Ocean Weather

Real-time monitoring

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Identifying ocean events and seasonal trends of bio-physical water properties and Dynamic anomalous marine conditions in the Gulf of Mexico.

DYNAMIC ANOMALY PROPERTIES "DAP"

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USM OWX - Restore

Ocean Weather Laboratory – Identifying Events and Abnormal Bio-optical and Physical Properties in the Gulf of Mexico

GOALS and Applications :

Examples from Presentations and Publications

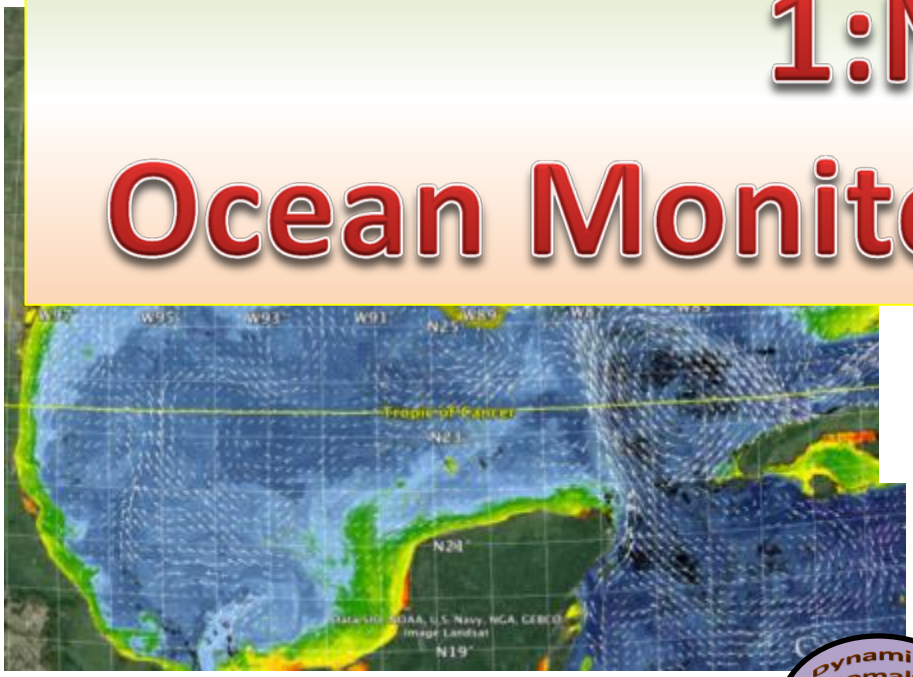
1. Ocean Weather Laboratory's unique weekly / daily products to monitor ecosystem bio-optical physical properties Gulf of Mexico
2. Identify dynamic changing properties and locations where "normal and abnormal" properties are occurring. 2013 – 2018

   Dynamic Tool EVENTS and HOTSPOTS -products generated
3. Identifying Seasonal Trends of Bio - Physical properties at Stations – and correlations. - metric for monitoring climate changes
4. Applications - -Management Tools – Fisheries

   Locations for Adaptive Sampling Station anomaly Locate Possible Data Collection Gaps
5. Identifying Ocean Events- Flower Garden Banks, BonnieCarrie, Hurricanes, 2017
6. Data Public Access-

Ocean Weather Laboratory

1:New Ocean Monitoring Products



3 km

CDOM
Detritus
Phytoplankton
Sea surface Temperature
Sea surface Salinity

Euphotic Depth

Sea Surface Height
Current Vectors
Current Magnitude
Model Differences
Regional Cross Sections

New Products — "Hotspots" Abnormal Environmental Conditions

Dynamic Anomaly DAP Properties

Dynamic Anomaly Products (DAP)
Weekly and - Moving Averages
Anomaly, Standard Deviation Masks (1,2,3)

- **Rapidly changing ocean processes r… near real products to support adaptive sampling , decision making**

OWX- Google

- **Where to send gliders for identifying processes, & River Filaments**
- **Integration models and satellite improve product validation and determine uncertainty / anomalies.**

Satellite Products :

1) Chlorophyll - chl 2) SST - mcsst
3) Euphotic Depth – ZEU 4) Absorption 443 a443
5) Backscattering (particles) 6) Salinity-sal 7) Kd Diffuse

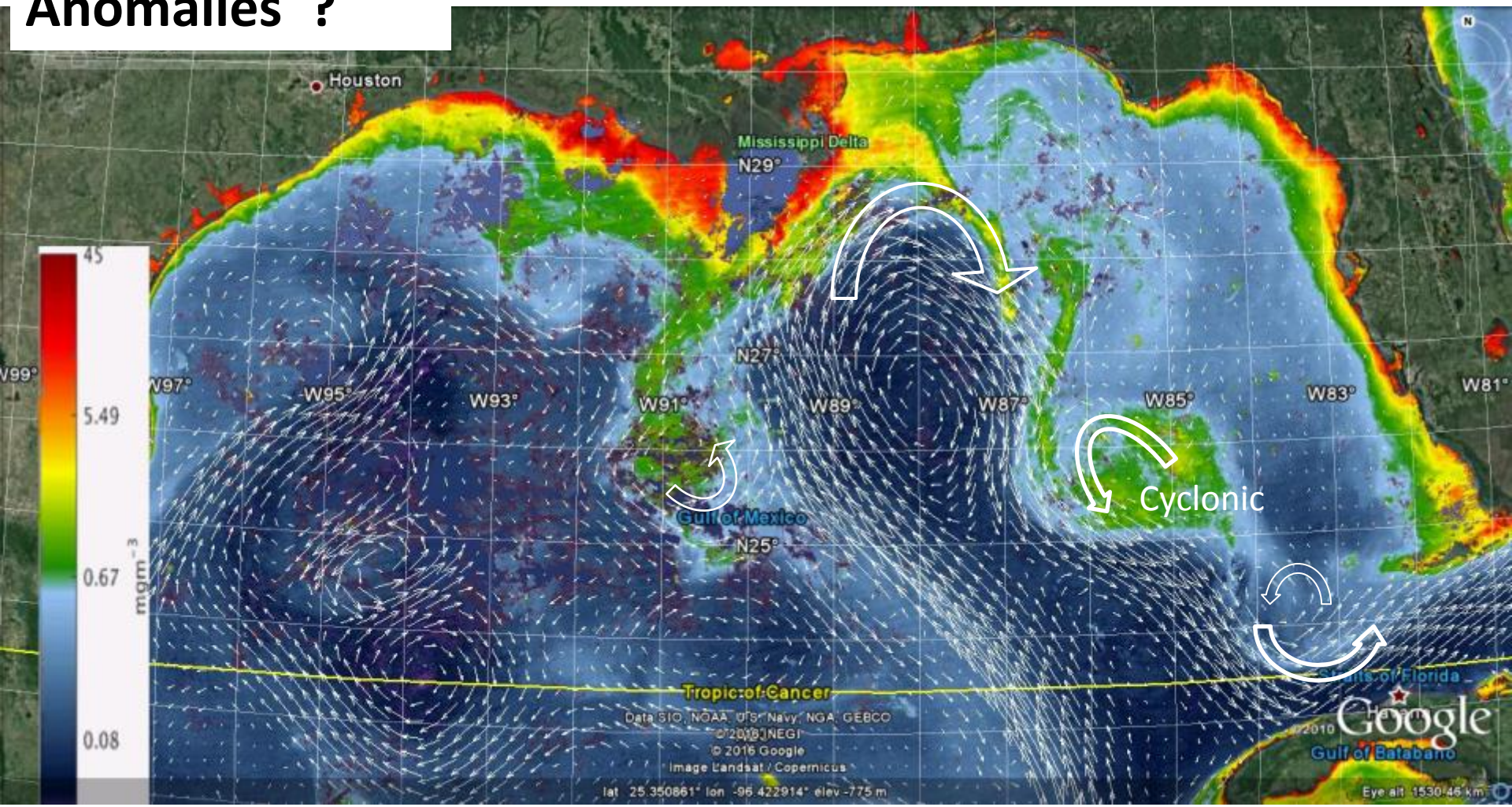
Circulation –America Seas Model

1) Sea Surface Temperature - 2) Surface Salinity –
3) Surface Current magnitude 4) direction

How define DAP Anomalies ?

Events in 2015 Chlorophyll - Surface Currents

Weekly means



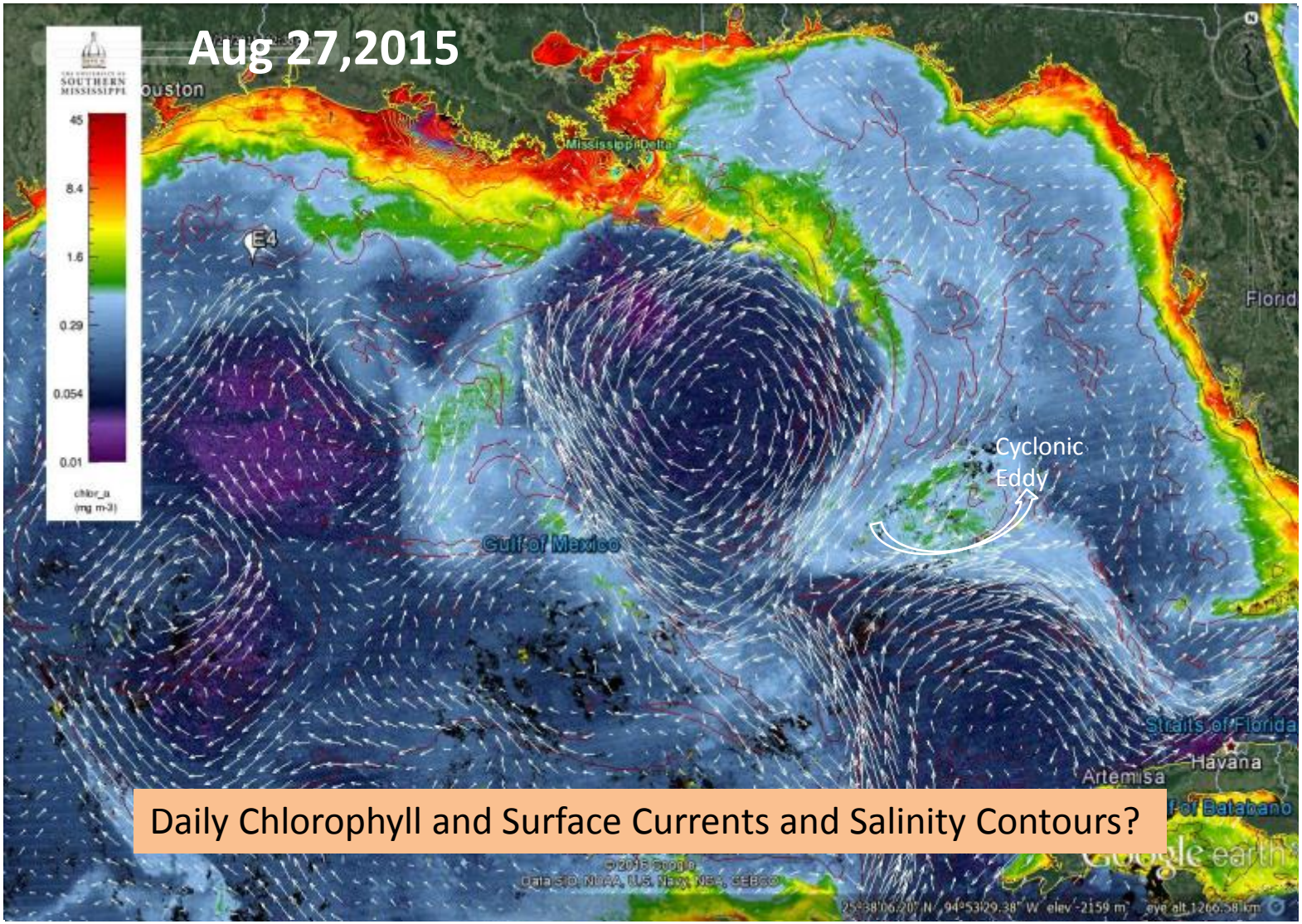
Jan 1 | Feb | Mar | Apr | May | Jun | July | Aug | Sept | Oct | Nov | Dec

 Plume → Key West

Event - Mississippi Plume to Key West Aug 2015
LOOP Current

Plume to Key West

How Abnormal was this advent in last few months?
What regions were affected? Define Level of Uncertainty?

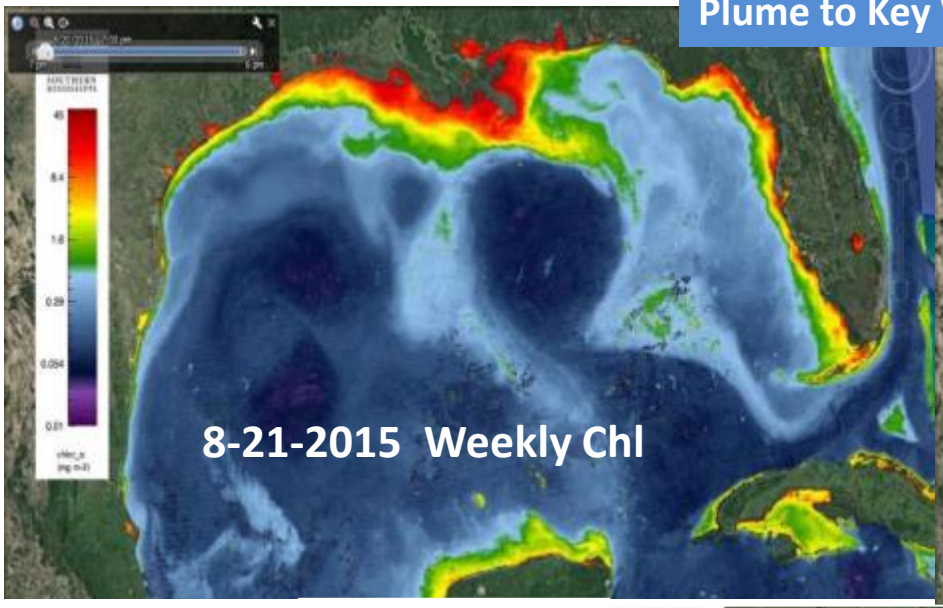


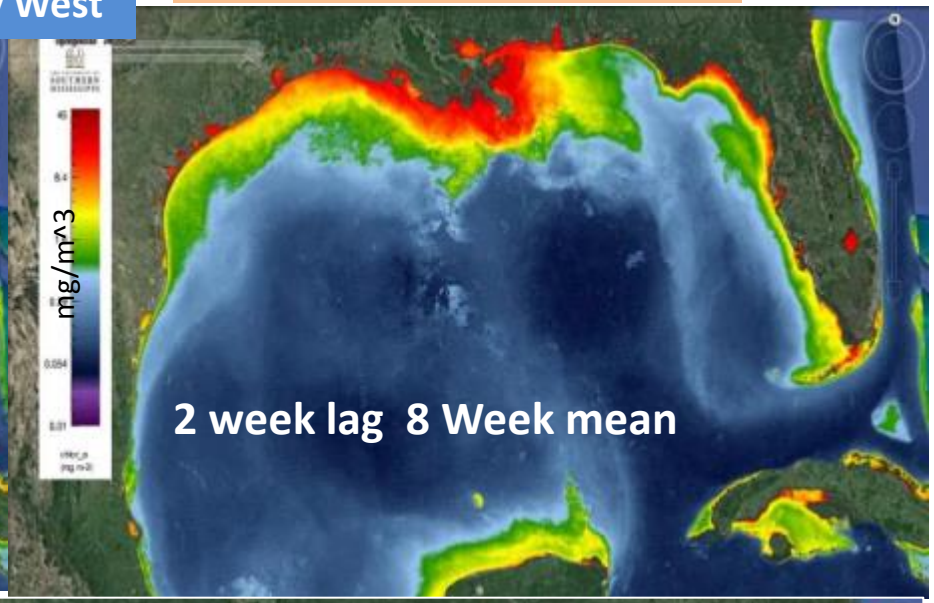
Defining Dynamic Anomalies Properties –DAP

Where are the abnormal Hotspots in 8-21- 2015

Chlorophyll Hotspots

Plume to Key West



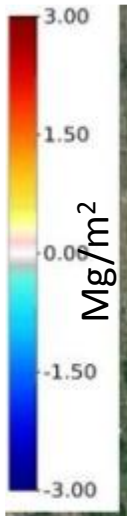


Difference

Higher

None

Lower



Trie
If th

Chl, Eu, bb, Sal
SST, Currents

Defining the Level of Abnormality
Is the Anomaly within the Variance of the Region

Plume to Key West

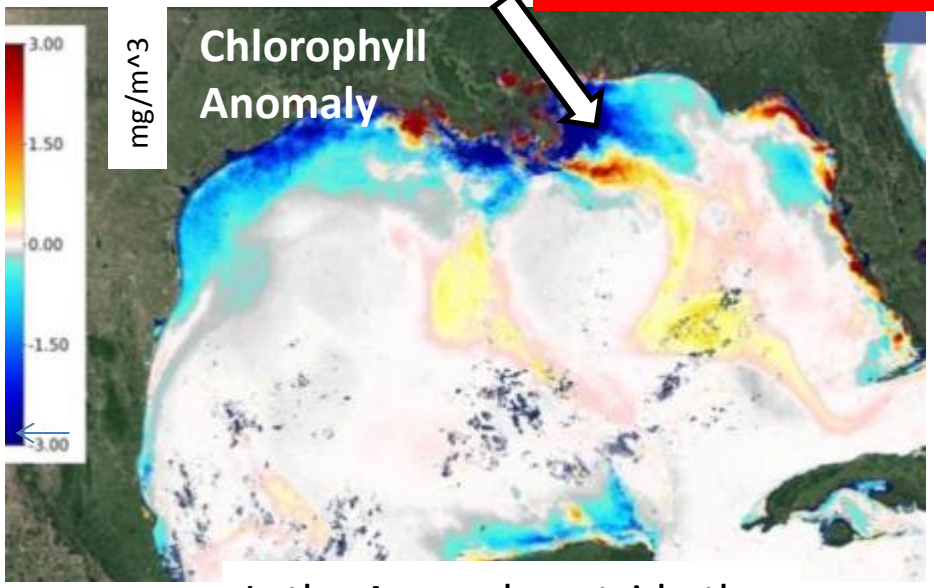
8-21-2015 Week

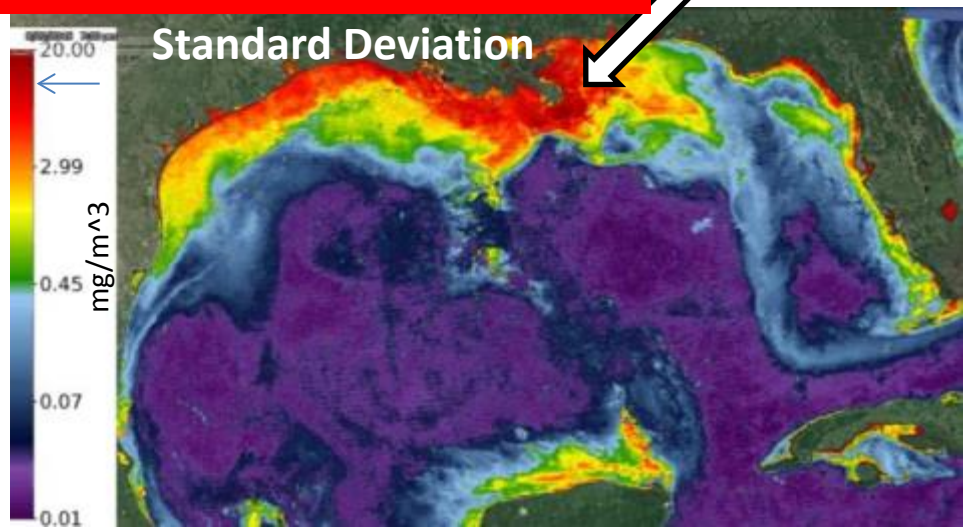
Dynamic Anomaly DAP Properties

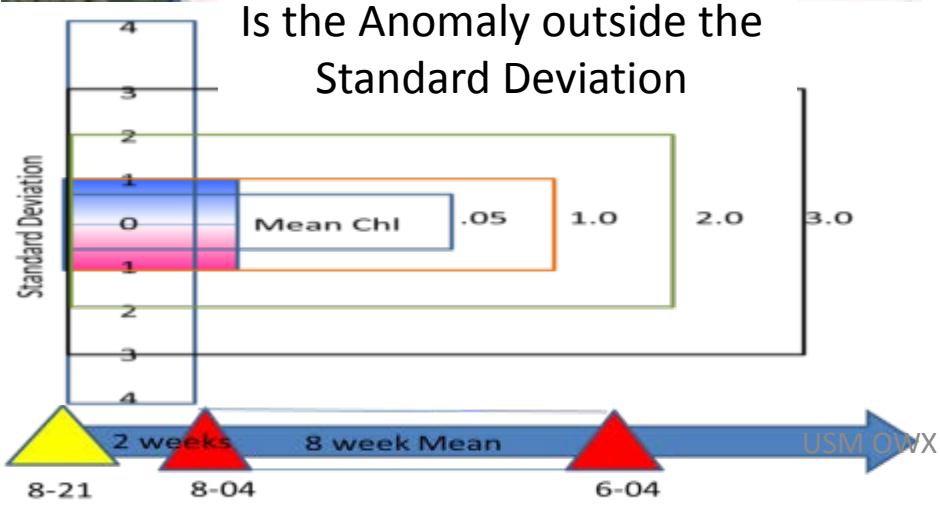
For each pixel, how far is the anomaly outside the Standard Deviation

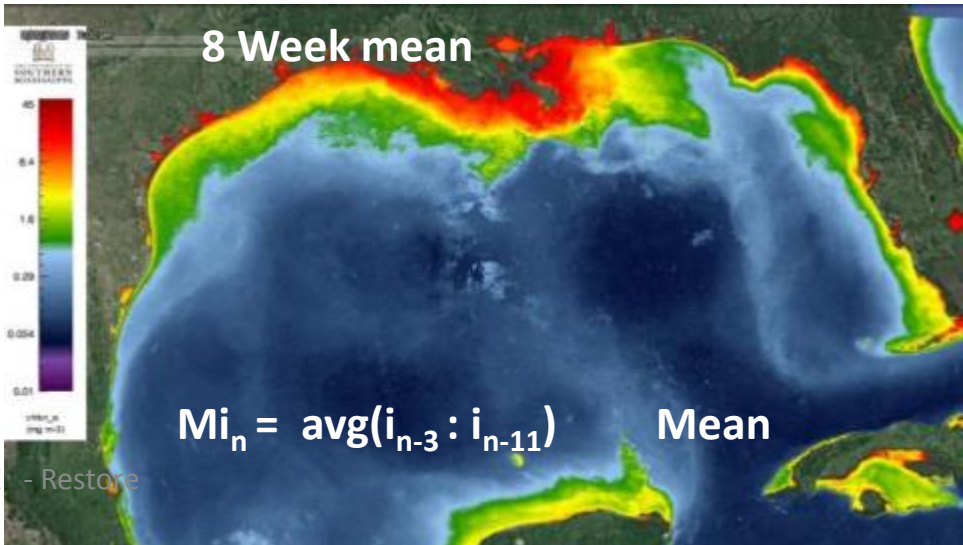
-3 mg/m

+/- 10mg/m3









USM OWX - Restore

Chl_ Anomaly_8-15- 2week lag – 8 week average

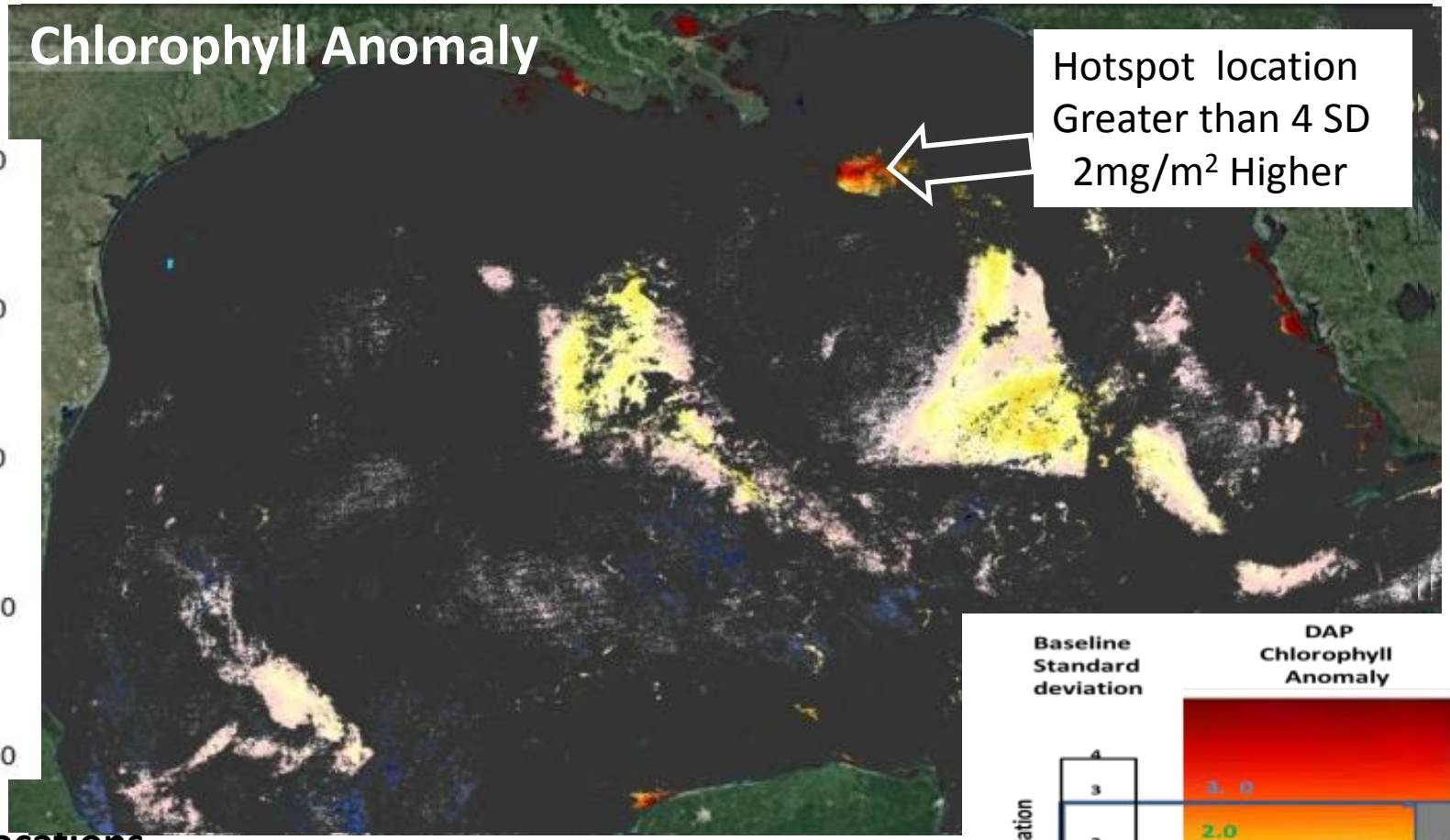
8-21-2015 Week

HOW ABNORMAL IS THE DYNAMIC HOTSPOT ?

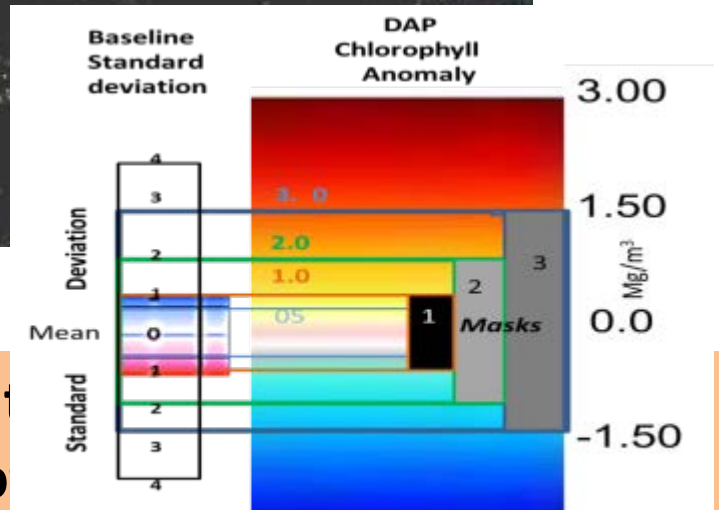
Masking the Different Level of the Standard deviation

