SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Benthic Flux Projects:

In Support of the Northern Everglades River Watershed Research & Water Quality Monitoring Program - St. Lucie River Watershed

January 15, 2008

sfwmd.gov

The Characterization and Quantification of Benthic Nutrient Fluxes in the St. Lucie River and Estuary

- Objectives
  - Provide estimates representative of system-wide benthic nutrient (Nitrogen and Phosphorus) flux rates in support of the development of a RW Research and Water Quality Monitoring Plan under the RWPP for the CRE system;
  - Identify “hot spots” of benthic nutrient flux loading to the CRE, which will serve as the focus of future research and monitoring efforts to determine temporal and event-based variation of nutrient fluxes in, and load reductions to, the CRE;
  - Provide data in support of current and future water quality modeling efforts.

Proposed Sites for Core Incubation of Benthic Nutrient Fluxes in the SLRE

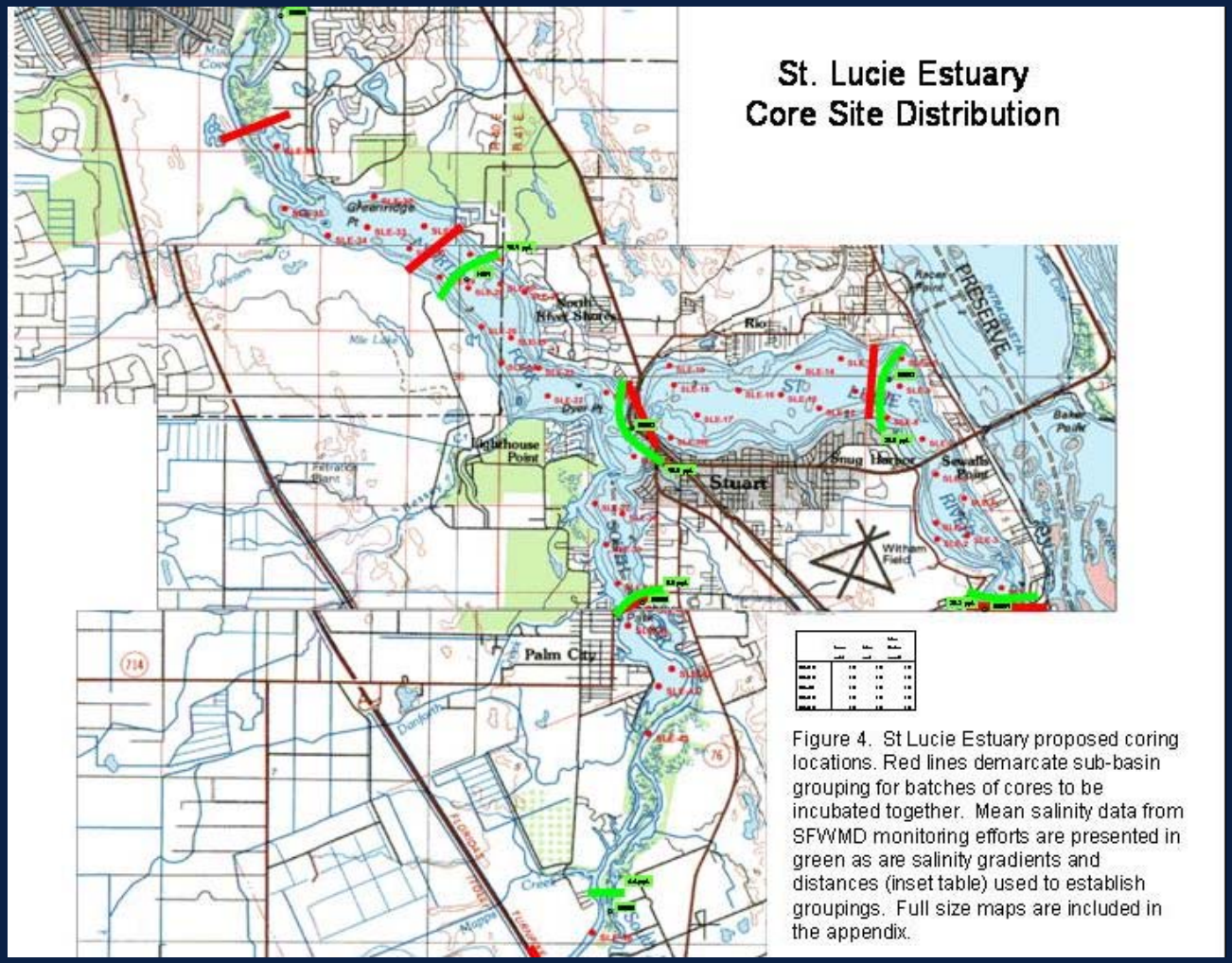
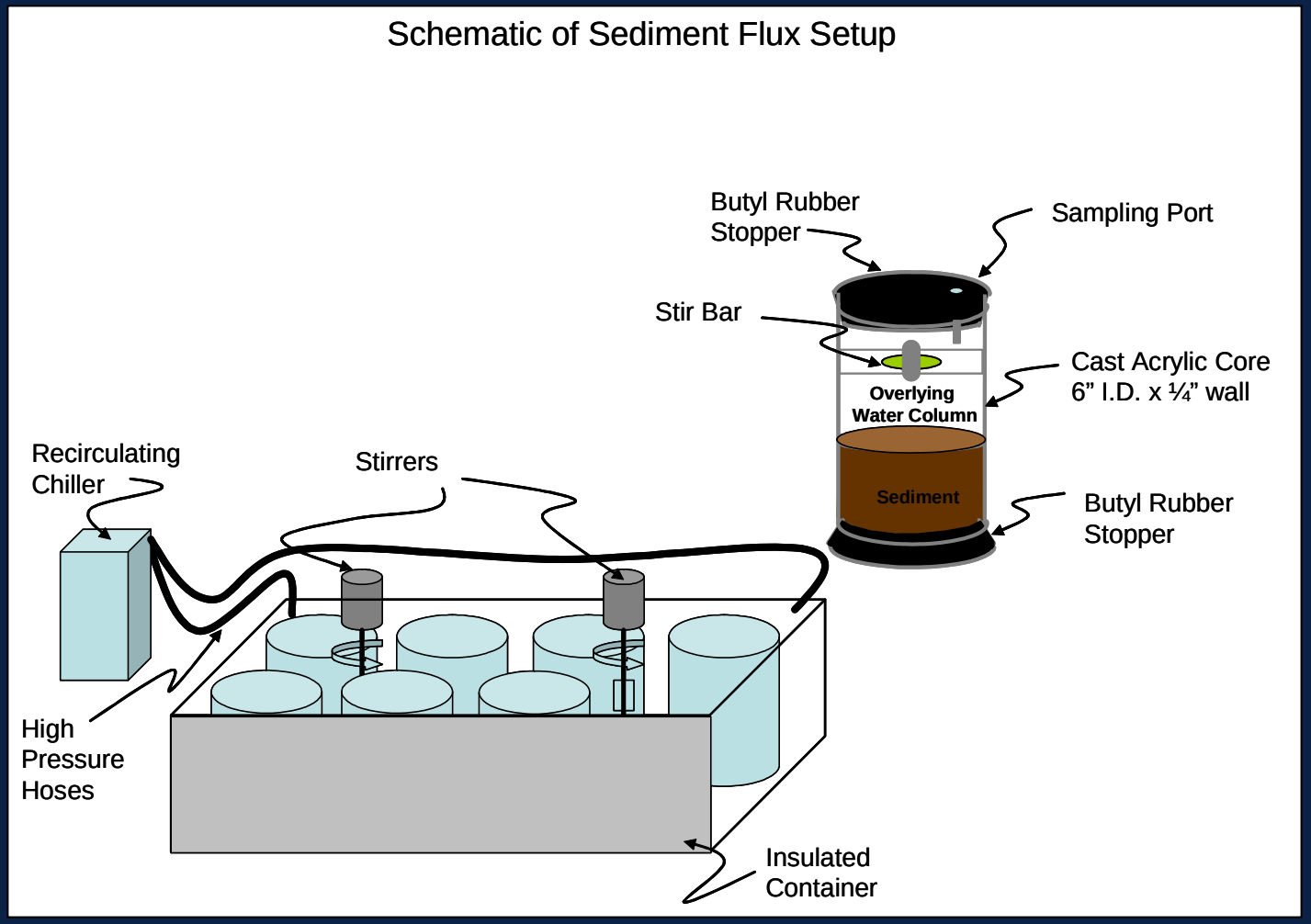


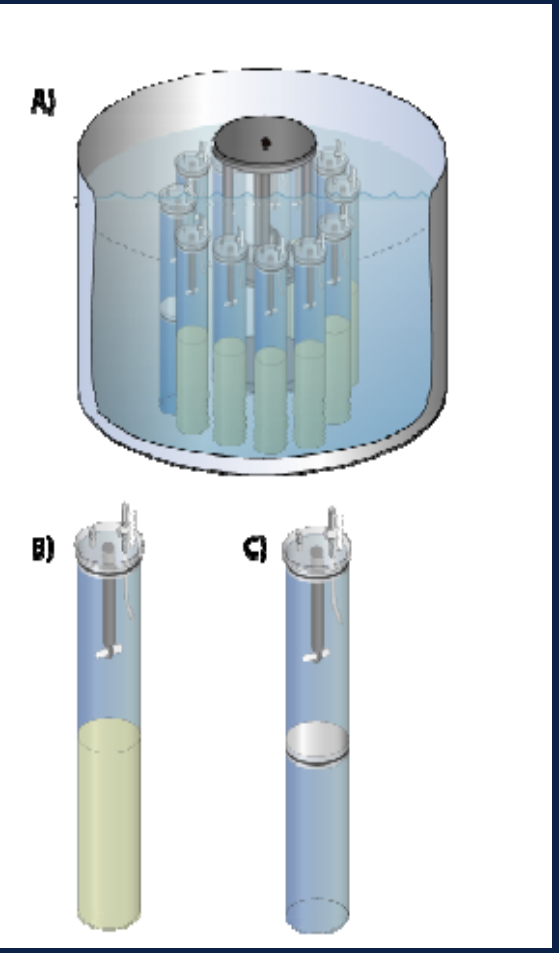
Figure 4. St Lucie Estuary proposed coring locations. Red lines demarcate sub-basin grouping for batches of cores to be incubated together. Mean salinity data from SFWMD monitoring efforts are presented in green as are salinity gradients and distances (inset table) used to establish groupings. Full size maps are included in the appendix.

Sediment Cores: Incubation Diagram



Sediment Chambers/Cores: Incubation Diagram

Remotely Incubated Cores



In Situ Chambers

An Assessment of Processes Controlling Benthic Nutrient Fluxes in the Caloosahatchee River and Estuary and the St. Lucie River and Estuary

- Objectives
  - Determine the rates of benthic nutrient fluxes and environmental factors controlling these rates in the CRE and SLRE;
  - Identify the methodology needed to ensure the accurate measurement of benthic nutrient fluxes for application in future research and monitoring efforts to determine temporal and event based variation in support for current and future WQ modeling efforts;
  - Provide current data for comparison/verification of questionably high benthic nutrient fluxes previously measured in the SLRE system.

