St. Lucie Estuary: Analysis of Annual Cycles and Integrated Water Column Productivity

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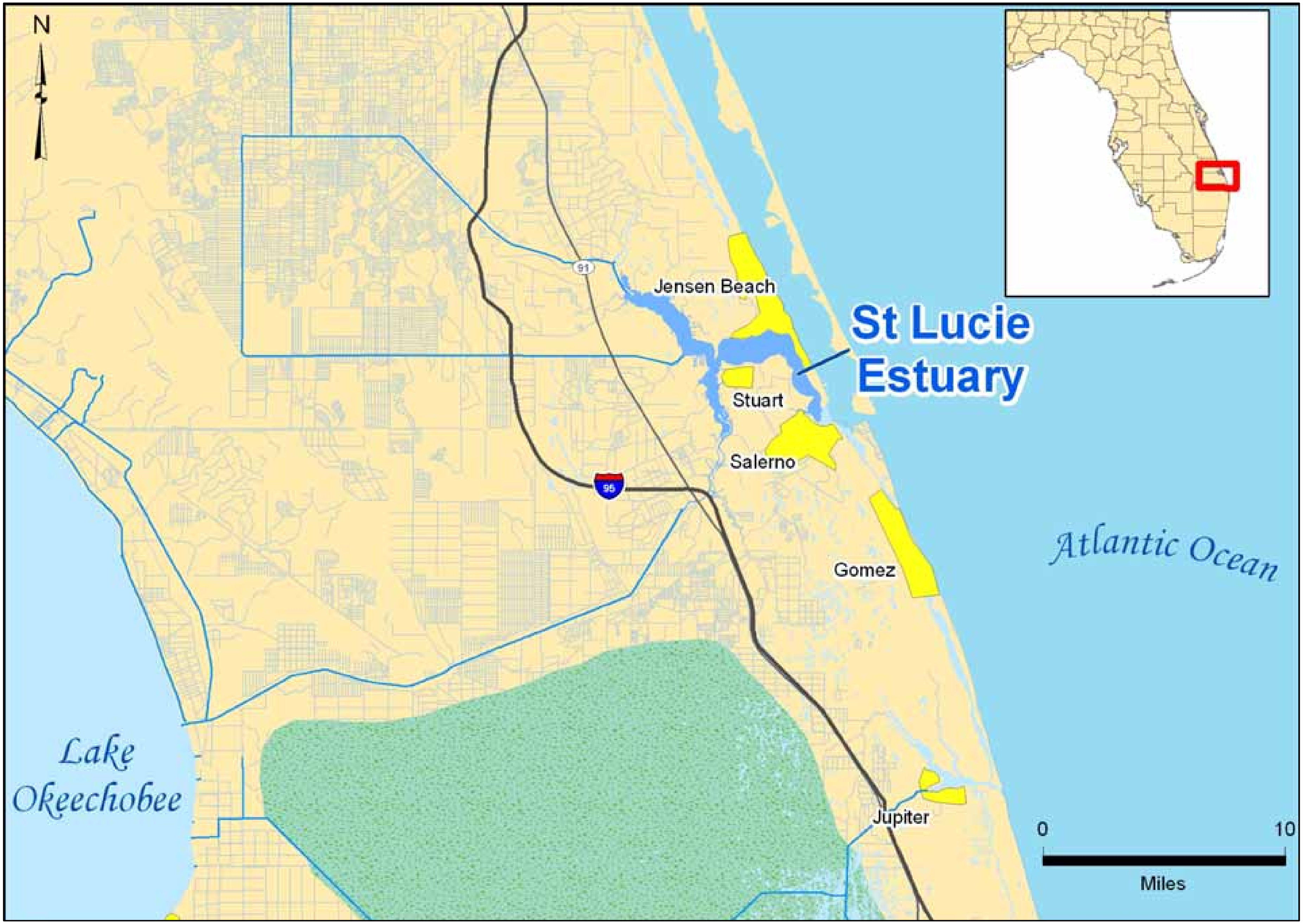
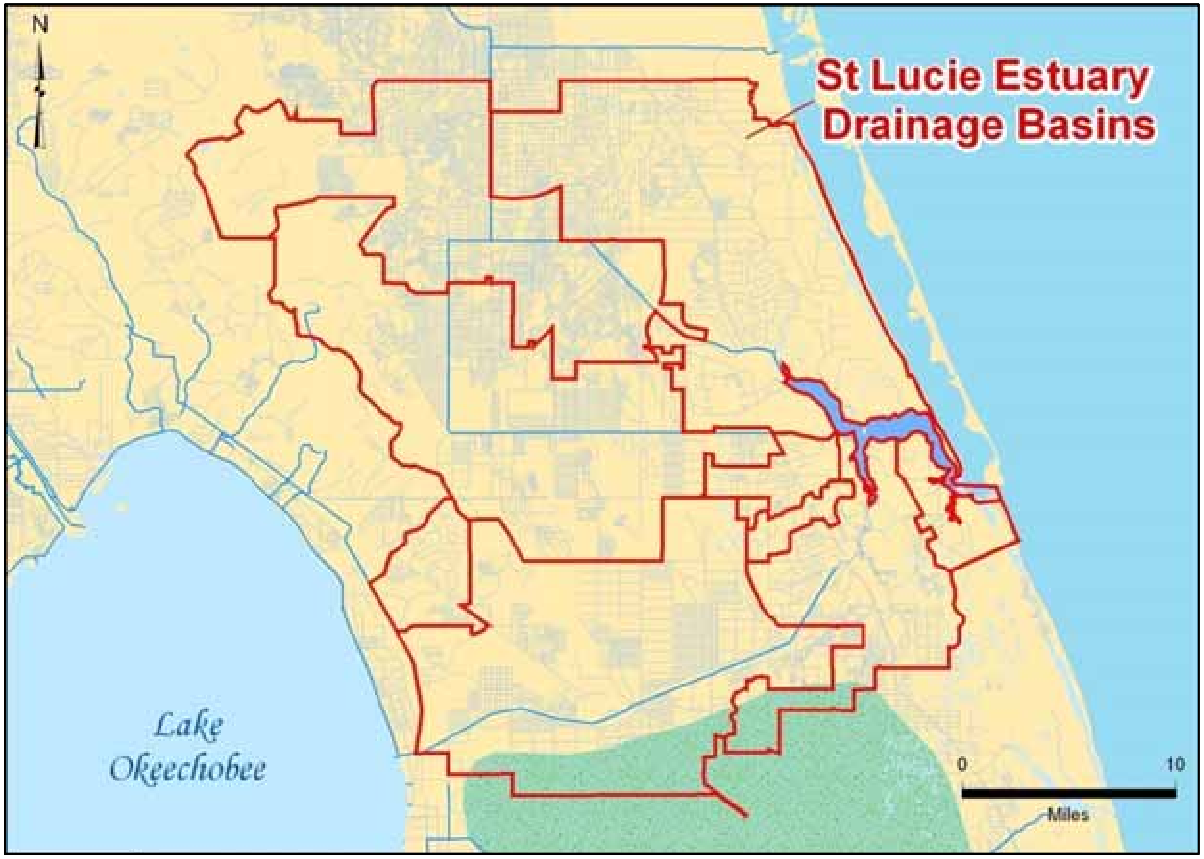
Overview

