# CONTAMINANT CONCENTRATIONS AND BIOMARKER RESPONSES OF FISH FROM THE MOBILE, APALACHICOLA, SAVANNAH, AND PEE DEE RIVER BASINS

J.E. Hinck[1], V.S. Blazer[2], N.D. Denslow[3], T.S. Gross[4], T.W. May[1], C.E. Orazio[1], J.J. Coyle[5], P.J. Anderson[5], and D.E. Tillitt[1]

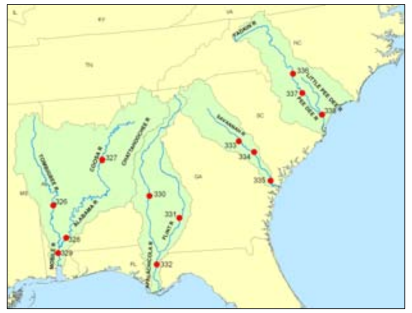
[1]USGS, Columbia, MO; [2]USGS, Kearneysville, WV; [3]University of Florida, Gainesville, FL; [4]USGS, Gainesville, FL; [5]USGS BEST Program, Fort Collins, CO

## ABSTRACT

Many chemical manufacturers, pulp and paper mills, textile operations, and power plants are located in the Mobile, Apalachicola, Savannah, and Pee Dee River Basins. Contaminants released from these industries and other sources may pose a risk to fish in nearby waters. To address these concerns, the Large River Monitoring Network (LRMN) of the Biomonitoring of Environmental Status and Trends (BEST) Program measured tissue concentrations of selected contaminants and evaluated biomarker responses in largemouth bass (*Micropterus salmoides*) and common carp (*Cyprinus carpio*) from four sites in the Mobile River Basin and three sites each in the Apalachicola, Savannah, and Pee Dee River Basins. Elemental contaminant concentrations did not exceed effects thresholds in whole body composite samples except for mercury (Hg), selenium (Se), and zinc (Zn); concentrations of these three contaminants may be harmful to fish, fish-eating wildlife, or both at some sites. Organochlorine residues and dioxin-like activity are currently being analyzed in the samples. Mean hepatic EROD activity varied in bass among basins but was uniformly greater in carp (>20 pmol/min/mg) from Mobile River Basin sites. Health assessment index (HAI) scores were highest in fish from Mobile River Basin sites due to liver, spleen, kidney, and fin lesions. Other fish health indicators [condition factor (CF), somatic indices (HSI, SSI)] were anomalous in fish from several sites. Multiple reproductive biomarkers including vitellogenin (vtg) concentrations, gonadosomatic index (GSI) values, and steroid hormone (E, KT) concentrations were anomalous in fish (primarily bass) from the Pee Dee basin, which indicates an endocrine response in fish from these sites. Moreover, ovotestes (ovt) were found in male bass from all basins; such wide occurrence of this condition has not been previously reported by the BEST-LRMN Program. These data will aid in characterizing fish health and contaminant concerns in the Mobile, Apalachicola, Savannah, and Pee Dee River Basins.

## INTRODUCTION

The BEST-LRMN Program has assessed contaminants and biomarker responses in selected fish species from multiple U.S. river basins including the Mississippi, Rio Grande, Columbia, Yukon, and Colorado. Four important river basins in the southeastern U.S. including the Mobile, Apalachicola, Savannah, and Pee Dee were sampled in the fall of 2004 (Fig. 1). Forty fish (ten of each gender, two species) from each site were collected by electrofishing. A predator species (largemouth bass; *Micropterus salmoides)* and a benthivorous species (common carp; *Cyprinus carpio*) were targeted at each site. Fish were held alive until the field health assessment was performed. Specific tissues and fluids were collected from individual fish for biomarker analyses, and whole carcasses were frozen for organochlorine residue (e.g., pesticides, total PCBs) and elemental contaminant (e.g., mercury, selenium, arsenic) analyses. The suite of selected methods responds to a wide variety of contaminants. Potential sources of contamination in the basins include paper mills, chemical manufacturing plants, waste water treatment facilities, agricultural applications, and urban runoff. Results from this study will also be compared to biomonitoring results from previous LRMN studies in order to refine benchmark values for many biomarkers. Moreover, this study will help to identify areas that warrant further investigation into the effects of chemical contaminants in fish from the Mobile, Apalachicola, Savannah, and Pee Dee River Basins.



