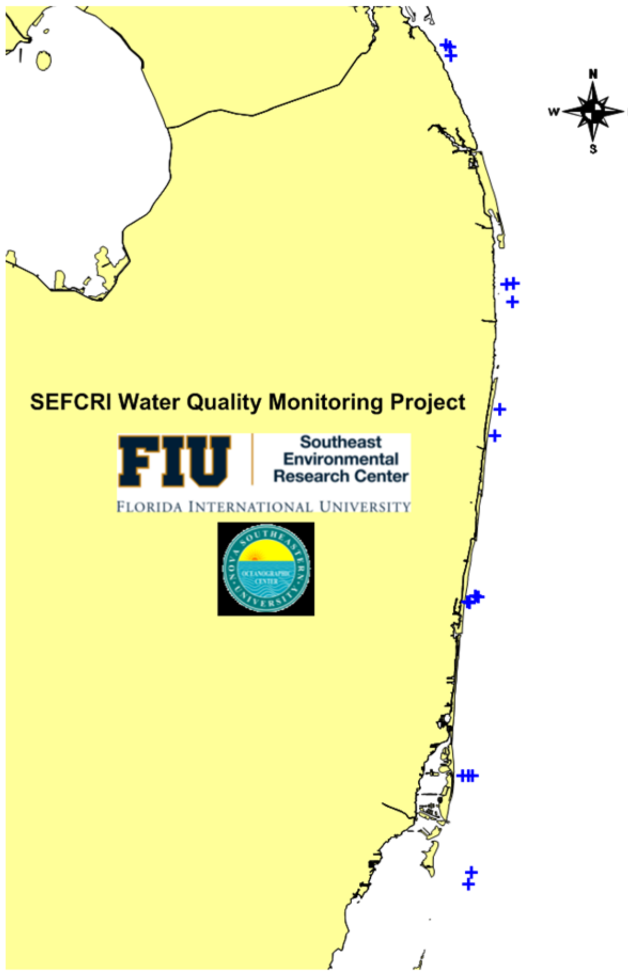
2011 ANNUAL REPORT
OF THE WATER QUALITY MONITORING PROJECT
FOR THE SOUTHEAST FLORIDA CORAL REEF INITIATIVE (SEFCRI)



Joseph N. Boyer, Henry O. Briceño, and Jeff Absten
Southeast Environmental Research Center
OE-148, Florida International University
Miami, FL 33199
http://serc.fiu.edu/wqmnetwork/

David Gilliam and Dick Dodge
Nova Southeastern University Oceanographic Center
National Coral Reef Institute
8000 North Ocean Drive, Dania Beach, FL 33004
http://www.nova.edu/ocean/

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EXECUTIVE SUMMARY

This report serves as a summary of our efforts to date in the execution of the Water Quality Monitoring Project for the Southeast Florida Coral Reef Initiative (SEFCRI). The period of record for this report is Dec. 2009 – Sep. 2011 and includes data from 8 quarterly sampling events at 22 stations along the coast including Miami-Dade, Broward, Palm Beach, and Martin Counties.

Field parameters measured at each station include salinity (practical salinity scale), temperature (ºC), dissolved oxygen (DO, mg l^{-1}), turbidity (NTU), and light attenuation (K_d, m^{-1}). Water quality variables include the dissolved nutrients nitrate (NO_3^-), nitrite (NO_2^-), ammonium (NH_4^+), dissolved inorganic nitrogen (DIN), and soluble reactive phosphate (SRP). Total unfiltered concentrations include those of nitrogen (TN), organic nitrogen (TON), organic carbon (TOC), phosphorus (TP), silicate (SiO_2) and chlorophyll *a* (CHLA, µg l^{-1}). All values are reported in ppm unless noted otherwise.

Although this project is relatively new, several important results have been realized so far. First, is documentation of differences in water quality among regions as clustered by county. Ongoing quarterly sampling of 22 stations in the SEFCRI has provided us with the ability to explore the spatial component of water quality variability in the region. By stratifying the sampling stations according to county we report some interpretations as to the relative importance of external vs. internal factors on the ambient water quality within the SEFCRI. The general consensus, for only 8 sampling event, is that the overall water quality is very good but that there are large excursions from the median due to events. Sites off Martin County were slightly elevated in DIN, TP, and CHLA but lower in salinity. We ascribe these localized effects to terrestrial freshwater inputs from the Loxahatchee River.

Trend analysis was not performed as there were only 8 sampling events spread over 2 years. However, seasonal differences were pronounced in some variables due to differences in water patterns and precipitation/terrestrial inputs between wet and dry periods.

The large scale of this monitoring program has allowed us to assemble a much more holistic view of broad physical/chemical/biological interactions occurring over the South Florida hydroscape.

Much information has been gained by inference from this type of data collection program in a sister program, the Florida Keys National Marine Sanctuary: major nutrient sources have be confirmed, relative differences in geographical determinants of water quality have been demonstrated, and large scale transport via circulation pathways have been elucidated. In addition we have shown the importance of looking "outside the box" for questions asked within. Rather than thinking of water quality monitoring as being a static, non-scientific pursuit it should be viewed as a tool for answering management questions and developing new scientific hypotheses. We expect that continued monitoring of SEFCRI will answer some of these same questions.

We continue to maintain a website (http://serc.fiu.edu/wqmnetwork/) where data and reports from the SEFCRI Project are available.

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Principal Investigators:
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Southeast Environmental Research Center
OE-148, Florida International University
Miami, FL 33199
http://serc.fiu.edu/wqmnetwork/

David Gilliam and Dick Dodge
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1. Background

The counties of Southeast Florida (Miami Dade, Broward, Palm Beach, and Martin) are highly urbanized, containing one third of Florida's population of 18 million people with development occurring directly along the coast. Due to the close proximity of the northern Florida Reef Tract to the urbanized shoreline, ~1.5 km from shore, southeast Florida's coral reefs are directly impacted by anthropogenic stressors. Terrestrial runoff and wastewater effluent disposal methods may be impacting the reef resource by degrading the water quality. However, to date, minimal offshore water quality monitoring, needed to determine these impacts, has been conducted in the southeast Florida region. The objective of the Southeast Florida Coral Reef Water Quality Monitoring Project (SECREMP) is to determine if there is a decline or recovery of coastal and offshore water quality in Southeast Florida and if water quality may be linked to land-based sources of pollution, or changes in coral condition.

Due to the extent (~105 miles) of the southeast Florida coast geographic gaps ranging from 30-50 km exist between these sampling sites. These gaps and the lack of understanding of inshore to offshore fate of nutrients fate limit the ability to develop land-based nutrient loads for the reef tract. We expect that this rudimentary water quality monitoring program will begin to address this issue.

2. Project History

A NOAA CRCP grant in FY09 to the National Coral Reef Institute at Nova Southeastern University (NSU-NCRI) allowed for one year of baseline water quality data to be collected at the 17 SECREMP monitoring sites. The first water sample collection occurred December 2009. A subsequent proposal was awarded for FY10 under the same program to provide for water quality sampling and analysis through September 2011. A grant from EPA Region 4 to the Southeast Environmental Research Center at Florida International University (FIU-SERC) provided funds to continue monitoring and to add 5 sites (22 total) to fill in some geographic gaps in monitoring and assist in developing onshore to offshore water quality trends. Sites were located in the geographic gaps at other SECREMP sites in an effort to relate water quality with changes in the reef health (e.g. coral cover declines).

In a collaborative effort between NOAA, EPA, the Florida Department of Environmental Protection's Coral Reef Conservation Program (FDEP-CRCP), NSU-NCRI, and FIU-SERC, a coastal water quality monitoring program for southeast Florida will be implemented using similar water sampling methods and standards used for the Florida Keys National Marine Sanctuary (FKNMS) Water Quality Protection Program (http://floridakeys.noaa.gov/wqpp/welcome.html). The SEFCRI Water Quality Monitoring Project consists of quarterly surveys during which physical, chemical, and biological water quality parameters were measured and water samples collected for laboratory analysis. Long-term funding is currently being sought to maintain and expand the water quality monitoring program.

