Utilization of Stable Isotopes for Tracing Sources of Nutrients in the Caloosahatchee River and Estuary, Florida

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Introduction:

- Southwest Florida's Caloosahatchee River Estuary (CRE) has been dramatically altered by population growth and development in its local watershed, and by changes in the water management region of central and southern Florida (Barnes et al., 2006).
- A large portion of the CRE and its surrounding land is occupied by agriculture and rangelands. As of 2017, 47% of the surrounding area of the CRE watershed is rangelands.
- Runoff inputs nutrients (such as fertilizers & pesticides) from the watershed into the CRE.
- Elemental content (C:N:P) and stable isotopic ratios ($\delta^{13}C$ & $\delta^{15}N$) can be effective ecological indicators and tracers of nutrients and organic matter in aquatic ecosystems (Lapointe, 1997, Johnson et al., 2006).
- For example, groundwater contaminated with septic tank effluent has high $\delta^{15}N$, and algae grown with wastewater sources have elevated $\delta^{15}N$ signatures (Dailer et al., 2010).
- To determine the input source, samples were taken from 42 different sites and analyzed for elemental composition (C:N), nutrients (dissolved/total N & P) and analyzed for stable isotope concentrations ($\delta^{13}C$ & $\delta^{15}N$).

Objective & Hypothesis:

- To enhance water quality data collection in the CRE, and to collect key data types needed to distinguish pollutant sources and harmful conditions at scales relevant to management.
- Local watershed inputs including municipal waste and groundwater sources of nutrients are key factors in water quality degradation that must be addressed.

Study Sites:

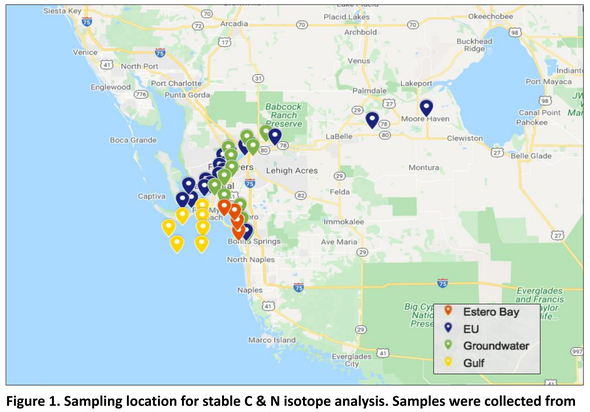

Figure 1. Sampling location for stable C & N isotope analysis. Samples were collected from 42 sampling locations, both in June 2020 (wet season) & Feb 2021 (dry season). Legend: Groundwater (GW), Caloosahatchee Estuary (EU), Estero Bay (EB), and Gulf of Mexico (GOM).

Stable Isotope tracing reveals that mixed sources of nutrients are key factors affecting water quality.

Methodology:

- Water samples for nutrient and isotopic analysis were collected twice Summer 2020 (wet season) and Winter 2021 (dry season) from 42 sites from the study sites (Fig. 1).
- Up to 1L of water was filtered through pre-baked and weighed 0.45 µm pore size GFF filters, filters were dried, and analyzed for elemental contents at FGCU, while sub-samples prepared for $\delta^{15}N$ analysis were analyzed at an outside facility.
- In addition, 200 mL of water samples were collected from each location, passed through 0.45 µm pore size GFF filters, then processed similarly for C:N:P ratio and $\delta^{15}N$ analysis.

Figure 6. the collection of water samples at the Imperial river (IR) sites.

Results and Discussions:

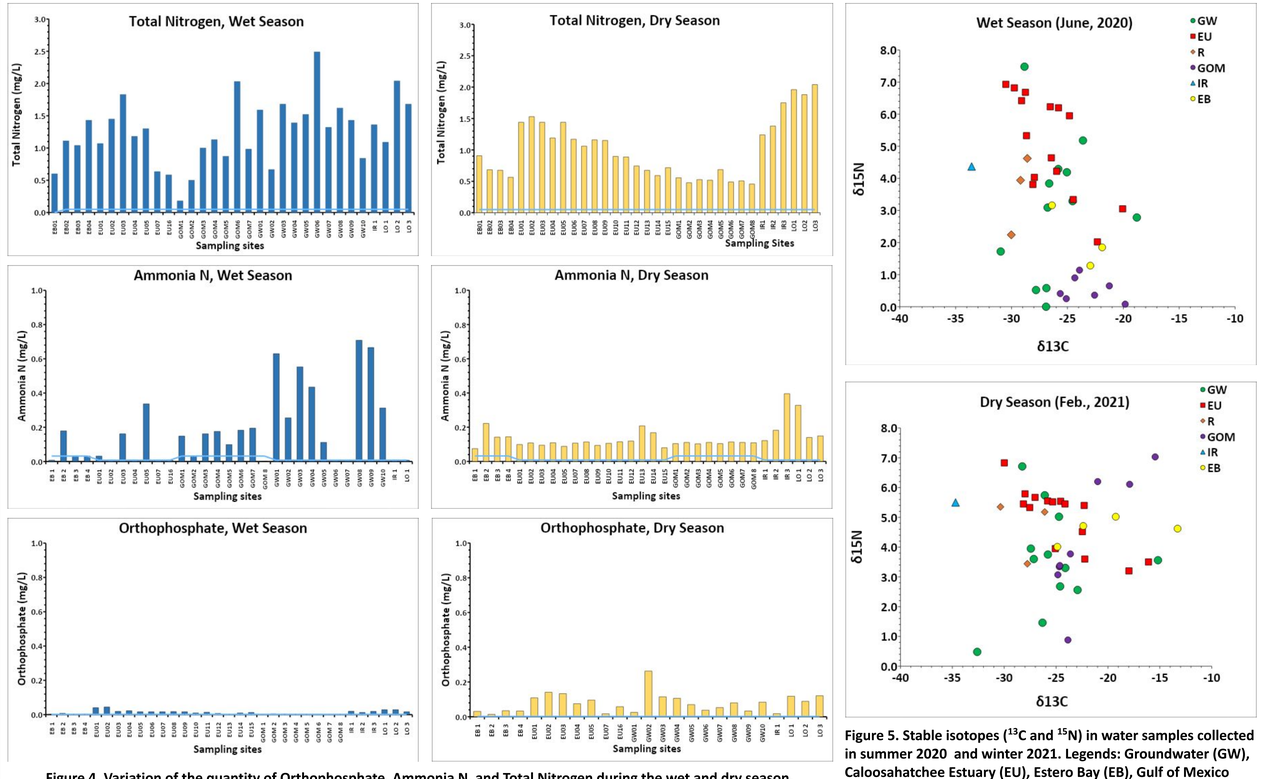

Figure 4. Variation of the quantity of Orthophosphate, Ammonia N, and Total Nitrogen during the wet and dry season, compared to the MDL.

Figure 5. Stable isotopes (^{13}C and ^{15}N) in water samples collected in summer 2020 and winter 2021. Legends: Groundwater (GW), Caloosahatchee Estuary (EU), Estero Bay (EB), Gulf of Mexico (GOM), Upper River (R) and Imperial River (IR).

Conclusions:

- The results for stable isotopes (^{13}C and ^{15}N) analysis (Fig. 5) shows a seasonal variation in isotopic composition in suspended particulate samples.
- There was a strong differentiation in isotopic composition between GOM and estuarine samples in the wet season, with both $\delta^{13}C$ and $\delta^{15}N$ values more depleted in Gulf sites (Fig. 5).
- However, there were no clear differences in isotopic composition in the dry season, and the Gulf samples were more enriched in ^{13}C and ^{15}N isotopes.
- The depletion in ^{13}C and ^{15}N during wet season could be due to increased plankton production and preferential uptake of lighter isotopes over the heavier ones.
- Orthophosphate makes a strong showing in the upper parts of the river and is present in high levels in the groundwater wells we tested during dry season (Fig. 4).
- Ammonia was under MDL at most sites during the wet season, they become quite elevated during the dry season (Fig. 3).

Broader Implications:

- Develop recommended water quality criteria for protecting designated uses of water.
- Assist states, authorized tribes, and territories in adopting water quality standards that support designated uses.
- Establish pollution reduction targets for impaired waters. Specific outputs and outcomes are listed for each of the proposal's objectives.

Literature Cited:

- Barnes et al., 2006. Caloosahatchee Estuary and Charlotte Harbor Conceptual Model. Southwest Florida Feasibility Study.
- Dailer et al., 2010. Using $\delta^{15}N$ values in algal tissue to map locations and potential sources of anthropogenic nutrient inputs on the island of Maui, HI, USA. Mar. Poll. Bull. 60:655-671.
- Lapointe, 1997. Nutrient thresholds for bottom-up control of macroalgal blooms on coral reefs in Jamaica and southeast Florida. Limnology and Oceanography 42:1119-1131.

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