

# What causes phytoplankton blooms in the Caloosahatchee Estuary, Florida?

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## Introduction

The Caloosahatchee Estuary, located in southwest Florida, is a highly altered and managed estuary. During the dry season or periods of low freshwater discharge, salinities exceeding 10 are often observed upstream, whereas during high freshwater releases, salinity at the mouth of the estuary can drop below 5. As freshwater inflow is a main controlling factor of both nutrient and light availability for phytoplankton in the Caloosahatchee estuary, phytoplankton growth can vary greatly throughout the year. Phytoplankton blooms can be harmful in a number of ways. The increased biomass of phytoplankton in the water column can cause self-shading, reducing phytoplankton photosynthetic rates. If blooms persist or are chronic occurrences, the lack of sunlight can be detrimental to seagrass beds. Large fish kills can also occur as the bloom dies-off and the decomposing phytoplankton cause hypoxic (or even anoxic) conditions. The **purpose** of this study was to examine the phytoplankton flora over the course of two years at 14 locations in the Caloosahatchee Estuary to determine what phytoplankton species were the most common bloom formers.

## Methods

### Field Methods

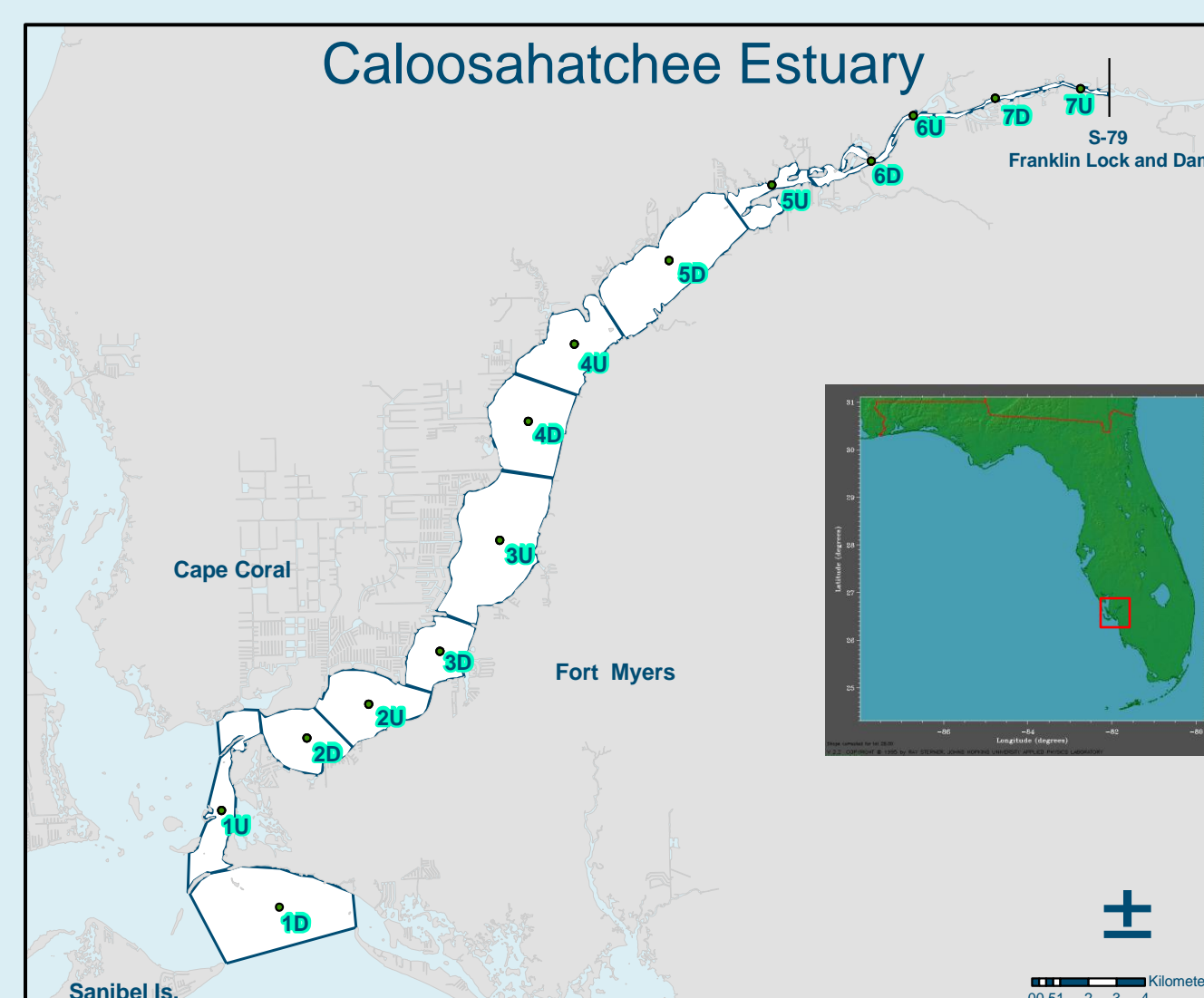
- Night-time sampling occurred monthly from May 2008 to April 2010 at 14 stations on a flood tide.
- Plankton samples were collected using a vertical net tow, 10 µm mesh net.
- Environmental data was collected with a YSI Sonde.
- River flow data out of Franklin Lock (S79) was obtained from the DBHYDRO website ([http://my.sfwmd.gov/dbhydroplsql/show\\_dbkey\\_info\\_main\\_menu](http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info_main_menu)).
- A three-day running average was applied to the river flow data, which were then correlated against phytoplankton abundance data with a 40-day lag. The 40-day lag provided the best overall correlation between river flow and chlorophyll-a concentrations (unpublish. data).

