A Nitrogen Isotopic Study of Greater Biscayne Bay: Implication for Sources of Nutrients

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Funding from SFC CESU/BNP
Take Home Message

• In Biscayne Bay there is a clear signature of isotopically positive N derived from anthropogenic sources in the Nitrate, POM, algae, sponges, seagrasses, and sediments.
• No temporal trends in any of the components measured suggesting the contamination is a permanent feature.
• This signature is only present close to the land and is not agricultural in origin.
Biscayne Bay

• An area of outstanding water in which the flora and fauna has declined over the past century as a result of the input of sewage, dredging, pollution and other activities

• Adjacent to a pollution of ~5 million people who create waste …. 

• Adjacent to large land fill ‘Mount Trashmore’ and Black Point Sewage Treatment Plant
What are the Ranges?

\[ \delta^{15} N(0/00) = \frac{N^{15}/^{14}N_{sample}}{N^{15}/^{14}N_{standard}} - 1 \times 1000 \]

Figure 2-15. General distribution of \( \delta^{15}N \) for various natural substances (revised after Miyake and Wada, 1967; Wlotzka, 1972; and Kaplan, 1975)
What do different values mean?

“You are what you eat… plus a few per mille”
Atm N₂ → N₂O → NO → NO₂

Nitrogen Fixation:

\[ N₂ + 8H^+ + 8e^- + 16ATP = 2NH₃ + H₂ + 16ADP + 16Pi \]

\[ \Delta = 0 \]

Denitrification:

\[ \Delta = 28 \]

Assimilation:

\[ \Delta = \sim 2-4 \]

Mineralization:

\[ \Delta = 15-35 \]

Nitriﬁcation:

\[ \Delta = \sim 0 \]

Volatilization:

\[ \Delta = 20 \]

Lamb 2006
Nitrogen as Indicator of Sewage

- Numerous papers have been published which report the use of stable isotopes in benthic organisms in order to distinguish sewage
  - (Heikoop et al. 2000a,b; Sammarco et al., 1999; Risk and Erdmann, 2000; Costanzo et al., 2001, 2004).

Risk and Erdman 2000
Measured $\delta^{15}\text{N}$ values in *Codium sp.* from Jupiter Inlet. Values reached to almost +12‰ during summer which he concluded was a result of freshwater bringing high $\delta^{15}\text{N}$ nitrogen from animal waste.

Lapointe (1997)
Data from Lamb et al. (In Prep.)
Data from Lamb et al. (In Prep.)
Data from Lamb et al. (In Prep.)
Florida Reef Tract

Data from Lamb et al. (In Prep.)
Data from Lamb et al. (In Prep.)
Data from Lamb et al. (In Prep.)
Data from Lamb et al. (In Prep.)
Data from Lamb et al. (In Prep.)
Average salinity from 1997-2009 (Data from FIU)
Average NOx from 1997-2009 (Data from FIU)
Green Algae

Penicillus sp.
Udotea sp.
Rhipocephalus sp.
Avrainvillea sp.
Caulerpa sp.
Ulva sp.
Acetabularia sp.

Nitrogen
Red Algae

Laurencia sp.
Murrayella sp.
Galaxaura sp.

Also
Brown Algae
Sponges

Nitrogen

$\delta^{15}\text{N}$
Sedimentary Organic Material

$\delta^{15}N$

Nitrogen
Dissolved Nitrate Biscayne Bay

- Atmospheric Input
- Fixation and Fertilizer
- Higher Trophic Input

\( \delta^{15}N \) (

\( \delta^{18}O \) (%)
The Growing Human Footprint on Coastal and Open-Ocean Biogeochemistry

*Scott Doney* *Science* 2010

$1.5 \times 10^6$ kg to Biscayne Bay in a year
Nitrogen Isotopic Composition (ppt)

- Green Algae
- POM
- Seagrass
- Red Algae
- DIN
- CGW
Data from Lamb et al. (In Prep.)
Data from Lamb et al. (In Prep.)
Conclusions

• In Biscayne Bay there is a clear signature of isotopically positive N derived from anthropogenic sources in the Nitrate, POM, algae, sponges, seagrasses, and sediments.
• No differences in the trends between any of these components
• Appears to be a constant source
• This signature is only present close to the major sources of N and is not agricultural in origin