Assessment of Bioaccumulation of Fly-Ash Associated Metals by Fish in the Area of the Kingston Fly Ash Release

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Introduction

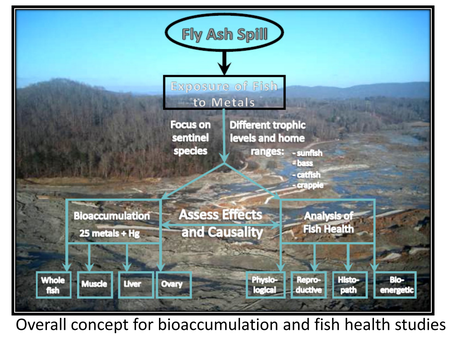
As a major component of the comprehensive biological monitoring and assessment project related to the TVA Kingston fly ash release, we conducted a fish bioaccumulation study to determine if fly ash-associated metals were being incorporated through the food chain into upper-level consumers. Multiple species of fish, representing different trophic levels and home ranges, were sampled at sites in the immediate vicinity of the fly ash release and at multiple reference sites upstream and downstream of the release. Muscle, liver, and ovarian tissue from individual fish were analyzed for 25 metals typically associated with fly ash including selenium, mercury, and arsenic.

Objectives

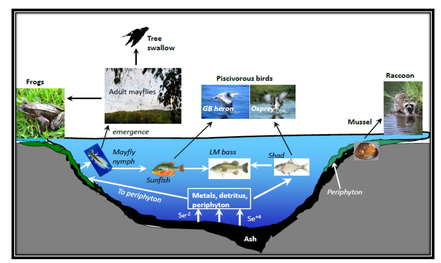
- Determine if fly ash-associated metals are being incorporated through the food chain into upper-level consumers
- Evaluate the relationship between bioaccumulation of fly ash-associated metals and health responses in sentinel fish species

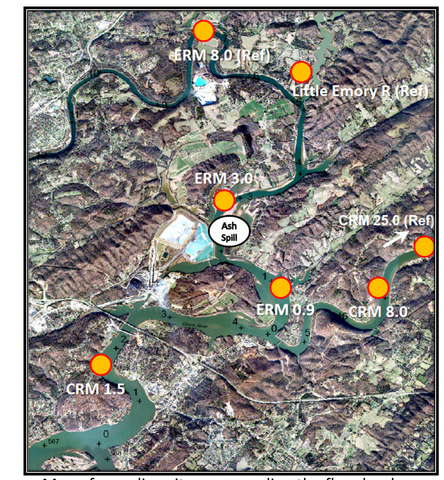
Approach

- Eight individuals each of adult bluegill sunfish, largemouth bass, and channel catfish were collected at each of 4-6 sites by electrofishing or gill netting. Each fish was tagged with a unique five-digit ID number.
- A blood sample was taken from each fish immediately upon capture, and analyzed the same day with a VetScan VS2 veterinary diagnostic machine.
- A health assessment was conducted for each fish including length and weight; organ weight; gall bladder size and color; liver color, condition of eyes, gills, and spleen; lipid level; visceral weight; and feeding level.
- Muscle, liver, and ovary tissues were taken from six individuals of each species and analyzed for presence of 25 metals.
- Subsamples of muscle, liver, and ovary tissues were freeze-dried to obtain percent dry weight.
- Composite histopathology score was calculated based on a sum of lesions in liver, gills, and kidneys.
- Gizzard shad were collected and composited into three groups of ten fish per site for metals analysis



Overall concept for bioaccumulation and fish health studies (above), and trophic relationships in the area of the spill (below)

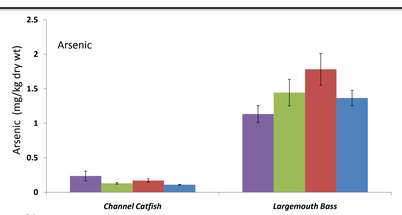


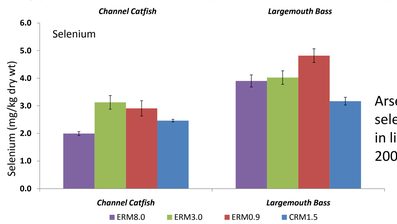


Map of sampling sites surrounding the fly ash release

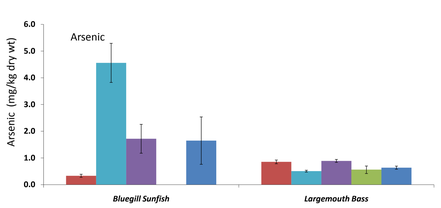
Results

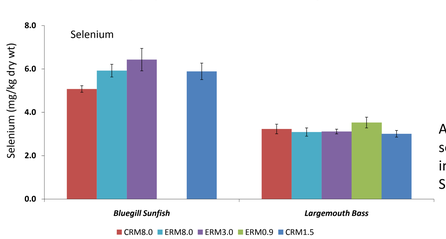
- All figures show sites in a downstream gradient
- Error bars are standard error on all figures



