10-2017

Dietary Transfer of Heavy Metals in Manatees

E. M. Smith
Nova Southeastern University

Dimitri Giarikos
Nova Southeastern University, giarikos@nova.edu

A. Daniels
US Geological Survey

Amy Hirons
Nova Southeastern University, hirons@nova.edu

Dietary Transfer of Heavy Metals in Manatees

E. M. Smith[1]; D. Giarikos[1]; A. Daniels[2]; A. C. Hirons[1]
es1429@nova.edu; giarikos@nova.edu; andre_daniels@usgs.gov; hirons@nova.edu
Nova Southeastern University[1]; U.S. Geological Survey[2]

NSU NOVA SOUTHEASTERN UNIVERSITY
Halmos College of Natural Sciences and Oceanography

Abstract In recent decades, manatees and dugongs globally have exhibited potentially detrimental levels of a variety of heavy metals in their body tissues. The threatened Florida manatee (*Trichechus manatus latirostris*), which is a subspecies of the West Indian manatee (*Trichechus manatus*), has shown corresponding high levels of heavy metals in their blood, skin, liver, and kidneys. As obligate herbivores, these animals rely heavily upon seagrasses as a major component of their diet. Globally, seagrasses at low latitudes have high levels of heavy metals in their tissues. Detrimental levels of heavy metals in Sirenians have not been established until now. This study is assessing the heavy metal concentrations of seagrasses in South Florida as a major dietary contributor to manatees, and investigating possible sources of these metals.

Introduction

The Florida manatee is a threatened marine mammal that resides in shallow waters around the coast of Florida (US FWS). Manatees inhabit rivers, bays, and estuaries in areas high in vegetation, such as seagrass beds. Manatees do not uproot these grasses, but consume only the shoots, blades, and attached epiphytes. These seagrasses may contain excessive levels of a variety of heavy metals. Heavy metals can be essential or non-essential, though all have toxicity thresholds. Health impacts of heavy metal toxicity include immunosuppression, reproductive impairments, neurological deficits, deformities, and population declines.

Objectives

- Establish whether seagrasses in South Florida could be a source of heavy metals to Florida manatees.
- Multi-species comparison of heavy metal concentrations in seagrasses across location, season, and plant part.

Materials & Methods

Three species of seagrasses, *Thalassia testudinum* (turtle grass), *Halodule wrightii* (shoal grass), and *Syringodium filiforme* (manatee grass), are being collected from three regional locations monthly for a period of one year (Figure 1).