### Lab Methods

- Counts performed on Olympus BX51 Microscope and a Plankton Chamber slide.
- 100 fields or organisms were identified to the lowest practical taxon at both 40x and 20x magnifications.
- A subsample of 48 collections was chosen for analysis. These samples were selected by dividing the estuary into 4 sections (lower, lower-mid, upper-mid, and upper estuarine) with one sample analyzed for each portion of the estuary for every other month of the sampling period.
- Total number of cells/L and volume/L were calculated.

### Statistics

- Correlations were run (JMP) between the top 33 bloom species (top 20 by volume, cells/L, and overall occurrence – see table 1) and environmental variables.
- Multidimensional scaling analysis was conducted on the phytoplankton assemblages of the 48 samples to determine how the different samples were spatially related to each other (PRIMER 6).
- BEST analysis (PRIMER 6) was then used to analyze how the environmental variables related to the phytoplankton distributions.



**Figure 1:** Site map. Sites 1D& 1U represent the lower estuary. Sites 2D-3U were used to analyze the lower-mid estuary. The upper-mid estuary consists of sites 4D-6D and the upper estuary is represented by sites 6U-7U.



## Results

**Table 1:** Top 20 “bloom” taxa by the four criteria listed below.

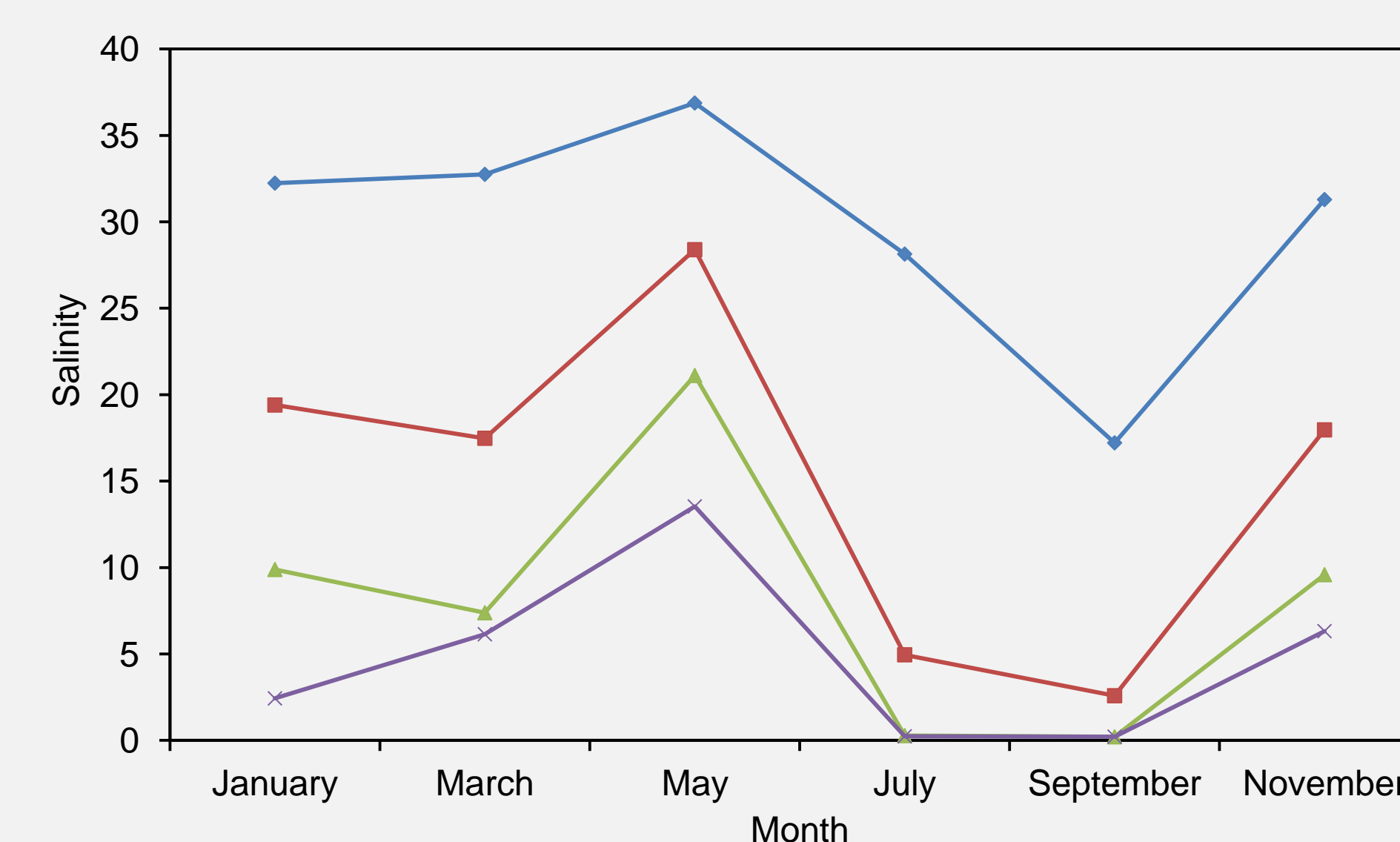
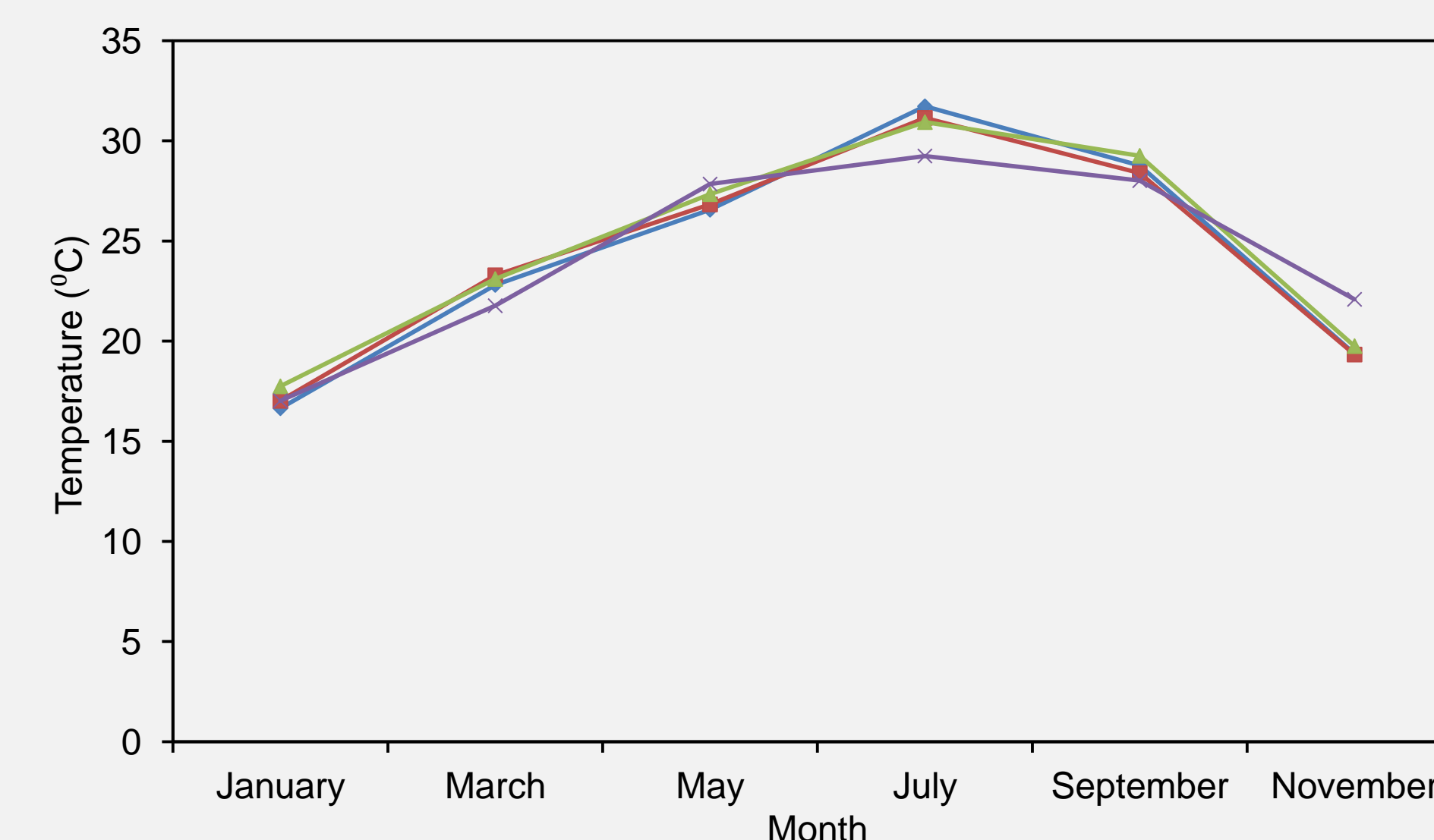
Species	Overall volume?	Overall cells/L?	Single bloom by volume?	Single bloom by cells/L?
<i>Akashiwo sanguinea</i>	Yes		Yes	
<i>Aulacoseira</i> “fine”		Yes		Yes
Centric diatom >30 µm	Yes		Yes	
Centric diatom 15-20 µm		Yes		
Centric diatom 20-30 µm	Yes	Yes	Yes	
<i>Cerataulina</i> sp.	Yes	Yes	Yes	
<i>Chaetoceros lacinioides</i>		Yes		
Chlorophyte filamentous	Yes	Yes		Yes
<i>Coscinodiscus</i> spp. >80 µm	Yes		Yes	
