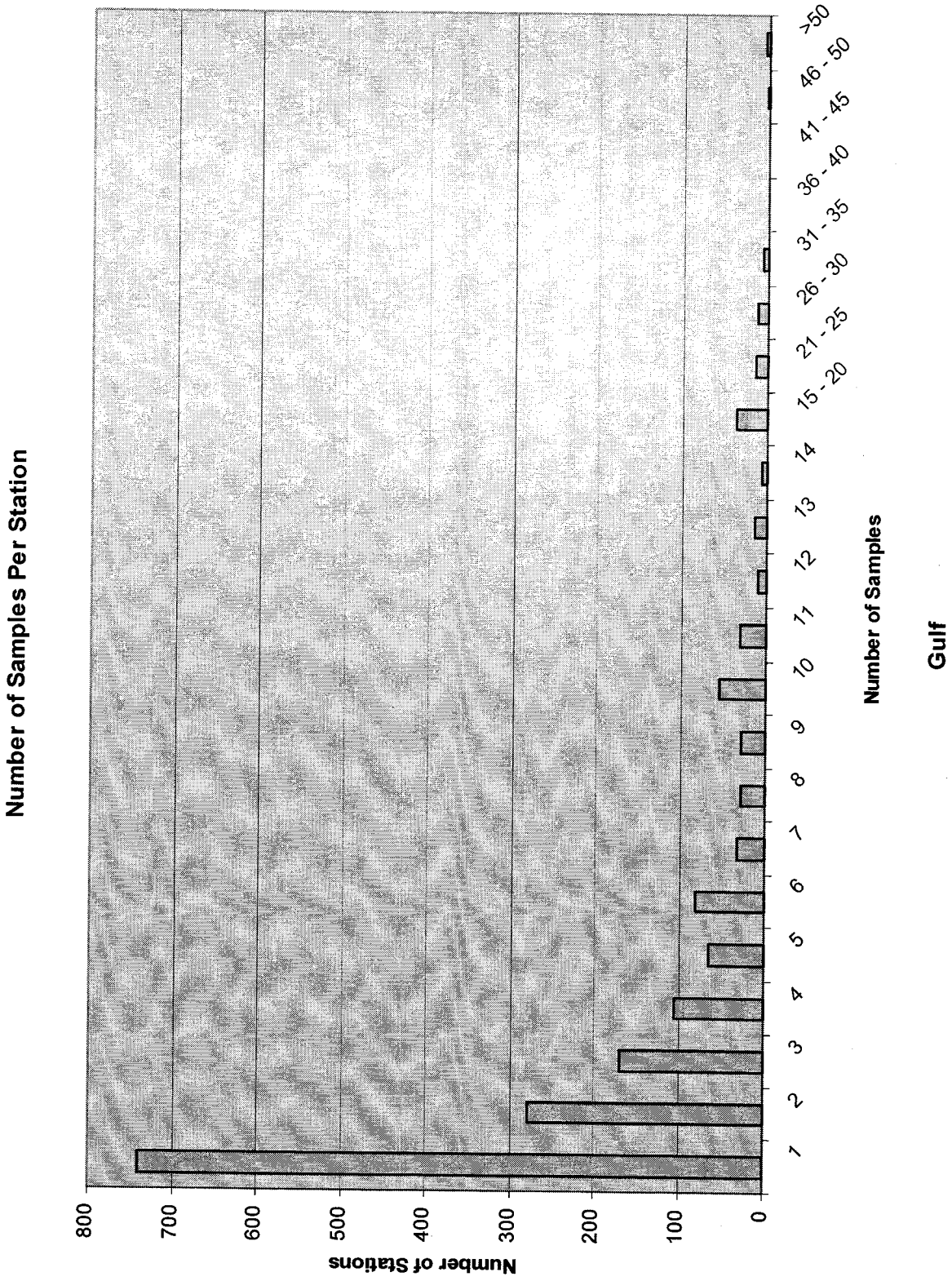
300
400
500
600
700
800
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15 - 20
21 - 25
26 - 30
31 - 35
36 - 40
41 - 45
46 - 50
>50
Number of Samples
Atlantic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Number of Stations
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700
600
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0
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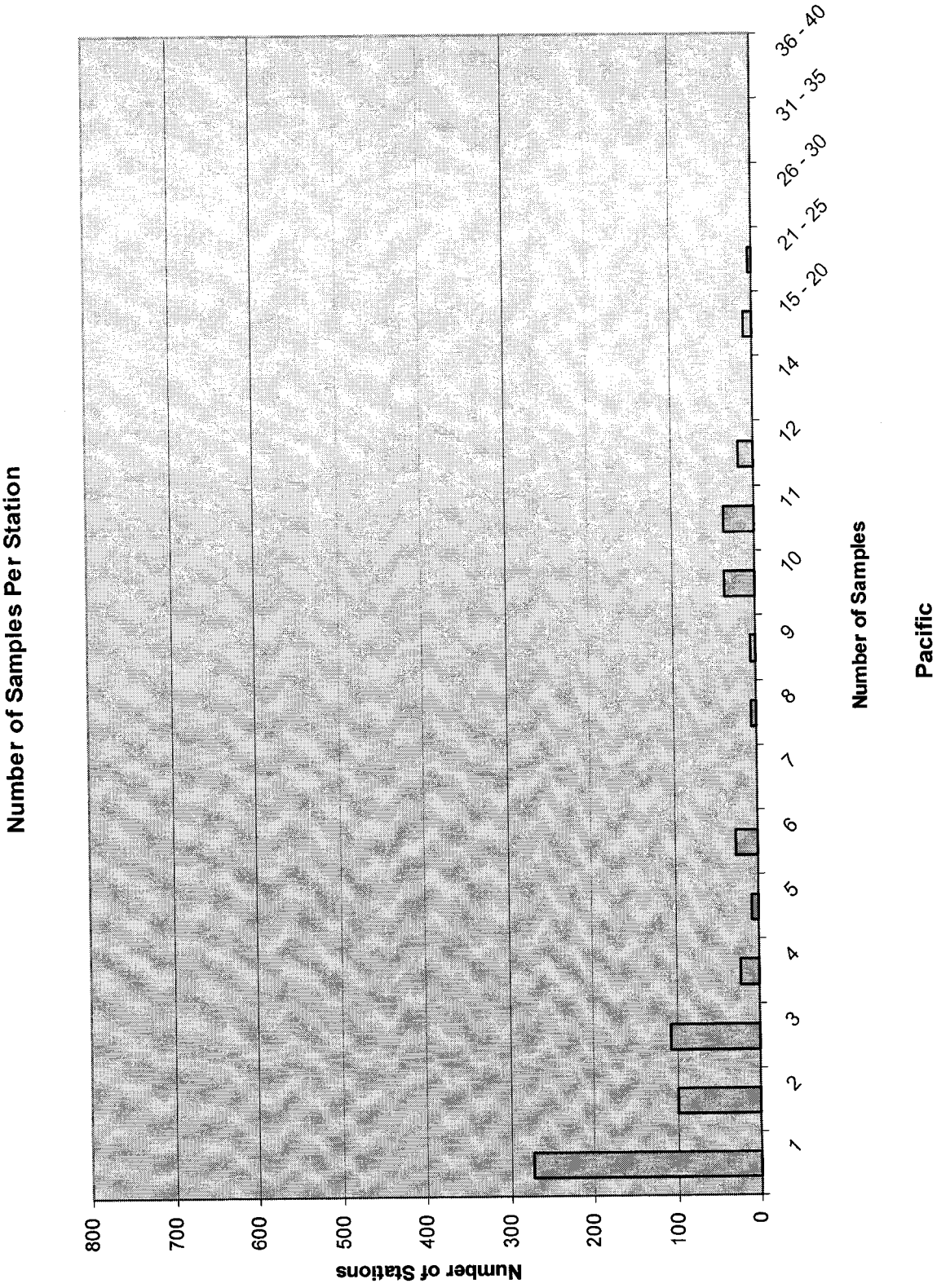
14
15 - 20
21 - 25
26 - 30
31 - 35
36 - 40
41 - 45
46 - 50
>50
Number of Samples
Gulf


