United States Environmental Protection Agency
Region 4
Science and Ecosystem Support Division
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Everglades Ecosystem Assessment
Phase IV

Miami, Florida
September 23-29, 2013

SESD Project Identification Number: 13-0513

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Title and Approval Sheet

Title: Everglades Ecosystem Assessment
Phase IV 2013 Report

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12/2/14
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12/2/14
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Introduction

In September 2013, the US Environmental Protection Agency/Region 4 Science and Ecosystem Support Division initiated a comprehensive sampling of the Florida Everglades as part of a recurring Everglades Ecosystem Assessment described in the next section. Due to a federal government shutdown during the sampling period, the project was not completed as planned. However, analysis was completed for the samples obtained prior to the shutdown. This report presents the data from those samples, collected from September 23 – 29, 2013. Summary statistics on mercury, phosphorus, and sulfur are presented for Everglades National Park (ENP). The majority of the stations that were sampled fell in that subarea of the publicly owned greater Everglades freshwater flow-way. Only biogeochemical results are included here. Plant community mapping information was collected by other Principle Investigators, at Florida International University (FIU). They will present those findings in a separate report.

Background

Phases I - III: Since 1993, the U.S. Environmental Protection Agency, Region 4 (EPA) has been conducting a landscape-level assessment of the Florida Everglades ecosystem in association with many partners, including Everglades National Park (Park). The Program uses EPA's Environmental Monitoring and Assessment Program (EMAP) statistical survey design to sample all of the Marl Prairie/Rocky Glades and the Everglades Ridge and Slough physiographic regions, which make up the central Everglades flow-way. The Everglades Ecosystem Assessment [EEA, also known as Everglades Regional EMAP (REMAP)] is the only comprehensive monitoring and assessment program that preceded the development of the Comprehensive Everglades Restoration Program (CERP), which subsequently defined several monitoring and assessment objectives to include: documenting status and trends, determining baseline variability, detecting responses to management actions, and improving the understanding of cause and effect relationships. The EEA has provided this information system- wide for the entirety of the freshwater Everglades. In Phases I (1993-1996) and II (1999) EPA provided pre-2000 baseline conditions for a broad array of indicators against which future changes can be measured. In Phase III (2005) changes were detected in mosquitofish mercury burdens and soil phosphorus concentrations. EEA Program data have been featured in about 25 peer-reviewed publications and cited in about 100 others to date.

The overarching objective of the EEA is to measure the condition of ecological resources in the Marl Prairie/Rocky Glades and the Everglades Ridge and Slough physiographic regions; and to document ecosystem responses as CERP restoration efforts change the quality, quantity, timing and distribution of water, and as State agencies implement control strategies for pollutants such as phosphorus, sulfur, and mercury. EEA employs an integrated, holistic approach in a consistent manner at the landscape level -- the only effort to do so throughout the entire freshwater Everglades ecosystem.

EEA has provided data relevant to 23 CERP performance measures for the Everglades Ridge and Slough and the Marl Prairie/Rocky Glades physiographic regions -- seven for the Greater Everglades, one for the Miccosukee Reservation, three for Everglades National Park, one for soil performance, one for animal performance, five for plant performance and five for hydrological performance. Among these 23 are nine water quality measures.

This monitoring and assessment project has been guided from the outset by the following seven policy-relevant questions which are equally applicable to the four major issues affecting the Everglades ecosystem (hydropattern modification, eutrophication, habitat alteration and mercury contamination): What is the magnitude of the problem? What is the extent of the problem? Has it changed over time? What are the associations with the problem? What are the sources of the problem? What is the risk to ecological resources? What are the solutions?

In Phase IV of the Program, EPA continues change detection and assessments of:

- concentrations of drivers, including nitrogen, phosphorus, carbon, and sulfur, in water and soil over time and space;
- hydropattem modifications in the system and responses during the wet season;
- soil thickness;
- habitat alterations associated with nutrient loading and hydropattem changes;
- methylmercury contamination;
- mechanisms controlling mercury methylation;
- bioaccumulation of methylmercury;
- interacting stressors through structural equation modeling; and
- management implications of these issues.

The information will be critical as baseline data for the Central Everglades Planning Project, a new component of CERP that features restoration of the central flow-way.

Methods

Design: The probability design EPA uses to sample the Everglades marsh was developed from the EMAP base grid in order to ensure spatial coverage. The design includes stratification by the four major subareas of the system, the Water Conservation Areas [WCA 1 (also known as Arthur R. Marshal Loxahatchee National Wildlife Refuge – LOX), WCA2, and WCA3], and the Park, to ensure that coverage of smaller subareas is adequate for obtaining variance estimates. A consistent sample size of approximately 125 random points per seasonal survey ensures acceptable confidence intervals around estimated environmental parameters. This design criterion is compatible with logistical considerations

allowing helicopter- supported crews to complete all sampling in about 15 days, which also matches throughput capacities of cooperating analytical laboratories.

In Phase IV, EPA utilized an improved design that features a 50-50 mix of new random points and points from the previous Phase (III, 2005). EPA's Office of Research and Development (ORD), Western Ecology Division, National Health and Environmental Effects Research Laboratory provided the statistical design and sample draw. The 2014 statistical design is a probability survey design that consists of two parts: a) 50% of the sites are a probability subsample of the prior survey design (2005) and b) 50% of the sites are a new probability sample. Since the two designs are completed independently, the combined survey design is also a probability survey design. The combined design has two objectives. The first objective is to estimate the current status as has been done in the past. The second objective is to estimate change between the two time periods (2005 and 2014). ORD has determined that the power of detecting a change is increased by visiting 50% of the sites in both time periods. ORD simulation studies of alternative designs for estimating change favor survey designs where approximately 50% of the sites are visited in both time periods. The change estimation is based not only on the panel of 50% sites visited twice but also on the panel of sites from the first time period (2005) and on the panel of sites from the current time period (2014).

EPA's synoptic, probabilistic approach is the only one that produces quantitative statements with known confidence about environmental condition across an entire resource over space and time. For example, the proportion of the Everglades having a total phosphorus concentration greater than 400 mg/kg (the CERP goal) in soil was 49.3 ±7.1 % in 2005, and this proportion is statistically significantly greater than the 33.7 ± 5.4 % measured in 1995-1996.

Tasks: EPA attempted to conduct a probabilistic, multimedia, synoptic survey of the entire freshwater flow-way of the greater Everglades ecosystem in the fall (wet season) of 2013. This survey focused on the biogeochemistry of key pollutants in the marsh, namely mercury, phosphorus, and sulfur. Media sampled were surface water, bottom water, periphyton, soil, floc, macrophytic vegetation, and mosquitofish.

There was no dry season survey in Phase IV. Pore water, sampled in Phases II and III, was replaced by bottom water. Aquatic community sampling by throw-trap, conducted in Phase III, was omitted. These changes were made to match the Phase IV effort to available funding.

Field Protocols: Crews obtained samples of water, floc, soil, periphyton, and mosquitofish at each station. EPA Region 4 Field Branch SOPs, which can be found at http://www.epa.gov/region4/sesd/fbqstp/index.html, were followed as applicable. At half of the stations whole sawgrass plants and sawgrass leaf clippings were also collected. At these stations plant association(s) present were classified at the 2-meter

scale, with a total of up to four GPS locations obtained at sub-meter accuracy in the association(s) present.

Sediment, benthic periphyton, and floc were collected in core tubes. A vacuum chamber was used to collect a clean sample of surface water for trace-level mercury analysis. Periphyton in the water column was collected by direct dipping. Mosquitofish were collected with an "A"-frame dip-net for analysis of whole-body total mercury. A number of procedures have been developed specifically for the Program over the years. These techniques and equipment, including a new technique under development for collection of bottom water for sulfide analysis, are described in the Quality Assurance Project Plan.