3. Benefit

The general objective of water quality monitoring is to measure the status and trends of water quality parameters to evaluate progress toward achieving and maintaining water quality standards and protecting and restoring the living marine resources of the ecosystem. SEFCRI Water Quality Monitoring Project data will be used to assist in resource protection and management decisions for the southeast Florida region. Specific objectives of this project are as follows:

- To provide data needed to make unbiased statements about the status of water quality parameters in the southeast Florida region as a whole, and within defined strata; and with continued funding support for a long term water quality monitoring program, statistically rigorous statements about the status and temporal trends of water quality can be incorporated
- To help define reference conditions in order to develop resource-based water quality standards (biocriteria)
- To provide a framework for testing hypothesized pollutant fate/effect relationships through process-oriented research and monitoring
- To assist with making informed management actions and policy development processes for improved coral reef resource conservation in Florida

4. Methods

Field sampling was performed quarterly at 17 SECREMP sites (2010, thereafter at 22 sites) by staff from the NSU-NCRI (Fig. 1). Sampling was conducted from small boats with facilities for sample processing on board and equipped to satisfy the technical and safety requirements of the project. Semi-continuous measurements were made throughout the water column using the Seabird CTD to generate a depth profile of each of the following variables: depth (m), temperature (°C), salinity (PSU), dissolved oxygen (DO, mg l^{-1}), and photosynthetically active radiation (PAR, µE m^{-2} s^{-1}). The vertical light attenuation coefficient (K_d in m^{-1}) was calculated for the cast as a log function from PAR measurements through the water column.

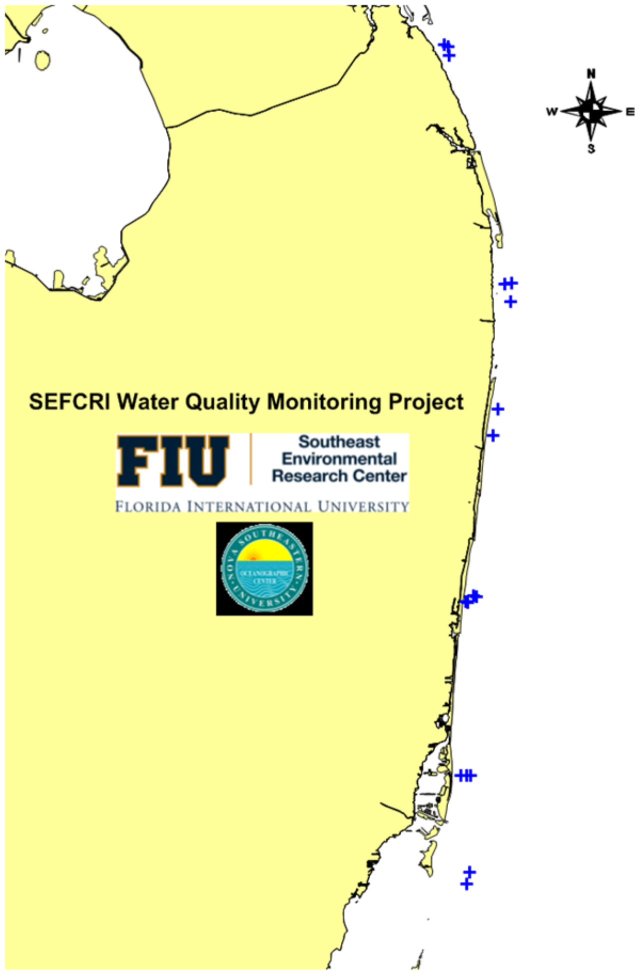

Figure 1. Map of SEFCRI region showing field sampling sites distributed along coast.

Water samples were collected at depth and at the surface at each site using a Niskin bottle sampler, preserved on ice and transported to FIU-SERC for nutrient analysis. Samples were analyzed for ammonium (NH_4^+), nitrate+nitrite (NO_x^-), nitrite (NO_2^-), total nitrogen (TN), soluble reactive phosphorus (SRP), total phosphorus (TP), total organic carbon (TOC), silicate (SiO_2), chlorophyll *a* (CHLA, µg l^{-1}), and turbidity (NTU) using standard laboratory methods. Some parameters were not measured directly but calculated by difference. Nitrate (NO_3^-) was calculated as NO_X^- - NO_2^-; total dissolved inorganic nitrogen (DIN) as NO_X^- + NH_4^+., and total organic nitrogen (TON) as TN - DIN. All variables are reported in ppm (mg l^{-1}) unless otherwise noted.

Dissolved nutrients were defined using Whatman GF/F filters with a nominal pore size of 0.8 µm. A 60 ml sample was collected from a Niskin bottle using a syringe and filtered through a 25 mm Whatman GF/F filter. The filtrate was collected in a 60 ml high density polyethylene (HDPE) bottle and the filter stored in a vial with 90% acetone for extraction of CHLA. An additional 120 ml sample was collected directly from the Niskin bottle for analysis of TN, TP, and turbidity.

NH_4^+ was analyzed by the indophenol method (Koroleff 1983). NO_2^- was analyzed using the diazo method and NO_x^- was measured as nitrite after cadmium reduction (Grassoff 1983a,b). The ascorbic acid/molybdate method was used to determine SRP (Murphy and Riley 1962). High temperature combustion and high temperature digestion were used to measure TN (Frankovich and Jones 1998; Walsh 1989) and TP (Solórzano and Sharp 1980), respectively. TOC was determined using the high temperature combustion method of Sugimura and Suzuki (1988). Silicate was measured using the heteropoly blue method (APHA 1995). Detailed protocols are presented in EPA (1993).

Samples were analyzed for CHLA content by spectrofluorometry of acetone extracts (Yentsch and Menzel 1963). Protocols are presented in EPA (1993) and elsewhere as noted.

In accordance with EPA policy, the SEFCRI water quality monitoring program will adhere to existing rules and regulations governing QA and QC procedures as described in EPA guidance documents. The principal investigator will consult with the EPA Region IV QA/QC Officer on any issues involving QA/QC matters.

5. Results

We have found that water quality monitoring programs composed of many sampling stations situated across a diverse hydroscape are often difficult to interpret due to the “can’t see the forest for the trees” problem (Boyer et al. 2000). At each site, the many measured variables are independently analyzed, individually graphed, and separately summarized in tables. This approach makes it difficult to see the larger, regional picture or to determine any associations among sites. In order to gain a better understanding of the spatial patterns of water quality of the SEFCRI, we attempted to reduce the data matrix into fewer elements which would provide robust estimates of condition and connection. Ongoing quarterly sampling of 22 stations in the SEFCRI has provided us with the ability to explore the spatial component of water quality variability in the region. By stratifying the sampling stations according to county we report some interpretations as to the relative importance of external vs. internal factors on the ambient water quality within the SEFCRI (Fig. 2). The general consensus, for only 8 sampling event, is that the overall water quality is very good but that there are large excursions from median due to events.