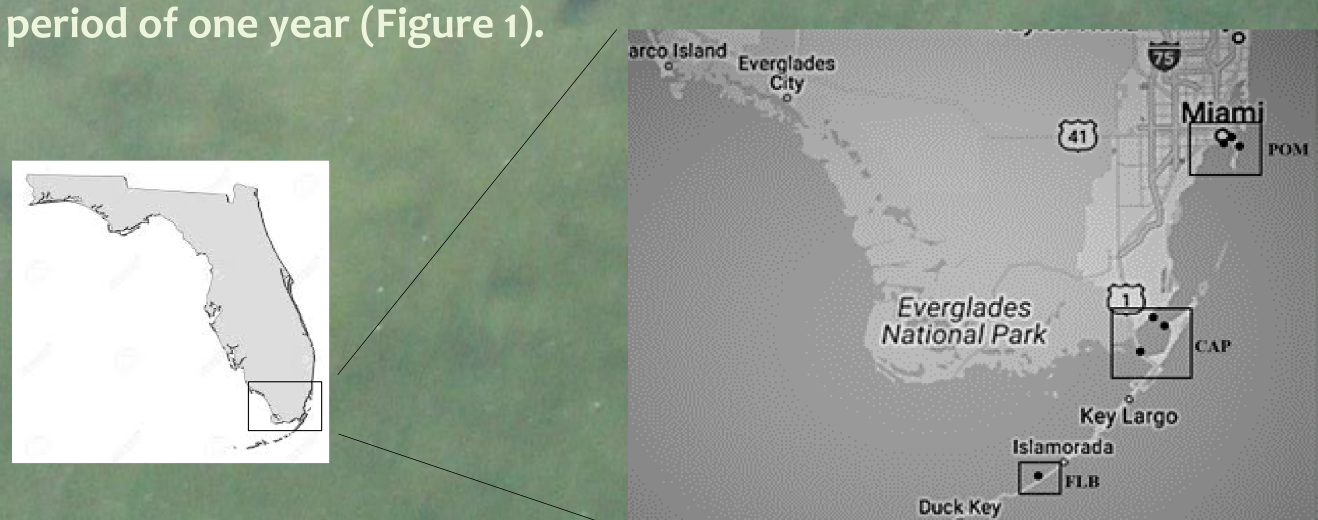

Figure 1. Map of sampling locations in South Florida: the Port of Miami (POM), Card Sound Aquatic Preserve (CAP), and Florida Bay (FLB).

During sampling, multiple individuals of each species are collected. Removal includes blades, shoots, roots, and horizontal rhizomes (Figures 2a & 2b). The samples are separated by part, cleaned, dried, ground into a homogenous powder, and digested in a solution of nitric and sulfuric acids. *T. testudinum* blades with epiphytes are also analyzed to determine their contribution of heavy metals. The samples are then analyzed for an array of heavy metals using a Shimadzu Atomic Absorption Spectrophotometer (AA-6200) and HVG-1. The ten heavy metals being analyzed include arsenic (As), cadmium (Cd), copper (Cu), iron (Fe), manganese (Mn), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn).

Figure 2a. Collection of seagrass samples using a shovel sieve.

Figure 2b. Seagrass species collected: T. testudinum (left, with plant parts labeled), H. wrightii (middle), and S. filiforme (right).

Results

The highest average contamination values found in seagrasses were Fe (168.20 ± 191.53 µg/g), Zn (81.58 ± 63.97 µg/g), and Mn (26.71 ± 0.79 µg/g). The lowest concentrations were Se (0.34 ± 0.11 µg/g), As (0.48 ± 0.45 µg/g), and Cd (1.16 ± 0.94 µg/g). Florida manatee blood and seagrass concentrations show similar patterns. Note the highest concentration levels for both groups are Fe, Mn, and Zn. They both also show slight elevations in Pb, Cu, and Ni (Figure 3).