Outcome

Thirty-six (36) stations were sampled in ENP in late September 2013 (Figure 1). One station in Big Cypress National Preserve was also sampled. This station is included in the analyses presented in this report because it was located on land managed by the National Park Service (NPS) in the Everglades freshwater flow-way. In ENP, two stations were rejected because of safety concerns about landing on site, two others were missed due to the shutdown, and one was not attempted because of the potential to disturb an endangered species of butterfly. All media were sampled in accordance with the Quality Assurance Project Plan.

Fourteen (14) stations in Water Conservation Area 3 were also sampled in September 2013. These stations are not included in the statistical analyses presented in this report because they are an incomplete subsample of lands outside NPS administrative boundaries.

All biogeochemical data from all 51 stations will be provided with this report. All data were subjected to a 100% review process, consisting of verification by an independent Project Quality Assurance Officer (QAO) and validation by the Project Leader and Associate Project Leader.

At approximately 25 of the 51 stations, plant community mapping information was collected. Details of that part of the 2013 effort will be conveyed separately to the National Park Service by FIU.

Water levels in ENP were comparable to 2005 (Figure 2).

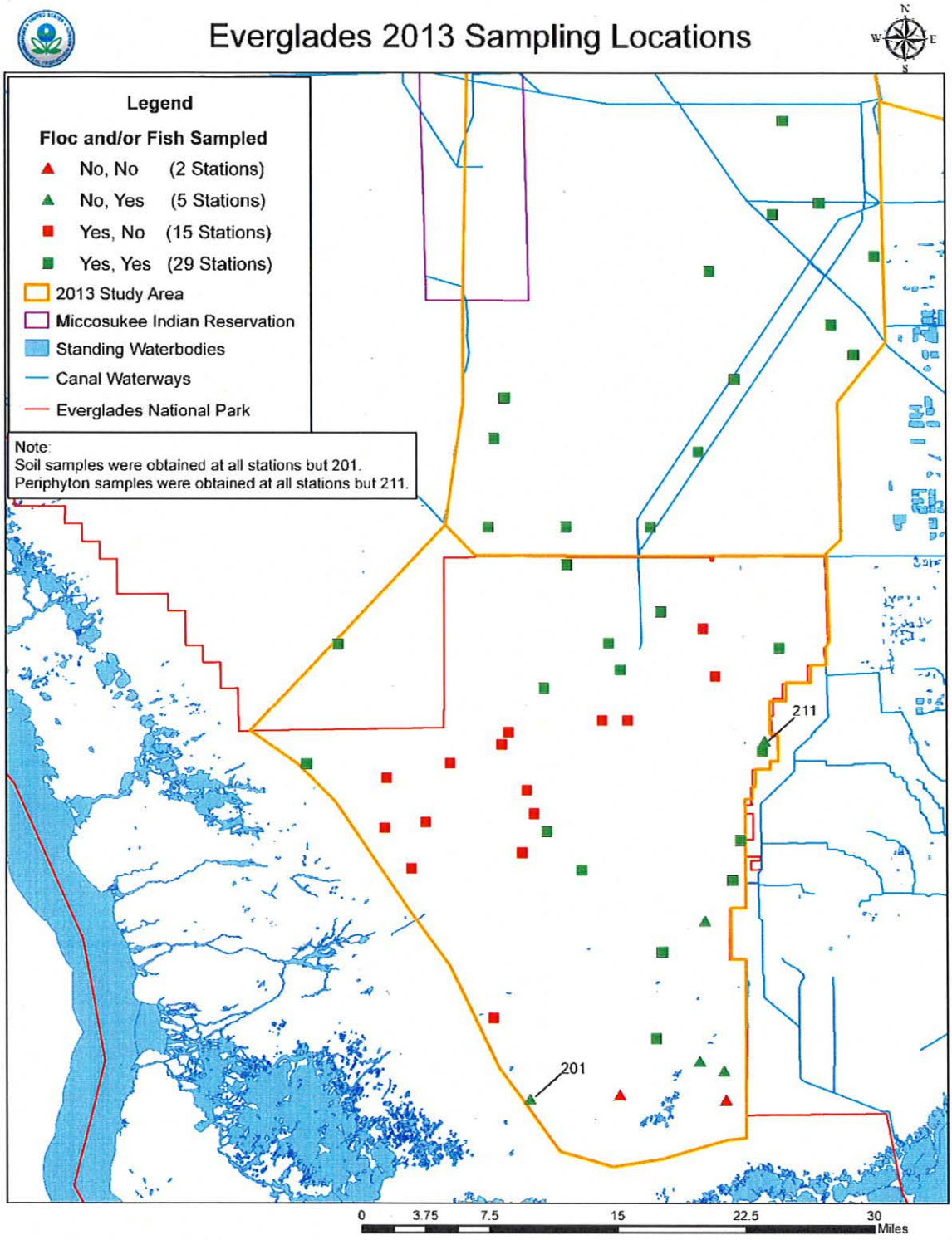

Figure 1. REMAP stations sampled in late September 2013, in the southern part of the publicly owned greater Everglades freshwater flow-way.

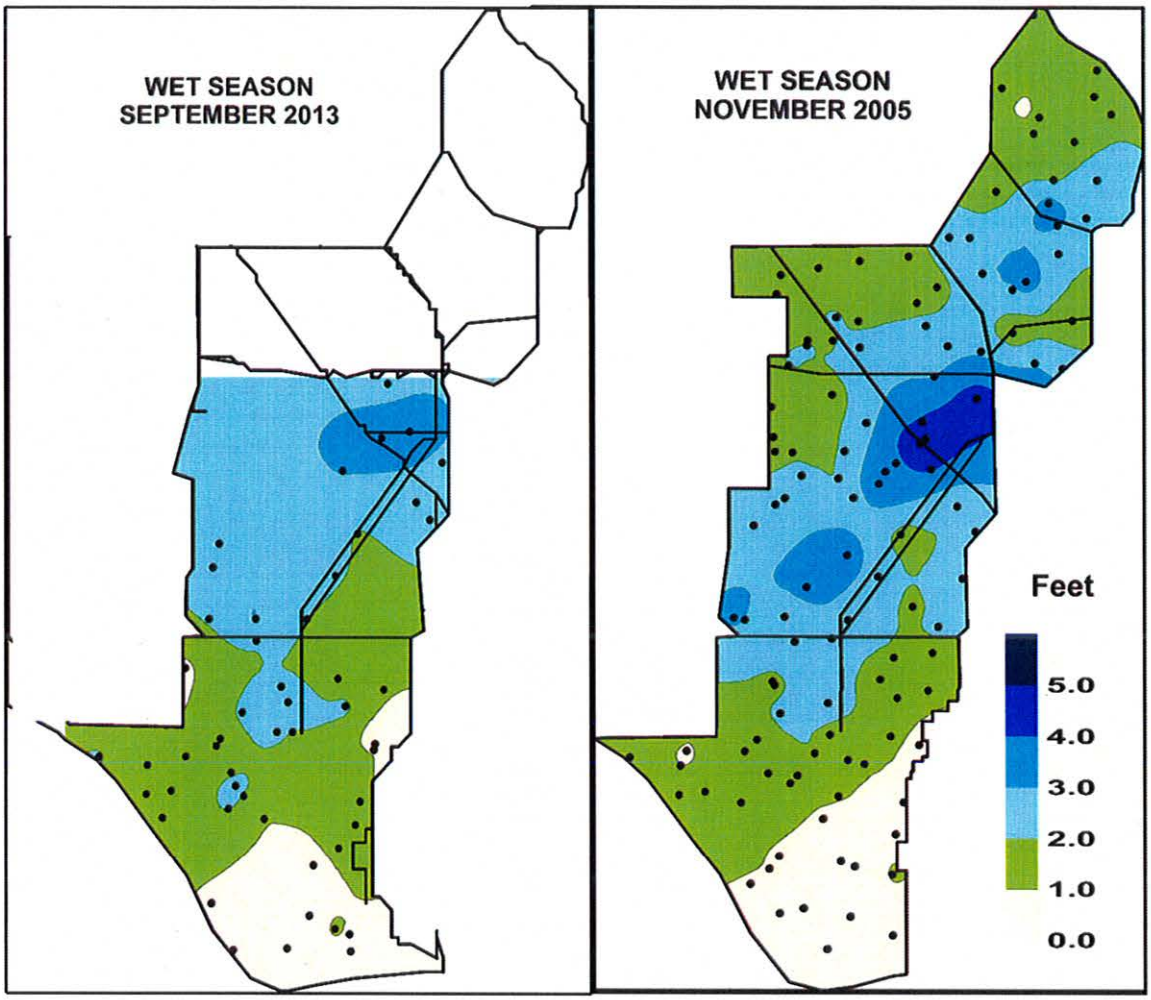

Figure 2. Water depths during the 2013 Everglades Ecosystem Assessment (left) and during the 2005 wet season survey (right). The black dots are station locations.

