

**UNIVERSITY OF  
SOUTH FLORIDA**  
College of MARINE SCIENCE



**SECOORA**  
Southeast Coastal Ocean Observing  
Regional Association

- 1. Red Tide:** What we know, don't know and what is needed.
- &
- 2. Circulation tools/applications for Florida's West Coast.**

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**Suncoast Tropical Fruit and Vegetable Club**

**Nokomis, FL**

**6/12/19**

# 1. Red tide

# Knowns:

- Florida **red tide**, a bloom of the toxic dinoflagellate, *Karenia brevis*, is naturally occurring.
- It initiates offshore under oligotrophic (nutrient depleted) conditions.
- It manifests as a nuisance when transported to the coastline.
- Both the offshore conditions and transport are determined by the ocean circulation.

# Unknowns:

- Do humans exacerbate *K. brevis* blooms?
- What terminates a *K. brevis* bloom?
- Might there be means for mitigation?

# What is needed:

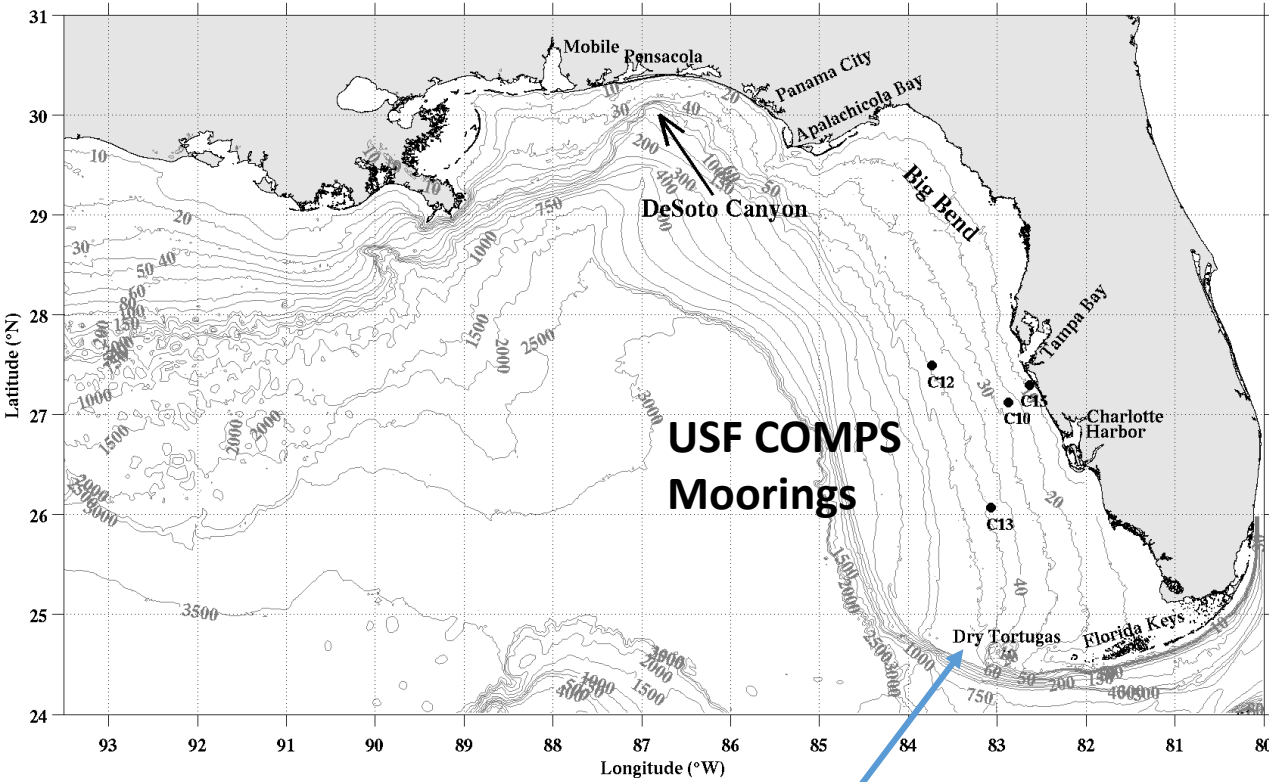
- More systematic, full water column observations.
- Support for necessary modeling and tracking.
- Laboratory and microcosm mitigation experiments.
- Solutions to known human-made problems.



