# Mercury Transfer Through an Everglades Aquatic Food Web

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Aquatic animal and plant species accumulate mercury in body tissues, from which it is passed by consumption to higher trophic levels in the food web. Top-level carnivores may accumulate burdens at which toxic effects, such as nerve damage, convulsions, or death, become evident. Of the various forms of mercury, methylmercury is the most toxic and accumulatory mercury compound. It is produced mainly by the microbial methylation of inorganic Hg in aquatic systems. Although the mercury contamination problem in the Everglades is now well-publicized, the processes by which mercury is made available to the biota, the extent of contamination in species at various trophic levels, and the pathways by which mercury is passed through the Everglades biota are poorly understood. Those questions are being addressed in this project, which began in March 1995, with field and laboratory data collections completed in the summer of 1998. A final report has been produced and manuscripts of the study segments are being prepared for publication.

Past studies of mercury in the biota have focused on the top-level predators in the Everglades, with little analytical emphasis being placed on the smaller fishes and invertebrates upon which the predatory fishes, wading birds, and small alligators feed. To understand the extent of the contamination problem, and to identify the most important routes by which mercury is being passed to the top levels in the system, mercury concentrations must be measured at lower trophic levels in the Everglades aquatic food web. It is not possible to obtain information on food web pathways and marsh hydropattern relationships from the extensive literature on mercury because few studies have taken the approach of examining an entire aquatic assemblage. In addition, most studies of mercury bioaccumulation and food web transfer have been done either in the laboratory, in temperate lakes and reservoirs, or in riverine or marine systems. Those results are not very transferable to a subtropical wetland like the Everglades. The need for research in non-temperate systems, particularly wetlands, is increasingly important to understand and deal with the mercury problem in the Everglades.

This study examined the pathways of mercury (Hg) bioaccumulation and its relation to trophic position and hydroperiod in the Everglades by performing three related studies. The project was divided into three segments formulated to support and extend other State and Federal study plans intended to address the mercury contamination problem in Florida. Element I described the food habits and trophic positions of Everglades freshwater fishes at high-water and low-water periods from three habitats; Element II addressed total mercury concentrations in Everglades freshwater biota, as related to trophic position, at one study location; and Element III examined the effects of time-of-year and site hydroperiod on mercury levels of wild and caged mosquitofish at three pairs of Everglades locations. This study was conducted entirely within Everglades National Park (ENP), Florida, in spikerush marshes and alligator holes, where past sampling for mercury had demonstrated some of the highest Hg levels in Everglades aquatic biota. Detailed site descriptions are provided within the Element sections. The sampling for Elements I and II was done in northern Shark Slough, centering on a long-hydroperiod, central Everglades marsh complex designated as 1-L. The caged and wild mosquitofish studies in Element III were run at three pairs of long- and short-hydroperiod sites in northern Shark Slough, middle Shark Slough, and in Taylor Slough.

To describe dietary differences in fishes across habitat and season for Element I, 4,000 stomachs of 32 native and introduced species were analyzed. Major foods included periphyton, detritus/algal conglomerate, small invertebrates, aquatic insects, decapods, and fishes. Florida gar, largemouth bass, pike killifish, and bowfin were at the top of the piscine food web. Using gut contents, the fishes were classified into trophic groups of herbivores, omnivores, and carnivores. Stable-isotope analysis of fishes and invertebrates gave an independent assessment of trophic placement. Element II tested for correlations of total mercury to trophic position. Over 1,000 fish, 620 invertebrate, and 46 plant samples were analyzed with an atomic fluorescence spectrometer. Mercury varied within and among taxa. Most invertebrates were in the range of 25 to 200 $ng \cdot g^{-1}$. Small-bodied fishes varied from 78 to >400 $ng \cdot g^{-1}$. Large predatory fish had the highest concentrations, up to 1515 $ng \cdot g^{-1}$. Hg concentrations among the fishes and the invertebrates were positively correlated with trophic position. Element III examined the effects of season and site hydroperiod on mercury in wild and caged mosquitofish at three pairs of marshes. Twelve monthly collections of wild mosquitofish were analyzed. Hydroperiod significantly affected concentrations, but there were interactions among marsh hydroperiod, fish size, site, and time-of year. A complimentary experiment to control for wild-fish dispersal, and to measure *in situ* uptake and growth, used captive-reared, low-mercury fish stocked into field cages in those marshes. Neonate fish with mercury levels from 7 - 14 $ng \cdot g^{-1}$ were introduced in six trials. Uptake rates ranged from 0.25-3.61 $ng \cdot g^{-1}d^{-1}$, and there were interactions among time-of-year, site and hydroperiod. Survival normally exceeded 80 percent. Growth varied with time of year, site and hydroperiod, but greatest growth occurred in the short-hydroperiod marshes. The results suggest that bioaccumulation through the diet strongly determines mercury in Everglades fishes and invertebrates, and that, although hydroperiod plays a role in mercury uptake, its effect varies with season and specific location.

