Ecological Characteristics of Biscayne Bay

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South Florida Water Management District
Governing Board Workshop
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Photo Credit: Kathy Haunert

Key Biscayne Bay Characteristics

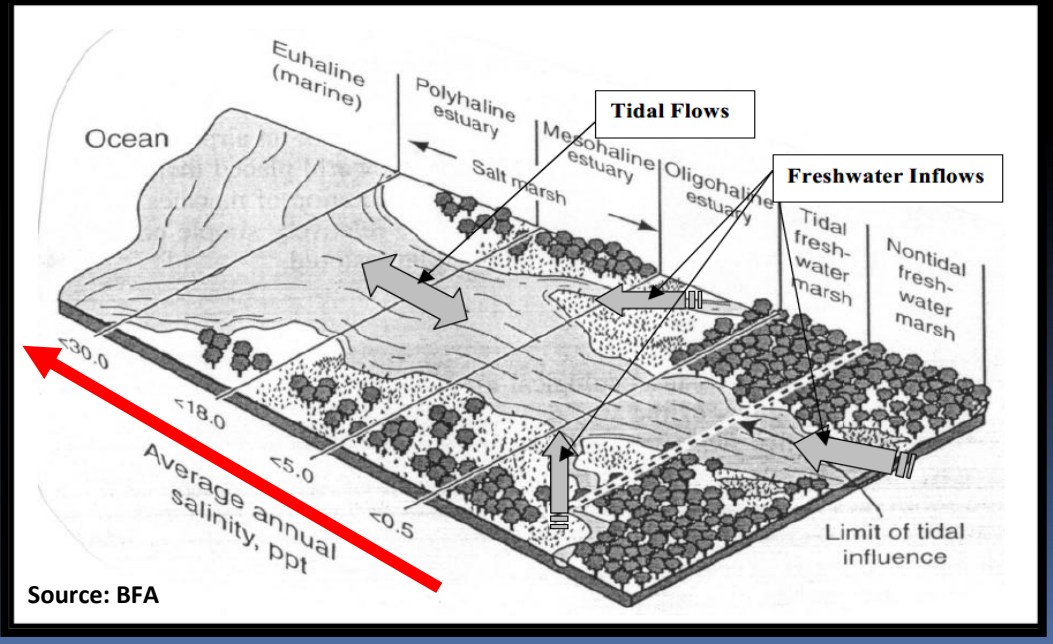
1. **Pre-Drainage Characteristics:** Importance of Transverse Glades and Creeks for Maintaining Estuarine Salinity Zones
2. **Post-Drainage Characteristics:** Effects of Urbanization on the Bay's Water Quality and Ecology
3. **Benthic Habitats:** Seagrass Losses
4. **Algae:** Macro- and Micro-algal Blooms and Accumulation
5. **Epifauna and Fish:** SAV- and Mangrove-Associated Epifauna and Fish Communities
6. **Recent Fish Kill Events**
7. **Effects of Extreme Weather Events on the Bay:** Hurricane Irma

Pre-Drainage Characteristics

Courtesy: Little River Conservancy

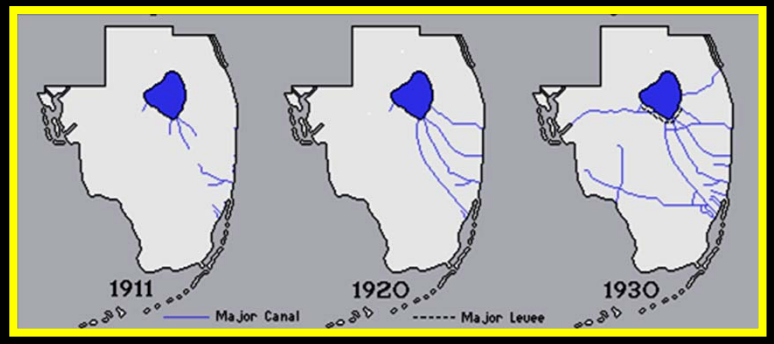
An offshore freshwater spring in Biscayne Bay ~1930

Rainfall-driven system with estuarine salinity conditions

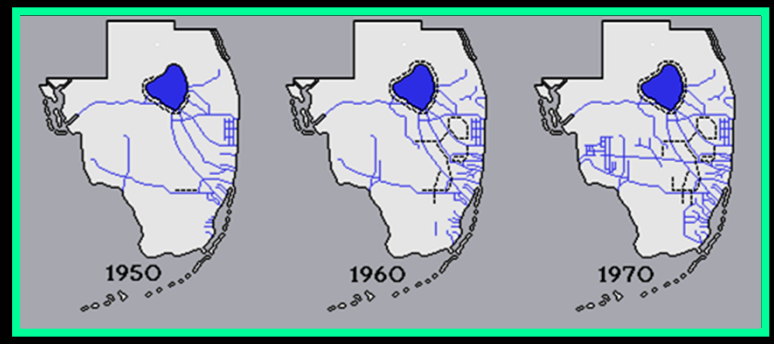


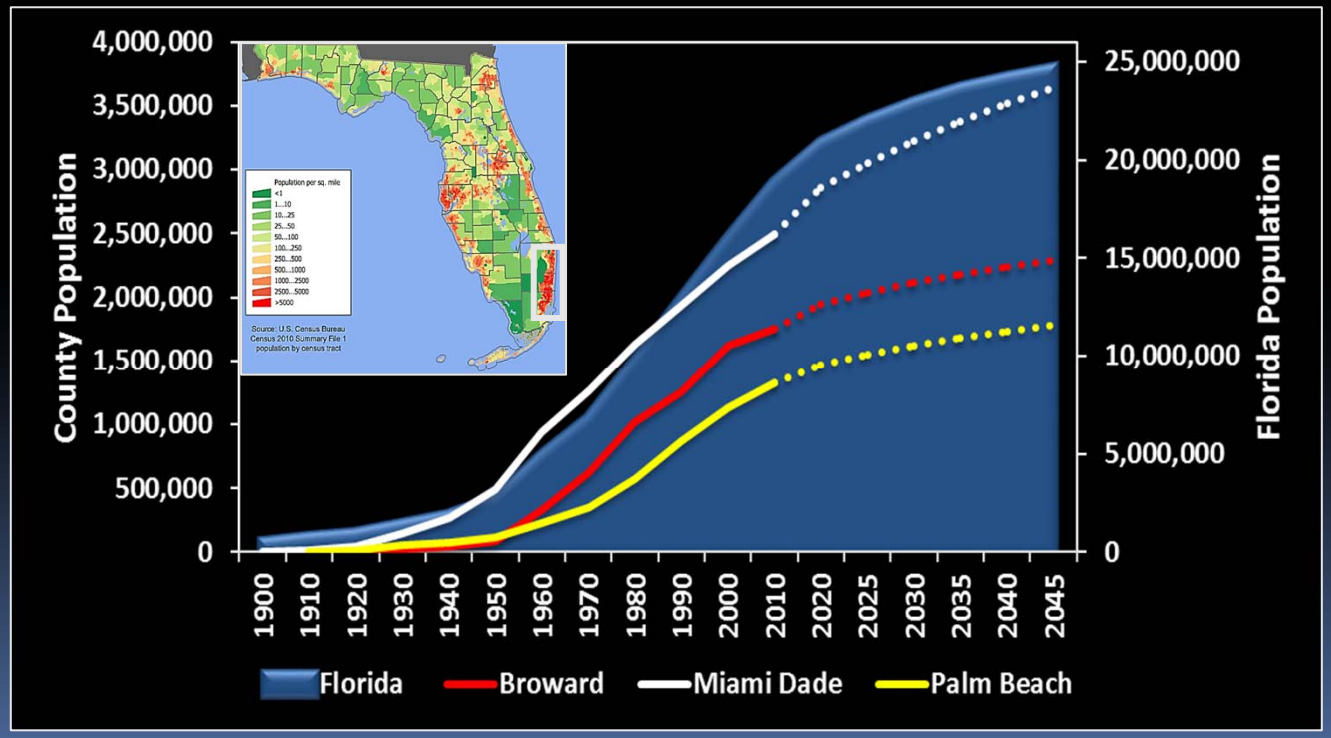
Changes in the Region's Population Growth and Hydrology since 1900

Pre-1948 Drainage Projects

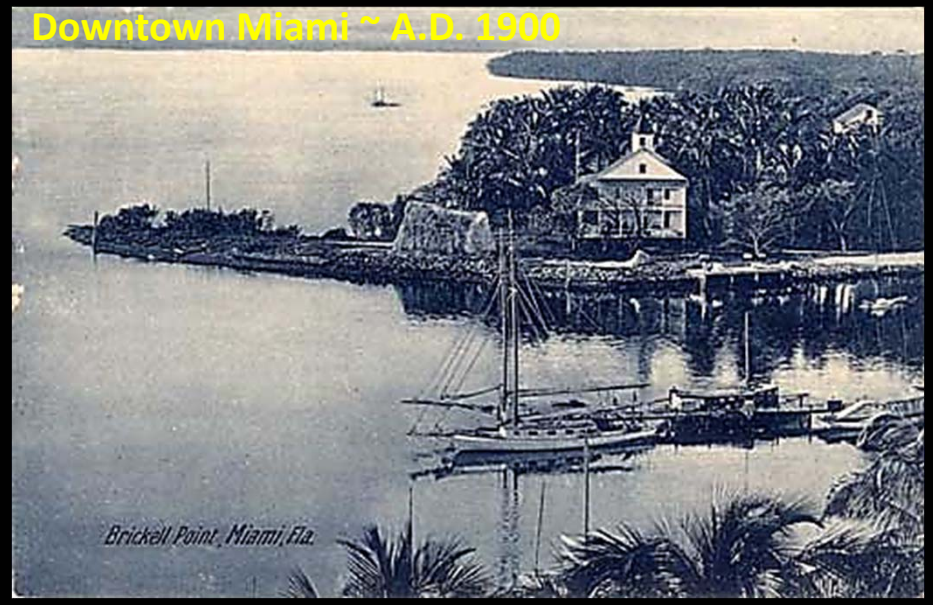


Post-1948 C & S Florida Project





Downtown Miami ~ A.D. 1900



Downtown Miami A.D. 2020

Source: U.S. Census 2010

Presenter: Anna Wachnicka

Effects of Urbanization on Biscayne Bay Ecosystem

Drivers of Change

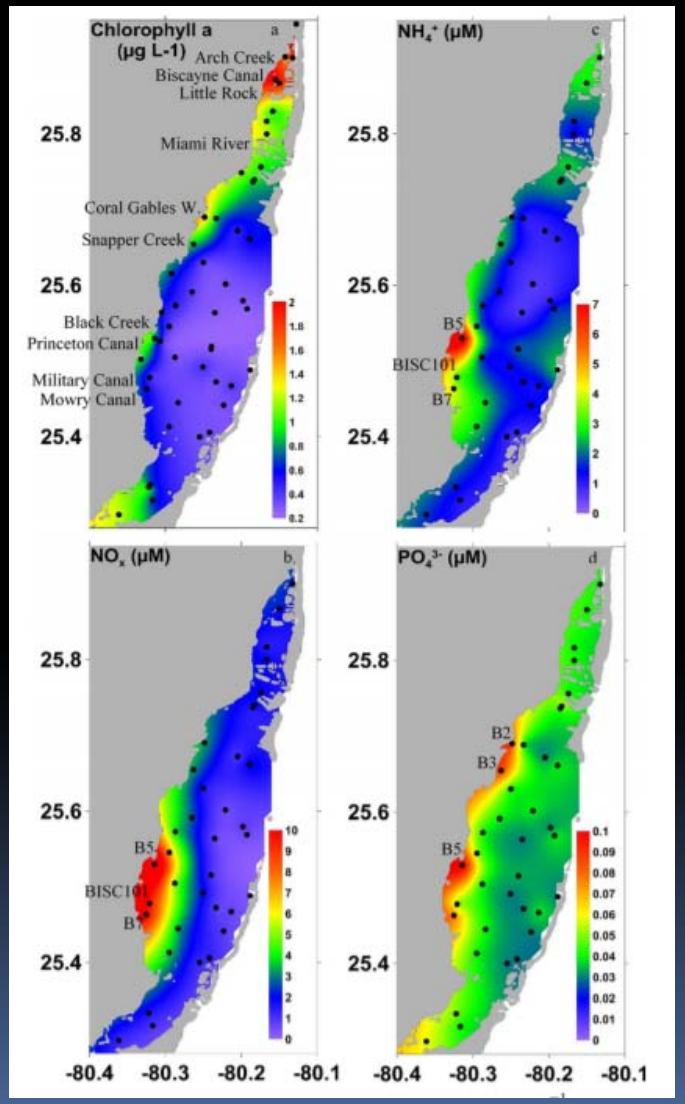
- Pulsed freshwater inflows/ dry season hyper salinity
- Degraded water quality
- Altered water circulation & residence time
- Benthic habitat loss
- Micro- & macro-algal blooms
- Shift in species richness and diversity
- Saltwater encroachment

