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Mercury Levels in Marine and Estuarine Fishes of Florida 1989–2001

Douglas H. Adams, Robert H. McMichael, Jr., and George E. Henderson

Florida Fish and Wildlife Conservation Commission

FMRI Technical Report TR-9

Second Edition, Revised • 2003

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Mercury Levels in Marine and Estuarine Fishes of Florida 1989–2001

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Cover Photograph

Collected fish aboard FWC research vessel on the Atlantic coast of Florida.

Photo by D. H. Adams

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Acronyms of agencies cited in this report

DEP	Florida Department of Environmental Protection
DOH	Florida Department of Health
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
FMRI	Florida Marine Research Institute
FWC	Florida Fish and Wildlife Conservation Commission
HRS	Florida Department of Health and Rehabilitative Services
NMFS	National Marine Fisheries Service
SAFMC	South Atlantic Fishery Management Council

Please contact the following agencies for further information

For information regarding mercury in marine fishes and other marine fisheries issues:

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St. Petersburg, FL 33701-5020
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E-mail mercury@fwc.state.fl.us

For information regarding mercury management, regulation, and science issues:

Florida Department of Environmental Protection
Mercury Program Coordinator
Twin Towers Building 669-A, MS-6540
2600 Blair Stone Road
Tallahassee, FL 32399-2400
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Florida Department of Health
Bureau of Community Environmental Health
4052 Bald Cypress Way, Bin A08
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Mercury Levels in Marine and Estuarine Fishes of Florida 1989–2001

Abstract

The Florida Fish and Wildlife Conservation Commission's Florida Marine Research Institute (FWC-FMRI) has examined total mercury levels in muscle tissue from a variety of economically and ecologically important species as part of an ongoing study to better understand mercury contamination in marine fishes. The FWC-FMRI Mercury Program is one of the most comprehensive programs in the United States for monitoring mercury levels in marine and estuarine fishes. Because mercury, a toxic metallic element, has been shown to bioaccumulate in fish tissue, humans consuming fish can potentially consume significant levels of mercury. We examined the concentration of total mercury in 6,806 fish, representing 108 species from 40 families. Species represented all major trophic groups, from primary consumers to apex predators. The majority of individuals we examined contained low concentrations of mercury, but concentrations in individual fish varied greatly within and among species. Species with very low mean or median mercury concentrations tended to be planktivores, detritivores, species that feed on invertebrates, or species that feed on invertebrates and small fish prey. Apex predators typically had the highest mercury concentrations. In most species, mercury concentration increased as fish size increased. Sampling in Florida waters is continuing, and future research relating mercury levels to fish age, feeding ecology, and the trophic structure of Florida's marine and estuarine ecosystems will help us better understand concentrations of this element in marine fishes.

Introduction

Florida's marine and estuarine waters support productive commercial and recreational fisheries. During 2000, approximately 53 million pounds of fish valued at $74 million were landed by Florida's commercial fisheries (Murphy *et al.,* 2001). In Florida's recreational fisheries during 2000, of the approximately 150 million fish caught, 69 million fish (64 million pounds) were retained for consumption (Murphy *et al.,* 2001).

Mercury, a toxic metallic element, has been shown to bioaccumulate in fish tissue, which can be a major source of mercury in human diets (Phillips and Buhler, 1978; Turner *et al.,* 1980; Lyle, 1986). Fish consumption has been positively correlated with mercury level elevations in humans (Choy *et al.,* 2002; Hightower and Moore, 2003). Concerns about mercury contamination in Florida fishes arose in 1982 when a study by the Florida Fish and Wildlife Conservation Commission (FWC), Department of Health (DOH), and Department of Environmental Protection (DEP) detected elevated mercury levels in largemouth bass, *Micropterus salmoides,* in northwest Florida. Additional studies further identified elevated levels of mercury in freshwater fish species in Florida (Ware *et al.,* 1991; Lange *et al.,* 1993). In 1989, the DOH issued its first health advisories warning of excessive mercury levels in freshwater fish from approximately 800,000 hectares of Florida's freshwater systems (Lange *et al.,* 1993). In 1989, the FWC's Florida Marine Research Institute (FWC-FMRI; formerly of the DEP), working cooperatively with other state agencies, began an ongoing study to investigate mercury levels in marine and estuarine fishes of Florida. Collection of marine and estuarine fish samples by FWC-FMRI began in April of 1989. In May 1991, results from this study and other research prompted the DOH to issue a health advisory urging limited consumption of all shark species from Florida waters (HRS, 1991). Because mercury concentrations were in excess of State of Florida guidelines, DOH recommended that adults should eat shark no more than once a week and that children and women of childbearing age should eat shark no more than once a month. In October 1995, a second health advisory was issued recommending limited consumption of several marine species from certain portions of Florida's coastal waters: gafftopsail catfish, *Bagre marinus;* crevalle jack, *Caranx hippos;* spotted seatrout, *Cynoscion nebulosus;* ladyfish, *Elops saurus;* and Spanish mackerel, *Scomberomorus maculatus* (HRS, 1995). In June 1996, a third health advisory urging limited consumption was issued because of high levels of mercury in king mackerel, *Scombero-*

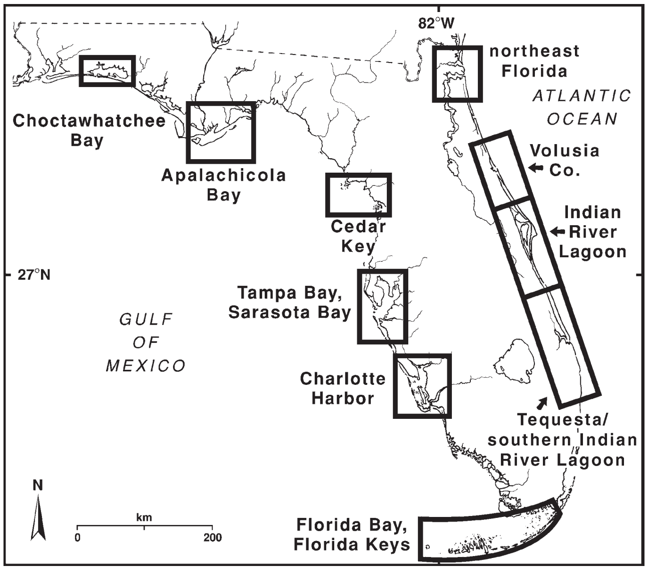


Figure 1. *Map of study areas in Florida where fish used in mercury analyses were collected.*

morus cavalla, caught in the Gulf of Mexico (HRS, 1996). On 23 March 2000, the states of Florida, Georgia, North Carolina, and South Carolina issued a joint health advisory regarding high levels of mercury in large king mackerel from the southeastern United States coastline (DOH, 2000). The consumption limits reflected those outlined in Florida's 1996 advisory. The other Gulf of Mexico states took independent action and the expanded scope includes all Atlantic and Gulf of Mexico waters in the southeastern United States. In January 2003, an updated advisory was issued that recommended no consumption of large sharks (>43 inches, or approximately 1,090 mm total length), and limited consumption of sharks less than 43 inches (approximately 1,090 mm total length). Limited consumption of the following fish in all coastal areas of Florida was also recommended: large (>20 inches or approximately 508 mm total length) spotted seatrout, *Cynoscion nebulosus;* little tunny, *Euthynnus alletteratus;* cobia, *Rachycentron canadum;* greater amberjack, *Seriola dumerili;* bluefish, *Pomatomus saltatrix;* and crevalle jack, *Caranx hippos.* The January 2003 advisory also recommended limited consumption of the following fishes from certain portions of Florida's coastal waters: gag, *Mycteroperca microlepis;* Spanish mackerel, *Scomberomorus maculatus;* gafftopsail catfish, *Bagre marinus;* common snook, *Centropomus undecimalis;* red drum *Sciaenops ocellatus;* great barracuda *Sphyraena barracuda;* spotted seatrout, *C. nebulosus* (all sizes); permit, *Trachinotus falcatus;* wahoo, *Acanthocybium solanderi;* ladyfish, *Elops saurus;* snowy grouper, *Epinephelus niveatus;* blackfin tuna *Thunnus atlanticus;* and almaco jack *Seriola rivoliana* (DOH, 2003).

Current DOH guidelines recommend that fish containing less than 0.5-ppm of total mercury be consumed following federal EPA guidelines and that fish containing 0.5 to 1.5 parts per million (ppm) of total mercury should be consumed in limited amounts; fish containing greater than 1.5 ppm of total mercury should not be consumed (see Florida Department of Health Guidelines, facing page). DOH guidelines are directed primarily at recreationally caught fish. The Florida Department of Agriculture and Consumer Services in conjunction with the U.S. Food and Drug Administration regulates the commercial seafood marketplace.

In this report, we offer a summary of the total mercury levels found in marine and estuarine fishes collected in Florida waters from April 1989 to May 2001. This is a continuation of a technical report produced by FWC-FMRI in 2001 (Adams and McMichael, 2001) and includes data regarding many additional species and 3,979 additional fish samples collected between January 1995 and May 2001.

Methods and Materials

Fish samples analyzed in this study were collected by staff from FWC-FMRI's Fisheries-Independent Monitoring Program from Florida estuaries and adjacent coastal waters or from recreational and commercial fisheries in the nearshore and offshore waters of Florida. Beginning in July 2000, samples were also collected from recreationally and commercially landed fish by staff from FWC-FMRI's Fisheries-Dependent Monitoring Program. Study areas included the Indian River Lagoon, Tampa Bay, Charlotte Harbor, Choctawhatchee Bay, Cedar Key, Apalachicola Bay, Volusia County, Tequesta/southern Indian River Lagoon, Sarasota Bay, Everglades coastal waters, Florida Keys/Florida Bay, and the northeast Florida area as well as nearshore and offshore waters of the Atlantic and gulf coasts adjacent to these areas (Figure 1). Samples were collected from April 1989 to May 2001.

Fish were placed directly on ice and returned to the laboratory or were processed in the field; species, standard length (SL), and sex were recorded. Precaudal length (PCL) was recorded for all shark species, and disk width (DW) was recorded for all ray species. To allow our data to be compared with those from other studies, total length (TL), fork length (FL), and other morphometric characters were also measured. When possible, maturity of sharks was determined by macroscopic examination of gonads, examination of claspers on male specimens, or by comparison of shark size with estimates of size at birth or maturity from previous studies.

A clean stainless-steel knife was used to remove axial muscle tissue samples from the left dorsal area

Florida Department of Health Guidelines for Issuing Fish Consumption Advisories

Mercury level above 1.5 ppm—No Consumption.

The specific fish species from the specific water body should not be eaten in any amount.

Mercury level 0.5 to 1.5 ppm—Limited Consumption.

Women of childbearing age and children under age 10 should not eat more than 8 ounces of listed fish species from specified water bodies over a 4-week period. Others should limit consumption of listed fish species from these locations to no more than 8 ounces a week. (**Note:** A 4-ounce serving of raw fish is about the size of a slice of sandwich bread.)

Mercury level below 0.5 ppm—Follow EPA Guidelines.

EPA Guidelines. Some water bodies have been tested and fish have been found to have low mercury levels. For these locations, and for locations where data is limited or not available, DOH recommends following guidelines set by the U.S. Environmental Protection Agency (EPA). These guidelines are summarized here: EPA advisories cover all water bodies in the United States and apply only to fish caught by you, your family, and friends. They recommend the following:

• Women who are pregnant or may become pregnant, and nursing mothers should, in a week's time, eat no more than 8 ounces of fish caught by themselves, family, and friends.

• Children under age 10 should, in a week's time, eat no more than 3 ounces of fish caught by themselves, family and friends.

More information on EPA advisories is online at www.epa.gov/waterscience/fishadvice/advice.html

FDA advises that women of childbearing age and pregnant women may, each week, eat an average of 12 ounces of fish purchased in stores and restaurants. Therefore, if in a given week you eat 12 ounces of cooked fish from a store or restaurant, then do not eat any fish caught by family or friends that week. This is necessary in order to keep the total level of methyl mercury contributed by all fish at a low level in your body. More information regarding FDA advisories is online at www.cfsan.fda.gov/~dms/admehg.html

DOH is not constrained by a fixed numerical mercury level and can deviate from those listed above based on DOH's best professional judgment.

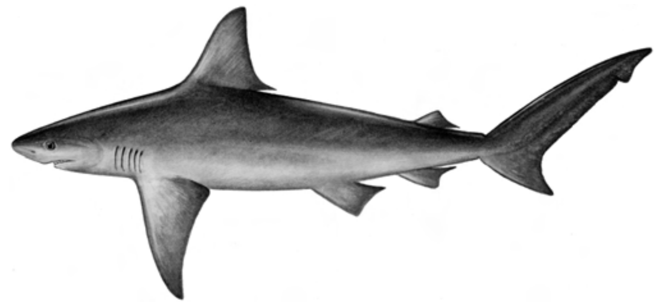
above the lateral line and anterior to the origin of the first dorsal fin. White muscle tissue taken from this region is representative of the portion of fish consumed by humans. Care was taken to assure that the sample made no contact with epidermal or dermal layers, scales, or other surrounding surfaces during the extraction process. Tissue samples were immediately placed in sterile polyethylene vials and frozen at –20°C until analyzed. Before analysis, tissue samples were digested using standard procedures in accord with EPA Method 245.1 to convert all mercury in the sample to Hg(II) (EPA, 1991; Frick, 1996). The mercury in each digested sample was reduced to elemental mercury by reaction with excess stannous chloride. This elemental mercury [Hg(0)] was purged from solution in a gas-liquid separator and swept into an atomic absorption spectrometer for detection and quantification by cold vapor atomic absorption spectrometry following standardized procedures (EPA, 1991; Booeshahgi *et al.,* 1995) at the DEP Chemistry Laboratory. Quality control measures included analysis of laboratory method blanks, duplicate or triplicate tissue samples, duplicate matrix spikes, and standard fish-tissue reference material (DORM-1 or DOLT-2, obtained from the National Research Council of Canada) for each group of 20 or fewer fish samples analyzed (EPA, 1991; Frick, 1996; T. Chandrasekhar, DEP, personal communication). All total mercury levels are reported as parts per million (ppm) wet weight. Linear regressions were used to describe relationships between fish size and total mercury concentration. Mercury data used in regressions were log transformed when appropriate to meet homoscedasticity requirements. Differences in the sizes of fish from three or more study areas were examined by using a Kruskal-Wallis test; a Mann-Whitney Rank Sum test was used when sizes of fish from only two study areas were compared. We used a *t*-test or Mann-Whitney Rank Sum test, as appropriate, to test for significant differences in the total mercury levels of males and females of selected fish species. We also used a *t*-test or Mann-Whitney Rank Sum test to determine whether there were significant differences in the lengths of males and females of selected fish species.

Results and Discussion

From April 1989 to May 2001, a total of 6,806 fish representing 108 species from 40 families were collected from Florida estuaries and adjacent coastal waters for mercury analysis. Species represented all major trophic groups, ranging from primary consumers to apex predators (species that occupy the highest trophic levels). A total of 2,023 fish, representing 68 species, were collected from the Indian River Lagoon and adjacent waters; 1,661 fish, representing 58 species, were collected from Tampa Bay and adjacent waters; 905 fish, representing 49 species, were collected from Florida Keys/Florida Bay; 594 fish, representing 45 species, were collected from Charlotte Harbor; 435 fish, representing 16 species, were collected from Cedar Key; 246 fish, representing 12 species, were collected from Apalachicola Bay; 228 fish, representing 23 species, were collected from Choctawhatchee Bay; 212 fish, representing 16 species, were collected from northeast Florida; 205 fish, representing 28 species, were collected from Volusia County waters; and 204 fish, representing 15 species, were collected from Tequesta/southern Indian River Lagoon. The remainder of the fish were collected from Everglades coastal waters, Sarasota Bay, and nearshore and offshore waters along the Atlantic and gulf coasts of Florida.

Results of mercury analyses of species with total sample sizes greater than or equal to 40 fish are discussed below. Species are presented in phylogenetic order according to Nelson (1984) and Robins *et al.* (1991). Summary results for all species, regardless of sample size, are presented in the Appendix Table.

Bull shark
Carcharhinus leucas



The bull shark, *Carcharhinus leucas,* is an apex predator that inhabits estuarine, nearshore, and offshore waters of both the gulf and Atlantic coasts of Florida. Bull sharks commonly enter estuarine waters and are one of the only shark species to penetrate far into freshwater habitats (Thorson, 1971, 1972; Thomerson and Thorson, 1977). Adult females give birth to 1–13 pups in estuarine waters during the spring and summer months (Compagno, 1984). Along the Atlantic coast of Florida, juveniles use coastal lagoon habitats for up to several years (Snelson *et al.,* 1984; FWC-FMRI, unpublished data). Females of this species mature at approximately 18+ years and males at 14–15 years; the maximum estimated age for bull sharks in the northern Gulf of Mexico is 24.2 years (Branstetter and Stiles, 1987). Based on preliminary results, the maximum unvalidated age estimate for this species in Atlantic waters of the southeastern United States is 26 years (NMFS/FWC-FMRI, unpublished data). In Florida waters, bull sharks feed on a wide variety of fishes and, to a lesser degree, on crabs and shrimps (Dodrill, 1977; Snelson *et al.,* 1984; D. Adams, unpublished data).

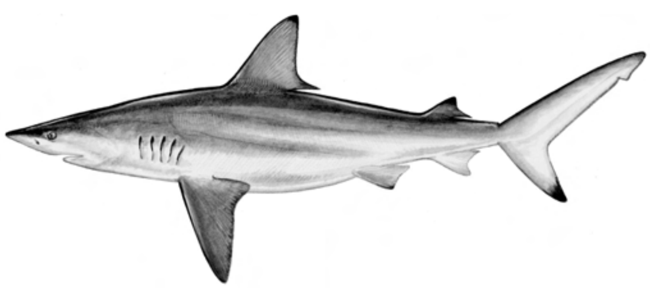
This shark is landed as part of the commercial shark fishery for large coastal species and is also frequently caught by recreational shark fishermen in many areas (Branstetter, 1986; NMFS, 1993). There is a seasonal recreational fishery for juvenile bull sharks in the Indian River Lagoon system (Adams, 1995) and in other estuaries in Florida. There is no size limit for bull sharks, but the current recreational bag limit in Florida is one per person per day or 2 per vessel per day, whichever is less.

Bull sharks analyzed for mercury were collected from the Indian River Lagoon (n = 55), Charlotte Harbor (n = 3), and Tampa Bay (n = 1). These 59 bull sharks were juveniles and ranged from 552 to 1,075 mm precaudal length (PCL). Total mercury levels for individual fish ranged from 0.24 to 1.70 ppm (Appendix Table). The mean total mercury level for fish from the Indian River Lagoon was 0.78 ppm (median = 0.74 ppm) and in those from Charlotte Harbor was 0.97 ppm (median = 1.20 ppm), both of which were greater than 0.5 ppm.

Approximately 82% of all bull sharks from the Indian River Lagoon tested had total mercury levels greater than or equal to 0.5 ppm. Three bull sharks collected from this area contained total mercury levels greater than or equal to 1.5 ppm.

Analysis of bull sharks from the Indian River Lagoon revealed a significant positive correlation between total mercury level and fish length ($P < 0.001$), indicating that mercury levels tend to increase as bull sharks grow. In May 1991, the Florida Department of Health (DOH) released a health advisory urging limited consumption of all shark species from Florida waters. Because mercury concentrations were in excess of U.S. Food and Drug Administration and state standards, DOH recommended that adults should eat shark no more than once a week, and children and women of childbearing age should eat shark no more than once a month. (HRS, 1991: p. 2). In January 2003, DOH issued an updated health advisory recommending no consumption of large sharks (>43 inches, or approximately 1,090 mm TL), and limited consumption of sharks less than 43 inches TL (DOH, 2003).

Blacktip shark
Carcharhinus limbatus



The blacktip shark, *Carcharhinus limbatus,* inhabits estuarine, nearshore, and offshore waters of both the gulf and Atlantic coasts of Florida. Florida estuaries serve as important nursery habitats for this species (FWC-FMRI, 1991–2000). Adult females have a one-year gestation period and give birth to 1–10 pups during the spring and summer months (Compagno, 1984). The complete reproductive cycle, including biennial ovulation, lasts two years (Castro, 1995). Females of this species mature at approximately 6–7 years and the males at 4–6 years; blacktip sharks have a maximum age of 11 years (Killam and Parsons, 1989; Wintner and Cliff, 1996). This species feeds on a variety of fishes and, to a lesser degree, on crabs and other invertebrates (Bass *et al.,* 1973; Dodrill, 1977; Dudley and Cliff, 1993).

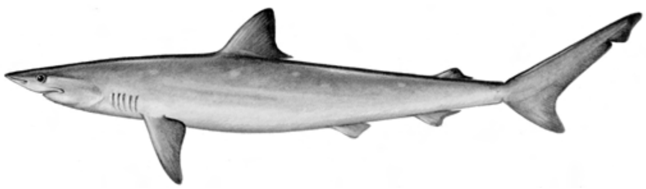
This apex predator supports major commercial and recreational fisheries throughout Florida. It is frequently landed as a major component of the commercial fishery for large coastal sharks and composes a substantial proportion of the recreational shark catch in many areas (Parrack, 1990; NMFS, 1993, 2000). Blacktip sharks, along with sandbar sharks, *C. plumbeus,* are frequently targeted because of the quality and high market value of their meat and fins (NMFS, 1993; Brown, 1999; Shotton, 1999). There is no size limit for blacktip sharks, but the current recreational bag limit in Florida is one per person per day or 2 per vessel per day, whichever is less.

Mercury levels detected in individual blacktip sharks from Florida waters were often greater than 0.5 ppm. Blacktip sharks used in the mercury analyses were collected from Tampa Bay, the Indian River Lagoon and adjacent offshore waters, Charlotte Harbor, and Florida Keys/Florida Bay. Most of the 98 blacktip sharks were juveniles and smaller adults (405–1,510 mm PCL), but 4 embryos (ranging 223–235 mm PCL) were also analyzed. Total mercury levels in individual fish ranged from 0.03 to 2.60 ppm. Total mercury levels in 4 embryos collected from a single 1,050-mm-PCL female whose total mercury level was 2.30 ppm, ranged from 0.63 to 0.78 ppm (mean = 0.69 ppm; median = 0.68 ppm) (Adams and McMichael, 1999). Comparisons of pregnant females and their associated embryos in this and related species indicate that transmission of mercury from maternal sources may be an important factor in accumulation of mercury in shark muscle tissue (Adams and McMichael, 1999). The mean total mercury level in each of the study areas was greater than 0.5 ppm; these mean levels ranged from a minimum of 0.54 ppm in Tampa Bay (median = 0.47 ppm) to a maximum of 1.84 ppm in Florida Keys/Florida Bay (median = 1.85 ppm). Similar mercury levels have been documented for blacktip sharks in Australian coastal waters (Lyle, 1984, 1986).

Analysis of blacktip sharks from Tampa Bay and the Indian River Lagoon and adjacent offshore waters revealed a significant positive correlation between total mercury level and blacktip shark length ($P < 0.0001$), indicating that mercury levels tend to increase as blacktip sharks grow.

In May 1991, the Florida Department of Health (DOH) released a health advisory urging limited consumption of all shark species from Florida waters. Because mercury concentrations were in excess of U.S. Food and Drug Administration and state standards, DOH recommended that adults should eat shark no more than once a week, and children and women of childbearing age should eat shark no more than once a month. (HRS, 1991: p. 2). In January 2003, DOH issued an updated health advisory recommending no consumption of large sharks (>43 inches, or approximately 1,090 mm TL), and limited consumption of sharks less than 43 inches TL (DOH, 2003).

Atlantic sharpnose shark
Rhizoprionodon terraenovae



The Atlantic sharpnose shark, *Rhizoprionodon terraenovae,* is a common species that inhabits estuarine, nearshore, and offshore waters of the gulf and Atlantic coasts of Florida. Adult females have a 10- to 11-month gestation period and give birth to pups during the late spring and summer (Parsons, 1983). This species matures at approximately 2.4–3.9 years (Parsons, 1985) and lives for up to 8–10 years in the Gulf of Mexico (Branstetter, 1987). In the southeastern U.S. Atlantic, sexual maturity is attained at 3 years and the maximum age is 11+ years (Loefer and Sedberry, 2003). Atlantic sharpnose sharks feed on a variety of fishes, crabs, and shrimp (Clark and von Schmidt, 1965; D. Adams, unpublished data).

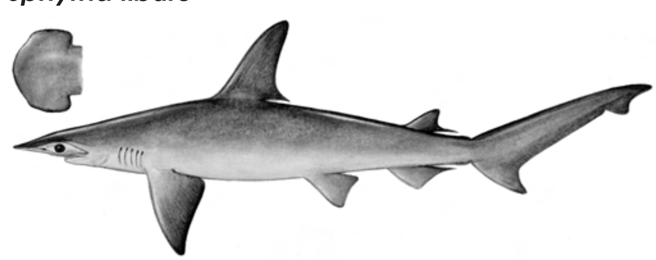
This species is commonly caught by recreational shark fishermen (Parrack, 1990; NMFS, 1993). The Atlantic sharpnose shark is a major component of the U.S. Atlantic commercial fishery for small coastal shark species. It is routinely landed both recreationally and commercially on the Atlantic coast of Florida in the Cape Canaveral region (D. Adams, personal observation) and is discarded in large numbers during shrimp trawling operations (NMFS, 1993). This species is also frequently caught in the Gulf of Mexico during longline fishing operations that target other shark species (Russell, 1993). There is no size limit for Atlantic sharpnose sharks, but the current recreational bag limit in Florida is one per person per day or two per vessel per day, whichever is less.