# West Florida Continental Shelf

*“To be oligotrophic, or not to be oligotrophic, that is the question.”*

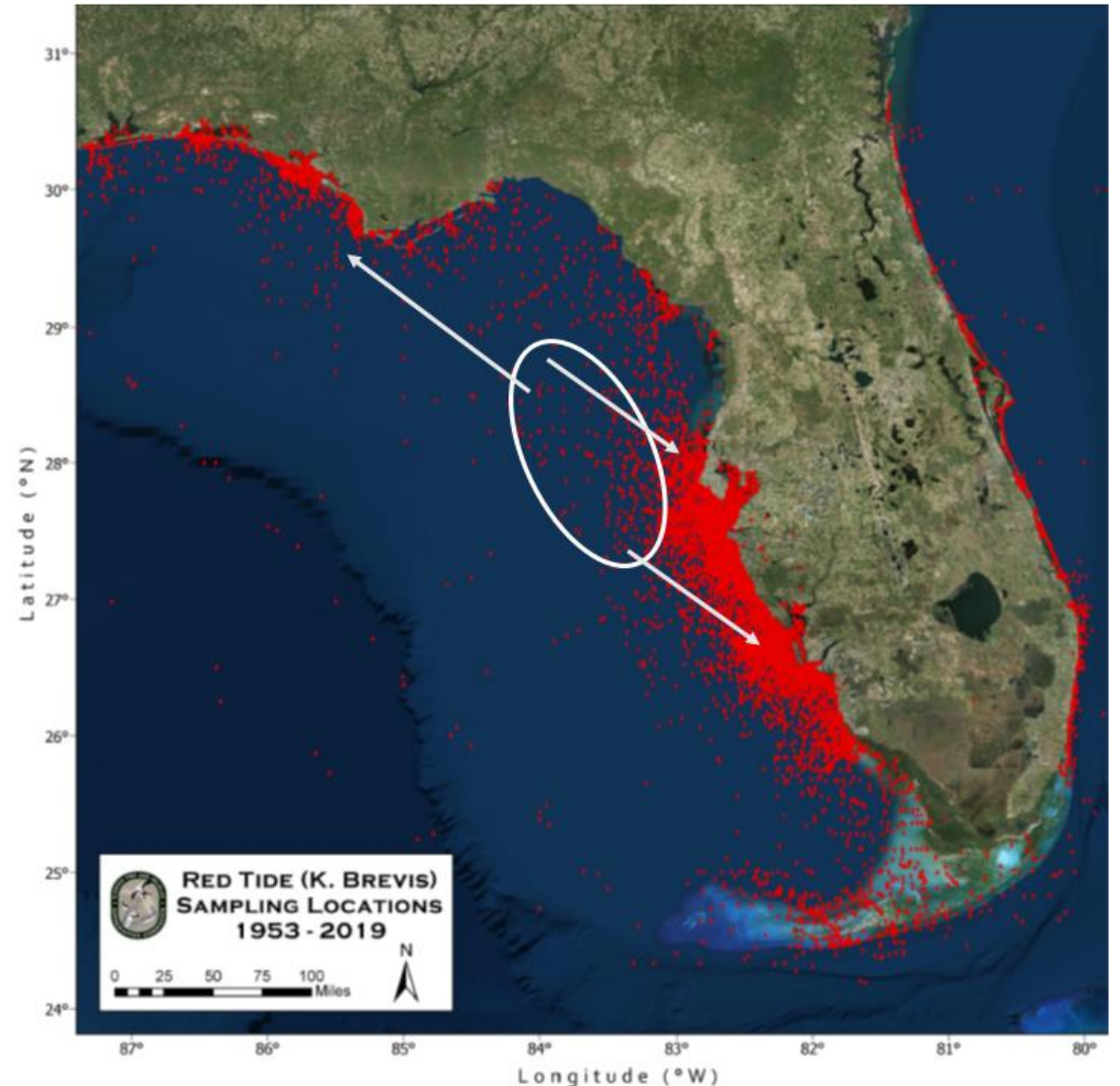
So how does the shelf get its nutrients?



The WFS “Pressure Point”  
Is critical in determining water properties.

# *K. brevis* Cell Counts: 1953-2015

A spatial order exists for WFS ecology, implying offshore initiation and transport pathways to the coastline.