Effects

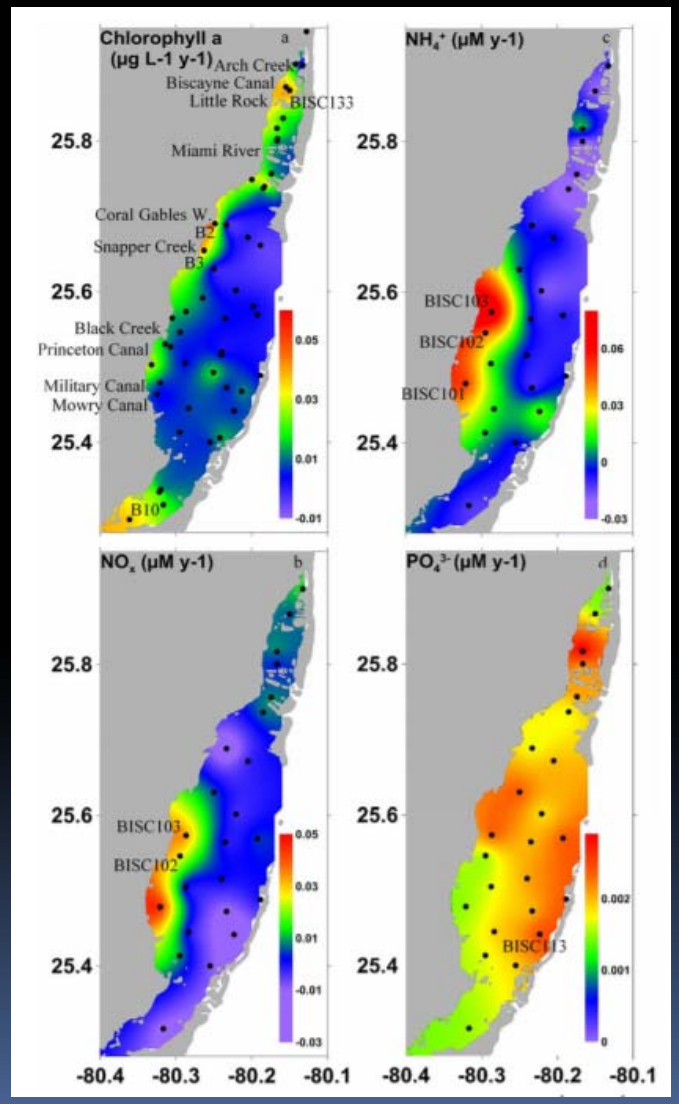
Presenter: Anna Wachnicka

Long-Term Changes in Water Quality within the Bay

Average Concentrations (1995–2014)



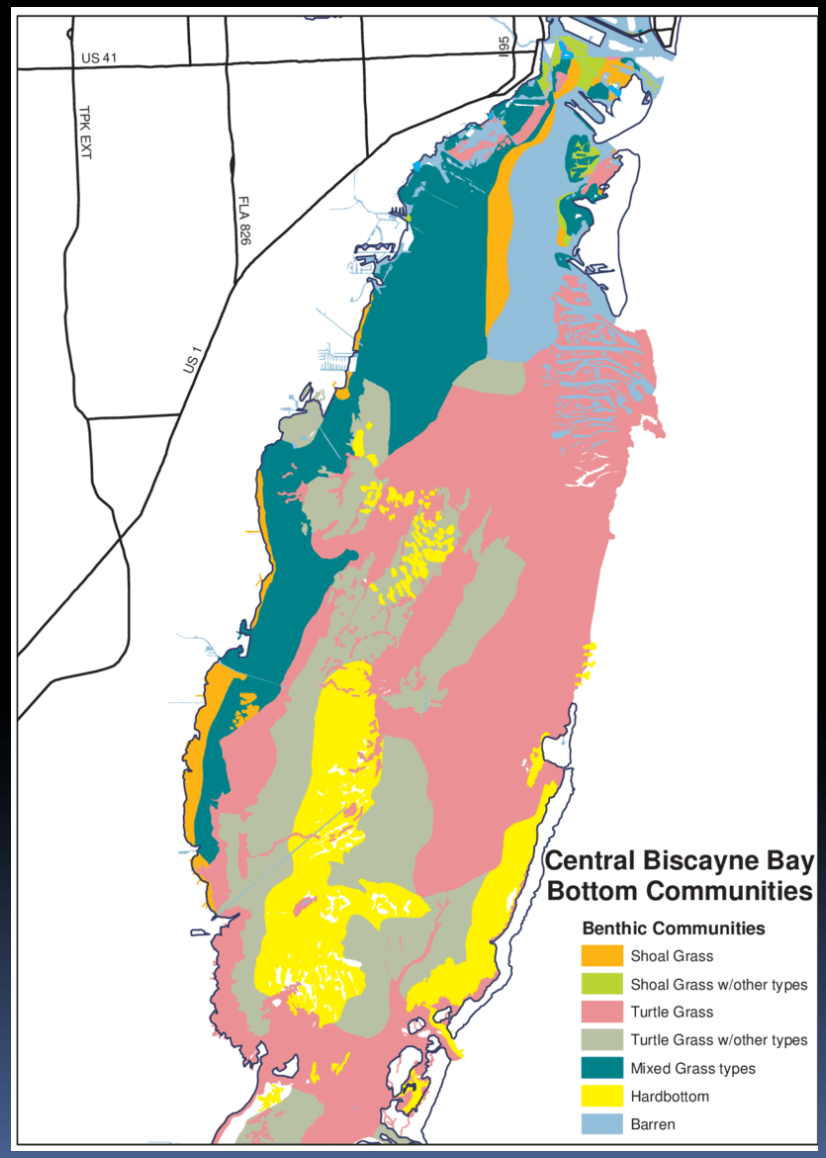
Annual Rate of Change (1995–2014)



- Chlorophyll *a* and phosphate concentrations have increased throughout the Bay
- Chlorophyll *a* concentrations in Northern and nearshore areas of Central Bay are increasing at a higher rate compared to the rest of the Bay

Source: Millette et al., 2019

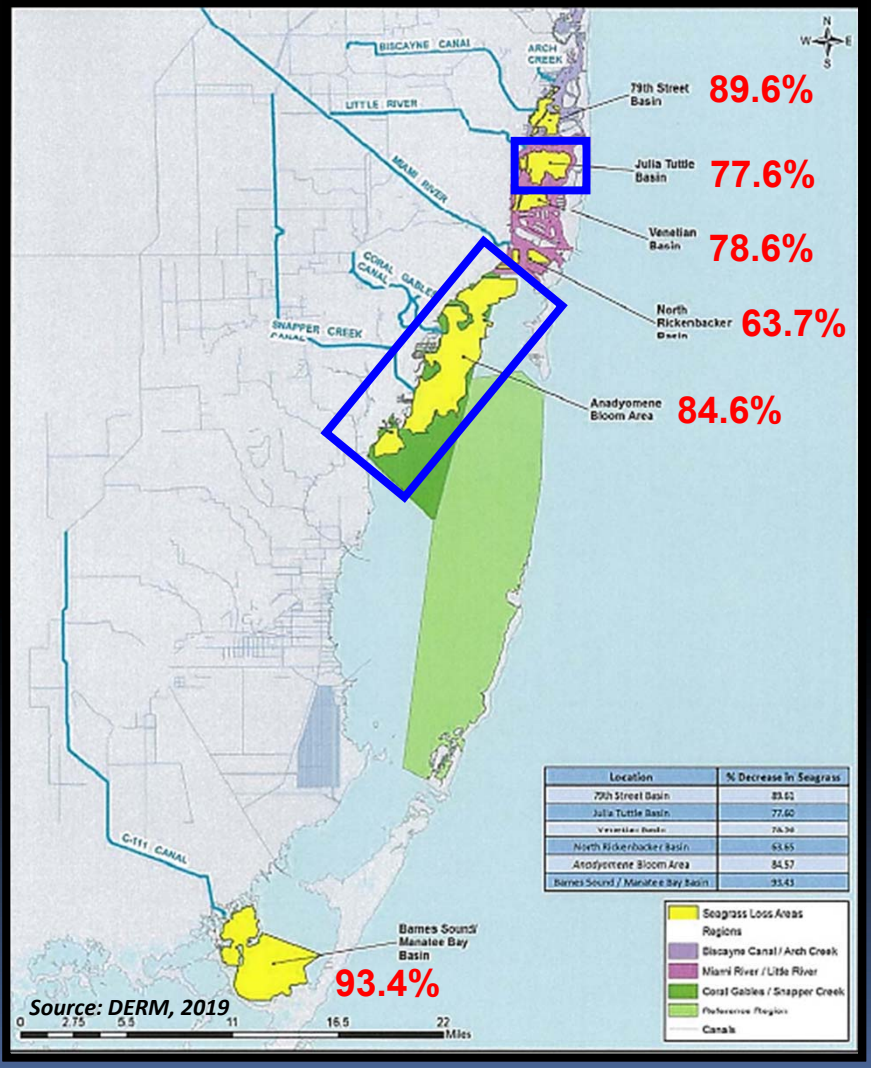
Biscayne Bay Benthic Communities



Source: Miller et a., 2005

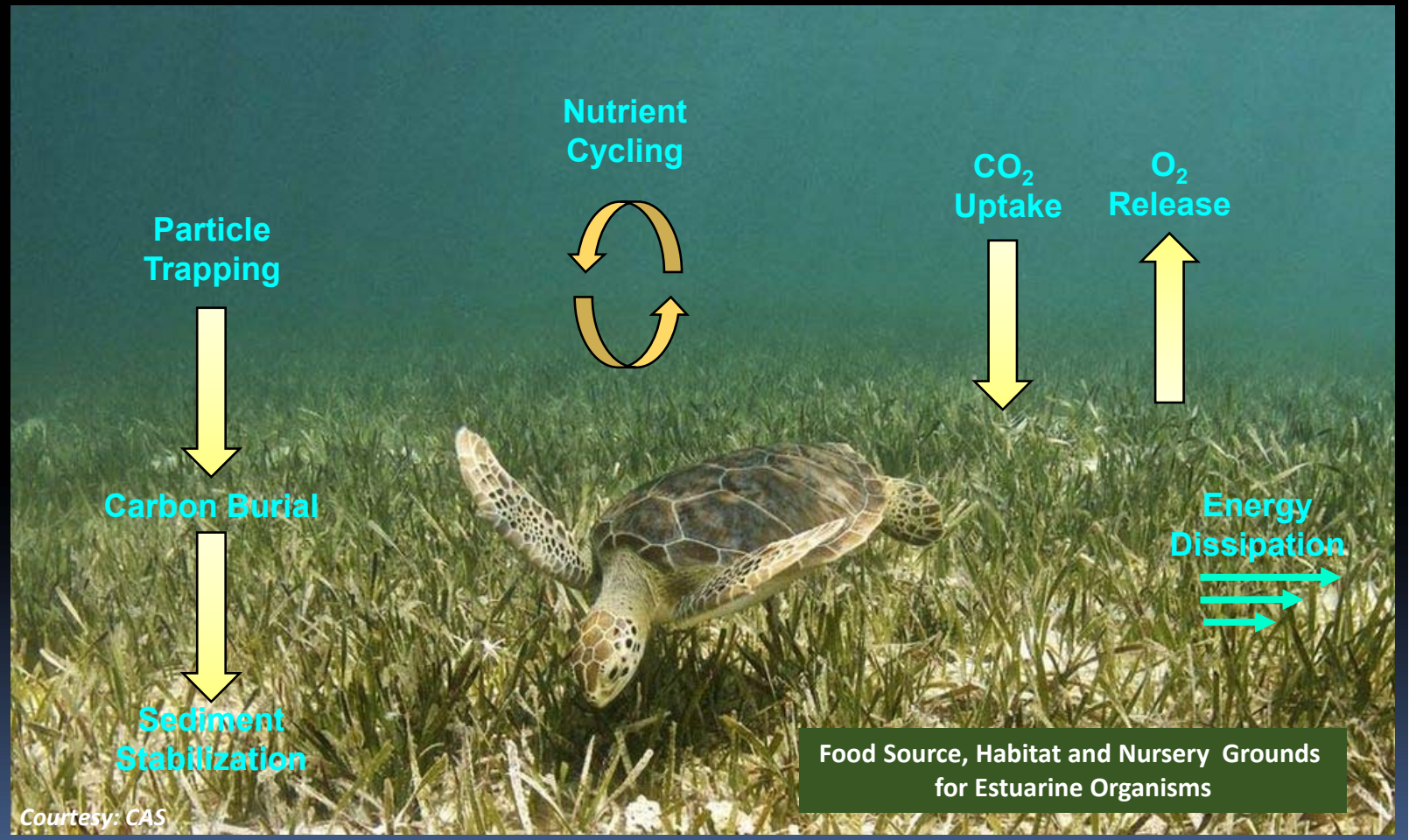
Decline in Seagrass Cover in Biscayne Bay

Seagrass Losses in Biscayne Bay (2005 – 2018)



