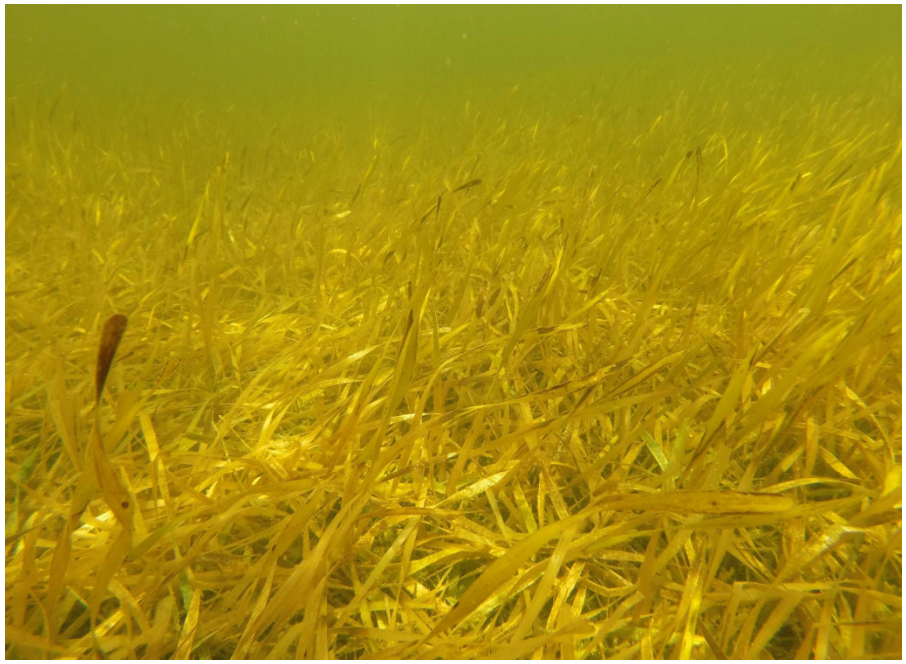
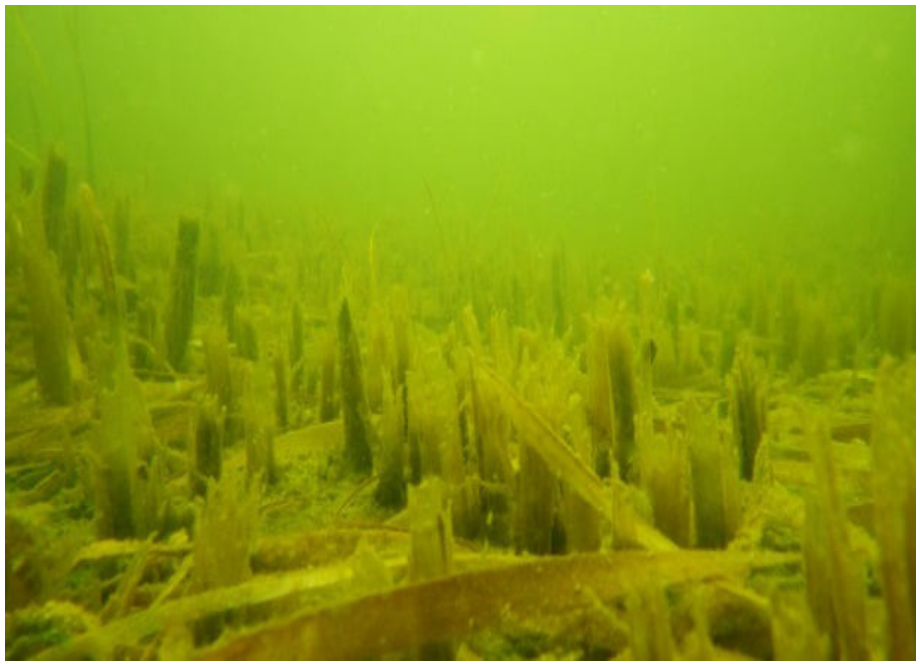
Florida Bay Seagrass Die-off Summary

David Rudnick
Everglades National Park

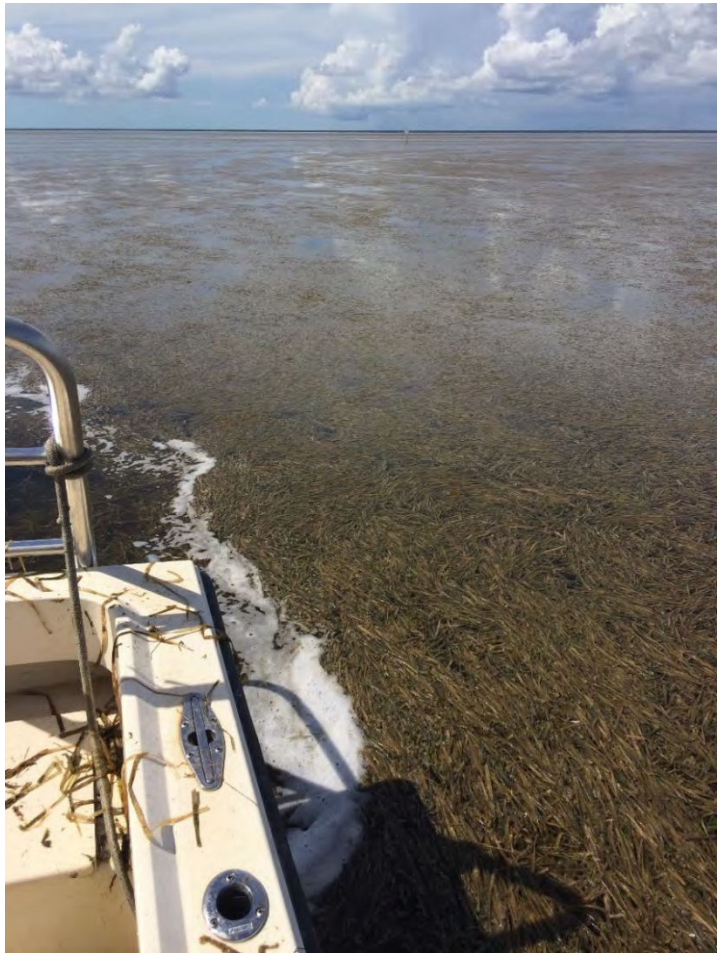
RECOVER Annual Science Meeting
March 1, 2016

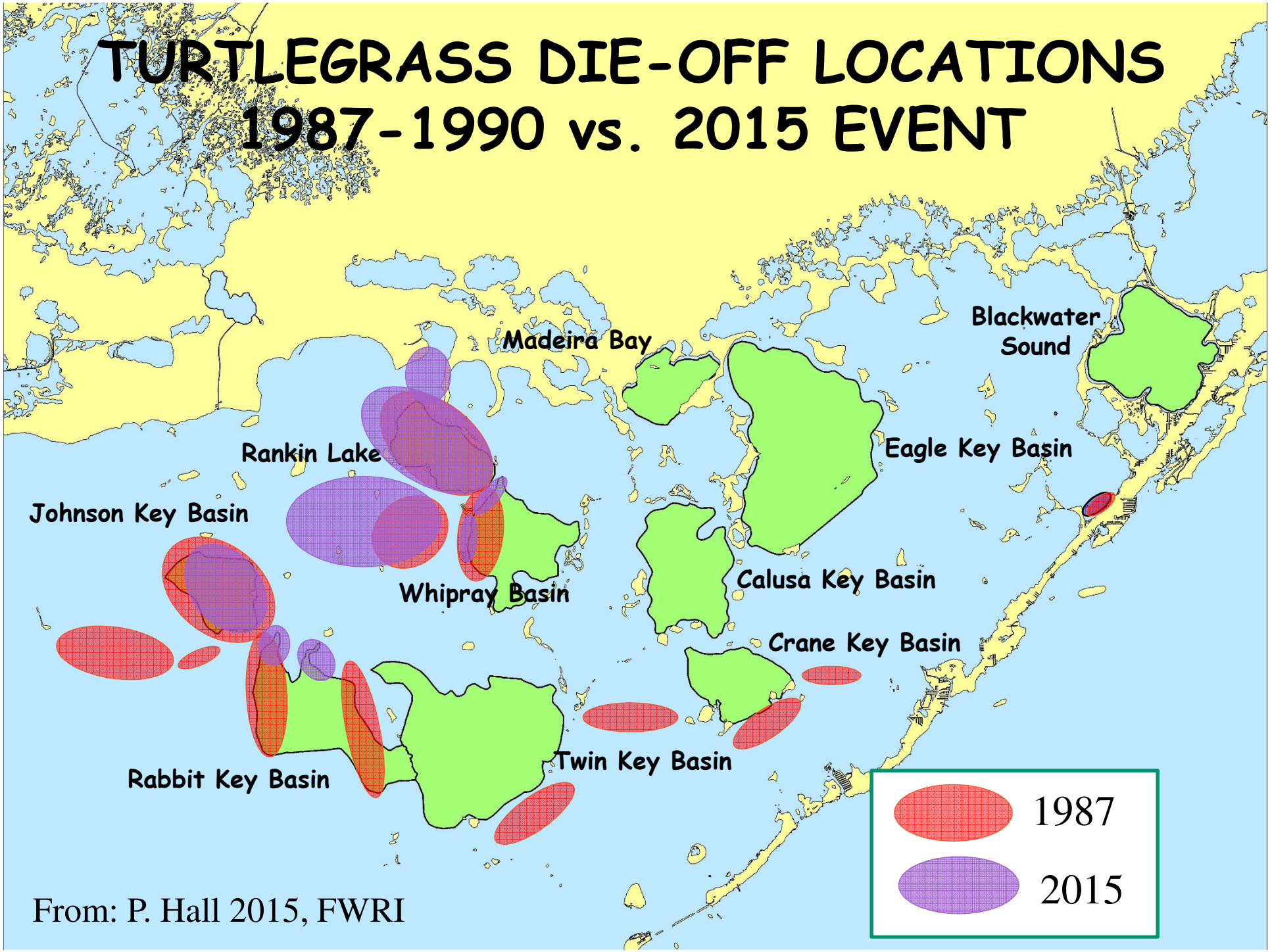
Turtlegrass Die-off During the Summer of 2015