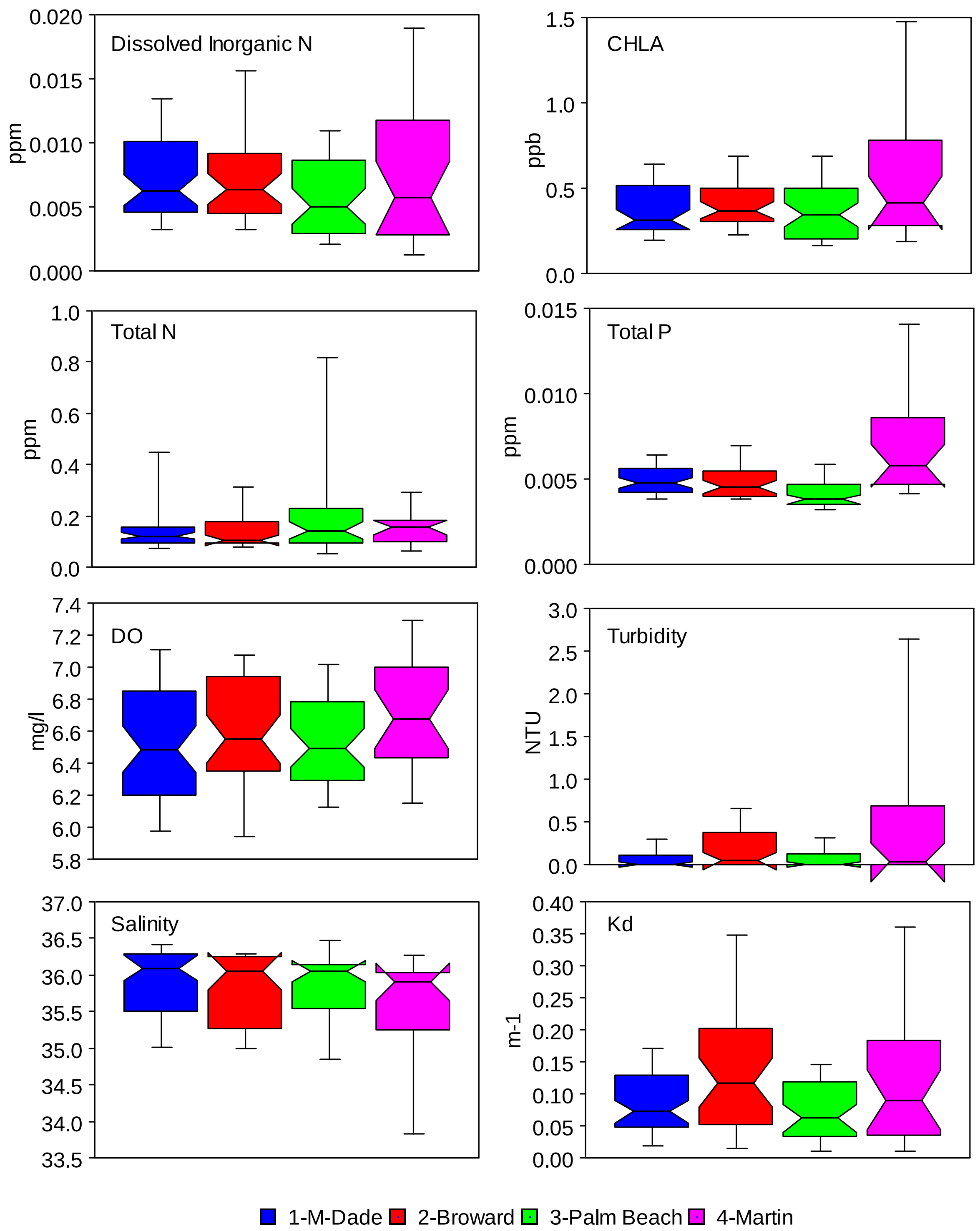

Figure 1. Box-and-whisker plots showing median and distribution of variables from 8 sampling events as grouped by County.

Dissolved inorganic N in all regions is generally at or below 10 **ppb**, a very low value and indicative of oceanic conditions. Ammonium is typically higher than nitrate as would be expected. CHLA is generally less than 0.5 ppb except for sites off Martin County where values a slightly higher. Total N in all areas is below 0.1 ppm and Total P is around 5 **ppb**, except for sites off Martin County which are significantly higher, but still under 10 **ppb** (Fig. 2).

DO ranges between 6 and 7 ppm for all areas with no excursions less than 4 ppm. Turbidity is also low (typically under 0.5 NTU) and this is reflected in the low light extinction coefficients (K_d). Salinity ranges between 35 and 36.5 but the sites off Martin County experience lowest salinity events down to 33. We expect this is due to freshwater releases from the Loxahatchee River.

Along with spatial differences in water quality, there are differences with depth as well. Table 1 shows those areas having significant differences between surface and bottom waters. Dissolved inorganic N is typically higher in surface waters while salinity is lower. This is evidence of freshwater loading to surface from terrestrial and atmospheric sources. Slightly higher CHLA in surface and higher Total P in bottom is indicative of P uptake by phytoplankton in surface waters. Oddly, we found DO to be higher in bottom waters but this may be due to generally lower temperatures in this region.

	County Region			
	Broward	Miami-Dade	Palm Beach	Martin
NO_x^-	**0.003**	**0.004**	**0.001**	**0.02**
NH_4^+	**0.09**	NS	**0.09**	NS
TN	**0.09**	NS	NS	**0.07**
TP	**0.005**	NS	**0.003**	**0.08**
TOC	**0.04**	NS	NS	**0.05**
SiO_2	NS	NS	NS	NS
CHLA	**0.01**	NS	**0.07**	**0.02**
Turbidity	NS	NS	NS	NS
Salinity	**0.001**	**0.001**	**0.001**	**0.001**
Temp.	**0.08**	**0.02**	**0.001**	**0.007**
DO	**0.02**	**0.04**	**0.07**	NS

surface is greater
bottom is greater

Table 1. *Difference between surface and bottom concentrations of variables by county grouping from Kruskall-Wallace test of significance (p<0.10). Values in green denote surface values being higher than bottom. Values in **red** mean bottom values are greater than those at the surface.*

Trend analysis was not performed as there are only 8 sampling events spread over 2 years. However, seasonal differences were pronounced in some variables due to differences in water patterns and precipitation/terrestrial inputs between wet and dry periods. Examples are shown in Fig. 2-6.

This brings up another important point; when looking at what are perceived to be local trends, we find that they seem to occur across the whole region but at more damped amplitudes. This spatial autocorrelation in water quality is an inherent property of highly interconnected systems such as coastal and estuarine ecosystems driven by similar hydrological and climatological forcing. It is clear that trends observed inside the SEFCRI are influenced by external, regional conditions.

The large scale of this monitoring program has allowed us to assemble a much more holistic view of broad physical/chemical/biological interactions occurring over the South Florida hydroscape. Much information has been gained by inference from this type of data collection program in a sister program, the Florida Keys National Marine Sanctuary: major nutrient sources have be confirmed, relative differences in geographical determinants of water quality have been demonstrated, and large scale transport via circulation pathways have been elucidated. In addition we have shown the importance of looking "outside the box" for questions asked within. Rather than thinking of water quality monitoring as being a static, non-scientific pursuit it should be viewed as a tool for answering management questions and developing new scientific hypotheses. We expect that continued monitoring of SEFCRI will answer some of these same questions.