0 , .5, 1, 1,5, 2, 3, 4,

Plume to Key West



Locations Greater than → 4.0 Standard Deviation Mask

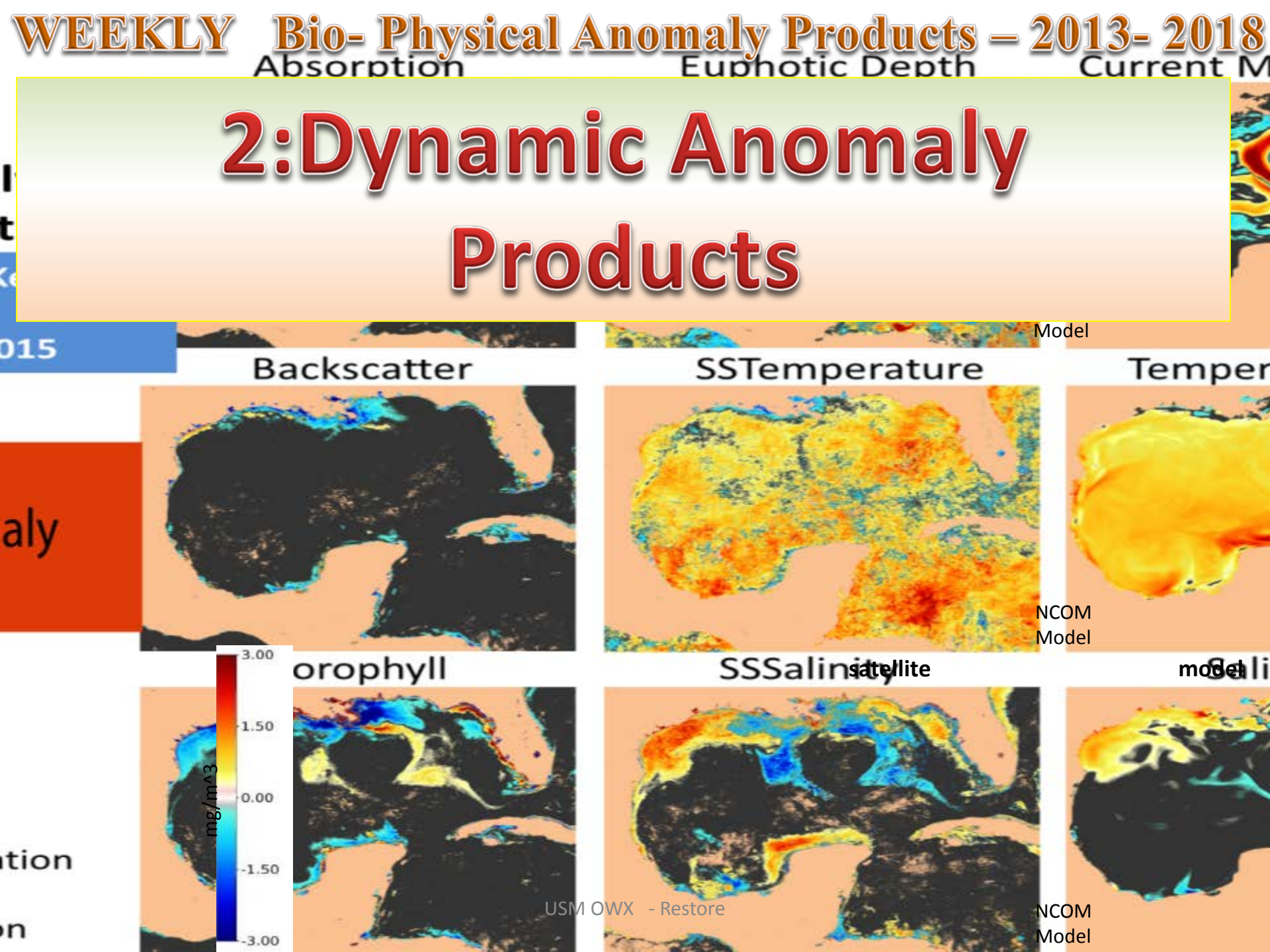


Levels of Abnormal Chlorophyll outside

Location of Hotspo

WEEKLY Bio- Physical Anomaly Products – 2013- 2018

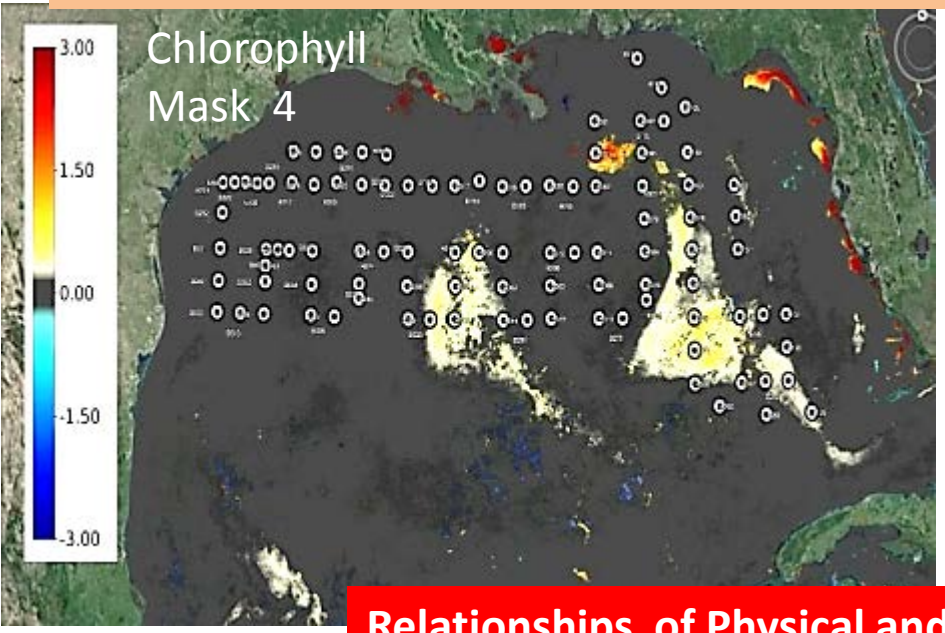
2:Dynamic Anomaly Products

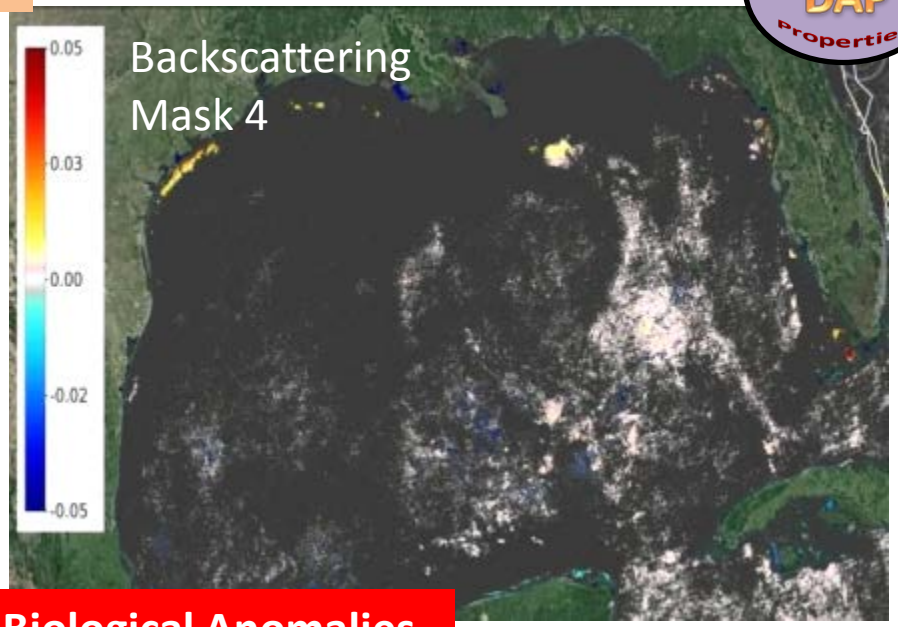


Inter comparison of Hotspots

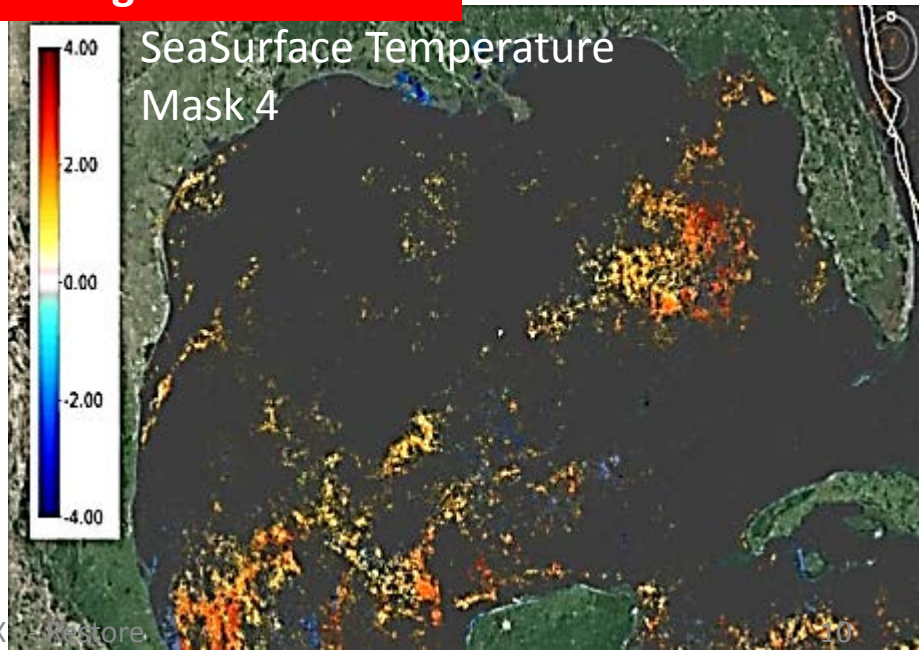
Plume to Key West *8-21-2015 Week*

Dynamic Anomaly DAP Properties





Relationships of Physical and Biological Anomalies

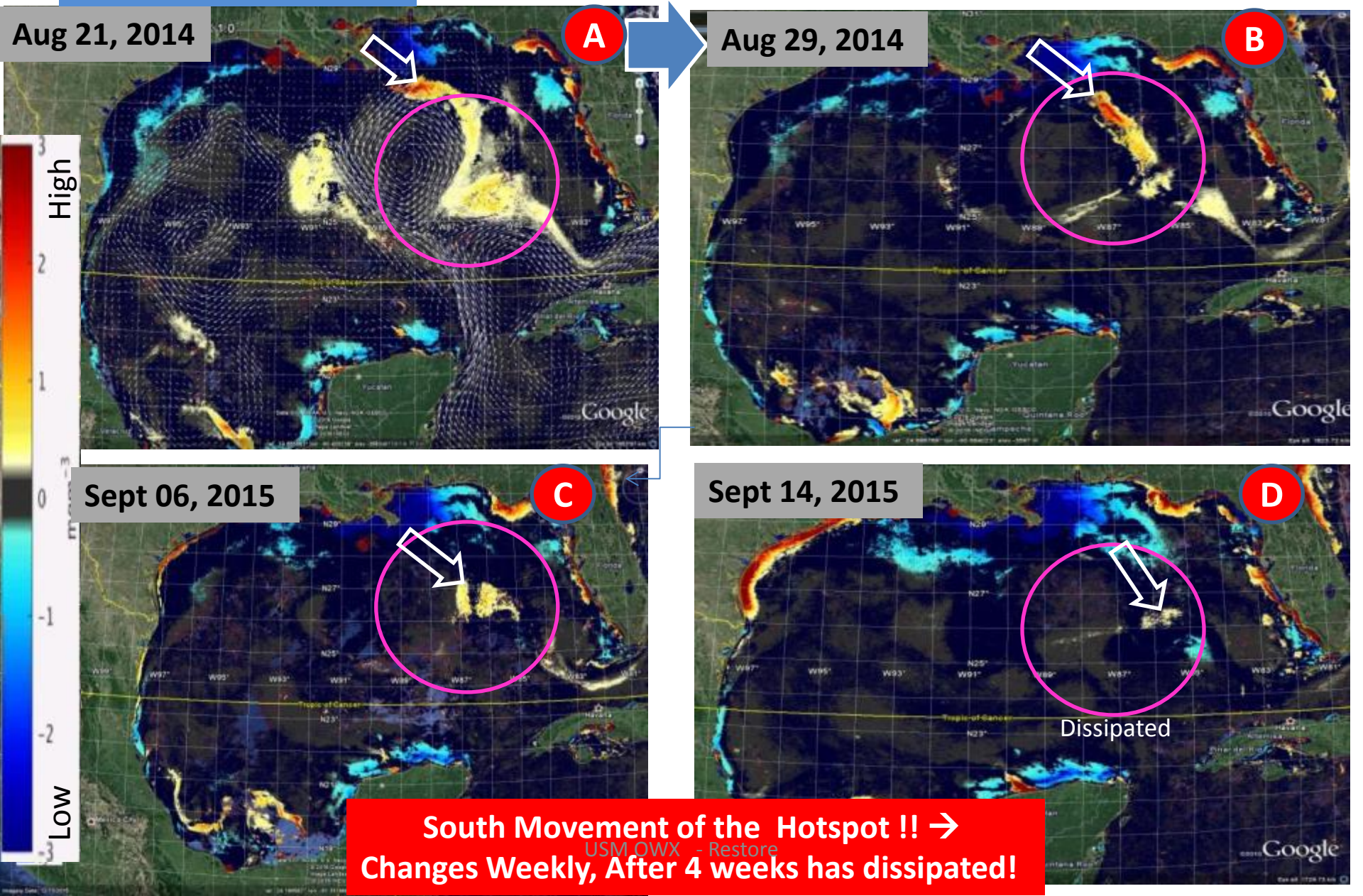


How Does the Chlorophyll Anomaly Change Weekly?

Dynamic Anomaly DAP Properties

MS Plume to Key West

Mask 1 Std Deviation



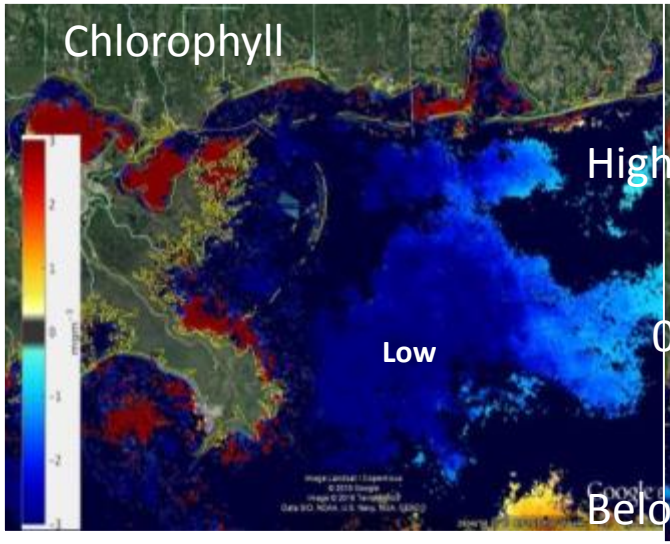
South Movement of the Hotspot !! →
Changes Weekly, After 4 weeks has dissipated!

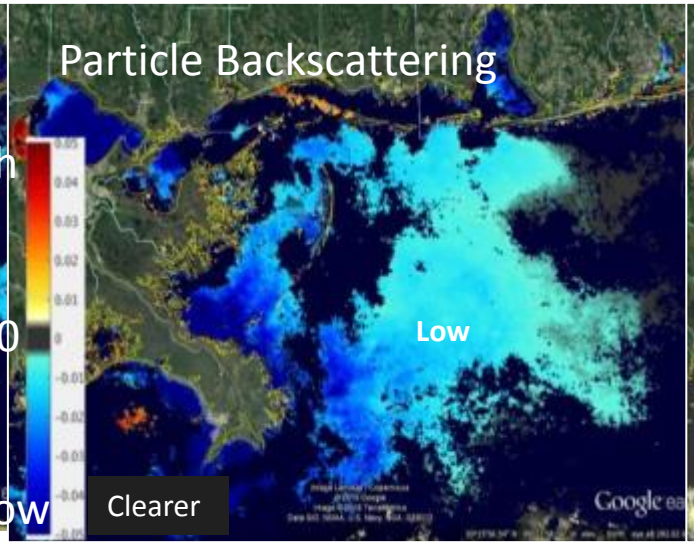
USM OWX - Restore

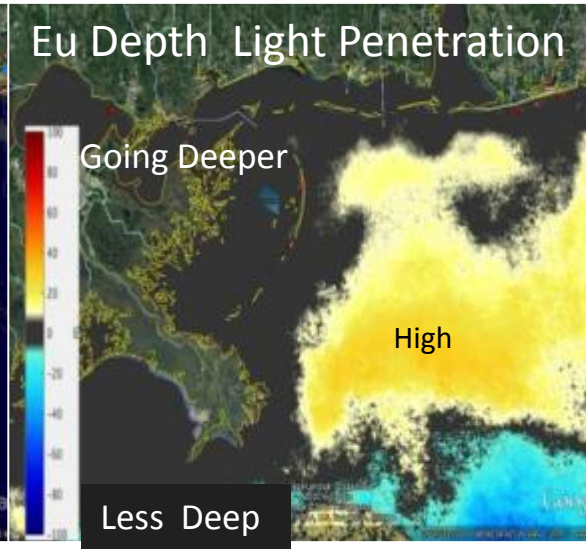
Coastal Hotspots on the shelf - Anomalies

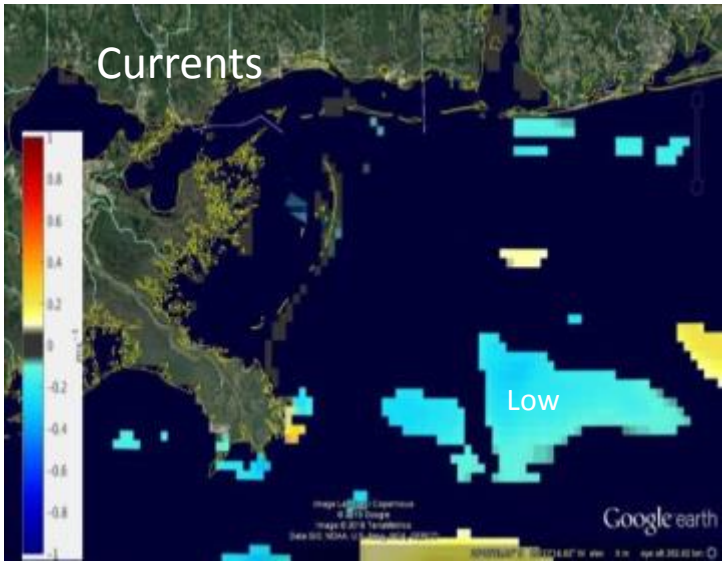
How properties changed for week of Aug 21, 2015?

MASK 1 Standard Deviation



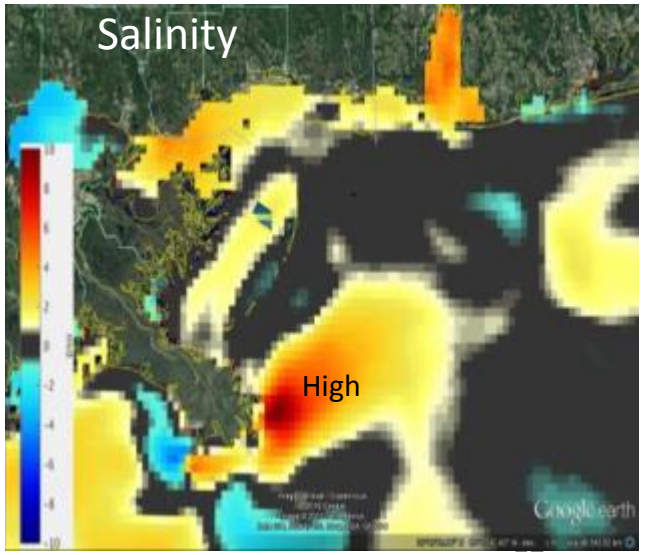






Were the regions abnormal ?
What is Impact on the Ecosystem ?

Note there are Similar and Different regions



Dynamic Anomaly Properties (DAP) – Products Description

***Biological, Optical, and Physical* Ocean anomaly properties** for the Gulf of Mexico are weekly products using (VIIRS) satellite and America Seas NCOM ocean model

Positive anomaly indicates an increase and negative values a decrease.

11 Biological, Optical, and Physical properties with 10 products for each.

FORMAT data Files are both NCDF and kml format for use in 'GOOGLE Earth'.

10 x 10 = 100 products each week = TOTAL 4 TB 2013- 2018

A - Properties

Bio- optical physical *name*

VIIRS - 750 m resolution

1. Chlorophyll→ CHL
2. Zeu- Photic depth ZEU
3. Sea Surf Temperature MCSST
4. Kd- Attenuation Coef KD486
5. BB551- Backscattering BB551
6. Absorption 443 A443
7. Salinity (absorption 486-550) SAL

America Seas Model -3 km resolution

8. Sea Surf Temperature amsst
9. AmSalinity amsal
10. *AmCurrents* amcurr
11. Am AbCurrent Vector amC1

B - Products –KML

For each property

File Name

1. Weekly
2. StDev Mask 4
3. StDev Mask 3
4. StDev Mask 2
5. StDevmask1
6. StDevMask1.5
7. StDevMask0.5
8. StDev Image
9. Anomaly
10. 8Wk Avg

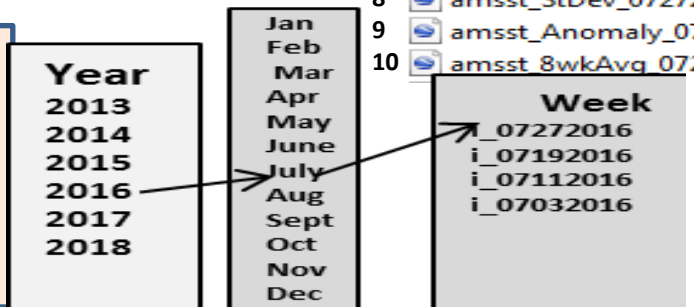
C - File Names – Chlorophyll & AMSST

1. CHL_Weekly_07272016_.kmz
2. CHL_StDevMask4_07272016_.kmz
3. CHL_StDevMask3_07272016_.kmz
4. CHL_StDevMask2_07272016_.kmz
5. CHL_StDevMask1_07272016_.kmz
6. CHL_StDevMask15_07272016_.kmz
7. CHL_StDev_Mask05_07272016_.kmz
8. CHL_StDev_07272016_.kmz
9. CHL_Anomaly_07272016_.kmz
10. CHL_8wkAvg_07272016_.kmz

1. amsst_Weekly_07272016_.kmz
2. amsst_StDevMask4_07272016_.kmz
3. amsst_StDevMask3_07272016_.kmz
4. amsst_StDevMask2_07272016_.kmz
5. amsst_StDevMask1_07272016_.kmz
6. amsst_StDevMask15_07272016_.kmz
7. amsst_StDev_Mask05_07272016_.kmz
8. amsst_StDev_07272016_.kmz
9. amsst_Anomaly_07272016_.kmz
10. amsst_8wkAvg_07272016_.kmz

Web Site

DAP data is Organized by year, month, week 2013 - 2018. The weekly products represents 8 day following the date.
Example 07272016 is July 272016 to Aug 3,2016.



Arnone, R., Jones, B. " Monitoring abnormal bio-optical and physical properties in the Gulf of Mexico ", *Proc. SPIE* 10186, Ocean Sensing and Monitoring IX, 101860O (May 22, 2017); http://dx.doi.org/10.1117/12.2266789

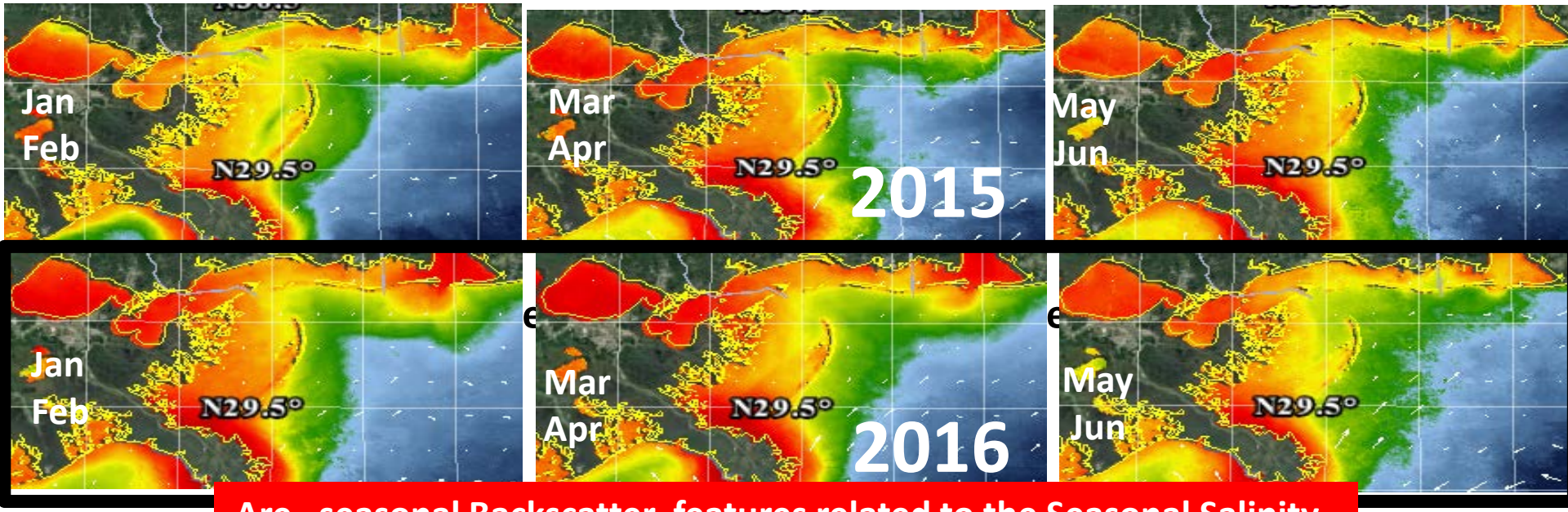
3- Identifying Seasonal trends of bio-physical properties and anomalies at on Mississippi Shelf and stations and Correlations

can be applied anywhere in Gulf

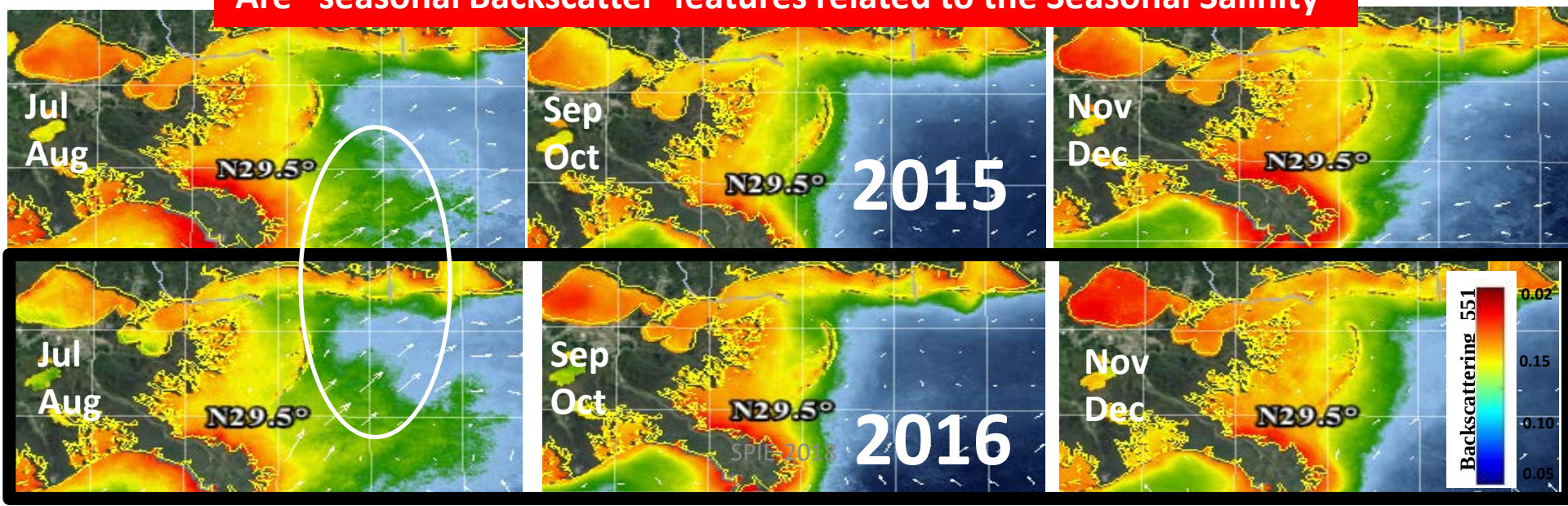
Using the DAP products to identify changes,
applications -metric for monitoring climate change.

Arnone, R. Jones, B. Ladner, S. Soto,I. "Seasonal trends of biophysical ocean properties and anomalies across the Mississippi Shelf ", Proc. SPIE 10631, Ocean Sensing and Monitoring X, 1063102 (15 May 2018); doi: 10.1117/12.2309427; https://doi.org/10.1117/12.2309427

Seasonal Cycle 2015 – 2016 - Surface Backscattering

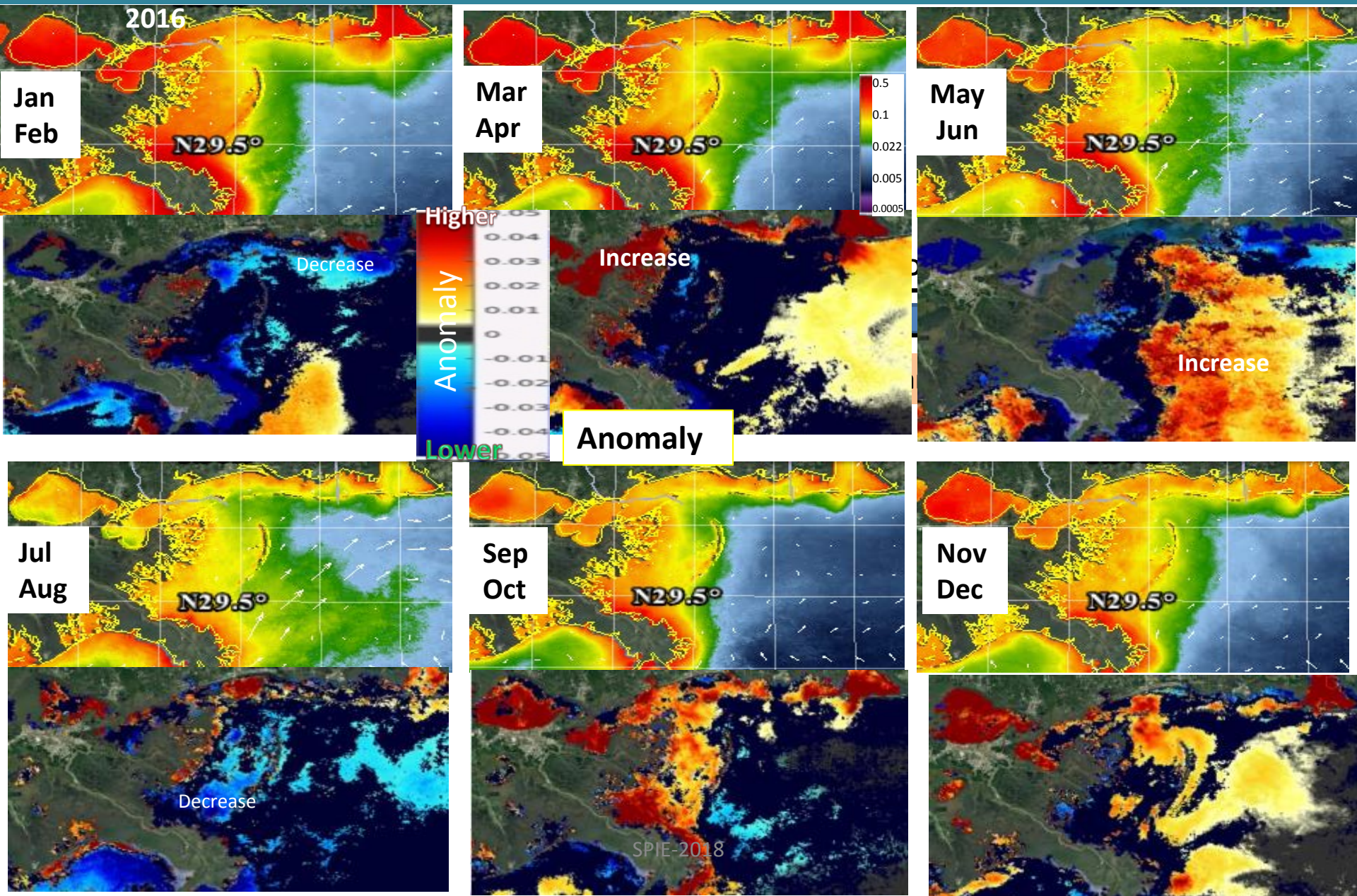


Are seasonal Backscatter features related to the Seasonal Salinity

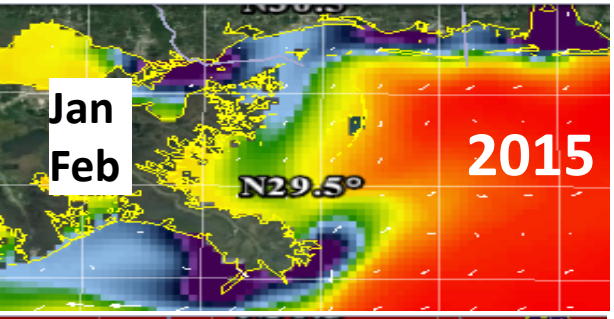


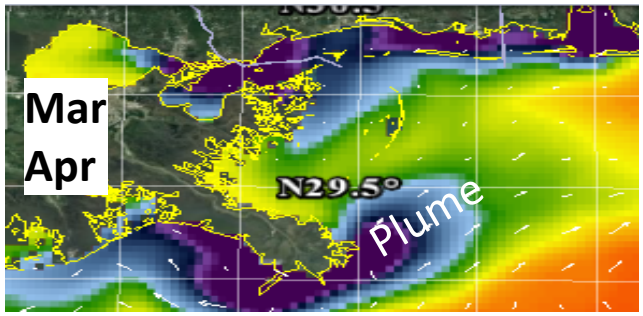
Seasonal 2 month Cycles on MS Shelf

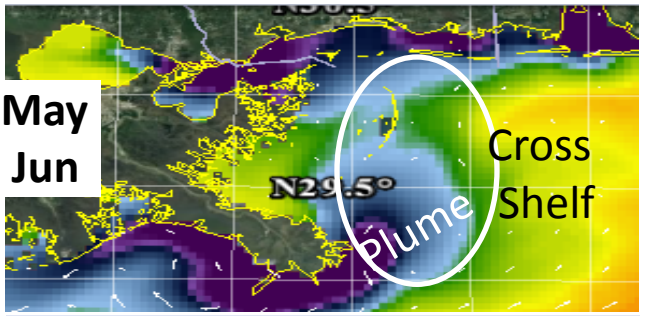
Particles Backscattering → Nowcast and Seasonal Anomaly Cycle

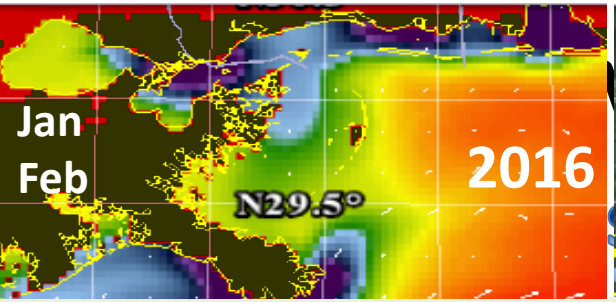


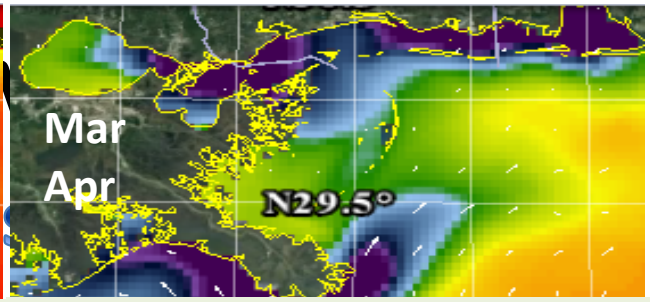
Surface Salinity 2 month Cycles on Miss Shelf 2015 –2016