Most of the Atlantic sharpnose sharks analyzed were collected from nearshore and offshore waters of the Atlantic coast of Florida adjacent to the Indian River Lagoon system (n = 81), and a limited number were collected from Volusia County offshore waters (n = 4). Mercury levels detected in Atlantic sharpnose sharks from Florida's Atlantic coast waters were usually high. Precaudal lengths (PCL) of the 85 juvenile and adult Atlantic sharpnose sharks collected ranged from 220 to 857 mm. Total mercury levels for individual fish from offshore waters of the Atlantic coast of Florida adjacent to the Indian River Lagoon system ranged from 0.11 to 2.30 ppm. The mean total mercury level was 1.06 ppm, and the median was 0.95 ppm (Appendix Table). Similar mercury levels were found in Australian sharpnose sharks, *Rhizoprionodon taylori,* and milk sharks, *R. acutus,* from Australian waters (Lyle, 1986). Of the 85 juvenile and adult Atlantic sharpnose sharks tested from Florida waters, approximately 71% had total mercury levels greater than or equal to 0.5 ppm. Approximately 28% of juvenile and adult Atlantic sharpnose sharks tested from Florida waters contained total mercury levels greater than or equal to 1.5 ppm. Total mercury levels in six embryos from pregnant female Atlantic sharpnose sharks collected from offshore waters of the Atlantic coast of Florida adjacent to the Indian River Lagoon system ranged from 0.17 to 0.29 ppm (mean = 0.22 ppm; median = 0.19 ppm). Atlantic sharpnose shark embryos analyzed ranged from 74 to 85 mm PCL. Mercury levels in Atlantic sharpnose shark embryos within each litter were similar and ranged from 8.3% to 15.3% of the total mercury levels in their respective mothers (Adams and McMichael, 1999).

Analysis of Atlantic sharpnose sharks from offshore waters of the Atlantic coast of Florida adjacent to the Indian River Lagoon system revealed a significant positive correlation between total mercury level and fish length ($P < 0.0001$). Total mercury level in this species increases as individuals grow. Total mercury levels for larger sharks (>500 mm PCL) were usually high (>0.5 ppm). Although precaudal lengths of females examined in this study were significantly larger than those of males (*t*-test, $P < 0.05$), total mercury levels for females and males were not significantly different (Mann-Whitney rank sum test, $P > 0.1$).

In May 1991, the Florida Department of Health (DOH) released a health advisory urging limited consumption of all shark species from Florida waters. Because mercury concentrations were in excess of U.S. Food and Drug Administration and state standards, DOH recommended that adults should eat shark no more than once a week, and children and women of childbearing age should eat shark no more than once a month (HRS, 1991: p. 2). In January 2003, DOH issued an updated health advisory recommending no consumption of large sharks (>43 inches, or approximately 1,090 mm TL) and limited consumption of sharks less than 43 inches TL (DOH, 2003).

Bonnethead shark
Sphyrna tiburo



The bonnethead shark, *Sphyrna tiburo,* is common in coastal waters of Florida. This species of small hammerhead shark is frequently caught by recreational fishermen and is landed as part of the commercial fishery for small coastal shark species (Parrack, 1990; NMFS, 1993). There is no size limit for bonnethead sharks, but the current recreational bag limit in Florida is one per person per day or two per vessel per day, whichever is less.

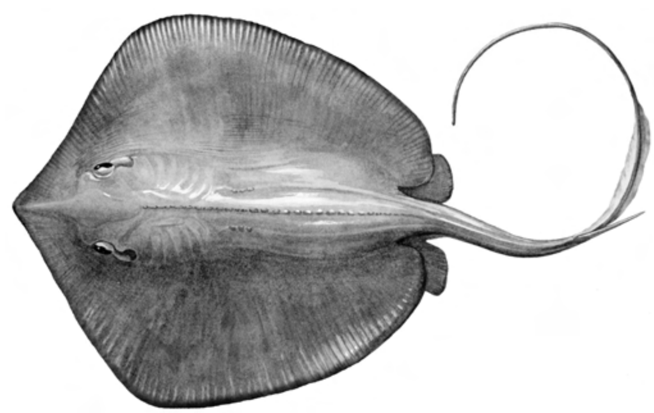
This predator inhabits estuarine, nearshore, and offshore waters of both the gulf and Atlantic coasts of Florida. The gestation period for this species is approximately 4–5 months (Parsons, 1993a)—the shortest known gestation period of any placental viviparous shark species (G. Parsons, University of Mississippi, personal communication). Females give birth to 4–16 pups (Compagno, 1984). This species matures at approximately 2 years of age and is estimated to live 7+ years (Parsons, 1993b). Bonnethead sharks feed principally on crabs, shrimps, and other invertebrates (Parsons, 1987; Cortes *et al.,* 1996; D. Adams, unpublished data).

Bonnethead sharks used in the mercury analyses were collected from the Indian River Lagoon and adjacent offshore waters, Tampa Bay, Charlotte Harbor, Choctawhatchee Bay, and Florida Keys/Florida Bay. The 213 bonnethead sharks sampled ranged from 206 to 1,081 mm PCL. The majority of samples were collected from the Indian River Lagoon and adjacent offshore waters (n = 137). Included with the juvenile and adult bonnethead sharks examined from this area were 41 near-term embryos (206 to 255 mm PCL). Mercury levels detected in bonnethead sharks from Florida waters were often greater than 0.5 ppm. Total mercury levels for individual fish ranged from 0.03 to 1.60 ppm (Appendix Table). The mean total mercury levels ranged from a minimum of 0.34 ppm for fish in Charlotte Harbor (median = 0.27 ppm) to a maximum of 1.14 ppm for fish in Florida Keys/Florida Bay (median = 1.20 ppm). Total mercury levels for juvenile and adult bonnethead sharks (results from embryos not included) from the Indian River Lagoon and adjacent offshore waters (297–1081 mm PCL) ranged from 0.13 to 1.5 ppm (mean = 0.50 ppm; median = 0.29 ppm). Total mercury levels for the 41 embryos examined ranged from 0.08 to 0.35 ppm (mean = 0.16 ppm; median = 0.13 ppm). Total mercury levels in embryos of this species equaled 9.1%–60.4% of levels observed in their respective mothers (Adams and McMichael, 1999).

Analysis of bonnethead sharks from the Indian River Lagoon and adjacent offshore waters revealed a significant positive relationship between total mercury level and fish length ($P < 0.0001$), indicating that mercury levels tend to increase as bonnethead sharks grow. The relationship between total mercury level and fish length was not as strong for bonnethead sharks collected from Tampa Bay ($P > 0.001$), but it also indicated that mercury levels increase as individuals grow.

In May 1991, the Florida Department of Health (DOH) released a health advisory urging limited consumption of all shark species from Florida waters. Because mercury concentrations were in excess of U.S. Food and Drug Administration and state standards, DOH recommended that adults should eat shark no more than once a week, and children and women of childbearing age should eat shark no more than once a month. (HRS, 1991: p. 2). In January 2003, DOH issued an updated health advisory recommending no consumption of large sharks (>43 inches, or approximately 1,090 mm TL), and limited consumption of sharks less than 43 inches TL (DOH, 2003).

Atlantic stingray
Dasyatis sabina

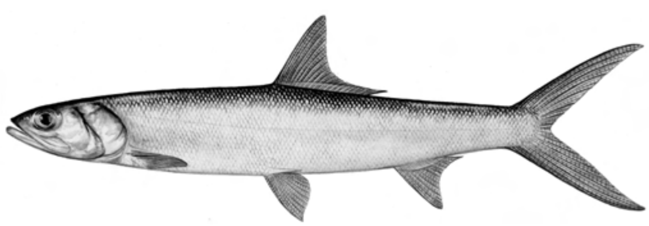


The Atlantic stingray, *Dasyatis sabina,* is found in estuarine and nearshore waters along Florida's Atlantic and gulf coasts, where they inhabit a range of estuarine and nearshore habitats, including seagrass flats, open-sand flats, mud flats, and channels or basins (Schwartz and Dahlberg, 1978; FWC-FMRI, 1991–2000). This species also enters freshwater habitats (Gunter, 1938a), and a permanent freshwater population has been documented in the St. Johns River on the Atlantic coast of Florida (Tagatz, 1968; Johnson and Snelson, 1996). The mating season for Atlantic stingrays in Florida waters extends from October through March (Lewis, 1982; Snelson *et al.,* 1988; Johnson and Snelson, 1996). Although age and growth studies have been attempted (Schmid, 1988), little is known regarding age or growth rate of this species. This species feeds principally on invertebrate prey such as amphipods, mysids, and mollusks (Cook, 1994).

This abundant species is not routinely pursued by commercial or recreational fishermen, but it is occasionally harvested for human consumption or to be used as shark or crab bait. Atlantic stingrays are frequently caught as bycatch in many fisheries operating in Florida waters.

Atlantic stingrays used in the mercury analyses were principally collected from the Indian River Lagoon (n = 35), but a limited number of samples were also collected from Charlotte Harbor (n = 9), Choctawhatchee Bay (n = 6), northeast Florida (n = 4), and Tampa Bay (n = 4). The 58 Atlantic stingrays collected ranged from 94 to 329 mm disk width. Disk widths of female and male Atlantic stingrays examined in this study were not significantly different (Mann-Whitney rank sum test, $P > 0.1$). Mercury levels detected in Atlantic stingrays were usually low. Total mercury levels for individual fish ranged from 0.01 to 0.54 ppm (Appendix Table). The mean total mercury level for fish in the Indian River Lagoon, where the majority of samples were collected, was 0.16 ppm, and the median was 0.16 ppm. When we analyzed the relationship between mercury level and size of Atlantic stingray from the Indian River Lagoon, we found a significant positive correlation between total mercury level and disk width ($P < 0.001$), indicating that mercury levels tend to increase as Atlantic stingrays grow. Total mercury levels in females and males were not significantly different (t-test, $P > 0.1$). Only one Atlantic stingray collected from Florida waters contained a total mercury level greater than or equal to 0.5 ppm.

Ladyfish
Elops saurus



The ladyfish, *Elops saurus,* inhabits estuarine, nearshore, and coastal waters of the gulf and Atlantic coasts of Florida. There may be more than one species or stock of ladyfish in Florida waters (Smith, 1990; Schmid, 1992; McBride *et al.,* 2001), and further research is currently being conducted by FWC-FMRI scientists to answer this question. Ladyfish spawn in fall and spring, probably offshore (Zale and Merrifield, 1989), and larval and juvenile ladyfish are frequently collected in a variety of Florida estuarine habitats (FWC-FMRI, 1991–2000; McBride *et al.,* 2001). Little is known regarding the age and growth of this species (Zale and Merrifield, 1989). Ladyfish feed principally on midwater fishes and decapod crustaceans (Darnell, 1958; Sekavec, 1974).

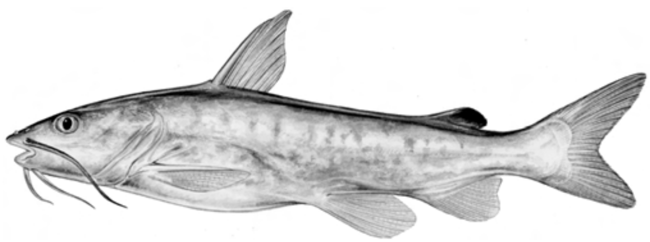
Ladyfish are frequently caught by recreational fishermen, and the species supports a commercial fishery throughout Florida. In 2000, approximately 498,000 pounds of ladyfish were landed from Florida waters (Murphy *et al.,* 2001). The majority (98%) of Florida's ladyfish landings are from the commercial fishery along the gulf coast. The recreational fishery in Florida catches more than 2,000,000 fish each year, but only 5%–10% are actually retained (Murphy and Muller, 1998; Murphy *et al.,* 2000).

The 218 ladyfish used in the mercury analyses were collected in Tampa Bay, the Indian River Lagoon, Charlotte Harbor, Florida Keys/Florida Bay, Choctawhatchee Bay, Cedar Key, and, Apalachicola Bay; they ranged from 115 to 580 mm standard length (SL). Total mercury levels for individual fish ranged from 0.02 to 2.60 ppm. The mean total mercury levels varied by study area (Appendix Table). Mean total mercury levels were higher for fish from the Indian River Lagoon (mean = 0.72 ppm; median = 0.56 ppm) and Tampa Bay (mean = 0.52 ppm; median = 0.42 ppm) than for fish from Charlotte Harbor (mean = 0.34 ppm; median = 0.23 ppm) and Apalachicola Bay (mean = 0.09 ppm; median = 0.06 ppm). The comparatively lower levels detected in ladyfish from Charlotte Harbor may be related to the fact that ladyfish collected from Charlotte Harbor were significantly smaller than those collected from the Indian River Lagoon or Tampa Bay (Kruskal-Wallis test, $P < 0.01$; Dunn's method, $P < 0.05$). Ladyfish collected in Apalachicola Bay contained lower overall mercury levels than did the ladyfish collected in any of the other Florida sampling areas; however, fish sampled from Apalachicola Bay were significantly smaller (mean = 258 mm SL) than those collected in the Indian River Lagoon (mean = 373 mm SL), Tampa Bay (mean = 350 mm SL), and Charlotte Harbor (mean = 317 mm SL) (Kruskal-Wallis test, $P < 0.01$; Dunn's method, $P < 0.05$).

Analysis of ladyfish from the Indian River Lagoon, Charlotte Harbor, and Apalachicola Bay revealed a significant positive correlation between total mercury level and length of fish ($P < 0.0001$), and analysis of ladyfish from Tampa Bay revealed a weak positive correlation ($P < 0.01$). The positive correlation between total mercury level and fish length in each study area indicates that mercury levels tend to increase as ladyfish in Florida grow. Mercury levels for ladyfish collected in all study areas were variable; however, in most areas, a high percentage of the fish in the larger size-classes (≥380 mm SL) had mercury levels greater than or equal to 0.5 ppm (Tampa Bay = 73%; Charlotte Harbor = 63%; Indian River Lagoon = 100%). Only three fish collected from Apalachicola Bay were greater than 380 mm SL, and none of these had mercury levels greater than or equal to 0.5 ppm.

After reviewing these results, the Florida Department of Health released a health advisory on 6 October 1995 urging limited consumption of ladyfish from Tampa Bay and the Indian River Lagoon (HRS, 1995: p. 2).

Hardhead catfish
Arius felis



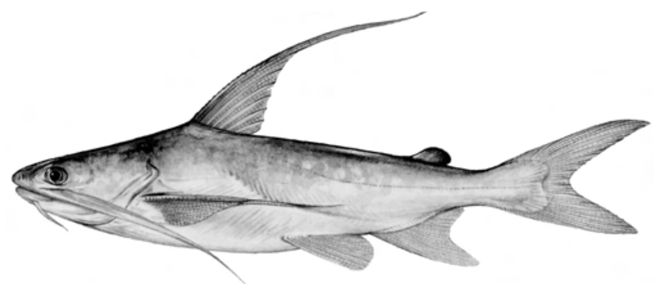
Hardhead catfish, *Arius felis,* are abundant in estuarine and nearshore coastal waters throughout Florida. Hardhead catfish spawn in estuarine habitats from May to August (Jones *et al.,* 1978), and males carry developing eggs and juveniles in their mouths during this time (Ward, 1957). After leaving the protection of the male's mouth, juvenile hardhead catfish occupy a wide range of estuarine habitats (FWC-FMRI, 1991–2000; Adams & Tremain, 1995). Adults inhabit estuaries or nearshore waters, and a portion of the adult population may migrate offshore during winter months to avoid the low temperatures of inshore waters (Muncy and Wingo, 1983; FWC-FMRI, 1994, 1995; FWC-FMRI Nearshore Gillnet Survey, unpublished). This species often concentrates near thermal effluent plumes of coastal power plants (Gallaway and Strawn, 1974; FWC-FMRI, unpublished data). Hardhead catfish reach sexual maturity at approximately 2 years of age (Benson, 1982). Doermann *et al.* (1977) reported a maximum age of 5–8 years, but recent research at FWC-FMRI indicates that the maximum age for this species may be 20 years or more.

Hardhead catfish are opportunistic omnivores that feed on algae, seagrasses, coelenterates, polychaetes, crustaceans, small fishes, and occasionally human garbage (Merriman, 1940). Diets of hardhead catfish and gafftopsail catfish, a related species, are similar (Merriman, 1940). Gunter (1945), Darnell (1961), Gallaway and Strawn (1974), and others have reported that blue crabs were common in the diet of this species.

This demersal species is frequently encountered by recreational and commercial fishermen. It is landed as bycatch during a variety of inshore and nearshore commercial fishing operations. The Indian River Lagoon is the area of highest commercial landings for this species (Murphy and Muller, 1995). Although it is not favored as a food fish, recreational fishermen occasionally land hardhead catfish and commercial fishermen mix large hardhead catfish with gafftopsail catfish, *Bagre marinus,* landings for use as food fish.

Hardhead catfish were principally collected from Tampa Bay, the Indian River Lagoon, and Choctawhatchee Bay. A total of seven samples were also collected in Charlotte Harbor. The 45 hardhead catfish analyzed for total mercury levels ranged from 210 to 390 mm standard length. Mercury levels detected in hardhead catfish from Florida waters were usually low. Total mercury levels for individual fish ranged from 0.02 to 0.50 ppm. The mean total mercury levels for hardhead catfish were low in all study areas, ranging from 0.15 (median = 0.12 ppm) for fish from the Indian River Lagoon to 0.23 (median = 0.23 ppm) for those from Choctawhatchee Bay. Only one hardhead catfish tested from Florida waters (collected in Tampa Bay) had a total mercury level equal to 0.5 ppm, and no individuals contained levels greater than this level.

Gafftopsail catfish
Bagre marinus



Gafftopsail catfish, *Bagre marinus,* is a demersal species that inhabits estuarine and nearshore waters of the gulf and Atlantic coasts of Florida. Gafftopsail catfish spawn over inshore mud flats from May to August (Jones *et al.,* 1978), and males carry developing eggs and juveniles in their mouths during this time (Ward, 1957). Feeding by males carrying eggs or juveniles has not been documented. After leaving the protection of the male's mouth, juvenile gafftopsail catfish commonly inhabit channels and basins within estuaries (FWC-FMRI, 1991–2000). Juveniles and larger subadults may also move into nearshore continental shelf waters (Gunter, 1938b). Adults inhabit estuaries and nearshore shelf waters (Muncy and Wingo, 1983; FWC-FMRI, 1991–2000; FWC-FMRI Nearshore Gillnet Survey, unpublished). Gafftopsail catfish reach sexual maturity before 2 years of age (Benson, 1982).

Gafftopsail catfish are opportunistic omnivores that feed on algae, seagrasses, coelenterates, polychaetes, crustaceans, small fishes, and occasionally human garbage (Merriman, 1940). Gunter (1945), Darnell (1961), Gallaway and Strawn (1974), and others have reported that blue crabs were common in the diet of this species.

Gafftopsail catfish are commonly encountered by recreational and commercial fishermen throughout Florida. In the minor commercial fishery that this species supports, it is landed as bycatch during a variety of inshore and nearshore fishing operations. Most of the commercial landings of this species are from the Indian River Lagoon (Murphy and Muller, 1995). Recreational fishermen occasionally land gafftopsail catfish as a food fish.

Gafftopsail catfish used in the mercury analyses were principally collected from Tampa Bay (n = 59) and the Indian River Lagoon (n = 11). A smaller number of samples were also collected in Charlotte Harbor (n = 4) and Choctawhatchee Bay (n = 4). The 78 gafftopsail catfish analyzed ranged from 115 to 528 mm standard length (SL). Mercury levels detected in gafftopsail catfish from Florida estuarine waters were variable; however, levels in larger fish were often greater than or equal to 0.5 ppm. Total mercury levels for individual fish ranged from 0.02 to 1.80 ppm. The mean total mercury level for this species in Tampa Bay was 0.60 ppm and the median was 0.54 ppm. The mean total mercury level for fish from the Indian River Lagoon was 0.33 ppm and the median was 0.38 ppm. The higher mean total mercury level observed in fish from Tampa Bay may be due, in part, to the larger mean size of gafftopsail catfish tested from this region. The mean standard length of fish examined from Tampa Bay (374 mm SL) was greater than that of fish from the Indian River Lagoon (302 mm SL).

Analysis of gafftopsail catfish from Tampa Bay indicated a positive correlation between total mercury level and fish length ($P < 0.01$). Mercury levels of gafftopsail catfish collected in Tampa Bay were variable, but mercury levels of larger fish (>350 mm SL) were often greater than or equal to 0.5 ppm.

After reviewing these results, the Florida Department of Health released a health advisory on 6 October 1995 (HRS, 1995: p. 2) urging limited consumption of gafftopsail catfish from Tampa Bay waters. Mercury levels in gafftopsail catfish from other Florida study areas (the Indian River Lagoon, Choctawhatchee Bay, Florida Keys/Florida Bay) were considered "potentially problematic" (HRS, 1995: p. 3).

In January 2003, DOH issued an updated health advisory recommending limited consumption of gafftopsail catfish from Choctawhatchee Bay and Tampa Bay (DOH, 2003).

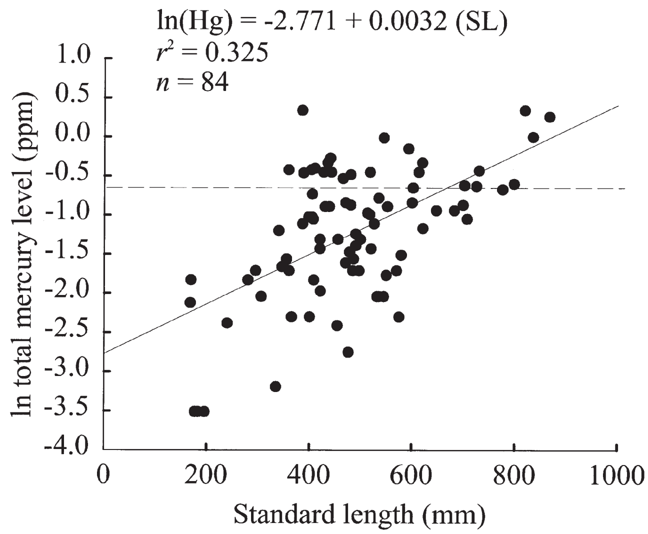
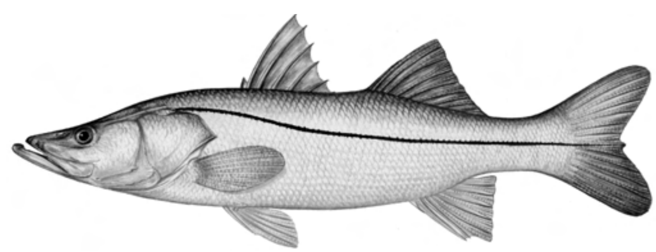


Figure 2. *Relationship between ln total mercury level (ppm) and standard length (mm) of common snook,* Centropomus undecimalis, *from Tampa Bay, Florida. The dashed line represents the antilog equivalent of the 0.5-ppm threshold level.*

Common snook
Centropomus undecimalis



Common snook, *Centropomus undecimalis,* inhabit mangrove-fringed bays, marshes, tidal creeks, and other estuarine habitats as adults and juveniles (Gilmore *et al.,* 1983; McMichael *et al.,* 1989; FWC-FMRI, 1992). Adults are also found in inlet and nearshore waters during the warmer months. Adult common snook tend to migrate seaward, moving out through inlets and passes during the spawning season (Volpe, 1959). Spawning occurs from April to October near inlets and coastal passes. Common snook on Florida's Atlantic and gulf coasts form two genetically distinct stocks (Tringali and Bert, 1996). Common snook inhabiting the Atlantic coast grow faster and to a larger size than do those from the gulf coast (Taylor *et al.,* 1993, 2000). This species can live up to 21 years (Taylor *et al.,* 2000). Growth rates are variable, and females typically grow to larger sizes and live longer than males do. Common snook are protandric hermaphrodites; males develop into females between the ages of 2 and 7 years (Taylor and Grier, 1991). Females less than 444 mm SL are not commonly encountered (Taylor *et al.,* 2000). Snook are

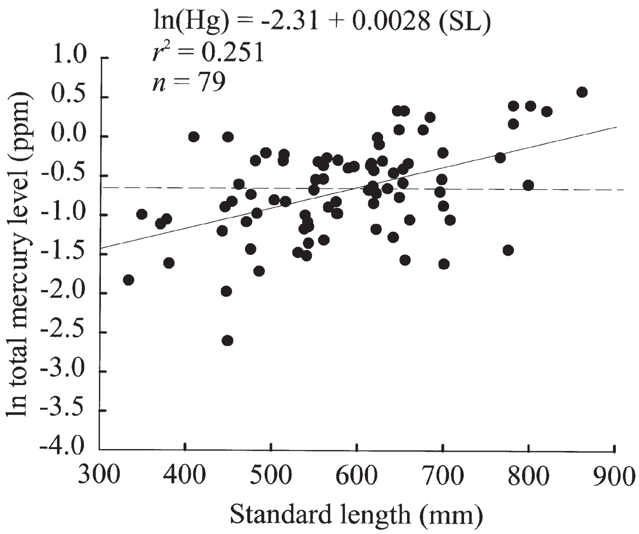


Figure 3. *Relationship between ln total mercury level (ppm) and standard length (mm) of common snook,* Centropomus undecimalis, *from Florida Keys/Florida Bay, Florida. The dashed line represents the antilog equivalent of the 0.5-ppm threshold level.*

opportunistic predators that feed on a wide variety of fishes and crustaceans (Seaman and Collins, 1983).

The common snook is one of Florida's premier gamefish. In 2000, 75,059 common snook, weighing a total of approximately 593,849 pounds, were recreationally landed from Florida waters. Landings were slightly higher (52% by weight; 54% by number of fish) on the gulf coast than on the Atlantic coast of Florida during 2000 (Murphy *et al.*, 2001). Commercial harvest of snook was abolished in 1957 to reduce overall exploitation rates (Volpe, 1959). Because of a continued decline in snook populations caused by recreational fishing pressure and habitat degradation, recreational harvest restrictions were implemented in 1985.

