

# **Virtual buoy system (VBS) to monitor coastal and estuarine water quality from satellite measurements**

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EPA, NOAA/AOML, NASA, U Mass Boston....

**Funding provided by USF, NASA, NOAA, EPA, USGS, and Endowed Fellowships**

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**10<sup>th</sup> National Water Quality Monitoring Conference, 2-6 May 2016, Tampa, Florida**

# USF Optical Oceanography Team

Optical Oceanography Laboratory Team



Group photo taken September 14, 2013 at Fort De Soto Park

# One approach to assessing light limitation: MODIS time series optical water quality (OWQ) data- [optics.marine.usf.edu](http://optics.marine.usf.edu)



Florida Fish and Wildlife  
Conservation Commission

Optical Oceanography Laboratory  
College of Marine Science

Optical Water Quality and Seagrass Data for the Suwannee River Estuary – A Joint Project between FWC and USF, supported by FDEP & NASA

## Menu

- Home
- + People
- + Projects
- + Satellite Data Products
- + Virtual Buoy Products
- + Airborne Data Products
- + Publications
- + Events
- + Links
- + Contact

## Welcome to Florida's Suwannee River Estuary Region

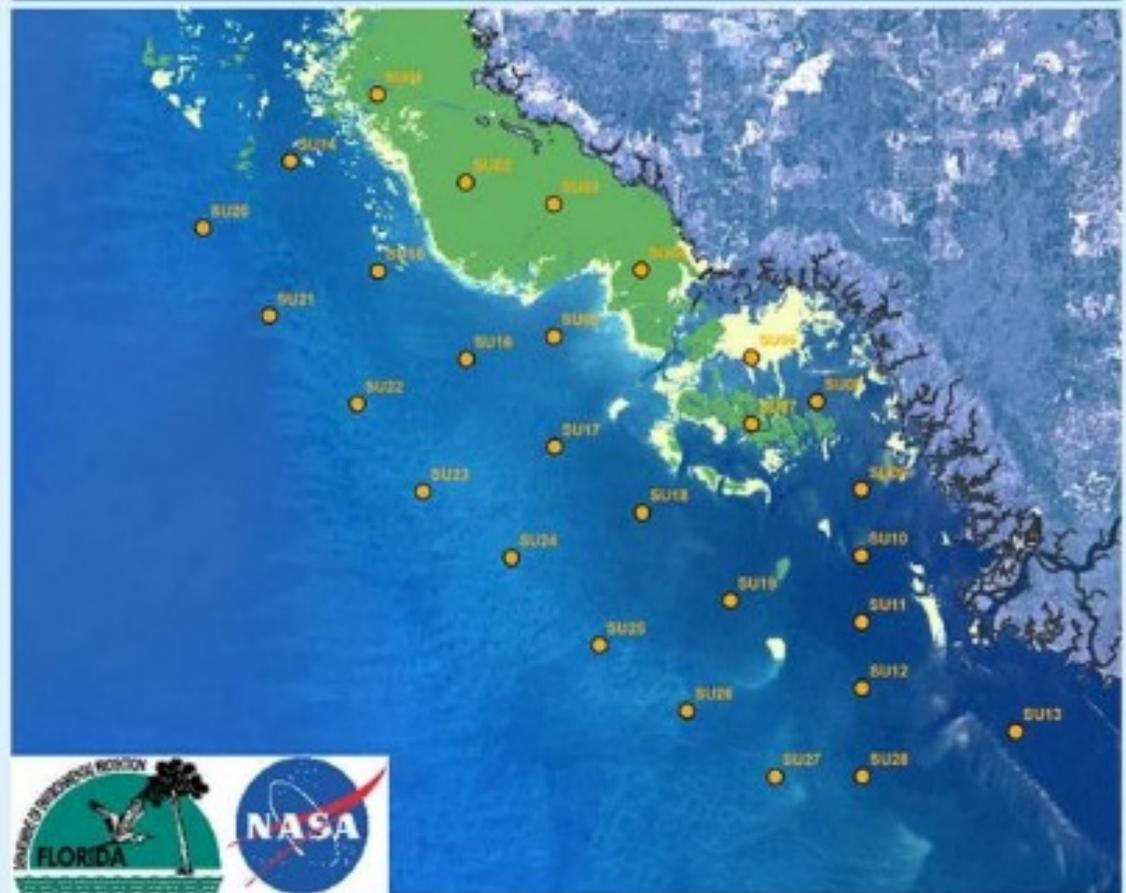
The Big Bend area of Florida's coast has over 600,000 acres of seagrass supporting many economically important species of fish and shellfish.

Healthy seagrass beds depend on water clarity, and this website provides access to historical and real-time water clarity and seagrass abundance data for the Suwannee River Estuary and nearby coastal waters.

## Quick Links

By clicking on any of the stations on the image to the right, you will be taken to the data for that station. These links can also be found in the menu to the left under the Projects section. If you are looking for the Steinhatchee Big Bend Region page you can click here:

Suwannee Station Clickable Map



Click on any of the stations above to see the data.

# What Water Quality Parameters Are We Interested In? Why? And What Parameters Can Satellites “See?”

- Dissolved Oxygen
- pH
- Nutrients
- Bacteria



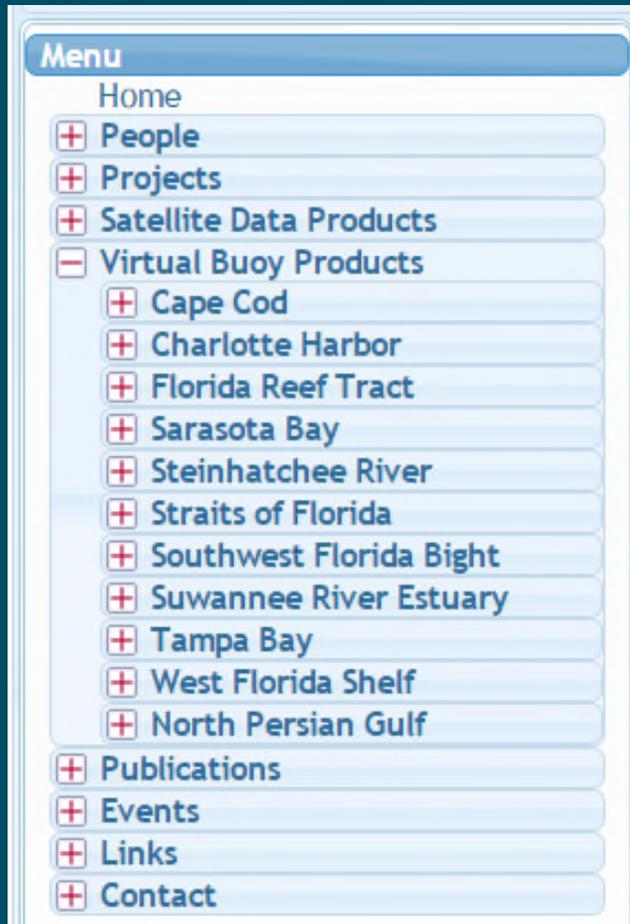
- Chlorophyll
- Water Clarity
- Turbidity (Sediment)
- Colored Dissolved Organic Matter
- Temperature



# Optical Water Quality: How?

**Generate, analyze, and serve remote sensing data products**

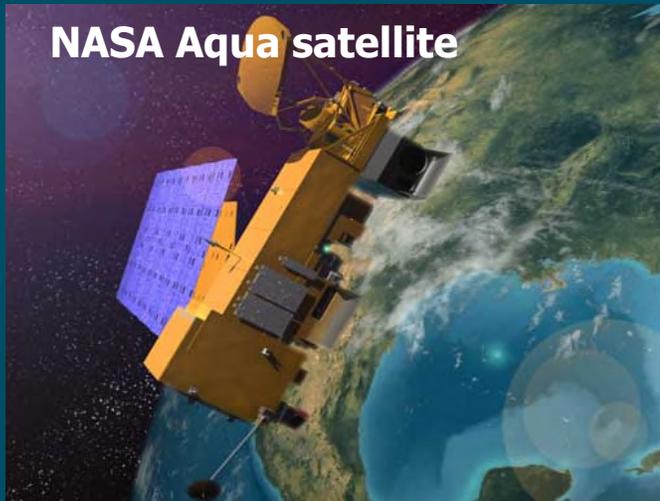
**supported by field and laboratory measurements, optical modeling, and algorithm development and validation**



