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Mercury Concentrations in Spotted Seatrout (*Cynoscion nebulosus*) from Northwest Florida

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We determined total mercury concentrations in dorsal muscle tissue of 112 spotted seatrout (*Cynoscion nebulosus*) collected between 1993 and 1996 from Pensacola Bay and Choctawhatchee Bay, FL. We describe the relationships of length, weight, age, and sex to total mercury concentrations in this species. Fish ranged in size from 235 to 613 mm total length (TL), with a mean of 463 mm TL. The majority (84%) of the fish collected were female. The mean total mercury concentration detected in all fish combined was 0.40 ± 0.15 ppm, and in individual fish, total mercury concentration ranged from 0.11 to 0.88 ppm. We detected no significant differences in mercury concentrations between sexes. Total mercury concentration was positively correlated with fish TL and weight. However, no relationship was evident between total mercury concentration and age. Mercury concentrations detected in the majority of spotted seatrout examined from northwest Florida were below the State of Florida's limited-consumption advisory of 0.5 ppm.

In Florida, spotted seatrout (*Cynoscion nebulosus*) is one of the most sought after estuarine sportfish (Futch, 1970; Rutherford et al., 1989; Muller, 1997; Murphy and Muller, 1998). Spotted seatrout can be caught along the entire coast of Florida, including Florida Bay. Recreational anglers, fond of this species' fine taste and catchability, caught 98% of the spotted seatrout landed in Florida during 1997 (Murphy and Muller, 1998). Because of the popularity of spotted seatrout, determining the concentrations of potential contaminants is important for human health concerns. The potential health risks to humans from mercury-contaminated fishes have been well documented (McAlpine and Araki, 1959; Irukayama, 1977). In addition, public awareness of mercury bioaccumulation in fishes has increased in recent years because of health advisories about the consumption of contaminated fishes throughout Florida (Florida Department of Health and Rehabilitative Services [FHRS], 1991, 1995) and the nation (U.S. Environmental Protection Agency [EPA], 1995).

In 1982, elevated mercury concentrations were detected in largemouth bass (*Micropterus salmoides*) from the Santa Fe River, FL (Florida Game and Freshwater Fish Commission [GFC], 1990). These findings initiated a statewide survey of the concentrations of mercury in fishes from approximately 20 freshwater systems and led to the numerous health advisories issued by the FHRS (GFC, 1990). The FHRS recommends that fish containing 0.5–1.5 ppm of total mercury should be consumed in limited quantities, and fish having greater than 1.5 ppm of total mercury should not be consumed at all. The State of Florida's mercury survey was later expanded to include estuarine and marine fishes. In March 1990, the Florida Fish and Wildlife Conservation Commission's (formerly Florida Department of Environmental Protection) Florida Marine Research Institute initiated a survey to determine mercury concentrations in commonly consumed estuarine and marine fishes.

Mercury has been detected in spotted seatrout tissue from four south Florida estuarine systems (Strom and Graves, 1995; Adams and McMichael, in press) and other coastal regions (Mathews, 1994). In a 1995 health advisory, State of Florida officials urged limited consumption of spotted seatrout from Florida Bay, the Florida Keys, and Charlotte Harbor (FHRS, 1995). However, mercury concentrations in spotted seatrout from estuarine waters in northwest Florida have not been studied. Therefore, we examined the relationship of total mercury concentrations to length, weight, age, and sex of spotted seatrout from Pensacola Bay and Choctawhatchee Bay in the northwest region of Florida.