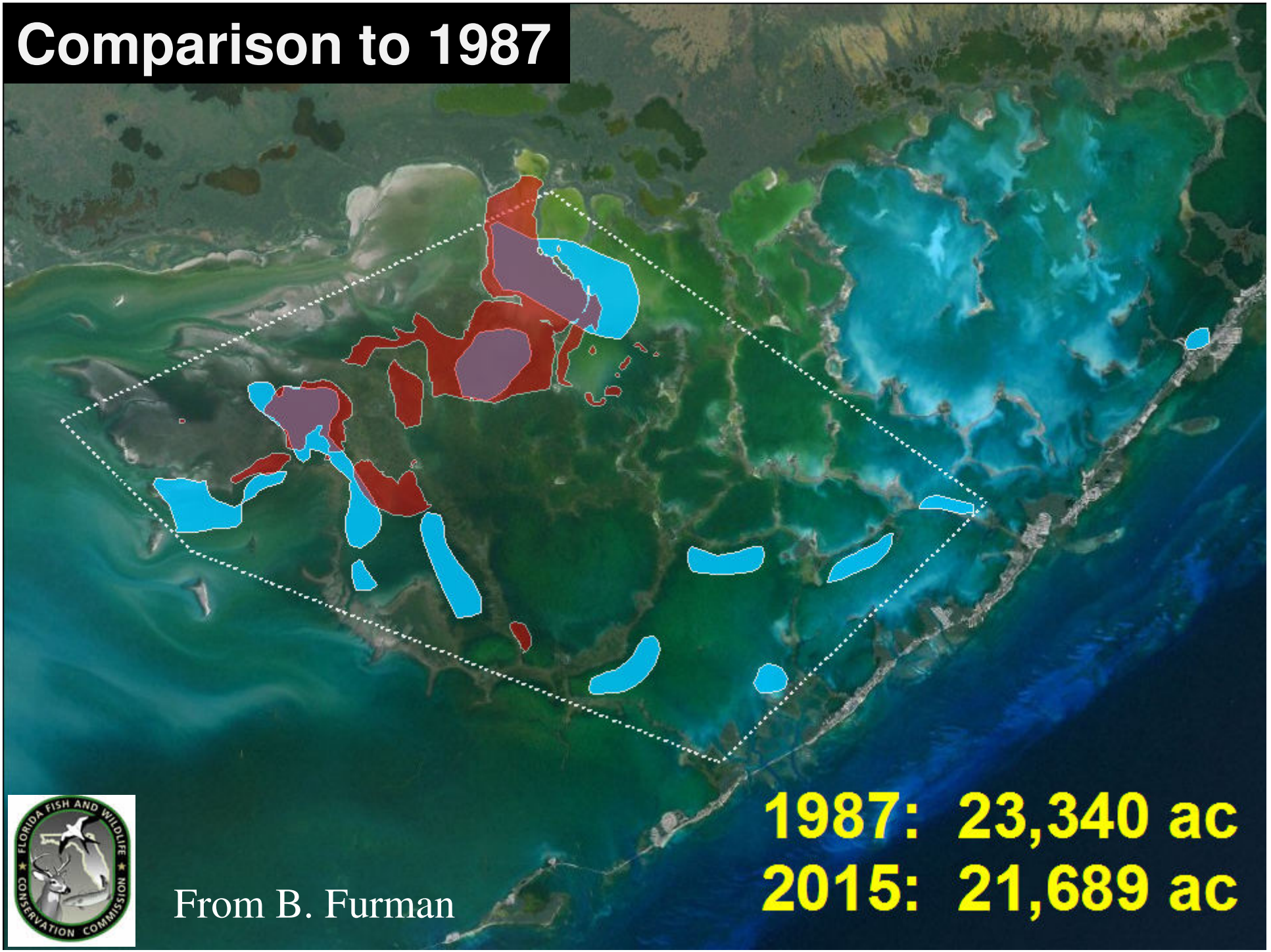


Turtlegrass Detritus Produced with Die-off

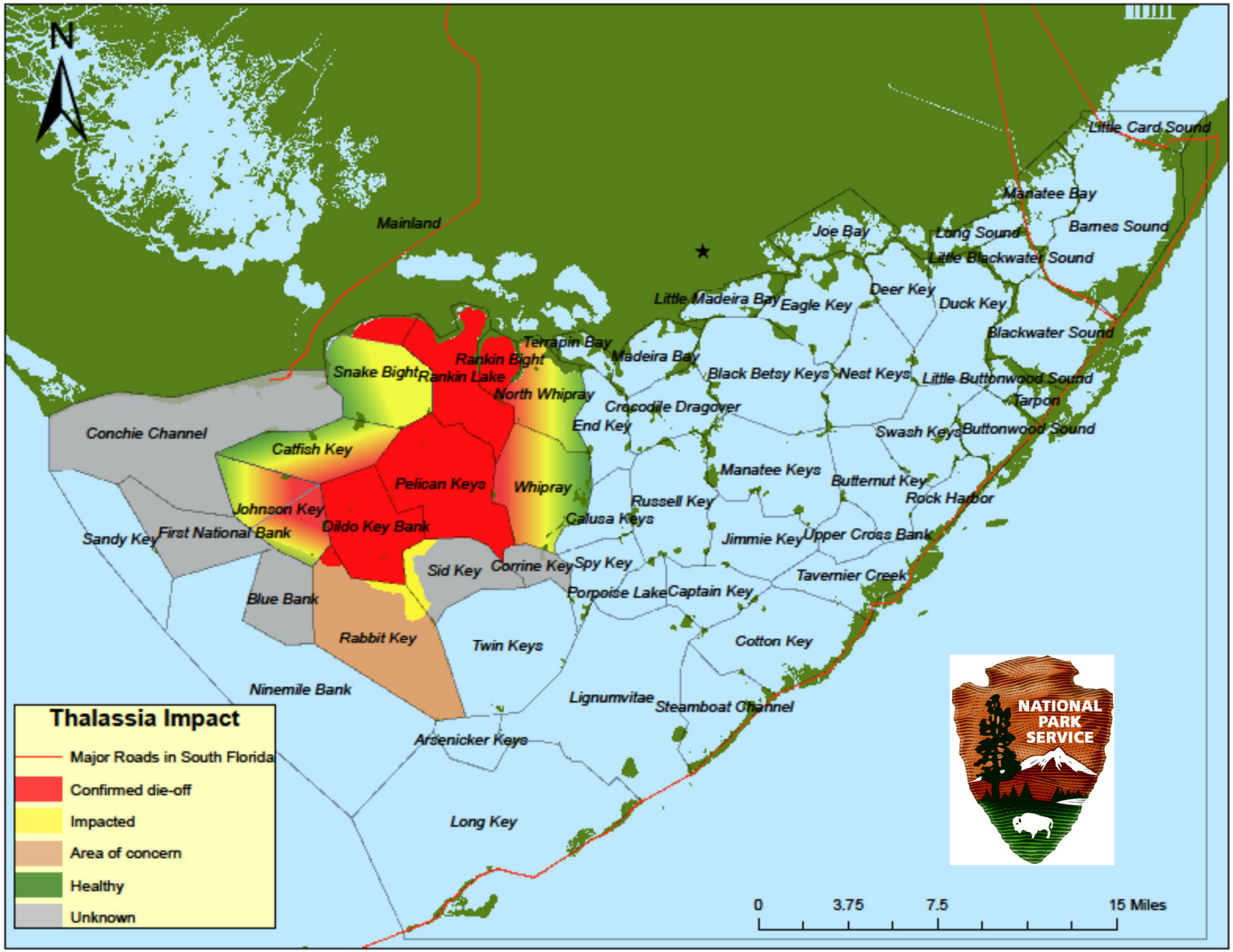


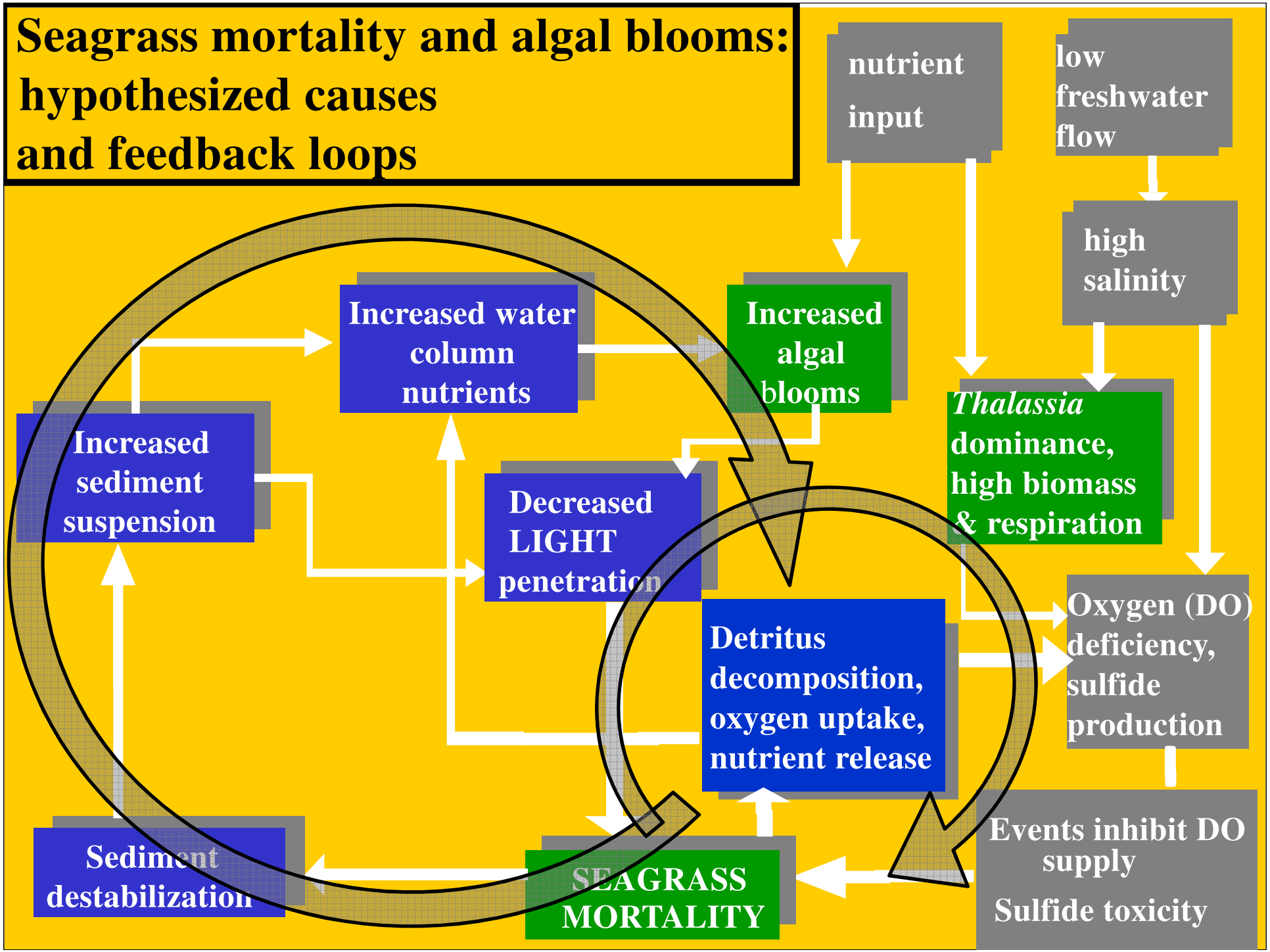

TURTLEGRASS DIE-OFF LOCATIONS
1987-1990 vs. 2015 EVENT
Madeira Bay
Blackwater Sound
Rankin Lake
Eagle Key Basin
Johnson Key Basin
Whipray Basin
Calusa Key Basin
Crane Key Basin
Twin Key Basin
Rabbit Key Basin
1987
2015
From: P. Hall 2015, FWRI