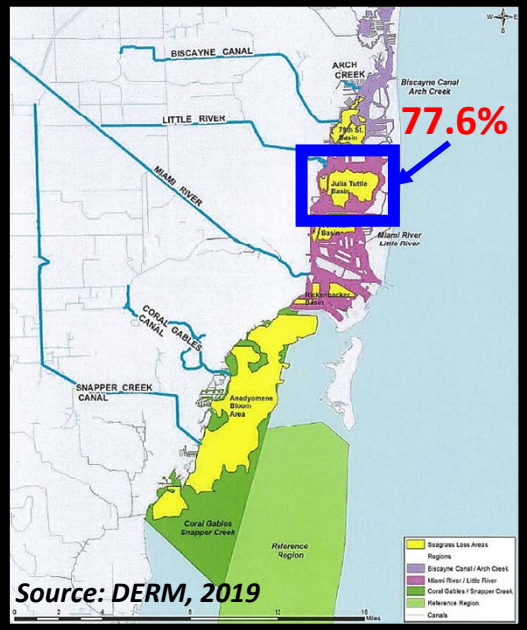
Source: DERM, 2019

The Role of Seagrasses in Estuarine Ecosystems

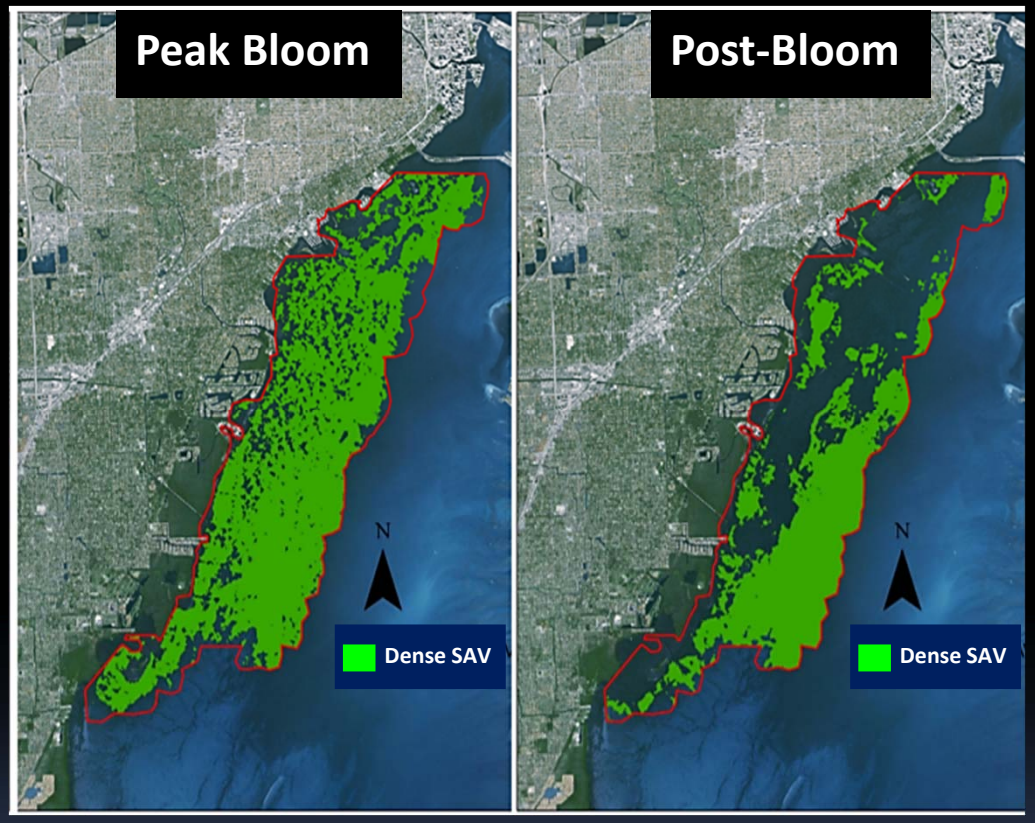


Courtesy: CAS

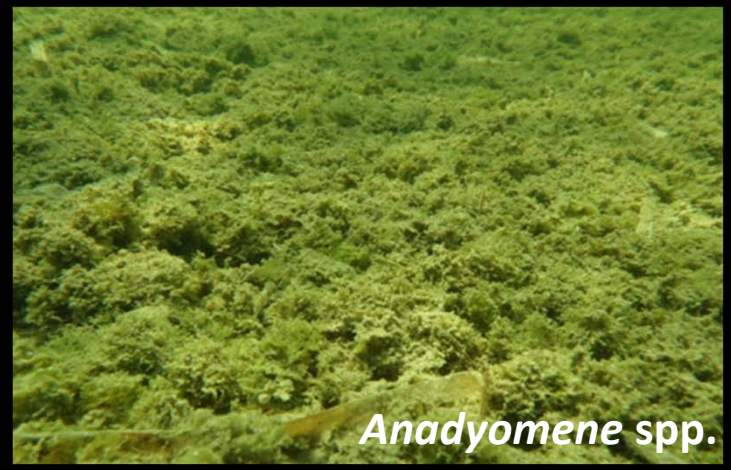
Decline in Seagrass Beds in Julia Tuttle Basin in North Biscayne Bay



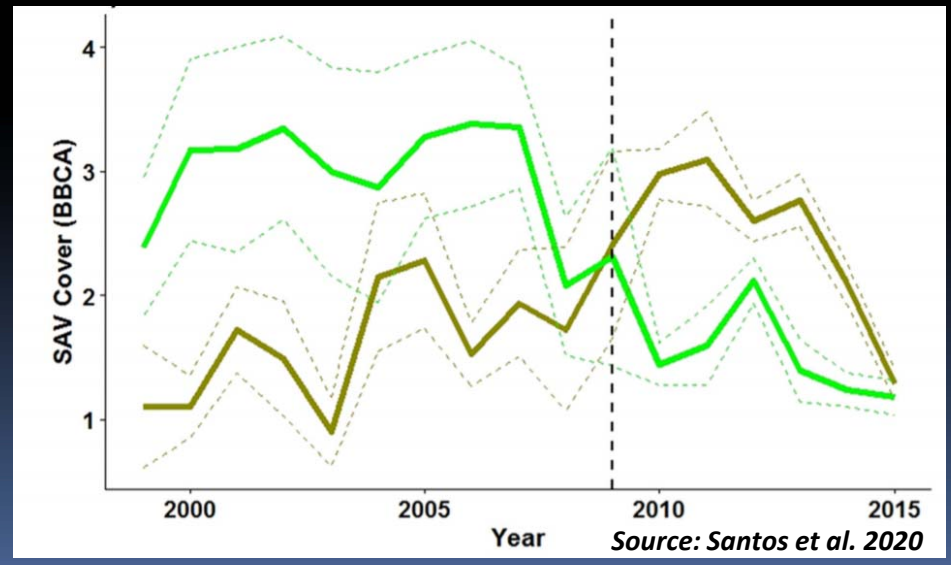
Impacts of *Anadyomene* Bloom on Seagrass Community in Northwestern Biscayne Bay



Source: Santos et al. 2020



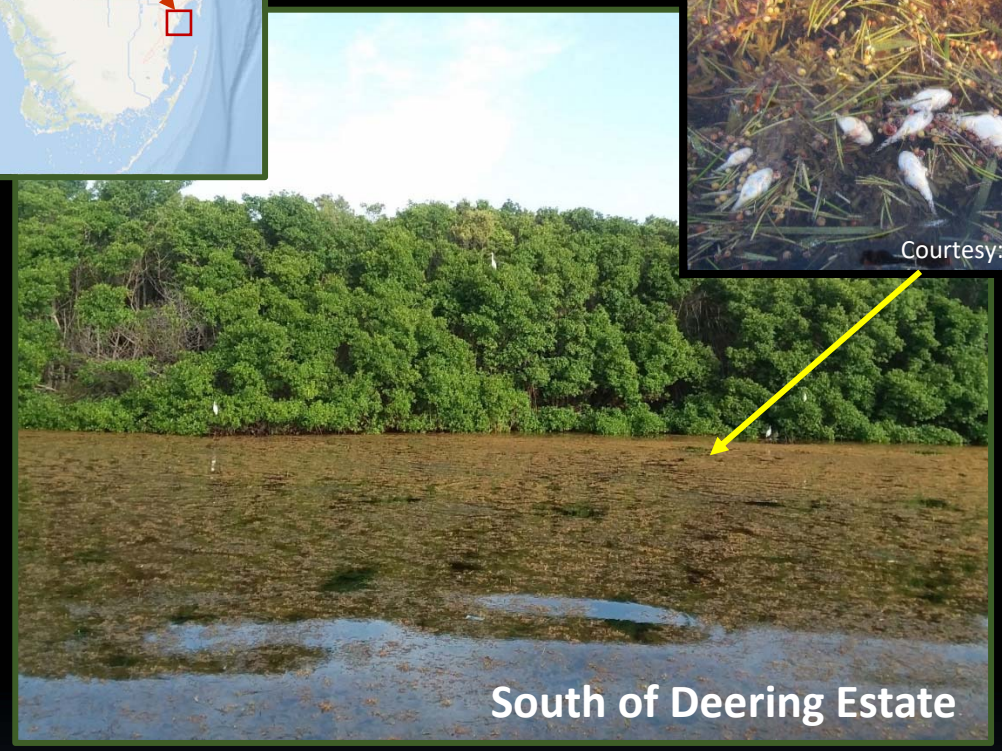
Courtesy: L. Collado (FIU)



Source: Santos et al. 2020

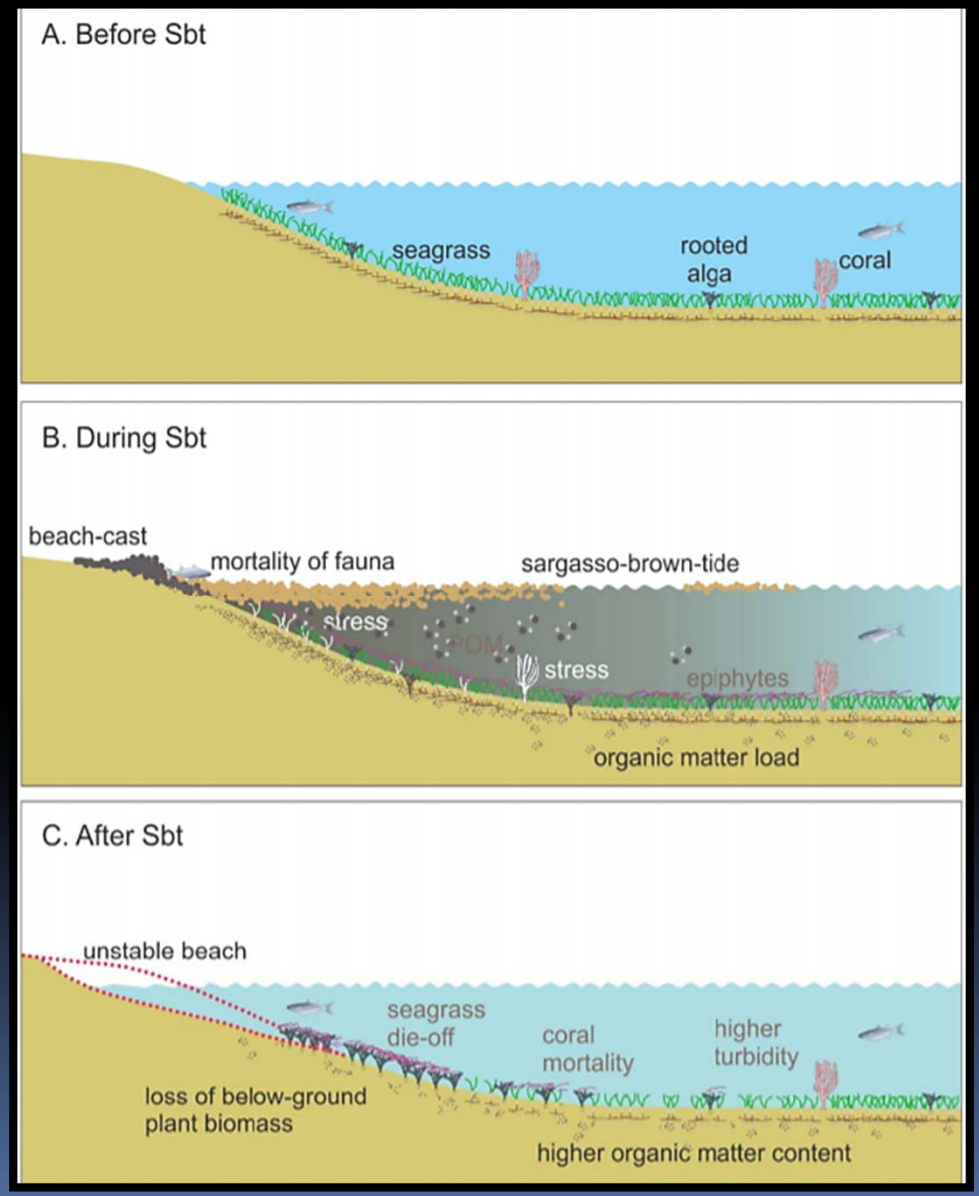
- **Significant reductions of seagrass cover and a seascape structure transformation after *Anadyomene* spp. bloom**

Effects of Sargassum Seaweed Accumulation



Effects of Sargassum Accumulation:

- Decreased light penetration and seagrass mortality
- Nutrient influx/Eutrophication
- Hypoxia and epifauna mortality
- Long recovery period