Proposed Sites for Chamber and Core Incubations of Benthic Nutrient Fluxes in the SLRE

Previous Benthic Chamber Deployments:

St. Lucie Estuary Productivity Study, April 2001-March 2002

Parameters:

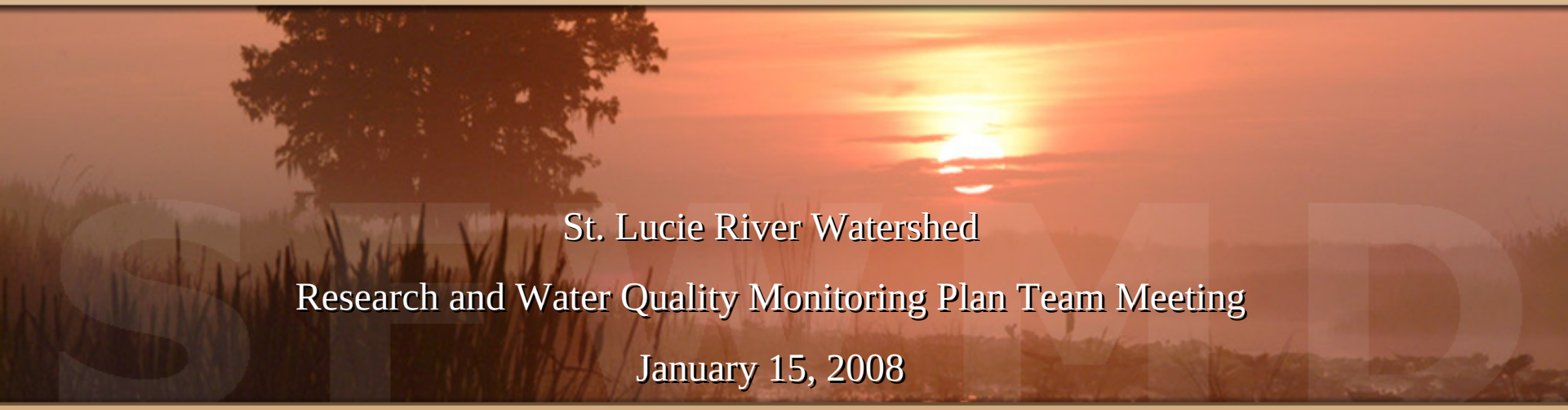
In Situ Water Column	Incubation Water Column	Incubation Pore Water	Core Sediment Surface
Dissolved Oxygen	Dissolved Oxygen	Dissolved Oxygen	Chlorophyll *a*
Dissolved Silica	Dissolved Silica	Dissolved Silica	CPN
NH_4	NH_4	NH_4	Grain Size
NO_x	NO_x	NO_x	
DIP	DIP	DIP	
DON	DON	DON	
DOP	DOP	DOP	
TN	N_2		
TP			
Depth			
Temperature			
Salinity			
PAR (Sediment Surface)			
Chlorophyll *a*			

Products:

1. Flux Rates of N and P at 50 (4) locations within the CRE: Identify sediments as sources or sinks for N and P on two (2) scales:
   - Locally (source "hot spots")
   - Regionally (i.e. systemwide)
2. Provide a map of sediment type (fine, medium, coarse) – insight into distributions of benthic flora and fauna (e.g. potential oyster habitat)
3. Identify future sediment flux monitoring needs
   - spatial heterogeneity (how many sites needed)
   - importance of sediment inputs relative to surface loads
   - extent of sediment denitrification
   - realistic sediment oxygen demands (dark measurements)
4. Comparison of measurements between groups and methodology – validation of *in situ* vs. remote incubations AND previous (2000-2001) high measurements.

Schedule:

1. 1/4/08: KickOff Meeting
2. Field Work
   - 1/(28-31)/08 Systemwide Cores
   - 2/(19-21)/08 Chambers/Cores
3. 3/08: Sample Analyses/Progress Report
4. 4/08: Data Analyses/Draft Final Report
5. 5/08: Final Project Report



St. Lucie River Watershed

Research and Water Quality Monitoring Plan Team Meeting

January 15, 2008

Dynamics of Flow, Salinity, and Water Quality in St. Lucie Estuary

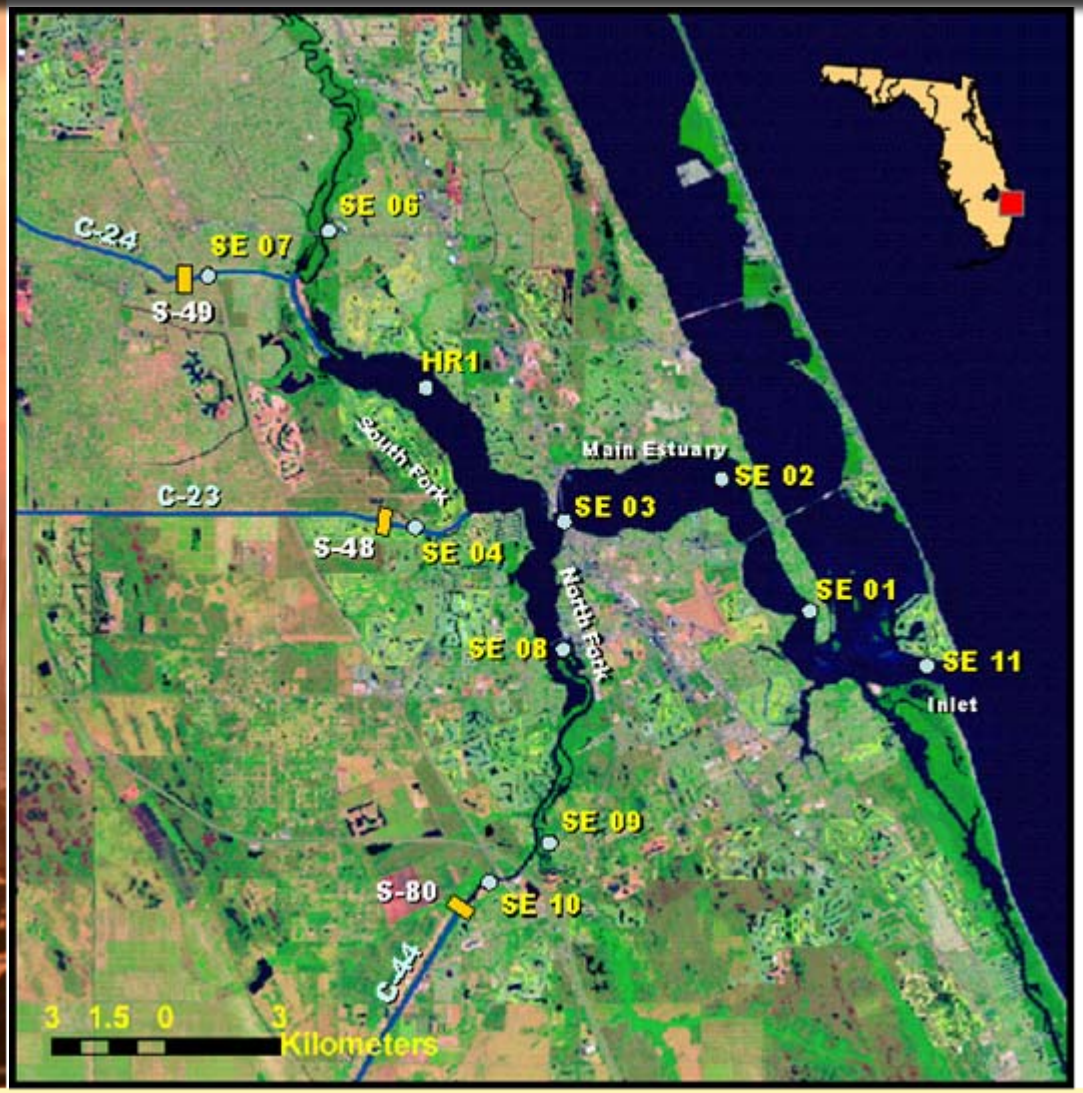
Data Sources

- Eleven WQ monitoring stations (SE01 to SE11)

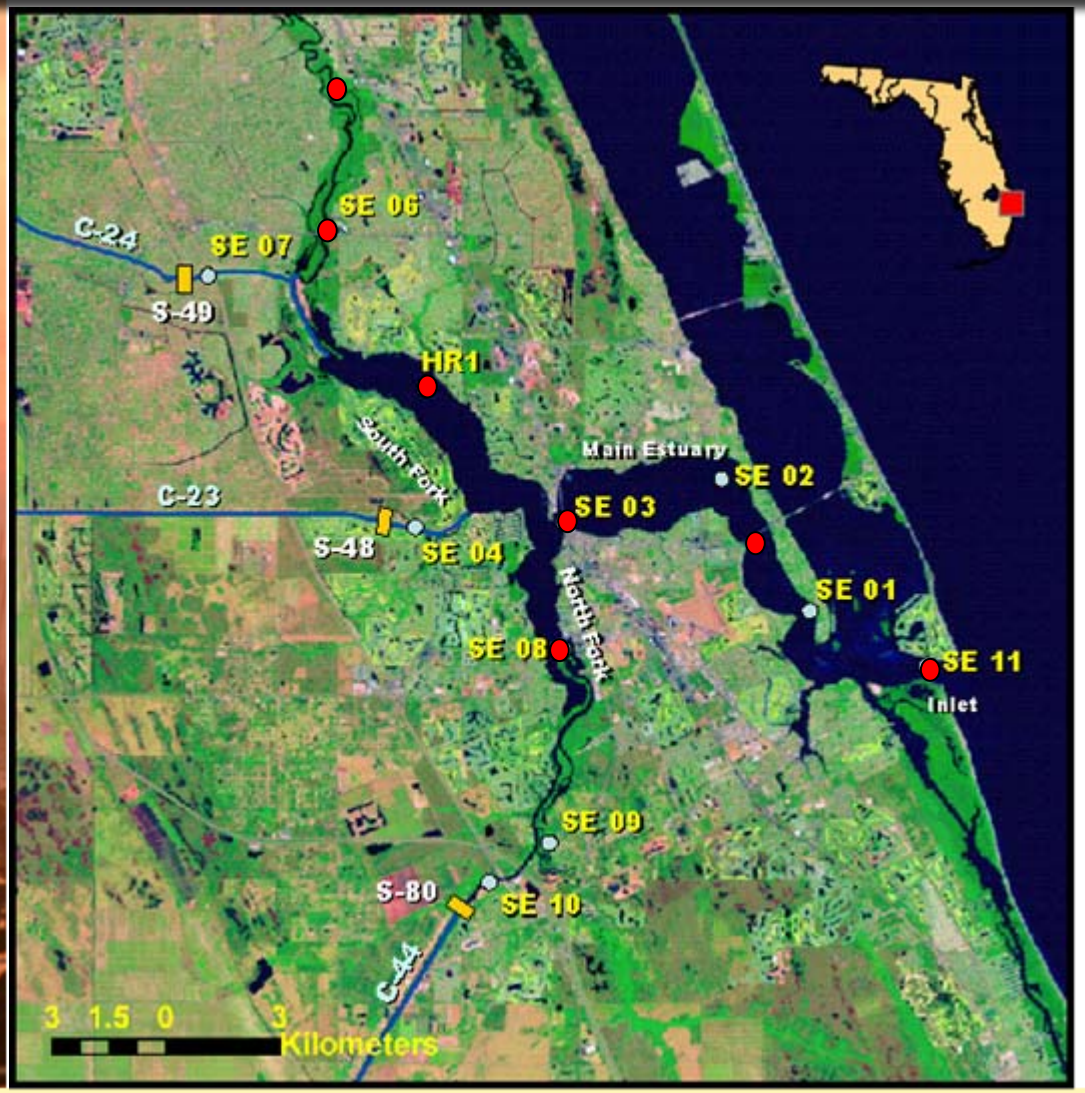
  July1992 to December 2006
- Eight continuous salinity monitoring

  1998 to 2007

SLE Water Quality Monitoring Stations



Salinity Monitoring Stations



Salinity Stations

Method

- Statistical analysis
- Correlation analysis
- Estuary divided into four sections:

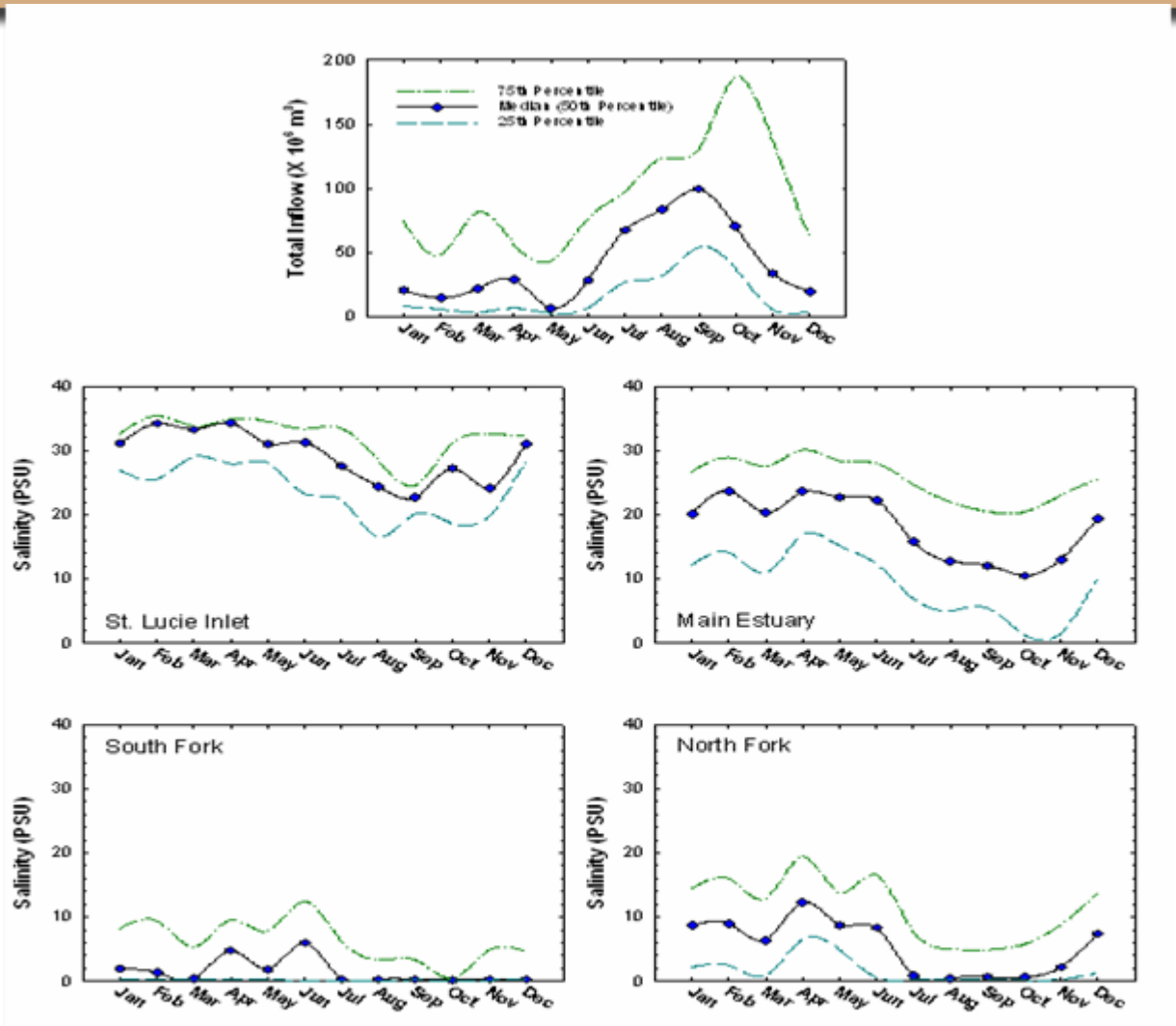
Inlet area,

Main Estuary

South Fork

North Fork

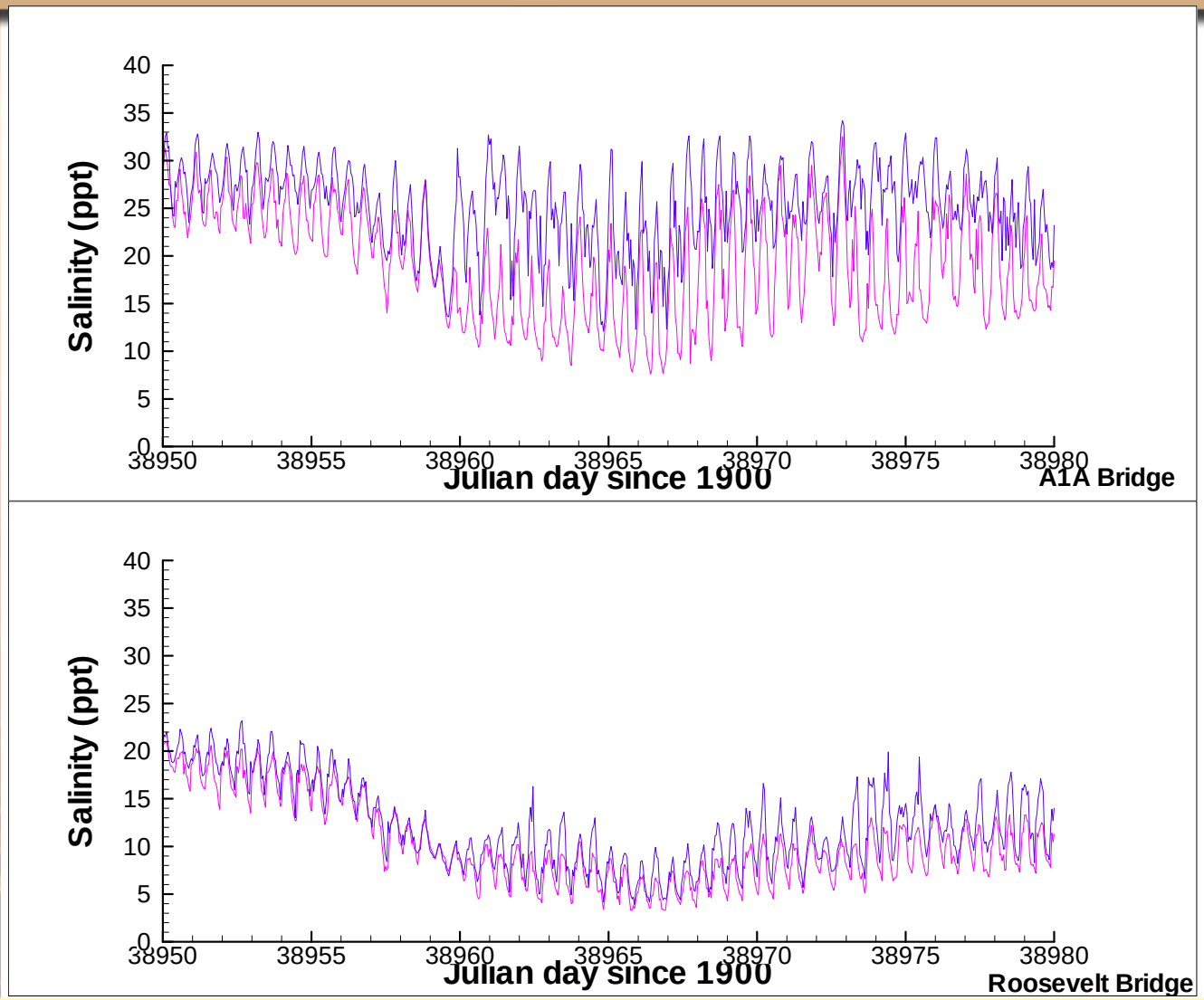
Salinity Range & Variation



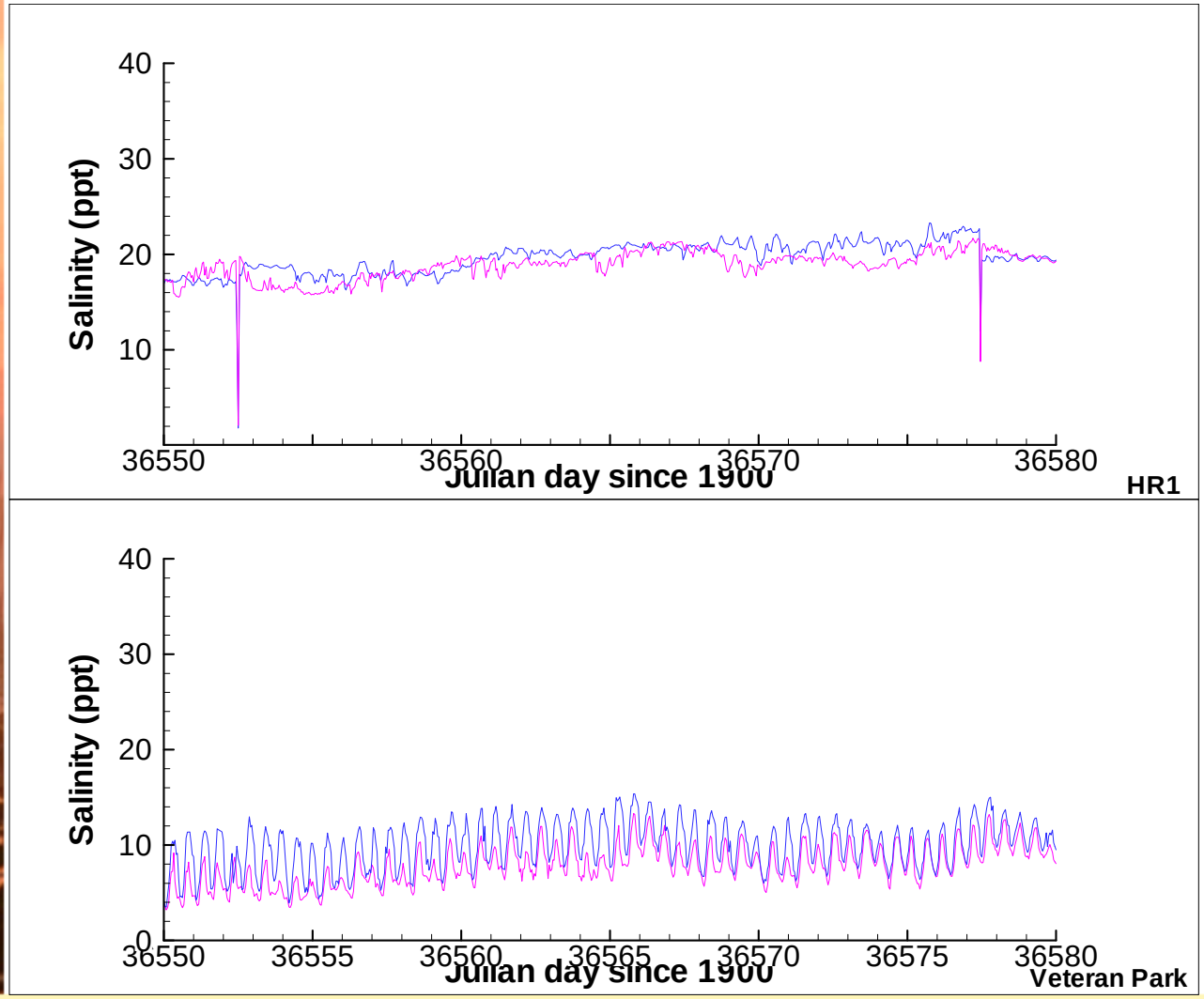
Salinity Range &Variation

Section	mean	Standard deviation	Min	Percentile					Max
				5	25	50	75	95	
South Fork	3.8	5.1	<0.1	0.1	0.2	0.4	6.3	15.5	23.6
North Fork	7.1	7.2	<0.1	0.1	0.5	4.9	12.2	20.9	39.0
Main Estuary	17.4	10.3	<0.1	0.4	8.6	18.6	26.1	32.4	36.4
Inlet area	27.2	7.9	0.6	9.6	22.9	29.6	33.3	35.7	36.5
Entire Estuary	11.0	10.5	<0.1	0.1	0.6	8.2	19.1	31.0	39.0

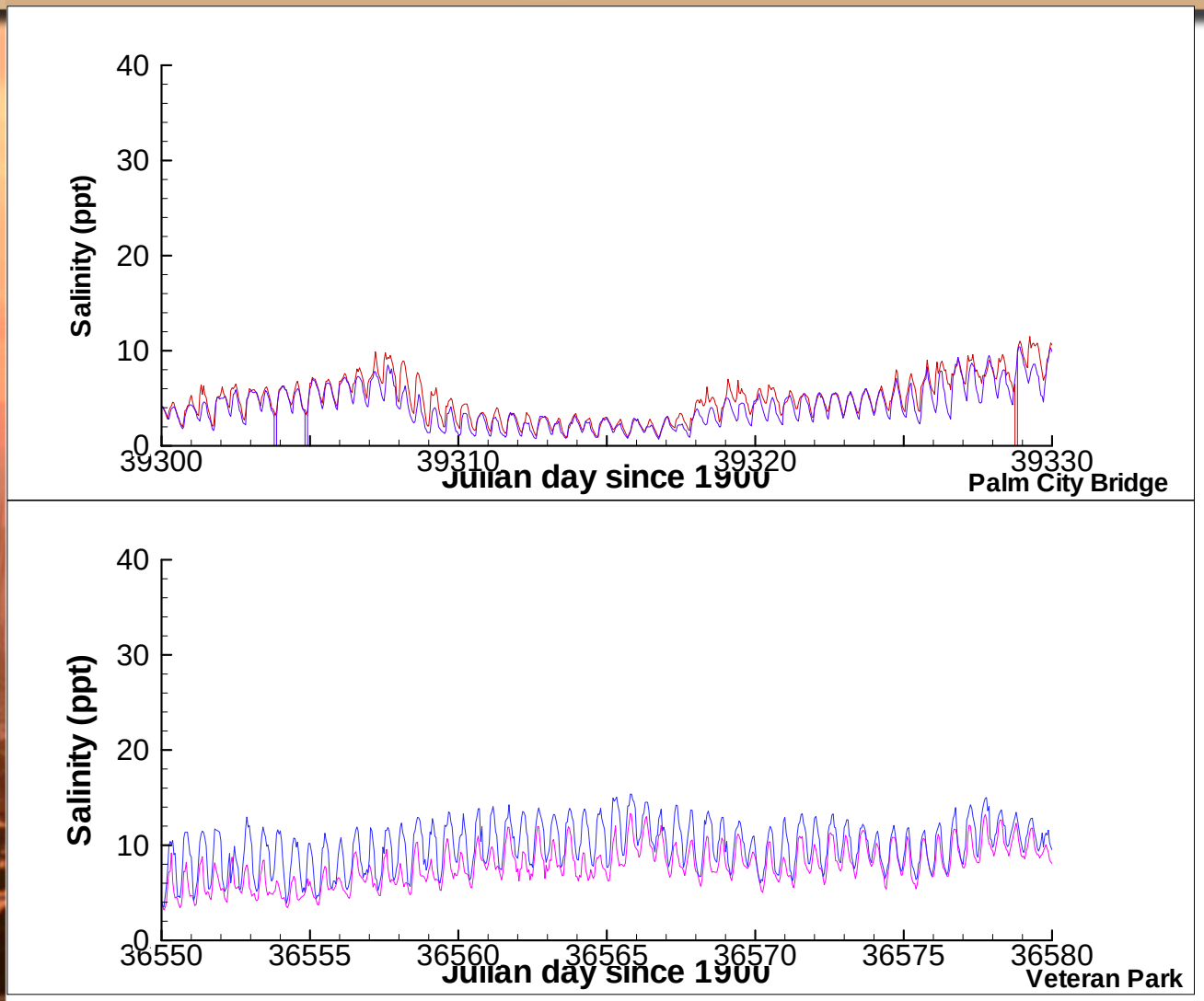
Stratification (Main Estuary)



