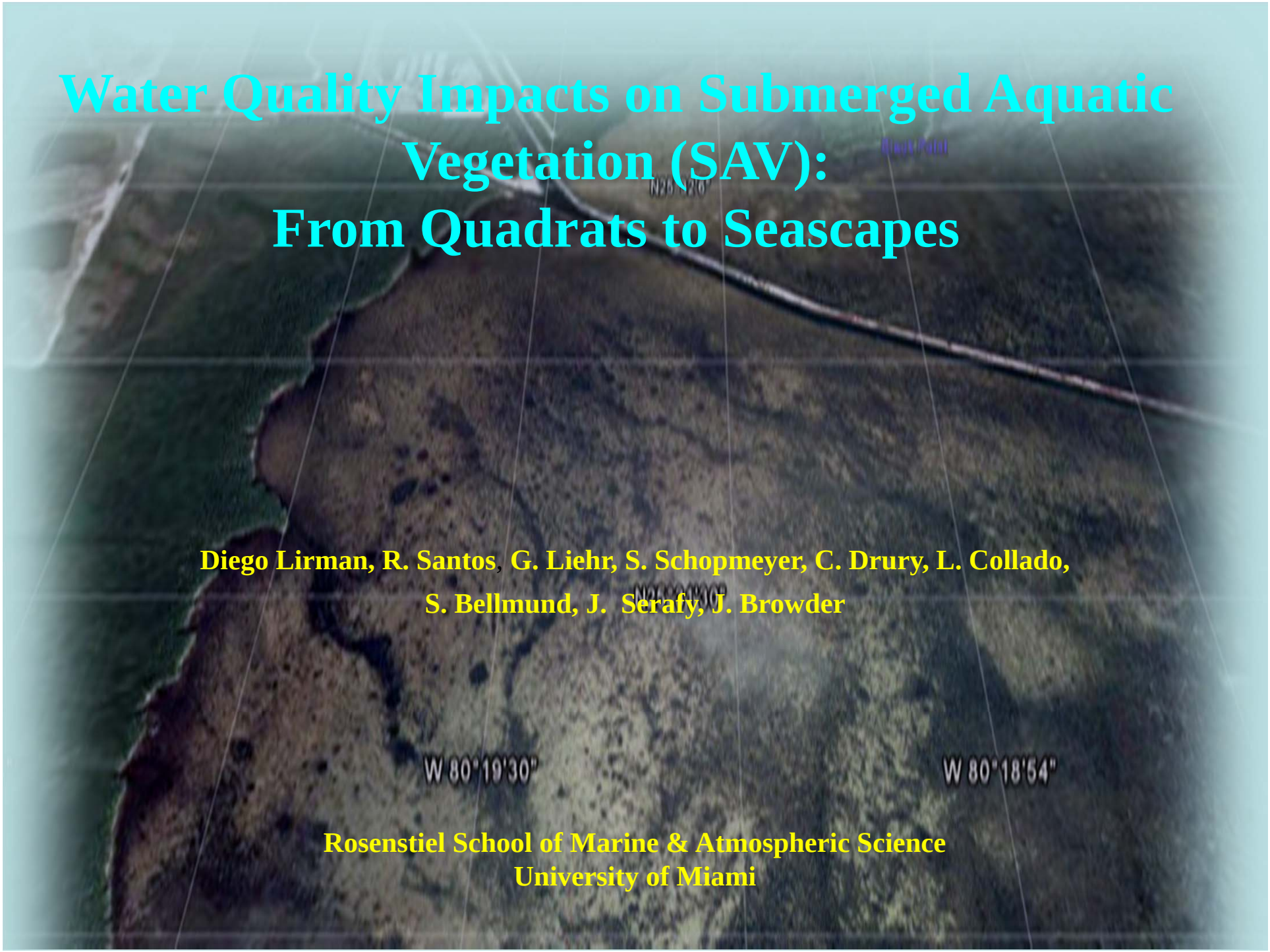
# Water Quality Impacts on Submerged Aquatic Vegetation (SAV): From Quadrats to Seascapes

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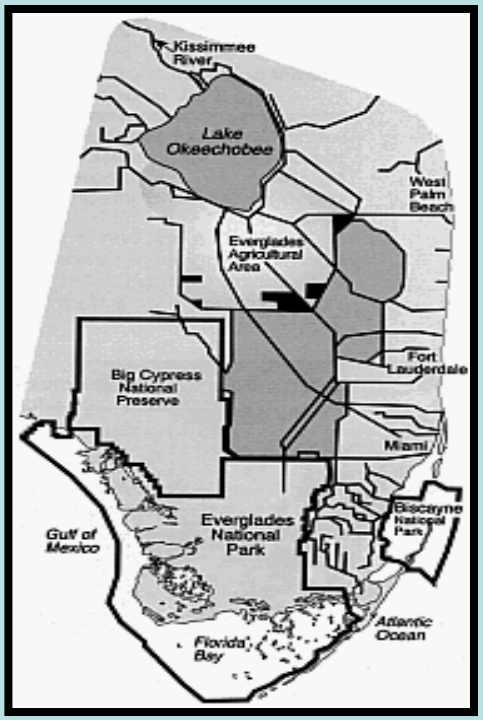
# COMPREHENSIVE EVERGLADES RESTORATION PLAN (CERP)

## HISTORICAL


**CS&F Project (1948)**

**RESTORATION**

## PRESENT




- **CONNECTED HABITATS**
- **INTEGRATED NATURAL HYDROLOGY / SHEETFLOW**
- **NATURAL HYDROPERIOD**
- **LOWER NUTRIENTS**

- **FRAGMENTED HABITATS**
- **MANAGED HYDROLOGY / REDUCED FLOW / PULSED RELEASES**
- **ALTERED HYDROPERIOD**
- **HIGHER NUTRIENTS**

