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A survey of trace element distribution in tissues of stone crabs (*Menippe mercenaria*) from South Carolina Coastal Waters

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ABSTRACT

The stone crab (*Menippe mercenaria)* is an important component of the estuarine food web as both predator and prey. Stone crabs live in sediment, primarily consume oysters, and as a result, have the potential to accumulate significant quantities of pollutants including metals. In South Carolina, the stone crab is becoming a targeted fishery as an ecologically sustainable seafood choice. To date, no studies have reported metals in stone crab tissues. This study examined the distribution of major and minor trace elements in chelae and body muscle, gill, and hepatopancreas. Crabs were collected from three tidal areas within Charleston County, South Carolina, with differing upland use. Results were compared by collection location and by tissue type. Concentrations of some metals associated with anthropogenic activities were up to three times higher in crabs from sites adjacent to more urbanized areas. Concentrations in edible tissues were below historical FDA levels of concern.

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The stone crab (*Menippe mercenaria)* is an important component of the estuarine food web as both predator and prey. Benthic crustaceans with restricted mobility may be especially sensitive to pollution and other types of habitat degradation because they reside on bottom sediments where chemical contaminants accumulate. While stone crabs are carnivores not detritivores, they live in burrows and primarily consume oysters (Williams, 1984; Caldwell, 1992). Oysters are known to bioaccumulate contaminants, and as a result, stone crabs have the potential to accumulate significant amounts of pollutants including metals which may be biomagnified in the food chain to higher trophic levels including human consumers (Karouna-Renier et al., 2007). The stone crab can serve as a potential sentinel species in coastal areas by reflecting the effects of natural and anthropogenic stressors. Sustainable fisheries organizations encourage selection of stone crabs as an ecologically sustainable choice, since the crab is returned alive to the water after removal of a single claw (Lindberg and Marshal1, 1984; Gerhart and Bert, 2009). Stone crab claw ranks third in value as a marine fishery in Florida, with annual landings exceeding 3 million pounds (Swingle et al., 2001). In South Carolina, stone crab is an emerging targeted fishery, with most landings near Charleston and Beaufort Counties (G. Steele, Data Manager, Office of Fisheries Management, South Carolina Department of Natural Resources (SCDNR), Pers. Comm., 2009).

Charleston County is an area typical and fairly representative of other coastal areas in the southeastern USA where urbanization rates are increasing (Sanger et al., 1999). Three study areas were evaluated to determine relative percentage of each land cover class using raster data from SCDNR's GAP Analysis Program. The land cover classes represent natural and man-made vegetation types determined through aerial photography and ground assessment points. The North Edisto River receives mostly rural and agricultural

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input, the Stono River Inlet is primarily residential, and Charleston Harbor receives inputs from urbanized and industrial sources. The three areas were similar for combined areas of marine water and marsh, but Charleston Harbor had only half the marsh coverage as the other two areas. Total land coverage classified as urban (including residential, industrial, commercial and transportation development) for North Edisto, Stono River, and Charleston Harbor were 0.38%, 2.79%, and 31.00%, respectively.

Sediment associated invertebrates have the potential to bioaccumulate metals from metal-rich sediments (Corrêa et al., 2005; Holland et al., 2004). Sanger et al. (1999) reported higher levels of some metals in the sediment and biota of estuaries along coastal South Carolina due to urbanization. Anthropogenic inputs from local industrial, farming, and recreational activities are thought to be the primary contributors to any elevated trace metals in Charleston County sediments (Sanger et al., 1999). To date, no studies have examined tissue concentrations of metals in stone crabs. The objective of this study was to examine the distribution of major and minor trace elements in four tissues from stone crabs collected from three areas adjacent to Charleston County, SC, with differing upland use.

Stone crabs were collected near the mouth of each estuary where densities are typically highest (Fig. 1). Vinyl-coated 12-gauge wire mesh (1.5″ square) traps with PVC bait wells ~24″ × 24″ × 20″ weighted with a $^{5}/_{8}$″ rebar H-irons to ~10 lb were baited with menhaden *(Brevoortia tyrannus)* and fished 24 h after being set. A total of fifteen crabs, five from each site, were collected under SCDNR Experimental Permit EX09-0067 using an 18’ boat during August and September of 2008. Only adult male hard-shelled crabs with a legal sized propodus (greater than 70 mm), both claws intact, and a carapace width of at least 80 mm were collected for trace element analysis. Males were the gender targeted since gender difference in accumulation is not commonly found in crabs (Chen et al., 2005), and male crab migration ranges in an estuary are generally smaller than those of females (Karouna-Renier et al., 2007). All collected crabs were sexually mature adults; the median size for male stone crabs at morphological maturity is 70 mm (Gerhart and Bert, 2008). Collected crabs were placed over ice in coolers for transport.