Source: Tussenbroek et al 2017

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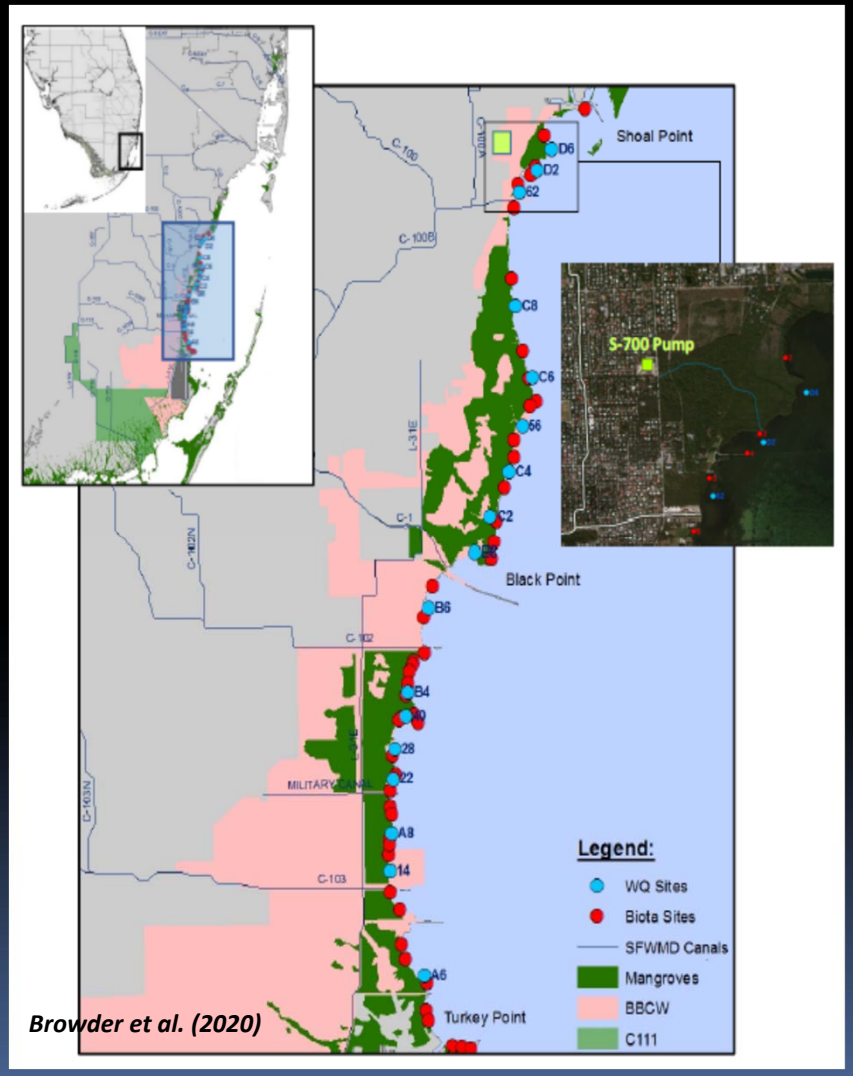
Integrated Biscayne Bay Ecological Assessment and Monitoring Program (IBBEAM)



Browder et al. (2020)

2004-Present

Water Properties
(YSI network: salinity, temperature, dissolved oxygen)

→ 17 Fixed Stations
15-Min data; all sites
(instantaneous)

2008-Present

Submerged Aquatic Vegetation
(Photo quadrats: diversity, species-specific cover, canopy height)

→ 47+ Fixed Stations*
210 Random Sites
Dry and Wet Season
Photo/Visual Surveys

2005-Present

Epifauna (SAV-associated)
(Throw traps: diversity, species-specific cover, canopy height)

→ 47+ Fixed Stations*
Dry and Wet Season
Throw-Traps

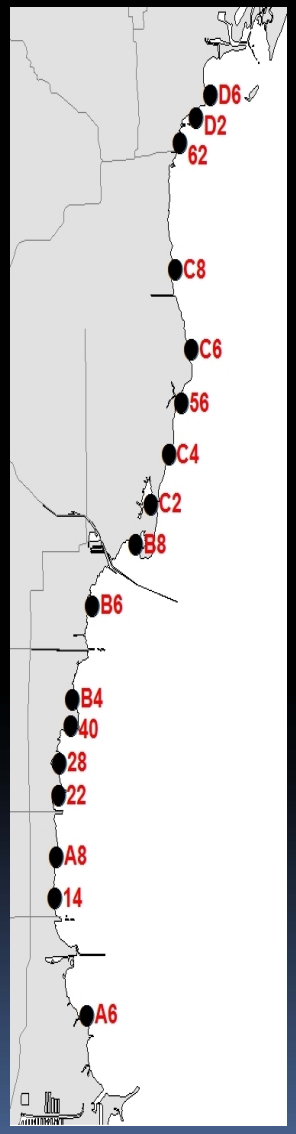
1998-Present

Mangrove Fishes
(Visual belt-transects: diversity, species-specific density, size-structure)

→ 47+ Fixed Stations*
Dry and Wet Season
Visual Surveys

Courtesy: Serafy (NOAA/UM)

Spatial and Temporal Salinity Patterns at IBBEAM Locations



Mesohaline Persistence Index

WYR	2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		2020		Mean	
CYR	2009	2010	2010	2011	2011	2012	2012	2013	2013	2014	2014	2015	2015	2016	2016	2017	2017	2018	2018	2019	2019			
Month	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct	Nov-Apr	May-Oct		May-Oct	Nov-Apr
Season	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet		Wet	Dry
D6			0.00	0.00	0.78	0.33	2.81	0.00	7.27	0.00	0.00	0.00	0.00	2.80	1.27	0.00	6.26	0.00	6.48	0.00	0.00		2.76	0.35
D2			0.00	0.00	0.31	0.20	3.51	0.00	4.60	0.00	0.00	0.00	0.11	4.84	0.94	0.00	5.01	0.00	4.14	0.00	0.36		2.11	0.56
62	0.39	0.11	2.36	0.01	0.58	1.75	6.97	0.00	6.65	0.19	0.13	0.02	0.26	10.84	4.86	0.00	6.00	1.01	7.96	0.00	3.07		3.81	0.95
C8			3.30	0.00	1.50	2.35	12.65	0.00	9.86	1.08	0.32	0.00	1.64	8.36	5.10	0.00	10.77	1.72	8.01	0.00	0.80		5.63	1.50
C6			2.18	0.20	2.13	2.31	20.27	0.00	11.79	0.06	0.26	0.00	0.04	12.48	3.94	0.00	10.31	0.72	7.74	0.00	2.55		6.56	1.75
56	4.02	0.31	5.58	0.14	1.68	1.59	24.22	0.09	23.05	0.22	0.28	0.00	0.00	9.05	11.99	0.00	13.45	0.81	22.48	0.00	6.04		12.74	1.01
C4			7.75	0.21	6.54	3.41	33.21	0.00	42.33	1.56	4.43	0.00	0.00	25.63	17.55	0.02	19.31	3.89	32.51	0.00	6.19		18.01	3.86
C2			3.25	2.51	4.72	2.13	24.36	0.22	19.44	2.85	4.23	0.10	0.30	27.41	15.42	0.03	25.23	8.07	18.18	0.00	6.40		13.14	4.81
B8			11.73	7.61	3.08	3.14	38.90	0.71	41.34	7.64	2.91	10.80	0.10	47.40	13.54	0.00	25.47	10.09	20.30	0.22	4.42		16.67	9.73
B6			24.24	8.25	10.60	20.73	31.92	37.50	19.43	12.27	8.21	12.25	6.11	20.63	23.38	6.01	15.20	12.33	15.10	4.50	10.48		15.72	14.94
B4			12.32	4.06	7.67	26.14	14.47	10.51	11.65	22.45	7.84	13.34	15.38	33.47	16.27	10.36	13.11	29.99	16.15	4.93	7.79		12.57	17.25
40	13.94	10.59	11.91	9.52	17.25	45.35	39.71	10.59	22.65	26.41	7.86	9.77	5.05	65.96	31.15	9.04	17.51	31.29	15.95	8.27	6.65		17.80	20.07
28	10.05	7.83	14.76	9.51	16.75	31.91	24.97	6.07	17.45	24.39	7.20	6.41	2.95	64.01	30.89	8.26	17.43	34.86	13.23	5.06	5.16		14.91	17.47
22	10.00	9.13	12.89	10.03	12.20	33.22	16.73	3.56	19.36	24.95	7.13	4.84	4.07	53.96	12.60	5.08	16.40	18.32	23.98	4.24	4.54		13.40	15.28
A8			13.38	6.33	7.40	12.27	14.67	7.97	8.67	8.52	3.58	6.08	4.17	13.90	7.93	7.07	10.17	11.36	20.18	2.34	3.09		9.32	8.43
14	7.27	9.05	13.14	6.33	11.71	9.34	10.32	8.40	7.47	3.52	4.35	7.10	5.26	10.31	6.42	8.57	9.81	13.33	12.80	2.58	3.13		8.40	9.03
A6			4.90	2.96	3.53	5.05	11.59	1.17	4.39	3.17	1.45	0.49	5.28	7.15	2.57	2.53	15.70	9.28	9.21	0.00	0.00		5.97	3.53
DJ		91.96	32.79	64.87	35.71																		34.25	78.42

*** Cells not color-coded (i.e., white) represent absent or incomplete (gray values) datasets*

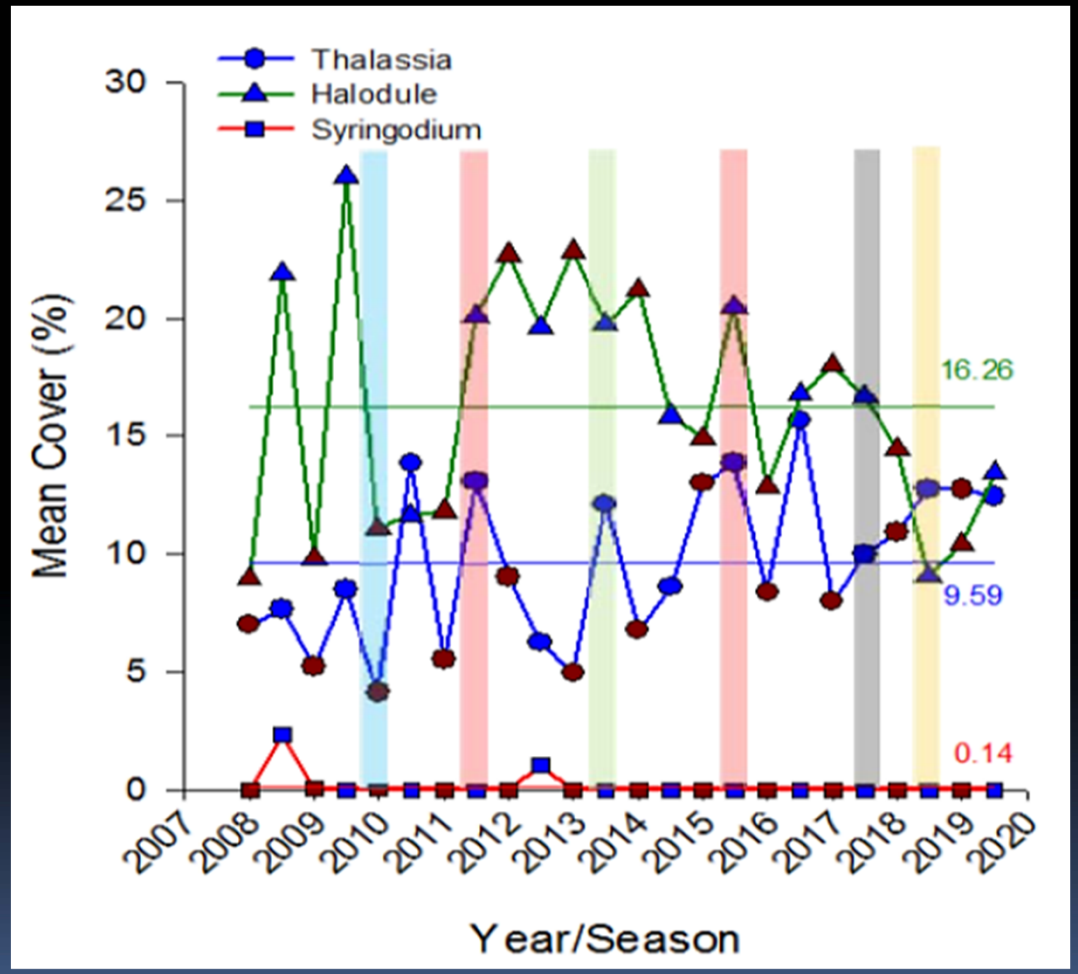
Salinity

Good — Poor

- **The goal is to increase the persistency of mesohaline conditions in nearshore areas of the Bay**
- **Currently, the nearshore zone does not receive enough freshwater to maintain persistent mesohaline conditions**

Courtesy: Browder and Serafy (NOAA/UM)

Spatial and Temporal Differences in Seagrass Cover in Nearshore Areas of Western Biscayne Bay



- ***Halodule*** **sp. cover decreased to less than half former state, while *Thalassia* sp. increased over the last 14 years**

