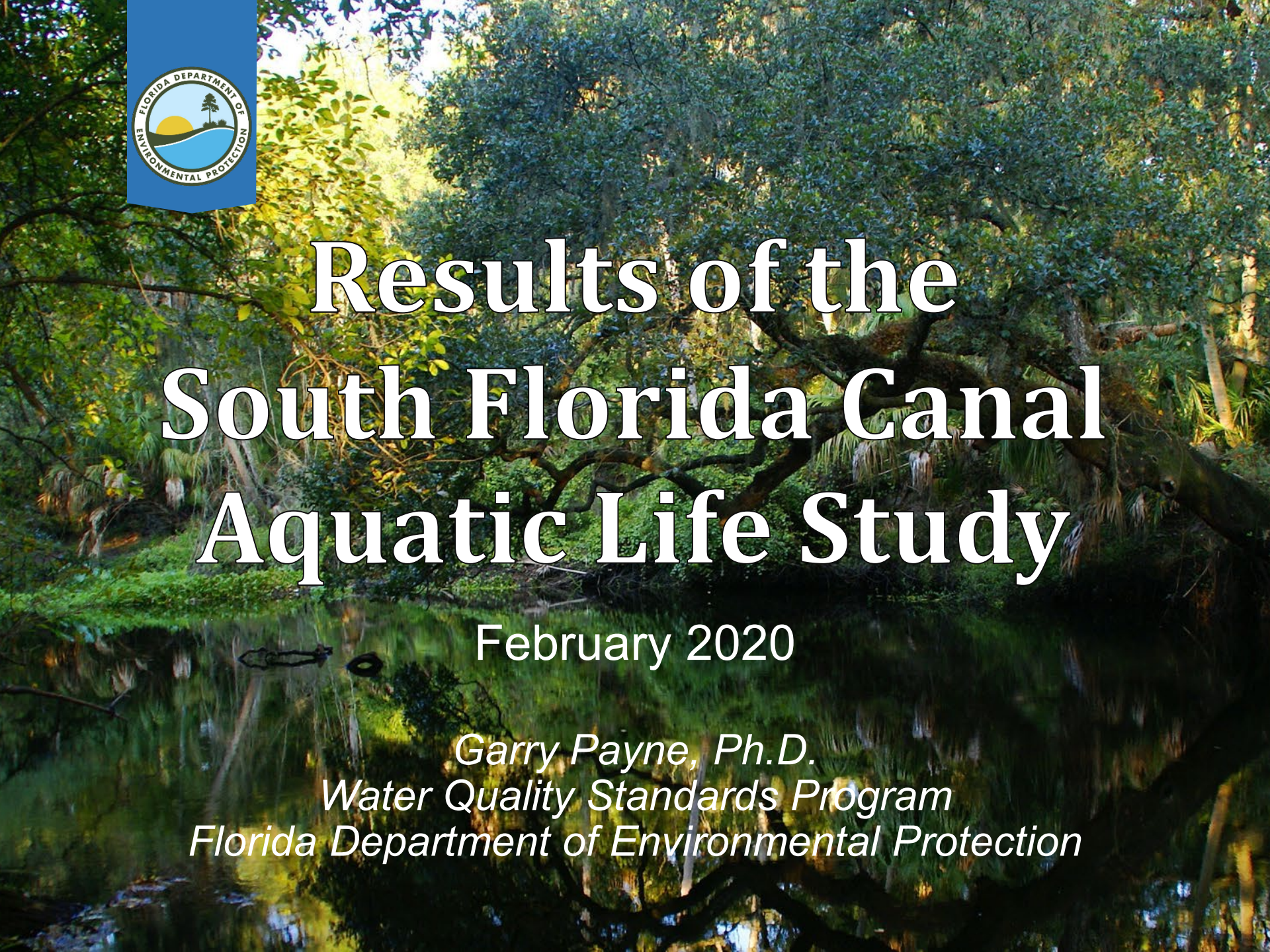

Results of the South Florida Canal Aquatic Life Study

February 2020

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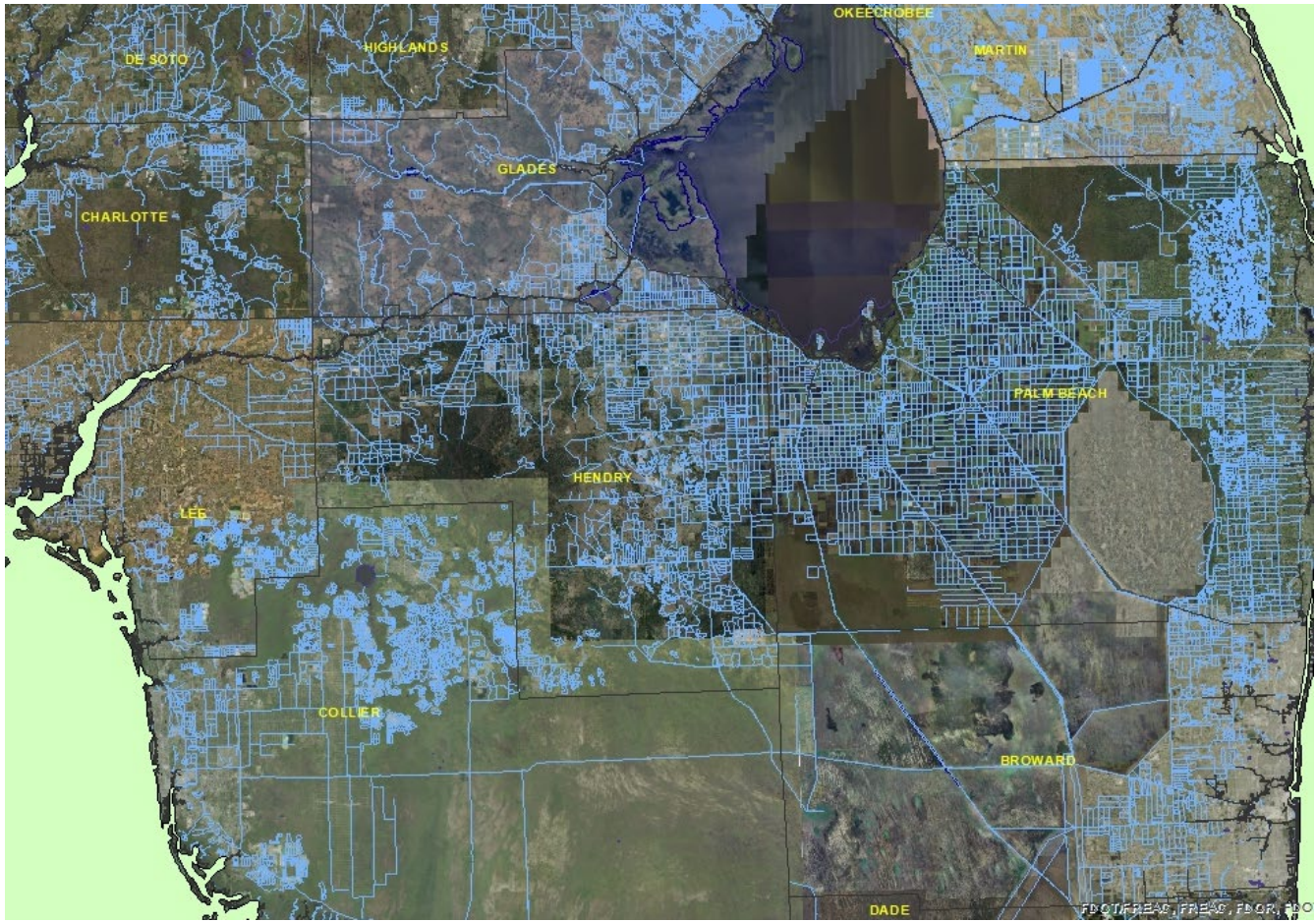
Water Quality Standards Program
Florida Department of Environmental Protection

Canals are South Florida

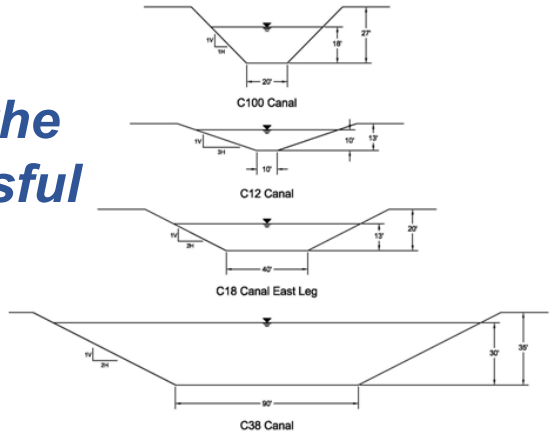
Other than the Everglades and Lake Okeechobee, canals are the predominant freshwater features in South Florida

- Built as part of the Central and Southern Florida Flood Control project by the USACOE
- Designed and constructed from 1920s to 1970s
- 2,600 miles of canals, 64 pump stations and more than 800 water control structures and 700 culverts
- Managed by SFWMD and USACOE



Canals are Different
Than Natural Streams

Canals are generally man-made waterbodies with the primary purpose of moving water, which is a stressful habitat for biological communities



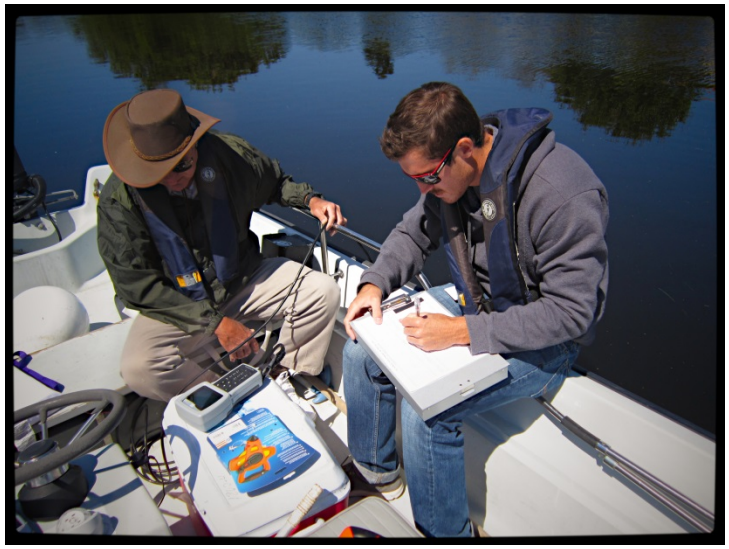
- Generally very deep with steep banks
- Usually highly managed
- Flow highly variable
- Can act as streams or lakes or something unique

Study Objective

Perform a Comprehensive Assessment of South Florida Canals and Their Aquatic Life

- Assess aquatic life in South Florida canals;
- Evaluate the differences in conditions among South Florida canals;
- Determine interrelationships between aquatic life in canals and physical, chemical, hydrologic, etc. variables; and
- Collect information that can be used to guide management decisions

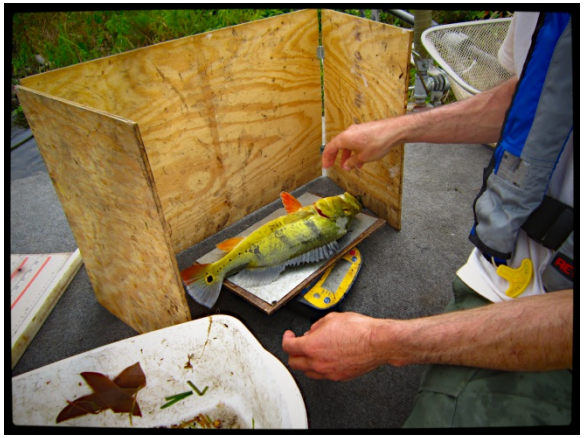
Water Quality Sampling



- Sampling initiated Nov. 2012 and completed Oct. 2016
- Monthly collections for TKN, TP, NOx, TOC, Color, Turbidity, and Chlorophyll-*a*
- Quarterly sonde deployments at selected sites to collect diurnal DO data, with vertical profile data taken before and after deployment
- Information on physical attributes of canals, canal management, flow and other canal disturbance factors was also collected

Biological Sampling

- Habitat Assessment
- Stream Condition Index (SCI)
- Linear Vegetation Survey (LVS)
- Rapid Periphyton Survey (RPS)
- Phytoplankton
- Zooplankton (specific method for this study)
- Fish presence/absence (subset of sites)



Biological Measures

Stream Condition Index (SCI):