Number of Samples Per Station
Number of Stations
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700
600
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300
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0
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14
15 - 20
21 - 25
26 - 30
31 - 35
36 - 40
Number of Samples
Pacific

APPENDIX H

SUMMARY STATISTICS ON MERCURY CONCENTRATIONS IN FISH AND SHELLFISH SPECIES

Table H-1. Mean and Maximum Total Mercury Concentrations for Atlantic Species

Common Name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Alewife	0.156	0.240	5
Almaco jack	0.563	0.563	1
American eel	0.207	0.800	107
American oyster	0.036	0.250	471
Atlantic croaker	0.090	0.550	58
Atlantic guitarfish	0.190	0.190	1
Atlantic salmon	0.205	0.610	6
Atlantic sharpnose shark	1.005	2.300	89
Atlantic stingray	0.157	0.440	39
Banded rudderfish	0.437	0.623	2
Barracuda	0.521	3.100	28
Black drum	0.178	0.850	60
Black grouper	1.194	1.600	5
Black sea bass	0.150	0.160	2
Blackfin tuna	1.162	1.162	1
Blacknose shark	0.580	0.750	6
Blacktip shark	1.037	2.300	42
Blue crab	0.432	3.680	86
Blue marlin	2.243	3.085	2
Blue mussel	0.061	0.500	641
Blue striped grunt	0.354	0.400	3
Bluefish	0.401	1.600	174
Bluntnose ray	0.081	0.140	10
Bonefish	0.531	1.100	13
Bonnethead shark	0.433	1.500	143
Bull shark	0.794	1.700	51
Calico bass	0.670	0.670	1
Cero mackerel	0.188	0.264	3
Cobia	0.815	1.700	11
Coho salmon	0.038	0.050	5
Common snook	0.339	1.800	263
Crab	0.480	0.900	5
Crevalle jack	0.698	3.900	119
Croaker	0.118	0.280	30
Dolphin	0.072	0.191	14
Dusky shark	1.627	6.900	13
Eagle ray	0.120	0.120	2
Eel	0.290	0.430	5
Finetooth shark	0.200	0.200	1
Florida pompano	0.083	0.150	20

(continued)

Table H-1. (continued)

Common Name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Flounder	0.219	0.440	19
Fourspine stickleback	0.015	0.015	1
Gafftopsail catfish	0.382	0.720	15
Gag grouper	0.538	1.000	13
Gizzard shad	0.020	0.170	32
Gray snapper	0.235	0.670	165
Great white shark	4.508	6.533	4
Greater amberjack	0.508	0.990	7
Grey triggerfish	0.112	0.160	2
Grouper	0.398	0.398	1
Grunt	0.310	0.310	1
Gulf flounder	0.197	0.580	35
Hardhead catfish	0.152	0.340	13
Hogfish	0.145	0.154	3
Inshore lizardfish	0.227	0.363	2
Jack	0.020	0.020	1
Jewel box	0.025	0.036	6
King mackerel	0.979	3.500	118
Ladyfish	0.597	2.600	48
Lane snapper	0.218	0.289	4
Leatherjacket	1.450	1.700	3
Lemon shark	0.670	0.690	2
Little tunny	1.178	2.150	5
Lookdown	0.156	0.240	5
Mullet	0.095	0.480	25
Mutton snapper	0.255	0.328	7
Northern hog sucker	0.070	0.070	1
Ocean pout	0.105	0.200	3
Ocean sunfish	0.021	0.021	1
Oyster	0.187	1.200	20
Permit	0.276	1.600	23
Pigfish	0.133	0.410	33
Pinfish	0.182	0.550	9
Pompano	0.105	0.235	7
Rainbow smelt	0.152	0.360	10
Red drum	0.311	2.700	234
Red grouper	0.303	0.430	7
Red snapper	0.880	2.800	4
Rock sea bass	0.066	0.066	2
Sailfish	0.110	0.110	1
Sand drum	0.056	0.073	6
Sand shark	0.300	0.300	1

(continued)

Table H-1. (continued)

Common Name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Sand tiger shark	0.300	0.300	1
Sandbar shark	0.979	2.100	19
Scalloped hammerhead	0.818	1.800	12
Scamp grouper	0.295	0.450	2
Scup	0.033	0.072	10
Sea bream	0.180	0.180	2
Sea catfish	0.140	0.140	1
Sea trout	0.140	0.540	37
Shark	1.034	3.100	12
Sheepshead	0.186	0.490	53
Shortfin mako	1.845	3.200	2
Shortnose sturgeon	0.120	0.120	1
Shrimp	0.072	0.240	34
Silver perch	0.362	1.100	22
Silver seatrout	0.237	0.237	1
Smooth butterfly ray	0.123	0.170	8
Smooth dogfish	0.570	1.600	4
Smooth edged jewelbox	0.025	0.036	6
Snowy grouper	0.463	0.951	7
Southern flounder	0.128	0.520	83
Southern kingfish	0.080	0.240	19
Spadefish	0.240	0.260	2
Spanish mackerel	0.371	1.000	73
Spinner shark	0.608	0.970	10
Spot	0.086	0.360	95
Spotted seatrout	0.538	2.500	373
Striped bass	0.154	0.840	216
Striped mojarra	0.117	0.250	6
Striped mullet	0.038	0.240	69
Summer flounder	0.036	0.110	34
Tarpon	0.226	0.690	22
Tiger shark	2.175	3.900	2
Tripletail	0.119	0.360	31
Vermillion snapper	0.428	0.756	2
Wahoo	0.393	0.698	5
Weakfish	0.265	0.840	61
White grunt	0.306	0.380	3
White marlin	0.290	0.310	2
White mullet	0.051	0.250	16
White perch	0.180	1.200	157
White shrimp	0.067	0.140	17
Winter flounder	0.026	0.090	9

(continued)

Table H-1. (continued)

Common Name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Yellow jack	0.410	0.410	2
Yellowedge grouper	0.375	0.410	3
Yellowfin menhaden	0.070	0.100	3
Yellowfin tuna	0.261	0.302	2
Yellowtail snapper	0.164	0.250	5

Table H-2. Mean and Maximum Total Mercury Concentrations for Gulf of Mexico Species

Common name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
American oyster	0.080	0.720	1634
Atlantic croaker	0.054	0.588	225
Atlantic guitarfish	0.190	0.190	1
Atlantic menhaden	0.102	0.102	1
Atlantic sharpnose shark	0.370	0.370	1
Atlantic spadefish	0.336	0.470	7
Atlantic stingray	0.266	0.540	24
Atlantic thread herring	0.145	0.240	9
Barracuda	0.988	2.800	28
Black drum	0.443	6.620	233
Black grouper	0.907	1.400	7
Black sea bass	0.134	0.210	12
Black tuna	0.823	1.100	3
Blackfin tuna	0.684	1.040	2
Blacknose shark	0.440	0.530	2
Blacktip shark	0.712	2.600	65
Blue crab	0.141	2.650	239
Blue marlin	3.085	6.800	8
Blue runner	0.180	0.180	1
Bluefish	0.891	2.000	47
Bluntnose ray	0.185	0.590	16
Bonefish	0.500	0.500	1
Bonnethead shark	0.548	1.600	73
Brown shrimp	0.033	0.197	14
Bull shark	0.792	1.300	11
Clam	0.017	0.017	1
Cobia	0.535	2.000	24
Common snook	0.466	2.080	237
Cownose ray	0.248	0.640	6
Crevalle jack	0.612	1.800	102
Croaker	0.054	0.090	8
Dolphin	0.126	0.490	29
Dusky shark	1.470	1.470	1
Fantail mullet	0.032	0.054	13
Finetooth shark	0.200	0.200	1
Florida pompano	0.177	0.490	43
Florida smoothhound shark	1.200	1.200	1
Flounder	0.672	1.680	9
Gafftopsail catfish	0.354	1.800	153
Gag grouper	0.347	1.060	63
Gray snapper	0.185	0.620	159
Great white shark	3.367	5.400	3