Common snook were collected from representative habitats in Tequesta/southern Indian River Lagoon, Tampa Bay, Florida Keys/Florida Bay, the Indian River Lagoon, Charlotte Harbor, and the Everglades. One fish was also collected from the Cedar Key area. The 424 common snook analyzed for total mercury levels ranged from 168 to 867 mm SL. Total mercury levels for individual fish ranged from 0.03 to 1.80 ppm (Appendix Table). Mercury levels detected in common snook from Florida estuarine waters were variable, and regional differences were detected. Total mercury levels in fish from the Atlantic coast, the gulf coast, and Florida Keys/Florida Bay were significantly different (Kruskal-Wallis test, $P < 0.0001$; Dunn's method, $P < 0.05$). Mean total mercury levels were similar for gulf coast fish from Tampa Bay (0.39 ppm; median = 0.34 ppm) and Charlotte Harbor (0.37 ppm; median = 0.36 ppm). The mean total mercury levels for Atlantic coast snook from Tequesta/southern Indian River Lagoon (0.22 ppm; median = 0.21 ppm) and the Indian River Lagoon (0.22 ppm; median = 0.21 ppm) were the same. Mercury levels in snook from the Florida Keys/Florida Bay (mean = 0.60 ppm; median = 0.51 ppm) and from the Everglades (mean = 0.63 ppm; median = 0.57 ppm) were significantly higher than levels from all other areas (Kruskal-Wallis test, $P < 0.0001$; Dunn's method, $P < 0.05$). The relatively low mean level detected in common snook from the Florida Atlantic coast may be related to the smaller size of fish collected in that area. Common snook collected from the Atlantic coast (262–745 mm SL; mean = 433 mm SL) were significantly smaller than those sampled from the gulf coast (168–867 mm SL; mean = 482 mm SL) and Florida Keys/Florida Bay (333–860 mm SL; mean = 574 mm SL) (Kruskal-Wallis test, $P < 0.0001$; Dunn's method, $P < 0.05$). Differences in mercury levels in fish from the Atlantic coast and those from the gulf coast of Florida may also be influenced by the differences in growth rates observed for these two distinct snook populations.

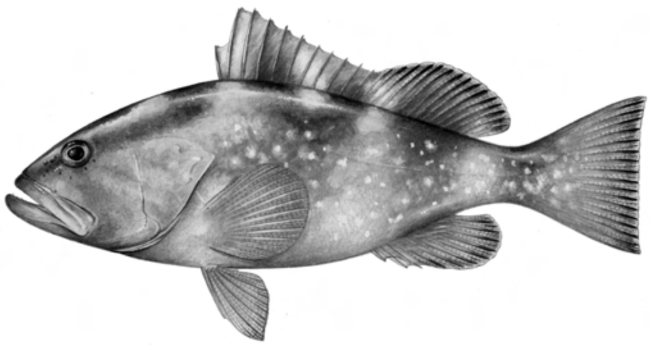
Significant positive correlations between total mercury level and fish length were detected for common snook collected from Tampa Bay ($P < 0.0001$) (Figure 2) and Florida Keys/Florida Bay ($P < 0.0001$) (Figure 3). Analyses of this species from Indian River Lagoon ($P > 0.001$), Tequesta/southern Indian River Lagoon ($P > 0.01$), and Charlotte Harbor ($P > 0.01$) showed comparatively weaker correlations between total mercury level and fish length. When common snook were pooled by Atlantic coast (Indian River Lagoon and Tequesta/southern Indian River Lagoon) and gulf coast (Tampa Bay and Charlotte Harbor) populations, there was a stronger relationship between total mercury level and fish length for gulf coast fish ($P < 0.0001$; $r^2 = 0.254$) than for Atlantic coast fish ($P > 0.001$; $r^2 = 0.057$).

Approximately 27% of all common snook from Florida waters had levels greater than or equal to 0.5 ppm. Although there was considerable variation, fish with mercury levels greater than or equal to 0.5 ppm (n = 91; 359–867 mm SL) were significantly larger than those with levels below 0.5 ppm (n = 333; 168–775 mm SL) (Mann-Whitney rank sum test, $P < 0.0001$).

A total of 103 common snook collected from Florida waters were within the legal or harvestable "slot limit" (approximately 547–721 mm SL; 660–864 mm TL). Approximately 44% of common snook within the legal "slot limit" had levels greater than or equal to 0.5 ppm, but only the Florida Keys/Florida Bay and the Everglades areas had "slot-limit" snook with mean total mercury levels greater than 0.5 ppm. Of common snook larger than the "slot limit" (n = 15), all but two fish had mercury levels greater than 0.5 ppm.

In January 2003, DOH issued a health advisory recommending limited consumption of common snook from Florida Keys/Florida Bay (DOH, 2003).

Red grouper
Epinephelus morio

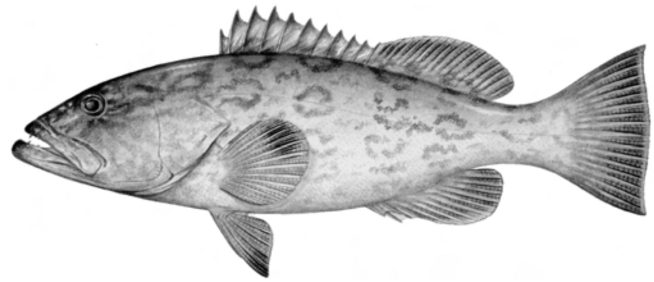


Red grouper, *Epinephelus morio,* principally inhabit nearshore and offshore waters of Florida, although juveniles are sometimes found in bays and inlets. Red grouper are protogynous hermaphrodites; females mature at age 4 to 6 and transition into males at age 7 to 14 (Moe, 1969). In the eastern Gulf of Mexico, spawning mostly occurs from March to June, with peak spawning activity in April and May (Moe, 1969), but spawning may occur from January to June (Johnson *et al.,* 1998). Red grouper feed on a variety of invertebrates and fish (Bullock and Smith, 1991).

This species is frequently landed in Florida's grouper-snapper fishery and is one of the most abundant grouper species in commercial catches on Florida's gulf coast (Bullock and Smith, 1991; FWC-FMRI, 2001). A total of 9,270,822 pounds of red grouper were landed in Florida in 2000, of which approximately 99% were landed from gulf coast waters (NMFS, Fisheries Statistics and Economic Division, personal communication). More than 75% of all red grouper landed from Florida gulf waters were caught in the commercial fishery (FWC-FMRI, 2001).

Red grouper were principally collected from offshore waters of the Gulf of Mexico (n = 39), but samples were also collected from the offshore waters adjacent to the Florida Keys (n = 4), the Indian River Lagoon (n = 3), and Volusia County (n = 3). Standard lengths (SL) ranged from 338 to 565 mm. Total mercury levels for individual fish ranged from 0.11 to 0.66 ppm. The mean total mercury level in red grouper from the Gulf of Mexico was 0.33 ppm, and the median was 0.32 ppm. Four of the 39 Gulf of Mexico red grouper tested had mercury levels greater than or equal to 0.5 ppm. Analysis of red grouper from Gulf of Mexico waters revealed no significant correlation between total mercury level and fish length ($P > 0.1$); however, no large red grouper (>565 mm SL) were examined in this study. Samples from larger specimens are required before the full range of mercury levels in this species can be determined.

Gag
Mycteroperca microlepis



Gag, *Mycteroperca microlepis,* are found in estuarine, nearshore, and offshore waters throughout Florida. Estuaries are important nursery habitats for this species (FWC-FMRI, 1991–2000; Grimes *et al.,* 1995). Gag are protogynous hermaphrodites; females mature between the ages of 3 and 4 and can begin to transform into males as early as age 5 (Collins *et al.,* 1987; Hood and Schlieder, 1992). Spawning occurs from approximately December to May (Hood and Schlieder, 1992). Gag are a long-lived, slow-growing fish that can live for more than 20 years (Collins, *et al.,* 1987; Hood and Schlieder, 1992). This species feeds primarily on fishes but also consumes a variety of invertebrates (Naughton and Saloman, 1985).

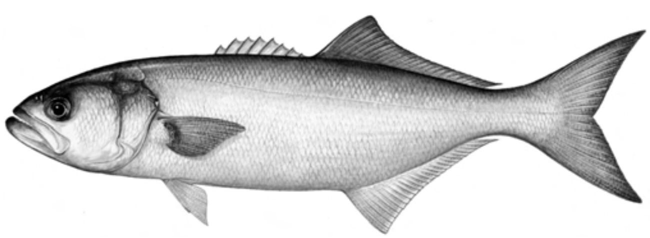
This species is an important component of Florida's grouper-snapper fishery. A statewide total of 7,221,271 pounds of gag were landed by the commercial and recreational fisheries in 2000, with approximately 90% landed from gulf coastal waters (FWC-FMRI, 2001).

Gag analyzed for mercury levels were principally collected from the Tampa Bay area, Cedar Key, and adjacent offshore waters of the Gulf of Mexico. Additional samples were collected from the Indian River Lagoon and adjacent offshore waters (n = 12), Charlotte Harbor (n = 3), Florida Keys/Florida Bay (n = 5), and from the offshore waters of Volusia County (n = 7). Mercury levels detected in sublegal-size gag (≤461 mm standard length [SL] on the gulf coast of Florida) were usually low and were all less than or equal to 0.39 ppm. Mercury levels in legal-size individuals (≥461 mm SL on the gulf coast of Florida) were typically higher; 43% of legal-size gag from Florida gulf coast waters had mercury levels greater than or equal to 0.5 ppm. Dorsal muscle tissue samples from all 97 gag (137–890 mm SL) had total mercury levels that ranged from 0.04 to 1.80 ppm (Appendix Table). The mean total mercury level for gag from the Tampa Bay area was 0.30 ppm, and the median was 0.21 ppm. Approximately 45% of gag collected from the Tampa Bay area were of legal size, and 47% of these legal-size fish had mercury levels greater than or equal to 0.5 ppm. The mean total mercury level for gag from the Cedar Key area was 0.47, and the median was 0.44 ppm. Ninety percent of all gag collected from the Cedar Key area were of legal size, and approximately 37% of these legal-size fish had mercury levels greater than or equal to 0.5 ppm.

Analysis of gag from the Tampa Bay area indicated there was a significant positive correlation between total mercury level and fish length ($P < 0.0001$). There was no significant relationship detected between total mercury level and fish length from fish in the Cedar Key area ($P > 0.05$); however, only gag within a relatively limited size range (450–725 mm SL) were examined from this location. The addition of larger and smaller size-class gag from the Cedar Key area may potentially alter these results. Because of the close proximity of Tampa Bay to Cedar Key adjacent offshore waters, we also analyzed gag pooled from these two areas (n = 70 fish) to examine the overall mercury-length relationship from the central Florida gulf coast. There was a significant positive correlation between total mercury level and fish length ($P < 0.0001$) for fish from the central Florida gulf coast region.

In January 2003, DOH issued a health advisory recommending limited consumption of gag from Cedar Key and Tampa Bay and adjacent waters (DOH, 2003).

Bluefish
Pomatomus saltatrix



Bluefish, *Pomatomus saltatrix,* are found in estuarine, nearshore, and offshore waters throughout Florida. This coastal pelagic, estuarine-dependent species spawns in offshore waters of the Atlantic during spring and summer (Chiarella and Conover, 1990; Juanes and Conover, 1995). Limited spawning may occur off the Florida and Georgia coasts during the fall (Kendall and Walford, 1979; Collins and Stender, 1988). Based on the occurrence of larvae, spawning in the northern Gulf of Mexico occurs during April and October through November (Ditty and Shaw, 1995). In the western North Atlantic, bluefish spend their early juvenile stage in nearshore or estuarine waters and return to continental shelf waters as large juveniles (Munch and Conover, 2000). Bluefish grow rapidly during their first year and most individuals are mature by age 2 (Deuel, 1964; Wilk, 1977). The maximum estimated age for this species is 12 years (Chiarella and Conover, 1990), with a recorded maximum total length of 1,100 mm and a recorded maximum weight of 12 kg (Robins and Ray, 1986).

Bluefish are one of the dominant marine piscivores along the United States Atlantic coast (Juanes *et al.,* 1996). Both juveniles and adult bluefish consume food at high rates and generally feed on fishes, although invertebrates are also consumed (reviewed in Oliver *et al.*, 1989; Buckel *et al.,* 1999a). The prey biomass consumed annually by bluefish along the U.S. Atlantic coast is estimated to be eight times the biomass of the total bluefish population itself (Buckel *et al.,* 1999b).

A total of 952,386 pounds of bluefish were landed in Florida by the recreational and commercial fisheries during 2001, with the majority being landed on the Atlantic coast (FWC-FMRI, Catch Rate Summary 1990-2002, FWC-FMRI Marine Fisheries Information System). Approximately 92% of the total landings on the Florida Atlantic coast during 2001 were from the recreational fishery (deSilva, 2002).

Two hundred and twenty-six bluefish, ranging from 103 mm to 783 mm SL, were collected from Florida waters. The majority of fish were collected from the Indian River Lagoon and adjacent offshore waters (n = 149), with additional fish collected from Tampa Bay (n = 27) and Charlotte Harbor (n = 25). The remaining 25 fish were collected from Florida Keys/Florida Bay, Tequesta/southern Indian River Lagoon, Volusia County offshore waters, or northeast Florida.

Bluefish collected from the Indian River Lagoon and adjacent offshore waters ranged from 239 mm to 731 mm SL, with a mean standard length of 346 mm. Total mercury levels in bluefish from this area ranged from 0.11 ppm to 1.50 ppm (mean = 0.44 ppm, median = 0.36 ppm). Total mercury levels in bluefish from Tampa Bay ranged from 0.26 ppm to 1.60 ppm, (mean = 0.87 ppm, median = 0.85 ppm) and in bluefish from Charlotte Harbor ranged from 0.28 ppm to 2.00 ppm (mean = 0.87 ppm, median = 0.68 ppm). Although sample sizes were unequal and the number of samples from gulf coast waters were comparatively low, preliminary analyses suggest that bluefish from Tampa Bay and Charlotte Harbor contained significantly higher total mercury levels than did those from the Indian River Lagoon and adjacent offshore waters (Kruskal-Wallis test, $P < 0.001$; Dunn's method, $P < 0.05$). Additional samples from Gulf of Mexico waters are required to fully understand the regional differences in total mercury content for this species. Analyses indicated significant positive correlations between

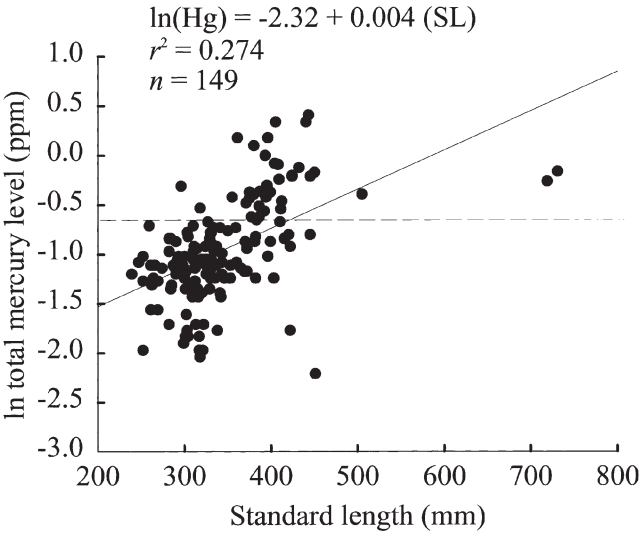


Figure 4. *Relationship between ln total mercury level (ppm) and standard length (mm) of bluefish,* Pomatomus saltatrix, *from the Indian River Lagoon and adjacent offshore waters, Florida. The dashed line represents the anti-log equivalent of the 0.5-ppm threshold level.*

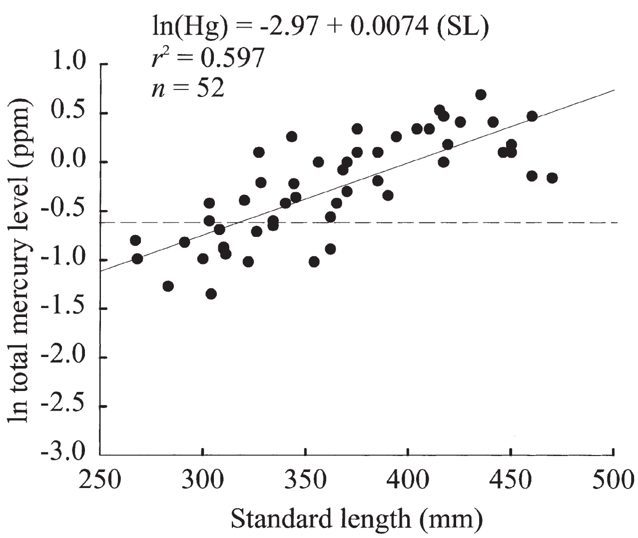


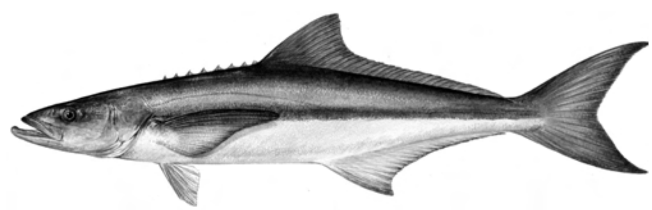
Figure 5. *Relationship between ln total mercury level (ppm) and standard length (mm) of bluefish,* Pomatomus saltatrix, *from central Florida gulf coast waters. The dashed line represents the anti-log equivalent of the 0.5-ppm threshold level.*

total mercury level and fish length in the Indian River Lagoon ($P < 0.0001$) (Figure 4), and in the central gulf coast (Tampa Bay and Charlotte Harbor bluefish results pooled) ($P < 0.0001$) (Figure 5).

Approximately 26% of all bluefish analyzed from the Indian River Lagoon and adjacent offshore waters contained total mercury levels greater than or equal to 0.5 ppm, and 1 individual contained a total mercury level greater than or equal to 1.5 ppm. Ninety percent of bluefish collected from the Indian River Lagoon and adjacent offshore waters were of legal size (≥305 mm FL or 281 mm SL). A total of 29% of legal-size bluefish from this area contained total mercury levels greater than or equal to 0.5 ppm. Approximately 81% of all bluefish analyzed from Tampa Bay contained total mercury levels greater than or equal to 0.5 ppm, and two of those individuals contained a total mercury level greater than or equal to 1.5 ppm. With the exception of one fish, all bluefish sampled from Tampa Bay were of legal size. Sixty-eight percent of all bluefish analyzed from Charlotte Harbor contained total mercury levels greater than or equal to 0.5 ppm, and four of those individuals contained a total mercury level greater than or equal to 1.5 ppm. With the exception of one fish, all bluefish sampled from Charlotte Harbor were of legal size.

In January 2003, DOH issued a health advisory recommending limited consumption of bluefish from all coastal waters of Florida (DOH, 2003).

Cobia
Rachycentron canadum



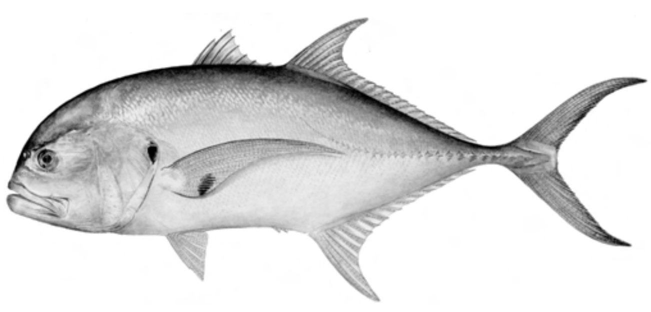
The coastal pelagic species cobia, *Rachycentron canadum,* is widely distributed along the Atlantic and gulf coasts of Florida. These fish are migratory, typically moving southward and/or offshore in response to decreased water temperatures in the fall and winter (Shaffer and Nakamura, 1989; Howse *et al.*, 1992; Franks *et al.*, 1991). Females mature at approximately 2 years of age (Lotz, *et al.*, 1996). In the southeastern United States, this species spawns from April to September (Brown-Peterson *et al.*, 2001). Maximum age observed in the northeastern Gulf of Mexico was estimated to be 9 for males and 11 for females (Franks *et al.*, 1999). Maximum age observed in North Carolina coastal waters was 14 for males and 13 for females (Smith, 1996). Cobia can grow to approximately 1,800 mm in length and up to 68 kg in total weight (Robins and Ray, 1986). Cobia feed on a wide variety of crustaceans, fish, and squid. In the north-central Gulf of Mexico, portunid crabs were the predominant food, with fish becoming more important as the length of cobia increased (Meyer and Franks, 1996).

Cobia is an important recreational species in the waters of the southeastern United States but the commercial fishery in Florida also lands these fish, typically as incidental catch. A total of 1,302,300 pounds of cobia were landed in Florida during 2000; approximately 88% of those were landed by the recreational fishery (FWC-FMRI, 2001; NMFS, Fisheries Statistics and Economic Division, personal communication).

Cobia were principally collected from offshore waters adjacent to the Indian River Lagoon (n = 20) and in Tampa Bay and adjacent offshore waters (n = 11), with the remainder of fish (n = 12) being collected throughout Florida coastal waters. Standard lengths of fish sampled ranged from 362 to 1342 mm. Mercury levels detected in the 43 cobia analyzed during this study ranged from 0.13 to 2.00 ppm. The mean total mercury level for cobia from offshore waters adjacent to the Indian River Lagoon was 0.57 ppm (median = 0.40 ppm). Analysis of cobia from offshore waters adjacent to the Indian River Lagoon revealed a positive correlation between total mercury level and fish length ($P < 0.001$). Approximately 39% of cobia analyzed from Florida waters contained mercury levels greater than or equal to 0.5 ppm. Approximately 14% of all cobia analyzed from Florida waters contained mercury levels greater than or equal to 1.5 ppm. All cobia containing mercury levels greater than or equal to 1.5 ppm were greater than 800 mm SL.

In January 2003, DOH issued a health advisory based on additional results recommending limited consumption of cobia from all coastal waters of Florida (DOH, 2003).

Crevalle jack
Caranx hippos



The crevalle jack, *Caranx hippos,* inhabits Florida's offshore, nearshore, and estuarine waters. The life history of this species is not well known. Crevalle jack probably spawn from April to June (Snelson, 1992) and can attain a total length of approximately 1,500 mm (Robins and Ray, 1986) and a total weight of approximately 23 kg (FWC-FMRI, unpublished data). Crevalle jack have been found to feed on a variety of fish and small invertebrates (Reid, 1954; Darnell, 1958), but data on the feeding habits of this species are limited.

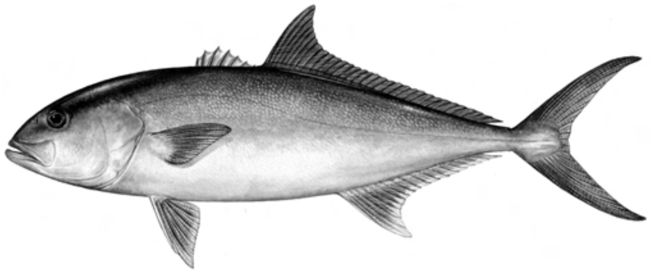
Crevalle jack support both commercial and recreational fisheries in Florida waters. A total of 2,293,200 pounds of crevalle jack were landed in Florida during 2000; approximately 69% of those were landed by recreational fishermen (FWC-FMRI, 2001; NMFS, Fisheries Statistics and Economic Division, personal communication). Fifty-one percent of crevalle jack landings were made on the gulf coast during the 1995–2000 time period (Murphy *et al.,* 2001).

Mercury levels detected in crevalle jack were moderately high in several of Florida's estuarine systems. Crevalle jack were collected in Tampa Bay, the Indian River Lagoon, Charlotte Harbor, Cedar Key, and Florida Keys/Florida Bay. The 169 crevalle jack (152–575 mm standard length) analyzed contained total mercury levels ranging from 0.02 to 3.90 ppm. Mean total mercury levels were comparable for fish from Tampa Bay (mean = 0.61 ppm; median = 0.57 ppm), the Indian River Lagoon (mean = 0.53 ppm; median = 0.54 ppm), and Charlotte Harbor (mean = 0.51 ppm; median = 0.44 ppm); however, levels in crevalle jack from Florida Keys/Florida Bay (mean = 0.97 ppm; median = 0.76 ppm) were noticeably higher (Appendix Table). Mean total mercury levels of fish from the Cedar Key area were lower (mean = 0.28 ppm; median = 0.30 ppm) than in fish from other study areas, but this was likely influenced by the relatively small size of the fish collected in this area (mean = 258 mm SL).

There were no significant correlations detected between total mercury level and fish length for crevalle jack from the Indian River Lagoon ($P > 0.01$) or from Tampa Bay ($P > 0.1$). Analysis of crevalle jack from Florida Keys/Florida Bay revealed a significant positive correlation between total mercury level and fish length ($P < 0.001$). Overall, mean total mercury levels in crevalle jack tested from Florida waters were often greater than or equal to 0.5 ppm. Approximately 54% of all crevalle jack examined in Florida had mercury levels greater than or equal to 0.5 ppm. In the Florida Keys, where the highest mercury burdens were detected, 65% of all crevalle jack had levels greater than or equal to 0.5 ppm.

After reviewing these results, the Florida Department of Health (HRS, 1995) released a health advisory on 6 October 1995 urging limited consumption of crevalle jack from specific Florida waters. In January 2003, DOH issued a health advisory recommending limited consumption of crevalle jack from all coastal waters of Florida (DOH, 2003).