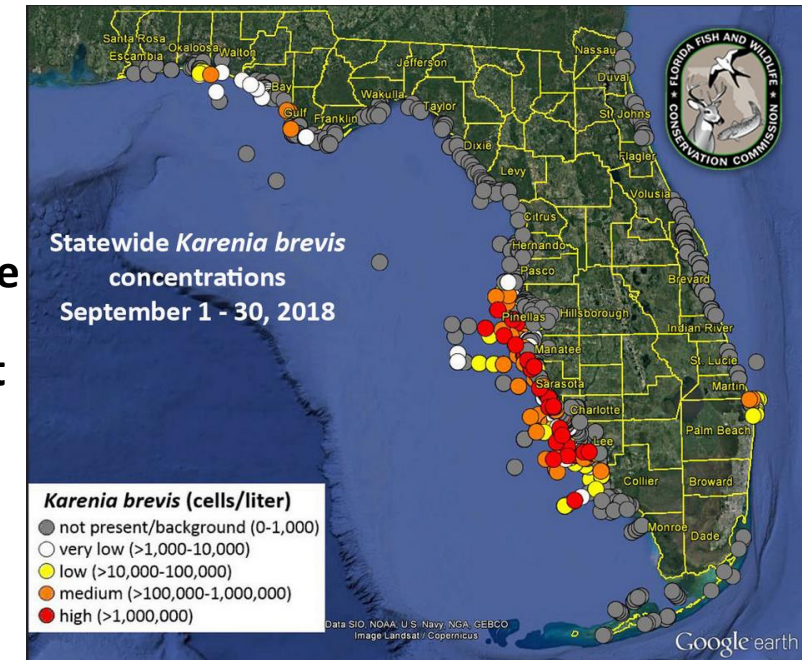
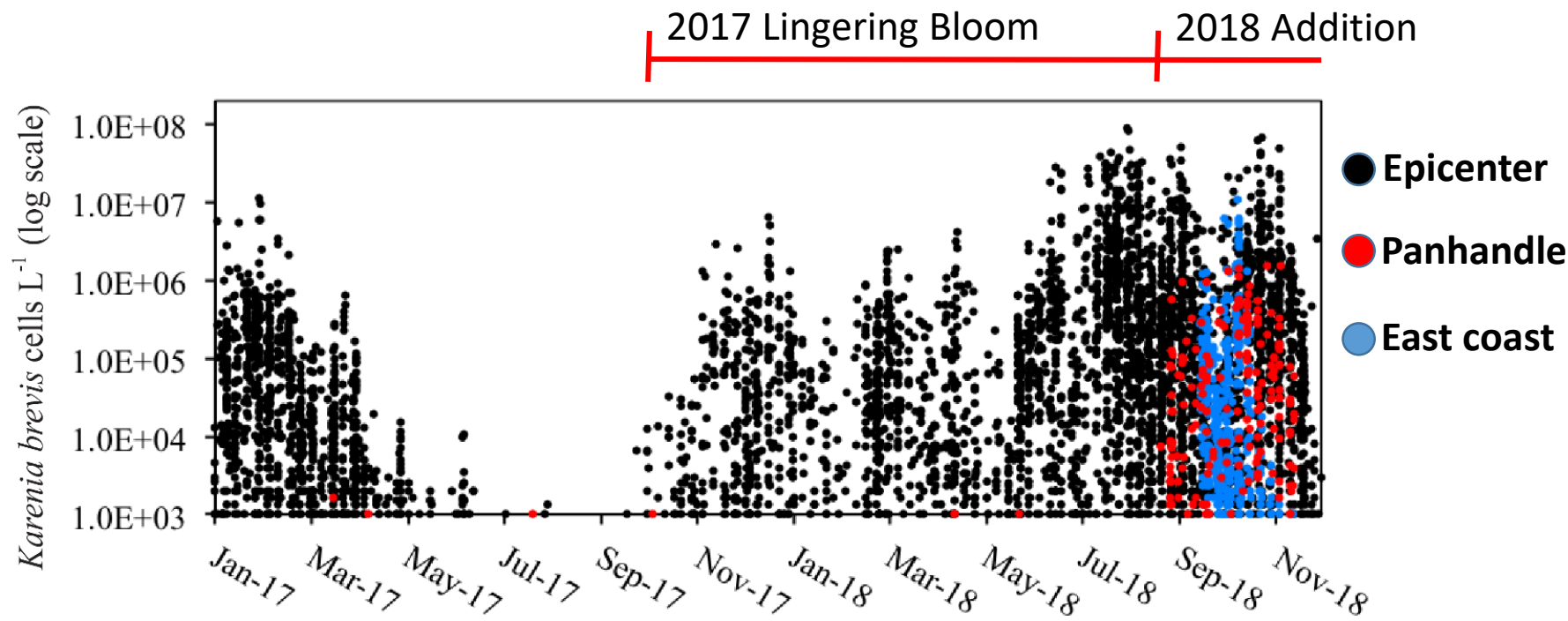
# What Happened in 2018?

2018 may have rivaled 2005 as the worst of the recent *K. brevis* red tide blooms.

Two factors were in play:

1. The 2017 bloom never dissipated, and it was particularly prevalent from Venice, FL southward.
2. Offshore conditions were conducive for a new bloom to form in spring through summer of 2018.

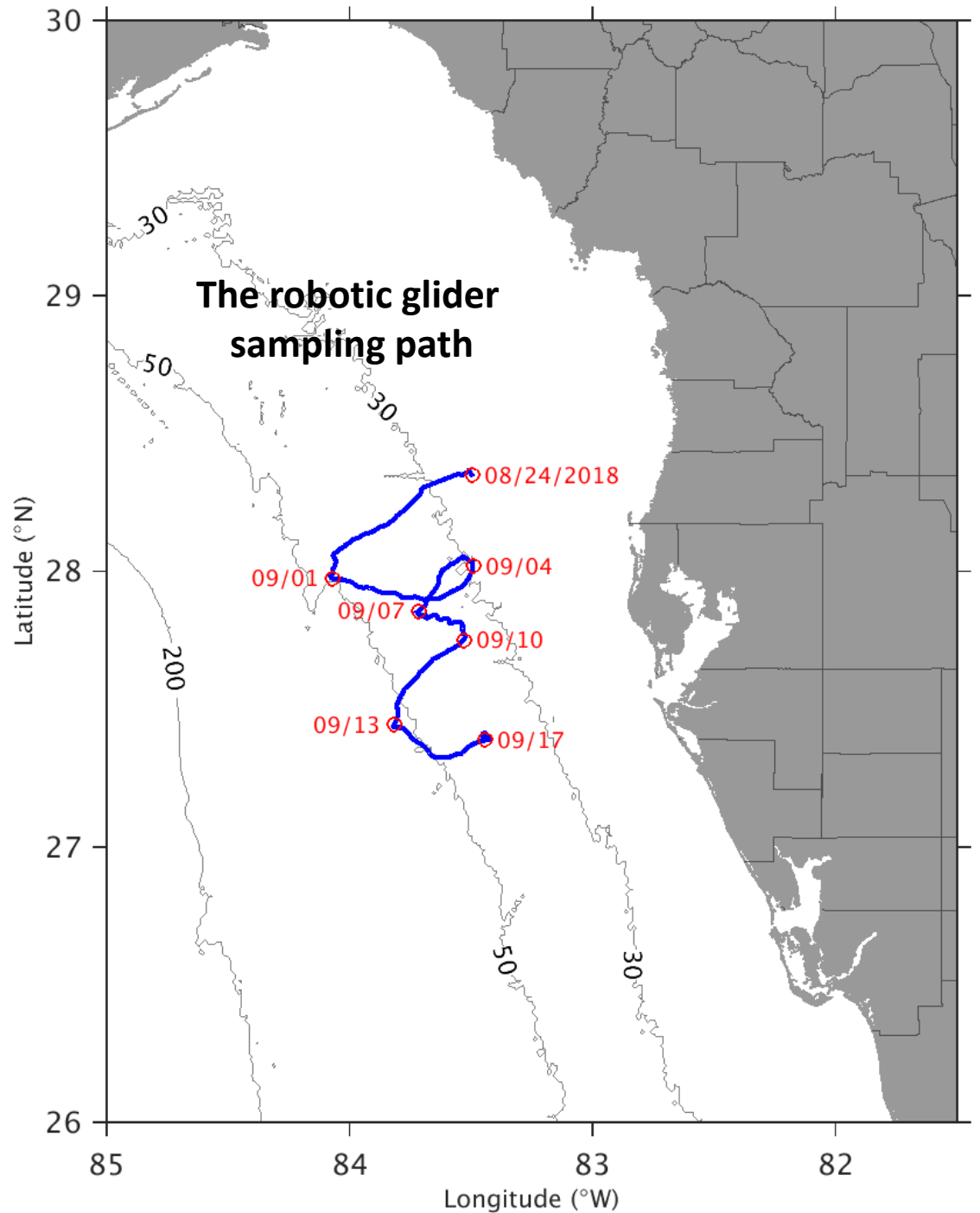
The confluence of these two factors accounts for what we experienced. Might Lake Okeechobee releases exacerbate existing blooms? Good question, but lacking a definitive answer.