- Description of St. Lucie Estuary
- Purpose of Project
- Overview of 2000-2001 SLE Productivity Study
- Data Analysis Tasks, Methods, and Results
- Management Implications and Follow-Up Actions


N
91
Jensen Beach
St Lucie
Estuary
Stuart
Salerno
95
Gomez
Atlantic Ocean
Lake
Okeechobee
Jupiter
0
10
Miles

St. Lucie Facts

- Surface area: ~11 mi^2
- Drainage area: ~827 mi^2
- Historic drainage area ~160mi^2
- Freshwater system until 1892
- Depth
  - Littoral margins: 3-7 ft
  - Channel: 10-17 ft
  - Mean tidal flux: ~0.9 ft
- Hydraulically connected to Lake Okeechobee & Everglades (1924), St. Lucie County ag. Lands (1950s) by canals

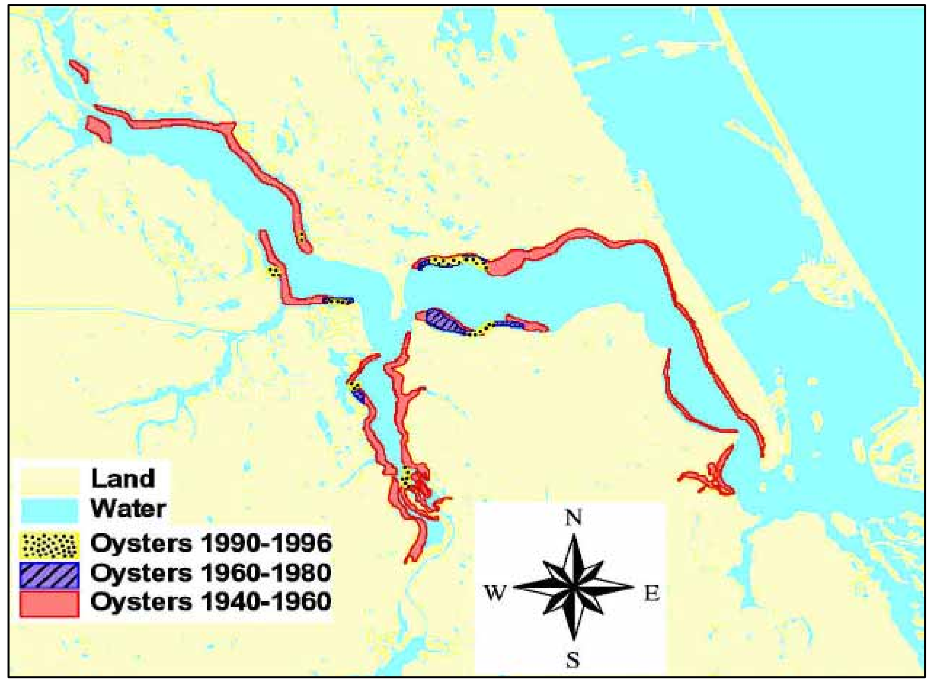


High DOC, tannin-stained (CDOM) freshwater inputs

Highly developed shoreline

Evidence of Impairment

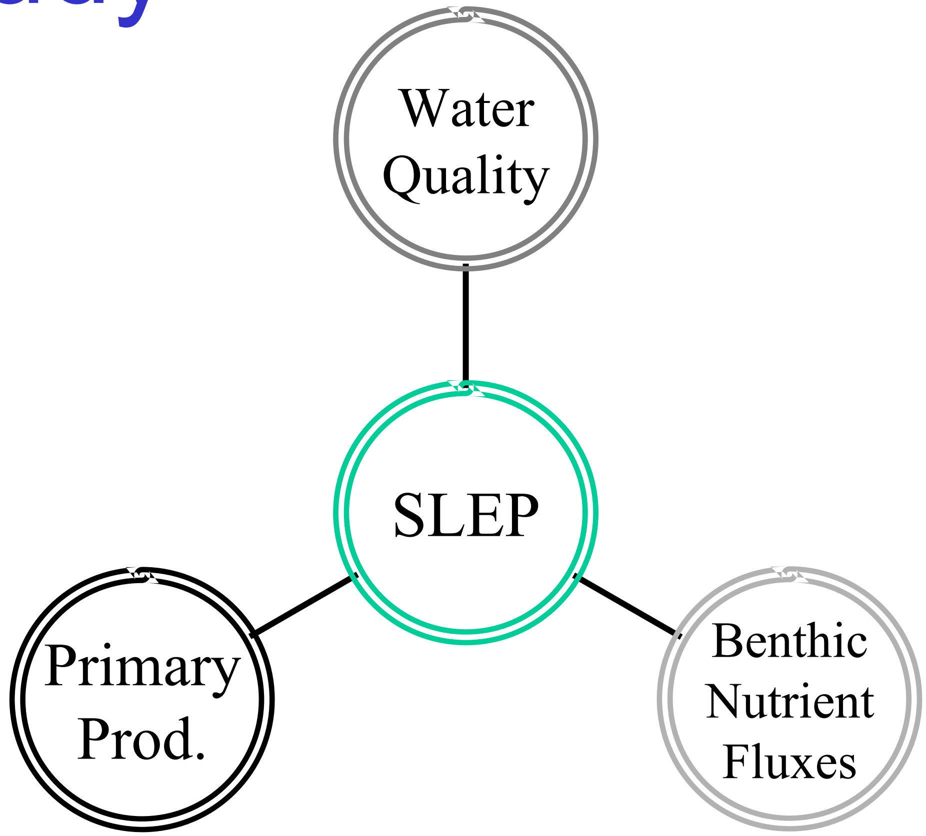
- High sedimentation rates; “ooze”/”muck”
- Eutrophic, algal-dominated system; blooms
- Loss of seagrass & oysters
- Benthic macroinvertebrate indices
- Health of the fish community



Source: Chamberlain and Hayward, 1996; IRL SWIM Plan, 2002 Update; Graves and Strom ,1992; Sime, 2005;