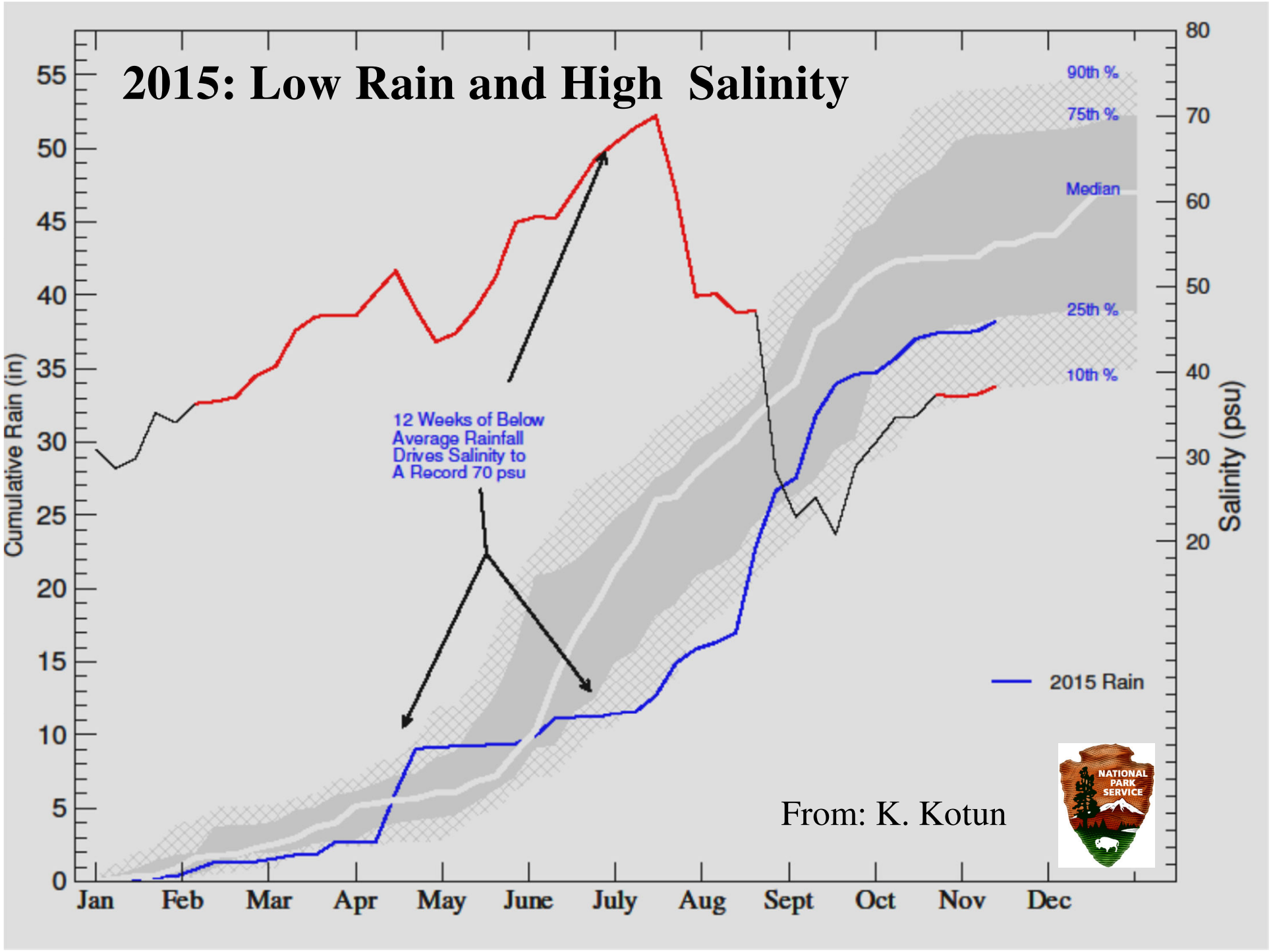
Comparison to 1987



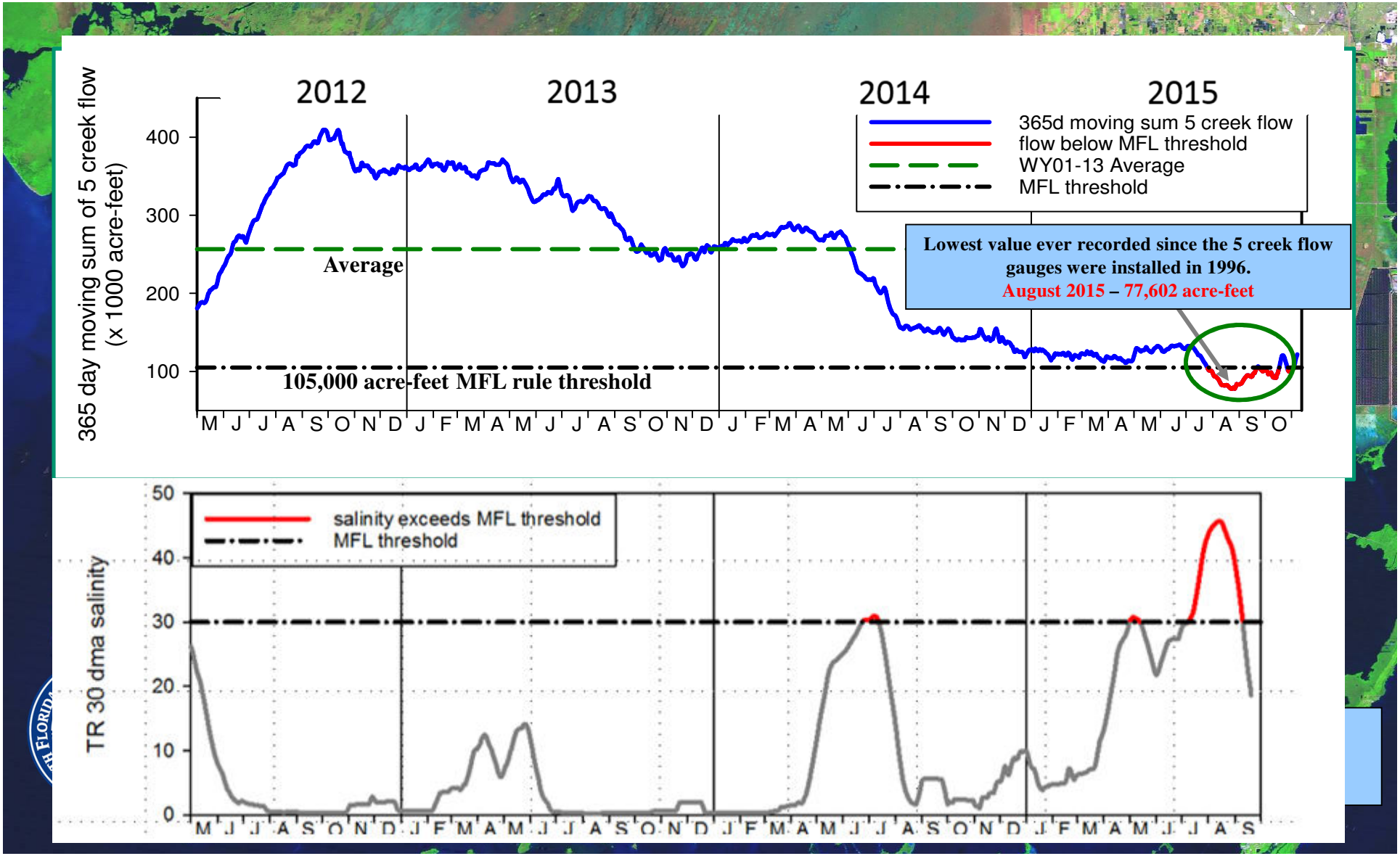
Estimated *Thalassia* Die-off Area (Jan. 2015)



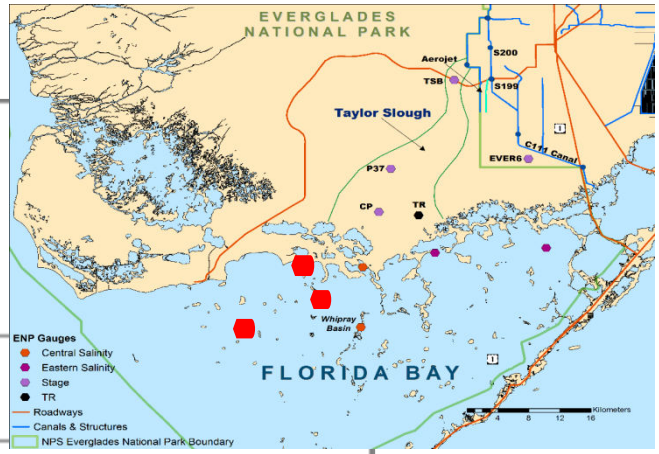

Seagrass mortality and algal blooms: hypothesized causes and feedback loops
nutrient input
low freshwater flow
high salinity
Increased water column nutrients
Increased algal blooms
Increased sediment suspension
Decreased LIGHT penetration
Thalassia dominance, high biomass & respiration
Detritus decomposition, oxygen uptake, nutrient release
Oxygen (DO) deficiency, sulfide production
Sediment destabilization
SEAGRASS MORTALITY
Events inhibit DO supply
Sulfide toxicity

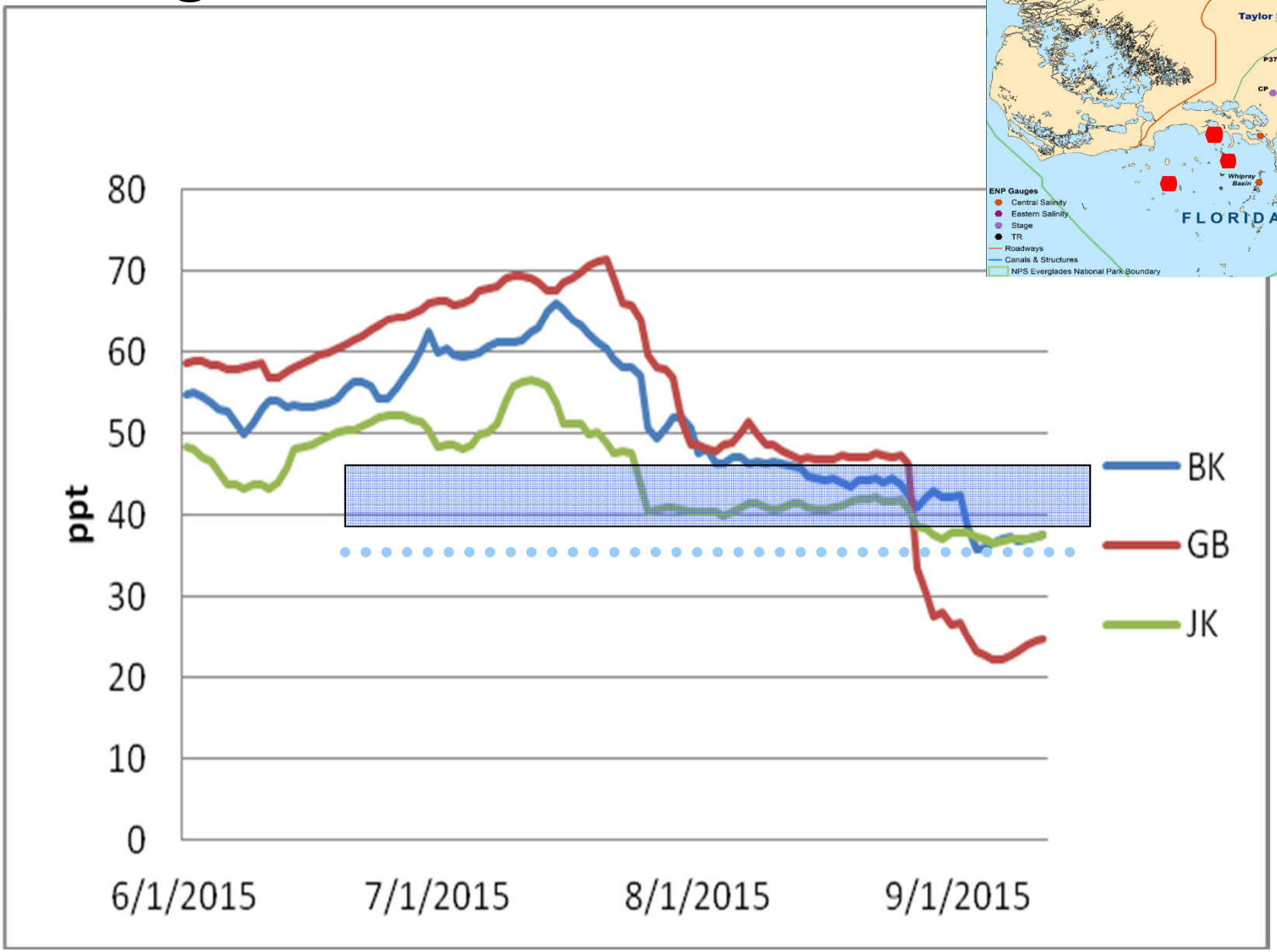

2015: Low Rain and High Salinity
90th %
75th %
Median
25th %
10th %
12 Weeks of Below
Average Rainfall
Drives Salinity to
A Record 70 psu
2015 Rain
From: K. Kotun
NATIONAL PARK SERVICE
Cumulative Rain (in)
Salinity (psu)
0
5
10
15
20
25
30
35
40
45
50
55
20
30
40
50
60
70
80
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

2012-2015 Conditions - Florida Bay Taylor River Salinity & MFL Flow



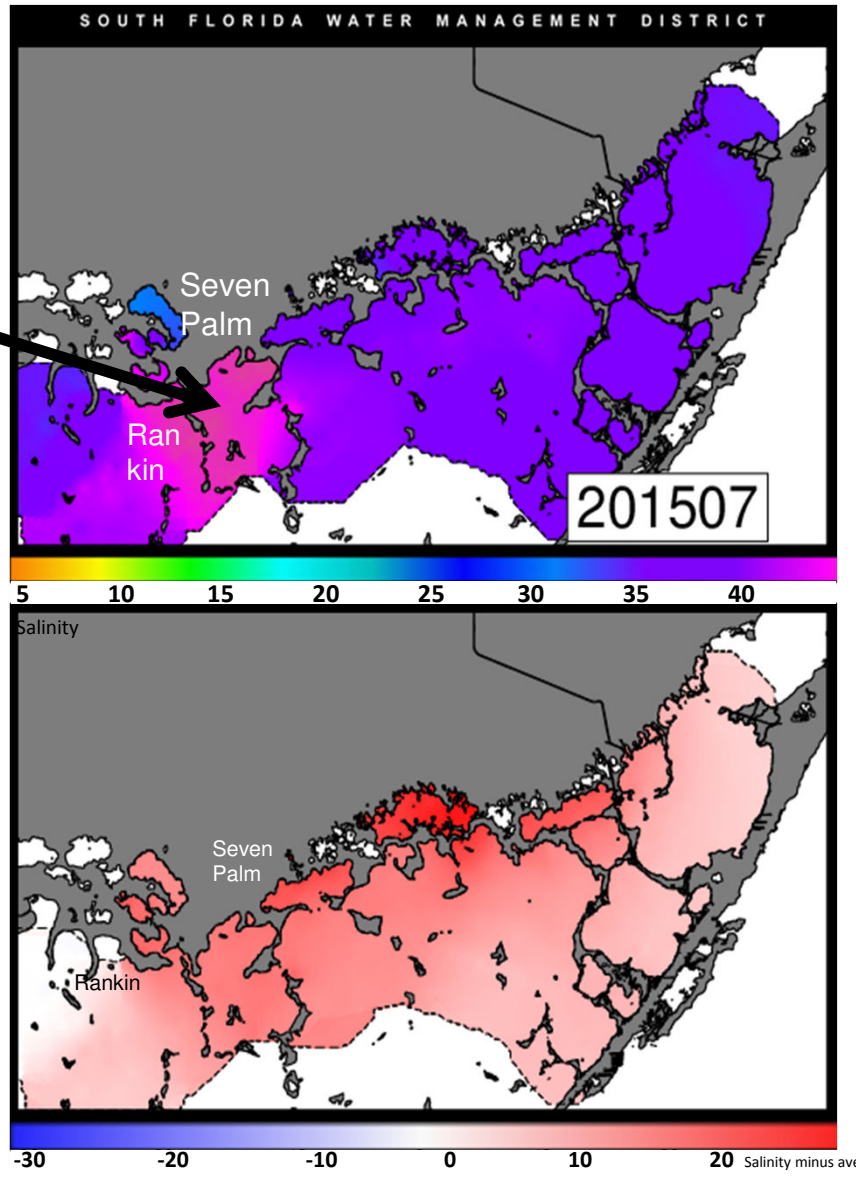
Record High Salinity in North-Central Florida Bay During the Summer of 2015





Mapping Florida Bay Salinity

> 50 Practical Salinity Units (psu)