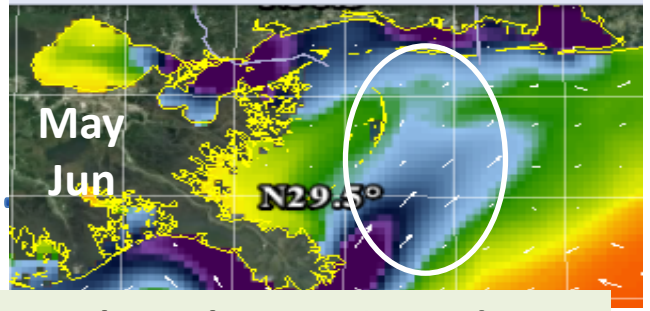






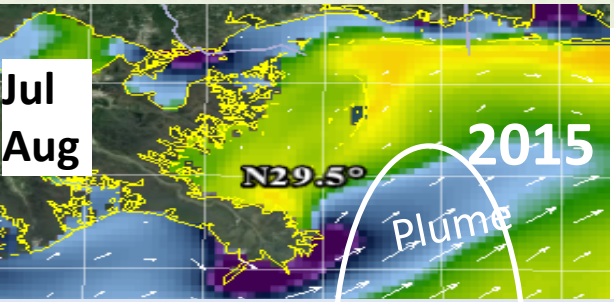


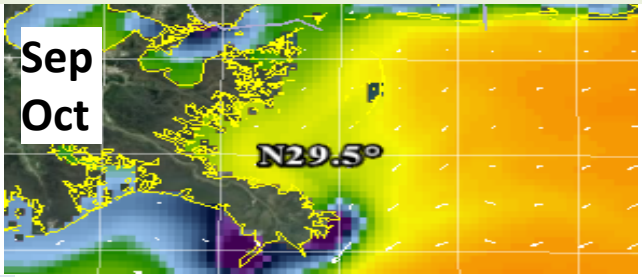


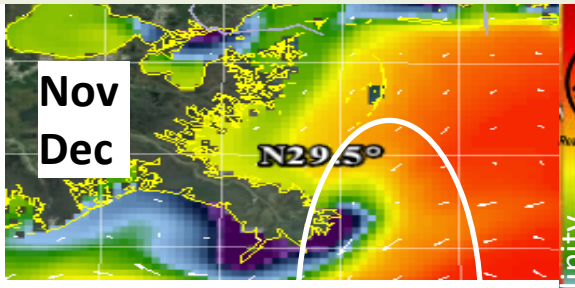


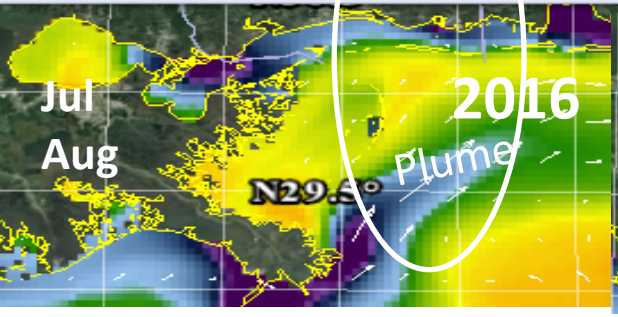
SIMILAR YEARLY FEATURES

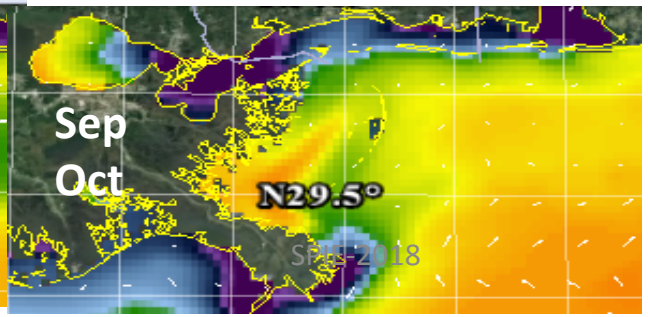
Have Additional Cycles for Bio-Physical Properties and Abnormal Trends showing similar yearly features to 2017

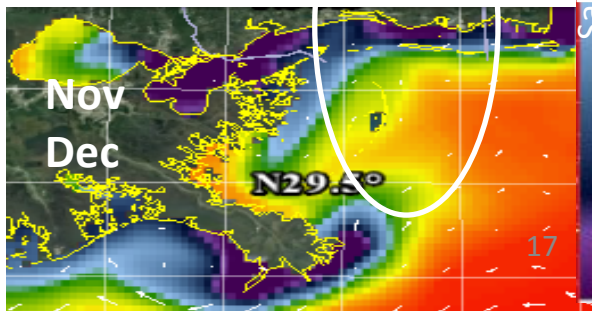








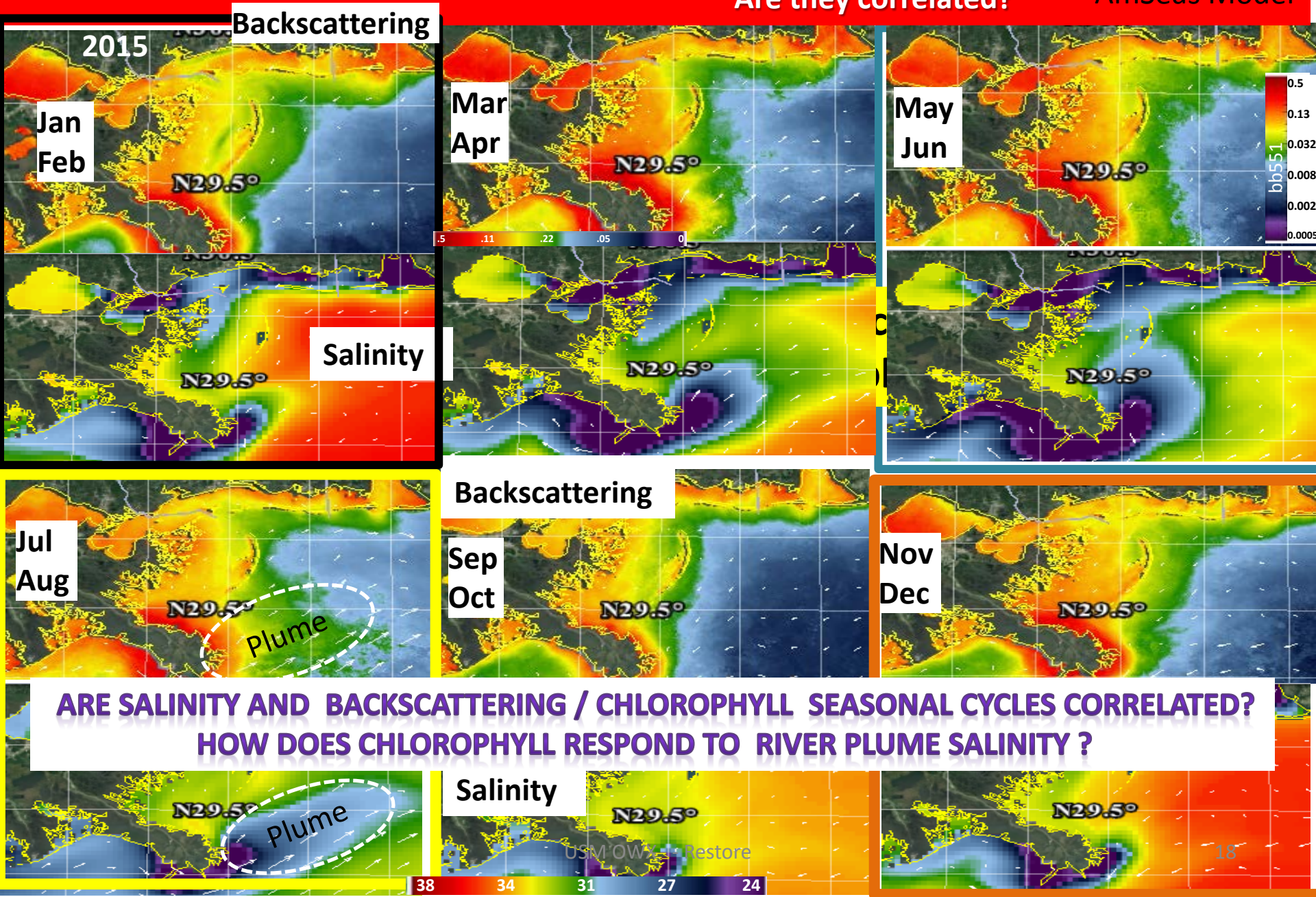




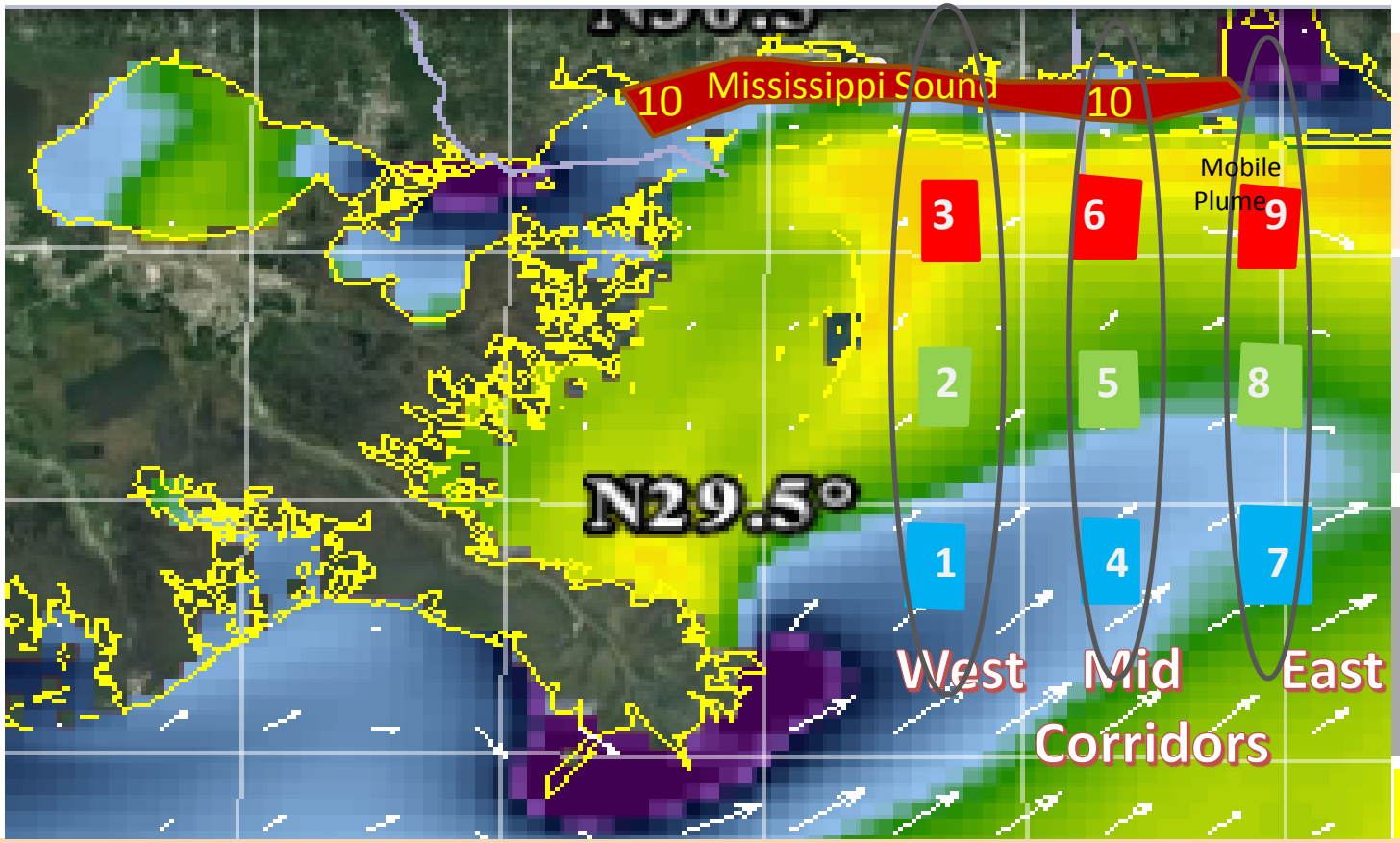
Seasonal Cycle 2015 – Backscattering + Surface Salinity

Are they correlated?

AmSeas Model



Regions for Characterizing the Miss Shelf Seasonal Cycles



Corridors

1 – Offshore West
2- Mid West
3- Coast West

4. Offshore Mid
5. Mid – Mid
6. Coast Mid

7. Offshore East
8. Mid – East
9. Coast – East

Mobile Plume

10. Miss. Sound

10 ROI (Region of Interest) areas for seasonal trends ~ 280 km 1100km

- Physical and bio-optical VIIRS Satellite and AMSeas Model

-Chlorophyll – Salinity – Temperature – Particle Backscattering 551- Euphotic Depth

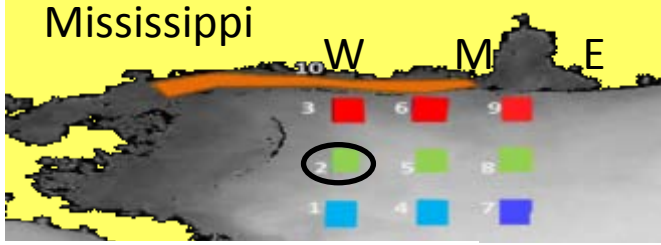
- Monthly "Mean and abnormal" Water Mass Cycle

Seasonal Forecast

Seasonal Chlorophyll 2016

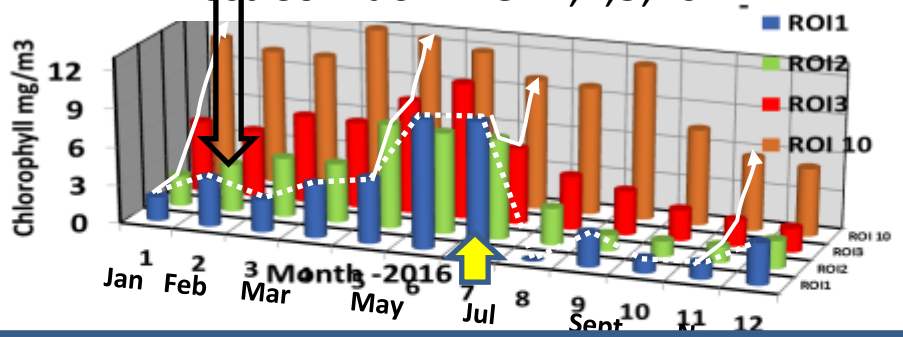
Seasonal Nowcast and Anomaly

Can define how a location (Stations) changes during the year



Nowcast

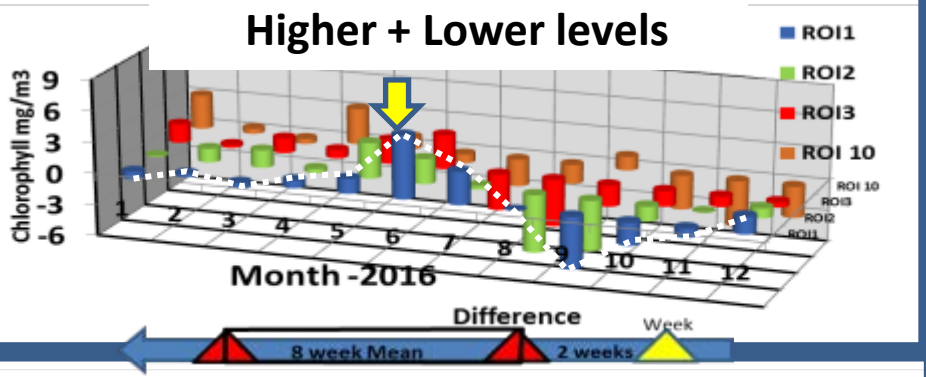
West Corridor ROI 1,2,3,10



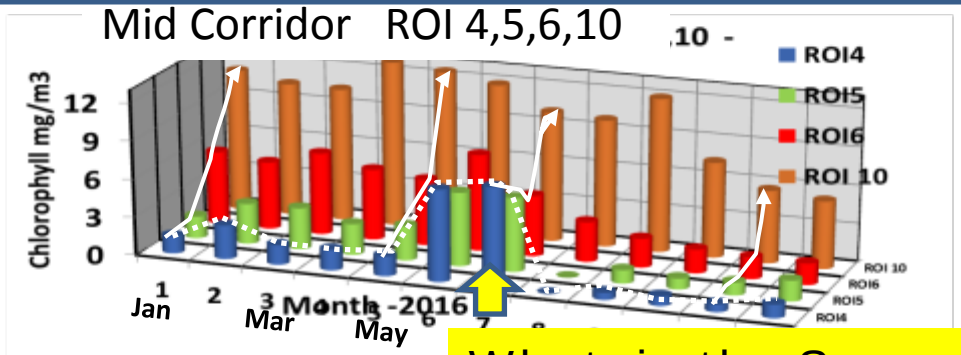
DYNAMIC ANOMALY

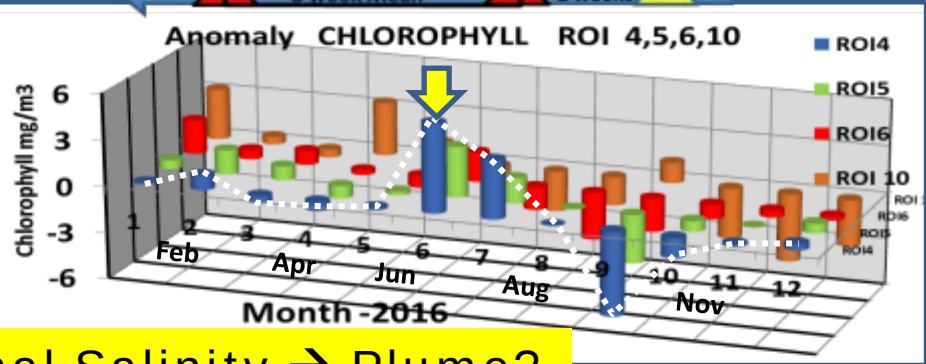
Identifies Seasonal Events

Higher + Lower levels



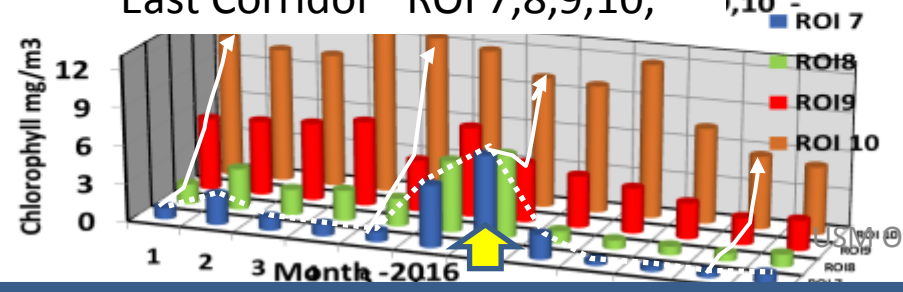
Mid Corridor ROI 4,5,6,10

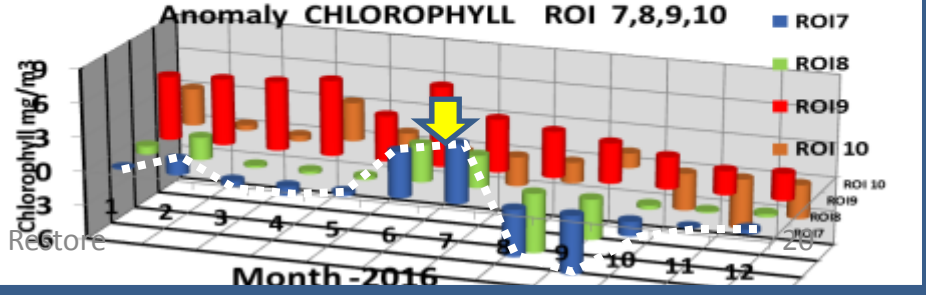




What is the Seasonal Salinity → Plume?

East Corridor ROI 7,8,9,10,



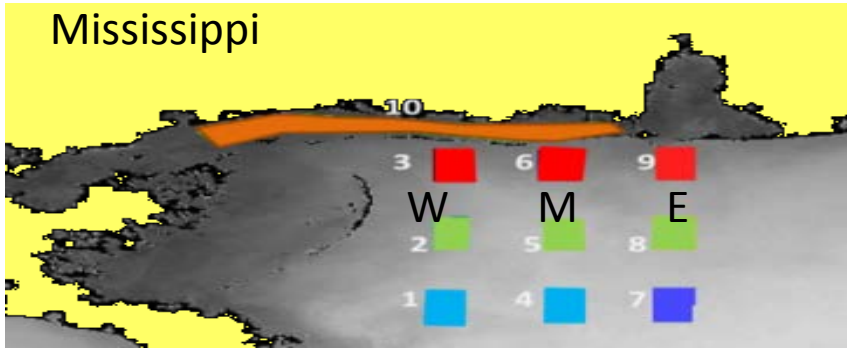


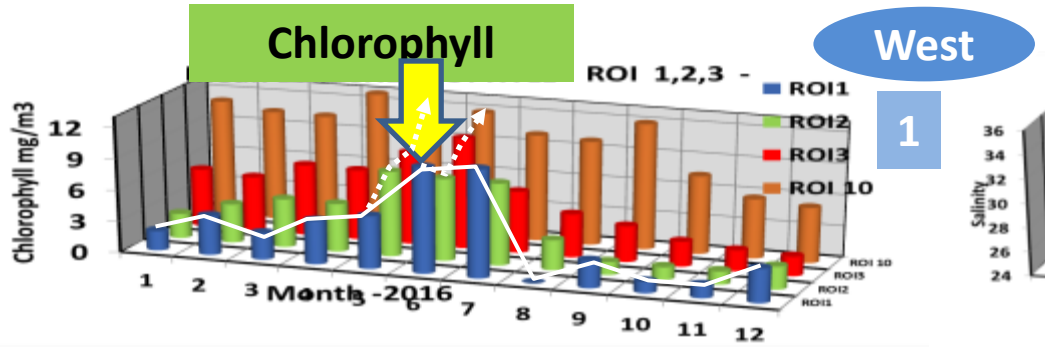
2016 Seasonal Cycle

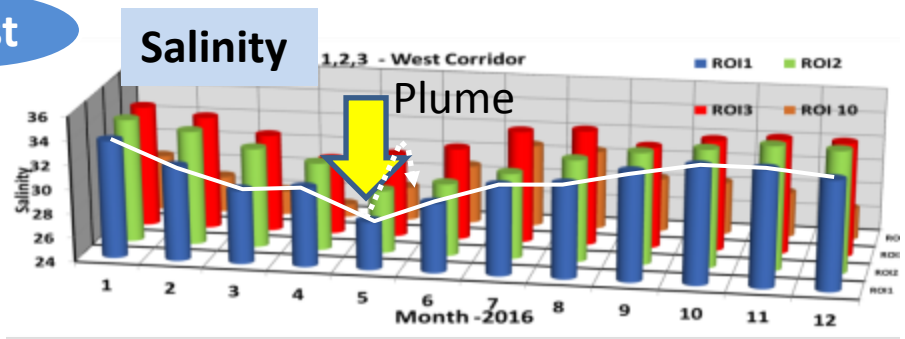
Locations have Different Cycles

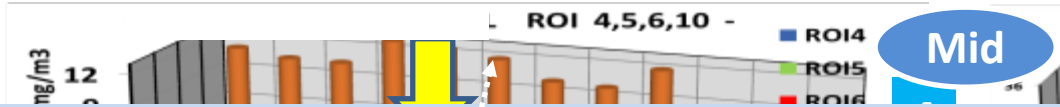
Monthly offset between the Salinity Plume and Chl

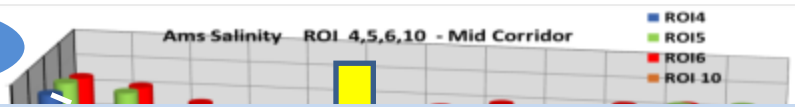
Takes time for chlorophyll to respond to Plume ?











Monthly Seasonal Correlation Scatter Plots

How are Bio-physical properties linearly related in the monthly cycle.

Forecast of how properties are related !

How Chlorophyll responds to Salinity etc.

Chlorophyll Responding (1 month DELAY)

2016 Seasonal Correlation of Salinity and Chlorophyll

Lower salinity from River affect the Chlorophyll Cycles

Variable correlation at different locations

Offshore	1 y = -0.9212x + 33.055 R² = 0.2663	4 y = -1.2767x + 44.902 R² = 0.3361	7 y = -1.1982x + 42.533 R² = 0.388
Mid	2 y = -1.42[illegible]0.059 R² = 0.8435	5 y = -0.4974x + 18.735 R² = 0.3086	8 y = -0.6423x + 23.553 R² = 0.3586
Coast	3 y = -1.4931x + 53.979 R² = 0.431	6 y = -0.8828x + 33.099 R² = 0.2255	9 y = -0.8508x + 32.32 R² = 0.3427

High

Ms Sound

10 Low
y = -0.1839x + 15.25
R² = 0.0138

Response of the Chl to Salinity

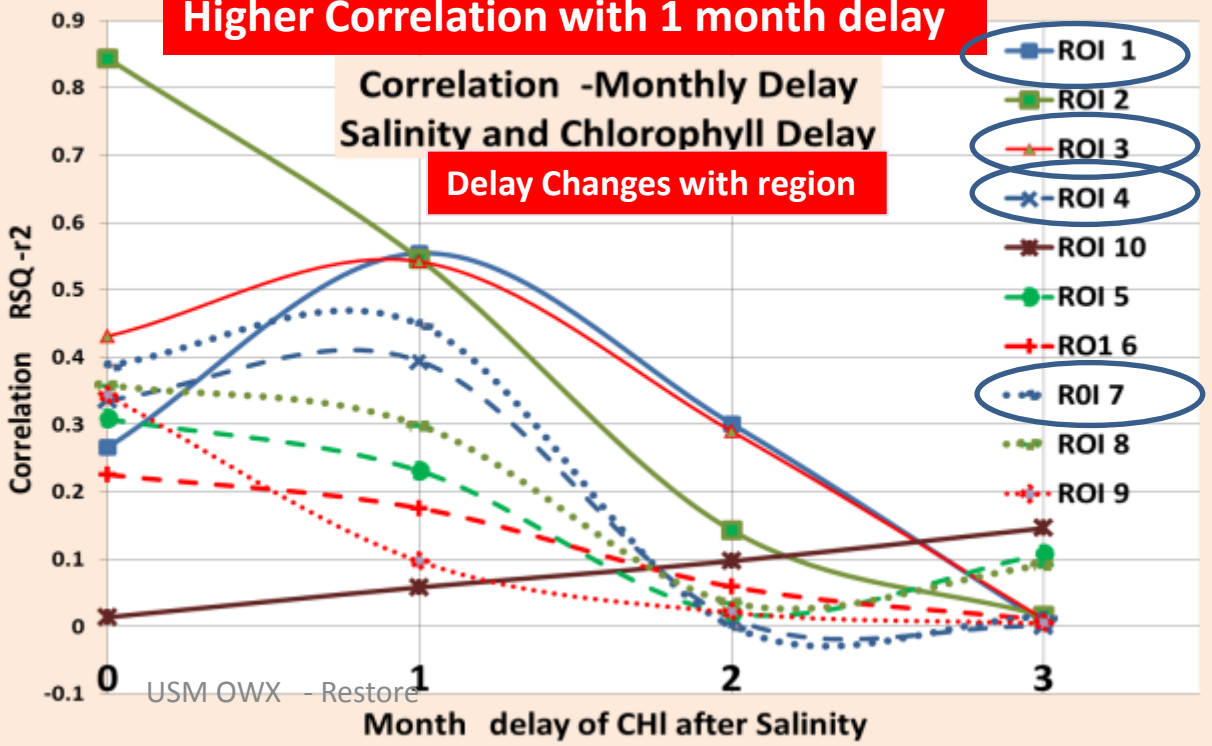
Takes time for Chl to respond to Salinity Plume.

How does R2 change with Month Delays?

1month salinity – Jan ----- Dec 2016
chlor - Feb-2016 - Jan-2017

Higher R2 with 1 month delay!! **Certain locations ! Different areas respond differently to salinity!**

Higher Correlation with 1 month delay



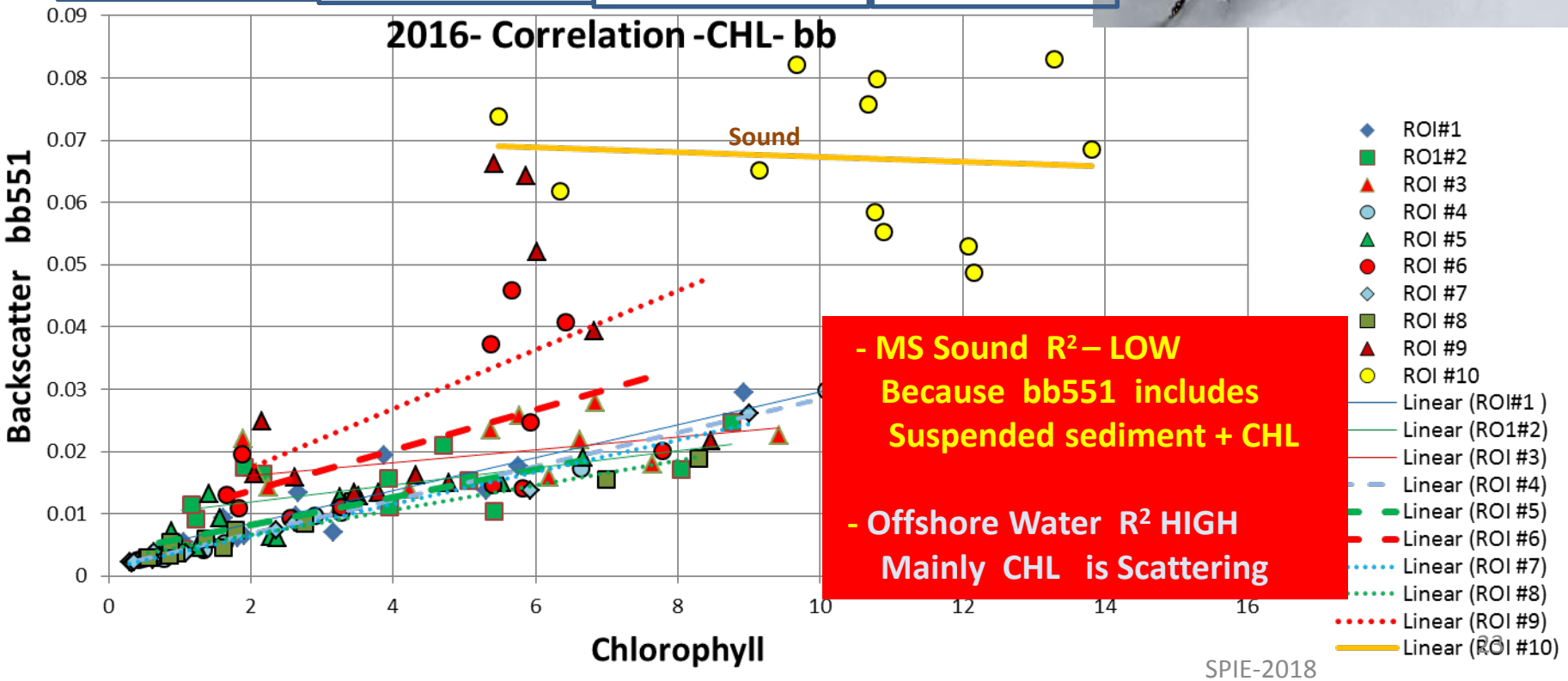
Seasonal Correlation Chlorophyll and Backscattering 2016

Changes with the Different Regions

Weaker R2 as move toward coast

	West	Mid	East	Ms Sound
Offshore	1 *Offshore* $y = 0.0026x + 0.0031$, $R^2 = 0.9185$	4 *High R2* $y = 0.0027x + 0.0014$, $R^2 = 0.9852$	7 $y = 0.0026x + 0.0013$, $R^2 = 0.9786$	
Mid	2 $y = 0.0014x + 0.0091$, $R^2 = 0.4203$	5 $y = 0.0022x + 0.0038$, $R^2 = 0.7118$	8 $y = 0.002x + 0.0026$, $R^2 = 0.9495$	10 $y = -0.0004x + 0.071$, $R^2 = 0.0063$
Coast	3 $y = 0.001x + 0.0142$, $R^2 = 0.2225$	6 $y = 0.0033x + 0.0073$, $R^2 = 0.2898$	9 $y = 0.0048x + 0.0078$, $R^2 = 0.2134$	

Sound is Poor R2



- MS Sound R^2 – LOW
  Because bb551 includes
  Suspended sediment + CHL

- Offshore Water R^2 HIGH
  Mainly CHL is Scattering

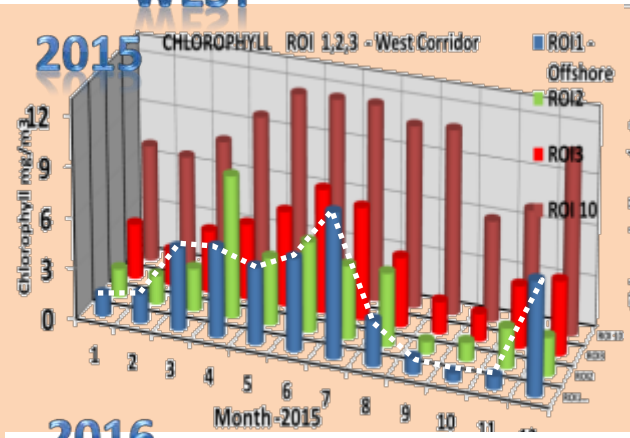
Changes in Seasonal Chlorophyll 2015 – 2016 - 2017