**Figure 1.** Field cages in Shark Slough into which captive mosquitofish were stocked to measure mercury uptake in Element III.

The diet data have been used to describe the structure of the aquatic food web and its changes with water-level fluctuations. Statistical analyses indicate a strong positive correlation between the trophic position of both fishes and invertebrates and their mercury levels, demonstrating bioaccumulation with diet. The mosquitofish seems to be a good candidate for measuring *in situ* uptake of mercury in field cages. Patterns of mercury concentrations in wild and caged fishes at the same locations were similar across hydroperiod and season, but site hydroperiod did not explain much of the variation in mercury in the fishes. These data, combined with landscape-level studies of mercury geochemistry and patterns of concentrations in biota, will be useful as Performance Measures in the Restudy. The results were used in Phase 1 of the South Florida Mercury Program, in the development of the EPA BASS model of bioaccumulation, and in comparison with other studies in the Everglades.

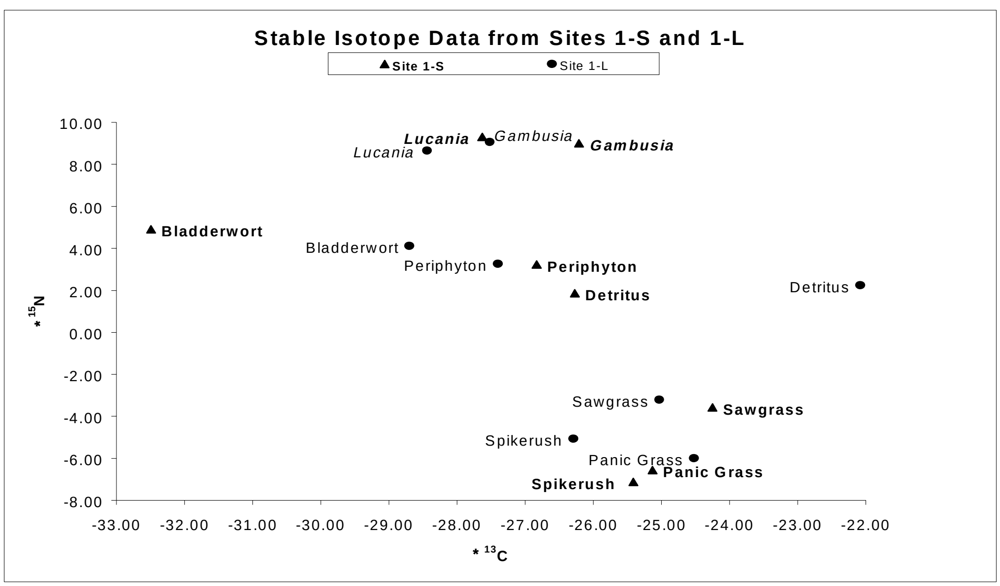


**Figure 2.** Stable-isotope data for mosquitofish *(Gambusia holbrooki)* and bluefin killifish *(Lucania goodei)*, and associated primary producers from long- and short hydroperiod marshes in northern Shark Slough, ENP in February, 1996.