Development, Persistence and Impacts of a Decade-Long Macroalgal Bloom in Biscayne Bay

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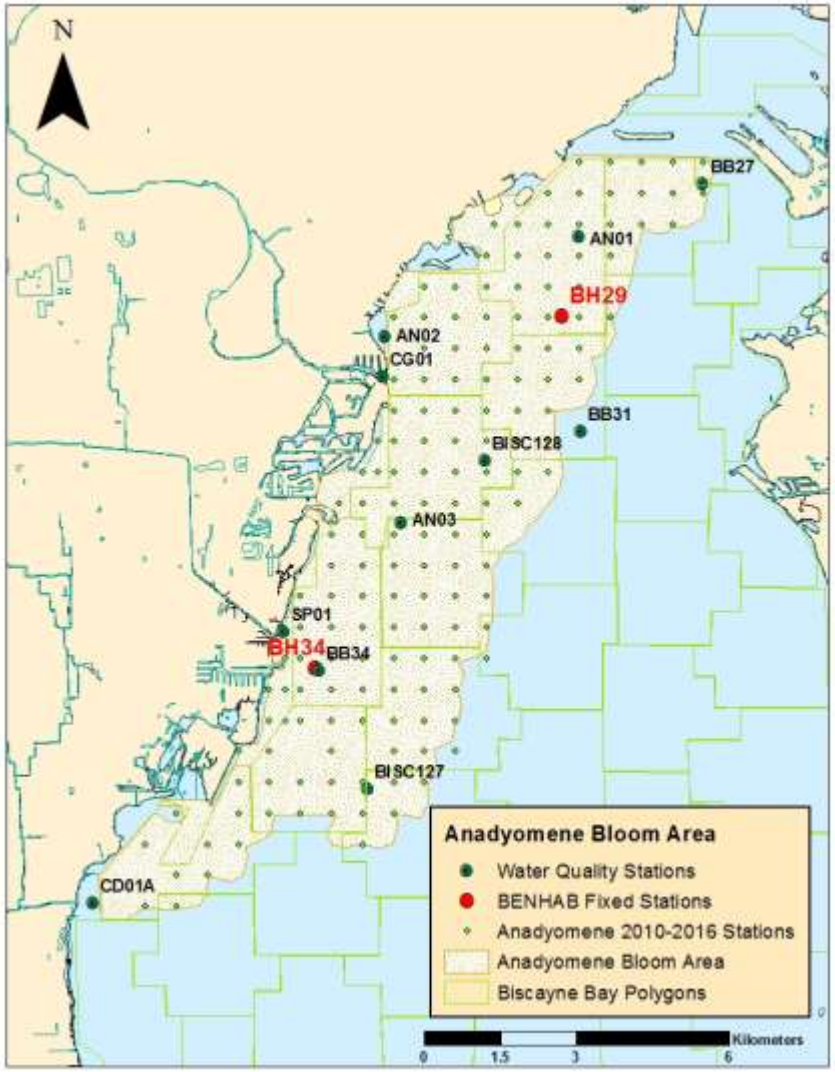
Overview

- DERM had been conducting annual surveys of stratified random stations since 1999 and fixed transects since 1985.
- Period of Record showed overall stable seagrass community throughout central Biscayne Bay, Rickenbacker to Card Sound, through 2004.
- Bloom became apparent in 2009-2010 and reviews of the data indicate development in 2004-2005.
- Bloom is composed of two species in the genus *Anodyomene*.
- Bloom has remained confined to the North Central Inshore (NCI) region of the bay.

Bloom Composition

- Two species in the genus *Anadyomene*
- Image 1: *Anadyomene stellata*
  - Found throughout Central Southern Biscayne Bay <5% cover.
  - Present throughout the bloom area, with some areas of dominance in the north.
- Image 2: *Anadyomene* sp.
  - DNA unable to confirm identification, appears morphologically closest to *Anadyomene linkiana* - previously described from single specimen collected from deep waters in the Bahamas.
  - Dominant throughout the bloom, regularly >75% cover during 2010-2013 and attaining high biomass.
  - **Not previously recorded in Biscayne Bay or elsewhere in Florida.**

Monitoring Program



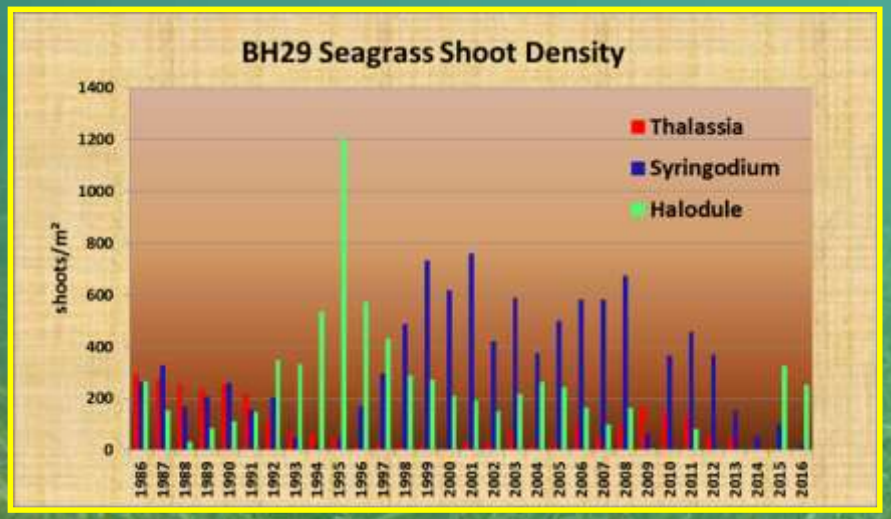
Biscayne Bay Monitoring Program (1999-2016):

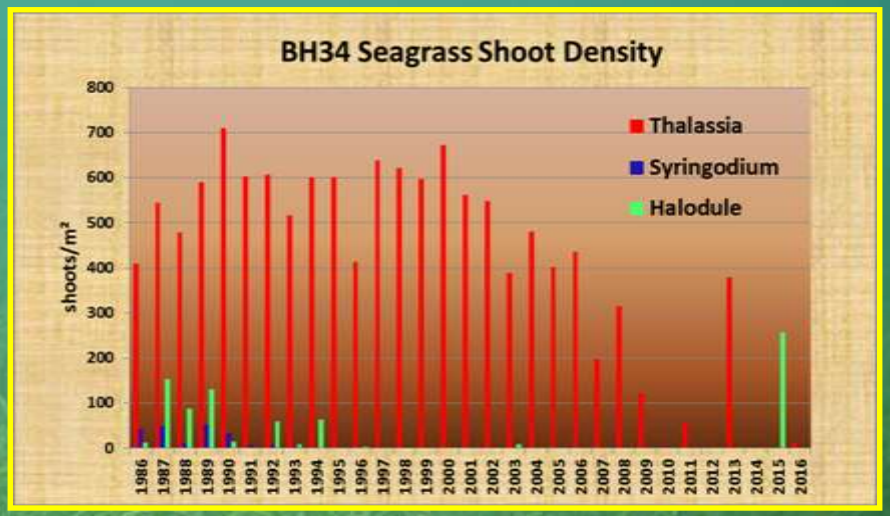
- SAV surveys at 11 fixed stations and 101 sampling sites within Biscayne Bay.
- 11 water quality stations within the bloom area.
- Visual percent cover is estimated using the Braun-Blanquet scale (BBCA) for both seagrass and macro algae in a 0.25m^2 grid.