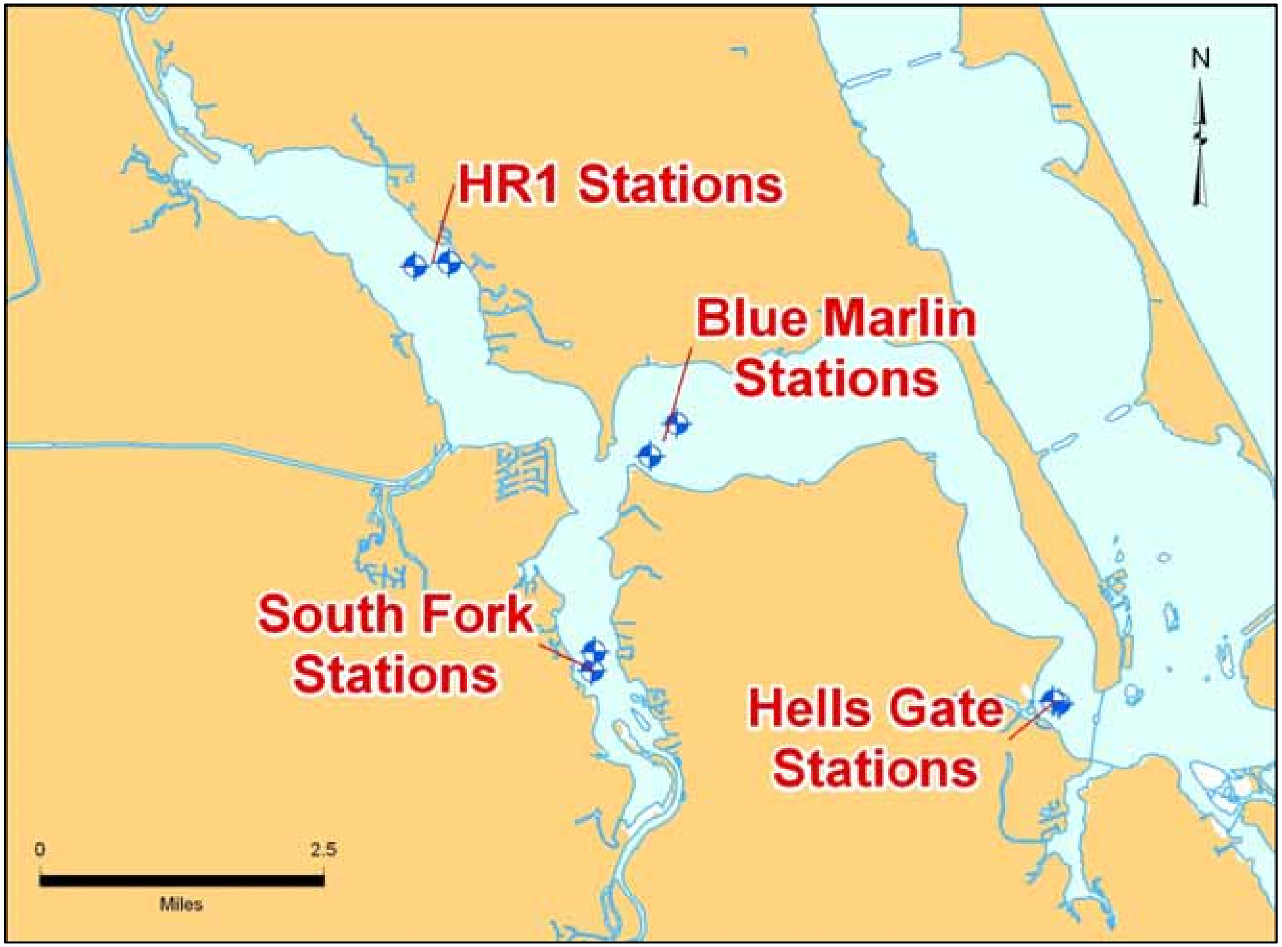
2000-2001 SLE Productivity Study

- Purposes
  - Improve understanding of nutrient sources, cycling, and fluxes
  - Support PRGs and TMDLs
- Partners
  - SFWMD
  - Harbor Branch Oceanographic Institute
  - Malcolm Pirnie, Inc.



Water Quality Monitoring

- 4 locations, 8 stations
- Monthly sampling
  (Jan 2000 – March 2001)
- Weekly sampling for 8-week periods
  - Aug-Oct 2000
  - Jan-Feb 2001
- Constituents by depth
  - Field parameters
  - Light attenuation
  - Nutrients
  - Chlorophyll-*a*
  - Primary Productivity
    - In-situ incubation
    - Variable depths
    - D.O. by Winkler method



SLEP Data Analysis Tasks

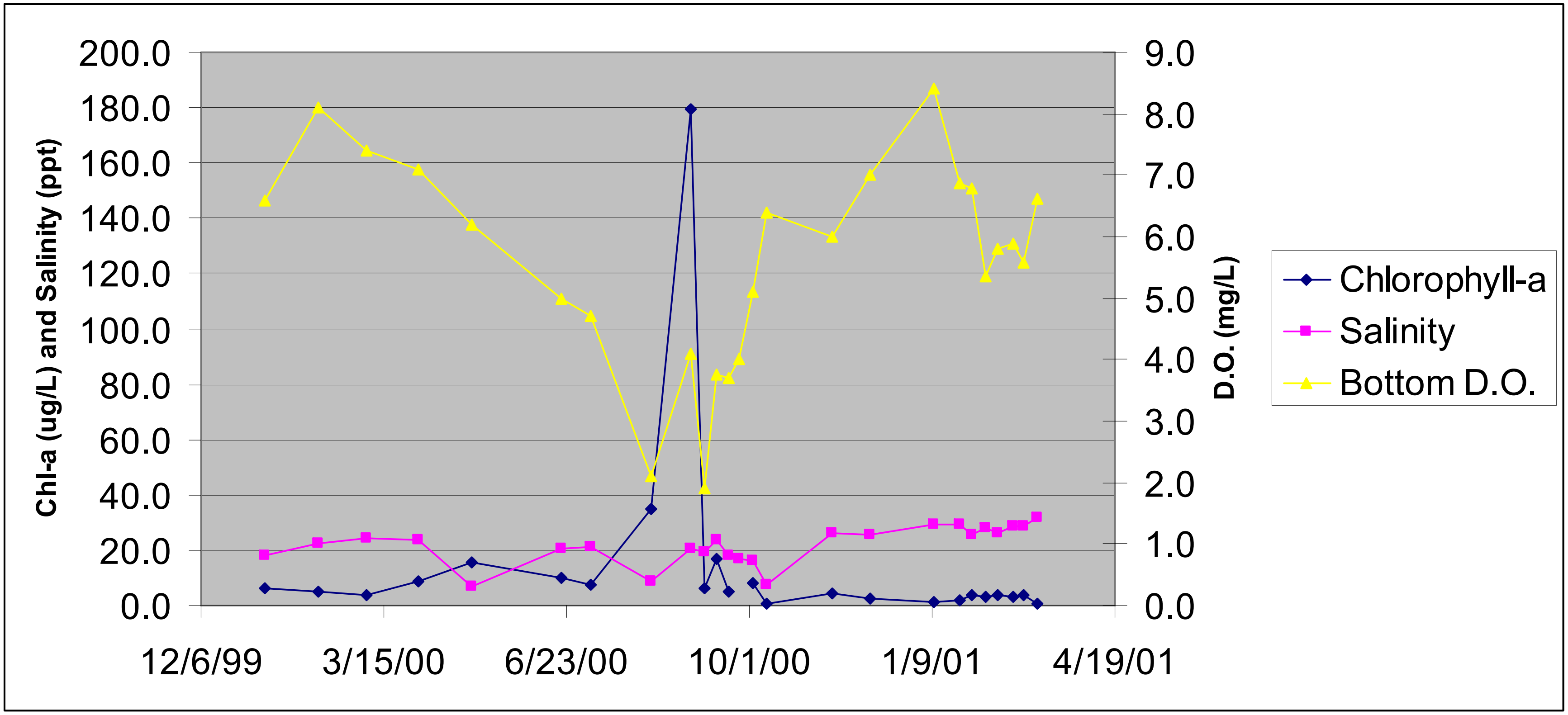
1. Identify Spatial and Seasonal Trends in Water Quality
   - Interpret trends with regard to major drivers of water quality and phytoplankton growth
2. Primary Productivity Modeling
   - Predict depth-integrated primary productivity as a function of water quality and light-related variables
3. Benthic Nutrient Flux Analysis
4. Estuarine Nutrient Budget