Results and Discussion

Descriptive statistics for key pollutants are shown in Table 1. Overall, these numbers indicate that conditions in the Park appeared to be better than during the 2005 REMAP wet-season survey, judging by visual comparison to krigs of the 2005 data (Scheidt and Kalla 2007). However, there were still conspicuous local impacts, as krigs of the 2013 data (shown in several figures on later pages of this report) indicate.

Table 1. Distribution of values for selected pollutants in Everglades National Park from the 2013 REMAP survey.

	SO4 SW	**meHg SW**	**tHg SW**	**H2S BW**	**TP SD**	**tHg FS**
	mg/l	ng/l	ng/l	ug/l	ug/g	ng/g
Min	0.02	0.020	0.559	12	99	3.3
Q1	0.02	0.046	1.046	12	206	15.4
Median	0.11	0.061	1.350	14	342	27.4
Q3	1.30	0.093	1.617	20	401	46.0
Max	11.0	0.236	3.021	41	764	152

Notes: SO4 = sulfate, SW = surface water, meHg = methyl mercury, tHg = total mercury, H2S = sulfide, BW = bottom water, TP = total phosphorus, SD = soil, FS = mosquitofish, Q1, Q3 = 1st (above bottom 25%) and 3rd (below top 25%) quartiles, i.e., the middle half of the data.

Sulfate Sulfate in surface water (Figure 3) was generally lower than in previous REMAP Phases. The proportion of ENP with values ≤ 1 mg/l (the CERP goal) appeared to be slightly greater than in 2005, though only a fourth of the Park remained at background level [0.02 mg/l, the analytical method detection limit (MDL)]. As expected, all stations where values fell in the top quartile (> 1.3 mg/l) were found in areas of Shark Slough close to and downstream (southwest) of canal inflows, such as the end of the L-67 Extension and the S-12C and S-12D structures (Figure 4).

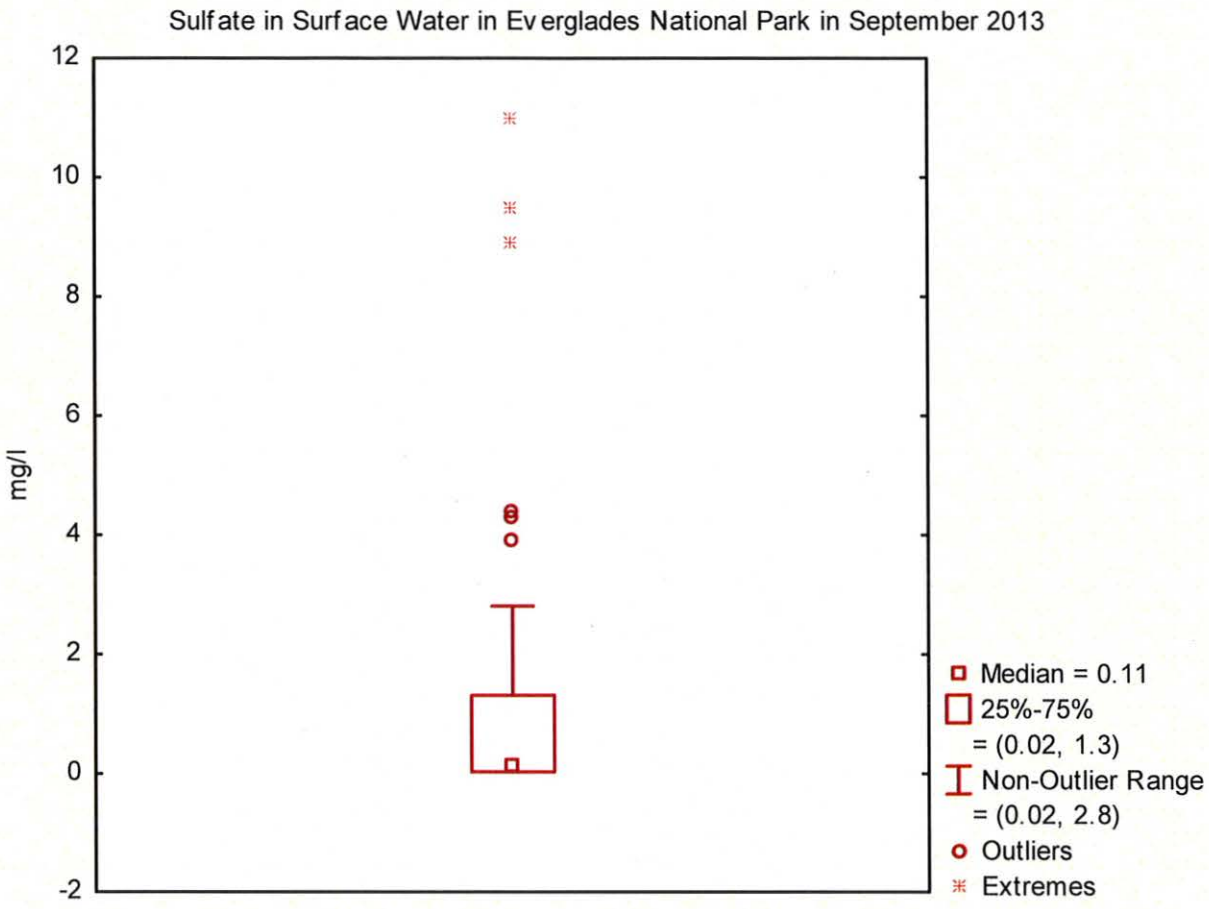

Figure 3. Box-and-whisker plot of sulfate from the Everglades Ecosystem Assessment in 2013.

