The Effects of the 2015-2016 El Nino on the Coastal Ecosystem around Sanibel Island, FL

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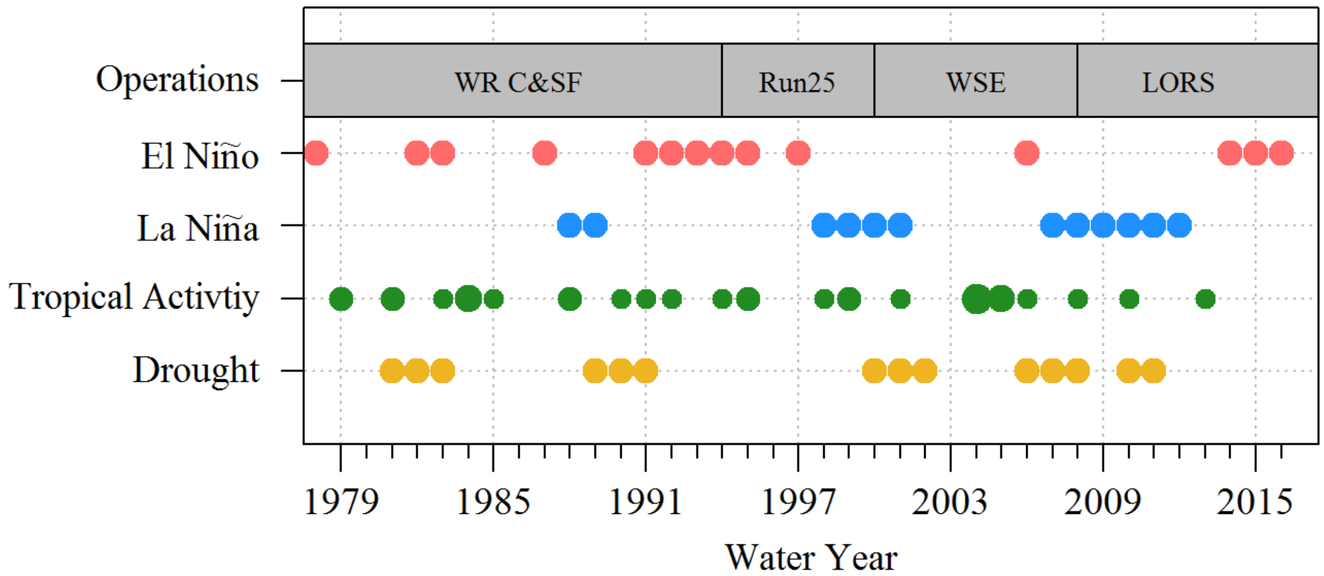
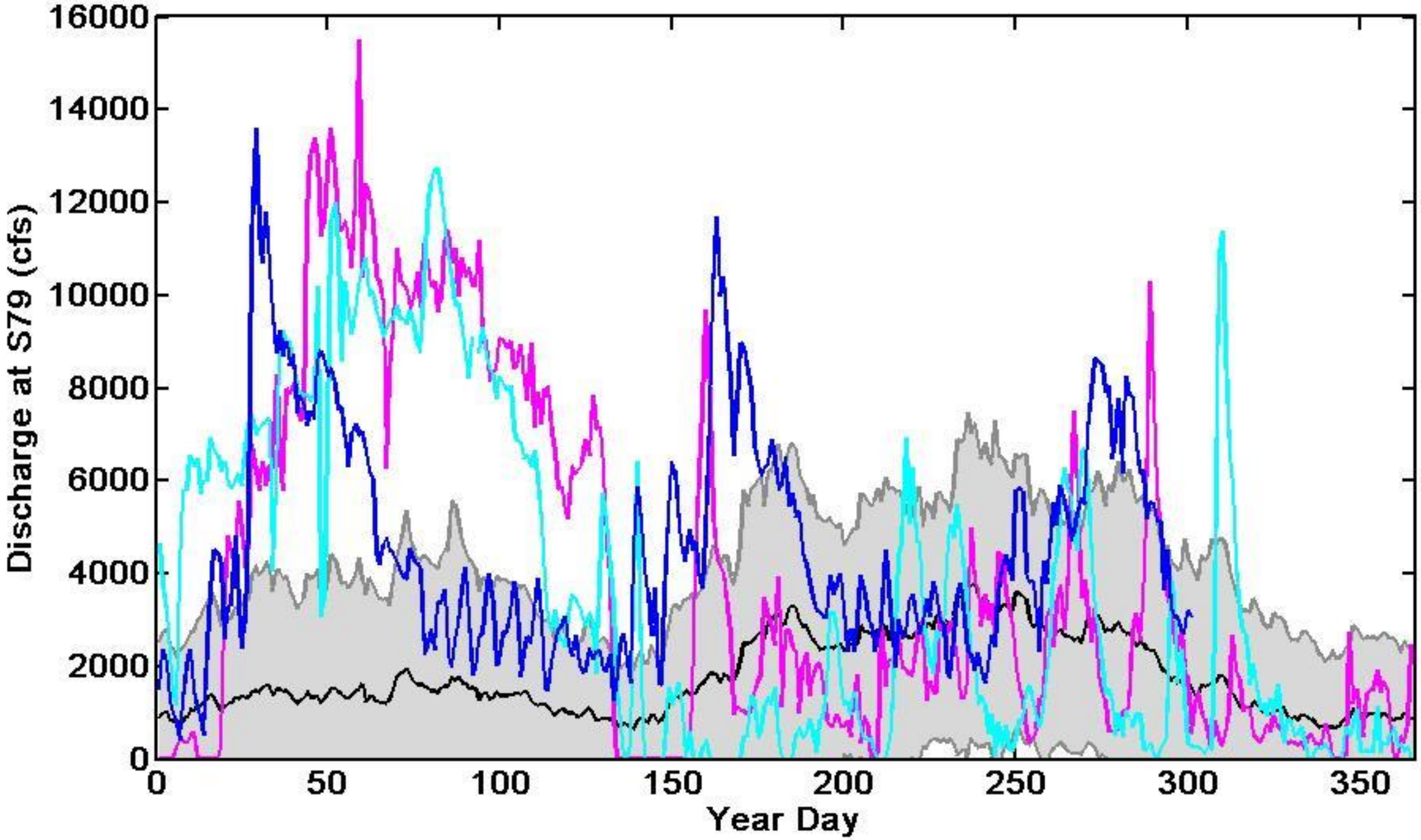


Figure 8. Lake Okeechobee operation timeline relative to climatic events. El Niño (red point) and La Niña (blue points) occurrence (Data Source: http://www.cpc.noaa.gov) , Tropical activity with the size of the point indicating the relative number of storms (Data Source: https://coast.noaa.gov) and identification of drought years (yellow points; Data Source: Abtew et al. (2009); Abtew and Ciuca (2017)). (Credit Paul Julien, FDEP)

2015-16 El Nino in SW Florida

- Severe weather (tornados, severe thunderstorms)
- Heavy rainfall
- Rainfall during the ‘dry season’ November-May
- Flood Control discharges from Lake Okeechobee in addition to watershed runoff

Grey - global average is 1966-2016
Magenta - 1983
Cyan - 1998
Blue 2016
Black line is average - grey shade is 1 s.d



- SCCF Marine Lab used existing research efforts to understand short and long term responses to 2016 El Nino
  - RECON (River, Estuary, & Coastal Observing Network)
  - 5-year Before After Control Impact (BACI; Geraldi et al. 2009) study of seagrass shoot density responses to wet season S-79 Flows
  - 3-year oyster restoration project (FDEP, FWC) that includes oyster settlement and density metrics

SCCF RECON

Sanibel-Captiva Conservation Foundation

River, Estuary and Coastal Observing Network

What is RECON?

Deployed in 2007-2008, 7 LOBO sites (Satlantic, Land Ocean Biogeochemical Observatory) to study freshwater discharges from the Everglades and watershed (event-driven)

Joined GCOOS 2011 as a non-federal data provider to deliver Real-time data to the GCOOS Data Portal

With GCOOS support, a Sensor Observation Service (SOS) was created, the first SOS on a non-agency database

Expanded to include Meteorological stations in 2012

Added current (1 m increments) and wave height at 1 site in the Gulf of Mexico

A similar regional system was deployed by FAU Harbor Branch on E. coast of Florida in 2015 (IRLO)