Anadyomene Dedicated Sampling (2010-2016):

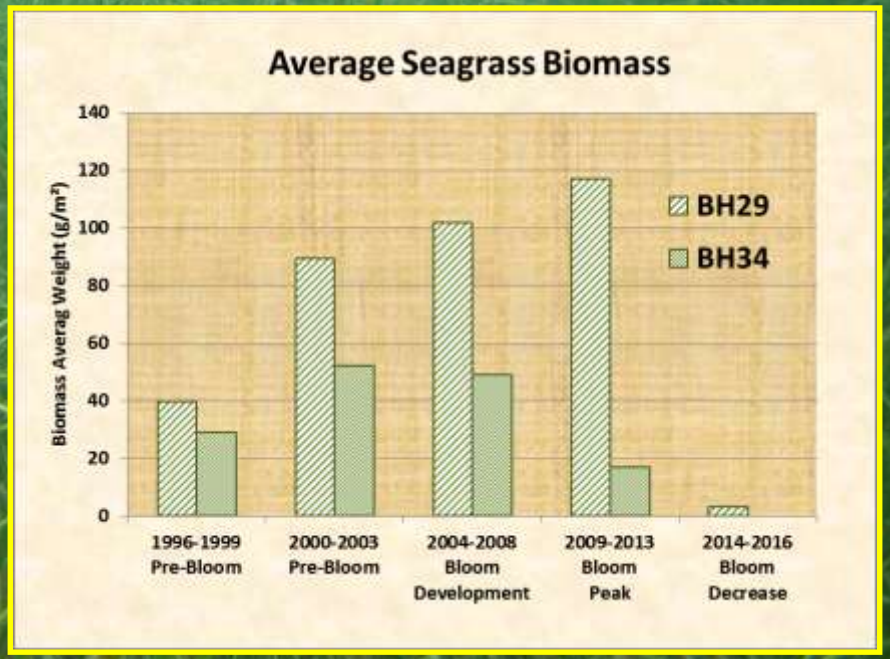
- Total bloom area is approximately 60km^2.
- 165 stations surveyed between 2010-2016 using the full sampling grid in the NCI.

NCI Seagrasses Fixed Stations

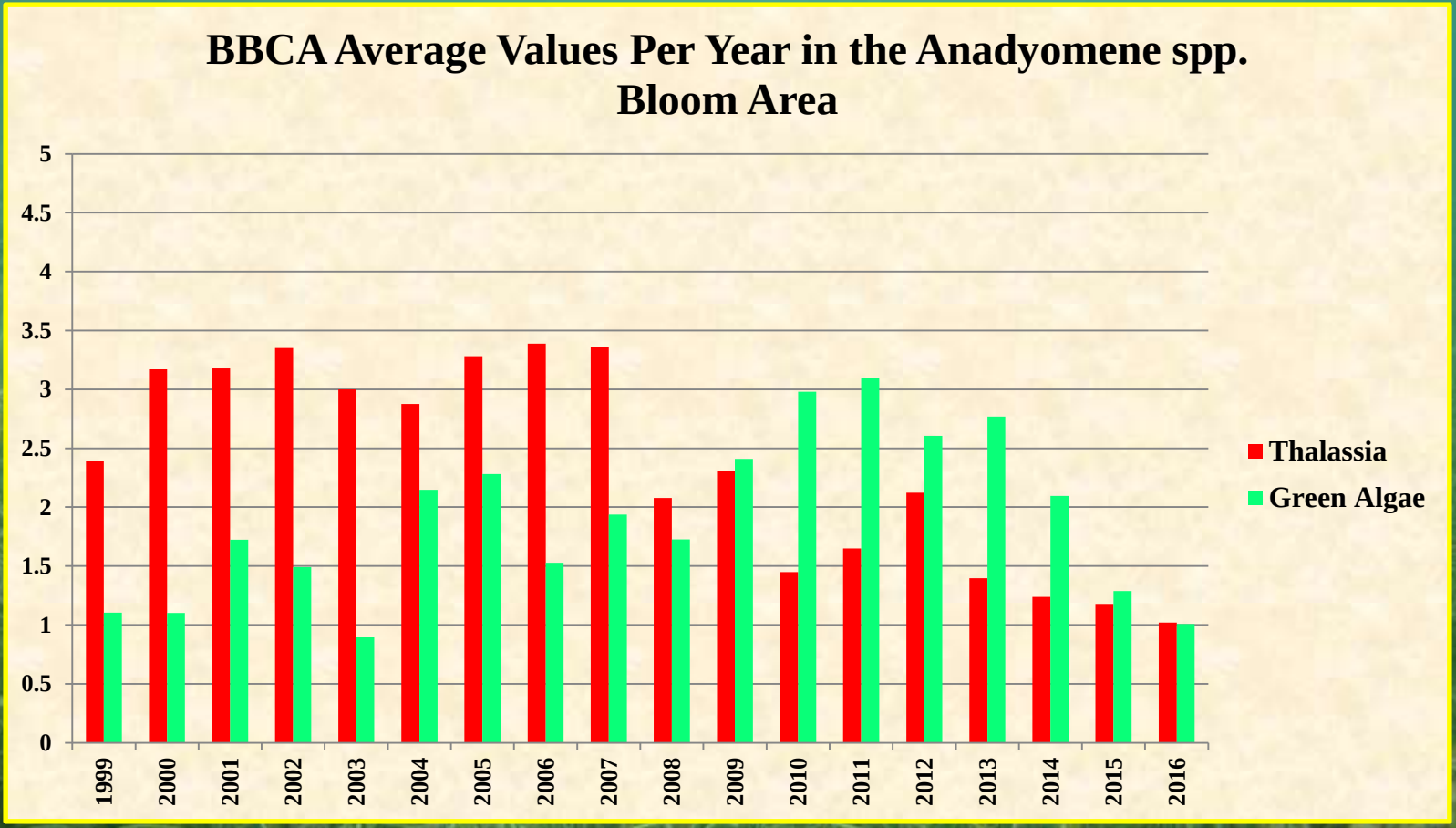




- Two fixed seagrass monitoring stations within in the bloom (BH29 and BH34).
- Period of Record dating to 1985, showing seagrass at high shoot densities through 2008.
- Significant seagrass biomass decrease during 2014-2016 within the bloom area.

