Reproductive Status of Fish Exposed to the TVA Kingston Steam Plant Fly Ash Spill

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Introduction

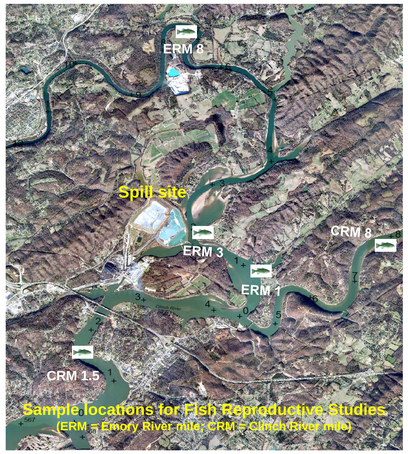
On December 22, 2008, a dike containing fly ash at the Tennessee Valley Authority's (TVA) Kingston Steam Plant in Tennessee failed and released a large quantity of ash into the adjacent Emory River. Ash deposits extended as far as 4 miles upstream in the Emory River and downstream past the confluence of the Emory River with the Clinch River, with ash detectable as far downstream as Tennessee River mile 564 (~4 miles downstream of the Tennessee River confluence with the Clinch River). Fly ash is enriched in a variety of metals, with selenium being of particular concern because of the potential for reproductive failure in fish populations exposed to highly elevated concentrations of this metal. As part of a broader effort at evaluating the risks of the fly ash spill to downstream fish populations, a study was begun in the spring of 2009 to investigate the potential reproductive consequences of the spill. Female fish of various species were collected immediately before or during their respective breeding seasons from sites within the spill zone and from upstream reference sites in both the Emory and Clinch Rivers, and examined for a variety of measures of reproductive condition including ovary size, appearance, and stages of oocyte development. Ovaries and other tissues were also analyzed for a suite of metals.

Objectives

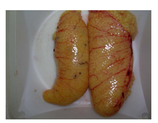
- Document the reproductive condition of sentinel fish species during the first reproductive season following the fly ash spill
- Obtain base-line data for longer-term studies in subsequent breeding seasons
- Determine if selenium is sufficiently elevated in fish tissues, and specifically in eggs or ovaries, to trigger follow-up studies focused on fish larval development

Procedures

- Female bluegill sunfish, largemouth bass, white crappie and channel catfish (target size of 8 or more) were collected from 5 sites in the Emory and Clinch Rivers by electrofishing or gillnetting (catfish only)

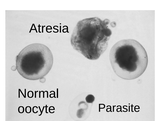


- Following capture, a blood sample was taken from each fish and the fish tagged with unique 5 digit ID number for later processing
- Muscle, liver, and ovary tissue (when sufficiently available) were obtained from 6 individuals of each species for bioaccumulation analysis
- Subsamples from all tissues were freeze-dried to express bioaccumulation results as percent dry weight
- Weighed pieces of ovary were fixed and preserved for later analysis, while other pieces were preserved for histology



← Largemouth bass ovary

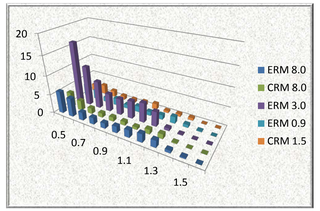
Normal and atretic sunfish oocytes →



- Ovary pieces were quantitatively analyzed with the aid of a dissecting microscope for oocyte developmental stage and size distributions, with particular emphasis on enumerating oocyte atresia
- Batch fecundity was estimated from the size of the leading clutch of developing oocytes and/or the abundance of post-ovulatory follicles in recently spawned ovaries

Results

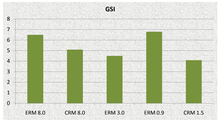
Oocyte Development in Largemouth Bass - Spring 2009