(continued)

Table H-2. (continued)

Common name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Greater amberjack	0.541	1.100	24
Grouper	0.390	0.390	1
Gulf flounder	0.268	1.100	133
Gulf menhaden	0.165	0.165	1
Gulf toadfish	0.172	0.250	6
Hardhead catfish	0.167	1.631	190
Hogfish	0.139	0.250	7
Irish pompano	0.183	0.250	3
Jewfish	1.147	3.300	13
King mackerel	1.085	4.470	385
Ladyfish	0.443	1.900	149
Lane snapper	0.246	0.380	10
Leatherjacket	0.210	0.210	2
Lemon shark	0.576	1.100	5
Little tunny	0.964	0.964	1
Mutton snapper	0.445	0.570	2
Northern kingfish	0.258	0.480	5
Oyster	0.049	0.055	5
Permit	0.486	2.300	140
Pigfish	0.196	0.660	26
Pinfish	0.131	0.170	6
Quahog	0.025	0.035	10
Red drum	0.497	4.620	594
Red grouper	0.324	0.660	44
Red snapper	0.093	0.159	13
Reef shark	2.250	2.250	1
Sand seatrout	0.475	1.200	99
Sandbar shark	0.448	1.260	13
Scaled sardine	0.330	0.330	1
Scalloped hammerhead	1.253	2.400	3
Scamp grouper	0.285	0.590	24
Sea bass	0.619	1.320	23
Sea catfish	0.107	0.380	16
Sea trout	0.580	0.580	1
Sheepshead	0.180	1.730	226
Shortfin mako	3.200	3.200	1
Shrimp	0.043	1.023	82
Silky shark	0.970	0.970	1
Silver perch	0.314	0.490	16
Silver seatrout	0.250	0.470	17
Smalltooth sawfish	0.700	0.700	1
Snowy grouper	0.918	1.900	22
Southern flounder	0.128	1.700	146
Southern kingfish	0.192	0.780	61

(continued)

Table H-2. (continued)

Common name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Southern stingray	0.170	0.190	3
Spanish mackerel	0.527	2.900	204
Speckled hind	0.203	0.340	7
Spinner shark	0.750	0.750	1
Spot	0.117	0.460	57
Spotted seatrout	0.320	1.500	546
Stone crab	1.360	2.020	3
Striped bass	0.209	0.400	19
Striped mojarra	0.088	0.250	18
Striped mullet	0.063	0.780	56
Tarpon	0.220	0.280	4
Tripletail	0.219	1.280	82
Vermillion snapper	0.250	0.250	1
Wahoo	0.588	1.400	13
Weakfish	0.142	0.390	126
White grunt	0.230	0.270	2
White marlin	0.310	0.310	1
White mullet	0.086	0.700	18
White shrimp	0.024	0.096	16
Yellowedge grouper	0.234	0.340	8
Yellowfin menhaden	0.155	0.280	13
Yellowtail snapper	0.120	0.130	2

Table H-3. Mean and Maximum Total Mercury Concentrations for Pacific Coast Species

Common name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Asian clam	0.051	0.115	49
Atlantic salmon	0.044	0.050	5
Barred sand bass	0.091	0.161	2
Barred surfperch	0.066	0.161	26
Bat ray	0.598	0.912	3
Black croaker	0.030	0.030	1
Black perch	0.028	0.152	305
Black rockfish	0.144	0.231	3
Blue mussel	0.025	0.202	340
Blue rockfish	0.068	0.116	4
Brown rockfish	0.370	1.150	38
Brown smooth hound shark	1.497	1.705	3
California corbina	0.047	0.115	10
California halibut	0.277	0.470	11
California killifish	0.057	0.070	3
California mussel	0.055	0.387	93
California scorpionfish	0.050	0.050	2
California sheephead	0.168	0.209	4
Chilipepper rockfish	0.008	0.008	1
Chinook salmon	0.092	0.160	108
Cockle	0.253	0.561	10
Coho salmon	0.046	0.390	167
Copper rockfish	0.165	0.690	28
Crab	0.168	0.240	4
Crab (shell)	0.040	0.040	4
Diamond turbot	0.040	0.082	9
Dungeness crab	0.220	0.256	3
Dungeness crab (claw)	0.413	0.429	2
Dungeness crab (hepatopancreas)	0.187	0.234	2
English sole	0.060	0.140	516
Fantail sole	0.025	0.025	2
Gaper clam	0.008	0.008	1
Gray smoothhound shark	0.522	0.970	5
Green sturgeon	0.130	0.130	1
Greenstriped rockfish	0.174	0.174	1
Halfmoon	0.043	0.046	2
Hawaiian oyster	0.219	3.914	21
Jack smelt	0.092	0.255	19
Kelp bass	0.159	0.244	6
Kelp rockfish	0.080	0.090	2
Leopard shark	0.951	1.310	18
Lingcod	0.334	0.334	1

(continued)

Table H-3. (continued)

Common name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Little neck clam	0.008	0.008	1
Longjaw mudsucker	0.021	0.040	8
Mosquitofish	0.105	0.120	2
Ocean white fish	0.092	0.092	1
Opaleye	0.049	0.087	6
Pacific angel shark	0.432	0.621	9
Pacific cod	0.109	0.180	29
Pacific hake	0.151	0.151	1
Pacific herring	0.039	0.104	131
Pacific oyster	0.056	0.144	64
Pacific sanddab	0.081	0.124	2
Pacific staghorn sculpin	0.046	0.080	9
Pile surfperch	0.144	0.167	2
Prickly sculpin	0.258	0.310	5
Queenfish	0.062	0.092	5
Quillback rockfish	0.296	1.060	233
Rainbow seaperch	0.026	0.068	4
Red rock crab	0.172	0.291	13
Red rock crab (claw)	0.139	0.140	2
Red rock crab (hepatopancreas)	0.106	0.125	2
Redtail surfperch	0.151	0.209	3
Rosethorn rockfish	0.356	0.411	2
Round stingray	0.300	0.300	1
Sargo	0.040	0.040	1
Sculpin	0.224	0.370	5
Shiner perch	0.070	0.070	1
Shiner surfperch	0.078	0.192	37
Silver surfperch	0.151	0.179	2
Sockeye salmon	0.027	0.040	9
Speckled sanddab	0.017	0.036	3
Splitnose rockfish	0.673	0.673	1
Spotfin surfperch	0.038	0.038	1
Spotted sand bass	0.206	0.396	10
Spotted scorpionfish	0.045	0.045	1
Spotted turbot	0.037	0.048	6
Starry flounder	0.080	0.080	1
Striped bass	0.457	0.895	26
Sturgeon	0.278	0.354	4
Threespine stickleback	0.106	0.230	12
Top smelt	0.107	0.107	1
Walleye surfperch	0.105	0.262	11
White croaker	0.121	0.344	44
White seaperch	0.059	0.134	6
White sturgeon	0.200	0.230	4

(continued)

Table H-3. (continued)

Common name	Mean Mercury Concentration	Maximum Mercury Concentration	Number of Samples
Yelloweye rockfish	1.184	1.440	2
Yellowfin croaker	0.086	0.147	14
Yellowfin goby	0.060	0.060	2

APPENDIX I

MERCURY IN MARINE LIFE LITERATURE ARCHIVE

APPENDIX I

MERCURY IN MARINE LIFE LITERATURE ARCHIVE

Adams, D.H., and R.H. McMichael, Jr. 1999. Mercury levels in four species of sharks from the Atlantic coast of Florida. *Fish. Bull.* 97:372–379.