Greater amberjack
Seriola dumerili



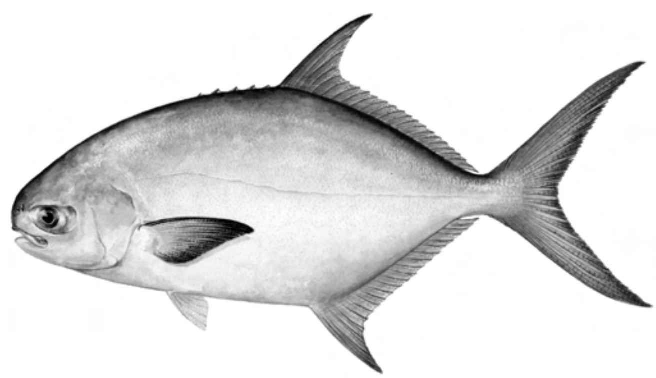
The greater amberjack, *Seriola dumerili,* is a pelagic and epibenthic species that is widely distributed along the Atlantic and gulf coasts of Florida. These fish are often associated with reef habitats, rock piles or ledges, and wrecks in offshore waters. This species spawns during the spring and summer, and the majority of individuals are mature by 3 to 4 years of age (Thompson *et al.,* 1992; reviewed in Cummings and McClellan, 2000). Maximum age observed was estimated to be 17 years (Manooch and Potts, 1997a), and all fish over 9 years of age, at least in the northern Gulf of Mexico, were female (Thompson *et al.,* 1999). Greater amberjack is one of the largest species in the family Carangidae and can grow to over 2,000 mm in length and up to 86 kg in total weight (Manooch and Potts, 1997b).

Greater amberjack are commercially important, as a bycatch of reef fish fisheries as well as a targeted commercial species, and also support a large recreational fishery in the waters of the southeastern United States (McClellan and Cummings, 1997). During the late 1970s, catches and utilization of greater amberjack increased as the species gained popularity as a gamefish and the demand for smoked amberjack meat grew (Cummings and McClellan, 1999). In the recent past, human consumption and overall marketability of this species has varied because of consumer concerns about parasite infestations within the muscle tissue (Berry and Burch, 1979; Manooch and Potts, 1997b) and ciguatera poisoning (Manooch and Potts, 1997b). The current recreational size limit in Florida waters is 28 inches fork length (approximately 711 mm FL), with a bag limit of one fish per person per day. Despite size limits, bag limits, and seasonal closures implemented in the early 1980s, landings in Florida waters have continued to be substantial. A total of 2,769,505 pounds of greater amberjack were landed in Florida during 2000, with 54% of the statewide total being landed by the recreational fishery (Murphy *et al.,* 2001). Between 50% and 70% of Florida landings since 1994 have been from the gulf coast (Murphy *et al.,* 2001). Migrational patterns determined from tag-recapture results (McClellan and Cummings, 1997) and genetic analyses indicate that in the southeastern United States greater amberjack form two subpopulations or stocks: one along the Atlantic coast, including the Florida Keys, and one in the northern Gulf of Mexico (Gold and Richardson, 1998).

A total of 67 greater amberjack were collected in Florida for mercury analysis, with the majority (approximately 61%) being from offshore waters near Volusia County on the Atlantic coast. Standard lengths of fish sampled ranged from 535 to 1,069 mm, and the mean size for all Florida fish was 806 mm. Mercury levels detected in individuals from Volusia County offshore waters ranged from 0.20 to 1.00 ppm and the mean total mercury level from this area was 0.46 ppm with a median of 0.38 ppm. Approximately 40% of greater amberjack tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm. No greater amberjack contained total mercury levels greater than or equal to 1.5 ppm. A total of 88% of greater amberjack collected from Florida waters were of legal size (≥711 mm FL or 647 mm SL). Approximately 42% of all legal-size greater amberjack analyzed in this study contained total mercury levels greater than or equal to 0.5 ppm. Analysis of greater amberjack from Volusia County offshore waters revealed a significant positive correlation between total mercury level and fish length ($P < 0.0001$).

In January 2003, DOH issued a health advisory recommending limited consumption of greater amberjack from all coastal waters of Florida (DOH, 2003).

Florida pompano
Trachinotus carolinus

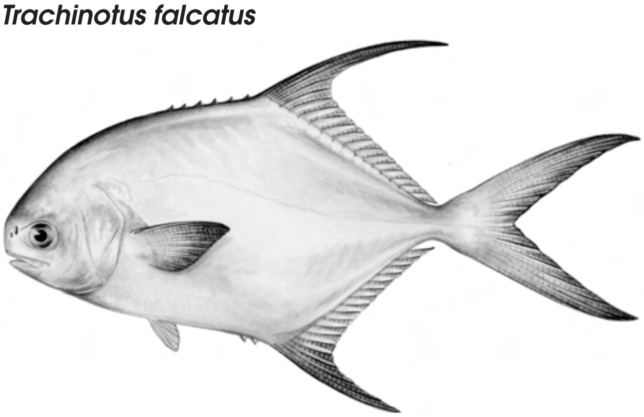


Florida pompano, *Trachinotus carolinus,* are found in Florida's nearshore and estuarine waters. Juvenile Florida pompano inhabit high-energy surf-zone areas but also occur within estuarine waters near oceanic inlets. Adult Florida pompano occur along coastal beaches and within estuaries (Berry and Smith-Vaniz, 1978; FWC-FMRI, 1991–2000), but adults also occur in offshore waters (Cody *et al.,* 2000). Spawning is thought to occur from spring to early fall, likely in offshore waters (Fields, 1962; Finucane, 1969). Florida pompano grow rapidly and can attain a length of approximately 255 mm SL after one year (FWC-FMRI, unpublished data). Most female Florida pompano mature between ages 2 and 3, with males likely maturing during their first year (FWC-FMRI, unpublished data). This species feeds on a wide variety of invertebrates, including amphipods, copepods, shrimps, gastropods, bivalves, and crabs, as well as small fishes (Finucane, 1969; Bellinger and Avault, 1971; Armitage and Alevizon, 1980).

Florida pompano are considered among the finest food-fish species and can yield one of the highest per pound prices of any marine food fish in the United States (Gilbert, 1986a). This species supports important recreational and commercial fisheries in Florida waters. Florida's overall landings totaled 1,160,463 pounds in 2000, with over 58% of total landings made by the recreational fishery (Murphy *et al.*, 2001). Approximately two-thirds of Florida's recreational fishery harvest of Florida pompano is made on the Atlantic coast (Murphy *et al.*, 1996).

Florida pompano were collected from the Indian River Lagoon and adjacent coastal waters (n = 51), Charlotte Harbor (n = 13), Tampa Bay (n = 10), and Florida Keys/Florida Bay (n = 4). Standard lengths of fish sampled ranged from 61 to 412 mm. Mercury levels detected in Florida pompano were typically low. Total mercury levels in individual fish ranged from 0.03 to 0.49 ppm. The mean total mercury levels ranged from 0.10 ppm (median = 0.10 ppm) in the Indian River Lagoon and adjacent coastal waters to 0.23 ppm (median = 0.21 ppm) in Tampa Bay. Analysis of Florida pompano from the Indian River Lagoon area revealed a weak positive correlation between total mercury level and fish length ($P < 0.01$). No Florida pompano collected from Florida waters contained mercury levels greater than or equal to 0.5 ppm.

Permit
Trachinotus falcatus



Permit, *Trachinotus falcatus*, are found in Florida's estuarine and nearshore waters along the central and southern Atlantic coast and the gulf coast. Juvenile permit inhabit high-energy estuarine shorelines, typically over sand-shell bottom (FWC-FMRI, 1991–2000), and along exposed sandy beaches of the gulf and Atlantic coasts of Florida. Adult permit occur near reefs, sand flats, and channels (Berry and Smith-Vaniz, 1978; FWC-FMRI, unpublished data). The biology and life history of permit are not well known. Permit spawn during the late spring and early summer (Armstrong *et al.*, 1996). Age and size at maturity of permit are not known, but preliminary data from Tampa Bay suggest that maturity does not occur until permit reach approximately 400 mm SL (FWC-FMRI, unpublished data). Permit can attain large sizes and have been reported to grow to 1,140 mm total length and 23 kg total weight (Robins and Ray, 1986). No other data regarding age and growth of this species are currently available. This species feeds on a wide variety of invertebrates, including amphipods, shrimps, gastropods, bivalves, and crabs (Randall, 1967; Finucane, 1969; Carr and Adams, 1973).

This species is landed recreationally and commercially, but data concerning the recreational harvest are limited. Florida's overall landings totaled 149,919 pounds in 2000 (Murphy *et al.*, 2001). More than 80% of the total commercial harvest of permit in Florida during 1981–1995 was landed on the gulf coast (Armstrong *et al.*, 1996).

Permit were principally collected from the Florida Keys/Florida Bay (n = 105) and Tampa Bay (n = 34), but a small number of samples were also collected from the Indian River Lagoon system (n = 18) and Charlotte Harbor (n = 6). Standard lengths of fish sampled ranged from 55 to 887 mm. Mercury levels detected in permit were usually low, and fish with relatively high levels were usually larger than the upper "slot limit" length for this species (462 mm SL). Total mercury levels for individual fish ranged from 0.02 to 2.30 ppm. Mean total mercury levels were low for fish in Tampa Bay (mean = 0.15 ppm; median = 0.11 ppm) and in the Indian River Lagoon (mean = 0.22 ppm; median = 0.08 ppm), but were noticeably higher in the Florida Keys/Florida Bay (mean = 0.61 ppm; median = 0.46 ppm).

Analysis of permit from the Florida Keys/Florida Bay area indicated a significant positive correlation between total mercury level and fish length ($P < 0.0001$). Analysis of permit from Tampa Bay revealed no significant correlation between total mercury level and fish length ($P > 0.1$); however, only fish from a limited size range (155–360 mm SL) were sampled from this area. Only one permit from Tampa Bay had mercury levels greater than or equal to 0.5 ppm. Approximately 46% of permit examined from the Florida Keys/Florida Bay area had mercury levels greater than or equal to 0.5

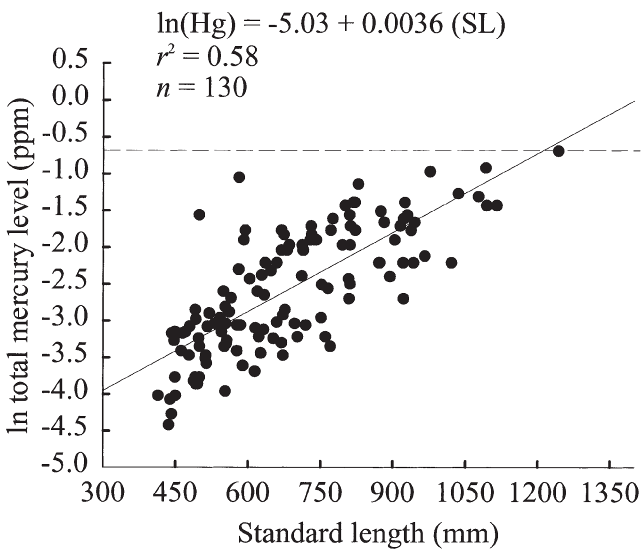
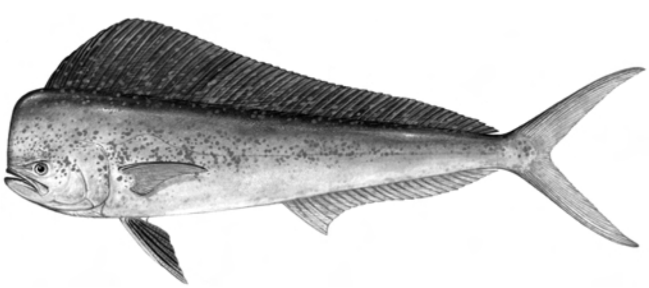


Figure 6. *Relationship between ln total mercury level (ppm) and standard length (mm) of dolphin,* Coryphaena hippurus, *from central Florida Atlantic offshore waters. The dashed line represents the antilog equivalent of 0.5-ppm threshold level.*

ppm. Most of the permit with higher mercury levels (≥0.5 ppm) were larger, presumably adult individuals (>600 mm SL). Approximately 3% of permit examined from the Florida Keys/Florida Bay area had mercury levels greater than or equal to 1.5 ppm.

In January 2003, DOH issued a health advisory recommending limited consumption of permit from Florida Keys/Florida Bay (DOH, 2003).

Dolphin
Coryphaena hippurus



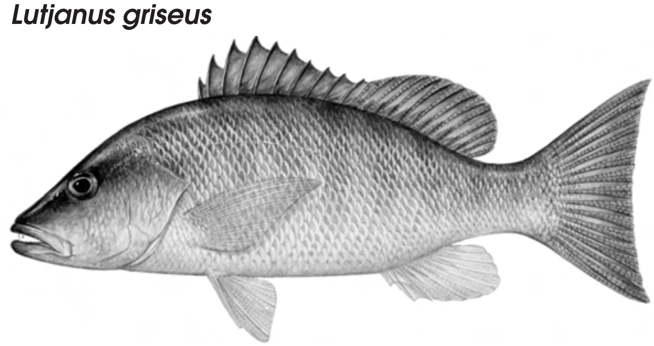
Dolphin, *Coryphaena hippurus,* is an offshore pelagic species found along both coasts of Florida and circumglobally in subtropical and tropical waters. In Florida, the majority of spawning occurs from December to May (Beardsley, 1967; FWC-FMRI, unpublished data). Dolphin first reach sexual maturity at approximately 450–500 mm FL (or approximately 418–465 mm SL) during their first year of growth (FWC-FMRI, unpublished data). Dolphin grow rapidly and can reach a length of 1,100 mm FL (approximately 1023 mm SL) during their first year (Massuti *et al.,* 1999). Current genetic information suggests that dolphin from the Atlantic, U.S. Caribbean, and Gulf of Mexico form one stock (SAFMC, 2000). Dolphin eat a wide variety of offshore fishes (*e.g.,* flying fish, halfbeaks, filefish, triggerfish, sargassumfish, tunas, jacks) and invertebrates (*e.g.,* squids, shrimps) and are also known to be cannibalistic (reviewed in Palko *et al.,* 1982; Manooch *et al.,* 1984; reviewed in SAFMC, 2000).

This species, often called mahi-mahi or dorado, supports significant recreational and commercial fisheries in Florida. A total of 9,344,560 pounds of dolphin were landed in Florida during 2000, with the majority (approximately 71%) being landed along the Atlantic coast (Murphy *et al.,* 2001). The vast majority (approximately 92%) of total landings in Florida are from the recreational fishery (Murphy *et al.,* 2001), similar to the proportion of total landings for recreational fisheries in other parts of the South Atlantic region (SAFMC, 2000). In the U.S. western North Atlantic, the largest percentage of dolphin landings have been reported from the Atlantic coast of Florida to North Carolina (Thompson, 1999).

A total of 205 dolphin, ranging from 410 mm to 1,305 mm SL, were collected from Florida waters for mercury analysis. The greatest number (n = 130) were collected from offshore waters adjacent to the Indian River Lagoon system along Florida's central Atlantic coast. Mercury levels for dolphin in Florida were low in all regions. The mean total mercury level for fish collected along Florida's central Atlantic coast was 0.11 ppm (median = 0.07 ppm). Analysis of dolphin from Florida's central Atlantic coast offshore waters revealed a significant positive correlation between total mercury level and fish length ($P < 0.0001$)(Figure 6).

Only one dolphin tested from Florida waters contained a total mercury level equal to 0.5 ppm. This 1,243 mm SL male (approximately 4 years old), the largest individual collected from offshore waters adjacent to the Indian River Lagoon system, contained 0.5-ppm total mercury.

Gray snapper
Lutjanus griseus



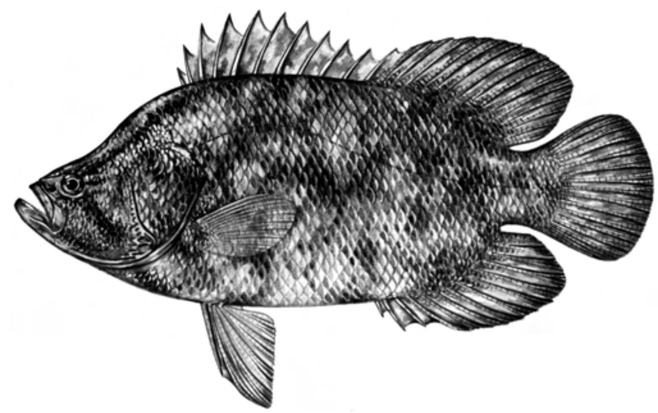
The gray, or mangrove, snapper, *Lutjanus griseus,* inhabits central and south Florida's reef and near-reef areas but also resides in estuarine habitats as adults and juveniles (Stark, 1971; Bortone and Williams, 1986; FWC-FMRI, 1991–2000). Spawning occurs in offshore waters from June to September (Stark, 1971). Both sexes of gray snapper attain sexual maturity at approximately 190 mm SL (Koenig, 1993). This species can live 25 years and grow to 764 mm total length (Johnson *et al.,* 1994). Gray snapper in north Florida waters tend to be larger and older than those caught in the fishery in south Florida (Manooch and Matheson, 1981; Johnson *et al.,* 1994). Along the Atlantic coast of Florida (using Sebastian Inlet [27.8°N latitude] as the north-south dividing line), gray snapper from the north tend to grow to a larger size and live longer than those from the south (Burton, 2001). These latitudinal age and growth differences are likely related to greater fishing pressure on gray snapper in south Florida (Manooch and Matheson, 1981). Gray snapper are opportunistic predators that feed on a variety of fish and crustaceans, but data on the feeding habits of this species are limited (Stark, 1971; Bortone and Williams, 1986).

Gray snapper support major commercial and recreational fisheries in Florida waters. A total of 1,911,450 pounds of gray snapper were landed in Florida during 2000; of those, approximately 64% were landed on the gulf coast (Murphy *et al.,* 2001). Overall landings have been relatively steady since 1982 on the Atlantic coast and since 1985 on the gulf coast, although there has been a slow decline on the gulf coast since 1995 (Murphy *et al.,* 2000).

Gray snapper were collected in Tampa Bay and adjacent offshore waters, the Indian River Lagoon, Charlotte Harbor, and Florida Keys/Florida Bay. A limited number of samples were also collected from Volusia County waters (n = 15) and Tequesta/southern Indian River Lagoon (n = 2). The 301 gray snapper analyzed for levels of total mercury ranged from 104 to 505 mm standard length (SL). The majority (77%) of fish collected from all areas were less than 300 mm SL. Mercury levels detected in gray snapper from Florida waters were usually low. Total mercury levels for individual fish ranged from 0.03 to 0.65 ppm. Mean total mercury levels were low in all study areas: Tampa Bay (mean = 0.23 ppm; median = 0.19 ppm), Indian River Lagoon (mean = 0.19 ppm; median = 0.17 ppm), Charlotte Harbor (mean = 0.13 ppm; median = 0.13 ppm), and Florida Keys/Florida Bay (mean = 0.21 ppm; median = 0.19 ppm) (Appendix Table).

Analyses indicated a positive correlation between total mercury level and fish length ($P < 0.0001$) of gray snapper from the Indian River Lagoon, Charlotte Harbor, and Florida Keys/Florida Bay; however, no large fish (>300 mm SL) were sampled from these areas. There were no significant correlations detected between total mercury level and fish length ($P > 0.01$) of fish from Tampa Bay. Approximately 84% of gray snapper collected from Florida waters were of legal size (≥254 mm TL or 202 mm SL), and of these individuals, approximately 3% contained total mercury levels greater than or equal to 0.5 ppm (n = 8). Overall, only nine gray snapper tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm. Six of these nine fish with levels greater than 0.5 ppm were from the Florida Keys/Florida Bay area.

Tripletail
Lobotes surinamensis



Tripletail, *Lobotes surinamensis,* is a pelagic species found throughout Florida's Atlantic and gulf coasts and globally in tropical and subtropical waters. This species is frequently observed near the surface near floating structure (*e.g.,* sargassum weed, flotsam) as well as in association with buoys, pilings, reefs, and related habitats. Along the U.S. Atlantic coast and in the Gulf of Mexico, this species spawns in offshore waters during spring and summer months (Merriner and Foster, 1974; Ditty and Shaw, 1994; FWC-FMRI, unpublished data). Tripletail grow rapidly during the first few years of life, and preliminary data indicate that this species may reach sexual maturity at age 1 (Armstrong *et al.,* 1996). Based on preliminary estimates, maximum ages for this species are age 6 for males and age 7 for females (FWC-FMRI, unpublished data).

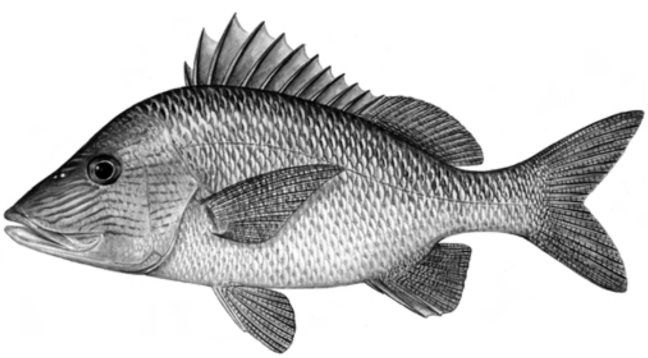
More than 90% of tripletail landings in Florida are from the Atlantic coast. A total of 558,916 pounds of tripletail were landed in Florida during 2000 (FWC-FMRI, 2001).

A total of 114 tripletail, ranging from 270 mm to 620 mm SL, were collected from Florida waters for mercury analysis. Most of these individuals (n = 104) were of legal size (≥381 mm TL or approximately 318 mm SL). The majority were collected from the Indian River Lagoon and adjacent offshore waters (n = 74; mean =

430 mm SL) and from Florida Keys/Florida Bay (n = 39; mean = 378 mm SL). Total mercury levels in tripletail from the Indian River Lagoon and adjacent offshore waters were typically low, ranging from 0.01 ppm to 0.61 ppm (mean = 0.13 ppm; median = 0.11). Although tripletail from Florida Keys/Florida Bay were significantly smaller in length than those collected from the Indian River Lagoon and adjacent offshore waters (*t*-test, $P < 0.001$), total mercury levels in fish from Florida Keys/Florida Bay (mean = 0.27 ppm, median = 0.19 ppm) were significantly higher (Mann-Whitney rank sum test, $P < 0.001$) than those in fish from the Indian River Lagoon and adjacent offshore waters.

Analysis indicated a significant correlation between total mercury level and fish length for tripletail from the Indian River Lagoon and adjacent offshore waters ($P < 0.0001$) and from Florida Keys/Florida Bay ($P < 0.0001$). Approximately 5% of all tripletail examined from Florida waters contained total mercury levels greater than or equal to 0.5 ppm. Of the six tripletail greater than or equal to 0.5 ppm, five were from Florida Keys/Florida Bay. No tripletail examined from Florida waters had a mercury level greater than 0.8 ppm.

White Grunt
Haemulon plumieri

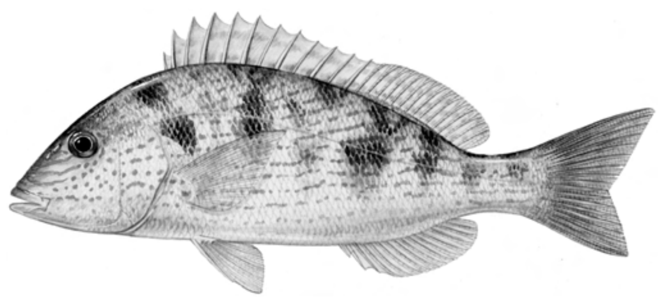


The white grunt, *Haemulon plumieri,* is a coastal species found throughout Florida. Along the U.S. Atlantic coast and in the Gulf of Mexico, this species spawns from spring to early fall, with peak spawning during April, May, and June (Padgett, 1997; Murie and Parkyn, 1999). Female and male white grunts first reach sexual maturity between 180 and 210 mm TL (approximately 143-167 mm SL). All individuals are mature when greater than 250 mm TL (approximately 198 mm SL) and are approximately 2 to 3 years old (Murie and Parkyn, 1999). The maximum age determined for this species is 27 years in the South Atlantic Bight (Padgett, 1997) and 14 years on the gulf coast of Florida (Murie and Parkyn, 1999). White grunt are known to feed upon worms, gastropods, and crustaceans (Böhlke and Chapman, 1968).

This species is commonly landed in Florida recreational and commercial fisheries. The majority of white grunt landings in both fisheries are from the Gulf of Mexico (Murphy *et al.,* 1999). Landings of white grunt in Florida are typically reported as an aggregate with other grunt species (*e.g.,* pigfish, *Orthopristis chrysoptera;* tomtate, *H. aurolineatum;* margate, *H. album*). Total Florida landings of grunts (all species combined) in 2000 were 2,825,451 pounds, with the majority (87%) being landed on the gulf coast (FWC-FMRI, 2001).

A total of 63 white grunts, ranging from 100 mm to 360 mm SL, were collected from Florida waters for mercury analysis. The greatest number (n = 32) were collected from Gulf of Mexico waters offshore from the Tampa Bay area. The mean standard length for fish collected in Gulf of Mexico waters off Tampa Bay was 240 mm. The mean total mercury level for fish collected Gulf of Mexico waters off Tampa Bay was 0.32 ppm (median = 0.31 ppm). Total mercury levels in all areas of Florida ranged from 0.07 ppm to 0.61 ppm. Approximately 11% of white grunts tested from Florida waters contained a total mercury level equal to 0.5 ppm. Analysis of white grunt from Tampa Bay indicated a weak positive correlation between total mercury level and fish length ($P < 0.01$). Additional samples from throughout Florida are required to fully assess mercury levels in this species.