# Virtual Antenna System (VAS)

<http://optics.marine.usf.edu>

Obtain satellite raw data from NASA through internet: ~40 GB per day



Images used by  
New York Times

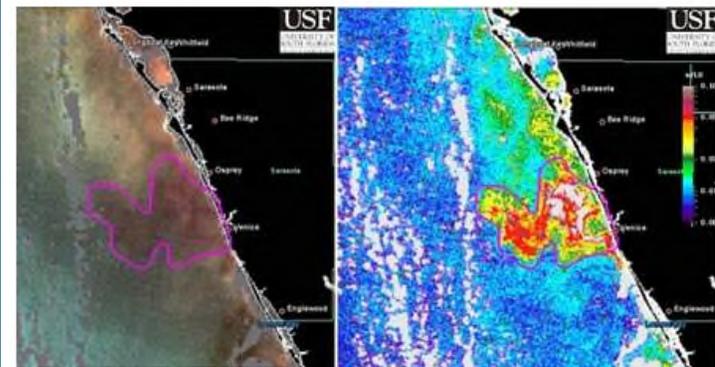


Serve data products to > 60 countries through  
Web portal: > 100 GB per day



Sarasota Herald-Tribune

**Small red tide outbreak causes concern**

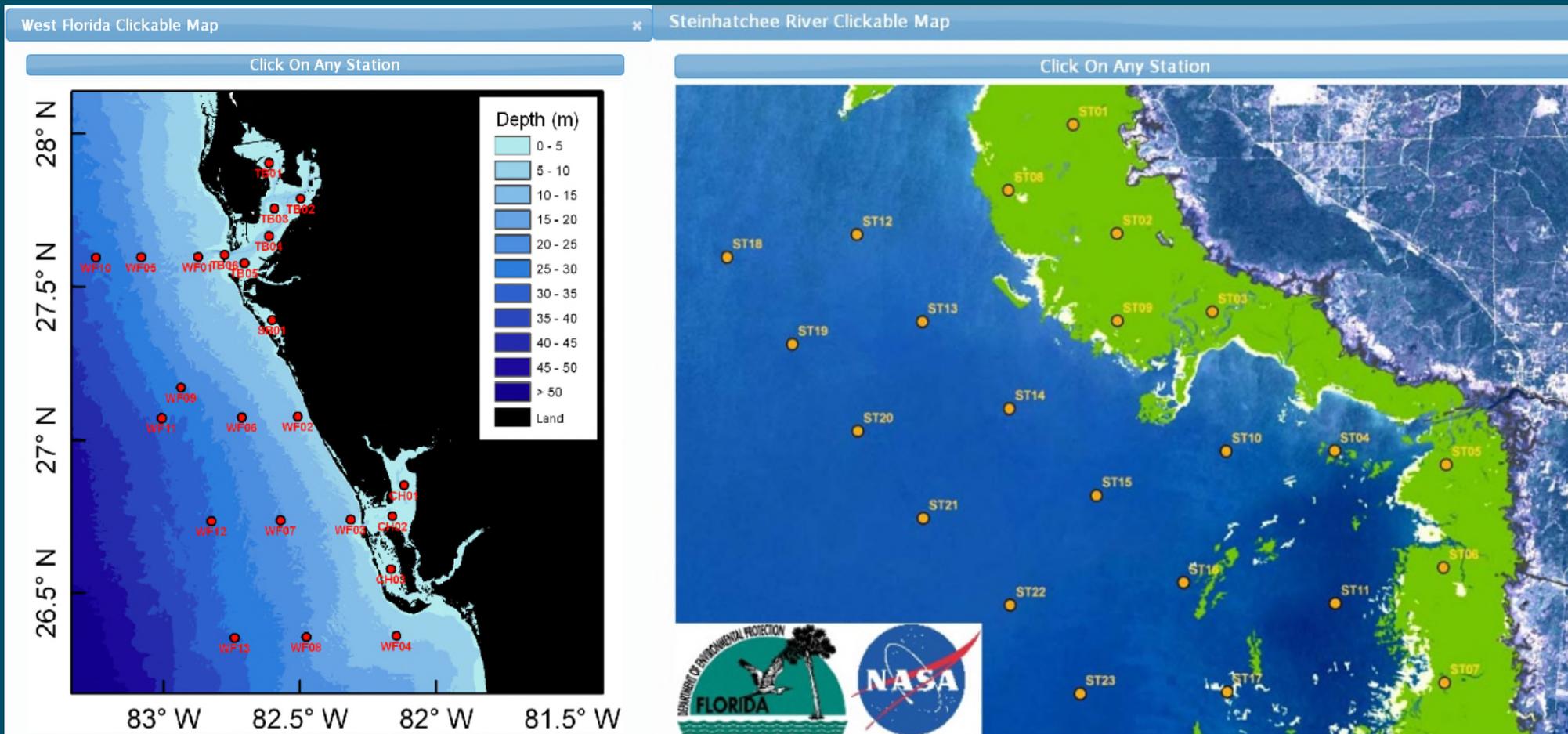


Scientists believe the area outlined in magenta is *Karenia brevis*, the algae bloom that causes red tide. The area to the north outlined in yellow may also be *Karenia brevis*. (Photo provided by University of South Florida)

# How to Make Information Available? Virtual Buoy System (VBS)

<http://optics.marine.usf.edu>

Under “Virtual Buoy Products” of the OOL Web



# Virtual Buoy System (VBS)

<http://optics.marine.usf.edu>

## Under “Virtual Buoy Products” of the OOL Web

Summary | SST | Chlorophyll-a | Kd(488) | Light Penetration | Secchi Disk Depth | Turbidity

Station Name: PG 02 - N. Persian Gulf  
[Clickable Map](#)

Latitude: 28.9367  
Longitude: 48.4570  
Depth in Meters: 22  
Current Imagery: /cgi-bin/optics\_data?roi=PERSIAN\_GULF&current=1

The table below shows the current conditions (most recent weekly and monthly means) at station PG 02, derived from MODIS data. Also included are conditions for the current week and month from last year, as well as the long term means (climatologies).

Current conditions which exceed one standard deviation from the climatological mean are considered "anomalies" and are color coded. Positive chlorophyll anomalies, for example, may indicate phytoplankton bloom conditions at the station. Negative SST anomalies in winter might adversely affect several marine organisms (e.g., manatees, fish, corals, and sea turtles).

This table is intended to provide a visual guide to current and developing conditions at this station. However, caution must be used in interpreting anomaly data. Due to limitations of MODIS measurements, the normal climatological conditions for certain stations or time spans may not be fully characterized. As such, truly anomalous conditions may not be identified. Alternatively, detected anomalies may actually be within the climatological norm.

The MODIS data represented in the table below is from week 30 which runs from 7/23/2014 through 7/29/2014 as well as historical climatology.

Product	Weekly Mean	Monthly Mean	Weekly Last Year	Monthly Last Year	Weekly Climatology	Monthly Climatology
Temperature (C°)	31.84	31.52	31.47	31.09	32.25	31.45
K <sub>d</sub> (488) (m <sup>-1</sup> )	0.17	0.17	0.11	0.10	0.10	0.12
Secchi Disk Depth (m)	4.41	5.09	6.97	7.35	7.10	6.52
Turbidity (NTU)	1.46	0.79	0.23	0.28	0.29	0.55
Chlorophyll-a concentration (mg m <sup>-3</sup> )	1.70	1.77	1.06	0.83	0.91	1.33
Light Penetration (%)	2.26	2.52	9.77	12.04	11.55	7.70