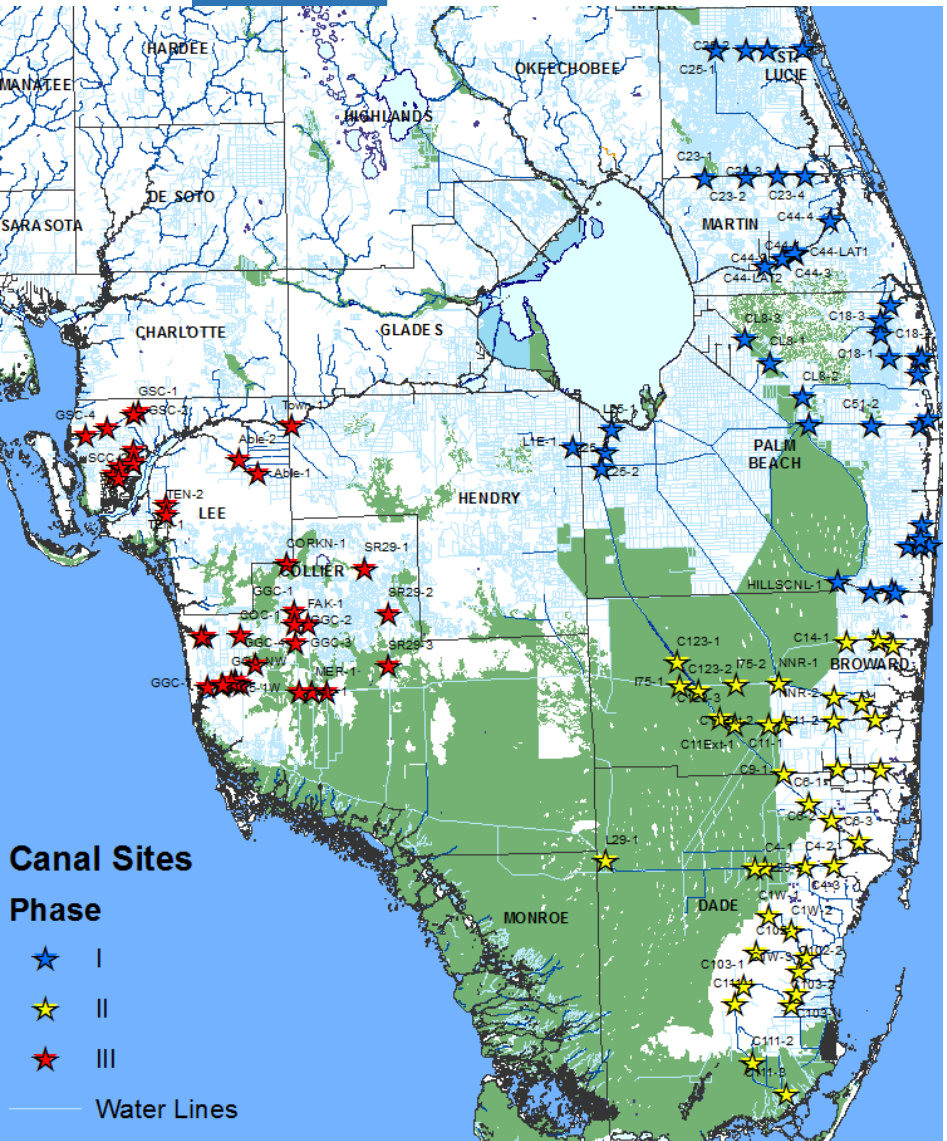
- Regional macroinvertebrate index comprised of 10 metrics selected to assess different aspects of structure and function of community to evaluate biological health of streams
  - Number of Sensitive taxa
  - Total Number of Taxa
  - Percent Trichoptera (caddisfly)
  - Percent Ephemeroptera (mayfly)
  - Number of Long-Lived Taxa (>year to complete life cycle)
  - Percent Tanytarsini
  - Number of Clinger Taxa
  - Percent Filter or Suspension Feeders
  - Percent Very Tolerant Taxa
  - Percent Dominant Taxa
- Not calibrated for Everglades bioregion
  - Used Peninsula SCI calculation to compare canals
- Passing score = average of at least 2 measurements of ≥ 40 and neither of the 2 most recent below 35

Biological Measures

Habitat Assessment (HA):

- Used in conjunction with the SCI to evaluate quantity and quality of available habitat (amount and type of habitat, flow, channelization, riparian buffer zone, *etc.*)
- In natural streams, productive habitat types include aquatic vegetation, snags, roots, leaf packs, and rocks
- Scores from 8 (worst) to 160 (best)
  - Poor < 40
  - Marginal 40 – 80
  - Suboptimal 80 – 120
  - Optimal ≥ 120
- Natural steams with HA scores <80 (*i.e.,* poor or marginal) not likely to pass SCI

Freshwater Sampling Sites
Selected To Capture Range Of Conditions (Phased Approach)



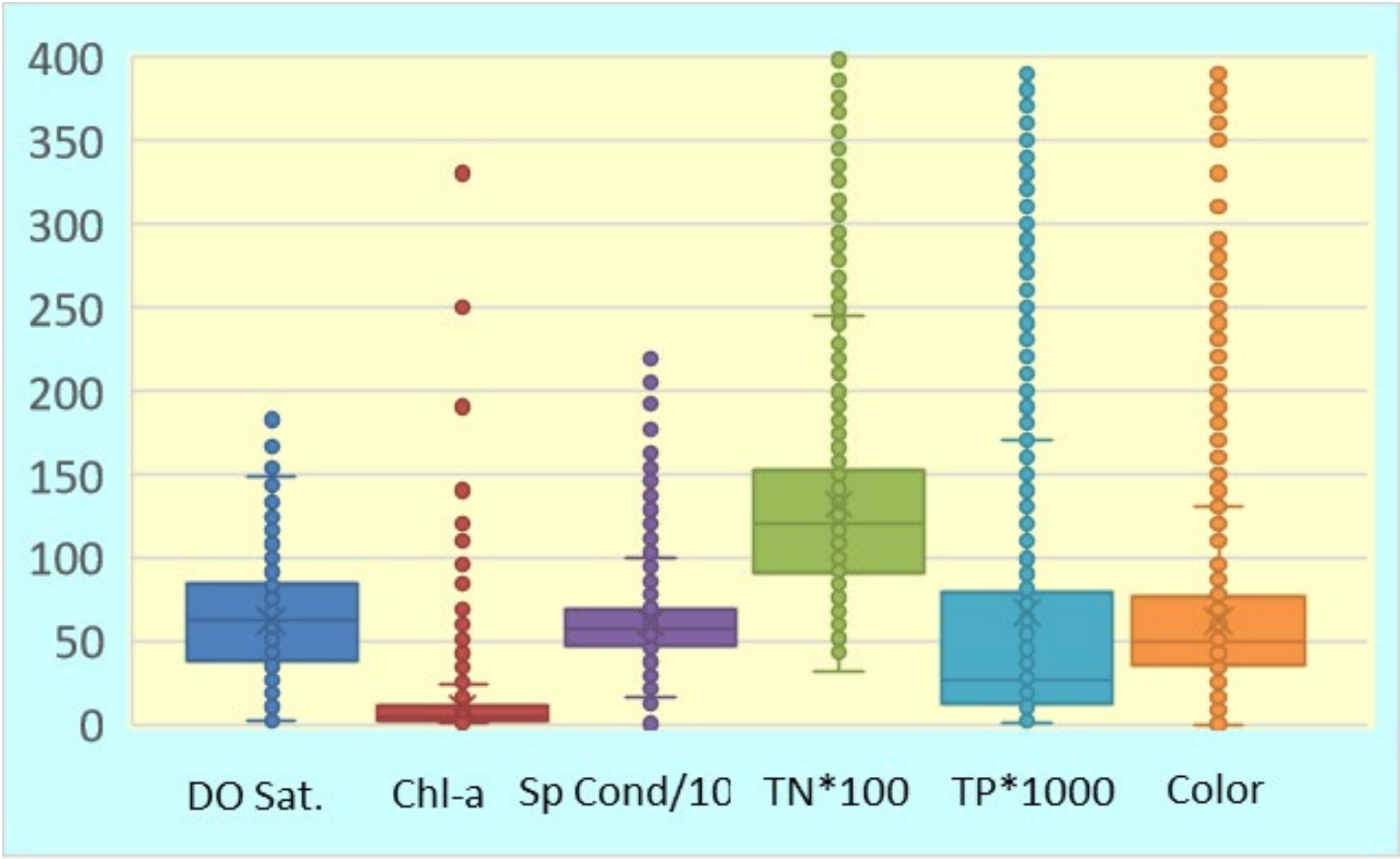
- **Phase I:** 42 sites in 15 canals located in St. Lucie, Martin, and Palm Beach Counties sampled in 2013
  - Less frequent sampling continued at 25 sites in 2014 -16 to build longer period of record
- **Phase II:** 38 sites in 14 canals located in Broward and Miami-Dade Counties sampled in 2014
  - Less frequent sampling continued at 28 sites in 2015 -16
- **Phase III:** 35 sites in 17 canals located in Lee, Collier, and Hendry Counties sampled in 2016

Results

Large differences observed between canals with respect to water quality

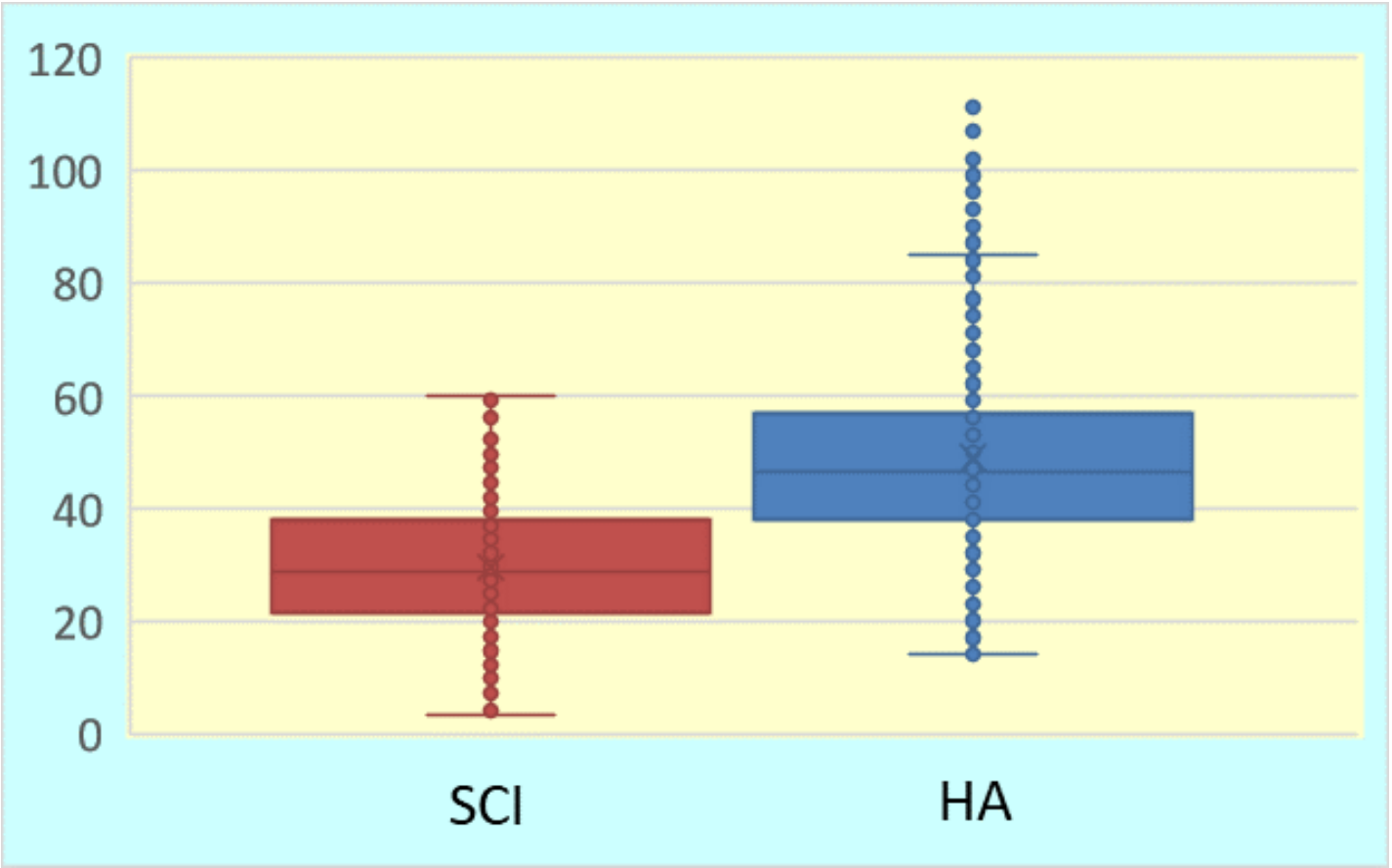
Results show wide range of conditions among canals for all parameters

- DO
- Chlorophyll
- Conductivity
- Nutrients
- Color
- TOC



Results

Biological differences among canals also apparent



- SCI Scores were generally low and highly variable with few passing scores
- HA Scores were also generally low (poor or marginal)

More Water Quality Results

Canals often do not meet water quality criteria for:

- DO
- pH
- Specific Conductance
- SCI* (Peninsula avg ≥ 40, none < 35)
- Chlorophyll-a* (Impairment threshold, 20 µg/L)

Parameter	Criteria	Percent of all Samples Exceeding Criteria	Percent of Canals with > 10% Exceedance by Phase		
			I	II	III
% DO Saturation[1]	38%	21.8	26.7	92.9	45
pH[1]	6.0 - 8.5 su	0.5	0	0	0
Specific Conductance[1]	1275 µmhos/cm	2.7	20	0	0
Chlorophyll-a	20 µg/L*	11.9	73.3	7.1	30
Turbidity[1]	29 NTU	2.2	6.7	0	0
SCI	avg ≥40, all ≥35*	68.4	92.5	86.8	68.6

[1]Natural background provisions of DO, pH, specific conductance and turbidity criteria were not considered.