# USF-CMS Responses

1. We deployed a robotic sampling device (a Webb Electronic Glider) from 8/24/18 to 9/17/18 to map water properties over the entire water column within the hypothesized *K. brevis* red tide initiation region.
2. We tracked the bloom using numerical circulation models.

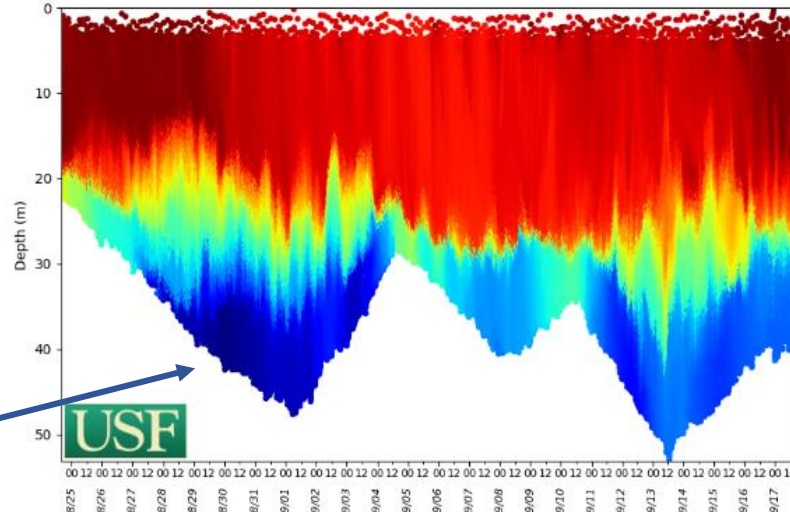
The robotic glider



# Water Properties Observed During the 8/24/18 to 9/17/18 Glider Mission

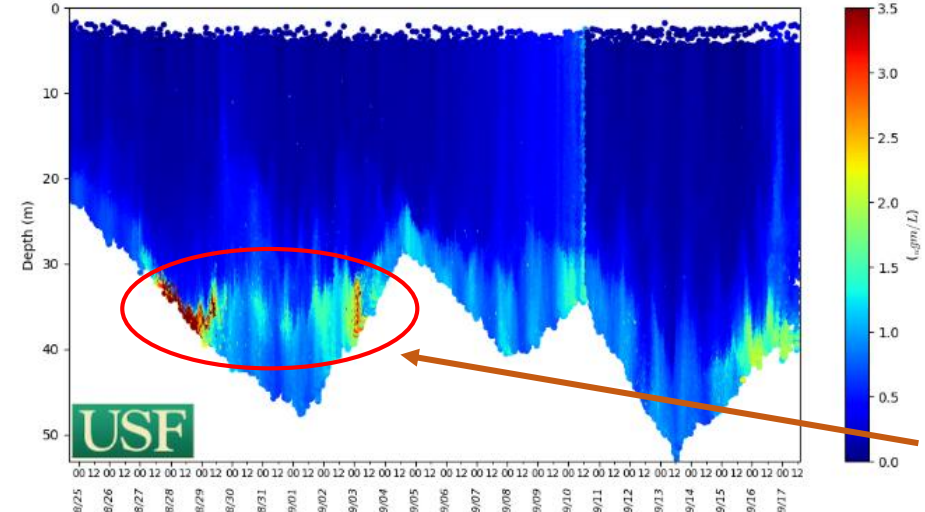
Note: 1) relatively cold, salty water near bottom indicative of an upwelling circulation, 2) elevated chlorophyll and reduced oxygen near bottom indicative of *K. brevis* with highest concentrations between the 30m-40m isobaths.