Task 1: Spatial and Seasonal Gradients in Water Quality

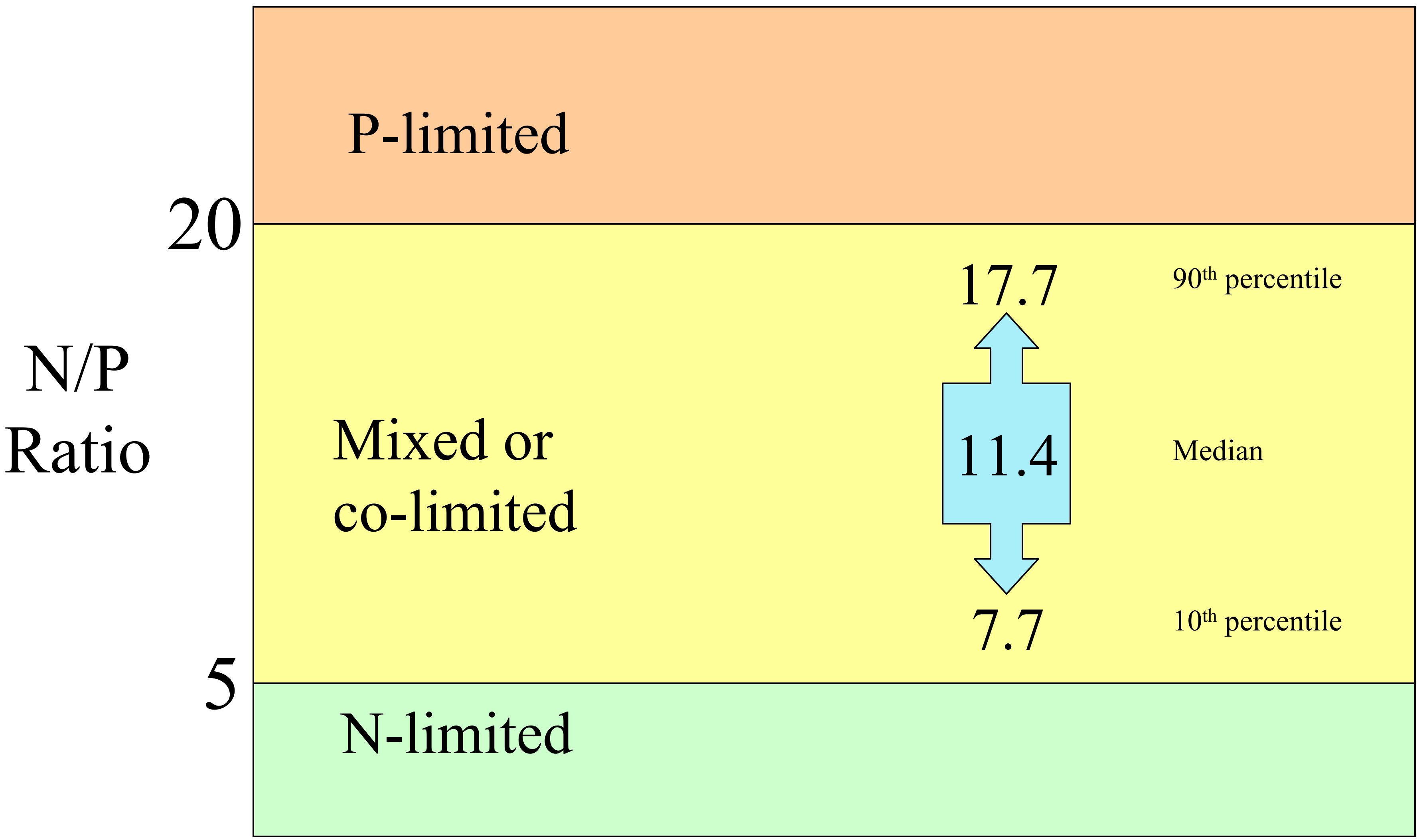
- Sub-Tasks
  - Hypothesis
  - Correlations between key variables
  - Seasonal differences
  - Spatial differences
    - Between regions of the estuary
    - Between shallow v. deep
- Methods
  - Graphical
  - Statistical
    - Principal Components Analysis
    - Correlation coefficients
    - Non-parametric hypothesis testing