* Not true water quality criteria (assessment thresholds)

Biology Results

Results of preliminary evaluations of the zooplankton, phytoplankton, and fish communities

- Low taxa richness in zooplankton results
- Most phytoplankton samples contain surprisingly few cells
- Same non-sensitive fish species dominate most canals (FWC electroshocking at select sites)
  - bass, bream, gar, tilapia, oscar, catfish
- Preliminary analyses of these communities indicated that they would not be useful in characterizing differences between canals

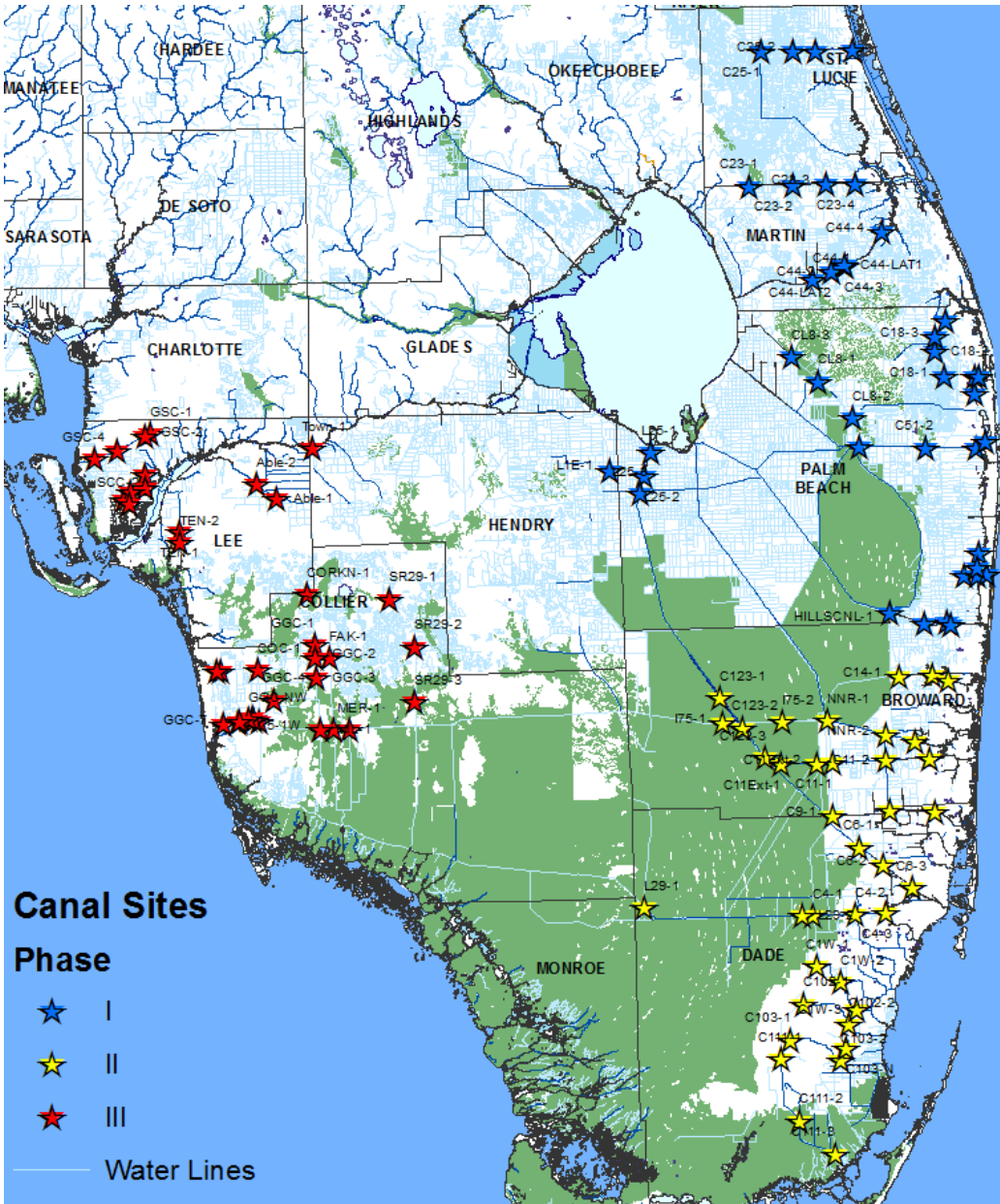
Biology Results

General results from evaluations of the Habitat Assessment and Stream Condition Index scores

- **Habitat Assessment scores range from 14 to 111 with an average of 49**
  - Habitat at most sites characterized as poor or marginal
  - Habitat primarily limited to aquatic vegetation
- **SCI scores are generally low and ranged from <5 to 64, with an average of 29.7 and few passing scores**
  - Only 16% (17 of 103) of sites had passing SCI scores (average ≥ 40)
  - Highest site average SCI score was only 46

Question!

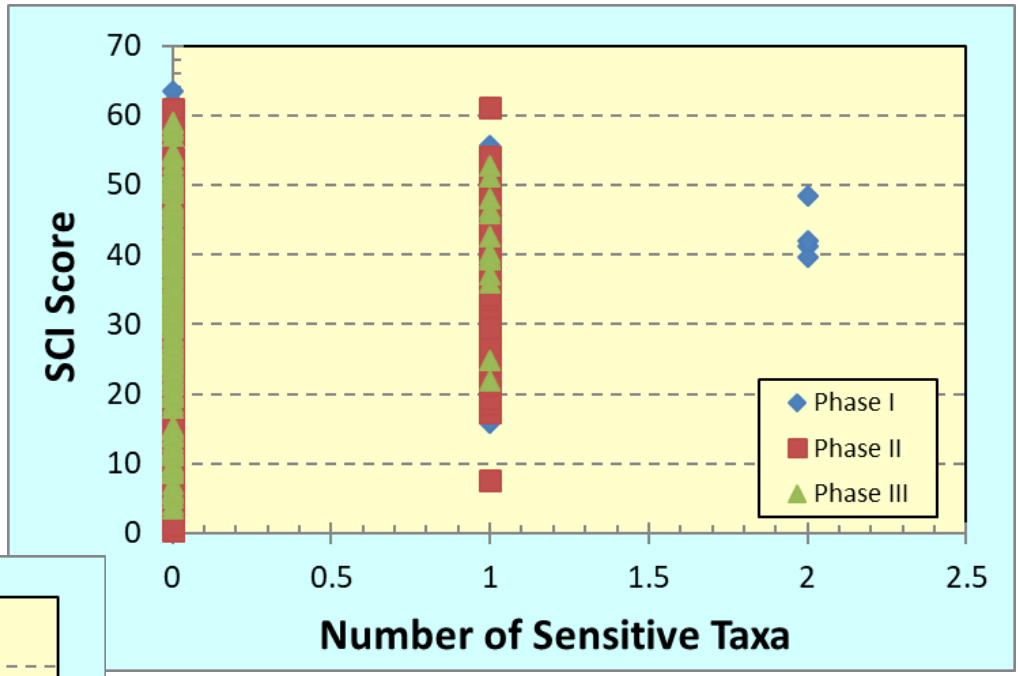
- **Where would you expect the lowest SCI (macroinvertebrate) scores to occur?**
- **Why?**

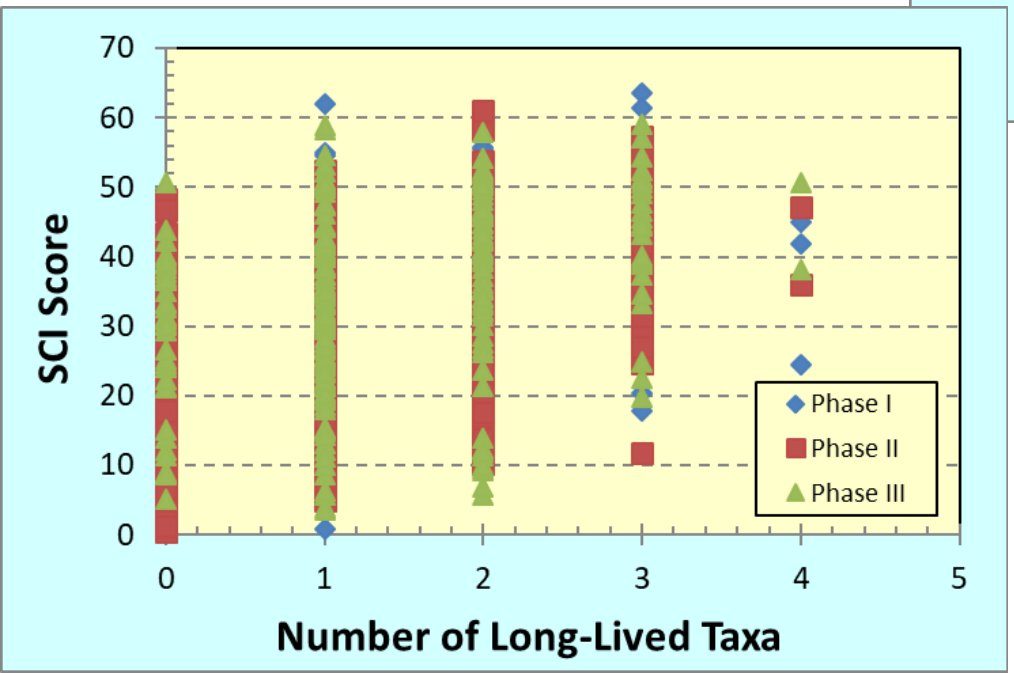


Results

Of the ten SCI metrics, SCI scores least influenced by:

- Number of Sensitive taxa
- Number of Long-lived taxa
- Number of Clinger taxa
- Number of Ephemeroptera taxa