Presenter: Anna Wachnicka

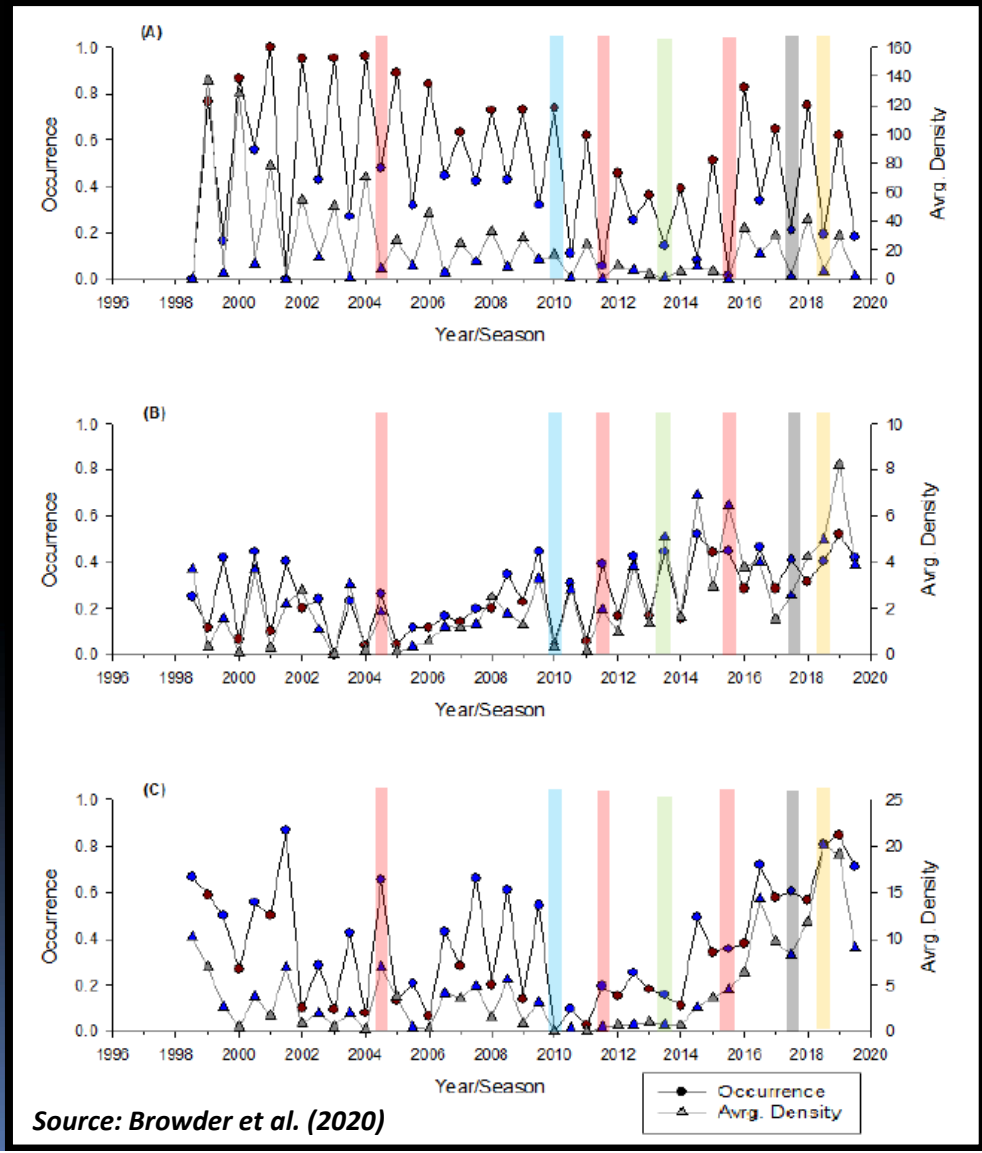
Source: Browder et al. (2020)

Spatial and Temporal Differences in Mangrove- and SAV-Associated Fish Species in Nearshore Areas of Western Biscayne Bay


goldspotted killifish


gray snapper


yellowfin mojarra

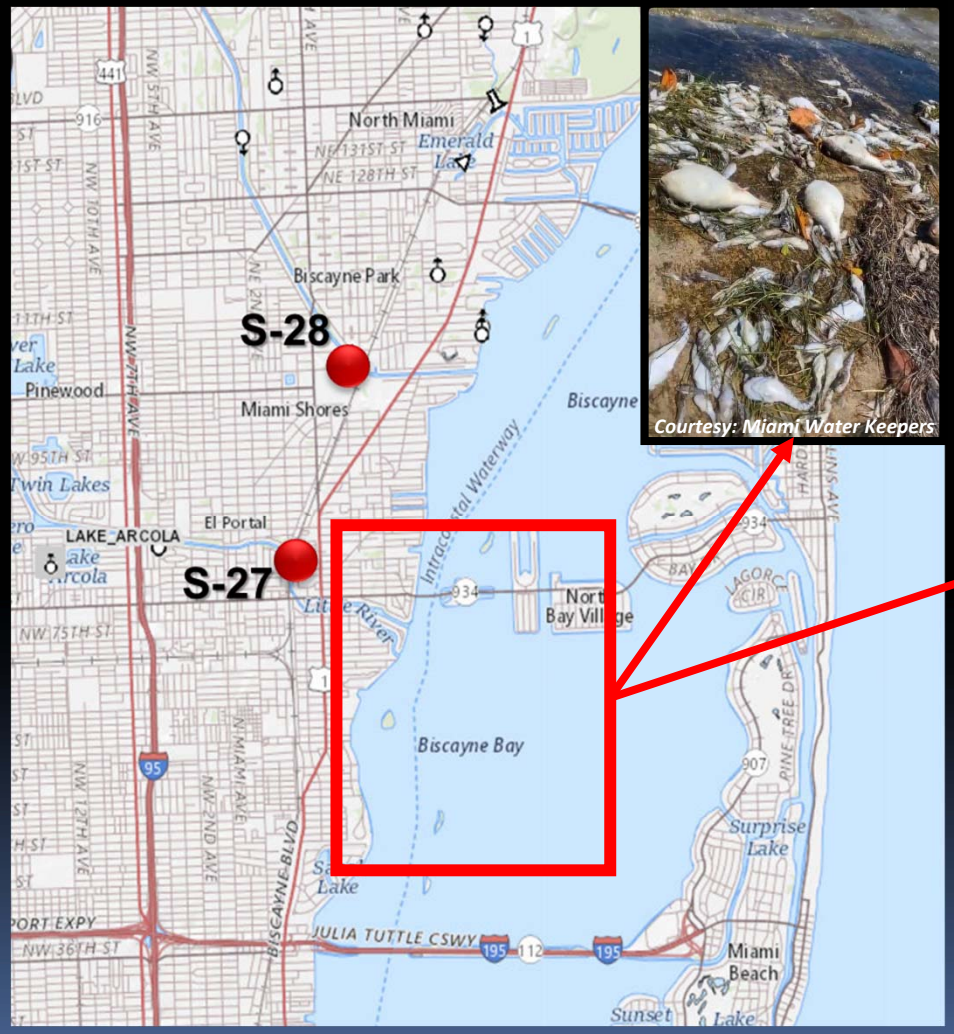


Source: Browder et al. (2020)

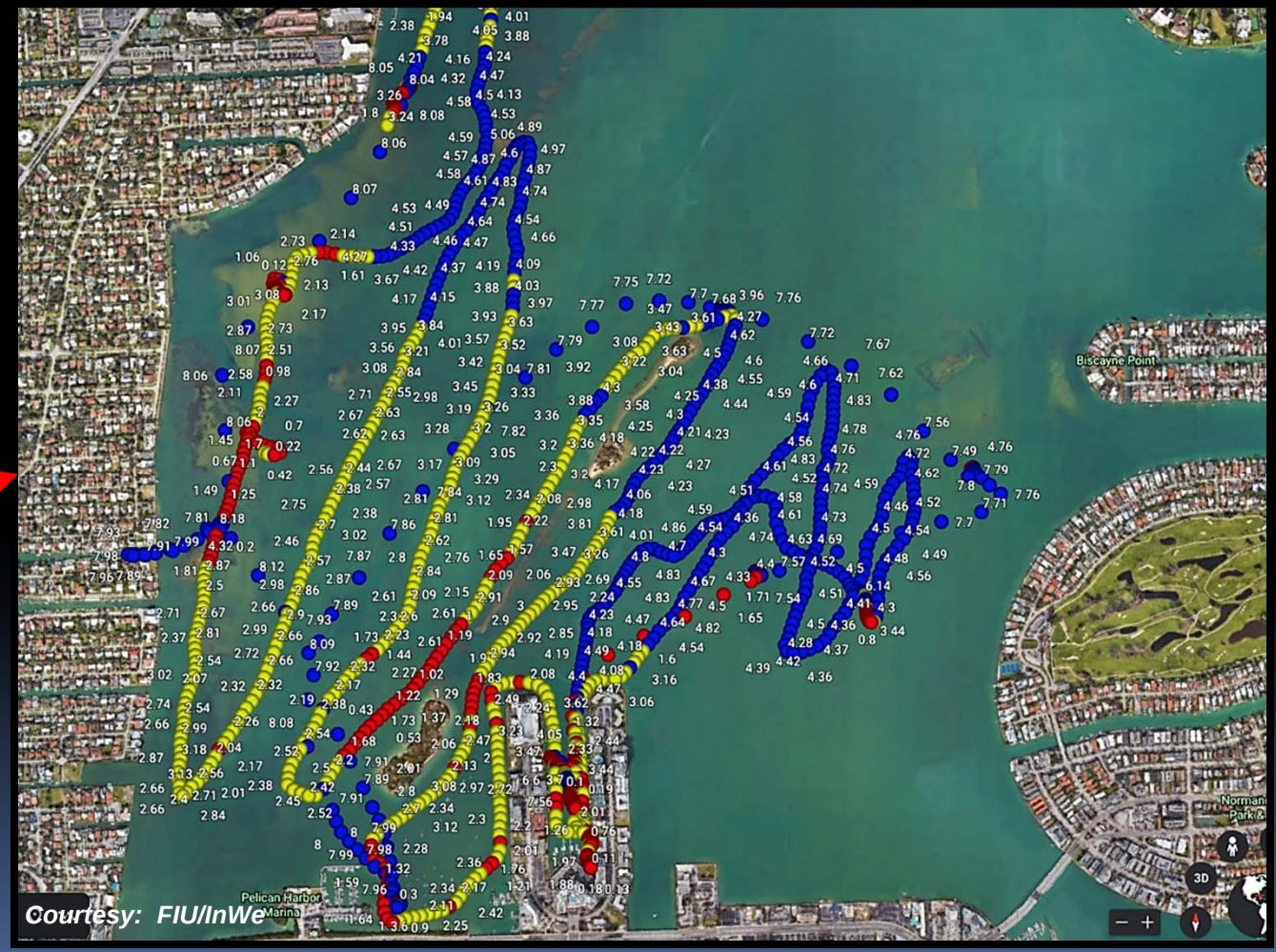
Presenter: Anna Wachnicka

August, 2020 Fish Kill and Low DO Events in North Biscayne Bay

Affected Area of the Bay



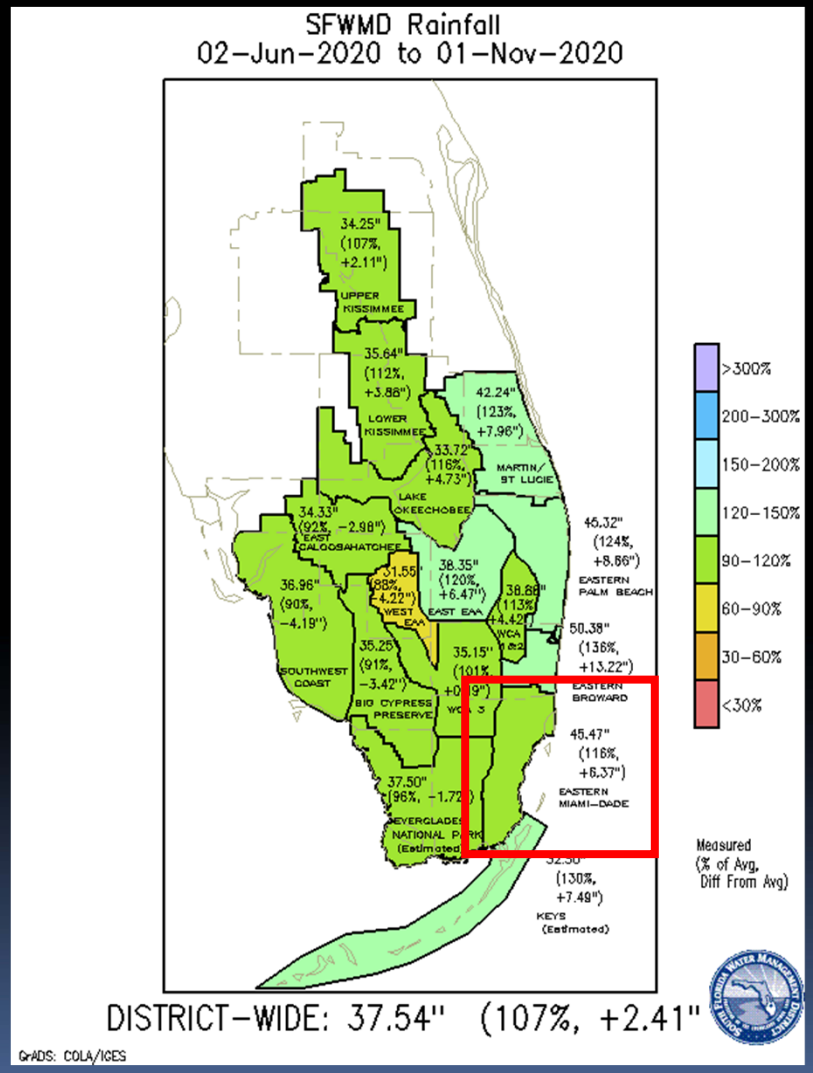
Spatial Differences in Dissolved Oxygen (mg/L) during August Fish Kill Event