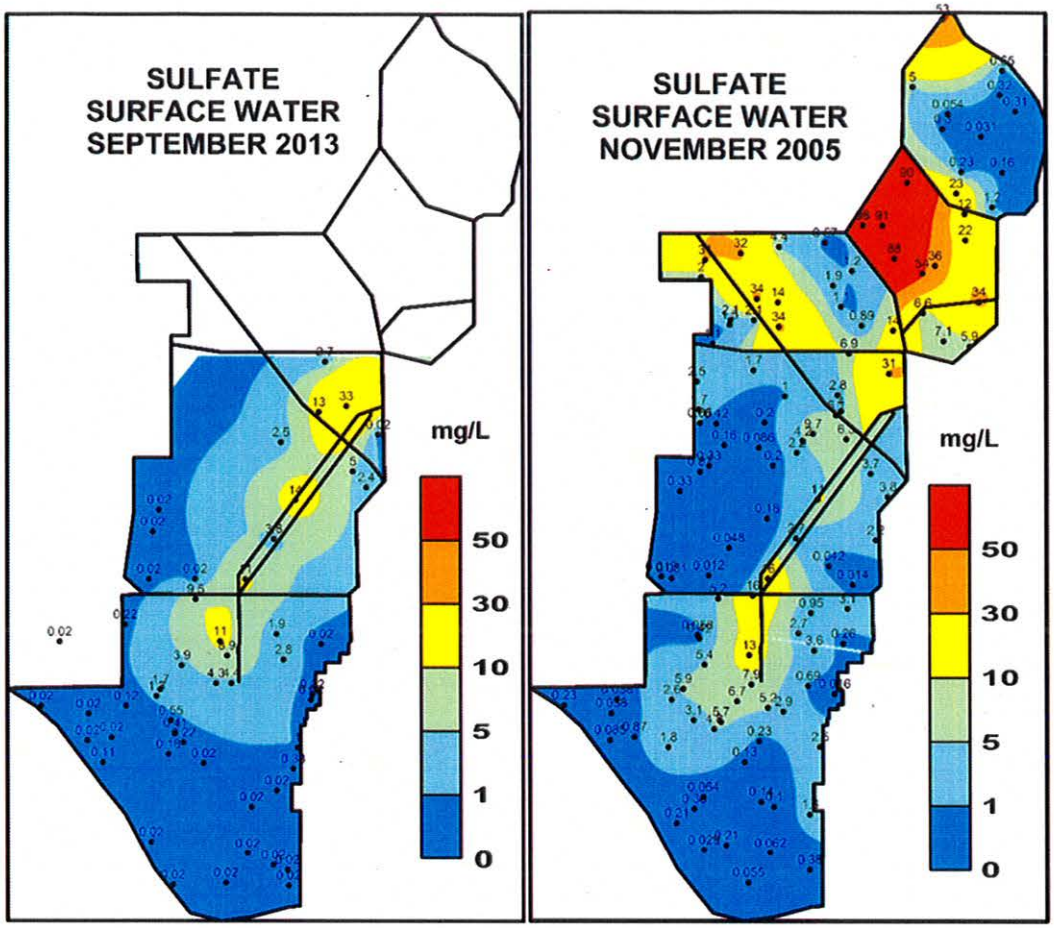

Figure 4. Krigs of sulfate from the Everglades Ecosystem Assessment in 2013 (left) and 2005 (right). The numbers next to the station locations are milligrams of sulfate per liter of surface water.

Mercury Surface water mercury is described in Figures 5 – 8. Methylated mercury appeared to be down by about an order of magnitude overall (2013 ENP median = 0.061 ng/l, 2005 = 0.125). This decline may be related to generally lower sulfate levels. Median total mercury in surface water appeared to be down somewhat (1.35 vs. 1.80), but not enough to explain the difference in methyl mercury concentrations. The MDL for total mercury in 2013 was five times less than the lowest value reported in 2005, affecting the data distribution and possibly contributing to the perceived reduction in total mercury levels.

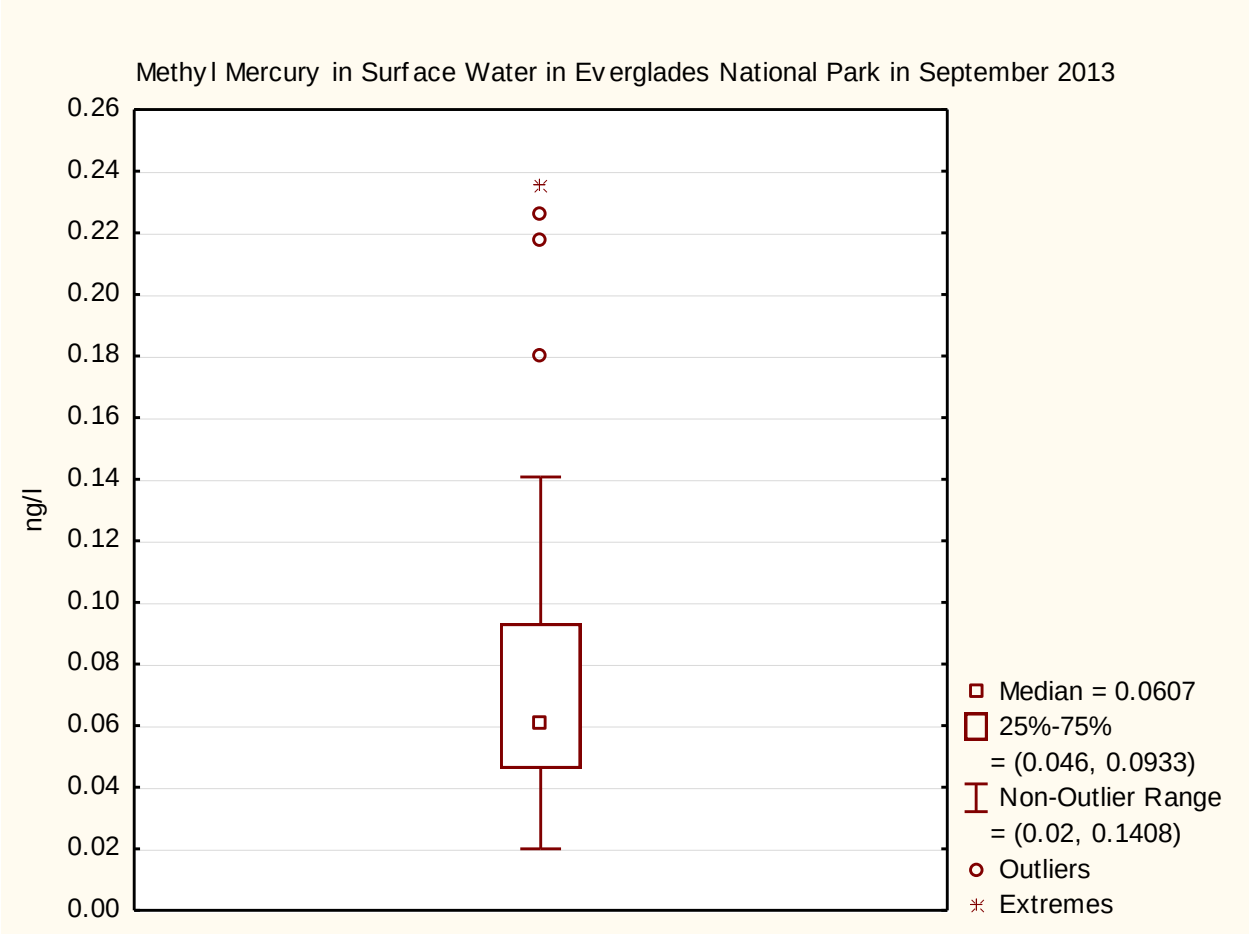

Figure 5. Box-and-whisker plot of methyl mercury from the Everglades Ecosystem Assessment in 2013.