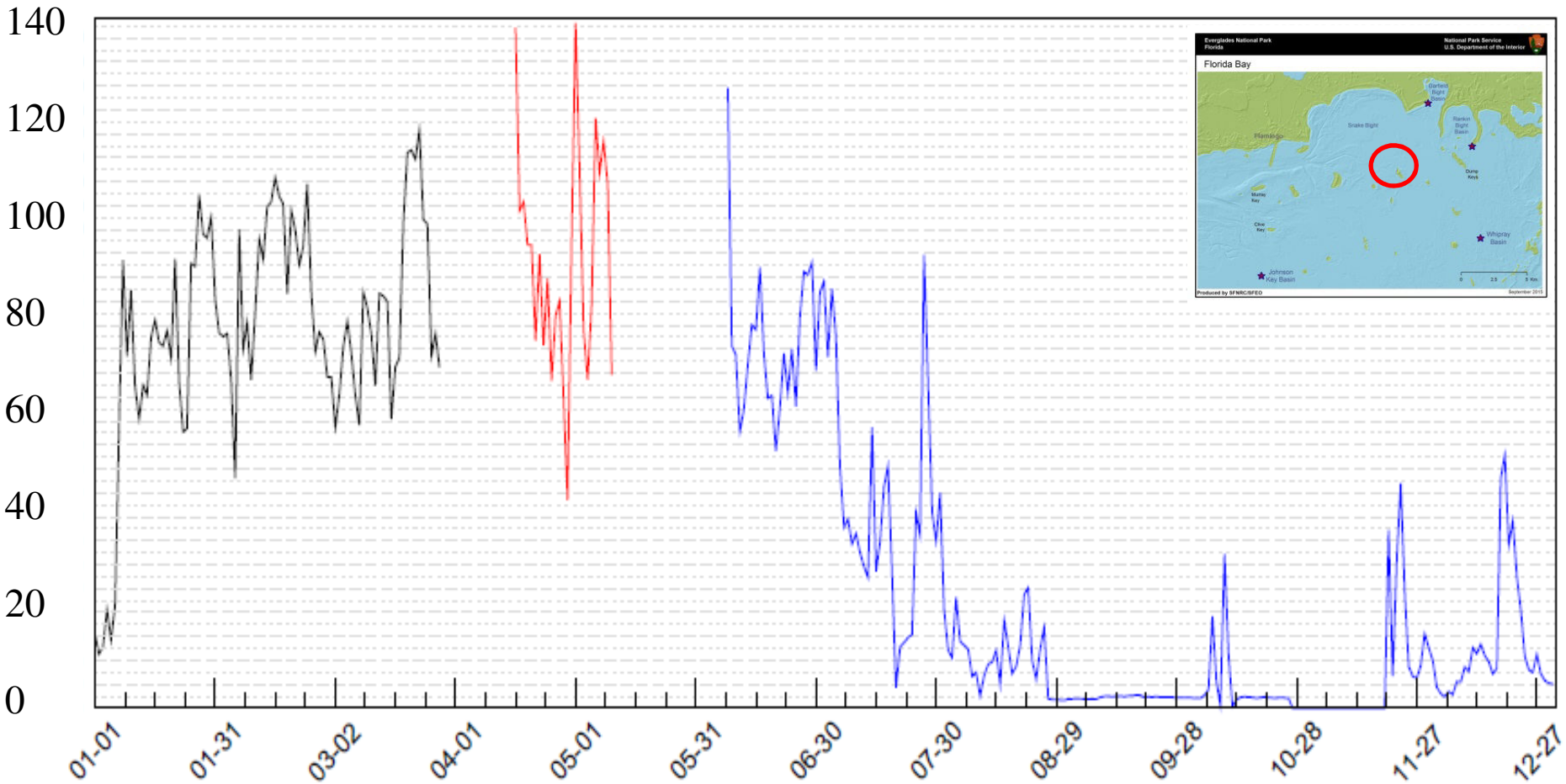


Late July 2015

Difference from 2006 – 2014 Average (Jun – Aug)

From Madden, Stachelek, Kelly

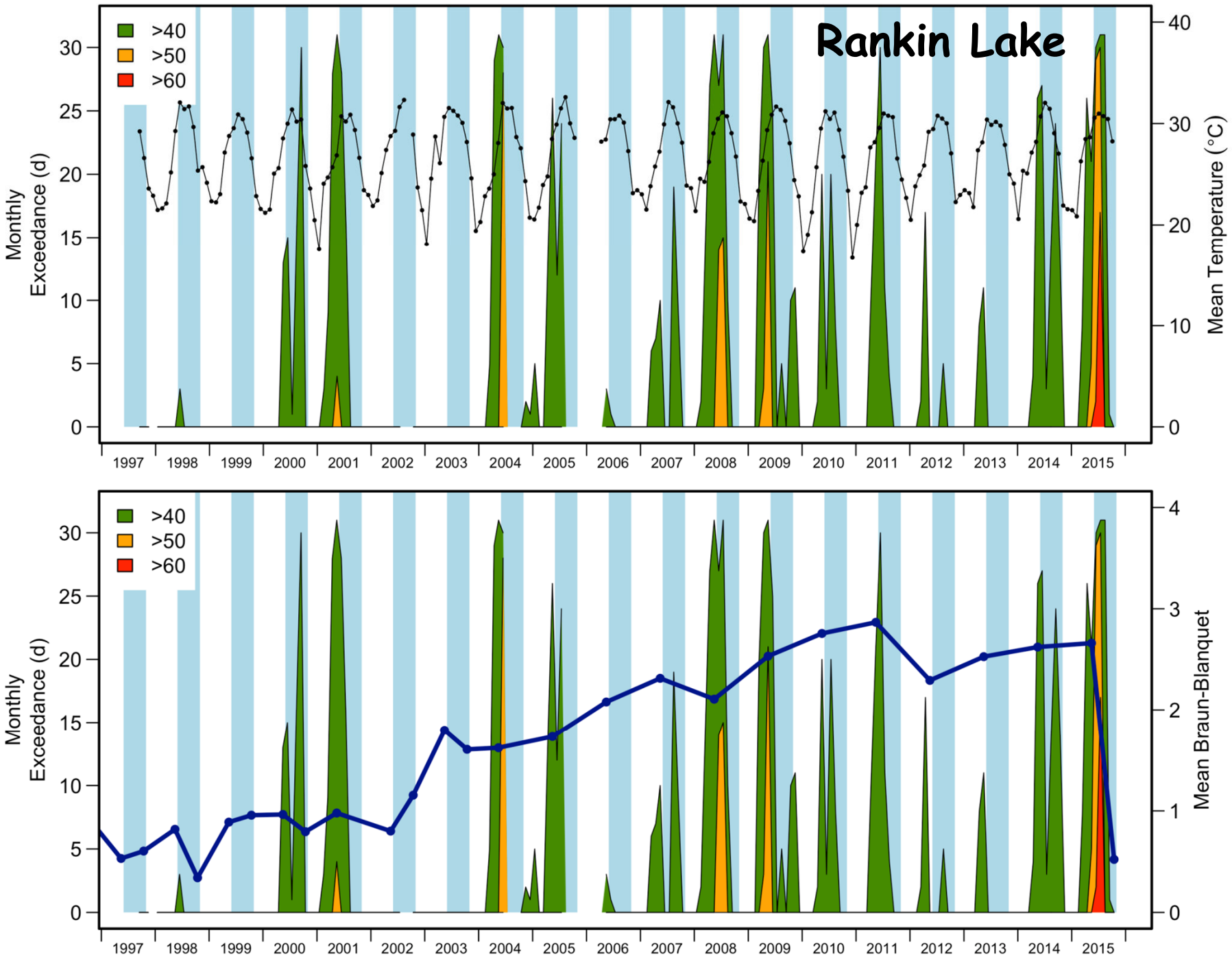
Percent Saturation Dissolved Oxygen at Buoy Key (2015)



Sediment Porewater Sulfide Concentrations (mM) in Die-off Areas.
Values > 2 mM are toxic to *Thalassia testudinum*.

	Florida Bay Basins			
DieOff Event/Sample	Johnson Key Basin	Rabbit Key Basin	Rankin Lake	Whipray Basin
1987-1991 Event				
Summer 1989	0.50	0.40	0.60	1.52
Fall 1989	2.85	2.55	1.45	1.23
Summer 1990	1.15	0.85	0.60	1.51
Fall 1990	3.70	3.15	4.78	
2015 Event				
Summer 2015	3.40		4.95	5.72
Fall 2015	4.23	1.71	6.53	

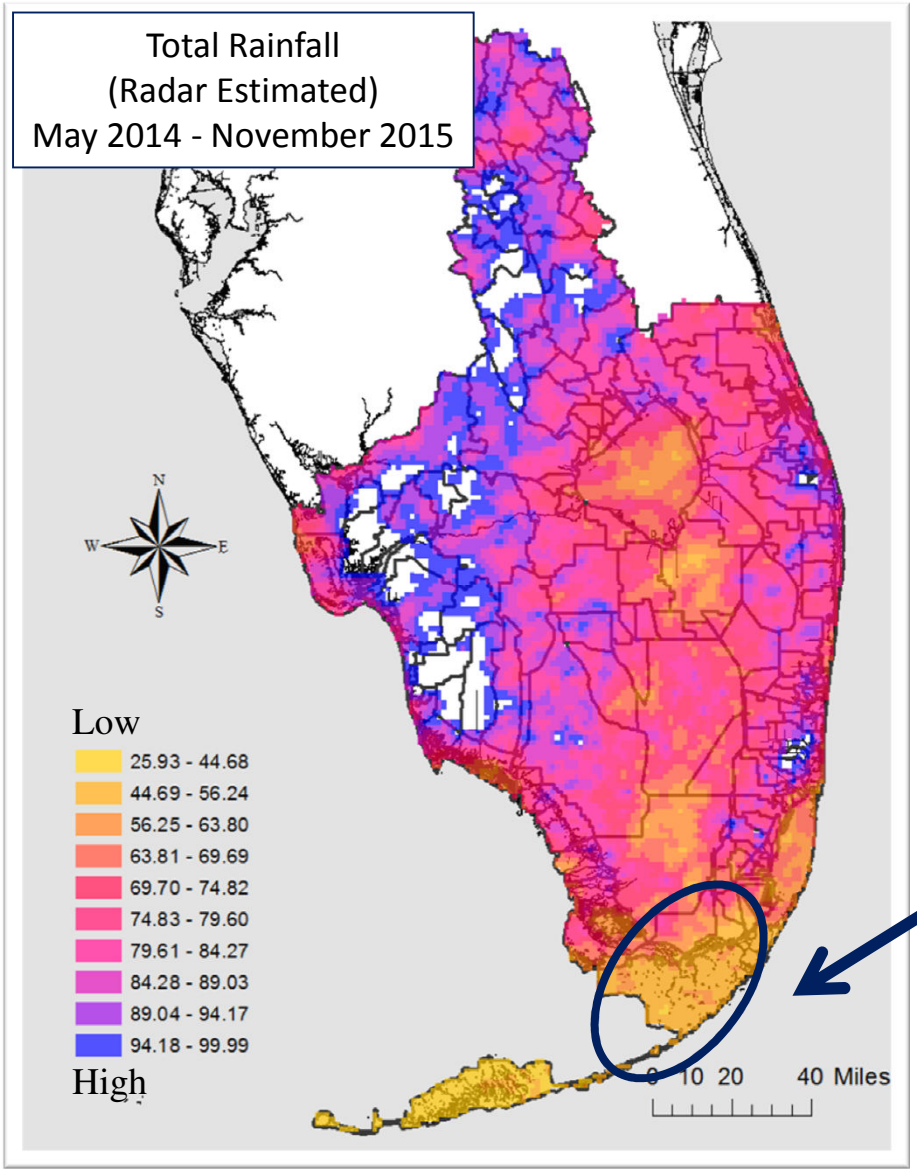
From P. Carlson, V. Absten


Rankin Lake
>40
>50
>60
Monthly Exceedance (d)
Mean Temperature (°C)
Mean Braun-Blanquet
0
5
10
15
20
25
30
0
10
20
30
40
0
1
2
3
4
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