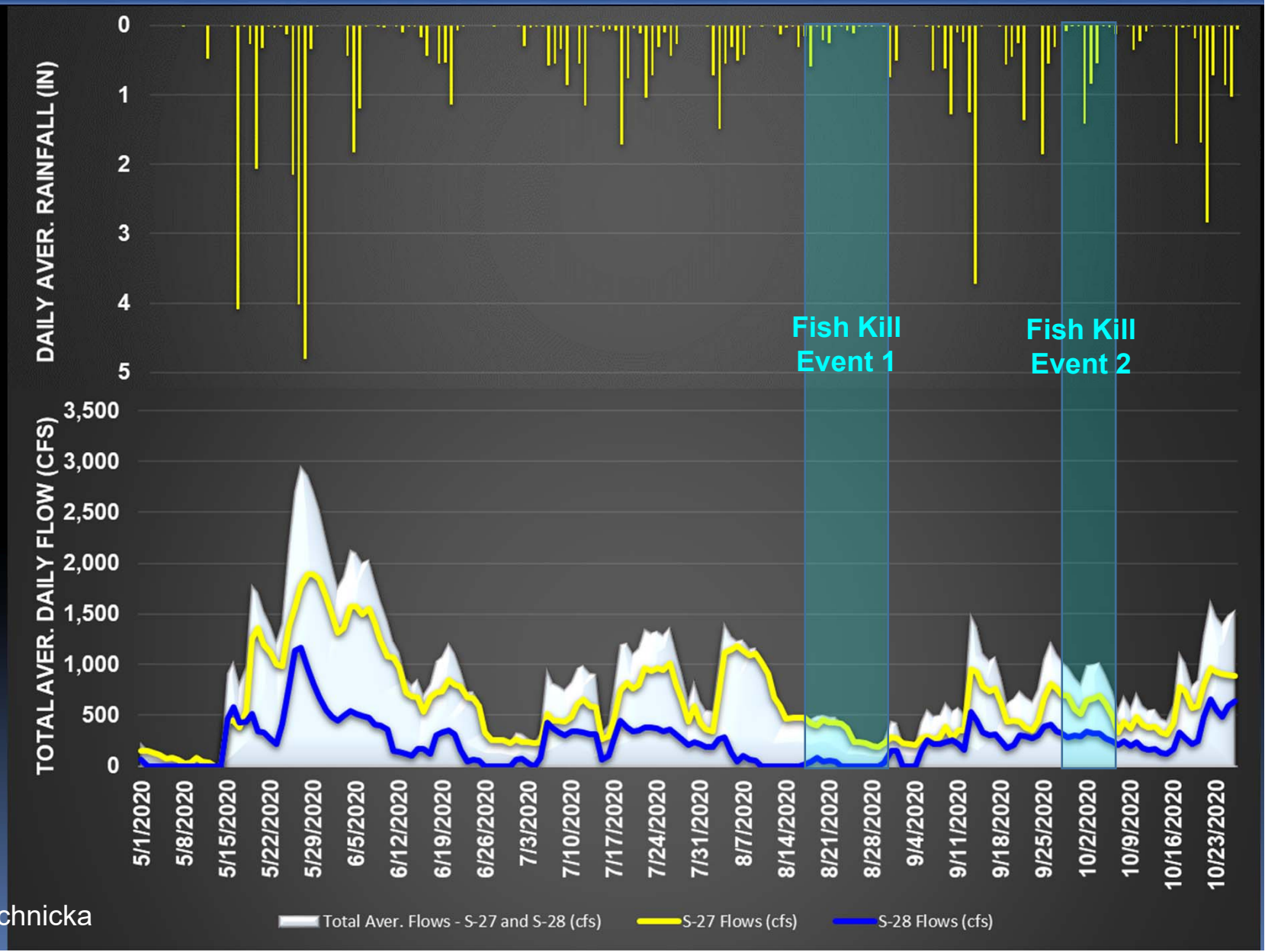


≥ 4 mg/L 2 - 4 mg/L < 2 mg/L

2020 Wet Season Canal Flows and Precipitation in North Bay

Seasonal Rainfall





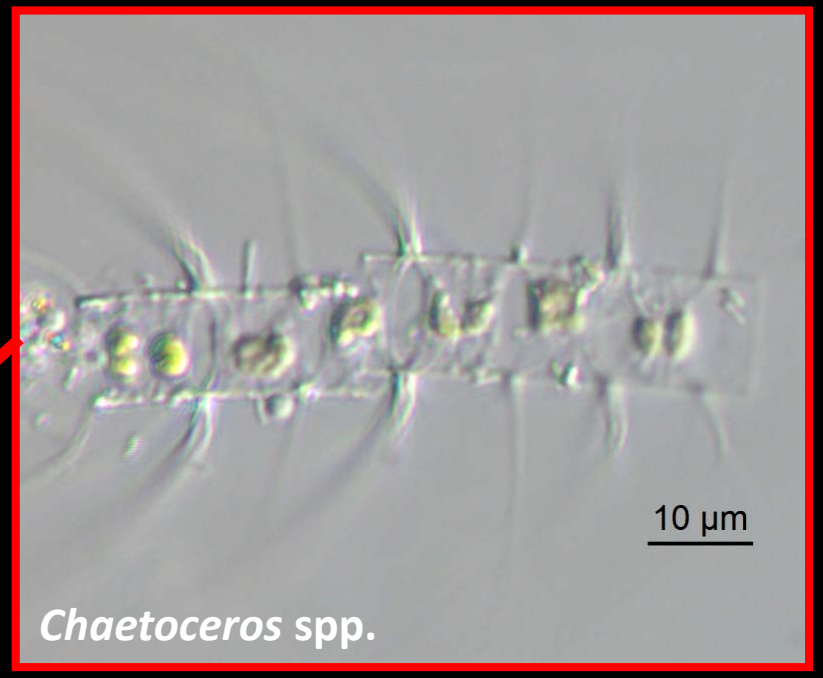
Presenter: Anna Wachnicka

August, 2020 Diatom Bloom in North Biscayne Bay

- Blooms developed in late-August following fish kills
- Bloom biomass dominated by <u>non-toxic</u> *Chaetoceros* diatom spp.

Courtesy: WPLG

North Biscayne Bay, August 21, 2020



***Chaetoceros* spp.**

Courtesy: Tom Frankovich (FIU)

June/July, 2013 Diatom Bloom in Biscayne Bay

Courtesy: DERM

Chaetoceros spp.

Three large visible "patches" of *Chaetoceros* spp. non-toxic diatom bloom:

- **Rickenbacker to south of Deering Estate**
- **South-central offshore of Convoy Point to shoreline of Elliott Key**
- **Arsenicker Keys through Card Sound and into northern Barnes Sound**

Phytoplankton net slimed by diatoms (July, 2013)

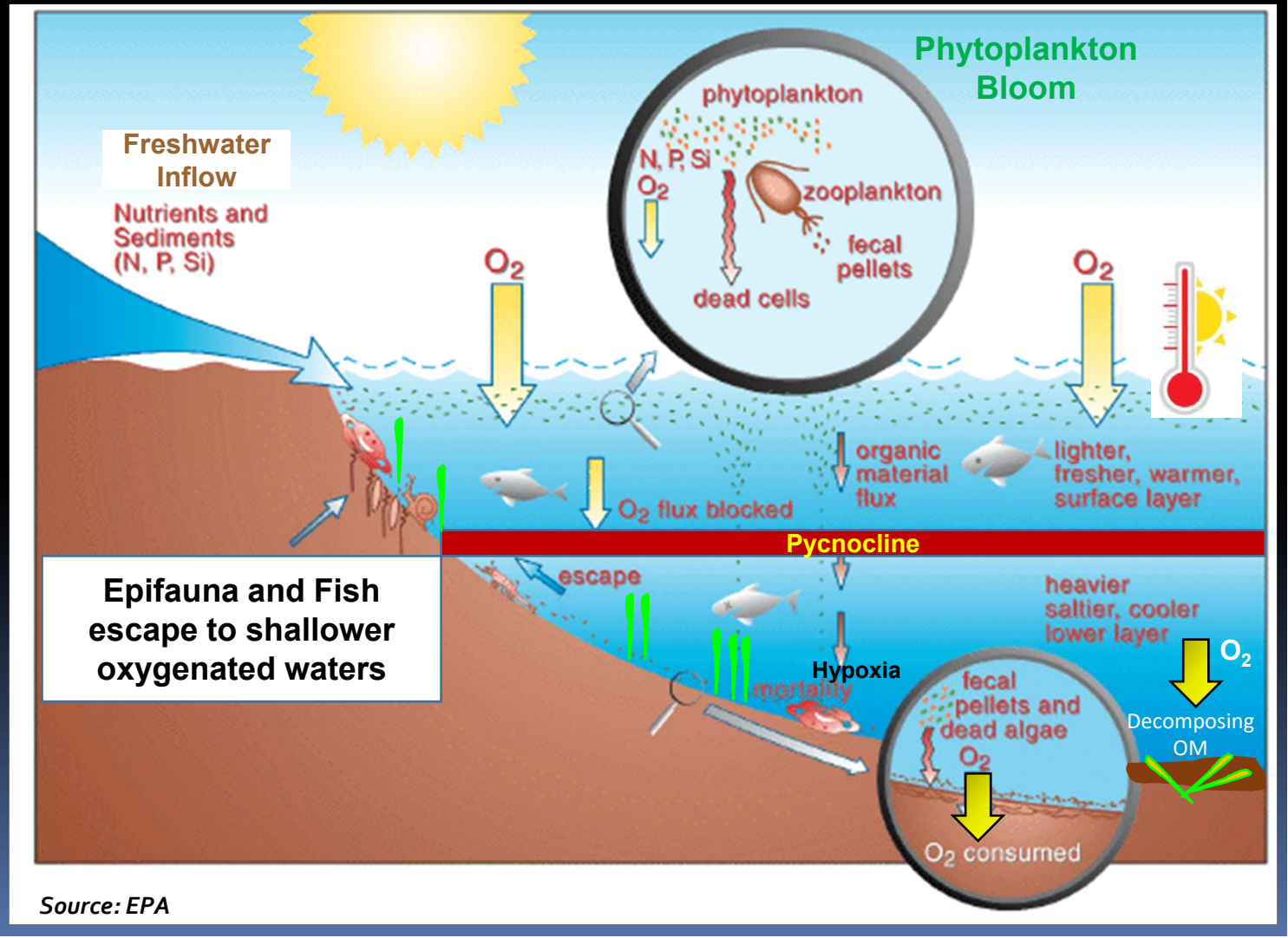
Courtesy: NOAA

Mechanism of Hypoxia and Fish Kill Events in North Biscayne Bay

Likely Factors Leading to Hypoxia, Fish Kill and Algal Blooms this Summer:

- External and internal nutrient loadings
- Stratified water column
- Stagnant, poorly- oxygenated warm water
- Restricted circulation and longer water residence time in North Bay
- Decomposition of dead organic matter on the bottom

Conceptual Diagram Depicting Formation of Summer Algal Blooms, Hypoxia and Fish Kills



Source: EPA

Presenter: Anna Wachnicka

Effects of Declining Water Quality on Estuarine Ecosystem

Declining water quality

Fish, shrimp, marine mammals decline /biodiversity decline

Decomposition of dead OM by bacteria/O_2 depletion

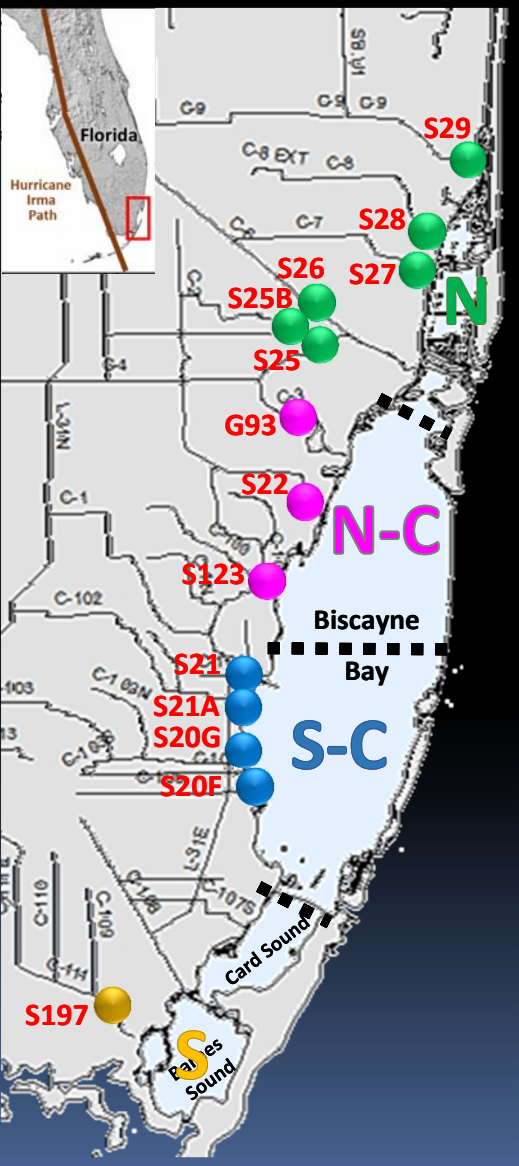
Loss of submerged aquatic vegetation (SAV)