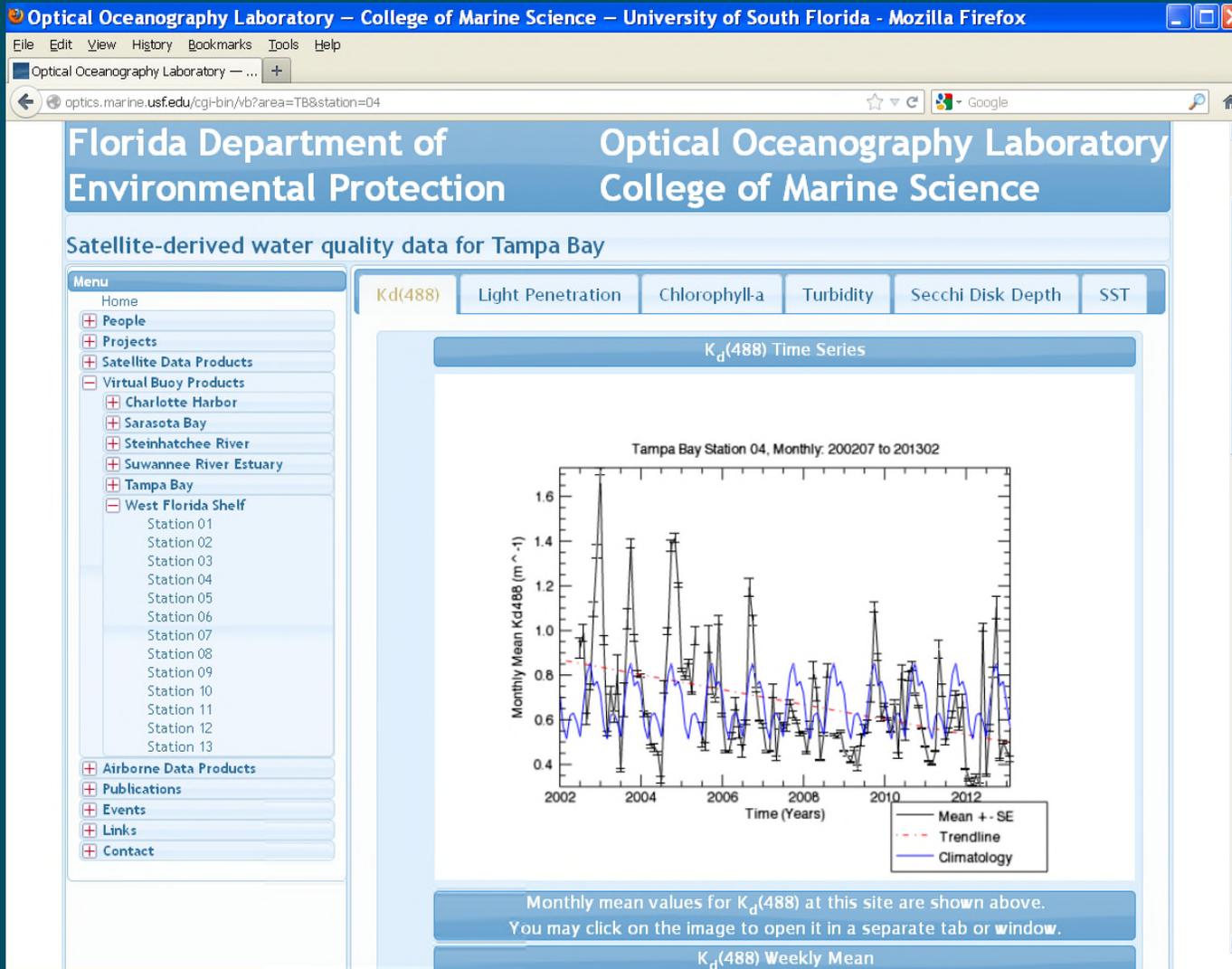
**Summary Table Guide**

Severe Positive Anomaly	Current data $\geq$ 2 st. dev. above climatology
Moderate Positive Anomaly	Current data $\geq$ 1 st. dev. above climatology
No Anomaly	Current data within 1 st. dev. of climatology
Moderate Negative Anomaly	Current data $\leq$ 1 st. dev. below climatology
Severe Negative Anomaly	Current data $\leq$ 2 st. dev. below climatology

# Virtual Buoy System (VBS)

<http://optics.marine.usf.edu>

Under “Virtual Buoy Products” of the OOL Web



VBS water quality data:

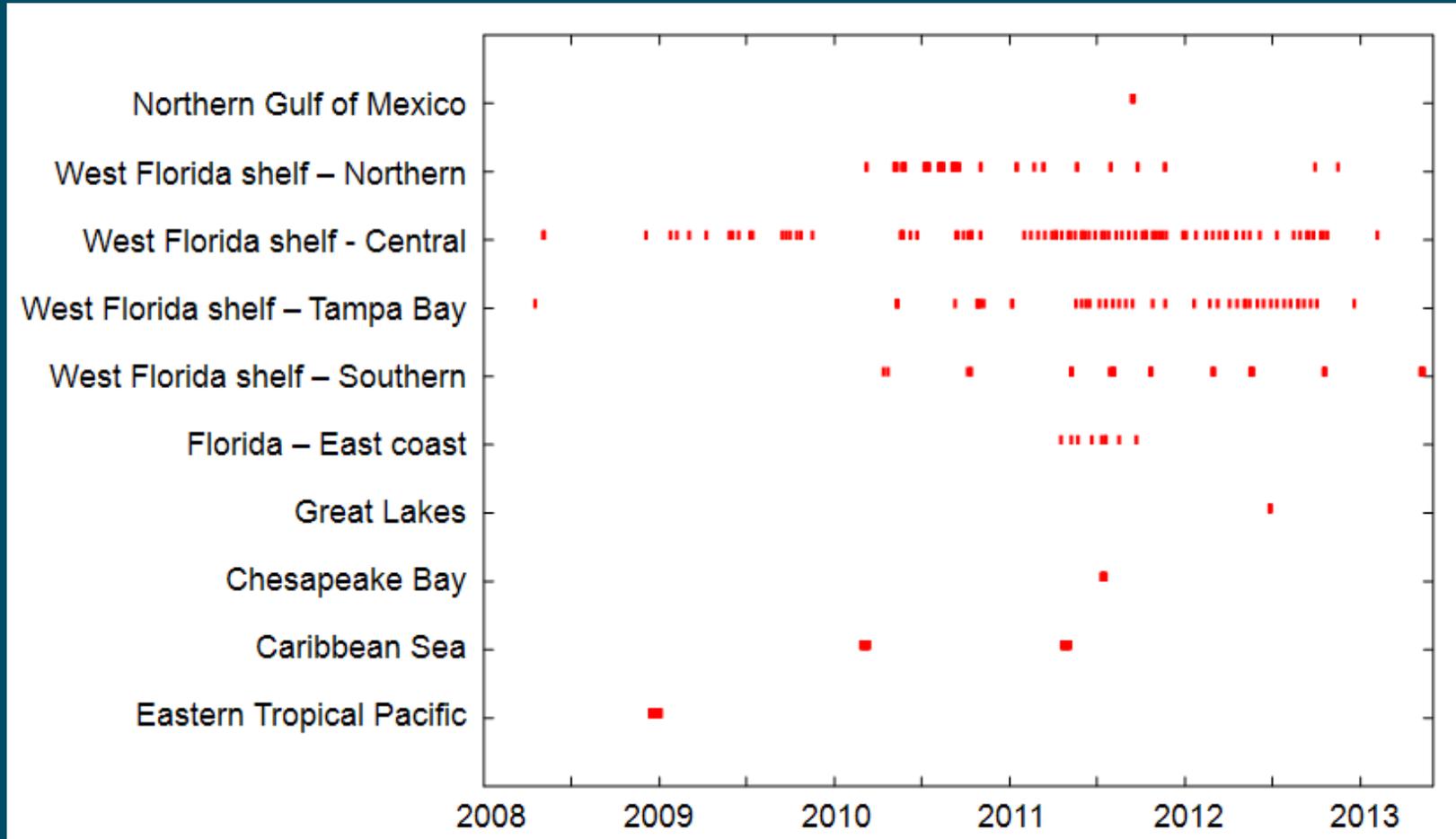
- Chlorophyll
- Turbidity
- Water clarity
- Secchi Disk Depth
- Bottom light
- SST

All available through a simple click, in both graphic and ASCII formats

# Optical Water Quality: How?

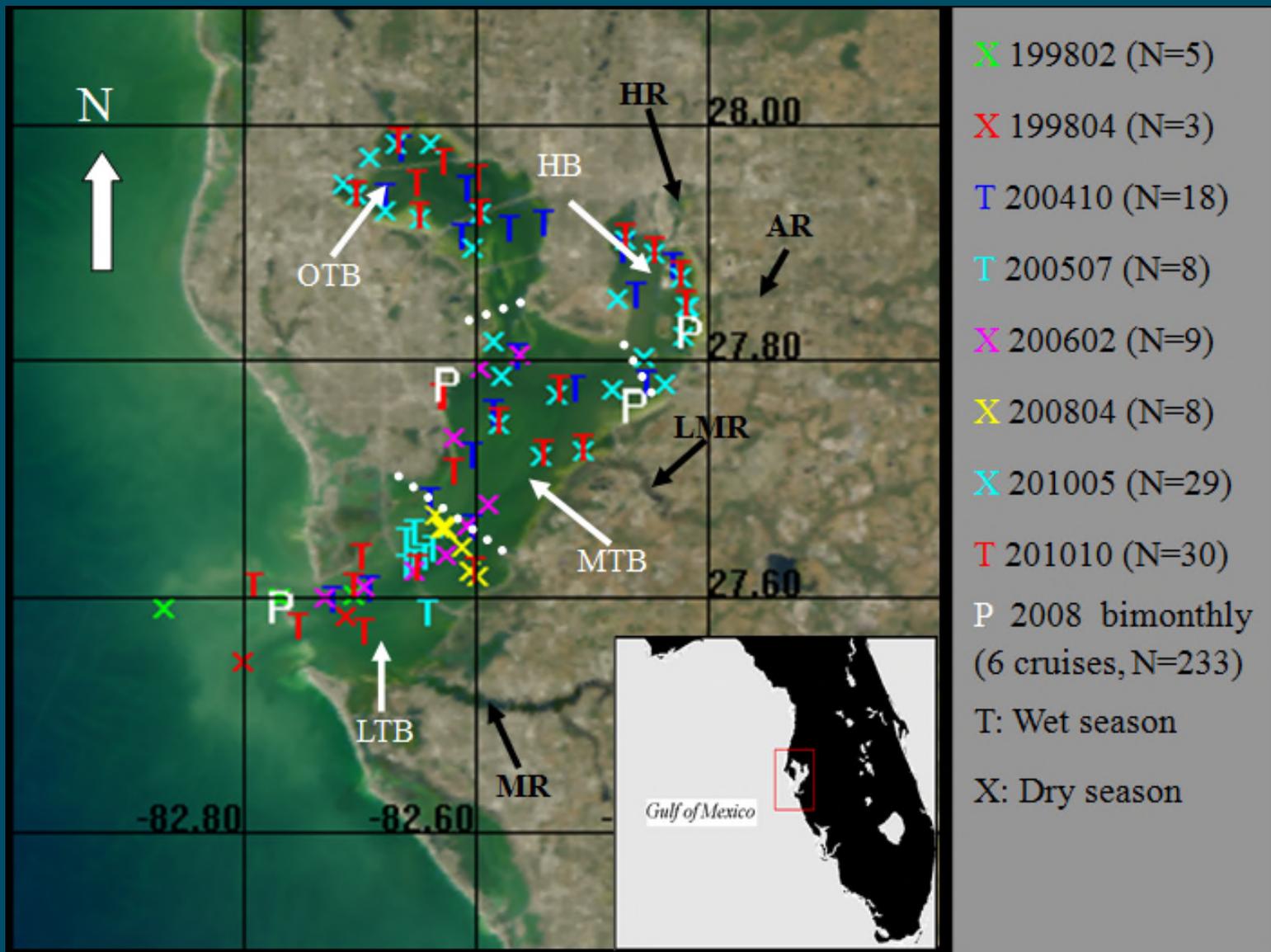
**Validation requires extensive field and laboratory measurements, optical modeling, algorithm development, remote sensing**

Field measurements and water sampling: Reflectance, light penetration, light absorption and scattering, fluorescence, turbidity, chlorophyll concentration, ....