STUDY AREAS

Choctawhatchee Bay is more than 66 km long, varies in width from 2.2 to 9 km, and has a surface area greater than 35,000 ha. Mean and maximum depths of Choctawhatchee Bay are 4 m and 13.1 m, respectively. Choctawhatchee Bay is located between 30°23′N and

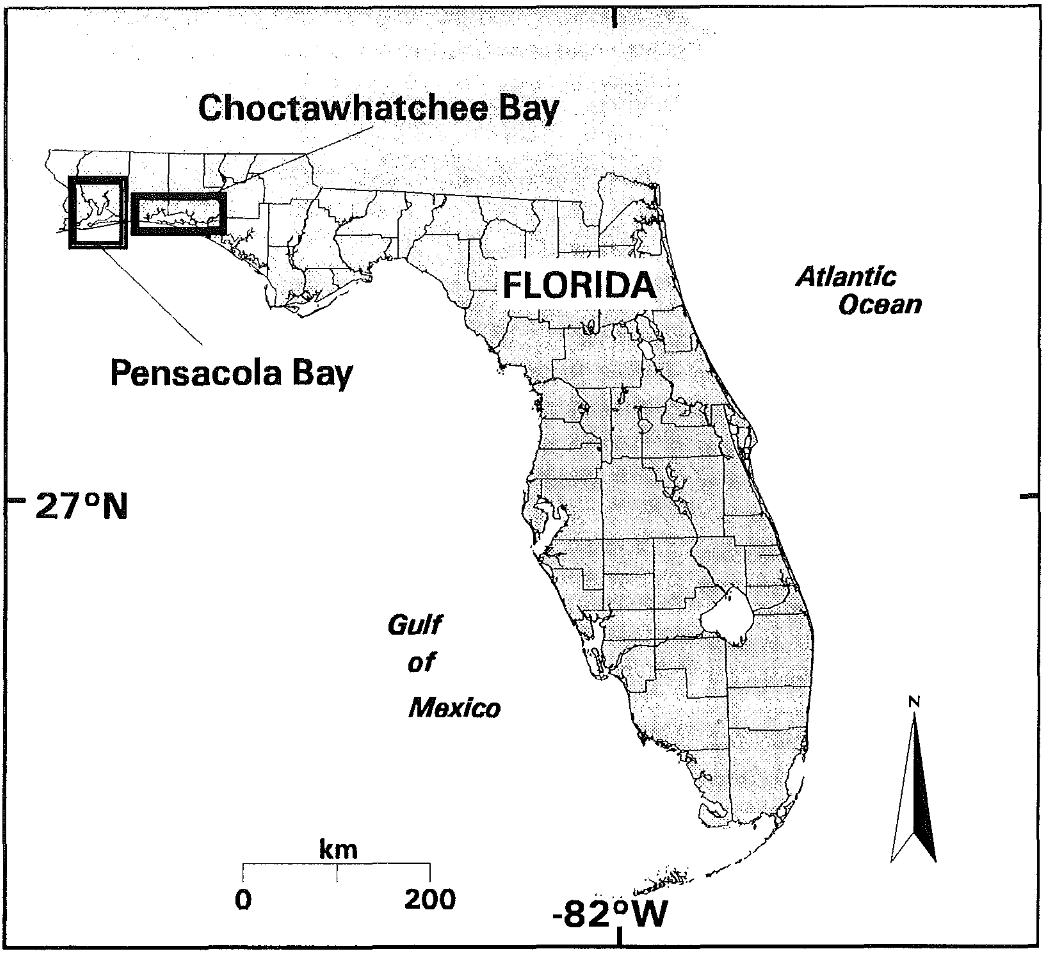


Fig. 1. Map of study areas in northwest Florida where spotted seatrout were collected.

30°55′N latitude and 86°05′W and 86°38′W longitude (Fig. 1). Pensacola Bay comprises more than 39,000 ha of surface area, and mean and maximum depths are 5.8 m and 14.3 m, respectively. Pensacola Bay is located between 30°19′N and 30°35′N latitude and 86°20′W and 86°53′W longitude.

Materials and Methods

We collected spotted seatrout in Choctawhatchee Bay with experimental floating-style monofilament gill nets (198 m long × 1.8 m deep) and a 183-m-long × 3-m-deep center-bag haul seine. Gill nets consisted of five separate panels with stretch mesh sizes ranging from 51 to 152 mm and were deployed at dusk and during the night. The 183-m seine had 38-mm stretch mesh of twisted nylon and was deployed during the day. Gill nets were used during spring (March to May) and fall (Oct. and Nov.) 1993 to 1995 and during May to Oct. 1996. The 183-m seine was used from Feb. to May and Sept. to Nov. 1995 and May to Oct. 1996. All sampling sites were randomly selected. After capture, each fish was immediately placed in a plastic bag and stored covered in ice or frozen until further processing. All spotted seatrout from Pensacola Bay were collected in commercial gill nets and obtained from commercial sources in 1995.