Adams, D.H., and R.H. McMichael, Jr. 2001. *Mercury Levels in Marine and Estuarine Fishes of Florida.* Florida Fish and Wildlife Conservation Commission. Florida Marine Resources Institute Technical Report TR-6: 1–35.

Airey, D. 1983. Total mercury concentrations in human hair from 13 countries in relation to fish consumption and location. *The Science of the Total Environment* 31:157–180.

Anan, Y., T. Kunito, I. Watanabe, et al. 2001. Trace element accumulation in hawksbill turtles (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) from Yaeyama Islands, Japan. *Environmental Toxicology and Chemistry* 20(12):2802–2814.

Atwell, L., K.A. Hobson, and H.E. Welch. 1998. Biomagnification and bioaccumulation of mercury in an Arctic marine food web: Insights from stable nitrogen isotope analysis. *Can. J. Fish. Aquat. Sci.* 55:1114–1121.

Audet, D.J., D.S. Scott, and S.N. Wiemeyer. 1992. Organochlorines and mercury in osprey eggs from the eastern United States. *J. Raptor Res.* 26(4):219–224.

Balthis, W.L., E.O. Voit, and G.M. Meaburn. 1996. Setting prediction limits for mercury concentrations in fish having high bioaccumulation potential. *Environmetrics* 7:429–439.

Bargagli, R., F. Monaci, J.C. Sanchez-Hernandez, and D. Cateni. 1998. Biomagnification of mercury in an Antarctic marine coastal food web. *Mar. Ecol. Prog. Ser.* 169:65–76.

Beck, K.M., P. Fair, W. McFee, and D. Wolf. 1997. Heavy metals in livers of bottlenose dolphins stranded along the South Carolina coast. *Marine Pollution Bulletin* 34:9:734–739.

Berg, V., K.I. Ugland, N.R. Hareide, D. Groenningen, and J.U. Skaare. 2000. Mercury, cadmium, lead, and selenium in fish from a Norwegian fjord and

off the coast, the importance of sampling locality. *J. Environ. Monit.* 2:375–377.

Bloom, N.S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. *Can. J. Fish. Aquat. Sci.* 49:1010–1017.

Bouquegneau, J.M., V. Debacker, S. Gobert, and J.P. Nellissen. 1997. Toxicological investigations on four sperm whales stranded on the Belgian Coast: Inorganic contaminants. In *Sperm Whale Deaths in the North Sea: Science and Management.* T.G. Jacques, and R.H. Lambertsen (ed.). *Bulletin De L'Institut Royal Des Sciences Naturelles de Belgique* 67:75–78.

Braune, B.M., G.M. Donaldson, and K.A. Hobson. 2001. Contaminant residues in seabird eggs from the Canadian Arctic. Part I. Temporal trends 1975–1998. *Environmental Pollution* 114:39–54.

Braune, B.M., G.M. Donaldson, and K.A. Hobson. 2002. Contaminant residues in seabird eggs from the Canadian Arctic. II. Spatial trends and evidence from stable isotopes for intercolony differences. *Environmental Pollution* 117:113–145.

Brim, M.S., S.K. Alam, and L.G. Jenkins. 2001. Organochlorine pesticides and heavy metals in muscle and ovaries of Gulf Coast striped bass (*Morone saxatilis*) from the Apalachicola River, Florida, USA. *J. Environ. Sci. Health* B36(1):15–27.

Burger, J. 1997. Heavy metals and selenium in herring gulls (*Larus argentatus*) nesting in colonies from eastern Long Island to Virginia. *Environmental Monitoring and Assessment* 48:285–296.

Burger, J., and M. Gochfeld. 1997. Risk, mercury levels, and birds: Relating adverse laboratory effects to field biomonitoring. *Environmental Research* 75:160–172.

Burger, J., C.D. Trivedi, and M. Gochfeld. 2000. Metals in herring and great black-backed gulls from the New York Bight: The role of the salt gland in excretion. *Environmental Monitoring and Assessment* 64:569–581.

Cantillo, A.Y., G.G. Lauenstein, and T.P. O'Connor. 1997. Mollusc and sediment contaminant levels and trends in South Florida coastal waters. *Marine Pollution Bulletin* 34:511–521.

Caurant, F., M. Navarro, and J.C. Amiard. 1996. Mercury in pilot whales: Possible limits to the detoxification process. *The Science of the Total Environment* 186:95–104.

Chan, H.M. 1998. A database for environmental contaminants in traditional foods in northern and Arctic Canada: Development and applications. *Food Additives and Contaminants* 15:2:127–134.

Chase, M.E., S.H. Jones, P. Hennigar, et al. 2001. Gulfwatch: Monitoring spatial and temporal patterns of trace metal and organic contaminants in the Gulf of Maine (1991–1997) with the blue mussel, *Mytilus edulis* L. *Marine Pollution Bulletin* 42(6):491–505.

Clark, K.E., W. Stansley, and L.J. Niles. 2001. Changes in contaminant levels in New Jersey osprey eggs and prey, 1989 to 1998. *Archives of Environmental Contamination and Toxicology* 40(2):277–284.

De Boer, J., and F. Smedes. 1997. Effects of storage conditions of biological materials on the contents of organochlorine compounds and mercury. *Marine Pollution Bulletin* 35(1–6):93–108.

DesGranges, J.L., J. Rodrigue, B. Tardif, and M. Laperle. 1998. Mercury accumulation and biomagnification in ospreys (*Pandion haliaetus*) in the James Bay and Hudson Bay regions of Québec. *Arch. Environ. Contam. Toxicol.* 35:330–341.

Dietz, R., F. Riget, and P. Johansen. 1996. Lead, cadmium, mercury and selenium in Greenland marine animals. *The Science of the Total Environment* 186:67–93.

Donaldson, G.M., B.M. Braune, A.J. Gatson, and D.G. Noble. 1997. Organochlorine and heavy metal residues in breast muscle of known-age thick-billed murres (*Uria lomvia*) from the Canadian Arctic. *Arch. Environ. Contam. Toxicol.* 33:430–435.

Downs, S.G., C.L. MacLeod, and J.N. Lester. 1998. Mercury in precipitation and its relation to bioaccumulation in fish: A literature review. *Water, Air, and Soil Pollution* 108:149–187.

Duffy, L.K., T. Rodgers, and M. Patton. 1998. Regional health assessment relating to mercury content of fish caught in the Yukon-Kuskokwim Delta Rivers system. *Alaska Medicine* 40(4):75–77.

Duffy, L.K., E. Scofield, T. Rodgers, et al. 1999. Comparative baseline levels of mercury, Hsp 70 and Hsp 60 in subsistence fish from the Yukon-Kuskokwim Delta region of Alaska. *Comparative Biochemistry and Physiology* C124:181–186.

Egeland, G.M., and J.P. Middaugh. 1997. Balancing fish consumption benefits with mercury exposure. *Science* 278:1904–1905.

Elliot, J.E., A.M. Scheuhammer, F.A. Leighton, and P.A. Pearce. 1992. Heavy metal and metallothionein concentrations in Atlantic Canadian seabirds. *Arch. Environ. Contam. Toxicol.* 22:63–73.