Cascading Impacts

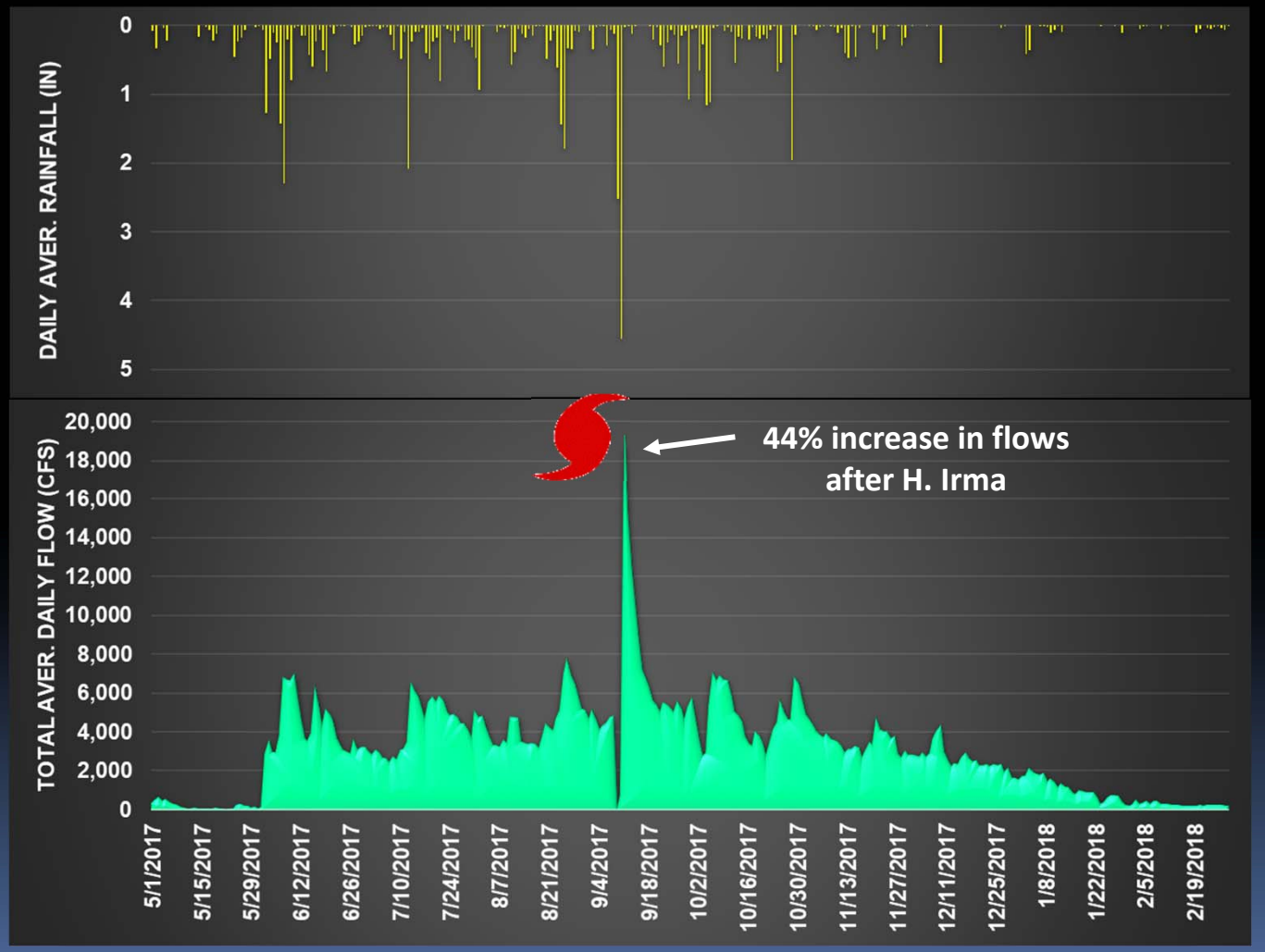
Further loss of SAV due to shading

Destabilization of sediments and release of nutrients

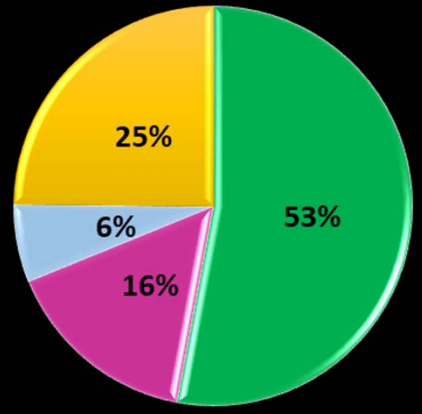
Effects of Extreme Weather Events on the Bay: 2017 Hurricane Irma



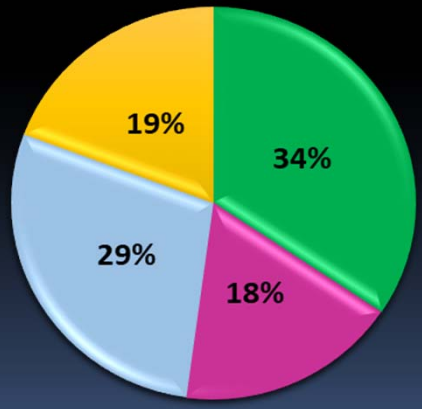
Rainfall vs. Canal Releases



20 Days Prior to Hurricane
(Total Aver. Inflow 204,873 acre-feet)



20 Days After Hurricane
(Total Aver. Inflow 295,781 acre-feet)



North (N) | North-Central (N-C)
South (S) | South-Central (S-C)

Source: Wachnicka et al. (2019)

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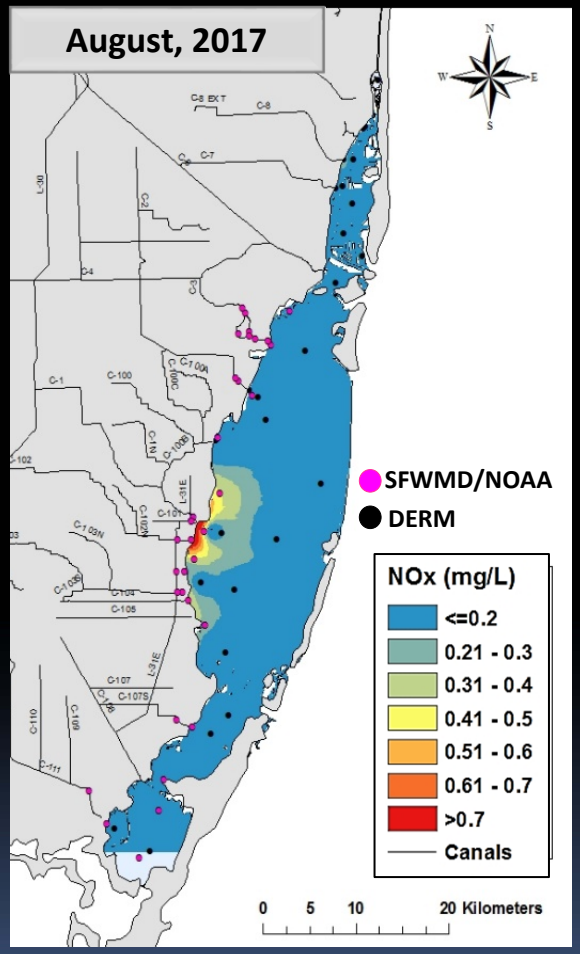
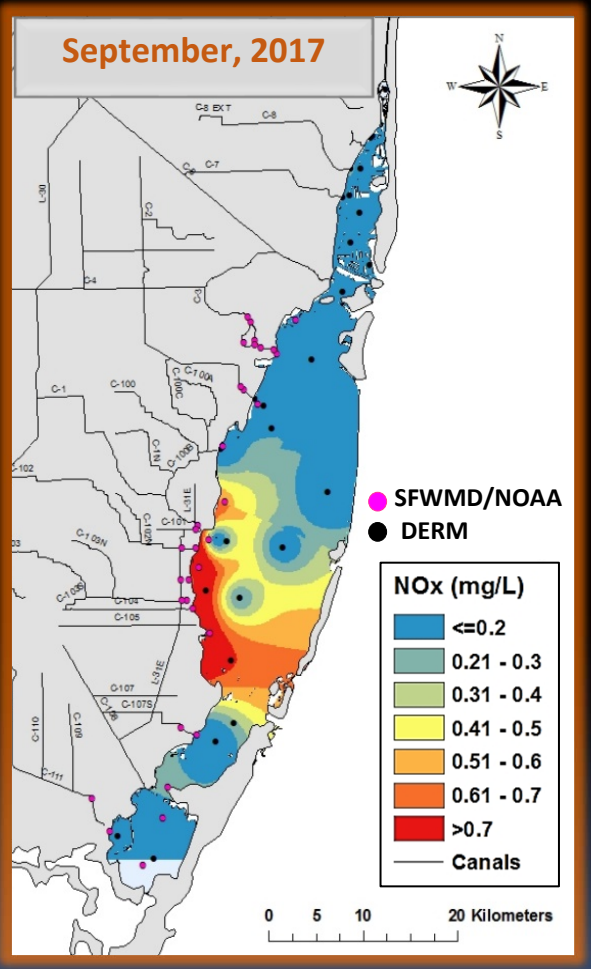
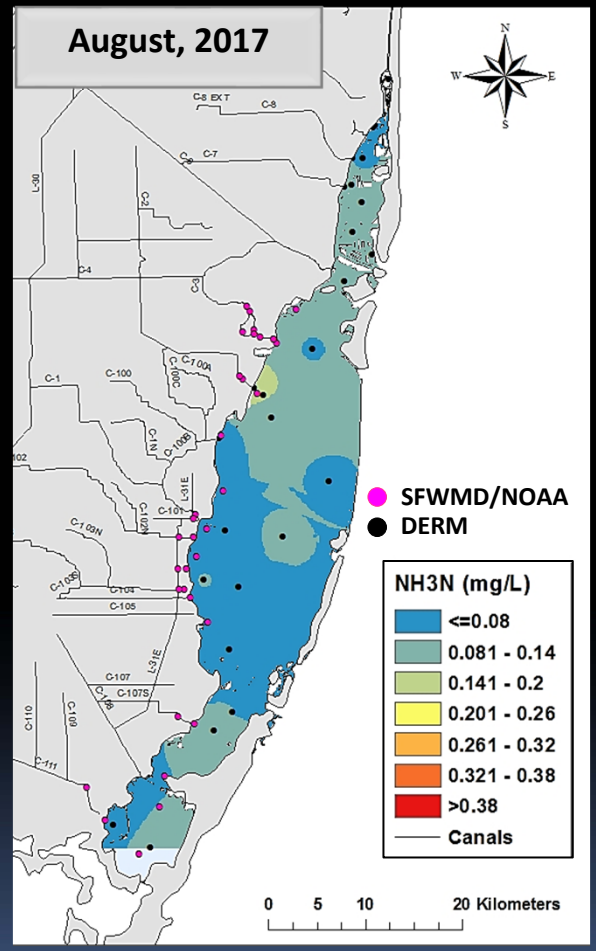
Post - Hurricane Irma Nutrient Enrichment of the Bay