Pigfish
Orthopristis chrysoptera



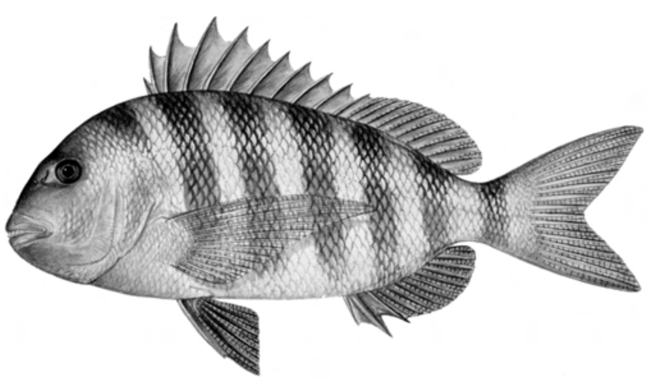
Pigfish, *Orthopristis chrysoptera,* are found in estuarine, nearshore, and offshore waters along Florida's Atlantic and gulf coasts. Adult and juvenile pigfish inhabit a wide range of estuarine habitats, such as seagrass flats, sponge reefs, and channels or basins (Darcy, 1983; Mitchell and Adams, 1993). Adult pigfish also occur in nearshore and offshore areas, including reefs, jetties, offshore platforms, and open-shelf habitats (Darcy, 1983). The biology of pigfish is not well known. Pigfish spawn during the spring in Florida (Springer and Woodburn, 1960, Reid, 1954), mature during the second year (Taylor, 1916; Hildebrand and Cable, 1930), can live for at least four years (Taylor, 1916; Hildebrand and Cable, 1930), and can reach a maximum size of 460 mm standard length (SL) and 0.9 kg (Courtenay and Sahlman, 1978). This species feeds primarily on benthic invertebrates such as amphipods and shrimps (Reid, 1954; Darcy, 1983; Carr and Adams, 1973).

This species is landed recreationally and commercially and is considered to be a good-quality food fish (Darcy, 1983). There is no season, size, or bag limit for this species. Pigfish are also used extensively as live bait by recreational and commercial fishermen. In the Indian River Lagoon system, the commercial hook-and-line fishery for spotted seatrout, *Cynoscion nebulosus,* is dependent upon recruitment of pigfish, which are used as bait. Pigfish landings are typically pooled with other grunt species (*e.g.,* white grunt, *Haemulon plumieri,* and tomtate, *H. aurolineatum*) (Murphy and Muller, 1995). Total Florida landings of grunts (all species combined) in 2000 were 2,825,451 pounds, with the majority (87%) being landed on the gulf coast (FWC-FMRI, 2001).

Pigfish were collected from the Indian River Lagoon (n = 21), Charlotte Harbor (n = 11), Florida Keys/Florida Bay (n = 11), Tampa Bay (n = 7), Choctawhatchee Bay (n = 1), and Volusia County waters (n = 1); sampled pigfish ranged from 107 to 260 mm SL. Mercury levels detected in pigfish were usually low. Total mercury levels in individual fish ranged from 0.02 to 0.66 ppm (Appendix Table). The mean total mercury level for pigfish in the Indian River Lagoon was 0.14 ppm (median = 0.12 ppm). The mean total mercury level for this species in Charlotte Harbor was 0.20 ppm (median = 0.13 ppm). The mean total mercury level for pigfish from Florida Keys/Florida Bay was 0.12 ppm, and the median was 0.12 ppm. Analysis of pigfish from the Indian River Lagoon revealed a weak positive correlation between total mercury level and fish length ($P < 0.01$). Florida-wide, only one pigfish (collected in Charlotte Harbor) tested had a mercury level greater than or equal to 0.5 ppm.

Sheepshead

Archosargus probatocephalus



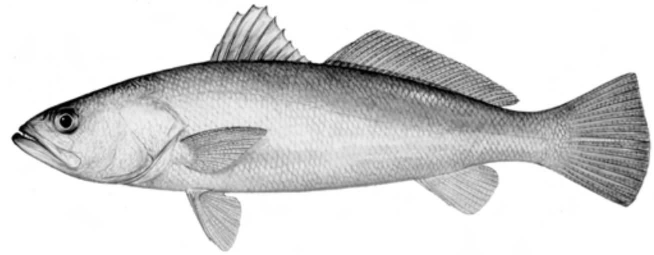
Sheepshead, *Archosargus probatocephalus,* inhabit a wide array of estuarine, nearshore, and offshore habitats along the gulf and Atlantic coasts of Florida. Spawning occurs from February through April (Tucker and Barbera, 1987; Render and Wilson, 1992). Sheepshead grow rapidly to an age of 6–8 years (Beckman *et al.,* 1991), and most are mature by age 2 (Render and Wilson, 1992). Maximum age is at least 20 years old (Beckman *et al.,* 1991). Sheepshead feed on algae and various invertebrates (Ogburn, 1984).

Sheepshead are landed recreationally and commercially in Florida waters. Total Florida landings were 2,874,370 pounds in 2000; of these, approximately 86% were derived from the recreational fishery (Murphy *et al.,* 2001).

Sheepshead were collected in Cedar Key (n = 62), Apalachicola Bay (n = 28), Tampa Bay (n = 27), Florida Keys/Florida Bay (n = 25), Charlotte Harbor (n = 17), Indian River Lagoon (n = 14), and Choctawhatchee Bay (n = 4). The 177 sheepshead analyzed for levels of total mercury ranged from 133 to 470 mm Standard Length. Mercury levels detected in sheepshead from Florida waters were usually low. Total mercury levels for individual fish ranged from 0.06 to 1.10 ppm (Appendix Table). Mean total mercury levels were low in all areas. The highest mean level was 0.24 ppm (median = 0.21), in sheepshead collected in Cedar Key. Mean total mercury levels in fish from all other areas were similar and ranged from 0.15 to 0.21 ppm. Overall, 2.8% of sheepshead (n = 5) tested from Florida waters had a level greater than or equal to 0.5 ppm. The majority (82%) of all sheepshead examined in this study were of legal size (≥305 mm TL or approximately 242 mm SL). Only 2.7% of legal-size sheepshead from Florida waters had a level greater than or equal to 0.5 ppm. Analysis of sheepshead in Tampa Bay ($P > 0.05$) and Apalachicola Bay ($P > 0.1$) indicated there was no significant correlation between total mercury level and fish length; however, significant correlations were detected for sheepshead in Cedar Key ($P < 0.0001$) and Florida Keys/Florida Bay ($P < 0.0001$).

Sand seatrout

Cynoscion arenarius



The sand seatrout, *Cynoscion arenarius,* is reportedly endemic to the Gulf of Mexico and occurs from southwest Florida to the Bay of Campeche, Mexico (Roessler, 1970; Hildebrand, 1955); it is one of the most abundant species in estuarine and nearshore waters of the gulf coast (Christmas and Waller, 1973). Preliminary results from ongoing research at FMRI suggest that this species also occurs on the Atlantic coast of Florida (FWC-FMRI, unpublished data).

Sand seatrout inhabit numerous types of habitat within estuarine and nearshore waters of the gulf. This species spawns during spring and late summer (Moffett *et al.*, 1979), matures during the first year at between 140 and 180 mm TL (approximately 106–143 mm SL) (Shlossman and Chittenden, 1981), and can attain total lengths of up to 590 mm (approximately 523 mm SL) (Trent and Pristas, 1977). Few sand seatrout appear to grow larger than 300 mm TL (approximately 254 mm SL) (Shlossman and Chittenden, 1981).

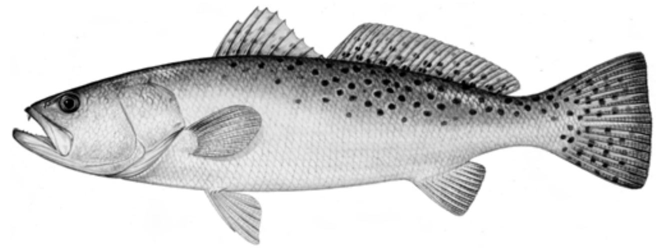
Juvenile sand seatrout feed on mysids, penaeoid shrimp, and copepods; adults feed mostly on small fishes (*e.g.*, bay anchovies, *Anchoa mitchilli;* gulf menhaden, *Brevoortia patronus*) (Reid *et al.*, 1956; Darnell, 1958; Moffett *et al.*, 1979; Sheridan, 1979; Overstreet and Heard, 1982). The diet of the sand seatrout is influenced by location and habitat type (Sheridan, 1979).

In 2000, 5,312 pounds of sand seatrout were commercially landed from Florida gulf coast waters (FWC-FMRI, 2001). An estimated 1,587,181 fish were landed recreationally in Florida during 2000 (FWC-FMRI, 2001).

A total of 104 sand seatrout were collected from areas throughout Tampa Bay, Cedar Key, and Charlotte Harbor for mercury analysis. The majority of samples were collected from the Hillsborough Bay and Safety Harbor regions of the Tampa Bay system. Standard lengths of sampled fish ranged from 145 to 337 mm. Mercury levels detected in sand seatrout from Florida waters were variable. Total mercury levels for individual fish ranged from 0.11 to 1.20 ppm. Mean total mercury levels were 0.46 ppm (median = 0.44 ppm) in Tampa Bay, 0.81 ppm (median = 0.80 ppm) in Charlotte Harbor, and 0.34 ppm (median = 0.32 ppm) in Cedar Key (Appendix Table). The mean total length of sand seatrout analyzed from Charlotte Harbor (283 mm SL) was larger than that of fish from Tampa Bay (224 mm SL) and Cedar Key (266 mm SL). Overall, sand seatrout collected in Charlotte Harbor were significantly larger than those sampled in Tampa Bay (Kruskal-Wallis test, $P < 0.0001$; Dunn's method, $P < 0.05$), and the higher mean total mercury level observed in Charlotte Harbor may be due, in part, to these size differences.

Analysis of sand seatrout from Tampa Bay indicated a weak positive correlation between total mercury level and fish length ($P < 0.01$), but further analyses of fish collected only from the Hillsborough Bay area of Tampa Bay (n = 30 fish) revealed a stronger relationship ($P < 0.001$). Approximately 62% of all sand seatrout analyzed from Florida waters contained levels greater than or equal to 0.5 ppm. No sand seatrout analyzed from Florida waters contained levels greater than or equal to 1.5 ppm.

Spotted seatrout
Cynoscion nebulosus



The spotted seatrout, *Cynoscion nebulosus,* occurs in estuarine and nearshore waters of the gulf and Atlantic coasts of Florida. Juvenile spotted seatrout frequently inhabit shallow seagrass beds in the estuaries where they were spawned (Tabb, 1966; McMichael and Peters, 1989). Adult spotted seatrout spawn from April to October in estuaries throughout Florida. This species matures at one to 4 years of age throughout its range (Klima and Tabb, 1959; Lorio and Perret, 1980). Mature, reproductively active spotted seatrout less than 1 year of age (age 0) have been reported from Florida waters (Crabtree and Adams, 1998). Spotted seatrout grow to 256–287 mm SL by the end of their first year, and females are generally larger than males at any given age (Murphy and Taylor, 1994). The maximum observed age for this species in Florida differs between estuarine areas, ranging from 5 to 9 years for males and from 6 to 8 years for females (Murphy and Taylor, 1994).

Juvenile spotted seatrout feed on mysids, penaeoid shrimp, and small fishes (Darnell, 1958; Carr and Adams, 1973; McMichael and Peters, 1989). Adults feed on shrimp and a wide variety of larger fishes, including mullet, *Mugil* spp.; pigfish, *Orthopristis chrysoptera;* pinfish, *Lagodon rhomboides;* anchovies, *Anchoa* spp.; mojarras, *Eucinostomus* spp.; silversides, *Menidia* spp.; Atlantic croaker, *Micropogonias undulatus;* silver seatrout, *Cynoscion nothus;* and occasionally other spotted seatrout (Darnell, 1958; Adams *et al.* 1973; FWC-FMRI, unpublished data).

This species supports major recreational and commercial fisheries throughout Florida. In 2000, a total of 3,275,700 pounds of spotted seatrout were landed recreationally and commercially from Florida waters, with greater than 80% being landed from the gulf coast (FWC-FMRI, 2001; NMFS, Fisheries Statistics and Economic Division, personal communication). Greater than 95% (by weight) of Florida landings are from the recreational fishery. The greatest fisheries-related impact upon spotted seatrout has historically been from recreational fishing activities (Gilmore, 1995).

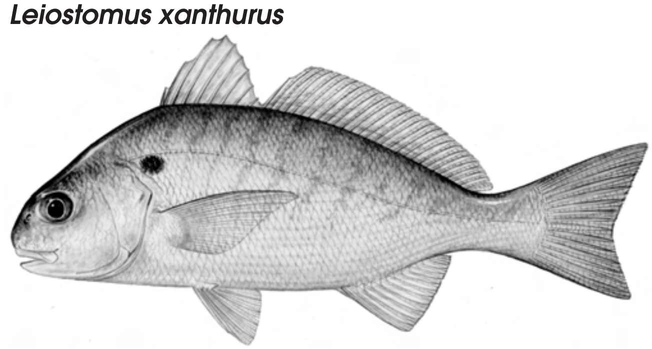
Spotted seatrout used in the mercury analyses (n = 786) were collected from the Indian River Lagoon, Cedar Key, Tampa Bay, Choctawhatchee Bay, Florida Keys/Florida Bay, Charlotte Harbor, and Apalachicola Bay. A limited number of fish were collected from the Everglades (n = 8) and from northeast Florida (n = 5). Standard lengths (SL) of sampled fish ranged from 143 to 680 mm. Mercury levels detected in spotted seatrout from Florida waters were variable, which may be related to the variable diet and growth rate of this species (Rider and Adams, 2000). Total mercury levels for individual fish ranged from 0.02 to 2.50 ppm (Appendix Table). The mean total mercury levels in most study areas were similar, ranging from 0.33 ppm in Apalachicola Bay (median = 0.28 ppm) to 0.47 ppm in the Indian River Lagoon (median = 0.41 ppm). The mean total mercury level was comparatively higher in the Florida Keys/Florida Bay (mean = 0.64 ppm; median = 0.43 ppm), but was only significantly higher than levels from fish from Apalachicola Bay and Tampa Bay (Kruskal-Wallis test, $P < 0.001$; Dunn's method, $P < 0.05$). Approximately 33% of all spotted seatrout tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm. Although the size of fish with mercury levels greater than or equal to 0.5 ppm was variable (252–680 mm SL; mean = 412 mm SL ± 81.1 SD), overall, these fish were significantly larger than those with total mercury levels less than 0.5 ppm (Mann-Whitney rank sum test, $P < 0.0001$).

Of the 786 spotted seatrout collected from Florida waters, 366 fish (approximately 47%) were of legal or harvestable size (326–437 mm SL; 381–508 mm TL, although one fish over 508 mm TL is allowed). Total mercury levels of legal-size fish ranged from 0.03 to 2.3 ppm. Total mercury levels of legal-size spotted seatrout were not significantly different from those of all other fish outside the legal "slot limit" (437 mm SL; 508 mm TL) (Mann-Whitney rank sum test, $P > 0.1$). Anglers in Florida are currently allowed one spotted seatrout greater than the upper size of the "slot limit" (FWC, 2002). Of the 164 spotted seatrout analyzed in this study that were larger than the upper size of the "slot limit," a total of 99 (approximately 60%) had mercury levels greater than or equal to 0.5 ppm.

Analysis of spotted seatrout indicated significant positive correlations between total mercury level and fish length ($P < 0.0001$) in the Indian River Lagoon, Cedar Key, Tampa Bay, Choctawhatchee Bay, and Charlotte Harbor. The relationship between total mercury level and fish length was not as clear for fish collected from Florida Keys/Florida Bay ($P > 0.001$) or from Apalachicola Bay ($P > 0.01$). Within the distribution of spotted seatrout from Florida Keys/Florida Bay, a group was isolated that contained higher levels of mercury than the other fish sampled from this area did. The majority of these "higher-level" fish were collected specifically from the Deer Key area, located in northeastern Florida Bay within the boundaries of the Everglades National Park (latitude ~25°11.113′N; longitude ~80°32.202′W). The spotted seatrout collected from this area of Florida Bay contained comparatively high levels, which may indicate this is a localized area where available mercury is high. Small-scale location effects may contribute to larger-scale regional differences in mercury, as was detected for this species in Florida Keys/Florida Bay. Elevated mercury levels in spotted seatrout from Florida Bay have been documented (Adams and McMichael, 2001; Strom and Graves, 2001), and additional investigations in this area are ongoing.

After reviewing the levels of mercury for this species, the Florida Department of Health released a health advisory on 6 October 1995 (HRS, 1995) urging limited consumption of spotted seatrout from Florida Keys/Florida Bay and from Charlotte Harbor. In January 2003, DOH issued an updated health advisory recommending limited consumption of spotted seatrout greater than 20 inches, or approximately 508 mm TL, from all coastal waters of Florida and limited consumption of all seatrout from Florida Keys/Florida Bay (DOH, 2003).

Spot
Leiostomus xanthurus

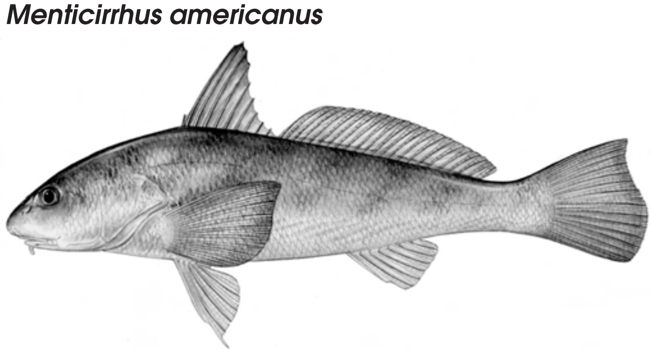


Spot, *Leiostomus xanthurus,* occur in most estuarine and coastal waters of Florida but are rare in Florida Bay and the lower Florida Keys (Chao, 1978; Darovec, 1983; FWC-FMRI, 1991, 1992, 1993, 1994, 1995). Spawning typically occurs in offshore waters from October to March (Springer and Woodburn, 1960; Warlen and Chester, 1985). Sexual maturity is reached at 170–210 mm TL (approximately 133–168 mm SL) at 2–3 years of age (Hildebrand and Schroeder, 1928; Music, 1974; Chao and Musick, 1977). Spot attain a total length of 100–115 mm by age 1 (Welsh and Breder, 1923; Weinstein and Walters, 1981) and can live for up to five years (DeVries, 1982). Juvenile and adult spot feed on infaunal and epibenthic invertebrates (Hales and Van Den Avyle, 1989).

Spot are abundant demersal fish and have historically supported both a commercial fishery and a minor recreational fishery in Florida waters. The elimination of use of entangling gear in July 1995 within Florida waters has significantly reduced or eliminated the traditional commercial fishery for spot (McRae *et al.,* 1997). A total of 92,934 pounds of spot were landed in Florida during 2000, with 82% landed by the commercial fishery (Murphy *et al.,* 2001). The majority (75%) of recorded landings in Florida during 2000 were from the Atlantic coast. Estimates of the recreational landings of this species in Florida are uncertain (Murphy and Muller, 1995; Murphy *et al.,* 2000). In other portions of the south Atlantic region, spot are considered popular sport fish, and recreational landings may exceed commercial landings (Hales and Van Den Avyle, 1989). Spot are also widely used as live bait along the Atlantic coast of Florida, primarily for common snook, *Centropomus undecimalis,* and other large sport fishes (FWC-FMRI, unpublished data). Spot were collected in the Indian River Lagoon (n = 21), Tampa Bay (n = 19) and Choctawhatchee Bay (n = 12). Additionally, nine spot were collected from northeast Florida, six spot were collected from northern Sarasota Bay, and four spot were sampled from Charlotte Harbor. Seventy-one spot, ranging from 101 to 313 mm standard length, were analyzed for total mercury. Total mercury levels for individual fish ranged from 0.02 to 0.46 ppm (Appendix Table). Mean total mercury levels were low in all study areas and were similar in the Indian River Lagoon (mean = 0.12 ppm; median = 0.11 ppm), Tampa Bay (mean = 0.11 ppm; median = 0.11 ppm), and Choctawhatchee Bay (mean = 0.16 ppm; median = 0.14 ppm).

Analyses of spot indicated a positive correlation between total mercury level and fish length in the Indian River Lagoon ($P < 0.0001$). Overall, total mercury levels for this species from Florida waters were low. No spot tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm.

Southern kingfish
Menticirrhus americanus

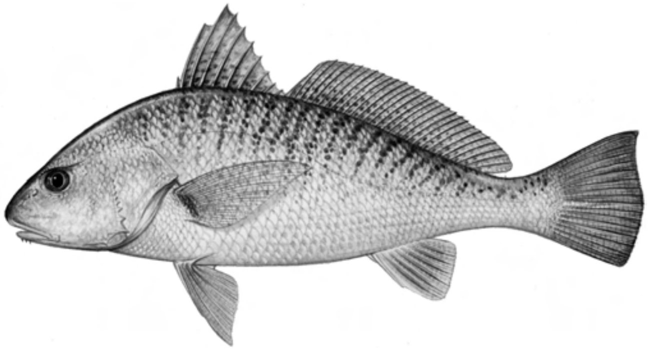


Three species of kingfish are found in Florida, but the southern kingfish, *Menticirrhus americanus,* is the most common inshore species (FWC-FMRI, 1991–2000). Kingfish are often referred to as "whiting." Southern kingfish principally occur in estuarine and nearshore areas over a wide array of habitat types (Irwin, 1970; McMichael and Ross, 1987; FWC-FMRI, 1991–2000). Spawning occurs principally in offshore waters (Irwin, 1970) from April to August in Florida (Reid, 1954), but year-round spawning has been documented in southern Florida waters (Jannke, 1971). Southern kingfish grow rapidly, and males mature during the first year at approximately 140–180 mm TL (110–145 mm SL) and females at approximately 150–220 mm TL (120–180 mm SL) (Smith and Wenner, 1985; Harding and Chittenden, 1987). Southern kingfish feed on infaunal and epibenthic invertebrates and small fishes (McMichael, 1981; Music and Pafford, 1984).

Southern kingfish are landed commercially and recreationally in Florida waters. Florida commercial kingfish landings ranged between 500,000 and 1,200,000 pounds per year from 1986 to 1995, and recreational landings ranged from 350,000 to 3,000,000 pounds per year during the same time period (Armstrong and Muller, 1996). A total of 1,800,000 pounds of kingfish were landed in Florida waters during 2000 (Murphy *et al.,* 2001). Approximately 75% of overall kingfish landings in Florida were southern kingfish (Armstrong and Muller, 1996).

Southern kingfish ranging from 121 to 348 mm standard length were collected in Tampa Bay (n = 25), northeast Florida (n = 19),and the Indian River Lagoon (n = 18). Additional southern kingfish were also sampled from Charlotte Harbor (n = 7), Cedar Key (n = 6), and Apalachicola Bay (n = 1). Mercury levels detected in southern kingfish from Florida waters were usually low. Total mercury levels for individual fish ranged from 0.02 to 0.78 ppm (Appendix Table). Mean total mercury levels were low in Tampa Bay (mean = 0.19 ppm; median = 0.16 ppm), in northeast Florida (mean = 0.13 ppm; median = 0.10 ppm), and in the Indian River Lagoon (mean = 0.08 ppm; median = 0.07 ppm). Only four southern kingfish from Florida waters (approximately 7.3%) had levels greater than or equal to 0.5 ppm. There was no apparent correlation between length and mercury level for southern kingfish from Tampa Bay ($P > 0.1$), but only a limited size range of fish was available from this area. Additional samples from throughout Florida are required to fully assess mercury levels in this species.

Atlantic croaker
Micropogonias undulatus

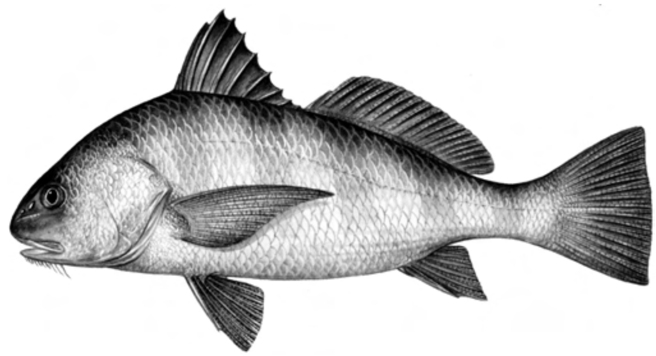


Atlantic croaker, *Micropogonias undulatus,* are found in estuarine and nearshore areas along Florida's Atlantic and gulf coasts, principally in central and northern Florida waters. Juvenile Atlantic croaker inhabit a wide range of estuarine habitats and move to nearshore areas as they grow. Adult Atlantic croaker occur in nearshore areas from the surf zone out to continental shelf waters and also seasonally inhabit estuarine areas in central and northern Florida. Atlantic croaker have a protracted spawning period, extending from July to December in Chesapeake Bay and Mid-Atlantic Bight (Barbieri *et al.,* 1994b; Morse, 1980) and possibly into early spring in both the South Atlantic Bight (Warlen, 1982) and Gulf of Mexico (Pearson, 1929; Gunter, 1938b). Little is known regarding the reproductive biology of this species in Florida, but spawning, inferred from the timing of recruitment of young-of-the-year fish, occurs during fall and winter. Atlantic croaker mature by the end of the first year or during the second year (Barbieri *et al.,* 1994b) and can live for up to 8 years (Barger, 1985; Barbieri *et al.,* 1994a). The feeding habits of this species can change during their lifetime, but a variety of benthic invertebrates are important in their diet (Darnell, 1958, 1961).

A total of 409,443 pounds of Atlantic croaker were recreationally and commercially landed in Florida during 2000, with the majority (67%) of landings from the Atlantic coast (Murphy *et al.,* 2001). Atlantic croaker are also used extensively as live bait by recreational fishermen targeting a variety of species. Along the central-east coast of Florida, Atlantic croaker are highly sought after and are often the preferred live bait used in the recreational fishery for common snook, *Centropomus undecimalis.*

Atlantic croaker were collected from northeast Florida (n = 23) and the Indian River Lagoon (n = 21), with a limited number of fish collected from Tampa Bay (n = 2) and Cedar Key (n = 1). Standard lengths of the 47 Atlantic croaker in this study ranged from 89 to 385 mm. Mercury levels detected in Atlantic croaker were low. Total mercury levels for individual fish ranged from 0.02 to 0.18 ppm (Appendix Table). The mean total mercury level for this species in northeast Florida was 0.06 ppm (median = 0.05 ppm). The mean total mercury level for Atlantic croaker in the Indian River Lagoon was also 0.06 ppm (median = 0.04 ppm). Analysis of Atlantic croaker from the Indian River Lagoon revealed a positive correlation between total mercury level and fish length ($P < 0.01$). There was no apparent correlation between length and mercury level for fish from northeast Florida ($P > 0.1$), but only a limited size range of fish was available from this area. All Atlantic croaker tested from Florida waters had a mercury level less than 0.2 ppm.