Elliott, J.E., and A.M. Scheuhammer. 1997. Heavy metal and metallothionein concentrations in seabirds from the Pacific coast of Canada. *Marine Pollution Bulletin* 34(10):794–801.

Elliott, J.E., R.J. Norstrom, and G.E.J. Smith. 1996. Patterns, trends, and toxicological significance of chlorinated hydrocarbon and mercury contaminants in bald eagle eggs from the Pacific Coast of Canada, 1990–1994. *Arch. Environ. Contam. Toxicol.* 31:354–367.

Fairey, R., K. Taberski, S. Lamerdin, et al. 1997. Organochlorines and other environmental contaminants in muscle tissues of sportfish collected from San Francisco Bay. *Marine Pollution Bulletin* 34(12):1058–1071.

Fleming, L.E., S. Watkins, R. Kaderman, et al. 1995. Mercury exposure in humans through food consumption from the Everglades of Florida. *Water, Air, and Soil Pollution* 80:41–48.

Francesconi, K.A., R.C. J. Lenanton, N. Caputi, et al. 1997. Long-term study of mercury concentrations in fish following cessation of a mercury-containing discharge. *Marine Environmental Research* 43(1–2):27–40.

Frodello, J.P., M. Romeo, and D. Viale. 2000. Distribution of mercury in the organs and tissues of five toothed-whale species of the Mediterranean. *Environmental Pollution* 108:447–452.

Galal-Gorchev, H. 1993. Dietary intake, level in food and estimated intake of lead, cadmium, and mercury. *Food Additives and Contaminants* 10(1):115–128.

Ginsberg, G.L., and B.F. Toal. 2000. Development of a single-meal fish consumption advisory for methylmercury. *Risk Analysis* 20(1):41–47.

Gochfeld, M., J.L. Belant, T. Shukla, et al. 1996. Heavy metals in laughing gulls: Gender, age and tissue differences. *Environmental Toxicology and Chemistry* 15(12):2275–2283.

Godley, B.J., D.R. Thompson, and R.W. Furness. 1999. Do heavy metal concentrations pose a threat to marine turtles from the Mediterranean Sea? *Marine Pollution Bulletin* 38(6):497–502.

Gordon, A.N., A.R. Pople, and J. Ng. 1998. Trace metal concentrations in livers and kidneys of sea turtles from southeastern Queensland, Australia. *Mar. Freshwater Res.* 49:409–414.

Grandjean, P., P. Weihe, L. Needham, et al. 1995. Relation of a seafood diet to mercury, selenium, arsenic, and polychlorinated biphenyl and other organochlorine concentrations in human milk. *Environmental Research* 71:29–38.

Hall, B.D., R.A. Bodaly, R.J. Fudge, et al. 1997. Food as the dominant pathway of methylmercury uptake by fish. *Water, Air, and Soil Pollution* 100:13–24.

Hellou, J., W.G. Warren, J.F. Payne, et al. 1992. Heavy metals and other elements in three tissues of cod, *Gadus morhua*, from the Northwest Atlantic. *Marine Pollution Bulletin* 24(9):452–458.

Hindell, M.A., N. Brothers, and R. Gales. 1999. Mercury and cadmium concentrations in the tissues of three species of Southern albatrosses. *Polar Biol.* 22:102–108.

Hughes, K.D., P.J. Ewins, and K.E. Clark. 1997. A comparison of mercury levels in feathers and eggs of osprey (*Pandion haliaetus*) in the North American Great Lakes. *Arch. Environ. Contam. Toxicol.* 33:441–452.

Jarman, W.A., K.A. Hobson, W.J. Sydeman, et al. 1996. Influence of trophic position and feeding location on contaminant levels in the Gulf of the Farallones food web revealed by stable isotope analysis. *Environmental Science and Technology* 30(2):654–664.

Jeffrey, A., and G. Barry. 2000. Some problems associated with the determination of mercury in plant material and biological tissue. *Commun. Soil Sci. Plant Anal.* 31(11–14):1929–1934.

Jewett, S.C., and A.S. Naidu. 2000. Assessment of heavy metals in red king crabs following offshore placer gold mining. *Marine Pollution Bulletin* 40(6):478–490.

Joiris, C.R., I.B. Ai, L. Holsbeek, et al. 1997. Total and organic mercury in Greenland and Barents Seas demersal fish. *Bull. Environ. Contam. Toxicol.* 58:101–107.

Kaneko, J. 1998. "Development of a stock profile for the Central North Pacific broadbill swordfish (*Xiphias gladius*) fishery." National Marine Fisheries Service. Abstract only.

Kannan, K., R.G. Smith, R.F. Lee, et al. 1998. Distribution of total mercury and methylmercury in water, sediment, and fish from South Florida estuaries. *Arch. Environ. Contam. Toxicol.* 34:109–118.

Kim, E.Y., K. Saeki, S. Tanabe, et al. 1996. Specific accumulation of mercury and selenium in seabirds. *Environmental Pollution* 94(3):261–265.

Kim, E.Y., R. Goto, S. Tanabe, et al. 1998. Distribution of 14 elements in tissues and organs of oceanic seabirds. *Arch. Environ. Contam. Toxicol.* 35:638–645.

Kim, E.Y., T. Murakami, K. Saeki, and R. Tatsukawa. 1996. Mercury levels and its chemical form in tissues and organs of seabirds. *Arch. Environ. Contam. Toxicol.* 30:259–266.

Kosatsky, T., and P. Foran. 1996. Do historic studies of fish consumers support the widely accepted LOEL for methylmercury in adults. *Neurotoxicology* 17(1):177–186.

Kosatsky, T., R. Przbysz, B. Shatenstein, et al. 1999. Contaminant exposure in Montrealers of Asian origin: Exploratory assessment. *Environmental Research* 80:S159–S165.

Kress, N., B. Herut, E. Shefer, et al. 1999. Trace element levels in fish from clean and polluted coastal marine sites in the Mediterranean Sea, Red Sea and North Sea. *Helgol Mar Res.* 53:163–170.

Kuehl, D.W., and R. Haebler. 1995. Organochlorine, organobromine, metal, and selenium residues in bottlenose dolphins (*Tursiops truncatus*) collected during an unusual mortality event in the Gulf of Mexico, 1990. *Arch. Environ. Contam. Toxicol.* 28:494–499.

Kuehl, D.W., R. Haebler, and C. Potter. 1994. Coplanar PCB and metal residues in dolphins from the U.S. Atlantic Coast, including Atlantic bottlenose obtained during the 1987/88 mass mortality. *Chemosphere* 28(6):1245–1253.

Kunito, T., I. Watanabe, G. Yasunaga, et al. 2002. Using trace elements in skin to discriminate the populations of minke whales in the Southern Hemisphere. *Marine Environmental Research* 53:175–197.

Kureeishy, T.W., and C. D'Silva. 1993. Uptake and loss of mercury, cadmium, and lead in marine organisms. *Indian Journal of Experimental Biology* 31:373–379.

Lake, C.A., J.L. Lake, R. Haebler, et al. 1995. Contaminant levels in harbor seals from the Northeastern United States. *Arch. Environ. Contam. Toxicol.* 29:128–134.

Lasorsa, B., and S. Allen-Gil. 1995. The methlymercury to total mercury ratio in selected marine, freshwater, and terrestrial organisms. *Water, Air, and Soil Pollution* 80:905–913.

Law, R.J. 1995. Metals in marine animals. In *Environmental Contaminants In Wildlife:Interpreting Tissue Concentrations.* Beyer, W.N., G.H. Heinz, and

A.W. Redmon-Norwood (eds.). SETAC Special Publication Series. CRC Press, Inc. Lewis Publications, Boca Raton, FL.