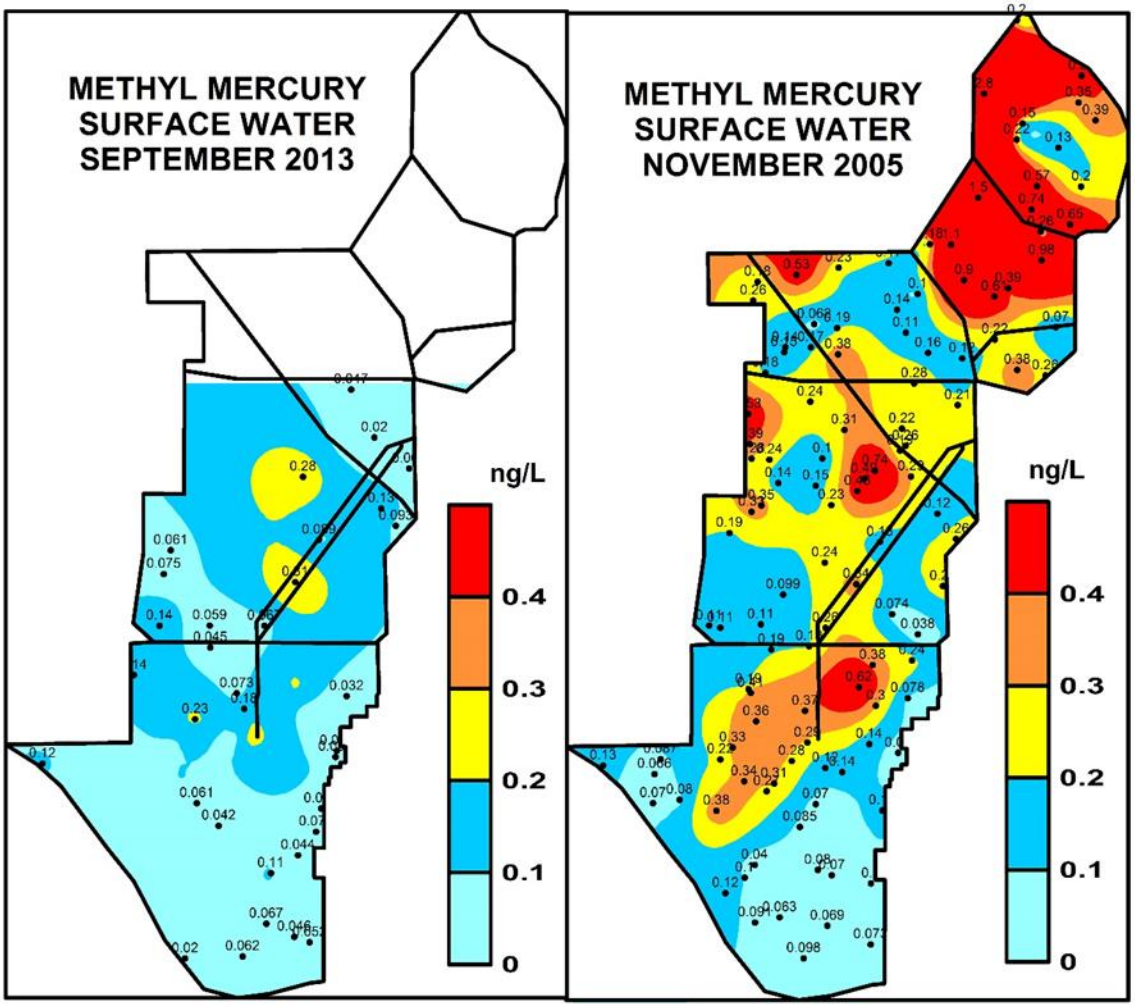

Figure 6. Krigs of methyl mercury from the Everglades Ecosystem Assessment in 2013 (left) and 2005 (right). Numbers next to the station locations are nanograms of methyl mercury per liter of surface water.

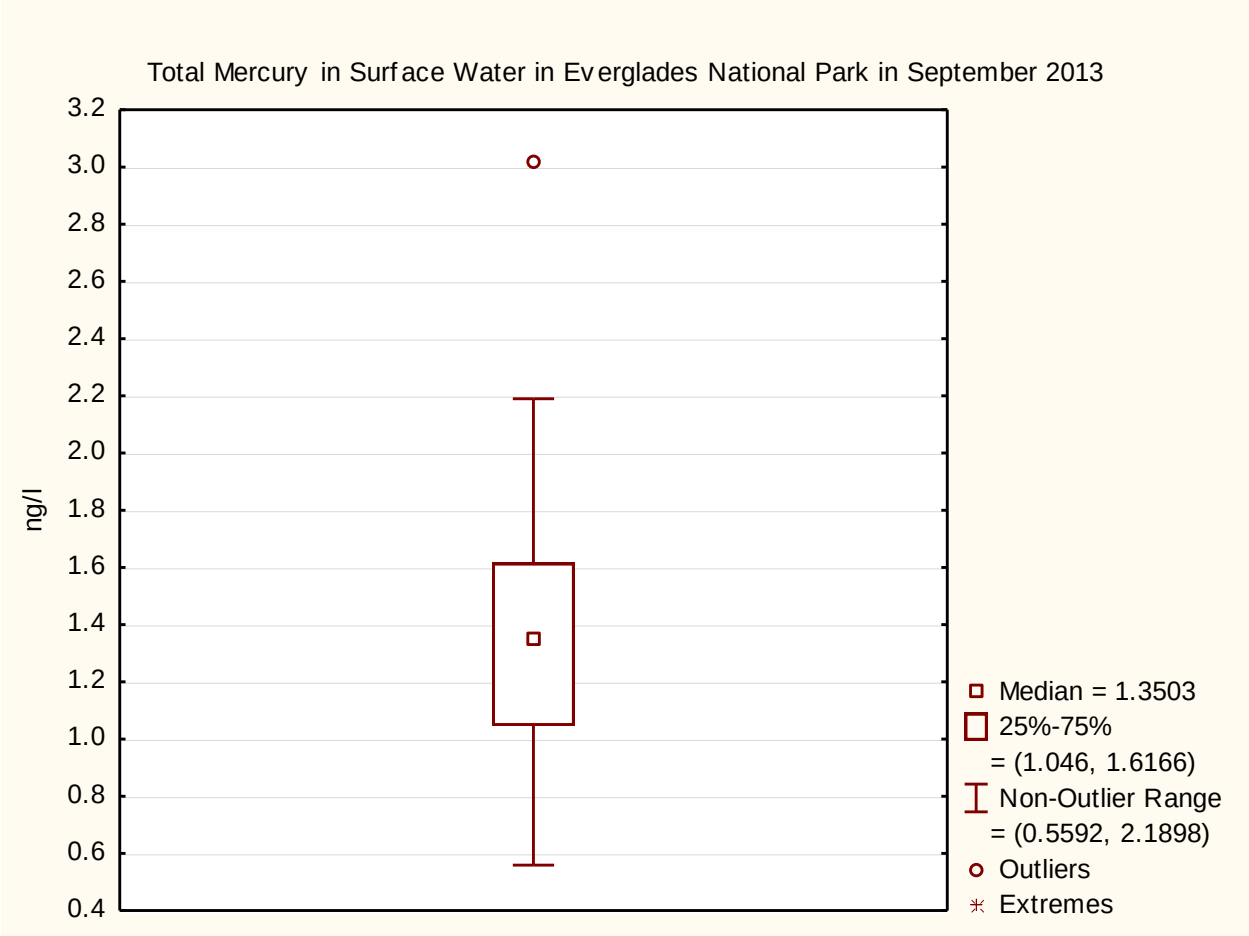

Figure 7. Box-and-whisker plot of total mercury in surface water from the Everglades Ecosystem Assessment in 2013.