usf-sam 2018-08-24 to 2018-09-17  
Water Temperature ( $^{\circ}\text{C}$ )



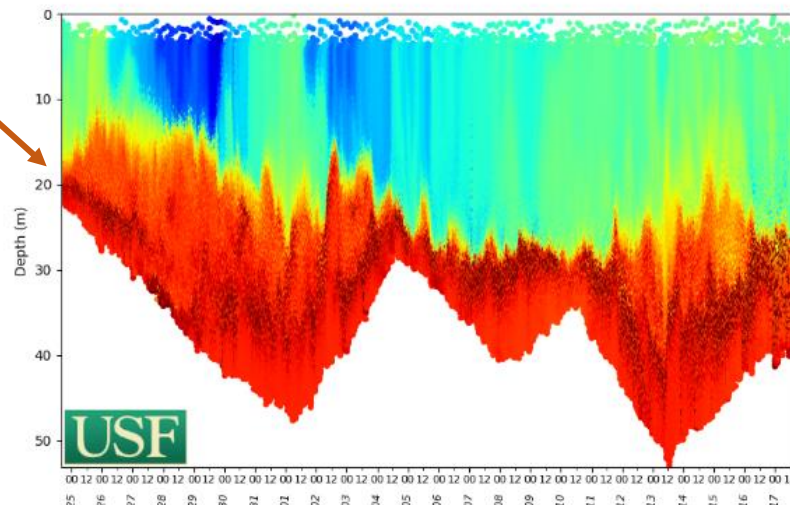
Cold  
&  
Salty

usf-sam 2018-08-24 to 2018-09-17  
Chlorophyll ( $\mu\text{g}/\text{m}^3$ )

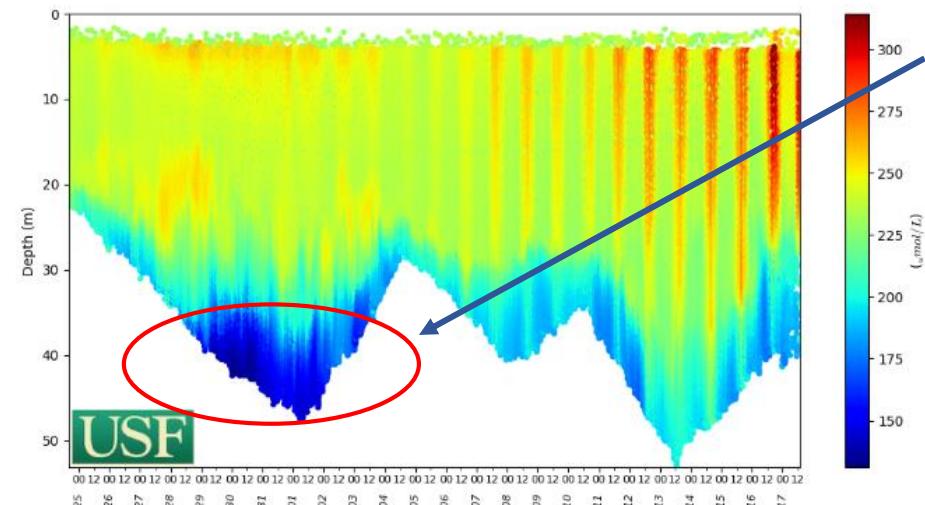


High Chl  
&  
Low Oxy

usf-sam 2018-08-24 to 2018-09-17  
Salinity PPT ( $10^{-3}$ )



usf-sam 2018-08-24 to 2018-09-17  
Dissolved Oxygen ( $\mu\text{mol}/\text{L}$ )