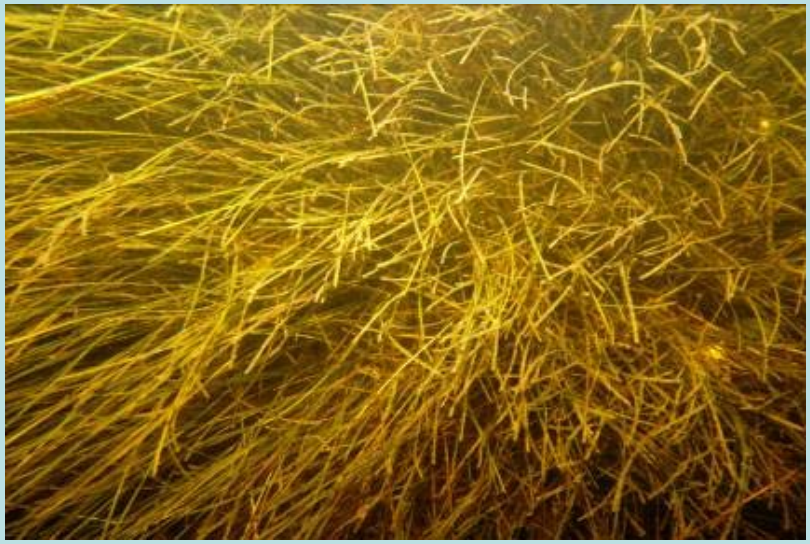
## CERP SAV Restoration Goals/Targets for Biscayne Bay:

1) **Provide mesohaline salinity patterns along the shoreline;**

**WILL THIS WORK????**

2) **Increase cover of seagrass in nearshore areas devoid of seagrass;**

3) **Increase the cover of *Halodule*, reduce the over-dominance of *Thalassia***



*Halodule*

*Thalassia*

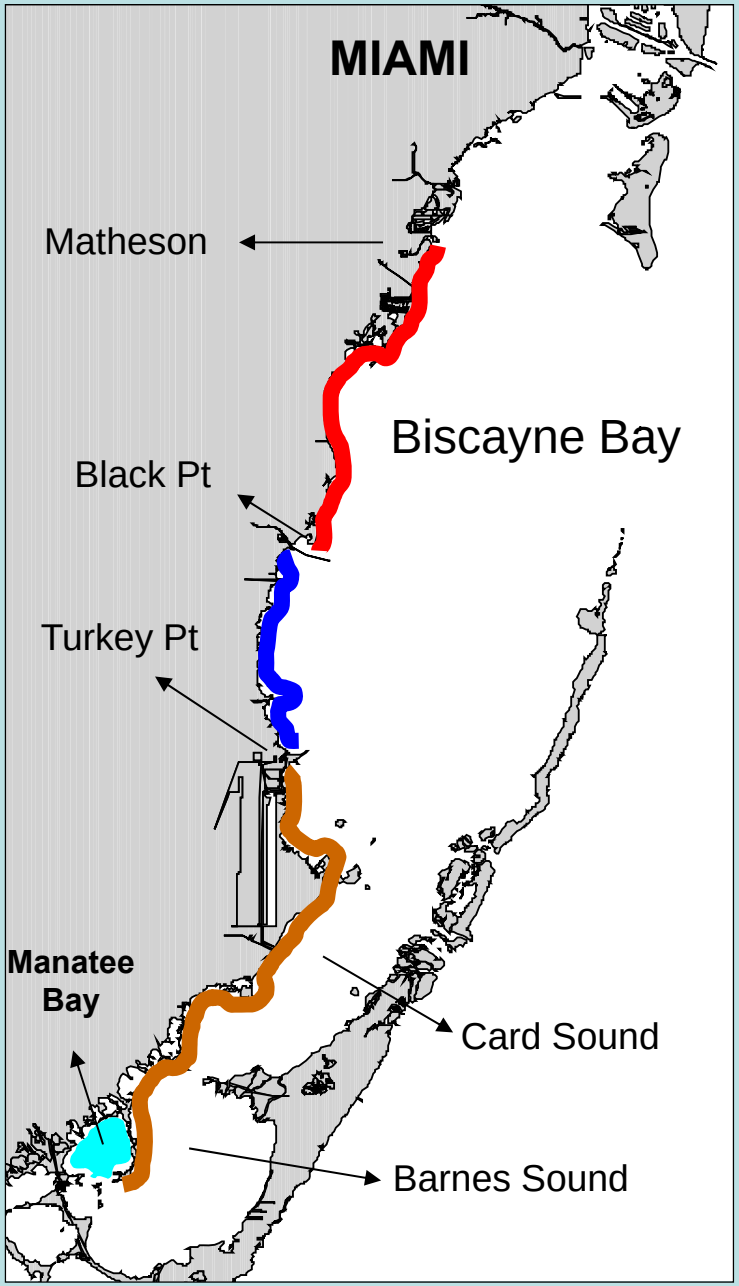
# Nearshore benthic habitats (< 500 m from shore)

- These habitats have been under-represented in monitoring efforts due to limited boat access ( < 1m in depth )
- Critical nursery habitats
- Jointly surveyed for fish and invertebrates (IBBEAM)
- Their location makes them susceptible to changes in freshwater deliveries

**These are the areas that were HISTORICALLY influenced by freshwater deliveries and PRESENTLY have the environmental and biological conditions proposed as CERP targets**