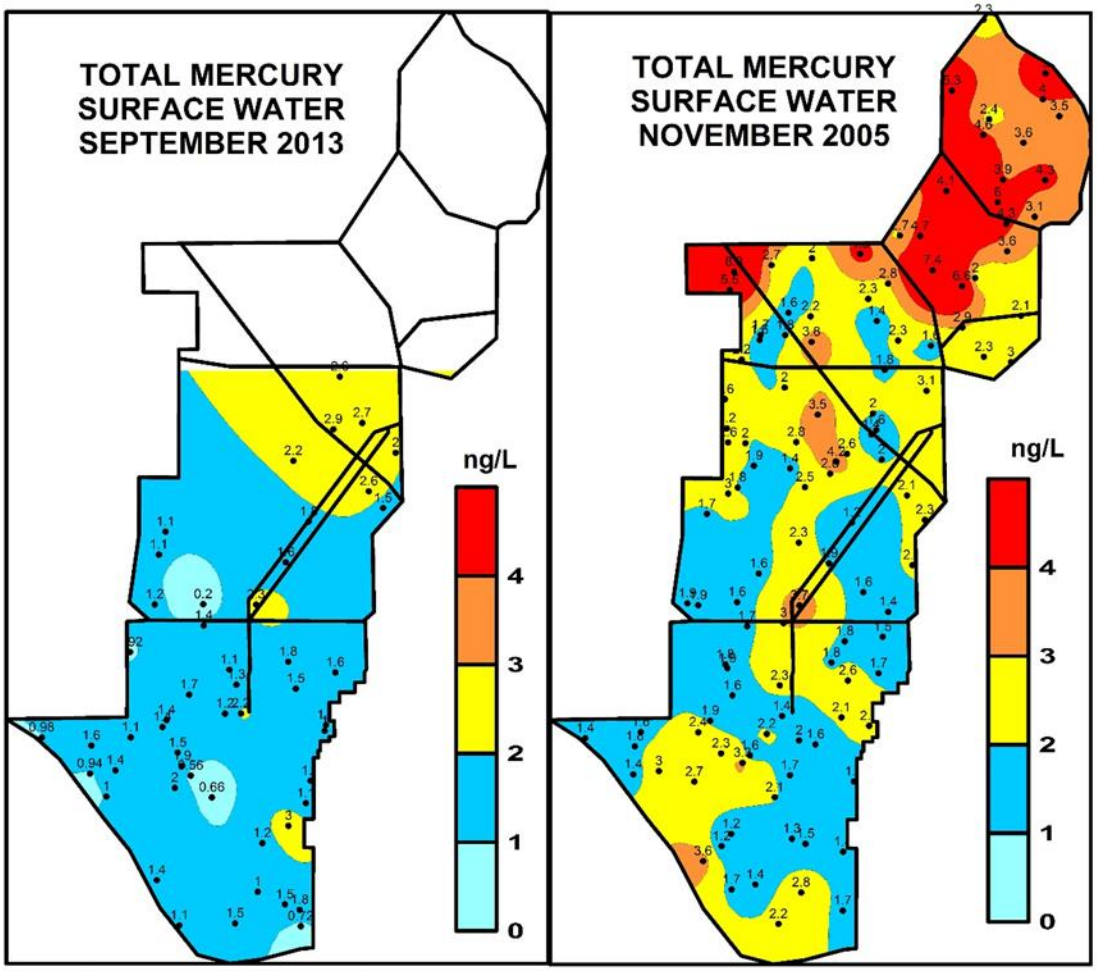

Figure 8. Krigs of total mercury in surface water from the Everglades Ecosystem Assessment in 2013 (left) and 2005 (right).

The somewhat limited data (21 stations) on mosquitofish mercury burdens obtained in 2013 (Figure 9) suggest a decline in the Park from 2005. In that year the hotspot in Shark Slough had several values above 200 ng/g, whereas in 2013 the maximum value was 152 ng/g (Figure 10). Nevertheless, about one-fifth of the data distribution in 2013 was above EPA's predator protection level of 77 ng/g. Again, most of these values were obtained in Shark Slough (Figure 11).

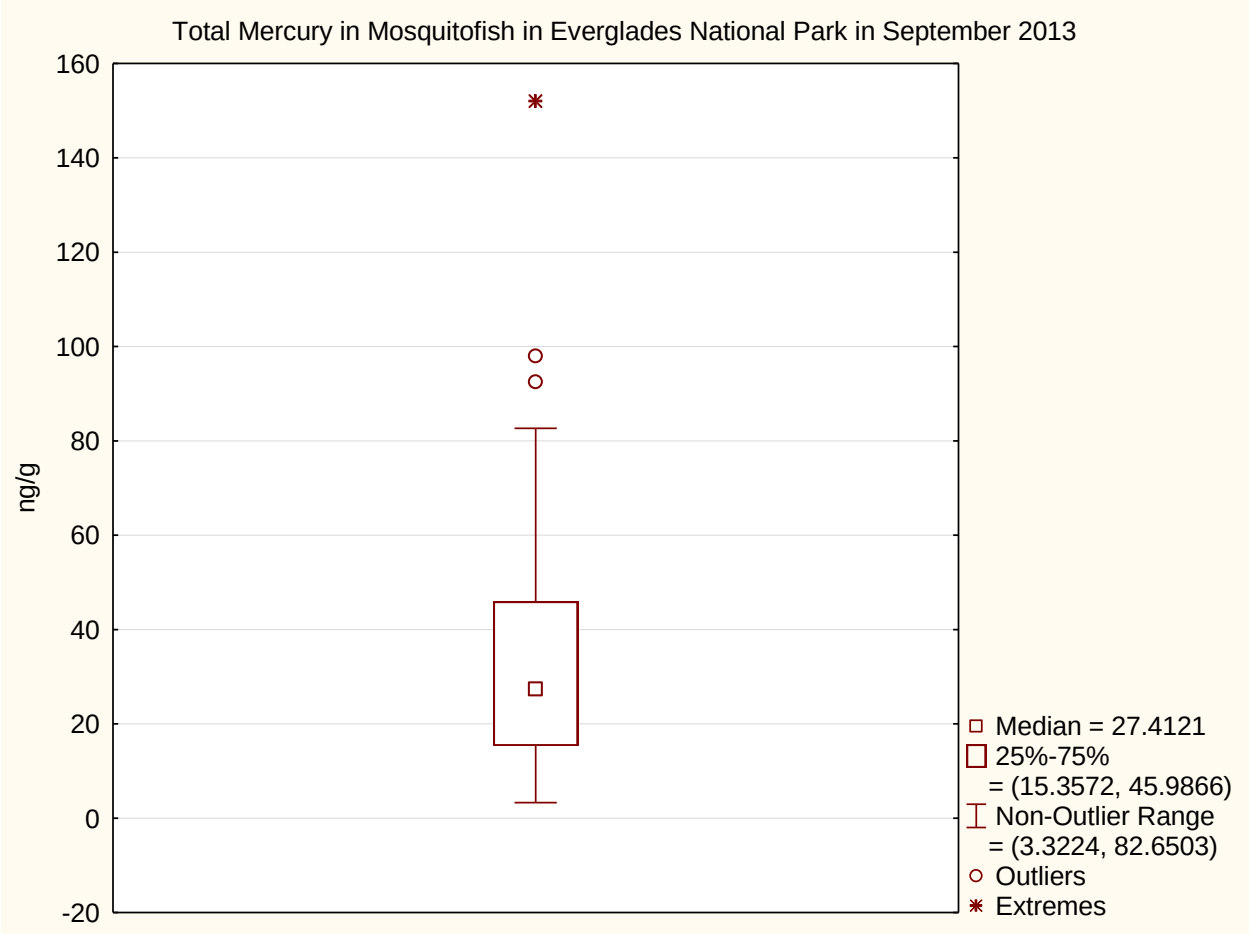

Figure 9. Box-and-whisker plot of total mercury in mosquitofish from the Everglades Ecosystem Assessment in 2013.