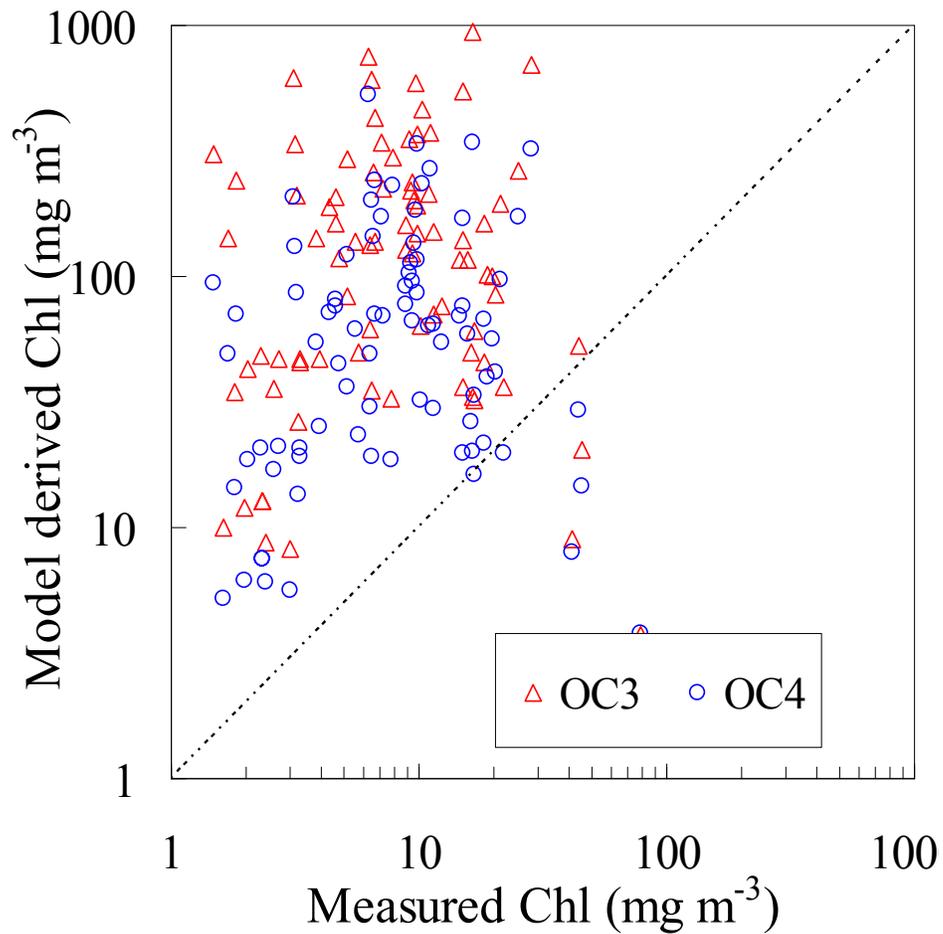
# Optical Water Quality: How?

Field and laboratory measurements, optical modeling, algorithm development, remote sensing