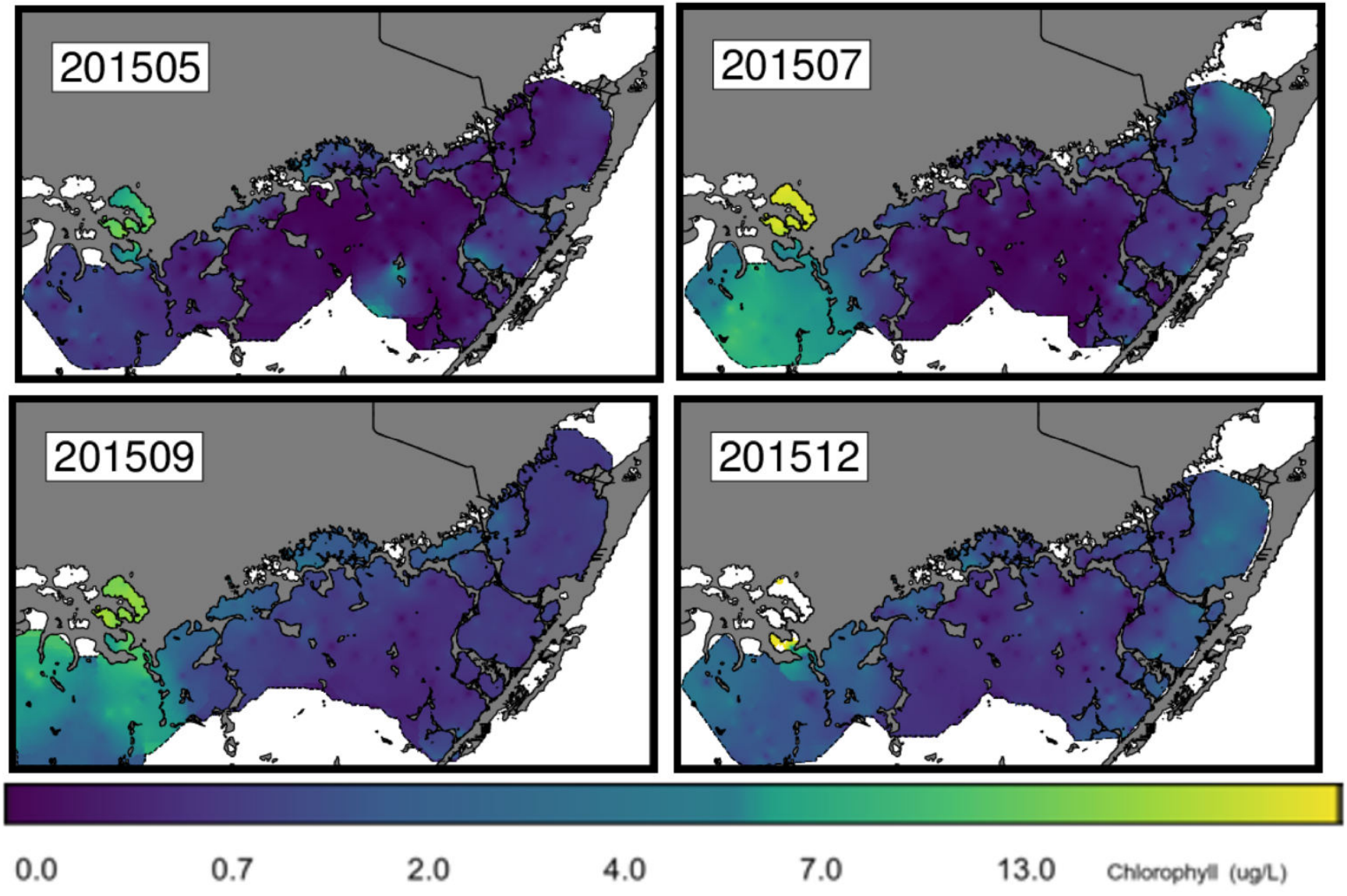
Conclusions

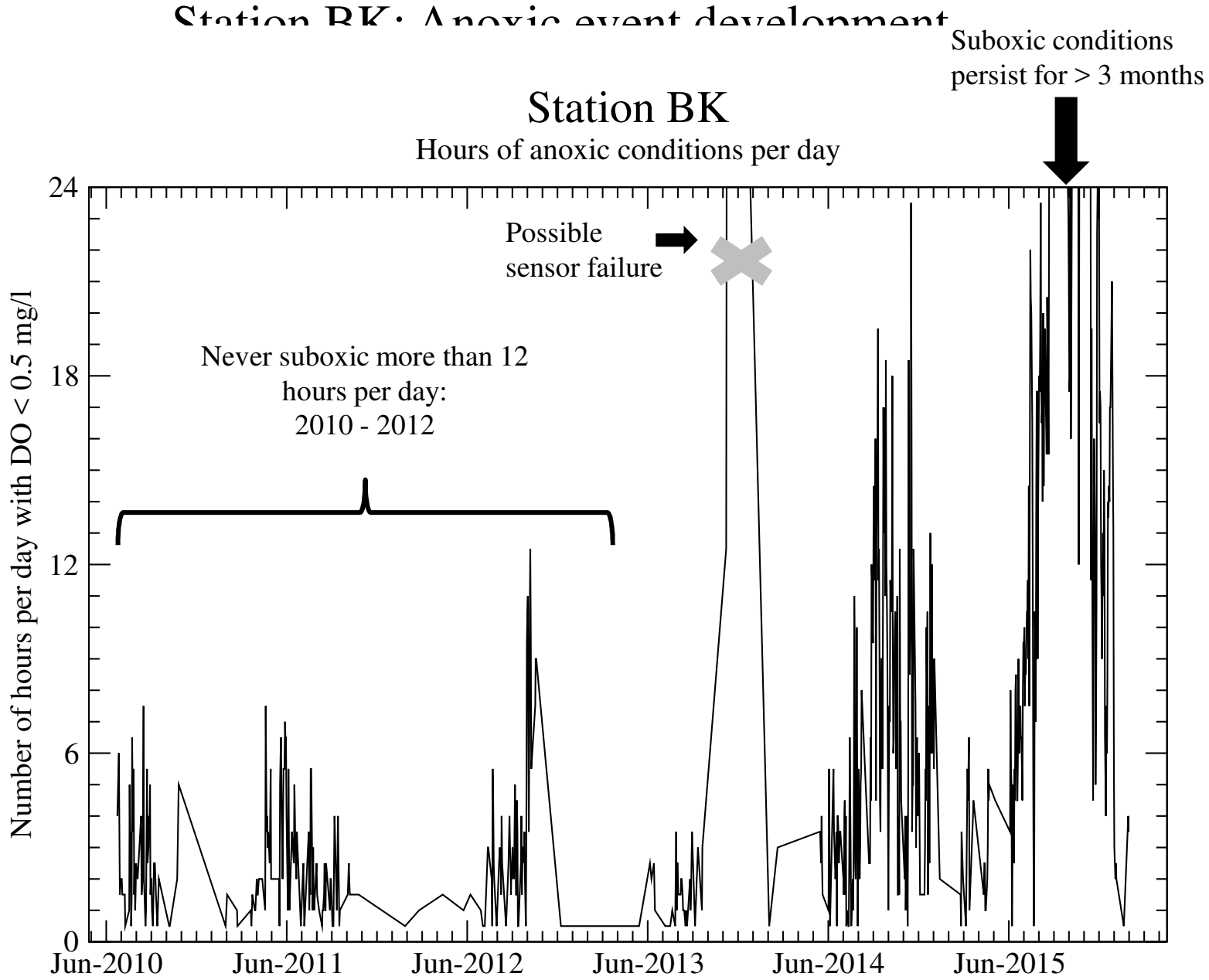
- A die-off of *Thalassia testudinum* began in July 2015 in north-central Florida Bay
- By January 2015, the location and spatial extent of this die-off was similar to that of the 1987-1990 die-off
- *Thalassia* die-offs are hypothesized to occur in high biomass beds, which develop in association with sustained high salinity and relatively high nutrients
- The lethal agents proximately causing die-off are anoxia and sulfide toxicity
- High salinity decreases dissolved oxygen supply and increases the risk of anoxia via stratification
- With nutrient release from decomposing seagrass detritus, Florida Bay is now poised for potential large-scale algal blooms

2015 Conditions - District Rainfall Distribution



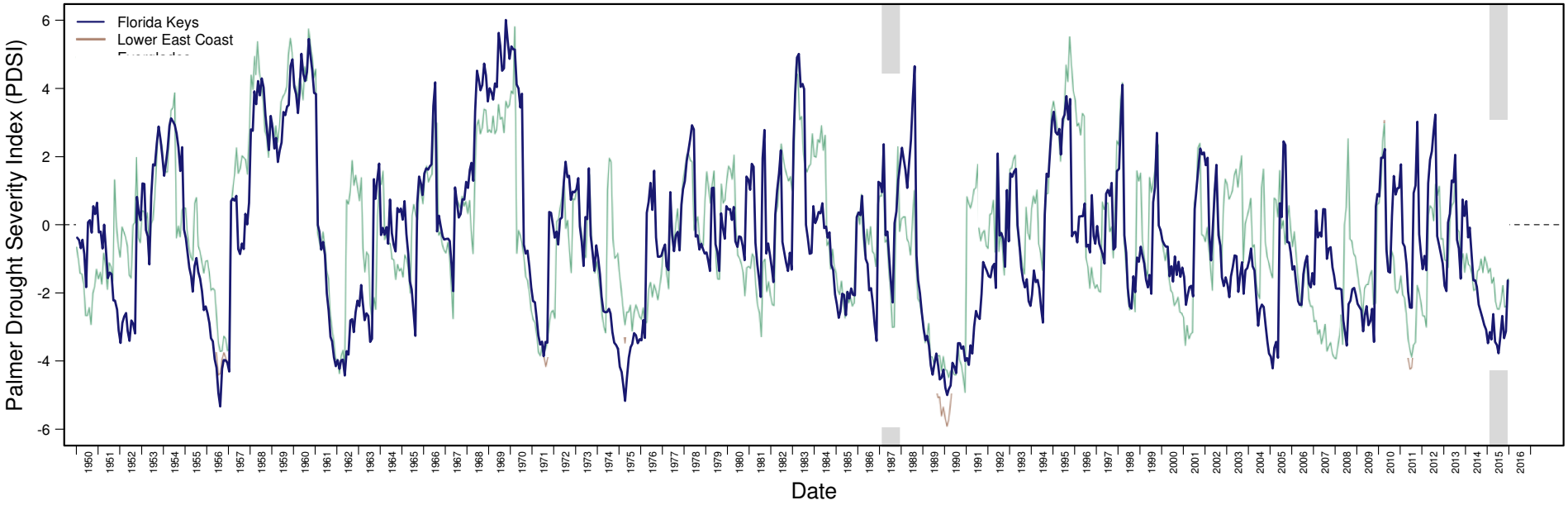
- Taylor Slough & Florida Bay received the lowest amounts of rainfall
- 25-45 inches since May 2014 compared to District-wide average of 80 inches


201505
201507
201509
201512
0.0
0.7
2.0
4.0
7.0
13.0
Chlorophyll (ug/L)


Station BK: Anoxic event development
Suboxic conditions
persist for > 3 months
Station BK
Hours of anoxic conditions per day
Possible
sensor failure
Never suboxic more than 12
hours per day:
2010 - 2012
Number of hours per day with DO < 0.5 mg/l
24
18
12
6
0
Jun-2010
Jun-2011
Jun-2012
Jun-2013
Jun-2014
Jun-2015

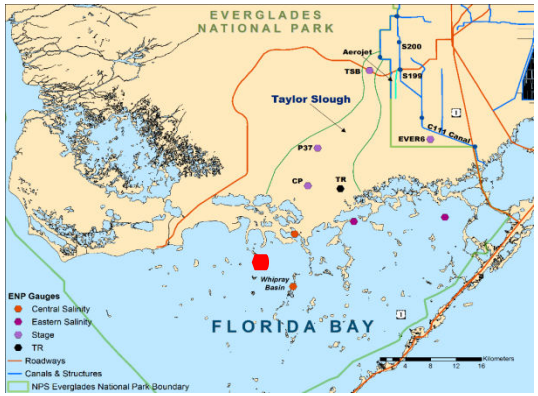
Detrital Mats

Climatology Everglades National Park



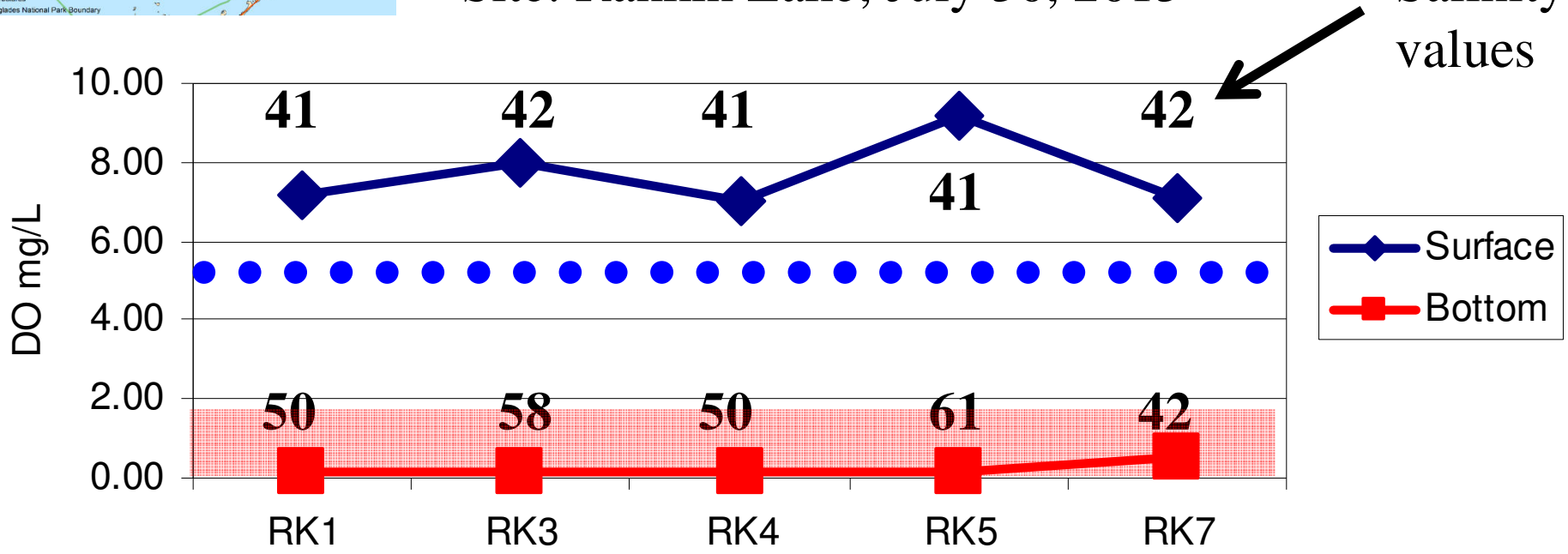
Data from NOAA

Was drought a factor in 1987?
What about other drought years?
We need a continuous response variable for die-off severity…