Law, R.J., R.L. Stringer, C.R. Allchin, and B.R. Jones. 1996. Metals and organochlorines in sperm whales (*Physeter macrocephalus*) stranded around the North Sea during the 1994/1995 winter. *Marine Pollution Bulletin* 32(1):72–77.

Lawson, N.M., and R.P. Mason. 1998. Accumulation of mercury in estuarine food chains. *Biogeochemistry* 40:235–247.

Leblanc, G.A. 1995. Trophic-level differences in the bioconcentration of chemicals: Implications in assessing environmental biomagnification. *Environmental Science and Technology* 29:154–160.

Lewis, M.A., G.I. Scott, D.W. Bearden, et al. 2002. Fish tissue quality in near-coastal areas of the Gulf of Mexico receiving point source discharges. *The Science of the Total Environment* 284:249–261.

Locarnini, S.J.P., and B.J. Presley. 1996. Mercury concentration in benthic organisms from a contaminated estuary. *Marine Environmental Research* 41(3):225–239.

Locascio, J.V., and P.J. Rudershausen. 2001. Mercury levels in gafftopsail catfish (*Bagre marinus*) from Tarpon Bay, Sanibel, Florida, USA. *Bull. Environ. Contam. Toxicol.* 67:510–518.

Locascio, J.V., and P.J. Rudershausen. 2000. An evaluation of mercury levels in spotted seatrout, *Cynoscion nebulosus*, in Tarpon Bay, J.N. "Ding" Darling Wildlife Refuge, Sanibel, Florida, with reference to previous studies. *Biological Sciences* 63(4):256–260.

Macintosh, D.L., J.D. Spengler, H. Ozkaynak, et al. 1996. Dietary exposures to selected metals and pesticides. *Environmental Health Perspectives* 104(2):202–209.

Mackey, E.A., P.R. Becker, R. Demiralp, et al. 1996. Bioaccumulation of vanadium and other trace metals in livers of Alaskan cetaceans and pinnipeds. *Arch. Environ. Contam. Toxicol.* 30:503–512.

Mason, R.P., W.F. Fitzgerald, and F.M.M. Morel. 1994. The biogeochemical cycling of elemental mercury: Anthropogenic influences. *Geochimica et Cosmochimica Acta.* 58(15):3191–3198.

Meador, J.P., D. Ernest, A.A. Hohn, et al. 1999. Comparison of elements in bottlenose dolphins stranded on the beaches of Texas and Florida in the Gulf of Mexico over a one-year period. *Arch. Environ. Contam. Toxicol.* 36:87–98.

Meador, J.P., U. Varanasi, P.A. Robisch, and S-L Chan. 1993. Toxic metals in pilot whales (*Globicephala melaena*) from strandings in 1986 and 1990 on Cape Cod, Massachusetts. *Can. J. Fish. Aquat. Sci.* 50:2698–2706.

Mendez, E., H. Giudice, A. Pereira, G. Inocente, and D. Medina. 2001. Total mercury content—fish weight relationship in swordfish (*Xiphias gladius*) caught in the southwest Atlantic Ocean. *Journal of Food Composition and Analysis* 14(5):453–460.

Miles, A.K., D.G. Calkins, and N.C. Coon. 1992. Toxic elements and organochlorines in harbor seals (*Phoca vitulina richardsi*), Kodiak, Alaska, USA. *Bull. Environ. Contam. Toxicol.* 48:727–732.

Miles, A.K., and H.M. Ohlendorf. 1993. Environmental contaminants in canvasbacks wintering on San Francisco Bay, California. *Calif. Fish and Game* 79(1):28–38.

Monteiro, L.R., and R.W. Furness. 1995. Seabirds as monitors of mercury in the marine environment. *Water, Air, and Soil Pollution* 80:851–870.

Monteiro, L.R., and R.W. Furness. 1997. Accelerated increase in mercury contamination in North Atlantic mesopelagic food chains as indicated by time series of seabird feathers. *Environmental Toxicology and Chemistry* 16(12):2489–2493.

Monteiro, L.R., J.P. Granadeiro, R.W. Furness, and P. Oliveira. 1999. Contemporary patterns of mercury contamination in the Portuguese Atlantic inferred from mercury concentrations in seabird tissues. *Marine Environmental Research* 47:137–156.

Muckle, G., P. Ayotte, E. Dewailly, S.W. Jacobsen, J.L. Jacobsen. 2001. Determinants of polychlorinated biphenyls and methylmercury exposure in Inuit women of childbearing age. *Environmental Health Perspectives* 109(9):957–963.

Muir, D., B. Braune, R. Norstrom, et al. 1999. Spatial and temporal trends and effects of contaminants in the Canadian Arctic marine ecosystem: A review. *The Science of the Total Environment* 230:83–144.

Muir, D., R. Wagemann, B.T. Hargrave, et al. 1992. Arctic marine ecosystem contamination. *The Science of the Total Environment* 122:75–134.

Nendza, M., T. Herbst, C. Kussatz, and A. Gies. 1997. Potential for secondary poisoning and biomagnification in marine organisms. *Chemosphere* 3(9):1875–1885.

Ng, P-S., H. Li, K. Matsumoto, et al. 2001. Striped dolphin detoxificates mercury as insoluble Hg(S, Se) in the liver. *Proc. Japan Acad.* 77(B):178–183.

NHANES (National Health and Nutrition Examination Survey). 2001. Blood and hair mercury levels in young children and women of childbearing age–United States, 1999. *Morbidity & Mortality Weekly Report* 50:8–12.

Nicholson, M.D., R.J. Fryer, and C.A. Ross. 1997. Designing monitoring programmes for detecting temporal trends in contaminants in fish and shellfish. *Marine Pollution Bulletin* 34(10):821–826.

Nigro, M., and C. Leonzio. 1996. Intracellular storage of mercury and selenium in different marine vertebrates. *Mar. Ecol. Prog. Ser.* 135:137–143.

O'Connor, T.P. 2002. National distribution of chemical concentrations in mussels and oysters in the USA. *Marine Environmental Research* 53(2):117–143.

Oliver, L.M., W.S. Fisher, J.T. Winstead, et al. 2001. Relationships between tissue contaminants and defense-related characteristics of oysters (*Crassostrea virginica)* from five Florida bays. *Aquatic Toxicology* 55:203–222.

Omaye, S.T. 2001. Shark-fin soup and methylmercury: To eat or not to eat? *Food Technology* 55(10):26.

Palmisano, F., N. Cardellicchio, and P.G. Zambonin. 1995. Speciation of mercury in dolphin liver: A two-stage mechanism for the demethylation accumulation process and role of selenium. *Marine Environmental Research* 40(2):109–121.

Phillips, C.R., D.J. Heilprin, and M.A. Hart. 1997. Mercury accumulation in barred sand bass (*Paralabrax nebulifer*) near a large wastewater outfall in the Southern California Bight. *Marine Pollution Bulletin* 34(2):96–102.

Ponce, R.A., G.M. Egeland, J.P. Middaugh, and P.R. Becker. 1997. Twenty years of trace metal analyses of marine mammals: Evaluation and summation of data from Alaska and other Arctic regions. *State of Alaska Epidemiology Bulletin* 1(3):2–15.

Rawson, A.J., J.P. Bradley, A. Teetsov, et al. 1995. A role for airborne particulates in high mercury levels of some cetaceans. *Ecotoxicology and Environmental Safety* 30:309–314.

Rider, S.J., and D.H. Adams. 2000. Mercury concentrations in spotted seatrout (*Cynoscion nebulosus*) from northwest Florida. *Gulf of Mexico Science* 2:97–103.