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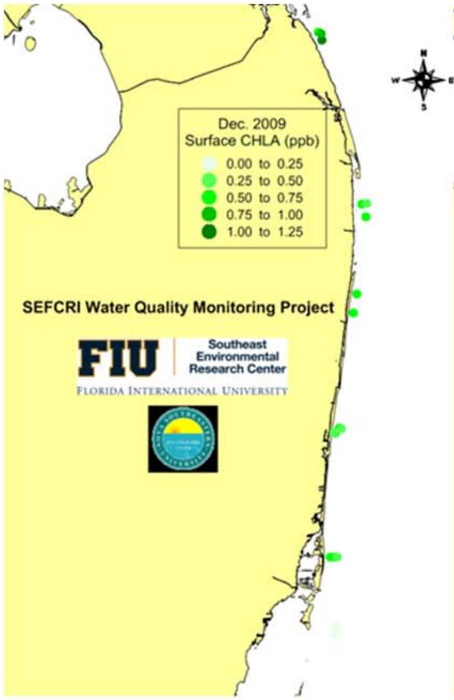
Dec. 2009
Surface CHLA (ppb)
0.00 to 0.25
0.25 to 0.50
0.50 to 0.75
0.75 to 1.00
1.00 to 1.25
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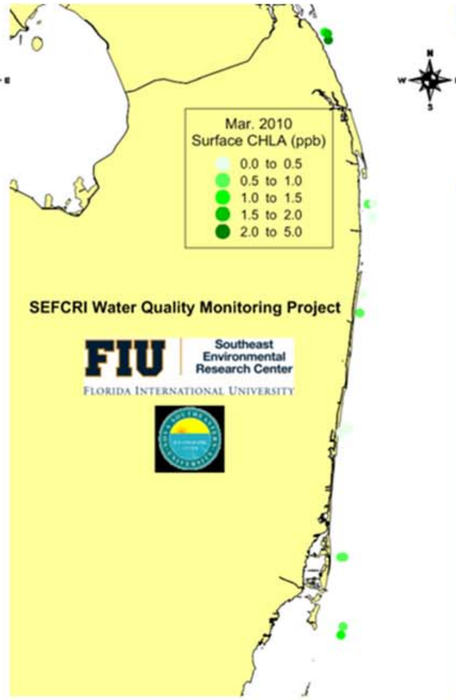
Mar. 2010
Surface CHLA (ppb)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 5.0
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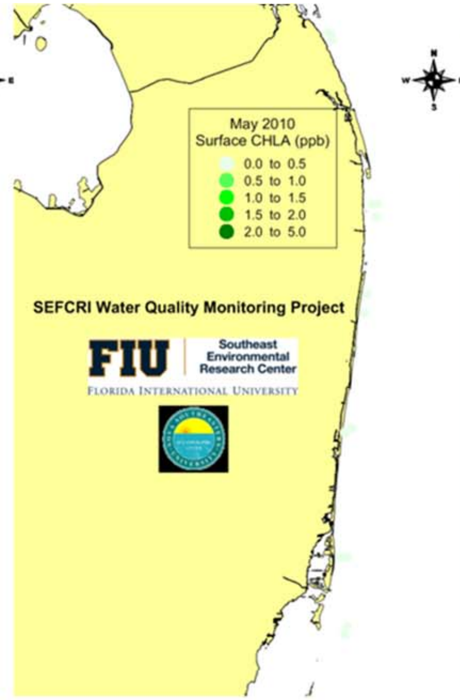
May 2010
Surface CHLA (ppb)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 5.0
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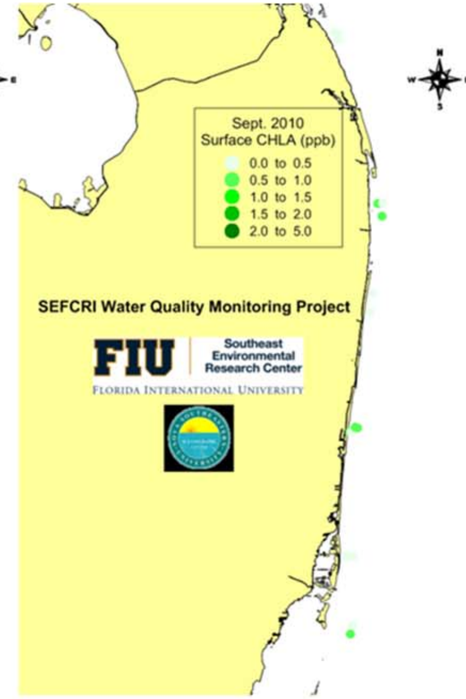
Sept. 2010
Surface CHLA (ppb)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 5.0
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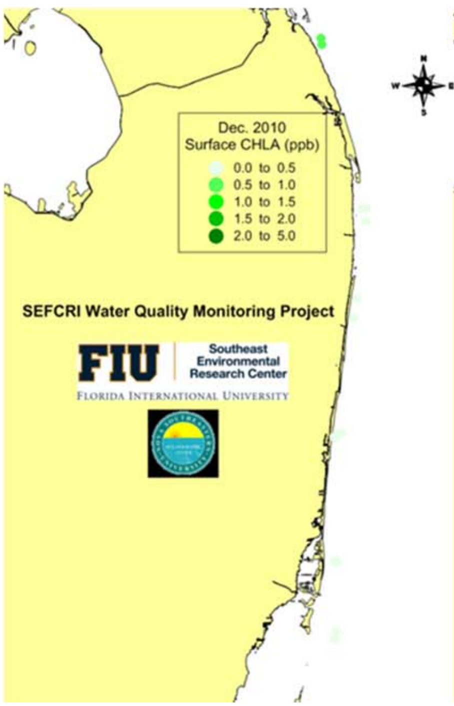
Dec. 2010
Surface CHLA (ppb)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 5.0
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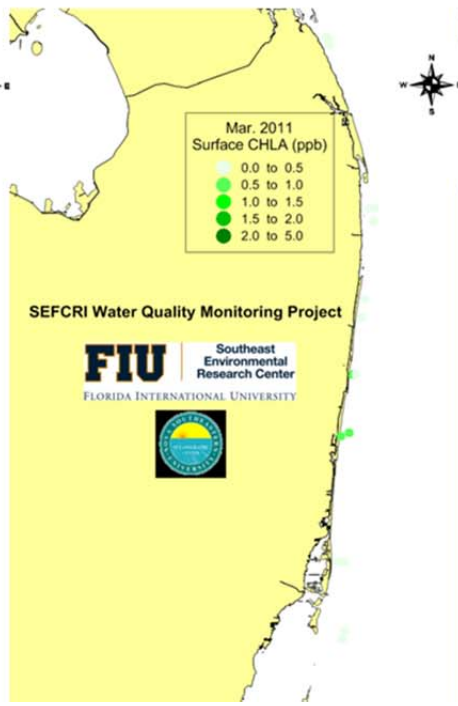
Mar. 2011
Surface CHLA (ppb)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 5.0
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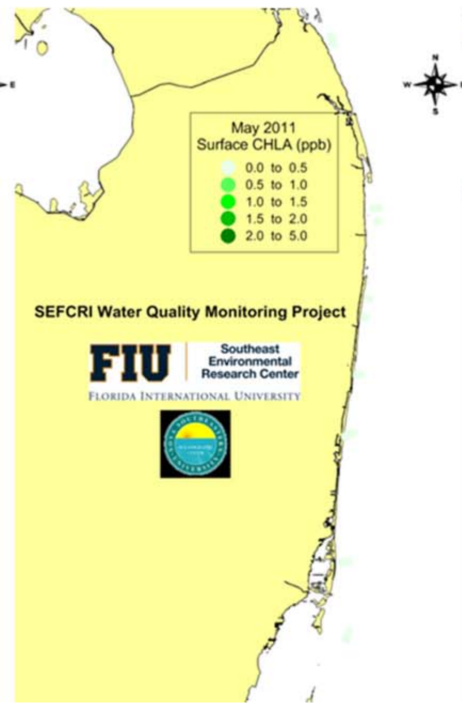
May 2011
Surface CHLA (ppb)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 5.0
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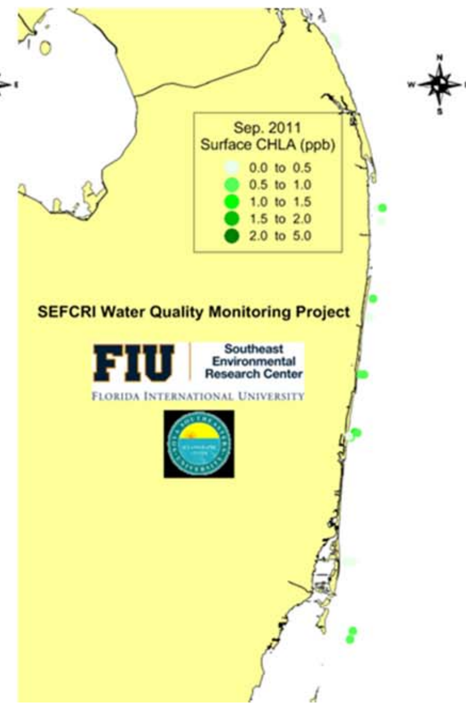
Sep. 2011
Surface CHLA (ppb)
0.0 to 0.5
0.5 to 1.0
1.0 to 1.5
1.5 to 2.0
2.0 to 5.0
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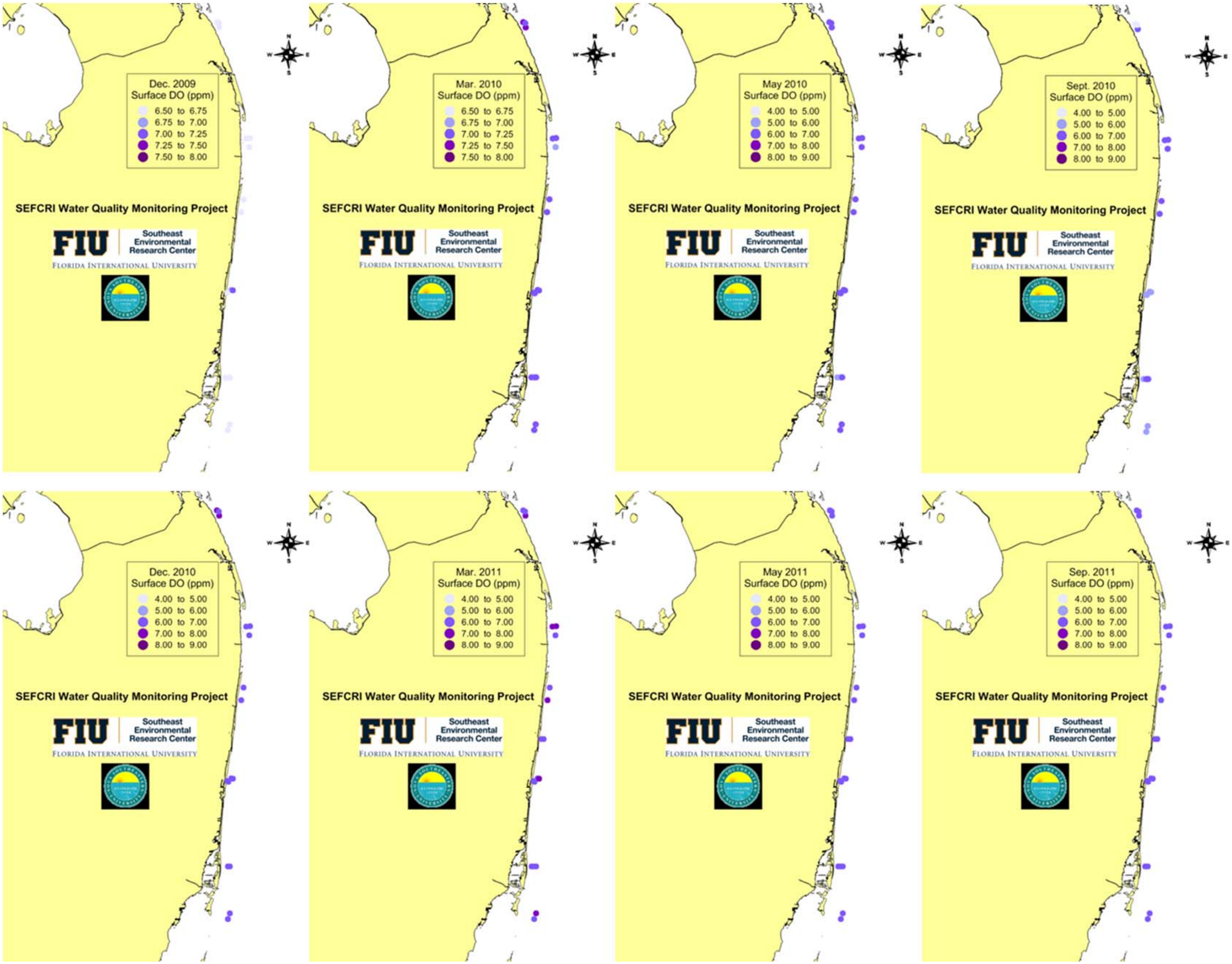
Dec. 2009
Surface DO (ppm)
6.50 to 6.75
6.75 to 7.00
7.00 to 7.25
7.25 to 7.50
7.50 to 8.00
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Mar. 2010
Surface DO (ppm)
6.50 to 6.75
6.75 to 7.00
7.00 to 7.25
7.25 to 7.50
7.50 to 8.00
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May 2010
Surface DO (ppm)
4.00 to 5.00
5.00 to 6.00
6.00 to 7.00
7.00 to 8.00
8.00 to 9.00
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Southeast Environmental Research Center
Florida International University
Sept. 2010
Surface DO (ppm)
4.00 to 5.00
5.00 to 6.00
6.00 to 7.00
7.00 to 8.00
8.00 to 9.00
SEFCRI Water Quality Monitoring Project