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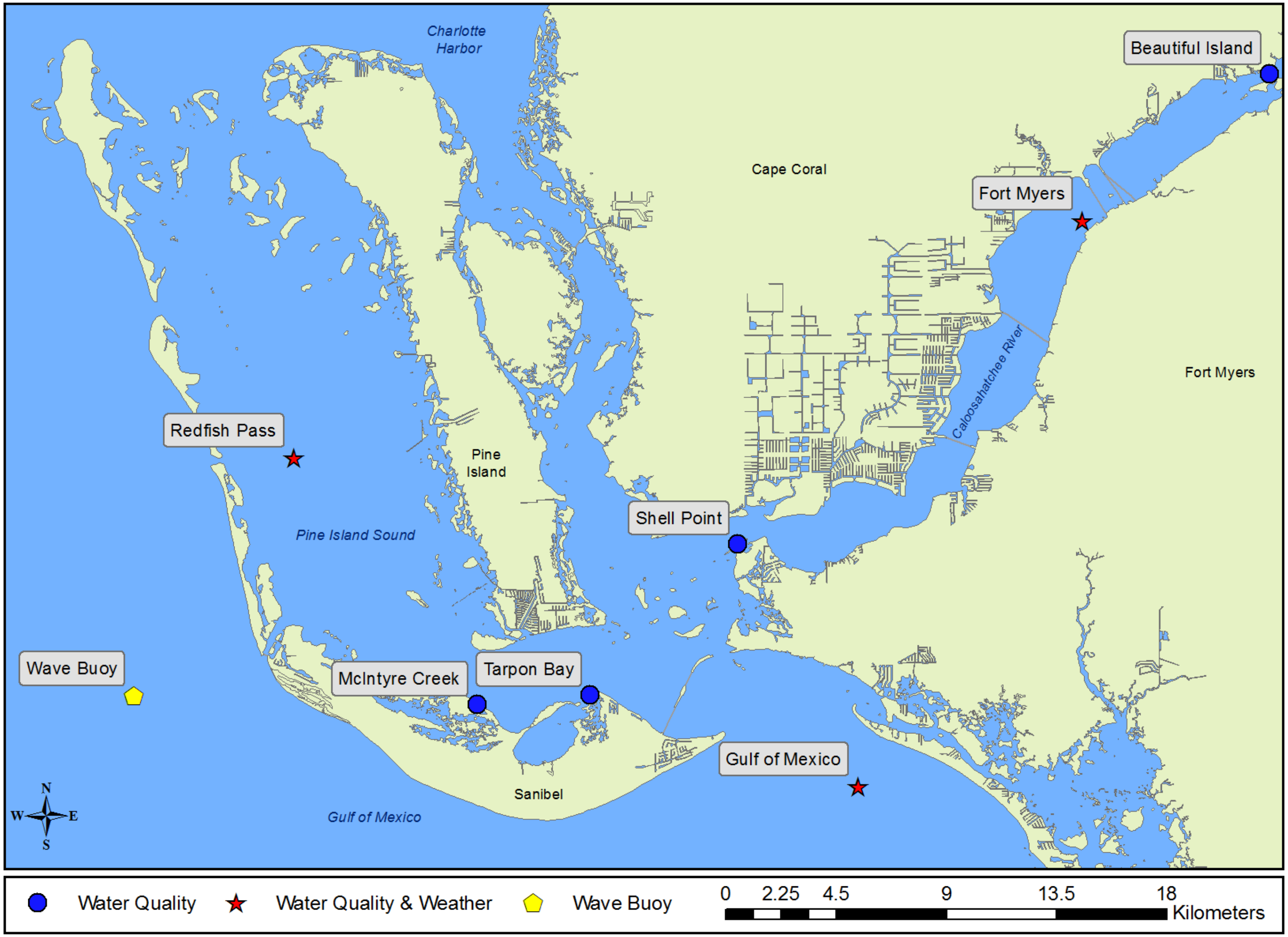
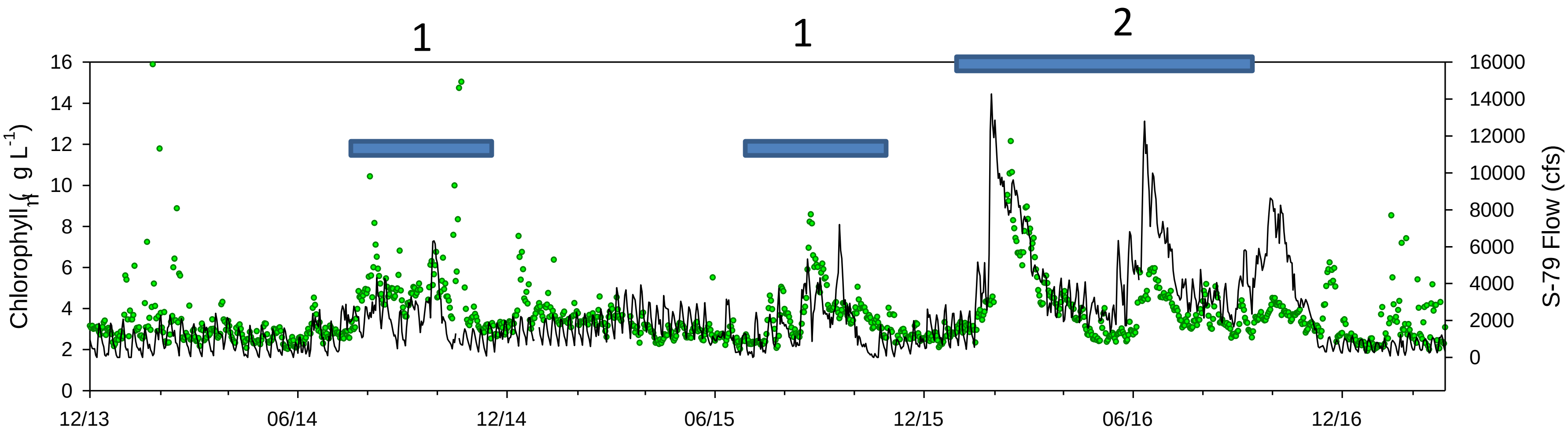
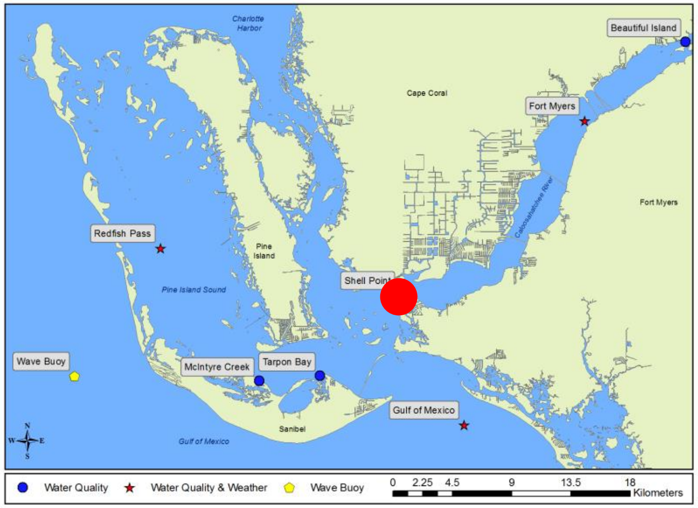


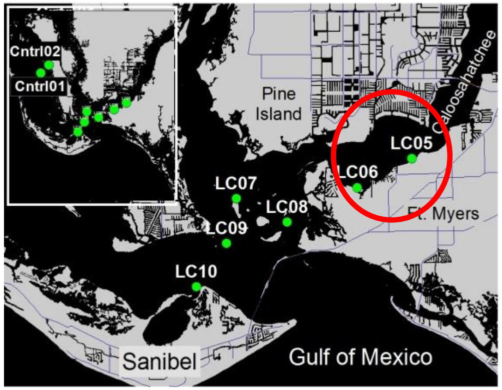


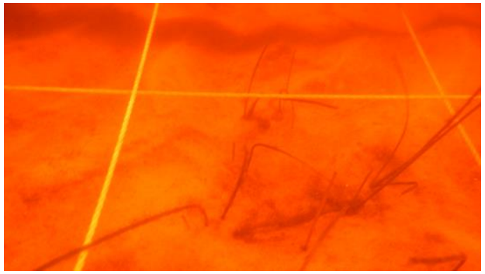
1. Higher chlorophyll associated with typical summer flows in 2014 and 2015
2. El Nino Flows during dry period with pronounced coordination with high flows from S-79 with a 1-2 week lag; exhibiting "dose-response" above 2,800 cfs; chlorophyll maximum to the lower estuary