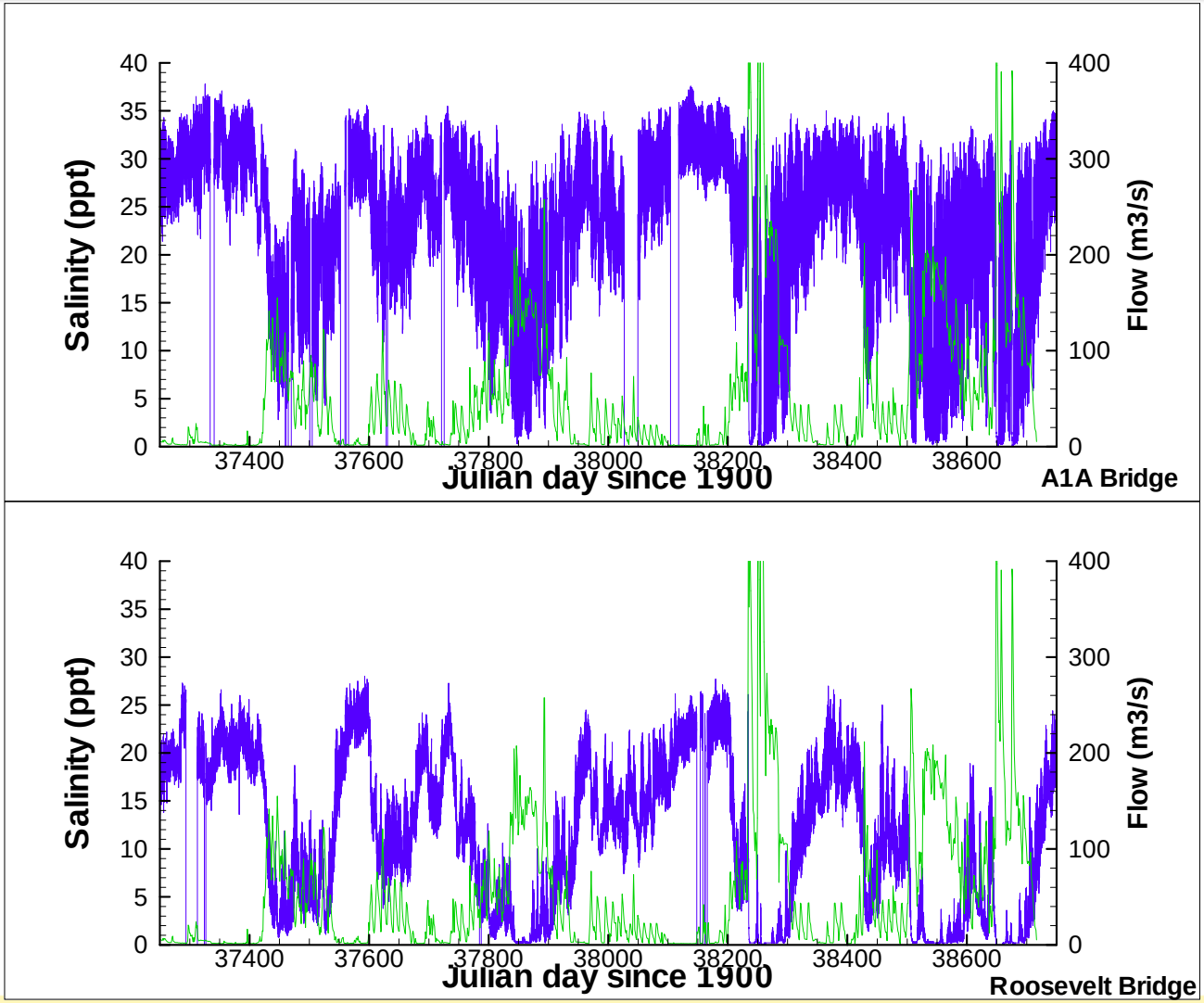
Stratification (North Fork)



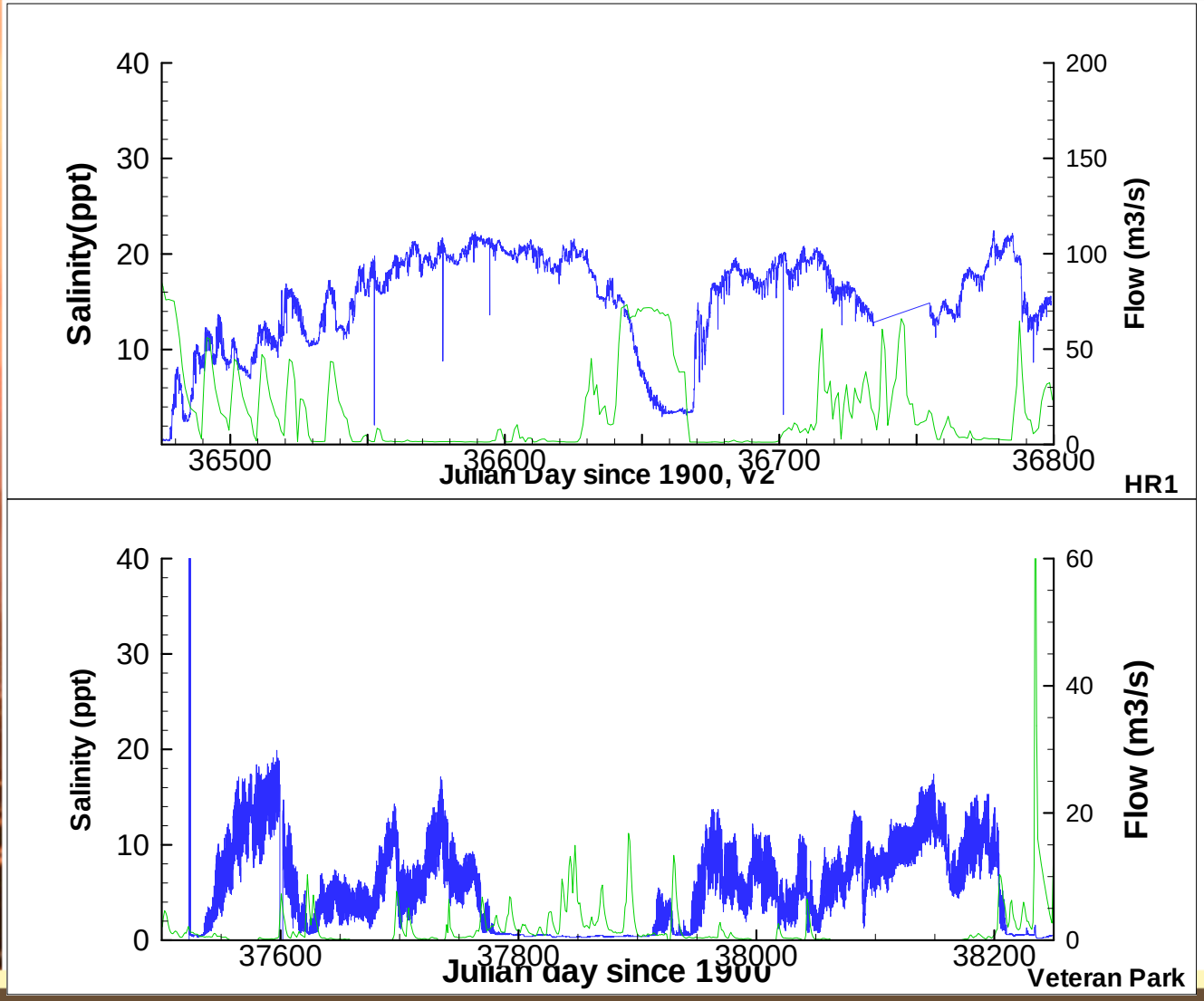
Stratification (South Fork)



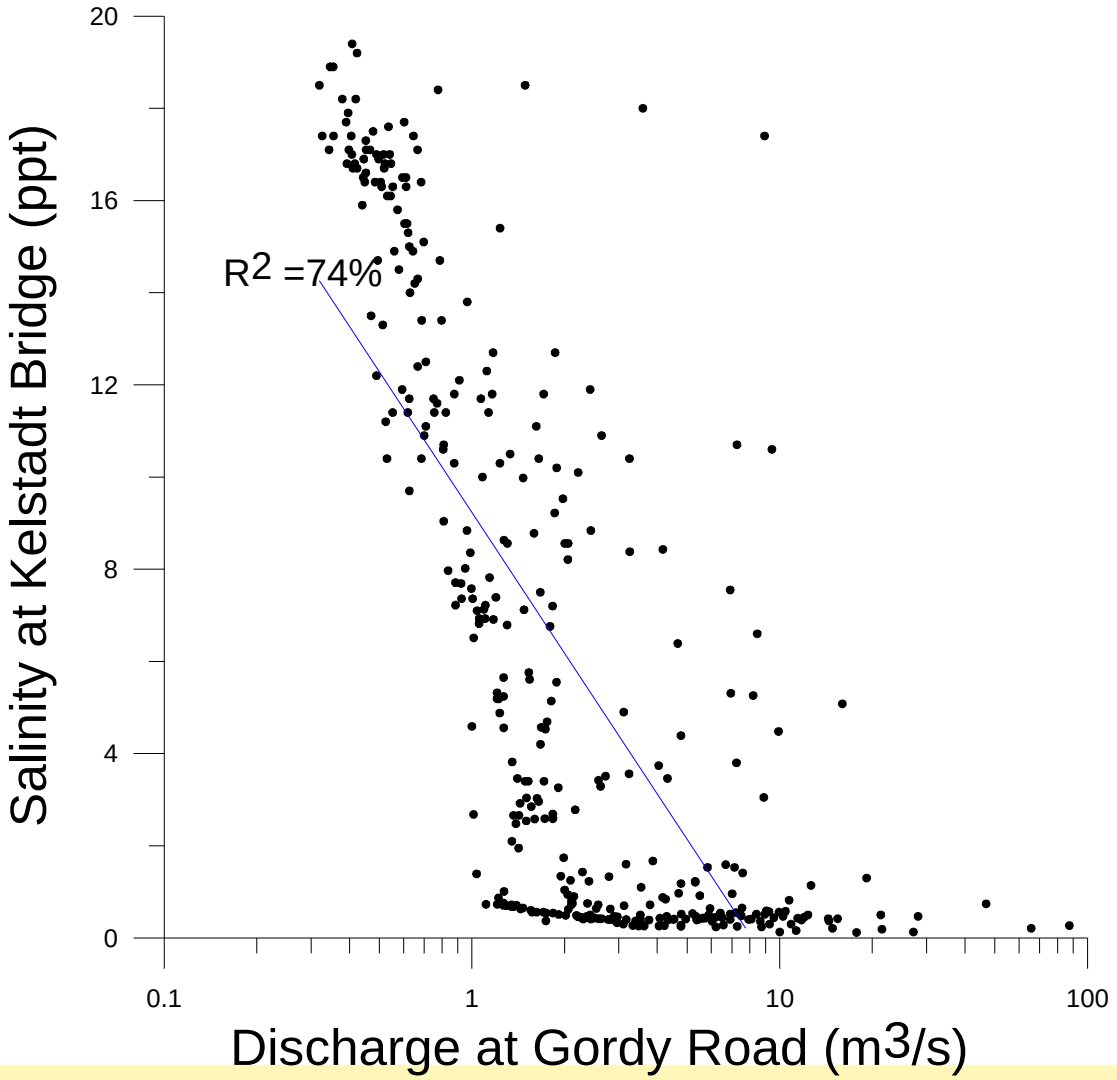
Flow-salinity correlation (Main Estuary)