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Southeast Environmental Research Center
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Dec. 2010
Surface DO (ppm)
4.00 to 5.00
5.00 to 6.00
6.00 to 7.00
7.00 to 8.00
8.00 to 9.00
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Mar. 2011
Surface DO (ppm)
4.00 to 5.00
5.00 to 6.00
6.00 to 7.00
7.00 to 8.00
8.00 to 9.00
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May 2011
Surface DO (ppm)
4.00 to 5.00
5.00 to 6.00
6.00 to 7.00
7.00 to 8.00
8.00 to 9.00
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5.00 to 6.00
6.00 to 7.00
7.00 to 8.00
8.00 to 9.00
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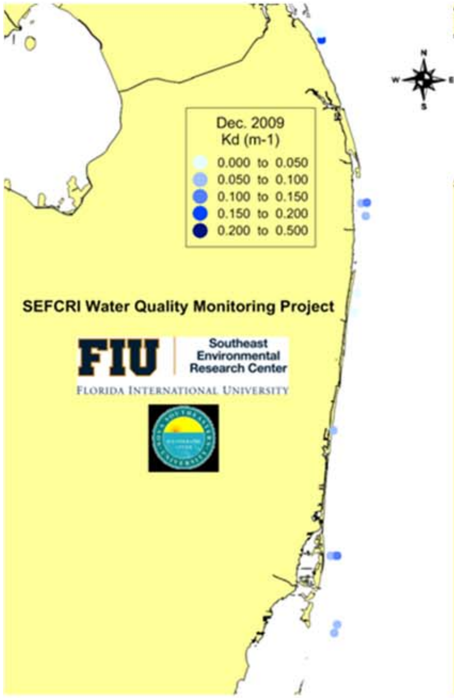
Dec. 2009
Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
0.150 to 0.200
0.200 to 0.500
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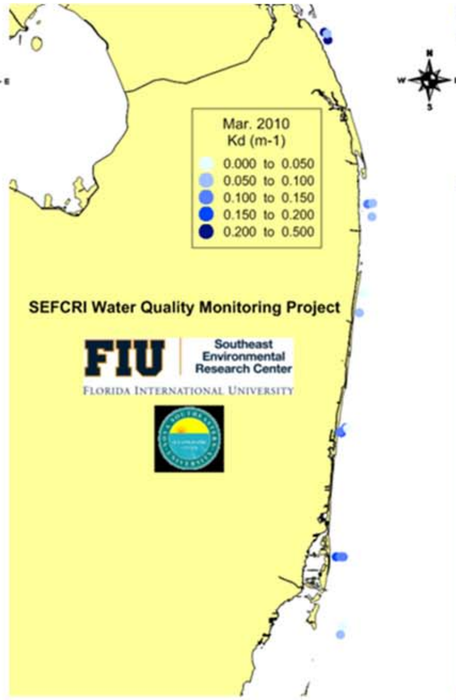
Mar. 2010
Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
0.150 to 0.200
0.200 to 0.500
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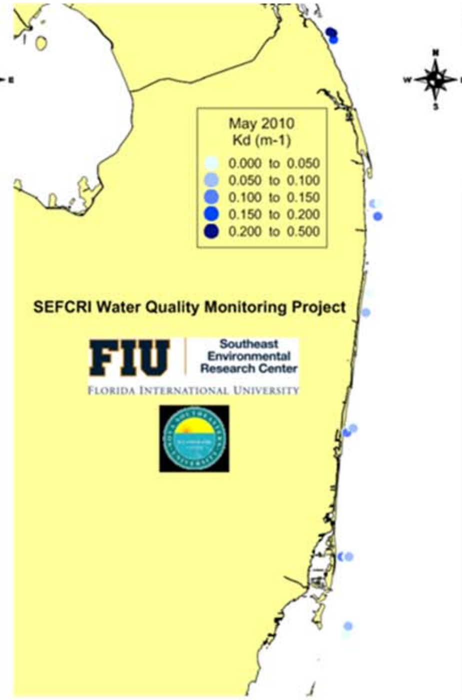
May 2010
Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
0.150 to 0.200
0.200 to 0.500
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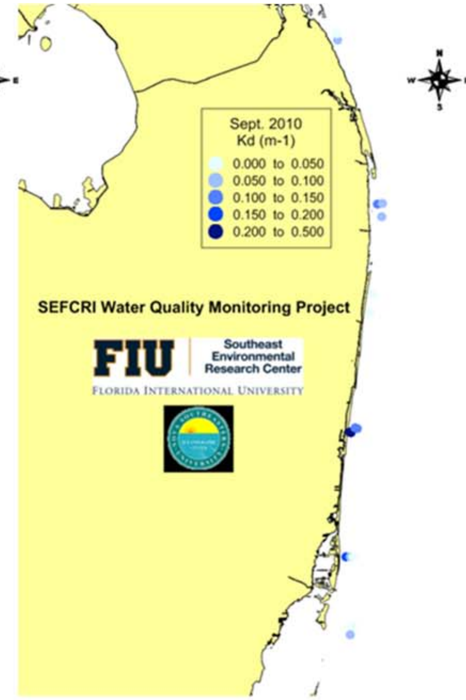
Sept. 2010
Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
0.150 to 0.200
0.200 to 0.500
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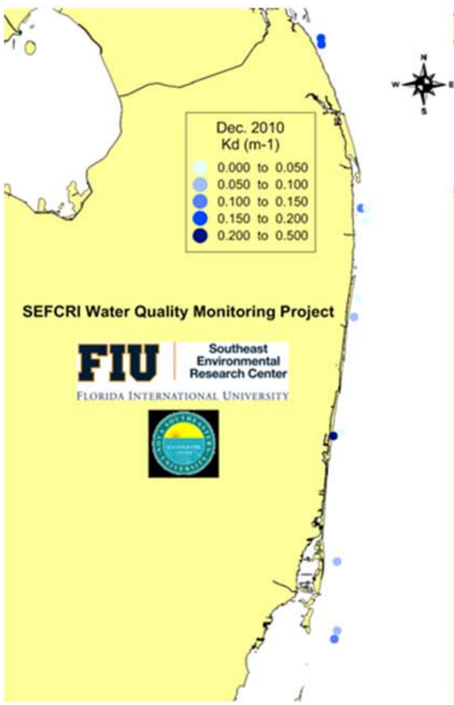
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Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
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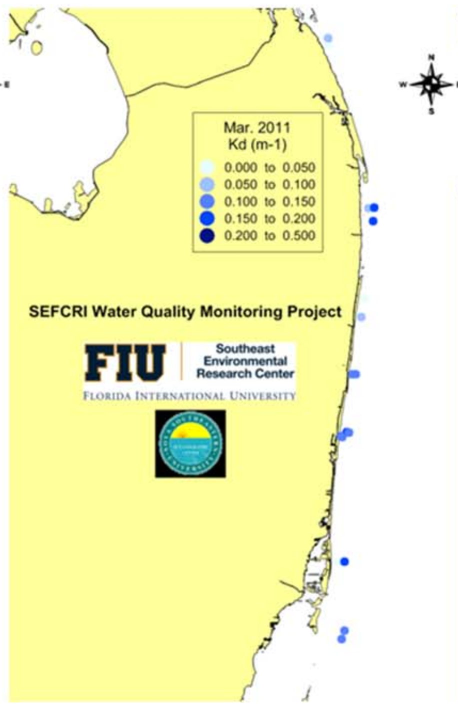
Mar. 2011
Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
0.150 to 0.200
0.200 to 0.500
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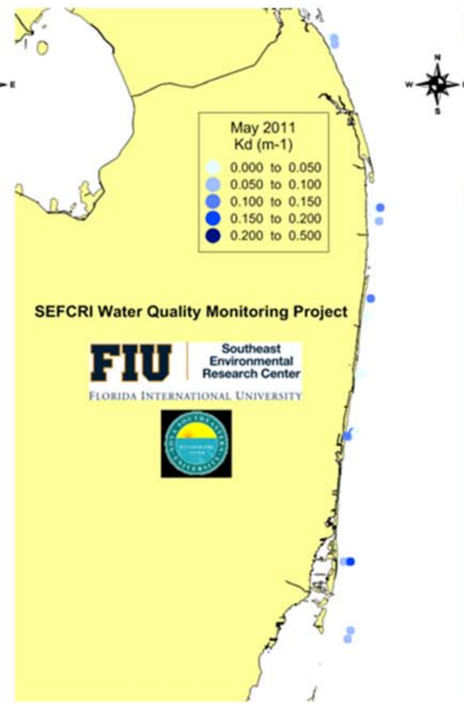
May 2011
Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
0.150 to 0.200
0.200 to 0.500
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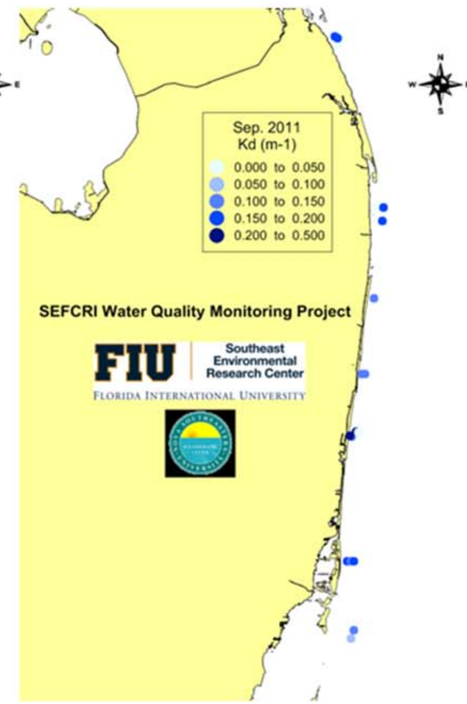
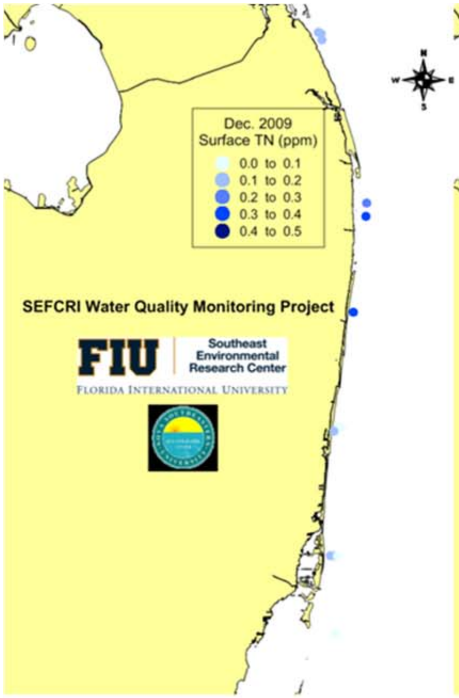
Southeast Environmental Research Center
Florida International University