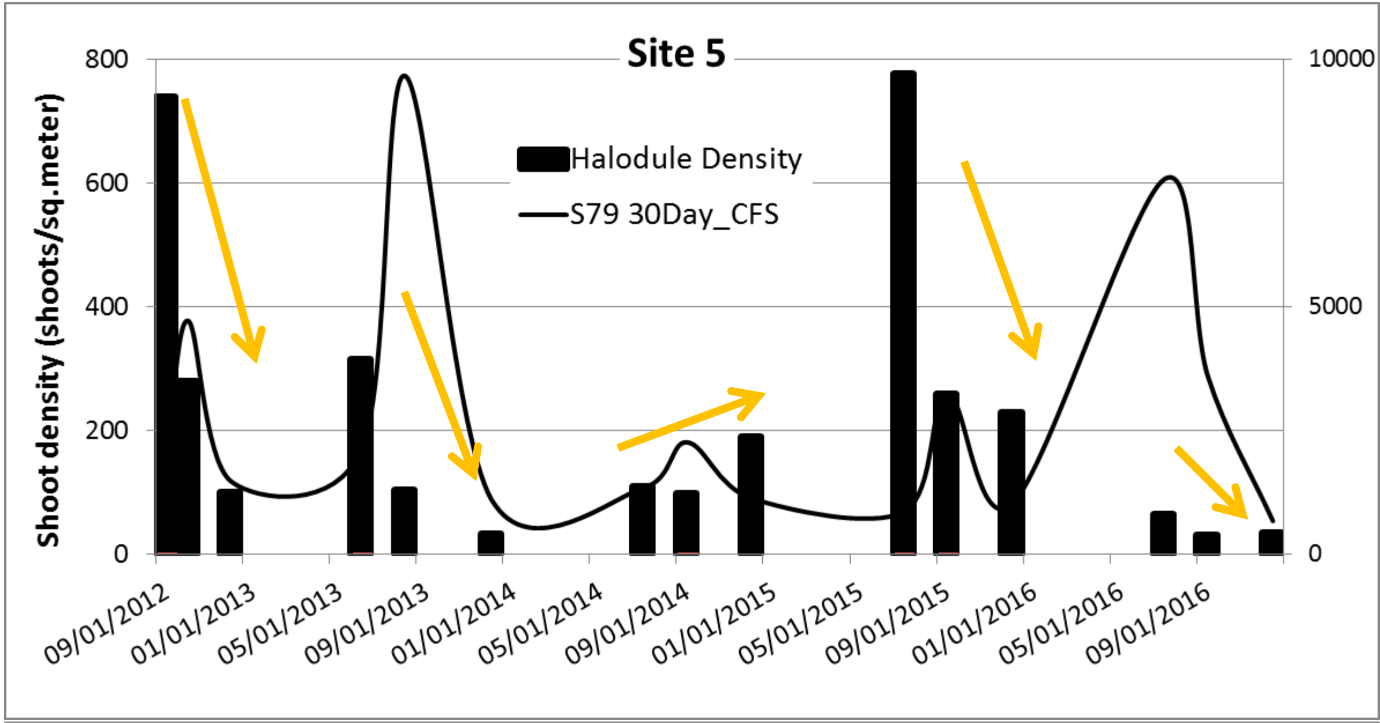


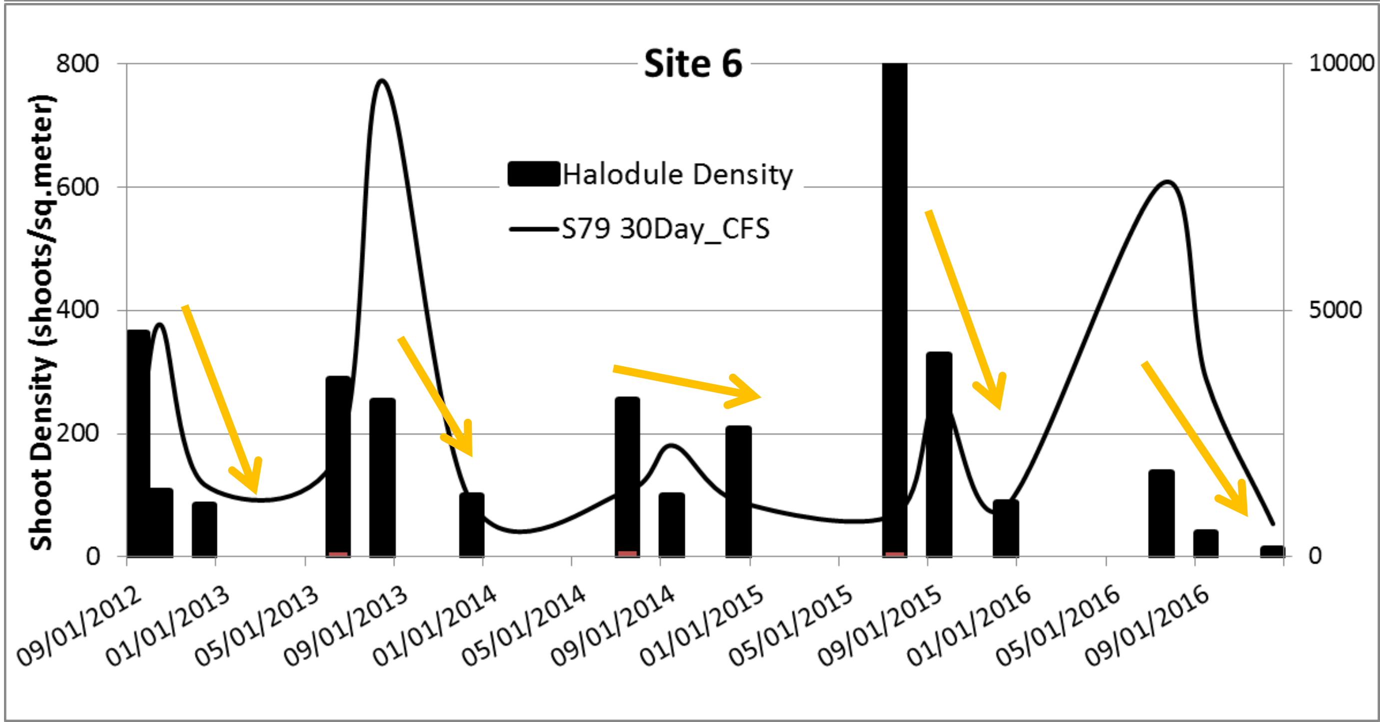
BACI SAV Upstream Sites

N=10, 1 m^2 quad
Shoot density

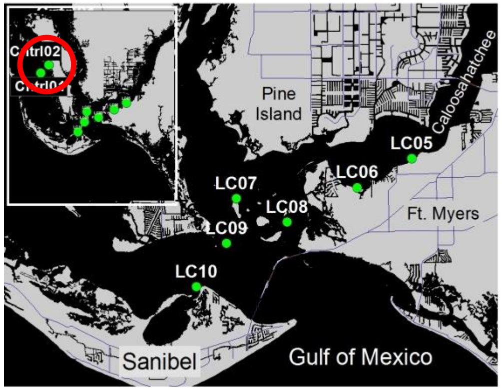




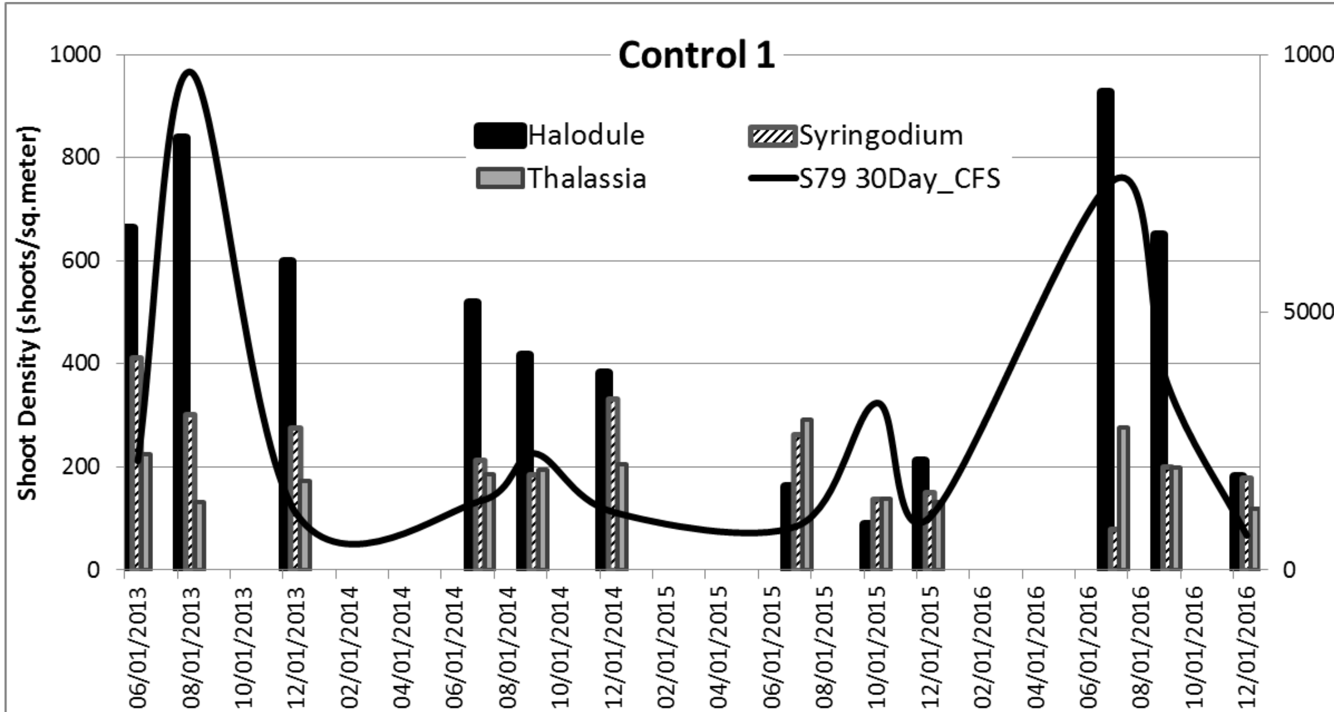


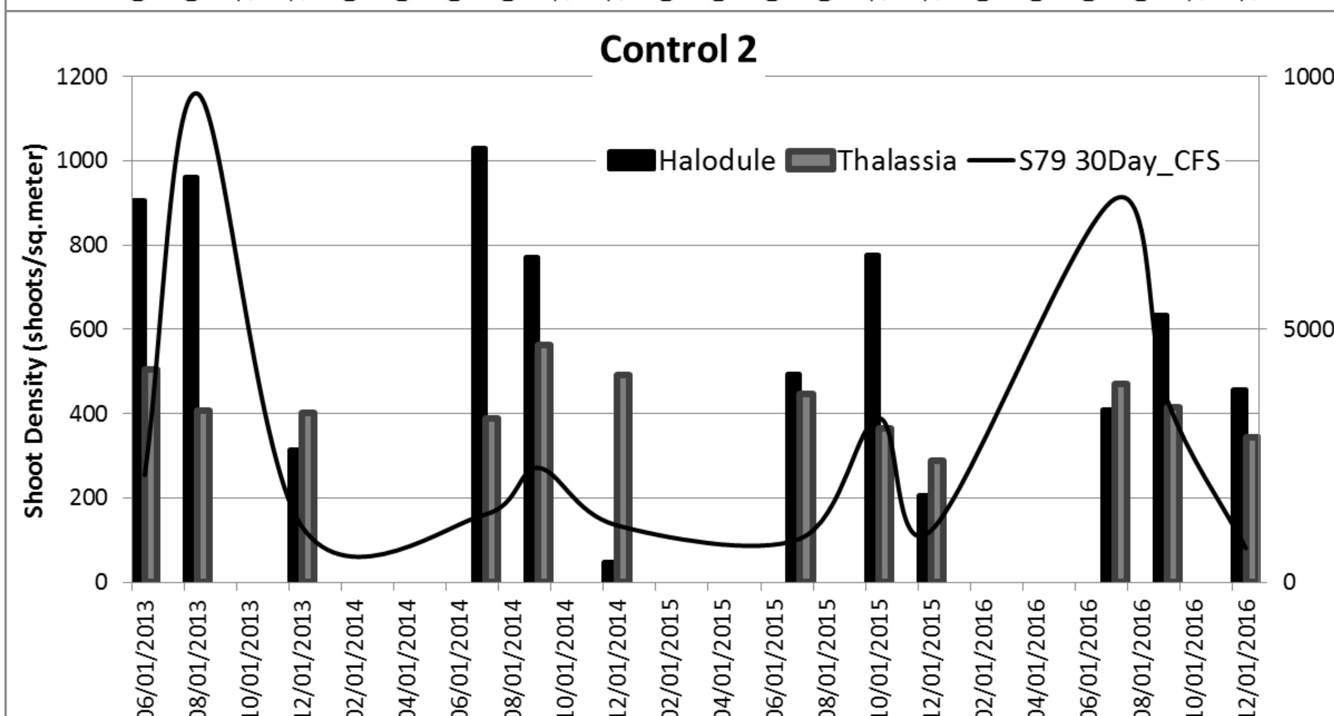


Control Sites Upper Pine Island Sound



Exhibiting a seasonal self-shading

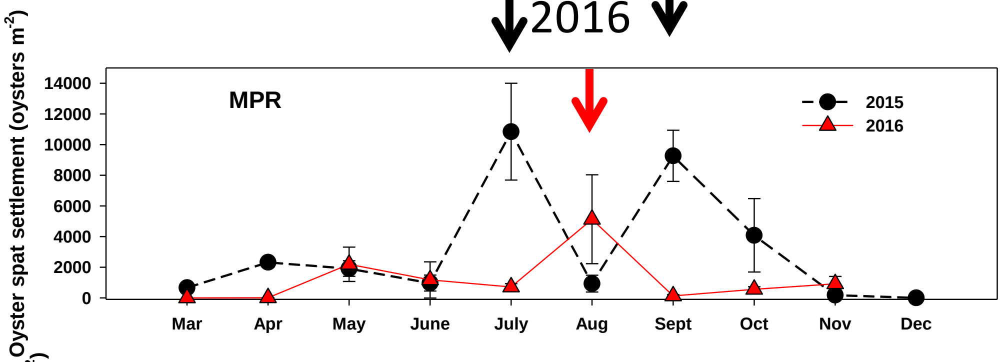


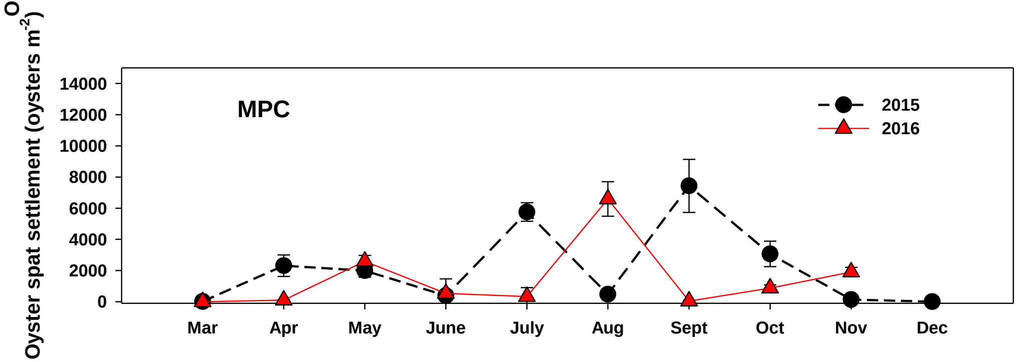