Flow-salinity correlation (North Fork)



Flow-salinity correlation



Flow-salinity correlation

Station	R^2	
A1A	0.81	SE02
SE03	0.81	US1
HR1	0.77	
SE06	0.74	Kelstadt
SE08	0.77	Palm City Bridge

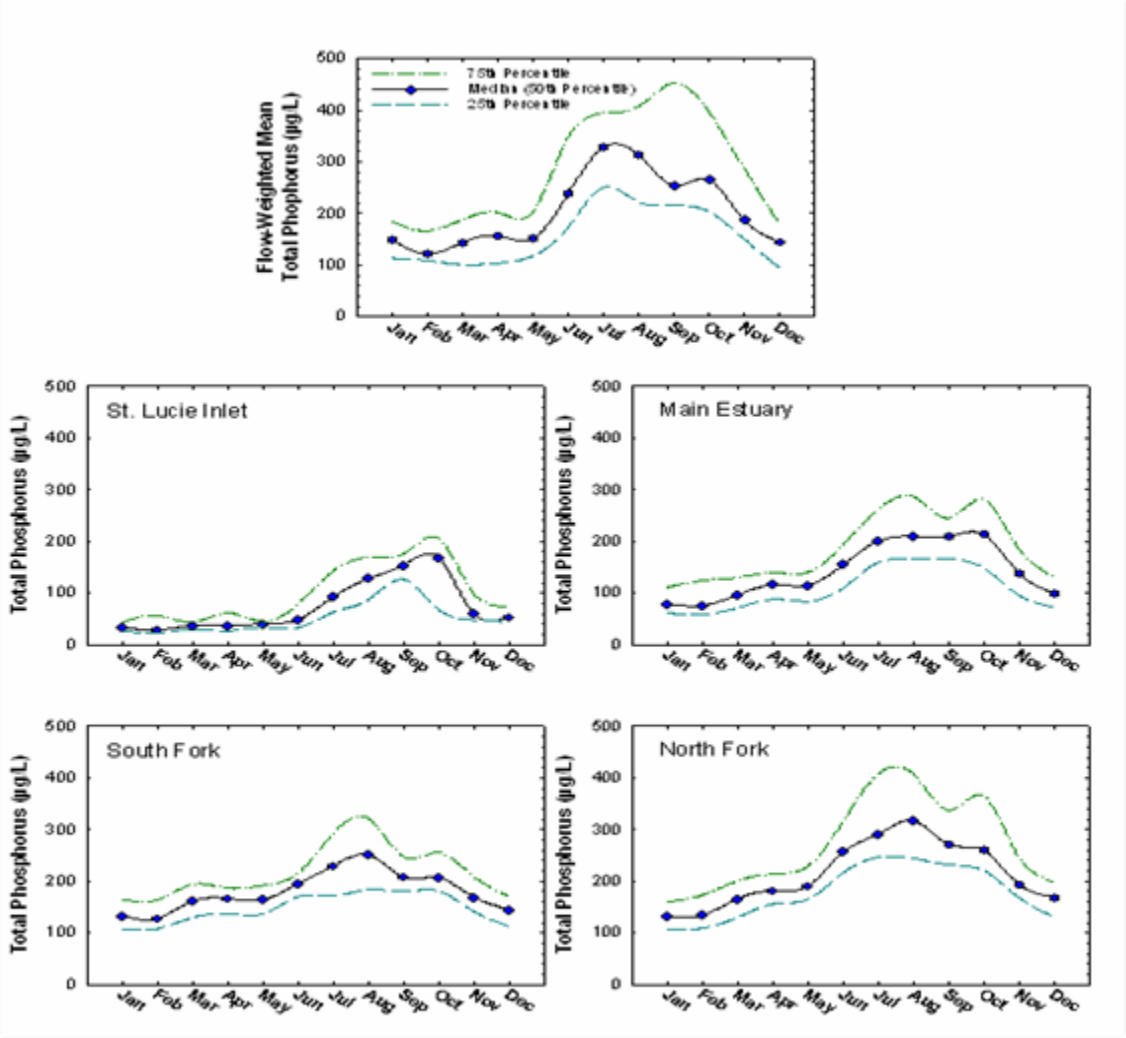
Salinity Summary

- Significant variation and salinity range due to seasonal and tidal changes
- Stratification during wet events

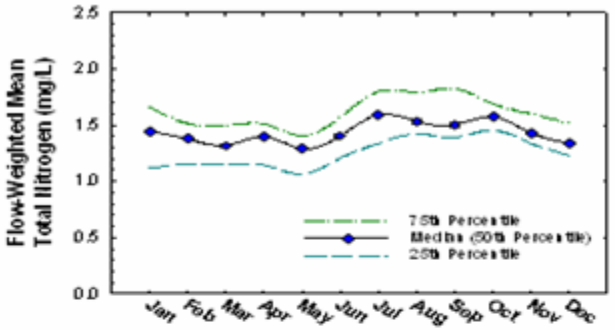
  Strong stratification at lower estuary

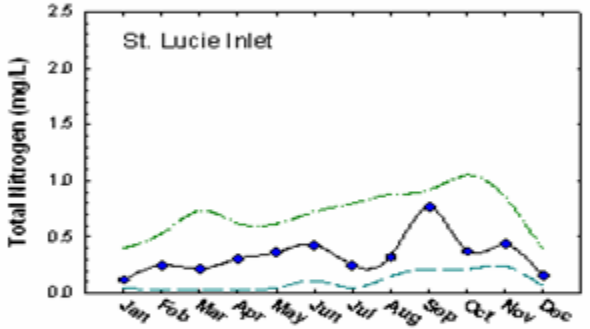
  NF more likely to be stratified than SF
- Strong correlation between flow and salinity