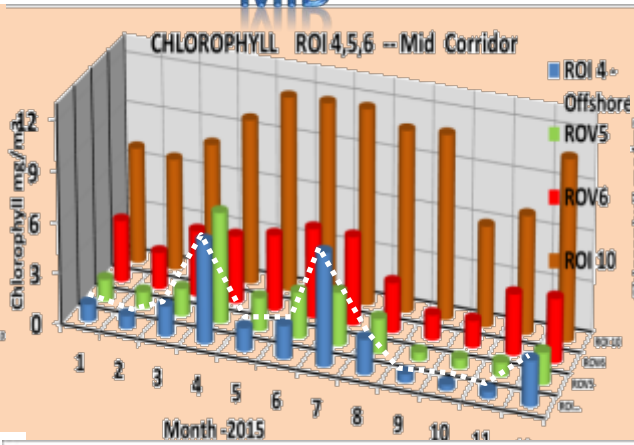
WEST

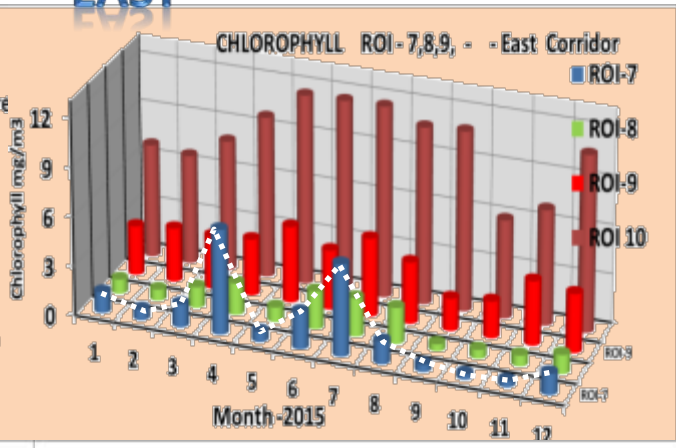
MID

EAST

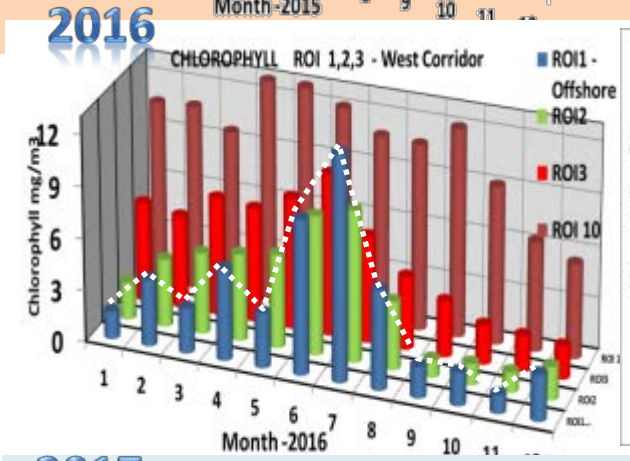
2015

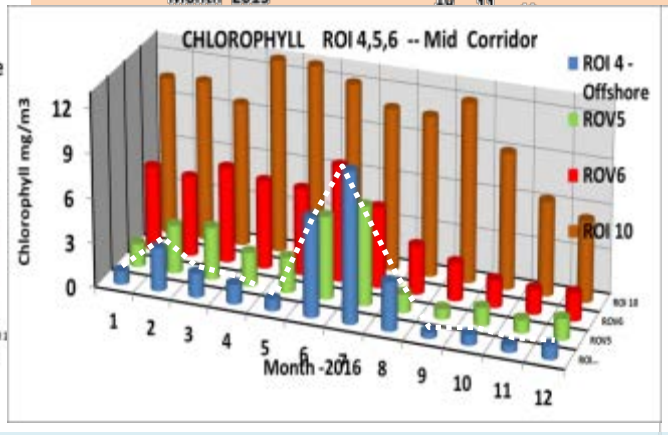


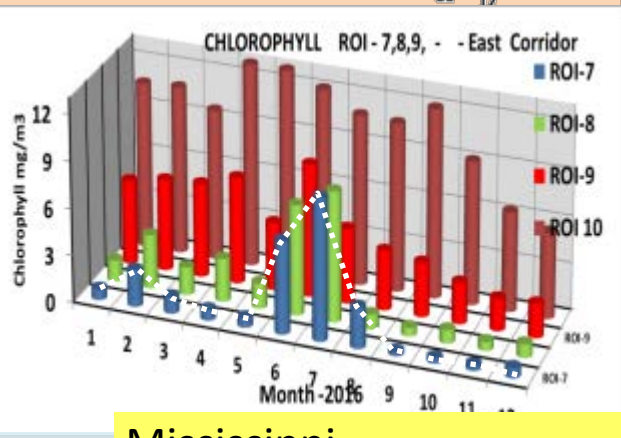




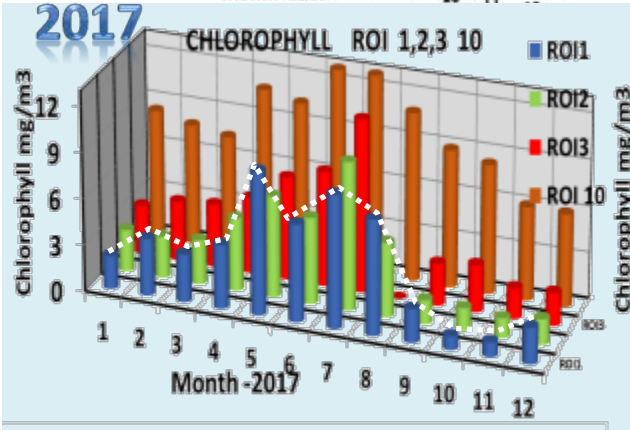
2016

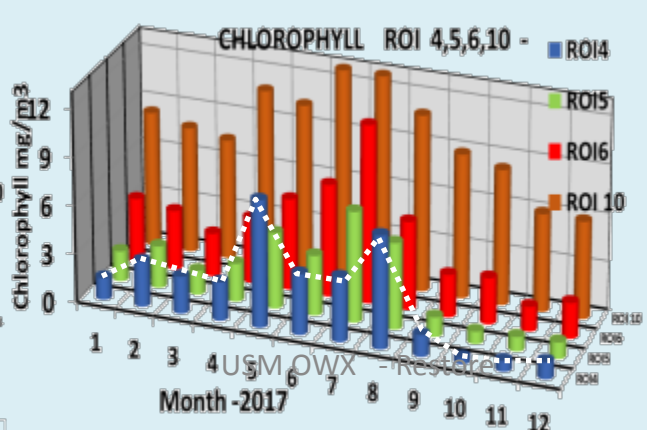


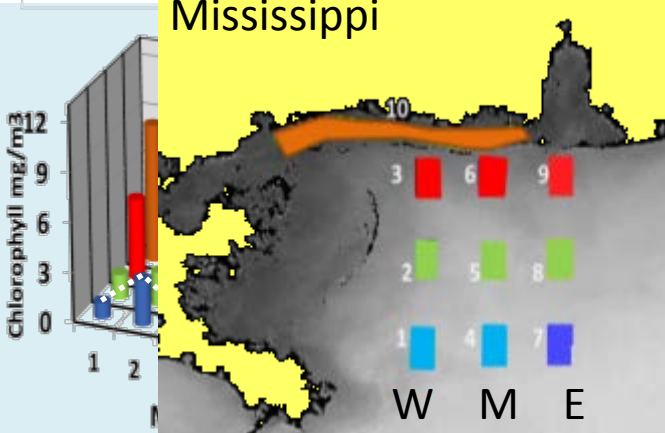




2017





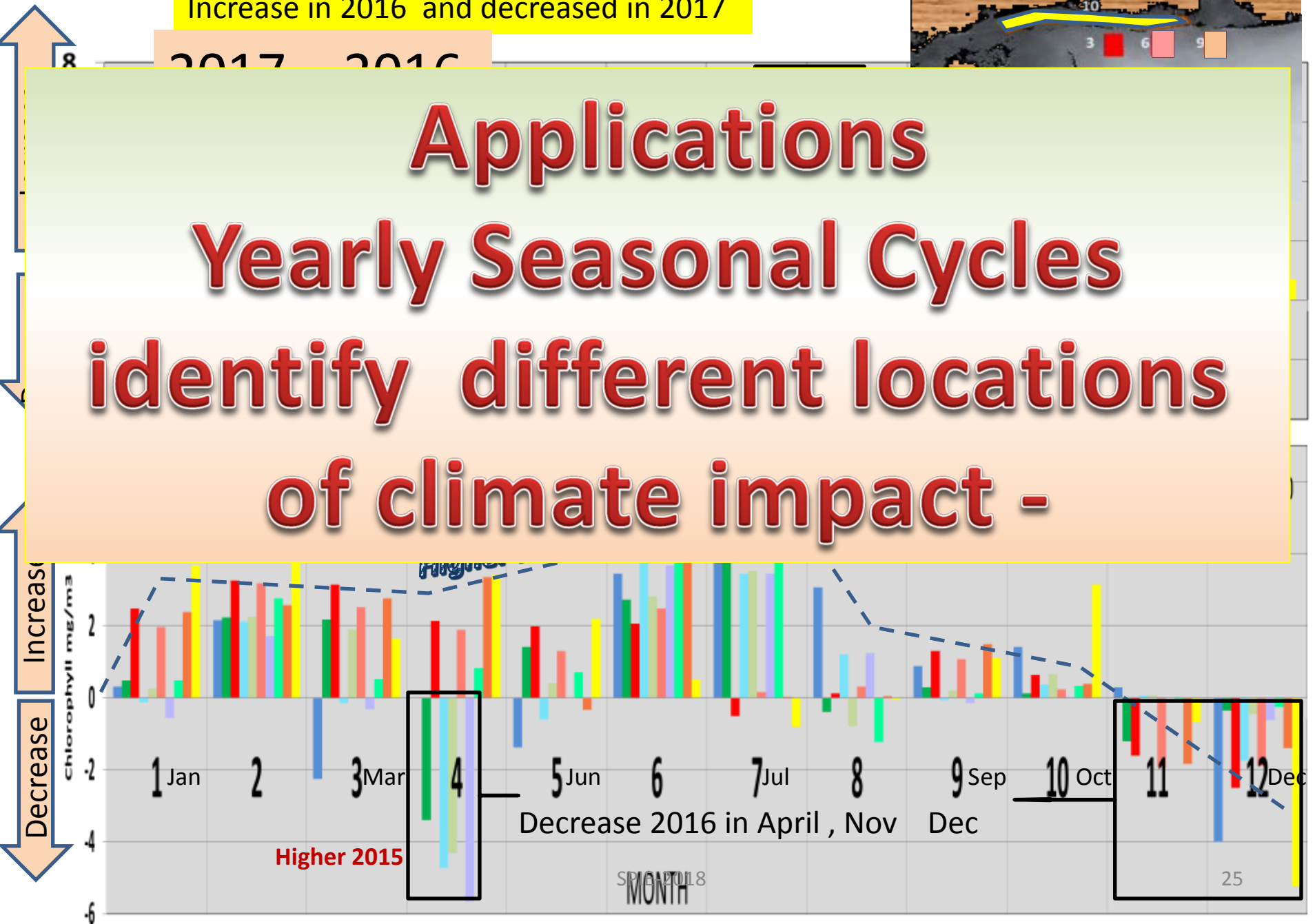


USM OWX - Restore

CHLOROPHYLL Yearly Changes – Difference All 10 ROI

Increase in 2016 and decreased in 2017

Applications Yearly Seasonal Cycles identify different locations of climate impact -



Sea Surface Temperature Yearly Changes – 2015- 2016- 2017

Difference in all locations 10 ROI

Location Varying Climate Change

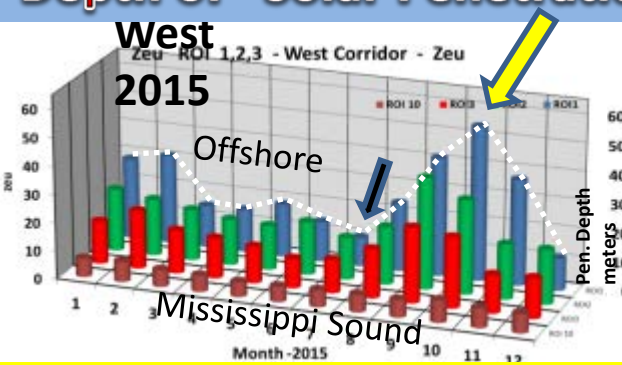
2017 – 2016

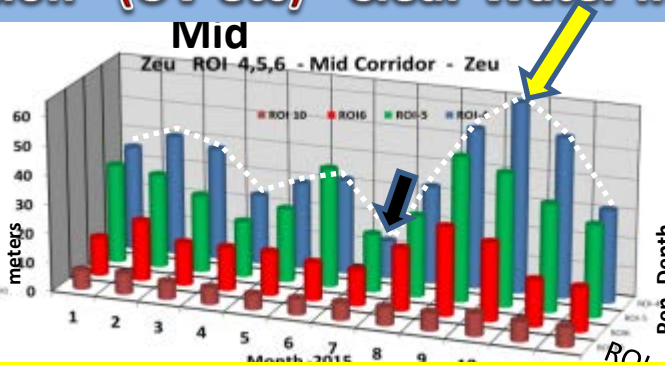
2016 – 2015

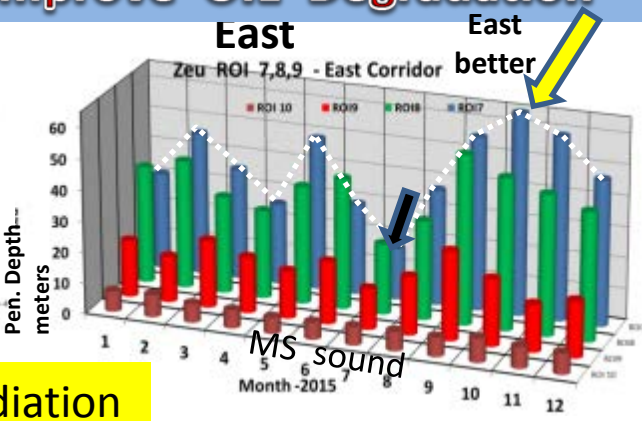
What are Months and location for Best OIL Degradation

Seasonal Euphotic depth Zeu 2015 – 2016 - 2017

Depth of Solar Penetration (UV etc) Clear Water improve OIL Degradation



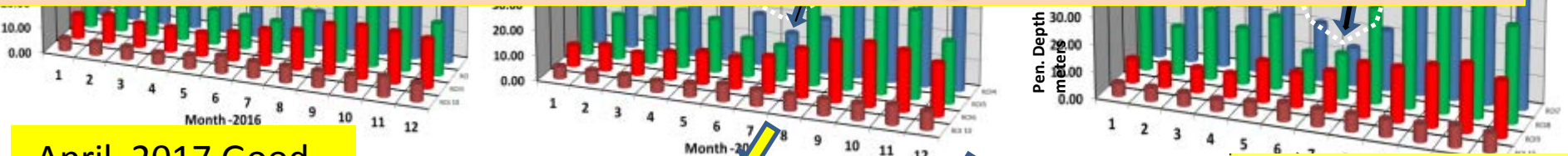




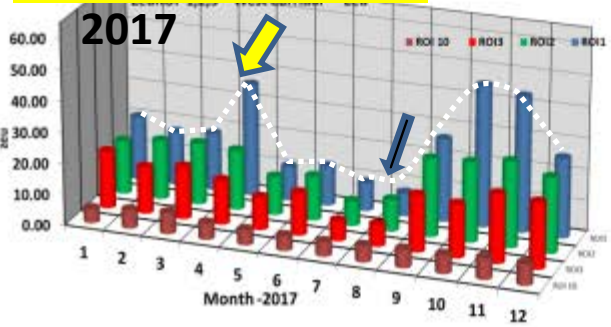
Greatest Zeu depth is best time for Oil Degradation from UV radiation

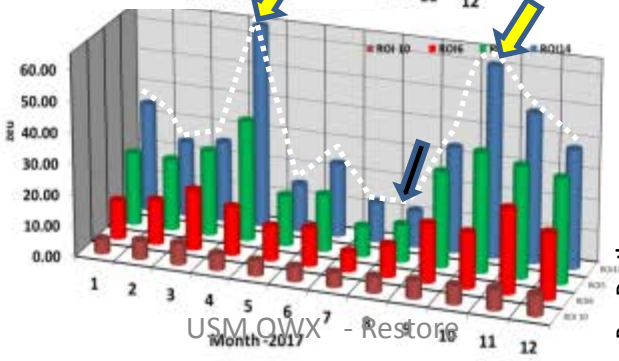
Best in Sep-Oct 2015- 2016 Worst in July

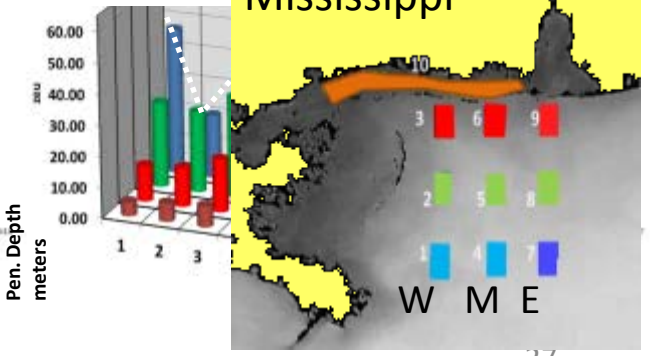
Seasonal DAP Applications



April 2017 Good







Applications of DAP Products seasonal Cycle

1) **SHELF Waters - monthly cycles has different cycles of bio-physical properties in offshore and coastal areas across the Mississippi shelf from 2015, 2016, and 2017**
   Can account for seasonal response in climate change. (Not yearly)
   Examples of monthly seasonal cycle differences between 2016 and 2015 and 2017 at each shelf location.

2) **Identifies Seasonal Forecast of the Ecosystem (specific location)**
   a. **When the MS river plume (low salinity) moves east ward → *May - June***
   b. **Offshore river plume affects the seasonal cross shelf cycle and properties**

3) **Ecological response - Seasonal Correlations between Bio-Physical properties changes at different regions across the shelf waters, and in Gulf.**
   (Chlorophyll to Salinity response is variable)
   Use DAP to identify a Region of Interest .

4. **Seasonal Photic depths shows locations that impact oil UV degradation.**

5. **Seasonal cycle identify how representative is a water mass at a location for time of year . Identify data gaps.**
   Can apply to Fisheries !!

4. Applications – Anomaly management

Tools – Fisheries

Location for adaptive Sampling

Is Station data normal / abnormal

Locate Possible Data Collection gaps

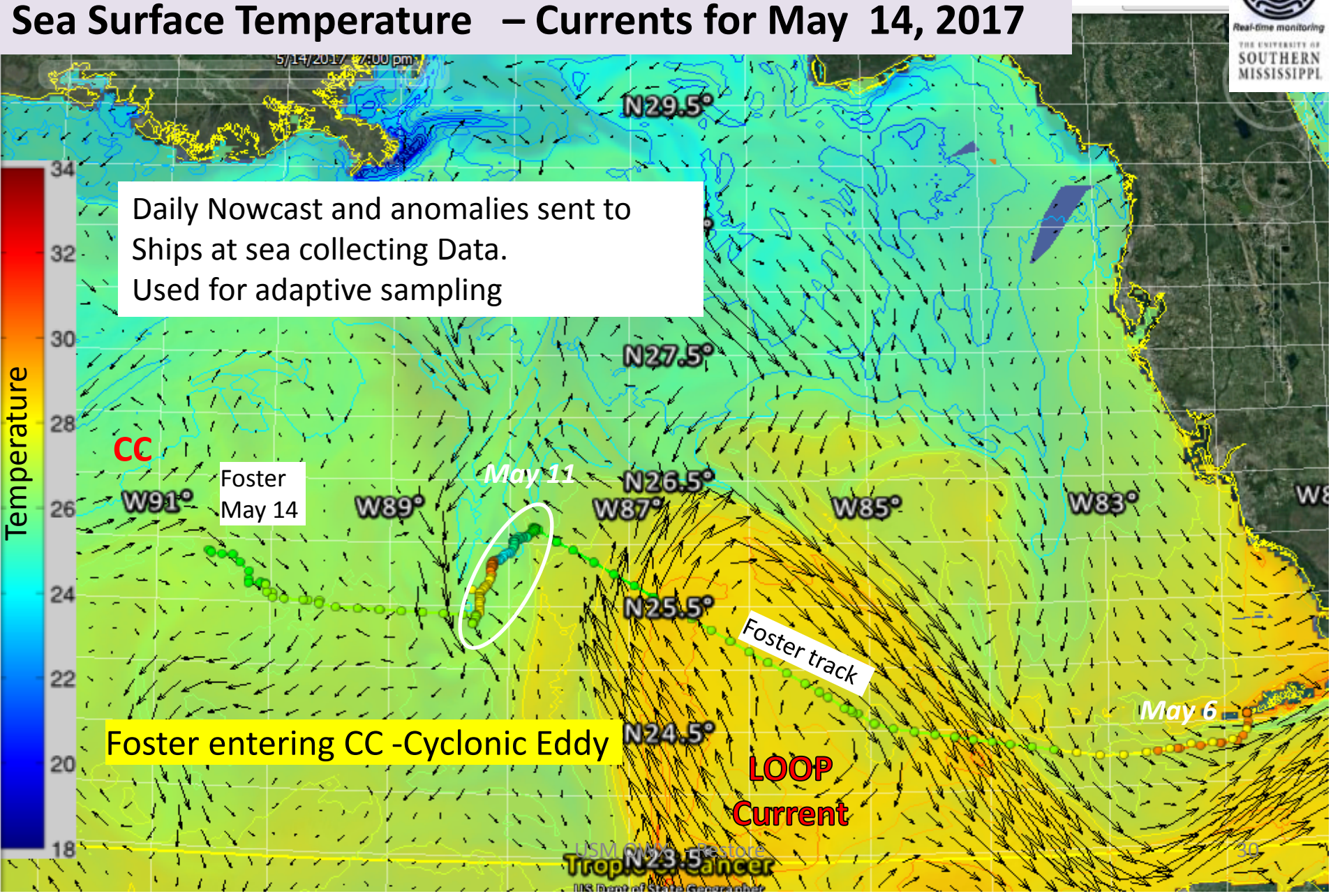
Daily DAP Data Sent to Ships at sea,
SeaMAP cruise,
Nancy Foster Blue Fine Tuna

NOWCAST

Foster Cruise May 14 2017

Cruise Track

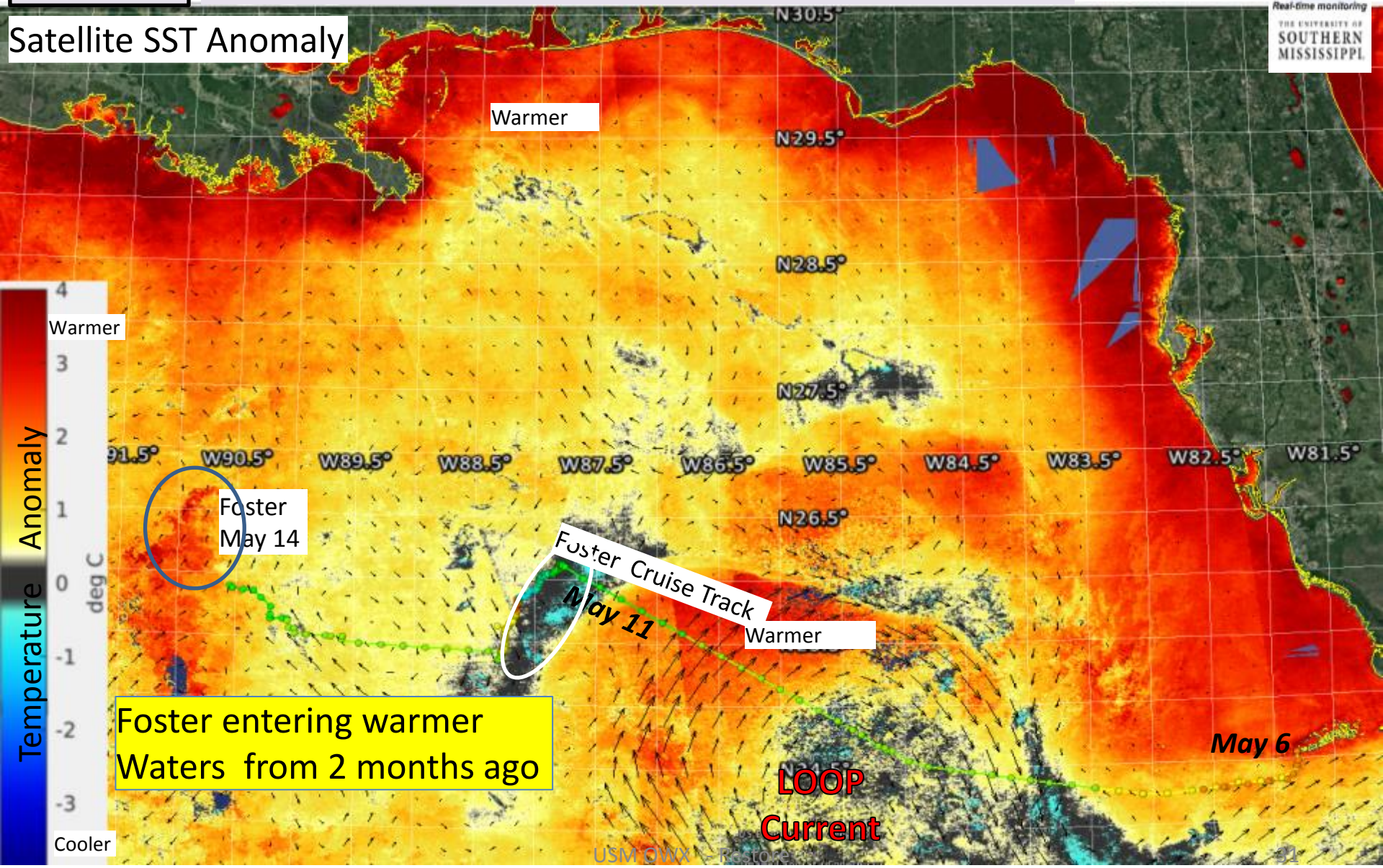
Sea Surface Temperature – Currents for May 14, 2017



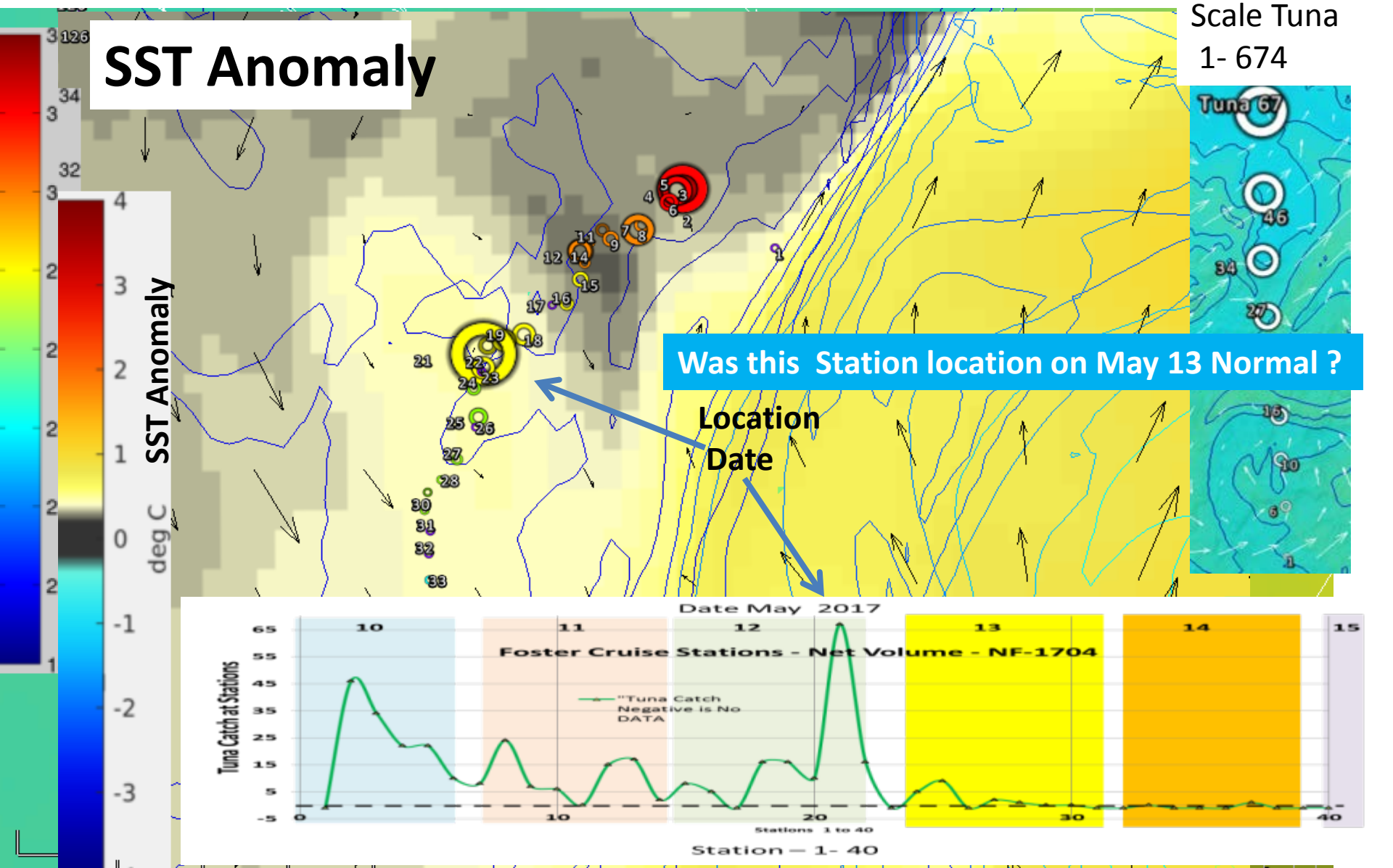
Foster (April 28 – May 14 2017)

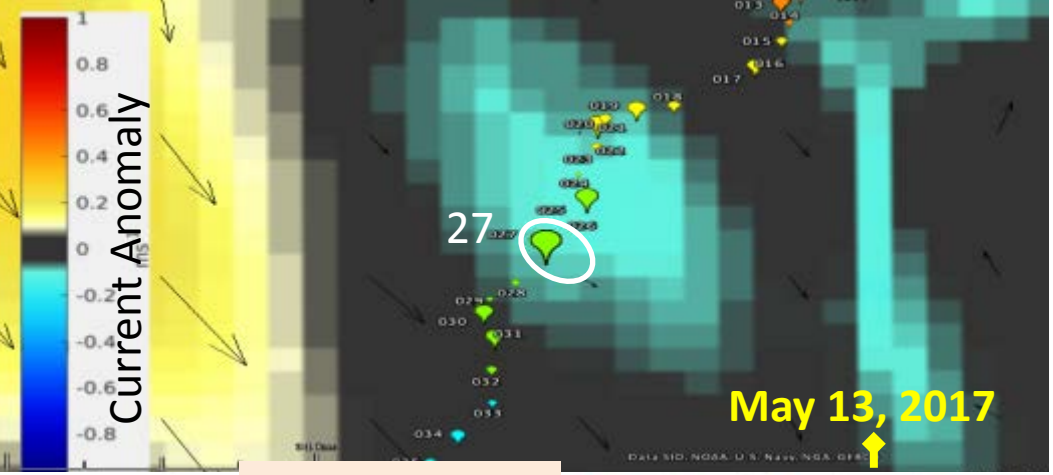
Anomaly

Sea Surface Temperature – Avg. Currents for May 1, 2017



Foster Fish Catch
Sea Surface Temperature May 2017





Stability of Station 27

2016- 2018

How location changes yearly :

Identify Stations Seasonal trends yearly

Only 3 shown

Apply to all Seamap Stations

define "stability" in stations every year!