Black drum
Pogonias cromis



Black drum, *Pogonias cromis,* inhabit estuarine and nearshore waters of the gulf and Atlantic coasts of Florida and range from New England to Argentina (Bigelow and Schroeder, 1953). Distinct subpopulations of black drum occur in the Gulf of Mexico and western Atlantic Ocean (Gold and Richardson, 1998). Results from tagging studies have indicated that black drum do not frequently move long distances between estuaries (Topp, 1963; Beaumariage, 1964, 1969; Osburn and Matlock, 1984), although this species is capable of extensive, long-range migrations (Murphy *et al.,* 1998).

Black drum spawn during the winter and early spring (Murphy and Taylor, 1989) in estuaries and open coastal waters (Simmons and Breuer, 1962; FWC-FMRI, unpublished data). Black drum are multiple spawners and produce large numbers of eggs during each spawning event, with the mean batch fecundity of an average-size female (6.1 kg total weight) estimated to be 1.6 million hydrated oocytes (Fitzhugh *et al.,* 1993). Juvenile black drum are found in estuarine creek and river habitats, typically over unvegetated mud substrates (Pearson, 1929; Peters and McMichael, 1990). Adults inhabit estuaries and nearshore shelf waters (Sutter *et al.,* 1986). Males begin maturing when they are 366–486 mm SL (2–5 years old), and females typically begin maturing at sizes greater than 538 mm SL (approximately 5 years old) (Murphy and Taylor, 1989; Nieland and Wilson, 1993). This large sciaenid can grow to 66 kg (Bigelow & Schroeder, 1928) and have a lifespan of approximately 60 years (Murphy and Taylor, 1989; Jones and Wells, 1998).

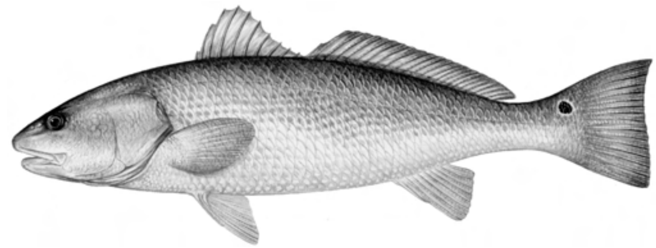
Juvenile black drum feed on bivalves, gastropods, amphipods, shrimps, and small fishes (Music and Pafford, 1984; Peters and McMichael, 1990). Adults consume bivalves, shrimps, crabs, and related benthic prey (Music and Pafford, 1984; FWC-FMRI, unpublished data). Black drum have strong pharyngeal teeth capable of crushing hard invertebrate shells. Stomachs of black drum examined during this mercury study often contained large amounts of crushed bivalve shell material and crab exoskeletons.

Black drum are caught by recreational and commercial fishermen throughout Florida, but the majority of fish are landed along the northeast and central Atlantic coast. Recreational fishermen accounted for 98% of the total landings of this species during 2000 (Murphy *et al.,* 2001). The black drum fishery along the Atlantic coast of Florida typically targets small, young fish (FWC-FMRI, unpublished data), but large (>800 mm SL), older fish are landed seasonally by recreational fishermen in this region. A total of 1,342,343 pounds of black drum were landed in Florida during 2000, which was more than double the total landed in 1999 (Murphy *et al.,* 2001).

A total of 71 black drum from Florida waters were used in mercury analyses. Black drum were principally collected in the Indian River Lagoon area and adjacent nearshore waters (n = 36) and Tampa Bay (n = 23). Standard lengths of sampled fish ranged from 193 to 1,049 mm. Mercury levels detected in black drum from Florida waters were typically low. Total mercury levels for individual fish ranged from 0.01 to 0.65 ppm. Mean total mercury levels were 0.14 ppm (median = 0.13 ppm) in the Indian River Lagoon area and 0.24 ppm (median = 0.21 ppm) in Tampa Bay (Appendix Table).

Approximately 91% of the black drum collected for mercury analysis were larger than the legal minimum size for this species in Florida (285 mm SL; 356 mm TL). Only one black drum tested contained a total mercury level greater than or equal to 0.5 ppm. This fish was the largest individual analyzed in this study (a 1049 mm SL adult collected in the nearshore waters adjacent to the Indian River Lagoon). Analyses indicated significant positive correlations between total mercury level and fish length ($P < 0.0001$) for black drum from the Indian River Lagoon area and from Tampa Bay. Although there was a positive correlation between mercury level and fish size, mercury levels in black drum collected in Florida, even in large, mature individuals, were usually low.

Red drum
Sciaenops ocellatus



The red drum, *Sciaenops ocellatus,* inhabits estuarine and nearshore waters of the gulf and Atlantic coasts of Florida. Adult red drum spawn during late summer and fall. Spawning occurs near inlets, bay entrances, inside estuaries, and in nearshore continental shelf waters (Mercer, 1984; Peters and McMichael, 1987). Red drum in the Indian River Lagoon system on the Atlantic coast of Florida are also capable of spawning in estuarine waters far from oceanic inlets (Murphy and Taylor, 1990; Johnson and Funicelli, 1991). Juvenile red drum are found in a wide range of estuarine habitats, including shallow seagrass beds, unvegetated mud-sand bottom, rivers, canals, boat basins, and creeks (Tabb, 1966; Mercer, 1984; Peters and McMichael, 1987; Adams and Tremain, 2000). Juveniles and larger subadults may also move into nearshore continental shelf waters during winter months (Mercer, 1984). Adults inhabit estuaries and nearshore shelf waters (Mercer, 1984; Murphy and Taylor, 1990). Males mature when they are 292–706 mm SL (1–3 years old), and females mature at 477–798 mm SL (3–6 years old) (Murphy and Taylor, 1990). Red drum grow rapidly through age 5 and then growth slows as the fish approach maturity. Similar growth rates have been observed for red drum on the gulf and Atlantic coasts of Florida (Murphy and Taylor, 1990). The maximum observed ages for this species in Florida were 24 years on the gulf coast and 33 years on the Atlantic coast (Murphy and Taylor, 1990). Red drum have been reported to live up to 56 years elsewhere along the U.S. Atlantic coast (Ross *et al.,* 1995).

Juvenile red drum feed on mysids, amphipods, polychaetes, and shrimp (Peters and McMichael, 1987). As juvenile red drum grow, they shift to the adult diet of shrimp, crabs, and fishes (Miles, 1950; FWC-FMRI, unpublished data).

Red drum are highly sought by recreational fishermen throughout Florida. This species was landed commercially until 1989, when regulatory actions made the sale of native red drum illegal. Landings of red drum in Florida have been generally stable since 1989, when current fisheries regulations were issued (Murphy *et al.,* 2001). Florida-wide recreational landings

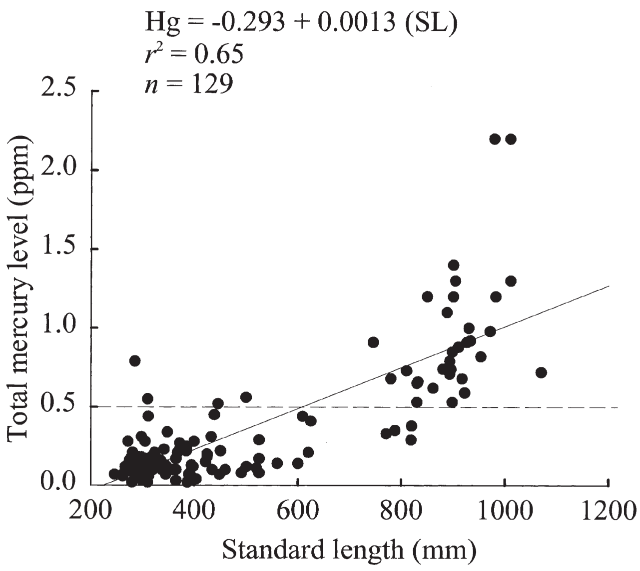


Figure 7. *Relationship between total mercury level (ppm) and standard length (mm) of red drum,* Sciaenops ocellatus, *from the Indian River Lagoon, Florida. The dashed line represents the 0.5-ppm threshold level.*

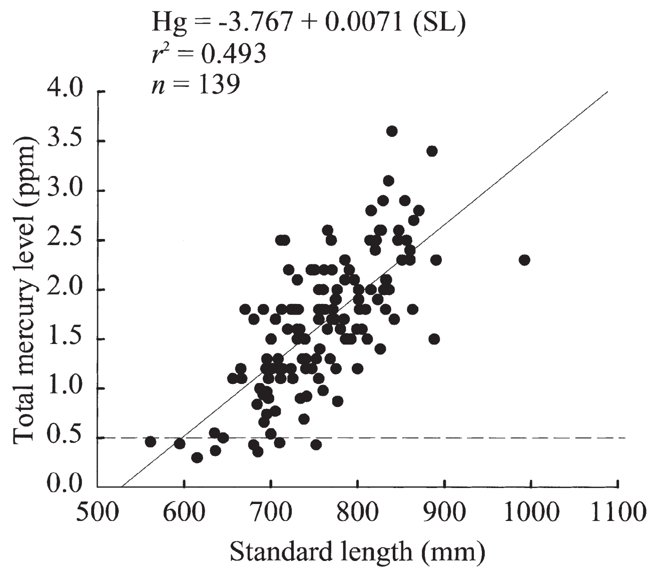


Figure 8. *Relationship between total mercury level (ppm) and standard length (mm) of red drum,* Sciaenops ocellatus, *from offshore waters adjacent to Tampa Bay, Florida. The dashed line represents the 0.5-ppm threshold level.*

totaled 553,320 fish (2,540,076 pounds) in 2000 (Murphy *et al.*, 2001).

Red drum (n = 682) used in mercury analyses were principally collected in Tampa Bay and adjacent coastal waters, Indian River Lagoon, Cedar Key, Apalachicola Bay, Florida Keys/Florida Bay, and Charlotte Harbor. Additional red drum were also collected in Choctawhatchee Bay (n = 15) and the Florida Everglades (n = 15). Standard lengths (SL) of sampled fish ranged from 180 to 1,070 mm. Mercury levels detected in red drum from Florida waters were variable but usually low in most areas. Total mercury levels for individual fish ranged from 0.02 to 3.60 ppm. The mean total mercury levels in all fish (juveniles and adults) from Florida study areas except Tampa Bay ranged from 0.18 ppm in Cedar Key (median = 0.18 ppm) to 0.48 ppm Florida Keys/Florida Bay (median = 0.35 ppm); the mean total mercury level from the Tampa Bay area was 1.10 ppm (median = 0.98 ppm) (Appendix Table). The higher mean total mercury level observed for fish from the Tampa Bay area was related to the fact that more than 59% of these fish were large (>565 mm SL), reproductively active adults from offshore waters. Of the red drum collected for mercury analysis, 257 fish (approximately 38%) were of legal, or slot-limit, size (374–565 mm SL; 457–689 mm TL). Total mercury levels of legal-size fish ranged from 0.02 to 2.70 ppm. Mean total mercury levels of legal-size red drum were relatively low (mean = 0.17–0.30 ppm) in most study areas tested, but the mean total level in Florida Keys/Florida Bay (mean = 0.52 ppm; median = 0.35 ppm) was higher. Overall, approximately 8% of legal-size red drum had mercury levels greater than or equal to 0.5 ppm.

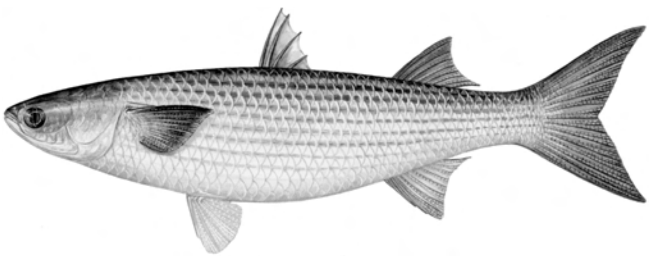
One hundred and thirty-nine large, reproductively active, adult red drum were collected from coastal waters offshore of the Tampa Bay area. These adult fish ranged from 561 to 992 mm SL (mean = 761 mm SL), and all but one of these fish were larger than 565 mm SL (the upper size of the "slot limit" for Florida red drum). Total mercury levels for individual offshore red drum ranged from 0.30 to 3.60 ppm. The mean total mercury level for these fish was 1.67 ppm (median = 1.70 ppm). Approximately 94% (n = 131) of all offshore red drum adults tested contained levels greater than or equal to 0.5 ppm, and 64% (n = 89) contained levels greater than or equal to 1.5 ppm. All offshore adult red drum with high mercury levels (≥1.5 ppm) were 670 mm SL or larger in length.

Analysis indicated significant correlations between total mercury level and fish length for red drum from the Tampa Bay area ($P < 0.0001$), Cedar Key ($P < 0.0001$), the Indian River Lagoon ($P < 0.0001$) (Figure 7) and Apalachicola Bay ($P < 0.001$). No significant correlation was detected between total mercury level and fish length for red drum from the Florida Keys/Florida Bay area ($P > 0.01$). Red drum collected specifically from offshore waters near the Tampa Bay area displayed a significant positive correlation between total mercury levels and fish length ($P < 0.0001$) (Figure 8). The majority of high mercury levels were found in fish larger than or near the maximum length of the "slot limit" for this species. With the exception of one smaller fish (527 mm

SL), all red drum with total mercury levels greater than or equal to 1.5 ppm were large fish (mean = 791 mm SL) that would not be consumed by humans because of current size regulations in Florida.

In January 2003, DOH issued a health advisory recommending limited consumption of red drum from Florida Keys/Florida Bay (DOH, 2003).

Striped mullet
Mugil cephalus

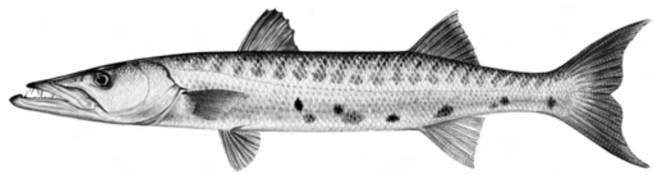


The striped mullet, *Mugil cephalus,* is one of the most abundant and widespread inshore species in the southeastern United States (Odum, 1970) and occurs in a variety of Florida estuarine and coastal water habitats (Collins, 1985; FWC-FMRI, 1991–2000). Only one genetic stock of this species occurs in Florida coastal waters (Campton and Mahmoudi, 1991). Spawning typically occurs from October to February (Anderson, 1958). Although inshore spawning has been reported (Breder, 1940), the majority of spawning has been documented in offshore waters (Anderson, 1958; Arnold and Thompson, 1958; Finucane *et al.,* 1978). Females reach sexual maturity at approximately 2–3 years of age (Leard *et al.,* 1995). Striped mullet feed on epiphytic and benthic microalgae, macrophyte detritus, and inorganic sediment particles (Collins, 1981, 1985).

This economically and ecologically important species is harvested by commercial and recreational fishermen throughout Florida. A total of 10,496,936 pounds of striped mullet were landed in Florida during 2000 (FWC-FMRI, 2001; NMFS, Fisheries Statistics and Economic Division, personal communication). Striped mullet are also widely used as live bait or cut bait throughout Florida (FWC-FMRI Angler Interview data, unpublished).

Striped mullet used in mercury analyses were collected mostly from Tampa Bay (n = 28), Cedar Key (n = 15), and the Indian River Lagoon (n = 14). Additional striped mullet were sampled from Charlotte Harbor (n = 7), Choctawhatchee Bay (n = 4), and the Florida Keys/Florida Bay (n = 3). The standard length of these fish ranged from 155 to 469 mm. Mercury levels detected in striped mullet from Florida waters were usually low. Total mercury levels for individual fish ranged from 0.01 to 0.78 ppm and were similar in Tampa Bay (mean = 0.08 ppm; median = 0.04 ppm), Cedar Key (mean = 0.02 ppm; median = 0.02 ppm), and the Indian River Lagoon (mean = 0.06 ppm; median = 0.04 ppm) (Appendix Table). Analysis of striped mullet from Tampa Bay suggested that there was no significant correlation between total mercury level and fish length ($P < 0.1$). There were not enough samples of striped mullet from the other study areas for us to determine relationships between mercury levels and fish size. Only one striped mullet tested from Florida waters (collected in Tampa Bay) had total mercury levels greater than or equal to 0.5 ppm.

Great barracuda
Sphyraena barracuda



Great barracuda, *Sphyraena barracuda,* occur in all tropical and subtropical seas except the eastern Pacific (deSylva, 1963). In Florida, barracuda are found in estuarine, nearshore, and offshore waters along the Atlantic and the gulf coasts, with highest abundances in the southern areas of the state. Juvenile barracuda occupy nearshore and estuarine seagrass or mangrove habitats but presumably move offshore at maturity (deSylva, 1963; Blaber, 1982; FWC-FMRI, 1991–2001). Adults are found principally around coral reefs, rock outcroppings, or artificial structures (Paterson, 1998). Spawning is thought to occur during the spring and summer in offshore waters (deSylva, 1963; Blaber, 1982; FWC-FMRI, unpublished data). Both male and female barracuda mature at approximately age 2 (FWC-FMRI, unpublished data). Barracuda feed almost entirely on fish throughout their life history (deSylva, 1963; Williams, 1965; Fahs, 1976; Schmidt, 1989).

Although great barracuda have been associated with ciguatera toxin poisonings in the region (Stewart, 1990 and references therein), this species is landed recreationally and commercially in Florida waters. In the recreational fishery, a total of 624,940 pounds of great barracuda were landed on the Florida Atlantic coast and 258,611 pounds were landed on the Florida gulf coast during 2000 (NMFS, Fisheries Statistics and Economic Division, personal communication). A total of 126,910 pounds of great barracuda were landed by the commercial fishery in Florida waters during 2000 (FWC-FMRI, 2001).

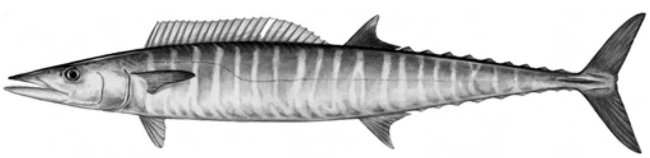
The majority of the 85 great barracuda analyzed in this study were collected from the Florida Keys/Florida Bay (n = 62) and the Indian River Lagoon (n = 19).

Standard lengths of fish sampled ranged from 119 to 1,096 mm. Total mercury levels for individual fish ranged from 0.08 to 3.10 ppm. The mean total mercury level for great barracuda from the Florida Keys/Florida Bay was 0.87 ppm (median = 0.72 ppm). The mean total mercury level for fish from the Indian River Lagoon was lower (mean = 0.16 ppm; median = 0.16 ppm); however, comparatively smaller fish (mean = 358 mm SL; range = 213–488 mm SL) were examined from this area. Fish collected from the Florida Keys/Florida Bay area were larger and covered a broader size range (mean = 628 mm SL; range = 119–1096 mm SL) than those examined from the Indian River Lagoon.

Analysis of great barracuda from the Florida Keys/Florida Bay area indicated a significant positive correlation between total mercury level and fish length ($P < 0.0001$), which indicates that mercury levels tend to increase as great barracuda grow. Approximately 56% of great barracuda analyzed from Florida waters contained mercury levels greater than or equal to 0.5 ppm. Eight percent of great barracuda analyzed from Florida waters contained mercury levels greater than or equal to 1.5 ppm. All fish containing total mercury at or above 1.5 ppm were large individuals (750–1,096 mm SL).

In January 2003, DOH issued a health advisory recommending limited consumption of great barracuda from Florida Keys/Florida Bay (DOH, 2003).

Wahoo
Acanthocybium solanderi



The wahoo, *Acanthocybium solanderi,* is an offshore pelagic species with a global distribution in tropical and subtropical waters. The biology of wahoo is not well understood, but FWC-FMRI is currently examining the life history characteristics of this species in Florida waters. Wahoo in the subtropical Atlantic and Gulf of Mexico are thought to spawn during summer months (Wollam, 1969; Hogarth, 1976), but preliminary data from the northern Gulf of Mexico and Bahamas suggests the possibility that limited spawning occurs in the early spring (Brown-Peterson *et al.,* 2000). Very little is known regarding the abundance and distribution of wahoo, but they are caught year round in Florida waters (SAFMC, 1998), with peak catches occurring during summer months (FWC-FMRI, 2001). Wahoo can attain a length of approximately 2,100 mm and a total weight of 83 kg (FWC-FMRI, unpublished data).

Preliminary results from a recent genetics study strongly suggest that wahoo in the Gulf of Mexico and off the U.S. Atlantic coast comprise one population (J. Franks, personal communication, Gulf Coast Research Laboratory, Ocean Springs, MS). Wahoo feed principally on pelagic fishes (*e.g.,* flying fish, *Cypselurus* spp.; ballyhoo, *Hemiramphus brasiliensis;* porcupinefish, *Diodon hystrix*) and, to a lesser extent, invertebrates (*e.g.,* squids) (Manooch and Hogarth, 1983; FWC-FMRI, unpublished data).

Wahoo are an important recreational and commercial species in Florida waters. In the recreational fishery, a total of 441,385 pounds of wahoo were landed on the Florida Atlantic coast and 92,620 pounds were landed on the Florida gulf coast during 2000 (NMFS, Fisheries Statistics and Economic Division, personal communication). A total of 55,003 pounds of wahoo were landed by the commercial fishery in Florida waters during 2000 (FWC-FMRI, 2001). The majority of commercially caught wahoo are landed as incidental catch from fisheries targeting other pelagic species (SAFMC, 2000).

A total of 61 wahoo were collected for mercury analysis from offshore waters of the Florida Atlantic and Gulf coasts. The majority of fish were collected in offshore waters adjacent to the Indian River Lagoon (n = 30) and offshore waters adjacent to Apalachicola Bay (n = 16). All wahoo sampled were of harvestable size, ranging from 845 to 1,338 mm SL. Total mercury levels for individual fish ranged from 0.04 to 1.40 ppm. The mean total mercury level for fish collected offshore from the Indian River Lagoon area was 0.27 ppm (median = 0.23 ppm). Eighteen percent of all wahoo tested from Florida had total mercury levels greater than or equal to 0.5 ppm, and no wahoo contained total mercury levels greater than 1.5 ppm. Analysis of wahoo from offshore waters adjacent to the Indian River Lagoon indicated a significant positive correlation between total mercury level and fish length ($P < 0.0001$).

In January 2003, based on additional data from south Florida, DOH issued a health advisory recommending limited consumption of wahoo from Florida Keys/Florida Bay (DOH, 2003).

King mackerel
Scomberomorus cavalla

The king mackerel, *Scomberomorus cavalla,* is a coastal pelagic species that is widely distributed along the Atlantic and gulf coasts. In Florida, the majority of spawning occurs from May through September, but there is some evidence that spawning occurs as early as April and as late as October (McEachran *et al.*, 1980; Finucane *et al.*, 1986). Little is known regarding the distribution and abundance of juvenile king mackerel, although juveniles have been documented to occur in both nearshore and offshore areas (Wollam, 1970; Dwinell and Futch, 1973; Collins and Wenner, 1988). Maximum age observed was 12 years for males and 14 years for females (Johnson *et al.*, 1983). Males mature at 4 years of age and approximately 718 mm fork length (FL) (Beaumariage, 1973). Females mature at 5–6 years of age and at 850–899 mm FL (Finucane *et al.*, 1986). King mackerel can attain a length of 1,725 mm FL and a total weight of 37.2 kg (Beaumariage, 1973). King mackerel feed principally on schooling fishes (*e.g.*, ballyhoo, *Hemiramphus brasiliensis;* scaled sardine, *Harengula jaguana;* and Atlantic thread herring, *Opisthonema oglinum*) and various invertebrates, including shrimp and squid (Beaumariage, 1973; Saloman and Naughton, 1983).

The king mackerel is an important commercial and recreational species throughout Florida. A total of 8,116,039 pounds of king mackerel were landed in Florida during 2000 (FWC-FMRI, 2001; NMFS, Fisheries Statistics and Economic Division, personal communication). Historical records indicate that approximately 90% of the total United States catch of this species has been landed in Florida (Godcharles and Murphy, 1986). Migration patterns and recent genetic studies indicate that in the southeastern United States, king mackerel form two stocks, one along the Atlantic coast and one in the Gulf of Mexico (Sutherland and Fable, 1980; Sutter *et al.*, 1991; Johnson *et al.*, 1993; Gold *et al.*, 1996).

A total of 142 king mackerel were collected in Florida for mercury analysis, with the majority being from offshore waters of the gulf coast of Florida. Fork lengths of fish sampled ranged from 620 to 1,378 mm, and the mean size for all Florida fish was 1,020 mm. All king mackerel sampled were of legal or harvestable size. Mercury levels detected in king mackerel from Florida waters were usually high. Total mercury levels for individual fish ranged from 0.19 to 4.00 ppm. The mean total mercury level for king mackerel from offshore waters of the gulf coast in the Tampa Bay region was 1.56 ppm (median = 1.35 ppm). Approximately 82% of all king mackerel tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm, and approximately 46% had total mercury levels greater than or equal to 1.5 ppm. King mackerel with high mercury levels (>1.5 ppm) were typically large individuals (mean = 1,156 mm FL). Analysis of king mackerel from central gulf coast waters indicated a significant positive correlation between total mercury level and fish length ($P < 0.0001$) (Figure 9).