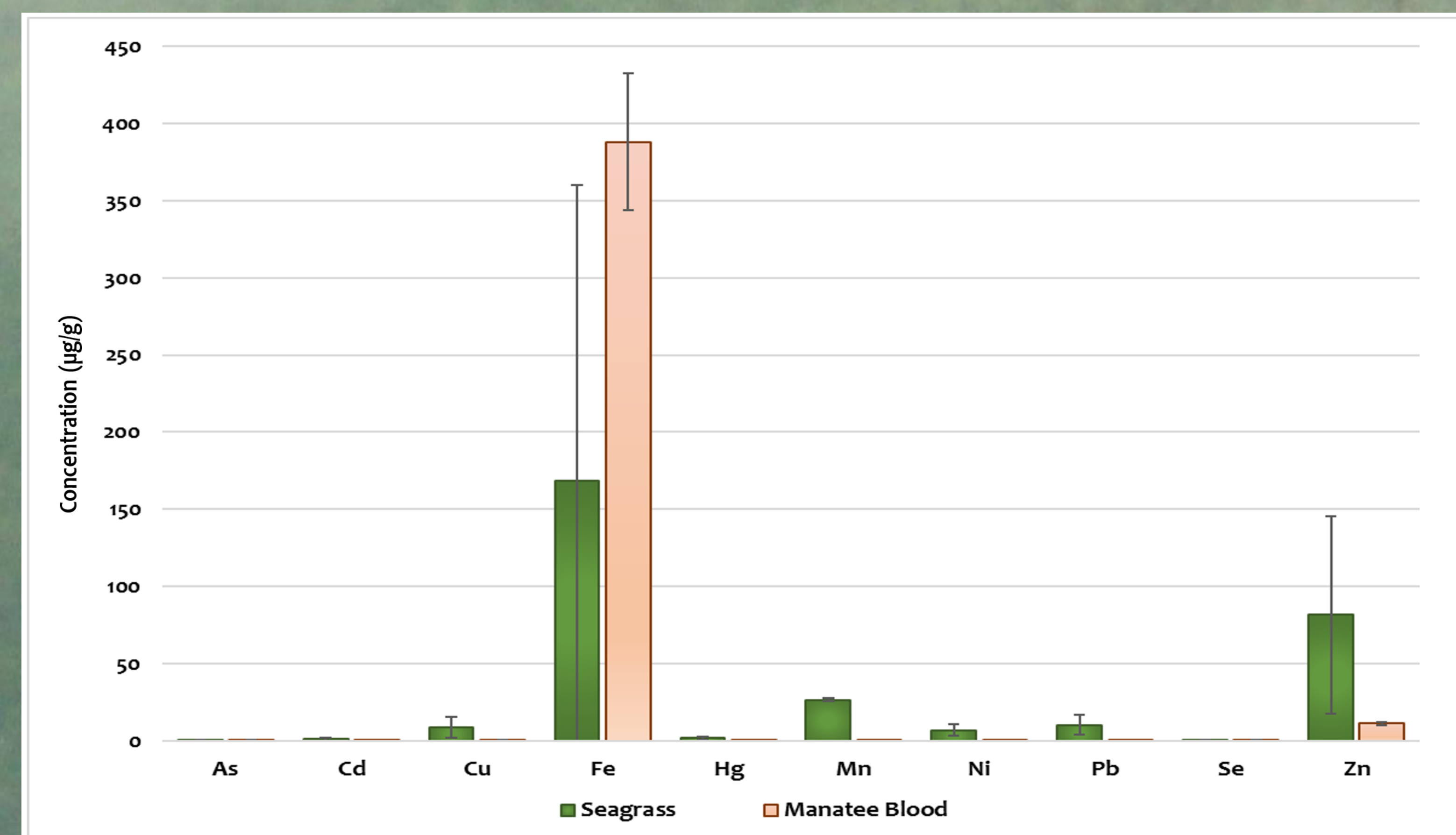

Figure 3. Mean concentrations of each heavy metal across all locations, species, and plant parts plotted against Florida manatee whole blood concentrations (Seigal-Willot et al., 2013).

- POM had significantly higher concentrations of Fe (p=0.008) and Ni (p=0.043), while FLB had significantly higher concentrations of Cu and Zn (p < 0.001 for both), and CAP had significantly higher concentrations of Mn (p<0.001) (Table 1).

Table 1. Heavy metals with significantly higher concentrations and their major sources by location.

Location	Prominent Heavy Metals	Major Sources
Port of Miami	Fe, Ni	Industrial Run-off, Municipal Waste, Sewage Discharge
Card Sound	Mn	Agricultural Run-off: Fertilizer
Florida Bay	Cu, Zn	Agricultural Run-off: Cooper Herbicide, Industrial Run-off

- *T. testudinum* blades with attached epiphytes had significantly higher concentrations of Fe, Mn (p < 0.001 for both), and Zn (p = 0.017) (Figures 4 & 5).

Figure 4. Example of *T. testudinum* blades with and without high epiphyte cover.

- Concentrations of Mn (p=0.011) and Fe (p<0.001) were significantly higher during the wet season than the dry season.
- Fe (p= 0.001) was significantly higher in *H. wrightii* while As (p= 0.005), Mn (p<0.001), and Zn (p= 0.007) were significantly higher in *T. testudinum*. There were no metals that were significantly higher in *S. filiforme* .