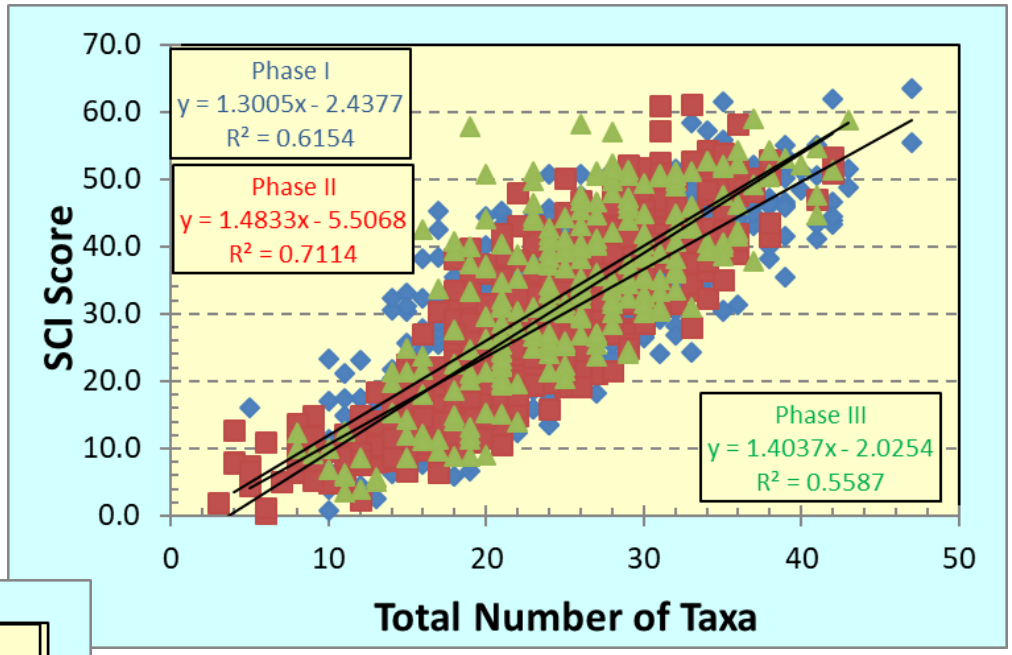


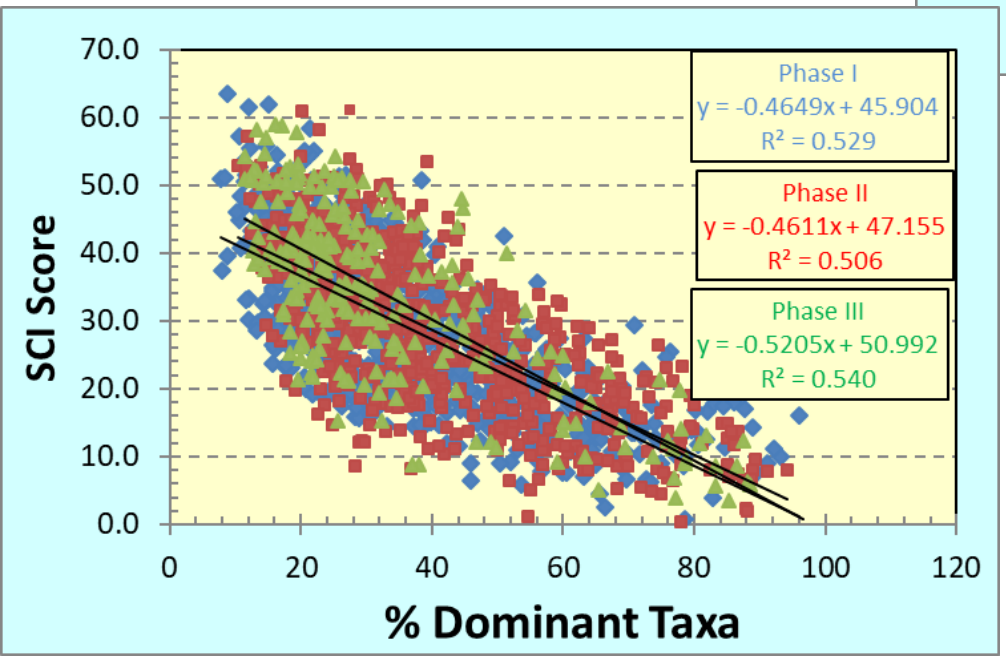
- Lack of correlation due to limited number of organisms in these groups

Results

Of the ten SCI metrics, SCI scores most highly driven by:

- Total number of taxa
- % Dominant



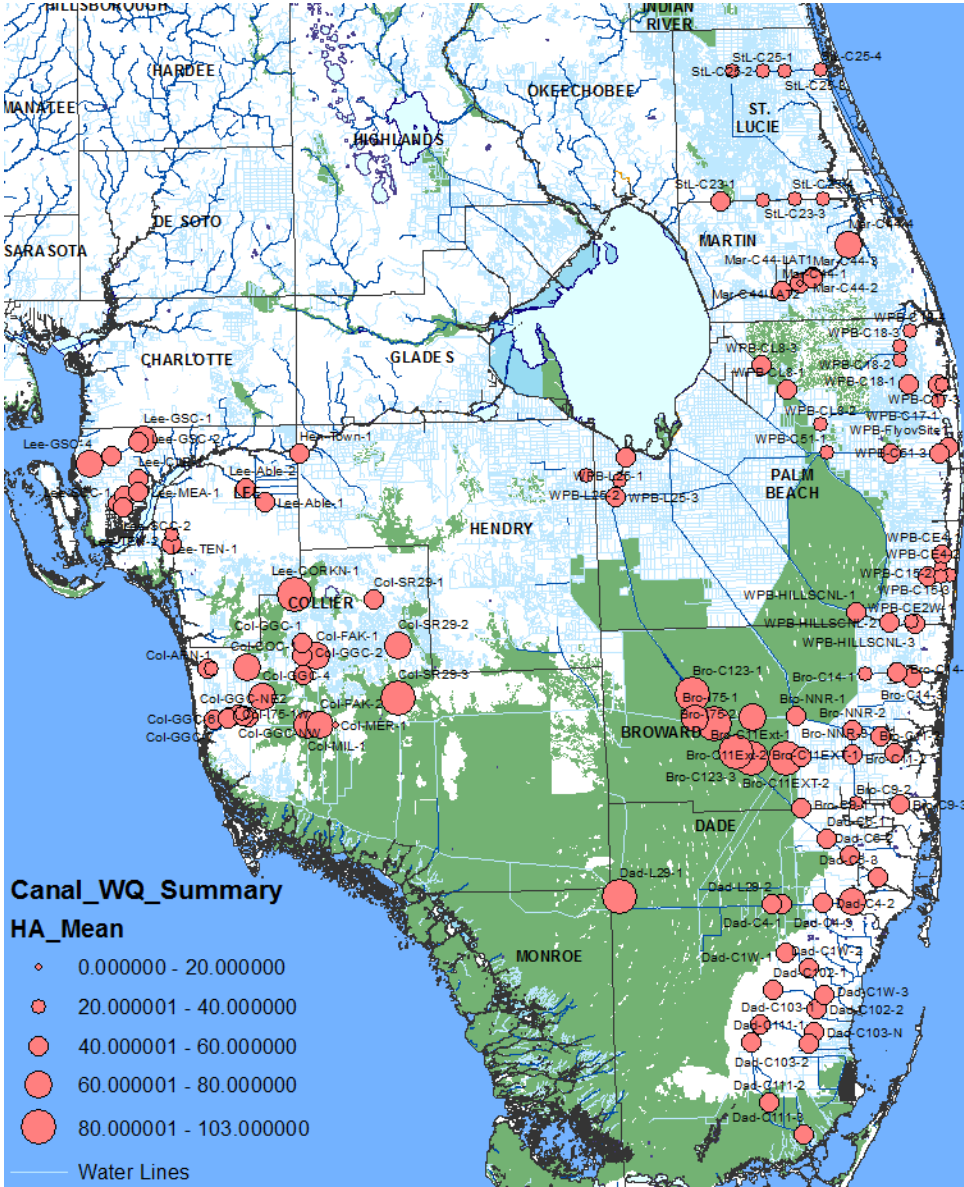


- SCI also correlated to # of chironimidae taxa
- Similar results for canals in all areas

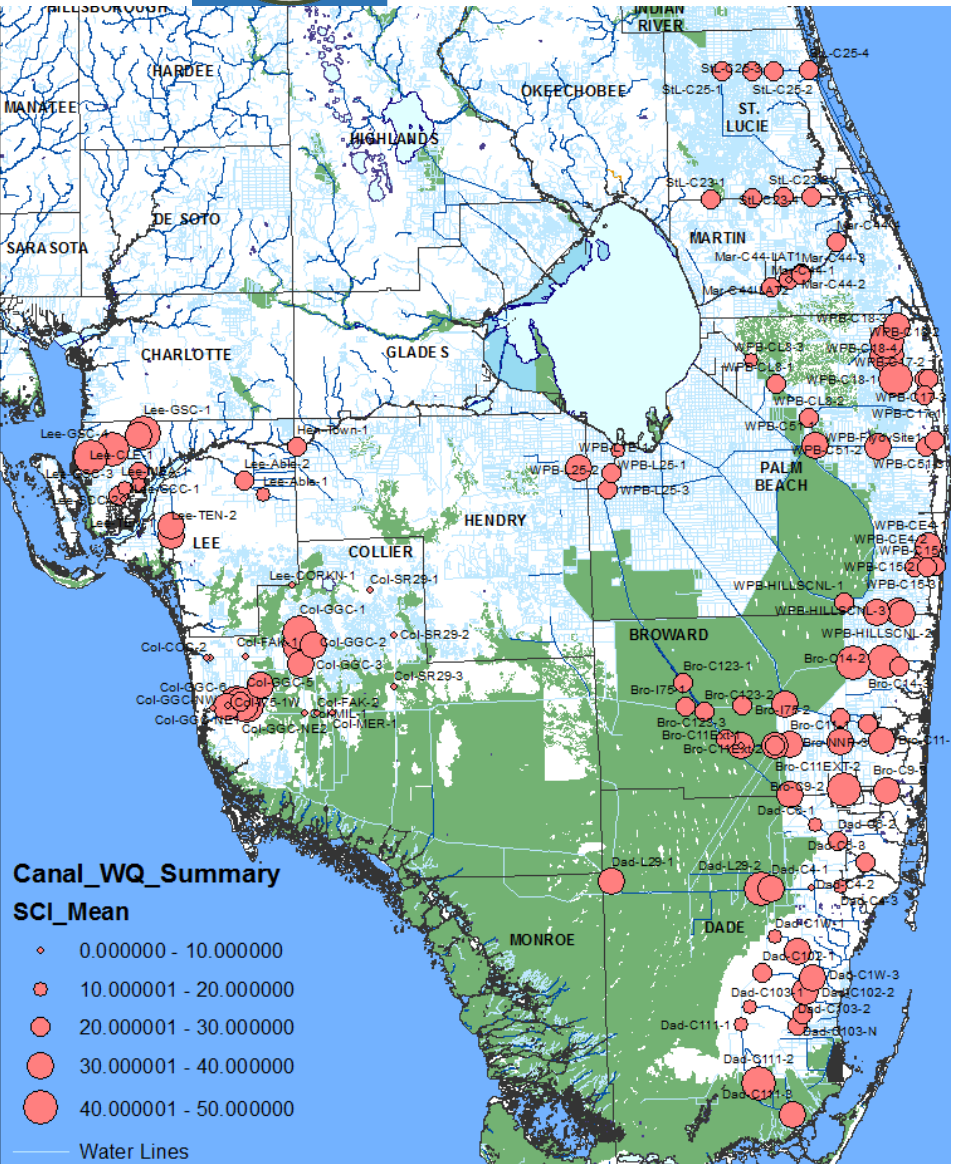
Spatial Analyses

Habitat Assessment

- **Highest HA scores found in Everglades canals (as expected)**
  - Less surrounding anthropogenic influence
  - More plants
  - Open to marsh = recruitment source
  - Better WQ (lower TP and chlorophyll-a levels)
- **Lowest HA scores for northeastern sites**



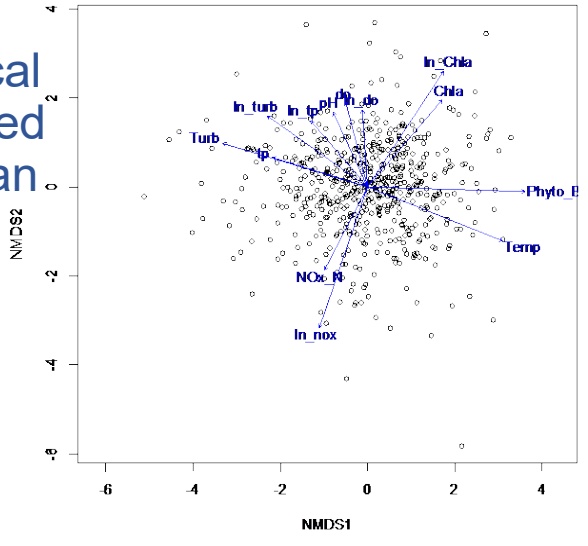
Spatial Analyses



SCI Scores

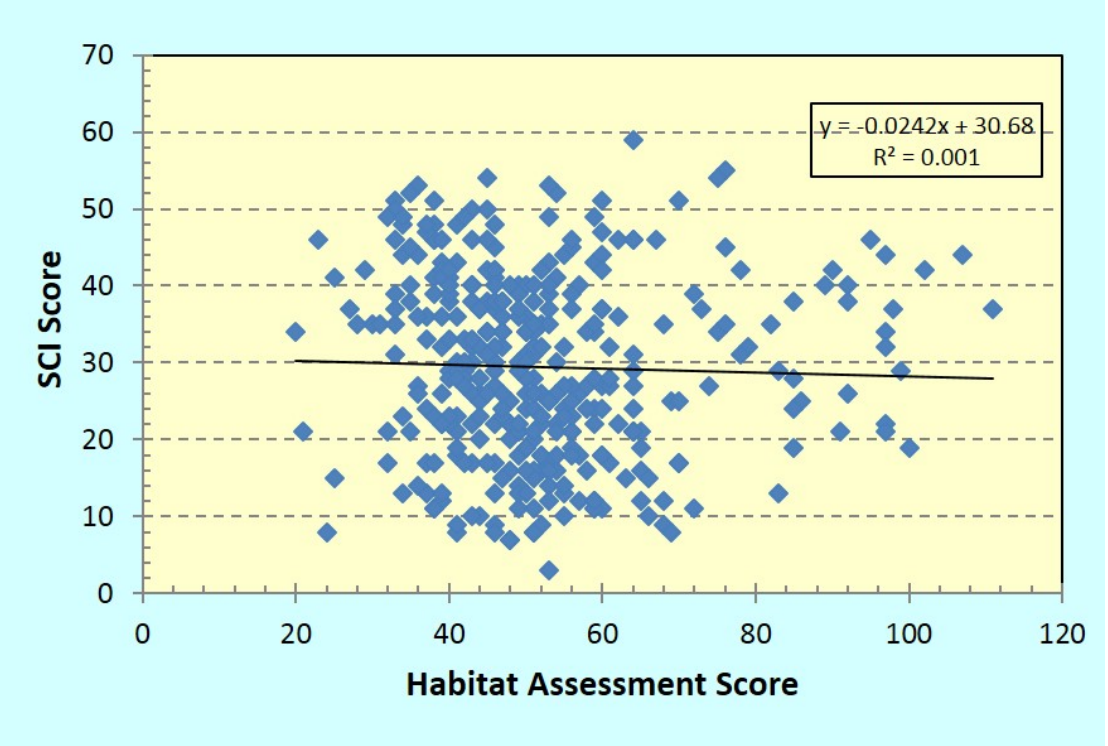
- **Low SCI scores found in Everglades canals (not expected!)**
  - Why???
- **Low SCI scores also found for northeastern sites**
  - Expected due to low HA scores