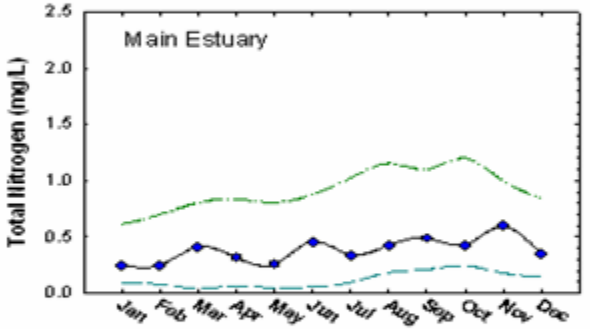
Water Quality Status & Trend, TP

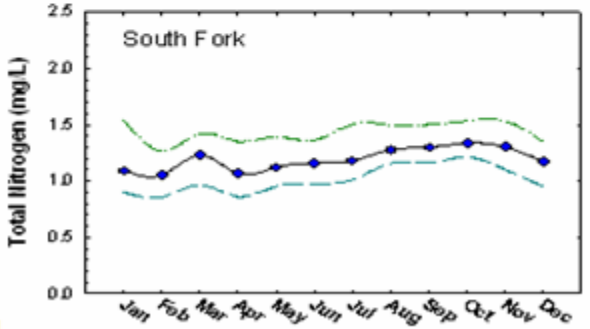


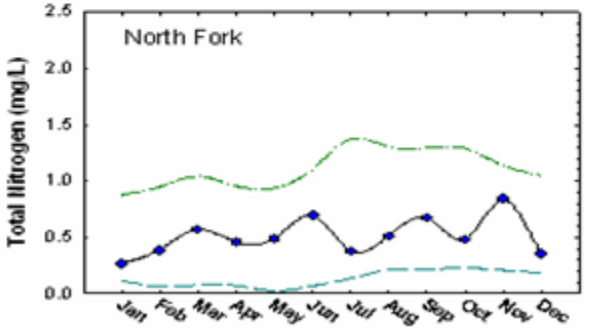
Water Quality Status & Trend, TN



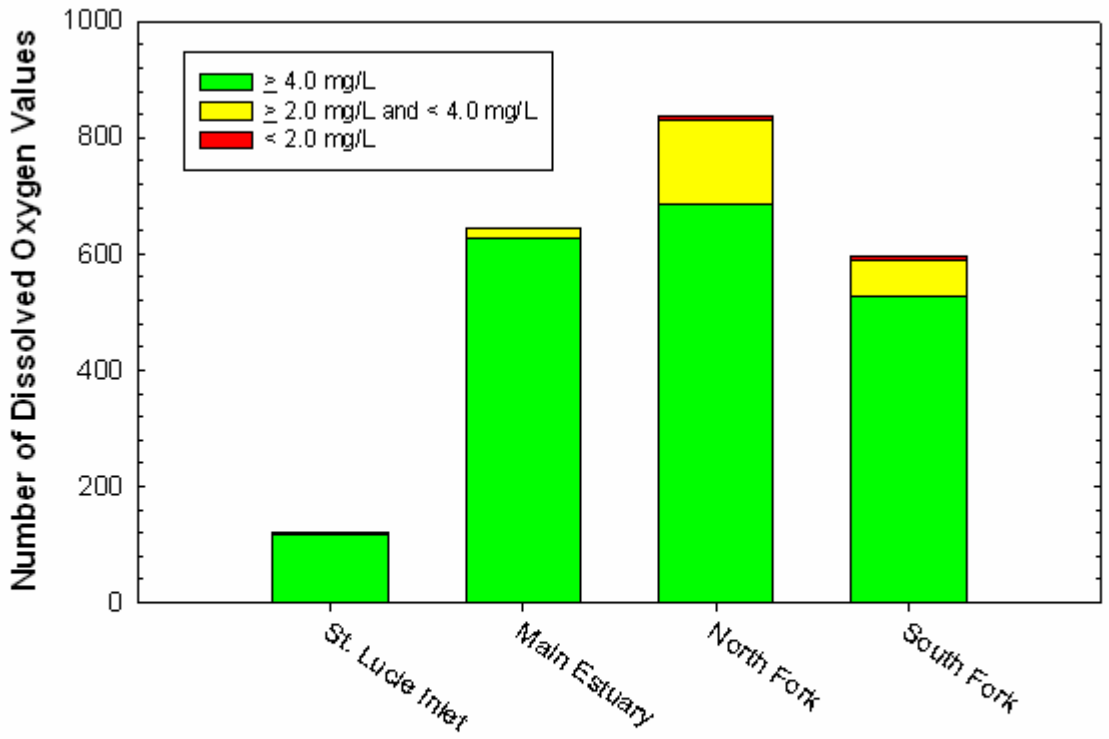








Water Quality Status & Trend, DO



Nutrient Susceptibility Index

DCP=Dissolved Concentration Potential

$$DCP = L(V_{fw}/i_{fw})(1/V_{tot}) = L/i_{fw}(V_{fw}/V_{tot})$$

$$= C_L * (1 - \frac{S_E}{S_o})$$

C_L= flow weighted nutrient concentration

S_E=estuary salinity
S_o=ocean salinity

Nutrient Susceptibility

For St. Lucie Estuary

S_o=35 ppt S_E=11 ppt

C_L	N (mg/L)	P (mg/L)
DCP	1.16	0.179

Nutrient Susceptibility

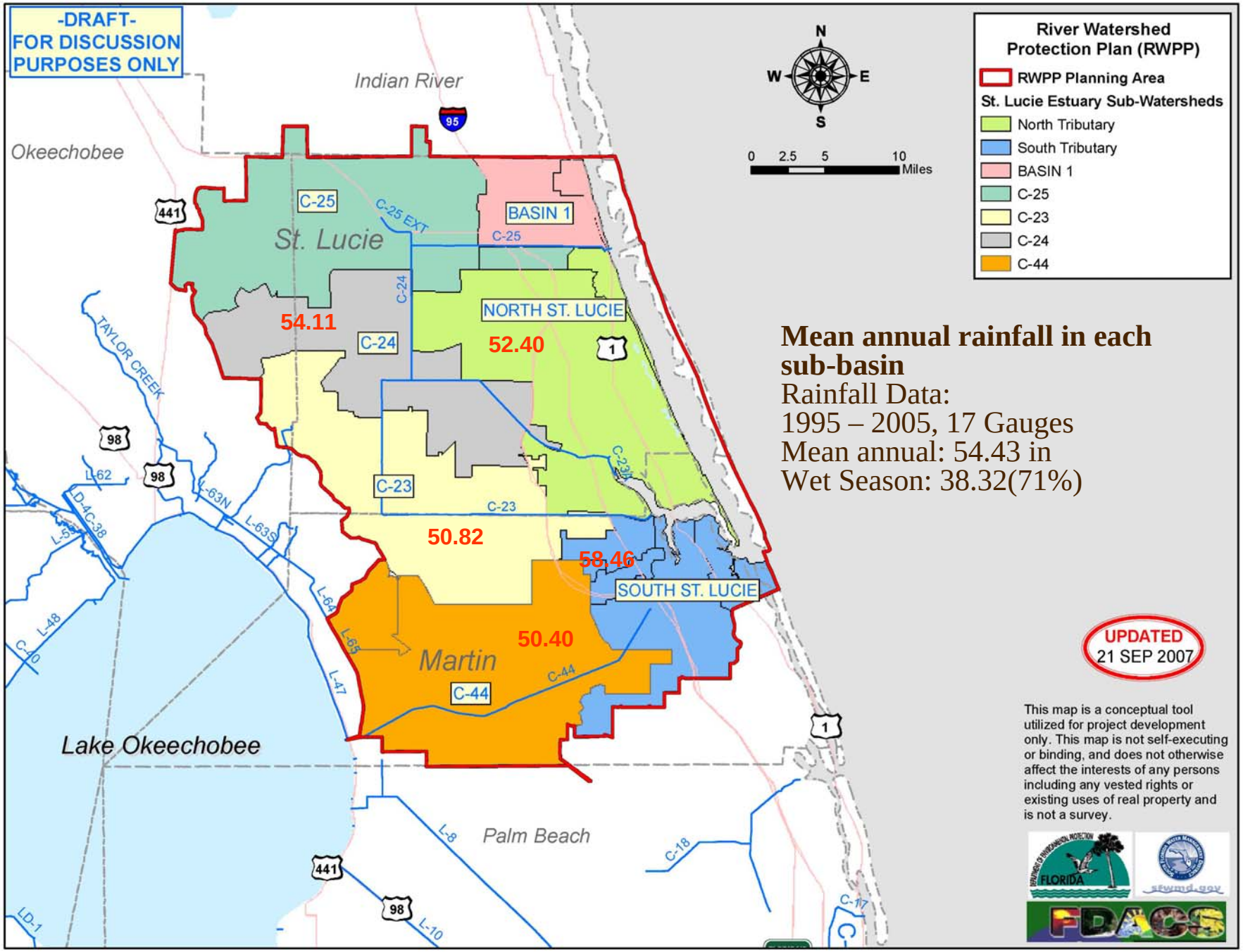
Table 1. Annual summary of freshwater flows and nutrient loads to the St. Lucie River

Water Year[a]	Total Freshwater Flow to Estuary[b] (m^3 X 10^6)	Phosphorus		Nitrogen	
		Loads[b] (metric tons)	Flow Weighted Mean[b] (µg/L)	Loads[b] (metric tons)	Flow Weighted Mean[b] (µg/L)
1993	922	204	221	1,169	1,268
1994	216	65	301	545	2,521
1995	1,391	236	170	2,035	1,463
1996	1,898	388	205	3,170	1,670
1997	427	71	167	658	1,542
1998	1,889	397	210	3,579	1,894
1999	472	127	270	757	1,603
2000	958	307	320	1,676	1,750
2001	246	53	215	348	1,414
2002	484	188	389	801	1,656
2003	728	189	260	1,056	1,450
2004	1,216	295	242	1,773	1,458
2005	1,470	601	409	3,224	2,193
2006	2,153	634	295	3,496	1,623
Mean	1,034	268	260	1,735	1,678

[a] Water year based on 12-month period starting in May and ending in April.
[b] Determined from gauged flow data and water quality samples collected at S-80, S-49 and S-48.

Water Quality Summary

- Strong seasonal cycle
- Correlation between loading and TN, TP in the estuary
- DCP - A useful index


-DRAFT-
FOR DISCUSSION
PURPOSES ONLY
Indian River
Okeechobee
St. Lucie
Martin
Palm Beach
Lake Okeechobee
C-25
C-25 EXT
BASIN 1
C-24
C-23
C-44
NORTH ST. LUCIE
SOUTH ST. LUCIE
54.11
52.40
50.82
58.46
50.40
TAYLOR CREEK
L-62
L-63N
L-63S
L-64
L-65
L-47
L-48
L-8
L-10
C-10
C-18
C-17
LD-1
D-4C-38
95
441
98
1
N
W
E
S
0 2.5 5 10
Miles
River Watershed
Protection Plan (RWPP)
RWPP Planning Area
St. Lucie Estuary Sub-Watersheds
North Tributary
South Tributary
BASIN 1
C-25
C-23
C-24
C-44
Mean annual rainfall in each sub-basin
Rainfall Data:
1995 – 2005, 17 Gauges
Mean annual: 54.43 in
Wet Season: 38.32(71%)
UPDATED
21 SEP 2007
This map is a conceptual tool utilized for project development only. This map is not self-executing or binding, and does not otherwise affect the interests of any persons including any vested rights or existing uses of real property and is not a survey.
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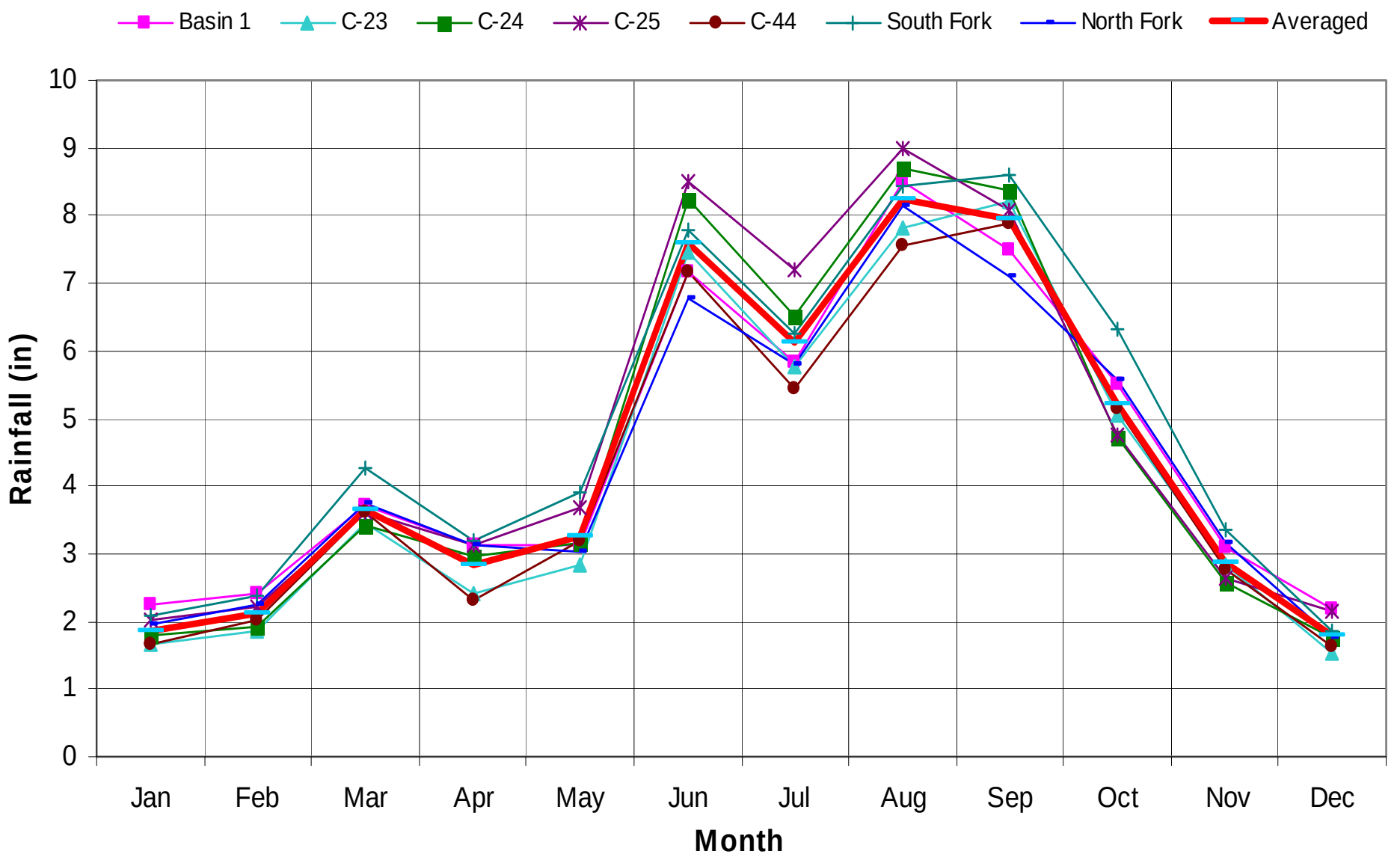
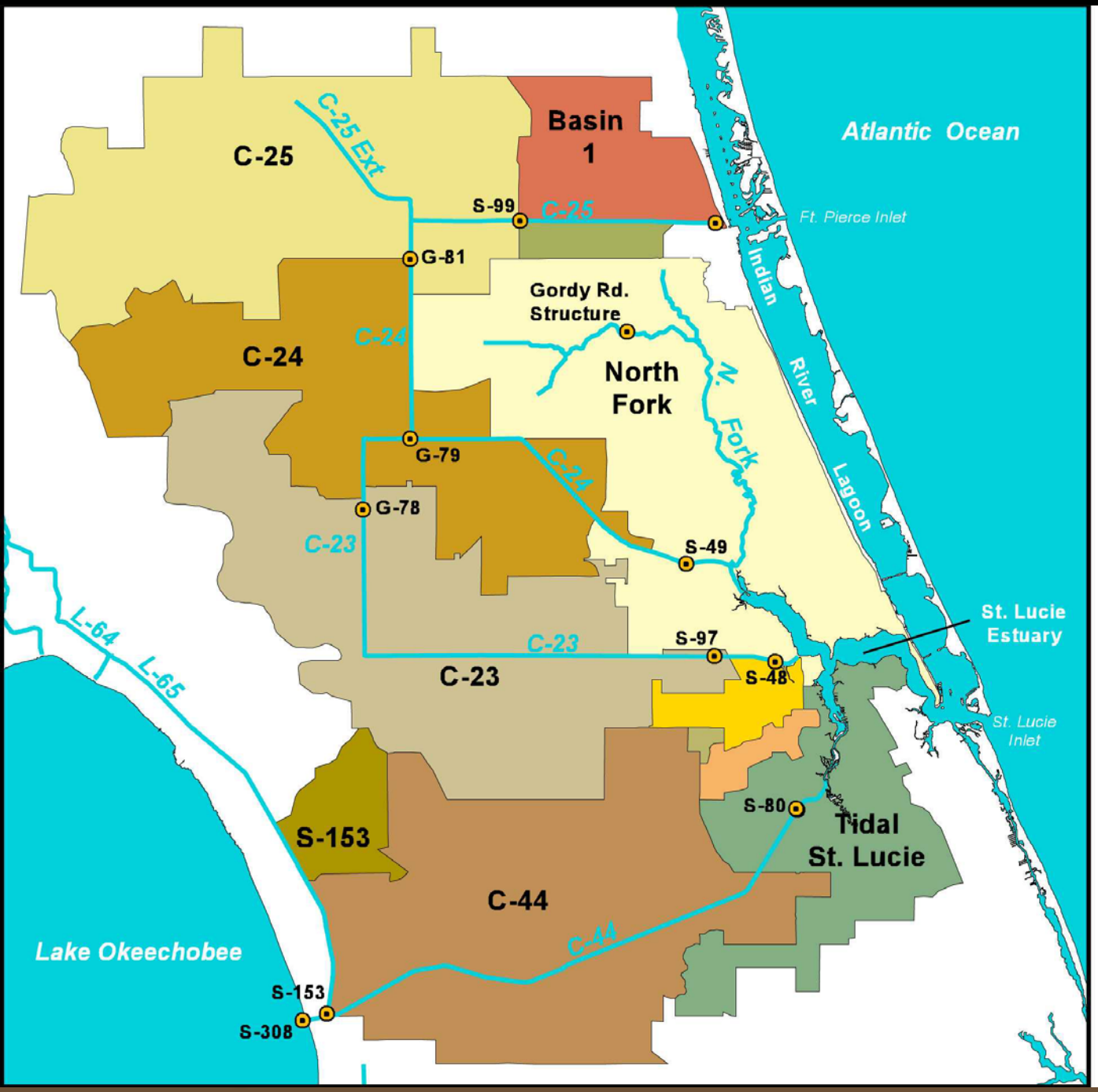
Seasonal Rainfall Distribution