**Understand the dynamics of these areas to predict what may happen elsewhere under CERP scenarios**

# QUADRAT-VIEW

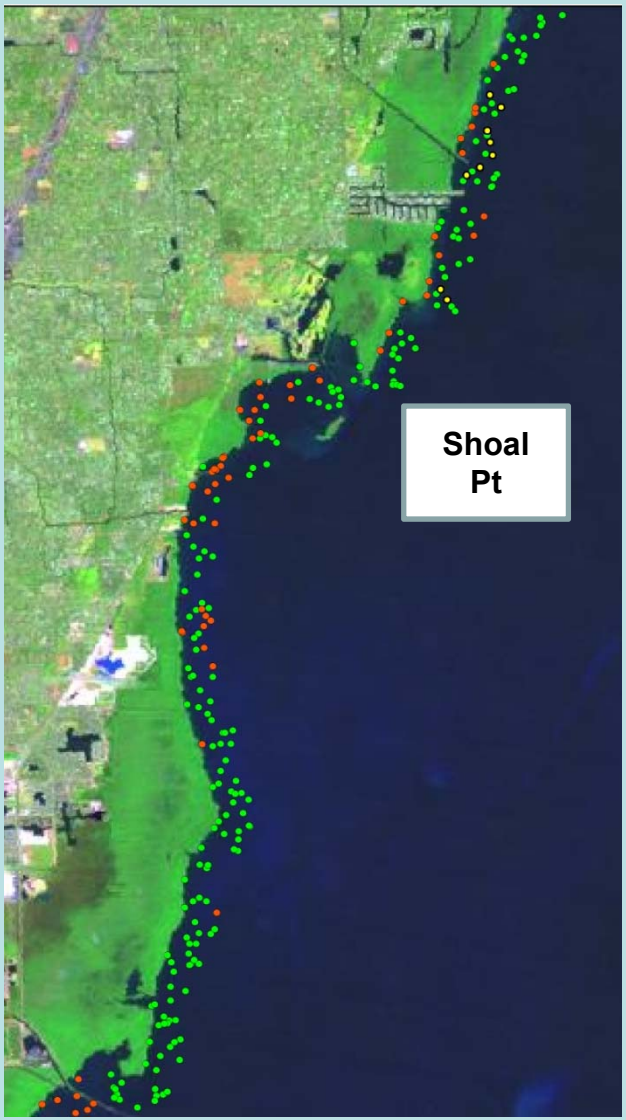


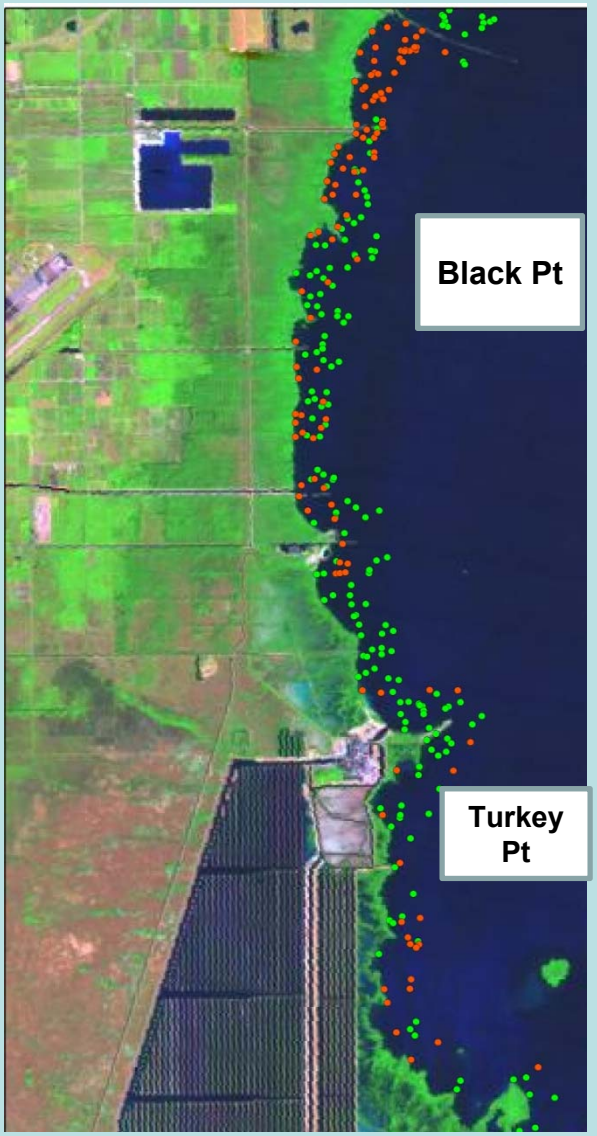

Lirman et al., 2014

- 4 survey regions (salinity, hydrodynamics)
- 5 cross-shelf buffers (100 m)
- Domain = 50 $km^2$
- > 2500 Sites (08-11), 10-20 images per site
- IBBEAM (2012-15), 150 sites per year