Mean size distribution of oocytes in the ovaries of female largemouth bass sampled from sites upstream and downstream of the Kingston fly ash spill in the spring of 2009. *Expressed as oocytes per g fish at 0.1 mm size increments.*

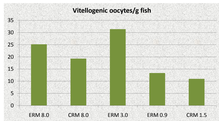
Picture by Richard T. Bryant

Largemouth Bass Gonadosomatic Indices (GSI) - Spring 2009

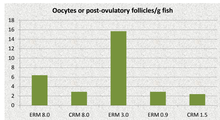


- Oocyte development appeared normal at all study sites for ovaries sampled at this stage of the breeding season
- The presence of numerous post-ovulatory follicles in fish from ERM 3.0 indicated a recent spawn, which might explain the relative abundance of smaller vitellogenic oocytes and atretic oocytes at this site
- Results shown are undergoing QA/QC review

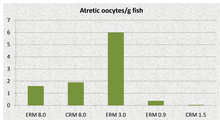
Largemouth Bass Vitellogenic Oocytes Spring 2009



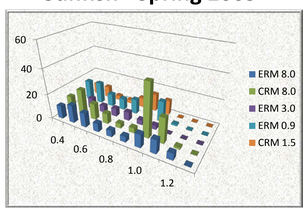
Largemouth Bass Batch Fecundity Spring 2009



Largemouth Bass Oocyte Atresia Spring 2009



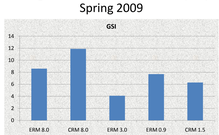
Oocyte Development in Bluegill Sunfish - Spring 2009



Mean size distribution of oocytes in the ovaries of female bluegill sampled from sites upstream and downstream of the Kingston fly ash spill in the spring of 2009. *Expressed as oocytes per g fish at 0.1 mm size increments.*

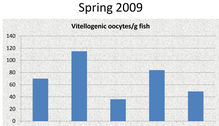
Picture by Richard T. Bryant

Bluegill Gonadosomatic Indices (GSI) Spring 2009

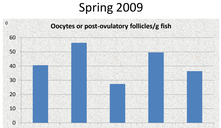


- Oocyte development was delayed in the ovaries of bluegill sampled from ERM 3, but otherwise appeared typical of prespawning fish
- The developmental delay might be related to the relatively low condition factors measured in these fish, suggesting a possible nutritional cause for the delay
- Results shown are undergoing QA/QC review

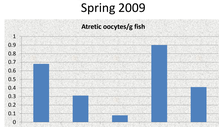
Bluegill Vitellogenic Oocytes Spring 2009



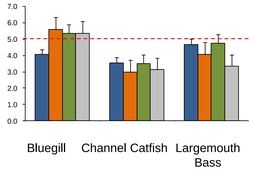
Bluegill Batch Fecundity Spring 2009



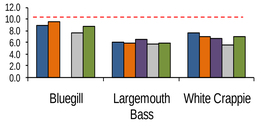
Bluegill Oocyte Atresia Spring 2009



Selenium in muscle tissue
(mg/kg dry wt)



Selenium in fish eggs
(mg/kg dry wt)



**Blue bars represent upstream reference site*

Conclusions

- Selenium is elevated in the muscle and ovarian tissues of some fish species sampled downstream of the fly ash spill
- Concentrations of selenium in bluegill tissues exceed or approach levels indicative of a risk for potential reproductive failure
- However, female fish collected at and downstream of the spill in spring/summer 2009 had few obvious reproductive abnormalities, other than a developmental delay in bluegill sunfish directly at the spill site

Future Directions

- Fish will again be sampled in the spring of 2010 and examined for reproductive condition and metal bioaccumulation approximately 1.5 years after the spill
- In addition, a new series of studies will be initiated in the spring of 2010 to specifically examine the potential effects of the fly ash spill on the early life stages of exposed fish populations
- These integrated field and laboratory studies are expected to provide a better understanding of the risks of fly ash exposure to fish populations affected by the Kingston spill.

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