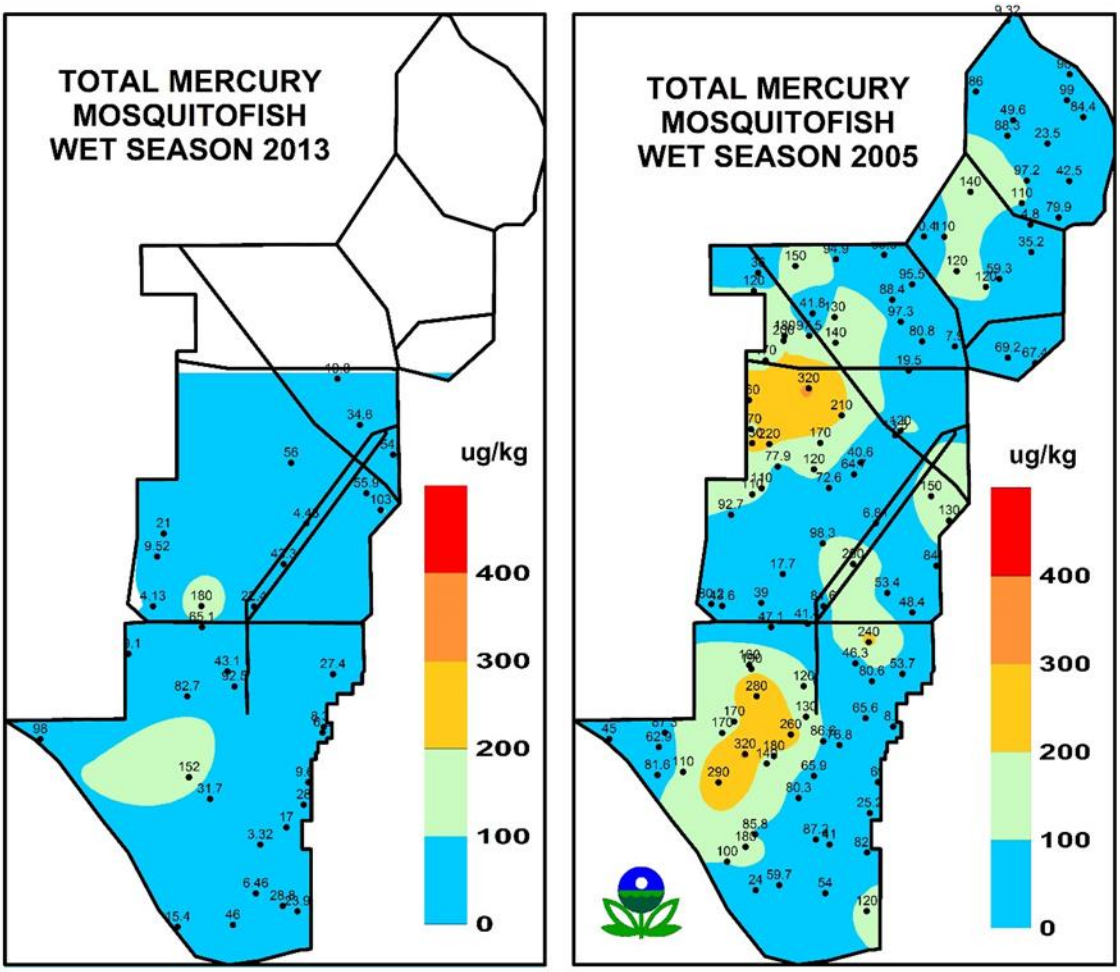

Figure 10. Krigs of total mercury in mosquitofish from the Everglades Ecosystem Assessment in 2013 (left) and 2005 (right).

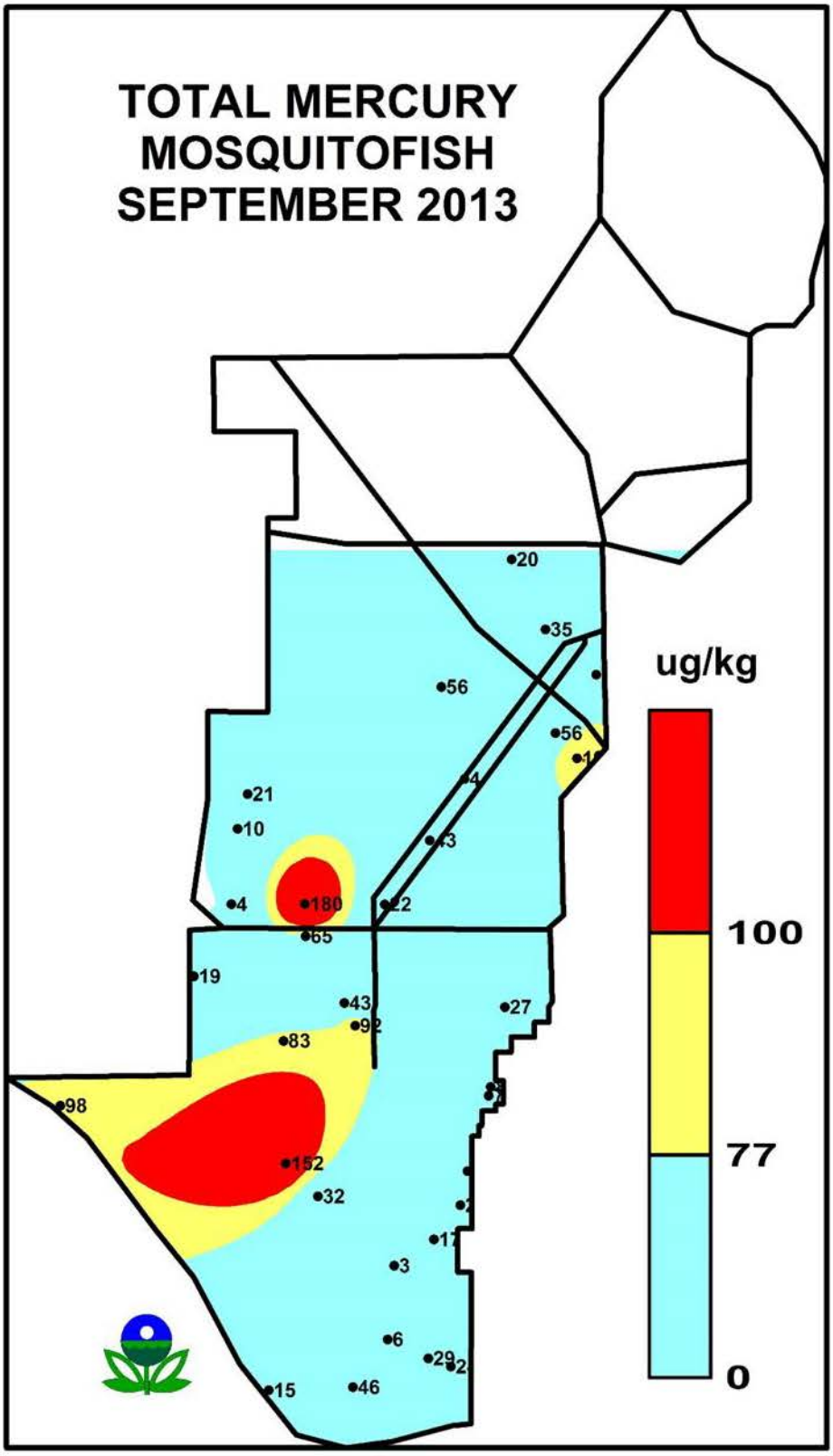

Figure 11. Krig of total mercury in mosquitofish from the Everglades Ecosystem Assessment in 2013.

Phosphorus One-fourth of the Park was above the CERP goal of 400 mg/kg of total phosphorus in soil (Figure 12). Most of these values were found in the vicinity of Shark Slough, extending downstream from the L-67 Extension to the freshwater margin in the southwest. Nevertheless, phosphorus did not exhibit the same strong signal as mercury and sulfur in this regard, as there were more values in that area below the goal than there were above it.