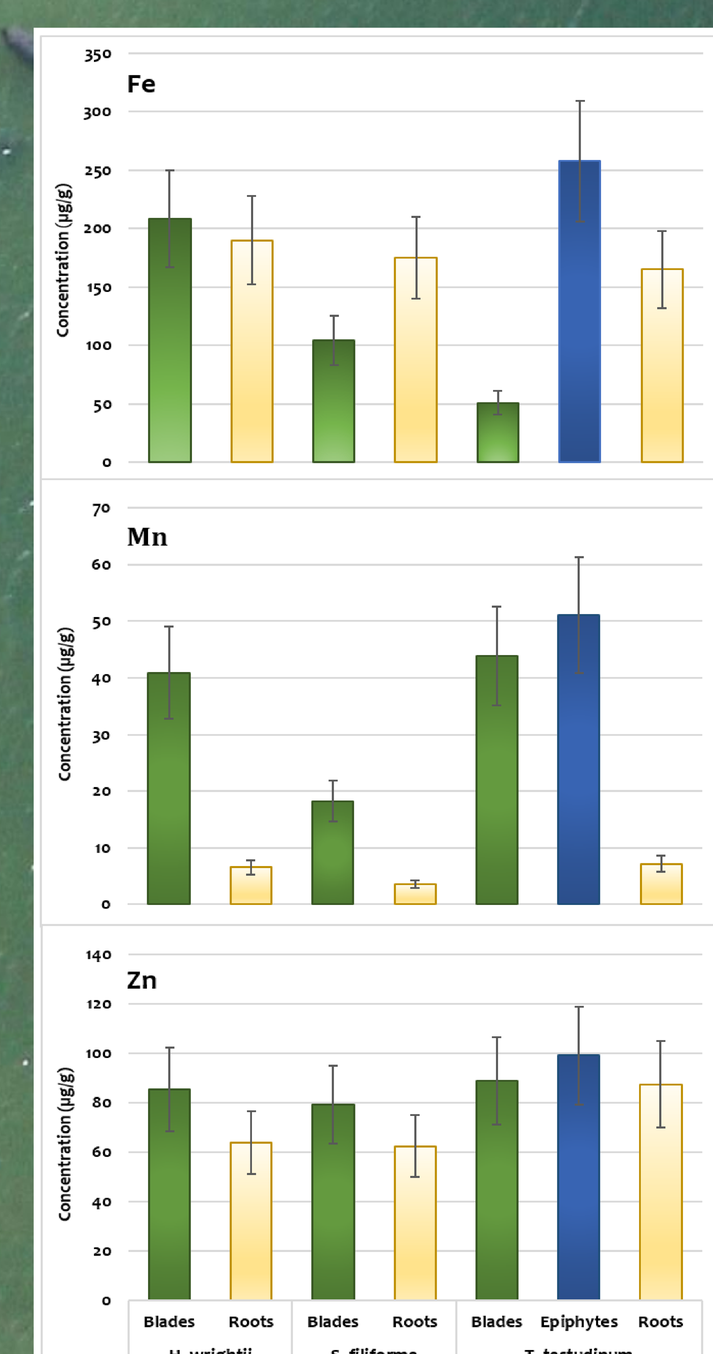

Figure 5. Mean concentrations of Fe, Mn, and Zn compared among plant parts and epiphytes.

Toxicity

Though toxicity values for manatees are difficult to determine, potentially toxic levels of As and Zn for *Trichechus manatus* were determined by Siegal-Willot et al., 2013.

- Concentrations of As exceeded the potentially toxic value of 0.49 ± 0.25 µg/g in 61% of samples, with a mean of 0.48 ± 0.40 µg/g and a maximum of 2.95 µg/g.
- Concentrations of Zn exceeded the potentially toxic value of 15.84 ± 2.47 µg/g in 98% of samples, with a mean value of 81.5 ± 63.9 µg/g and a maximum of 669.44 µg/g (Figure 6).