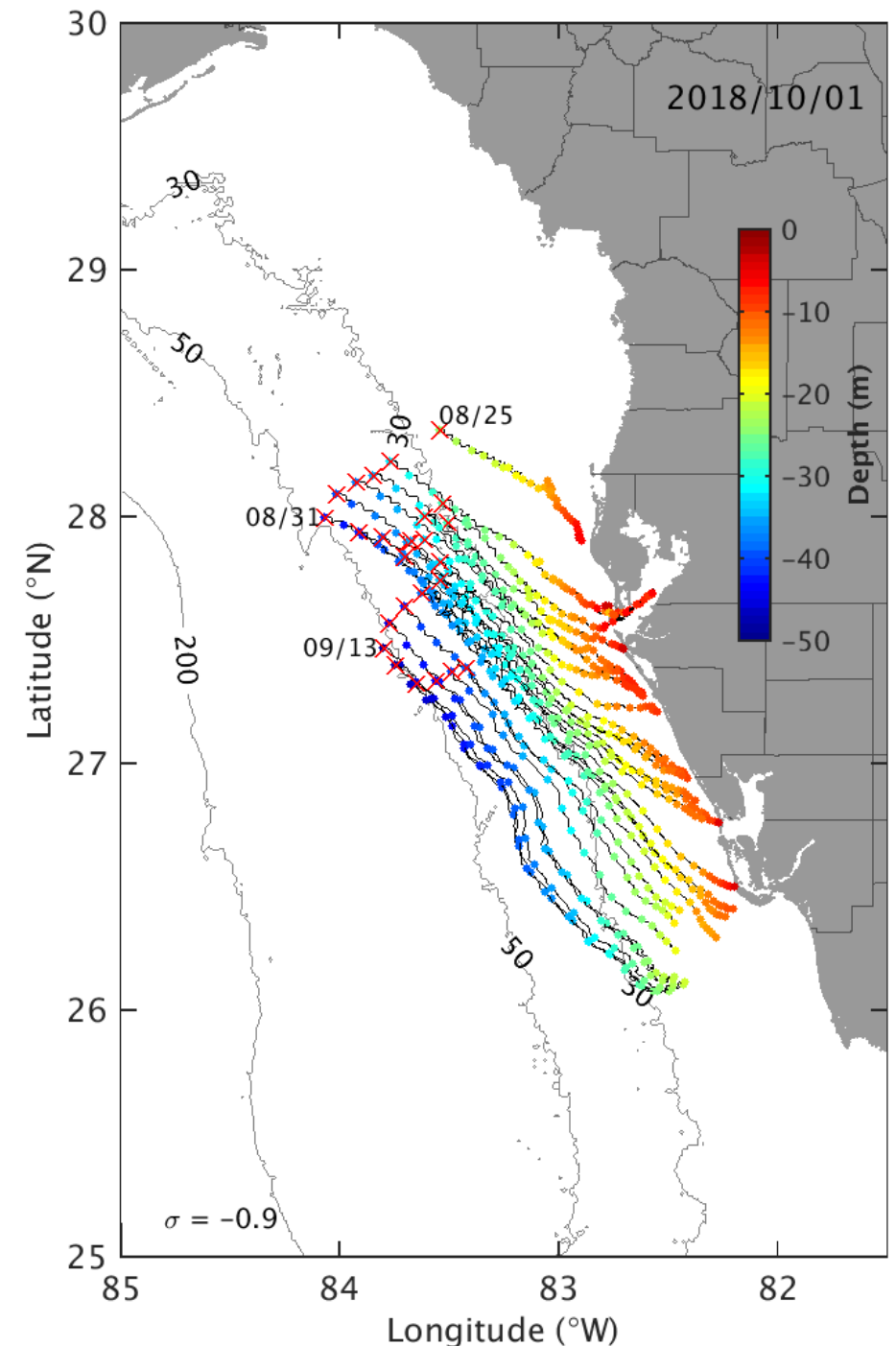
# Transport to the Coastline

Given observations indicative of *K. brevis* red tide, where would these cells go if transported by the circulation?

We applied our West Florida Coastal Ocean Model (WFCOM) to track simulated particles in 3-D. Beginning near bottom when the glider was at each of the **X** designated locations, the colored lines are the particle trajectories and depths ending on 10/1/18. All of the near bottom particles approached the coastline from northern Pinellas County to Lee County, consistent with the mid-shelf initiation hypothesis.

While not shown we also tracked particles from higher in the water column to the Panhandle coast (as influenced by TS Gordon) and from the west coast to the east coast.

Thus *K. brevis* red tide from the hypothesized initiation region accounts for the simultaneous occurrence in 2018 of blooms on Florida's west, Panhandle and east coasts.



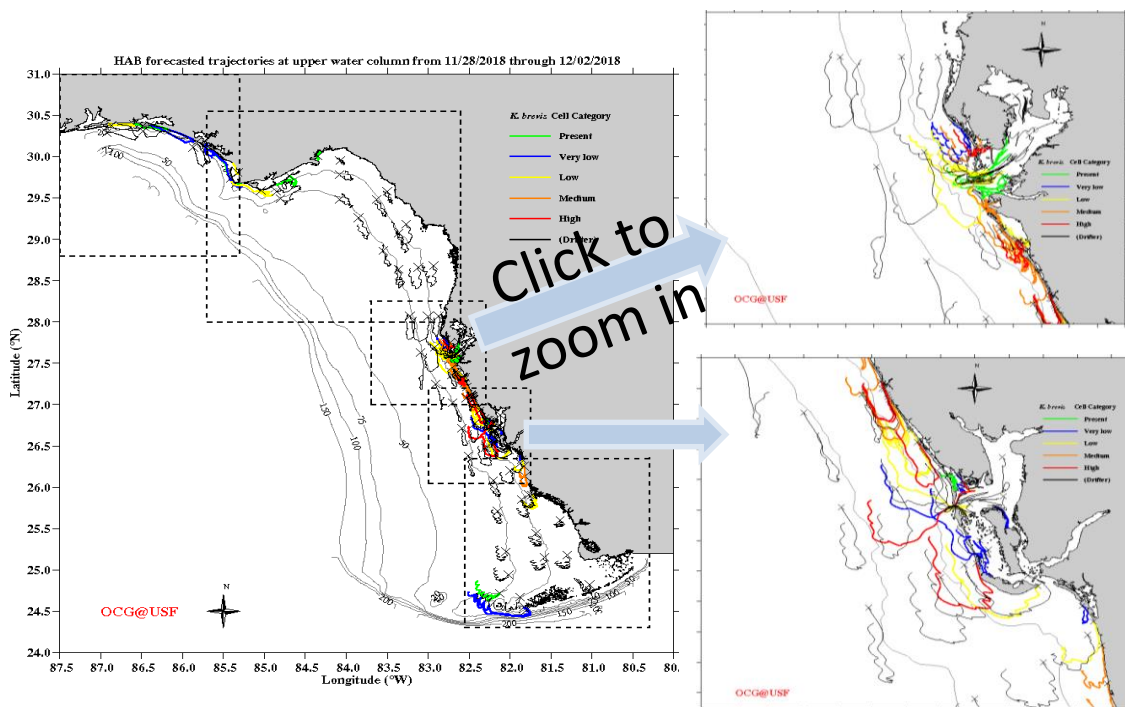


# Seasonal and Short-term (4.5-day) Forecasting by the USF-CMS/FWC-FWRI Collaboration for the Prediction of Red tide (CPR).