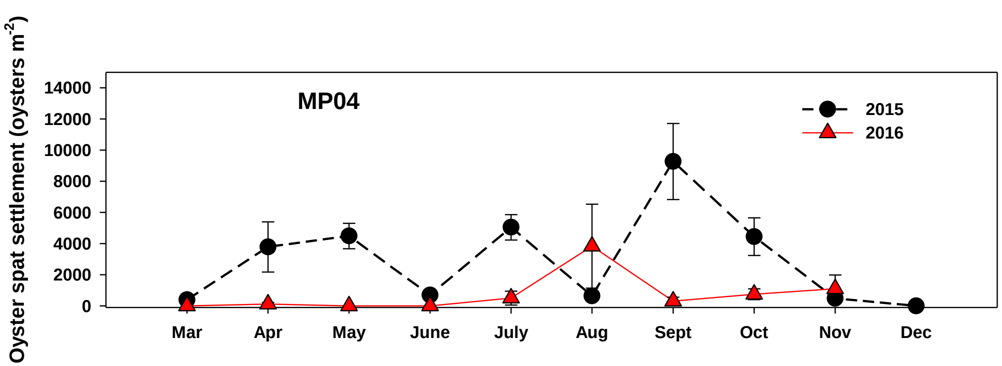
Oyster Settlement

2015

2016







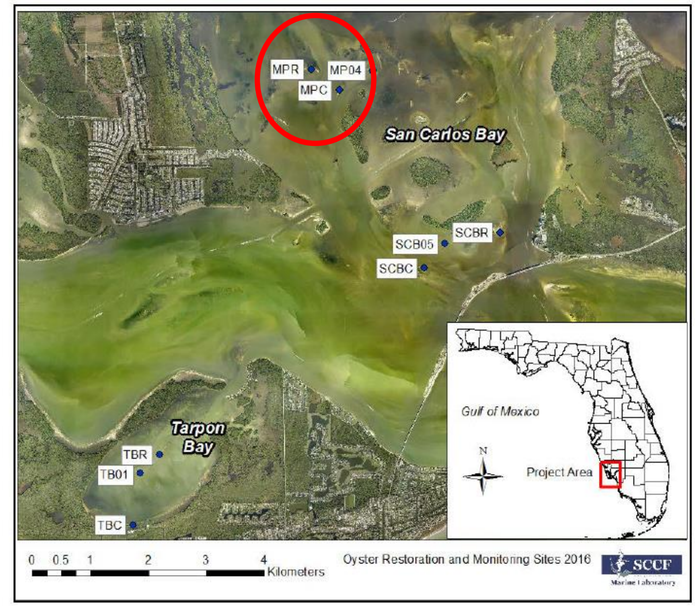
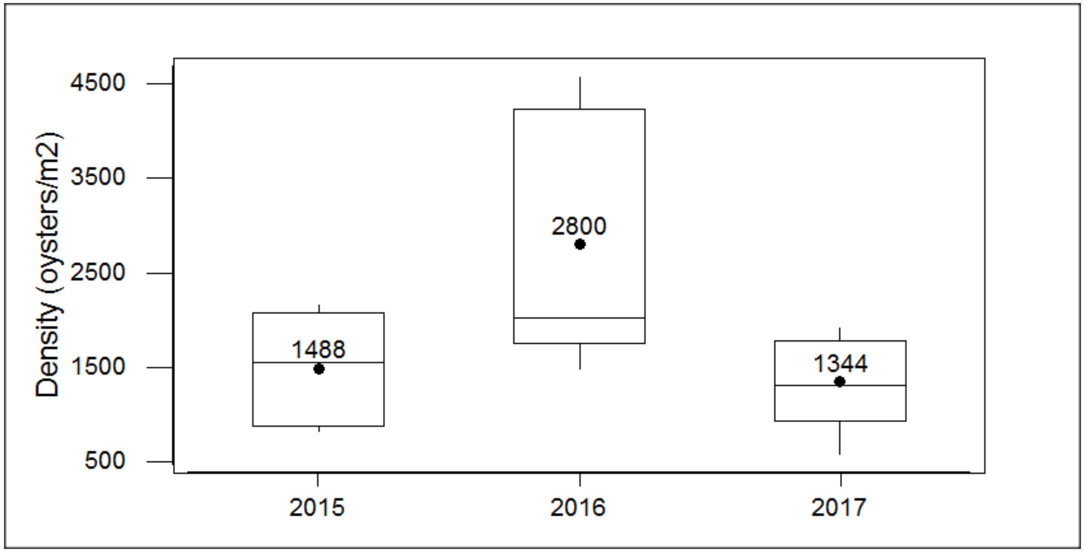
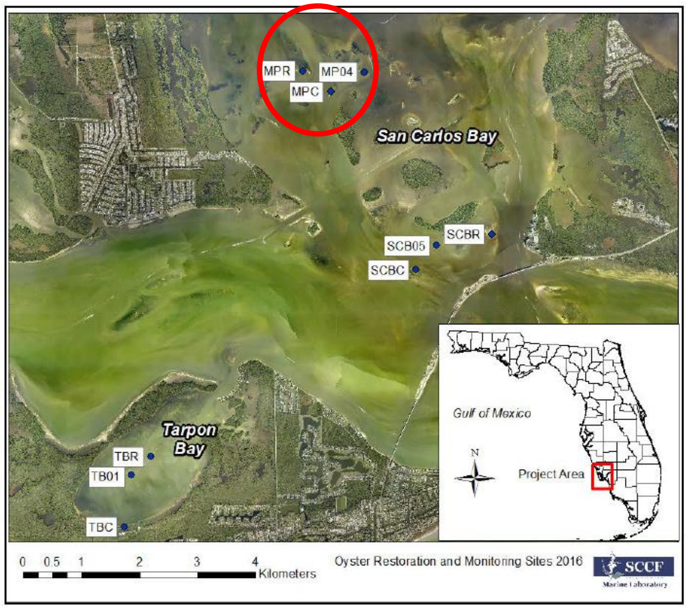


Figure 1. Map of S0752 Oyster Restoration and Monitoring sites (2016).

Oyster Density





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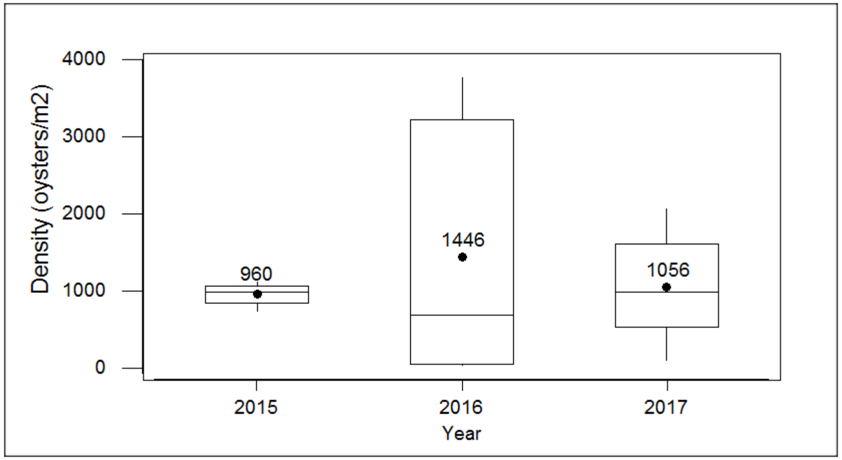
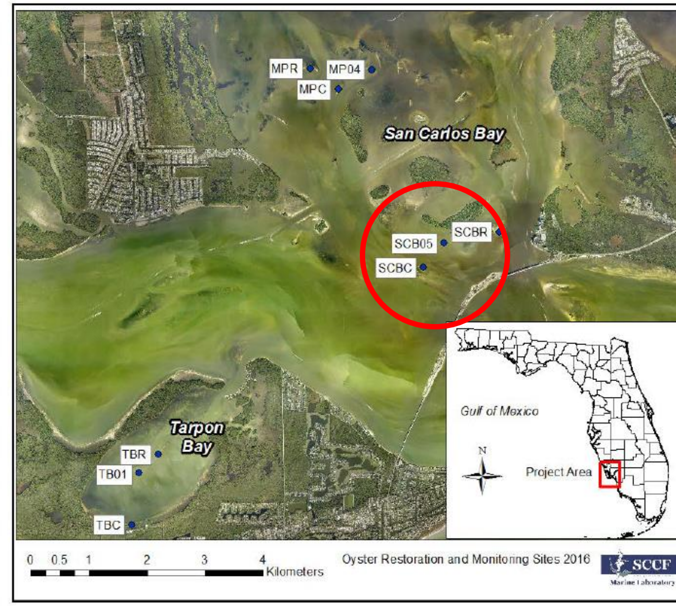
N=5, 1/16 m2 quadrat, collected in Feb.