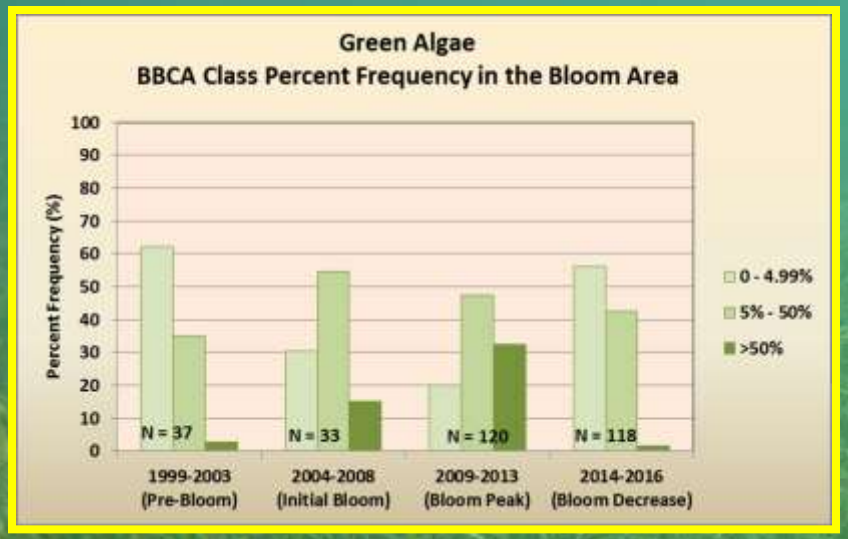


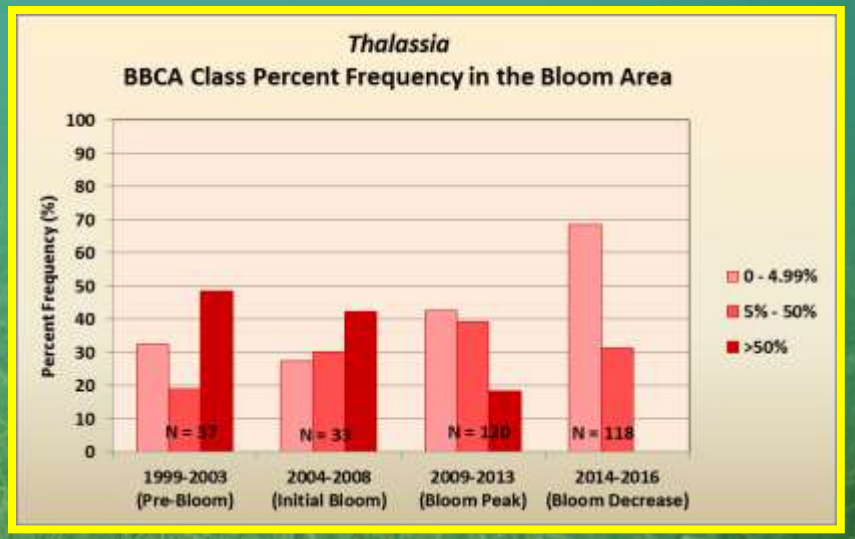
Seagrass Impacts



Shift in coverage from *Thalassia* dominant area to Green Algae dominance and subsequent decrease for both groups.