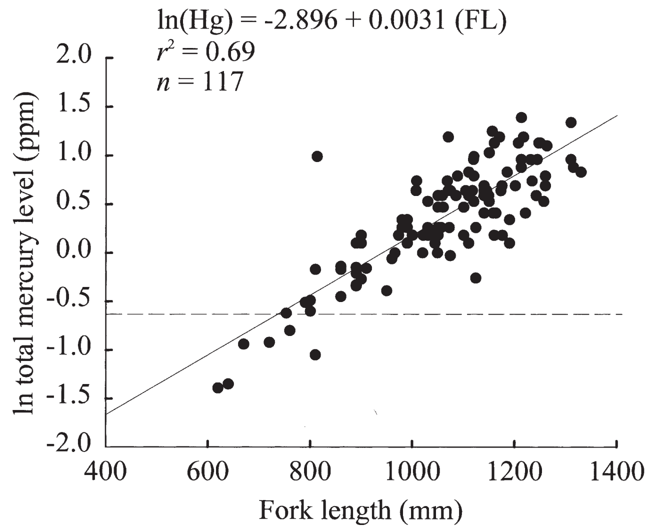


Figure 9. *Relationship between ln total mercury level (ppm) and fork length (mm) of king mackerel,* Scomberomorus cavalla, *from the central Florida gulf coast. The dashed line represents the antilog equivalent of the 0.5-ppm threshold level.*

A similar study conducted by the National Marine Fisheries Service (NMFS) also detected elevated levels of mercury in king mackerel collected in the southeastern United States (Meaburn, 1978). After reviewing results concerning fish from the gulf coast of Florida, the Florida Department of Health (HRS, 1996) released a health advisory on 4 June 1996 urging limited consumption of king mackerel from Florida waters, based on fish size. The advisory recommended limited consumption of king mackerel in the 838–990 mm FL size-class and no consumption of fish greater than 990 mm FL. No advisory was issued for king mackerel smaller than 838 mm FL. On 23 March 2000, the states of Florida, Georgia, North Carolina, and South Carolina issued a joint health advisory regarding high levels of mercury in large king mackerel from the southeastern United States coastline (DOH, 2000). The consumption limits reflected those outlined in Florida's 1996 advisory but included all Atlantic and Gulf of Mexico waters in the southeastern United States. In January 2003, DOH issued an updated health advisory recommending no consumption of large king mackerel (>39 inches, or approximately 990 mm FL), and limited consumption of king mackerel measuring 33 to 39 inches, or approximately 838 to 990 mm FL, from all coastal waters of Florida (DOH, 2003).

Spanish mackerel
Scomberomorus maculatus

Spanish mackerel, *Scomberomorus maculatus,* inhabit Florida's coastal and estuarine waters. Spawning occurs from mid-spring through summer (Finucane and Collins, 1986; Schmidt *et al.,* 1993). Juvenile Spanish mackerel use estuaries and nearshore, open-beach waters as nursery areas (Godcharles and Murphy, 1986). The maximum age has been determined to be 6 years for males and 11 years for females (Schmidt *et al.,* 1993). This species matures during the first year; females mature at 288–450 mm FL (approximately 266–417 mm SL) and males at 209–336 mm FL (approximately 193–311 mm SL) (Schmidt *et al.,* 1993). Spanish mackerel can attain a length of 770 mm FL (approximately 715 mm SL) and a total weight of 4.8 kg (Beardsley and Richards, 1970). Spanish mackerel feed on pelagic fish (*e.g.,* scaled sardine, *Harengula jaguana;* Atlantic threadfin herring, *Opisthonema oglinum;* anchovies, *Anchoa* spp.; and menhaden, *Brevoortia* spp.) and small invertebrates, including shrimp and squid (Miles and Simmons, 1951; Klima, 1959; Saloman and Naughton, 1983).

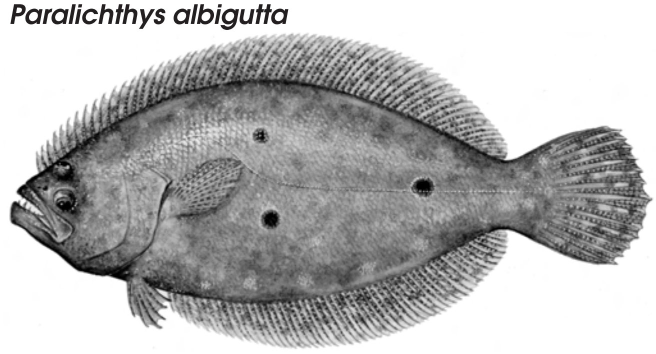
The Spanish mackerel supports major commercial and recreational fisheries throughout Florida. A total of 5,592,389 pounds of Spanish mackerel were landed in Florida during 2000 (FWC-FMRI, 2001; NMFS, Fisheries Statistics and Economic Division, personal communication). Since 1950, more than 92% of the total U.S. catch has been landed in Florida (Trent and Anthony, 1979). Concerns regarding overfishing have recently prompted size limits, daily bag limits, and recreational/commercial landings quotas (SAFMC, 1988). Migration and spawning patterns indicate that in the southeastern U.S., this species has an Atlantic stock and one or more Gulf of Mexico stocks (Skow and Chittenden, 1981; Collette and Russo, 1984; SAFMC, 1988).

A total of 389 Spanish mackerel were collected for mercury analysis in Tampa Bay (n = 187), the Indian River Lagoon and adjacent coastal waters (n = 98), Charlotte Harbor (n = 50), and other Florida waters. Standard lengths of fish sampled ranged from 132 to 715 mm. Mercury levels detected in Spanish mackerel from Florida waters were relatively high. Total mercury levels for individual fish ranged from 0.06 to 3.00 ppm. Mean total mercury levels from the three major study areas were 0.53 ppm (median = 0.47 ppm) in Tampa Bay, 0.32 ppm (median = 0.25 ppm) in the Indian River Lagoon region, and 0.71 ppm (median = 0.62 ppm) in Charlotte Harbor (Appendix Table). Standard lengths of Spanish mackerel collected in Charlotte Harbor were significantly larger than those collected from Tampa Bay or the Indian River Lagoon (Kruskal-Wallis test, $P < 0.0001$; Dunn's method, $P < 0.05$). There were no significant differences between lengths of fish collected from Tampa Bay and the Indian River Lagoon. Mercury levels in Spanish mackerel from the Indian River Lagoon region were lower and significantly different from the levels in gulf coast fish in Tampa Bay and Charlotte Harbor (Kruskal-Wallis test, $P < 0.0001$; Dunn's method, $P < 0.05$).

Approximately 37% of all Spanish mackerel from Florida waters had mercury levels greater than or equal to 0.5 ppm. The majority (approximately 82%) of the Spanish mackerel examined from Florida waters were of legal size (≥283 mm SL; ≥305 mm TL). A total of 44% of legal-sized Spanish mackerel had mercury levels greater than or equal to 0.5 ppm. A similar study conducted by the National Marine Fisheries Service (NMFS) in the southeastern United States also detected elevated mercury levels in Spanish mackerel (Meaburn, 1978). Significant positive correlations ($P < 0.0001$) between total mercury level and fish length were detected for Spanish mackerel from Tampa Bay, the Indian River Lagoon, and Charlotte Harbor.

After reviewing mercury results for this species, the Florida Department of Health (HRS, 1995) released a health advisory on 6 October 1995 urging limited consumption of Spanish mackerel from Tampa Bay and Charlotte Harbor waters.

Gulf flounder
Paralichthys albigutta



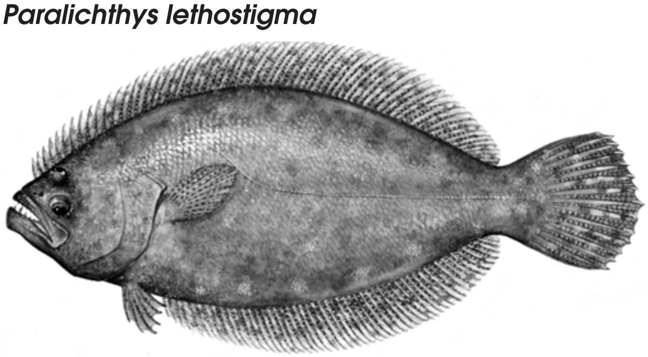
Gulf flounder, *Paralichthys albigutta,* inhabit coastal and estuarine waters throughout Florida, often preferring sand substrates or hard bottom (Gilbert, 1986b and references therein; FWC-FMRI, 1991–2000). Spawning occurs in offshore waters during fall and winter (Gilbert, 1986b and references therein). This species matures at approximately 2 years of age (Stokes, 1977) and can attain a total length of 710 mm and a total weight of 5 kg (Vick, 1964). Gulf flounder are opportunistic predators that feed on a variety of fish and crustaceans (Darnell, 1958; Stokes, 1977).

The gulf flounder is a valuable recreational and commercial species in Florida. Landings of this species in Florida are typically grouped with the southern flounder, *Paralichthys lethostigma,* and to a lesser extent with the summer flounder, *P. dentatus* (Gilbert, 1986b; Murphy *et al.,* 1994). Overall flounder landings are greatest in the fall, and approximately two-thirds of landings occur on the Atlantic coast (Murphy *et al.,* 1994).

A total of 190 gulf flounder were collected from Florida waters, with the majority collected from Charlotte Harbor (n = 71) and Tampa Bay (n = 65). A limited number of gulf flounder were also collected from Choctawhatchee Bay (n = 18), the Volusia County region (n = 15), the Indian River Lagoon (n = 8), Florida Keys/Florida Bay (n = 5), Apalachicola Bay (n = 5), and other areas of Florida. Standard lengths of fish sampled ranged from 115 to 500 mm. Mercury levels detected in gulf flounder from Florida waters were usually low. Total mercury levels for individual fish ranged from 0.01 to 1.10 ppm. Mean total mercury levels of gulf flounder were similar in Tampa Bay (mean = 0.20 ppm; median = 0.16 ppm), Charlotte Harbor (mean = 0.31 ppm; median = 0.28 ppm), Choctawhatchee Bay (mean = 0.20 ppm; median = 0.20 ppm), and Volusia County (mean = 0.14 ppm; median = 0.11 ppm) (Appendix Table).

Analysis of gulf flounder from Tampa Bay and Charlotte Harbor showed a positive correlation between total mercury level and fish length ($P < 0.0001$). There were not enough samples of gulf flounder from the other study areas for us to determine relationships between mercury levels and fish size. Overall, a low percentage of gulf flounder tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm (Tampa Bay = 2%; Charlotte Harbor = 13%; Choctawhatchee Bay = 0%). On a Florida-wide basis, approximately 62% of the gulf flounder analyzed were of legal size (≥305 mm TL or approximately 253 mm SL), and 11% of these fish contained total mercury levels greater than or equal to 0.5 ppm.

Southern flounder
Paralichthys lethostigma



Southern flounder, *Paralichthys lethostigma,* inhabit coastal and estuarine waters along the lower Atlantic coast of Florida and the upper gulf coast but are absent from the southern tip of Florida (Gilbert, 1986b and references therein; FWC-FMRI, 1991–2000). Genetic differentiation is not extensive for this species, and preliminary data indicate that one stock of southern flounder occurs in the southeastern United States (Blandon *et al.,* 2001). Both juveniles and adults are frequently found over mud, silt, or similar soft substrates (Powell and Schwartz, 1977; Stokes, 1977). Spawning occurs from September to April (Gunter, 1945) in waters between 20 and 60 m deep (Benson, 1982). This species matures at approximately 2 years of age (Stokes, 1977) and can attain a total length of 762 mm (Ginsburg, 1952). Southern flounder feed on a variety of fish and crustaceans (Reid, 1954; Darnell, 1958; Stokes, 1977).

The southern flounder is a valuable recreational and commercial species, principally along the Atlantic coast of Florida. Landings of this species in Florida are typically grouped with the gulf flounder, *Paralichthys albigutta,* and to a lesser extent with the summer flounder, *P. dentatus* (Murphy *et al.,* 1994). The vast majority of overall flounder landings on the Atlantic coast from the recreational fishery are composed of southern flounder, and although samples are limited, southern flounder also appears to be the principal species in the commercial fishery in this region (Murphy *et al.,* 1994).

A total of 67 southern flounder were collected from Florida waters, with the majority collected from the Indian River Lagoon (n = 23), northeast Florida (n = 18), and Volusia County (n = 17). A limited number of southern flounder were also collected from Apalachicola Bay (n = 6) and Choctawhatchee Bay (n = 3). Standard lengths of fish sampled ranged from 137 to 576 mm. Mercury levels detected in southern flounder from Florida waters were usually low. Total mercury levels for individual fish ranged from 0.04 to 0.50 ppm. Mean total mercury levels of southern flounder in Florida were low and were similar in all study areas examined. Mean total mercury levels covered a small range, from 0.08 ppm (median = 0.07 ppm) in northeast Florida to 0.18 ppm (median = 0.13 ppm) in the Indian River Lagoon (Appendix Table).

Seventy-two percent of southern flounder analyzed in this study were of legal size (≥305 mm TL). The total mercury content of all sublegal southern flounder examined from Florida waters was less than 0.15 ppm. Overall, only one southern flounder tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm. This 304-mm SL fish collected in the Indian River Lagoon contained 0.5-ppm total mercury. No southern flounder containing total mercury levels greater than 0.5 ppm were recorded from Florida waters.

Summary

Muscle tissue from a wide array of Florida marine and estuarine fish species representing many trophic levels were analyzed in this study. The majority of species we examined contained low mercury levels. Species with very low mean or median mercury levels tended to be planktivores (*e.g.,* menhaden, *Brevoortia* spp.), detritivores (*e.g.,* striped mullet, *Mugil cephalus*), species whose diet is mostly invertebrates (*e.g.,* Atlantic stingray, *Dasyatis sabina;* pompano, *Trachinotus carolinus;* pigfish, *Orthopristis chrysoptera;* sheepshead, *Archosargus probatocephalus;* and black drum, *Pogonias cromis*), or species with diets that include benthic invertebrates and small fish (*e.g.,* gray snapper, *Lutjanus griseus;* southern flounder, *Paralichthys lethostigma;* gulf flounder, *P. albigutta*).

The species with characteristically high levels of total mercury were often upper-level piscivores or omnivores (*e.g.,* crevalle jack, *Caranx hippos;* Spanish mackerel, *Scomberomorus maculatus;* ladyfish, *Elops saurus;* and bluefish, *Pomatomus saltatrix*). Apex predators (*e.g.,* king mackerel, *S. cavalla;* blacktip shark, *Carcharhinus limbatus;* and bull shark, *C. leucas*) routinely had high total mercury levels. Large king mackerel from the gulf coast of Florida often contained mercury levels greater than 0.5 ppm. Approximately 82% of all king mackerel tested from Florida waters had total mercury levels greater than or equal to 0.5 ppm, and approximately 46% had total mercury levels greater than or equal to 1.5 ppm. The majority of shark species examined contained mean total mercury levels that were greater than or equal to 0.5 ppm. These high levels are likely related to the relatively slow growth, longevity, and high trophic status of most of the shark species tested in this study. Additionally, comparisons between pregnant females and associated embryos and neonate sharks from Florida waters indicated that transmission of mercury from maternal sources to embryo may be an important factor contributing to the high levels of mercury in shark muscle tissue (Adams and McMichael, 1999).

Although some of the upper-trophic level and offshore pelagic species examined in this study contained comparatively high levels of total mercury, others did not. Dolphin, *Coryphaena hippurus,* contained very low mercury levels throughout Florida waters. The muscle tissue of this fast-growing offshore pelagic species did not accumulate high levels of mercury, and mean total mercury levels for this species were among the lowest observed in Florida marine fishes. The rapid growth rate and comparatively short life span of dolphin may be contributing factors to the low total mercury concentrations observed in this species.

Mercury levels for similar, coexisting fish species from the same family were sometimes quite different. For example, mercury levels in red drum, *Sciaenops ocellatus,* were usually higher than those found in black drum. This was especially apparent in the larger size-classes. Large red drum often contained higher levels than similar-size black drum. Low mercury levels were usually found in black drum, even in very large specimens (>1,000 mm SL). These differences may be related to differences in the feeding ecology of the two species. Black drum feed primarily on invertebrates (Simmons and Breuer, 1962), whereas red drum, which also prey on invertebrates, consume a greater proportion of fish (Miles, 1950; Simmons and Breuer, 1962; Boothby and Avault, 1971; Peters and McMichael, 1987; FWC-FMRI, unpublished data). Although available data are limited, certain invertebrates may contain mercury levels that are lower than those found in many fish species (Gardner *et al.,* 1975; Stickney *et al.,* 1975; Jop *et al.,* 1997).

Similarly, mercury levels for species within the same genus were sometimes divergent. Preliminary results for mercury levels contained in yellowfin tuna, *Thunnus albacares,* and blackfin tuna, *Thunnus atlanticus,* collected from the same region were strikingly different. Blackfin tuna from the offshore waters adjacent to the Indian River Lagoon system typically had higher mercury levels than yellowfin tuna from these waters. Although yellowfin tuna were larger (572–1,048 mm SL; mean = 813 mm SL) than blackfin tuna examined in this study (421–791 mm SL; mean = 686 mm SL), the mean mercury level in yellowfin tuna (mean = 0.30 ppm) was lower than that detected in blackfin tuna (mean = 1.16 ppm). Additional samples are currently being collected by FWC-FMRI to further investigate the mercury content differences between these closely related, sympatric species.

A number of species had highly variable total mercury levels. For example, total mercury levels for spotted seatrout, *Cynoscion nebulosus,* varied greatly with fish size and sampling area. In the Indian River Lagoon, total mercury levels for females were not significantly different from those for males; however, there was a stronger relationship between total mercury level and fish length for females than for males. Growth of spotted seatrout in Florida is highly variable, and females are typically larger at a particular age than males (Murphy and Taylor, 1994), which may explain some of the variation in total mercury levels observed. The diverse diet of this species (Lassuy, 1983; Johnson

and Seaman, 1986) may further explain the high variation in total mercury levels in spotted seatrout (Rider and Adams, 2000).

A positive relationship between total mercury level and fish length was observed for many species examined, indicating that mercury levels tend to increase as individuals of some species grow. This is an important consideration when retaining and consuming certain marine and estuarine fishes. Mercury results from this study directly support the current maximum size limit for red drum within the State of Florida. The majority of red drum containing high mercury levels were individuals larger than or near the maximum length of the "slot limit" for this species. With the exception of one smaller fish (527 mm SL), all red drum with total mercury levels greater than or equal to 1.5 ppm were large fish (mean = 791 mm SL) that would not be consumed by humans because of Florida's current size regulations.

Preliminary results indicate that regional differences in total mercury levels in muscle tissue of some Florida fish species may exist. Mercury levels in several species examined (*e.g.,* bluefish, *Pomatomus saltatrix;* Spanish mackerel, *Scomberomorus maculatus;* and common snook, *Centropomus undecimalis*) from both the gulf coast and the Florida Keys/Florida Bay regions were often higher than were mercury levels in fish of the same species and size sampled from the Atlantic coast of Florida. These large-scale regional differences may be related to differences in available mercury within these regions or other related factors. Because mercury cycles through atmospheric, aquatic, and terrestrial components of the environment and is deposited and made available from multiple sources, it is difficult to effectively quantify available mercury and correlate it with levels found within the muscle tissue of marine and estuarine fishes.

Localized elevation of mercury concentrations in freshwater and terrestrial organisms from specific areas, waterbodies, or specific habitat types has been detected in Florida (Lange *et al.,* 1993; Sepulveda, 1999; Rumbold *et al.,* 2002). Preliminary analyses from this study indicate that marine fish collected from specific, small-scale, localized areas can contain higher levels of mercury than similar fish collected from other nearby areas do. Elevated levels of mercury in spotted seatrout collected within a small, localized area of Florida Bay may influence the overall total mercury levels reported for this species from the Florida Keys/Florida Bay region. Within the distribution of spotted seatrout from Florida Keys/Florida Bay, a group was isolated that contained higher levels of mercury than did other fish sampled from this area. The majority of these "higher-level" fish were collected specifically from the Deer Key area, located in northeastern Florida Bay within the boundaries of the Everglades National Park (latitude ~25°11.113′N; longitude ~80°32.202′W). Although the historical movements and habitat use of these fish are unknown, this illustrates how sample groups containing elevated mercury levels collected from specific sites can influence regional results. These small-scale location effects potentially contribute to the larger-scale regional differences observed for several marine and estuarine fish species. Additional samples from this area and other areas in south Florida may help clarify these possible linkages.

Results of this study indicate that mean total mercury levels for the majority of species examined were below the 0.5-ppm threshold level designated by DOH. Data regarding other species (*e.g.,* king mackerel, Spanish mackerel, bluefish, ladyfish, crevalle jack, great barracuda, gafftopsail catfish, and blackfin tuna) support the current health advisories urging limited consumption because of high mercury levels (HRS, 1991, 1995, 1996; DOH, 2000, 2003). Mercury levels in Florida's estuarine and marine fishes varied by species, fish size, and sampling location. Sampling of fish for mercury analysis is continuing, and future research relating mercury levels to fish age, feeding ecology, and trophic structure of Florida's marine and estuarine ecosystems will help us to further identify the causes of these variations.

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APPENDIX TABLE

*Length and total mercury (Hg) data for marine and estuarine fishes collected from Florida waters from 1989 to 2001. Lengths of bony fishes are presented as mm standard length (lengths of king mackerel are presented as mm fork length). Lengths of shark species are presented as mm precaudal length, unless otherwise denoted. Lengths of ray species are presented as mm disk width. * = lengths are presented as mm total length. ** = lengths are presented as mm lower jaw total length. All total mercury levels are reported as parts per million (ppm) wet weight. Min. = minimum, Max. = maximum, Med. = median. IR = Indian River Lagoon and adjacent coastal waters; TB = Tampa Bay and adjacent coastal waters; CH = Charlotte Harbor; KY = Florida Keys/Florida Bay; FW = Choctawhatchee Bay; SB = Sarasota Bay and adjacent coastal waters; EV = Florida Everglades coastal waters; VC = Volusia County and adjacent coastal waters; TQ = Tequesta/southern Indian River Lagoon and adjacent coastal waters; JX = northeast Florida and adjacent coastal waters; AP = Apalachicola Bay and adjacent coastal waters.*

Family				Length (mm)			Hg (ppm)			
Species	Common name	Area	n	Mean	Min.	Max.	Mean	Med.	Min.	Max.
Odontaspididae										
Odontaspis taurus	Sand tiger shark	IR	1	1,100*	1,100	1,100	0.30	0.30	0.30	0.30
Lamnidae										
Carcharodon carcharius	White shark	CH	1	3,901*	3,901	3,901	5.40	5.40	5.40	5.40
		IR	4	2,980*	2,270	4,191	5.42	4.80	2.10	10.00
		KY	2	4,416*	3,962	4,870	4.30	4.30	2.60	6.00
Isurus oxyrinchus	Shortfin mako	KY	1	2,055*	2,055	2,055	3.20	3.20	3.20	3.20
Carcharhinidae										
Carcharhinus acronotus	Blacknose shark	CH	1	490	490	490	0.35	0.35	0.35	0.35
		IR	5	760	700	820	0.58	0.56	0.38	0.75
Carcharhinus brevipinna	Spinner shark	IR	9	844	659	1,000	0.61	0.63	0.31	0.97
Carcharhinus isodon	Finetooth shark	IR	1	470	470	470	0.20	0.20	0.20	0.20
Carcharhinus leucas	Bull shark	CH	3	742	680	850	0.97	1.20	0.42	1.30
		IR	55	757	552	1,075	0.78	0.74	0.24	1.70
		TB	1	665	665	665	0.66	0.66	0.66	0.66
Carcharhinus limbatus	Blacktip shark	CH	12	574	416	815	0.79	0.72	0.34	1.60
		IR	25	818	223	1,510	0.76	0.63	0.16	2.30
		KY	14	888	603	1,210	1.84	1.85	0.85	2.60
		TB	47	559	405	975	0.54	0.47	0.03	1.60
Mustelus norrisi	Florida smoothhound	CH	1	495	495	495	1.20	1.20	1.20	1.20
Negaprion brevirostris	Lemon shark	CH	3	851	703	960	0.70	0.56	0.43	1.10
		KY	2	882	610	1,155	0.65	0.65	0.61	0.70
		TB	1	565	565	565	0.18	0.18	0.18	0.18
Rhizoprionodon terraenovae	Atlantic sharpnose	IR	81	592	220	857	1.06	0.95	0.11	2.30
	shark	VC	4	630	592	662	0.57	0.40	0.37	1.10
Sphyrnidae										
Sphyrna lewini	Scalloped hammerhead	IR	6	379	279	654	0.44	0.45	0.33	0.54
		TB	3	821	582	1,060	1.25	1.10	0.26	2.40
Sphyrna tiburo	Bonnethead	CH	17	422	263	690	0.34	0.27	0.04	0.96
		FW	3	596	493	775	0.58	0.34	0.31	1.10
		IR	137	481	206	1,081	0.39	0.24	0.08	1.50
		KY	9	629	500	688	1.14	1.20	0.28	1.60
		TB	47	616	288	800	0.59	0.52	0.03	1.60
Pristidae										
Pristis pectinata	Smalltooth sawfish	TB	1	3,740	3,740	3,740	0.70	0.70	0.70	0.70
		KY	1	398	398	398	0.19	0.19	0.19	0.19