Oyster Density



N=5, 1/16 m2 quadrat, collected in Feb.



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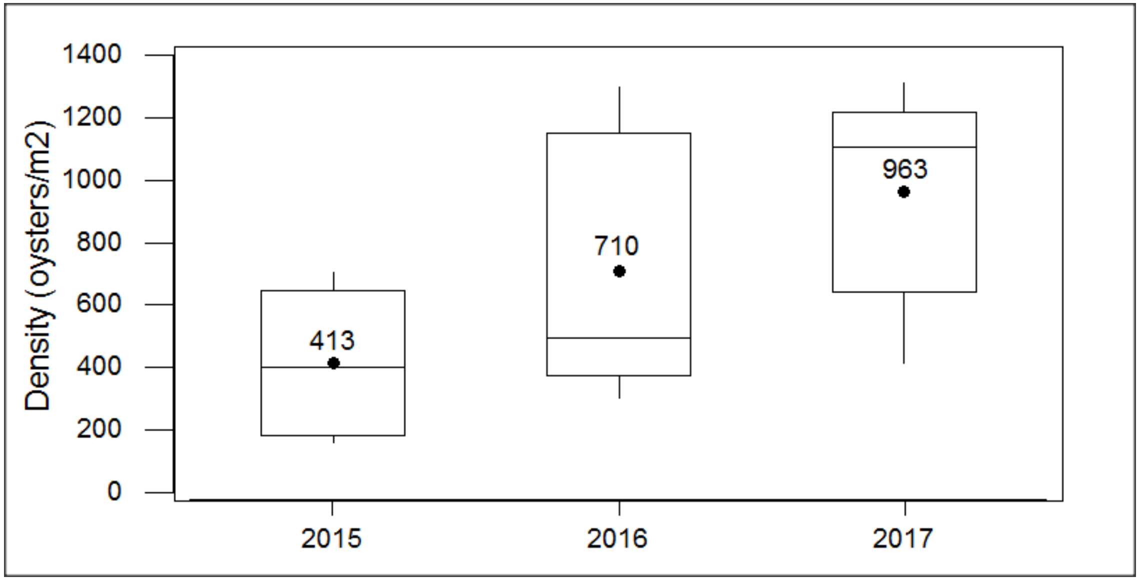

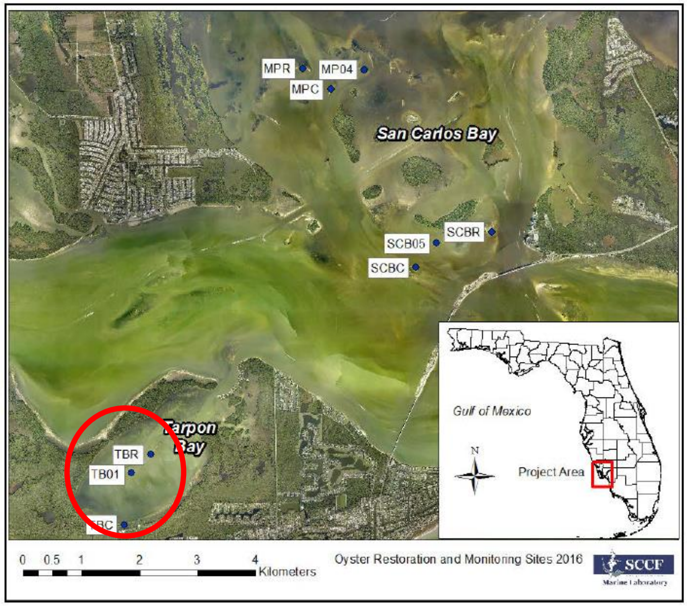

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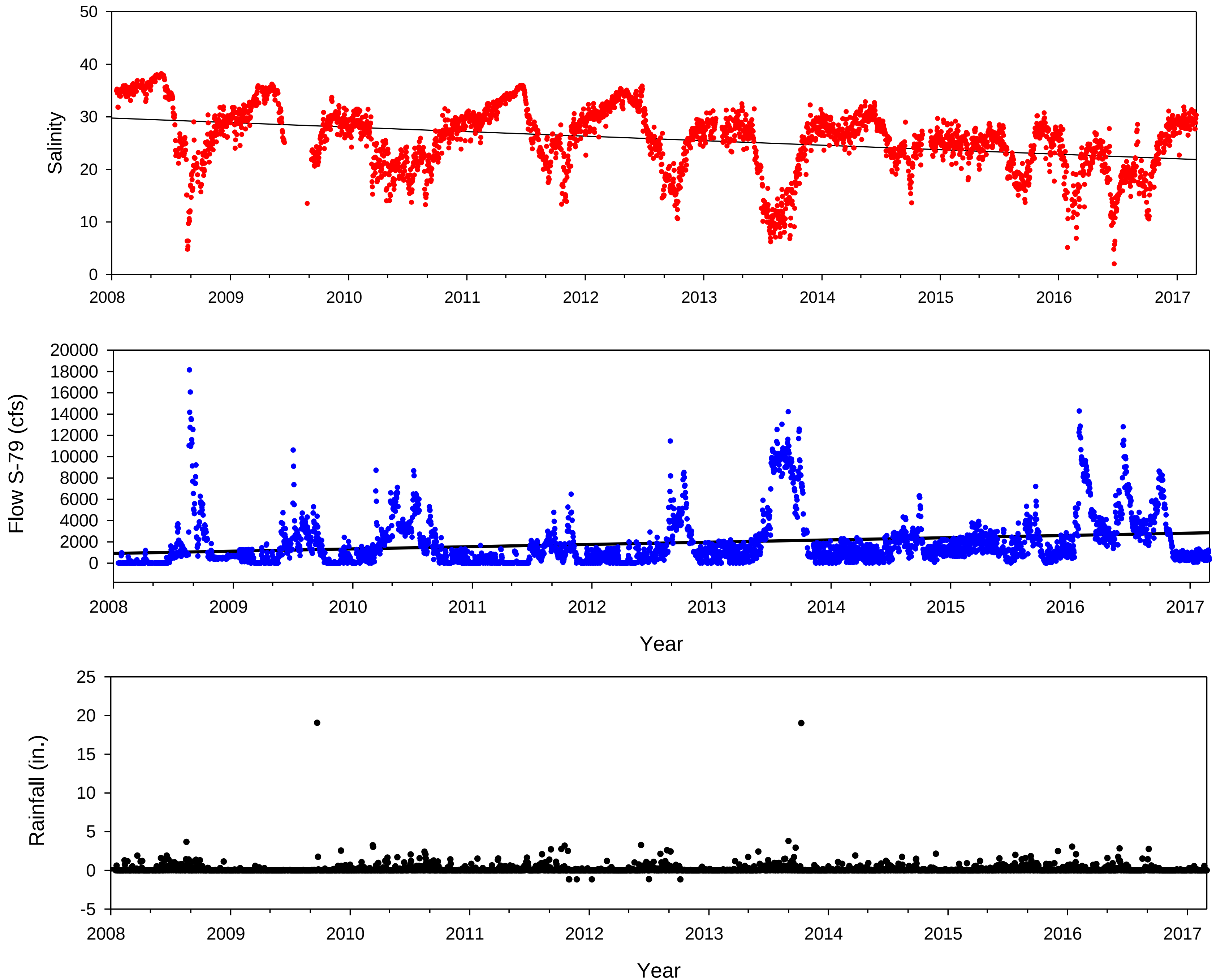
El Nino Summary

- Chlorophyll is responding to S-79 flows above 2,800 cfs, consistent with a nutrient loading conceptual model
- *Halodule* shoot densities decrease in response to S-79 flows (osmotic stress) every year. However, interannual flow differences exhibit a lag effect, high flows=lower densities the following year
- Oysters densities decreased near the Caloosahatchee but increased further down stream settlement
- Settlement was lower during high flows (larvae more sensitive to low salinities; adults spawn less)