IDENTIFY ABNORMAL STATIONS to

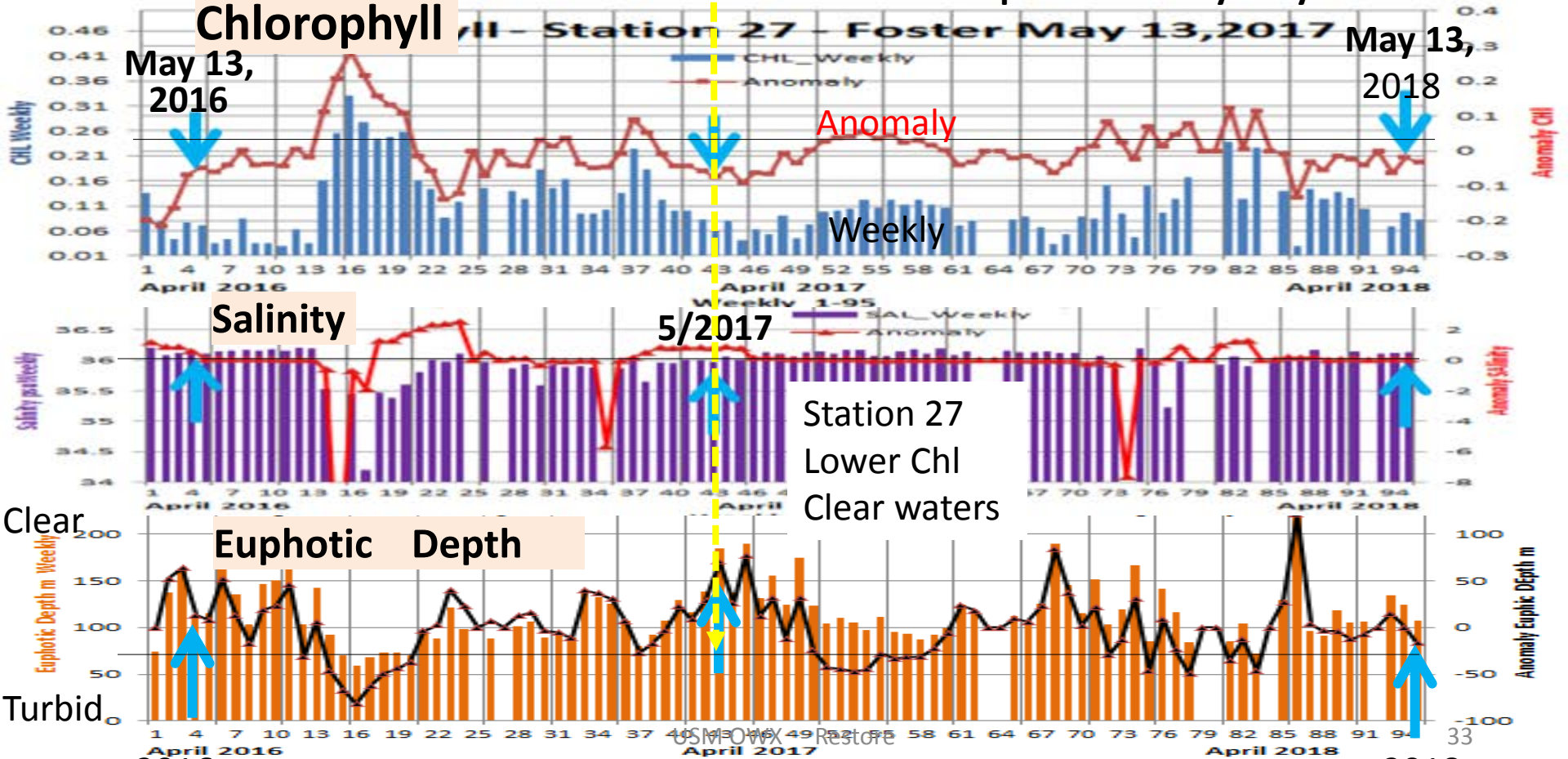
Improve Gulf's yearly fisheries

May 13, 2017

Chlorophyll

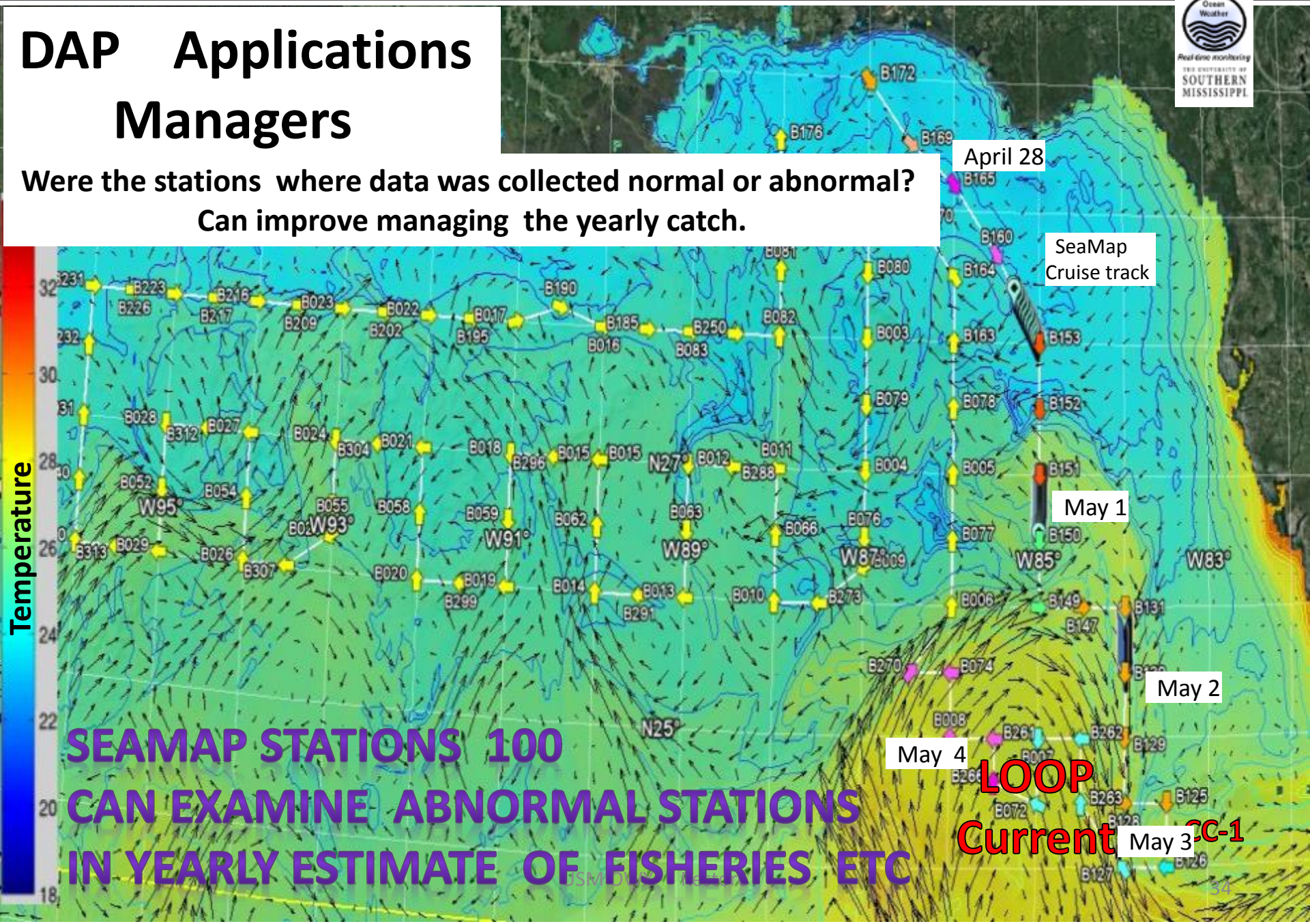
May 13, 2016

May 13, 2018



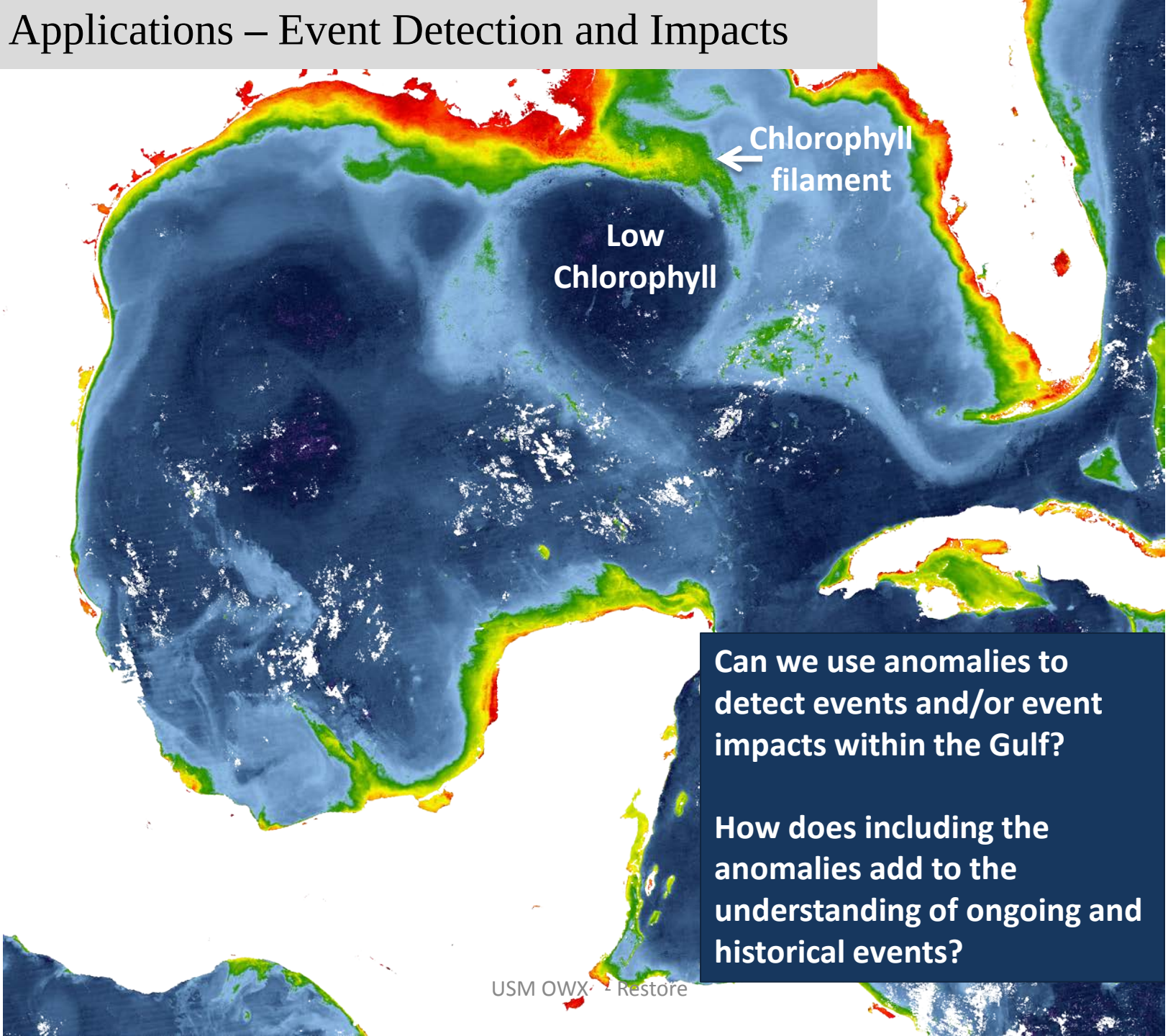
DAP Applications Managers

Were the stations where data was collected normal or abnormal?
Can improve managing the yearly catch.



5: Identifying Ocean Events- Flower Garden Banks, Bonnie Carrie, 2017 Hurricanes

DAP Applications – Event Detection and Impacts



Can we use anomalies to detect events and/or event impacts within the Gulf?

How does including the anomalies add to the understanding of ongoing and historical events?

Event 1 - 2016 Bonnet Carré Spillway Opening

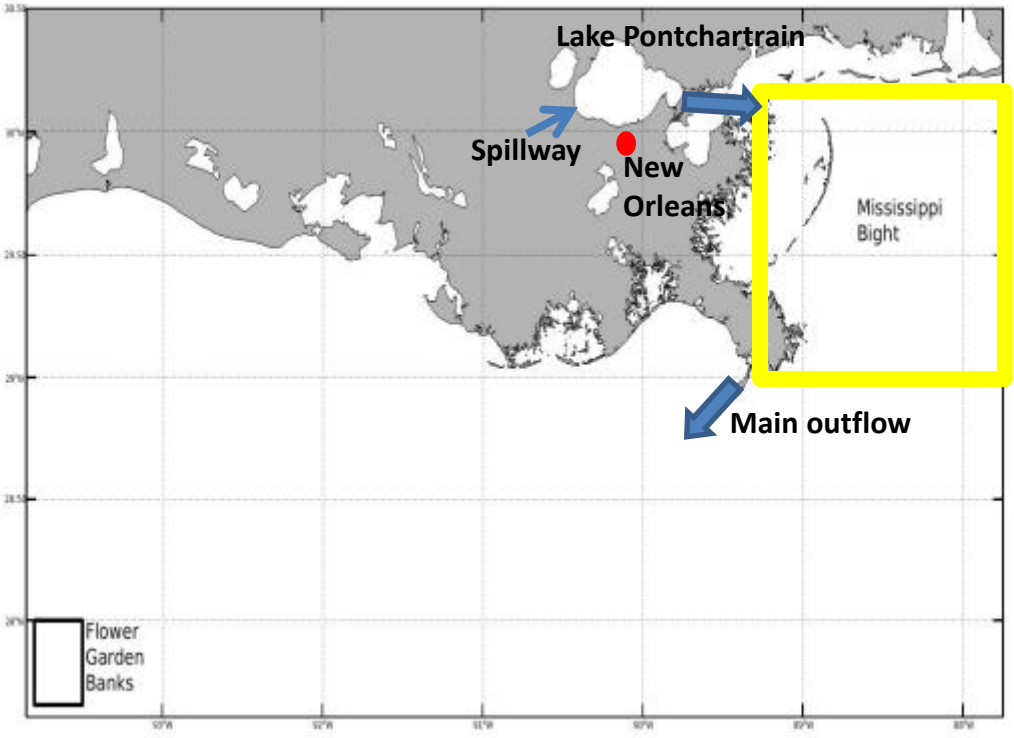
Built in 1931, the spillway is designed to mitigate flooding of the Mississippi River by diverting water from the main channel to Lake Ponchartrain

Opening the spillway leads to river water influx East of the Birdfoot Delta (main discharge is typically the west side of the delta)

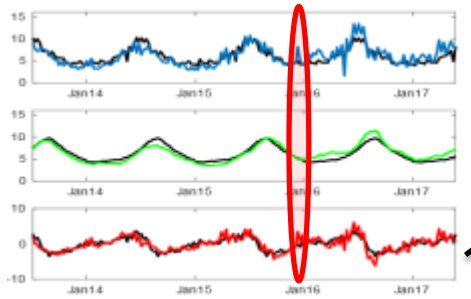
Spillway has only opened 11 times

Spillway is opened for 22 days (January 10 – February 1) to alleviate river outflow

The 2016 opening was the earliest calendar year opening in its history



Event 1 - 2016 Bonnet Carré Spillway Opening

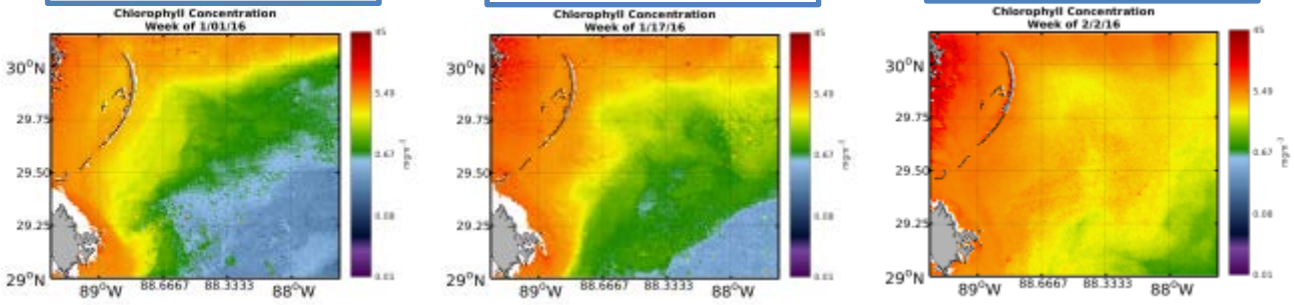


Pre-Opening

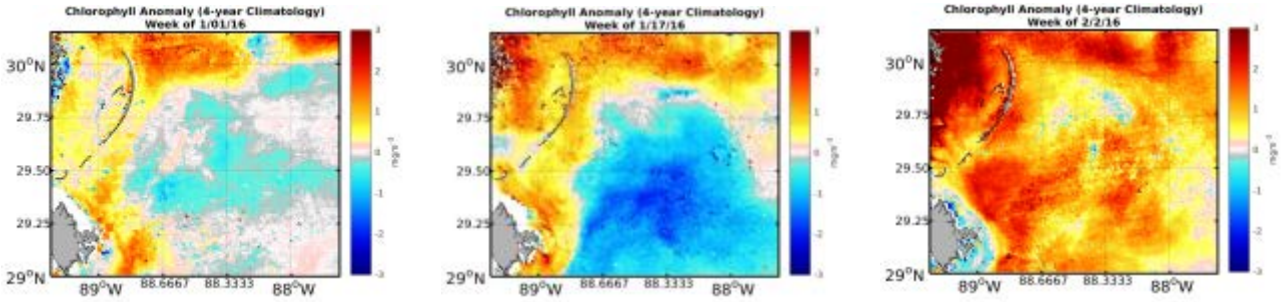
Maximum Outflow

Post-Closing

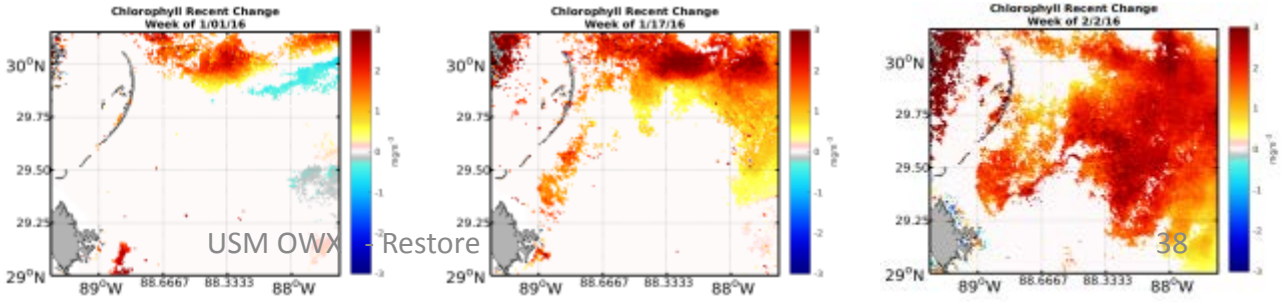
Mean Weekly Chlorophyll shows progression of front southeastward across the MS Bight during the spillway event.



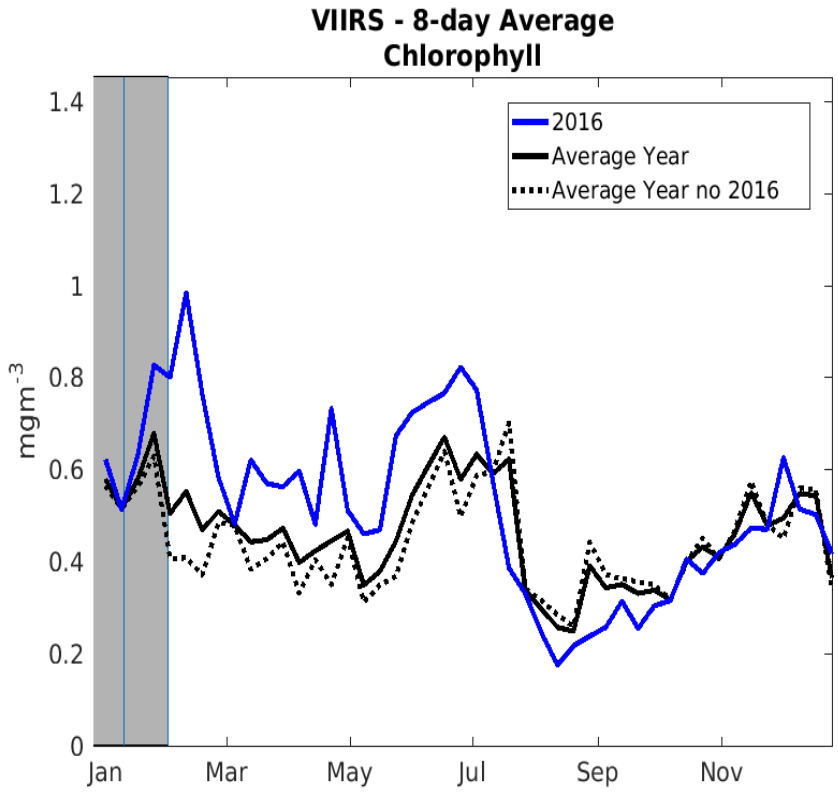
Anomaly of Chlorophyll based a derived **4-year climatology** shows increasing chlorophyll amplitude of deviation from typical conditions. **Entire region elevated by closing**.



Recent Change of Chlorophyll shows spatial variability in chlorophyll signal throughout the event due to movement/growth.



Event 1 - 2016 Bonnet Carré Spillway Opening



MS Bight Chlorophyll values (weeks of event):

Climatology : 0.53 – 0.66 mgm^{-3}

Climatology : 0.53 – 0.65 mgm^{-3} (no 2016)

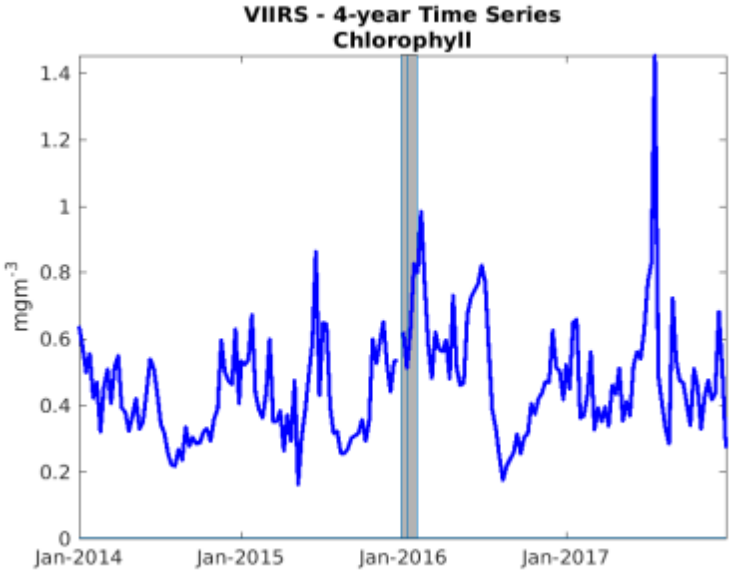
Year 2016 : 0.53 – 0.82 (1.0) mgm^{-3}

2016 event values are ~60 % higher than climatological values

Note this is averaged for the region and not the maximum detected

Event 1 - 2016 Bonnet Carré Spillway Opening

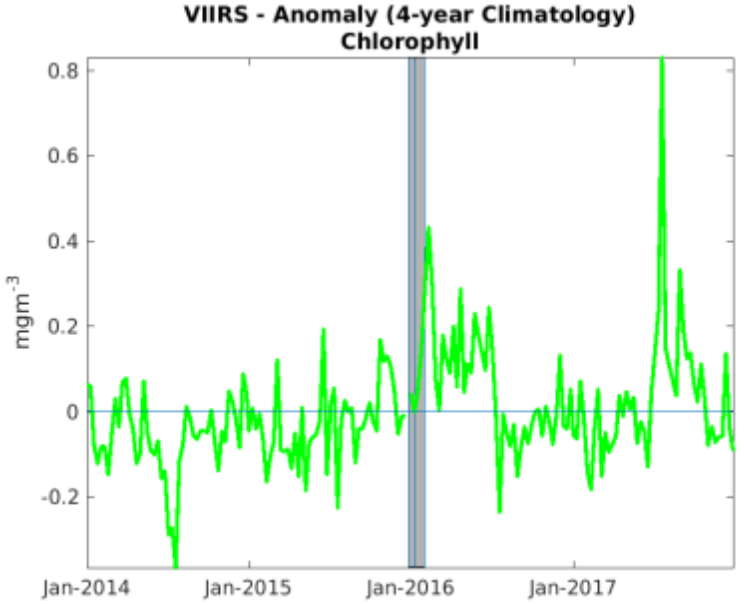
MS Bight Time Series of Chlorophyll
Peak value is 1.0 mgm^{-3} corresponding to Bonnet Carré
Spillway event is the 2nd highest Chlorophyll value observed
Other peaks at 1.41 mgm^{-3} and less than 1 mgm^{-3}



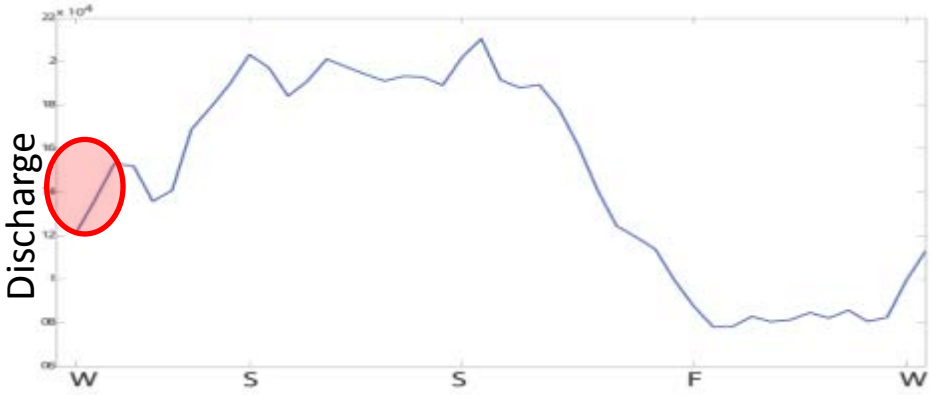
MS Bight Time Series of Chlorophyll Anomaly
Peak anomaly is (+)0.4 mgm^{-3} corresponding with Bonnet Carre

Second strongest positive anomaly is associated with the Bonnet Carré Spillway event

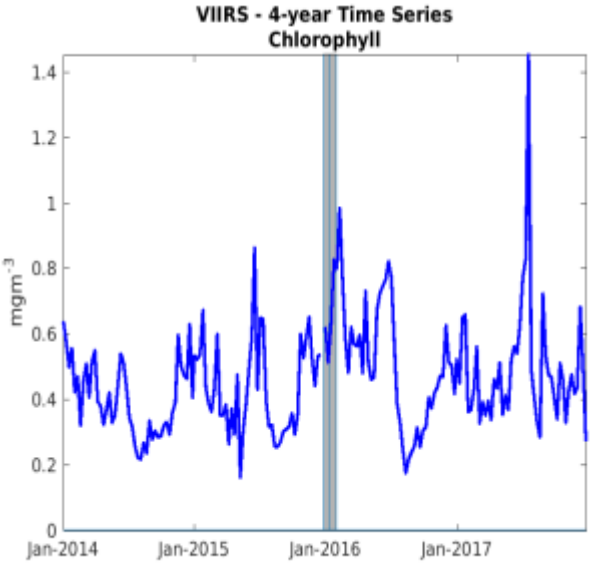
The positive anomaly persists until the last week of June 2016



Event 1 - 2016 Bonnet Carré Spillway Opening



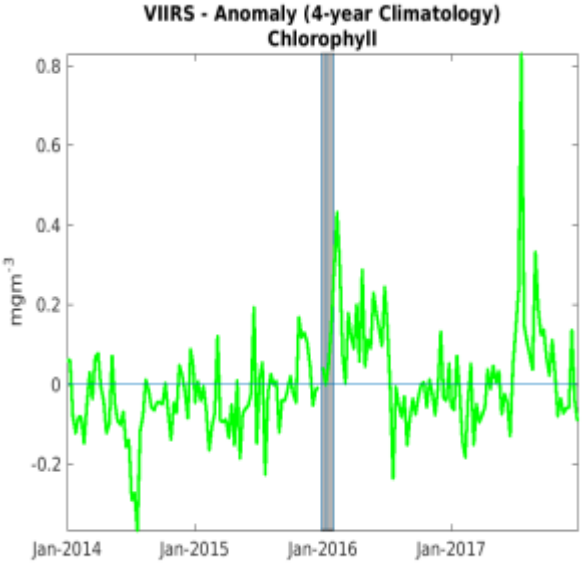
Mississippi River at Baton Rouge
Seasonal Discharge (USGS gauge)



Is the anomaly due only to absolute chlorophyll value?

11-year climatology of Mississippi River discharge indicates that the spillway was opened during a period of relatively low river flow

Previous works (Jones and Wiggert, 2015) show that the Mississippi River plume is typically constrained west of the Birdfoot Delta at this time of year due to wind-driven currents.



Event 1 - 2016 Bonnet Carré Spillway Opening

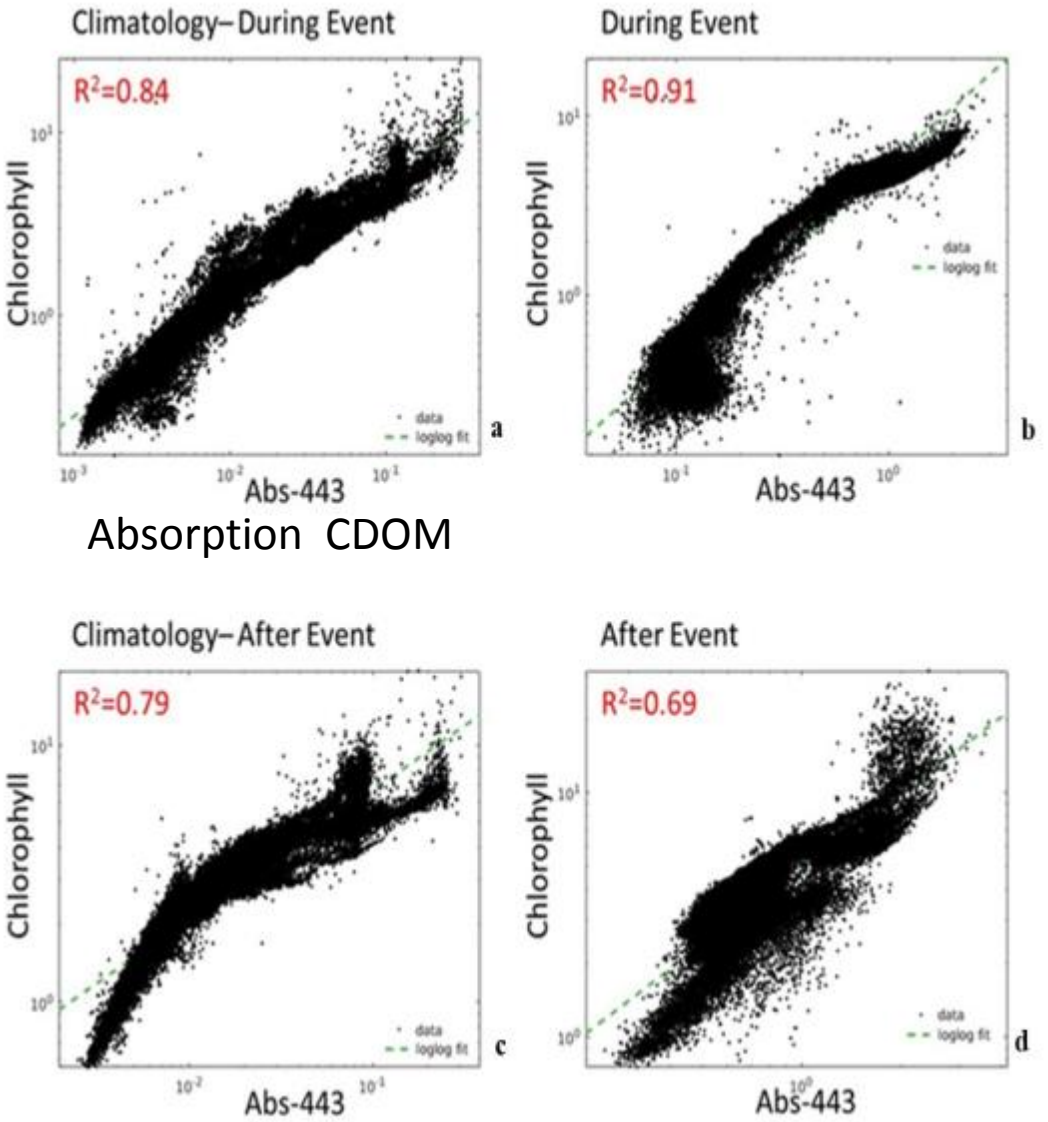
Is the anomaly due only to absolute chlorophyll value?