Family				Length (mm)			Hg (ppm)			
Species	Common name	Area	n	Mean	Min.	Max.	Mean	Med.	Min.	Max.
Dasyatidae										
Dasyatis americana	Southern stingray	TB	3	454	410	480	0.17	0.18	0.14	0.19
Dasyatis sabina	Atlantic stingray	CH	9	254	188	310	0.25	0.20	0.12	0.45
		FW	6	249	173	308	0.25	0.28	0.06	0.44
		IR	35	204	94	329	0.16	0.16	0.01	0.44
		JX	4	155	113	280	0.10	0.02	0.02	0.34
		TB	4	248	213	280	0.33	0.31	0.17	0.54
Dasyatis say	Bluntnose stingray	CH	1	200	200	200	0.02	0.02	0.02	0.02
		IR	7	273	150	383	0.07	0.08	0.02	0.14
		KY	2	250	200	300	0.11	0.11	0.10	0.12
		TB	14	390	254	540	0.20	0.17	0.06	0.59
Gymnura micrura	Smooth butterfly ray	IR	3	407	351	497	0.15	0.16	0.13	0.17
		KY	1	393	393	393	0.11	0.11	0.11	0.11
		VC	1	308	308	308	0.07	0.07	0.07	0.07
Myliobatidae										
Myliobatis freminvillei	Bullnose ray	IR	1	377	377	377	0.12	0.12	0.12	0.12
Rhinoptera bonasus	Cownose ray	CH	2	424	363	485	0.06	0.06	0.03	0.09
		TB	4	551	420	670	0.34	0.29	0.14	0.64
Acipenseridae										
Acipenser brevirostrum	Shortnose sturgeon	VC	1	834*	834	834	0.12	0.12	0.12	0.12
Lepisosteidae										
Lepisosteus platyrhincus	Florida gar	IR	1	435	435	435	0.09	0.09	0.09	0.09
Elopidae										
Elops saurus	Ladyfish	AP	50	258	215	395	0.09	0.06	0.02	0.73
		CH	35	317	240	495	0.34	0.23	0.08	1.60
		CK	3	342	335	350	0.18	0.17	0.13	0.23
		FW	6	357	295	420	0.53	0.53	0.34	0.69
		IR	30	373	115	580	0.72	0.56	0.04	2.60
		KY	16	322	235	425	0.36	0.31	0.07	0.99
		TB	78	350	209	472	0.52	0.42	0.07	1.90
Megalops atlanticus	Tarpon	IR	20	523	211	685	0.18	0.17	0.03	0.47
		KY	4	532	480	585	0.40	0.32	0.26	0.69
Albulidae										
Albula vulpes	Bonefish	KY	13	584	485	656	0.53	0.45	0.23	1.10
		CH	7	207	138	248	0.18	0.16	0.12	0.28
		FW	4	196	175	214	0.10	0.09	0.06	0.16
Clupeidae										
Brevoortia smithi	Yellowfin menhaden	IR	2	209	198	221	0.07	0.07	0.04	0.10
		TB	2	244	218	270	0.16	0.16	0.16	0.16
Opisthonema oglinum	Atlantic thread herring	CH	4	151	137	157	0.19	0.18	0.14	0.24
		FW	4	200	150	290	0.11	0.14	0.02	0.15
Harengula jaguana	Scaled sardine	CH	1	133	133	133	0.33	0.33	0.33	0.33
Synodontidae										
Synodus foetens	Inshore lizardfish	IR	3	398	370	443	0.36	0.36	0.15	0.58
		KY	1	212	212	212	0.09	0.09	0.09	0.09
Ariidae										
Arius felis	Hardhead catfish	CH	7	296	278	325	0.22	0.16	0.09	0.39
		FW	12	287	213	390	0.23	0.23	0.10	0.44
		IR	13	284	210	352	0.15	0.12	0.02	0.34
		TB	13	301	270	346	0.18	0.14	0.05	0.50

Family				Length (mm)			Hg (ppm)			
Species	Common name	Area	n	Mean	Min.	Max.	Mean	Med.	Min.	Max.
Bagre marinus	Gafftopsail catfish	CH	4	374	262	440	0.67	0.66	0.52	0.85
		FW	4	487	470	501	0.96	0.98	0.88	1.00
		IR	11	302	115	528	0.33	0.38	0.03	0.72
		TB	59	374	211	492	0.60	0.54	0.02	1.80
Batrachoididae										
Opsanus beta	Gulf toadfish	TB	6	220	200	244	0.17	0.19	0.06	0.25
Centropomidae										
Centropomus undecimalis	Snook	CH	59	479	285	710	0.37	0.36	0.12	1.10
		CK	1	700	700	700	0.19	0.19	0.19	0.19
		EV	19	619	448	730	0.63	0.57	0.19	1.50
		IR	76	454	262	745	0.22	0.21	0.06	0.42
		KY	79	574	333	860	0.60	0.51	0.07	1.80
		TB	84	484	168	867	0.39	0.34	0.03	1.40
		TQ	106	418	301	625	0.22	0.21	0.06	0.48
Serranidae										
Centropristis striata	Black sea bass	CH	1	202	202	202	0.17	0.17	0.17	0.17
		TB	11	131	98	173	0.13	0.12	0.08	0.21
		VC	9	226	205	245	0.14	0.14	0.12	0.17
Centropristis philadelphica	Rock sea bass	VC	1	125	125	125	0.07	0.07	0.07	0.07
Epinephelus itajara	Goliath grouper	TB	13	407	296	519	1.15	1.10	0.09	3.30
		CH	10	1,320	1,090	1,660	0.13	0.03	0.01	0.58
		EV	8	540	330	715	0.35	0.30	0.10	0.65
Epinephelus drummondhayi	Speckled hind	TB	7	422	290	713	0.20	0.15	0.12	0.34
Epinephelus flavolimbatus	Yellowedge grouper	IR	2	537	485	590	0.37	0.37	0.34	0.41
		TB	8	316	273	353	0.23	0.22	0.13	0.34
Epinephelus morio	Red grouper	IR	3	418	338	534	0.34	0.30	0.28	0.43
		KY	4	438	405	470	0.27	0.29	0.16	0.33
		TB	39	428	382	533	0.33	0.32	0.11	0.66
		VC	3	513	455	565	0.37	0.43	0.22	0.46
Epinephelus niveatus	Snowy grouper	IR	22	564	442	700	0.95	0.88	0.26	1.90
		TB	5	472	300	763	0.26	0.20	0.10	0.57
		VC	2	460	430	490	0.25	0.25	0.23	0.27
Mycteroperca microlepis	Gag	CH	3	293	190	355	0.16	0.14	0.13	0.22
		CK	32	570	450	725	0.47	0.44	0.22	0.87
		IR	12	540	174	835	0.38	0.33	0.13	1.00
		KY	5	511	428	605	0.46	0.35	0.24	0.82
		TB	38	378	137	783	0.30	0.21	0.04	1.06
		VC	7	719	514	890	0.68	0.40	0.12	1.80
Mycteroperca bonaci	Black grouper	KY	8	772	636	1,000	1.16	1.15	0.83	1.60
		TB	4	622	395	1,156	0.57	0.40	0.26	1.20
Mycteroperca phenax	Scamp	KY	1	495	495	495	0.45	0.45	0.45	0.45
		TB	23	427	305	560	0.28	0.28	0.07	0.59
		VC	5	531	378	610	0.35	0.37	0.14	0.45
Centrachidae										
Lepomis macrochirus	Bluegill	TB	1	200	200	200	0.14	0.14	0.14	0.14

Family / Species	Common name	Area	n	Length (mm) Mean	Length (mm) Min.	Length (mm) Max.	Hg (ppm) Mean	Hg (ppm) Med.	Hg (ppm) Min.	Hg (ppm) Max.
Pomatomidae										
Pomatomus saltatrix	Bluefish	CH	25	357	268	460	0.87	0.68	0.28	2.00
		IR	149	346	239	731	0.44	0.36	0.11	1.50
		JX	2	263	257	269	0.16	0.16	0.15	0.18
		KY	11	366	235	405	0.87	0.60	0.36	1.60
		TB	27	371	267	470	0.87	0.85	0.26	1.60
		TQ	7	369	306	437	0.66	0.65	0.06	1.50
		VC	5	592	103	783	0.61	0.72	0.10	0.86
Rachycenridae										
Rachycentron canadum	Cobia	CH	3	775	665	890	0.60	0.69	0.27	0.83
		IR	20	859	430	1,228	0.57	0.40	0.22	1.90
		JX	3	1,036	840	1,342	1.42	1.50	0.75	2.00
		KY	3	825	807	851	1.43	1.50	1.10	1.70
		TB	11	631	362	1,000	0.47	0.34	0.13	1.30
		TQ	2	948	876	1,020	0.41	0.41	0.33	0.50
		VC	1	960	960	960	0.76	0.76	0.76	0.76
Carangidae										
Caranx bartholomaei	Yellow jack	KY	1	450	450	450	0.41	0.41	0.41	0.41
Caranx hippos	Crevalle jack	CH	16	272	152	468	0.51	0.44	0.16	0.88
		CK	16	258	158	355	0.28	0.30	0.08	0.75
		IR	55	330	179	516	0.53	0.54	0.09	1.30
		KY	55	365	225	575	0.97	0.76	0.02	3.90
		TB	27	363	200	565	0.61	0.57	0.03	1.20
Caranx crysos	Blue runner	TB	1	207	207	207	0.18	0.18	0.18	0.18
Oligoplites saurus	Leatherjacket	FW	1	182	182	182	0.21	0.21	0.21	0.21
		IR	2	227	219	235	1.45	1.45	1.20	1.70
Selene vomer	Lookdown	IR	16	178	135	241	0.20	0.14	0.07	0.98
Seriola dumerili	Greater amberjack	AP	1	987	987	987	0.91	0.91	0.91	0.91
		FW	5	697	630	765	0.49	0.48	0.34	0.68
		IR	7	816	535	940	0.59	0.49	0.35	0.96
		JX	9	762	561	995	0.51	0.47	0.20	1.10
		KY	4	790	594	890	0.66	0.62	0.40	0.99
		VC	41	824	607	1,069	0.46	0.38	0.20	1.00
Seriola rivoliana	Almaco jack	VC	17	743	438	840	0.56	0.43	0.10	1.40
Seriola zonata	Banded rudderfish	VC	10	521	400	568	0.59	0.56	0.25	0.97
Trachinotus carolinus	Florida pompano	CH	13	306	193	395	0.18	0.18	0.06	0.28
		IR	51	273	61	412	0.10	0.10	0.04	0.37
		KY	4	295	203	371	0.15	0.11	0.03	0.35
		TB	10	266	250	336	0.23	0.21	0.08	0.49
Trachinotus falcatus	Permit	CH	6	270	189	312	0.20	0.13	0.06	0.66
		IR	18	277	55	887	0.22	0.08	0.06	1.60
		KY	105	615	312	812	0.61	0.46	0.06	2.30
		TB	34	267	155	360	0.15	0.11	0.02	0.51
Coryphaenidae										
Coryphaena hippurus	Dolphin	AP	8	943	651	1,070	0.17	0.17	0.05	0.34
		FW	1	837	837	837	0.06	0.06	0.06	0.06
		IR	130	685	414	1,243	0.11	0.07	0.01	0.50
		JX	2	877	876	879	0.22	0.22	0.20	0.25
		KY	24	636	410	1,305	0.09	0.04	0.02	0.49
		TQ	16	655	432	1,055	0.13	0.12	0.03	0.39
		VC	24	657	452	890	0.12	0.13	0.02	0.30

Family Species	Common name	Area	n	Length (mm) Mean	Min.	Max.	Hg (ppm) Mean	Med.	Min.	Max.
Lutjandidae										
Lutjanus griseus	Gray snapper	CH	35	218	158	290	0.13	0.13	0.06	0.32
		IR	75	267	104	430	0.19	0.17	0.08	0.65
		KY	140	246	152	396	0.21	0.19	0.03	0.62
		TB	34	266	133	437	0.23	0.19	0.09	0.54
		TQ	2	305	293	317	0.13	0.13	0.11	0.15
		VC	15	369	218	505	0.17	0.15	0.10	0.27
Lutjanus analis	Mutton snapper	IR	5	169	144	220	0.11	0.11	0.09	0.13
		KY	11	436	307	589	0.36	0.32	0.16	0.92
		TQ	14	379	291	560	0.31	0.31	0.18	0.54
		VC	2	347	320	375	0.28	0.28	0.25	0.31
Lutjanus campechanus	Red snapper	IR	1	552	552	552	2.80	2.80	2.80	2.80
		VC	4	541	510	580	0.27	0.27	0.18	0.35
Lutjanus synagris	Lane snapper	IR	1	239	239	239	0.21	0.21	0.21	0.21
		KY	4	212	189	244	0.34	0.33	0.27	0.43
		TB	9	242	180	291	0.27	0.28	0.19	0.38
		TQ	5	221	173	290	0.17	0.17	0.07	0.30
		VC	2	281	273	290	0.25	0.25	0.19	0.31
Ocyurus chrysurus	Yellowtail snapper	KY	29	301	235	386	0.15	0.13	0.04	0.28
		TQ	5	284	258	296	0.12	0.11	0.10	0.14
Rhomboplites aurorubens	Vermilion snapper	TB	1	226	226	226	0.25	0.25	0.25	0.25
		VC	3	255	210	324	0.10	0.11	0.06	0.13
Lobotidae										
Lobotes surinamensis	Tripletail	IR	74	430	270	620	0.13	0.11	0.01	0.61
		KY	39	378	290	494	0.27	0.19	0.02	0.76
		TB	1	270	396	396	0.07	0.07	0.07	0.07
Gerridae										
Diapterus plumieri	Striped mojarra	CH	13	158	82	233	0.08	0.07	0.02	0.15
		IR	5	190	151	242	0.12	0.13	0.01	0.25
		TB	5	186	151	250	0.12	0.09	0.07	0.25
Diapterus auratus	Irish pompano	CH	3	250	242	264	0.18	0.18	0.12	0.25
Haemulidae										
Haemulon plumieri	White grunt	CK	1	217	217	217	0.50	0.50	0.50	0.50
		KY	15	177	138	213	0.23	0.19	0.09	0.51
		TB	32	240	100	360	0.32	0.31	0.07	0.59
		TQ	15	234	194	263	0.27	0.21	0.14	0.61
Haemulon sciurus	Bluestriped grunt	KY	3	186	170	212	0.28	0.38	0.06	0.40
Orthopristis chrysoptera	Pigfish	CH	11	189	156	210	0.20	0.13	0.04	0.66
		FW	1	168	168	168	0.26	0.26	0.26	0.26
		IR	21	198	143	260	0.14	0.12	0.02	0.41
		KY	11	170	143	202	0.12	0.12	0.02	0.20
		TB	7	198	170	219	0.19	0.16	0.13	0.30
		VC	1	107	107	107	0.07	0.07	0.07	0.07
Sparidae										
Archosargus probatocephalus	Sheepshead	AP	28	371	271	440	0.17	0.17	0.06	0.40
		CH	17	278	170	365	0.21	0.16	0.08	0.66
		CK	62	340	225	470	0.24	0.21	0.06	1.10
		FW	4	233	185	300	0.16	0.14	0.08	0.27
		IR	14	326	183	437	0.16	0.13	0.07	0.45
		KY	25	249	133	429	0.19	0.13	0.06	0.52
		TB	27	286	215	429	0.15	0.13	0.07	0.43

Family / Species	Common name	Area	n	Length (mm) Mean	Length (mm) Min.	Length (mm) Max.	Hg (ppm) Mean	Hg (ppm) Med.	Hg (ppm) Min.	Hg (ppm) Max.
Archosargus rhomboidalis	Sea bream	KY	1	161	161	161	0.18	0.18	0.18	0.18
Lagodon rhomboides	Pinfish	CH	5	158	103	224	0.15	0.17	0.13	0.17
		IR	3	269	260	282	0.34	0.27	0.19	0.55
		KY	3	141	128	149	0.06	0.06	0.05	0.07
Sciaenidae										
Bairdiella chrysoura	Silver perch	CH	4	152	141	163	0.29	0.27	0.20	0.42
		FW	8	139	128	151	0.35	0.41	0.02	0.49
		IR	12	118	105	155	0.46	0.42	0.21	1.10
		KY	9	146	135	172	0.24	0.20	0.15	0.46
		TB	2	156	155	158	0.35	0.35	0.27	0.43
Cynoscion arenarius	Sand seatrout	CH	12	283	205	337	0.81	0.80	0.45	1.20
		CK	15	266	224	301	0.34	0.32	0.25	0.46
		TB	77	224	145	333	0.46	0.44	0.11	1.10
Cynoscion nebulosus	Spotted seatrout	AP	42	419	309	570	0.33	0.28	0.08	0.79
		CH	56	359	160	545	0.42	0.33	0.14	1.50
		CK	145	374	230	540	0.45	0.34	0.08	1.30
		EV	8	354	265	425	0.43	0.34	0.18	0.71
		FW	102	385	187	529	0.40	0.39	0.11	0.88
		IR	215	394	143	680	0.47	0.41	0.02	1.70
		JX	5	329	305	375	0.16	0.17	0.10	0.18
		KY	76	324	152	460	0.64	0.43	0.02	2.50
		TB	137	333	162	625	0.40	0.34	0.04	1.00
Cynoscion nothus	Silver seatrout	IR	16	195	171	230	0.24	0.24	0.09	0.39
		TB	1	258	258	258	0.47	0.47	0.47	0.47
Cynoscion regalis/arenarius	Species complex	IR	64	251	159	369	0.29	0.22	0.08	0.84
		JX	108	238	116	415	0.13	0.12	0.02	0.39
		VC	2	167	165	170	0.11	0.11	0.11	0.12
Leiostomus xanthurus	Spot	CH	4	193	185	201	0.14	0.14	0.09	0.18
		FW	12	123	101	161	0.16	0.14	0.03	0.46
		IR	21	213	118	313	0.12	0.11	0.02	0.36
		JX	9	146	125	164	0.04	0.04	0.02	0.07
		SB	6	201	165	220	0.08	0.08	0.04	0.12
		TB	19	184	163	211	0.11	0.11	0.03	0.25
Menticirrhus americanus	Southern kingfish	AP	1	295	295	295	0.33	0.33	0.33	0.33
		CH	7	262	216	300	0.37	0.36	0.17	0.50
		CK	6	259	238	273	0.13	0.12	0.08	0.20
		IR	18	202	147	289	0.08	0.07	0.02	0.24
		JX	19	193	121	238	0.13	0.10	0.02	0.78
		TB	25	279	229	348	0.19	0.16	0.04	0.75
Menticirrhus saxatilis	Northern kingfish	AP	1	300	300	300	0.21	0.21	0.21	0.21
		TB	3	237	221	265	0.29	0.24	0.15	0.48
Micropogonias undulatus	Atlantic croaker	CK	1	237	237	237	0.05	0.05	0.05	0.05
		IR	21	217	89	385	0.06	0.04	0.02	0.18
		JX	23	148	122	172	0.06	0.05	0.02	0.15
		TB	2	275	250	300	0.08	0.08	0.07	0.08
Pogonias cromis	Black drum	CH	2	288	287	289	0.08	0.08	0.06	0.09
		CK	1	430	430	430	0.18	0.18	0.18	0.18
		EV	5	373	330	410	0.13	0.12	0.05	0.22
		IR	36	588	243	1,049	0.14	0.13	0.02	0.65
		KY	4	407	378	430	0.10	0.11	0.02	0.18
		TB	23	470	193	850	0.24	0.21	0.01	0.49

Family				Length (mm)			Hg (ppm)			
Species	Common name	Area	n	Mean	Min.	Max.	Mean	Med.	Min.	Max.
Sciaenops ocellatus	Red drum	AP	82	451	358	618	0.20	0.20	0.06	0.69
		CH	28	518	279	702	0.31	0.24	0.05	0.87
		CK	133	398	223	606	0.18	0.18	0.06	0.55
		EV	15	385	273	560	0.26	0.25	0.15	0.40
		FW	15	408	180	621	0.17	0.13	0.05	0.35
		IR	129	506	246	1,070	0.37	0.18	0.02	2.20
		KY	45	455	230	628	0.48	0.35	0.10	2.70
		TB	235	660	200	992	1.10	0.98	0.07	3.60
Umbrina coroides	Sand drum	KY	5	183	173	201	0.06	0.06	0.04	0.07
Ephippidae										
Chaetodipterus faber	Atlantic spadefish	CH	5	226	190	253	0.33	0.29	0.24	0.45
		IR	1	232	232	232	0.26	0.26	0.26	0.26
		TB	2	226	225	227	0.34	0.34	0.21	0.47
		IR	1	165	165	165	0.02	0.02	0.02	0.02
Mugilidae										
Mugil cephalus	Striped mullet	CH	7	333	258	444	0.06	0.02	0.02	0.25
		CK	15	276	205	339	0.02	0.02	0.02	0.02
		FW	4	255	176	290	0.12	0.11	0.02	0.23
		IR	14	302	237	469	0.06	0.04	0.02	0.24
		KY	3	282	272	290	0.02	0.02	0.02	0.03
		TB	28	304	155	443	0.08	0.04	0.01	0.78
Mugil curema	White mullet	CH	11	259	248	271	0.03	0.03	0.02	0.05
		CK	2	205	200	210	0.02	0.02	0.02	0.02
		FW	2	143	128	158	0.11	0.11	0.05	0.17
		KY	15	250	181	290	0.05	0.02	0.02	0.25
		TB	3	236	205	265	0.03	0.03	0.02	0.04
Mugil gyrans	Fantail mullet	CH	9	201	160	263	0.03	0.02	0.02	0.04
		TB	3	250	240	260	0.04	0.04	0.04	0.04
Sphyraenidae										
Sphyraena barracuda	Great barracuda	CH	1	237	237	237	0.36	0.36	0.36	0.36
		IR	19	358	213	488	0.16	0.16	0.08	0.35
		KY	62	628	119	1,096	0.87	0.72	0.08	3.10
		TQ	3	612	602	622	0.54	0.55	0.44	0.63
Labridae										
Lachnolaimus maximus	Hogfish	KY	19	289	200	341	0.16	0.14	0.08	0.35
Scombridae										
Acanthocybium solanderi	Wahoo	AP	16	1,030	931	1,229	0.26	0.17	0.06	1.30
		FW	7	1,146	1,052	1,291	0.68	0.62	0.27	1.40
		IR	30	1,053	845	1,338	0.27	0.23	0.06	0.87
		JX	1	1,119	1,119	1119	0.36	0.36	0.36	0.36
		TQ	4	1,112	1,050	1,235	0.16	0.11	0.04	0.36
		VC	3	1,092	1,012	1,235	0.39	0.39	0.29	0.50
Euthynnus alletteratus	Little tunny	IR	2	616	605	628	2.15	2.15	1.50	2.80
		TB	9	527	458	582	0.40	0.39	0.16	0.69
		TQ	2	527	465	590	0.63	0.63	0.29	0.98
		VC	6	572	517	660	0.79	0.72	0.55	1.20
Scomberomorus cavalla	King mackerel	IR	16	787	648	1,280	0.55	0.33	0.19	2.50
		JX	3	958	928	1,002	0.74	0.44	0.39	1.40
		KY	2	1,311	1,245	1,378	1.70	1.70	1.30	2.10
		SB	19	1,125	1,000	1,310	2.08	1.80	1.20	3.80
		TB	98	1,045	620	1,330	1.56	1.35	0.25	4.00
		VC	4	747	685	850	0.29	0.24	0.23	0.45

Family / Species	Common name	Area	n	Length (mm) Mean	Min.	Max.	Hg (ppm) Mean	Med.	Min.	Max.
Scomberomorus maculatus	Spanish mackerel	AP	6	345	242	445	0.35	0.29	0.10	0.79
		CH	50	401	267	640	0.71	0.62	0.14	3.00
		CK	1	330	330	330	0.32	0.32	0.32	0.32
		FW	6	367	290	439	0.39	0.36	0.09	0.79
		IR	98	359	178	715	0.32	0.25	0.06	1.30
		JX	2	240	235	245	0.08	0.08	0.07	0.08
		KY	3	377	255	440	0.69	0.68	0.46	0.93
		SB	15	184	132	210	0.18	0.18	0.12	0.23
		TB	187	345	188	569	0.53	0.47	0.10	2.90
		TQ	20	482	383	618	0.39	0.38	0.22	0.58
		VC	1	343	343	343	0.23	0.23	0.23	0.23
Scomberomorus regalis	Cero	TQ	1	279	279	279	0.15	0.15	0.15	0.15
Thunnus albacares	Yellowfin tuna	IR	33	813	572	1,048	0.30	0.31	0.15	0.65
Thunnus atlanticus	Blackfin tuna	IR	22	686	421	791	1.16	1.20	0.16	2.00
Istiophoridae										
Istiophorus platypterus	Sailfish	TQ	1	1,800*	1,800	1,800	0.11	0.11	0.11	0.11
Makaira nigricans	Blue marlin	KY	8	2,254	2,080	2,565	3.08	2.75	0.98	6.80
Tetrapturus albidus	White marlin	IR	1	1,831**	1,831	1,831	0.27	0.27	0.27	0.27
		KY	1	1,545**	1,545	1,545	0.31	0.31	0.31	0.31
Bothidae										
Paralichthys dentatus	Summer flounder	JX	3	170	153	182	0.04	0.04	0.04	0.04
Paralichthys albigutta	Gulf flounder	AP	5	272	220	341	0.13	0.10	0.07	0.29
		CH	70	295	116	456	0.31	0.28	0.06	1.10
		CK	1	260	260	260	0.10	0.10	0.10	0.10
		FW	18	290	204	448	0.20	0.20	0.08	0.35
		IR	8	302	176	412	0.38	0.41	0.10	0.58
		JX	1	145	145	145	0.02	0.02	0.02	0.02
		KY	5	281	235	336	0.08	0.09	0.05	0.11
		TB	65	275	172	412	0.20	0.16	0.01	0.60
		TQ	2	485	471	500	0.39	0.39	0.32	0.46
		VC	15	220	115	340	0.14	0.11	0.04	0.35
Paralichthys albigutta	Southern flounder	AP	6	338	275	410	0.16	0.12	0.07	0.30
		FW	3	347	275	423	0.17	0.19	0.13	0.20
		IR	23	340	162	576	0.18	0.13	0.07	0.50
		JX	18	273	137	395	0.08	0.07	0.04	0.25
		VC	17	245	175	320	0.11	0.10	0.06	0.21
Balistidae										
Balistes capriscus	Gray triggerfish	VC	3	268	250	287	0.13	0.15	0.06	0.17
Molidae										
Mola mola	Ocean sunfish	IR	1	1,740*	1,740	1,740	0.02	0.02	0.02	0.02

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