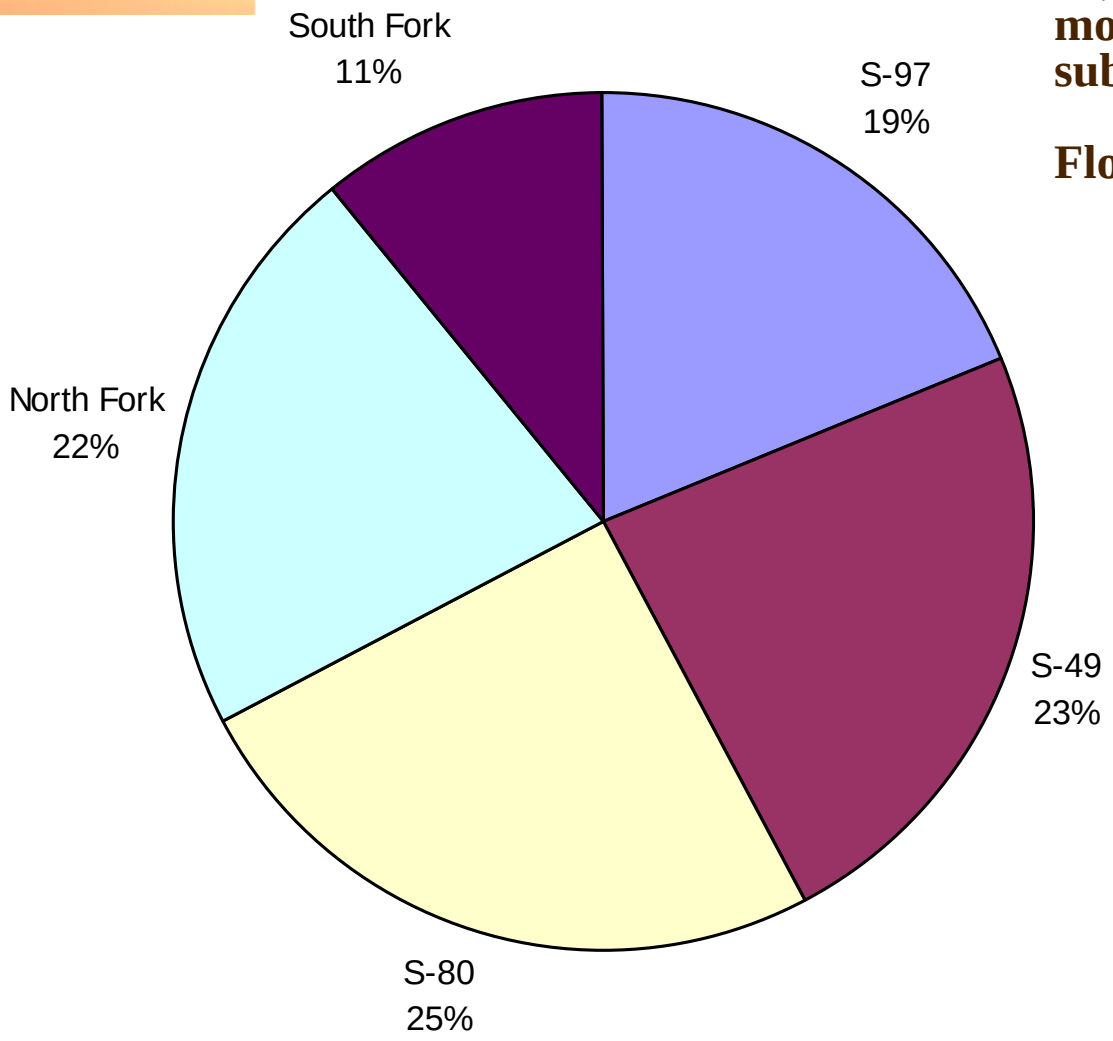




St. Lucie Estuary Watershed

Flow stations

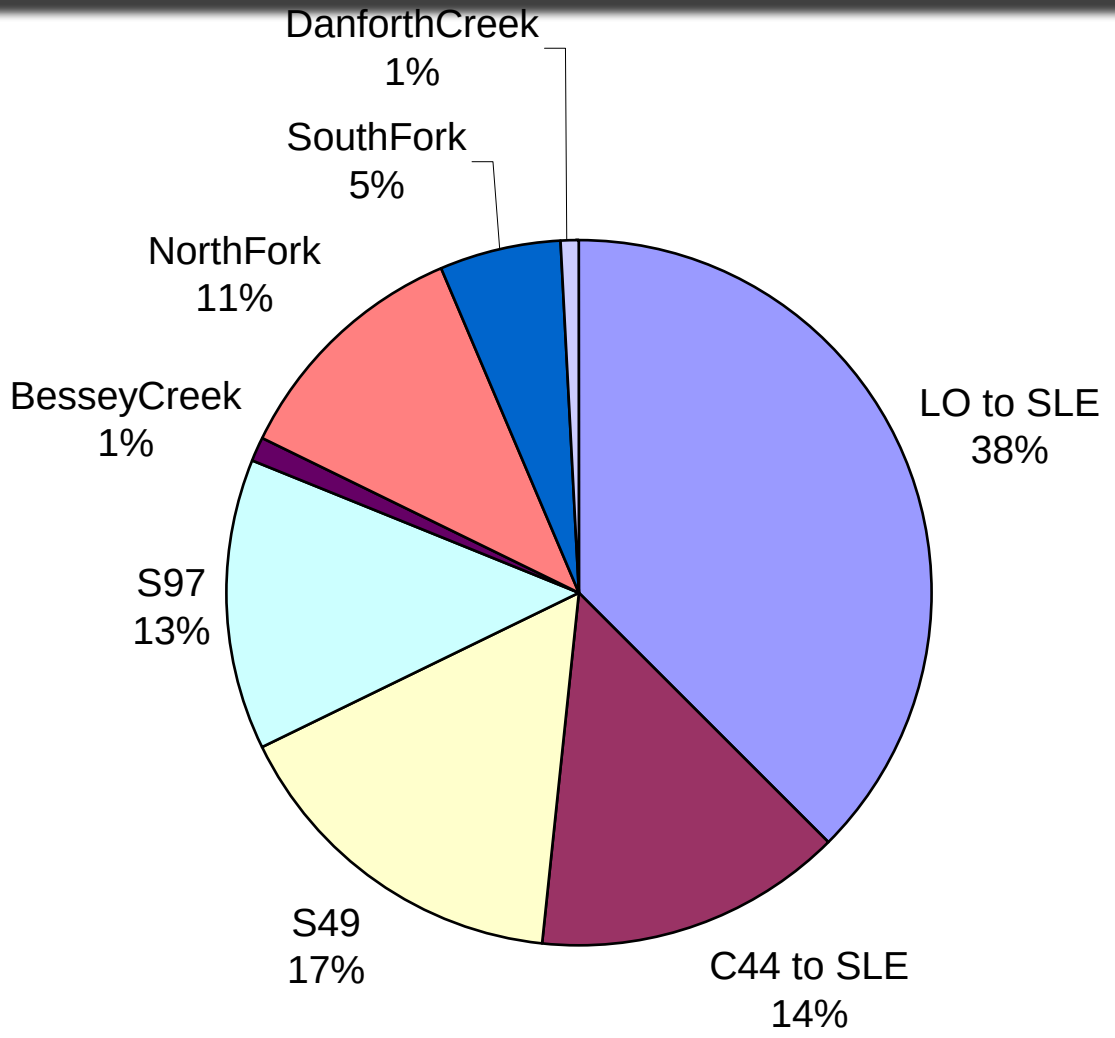
Flow data:



1995 – 2005 measured flow data at S-97, S-49, S-80, S-308, S-50, WaSh model output flow for South Fork sub-basin and North Fork sub-basin.

Flow from LO (S-308) is excluded.

Freshwater Inflow to St. Lucie Estuary in Percentage



1995-2005 Monthly Averaged Inflow to SLE (unit: cfs)
Without Lake Discharge

Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jan	982	120	135	1053	213	105	56	135	585	143	147
Feb	418	68	117	3020	152	65	46	311	133	363	98
Mar	659	1712	84	1402	50	125	46	102	480	109	1491
Apr	162	817	604	203	62	317	41	51	167	58	344
May	136	860	227	337	75	52	51	58	466	35	221
Jun	474	1425	820	147	1835	123	410	930	1201	258	4097
Jul	859	1054	1115	253	1023	822	1907	2472	1328	177	2313
Aug	5523	447	1906	1100	1414	543	2171	1272	3915	1675	1660
Sep	2831	599	1222	2918	1912	420	2668	1405	2107	9149	1298
Oct	7875	1738	322	564	5560	964	1212	245	787	1793	4333
Nov	570	278	279	3015	698	50	1612	84	530	184	4456
Dec	143	137	854	220	185	54	339	392	283	103	836

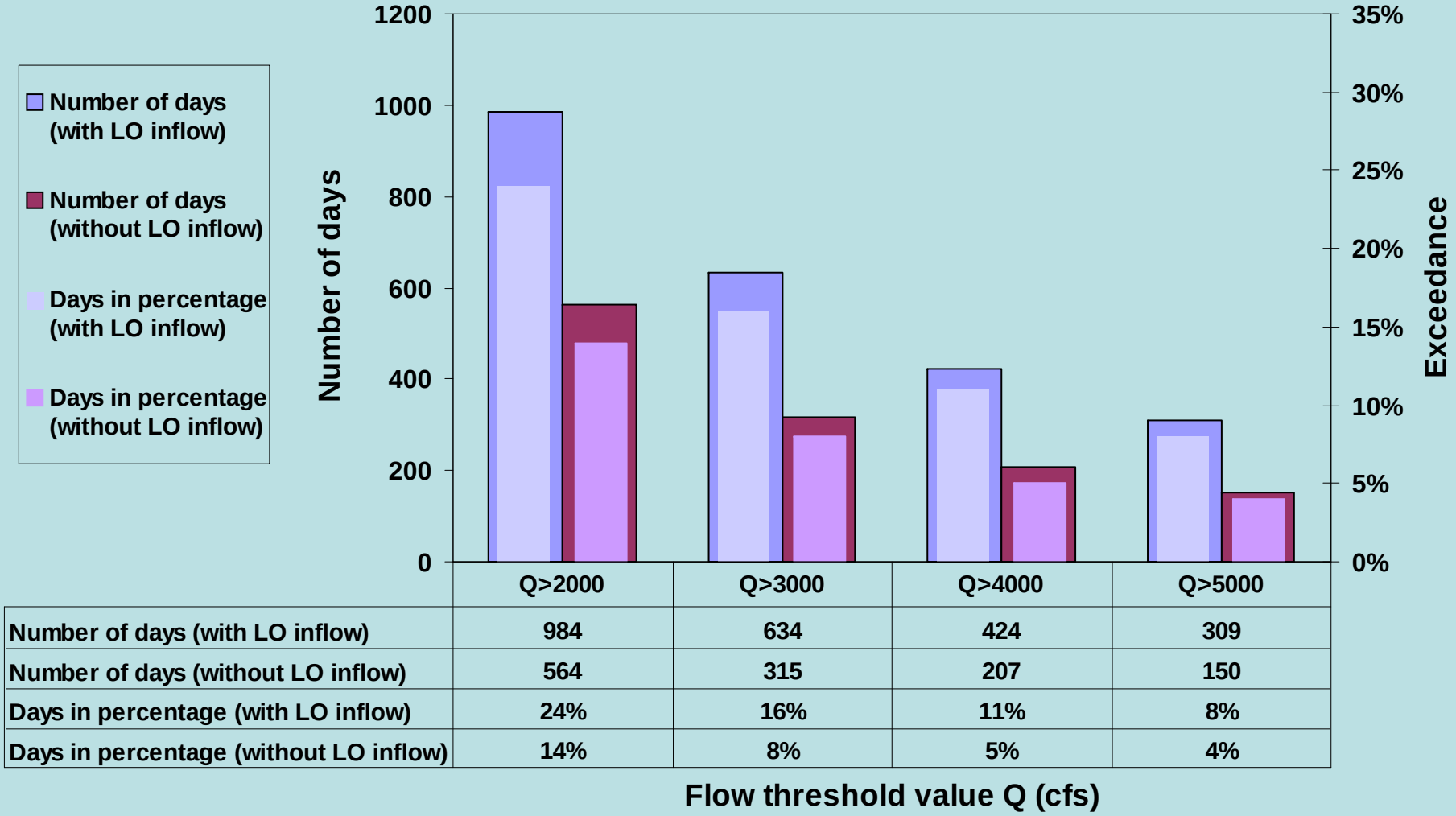
Note, Q>2000 cfs Q>3000 cfs

1995-2005 Monthly Averaged Inflow to SLE (unit: cfs)
With Lake Discharge

Month	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Jan	3277	924	140	3113	219	427	72	157	1597	651	354
Feb	1779	222	121	6235	169	92	71	321	794	739	454
Mar	1460	1727	90	8252	81	143	73	135	522	464	1892
Apr	759	1270	638	4547	198	773	55	84	219	266	1066
May	156	871	262	1191	92	1468	59	91	912	69	915
Jun	482	1712	850	169	1839	134	411	949	1799	273	4660
Jul	894	1858	1140	279	1027	830	1907	2523	1738	183	6019
Aug	6975	453	1918	1100	1419	569	2172	1484	4559	1677	3744
Sep	5662	628	1224	2919	1912	429	2672	1945	4844	9597	2124
Oct	10165	1743	341	568	6227	974	1220	543	1988	6636	4577
Nov	3931	308	310	3037	2137	85	1618	126	765	1971	6698
Dec	1119	150	1276	223	871	76	353	898	674	582	2937