Bloom Events

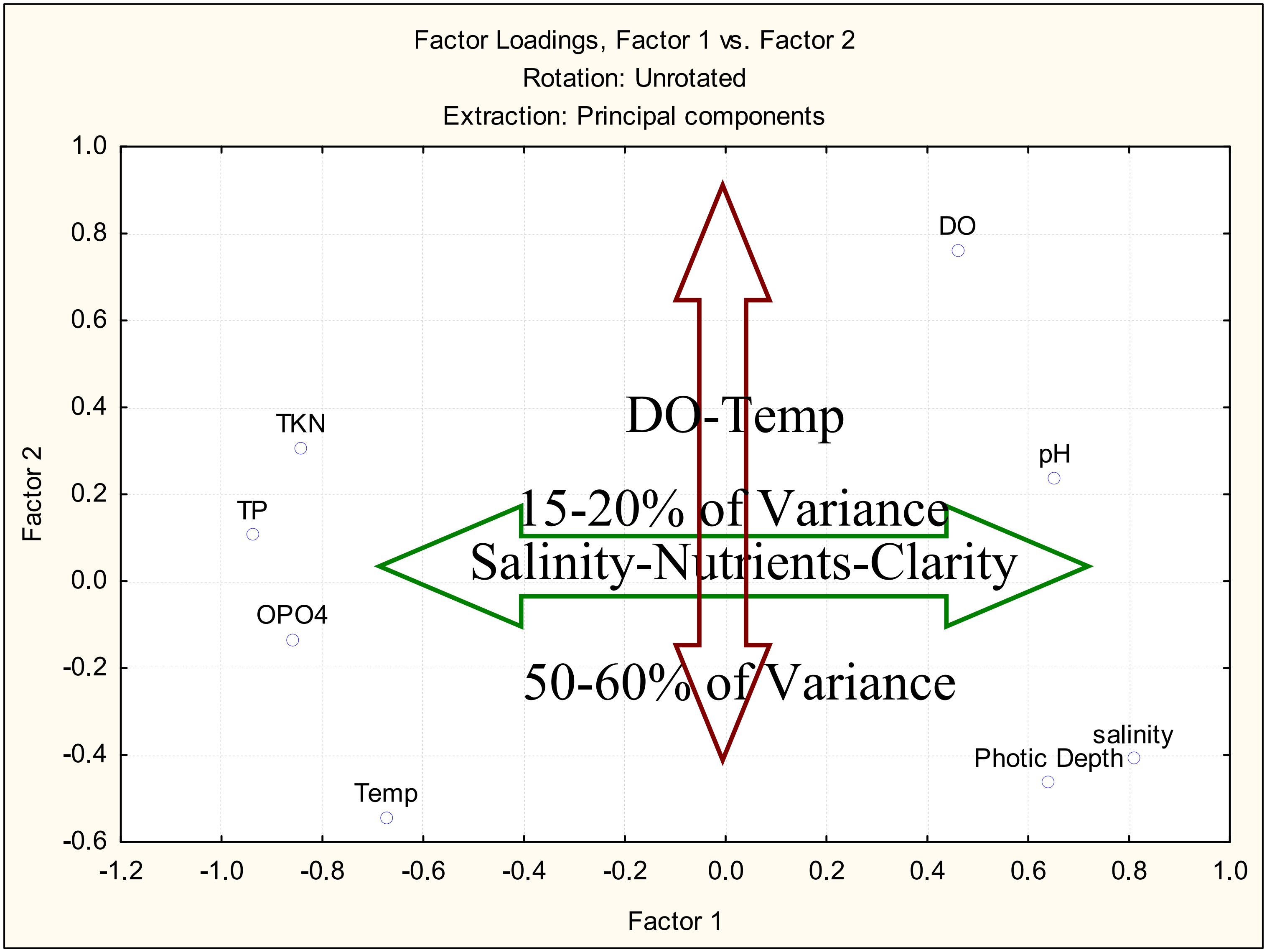
- Occur in summer around seasonal max temperature
- Follow large freshwater inputs
- Show evidence of contribution to low bottom D.O.



Nutrient Limitation



Correlations Between Key Variables
Principal Components Analysis



Correlations Between Key Variables
Spearman's ρ Correlations

- **Salinity as "master" variable**
  - **Direct correlations**
    - Light availability
    - Normalized primary productivity
    - pH
  - **Inverse correlations**
    - Nutrients (except ammonia)
    - Chlorophyll-*a*
    - Temperature
    - Net & Gross primary productivity

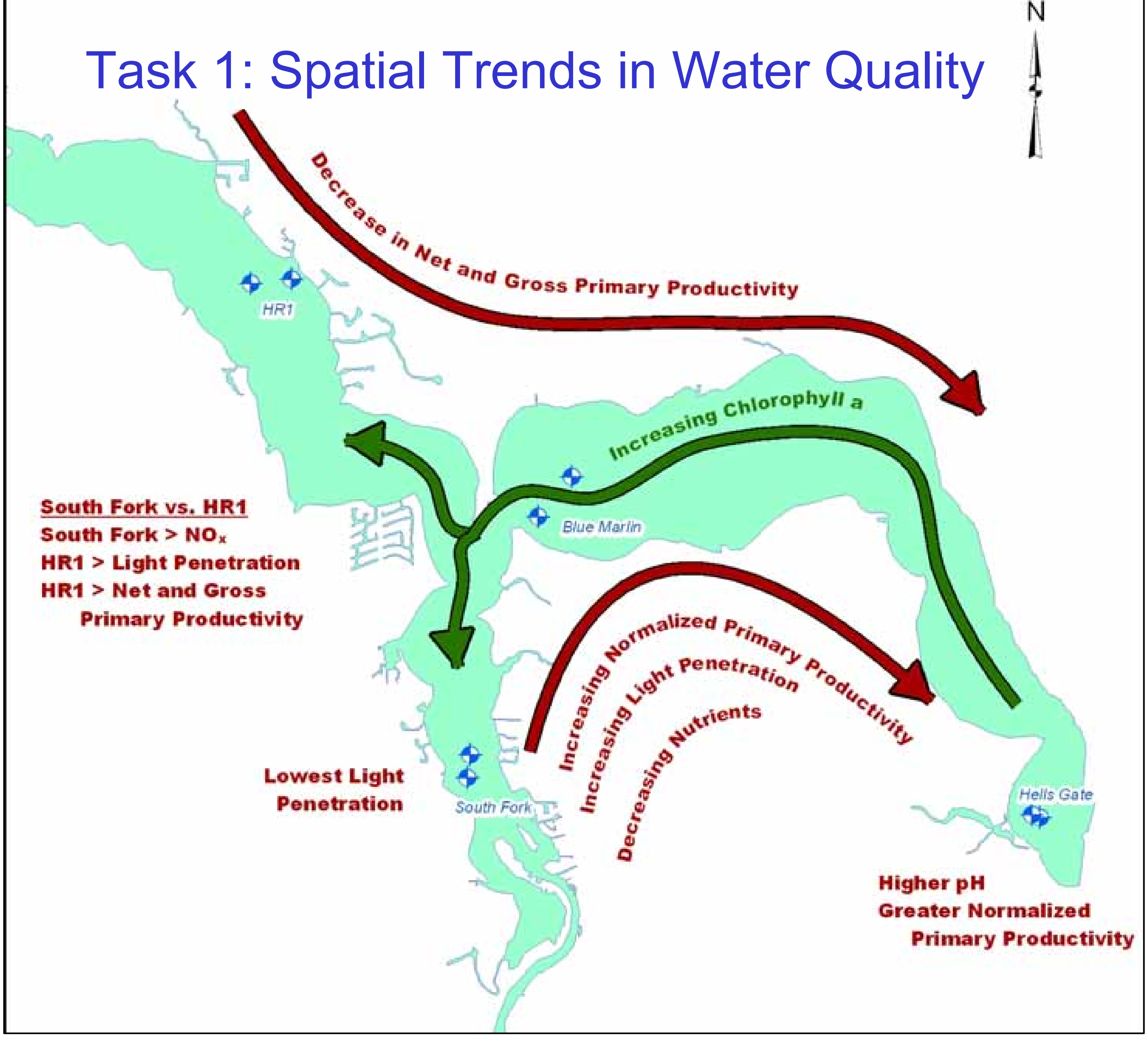
In short, as salinity increases water clarity increases and nutrients, algal biomass, and productivity decrease.