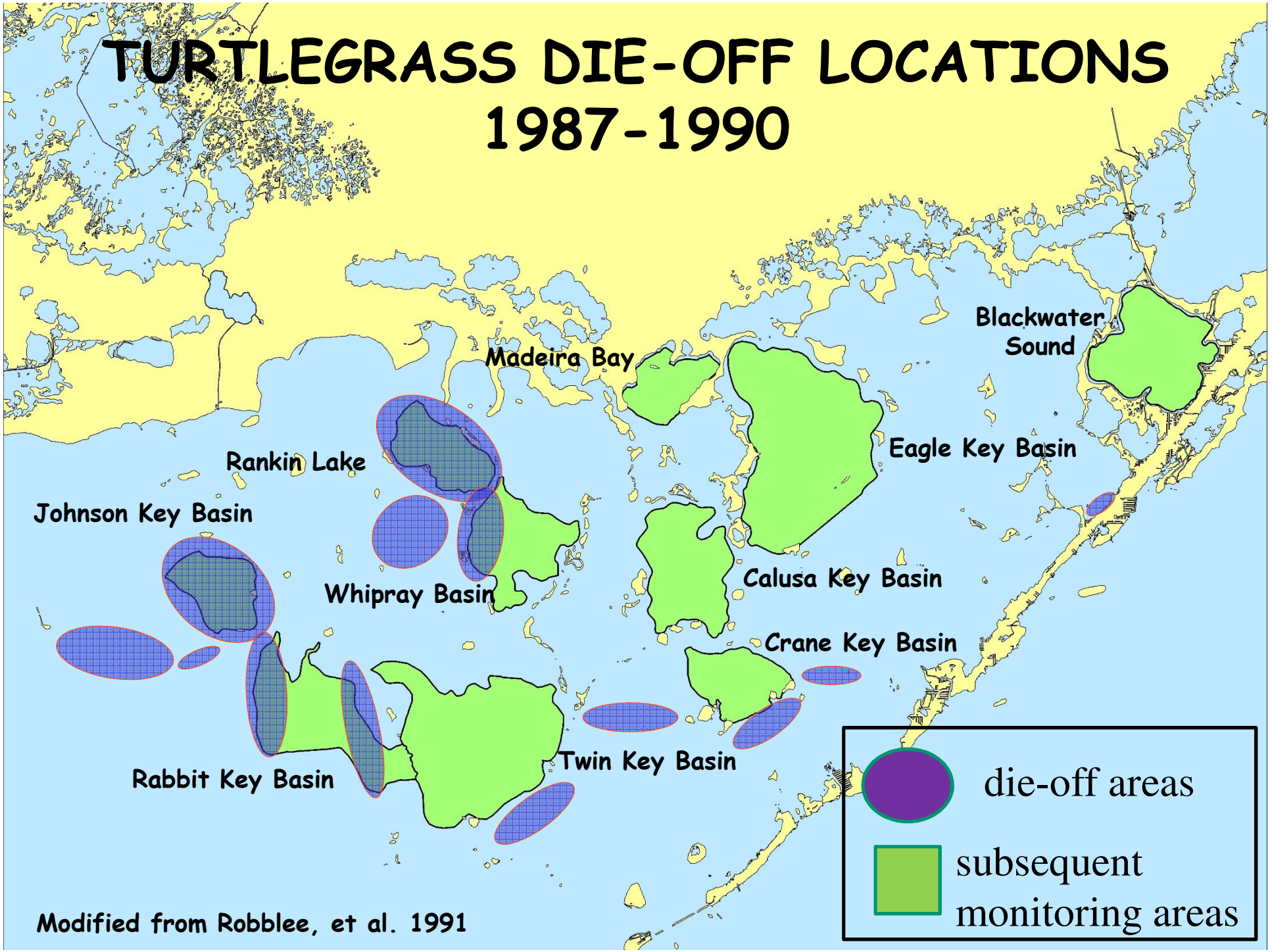


Anoxic Bottom Water in North-Central Florida Bay

Site: Rankin Lake; July 30, 2015



Stratification of water column likely important factor for die-off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Crane Key Basin
Twin Key Basin
Rabbit Key Basin
die-off areas
subsequent monitoring areas
Modified from Robblee, et al. 1991

Seagrass mortality and algal blooms: hypothesized causes and feedback loops

Long-term set up factors	• Stable, high **salinity** promotes *Thalassia* dominance • **Nutrient supply** promotes high biomass with high respiratory demand (especially root, rhizome)

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Proximate triggers	• **Anoxia** and associated **sulfide** appear to be the primary **lethal** agents • **Anoxia** promotes sulfate reduction, **producing toxic sulfide** • Dissolved oxygen (**DO**) **supply** (saturation) **decreases with increasing temperature and salinity** • **DO demand increases with temperature** • High night-time DO demand when low **light** (cloudiness, short photoperiod in autumn) • **Stratification** can yield rapid anoxia at bottom • High salinity (density) bottom water and low wind promote stratification

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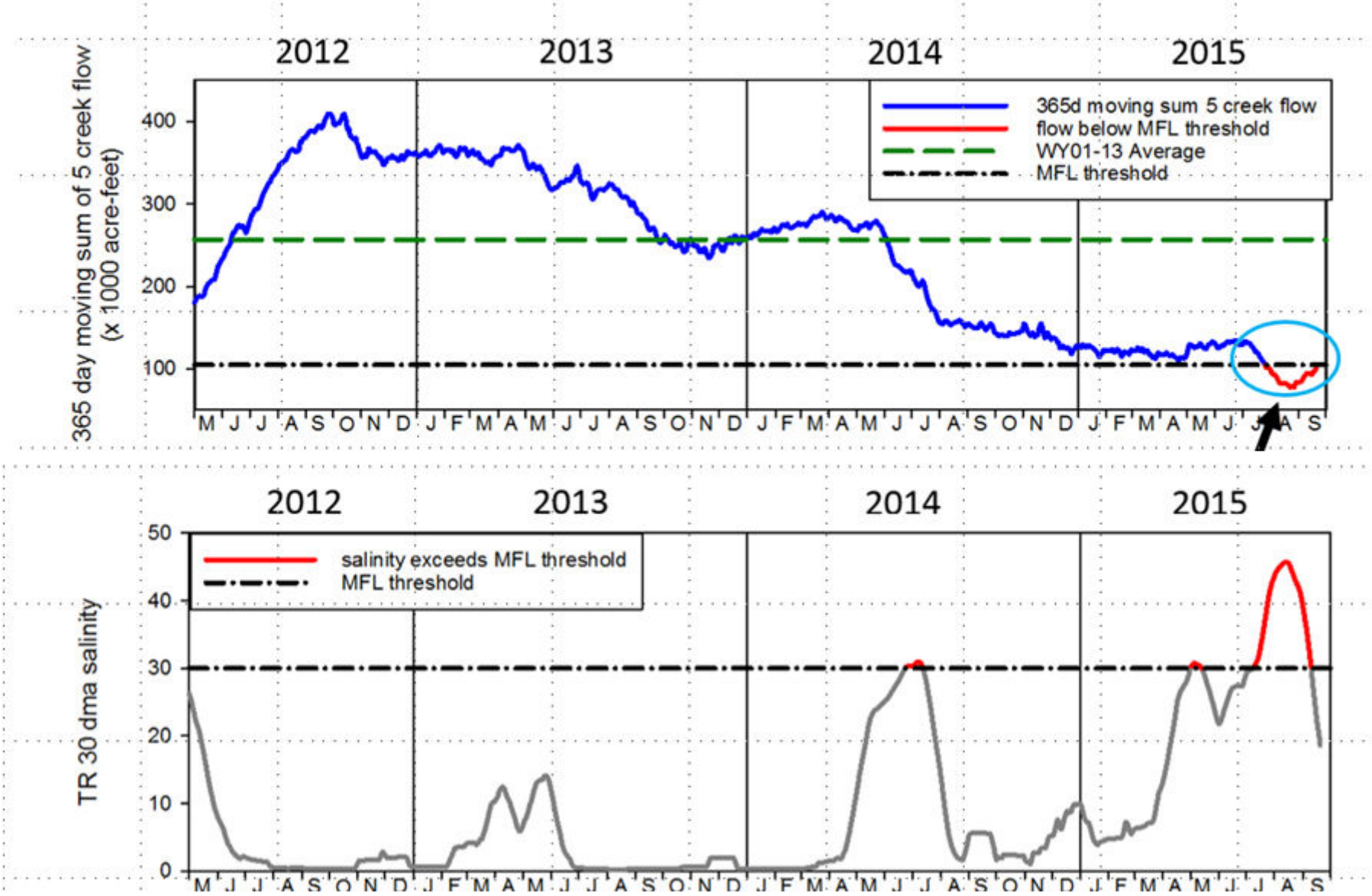
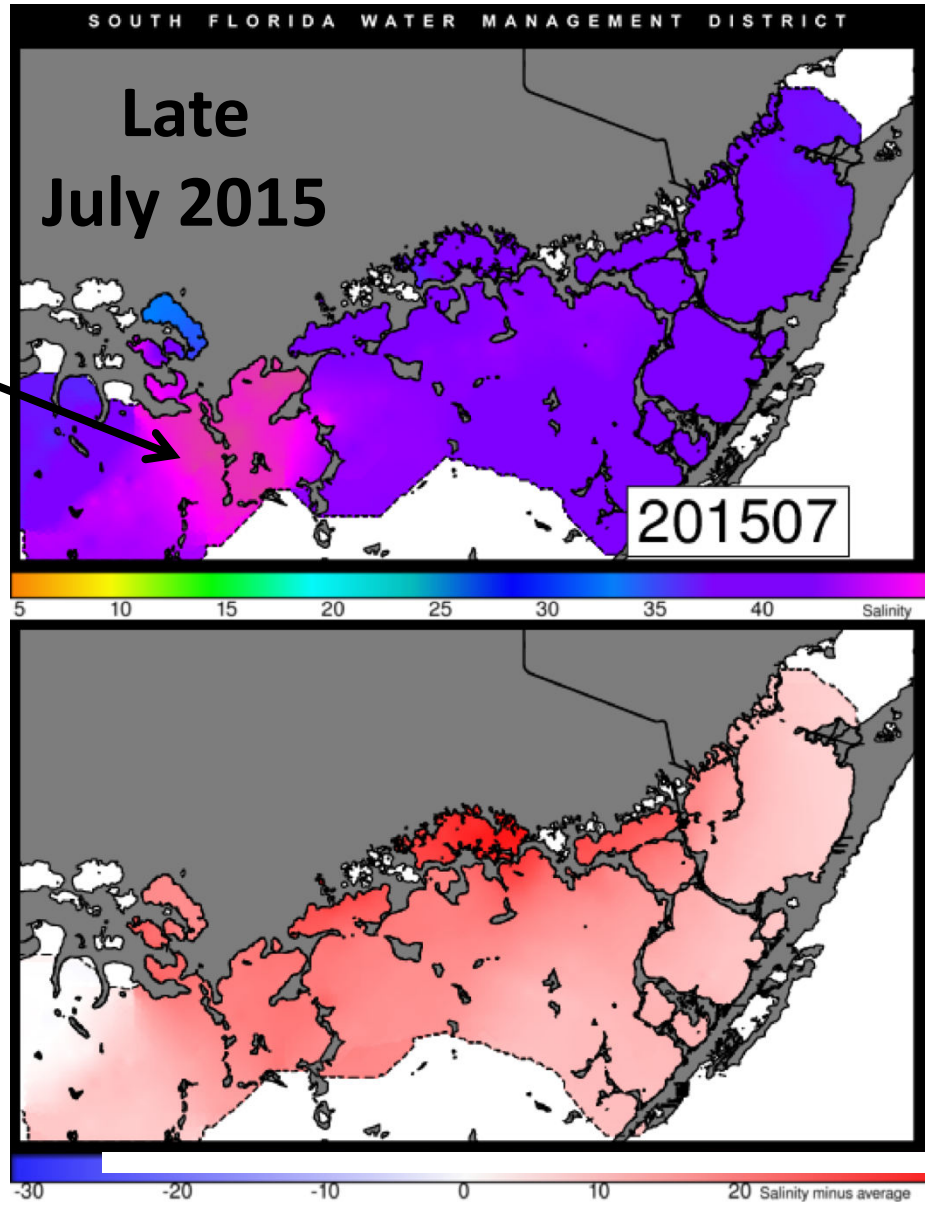
Feedback loops propagate more die-off	• Seagrass mortality produces **decaying detritus** that **consumes more DO** and produces more sulfide • **Nutrient release** from detritus **stimulates algal blooms** that **decreases light** and seagrass DO production • **Sediments** are destabilized with seagrass mortality and **resuspended**, further **decreasing light**