For each spotted seatrout, total length (TL; mm), weight (g), and sex were recorded. To determine fish age, sagittal otoliths were excised, sectioned, and read according to protocols described in Murphy and Taylor (1994). Approximately 10–15 g (wet weight) of muscle tissue was excised from the left dorsal musculature of each fish. This area of muscle is the portion of spotted seatrout usually consumed by humans. Each tissue sample was placed in a sterile 20-ml polyethylene vial and frozen at

TABLE 1. Mean total length (TL), mean weight (WT), mean mercury (Hg) concentration, and minimum (Min) and maximum (Max) total mercury concentrations by sex for spotted seatrout collected in Choctawhatchee Bay and Pensacola Bay, FL, 1993–1996. Mean TL, WT, and Hg were not significantly different for males and females ($P \geq 0.05$).

			Hg concentration (ppm)		
Sex	Mean TL (mm)	Mean WT (g)	Mean	Min	Max
Female	476 ± 67 (87)[a]	995 ± 372 (59)	0.41 ± 0.15 (87)	0.11	0.88
Male	431 ± 75 (17)	800 ± 329 (11)	0.44 ± 0.12 (17)	0.29	0.62

[a] Mean ± SD (sample size in parentheses).

−20 C. Tissue samples were digested and then analyzed by cold vapor atomic absorption spectrometry following standardized procedures (EPA, 1991; Booeshahgi et al., 1995; Frick, 1996) at the Florida Department of Environmental Protection's Division of Technical Services. Quality control measures consisted of analyzing laboratory blanks, duplicate or triplicate tissue samples, and standard fish tissue reference material (DORM-1 or DORM-2, obtained from the National Research Council of Canada) for each group of tissue samples analyzed (EPA, 1991; Booeshahgi et al., 1995; Frick, 1996). Mercury levels are reported as total mercury concentrations in parts per million (ppm) wet weight.

Total mercury concentrations were log transformed to normalize these data. Student's t-test was used to identify between-sex differences in the relationship of total length to mean mercury concentrations. Linear regressions were used to describe the relationships of total length, weight, and age to mercury concentrations.

RESULTS

We collected and processed 112 spotted seatrout from northwest Florida (49 from Pensacola Bay and 63 from Choctawhatchee Bay). Fish lengths ranged from 430 to 613 mm TL in Pensacola Bay and 235 to 560 mm TL in Choctawhatchee Bay. Weights of seatrout collected ranged from 140 to 2,002 g. Ages were obtained from 65 (24 from Pensacola Bay and 41 from Choctawhatchee Bay) of the 112 spotted seatrout collected. Fish ages ranged from 2 to 5 yr in Pensacola Bay and from 1 to 5 yr in Choctawhatchee Bay. Of the 112 seatrout collected, 87 were female, 17 were male, and 8 were unsexed.

Total mercury concentrations in spotted seatrout ranged from 0.11 to 0.88 ppm, with a mean of 0.40 ± 0.15 ppm and a median of 0.39 ppm. Nearly 82% (n = 98) of the fish collected had total mercury concentrations that were lower than the limited consumption advisory level of 0.5 ppm. There were no significant ($P \geq 0.05$) differences in total length, weight, or total mercury concentration between sexes (Table 1).