Sampling site
326 – Lavaca, AL
327 – Childersburg, AL
328 – Eureka Landing, AL
329 – Bucks, AL
330 – Omaha, GA
331 – Albany, GA
332 – Blountstown, FL
333 – Augusta, GA
334 – Sylvania, GA
335 – Port Wentworth, GA
336 – Rockingham, NC
337 – Pee Dee, SC
338 – Bucksport, SC

**Figure 1**. Fish sampling sites in the southeastern U.S.

## RESULTS

**Preliminary summary of chemical and biological indicator data that were anomalous in female (f) and male (m) bass (b) and carp (c).**

| Station | Contaminants and EROD | Fish health indicators | Reproductive biomarkers |
|---|---|---|---|
| Mobile River Basin | | | |
| 326 | Hg (b); Se (mc); EROD (b, fc) | HAI (b, c) | Ovt (mb) |
| 327 | Hg (b, c); EROD (mc) | HAI (fb, c) | Ovt (mb) |
| 328 | Hg (b, c); EROD (fc) | HAI (b, c); CF (mb) | none |
| 329 | Hg (b, c); Se (mc) | HAI (b, fc) | Ovt (mb) |
| Apalachicola River Basin | | | |
| 330 | Hg (b, c); Se (fc); Zn (fc) | none | Ovt (mb) |
| 331 | Hg (b, c); Zn (fc) | none | Ovt (mb) |
| 332 | Hg (b) | none | Ovt (mb) |
| Savannah River Basin | | | |
| 333 | Hg (b, c) | SSI (fb) | Ovt (mb); vtg (mb) |
| 334 | Hg (b, c) | none | Ovt (mb) |
| 335 | Hg (b, c) | none | Ovt (mb); GSI (fb) |
| Pee Dee River Basin | | | |
| 336 | Hg (b, c) | HSI (mb) | Ovt (mb); GSI (b); vtg (mb); KT (mb); E (fb) |
| 337 | Hg (b, c); EROD (b) | HAI (c) | Ovt (mb); vtg (mb); KT (fb) |
| 338 | Hg (b, c) | CF (-c); SSI (c) | Ovt (mb); GSI (c) |

### Contaminants and EROD

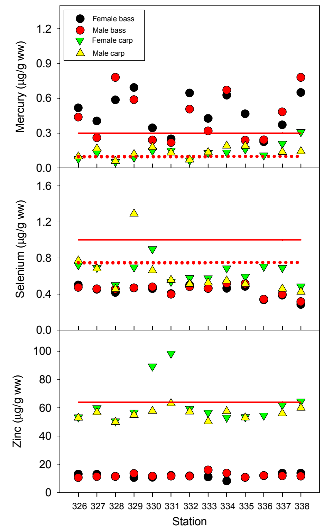


**Figure 2.** Elemental contaminant concentrations (conc.) exceeded effects thresholds for mercury (Hg), selenium (Se), and zinc (Zn). Dietary Hg conc. of 0.1-0.3 µg/g have been associated with reproductive impairment in common loons and mallards. Selenium conc. >0.75 µg/g may be harmful to fish-eating wildlife and >1.0 µg/g may be harmful to larval fish. Zinc conc. of 40-64 µg/g can affect the growth and survival of cyprinids.