Extensive statistical analyses conducted by Dr. Curt Pollman yielded little explanatory information about SCI response



Results

Extensive statistical analyses conducted by DEP and Dr. Curt Pollman indicated that canal SCI scores were not highly correlated to any hydrologic, chemical, or habitat measures



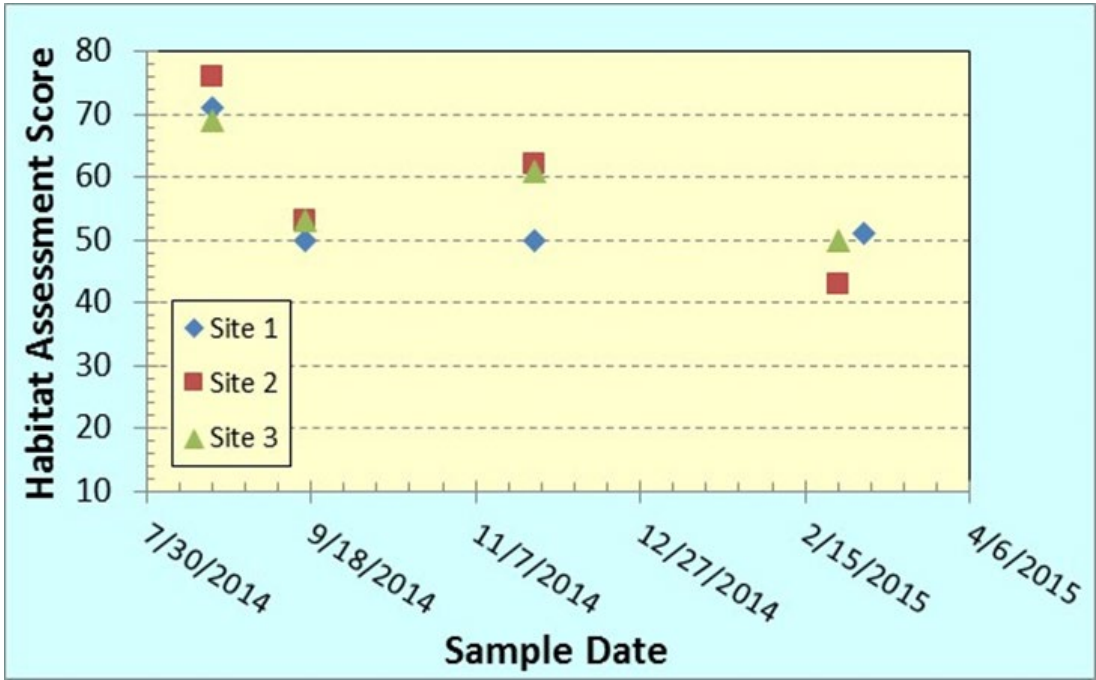
Other factors examined to help explain results

- Types of habitat available (inverts)
- Canal morphology
  - Width and depth
  - Presence of littoral area or ledge
- Vegetation maintenance activities
  - Frequency and days since last treatment
- Flow
- Connection to wetlands

Before-After Control Impact (BACI) Study Results

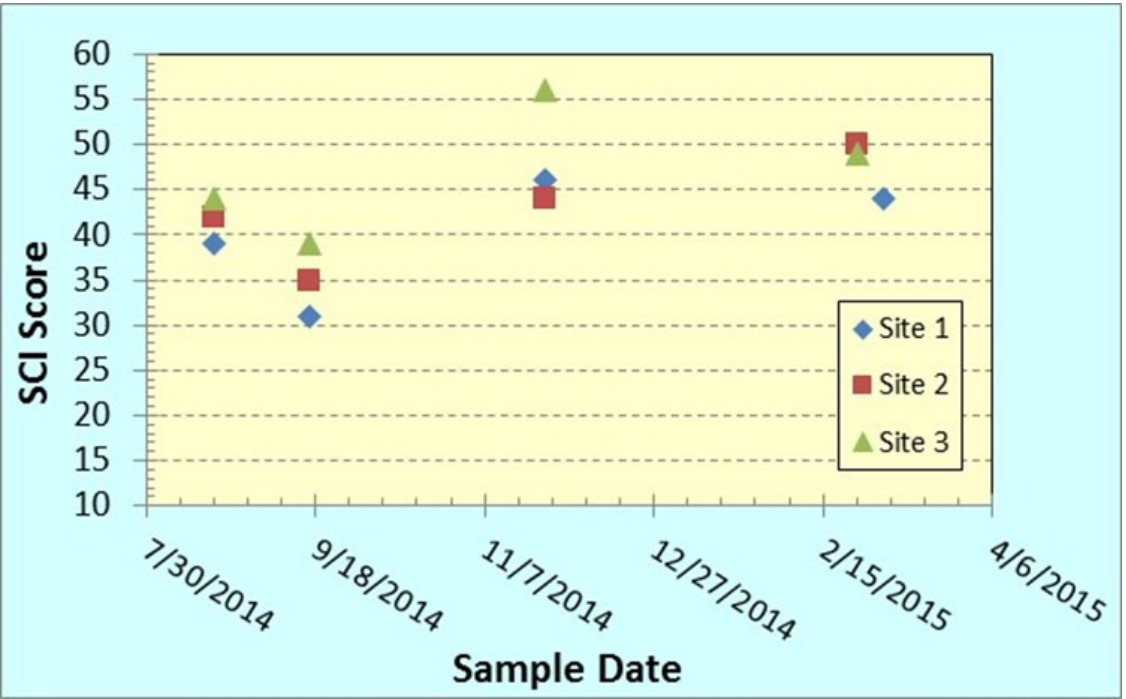
BACI Study conducted to determine effect of canal vegetation maintenance on macroinvertebrate community

- Study conducted at three sites in the C-18 canal
- C-18 canal selected due to relatively high HA and SCI scores and lack of previous treatment
- Sampling conducted immediately prior to and 1, 3, and 6 months following herbicide treatment by SFWMD
- Results show that HA scores were reduced following treatment due to reduction in vegetation



Before-After Control Impact (BACI) Study Results

- However, vegetation maintenance had minimal effect on SCI scores (likely due to limited habitat quantity and quality available in canals)
- Average SCI scores decreased slightly from 41.7 during pre-treatment to 35.0 1-month following treatment, then increased to 48.7 at 3-months following treatment

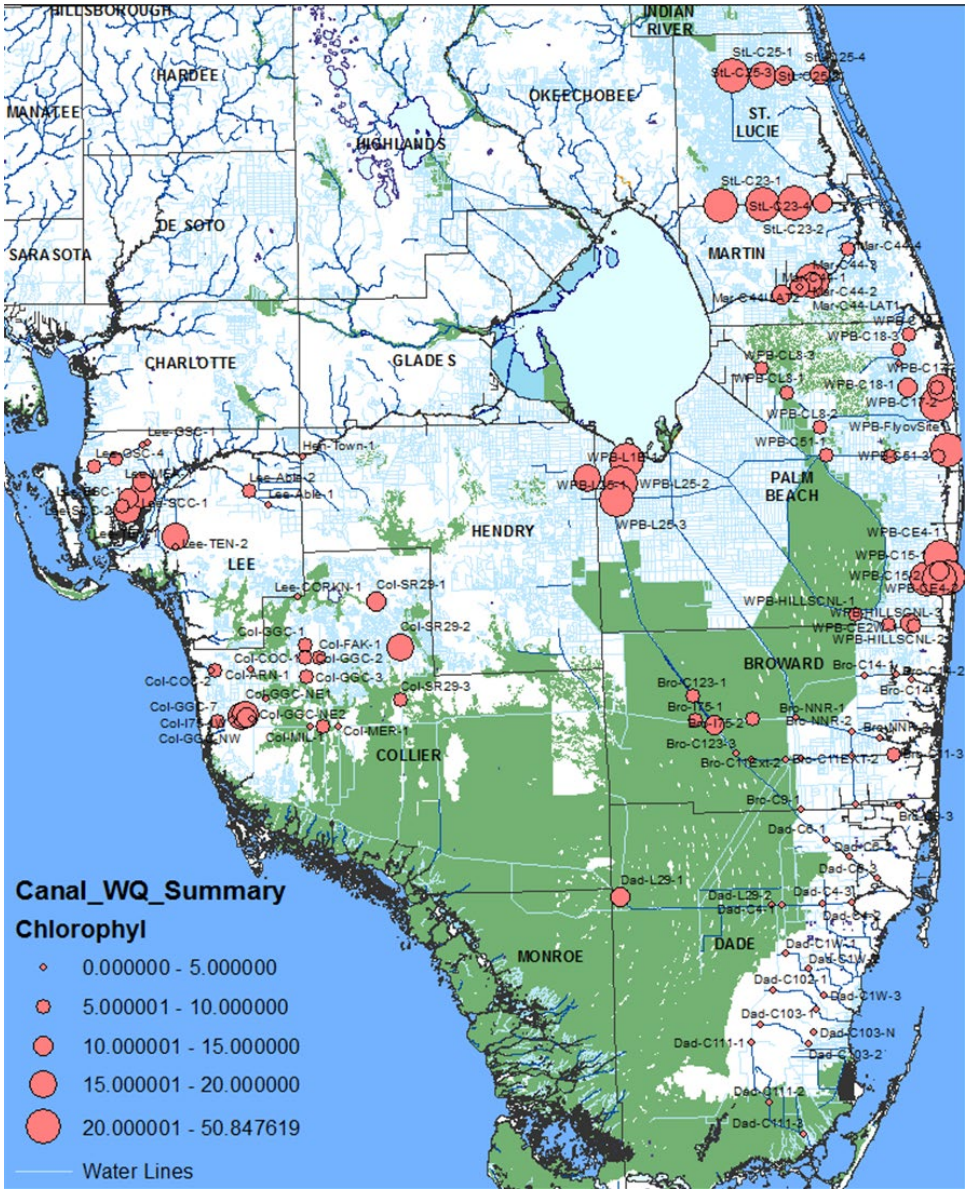


- Results of BACI study results support the finding that maintenance activities are not important factors in explaining differences among canals
- Habitat limitations can still explain differences between canals and natural streams