**% Cover by Taxon**
**Scale: 0-100 %**

# SAV Community Classification

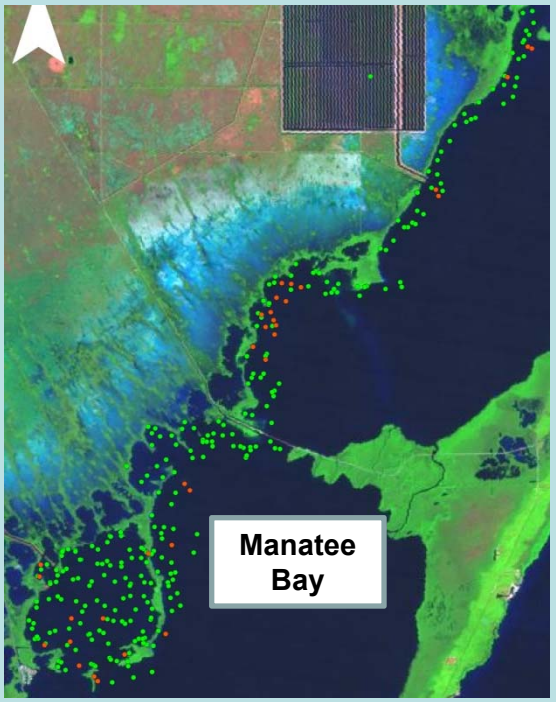



*Thalassia / Marine Algae*

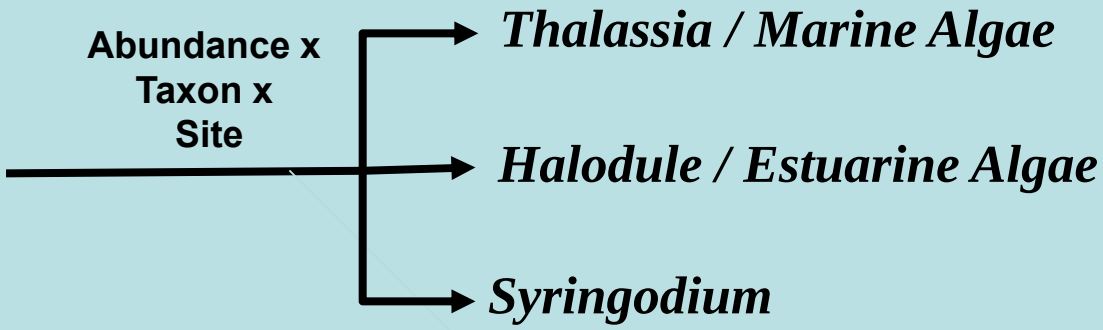
*Halodule / Estuarine Algae*

*Syringodium*




**Clear spatial patterns to macrophyte distributions**

# SAV Community Classification



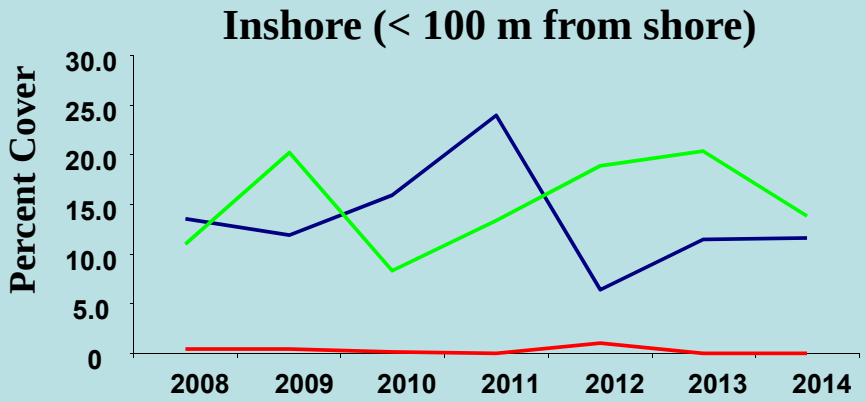

| Clusters | *"Thalassia"* | *"Halodule"* | *"Syringodium"* |
|---|---|---|---|
| % of sites | **77** | **22** | **1** |
| Depth (m) | **1.2 (0.5)** | **0.9 (0.4)** | **0.7 (0.3)** |
| Temperature (ºC) | **27.5 (3.2)** | **28.2 (3.7)** | **26.5 (4.2)** |
| Salinity (psu) | **30.8 (5.3)** | **27.7 (6.2)** | **30.6 (2.1)** |
| CV salinity | **0.17** | **0.22** | **0.06** |