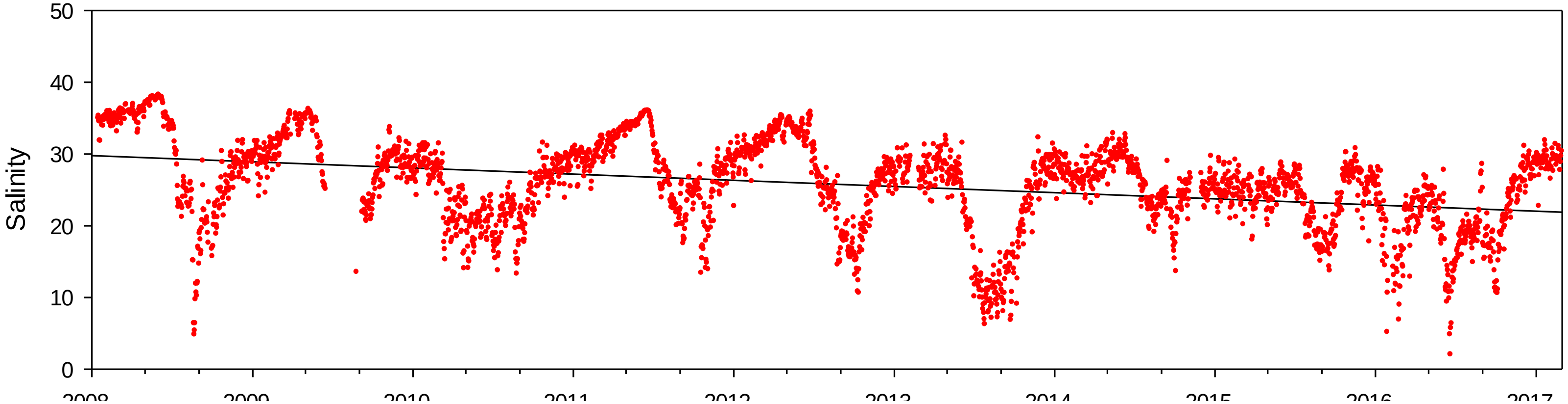
Resilience

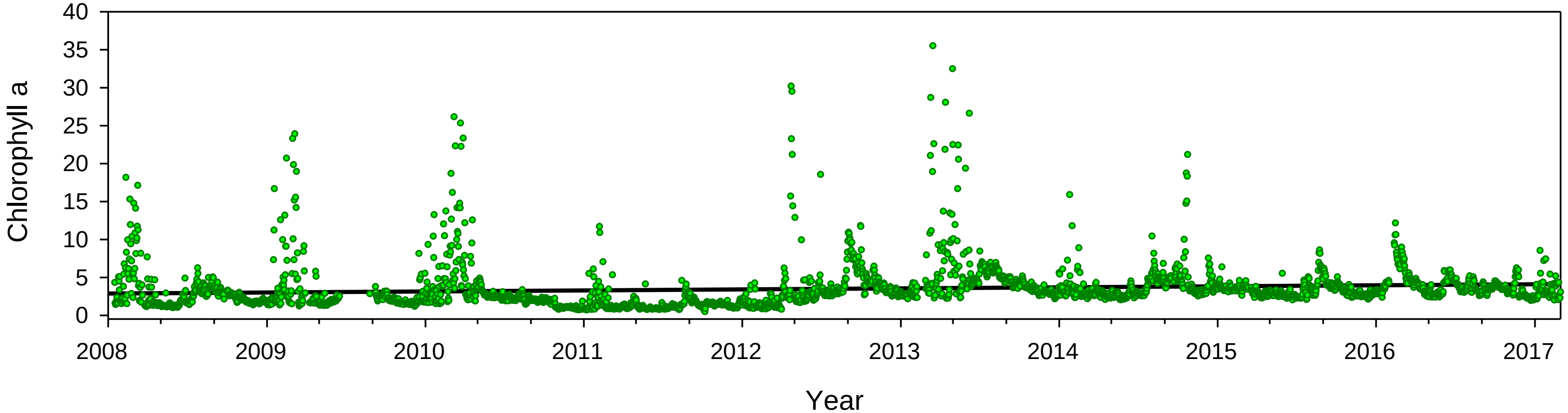
- Ability to absorb short term climate disturbances (hurricanes, tropical storms (e.g. Faye), cold fronts), while maintaining function
- Resilience is key for long-term persistence in the face of decadal drought/El Nino cycles, increased pollutant loads from land use changes, Everglades restoration
- Abrupt and unanticipated shifts in ecosystem state have led to significant changes in water quality habitat function, and fisheries catches (Scheffer et al. 2001, Folke et al. 2004, Levin and Lubchenco 2008, Leslie and Kinzig 2009)

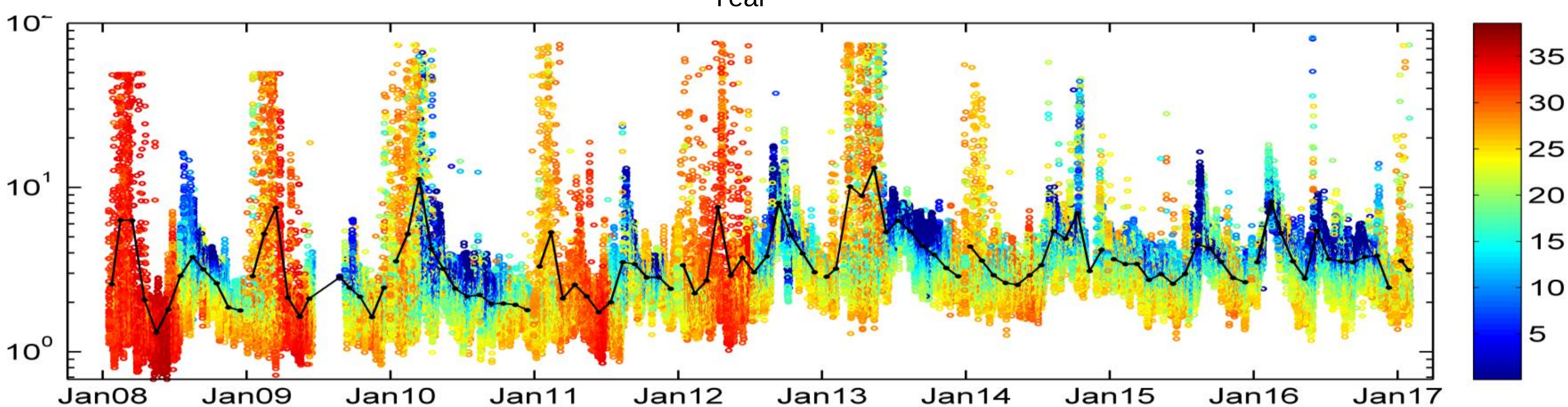
Ecosystem Type	State I	State II	Trigger Events	Factors affecting resilience
Coral Reefs	Hard coral	Macroalgae	Hurricanes, pathogens, sea urchin overgrazing	Climate change, overfishing, nutrient loading
Kelp forests	Kelp	Urchin	Sea urchin overgrazing	Removal of marine grazers (otters, crabs)
Shallow lagoons	Seagrass beds	Phytoplankton blooms	Hurricanes, freshwater runoff, pollution	Climate change, nutrient loading, sea-level rise, coastal development
Coastal Seas	Submerged vegetation	Filamentous algae	Increased sedimentation, pollution	Nutrient loading, removal of marine grazers (gastropods

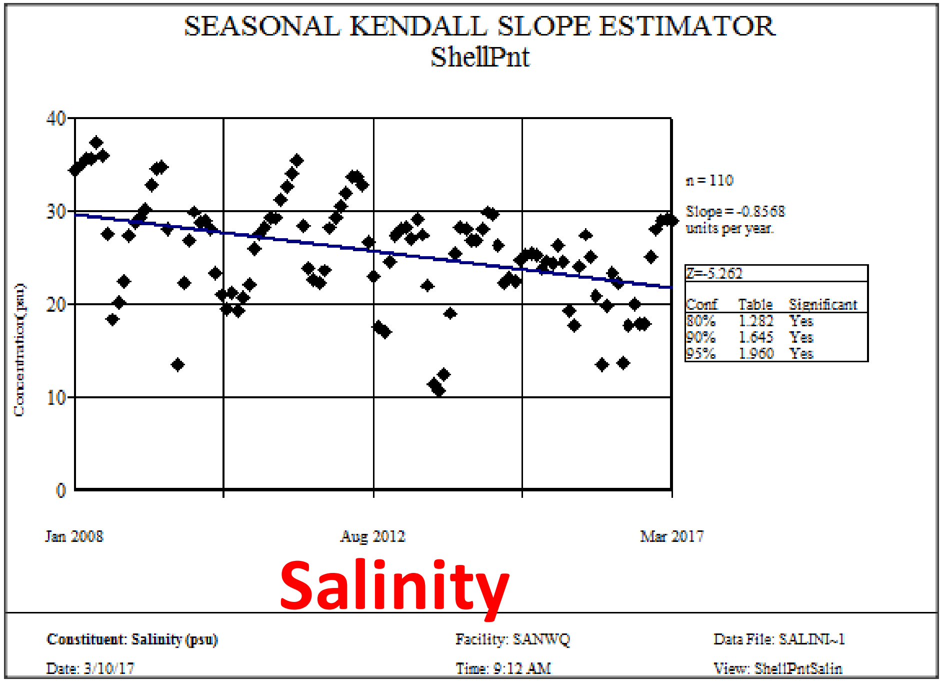

Salinity
50
40
30
20
10
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Flow S-79 (cfs)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Year
Rainfall (in.)
25
20
15
10
5
0
-5
Year