Typical chlorophyll to absorption relationship has an R^2 of 0.84

During the opening of the spillway, the R^2 increased to 0.91

Following the event, the R^2 decreased to 0.69, much weaker than previous or climatological (R^2 = 0.79)

The weakening contribution of chlorophyll to Absorption @443 points to increased detritus and CDOM to the region



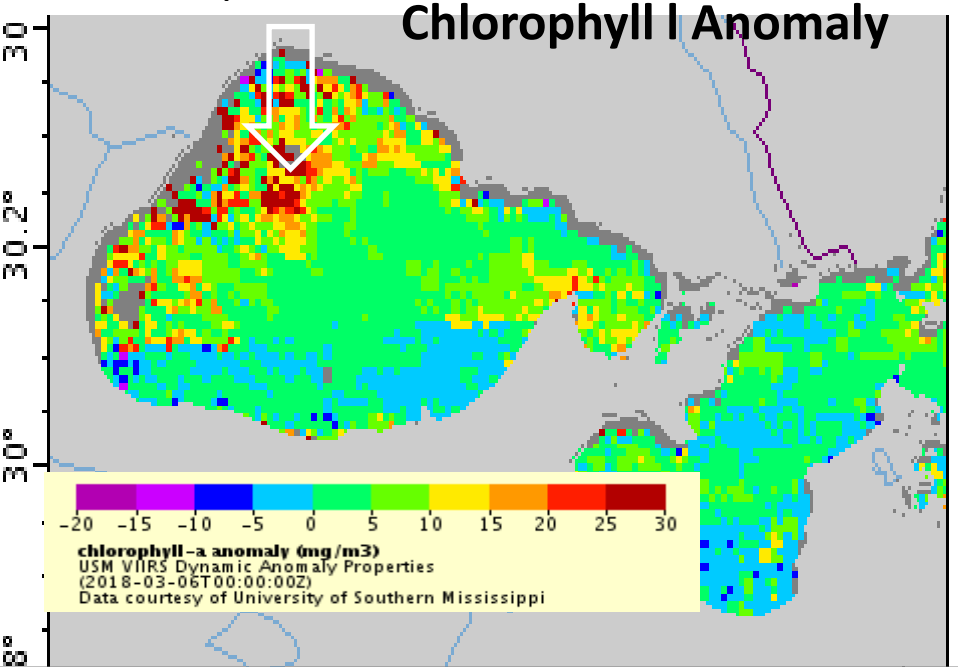
Event 1 - 2016 Bonnet Carré Spillway Opening

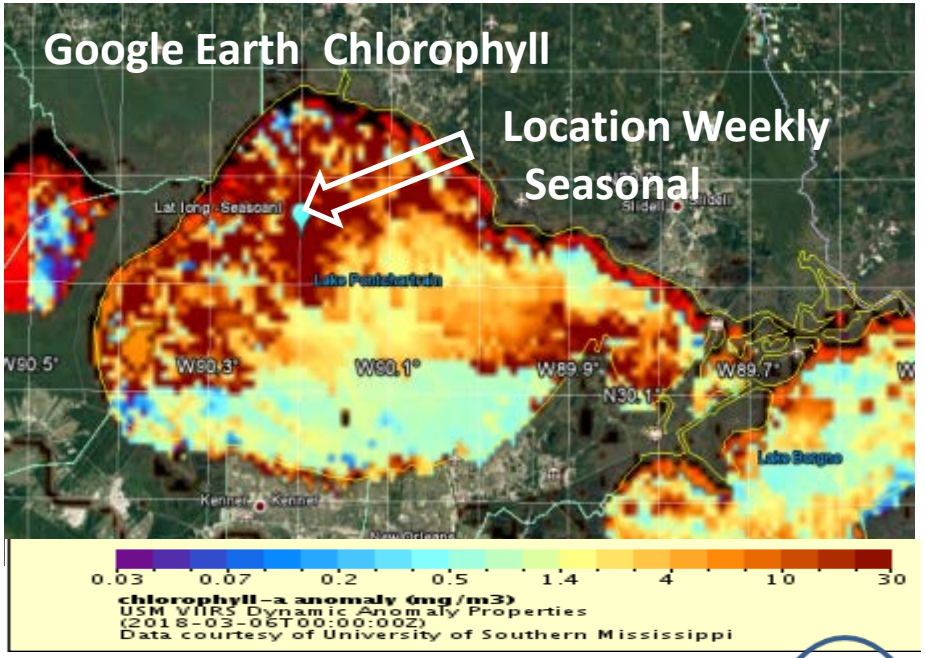
1. **Chlorophyll signals show the southeastward progression of flood waters across the MS Bight.**
2. **Chlorophyll was elevated above typical conditions for the entire study region following the spillway closing.**
3. **An immediate short-term response was noted as a peak in the Chlorophyll anomaly time series for the MS Bight. The peak was the second highest 4-year positive anomaly for the region, corresponding with historically lower MS River discharge and plume influx to the region.**
4. **The anomaly time series for MS Bight Chlorophyll shows that the elevated Chlorophyll persisted for months.**
5. **The weakening contribution of chlorophyll to Absorption @443 may indicate changes in water quality to the outer shelf.**
6. **The persistent chlorophyll/absorption signal and potential changes in water quality could pose significant ecosystem considerations with increasing spillway opening frequency.**
7. **A robust field study to validate local remote sensing signals and assist in monitoring is suggested.**

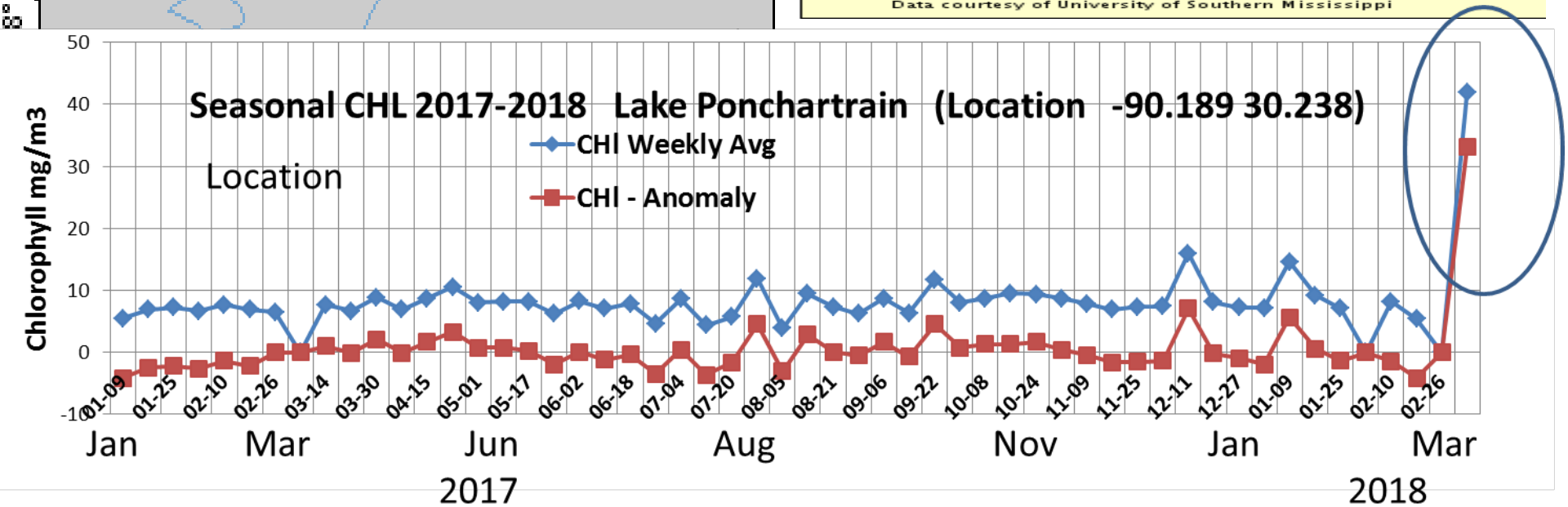
Recent Spillway Event – Sent to USGS March 6, 2018

Lake Pontchartrain

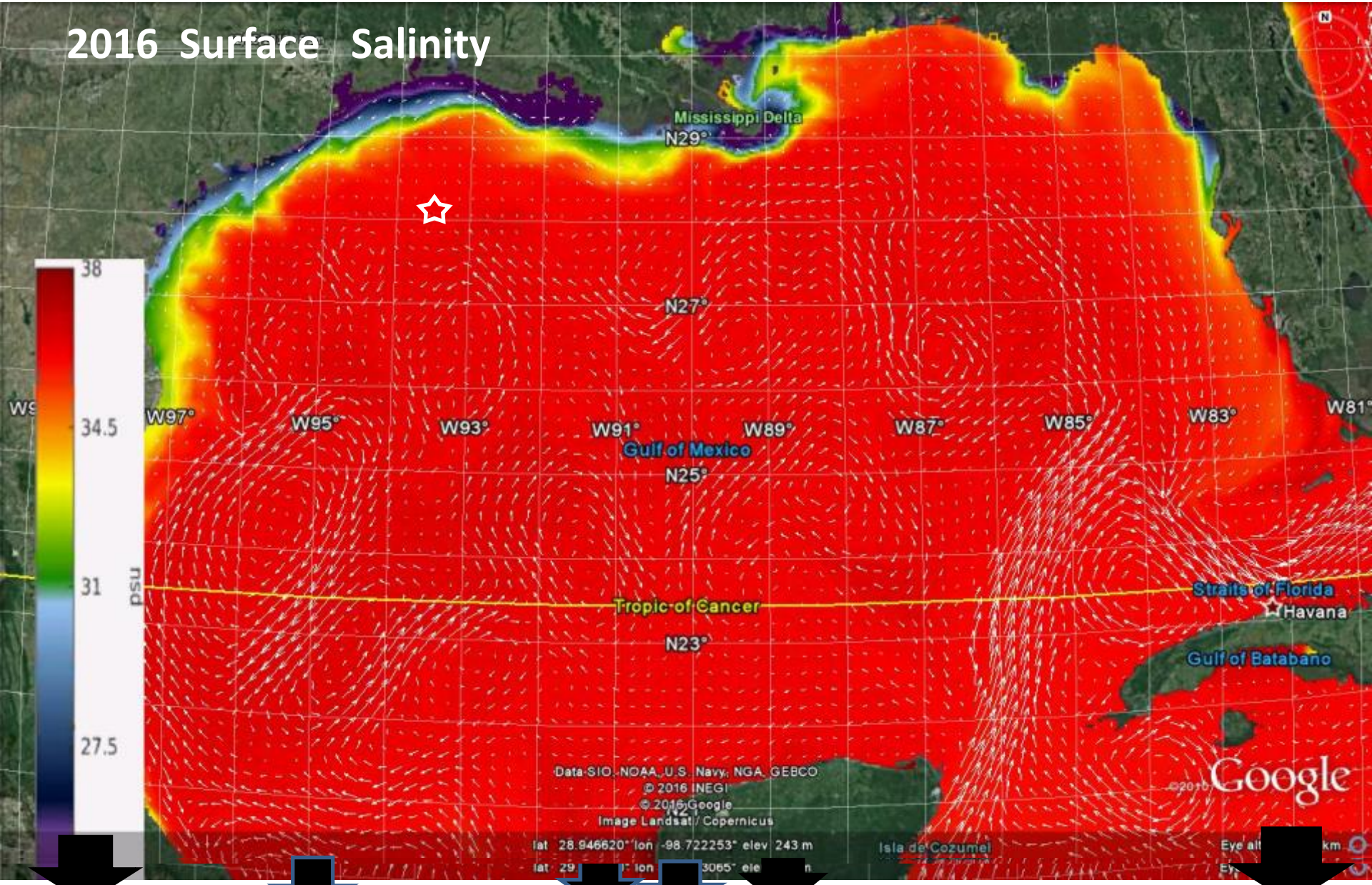
Hotspot Location







Second Event –Flower Garden Banks in 2016



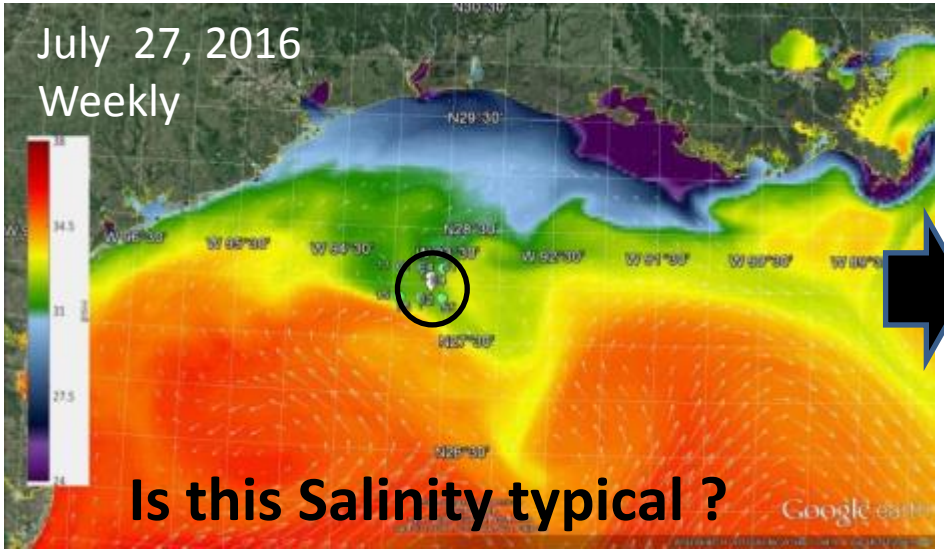
Jan 1 Feb Mar Apr May Jun July Aug Sept Oct Nov Dec

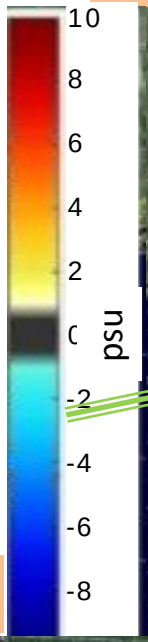
Second Event - Flower Garden Banks July 2016

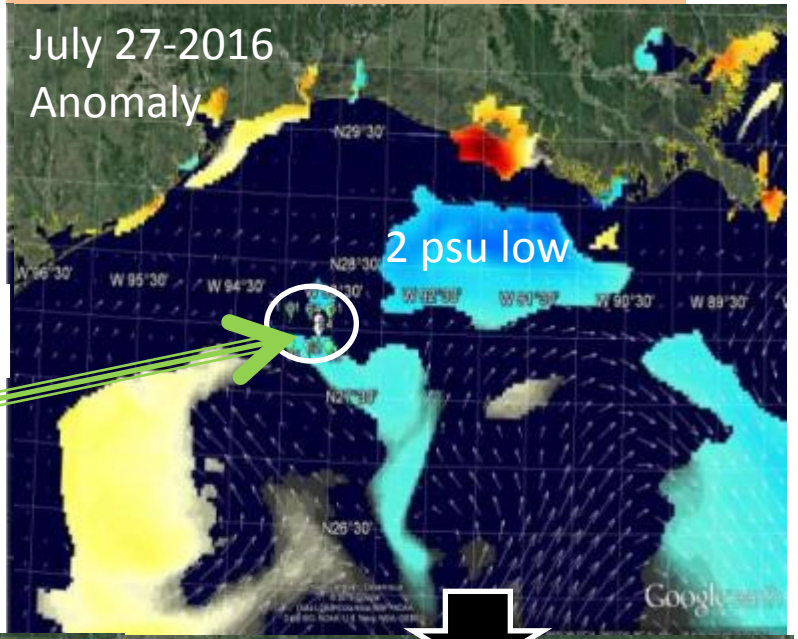
Dynamic Anomaly DAP Properties

Bleaching event was observed in late July

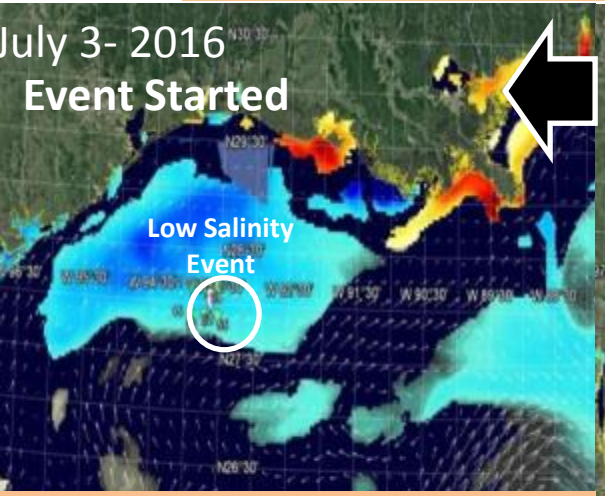
Salinity Anomaly - MASK 2

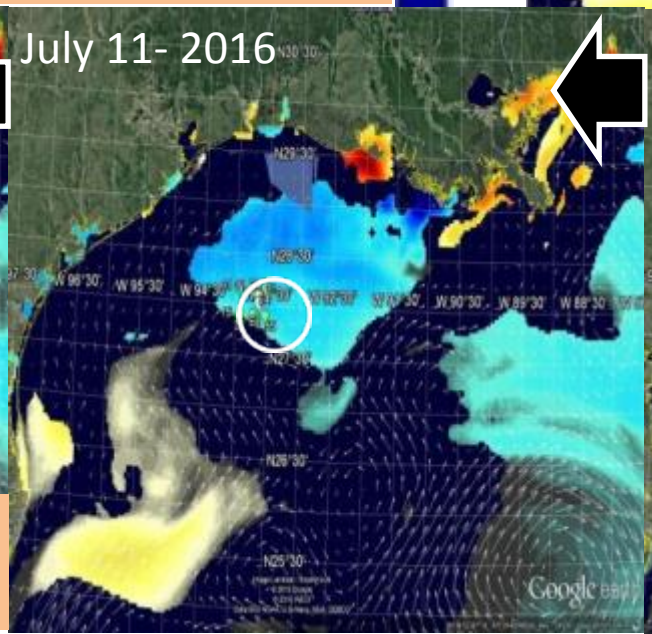


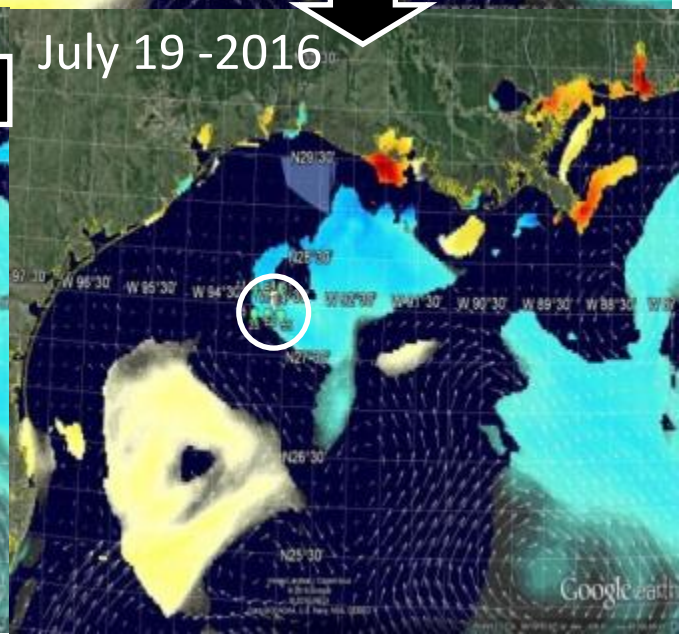




Weekly Changes in Salinity Anomaly

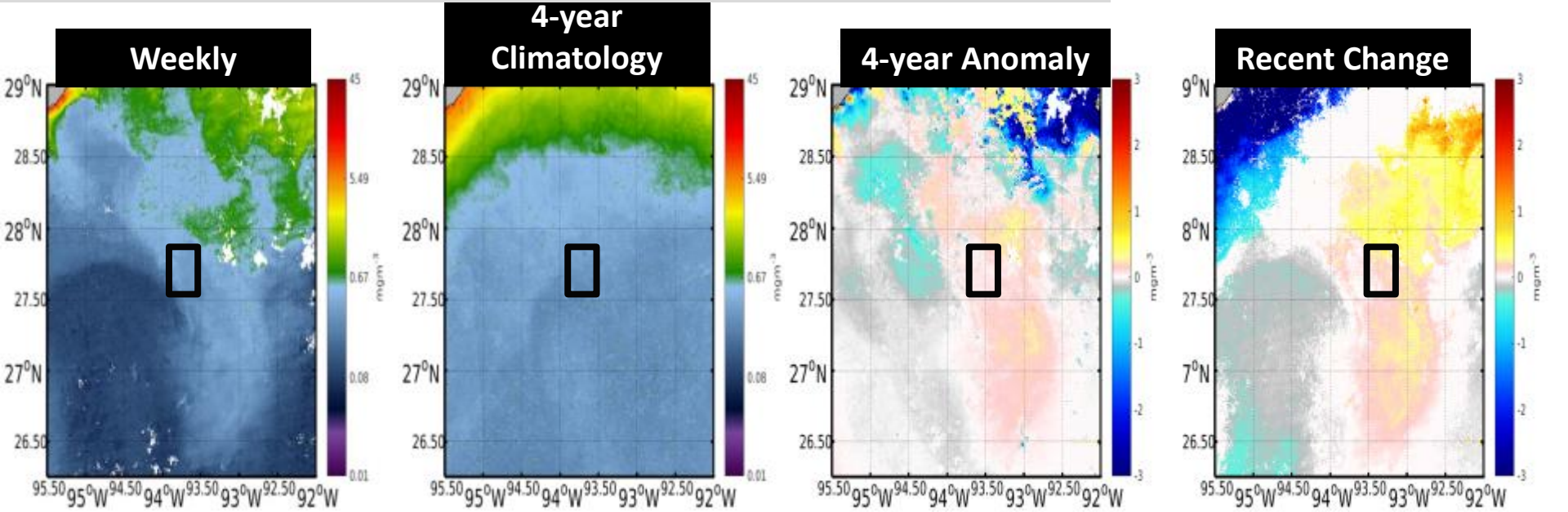






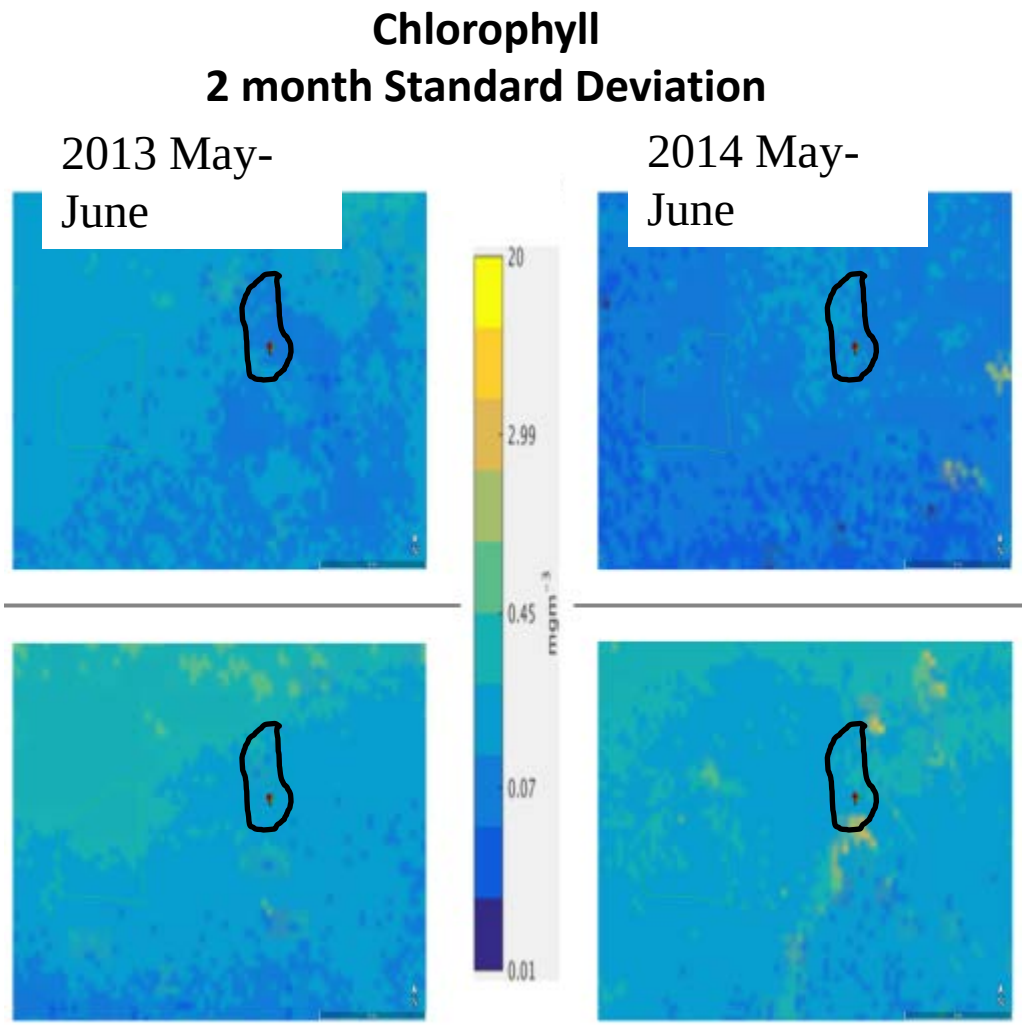
Large regional of Abnormal Low Salinity

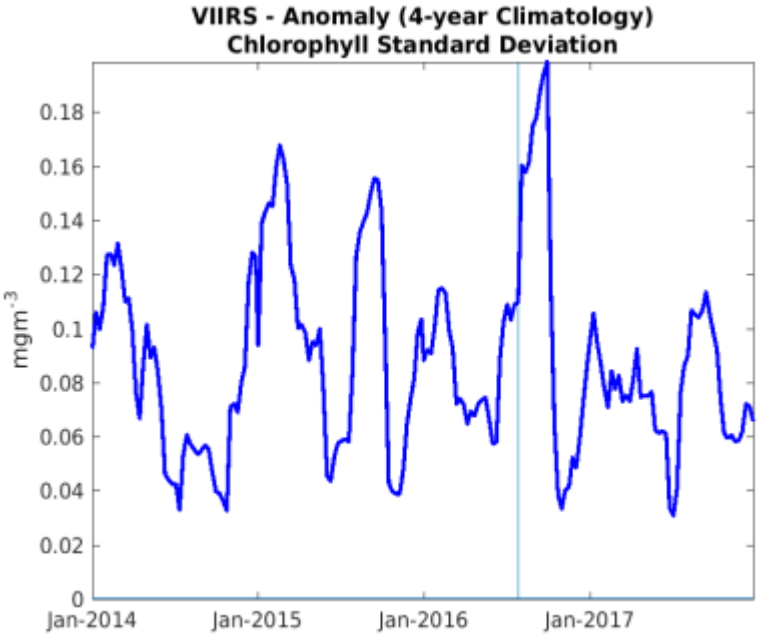
Event 2 - 2016 Flower Garden Banks Mortality



- Study region is a 50 x 50 km region encompassing both West and East Flower Garden Banks locations
- Inner-shelf chlorophyll-rich waters are seen to spread near the Flower Garden Banks Sanctuary during the week of discovery of the mass die-off
- Values at this week (0.65 mgm^{-3}) and in weeks leading up to the die-off are higher than typical (0.67 mgm^{-3}), but not in a range of concern
- Anomaly and Recent Change fields show a small elevation of chlorophyll above typical and recent mean conditions

Event 2 - 2016 Flower Garden Banks Mortality





Yearly plots of chlorophyll variability in the months leading up to the discovery of the die-off

maximum st. dev.

2013 – 0.08 mgm^{-3}
2014 – 0.08 mgm^{-3}
2015 - 0.21 mgm^{-3}
2016 - 3.11 mgm^{-3}

The time series of chlorophyll variability does not show the difference indicated by the maximum values

Event 2 - 2016 Flower Garden Banks Mortality

Is the anomaly due only to absolute chlorophyll value?

Typical chlorophyll to absorption relationship has an R^2 of 0.26

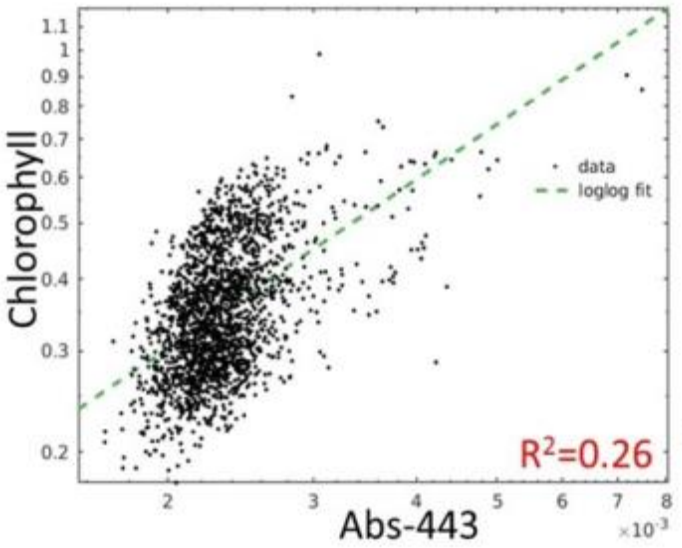
At the time of the mortality event, the R^2 increased to 0.68

The low typical relationship of chlorophyll to absorption @443 may be due to reef reflectance muting the chlorophyll signal

A phytoplankton bloom, may have caused the strengthening relationship during the event. However, turbid waters due to reported 'cloudiness' may have contributed as well.

Week July
5 years

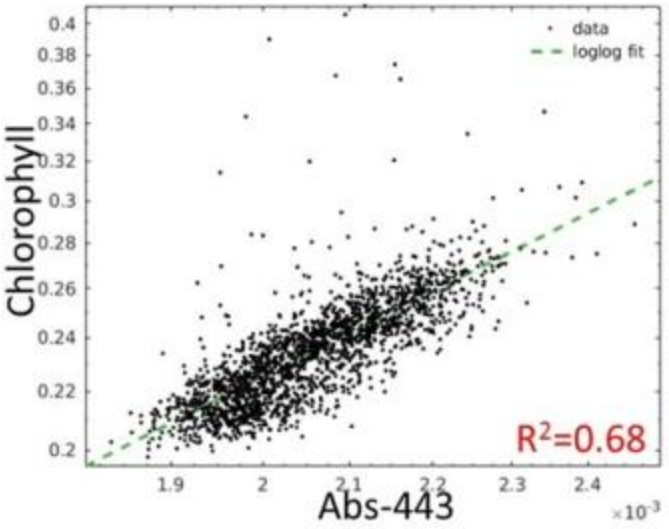
2013-2018
Full VIIRS record – Event time only



a

Week July
2016

During Event

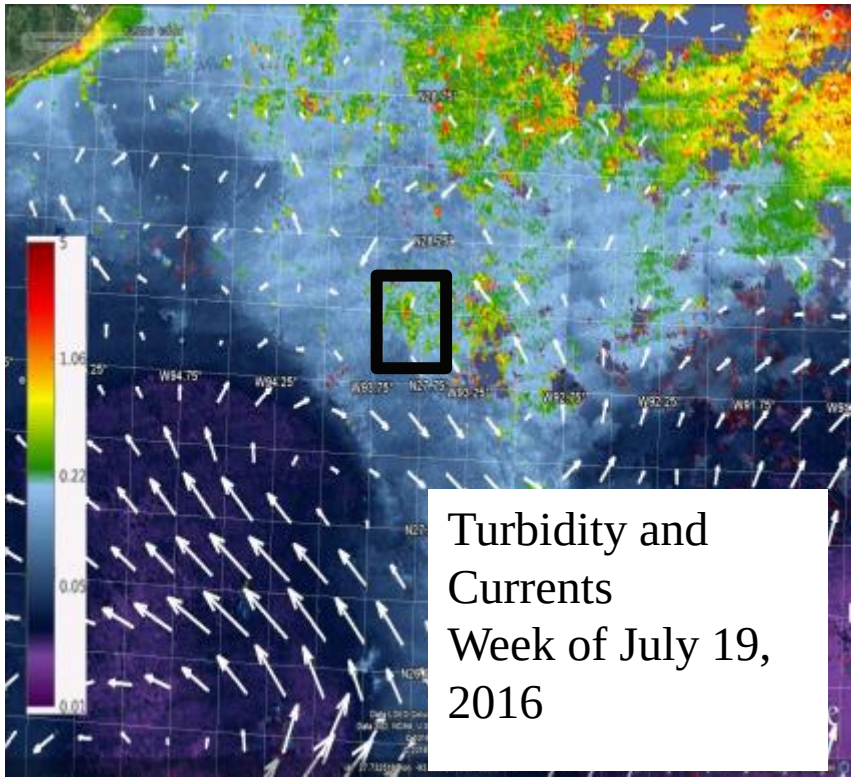


b

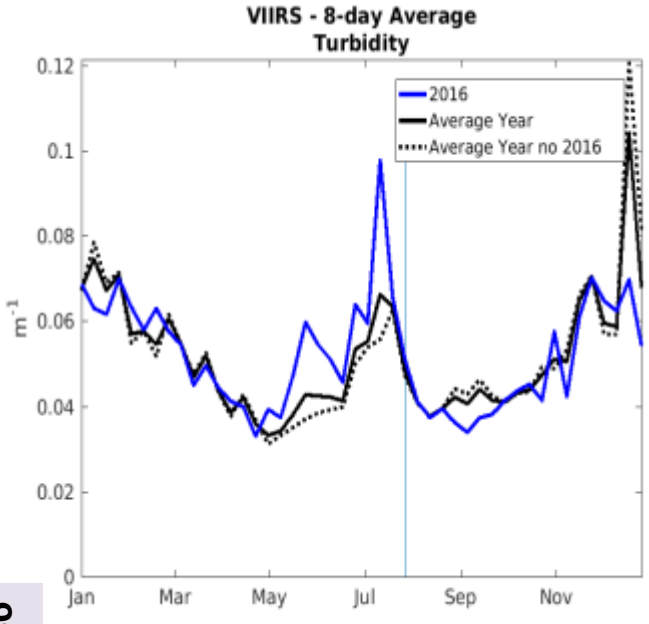
Event 2 - 2016 Flower Garden Banks Mortality

Turbidity (determined from Kd or diffuse attenuation coefficient) is elevated above climatological values for a period of 7 weeks before the discovery of the die-off.