***Halodule* dominates in habitats with low and variable salinity!!!**

***Thalassia* present everywhere, especially in habitats with high and stable salinity**

***Syringodium* found in very few sites, only in northern section of region**

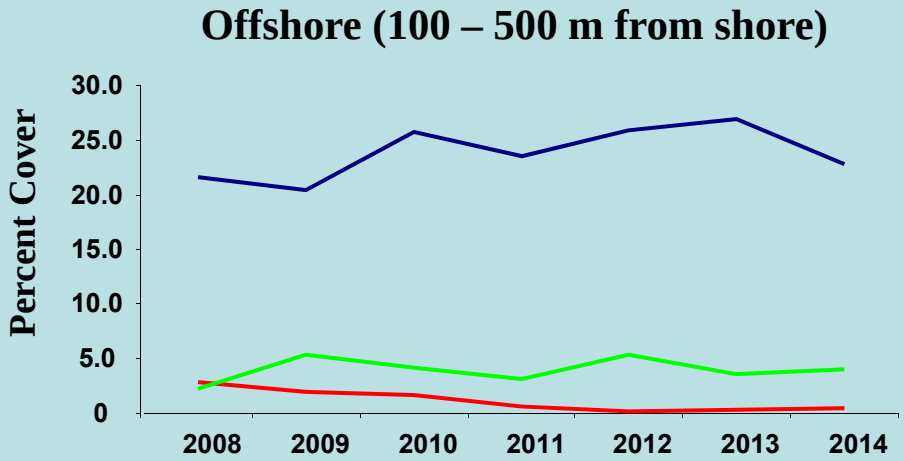
# Seagrass Cover




*Thalassia*

*Halodule*

*Syringodium*




**Dominance by *Thalassia* away from shore**

**Co-Dominance by *Thalassia* and *Halodule* alongshore**

# SAV – WQ Relationships

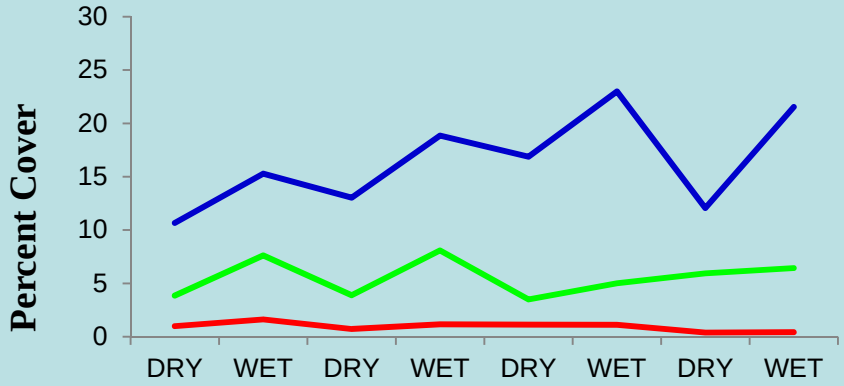
## Logistic Regression (presence-absence data)

| | Salinity | Temp | Depth | DO | K | ChiSq | R2 |
|---|---|---|---|---|---|---|---|
| *Thalassia* | P | ns | ns | N | N | < 0.01 | 0.09 |
| *Halodule* | N | ns | N | ns | P | < 0.01 | 0.28 |
| *Syringodium* | N | N | P | ns | ns | < 0.01 | 0.05 |
| *Laurencia* | N | N | ns | ns | ns | < 0.01 | 0.08 |
| *Halimeda* | P | N | ns | ns | ns | < 0.01 | 0.08 |
| *Penicilus* | P | N | ns | ns | N | < 0.01 | 0.04 |
| *Batophora* | N | P | N | ns | ns | < 0.01 | 0.21 |
| *Caulerpa* | N | N | P | ns | ns | < 0.01 | 0.1 |
| *Acetabularia* | N | P | ns | ns | ns | < 0.01 | 0.03 |
| *Udotea* | N | N | ns | ns | ns | < 0.01 | 0.08 |

**Salinity is the key driver of seagrass and macroalgae distribution in BB !!!**

**You modify Salinity, SAV will respond!!**

## Goal: Increase cover of seagrass in nearshore areas devoid of seagrass ..




| | |
|---|---|
| *Thalassia* | 16.5 % (17.1) |
| *Halodule* | 5.5 % (12.1) |
| *Syringodium* | 0.9 % (4.8) |
| **Macroalgae** | 21.0 % (17.4) |

**SG cover**

Dry = 18.4 % (15.9)

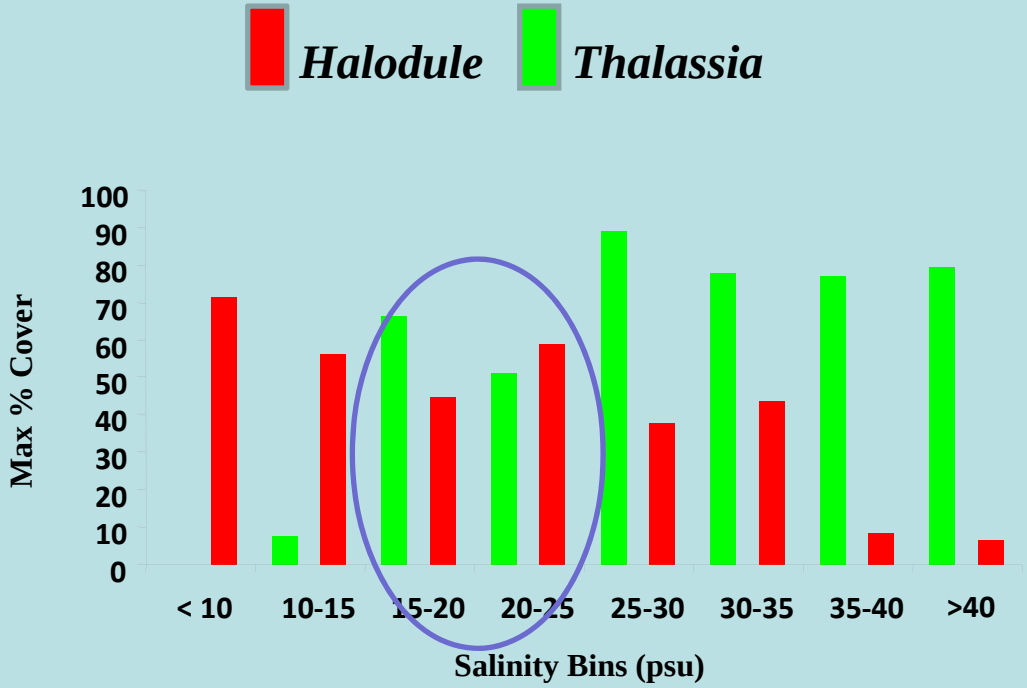
Wet = 27.8 % (20.3)