Correlations Between Key Variables
Spearman's ρ Correlations

- **Chlorophyll *a***
  - **Direct correlations**
    - Temperature
    - Orthophosphorus
    - TKN
    - Daily surface irradiance
    - Primary productivity
  - **Inverse correlations**
    - Nitrate + Nitrite, Ammonia
    - Salinity

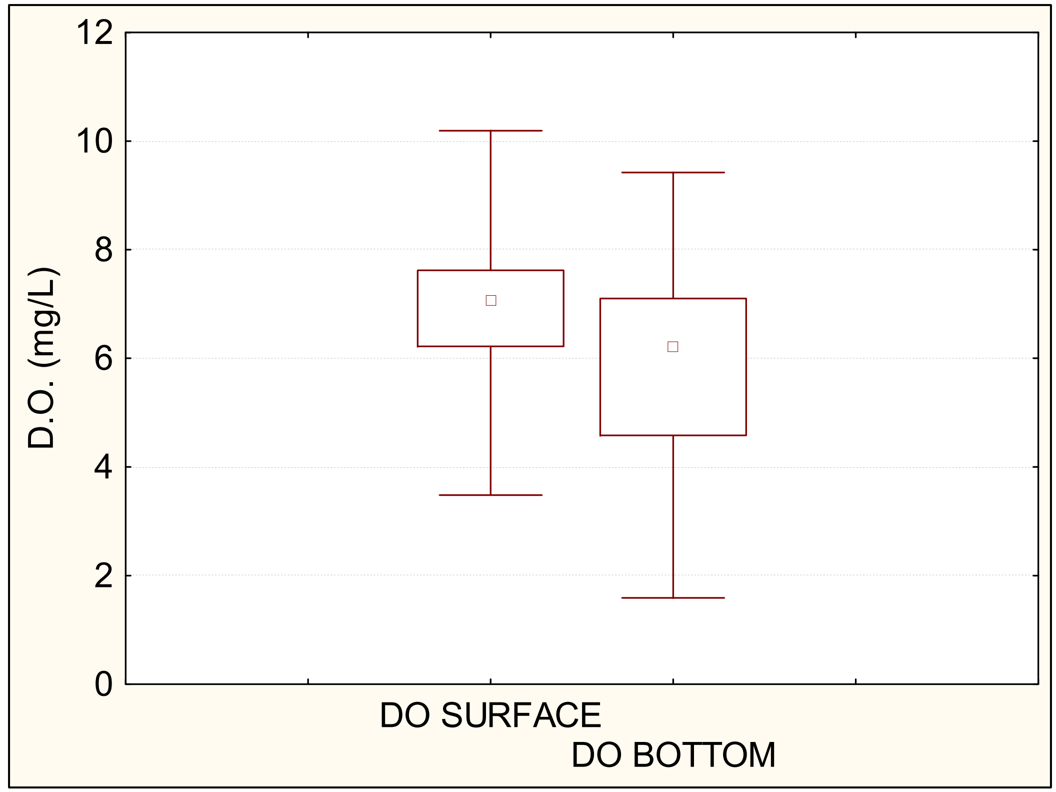
Low correlation between primary productivity and light availability.

Task 1: Spatial Trends in Water Quality



Task 1: Spatial Trends in Water Quality Variability with Depth

- Mild vertical salinity gradients
- DO, temperature lower with depth
- Chl-a, productivity lower with depth
- Shallow stations more turbid

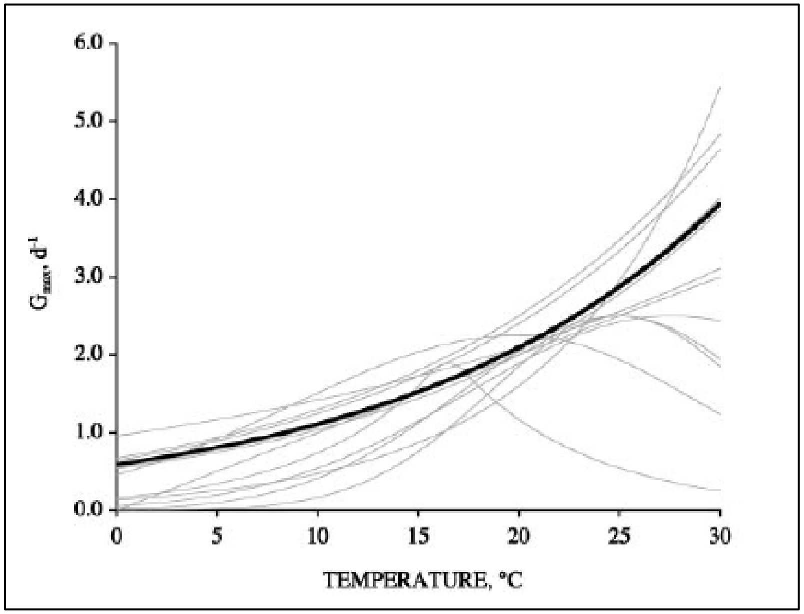


Task 1: Seasonal (Wet/Dry) Trends

Higher in Wet Season	Higher in Dry Season	No Seasonal Difference
Chlorophyll-*a* Gross Primary Productivity Net Primary Productivity OPO_4 Salinity Stratification Surface Irradiance Temperature TKN TP	Respiration Dissolved Oxygen pH Salinity	**Average k_d** Benthic Chlorophyll-*a* DNO_X **NH_4** Normalized Primary Productivity **Photic Depth** **Secchi** Vertical Salinity Gradient

Task 2 : Primary Productivity Modeling

- Key environmental variable.
- Resource-intensive measurements.
- Often estimated as function of temperature (*e.g.*, Eppley Curve).
- More successful models use:
  - Light availability
  - Algal biomass



From Brush and others (2002)