A significant positive relationship ($P < 0.0001$; $r^2 = 0.14$; n = 112) existed between log-transformed total mercury concentrations and fish length (Fig. 2). A significant positive relationship ($P < 0.0001$; $r^2 = 0.16$; n = 72) was also detected between log-transformed total mercury concentrations and fish weight (Fig. 3). These positive relationships indicated that mercury levels tended to increase with increasing size of spotted seatrout; however, mercury levels in fish of the same length or weight were variable. Total mercury concentrations were not related ($P \geq 0.05$) to age of spotted seatrout (Fig. 4). Spotted seatrout growth was highly variable in Pensacola Bay and Choctawhatchee Bay (Fig. 5). For example, age-1 fish in Choctawhatchee Bay ranged from 265 to 485 mm TL.

DISCUSSION

In our study, the concentrations of mercury in spotted seatrout from northwest Florida were generally lower than concentrations in spotted seatrout from several other estuaries in Florida (FHRS, 1995). According to a health advisory from FHRS (1995), spotted seatrout from Florida Bay and the Florida Keys had the highest reported mean mercury concentration at 0.75 ± 0.40 ppm, and mean mercury concentrations reported in spotted seatrout from Charlotte Harbor, Tampa Bay, and the Indian River lagoon ranged from 0.41 to 0.51 ppm. Mercury concentrations were similar in male and female spotted seatrout from northwest Florida and were similar in males and females from the Indian River lagoon and Florida Bay (Strom and Graves, 1995).

There was a significant positive relationship between total mercury concentration and total length. However, this relationship accounted

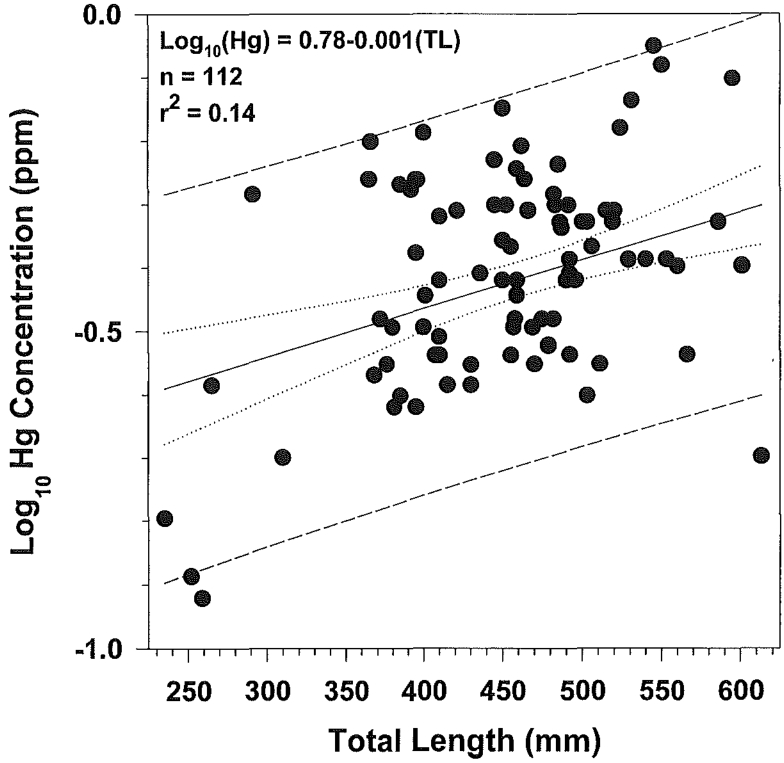
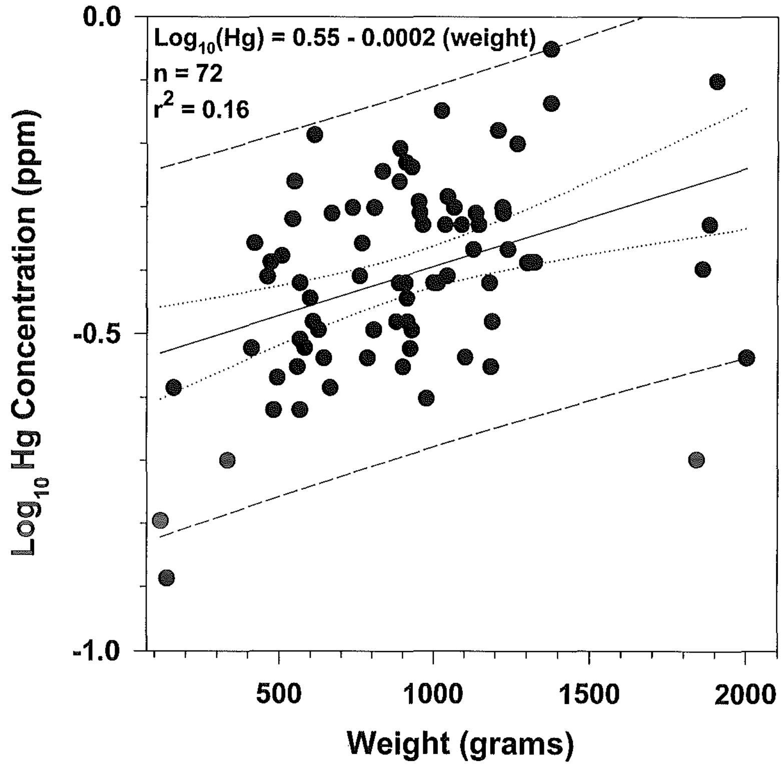