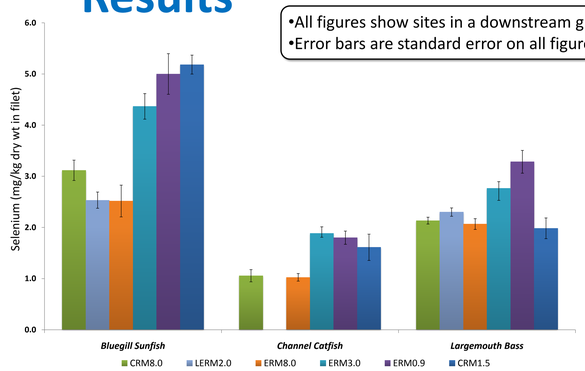


Arsenic (top) and selenium (bottom) in liver tissue, Spring 2009

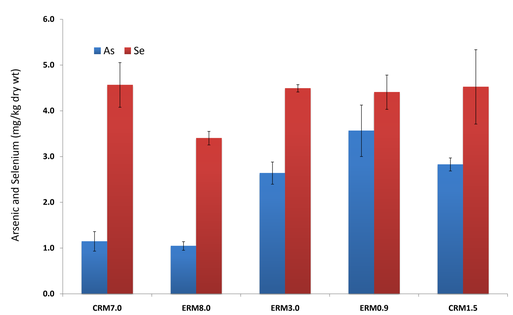




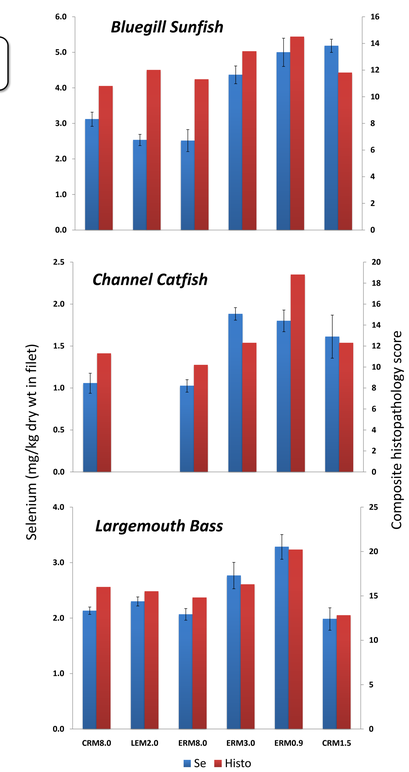
Arsenic (top) and selenium (bottom) in ovary tissue, Spring 2009



Selenium in muscle tissue, Fall 2009



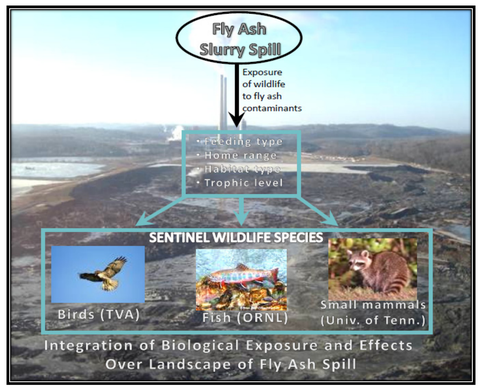
Arsenic and selenium in Gizzard Shad composite samples



Relationship between selenium in muscle tissue and composite histopathology score

Conclusions

- Of the 25 fly ash metals measured, selenium and arsenic are the only metals bioconcentrated above background levels in fish tissue
- Selenium in muscle tissue displays a spatial downstream gradient with levels being higher downstream of the spill
- Selenium levels in catfish are lower than bluegill and bass possibly indicating a high site fidelity for bluegill and a lower site fidelity for catfish
- Levels of selenium in liver and ovary are generally higher than in muscle for all 3 species, an important implication to reproductive fitness
- Spatial gradients in selenium of all three species general follow downstream patterns in the composite histopathology score, an overall indicator of fish health



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