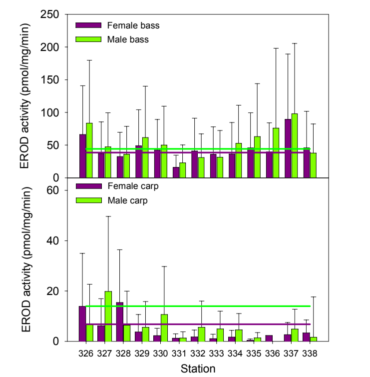


**Figure 3.** Mean hepatic ethoxyresorufin *O*-deethylase (EROD) activity was highest in bass from Stations 326 and 337 and carp from Stations 326, 327, and 328. Activities were generally higher in male fish than female fish. Data were compared to threshold levels for female (—) and male (—) bass and carp. Thresholds were determined by examining frequency distributions and computing geometric means and associated variance for each gender and species from the LRMN database. EROD thresholds were exceeded by bass at most sites; thresholds for carp were exceeded primarily in the Mobile River Basin.

### Fish health indicators and Reproductive biomarkers

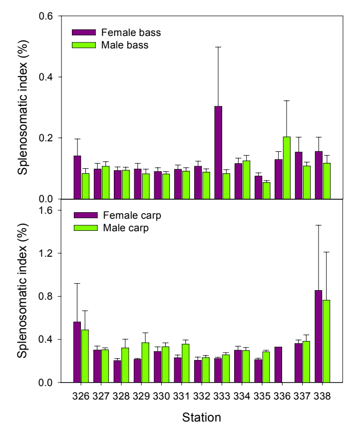


**Figure 4**. Spleens of female bass from Station 333 and carp from Station 338 were relatively large, as reflected in the high mean splenosomatic index (SSI) values at these sites.

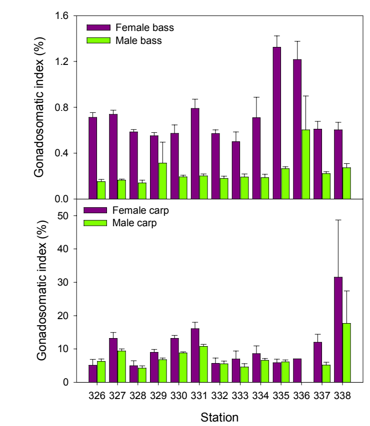


**Figure 5**. Gonads of bass from Stations 335 (females only) and 336 and carp from Station 338 were relatively large, as reflected in the high mean gonadosomatic index (GSI) values at these sites. These differences were not due to reproductive stage.

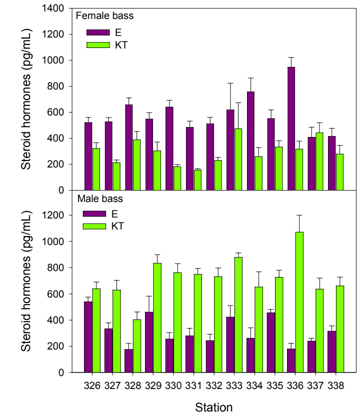


**Figure 6**. Mean 11-ketotestosterone (KT) conc. were > 17β-estradiol (E) conc. in female bass from Station 337. E conc. in female bass and KT conc. in male bass from Station 336 were relatively high.

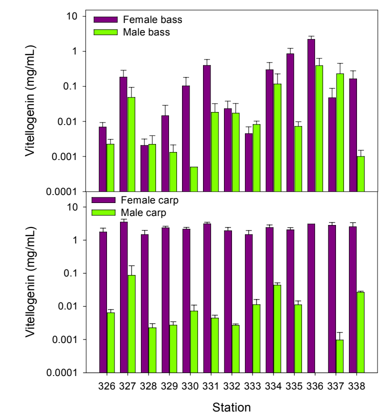


**Figure 7**. Mean vitellogenin (vtg) conc. were greater in male bass than female bass from Stations 333 and 337. Relatively high conc. (>0.1 mg/mL) were also measured in male bass from Station 336. These differences were not due to reproductive stage.

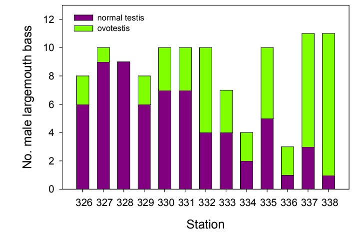


**Figure 8**. Intersex male bass (testicular tissue containing previtellogenic oocytes) were found at all sites except Station 328. Ovotestis (ovt) occurrence was ≥50% at Stations 332, 334, 335, 336, 337, and 338.