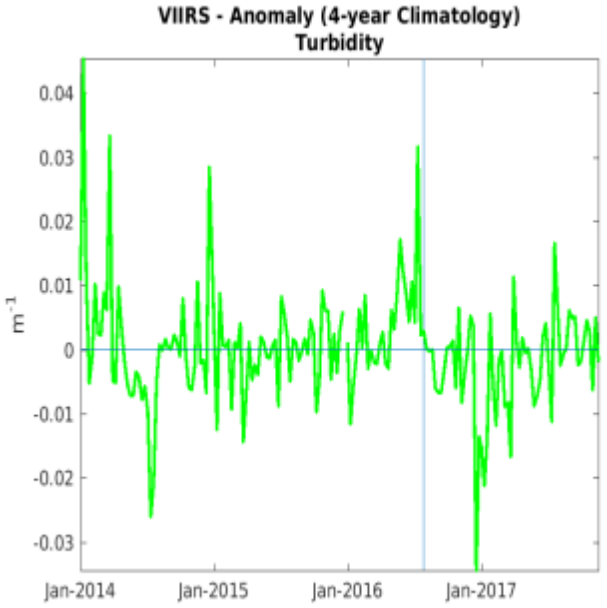
The climatology time series of turbidity shows that the weeks prior to the discovery of the die-off were within the 4 most a-typical turbidity periods for the region



Turbidity and Currents
Week of July 19, 2016



Kd-486



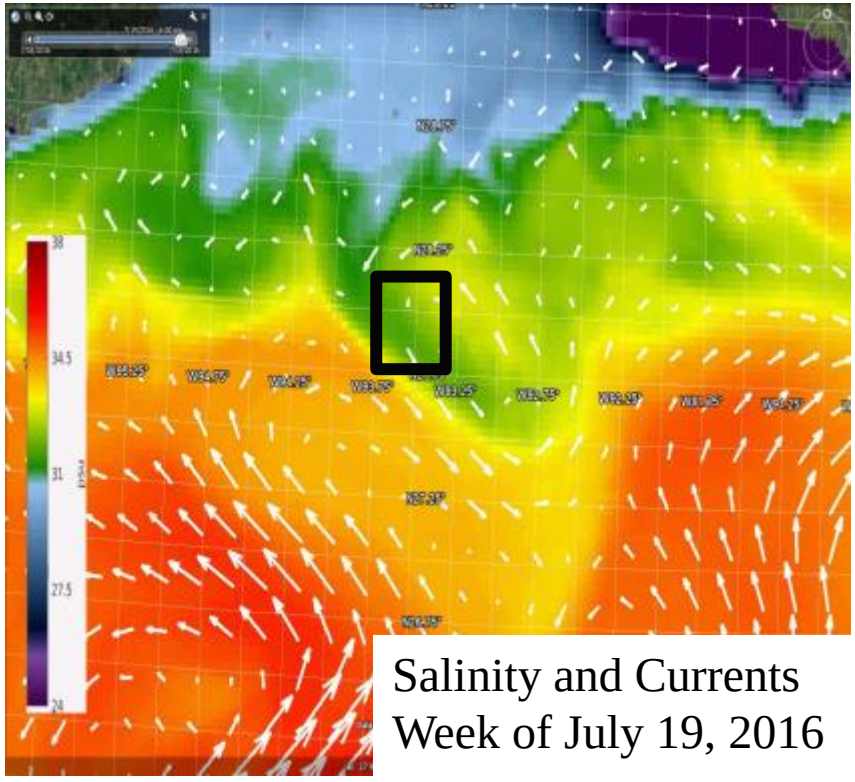
The positive anomaly is the most persistent positive anomaly recorded and occurs later in the calendar year than other peaks (Summer vs Winter)

Event 2 - 2016 Flower Garden Banks Mortality

Weekly current vectors averaged from model output show circulation features at the Flower Garden Banks region

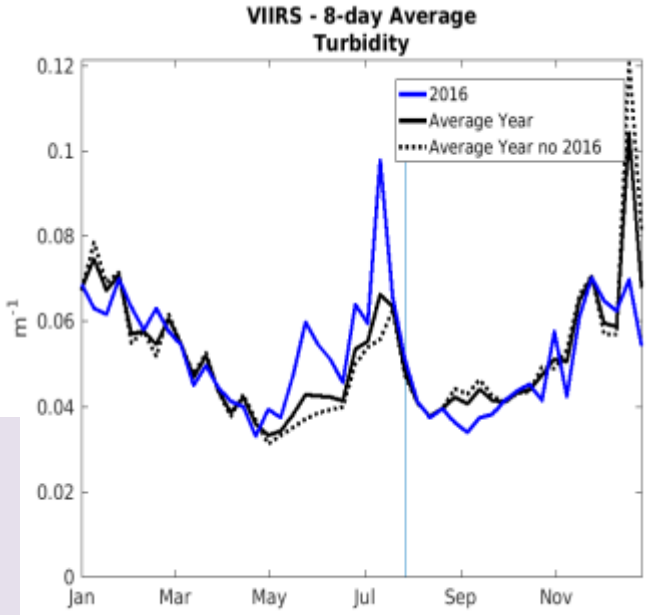
- A cyclonic feature above the study region
- Convergence of at the western edge of the region

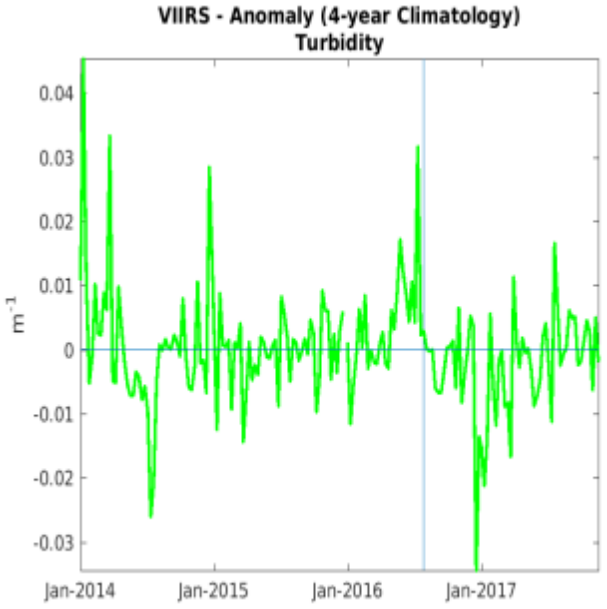
High salinity within the cyclonic circulation feature may be associated with upwelling



Salinity and Currents
Week of July 19, 2016

Diffuse Attenuation Kd-486





Event 2 - 2016 Flower Garden Banks Mortality

1. **Standard deviation of Chlorophyll at the East Flower Garden Banks in spring/summer 2016 indicates very localized fluctuations beyond typical chlorophyll concentrations seen in this region.**

2. **The Chlorophyll – Absorption relationship strengthens during the mortality event suggesting a bloom or increased regional turbidity due to the event itself.**

3. **Time series of observations shows an increase in turbidity at East Flower Garden Banks preceding the discovery of the mortality event. The increased turbidity falls outside of expected seasonal patterns and is persistent relative to other observed periods of elevated turbidity.**

4. **Apparent spread of Chlorophyll rich waters to the FGB region supports the possibility of coastal water migration as the event leading to coral mortality. However, salinity and currents point to upwelling and a convergence of circulation features as possible contributors.**

DAP Products applied to 2017 Hurricanes

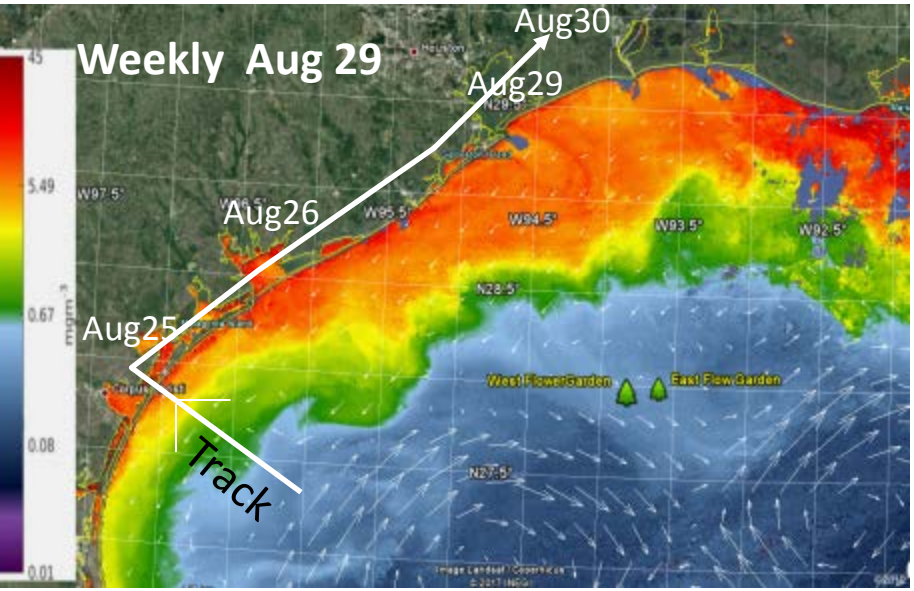
1)Harvey 2) Irma

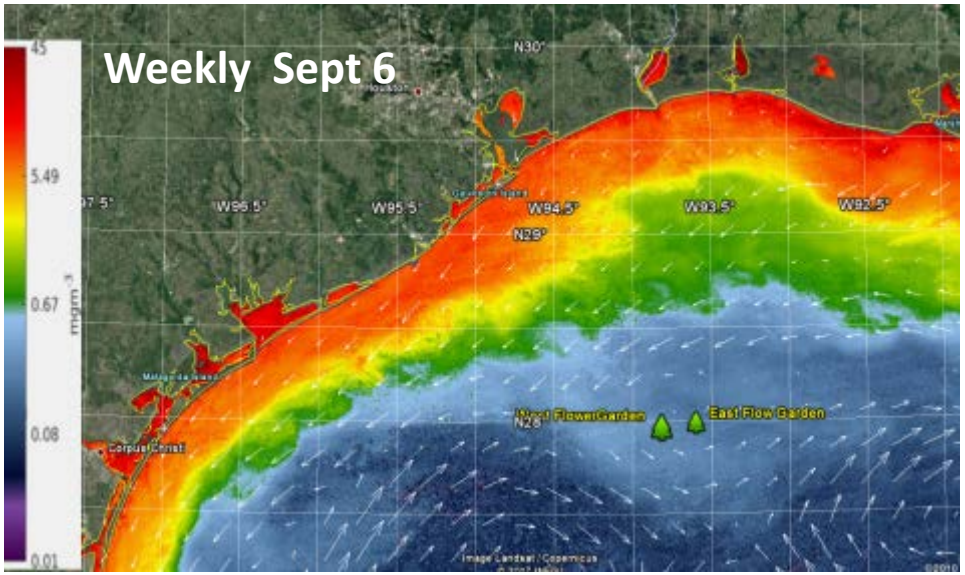
Abnormal Bio-Physical Conditions in the Gulf of Mexico

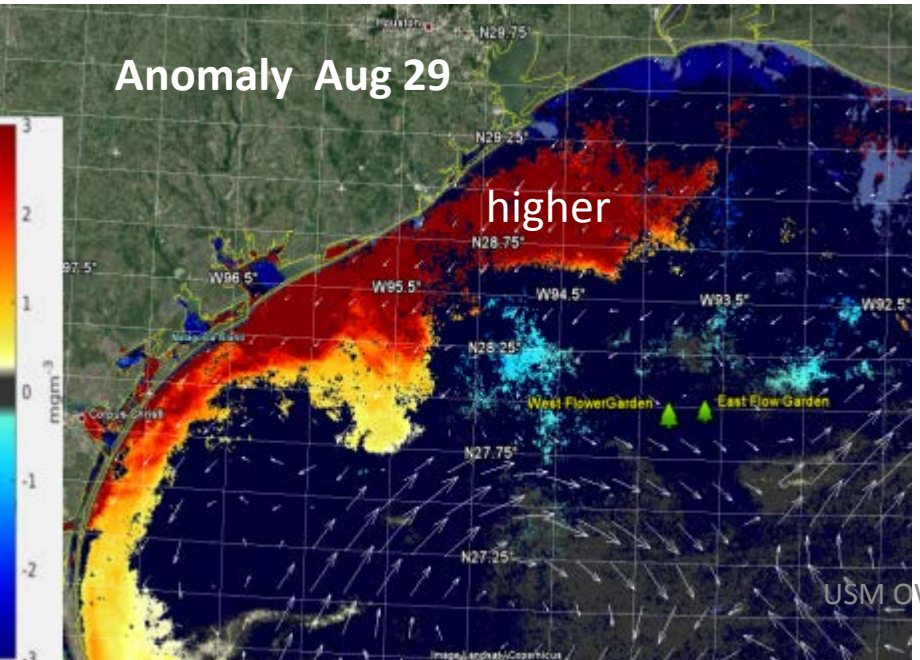
What affects did the Hurricanes have on ocean waters?

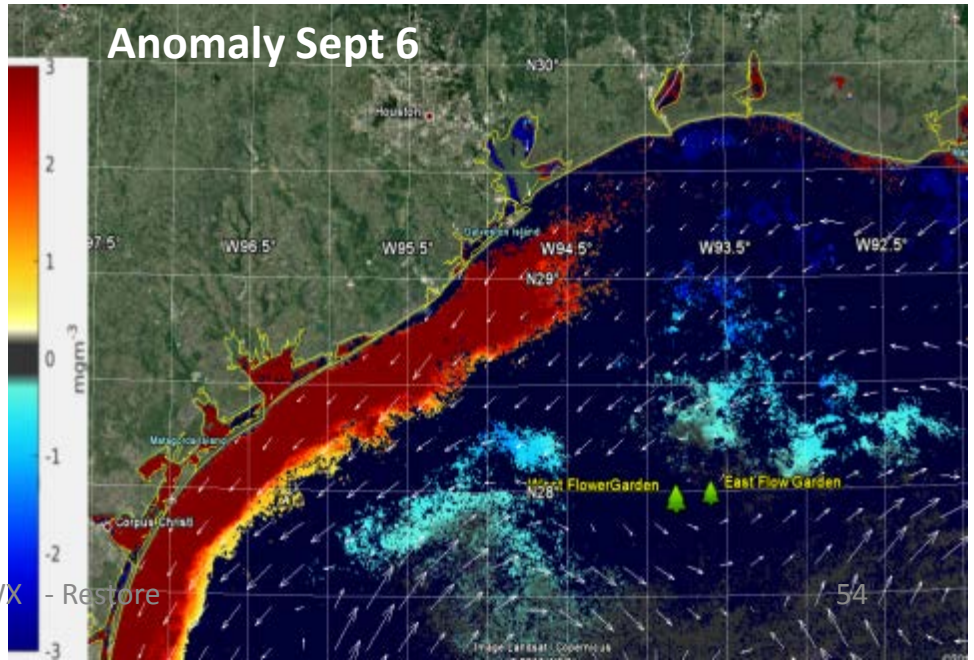
Storm Passed - Harvey Aug 22- 26, 2017
IRMA Sept 8-10

Chlorophyll Changes following from Hurricane Harvey
Aug 29 – Sept 22, 2017



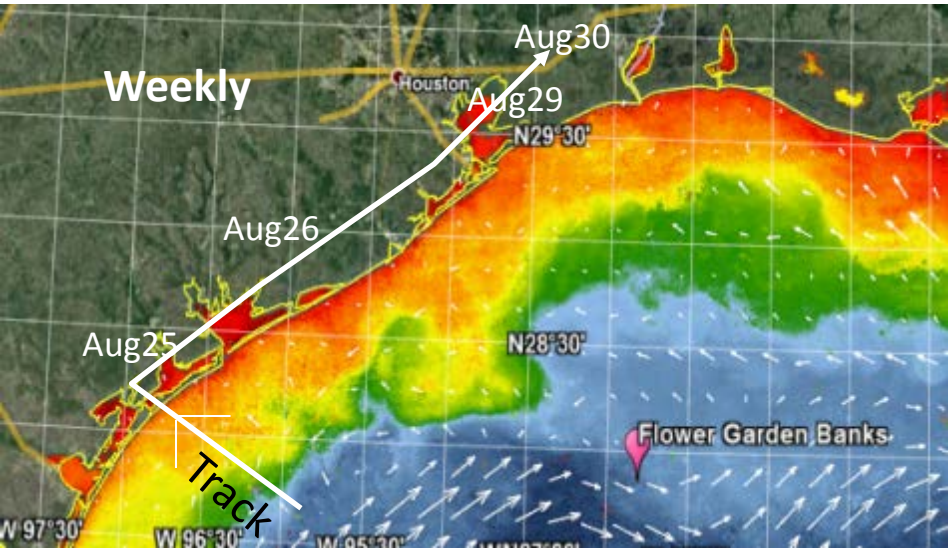




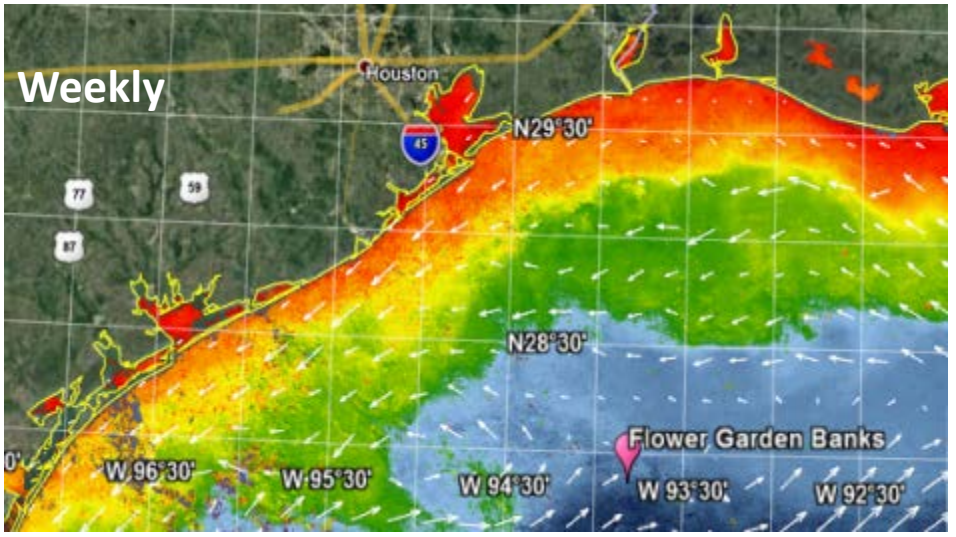


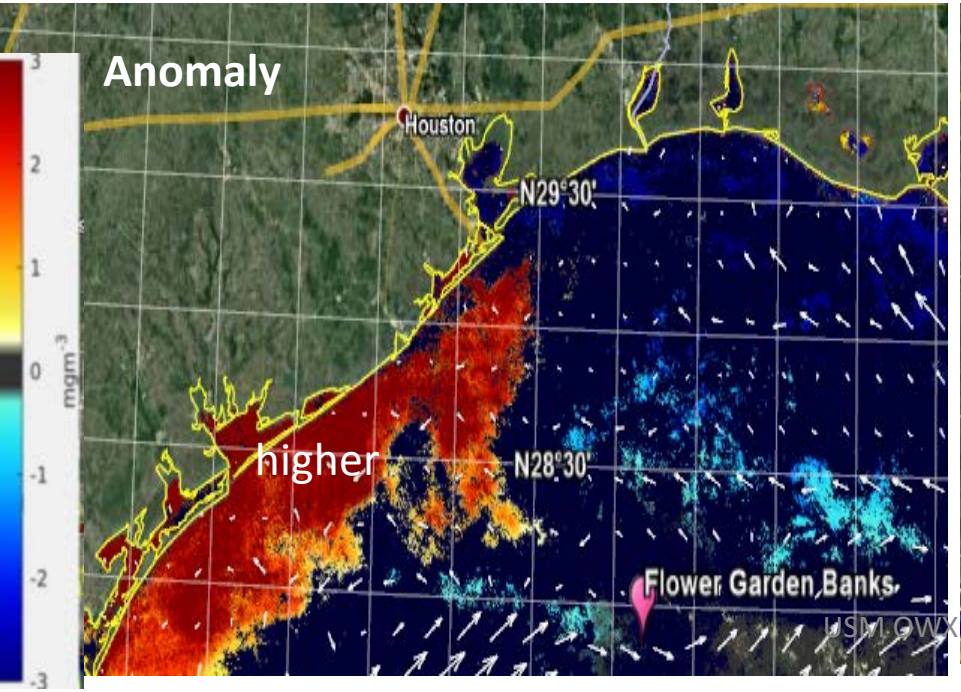
Chlorophyll Changes from Hurricane Harvey

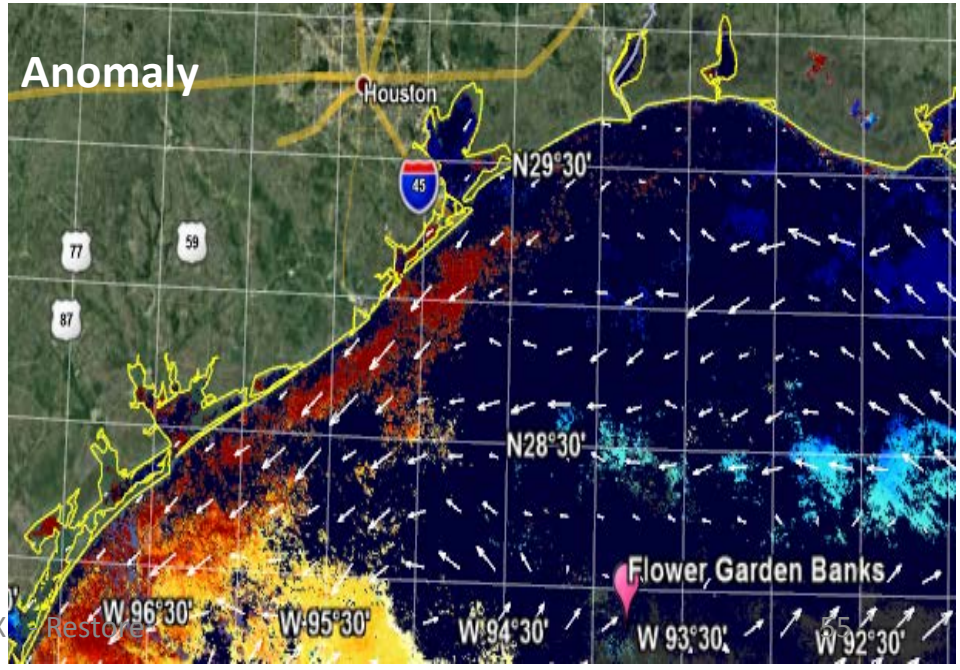
CHL- Sept 14,2017

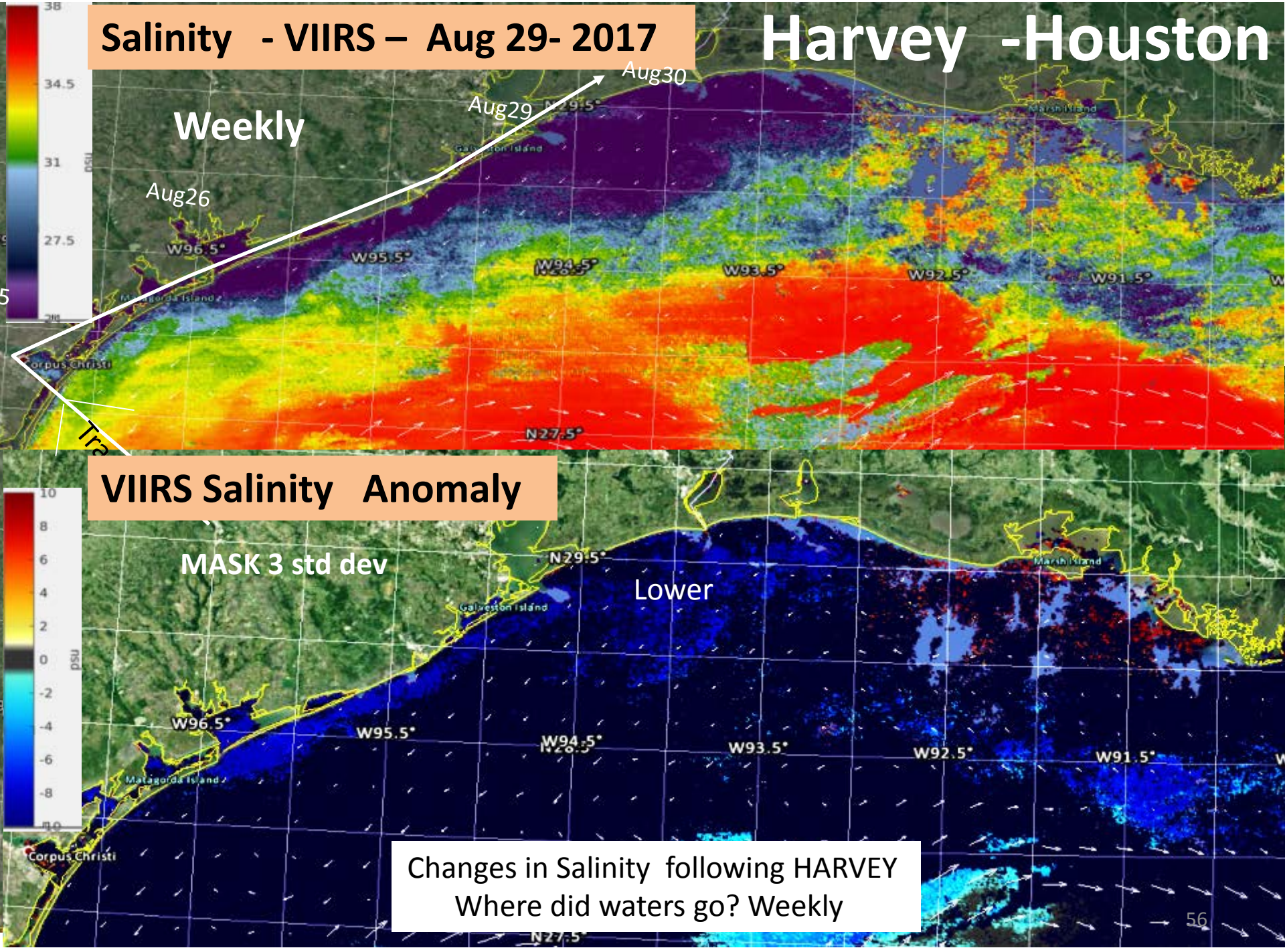


CHL- Sept 22,2017



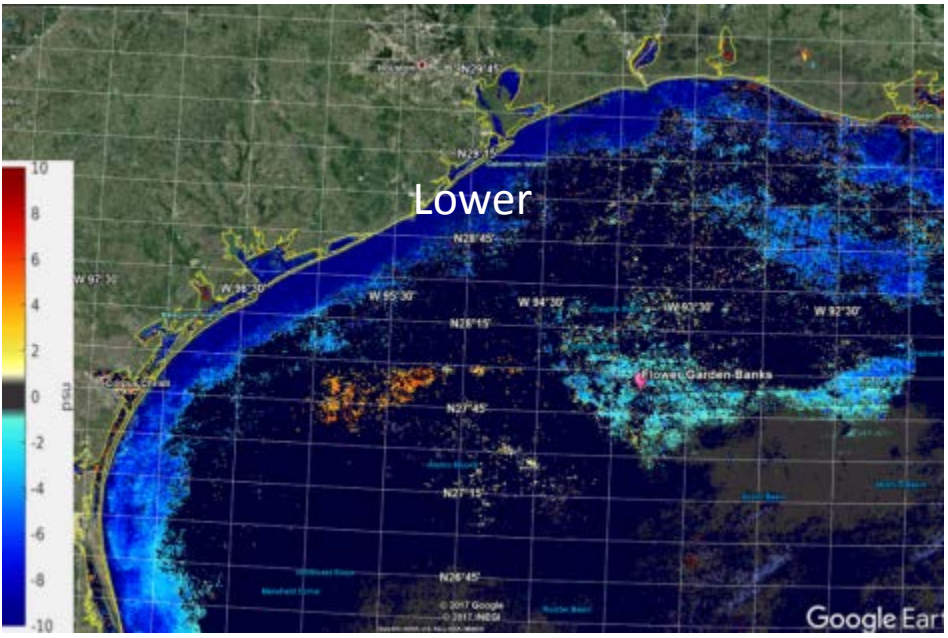




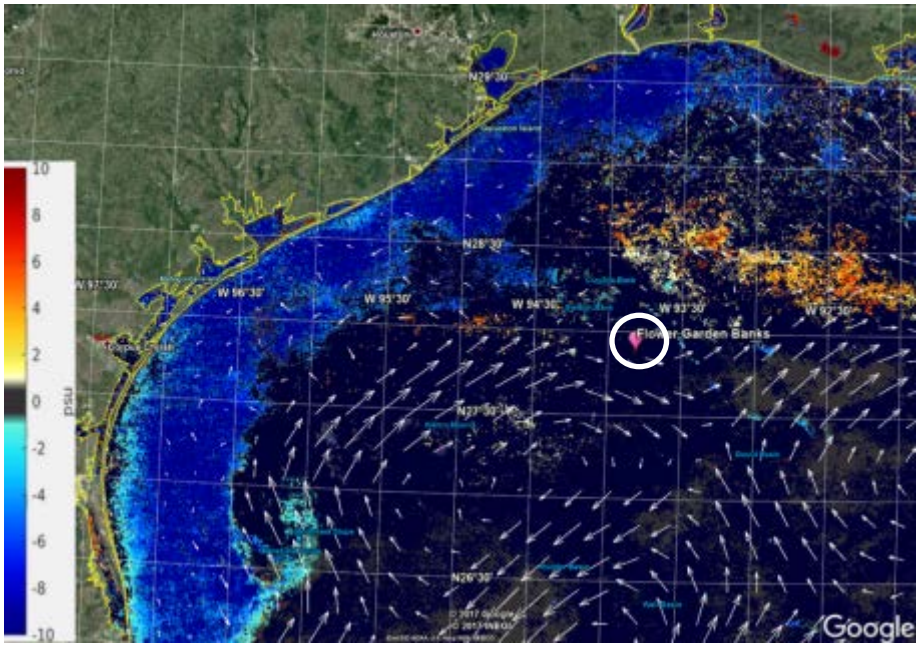

Salinity - VIIRS – Aug 29- 2017
Harvey -Houston
Weekly
Aug26
Aug29
Aug30
W96.5°
W95.5°
W94.5°
W93.5°
W92.5°
W91.5°
N27.5°
Corpus Christi
Matagorda Island
Galveston Island
Marsh Island
psu
VIIRS Salinity Anomaly
MASK 3 std dev
Lower
N29.5°
Changes in Salinity following HARVEY
Where did waters go? Weekly