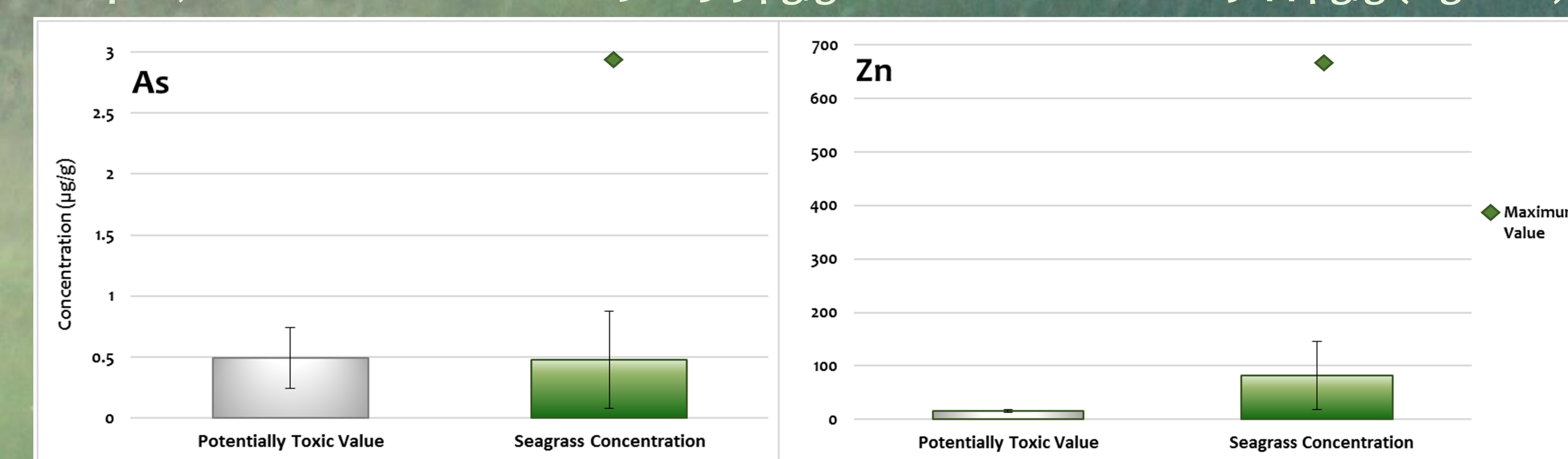

Figure 6. Mean and maximum concentrations of As and Zn in seagrasses compared to potentially toxic values of each metal (Siegal-Willot et al., 2013).

Stable Isotopes

Values show a trophic enrichment in $\delta^{15}N$ from the seagrasses in this study (primary producers) to the Florida manatee (herbivore). The $\delta^{13}C$ values show that these seagrasses are a carbon source for Florida manatees (Figure 7).