<i>Coscinodiscus</i> spp. 40-60 µm	Yes			
<i>Coscinodiscus</i> spp. 60-80 µm	Yes			
<i>Coscinodiscus granii</i>	Yes			
Cyanobacteria coccoid colonial		Yes		
Cyanobacteria filament		Yes		Yes
Dino, armored, auto 20-30 µm	Yes	Yes		
<i>Fragilaria</i> spp. 15-20 µm	Yes	Yes	Yes	Yes
<i>Fragilaria</i> spp. 5-10 µm		Yes		Yes
<i>Gonyaulax polygramma</i>	Yes		Yes	
<i>Gonyaulax</i> spp.	Yes			
<i>Jaaginema</i> spp.		Yes		
<i>Melosira</i> spp.		Yes		Yes
<i>Microcystis</i> spp.		Yes		
Pennate diatom 20-40 µm		Yes		
<i>Planktolyngbya</i> spp.		Yes		
<i>Planktothrix</i> spp.		Yes		Yes
<i>Proboscia alata</i>	Yes			
<i>Prorocentrum minimum</i>	Yes			
<i>Pseudo-nitzschia pungens</i> group	Yes	Yes	Yes	Yes
<i>Skeletonema subsalsum</i>	Yes	Yes	Yes	Yes
<i>Skeletonema tropicum</i>		Yes		Yes
<i>Surirella</i> spp.	Yes		Yes	
<i>Thalassiosira</i> spp. 20-40 µm	Yes		Yes	
<i>Thalassiosira</i> spp. 40-60 µm	Yes			

