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Chemical contaminants, health indicators, and reproductive biomarker responses in fish from rivers in the Southeastern United States

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ABSTRACT

Largemouth bass (*Micropterus salmoides*) and common carp (*Cyprinus carpio*) were collected from 13 sites located in the Mobile (MRB), Apalachicola–Flint–Chattahoochee (ARB), Savannah (SRB), and Pee Dee (PRB) River Basins to document spatial trends in accumulative chemical contaminants, health indicators, and reproductive biomarkers. Organochlorine residues, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin-like activity (TCDD-EQ), and elemental contaminants were measured in composite samples of whole fish, grouped by species and gender, from each site. Mercury (Hg) and polychlorinated biphenyls (PCBs) were the primary contaminants of concern. Concentrations of Hg in bass samples from all basins exceeded toxicity thresholds for piscivorous mammals (>0.1 μg/g ww), juvenile and adult fish (>0.2 μg/g ww), and piscivorous birds (>0.3 μg/g ww). Total PCB concentrations in samples from the MRB, ARB, and PRB were >480 ng/g ww and may be a risk to piscivorous wildlife. Selenium concentrations also exceeded toxicity thresholds (>0.75 μg/g ww) in MRB and ARB fish. Concentrations of other formerly used (total chlordanes, dieldrin, endrin, aldrin, mirex, and hexachlorobenzene) and currently used (pentachlorobenzene, pentachloroanisole, dacthal, endosulfan, γ-hexachlorocyclohexane, and methoxychlor) organochlorine residues were generally low or did not exceed toxicity thresholds for fish and piscivorous wildlife. TCDD-EQs exceeded wildlife dietary guidelines (>5 pg/g ww) in MRB and PRB fish. Hepatic ethoxyresorufin *O*-deethylase (EROD) activity was generally greatest in MRB bass and carp. Altered fish health indicators and reproductive biomarker were noted in individual fish, but mean responses were similar among basins. The field necropsy and histopathological examination determined that MRB fish were generally in poorer health than those from the other basins, primarily due to parasitic infestations. Tumors were found in few fish ($n=5$; 0.01%); ovarian tumors of smooth muscle origin were found in two ARB carp from the same site. Intersex gonads were identified in 47 male bass (42%) representing 12 sites and may indicate exposure to potential endocrine disrupting compounds. Comparatively high vitellogenin concentrations (>0.35 mg/mL) in male fish from the MRB, SRB, and PRB indicate exposure to estrogenic or anti-androgenic chemicals.

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1. Introduction

The southeastern United States is known for it diverse fauna which includes many threatened and endangered aquatic species. The region also provides important habitat for endemic aquatic species, nesting and brood habitat for duck and alligator populations, and wintering areas for migratory birds and waterfowl. Species diversity in rivers and streams of the southeastern United States has declined due to dam construction, channel modifications, poor water quality, and introduction of nonindigenous species (Lydeard and Mayden, 1995). Aquatic species may also be at risk due to exposure to chemical contaminants.

The rich soils, abundant forests, and warm climate of the southeastern United States have led to the development of agriculture, forestry, mining, and manufacturing industries that are dependent on local water sources. These industries have been associated with declines in water quality in the Mobile River Basin (MRB), Apalachicola–Chattahoochee–Flint River Basin (ARB), Savannah River Basin (SRB), and Pee Dee River Basin (PRB). Industrial discharges from chemical manufacturing plants, military facilities, pulp and paper mills, and coal-fired power plants; urban and agricultural runoff; mine drainage; and municipal wastewater effluents have previously been associated with declines in water and habitat quality in one or more of these basins. As a result, many MRB, ARB, SRB, and PRB waters have been listed as impaired. The lower MRB has one of the largest concentrations of major industrial manufacturers along the Gulf of Mexico that have released a variety of organochlorine chemicals into the basin (USFWS, 1996), and pesticides used in agricultural and heavily-populated residential areas of MRB, ARB, SRB, and PRB enter water systems in runoff. Elevated concentrations of pesticides, polychlorinated biphenyls (PCBs), and mercury (Hg) have been reported in water, sediment, and biota in these basins (Adair et al., 2003; Atkins et al., 2004; Gilliom et al., 2006; Johnson et al., 2002; U.S. Environmental Protection Agency (USEPA), 1992; USFWS, 1996), and fish consumption advisories for Hg and PCBs have been issued for large rivers and reservoirs in the MRB, ARB, SRB, and PRB to protect human health. Livestock and poultry production is intensive in the ARB, SRB, and PRB with multiple concentrated animal feeding operations producing large amounts of animal waste and byproducts that can enter nearby streams and rivers (Burkholder et al., 2007); excess nutrients, pharmaceuticals, and synthetic and natural hormones are concerns associated with this industry. Previous contaminant studies in these basins have focused on measuring chemical contaminant concentrations in biota, but few investigations have assessed the health of aquatic biota in the MRB, ARB, SRB, and PRB.