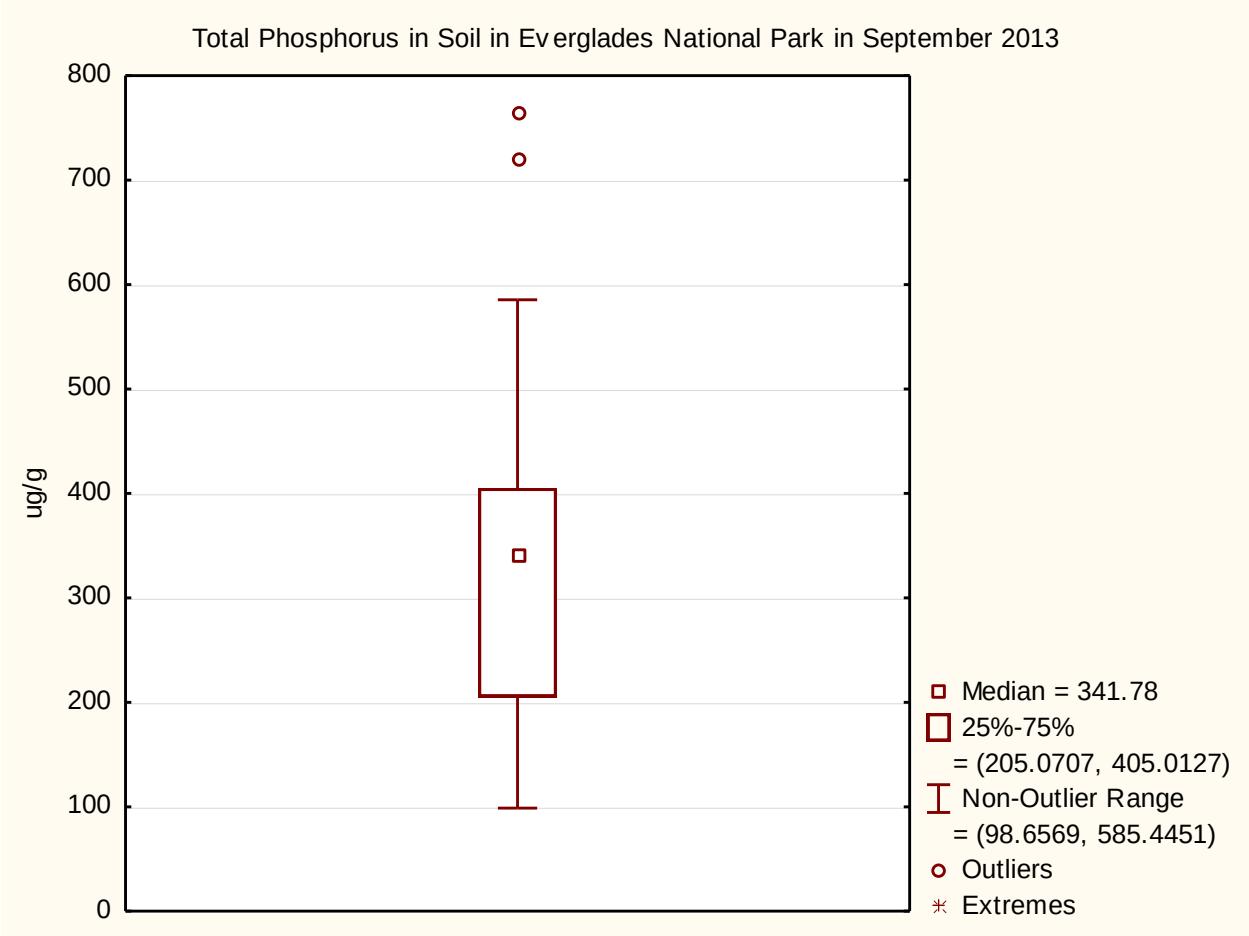

Figure 12. Box-and-whisker plot of total phosphorus in soil from the Everglades Ecosystem Assessment in 2013.

Sulfide Bottom-water sulfide (Figure 13) is an experimental parameter. The sampling method was developed to test a rapid surrogate for pore-water sulfide. The target medium is the nephloid layer, the centimeter of water just above the soil surface. Data from the 2014 survey of the entire greater Everglades study area, along with a contemplated side-by-side comparison to pore water, will be used to validate this parameter.

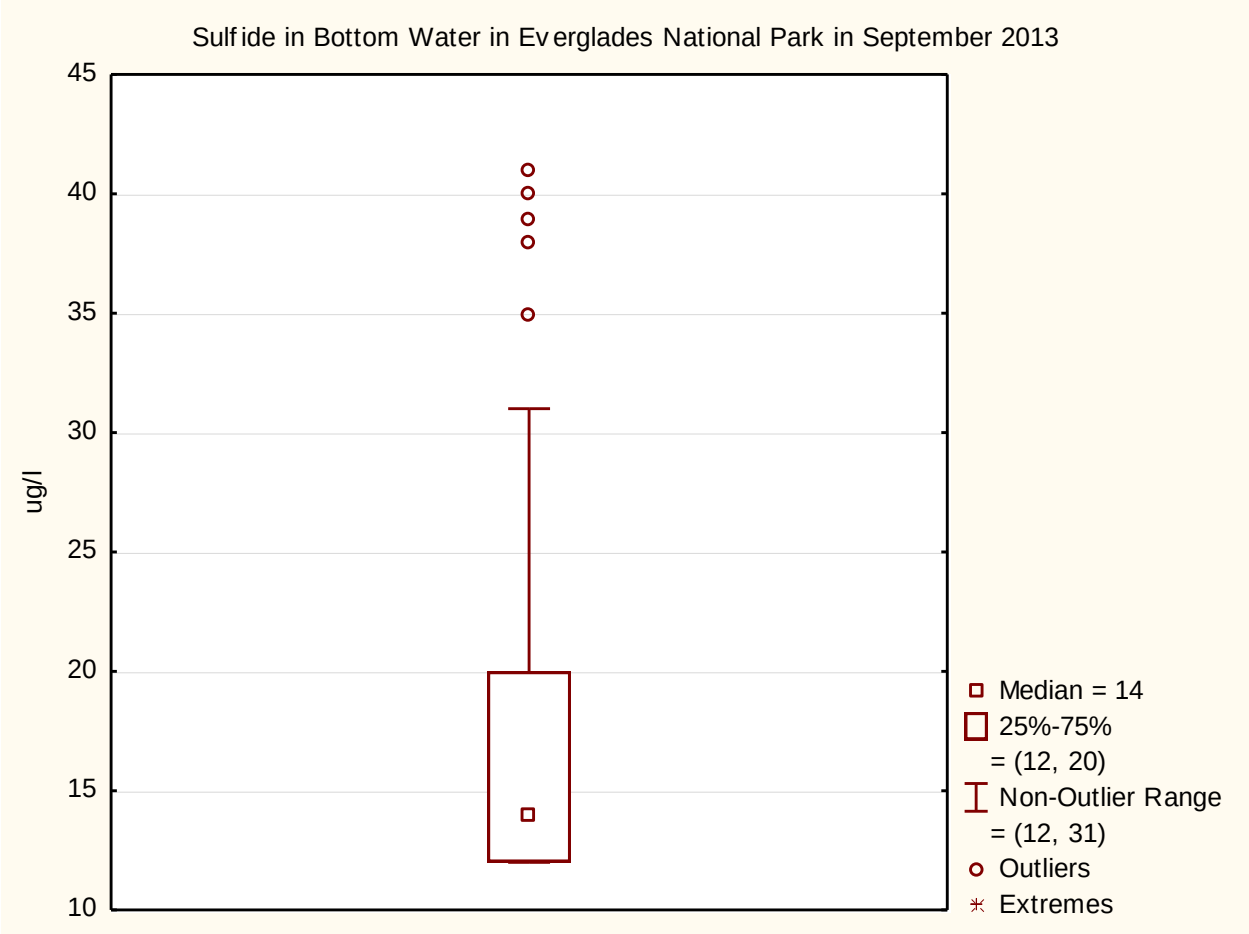

Figure 13. Box-and-whisker plot of sulfide in bottom water from the Everglades Ecosystem Assessment in 2013.

Quality Assurance

Prior to the survey, the QAO audited all participating laboratories at FIU. There were no findings that jeopardized any data to be produced for the Project.

At EPA, before commencement of field work, blanks were run on sample containers and sampling equipment, including the vacuum chambers, for trace-level mercury in water. In addition, filters were blanked for dissolved organic carbon (DOC). All results for mercury were below the laboratory minimum reporting limit, as were most of those for DOC, with the remainder falling between the minimum reporting limit and the method detection limit.

Trip blanks, air deposition blanks, and vacuum chamber blanks for mercury in water were collected daily during the survey. Forty-five blanks were obtained in all. Total mercury was found above the MDL of 0.2 ng/l in 12 blanks, and methyl mercury was found above the MDL of 0.02 ng/l in 5 blanks. Both species of mercury were detected in the same blank only once. The two highest detected concentrations of total mercury in blanks (one air and one trip) were equal to the lowest value found in surface water from the Everglades, 0.56 ng/l. The highest detection of methyl mercury in a blank, 0.049 ng/l from a chamber, exceeded the first quartile value by 0.003 ng/l. Absence of greater overlap between environmental and QA samples suggests that detections in blanks did not compromise the outcome of the Project.

Training on proper field methods was provided to all biogeochemical sampling crew members before the start of the survey. Training consisted of classroom presentations, field simulations conducted in the Athens, GA area, and demonstrations given on-site in the Everglades.

Field logbooks were audited by the Project Leader, Associate Project Leader, or Field Quality Assurance Officer at the end of each day of sampling. Implausible field data and other deficiencies in record-keeping were noted, and appropriate corrective actions were taken with the crews before leaving the field operations base.

References

Scheidt, D.J., and P.I. Kalla. 2007. Everglades ecosystem assessment: water management and quality, eutrophication, mercury contamination, soils, and habitat: monitoring for adaptive management: a REMAP status report. U.S. EPA Region 4, Athens, GA. EPA 904-R-07-001. 98 pp.

Acknowledgements

The assistance of REMAP Associate Program Manager Dan Scheidt, who provided the krigs for this report, is greatly appreciated.

END OF REPORT