Basic regression model

$$G_p = b_o + b_1 (BZ_pI_o)$$

B: Chorophyll-*a*

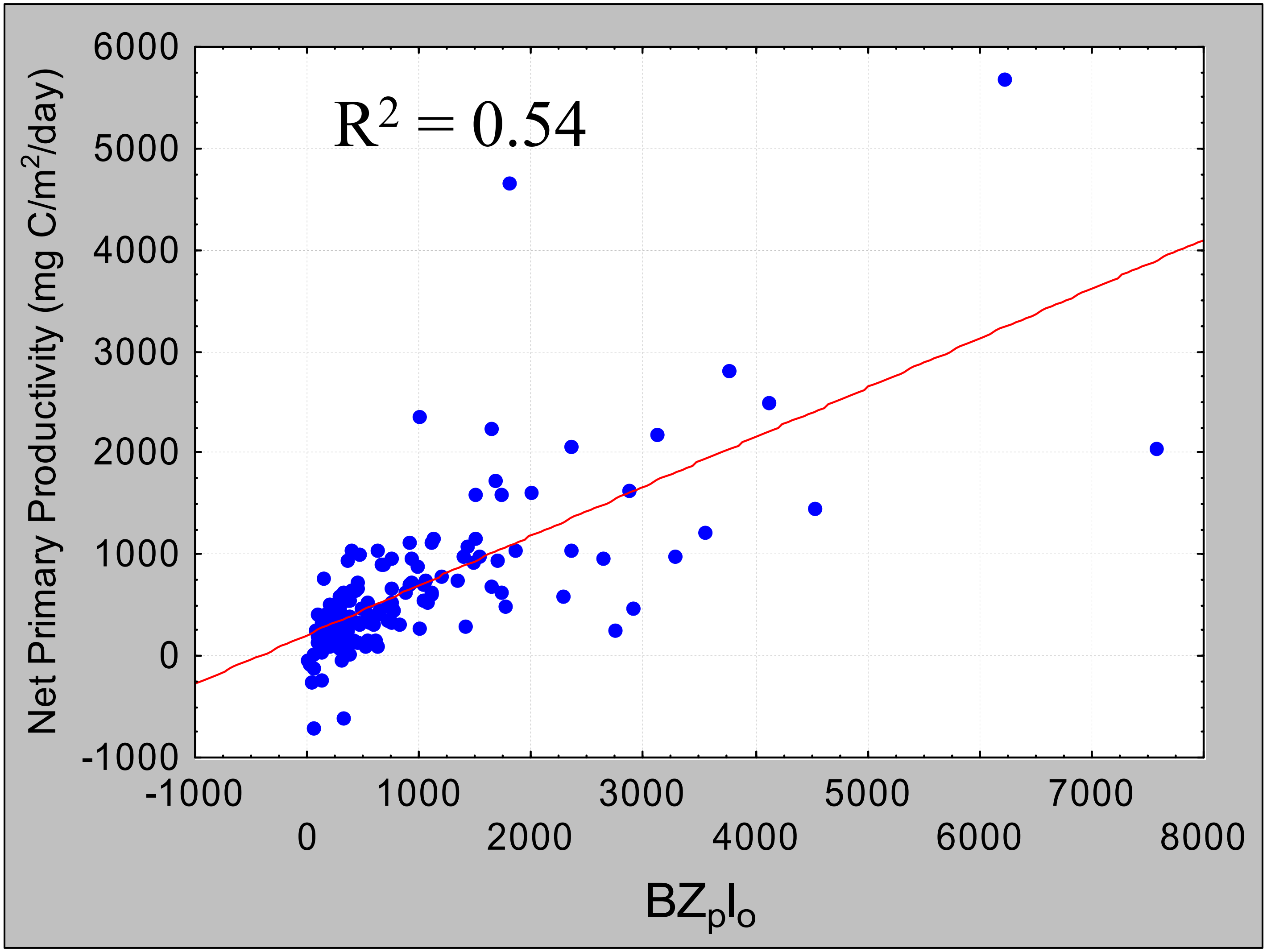
Zp: Photic depth

Io: Surface irradiance

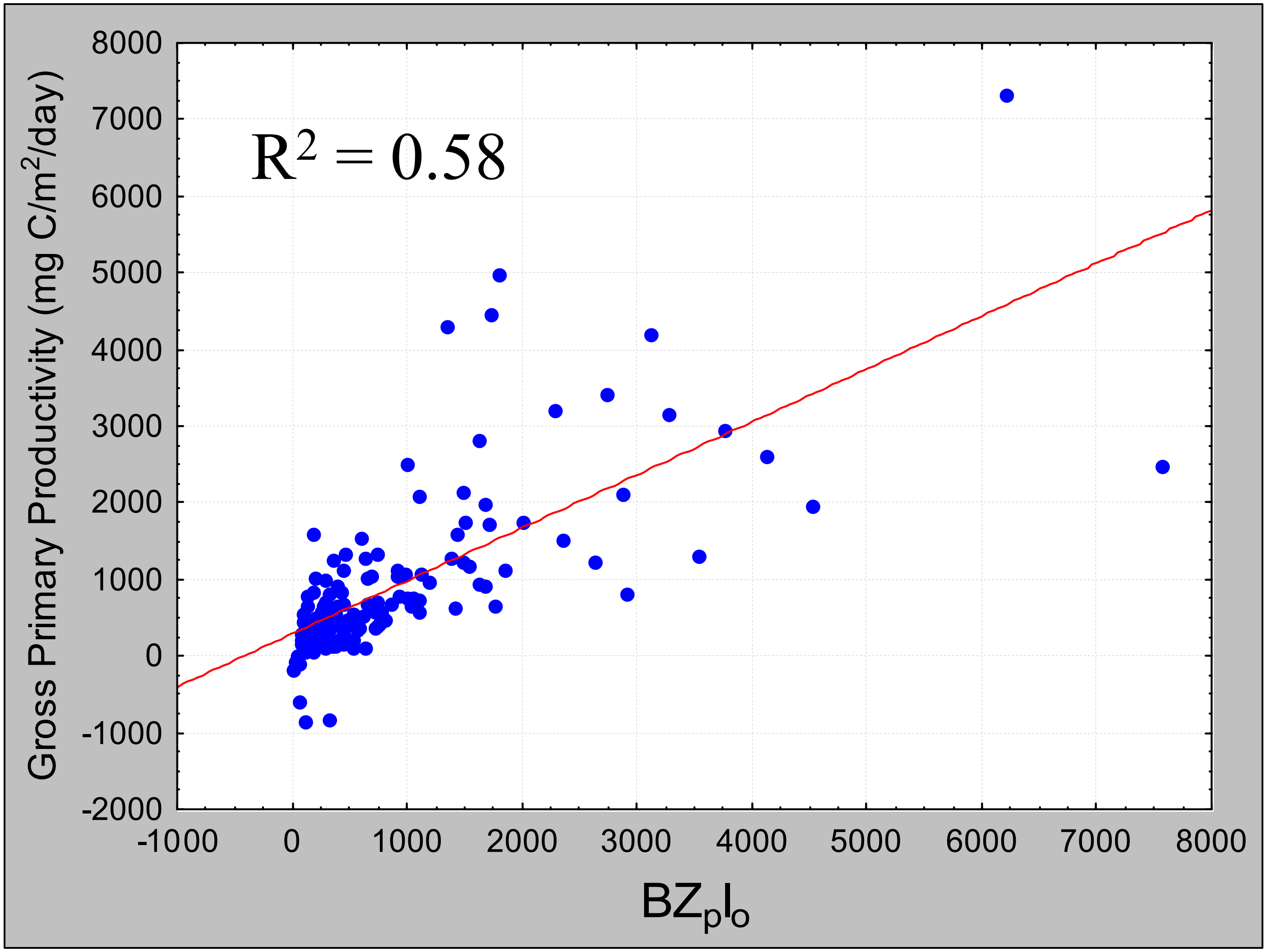
Does this model work for the St. Lucie Estuary?