**Table 2:** The number of taxon that are positively (+) or negatively (-) correlated (at the 0.05 significance level) to a selection of environmental variables. NS = not significant.

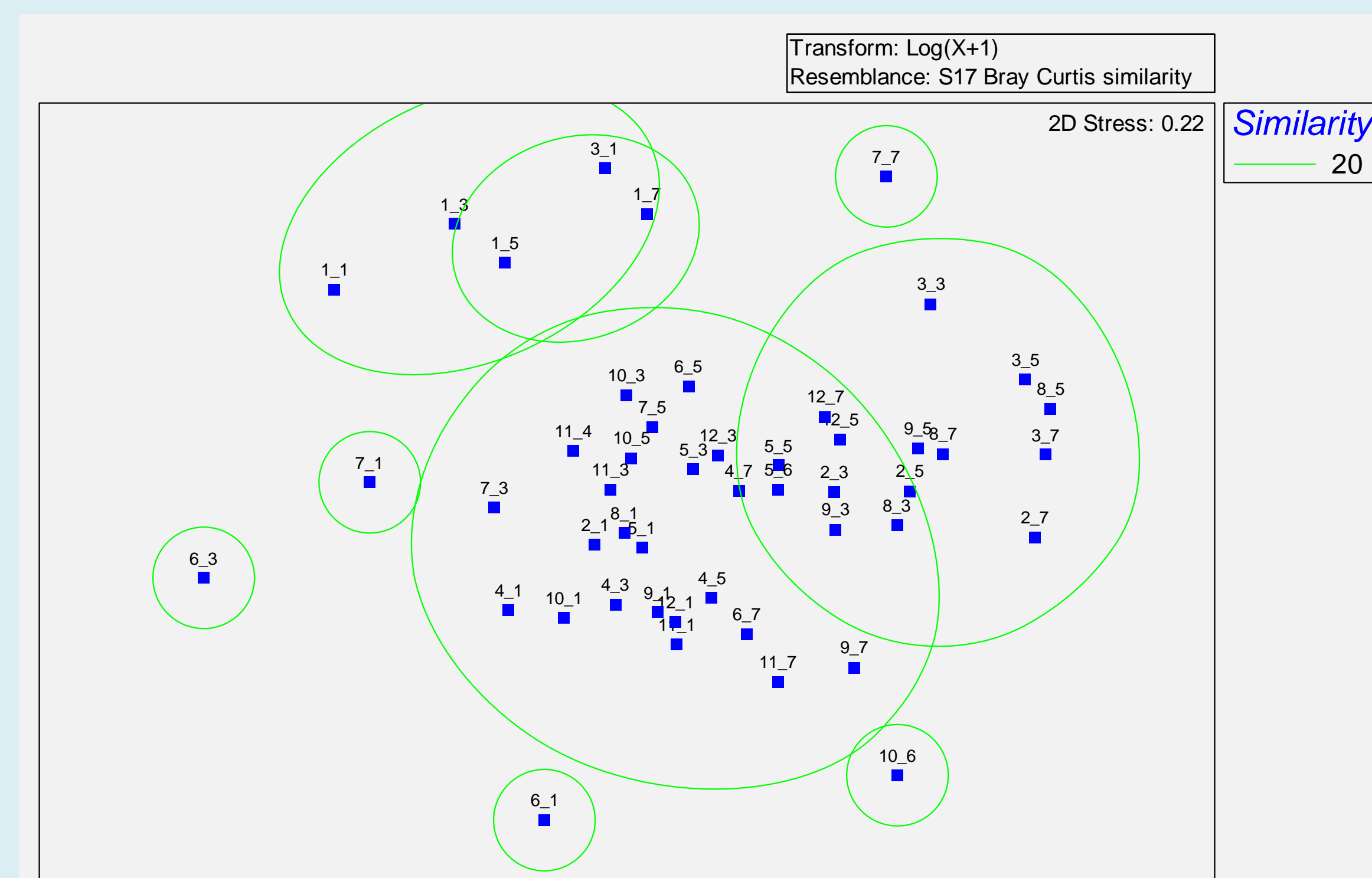
	Volume			Cells		
	+	-	NS	+	-	NS
Temp (°C)	4	0	29	4	0	29
Salinity	3	9	21	3	9	21
pH	1	4	28	1	3	29
DO%	3	7	23	3	7	23
DO (ppm)	2	3	28	2	3	28
Chl-a (µg L <sup>-1</sup> )	4	3	26	5	2	26
CDOM (QSE)	9	3	21	9	3	21
Flow (cfs)	2	3	28	1	3	29