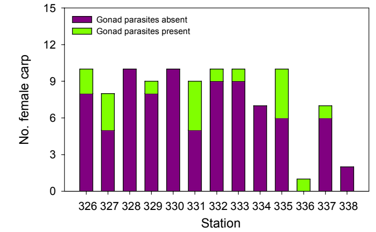


**Figure 9**. Prevalence of parasites observed in carp gonads. At most sites, the parasites noted were remnants of helminth parasites within granulomas. A sporozoan parasite was also noted within oocytes in female carp at Stations 326, 335 and 337 (Fig. 10).

### Gonadal histopathology

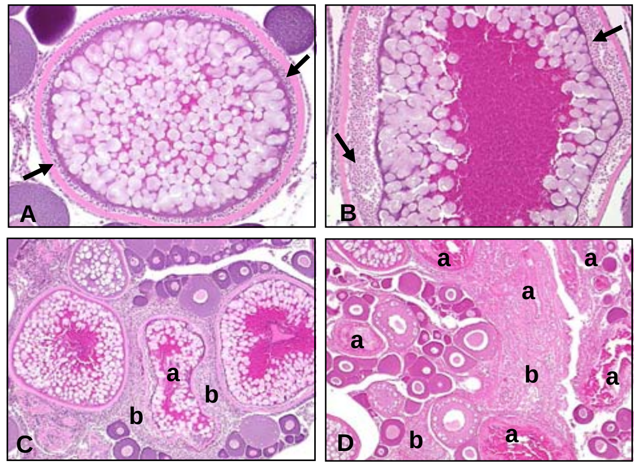


**Figure 10.** In addition to the helminth parasites found in carp gonads, an unidentified sporozoan parasite was noted within carp oocytes from Stations 326, 335, and 337. A and B. A layer of parasites (arrows) was observed within relatively normal appearing oocytes. C. As the oocytes begin to degenerate (a) extensive inflammation (b) is observed. D. The parasite infection results in many atretic eggs (a) and elicits a significant inflammatory response throughout the ovarian tissue (b).

## SUMMARY OF PRELIMARY RESULTS

- Mercury concentrations were elevated in fish from most sites and may be harmful to fish and wildlife (Fig. 2). Concentrations were among the highest measured by the BEST-LRMN Program.
- Hepatic EROD activity in carp from the Mobile River Basin indicated exposure to AhR agonists; EROD thresholds were exceeded in bass at most sites (Fig. 3).
- Vitellogenin and steroid hormone concentrations and gonadosomatic index values were anomalous in bass from the Pee Dee River Basin and may indicate endocrine disruption (Figs. 5-7).
- The broad occurrence of ovotestes in male bass (12 of 13 sites) is unprecedented in this biomonitoring program. The high proportion of individual fish from the Savannah and Pee Dee River Basins with ovotestes warrants further investigation (Fig. 8).
- Initial examination of ovarian tissue in carp revealed parasitic infestations associated with granulomas and inflammation; an unidentified sporozoan parasite was also noted (Figs. 9-10). It is unknown whether these histopathologies are related to contaminant exposure.
- Organochlorine pesticides and histopathology analyses need to be completed in order to evaluate all the chemical and biological endpoints.

## To obtain more information on the LRMN

For information on the BEST Program visit: *www.best.usgs.gov*
For public database: *www.cerc.usgs.gov/data/best/search/index.htm*
For publications (in pdf): *www.cerc.usgs.gov/pubs/pubs.htm*
Contact: Jo Ellen Hinck (jhinck@usgs.gov)

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**Acknowledgements**

The authors thank staff from multiple USGS science centers in Columbia, MO; Kearneysville, WV; and Gainesville, FL and the University of Florida that participated in this project. Additionally, we thank FWS from Daphne, AL for collection of fish from the Mobile basin and Robin Lipkin who created the map and assisted in formatting this presentation.