Fig. 2. Log_{10} total mercury (Hg) concentrations (ppm) versus total length regression for spotted seatrout in northwest Florida, 1993–96. Dotted lines represent 95% confidence intervals and dashed lines represent 95% prediction intervals.



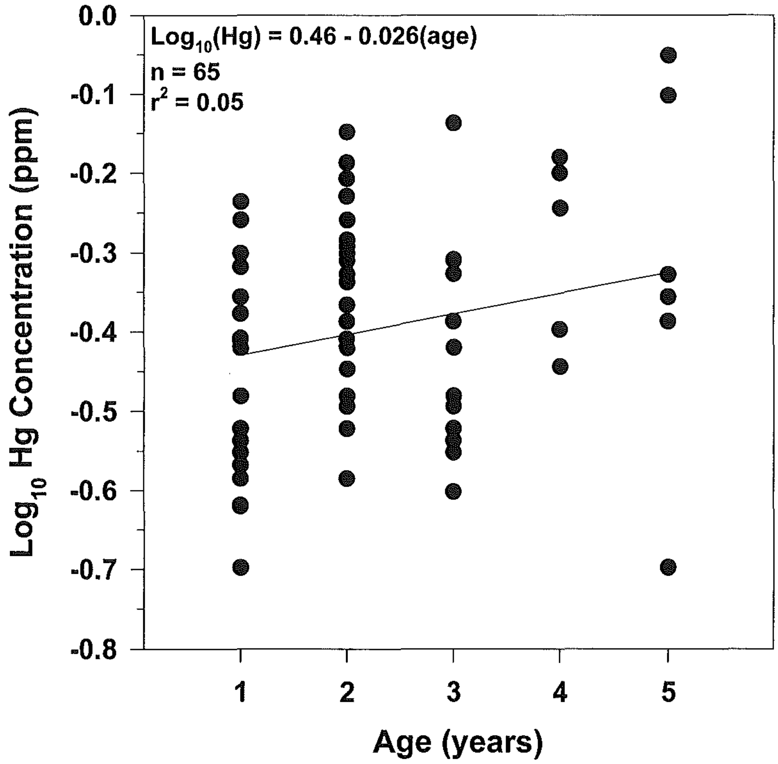


Fig. 4. Log_{10} total mercury (Hg) concentrations (ppm) versus age regression for spotted seatrout in northwest Florida, 1993–96.

for only 14% of the variation. Similarly, the relationship between total mercury concentration and total fish weight accounted for only 16% of the variation. These relatively weak relationships between mercury concentration and length or weight may be due to the variable lengths-at-age and variable weights-at-age of spotted seatrout from Pensacola Bay and Choctawhatchee Bay. Growth of spotted seatrout in Florida estuaries is highly variable (Murphy and Taylor, 1994; Bedee, 1997), which may help explain the high variation in mercury levels found in this species. For most fish species, the relationship between mercury concentration and fish length is less variable than is the relationship observed in our study of spotted seatrout, although wide variations in mercury concentrations within the same size class have been found in other fish species (Cross et al., 1973; Van Den Broek and Tracey, 1981; Boush and Thieleke, 1983; Fjeld and Rognerud, 1993; Mathieson and McLusky, 1995; Phillips et al., 1997).