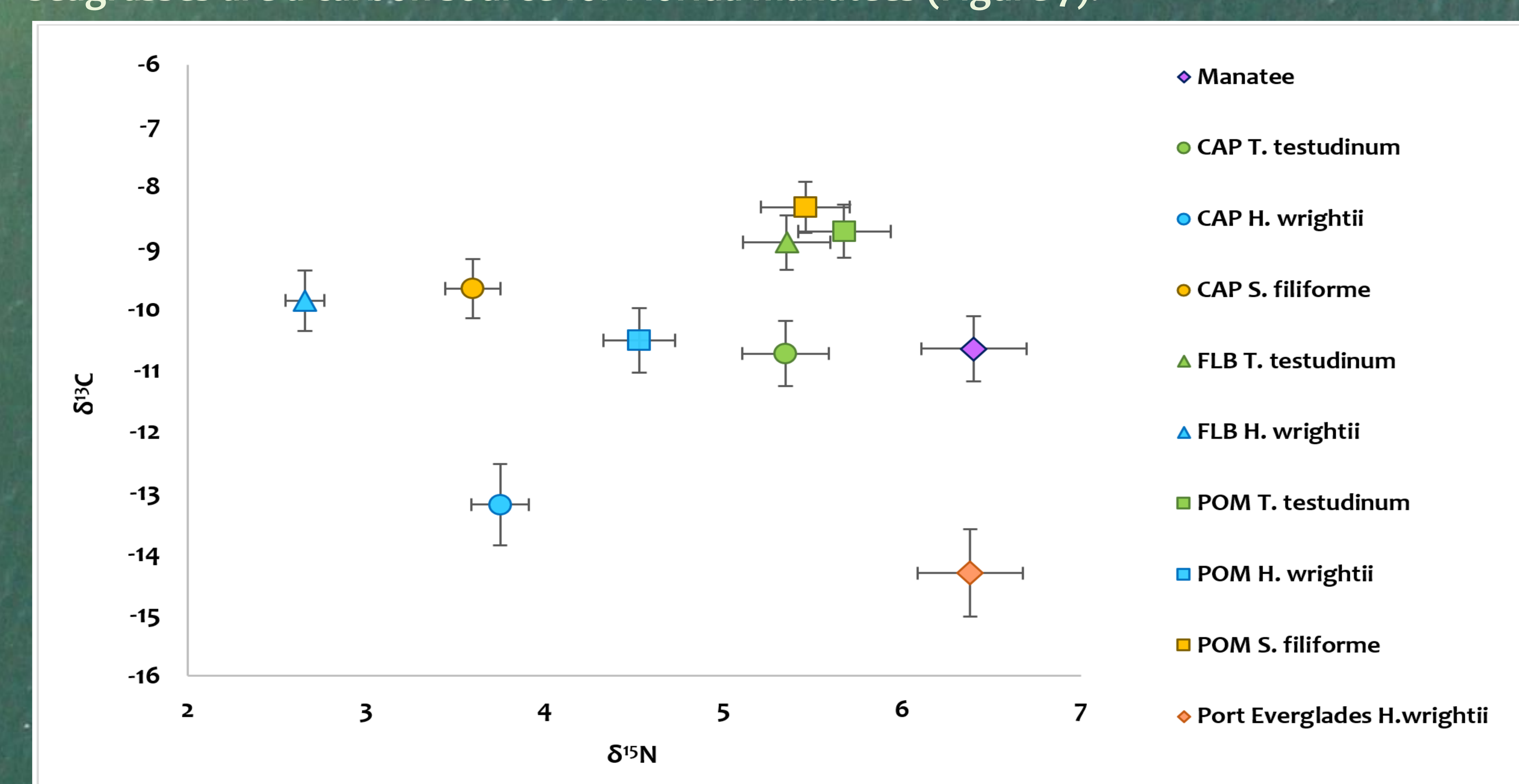

Figure 7. Stable isotope values for seagrasses by location (shape) and species (color) along with values found in Florida manatees (Alves-Stanley and Worthy 2009) and Port Everglades (Gabriel et al., 2015).

Key Findings

- Contributing factors: location, season, and diet preferences.
- Higher concentrations of Mn and Fe during the wet season suggest run-off is a major source of these metals into the coastal zone.
- Metals with the highest overall concentrations were also significantly higher in blades with attached epiphytes (Fe, Zn, Mn), suggesting epiphytes may be the main source of heavy metals to manatees.
- Fe concentrations were twice as high as any other metal and 7-25 times higher than the majority of the metals. As an essential metal, Fe may not pose as great a threat compared to non-essential metals.
- Further investigation includes sampling and analysis through the remainder of 2017 to assess seasonal trends and yearly averages of heavy metal contaminants.

USGS science for a changing world

Acknowledgements: Friends of Gumbo Limbo, the Lerner-Gray Grant Program, and the South Florida Chapter of the Explorers Club provided funds to support this research, and the Society for Marine Mammalogy provided travel funds to present at this conference. Dr. Christine France from the Smithsonian Museum Conservation Institute, Smithsonian Institution, conducted the stable isotope analysis.