Rincón-León, F., G. Zurera-Cosano, R. Moreno-Rojas, and M. Amaro-López. 1993. Importance of eating habits and sample size in the estimation of environmental mercury contamination using biological indicators. *Environmental Monitoring and Assessment* 27:193–200.

Rodgers, J.A., Jr. 1997. Pesticide and heavy metal levels of water birds in the Everglades agricultural area, South Florida. *Florida Field Naturalist* 25(2):33–41.

Rolfhus, K.R., and W.F. Fitzgerald. 1995. Linkages between atmospheric mercury deposition and the methylmercury content of marine fish. *Water, Air, and Soil Pollution* 80:291–297.

Ruelas, J.R., F. Paez-Osuna, and H. Perez-Cortes. 2000. Distribution of mercury in muscle, liver, and kidney of the spinner dolphin (*Stenella longirostris)* stranded in the southern Gulf of California. *Marine Pollution Bulletin* 40(11):1063–1066.

Saeki, K., Y. Okabe, E.-Y. Kim, et al. 2000. Mercury and cadmium in common cormorants (*Phalacrocorax carbo*). *Environmental Pollution* 108:249–255.

Sakai, H., K. Saeki, H. Ichihashi, et al. 2000. Species-specific distribution of heavy metals in tissues and organs of loggerhead turtle (*Caretta caretta*) and green turtle (*Chelonia mydas*) from Japanese coastal waters. *Marine Pollution Bulletin* 40(8):701–709.

Sanpera, C., R. Capelli, V. Minganti, and L. Jover. 1993. Total and organic mercury in North Atlantic fin whales: Distribution pattern and biological related changes. *Marine Pollution Bulletin* 26(3):135–139.

Storelli, M.M., E. Ceci, and G.O. Marcotrigiano. 1998. Comparison of total mercury, methylmercury, and selenium in muscle tissues and in the liver of *Stenella coeruleoalba* (Meyen) and *Caretta caretta* (Linnaeus). *Bull. Environ. Contam. Toxicol.* 61:541–547.

Storelli, M.M., and G.O. Marcotrigiano. 2000. Fish for human consumption: risk of contamination by mercury. *Food Additives and Contaminants* 17(12):1007–1011.

Storelli, M.M., and G.O. Marcotrigiano. 2001. Total mercury levels in muscle tissue of swordfish (*Xiphias gladius*) and bluefin tuna (*Thunnus thynnus*) from the Mediterranean Sea (Italy). *Journal of Food Protection* 64(7):1058–1061.

Storelli, M.M., R. Giacominelli-Stuffler, and G. Marcotrigiano. 2002. Mercury accumulation and speciation in muscle tissue of different species of sharks from Mediterranean Sea, Italy. *Bull. Environ. Contam. Toxicol.* 68:201–210.

Tahán, J.E., J.M. Sánchez, V. A. Granadillo, et al. 1995. Concentration of total Al, Cr, Cu, Fe, Hg, Na, Pb, and Zn in commercial canned seafood determined by atomic spectrometric means after mineralization by microwave heating. *J. Agric. Food Chem.* 43:910–915.

Thompson, D.R. 1996. Mercury in birds and terrestrial mammals. In *Environmental Contaminants in Wildlife Wildlife: Interpreting Tissue Concentrations.* Beyer, W.N., G.H. Heinz, and A.W. Redmon-Norwood (eds.). SETAC Special Publication Series. CRC Press, Inc. Lewis Publications, Boca Raton, FL.

Turoczy, N.J., L.J.B. Laurenson, G. Allinson, et al. 2000. Observations on metal concentrations in three species of shark (*Deania calcea, Centroscymnus crepidater*, and *Centroscymnus owstoni*) from southeastern Australian waters. *J. Agric. Food Chem.* 48:4357–4364.

Wagemann, R., E. Trebacz, G. Boila, et al. 1998. Methylmercury and total mercury in tissues of Arctic marine mammals. *The Science of the Total Environment* 218:19–31.

Wagemann, R., E. Trebacz, R. Hunt, and G. Boila. 1997. Percent methylmercury and organic mercury in tissues of marine mammals and fish using different experimental and calculation methods. *Environmental Toxicology and Chemistry* 16:(9):1859–1866.

Wagemann, R., and R.E.A. Stewart. 1994. Concentrations of heavy metals and selenium in tissues and some foods of walrus (*Odobenus rosmarus rosmarus*) from the eastern Canadian Arctic and Sub-Arctic, and association between metals, age, and gender. *Can. J. Fish. Aquat. Sci.* 51:426–436.

Wagemann, R., S. Innes, and P.R. Richard. 1996. Overview and regional and temporal differences of heavy metals in Arctic whales and ringed seals in the Canadian Arctic. *The Science of the Total Environment* 186:41–66.

Wagemann, R., W.L. Lockhart, H. Welch, and S. Innes. 1995. Arctic marine mammals as integrators and indicators of mercury in the Arctic. *Water, Air, and Soil Pollution* 80:683–693.

Wheatley, B., and S. Paradis. 1995. Exposure of Canadian Aboriginal peoples to methylmercury. *Water, Air, and Soil Pollution* 80:3–11.

Wilson, E.A., E.N. Powell, T.L. Wade, et al. 1992. Spatial and temporal distributions of contaminant body burden and disease in Gulf of Mexico oyster populations: The role of local and large-scale climatic controls. *Helgoländer Meeresunters* 46:201–235.

Wolfe, M.F., S. Schwarzbach, and R.A. Sulaiman. 1998. Effects of mercury on wildlife: A comprehensive review. *Environmental Toxicology and Chemistry* 17(2):146–160.

Wood, P.B., J.H. White, A. Steffer, et al. 1996. Mercury concentrations in tissues of Florida bald eagles. *J. Wildl. Manage.* 60(1):178–185.

Woshner, V.M., T.M. O'Hara, G.R. Bratton, et al. 2001. Concentrations and interactions of detected essential and non-essential elements in bowhead and beluga whales of Arctic Alaska. *Journal of Wildlife Diseases* 37(4):693–710.

Woshner, V.M., T.M. O'Hara, G.R. Bratton, and V.R. Beasley. 2001. Concentrations and interactions of selected essential and non-essential elements in ringed seals and polar bears of Arctic Alaska. *Journal of Wildlife Diseases* 37(4):711–721.

Zabik, M.E., and M.J. Zabik. 1996. Influence of processing on environmental contaminants in foods. *Food Technology* 50:225–229.

Zeisler, R., R. Demiralp, B.J. Koster, et al. 1993. Determination of inorganic constituents in marine mammal tissues. *The Science of the Total Environment* 139/140:365–386.

Zhang, X., A.S. Naidu, J.J. Kelley, et al. 2001. Baseline concentrations of total mercury and methylmercury in salmon returning via the Bering Sea (1999–2000). *Marine Pollution Bulletin* 42(10):993–997.

APPENDIX J

TROPHIC LEVEL AND FEEDING GUILD ASSIGNMENTS

APPENDIX J

TROPHIC LEVEL AND FEEDING GUILD ASSIGNMENTS

Trophic level and feeding guild information helps to characterize each species' potential exposure to mercury contamination. Because mercury bioaccumulates in fish, species at higher trophic levels and species that eat mostly fish (e.g., carnivores) are generally expected to have higher mercury tissue concentrations. As part of this study, RTI developed a procedure for defining the trophic levels and feeding strategies or guilds of key target species. In addition, RTI noted whether the species consumes one or more general classes of food: plants or algae, fish, and invertebrates. RTI devised decision rules for trophic level and feeding guild classification based on generally accepted food web principles (Cohen et al., 1990; Polis and Winemiller, 1996; Gerking, 1994), as described below. All food web data were based on documented information (Adams and McMichaels, 2001; Pattillo et al., 1997; Emmett et al., 1991; National Audubon Society, 1983; Virginia Polytechnic Institute, 2002). All food web information is based on feeding behavior of adults.