Mean Cover SG = 23%

**SG Presence**

98% sites

## Goal: Increase SG cover by creating Mesohaline conditions …….



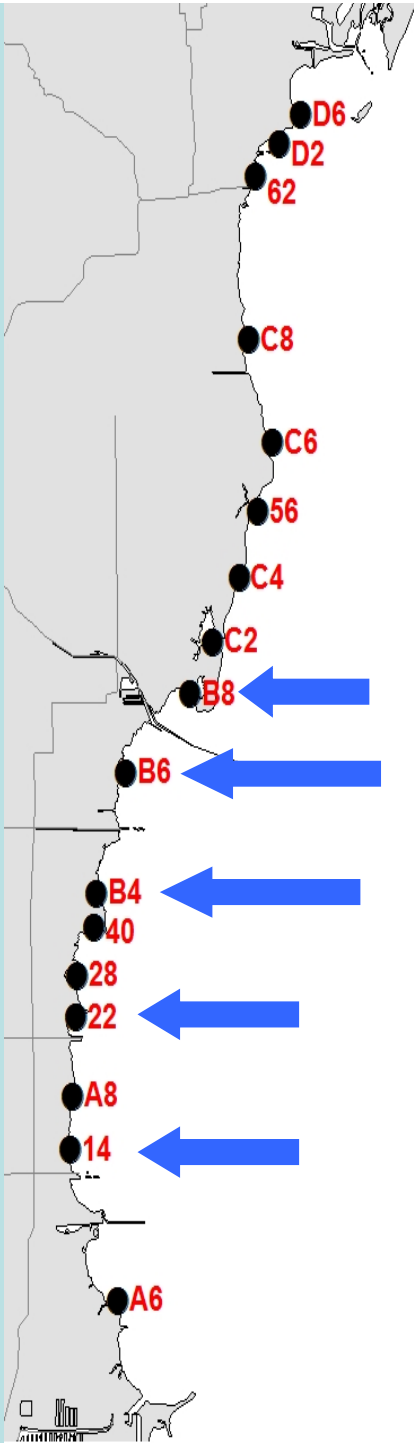

The combined mean cover of *Thalassia* and *Halodule* when both species are present (23%) is higher than the cover when only one of the species is present (17.4 % for *Thalassia* and 19.7 for *Halodule*)

**Creating salinity climates that are conducive to the co-occurrence of both species is one way to achieve the goal of increased seagrass cover**

# SALINITY METRICS: MESOHALINE INDEX

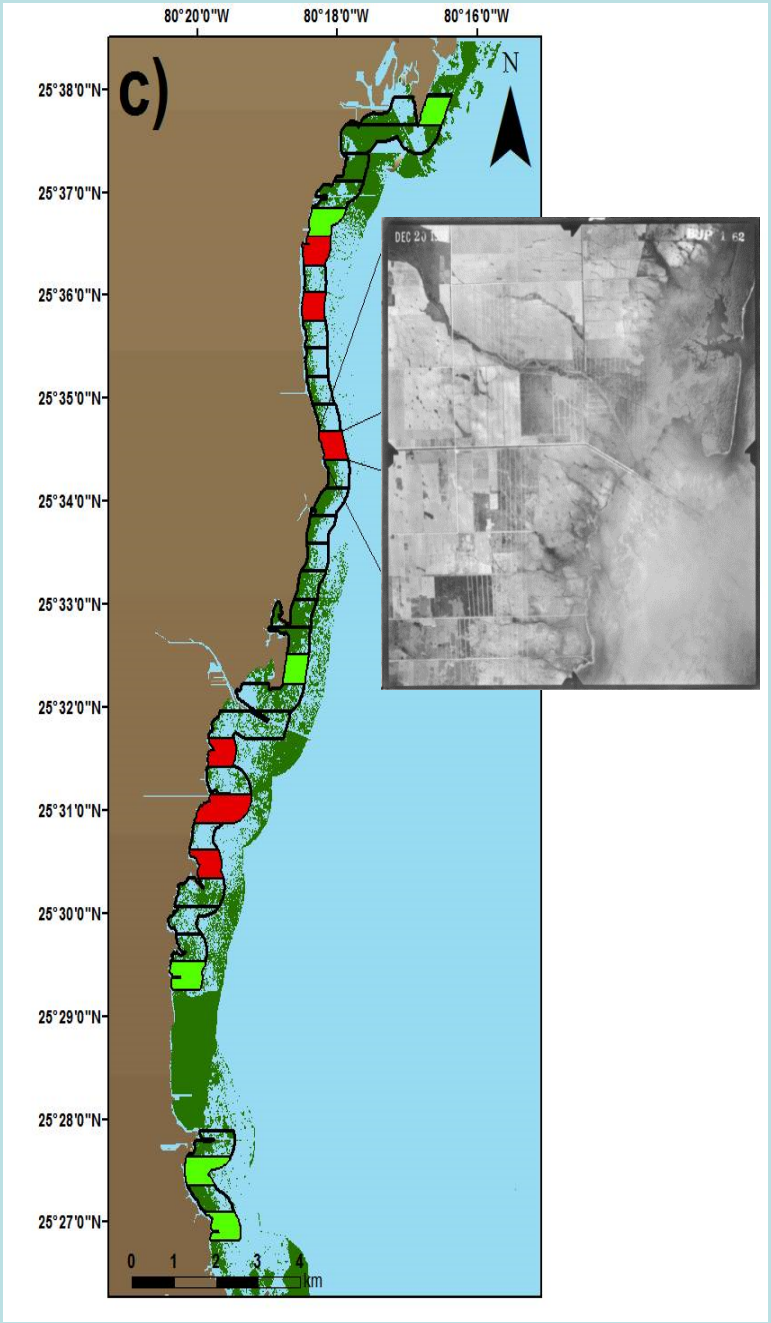
## Proportion of days when salinity ≤ 20