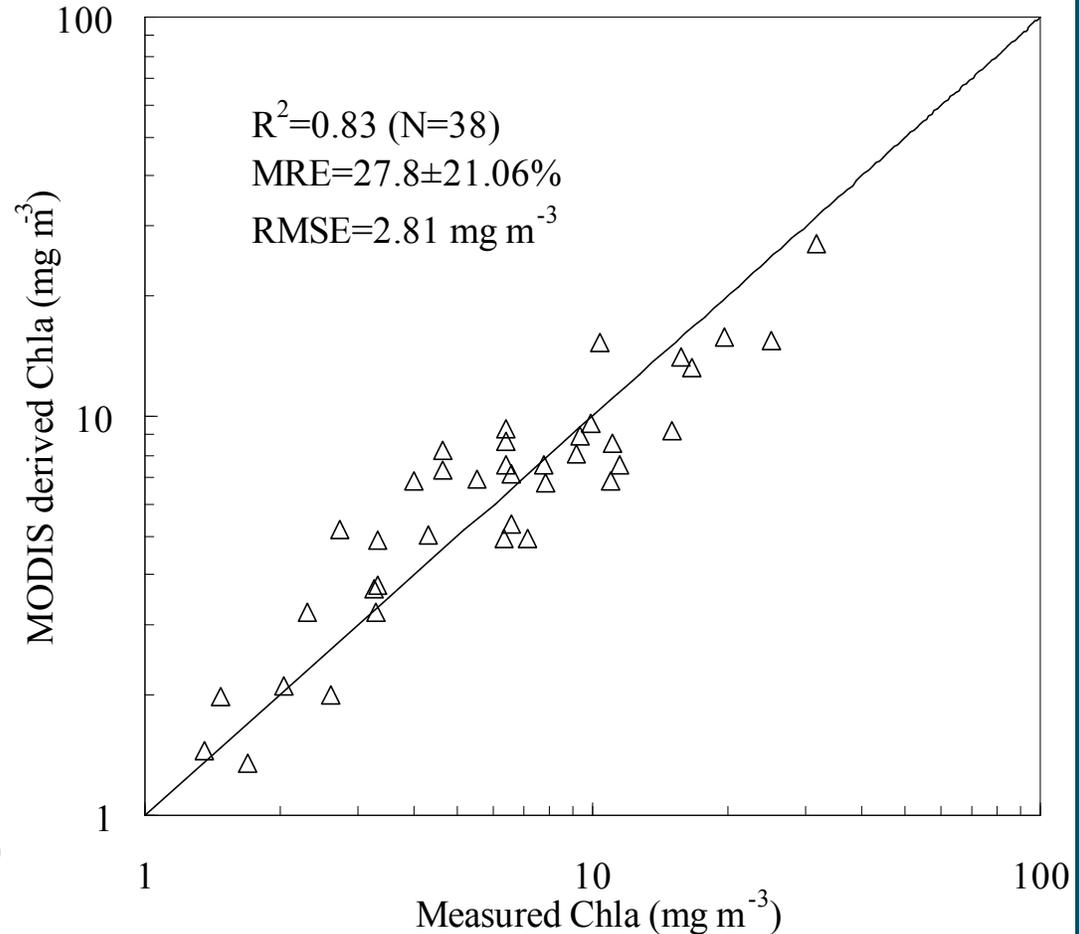


# Remote Sensing of Chlorophyll and Water Clarity

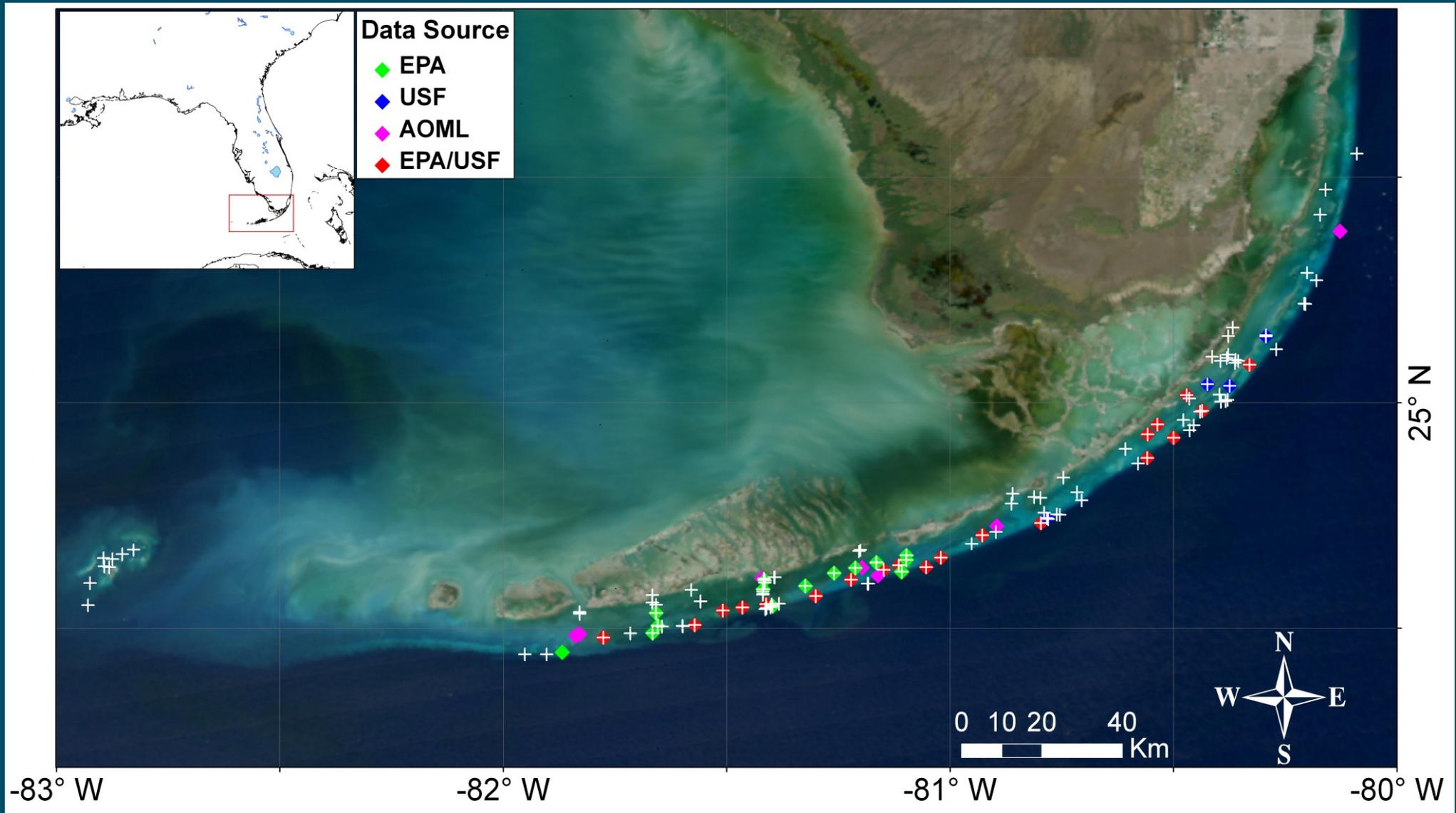
## NASA Standard Algorithms



## Le et al. (2013a, PIO)

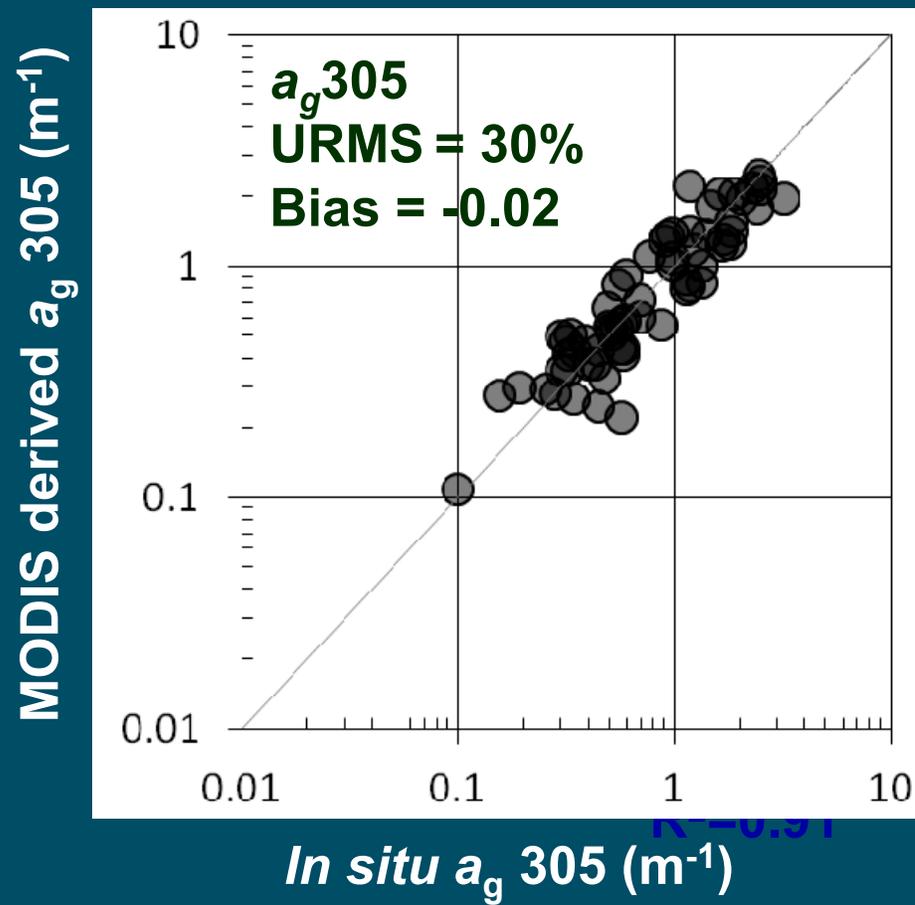
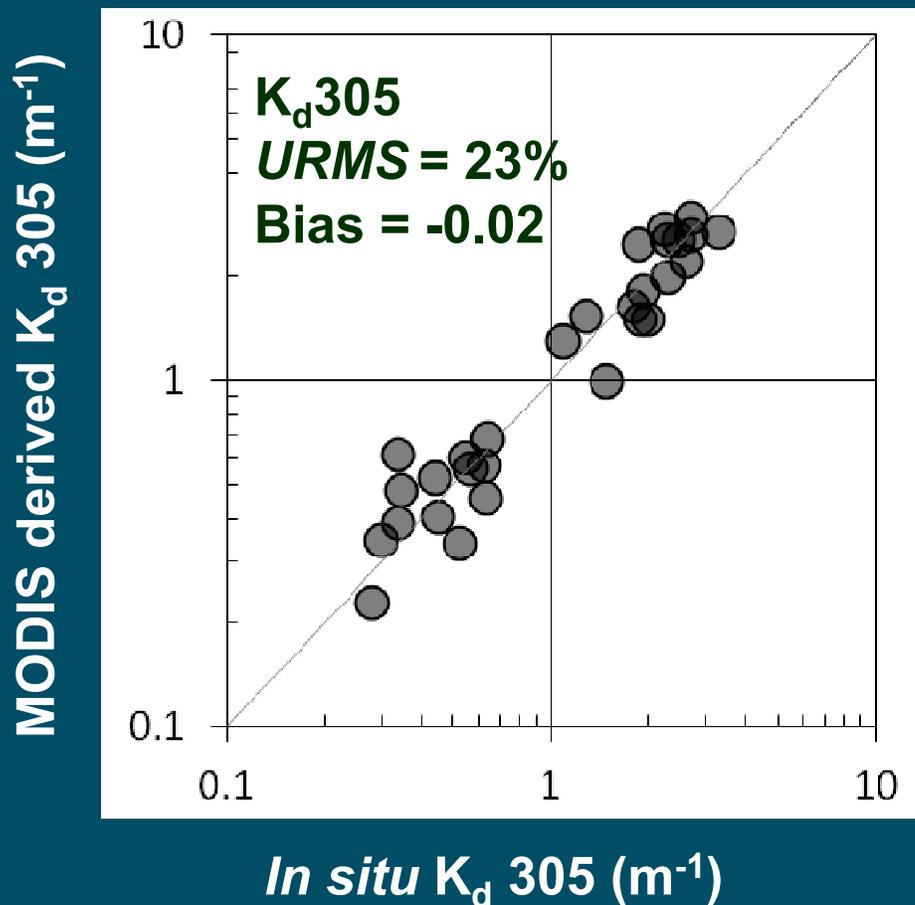