2012
2013
2014
2015
365 day moving sum of 5 creek flow
(x 1000 acre-feet)
400
300
200
100
365d moving sum 5 creek flow
flow below MFL threshold
WY01-13 Average
MFL threshold
M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
2012
2013
2014
2015
TR 30 dma salinity
50
40
30
20
10
0
salinity exceeds MFL threshold
MFL threshold
M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S

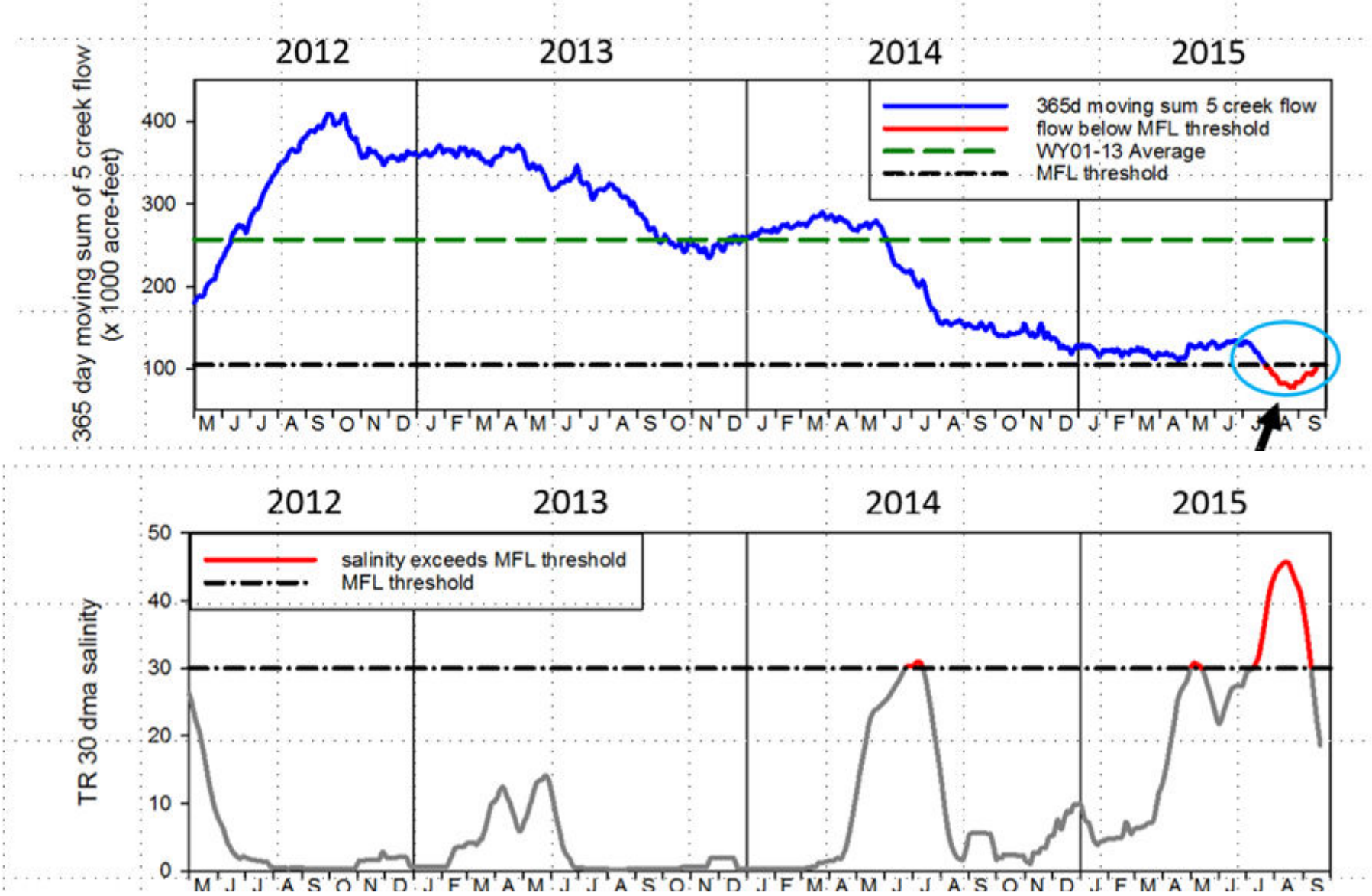
Mapping Florida Bay Salinity

- Average salinity – 35 psu
- In July, salinities exceeded 50 psu in large area of central Florida Bay
- Salinity as high as 72 psu measured at Garfield Bight



- Map shows how much salinity levels deviate from average conditions*
- Darker the pink coloration, the higher above average the salinity

* (2006-2014)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365 day moving sum of 5 creek flow
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400
300
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WY01-13 Average
MFL threshold
M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
2012
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2015
TR 30 dma salinity
50
40
30
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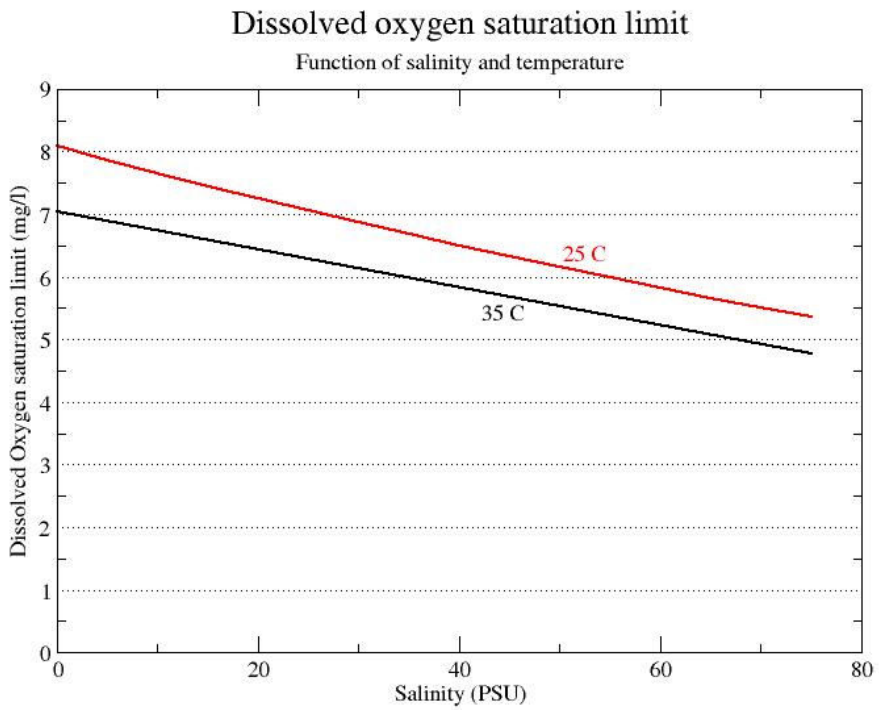
salinity exceeds MFL threshold
MFL threshold
M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S

Everglades National Park

South Florida Natural Resources Center



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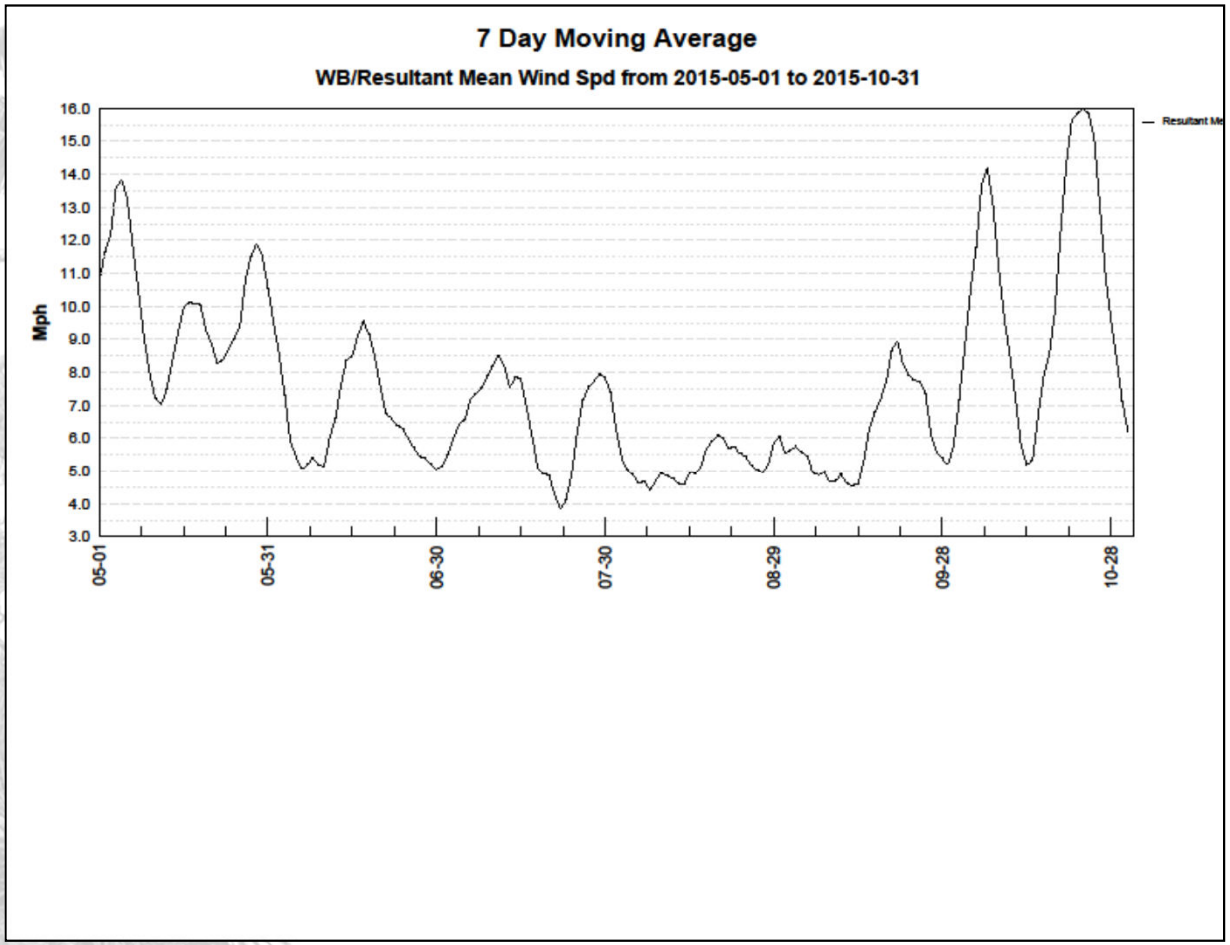
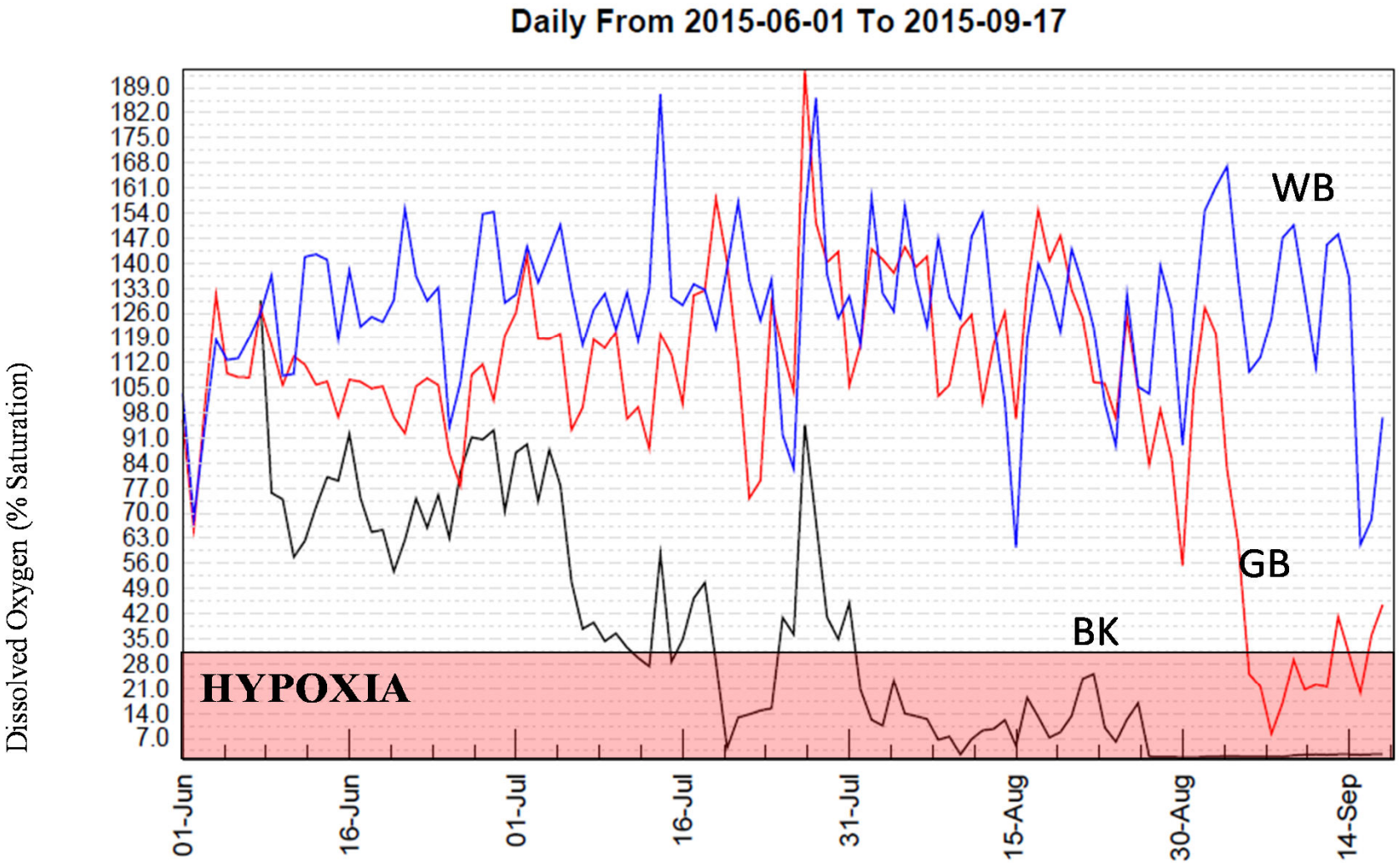
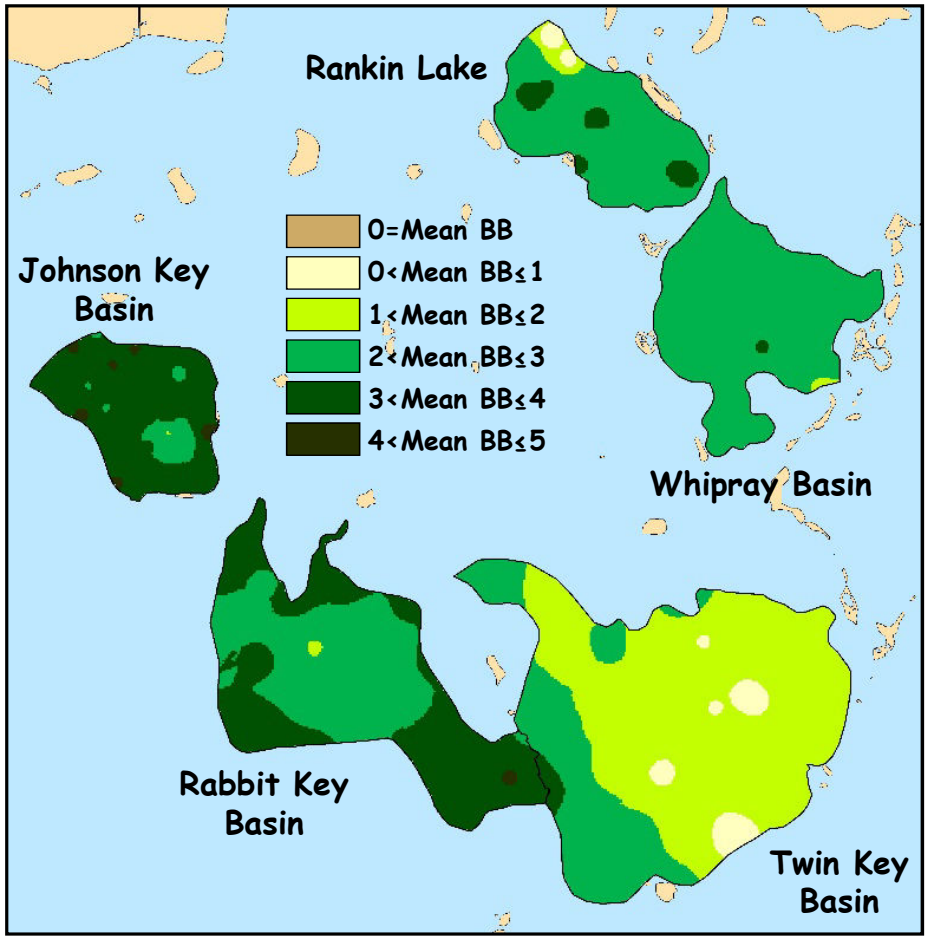