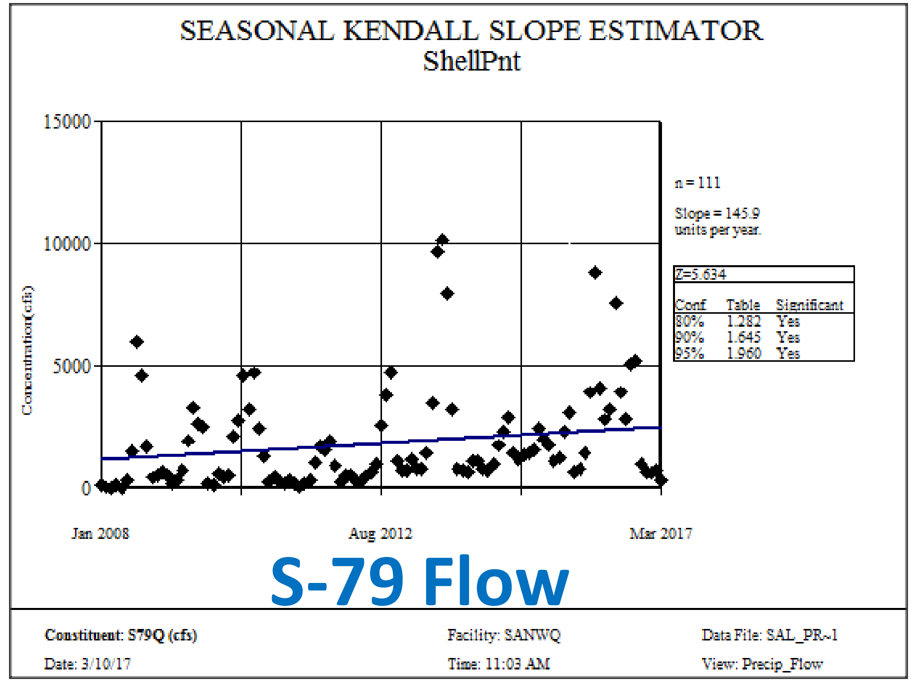
Shell Point

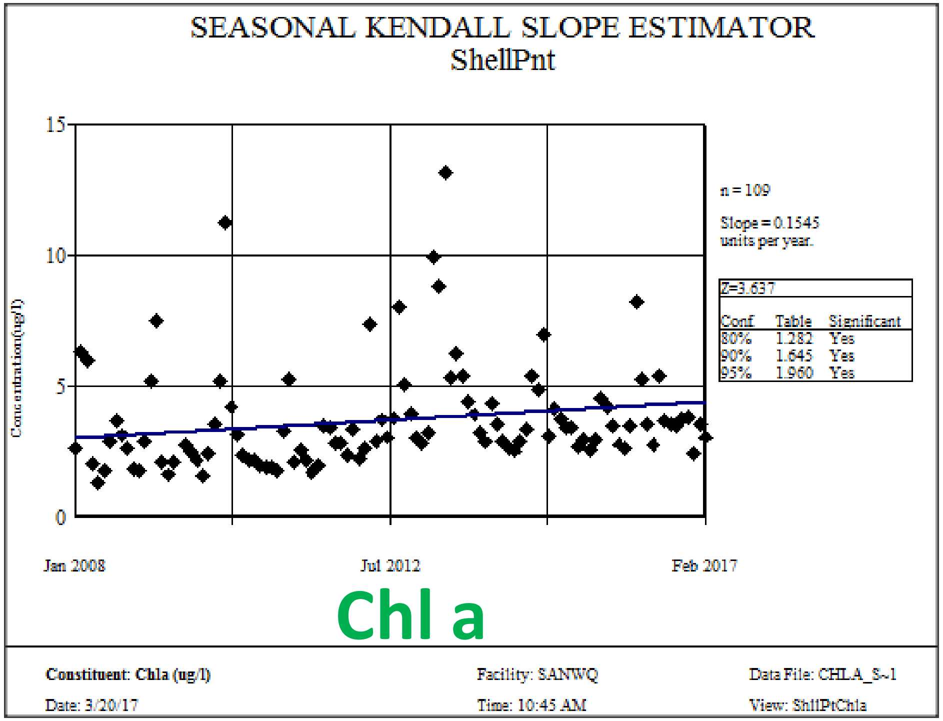

Salinity
0
10
20
30
40
50

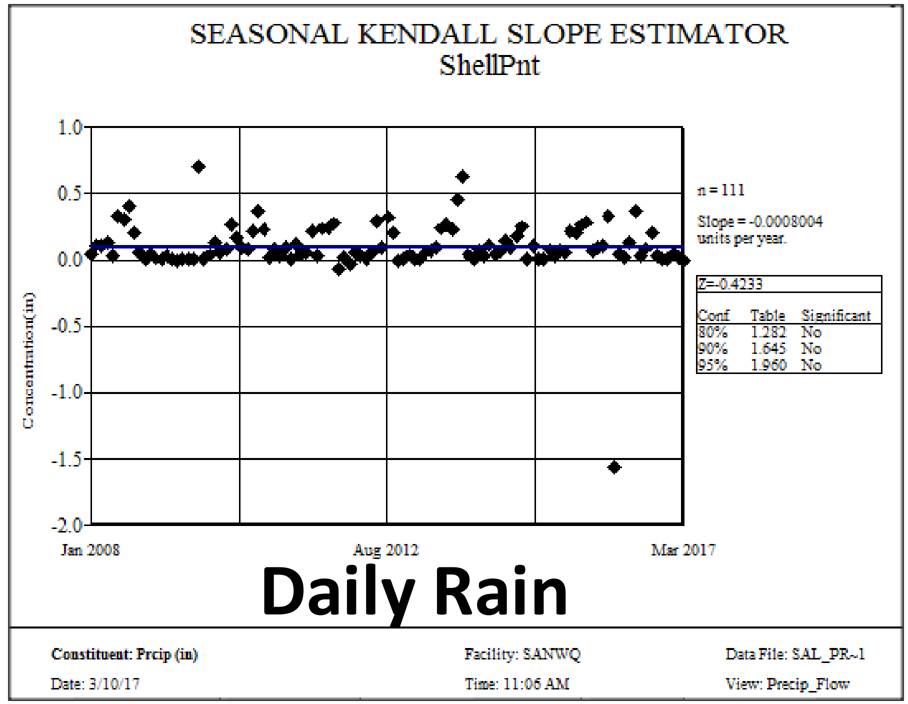

Chlorophyll a
0
5
10
15
20
25
30
35
40
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Year


Jan08
Jan09
Jan10
Jan11
Jan12
Jan13
Jan14
Jan15
Jan16
Jan17
5
10
15
20
25
30
35

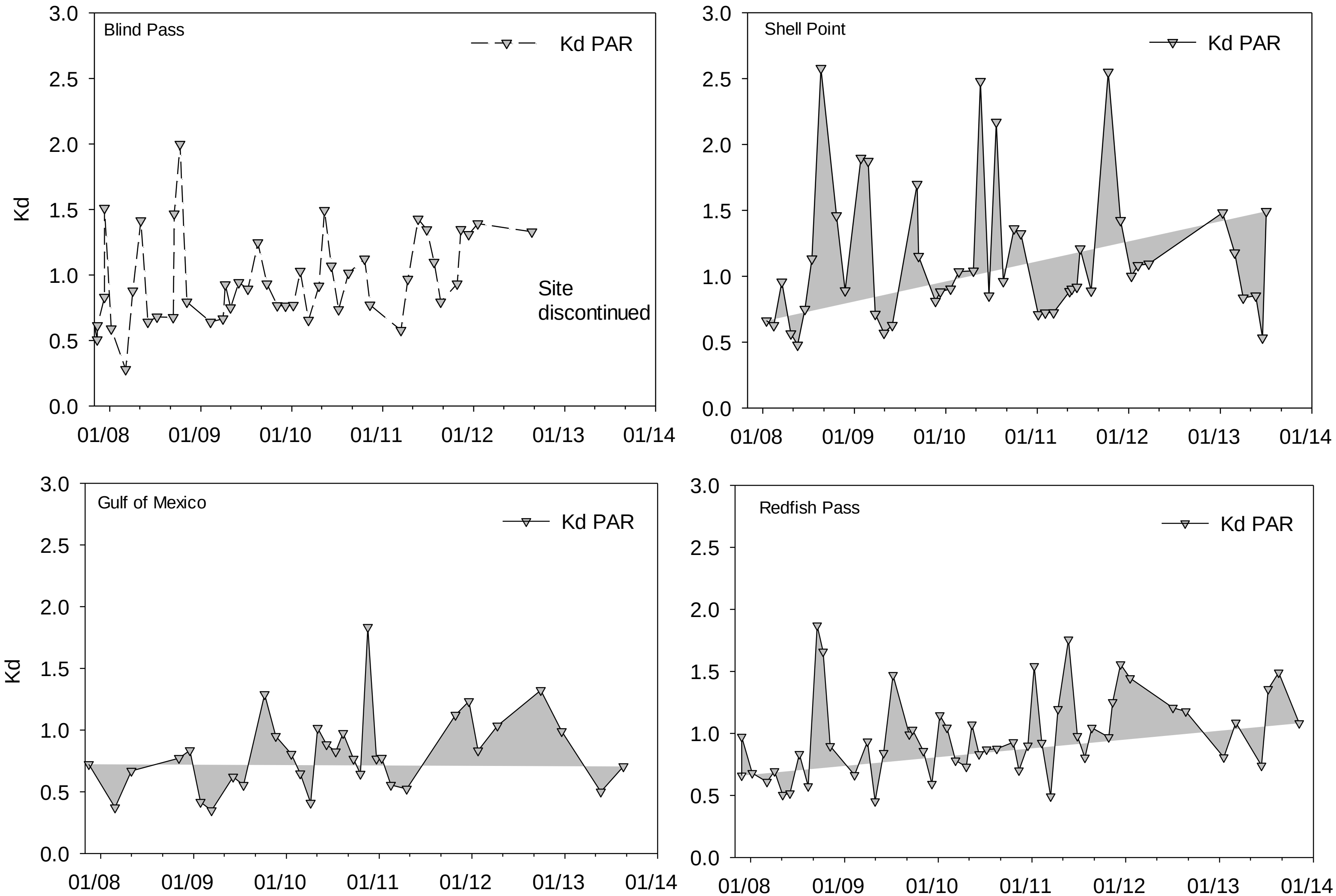

SEASONAL KENDALL SLOPE ESTIMATOR
ShellPnt
40
30
20
10
0
Concentration(psu)
Jan 2008
Aug 2012
Mar 2017
n = 110
Slope = -0.8568
units per year.
Z=-5.262
Conf Table Significant
80% 1.282 Yes
90% 1.645 Yes
95% 1.960 Yes
Salinity
Constituent: Salinity (psu)
Facility: SANWQ
Data File: SALINI~1
Date: 3/10/17
Time: 9:12 AM
View: ShellPntSalin


SEASONAL KENDALL SLOPE ESTIMATOR
ShellPnt
15000
10000
5000
0
Concentration(cfs)
Jan 2008
Aug 2012
Mar 2017
n = 111
Slope = 145.9
units per year.
Z=5.634
Conf Table Significant
80% 1.282 Yes
90% 1.645 Yes
95% 1.960 Yes
S-79 Flow
Constituent: S79Q (cfs)
Facility: SANWQ
Data File: SAL_PR~1
Date: 3/10/17
Time: 11:03 AM
View: Precip_Flow


SEASONAL KENDALL SLOPE ESTIMATOR
ShellPnt
15
10
5
0
Concentration(ug/l)
Jan 2008
Jul 2012
Feb 2017
n = 109
Slope = 0.1545
units per year.
Z=3.637
Conf Table Significant
80% 1.282 Yes
90% 1.645 Yes
95% 1.960 Yes
Chl a
Constituent: Chla (ug/l)
Facility: SANWQ
Data File: CHLA_S~1
Date: 3/20/17
Time: 10:45 AM
View: ShllPtChla


SEASONAL KENDALL SLOPE ESTIMATOR
ShellPnt
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
Concentration(in)
Jan 2008
Aug 2012
Mar 2017
n = 111
Slope = -0.0008004
units per year.
Z=-0.4233
Conf Table Significant
80% 1.282 No
90% 1.645 No
95% 1.960 No
Daily Rain
Constituent: Prcip (in)
Facility: SANWQ
Data File: SAL_PR~1
Date: 3/10/17
Time: 11:06 AM
View: Precip_Flow