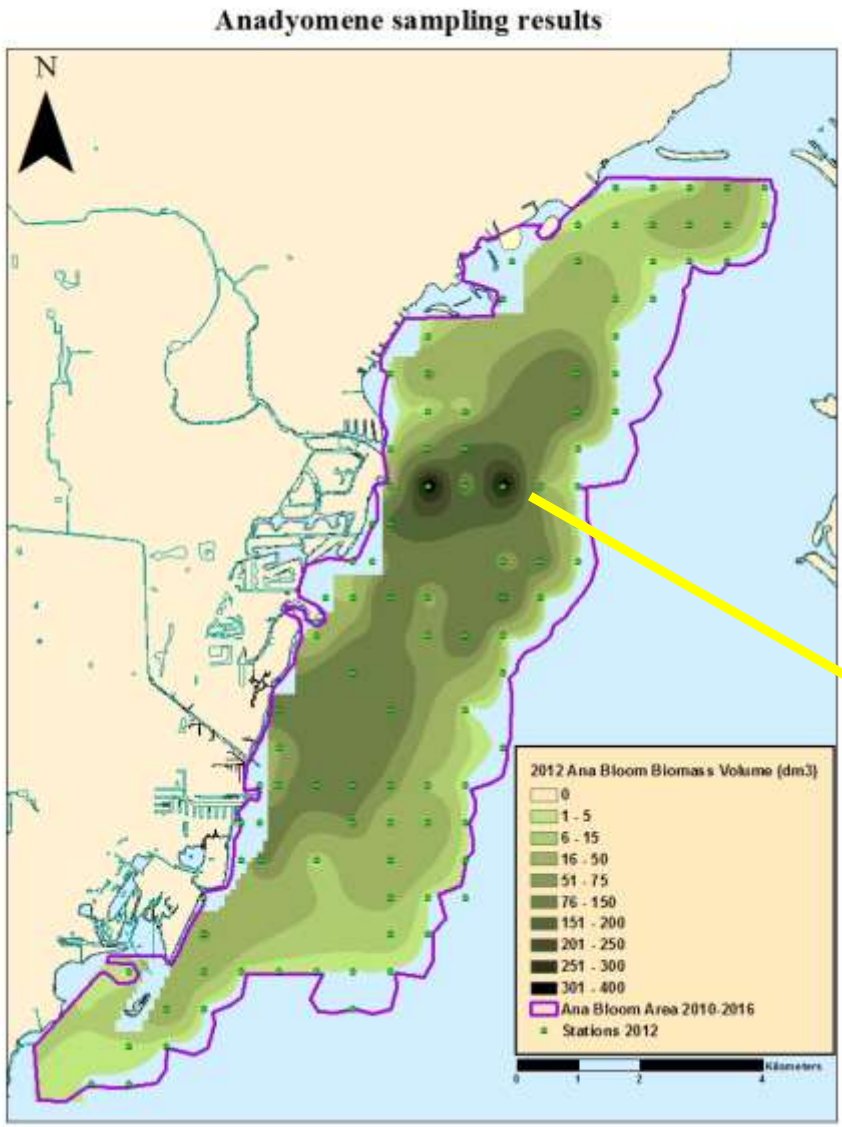
Seagrass Impacts





- **GREEN ALGAE: Increase in the highest BBCA categories (>50% coverage) during the bloom period (2004-2013). Return to the same abundance pattern observed during pre-bloom, (Green Algae low BBCA values) during 2014-2016 Bloom Decrease period.**
- **THALASSIA: Continuous decrease in the highest BBCA categories (>50% coverage). This BBCA categories disappeared during 2014-2016 Bloom Decrease period in the NCI area.**

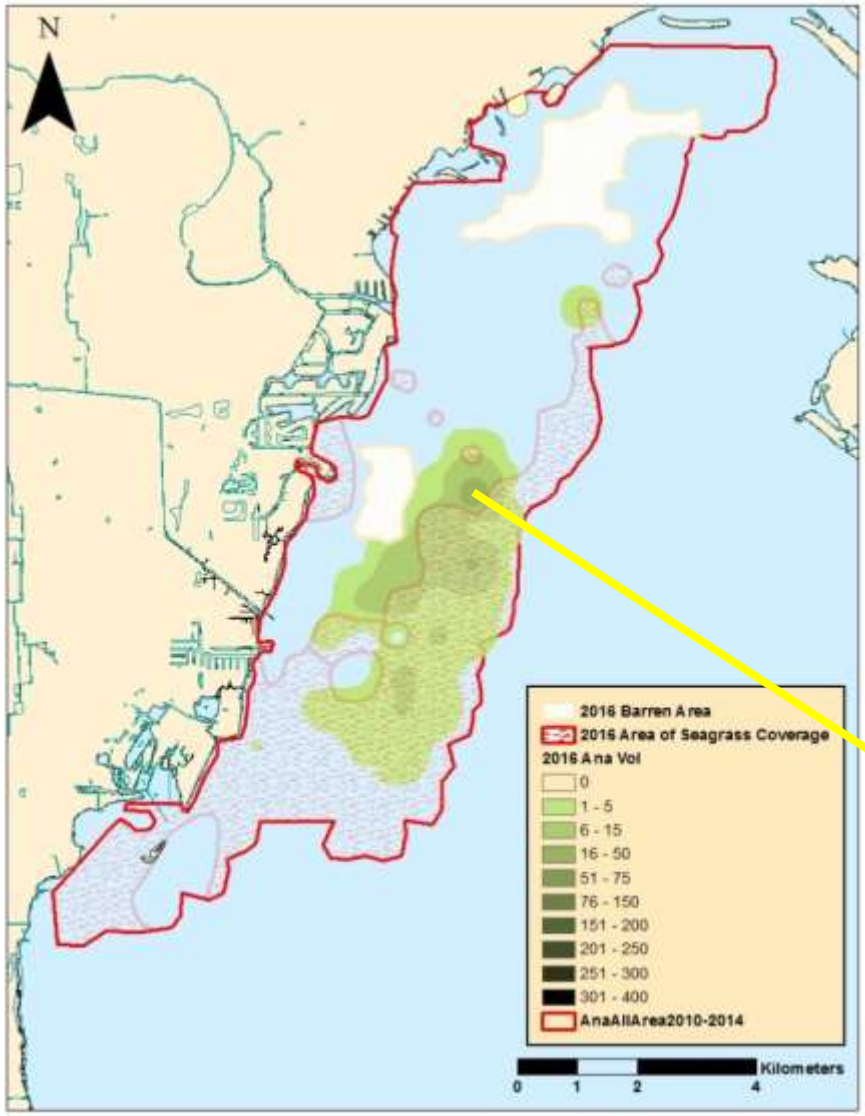
Bloom Peak



2012 Cubic volume evaluation:

- While the majority of station had >75% cover – biomass was noted as variable.
- Distinct Eastern fringe from 75-100% cover to absent between station 2000ft apart.
- Pattern of greatest biomass just offshore of the two main canals in the region: Snapper Creek and Coral Gables.

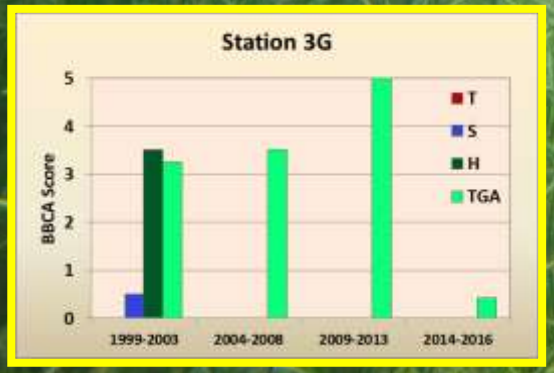
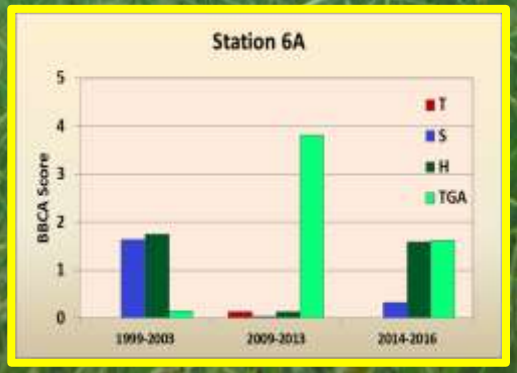
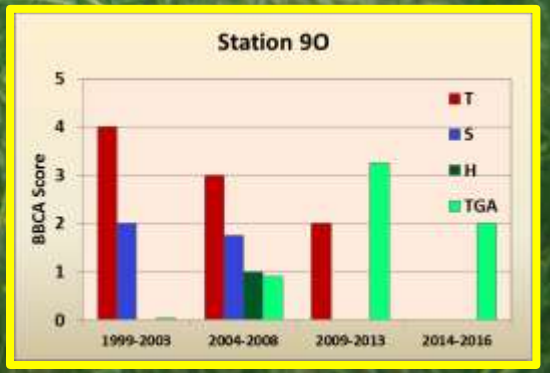
Bloom Current Status



2016 Cubic volume evaluation:

- General Decrease in the *Anadyomene* spp. volume (percent cover x height).
- Barren bottom areas throughout, specially off Matheson Hammock park and north to Coral Gables.
- Between 2012-2016, the reduction in the seagrass coverage area was 24.42km² (51.65 %).