# Water quality in the Florida Keys

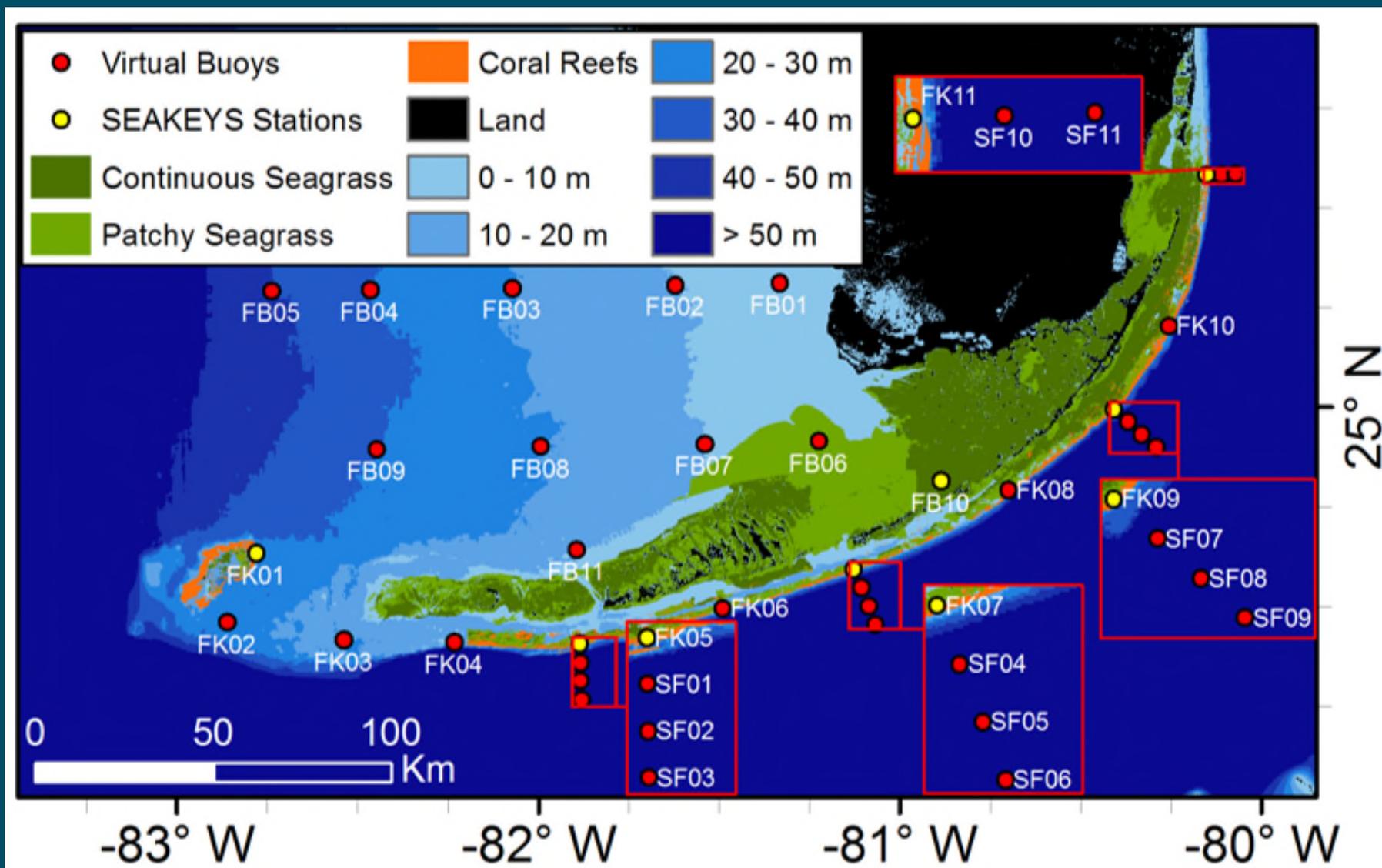


# Water quality in the Florida Keys

Data products over shallow waters (Barnes et al., 2014, RSE)



# VB stations in the Florida Keys



# Satellite-based water quality decision matrix (WQDM)

## Satellite data

Year	OTB	HB	MTB	LTB
1998	Yellow	Yellow	Red	Yellow
1999	Green	Green	Green	Green
2000	Green	Green	Green	Green
2001	Green	Green	Yellow	Yellow
2002	Green	Green	Yellow	Green
2003	Red	Yellow	Red	Yellow
2004	Red	Yellow	Yellow	Yellow
2005	Green	Green	Yellow	Yellow
2006	Green	Green	Green	Green
2007	Green	Green	Green	Green
2008	Green	Green	Green	Green
2009	Green	Green	Green	Green
2010	Yellow	Green	Green	Green
2011	Green	Green	Green	Green

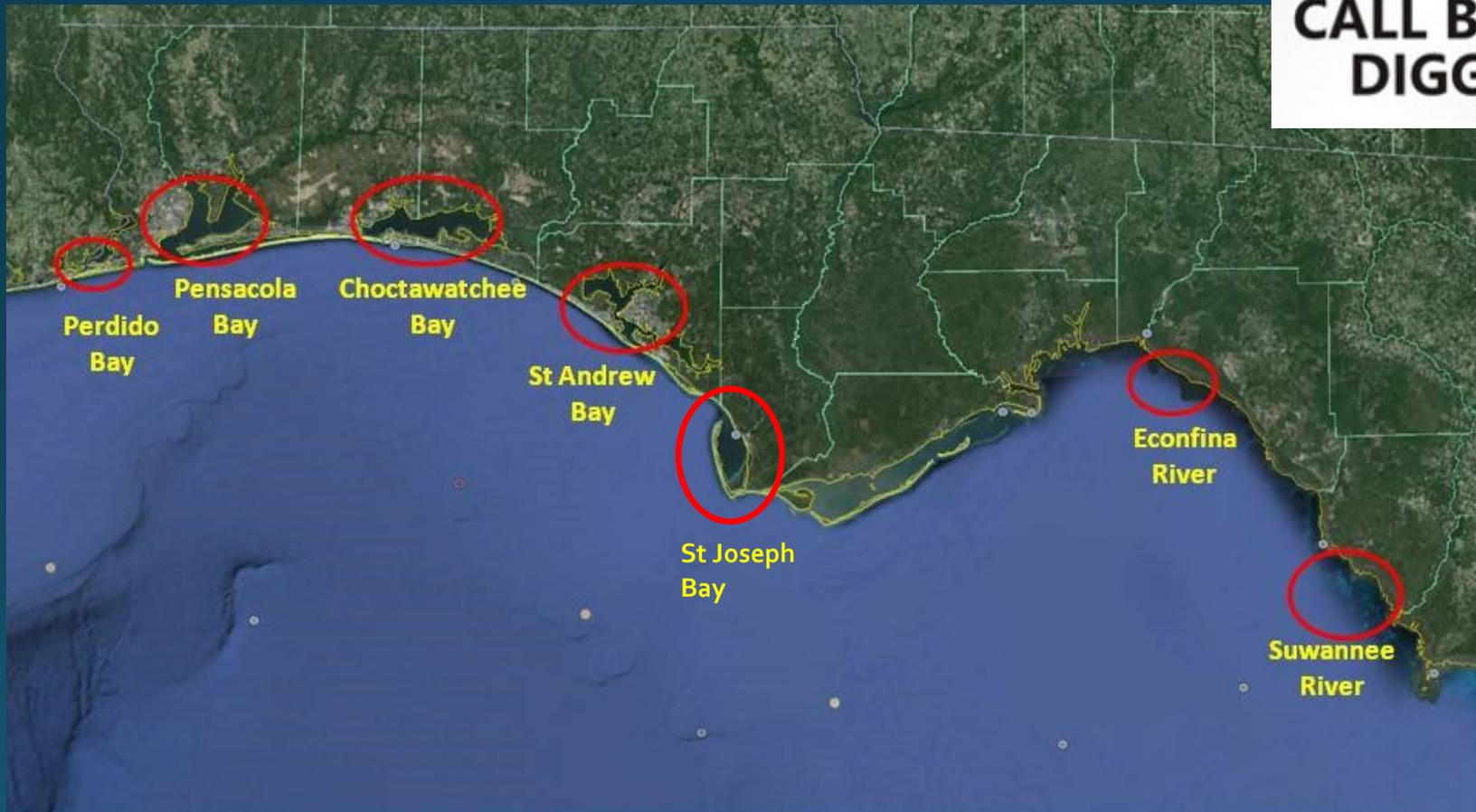
## EPCHC data

Year	OTB	HB	MTB	LTB
1998	Red	Red	Red	Red
1999	Yellow	Green	Yellow	Yellow
2000	Green	Green	Yellow	Yellow
2001	Yellow	Green	Yellow	Yellow
2002	Yellow	Green	Green	Green
2003	Red	Yellow	Green	Yellow
2004	Red	Green	Green	Yellow
2005	Green	Green	Yellow	Yellow
2006	Green	Green	Green	Green
2007	Green	Green	Green	Green
2008	Yellow	Green	Green	Yellow
2009	Yellow	Yellow	Green	Green
2010	Green	Green	Green	Green
2011	NA	NA	NA	NA

From Le et al. (2013b)