Dynamic Anomaly

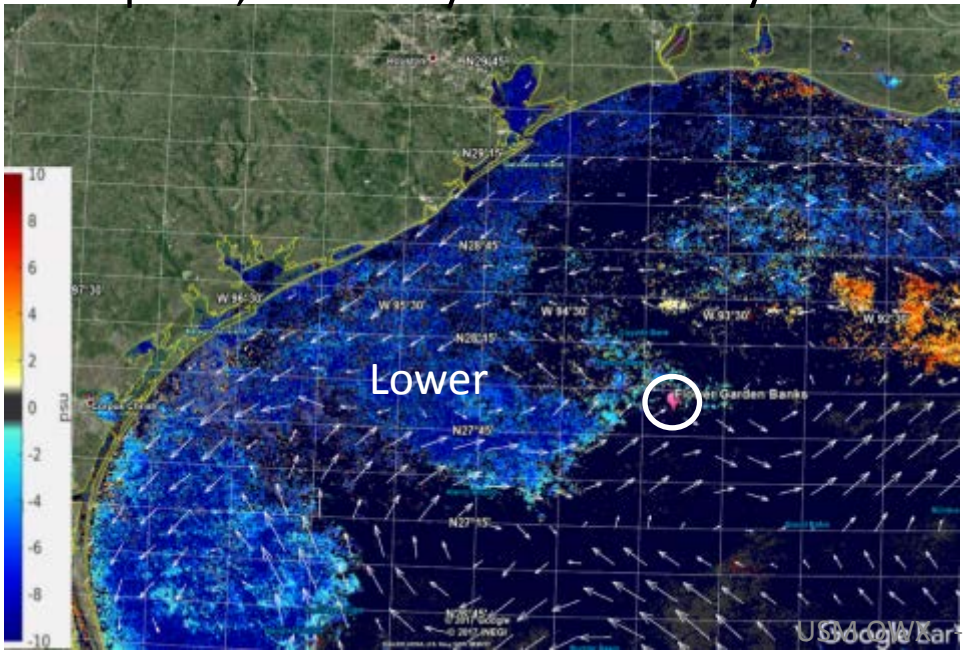
Sept 6, Anomaly VIIRS Salinity



Sept 14, Anomaly VIIRS Salinity



Sept 22, Anomaly VIIRS Salinity



Hurricane Harvey
Fresh water moved offshore
And South
Month later

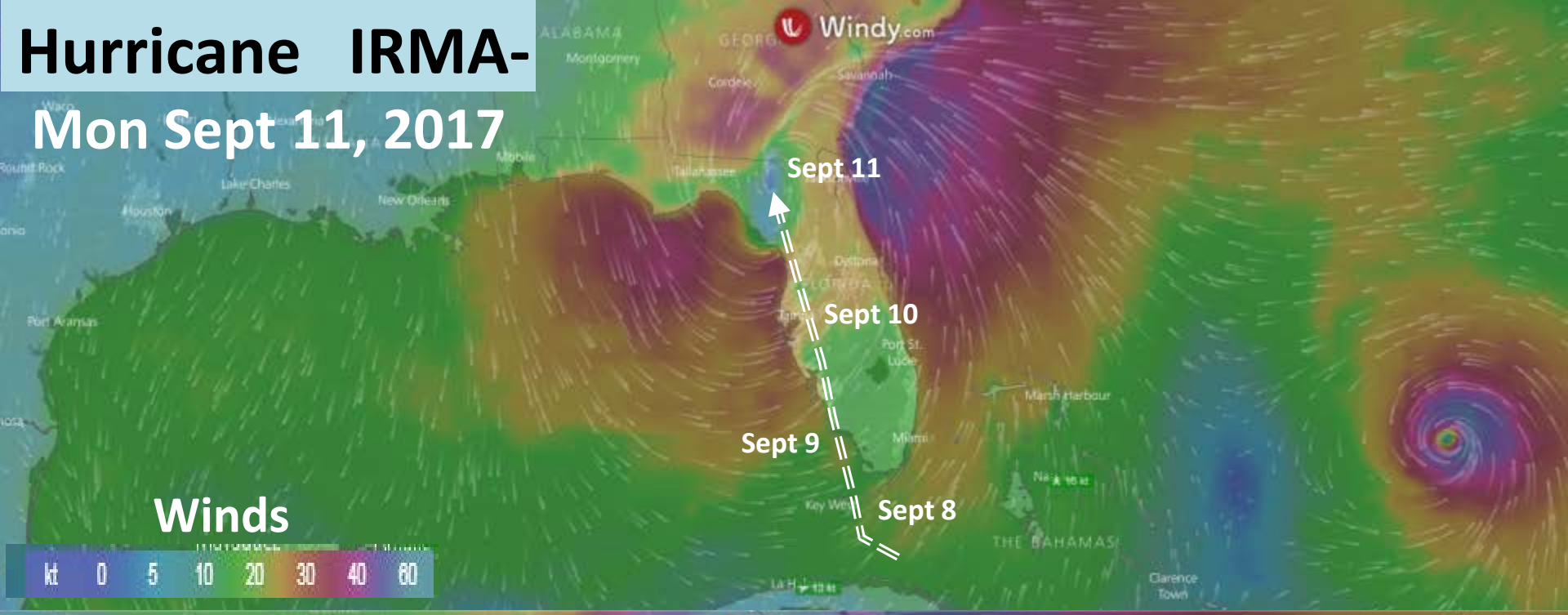
Didn't Reach Flower Garden Banks

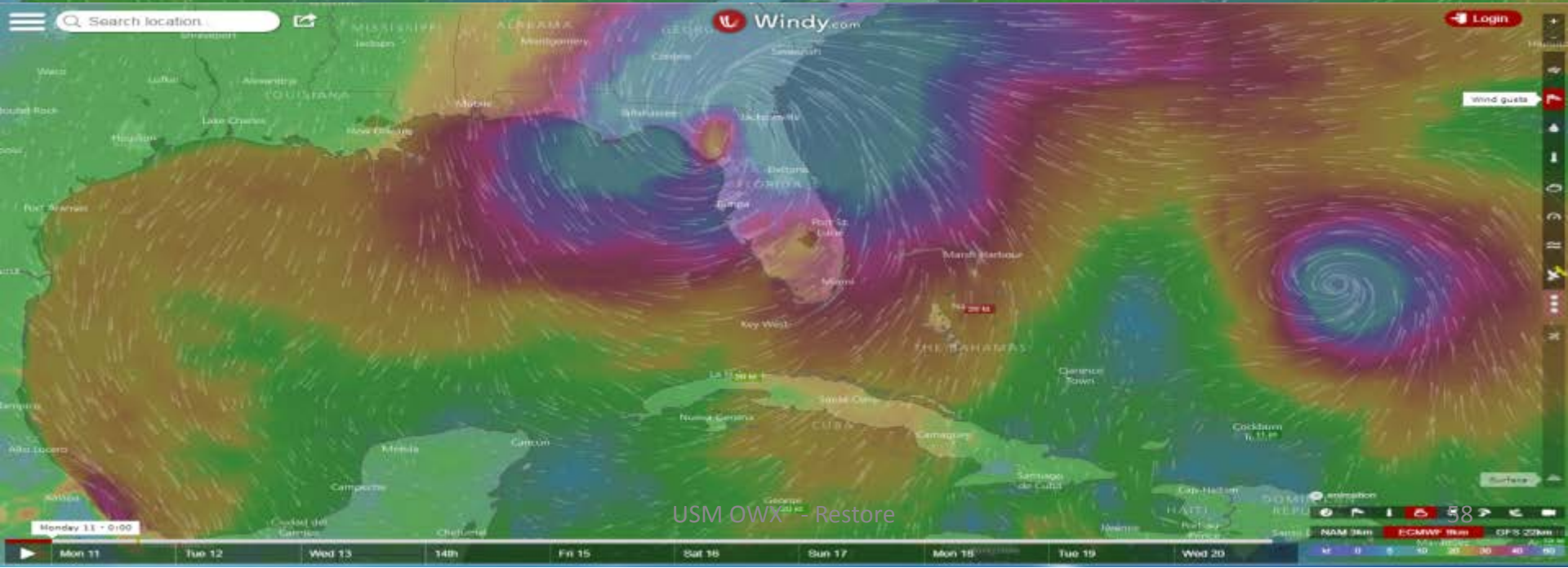
Harvey - Houston

USM GWI Restore

Hurricane IRMA-

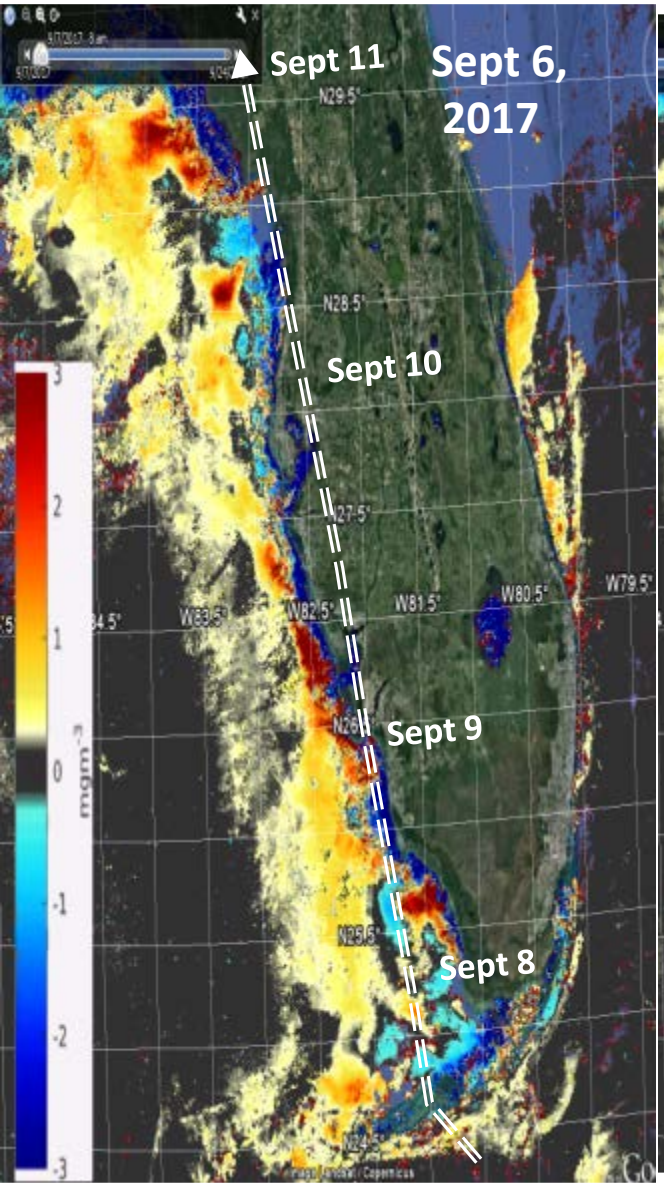
Mon Sept 11, 2017

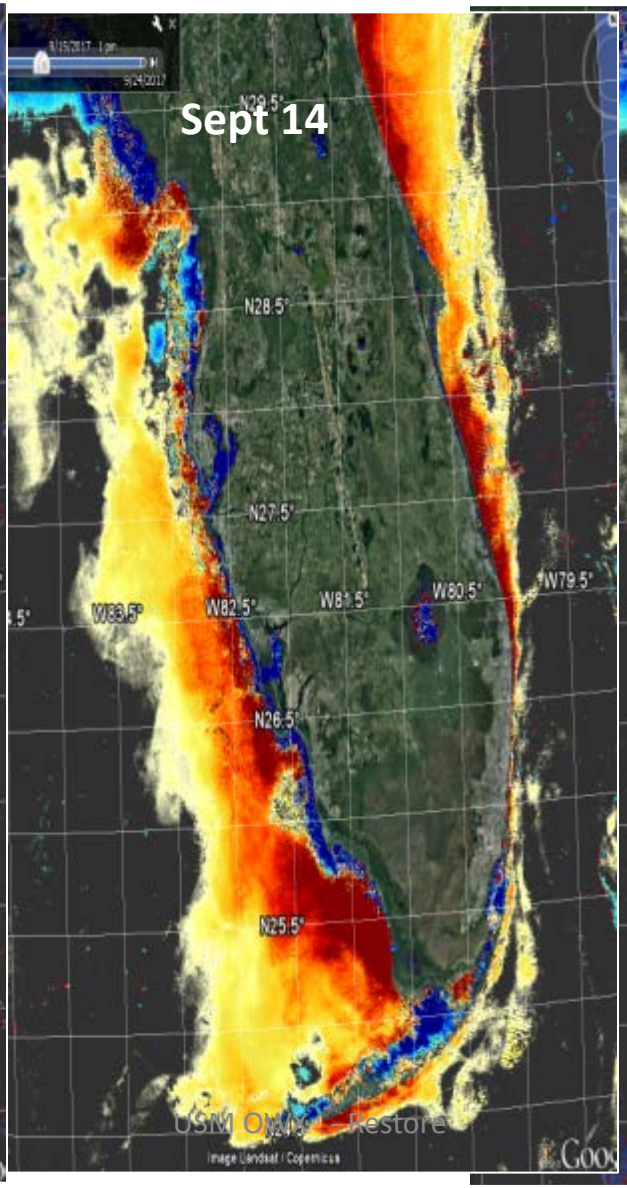


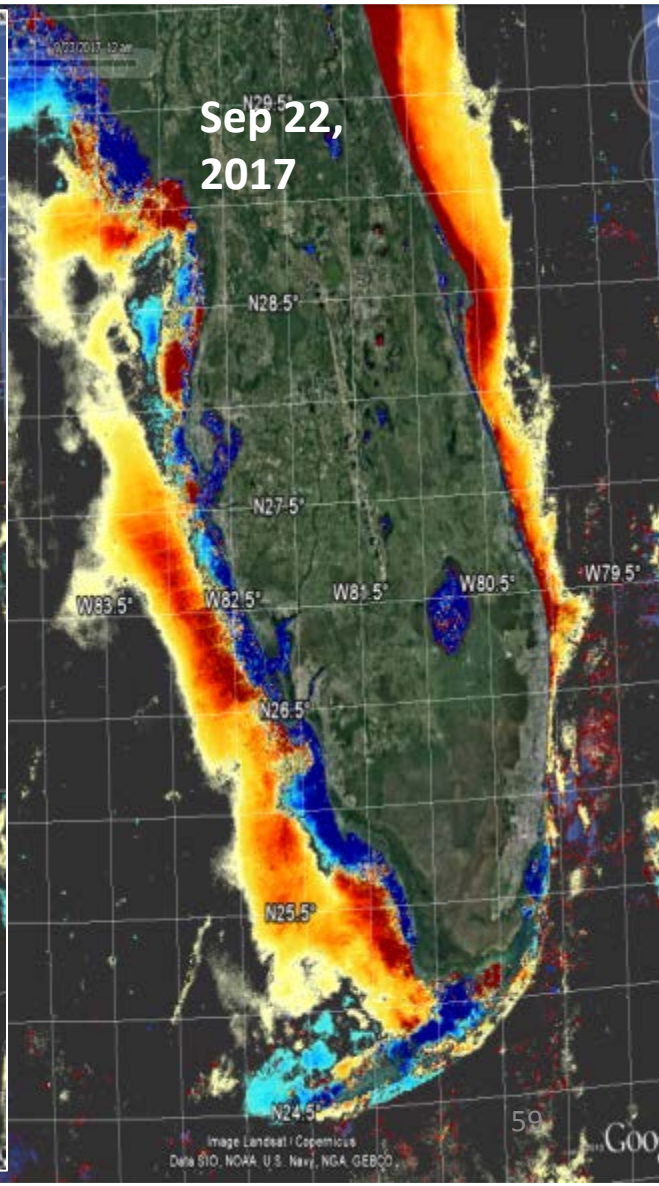


Chlorophyll Anomaly

Hurricane Irma

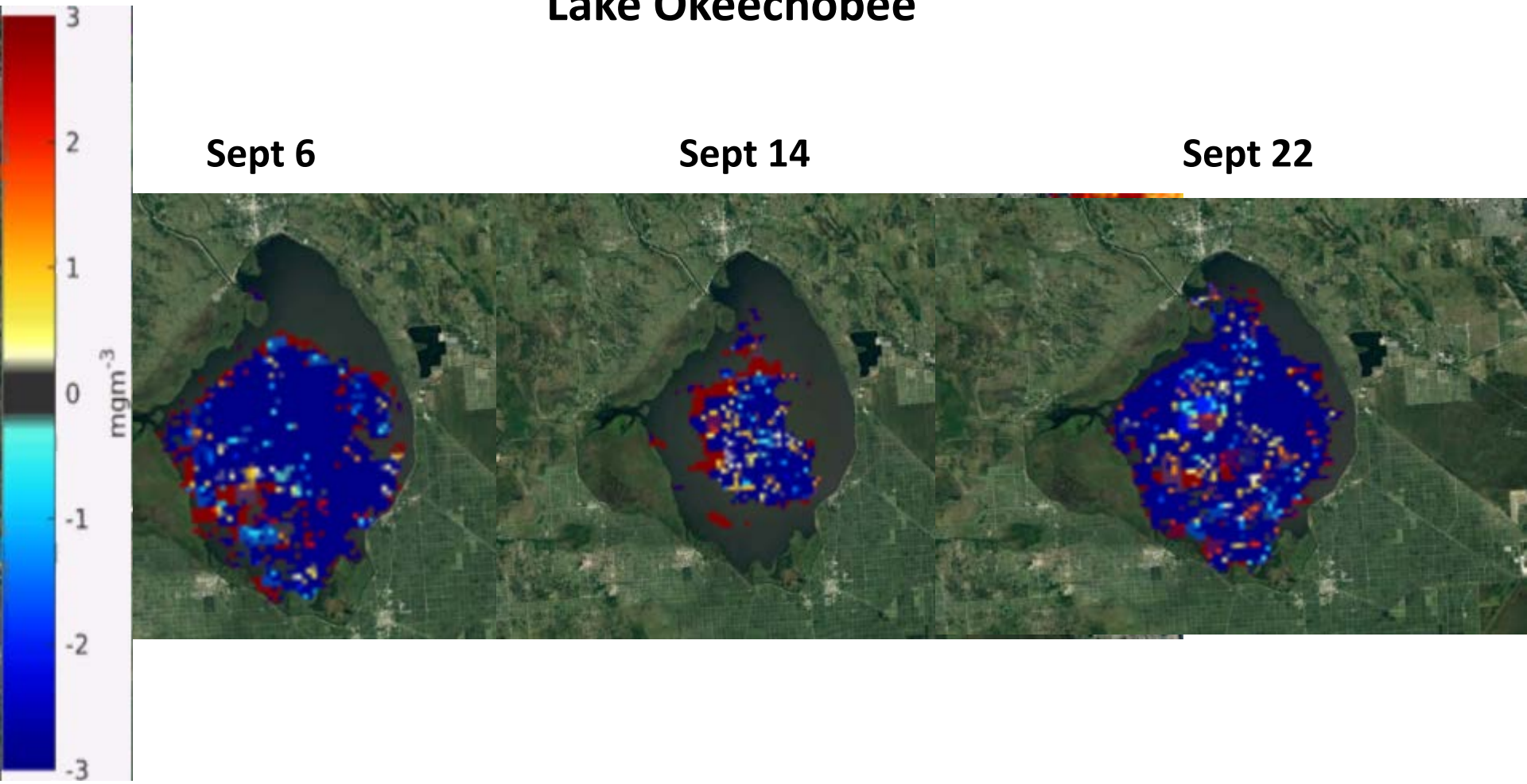




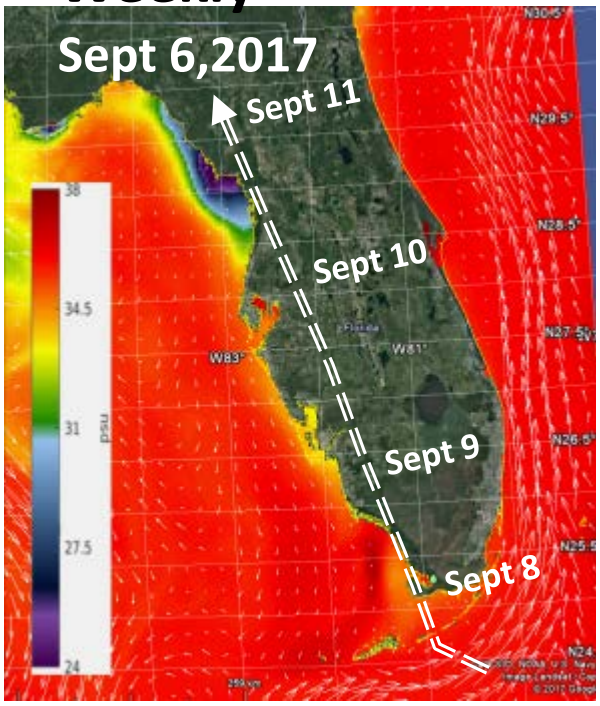


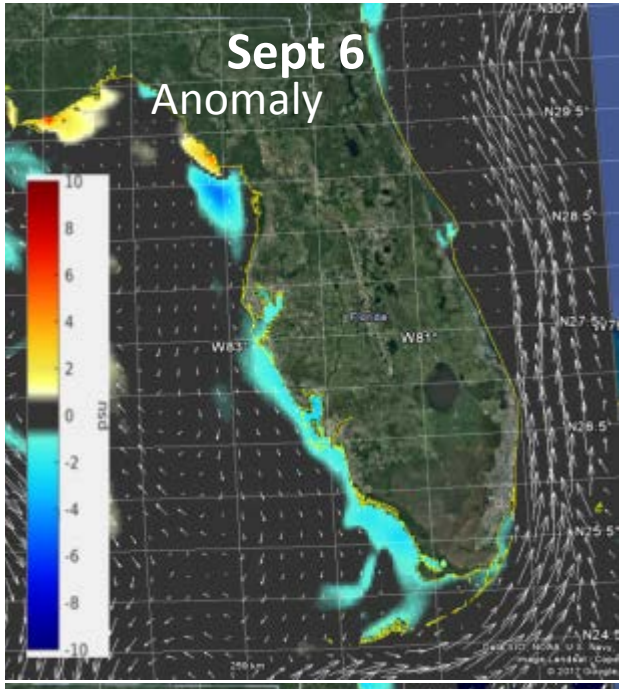
Hurricane Irma

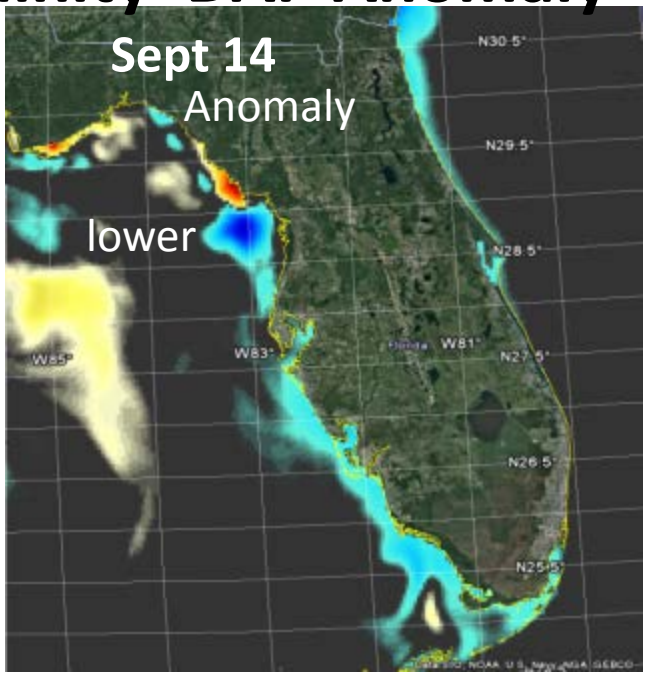
Chlorophyll Anomaly
Lake Okeechobee

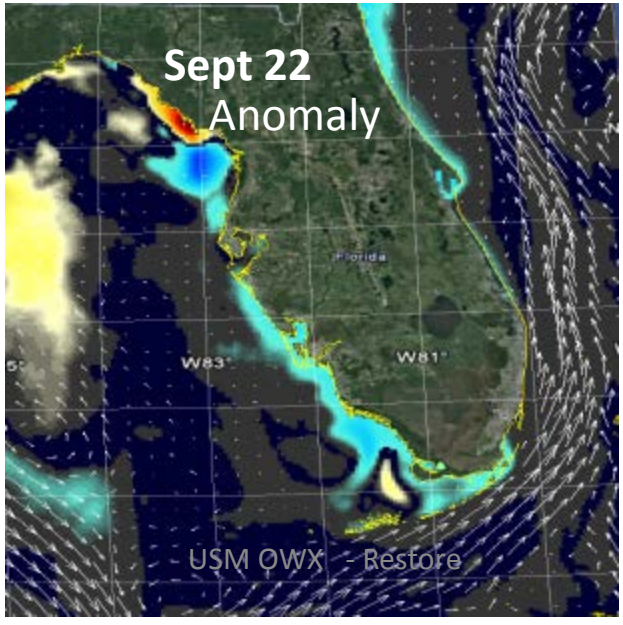


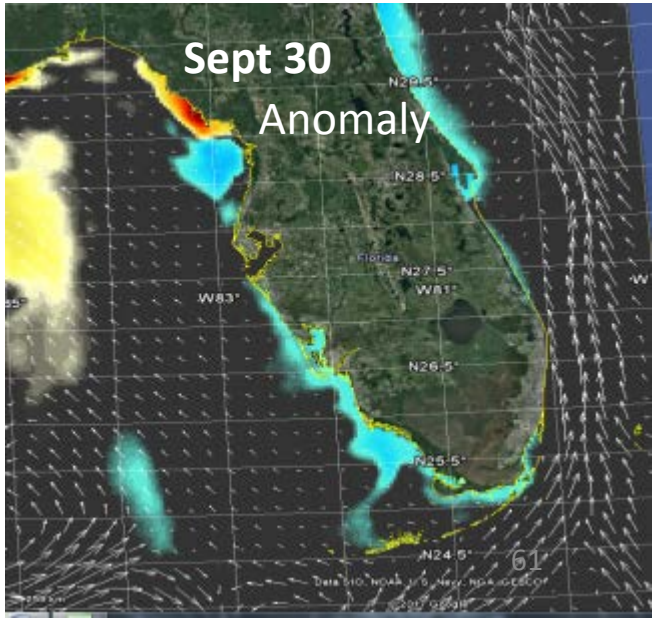
Hurricane Irma
Weekly Am Sea Model Salinity DAP Anomaly











Hotspots

Other Bio-Physical Products Available

Model and Satellite.

Applications of DAP Products Event Detection

1) DAP Anomalies can detect and monitor surface perturbations to any marine system through a uniquely broad range of parameters

2) Dynamic anomaly time series can be used to investigate event significance at a station
   1) Identify event starts as changes in anomaly time series slope
   2) Determine impact of an individual event by comparison with other peaks/troughs
   3) Monitor persistence of event impacts via elevated/reduced anomaly signatures

3) Dynamic anomaly maps allow determination of spatial impact of events and can be used to delineate localized effects

4) Standard deviation maps can be used to show changes in variability affecting a given station or study region

5) Within a study region, dynamic anomalies show the spatial variability of the event over time (i.e. which areas are experiencing increasing anomalous conditions or are stable)

PUBLICLY AVAILABLE DAP PRODUCTS 2013- 2018

a) The University of Southern Miss - Links to DAP products are:

- Product Description https://www.usm.edu/marine/dap and http://131.95.1.37/~owx/Outgoing/DAP/.dap/
- Weekly Dap images https://www.usm.edu/marine/gallery/dap-images

Web Site

b) NOAA- National Centers for Environmental Information (NCEI)–

LINKS

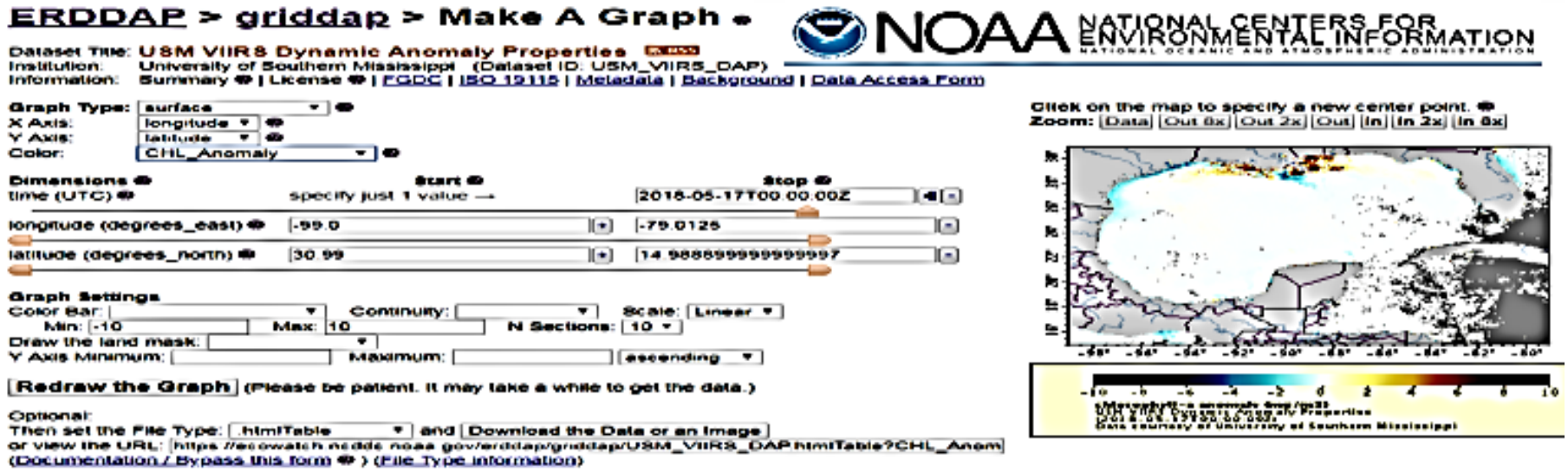
kmz format for use in google earth and NCEI format at NCDDC at:

kmz- https://ecowatch.ncddc.noaa.gov/thredds/catalog/usm_dap_kmz/catalog.html

Netcdf https://ecowatch.ncddc.noaa.gov/thredds/catalog/usm_dap_netcdf/catalog.html

NOAA's ERDDAP **Public Access to USM DAP Products at NOAA NCEI at Ecowatch[o1]** **ERRDAP**:

- USM AMSEAS_DAP .graph https://ecowatch.ncddc.noaa.gov/erddap/griddap/USM_AMSEAS_DAP.graph
- USM AMSEAS_DAP .data https://ecowatch.ncddc.noaa.gov/erddap/griddap/USM_AMSEAS_DAP.html
- USM_VIIRS_DAP.graph (Fig15) https://ecowatch.ncddc.noaa.gov/erddap/griddap/USM_VIIRS_DAP.graph



Summary

Identifying ocean events and seasonal trends of bio-physical water properties and Dynamic anomalous marine conditions in the Gulf of Mexico.

DYNAMIC ANOMALY PROPERTIES "DAP"

Satellite and Model Products for entire Gulf at 750 m and 3 km 2013- 2018

Weekly 100 products nowcast and abnormal bio-physical products

DYNAMIC ANOMALY PRODUCTS (DAP) short term baseline

Detect hotspots across the Gulf – where conditions are changing

Applications: "Decision Support Tool"

1) **Improve Adaptive Sampling of Ocean Hotspots - Google Earth Tools**
2) **How Physical hotspots affect Biological hotspots- (currents – chlorophyll)**
3) **Seasonal trends – of bio-physical properties – yearly cycles at any region of interest**
   - **NOWCAST at a location** (example when river plume is at location)
   - **Seasonal bio-physical correlations** - (how Plumes affect the ecosystem) salinity / chl
   - **Changes in seasonal cycle at different locations** (heating cooling affect the ecosystem)
4) **Identify Dap Gaps - Abnormal Stations Collection - Applied Fisheries, birds etc**
5) **Identify Events : Recent- Todays Hurricanes, Bonnie Carrie Spillway , Ocean Areas Affected Previous : What caused an event, Flower Garden**
6) **Forecast: Weekly DAP provides abnormal properties that can become event.**
7) **Public Access to Data – NCEI - National Centers for Environmental Information**

DAP Future Potential

- **Extend beyond the surface and address vertical ocean properties**
- **Encourage data reciprocation with end users to optimize current applications and develop new applications → Continued DAP Products ?**

THANK YOU

Acknowledgements

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Data are publicly available through National Centers for Environmental Information (NCEI) at https://ecowatch.ncddc.noaa.gov/thredds/catalog_AMSEAS_VIIRS_DAP.html

Coordination with:

- **Fisheries – 1) Blue Fin Tuna cruise**
  2) SeaMap cruise
- **Flower Garden banks**
- **USGS – Bonnie Carrie Spillway**
- **GOMRI – Concorde**
- **NOAA- NCEI**
- **Coastal Protection and Restoration Authority (CPMA)**

Rost Parsons -NCEI
John Lamkin -Foster
Estrella Malca
Andrew Millett - SeaMap
Glen Zapfe
Michelle A. Johnson -FGB
Daniel Dourte -CPMA- Balmor
Jim Sullivan, -HB
Mike Twardowski
Eric.J.Glisch -USGS

Ocean Weather
Real-time monitoring

THE UNIVERSITY OF SOUTHERN MISSISSIPPI GULF COAST

Consortium CONCORDE Coastal River-Dominated Ecosystems

GULF OF MEXICO RESEARCH INITIATIVE

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