Bloom Time Series

	Station 3G	Station 6A	Station 9O
2010-2012			
2014 - 2016			
			

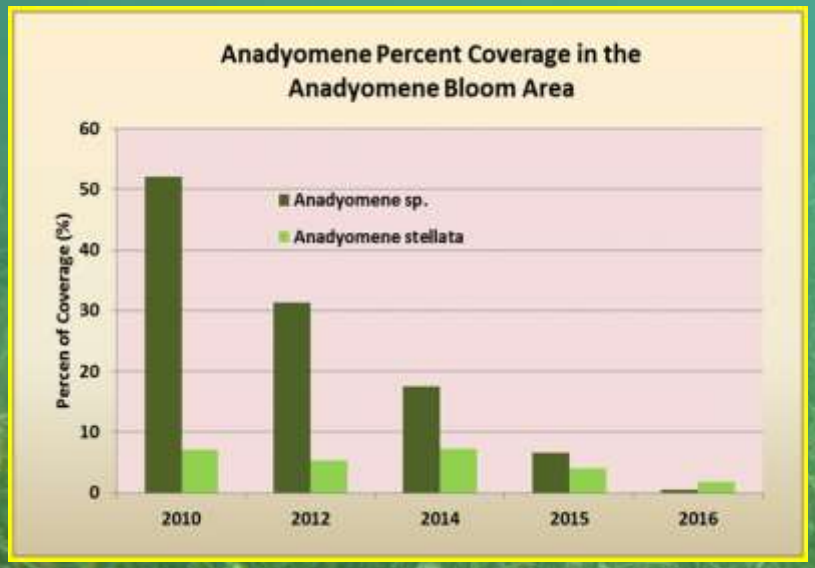
Seagrass Impacts

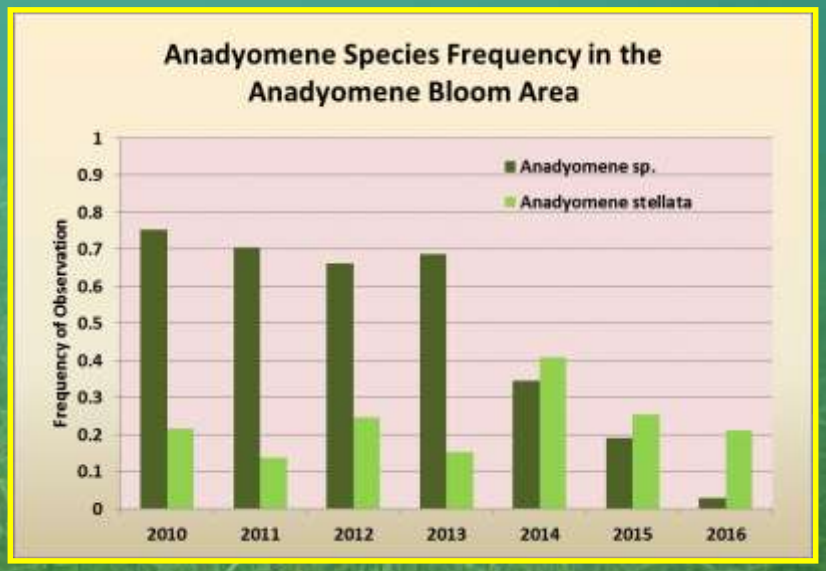
- During the pre-bloom (2000-2003) and bloom development (2004-2008) periods, the average Total Seagrass (TSG) coverage in the area was between 51 – 54 km².

- An estimated Seagrass Area of 42km² have been lost since 2004-2008, a decline of more than **75%** in TSG coverage.

	NCI Bloom Total Area (60 Km²)			
	Pre-Bloom	Bloom Development	Bloom Peak	Bloom Decrease
	2000-2003	2004-2008	2009-2013	2014-2016
Average Total Seagrass Coverage Area (Km²)	51.2	53.93	23.1	12.10