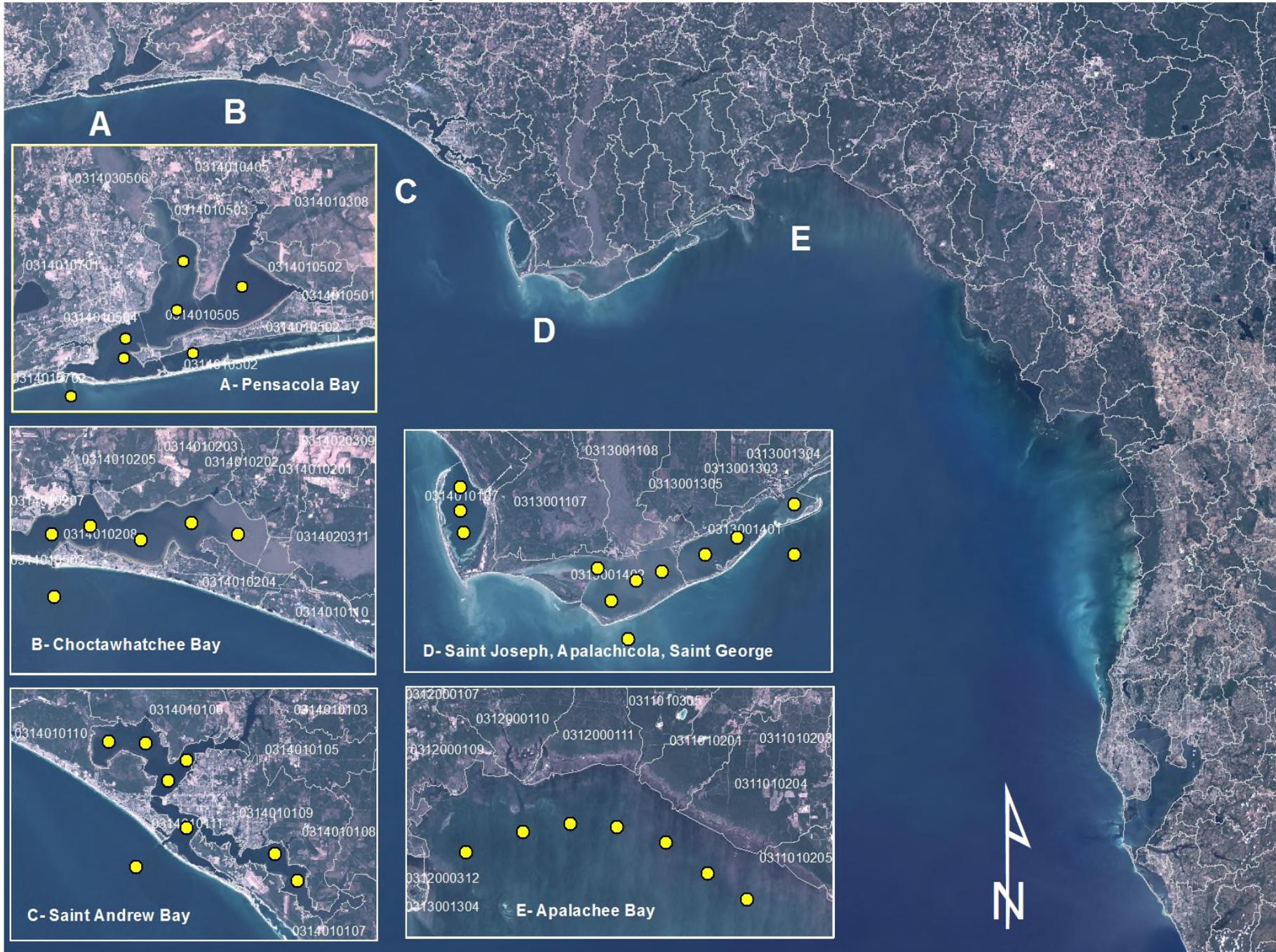
**Can we extend to other  
estuaries and coastal waters?**

# Roadblocks to Seagrass Recovery: Seagrass Restoration Planning



Tallahassee, March 7, 2016

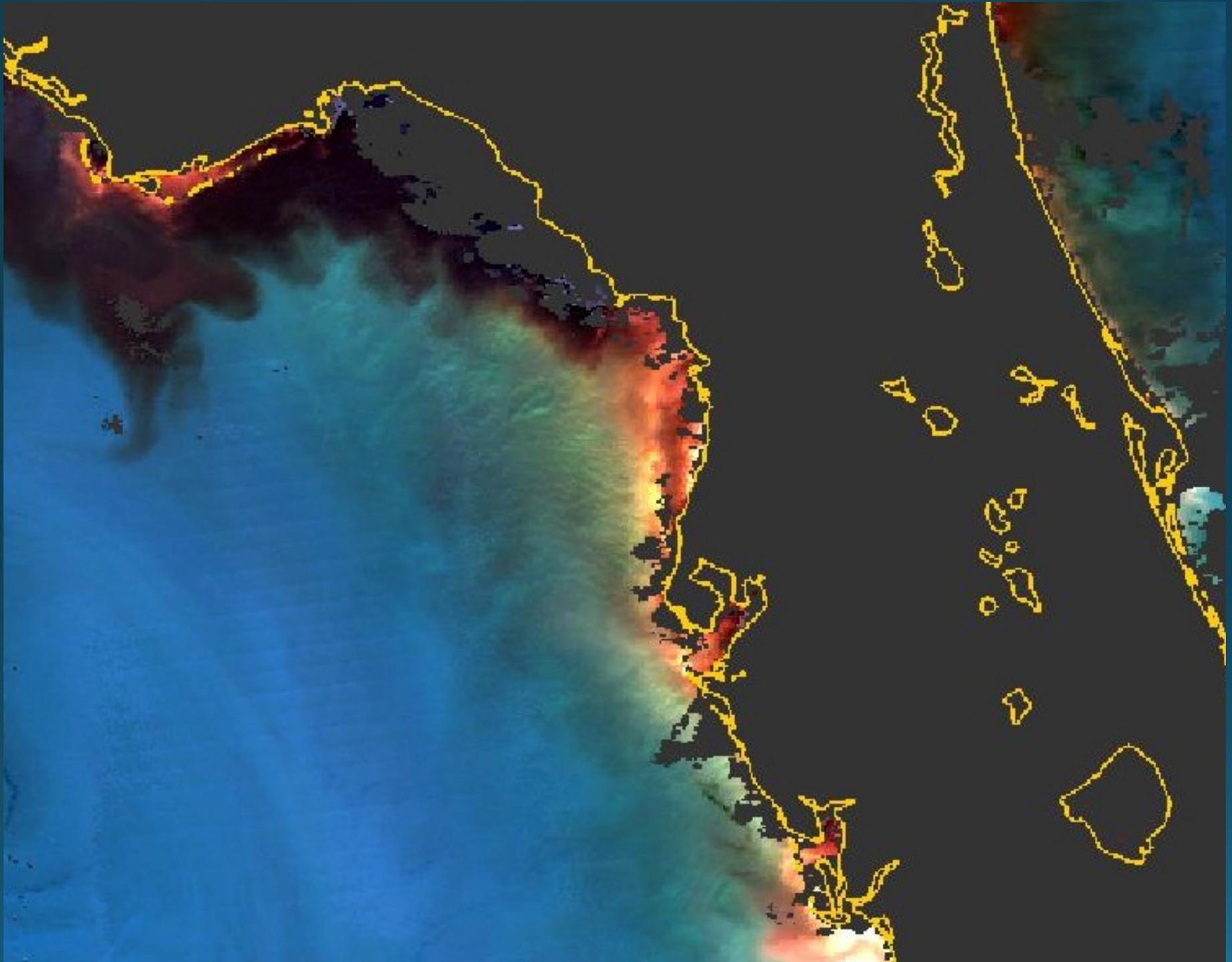
# Virtual Buoy Stations for Florida Panhandle Estuaries





Suspended sediment discharge after  
late January 2016 rain event

# MODIS Image- CDOM from Suwannee and Ochlockonee Rivers





Optical Water Quality and Seagrass Data for the Suwannee River Estuary © Seagrass Cover Data SU 02

- Home
- People
- Projects
- Satellite Data Products
- Virtual Buoy Products
- Airborne Data Products
- Publications
- Events
- Links
- Contact

Location / Bottom   Kd(488)   Light Penetration   Chlorophyll-a   aCDOM(413)   bbp(700)   SST

Station Name: SU 02 =Suwannee River Estuary

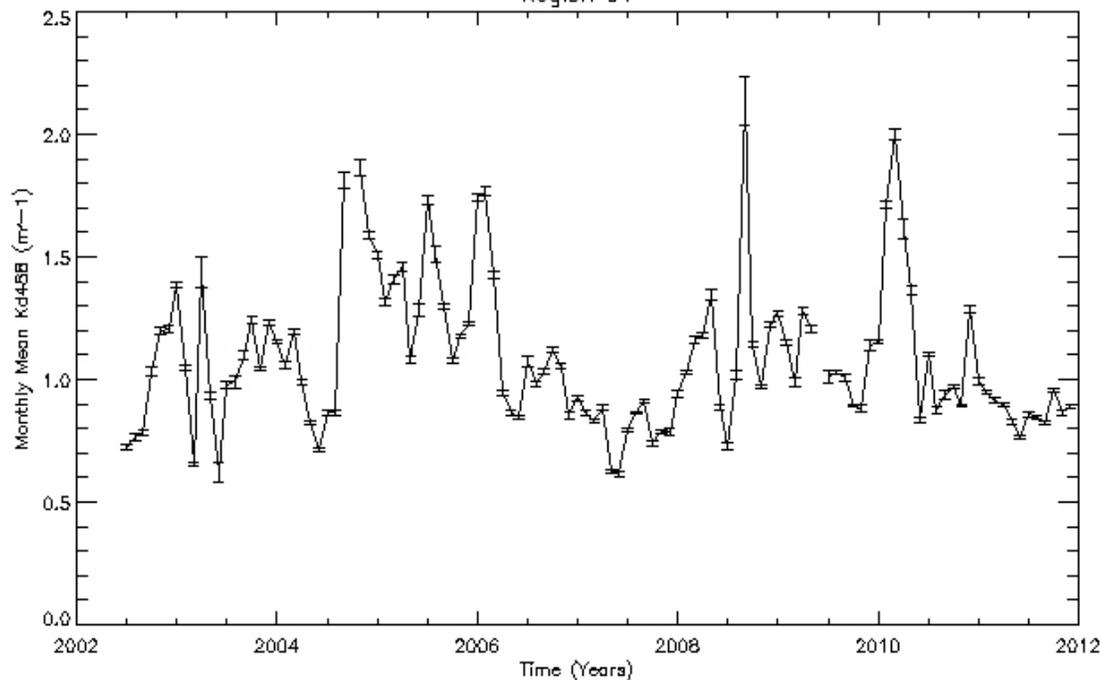
Measurement	Value Now	This week last year	This month last year	Long-term Average
Water Temperature	28.0	27.5	27.3	27.0
Chlorophyll	4.2	2.2	2.5	2.2
CDOM	10.2	5.5	5.0	5.3
Turbidity	2.4	3.2	2.8	2.5
Transparency (Kd488)	1.2	0.8	0.8	0.7
Light (% Surface)	18%	25%	25%	24%