Trophic Level Assignments

- Trophic level 1: Trophic level 1 species are primary producers (plants and algae); therefore, fish and shellfish are not assigned to this level.
- Trophic level 2: Fish that are prey species for other fish but that are not predators (e.g., they eat only plants and algae)
- Trophic level 3: Fish that are prey to other fish and are also predators
- Trophic level 4: Fish that are predators but are not prey to other fish (e.g., "top predators")

Feeding Guild Assignments

- Herbivores: Fish that eat only plant matter and/or algae
- Omnivores: Fish that eat animal matter (e.g., invertebrates and/or fish) or a combination of plant and animal matter
- Carnivores: Fish that eat only animal matter (invertebrates and/or fish)

Herbivores include fish or shellfish species that eat zooplankton as well as phytoplankton. Thus, bivalves are classified as herbivores in trophic level 2. This definition was considered appropriate because the exposure pathways for animals eating all types of plankton are considered similar. Also, a fish can be a carnivore while also being prey to larger fish, so carnivorous fish can be assigned to either

trophic level 3 or 4. The distinction between the two trophic levels is based on whether or not the fish species is prey to other fish. Information was not always available as to whether a species was preyed upon by other fish, so size was used as a determining factor to make the distinction. Carnivorous fish with reported average adult body lengths of less than 24 inches were assumed to be prey to other fish and were classified as trophic level 3. Using the Spanish mackerel as an example, references indicated that this fish eats a variety of small fish (anchovies herring-like fishes, scaled sardine, Atlantic thread herring, mullet, needlefish) and invertebrates (shrimp) (Virginia Polytechnic Institute, 2002). Thus, RTI classified this species as a carnivore and noted that it eats both fish and invertebrates. Size data for the Spanish mackerel indicated that average total body lengths ranging from 262 mm to 638 mm have been reported (Virginia Polytechnic Institute, 2002). The longest reported average body length (638 mm) is approximately 25 inches, so the Spanish mackerel was therefore classified as a trophic level 4 carnivore. The trophic level assignments for the key species in the Atlantic, Gulf of Mexico, and Pacific regions are summarized in Tables J-1, J-2, and J-3, respectively.

Table J-1. Trophic Level and Feeding Guild Assignments for Key Atlantic Species

Common Name	Scientific Name	Trophic Level	Feeding Guild Assignments	Food Preferences
Fishes				
All sharks		3/4	Carnivore	Fish, invertebrates
Striped bass	*Morone saxatilis*	3	Carnivore	Fish, invertebrates
White perch	*Morone americana*	3	Carnivore	Fish, invertebrates, plants
Bluefish	*Pomatomus saltatrix*	3	Carnivore	Fish, invertebrates
Crevalle jack	*Caranx hippos*	3	Carnivore	Fish, invertebrates
Red drum	*Scianenops ocellatus*	3	Carnivore	Fish, invertebrates
Spotted seatrout	*Cynoscion nebulosus*	3	Carnivore	Fish, invertebrates
King mackerel	*Scomberomorus cavalla*	4	Carnivore	Fish
Invertebrates				
Blue mussel	*Mytilus edulis*	2	Herbivores	Phytoplankton
American oyster	*Crassostrea virginica*	2	Herbivores	Phytoplankton
Blue crab	*Callinectes sapidus*	3	Omnivores	Fish, invertebrates, plants

Table J-2. Trophic Level and Feeding Guild Assignments for Key Gulf Species

Common Name	Scientific Name	Trophic Level	Feeding Guild Assignments	Food Preferences
Fishes				
Sharks		4	Carnivore	Fish
Grey snapper	*Lutjanus griseus*	4	Carnivore	Fish
Gafftopsail catfish	*Bagre marinus*	3	Carnivore	Fish, invertebrates
Hardhead catfish	*Arius felis*	3	Omnivore	Invertebrates, plants
Common snook	*Centropomus undecimalis*	3	Omnivore	Invertebrates, plants
Sheepshead	*Archosargus probatocephalus*	3	Carnivore	Fish, invertebrates
Red drum	*Sciaenops ocellatus*	3	Omnivore	Invertebrates, plants
Black drum	*Pogonias cromis*	3	Carnivore	Fish, invertebrates
Spotted seatrout	*Cynoscion nebulosus*	3	Carnivore	Fish, invertebrates
Weakfish	*Cynoscion regalis*	3	Carnivore	Invertebrates
Atlantic croaker	*Micropogonias undulatus*	3	Carnivore	Fish, invertebrates
King mackerel	*Scomberomorus cavalla*	4	Carnivore	Fish
Spanish mackerel	*Scomberomorus maculatus*	4	Carnivore	Fish, invertebrates
Southern Flounder	*Paralichthys lethostigma*	3	Carnivore	Fish, invertebrates
Gulf flounder	*Paralichthys albigutta*	3	Carnivore	Fish, invertebrates
Invertebrates				
American oyster	*Crassostrea virginica*	2	Herbivores	Phytoplankton
Blue crab	*Callinectes sapidus*	3	Omnivores	Fish, invertebrates, plants

Table J-3. Trophic Level and Feeding Guild Assignments for Key Pacific Species

Common Name	Scientific Name	Trophic Level	Feeding Guild Assignments	Food Preferences
Fishes				
All sharks		3/4	Carnivore	Fish, invertebrates
Quillback rockfish	*Sebastes maliger*	3	Carnivore	Invertebrates
All rockfish	*Sebastes spp*	3	Carnivore	Fish, invertebrates
English sole	*Pleuronectes vetulus*	3	Carnivore	Invertebrates
Pacific herring	*Clupea pallasi*	3	Carnivore	Fish, invertebrates
Pacific cod	*Gadus macrocephalus*	3	Carnivore	Fish, invertebrates
All surfperches		3	Carnivore	Invertebrates
Coho salmon	*Oncorhynchus kisutch*	3	Carnivore	Fish, invertebrates
Chinook salmon	*Oncorhynchus tshawytscha*	3	Carnivore	Fish, invertebrates
Invertebrates				
Blue mussel	*Mytilus edulis*	2	Herbivore	Phytoplankton

REFERENCES

Adams, D.H., and R.H. McMichaels. 2001. *Mercury Levels in Marine and Estuarine Fishes of Florida.* Florida Fish and Wildlife Conservation Commission, Florida Marine Resources Institute. Technical Report TR-6:1-35.

Cohen, J.E., F. Briand, and C.M. Newman. 1990. *Biomathematics. Volume 20: Community Food Webs.* Berlin: Springer-Verlag.

Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. *Distribution and Abundance of Fishes and Invertebrates in West Coast Estuaries. Volume II: Life History Summaries.* ELMR Report No. 8. Strategic Assessment Division, National Oceanic and Atmospheric Administration, Rockville, MD.

Gerking, S.D. 1994. *Feeding Ecology of Fish.* San Diego, CA: Academic Press.

National Audubon Society. 1983. *The Audubon Society Field Guide to North American Fishes, Whales, and Dolphins.* New York: Alfred A. Knopf.

Pattillo, M.E., T.E. Czapla, D.M. Nelson, and M.E. Monaco. 1997. *Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries. Volume II: Species Life History Summaries.* ELMR Report No. 14. National Oceanic and Atmospheric Administration, National Ocean Service, Strategic Environmental Assessments Division, Silver Spring, MD.

Polis, G.A., and K.O. Winemiller. 1996. *Food Webs: Integration of Patterns and Dynamics.* New York: Chapman and Hall.

Virginia Polytechnical Institute. 2000. Marine and Coastal Species Information Exchange (MACSIS). Available at http://fwie.fw.vt.edu/www/macsis.