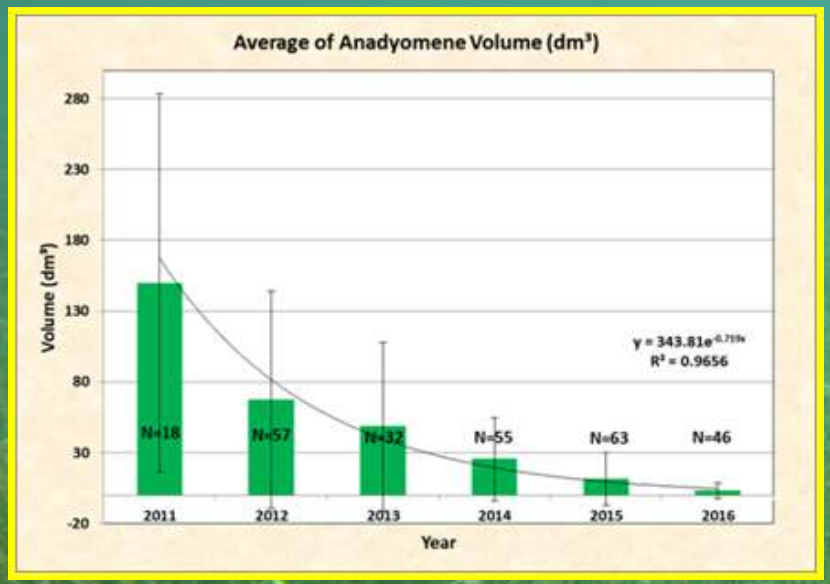
Bloom Decrease

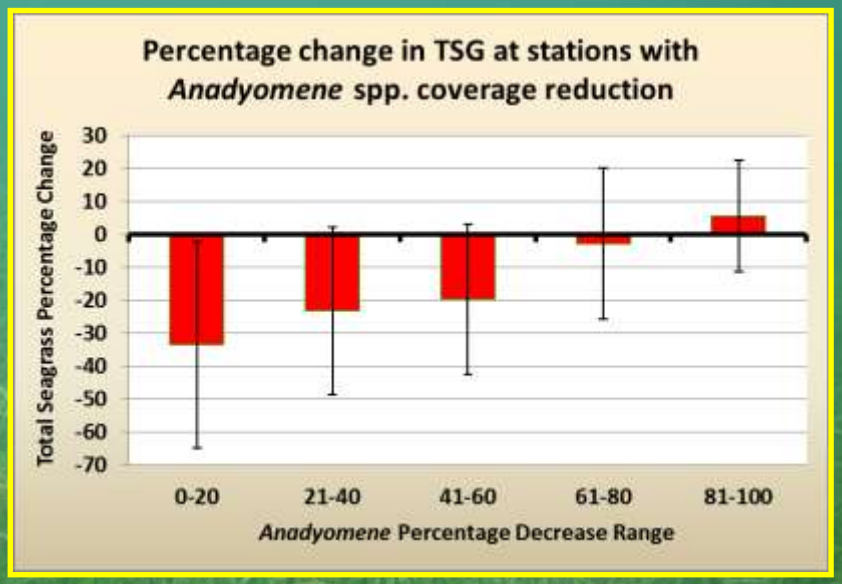




- *Anadyomene* sp. coverage decreased continuously since 2010 while *Anadyomene stellata* coverage remained low but stable.
- *Anadyomene* sp. presence in the area (frequency) remained constant until 2013 and has decreased since then.
- *Anadyomene stellata* has become the major bloom component in terms of frequency and coverage.

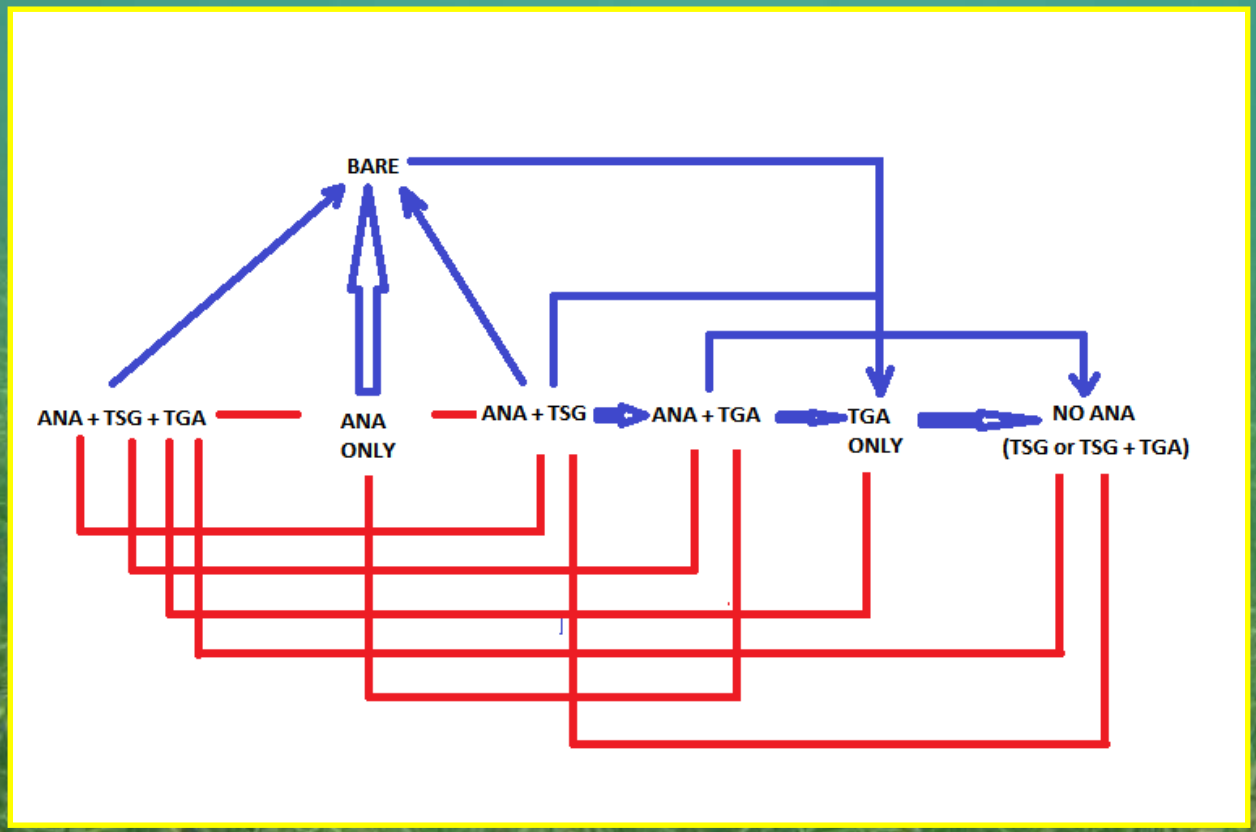
Seagrass Recovery





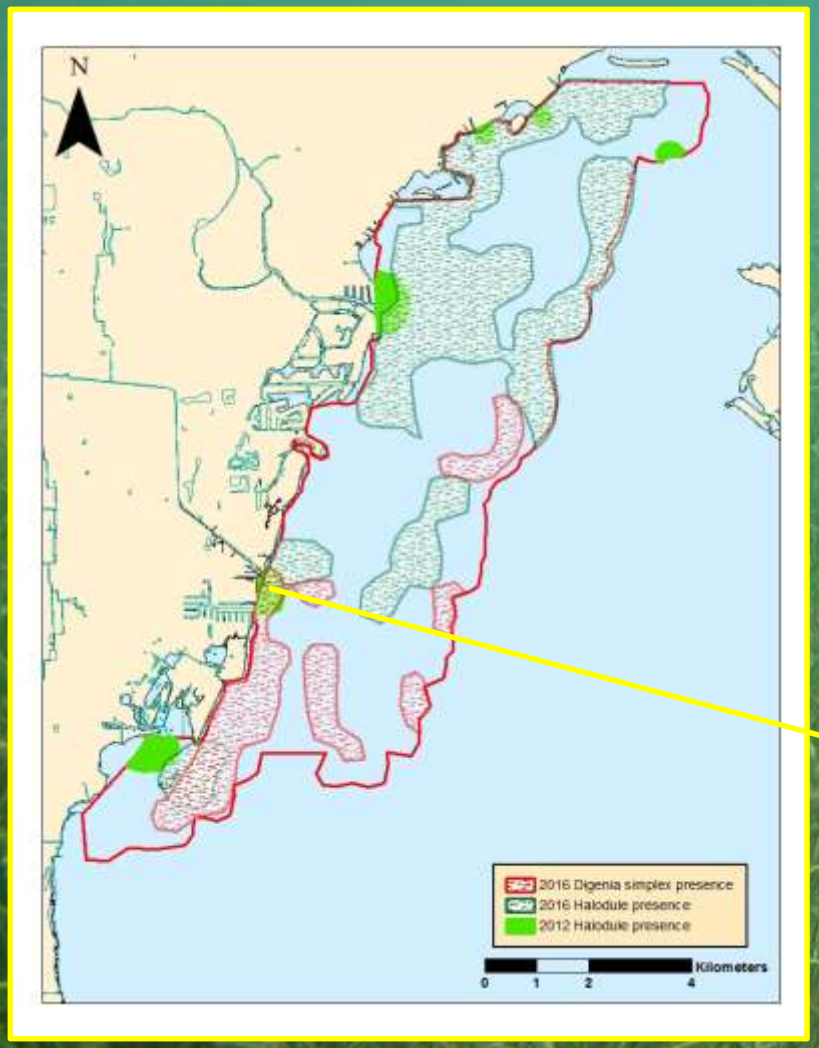
- Continuous reduction in algae bloom volume since 2011 to present (2016).
- Losses of seagrasses are ongoing where *Anadyomene* spp. persists.
- Only stations with a reduction in 80% or more in *Anadyomene* spp. coverage experienced some seagrass recovery.