**Table 3.** PRIMER BEST analysis was used to analyze how the environmental variables related to the phytoplankton distributions (by volume). Several environmental variable combinations were found to be significantly correlated (p<0.01) with the phytoplankton distributions.

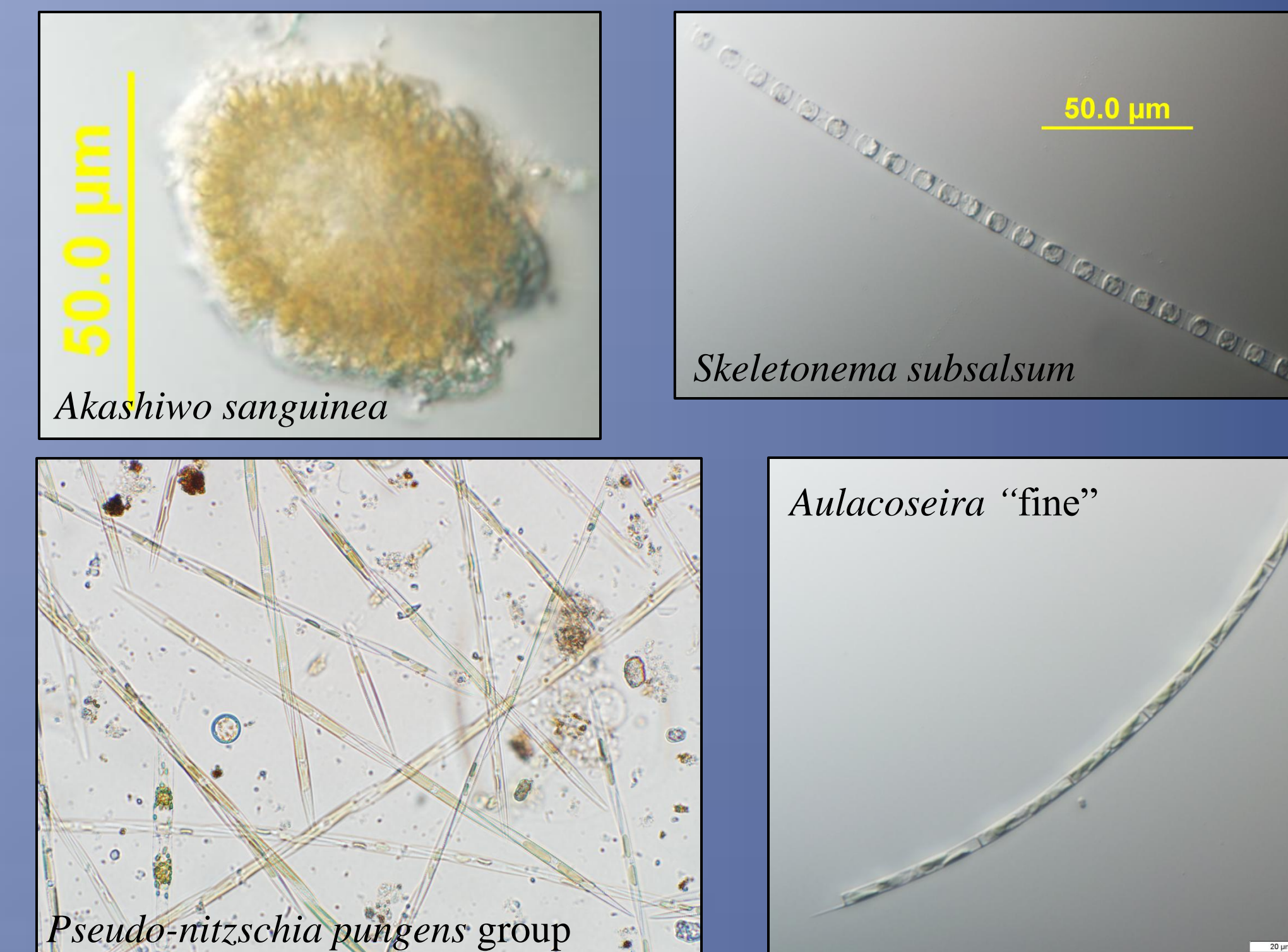
Parameters	correlation
salinity, distance	0.262
temperature, salinity, pH, CDOM, distance	0.26
temperature, salinity, CDOM, distance	0.26
temperature, salinity, pH, distance	0.26
salinity, pH, CDOM, distance	0.26
temperature, salinity, distance	0.26
salinity, CDOM, distance	0.26
salinity, pH, distance	0.26
CDOM	0.259
pH, CDOM	0.237



