Lake Okeechobee: Long-Term Water Quality Trends

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Objectives

• Conducting water and nutrient budgets for the lake from water years (WYs) 1973-2018 (WY=May 1st through April 30th).

• Assessment of the long term regional nutrient contribution to Lake Okeechobee.

• Tracking water quality trends for water quality flowing into or out of the lake.

• In-Lake water quality assessment and trophic state classification.
Lake Okeechobee

- Largest freshwater lake in Florida and described as the heart of the south Florida ecosystem.
- Provides flood control and water supply as well as many ecosystem services (habitat to migratory species, etc.).
- The subtropical climate has two distinct wet and dry seasons.
Inflows to Lake Okeechobee

- The hydrology of the lake is human-regulated and it receives inflows from the Northern, Eastern, Western and Southern regions.

- Usually lake water is drawn south by canals to irrigate sugarcane and other crops in the Everglades Agricultural Area (EAA).

- Reverse flow from the Southern region to the lake called back-pumping.
Data from WYs 1974-2018

• Nutrient loadings entering the lake from surface runoff, atmospheric deposition and internal nutrient releases were calculated.

• A database was created with water quality data, surface inflows and outflows, hydro-meteorological data and lake stages for the last 45 water years (WY1974-2018).

• 38 monitoring stations around the lake and 8 in-lake monitoring stations were used.
Budget Models

• Budgets were stated as a series of mass balance equations for four regions

\[ \Delta \text{Storage} = \sum \text{Inputs} - \sum \text{Outputs} \]

• Net Sedimentation rate equation used was:

\[ \sigma = \frac{[(M_{in} - M_{out}) - (\Delta M_{lake})]}{M_{lake}} \] (James et al. 1995 & Havens et al. 2005)

Where:

\( M_{in} \) is the yearly mass of nutrient entering the lake at the inflow structures and from atmospheric deposition.

\( M_{out} \) is the yearly mass leaving the lake at the outflow structures.

\( \Delta M_{lake} \) is the year-to-year changes in lake mass based on the first and last day of WY values.

\( M_{lake} \) is the average annual lake mass.
Temporal Trend Analysis

• Non-parametric Mann-Kendall trend test on an annual time scale as well as seasonal cycles.

• The change point detection algorithm was used to determine changes in flows, nutrient concentrations, and loads to the lake:
  ➢ Lake Okeechobee nutrient inflow and outflow loadings
  ➢ Nutrient concentrations as well as the in-lake nutrient concentrations
  ➢ Net P sedimentation rate
Results

- The average inflow and outflow were 4,607 million and 4,202 million m³ /yr, respectively.
- The surface inflow (2,671 million m³ /yr) was substantially higher than the surface outflow (1,846 million m³ /yr).
- About half of the water flowing into the lake was lost to ET.
Results

TP Inflow

- South 12% Pre 1986
- 87.41%
- 7.81%
- 0.73%
- 4.05%

TN Inflow

- South 37% Pre 1986
- 73.01%
- 5.16%
- 20.90%
- 0.94%
LAKE OKEECHOBEE
Phosphorus Budget

$Mg = \text{Megagram} \quad 1 \text{ Megagram} = 1 \text{ metric ton}$

ATMOSPHERIC DEPOSITION
+389.9 Mg

NORTHERN WATERSHED
-73 Mg

CALOOSAHATCHEE RIVER
-63.8 Mg

+3.32 Mg

ST. LUCIE RIVER
+67.56 Mg

+18.54 Mg

NET ACCUMULATION
277.52 Mg

EVERGLADES AGRICULTURE AREA (EAA)
+36.75 Mg

-69.96 Mg

Total phosphorus contributed by EAA from backpumping
11,400 Mg

23%

Total phosphorus in sediments, 1952-2018
49,000 Mg

A DANGEROUS TREND
The net sedimentation rate has been significantly decreasing since 1970. When the curve reaches the zero x axis, then the sediments will start releasing phosphorus. This can happen as early as 2035.

NOTE: Phosphorus numbers are based on a Lake Okeechobee mass balance conducted for 45 years from May 4, 1970 to April 26, 2015. Data were downloaded from USFWS.Florida Everglades Ecosystem Management database.
Net Sedimentation Rate

\[ y = -0.58 \ln(x) + 2.42 \]

\[ R^2 = 0.58 \]
TP Trend Analysis

Statistically Significant Increasing Trend:
- TP Outflow Loadings (Dry > Wet Season)
- TP Outflow FWMC
- TP Inflow FWMC (South)
TN Trend Analysis

Average Annual Unit Area TN Inflow Loadings (Mg/km²)

Water Year

West  East  South  North

TN Inflow FWMC (mg/L)
**Back-pumping**

- Average TP Conc. in back-pumping 0.19 mg/L
- Average In-Lake TP Conc. 0.10 mg/L
- Average TP Conc. of surface outflow southward 0.11 mg/L

- Average TN Conc. in back-pumping 4.35 mg/L
- Average In-Lake TN Conc. 1.54 mg/L
- Average TN Conc. of surface outflow southward 1.76 mg/L
Lake Impairment & Classification

TSI > 60 = Eutrophic State
Thank you!