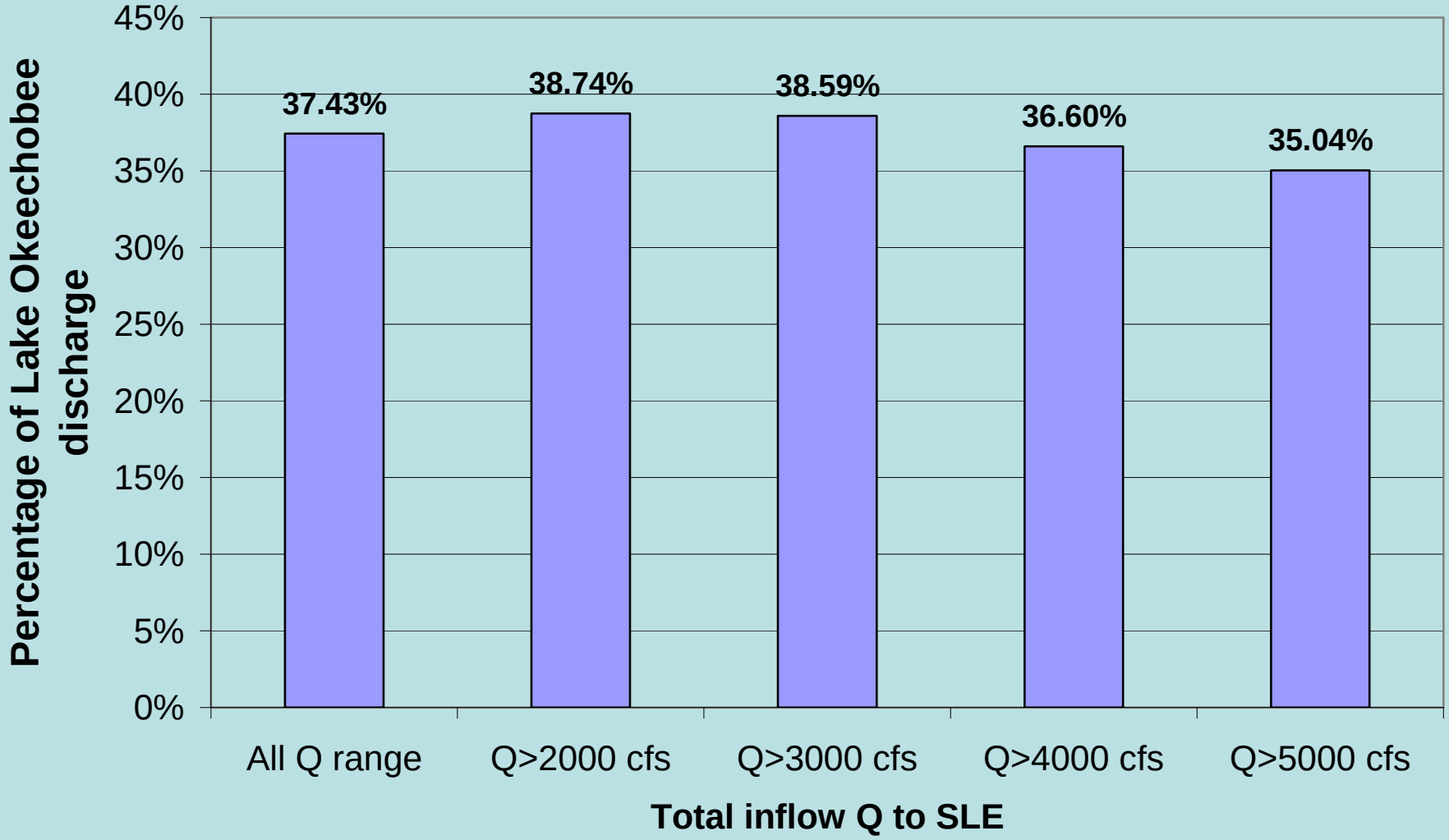
Note, Q>2000 cfs Q>3000 cfs

Percentage of days when total inflow to SLE exceeding certain thresholds from 01/01/1995 to 12/31/2005



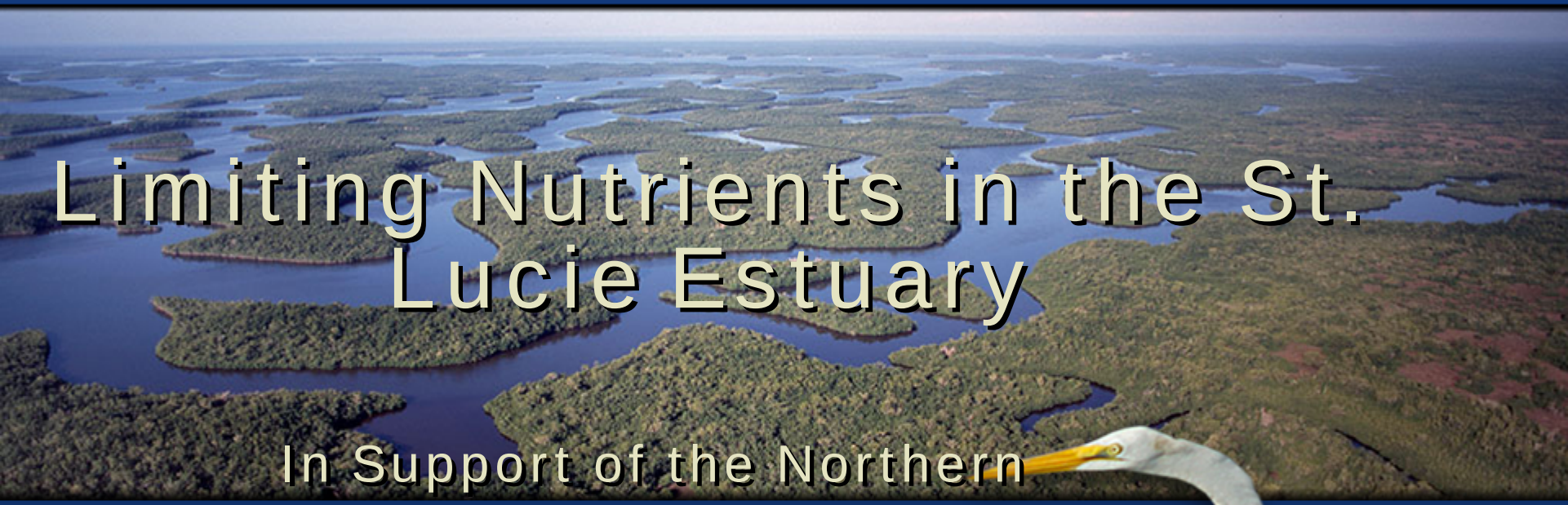
	Q>2000	Q>3000	Q>4000	Q>5000
Number of days (with LO inflow)	984	634	424	309
Number of days (without LO inflow)	564	315	207	150
Days in percentage (with LO inflow)	24%	16%	11%	8%
Days in percentage (without LO inflow)	14%	8%	5%	4%

Percentage of Discharge from the Lake Okeechobee in Total SLE Freshwater Inflow



SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Limiting Nutrients in the St. Lucie Estuary



In Support of the Northern Everglades Watershed Research & Water Quality Monitoring Program – St. Lucie Estuary Watershed

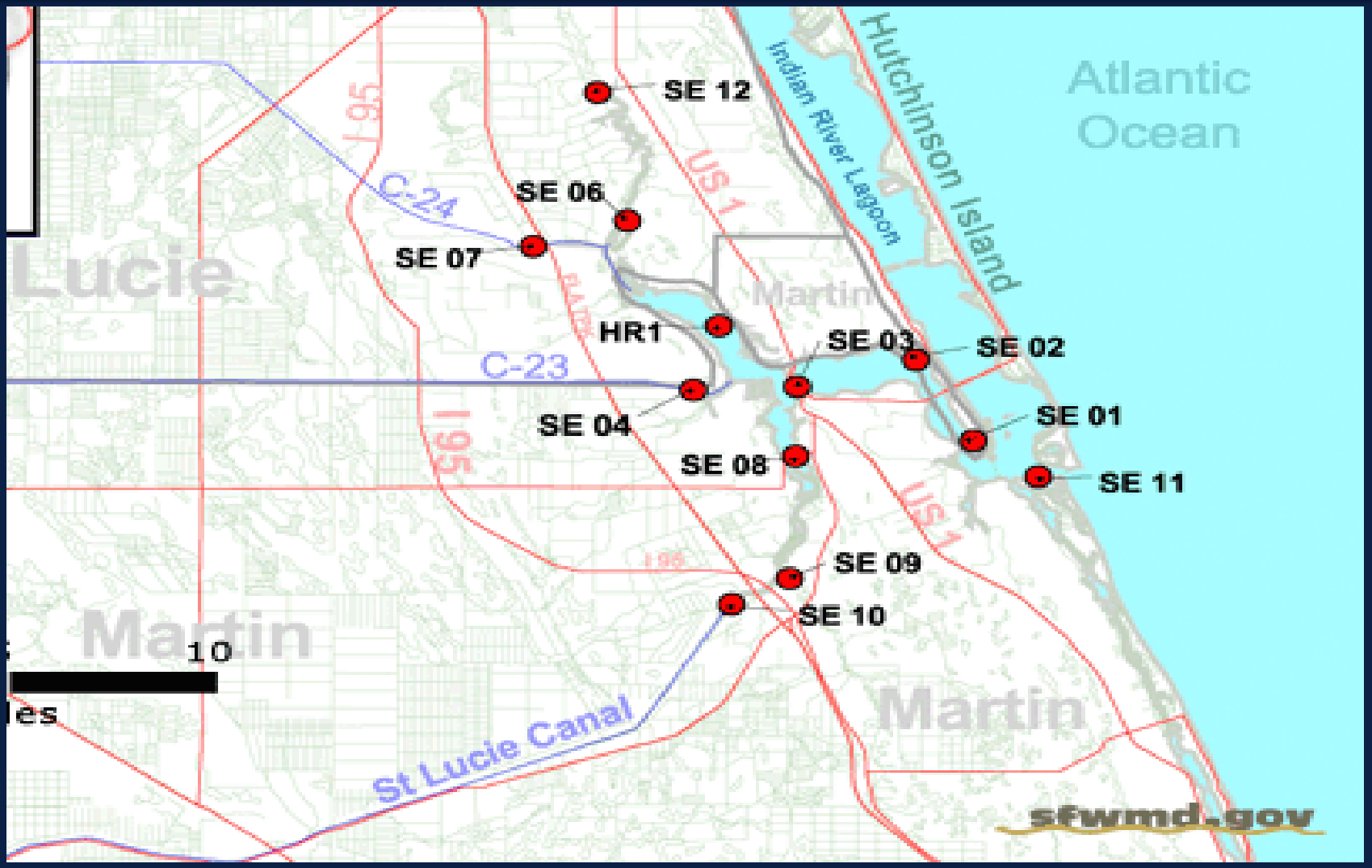
January 15, 2008

sfwmd.gov

Limiting Nutrients in the St. Lucie Estuary

- **Objectives**
  - Determine the nutrients (N, P, Si) limiting reproduction of phytoplankton in the estuary
  - Determine temporal and spatial changes of phytoplankton species composition (i.e. blue green and diatoms) in relation to available nutrients
  - Provide data in support of current and future water quality modeling efforts.

Limiting Nutrient Project Sampling Stations: 11, 2, 3, 8, and HR1



Products and Application:

1. Product: Peer reviewed documentation of the nutrients that are most influential to phytoplankton reproduction throughout the estuary during the wet and dry seasons.

   Application: Establishing the nutrient (s) that should be focused on when considering watershed, water quality management for a healthy estuary

2. Product: Documentation of phytoplankton species composition changes in response to nutrient concentrations in the estuary.

   Application: Development of water management techniques to enhance the probability of producing beneficial populations of phytoplankton for primary consumers (i.e. oysters)

Schedule:

- 3/07 to 4/08: Sample Analyses/Progress Reports
- 4/08: Data Analyses/Draft Final Report
- 5/08: Final Project Report