Seagrass Recovery



- Bare stations remained with no SAV coverage or developed into green algae as per 2016.
- Once *Anadyomene* kill all seagrass, station develop into a bare bottom or transition into a green algae area that develops into a mixed seagrass bed or green algae bed.

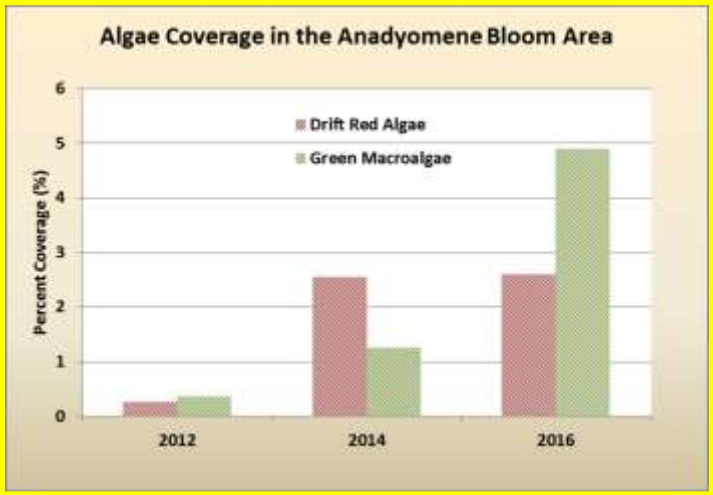
Seagrass Recovery

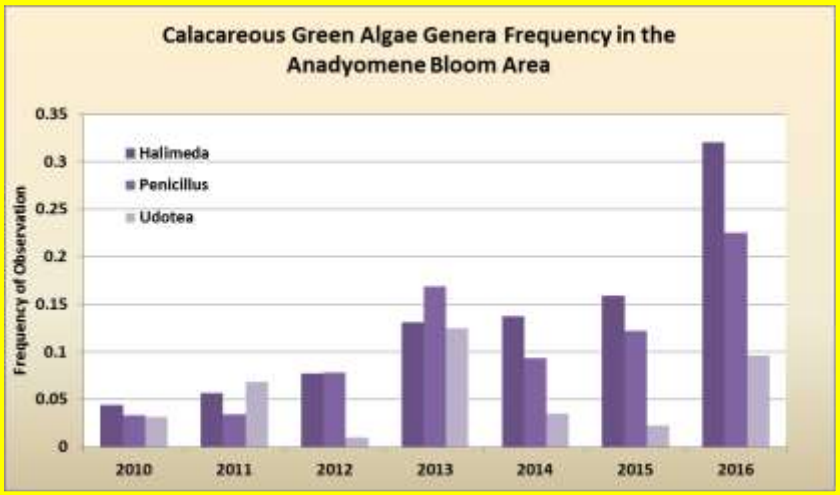


- Expanded presence of *Halodule wrightii* in the north of the bloom area observed since 2012.
- Red algae *Digenia simplex*, has become one of the main components of the Red Drift Algae group and a dominant macroalgae at some southern stations.