Sep. 2011
Kd (m-1)
0.000 to 0.050
0.050 to 0.100
0.100 to 0.150
0.150 to 0.200
0.200 to 0.500
SEFCRI Water Quality Monitoring Project
FIU
Southeast Environmental Research Center
Florida International University


Dec. 2009
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
SEFCRI Water Quality Monitoring Project
FIU
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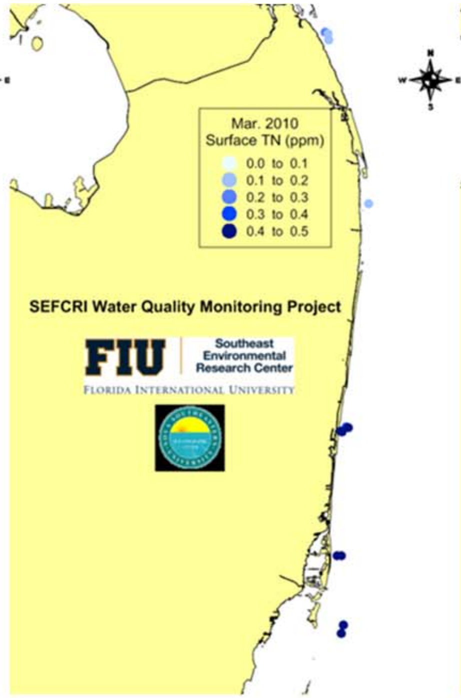
Florida International University