| WYR | 2004 | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CYR | 2004 | 2004 | 2005 | 2005 | 2006 | 2006 | 2007 | 2007 | 2008 | 2008 | 2009 | 2009 | 2010 | 2010 | 2011 | 2011 | 2012 | 2012 | 2013 | 2013 | 2014 | | |
| Month | 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 | Nov-Apr | May-Oct | Nov-Apr | | |
| Season | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | Wet | Dry | | |
| D6 | | | | | | | | | | | | | | 0.000 | 0.000 | 0.012 | 0.003 | 0.078 | 0.000 | 0.072 | 0.000 | 0.054 | 0.001 |
| D2 | | | | | | | | | | | | | | 0.000 | 0.000 | 0.005 | 0.006 | 0.072 | 0.000 | 0.075 | 0.000 | 0.051 | 0.002 |
| 62 | 0.001 | 0.074 | 0.001 | 0.155 | 0.001 | 0.105 | 0.000 | 0.085 | 0.000 | 0.105 | 0.000 | 0.015 | 0.002 | 0.103 | 0.000 | 0.019 | 0.020 | 0.248 | 0.000 | 0.216 | 0.006 | 0.113 | 0.003 |
| C8 | | | | | | | | | | | | | | 0.111 | 0.000 | 0.024 | 0.032 | 0.338 | 0.000 | 0.220 | 0.016 | 0.194 | 0.011 |
| C6 | | | | | | | | | | | | | | 0.109 | 0.003 | 0.032 | 0.035 | 0.579 | 0.000 | 0.383 | 0.001 | 0.331 | 0.013 |
| 56 | 0.074 | 0.143 | 0.031 | 0.376 | 0.000 | 0.273 | 0.000 | 0.346 | 0.009 | 0.211 | 0.000 | 0.048 | 0.014 | 0.140 | 0.003 | 0.070 | 0.043 | 0.646 | 0.001 | 0.445 | 0.007 | 0.270 | 0.011 |
| C4 | | | | | | | | | | | | | | 0.223 | 0.002 | 0.088 | 0.054 | 0.651 | 0.000 | 0.498 | 0.022 | 0.365 | 0.019 |
| C2 | | | | | | | | | | | | | | 0.338 | 0.037 | 0.186 | 0.088 | 0.688 | 0.007 | 0.418 | 0.145 | 0.430 | 0.044 |
| B8 | | | | | | | | | | | | | | 0.295 | 0.047 | 0.063 | 0.135 | 0.778 | 0.011 | 0.721 | 0.242 | 0.521 | 0.064 |
| B6 | | | | | | | | | | | | | | 0.647 | 0.137 | 0.366 | 0.399 | 0.666 | 0.439 | 0.534 | 0.538 | 0.553 | 0.325 |
| B4 | | | | | | | | | | | | | | 0.464 | 0.137 | 0.280 | 0.541 | 0.738 | 0.202 | 0.564 | 0.585 | 0.527 | 0.293 |
| 40 | 0.186 | 0.243 | 0.230 | 0.538 | 0.287 | 0.434 | 0.212 | 0.404 | 0.194 | 0.422 | 0.262 | 0.291 | 0.222 | 0.495 | 0.135 | 0.371 | 0.532 | 0.827 | 0.172 | 0.732 | 0.607 | 0.487 | 0.250 |
| 28 | 0.104 | 0.209 | 0.252 | 0.475 | 0.281 | 0.407 | 0.172 | 0.351 | 0.162 | 0.393 | 0.199 | 0.155 | 0.168 | 0.517 | 0.108 | 0.228 | 0.432 | 0.778 | 0.116 | 0.586 | 0.570 | 0.410 | 0.210 |
| 22 | 0.000 | 0.215 | 0.213 | 0.408 | 0.245 | 0.348 | 0.188 | 0.348 | 0.175 | 0.486 | 0.147 | 0.238 | 0.159 | 0.598 | 0.115 | 0.246 | 0.455 | 0.722 | 0.110 | 0.600 | 0.521 | 0.421 | 0.201 |
| A8 | | | | | | | | | | | | | | 0.440 | 0.118 | 0.190 | 0.419 | 0.605 | 0.138 | 0.512 | 0.411 | 0.436 | 0.225 |
| 14 | 0.166 | 0.168 | 0.227 | 0.445 | 0.298 | 0.344 | 0.250 | 0.415 | 0.284 | 0.381 | 0.261 | 0.243 | 0.230 | 0.443 | 0.134 | 0.212 | 0.566 | 0.568 | 0.220 | 0.535 | 0.251 | 0.375 | 0.274 |
| A6 | | | | | | | | | | | | | | 0.093 | 0.036 | 0.064 | 0.180 | 0.219 | 0.008 | 0.086 | 0.022 | 0.123 | 0.075 |
| DJ | | | | | | | | | | | | | | 0.818 | 0.299 | 0.564 | 0.223 | | | | | 0.691 | 0.261 |

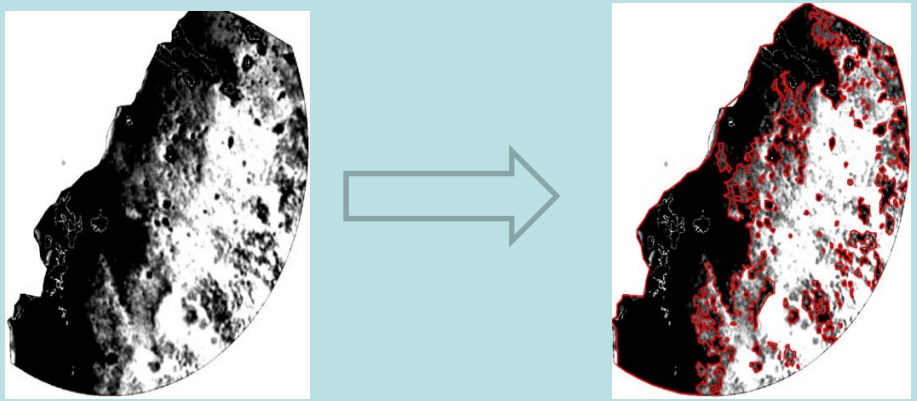



**Presently, only sites adjacent to freshwater canals experience mesohaline conditions for prolonged periods of time >>> Room to improve!!!!!**