Spatial Analyses

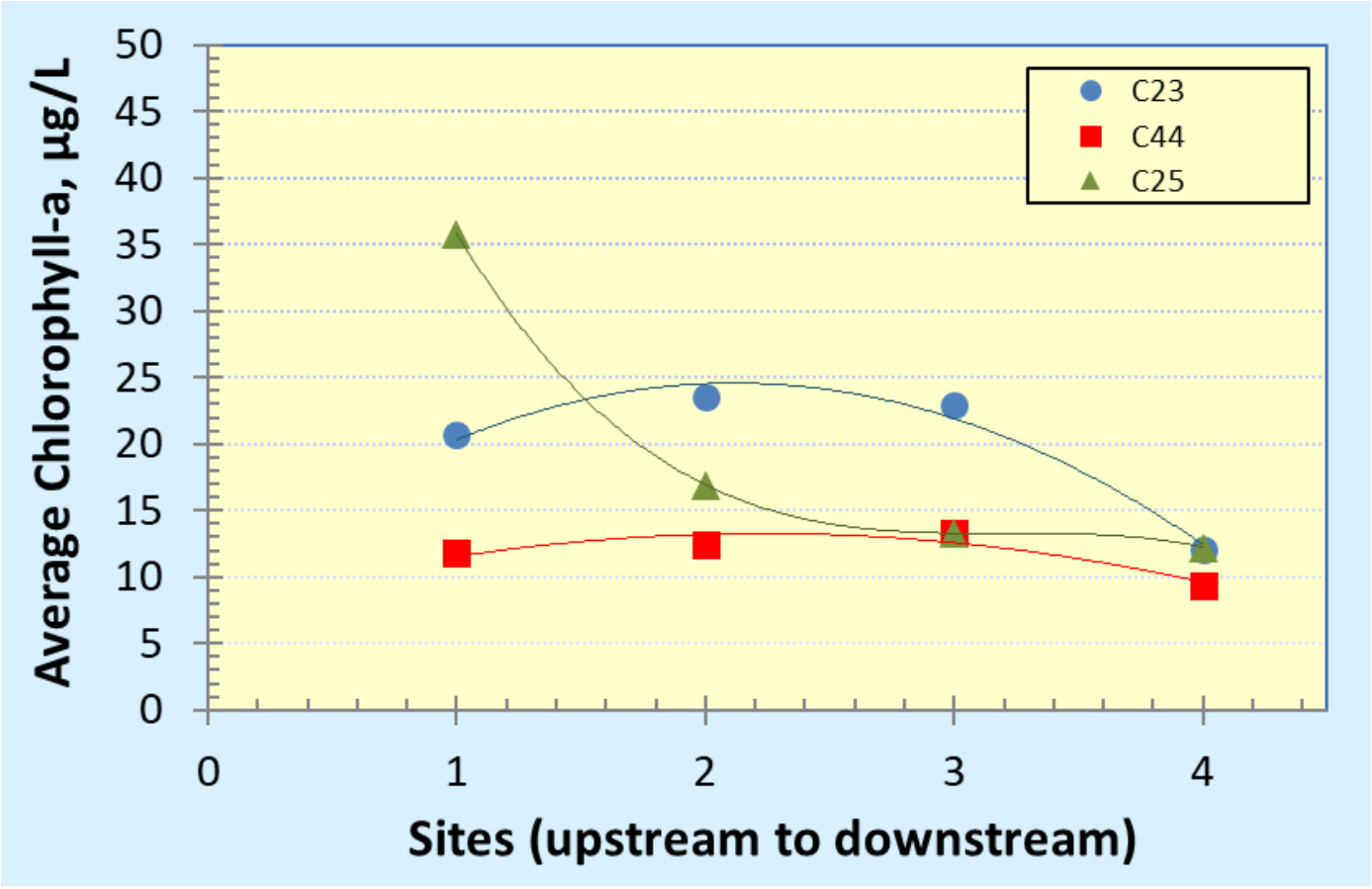
Chlorophyll-a

- Generally high in canals draining Lake Okeechobee and EAA (northeast, Phase I)
- Low in southeast and Everglades canals (Phase II)
- Moderate levels in western canals (Phase III)



Spatial Analyses

Chlorophyll-a Concentrations from Upstream to Downstream Sites



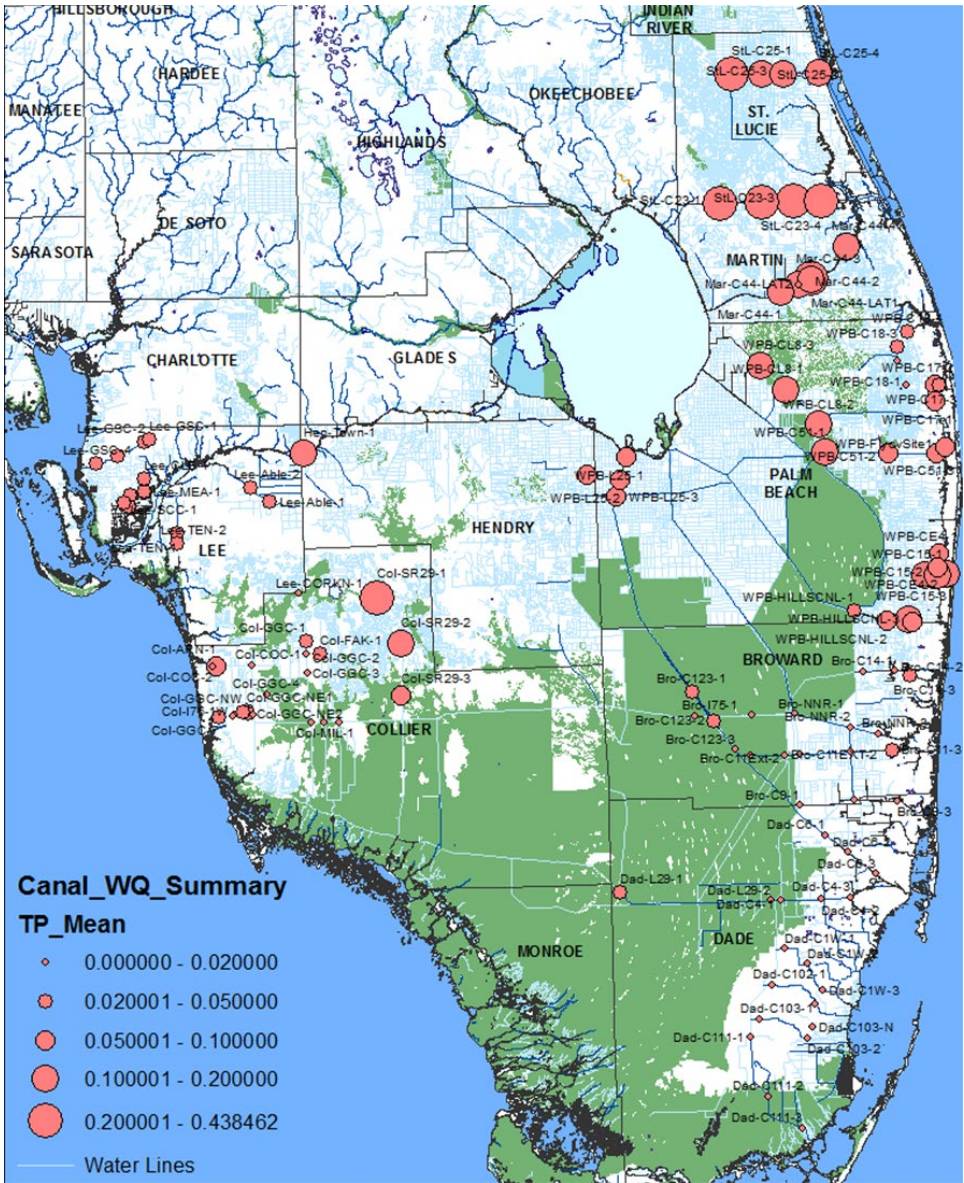
- Chlorophyll levels generally remain relatively consistent or decrease slightly from upstream to downstream sites
- Suggests that source water is primary influence on canal WQ (when flowing)

Spatial Analyses

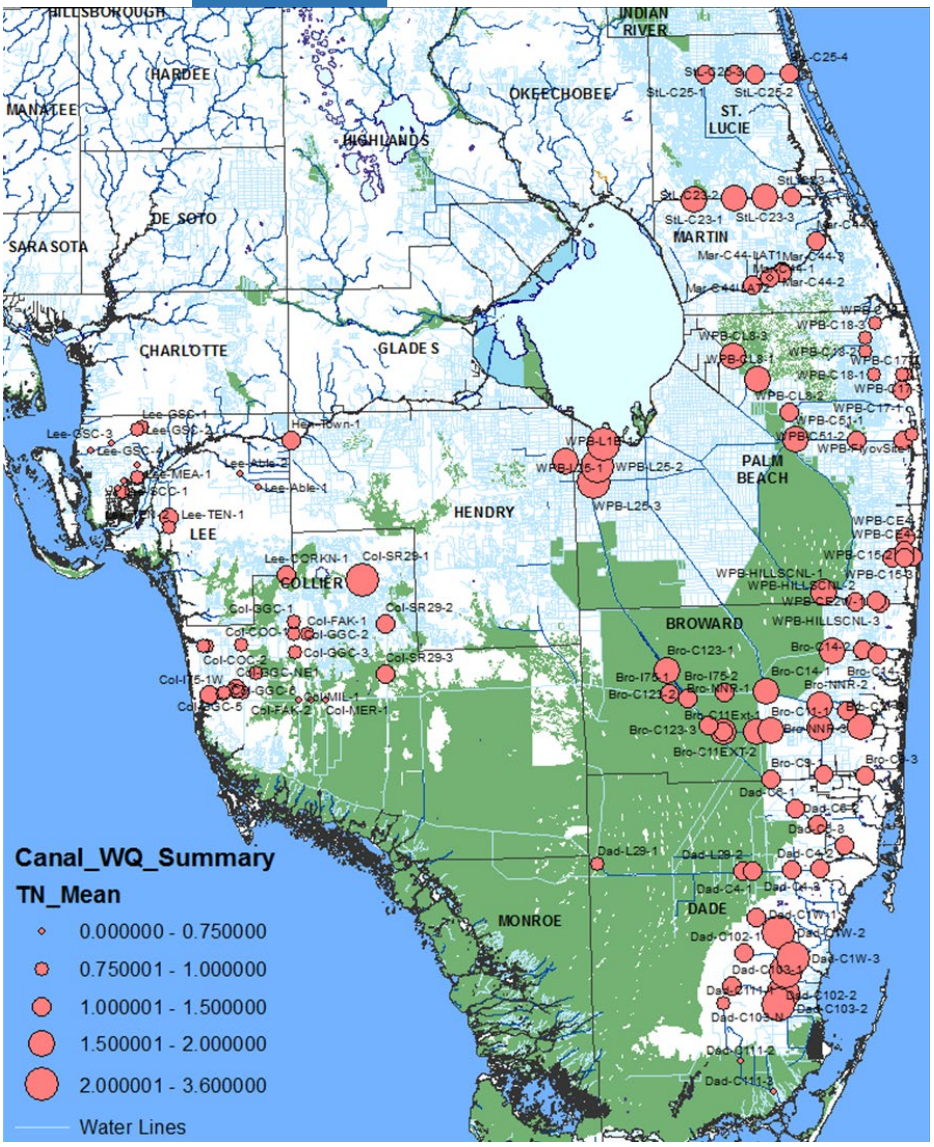
Total Phosphorus

General north to south gradient

- Typically higher concentrations in canals draining Lake Okeechobee and EAA
- Low TP in Everglades Canals
- Also low TP in SE Phase II canals (Everglades outflow and groundwater influence)
- Variable levels in southwest (Phase III) canals
- Similar pattern as chlorophyll