Better model available?

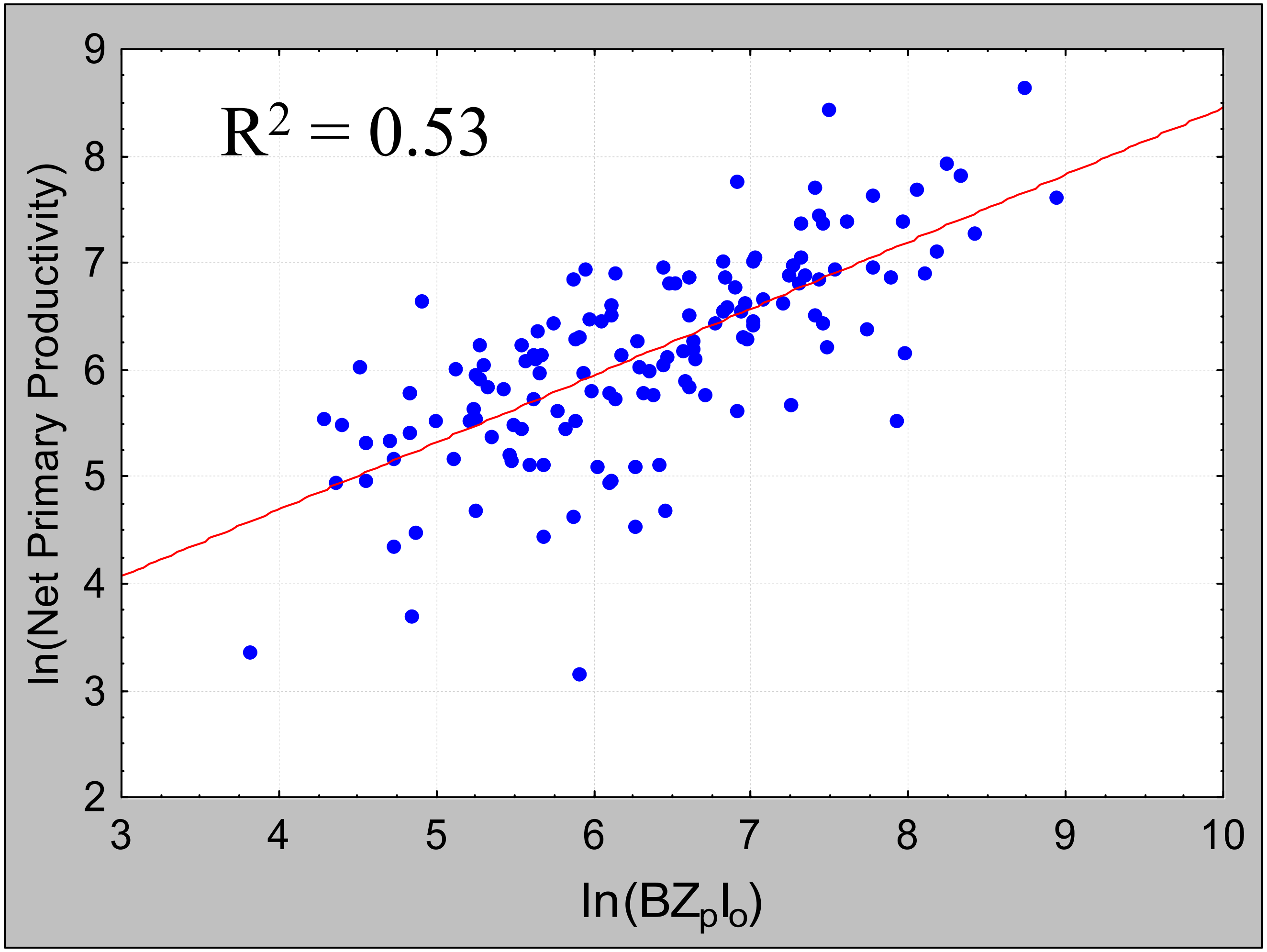
Net Primary Productivity



Gross Primary Productivity



Log Transformation Improves Regression Properties…



Source	Study area	b	m	R^2	Source	Study area	b	m	R^2
This study	St. Lucie Estuary				Harding et al. (1986)	Delaware Bay	131	0.39	0.76
	All Data: Net PP	164	0.55	0.55	Pennock & Sharp (1986)	Delaware Bay			
	All Data: Gross PP	227	0.79	0.58		Non-summer	100	0.07	0.68
	Shallow: Net PP	202	0.45	0.60		Summer	300	0.23	0.42
	Shallow: Gross PP	249	0.52	0.64	Cole & Cloern (1987)	San Francisco Bay; Puget Sound; New York Bight	150	0.73	0.82
	Deep: Net PP	133	0.63	0.56	Cloern (1987)	South San Francisco Bay	94	0.88	0.88
	Deep: Gross PP	230	0.99	0.65		North San Francisco Bay	63	0.67	0.72
Cole & Cloern (1984)	San Francisco Bay	58	0.82	0.82	Keller (1988a)	MERL	199	0.59	0.86
Cole et al. (1986)	San Francisco Bay				Keller (1988b)	Narragansett Bay; MERL	220	0.70	0.82
	Unfractionated	57	0.81	0.81	Cole (1989)	Tomales Bay	125	0.75	0.90
	Netplankton	34	0.73	0.73	Cloern (1991)	San Francisco Bay	0	1.1	0.93
	Nanoplankton	28	0.73	0.75	Mallin et al. (1991)	Neuse River estuary	Not reported	--	0.73
	Ultraplankton	25	0.76	0.55	Kelly & Doering (1997)	Mass. Bay; Boston Harb.	286	0.79	0.66
Harding et al. (1986)	Chesapeake Bay	176	0.74	0.69	Kromkamp et al. (1995)	Westerschelde estuary	32-317	0.22—0.72	0.32-0.83

Task 2: Primary Productivity Regressions Findings

- Use of multiple linear regression
  - Showed that most explanatory power came from chlorophyll-*a*, not light availability.
- Slopes, intercepts within ranges reported in literature
- Addition of nutrient terms (marginally significant)
  - TP coefficient positive
  - TKN, NH4, PO4 coefficients negative

<u>Recommendation</u>: Use simple linear regression with BZ_pI_o.

Findings, Management Implications and Follow-Up Actions

- Productivity can be modeled as function of algal biomass and light availability.

3. Benthic Nutrient Flux Analysis
4. Estuarine Nutrient Budget

Understand where the nutrients are going and what effects the CERP and TMDLs will have.