Mar. 2010
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
SEFCRI Water Quality Monitoring Project
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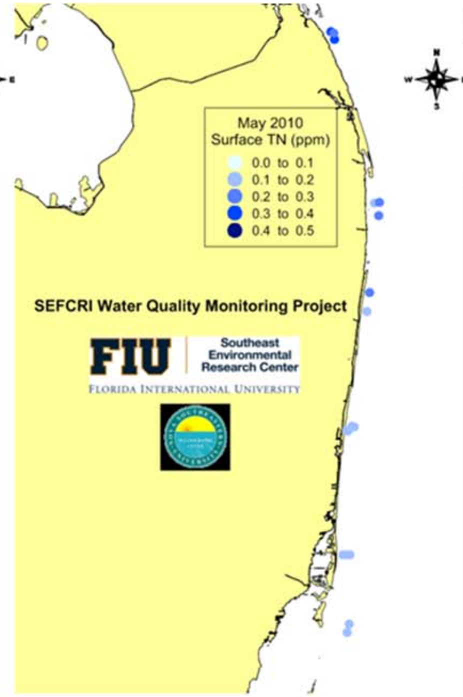
May 2010
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
SEFCRI Water Quality Monitoring Project
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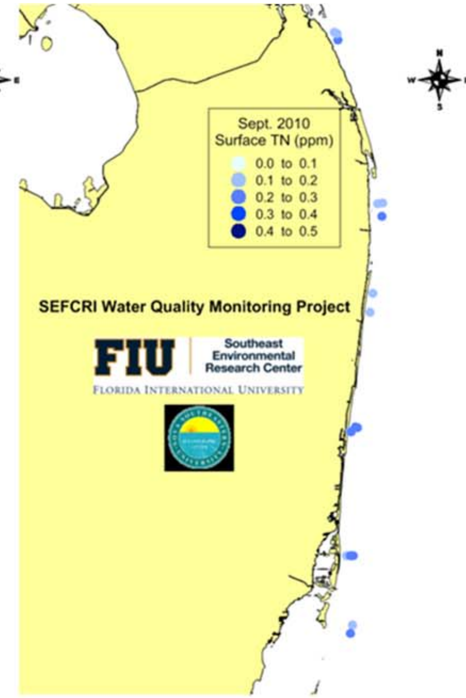
Sept. 2010
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
SEFCRI Water Quality Monitoring Project
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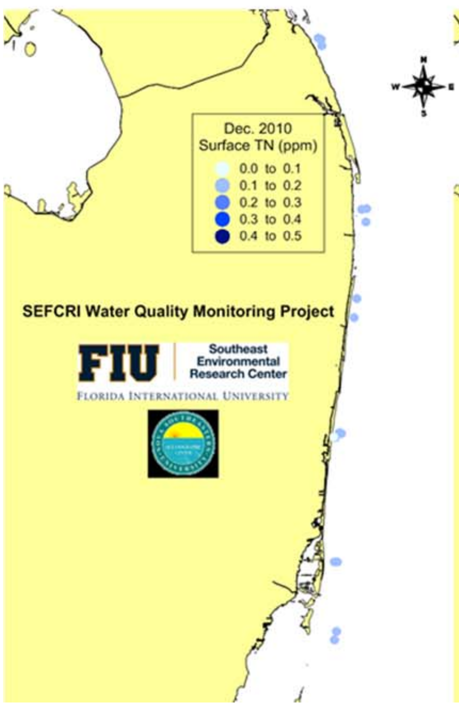
Dec. 2010
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
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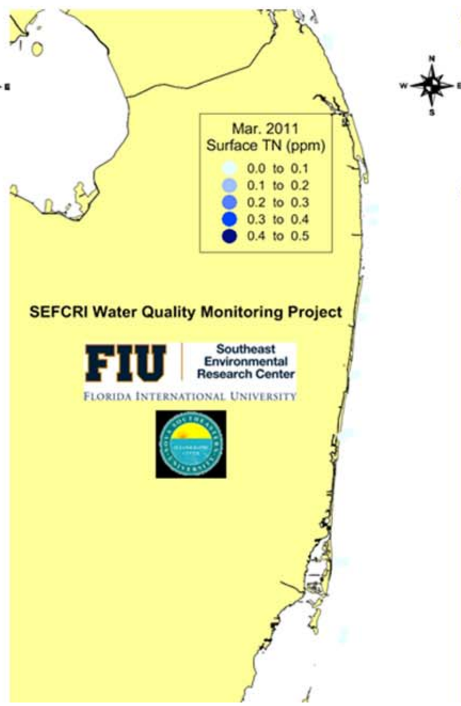
Mar. 2011
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
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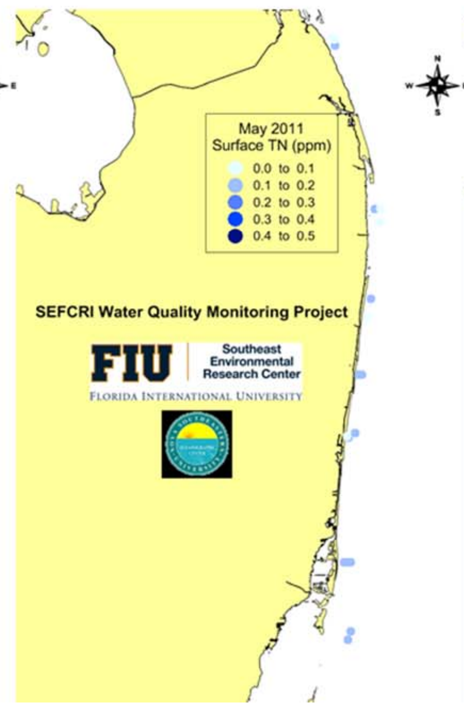
May 2011
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
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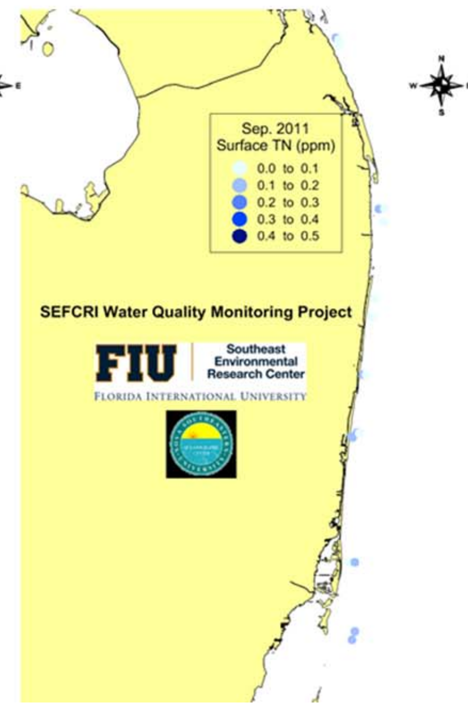
Sep. 2011
Surface TN (ppm)
0.0 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
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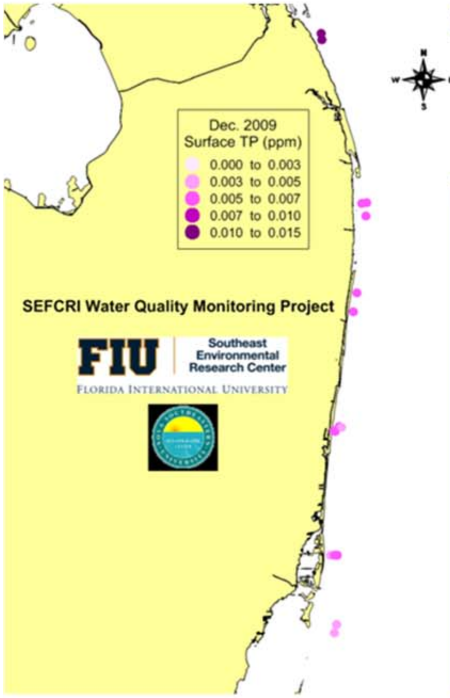
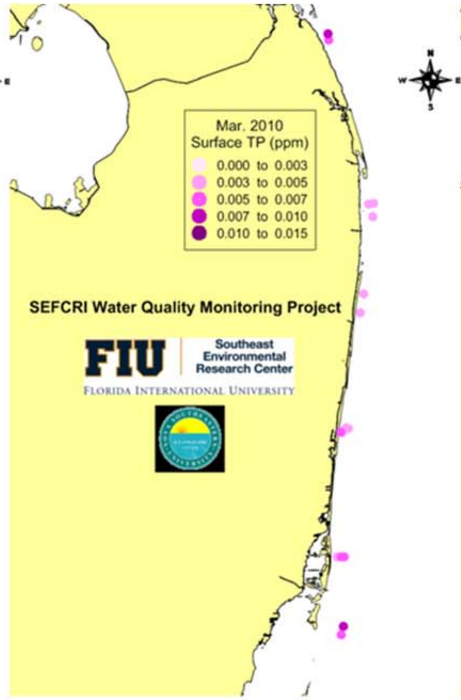
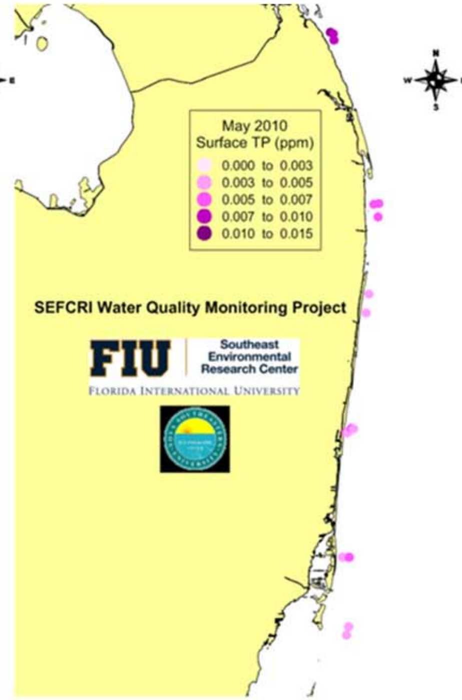
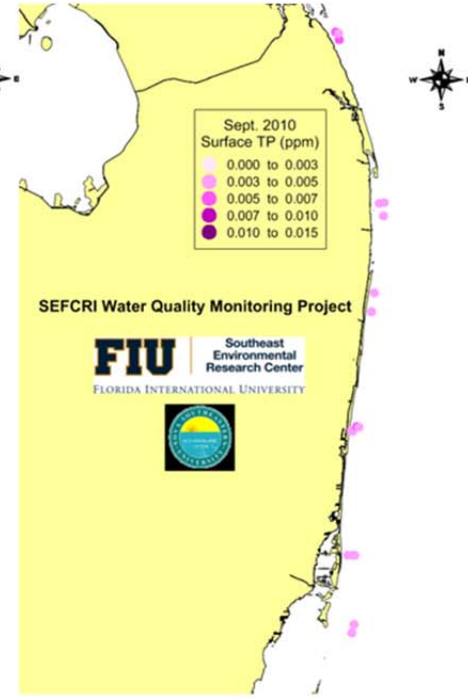