# SEASCAPE-VIEW




- ✓ **Use historical SAV seascape dynamics to understand how patterns of habitat loss and fragmentation relate to watershed management**



**B& W Aerial Images (1938-2009)**

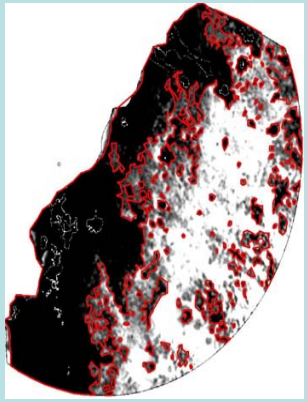
**SAV patches digitized**

Santos et al., 2015, Marine Ecology

# Historical Impacts of Freshwater Deliveries (1938-2009)

**Metrics:**

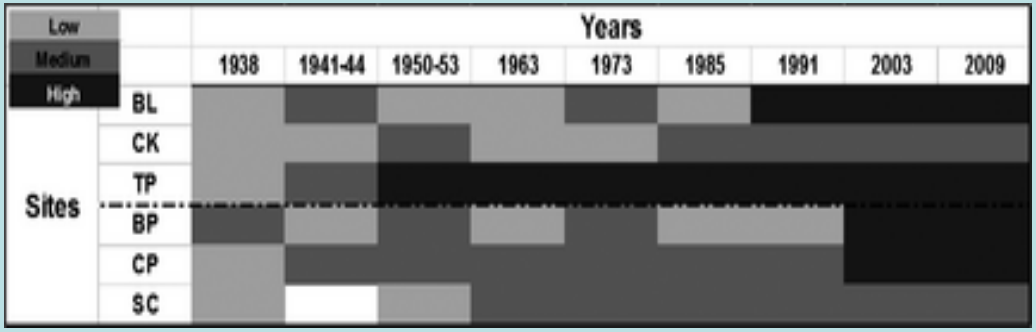
- ✓ **Habitat amount:**
  - ✓ **Area**
  - ✓ **Percent cover**
- ✓ **Habitat configuration**
  - ✓ **Density**
  - ✓ **Extension**
  - ✓ **Interspersion**
  - ✓ **Shape**



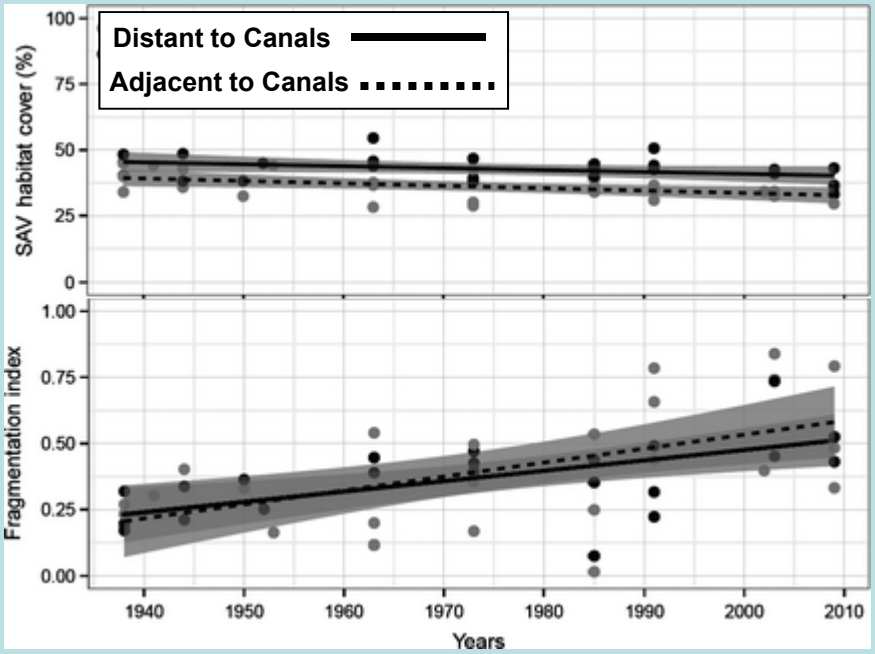

Black Point

# Historical Impacts of Freshwater Deliveries (1938-2009)

## Fragmentation Levels




- ✓ **Seascape Fragmentation has increased over time**




- ✓ **The mean SAV amount has declined by only 3% over 70 years!**
- ✓ **Seascapes are more fragmented today than 70 years ago**
- ✓ **Areas adjacent to canals have experienced sig. higher fragmentation**

# SAV in Western Biscayne Bay: Summary

**Salinity influences SAV communities at the quadrat and seascape scales !**

**Seagrasses are good indicators of salinity patterns**

**The co-existence of both *Thalassia* and *Halodule* is achieved in mesohaline environments with a mean salinity between 15 and 25 psu**

**These areas of co-existence have higher SG cover than mono-specific stands**

**Persistent Mesohaline conditions only encountered presently nearshore in the vicinity of canal-discharge areas**

**Expansion of mesohaline conditions is likely to result in increased seagrass abundance in western Biscayne Bay (a CERP target!)**

**SAV communities have become more fragmented over time (partly related to water management) with unknown impacts on associated fauna**


Funding
National Geodetic Survey
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NOAA NMFS
CERP RECOVER Program
US ACoE
NOAA LMRCSC