Digenia simplex
Station 12P

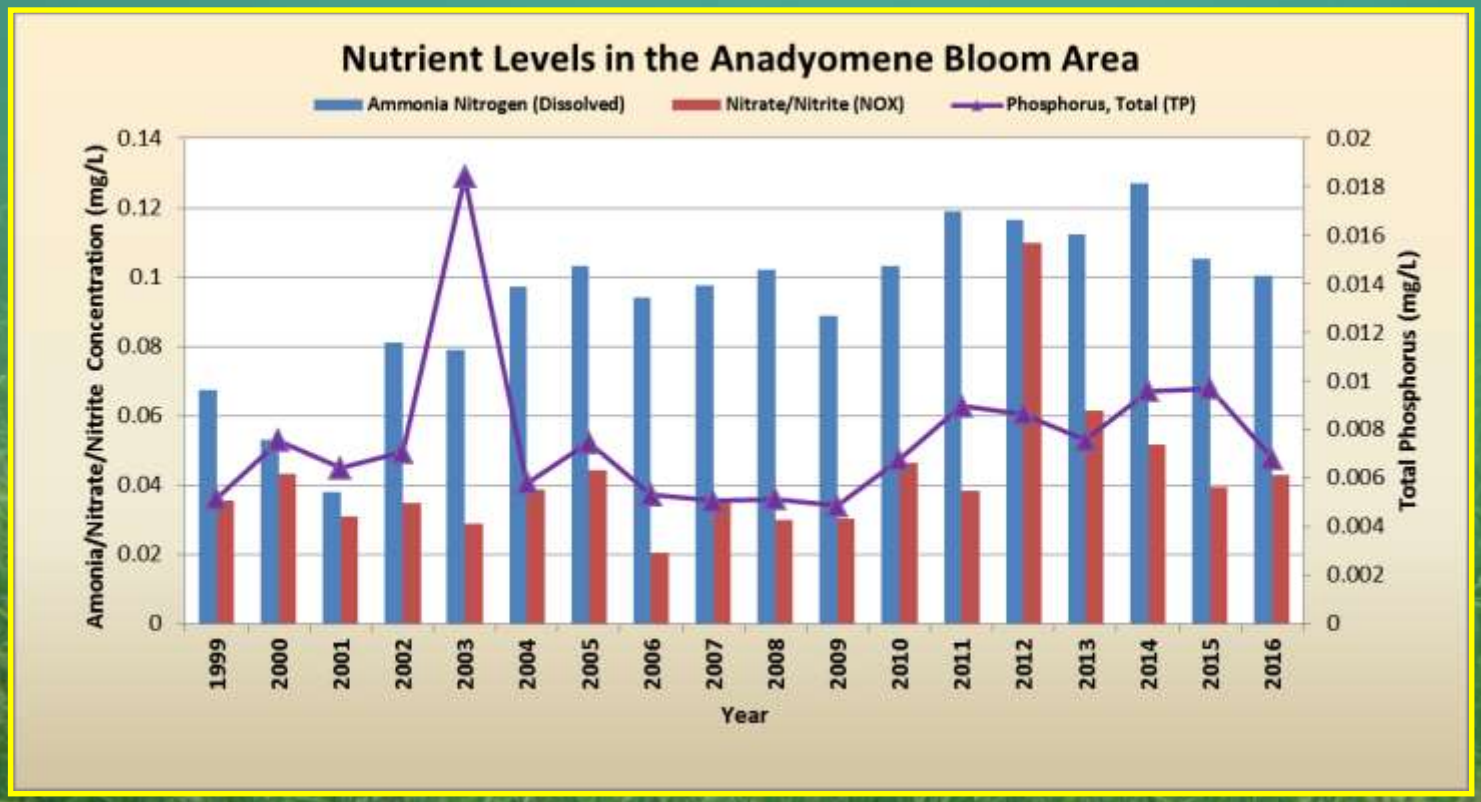
Algae increases





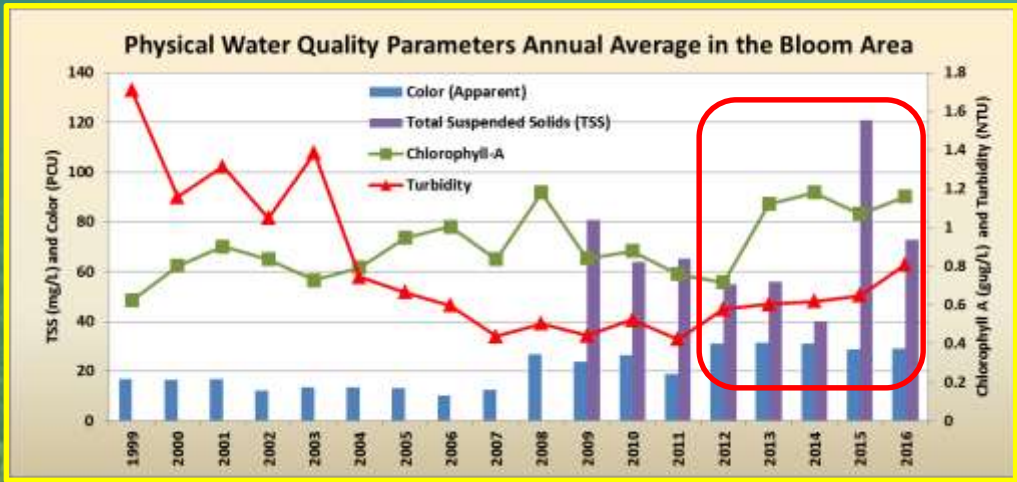
- Algae groups has increased their presence and coverage in the area in the period 2014-2016.
- Increases in calcareous green algae frequency, specially in the genera *Halimeda*, has been observed in the area.
- Through the Bloom Decrease period (2014-2016) Drift Red Algae coverage increased and has remained stable.

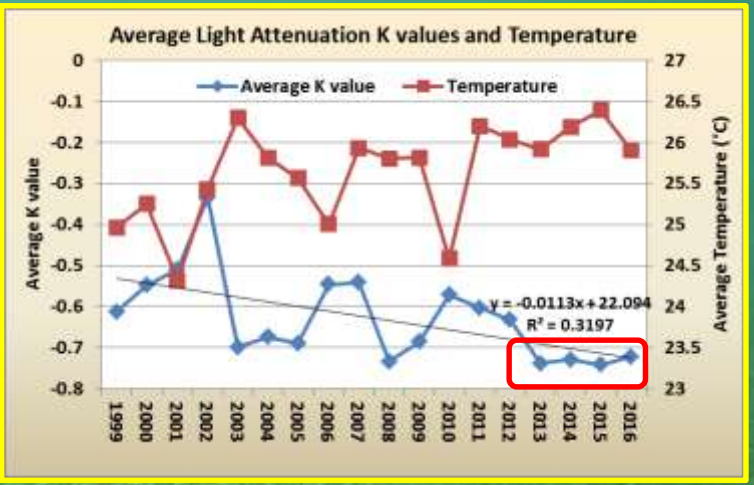
Water Quality



- High levels of Phosphorus in 2003, when first signs of the bloom were observed.
- Highest historical Nitrate/Nitrite levels in 2012.
- High levels of Nitrogen during 2011-2014.

Water Quality





Chlorophyll-A & Color (2012-2016)
TSS (2015)
Turbidity (2016)

Extreme cold mortality event (2010)
PAR values (2013-2016)

- Continuous decrease/mortality of the SAV.
- Increases sediment instability.
- Nutrients release that favored green microlagae growth.

SAV Summary

- Prior to the *Anadyomene* spp. bloom NCI had a stable diverse seagrass community, dominated by *Thalassia*.
- The *Anadyomene* spp. bloom developed rapidly during the 2004 – 2008 and peaked 2009-2013.
- Approximately 42km^2 of seagrass coverage has been lost in the bloom area, which is a decline of more than 75%.
- The bloom has decreased since 2014, mainly due to the decrease in the *Anadyomene* sp. component, however seagrass recovery has been minimal to date.
- Some increases in the macroalgae groups has been observed in the area, specially in the green algae genera *Halimeda* and the red drift algae *Digenia simplex*.

Water Quality Summary

- A peak in Total Phosphorus in 2003 preceded the beginning of the *Anadyomene* spp. bloom.
- Record low temperatures that triggered a mass mortality event during the 2010 winter followed by a record high temperature summer could have contributed to seagrass mortality and favored the *Anadyone* spp. increases.
- During the bloom peak period we observed higher than average values in nutrients (Nitrogen and Phosphorus).
- Through the period 2012-2016, increases in Turbidity, Chlorophyll-A levels and Total Suspended Solids were measured in the bloom area, along with low PAR values (decrease in light penetration). Such changes in water quality parameters has been associated to biomass (seagrass and algae bloom) mortality and subsequent sediment instability and microalgae increases in the water column.

Acknowledgements

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