Dec. 2009
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
0.007 to 0.010
0.010 to 0.015
SEFCRI Water Quality Monitoring Project


Mar. 2010
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
0.007 to 0.010
0.010 to 0.015
SEFCRI Water Quality Monitoring Project


May 2010
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
0.007 to 0.010
0.010 to 0.015
SEFCRI Water Quality Monitoring Project


Sept. 2010
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
0.007 to 0.010
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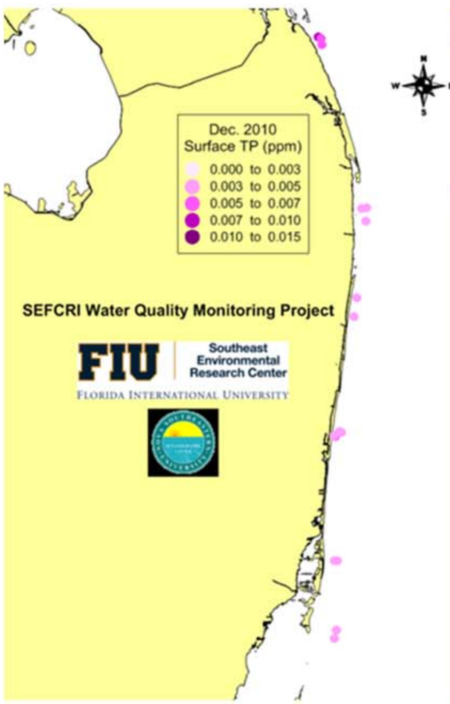
SEFCRI Water Quality Monitoring Project


Dec. 2010
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
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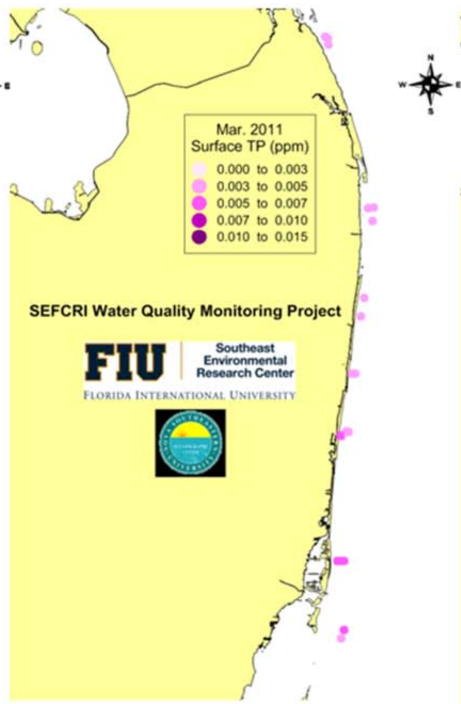
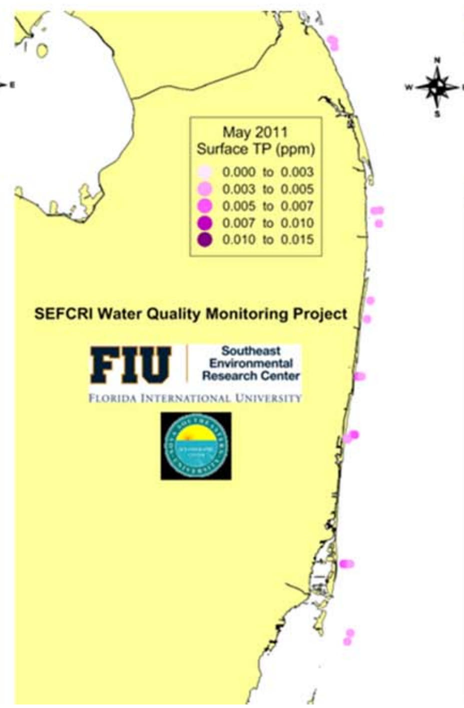
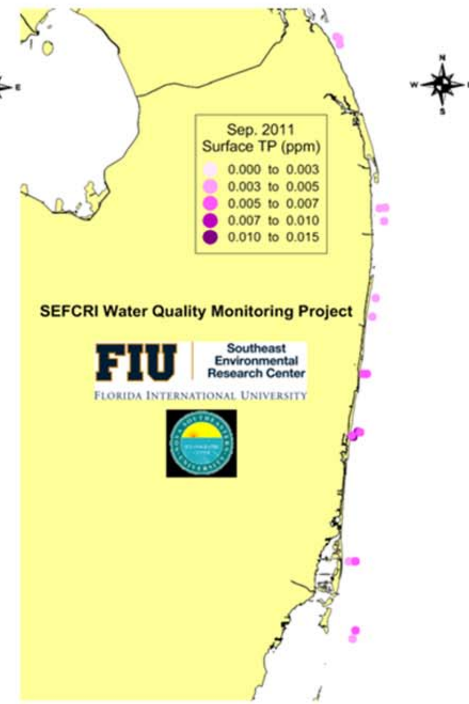
SEFCRI Water Quality Monitoring Project


Mar. 2011
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
0.007 to 0.010
0.010 to 0.015
SEFCRI Water Quality Monitoring Project


May 2011
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
0.007 to 0.010
0.010 to 0.015
SEFCRI Water Quality Monitoring Project


Sep. 2011
Surface TP (ppm)
0.000 to 0.003
0.003 to 0.005
0.005 to 0.007
0.007 to 0.010
0.010 to 0.015
SEFCRI Water Quality Monitoring Project

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