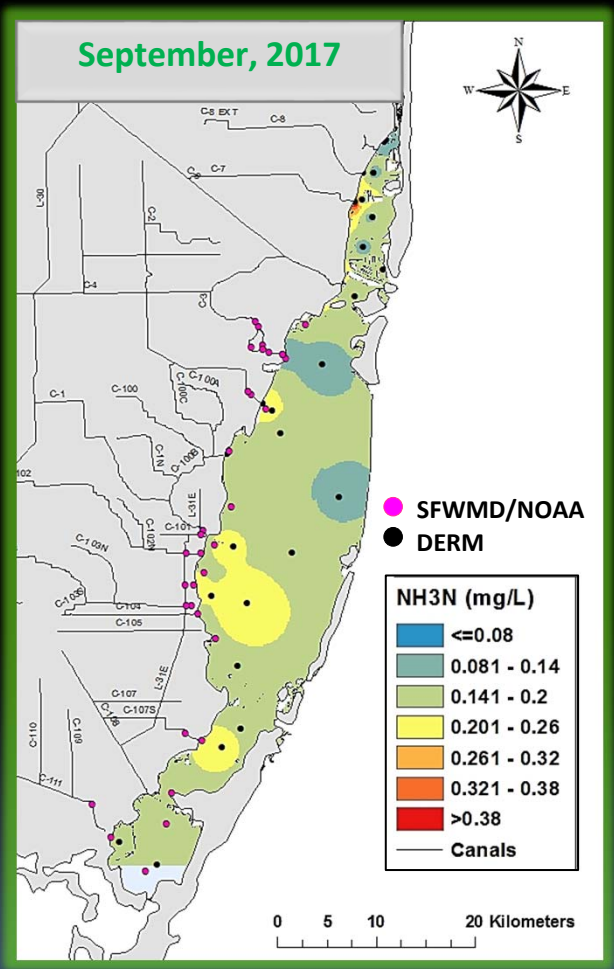
Nitrate and Nitrite





Ammonia

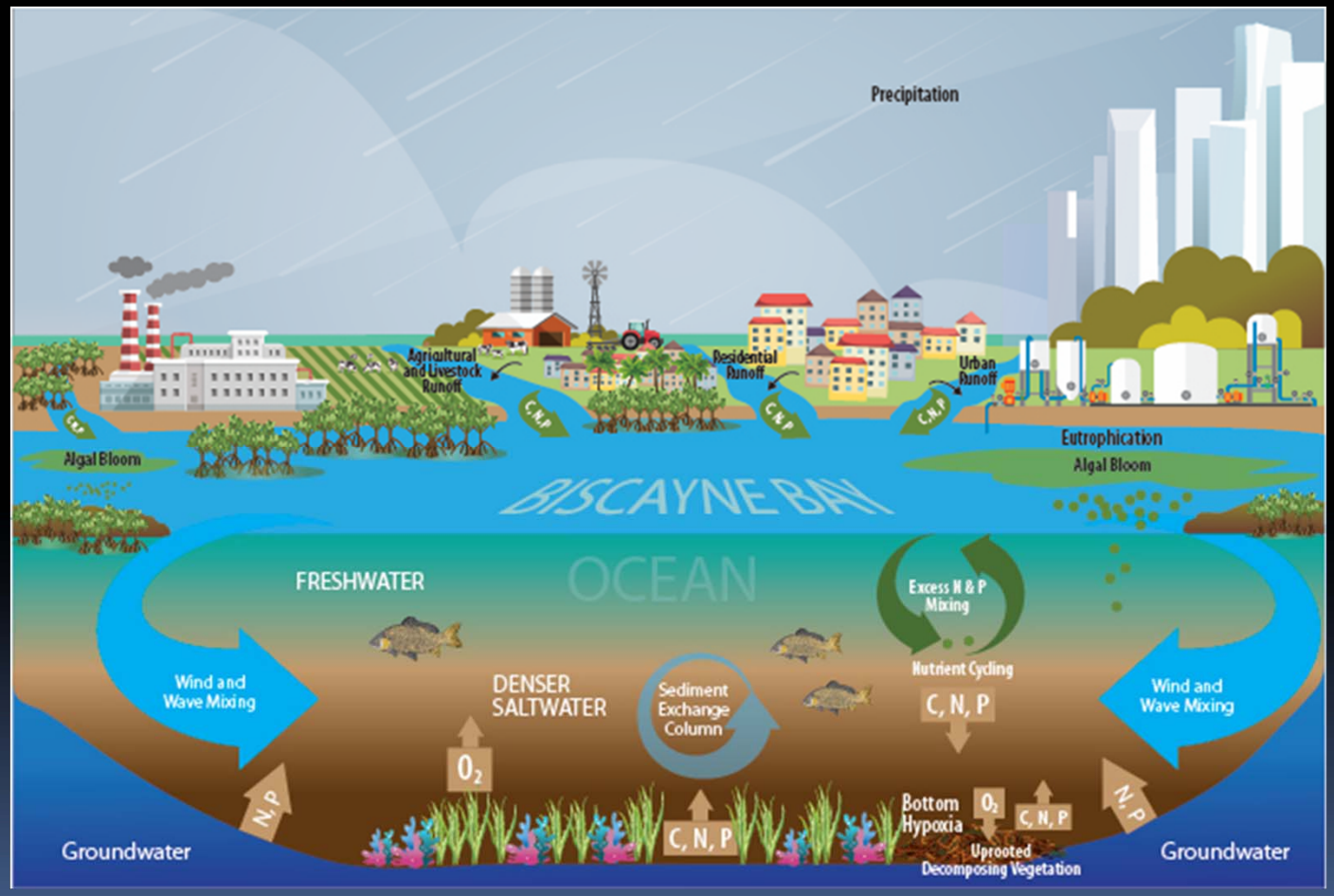




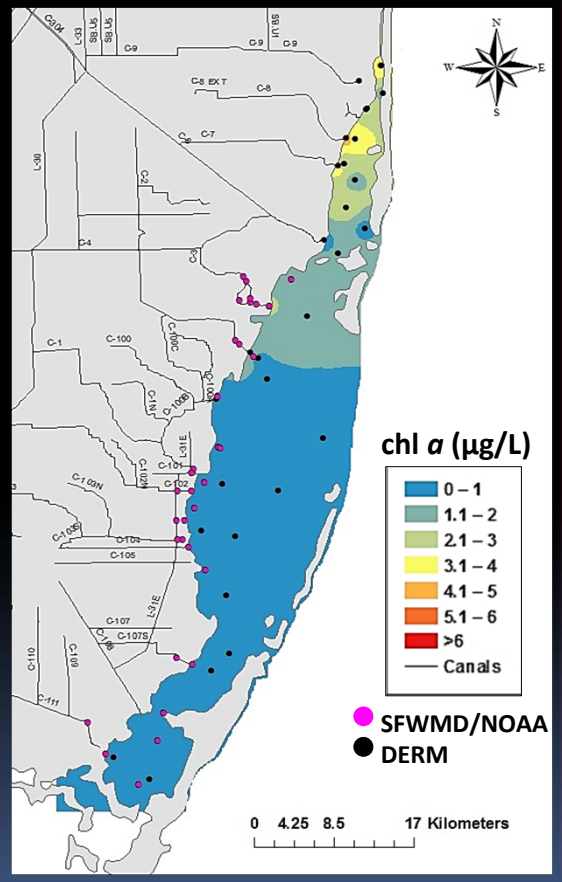
Source: Wachnicka et al. (2019)

Post - Hurricane Irma Phytoplankton Blooms

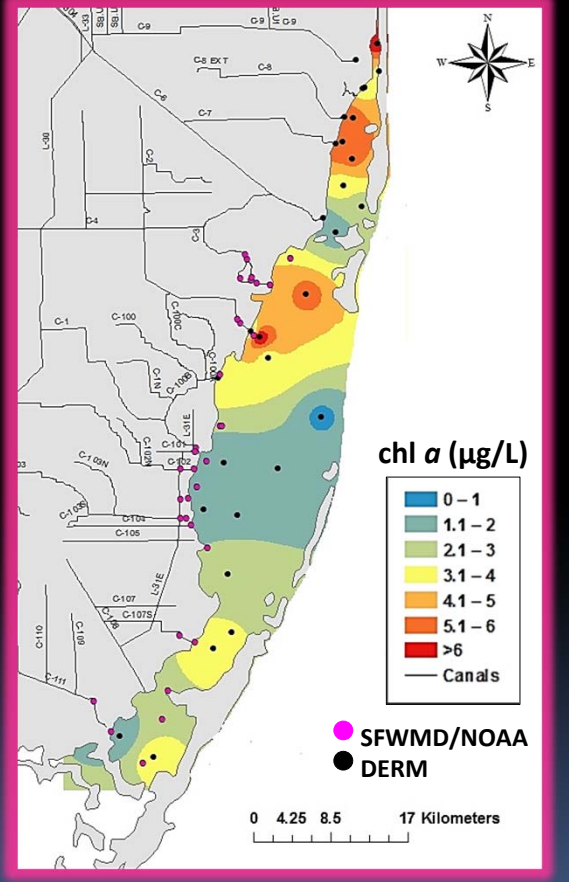
Functional Linkages Between Hydrology, Nutrient Inputs & Phytoplankton Blooms after H. Irma



August 2017
(2 weeks before the Hurricane)



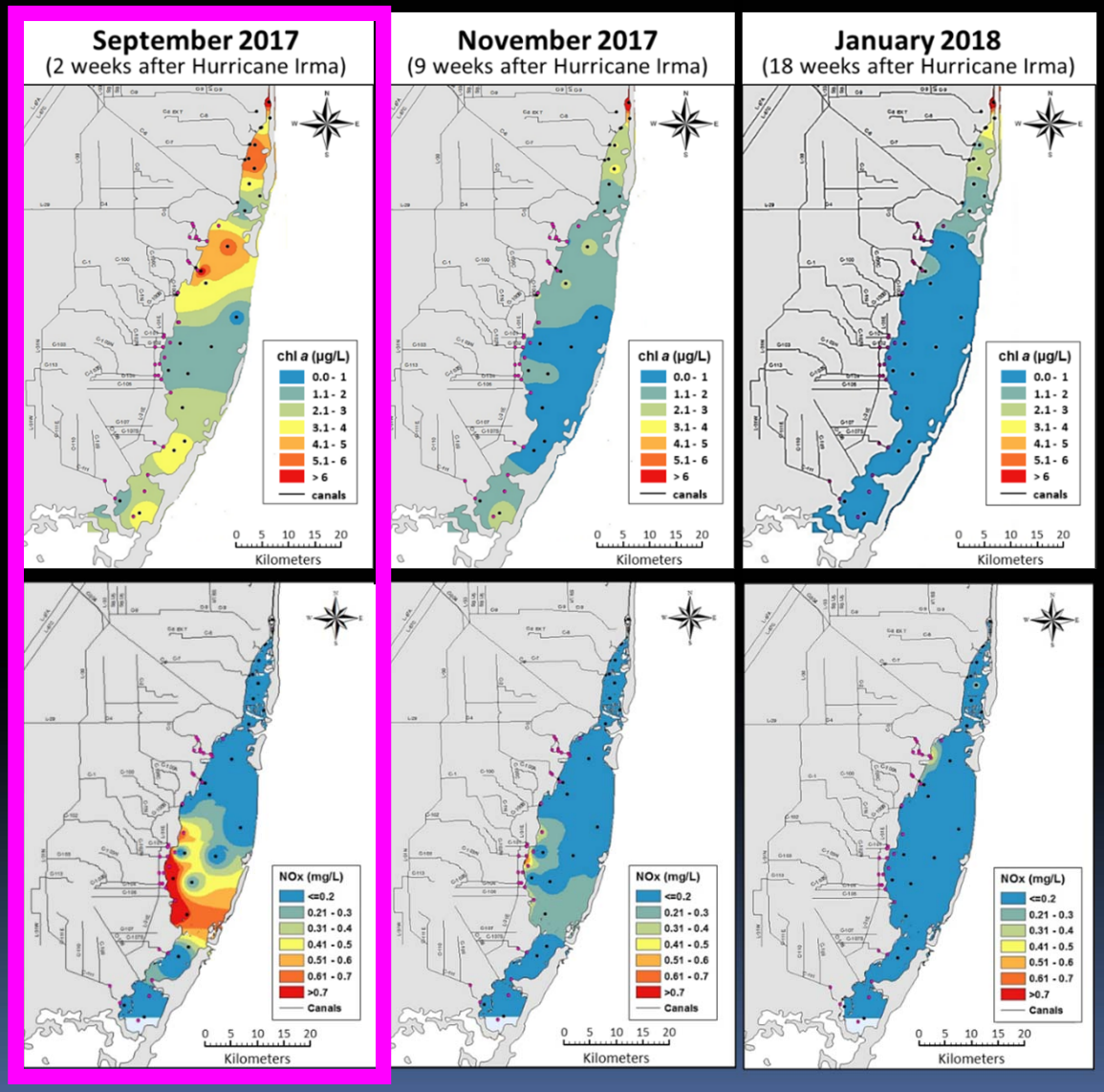
September 2017
(2 weeks after the Hurricane)

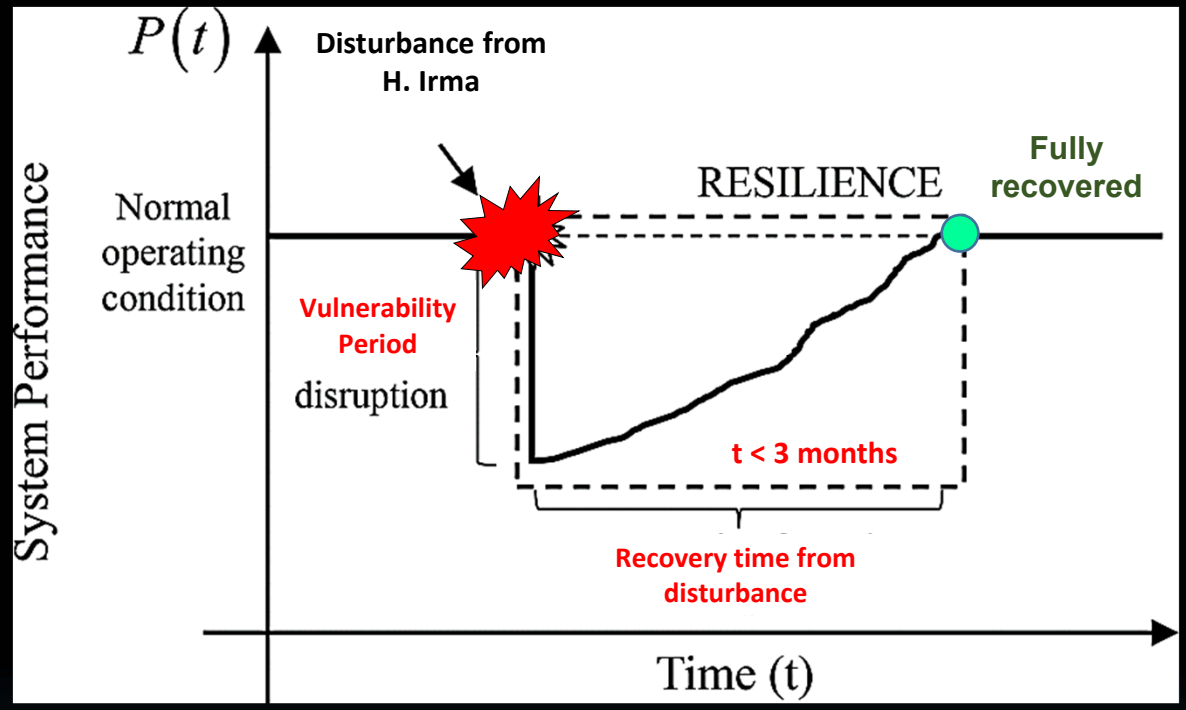


Presenter: Anna Wachnicka

Source: Wachnicka et al. (2019)

Post – Hurricane Irma Recovery





- **Biscayne Bay is resilient to short-term disturbances like hurricanes**
- **It took the Bay < 3 months to recover from H. Irma**

Source: Wachnicka et al. (2019)