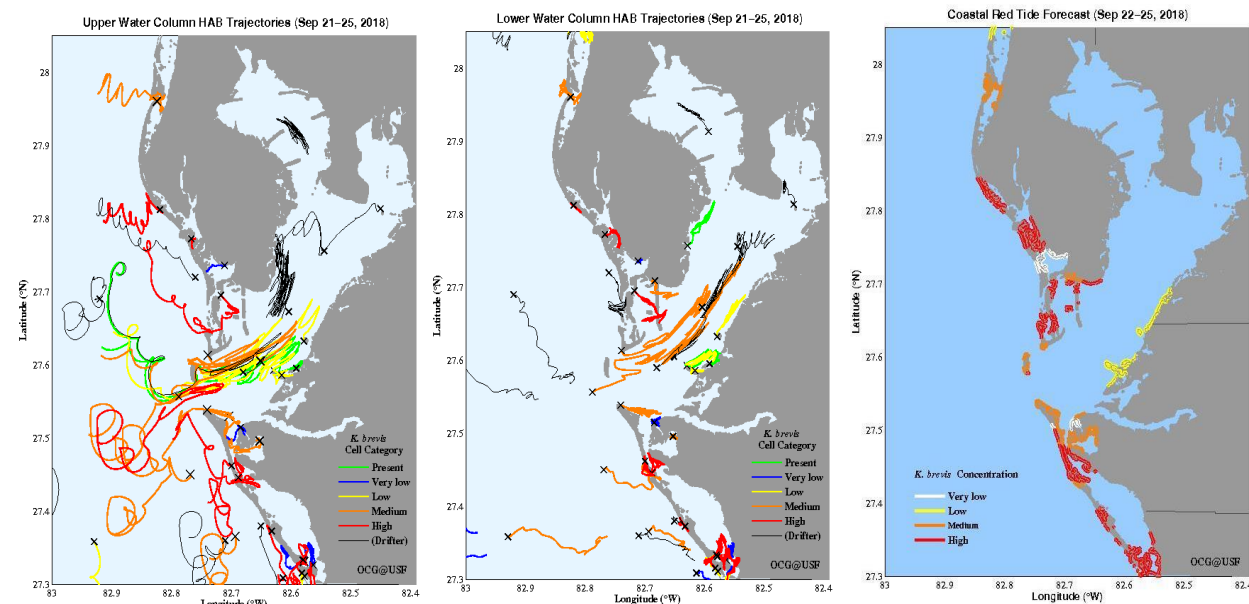
**Seasonal:** Based on mid-shelf nutrient conditions determined by the circulation.

**Short-term:** Based on observations (FWC-FWRI) and two different circulation models (USF-CMS): the West Florida Coastal Ocean Model (WFCOM) and the Tampa Bay Coastal Ocean Model (TBCOM)

### WFCOM for the entire West Florida Shelf



### TBCOM for Tampa Bay



[http://ocgweb.marine.usf.edu/hab\\_tracking/](http://ocgweb.marine.usf.edu/hab_tracking/)

# Pathway Forward:

1. Predictions require understanding, observations and models. *K. brevis*, and anything of an ecological nature, is an interdisciplinary problem. Improved *K. brevis* capabilities will not be achieved by studying the organism biology alone. Similar can be said for fisheries management.
2. Observations:
  - Regular glider surveys are needed to ascertain T/S/Chl/CDOM/O<sub>2</sub> across the incipient bloom region.
  - Glider surveys must be supplemented by cruises to determine nutrients and cell counts when and where gliders indicate elevated Chl/CDOM.
  - Strategically placed moorings (COMPS buoys C12 and C10) should be outfitted with near bottom nutrient sensors.
3. Models:
  - WFCOM and TBCOM require stabilized funding, inclusion of active biology and data assimilation.
  - But it must be realized that while 7 state variables with few parameterizations are required for the circulation, many more are required for *K. brevis*, and each with multiple parameterizations. Ecological prediction without adequate observations will fail. The good news is that our circulation-based approach to seasonal prediction, while incomplete, is bearing fruit (correct in 20 of 25 years).
4. What determines *K. brevis* red tide bloom termination remains unknown. This may hold the key to mitigation and, equally importantly, mitigation without unintended consequences worse than the red tide itself.