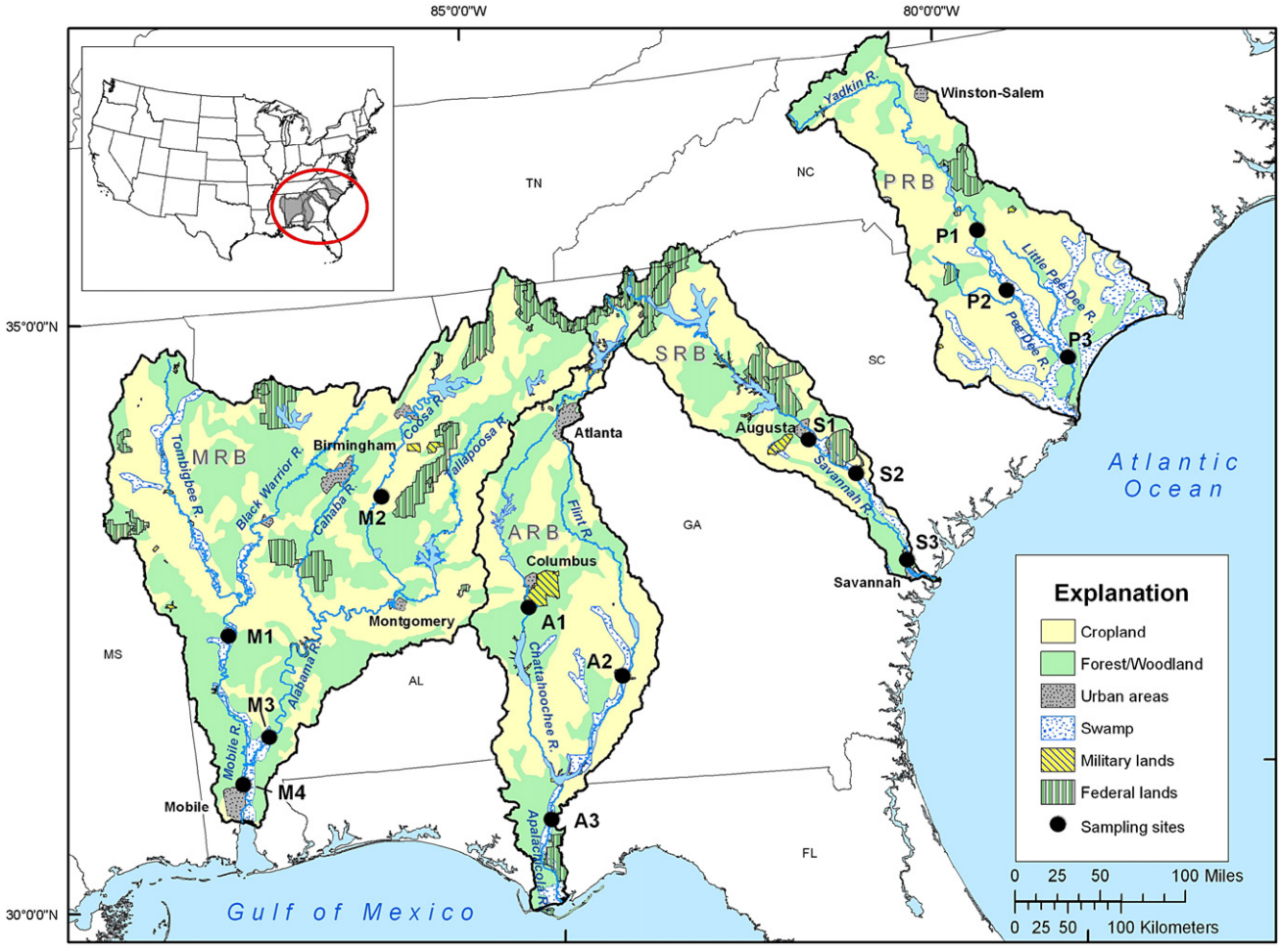

Fig. 1 – Map of the Mobile, Apalachicola–Chattahoochee–Flint, Savannah, and Pee Dee River Basins illustrating landuse, waterways, state boundaries, and locations sampled.