Temperature did not vary much across zones (top graph) and was highest in summer months and lowest in winter months. Salinity, however did show differences (bottom graph), being higher downstream (and lower upstream). Salinity also varied between wet and dry seasons. Blue = lower zone; red = lower-mid zone; green = upper-mid zone; and purple = upper zone.



Multidimensional Scaling (MDS) analysis plot displaying how the phytoplankton assemblages from the 48 samples relate to each other in two-dimensional space. The green boundaries represent the 20% similarity boundaries (Bray-Curtis) where samples inside of each circle are >20% similar, and samples from different circles are <20% similar. The 2D stress value of 0.22 indicates that the two-dimensional plot has some difficulty in capturing the spatial separation of the samples, best depicted by the circles that overlap (i.e., one circle is actually in front of the other).



## Discussion

- Blooms were evident year round, occurring upstream when freshwater inflows were low and further downstream as rates of discharge increased.
- Common bloom species included *Skeletonema subsalsum*, *S. tropicum*, *Pseudo-nitzschia pungens* group, *Cerataulina* sp., *Akashiwo sanguinea*, and *Gonyaulax polygramma*.
- Cyanobacteria blooms (e.g. *Microcystis* spp.) were more common during high flows.
- Salinity was most often negatively correlated with species abundance (Table 2), whereas CDOM was most often positively correlated with species abundance. These results suggest the importance of freshwater inflow in determining the species make-up and biomass in the Caloosahatchee Estuary.

## Further Research

- Finish counting and data analysis of the remaining plankton samples collected during the two year study.
- Several species encountered in this study have caused HABs in other areas; therefore these species need to be considered in the management of freshwater inflow from S79 in order to minimize the threat of HABs in the Caloosahatchee estuary.
- Refine data analysis to better incorporate effects of variable flow on nutrients and residence time.

## Acknowledgments

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