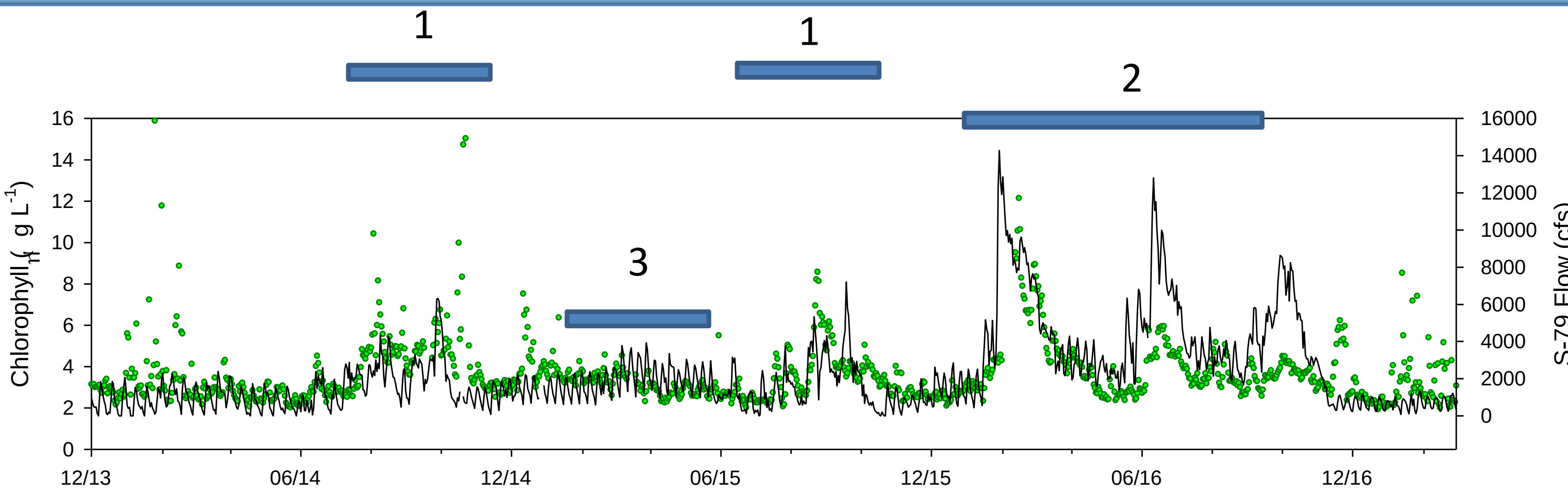
Transparency KdPAR



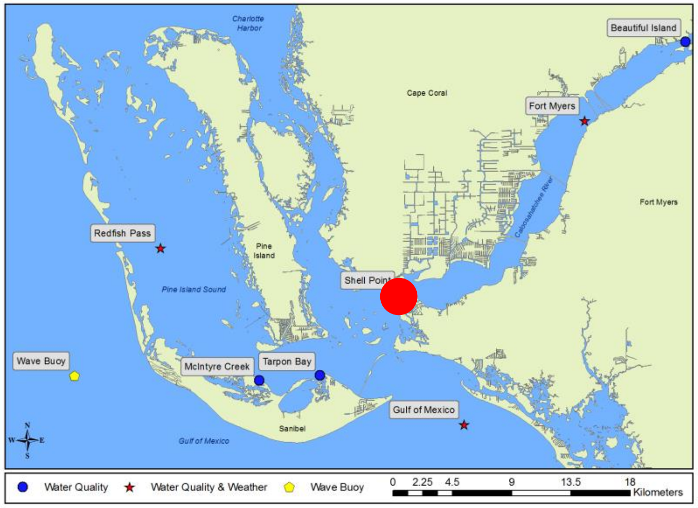
Milbrandt, E.C, R.D. Bartleson, A. Martignette, M. Thompson, J.Siwicke, 2016. Evaluating light attenuation and low salinity periods in the lower Caloosahatchee estuary using RECON (River, Estuary, and Coastal Observing Network). CHNEP Special Issue, Florida Scientist 79: 109-124.

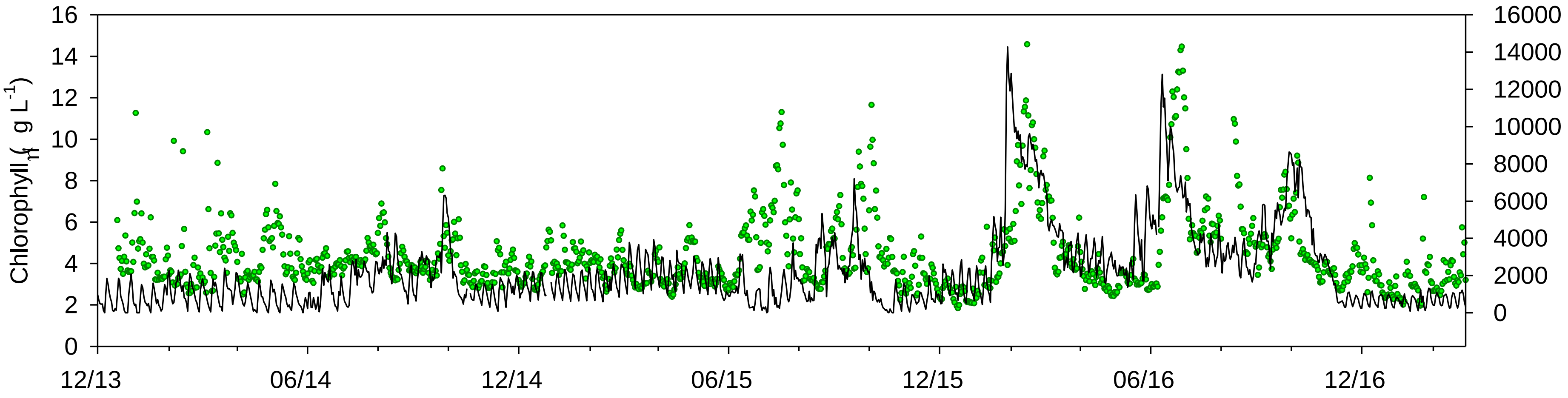
SCCF RECON

Sanibel-Captiva Conservation Foundation
River, Estuary and Coastal Observing Network

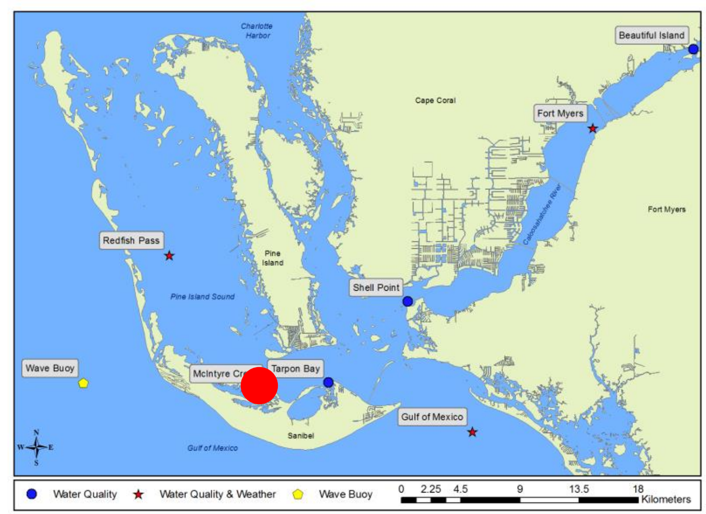


1. Higher chlorophyll values associated with typical summer flows in 2014 and 2015
2. El Nino Flows exhibiting the 'dose-response' expected by nutrient loading.
3. Return to a baseline dry season chlorophyll (resilience to wet season flow)

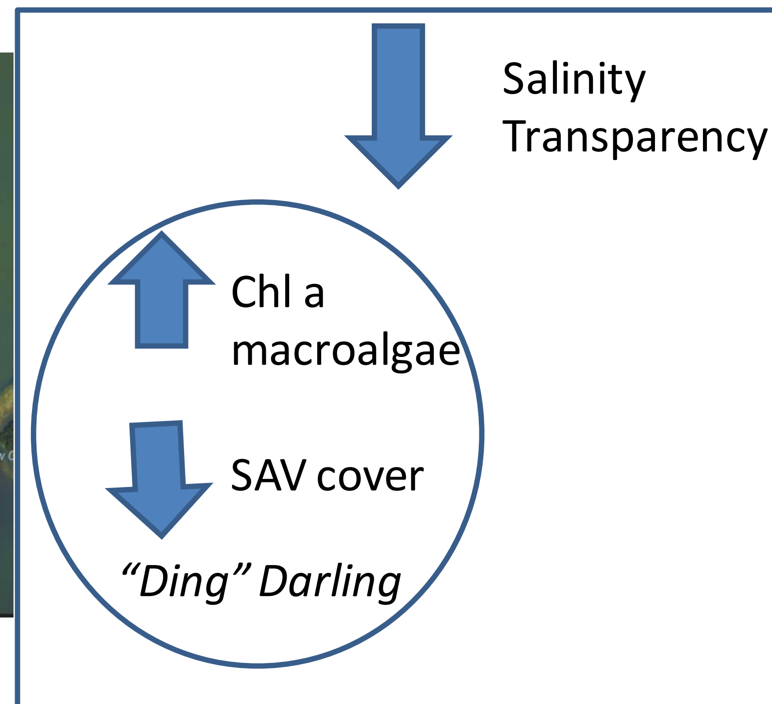




1. Responses in McIntyre Creek driven by S-79 flows (Booth et al. , 2016 salinity). Watershed of site is 99% mangrove or wooded wetland, flow mostly tidal.
2. Residual high chlorophyll after high flows may be the result of higher residence times in back bays delaying a return to a baseline condition (less resilient to perturbation)



Working hypothesis is that the back bays in the "Ding" Darling Refuge are functionally impaired and less resilient to large scale perturbations because of long-term increases in flow and chlorophyll, and decreases in salinity



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239-395-4617

Cited:
Amanda Booth et al. 2016 Flow Effects of variations in flow characteristics through W.P. Franklin Lock and Dam on downstream water quality in the Caloosahatchee River Estuary and in McIntyre Creek in the J.N. "Ding" Darling National Wildlife Refuge, southern Florida, 2010–13
Scheffer, M., S. Carpenter, J.A. Foley et al. 2001. Catastrophic shifts in ecosystems. Nature 413:591-596.
Folke, C., S. Carpetner, B. Walker, et al. 2004. Regime shifts, resilience and biodiversity in ecosystem management. Ann Rev. Ecol. Evol. Syst. 35:557-581
Levin, S.A. and J. Lubchenco. 2008. Resilience, robustness and mareine ecosystem based management. BioScience 58:27-32
Leslie, H.M. and A.P. Kinzig. 2009 Relilience Science. In: Ecosystem based management for the oceans, (K.L. McLeod and H.M. Leslied eds.) pp. 55-73 Washington DC, Island Press.