Spatial Analyses



Total Nitrogen

No distinct spatial pattern

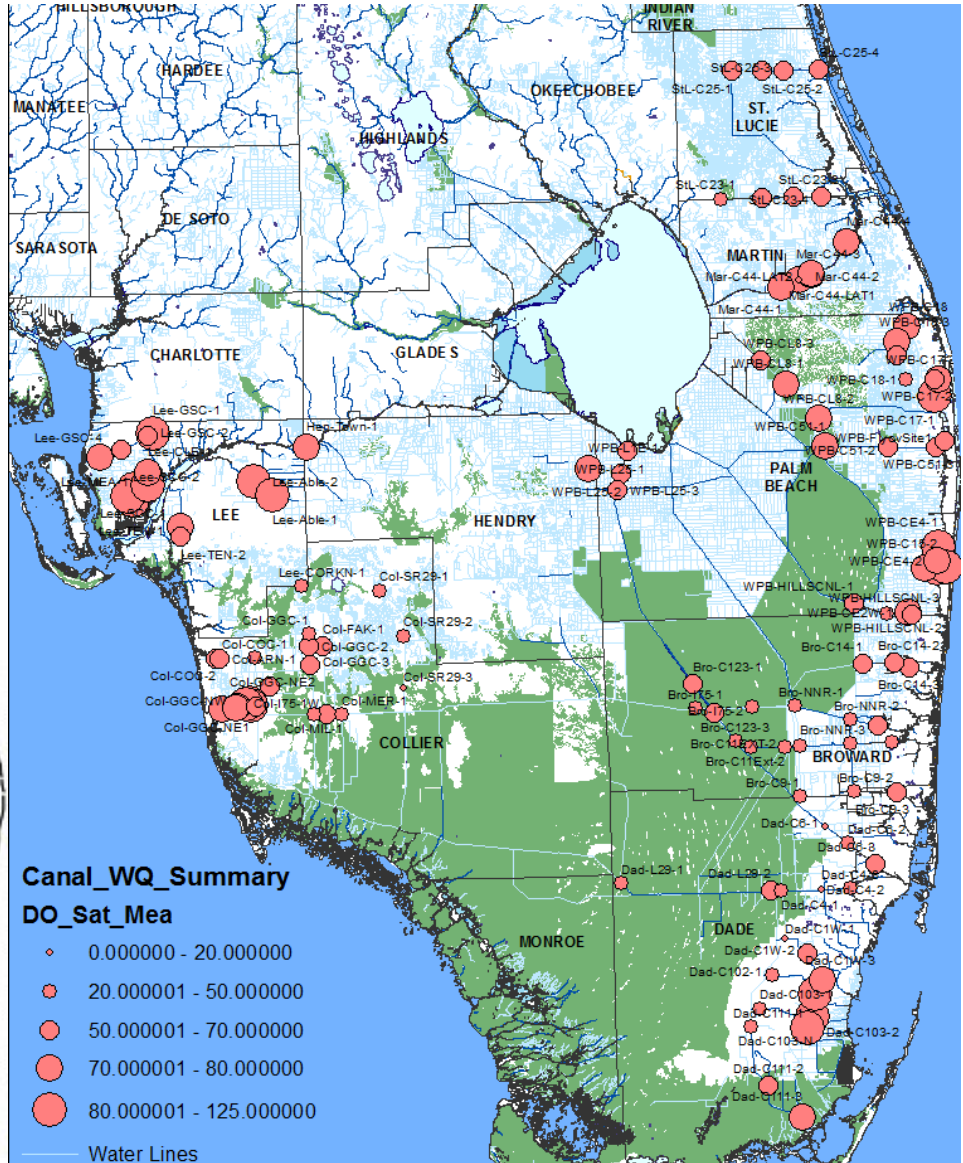
- High near Lake Okeechobee
- Also high in some SE canals due to high NOx levels

Spatial Analyses

Dissolved Oxygen

Lowest DO levels in Everglades Canals

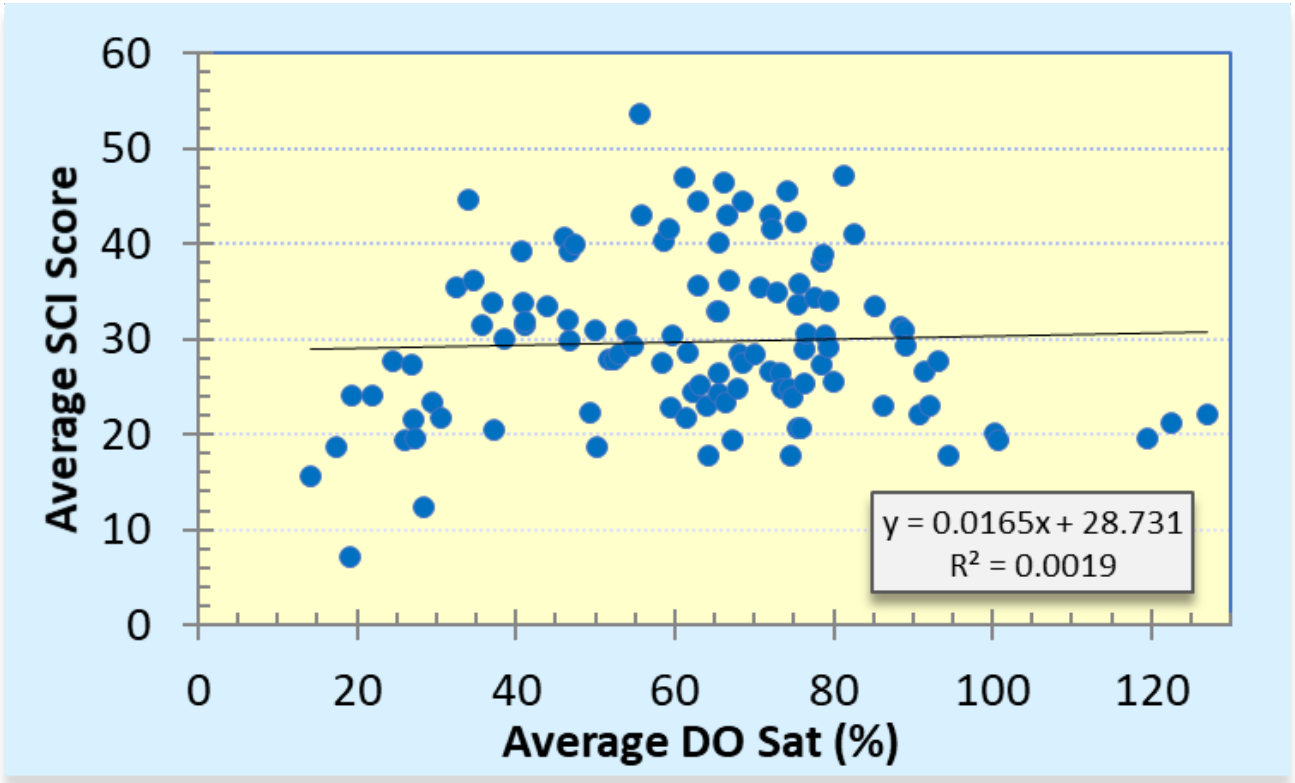
- Wetlands (Everglades) known to exhibit low DO (DO Site Specific Alternative Criteria, SSAC)
- Explains low SCI scores in Everglades canals?



DO Analyses

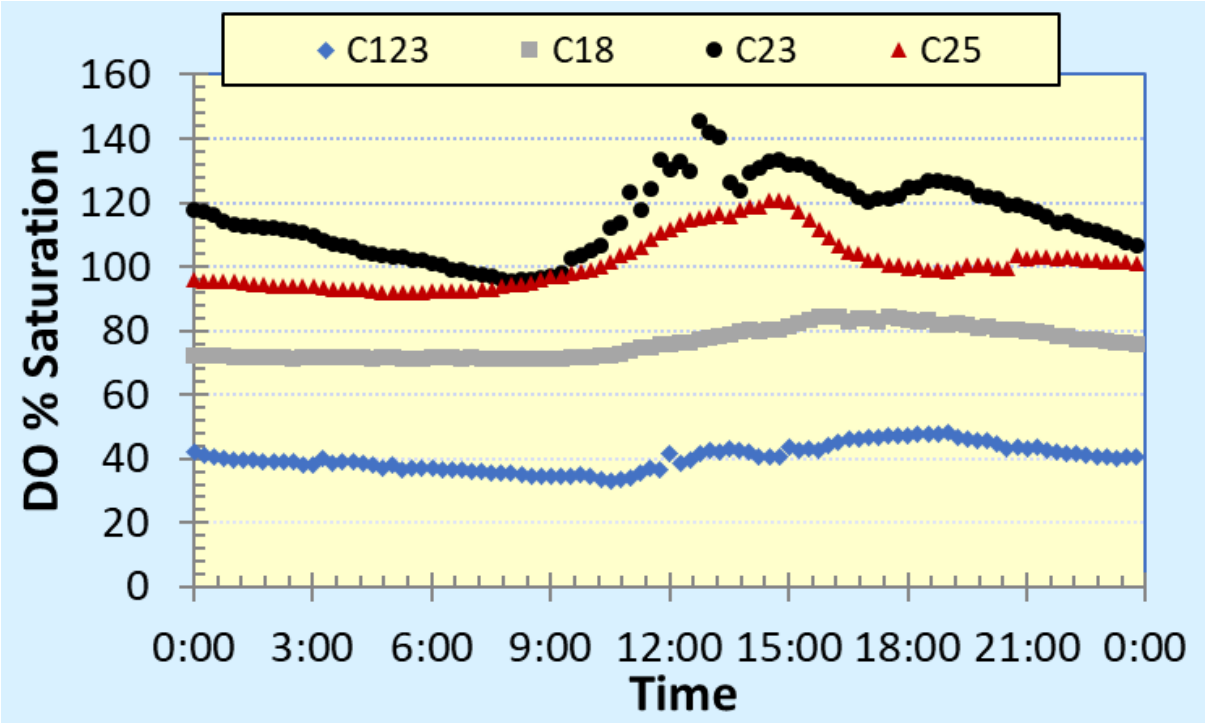
Bugs need oxygen to survive, but ….

- Plotting the SCI scores vs. DO saturation levels for all sites didn't show significant relationship (nor did previous statistical analyses)
- Wide range in average DO levels (14 – 127% saturation)



Spatial Analyses

Dissolved Oxygen Varies during the Day



DO commonly exhibits diel pattern

- Low early morning (before sunrise)
- Highest mid-afternoon

Increased diel fluctuations can result from nutrient enrichment

Can also be influenced by other factors

- Flow
- Cloud cover
- Temperature

Spatial Analyses

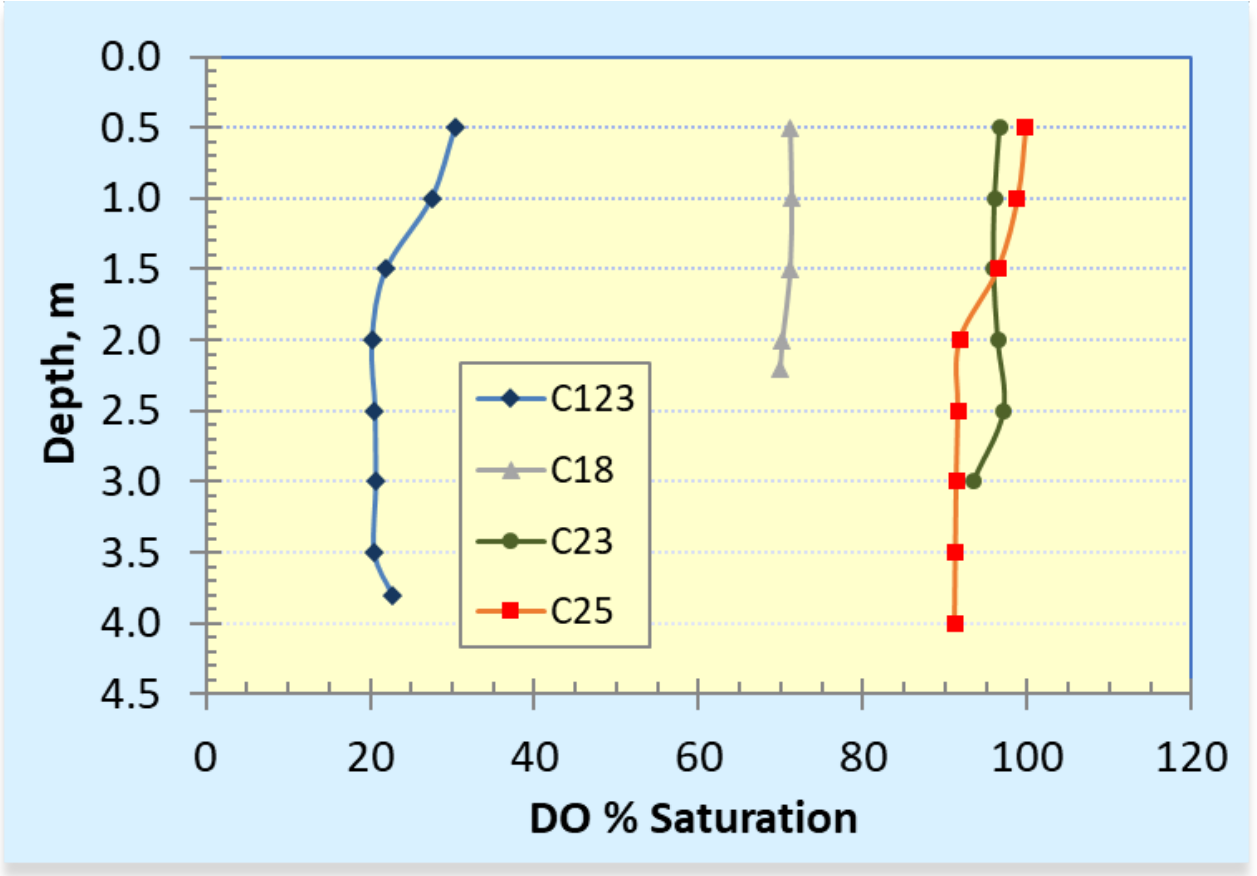
Dissolved Oxygen Changes with Depth

DO typically decreases with depth due to:

- SOD
- Less photosynthesis
- Less mixing

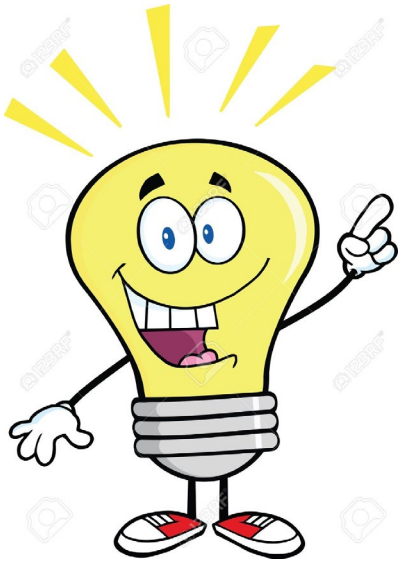
DO low in Everglades Canals (C123) and decreases more with depth

- More SOD (muck)
- Less flow



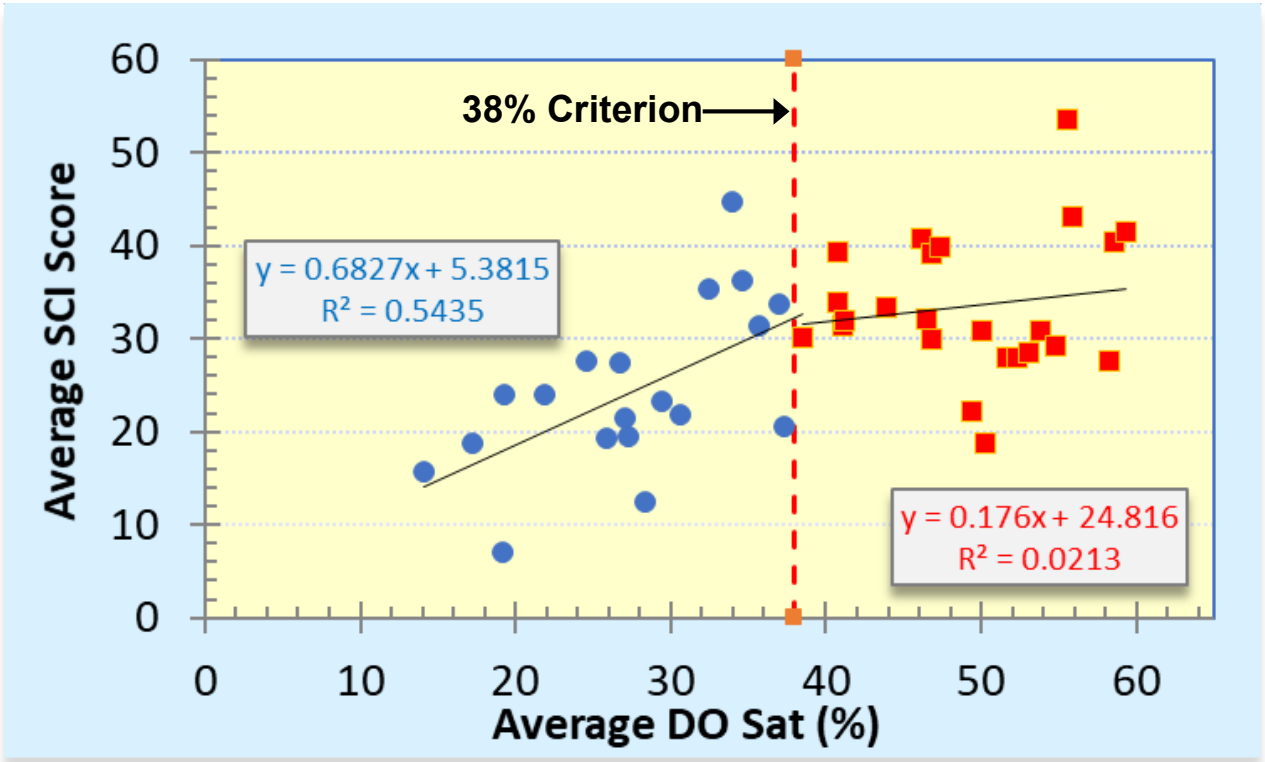
DO Analyses

New way of thinking



By evaluating only sites where DO level may be an issue (i.e., sites with DO levels below ~60% saturation), a significant response is revealed

- Response masked by including sites with higher DO levels where DO was not controlling factor
- Helps explains low SCI scores in Everglades canals?
- Indicates that existing 38% DO saturation criteria may be appropriate for canals



Summary

Canals are Complex Waterbodies that are Not Well Understood

Canals are:

- Largely man-made waterbodies that are managed to varying extents
- Water quality strongly influenced by source water
- Canals often do not meet WQ criteria for DO, or thresholds for chlorophyll or SCI
- Limited biological communities influenced by a complicated mix of “natural” and anthropogenic factors

Summary

Canals are Complex Waterbodies that are Not Well Understood

Canals are:

- Biological (macroinvertebrate) communities are not responding to the same factors in all of the canals (multiple factors)
- Biological responses are probably not linear
- Need to utilize different conceptual approaches to find relationships

New Concept

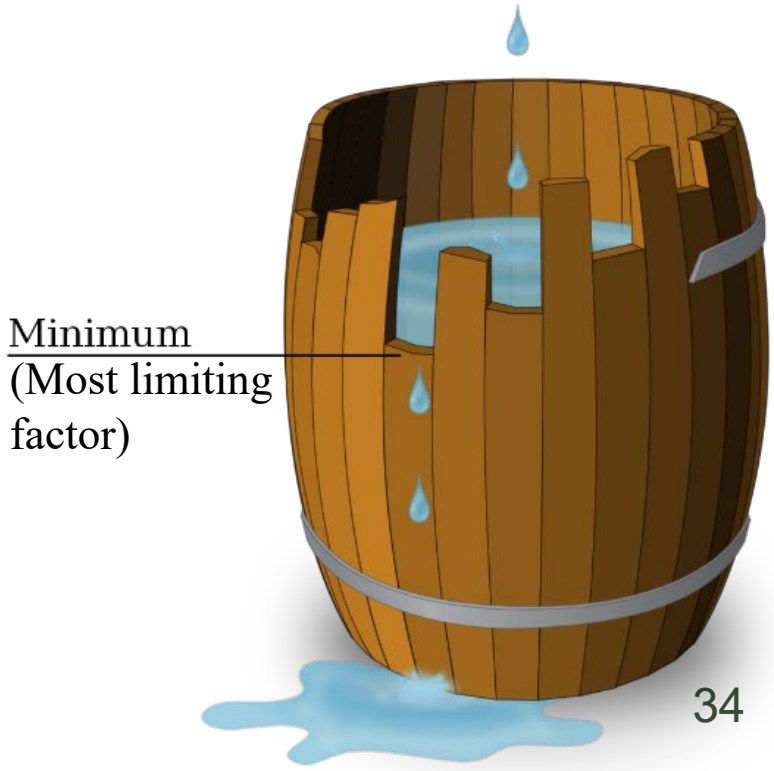
Because Canals are Complex Waterbodies May Need a New Approach to Better Understand

Liebig's Law of the Minimum

- First stated by Justus von Liebig in 1840
- Concept historically applied to nutrition and fertilization of agricultural crops
  - "Plant growth is dictated not by total resources available, but by the scarcest resource (limiting factor)"
- Concept has been broadened into a general model and more frequently applied to biological communities and in ecosystem models for other factors
- Shelford's Law of Tolerance includes the limiting effects of excesses of chemical nutrients and other environmental factors

Liebig's Barrel

No matter how much water you put in the barrel, the amount of water held is controlled by the lowest stave (i.e., most limiting factor)



Applying the New Concept

Application of Liebig's Law to Canal Study Results

Water in barrel = SCI (macroinvertebrates)
Staves in barrel = factors controlling SCI

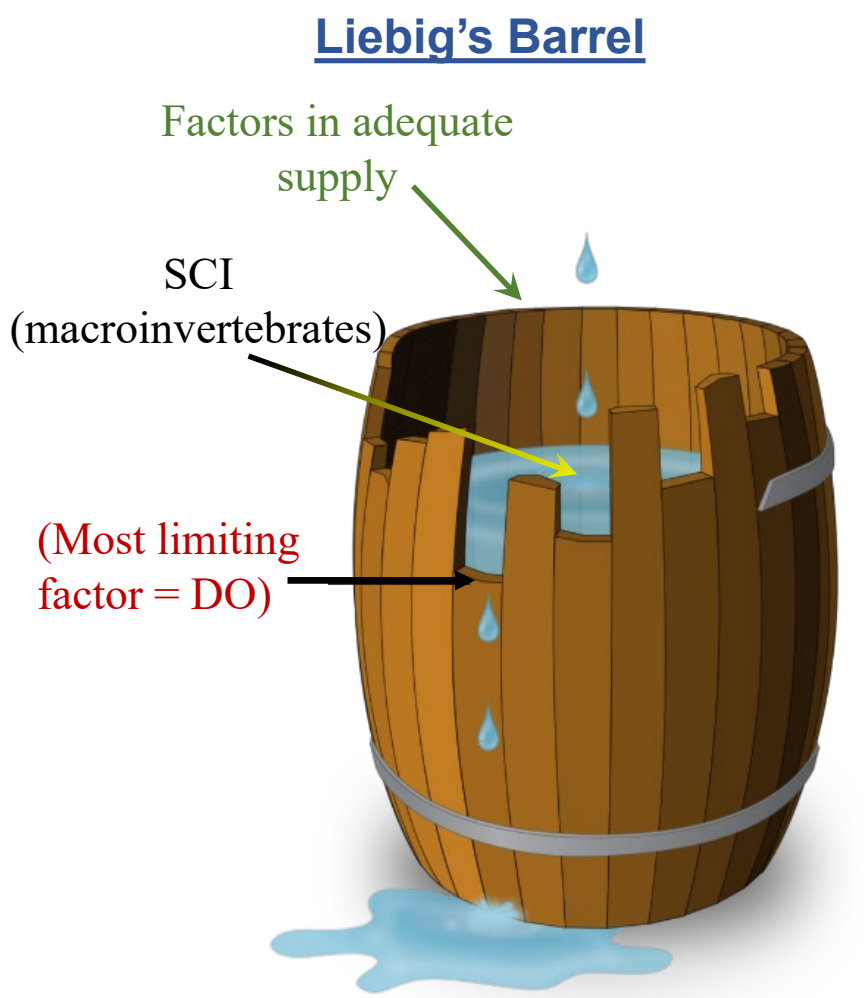
<u>Comparing canals to natural streams</u>,

- The limited quantity and quality of productive habitat available in the canals compared to natural streams can be thought of as cutting the barrel in half for the canals
  - The canals will never support the same macroinvertebrate community as natural streams due to habitat restrictions

Natural Streams

Canals

Applying the New Concept



Application of Liebig's Law of the Minimum to Canal Study Results

Water in barrel = SCI (macroinvertebrates)
Staves in barrel = factors controlling SCI

Explaining results for individual canals

- For example: the Everglades canals exhibit good water quality, good habitat, and minimal anthropogenic impacts (barrel staves representing these factors are high)
- However, the macroinvertebrate community (SCI) is most limited by low DO levels (lowest stave in the barrel)

What Now?

Any future steps to address the water quality of South Florida canals must acknowledge:

- Canals are different from natural streams or lakes
  - Typically man-made waterbodies with the primary purpose of moving water
  - Generally very deep with steep banks
  - Managed to varying extents
  - Highly variable flow
  - Can act as streams or lakes or ??
- They often do not meet all of the water quality criteria applicable to natural streams (DO, nutrients)
- They do not support the same biological communities
  - Limited habitat and very stressful environment
- Large variation among canals with respect to morphology, management, water quality, and biology
  - All canals are not the same and not expected to be
- Ongoing Everglades Restoration Activities

What Now?
Regulatory Framework

How can we do this? Or do we need to?
(No perfect solution!)

<u>To acknowledge the fact that canals are different from natural waterbodies</u>

1. Develop new waterbody type (*e.g.*, South Florida Canals) within Class III such as done to distinguish differences between streams and lakes for nutrient and DO criteria
2. Reclassify all or a portion of the South Florida Canals (subclass of Class III)
3. Other Ideas?

What Now?
Regulatory Framework

How can we do this? Or do we need to?
(No perfect solution!)

<u>To develop revised criteria for canals</u>

(DO, nutrients, biology)

How do we set expectations for canals and derive criteria?

1. Canal specific or regional numeric criteria
2. Narrative criteria (trends)
3. Combination of numeric and narrative criteria
4. Other Ideas?

Questions or Comments?

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