Dissolved Oxygen

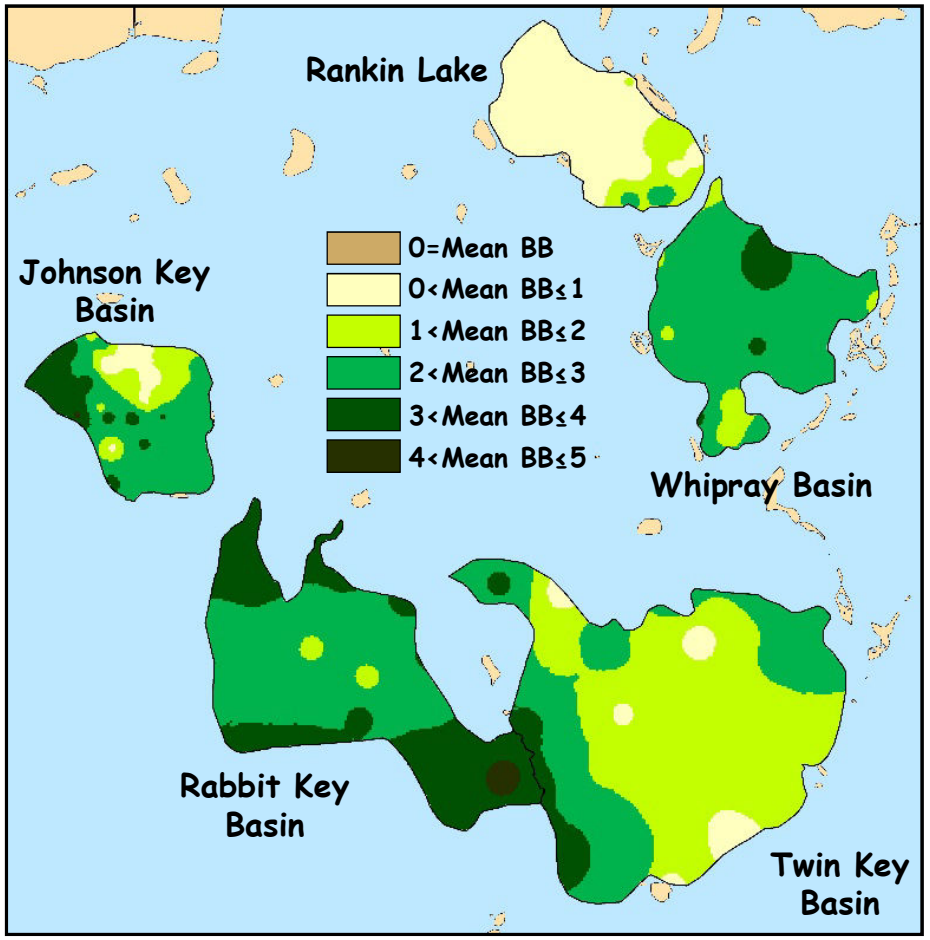


BK-Buoy Key (black) GB-Garfield Bight (red)

WB-Whipray Basin (blue)

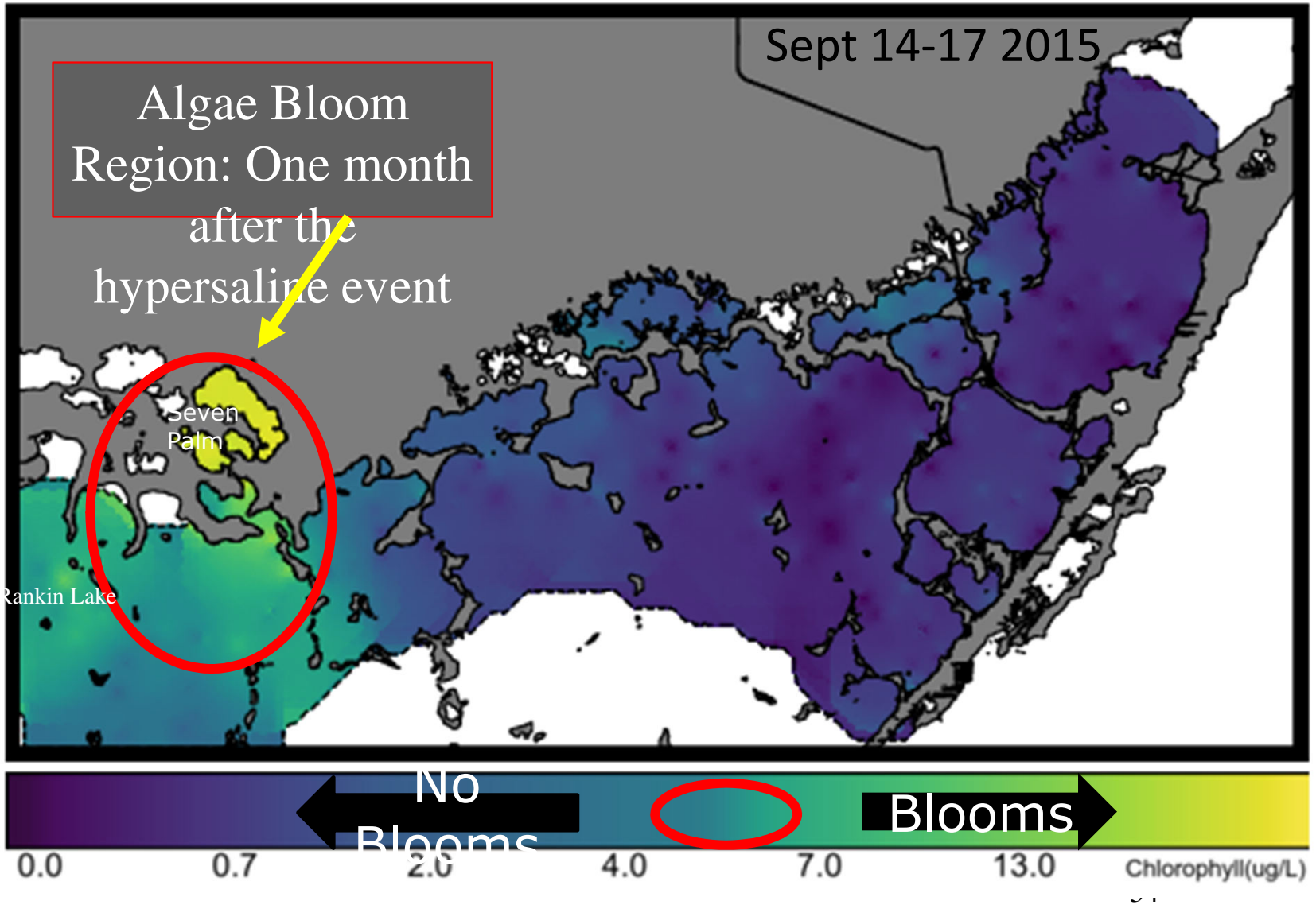


SUMMER 2015



FALL 2015

Florida Bay
Algal Bloom Location



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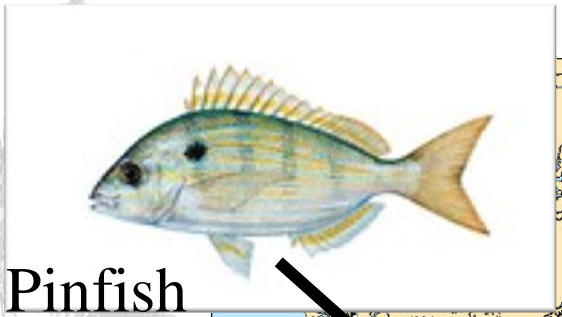
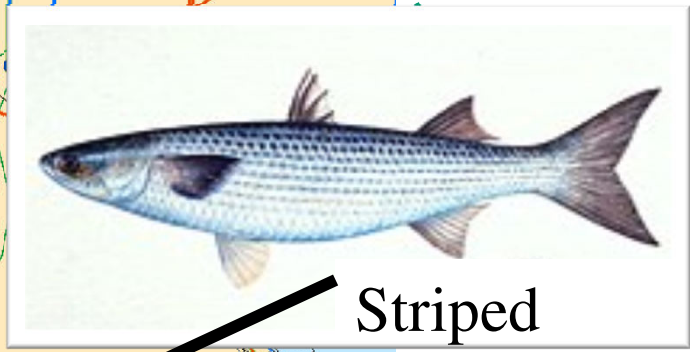


Pinfish



Striped
Mullet

Gulf Toadfish

Florida Bay Conceptual Ecological Model