In the laboratory, crabs were cryoanesthetized and dissected. Concentrations of selected elements (Ag, Al, As, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Li, Mn, Ni, Pb, Sb, Se, Sn, Tl, U, V, and Zn) were measured in chelae muscle, body muscle, gill, and hepatopancreas. Tissue samples were homogenized and stored in acid-washed straight side, clear polypropylene containers (Scientific Specialties, Hanover, MD) at −40 °C until processing for analysis. A portion of each homogenate was dried to estimate the dry fraction. The dry fraction of each tissue sample was determined gravimetrically with an AX205 analytical balance (Mettler Toledo, Columbus, OH) after drying for 48 h in an 80 °C Isotemp® 200 series oven (Fisher Scientific, Pittsburgh, PA). Average moisture content for all crabs was 84.7 ± 1.9% for gill (range = 81.5–88.7%), 78.1 ± 1.6% for muscle tissues (range = 75.1–82.9%), and 68.9 ± 6.4% for hepatopancreas (range = 56.8–79.1%).

Homogenized tissue samples (~0.2 g) were digested in closed Teflon digestion vessels with 10 mL of ULTREXII ultrapure nitric acid (J.T. Baker, Phillipsburg, NJ) in a 1000 W CEM MDS-2100 Microwave (CEM Corp., Matthews, NC) for 60 min at 66% of power and a maximum pressure of 120 psi. After the first digestion, 2 mL of ULTREXII ultrapure 30% hydrogen peroxide (J.T. Baker) was added for an additional 10 min microwave digestion at 66% power and 80 psi to complete oxidation of organic matter. The solution was diluted to a final volume of 50 mL with Millipore deionized water for trace element analysis.

A Perkin Elmer (PE) Sciex ELAN® 6100 Inductively Coupled Plasma Mass Spectrometer with an AS-91 autosampler (Perkin Elmer,

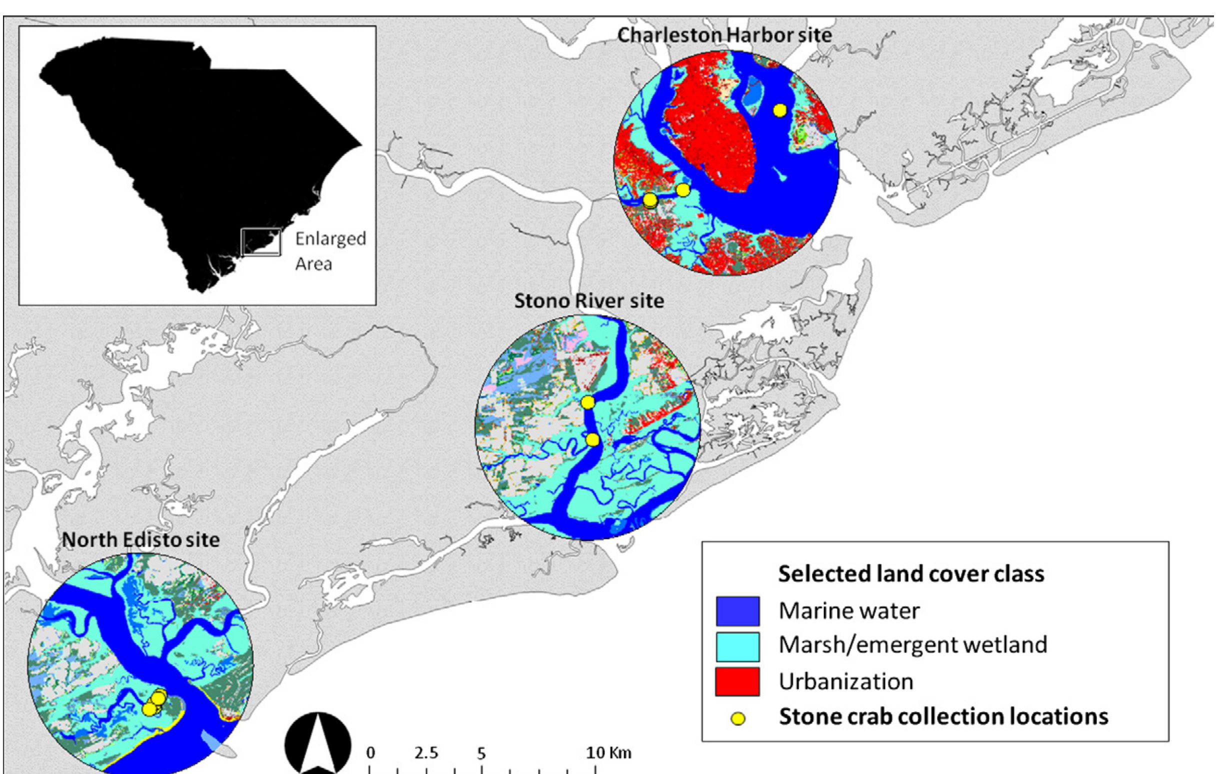

Fig. 1. Study area in Charleston County, South Carolina, showing collection locations of stone crabs and selected land cover classes. Selected land cover classes determined by SCDNR through aerial photography and ground assessment points as part of the SC Gap Analysis Program (http://www.dnr.sc.gov/GIS/gap/mapping.html).