Bottom Image SU 02

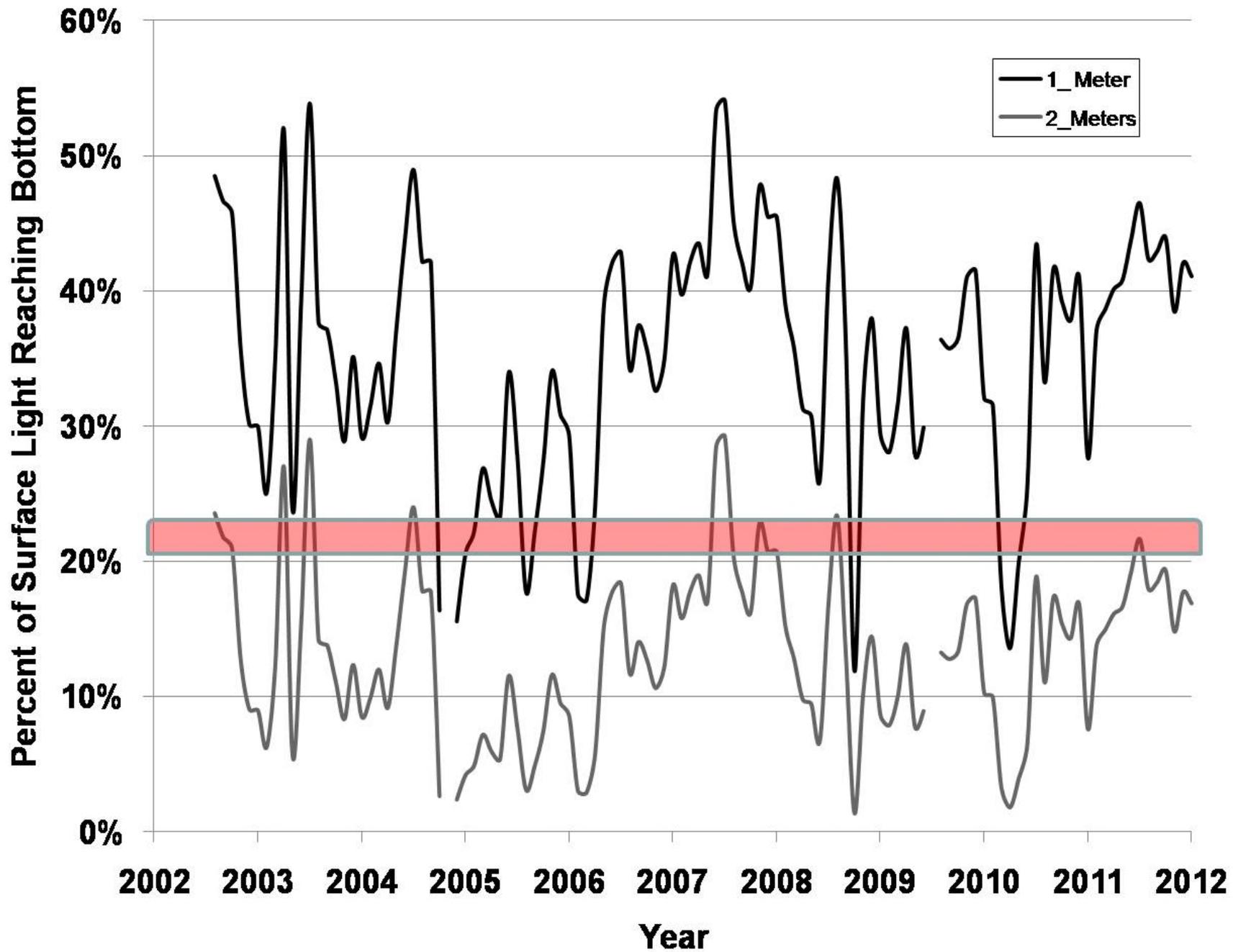


This is an image representative of the bottom of Station SU 02. It is described as "DECO" which is explained to the left in the "Bottom Type" section. Click on the image to open a larger image.

Region 01



# Light Penetration in Water Column



# GOMA Gulf Monitoring Network Design (draft report on 1/18/2013, from Steven Wolfe)

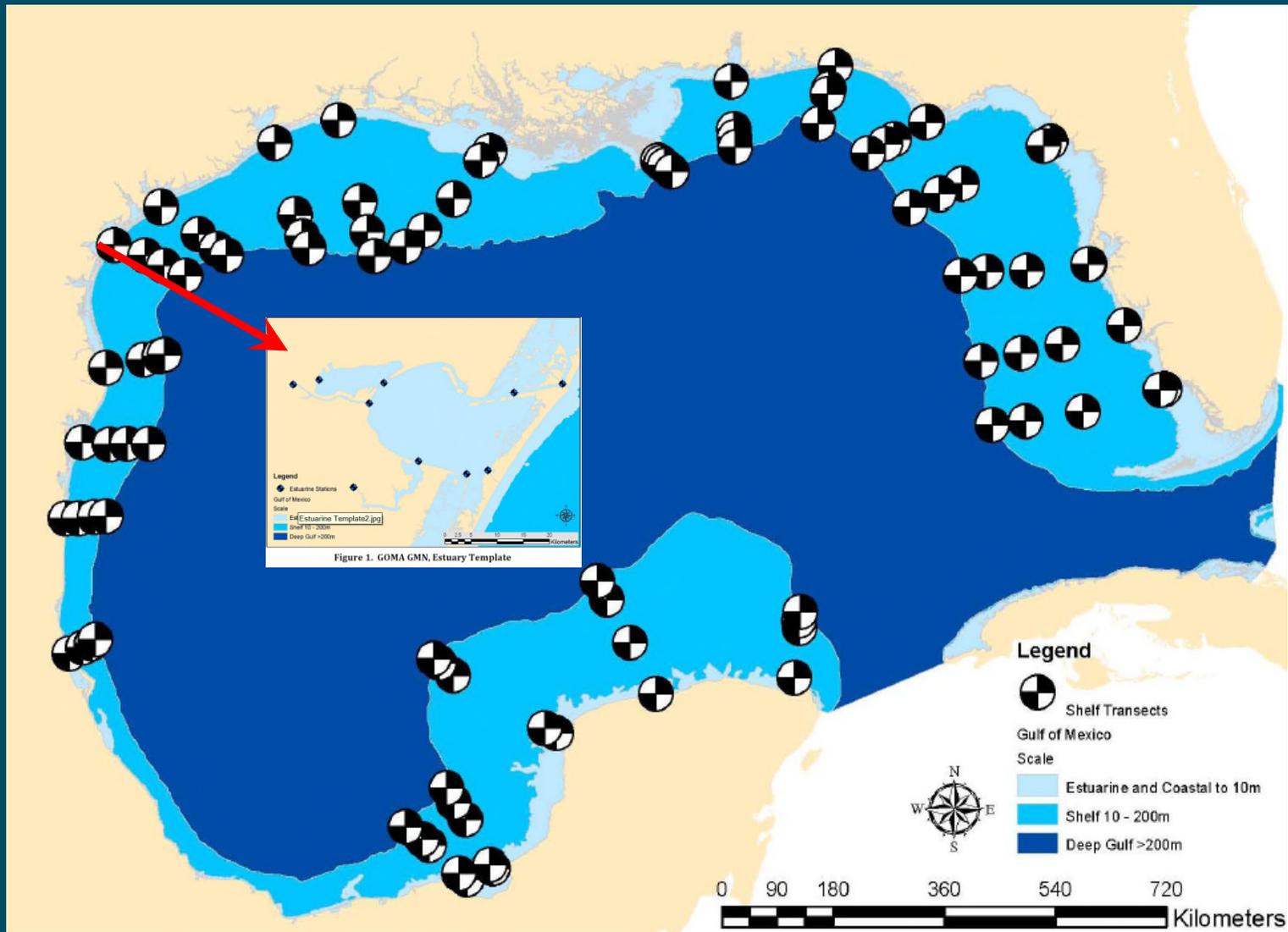


Figure 3. GOMA GMN, Shelf Transects

# Summary

## ➤ Coastal WQ data products

- Water clarity, water turbidity, Chl, CDOM, SST, BLA
- Generated for several estuaries around the GOM and in other regions
- Customized algorithms and validated products only available for Tampa Bay, Florida Keys, and Chesapeake Bay

## ➤ Management decision support

- Satellite-based water quality decision matrix
- Virtual Buoy products for several testing areas (Tampa Bay, Central WFS, Suwannee Estuary)
- VB products extendable to other estuaries – provided that algorithms are updated and validated

# A Note on Continuity

Chl for Tampa Bay: MODIS/Aqua: 2002 – present; VIIRS: 2011 - present