Fish age was not closely related to total mercury concentration in the muscle tissue of spotted seatrout from northwest Florida. In fish populations with predictable growth, older fish typically have higher mercury concentrations than do younger fish of the same species (MacCrimmon et al., 1983; Munn and Short, 1997; Phillips et al., 1997). Because fish eliminate mercury very slowly in relation to their uptake of it (Lockhart et al., 1972; McKim et al., 1976), mercury concentrations in fish tissue tend to increase with fish age. The increase in mercury with age is likely caused by increased exposure time, but it also may be related to ontogenetic changes in diet in some species of fishes (MacCrimmon et al., 1983; Mathers and Johansen, 1985). Spotted seatrout are known to feed on a variety of invertebrate and fish species (Lassuy, 1983; Johnson and

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Fig. 3. Log_{10} total mercury (Hg) concentrations (ppm) versus total weight regression for spotted seatrout in northwest Florida, 1993–96. Dotted lines represent 95% confidence intervals and dashed lines represent 95% prediction intervals.

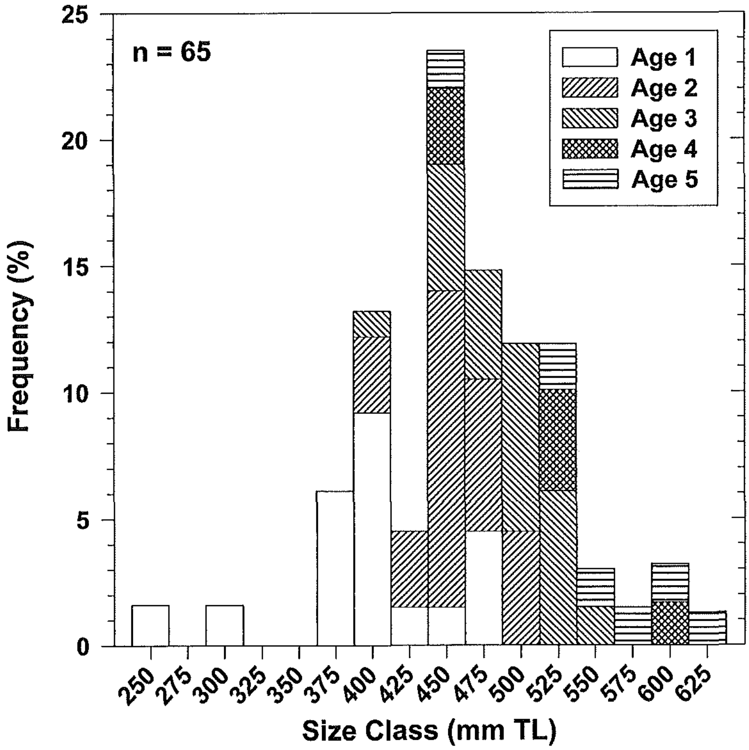

Fig. 5. Length-to-age frequency histogram for spotted seatrout collected in northwest Florida, 1993–96, both sexes combined. Fish were grouped in 25-mm size classes (e.g., 375-mm size class = 362.5–387.4 mm).

Seaman, 1986); because mercury concentrations may be highly variable in such a variety of prey items, the diverse diet of spotted seatrout may further explain the high variation in mercury levels found in this species.

In summary, mercury concentrations in spotted seatrout from northwest Florida were generally lower than concentrations in spotted seatrout from other Florida estuarine systems. Although mercury levels in muscle tissue varied depending upon the length, weight, and age of the fish, the majority of spotted seatrout collected in this study contained mercury levels lower than the State of Florida's threshold of 0.5 ppm.

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