## **2. Circulation tools for Florida's West Coast.**

# Observations: <http://comps.marine.usf.edu>

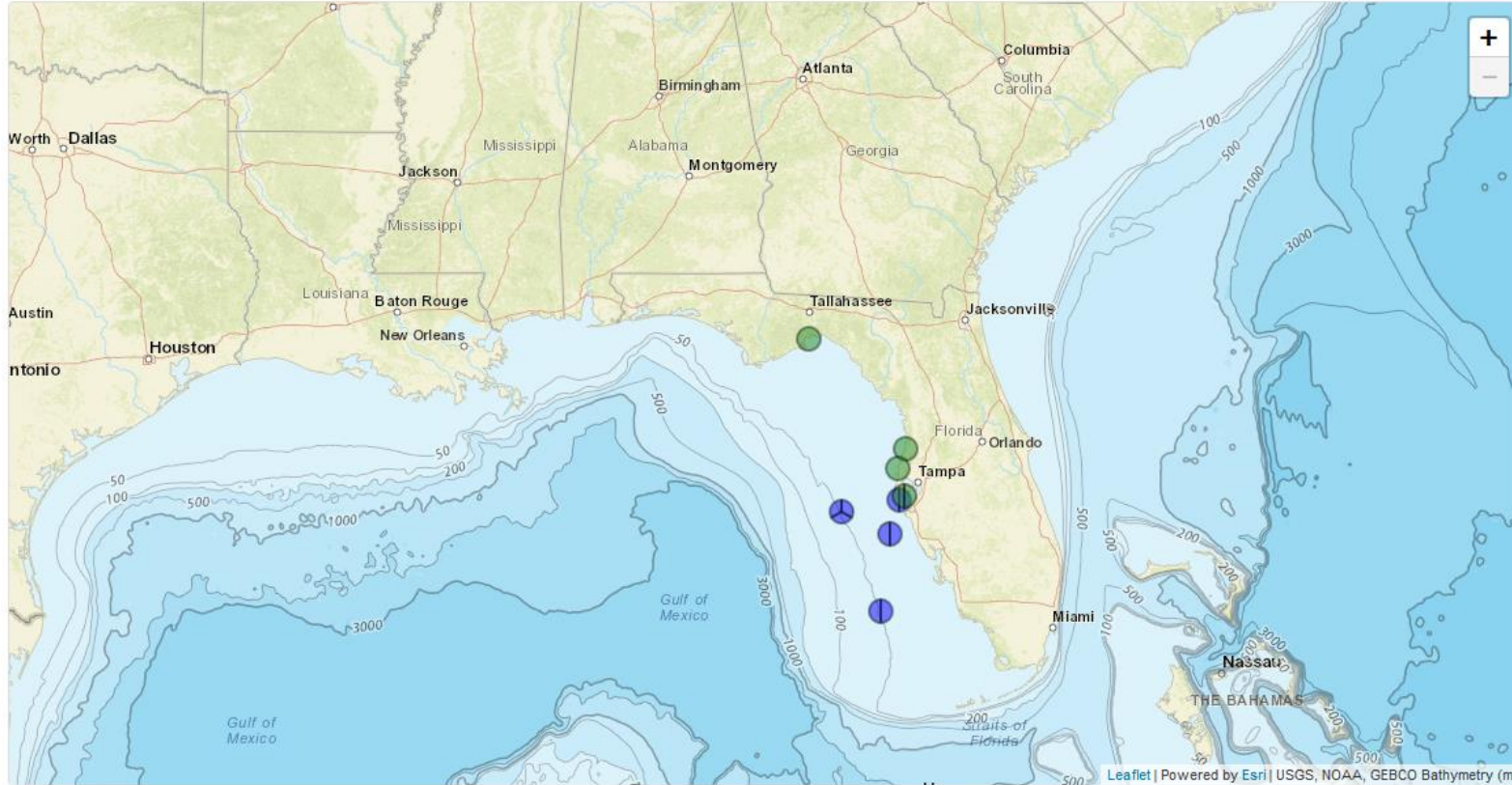
**MAPS**

- Radar Imagery
- Tropical Cyclones

**COMPS STATIONS**

- APK
- C10
- C10\_INWATER
- C12
- C12\_INWATER
- C12\_WQ
- C13
- C13\_INWATER
- C21
- C21\_INWATER
- CLB
- CLB\_WQ
- FHP
- SHP

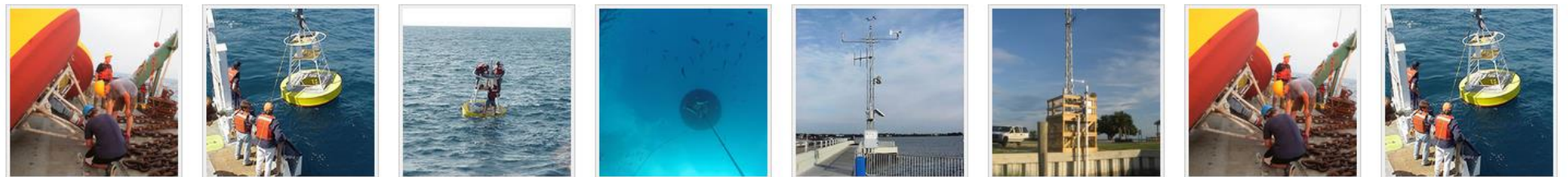
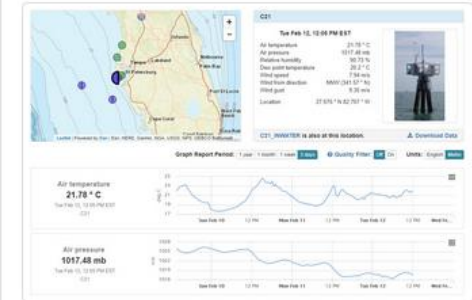
Reset



## Welcome to COMPS!

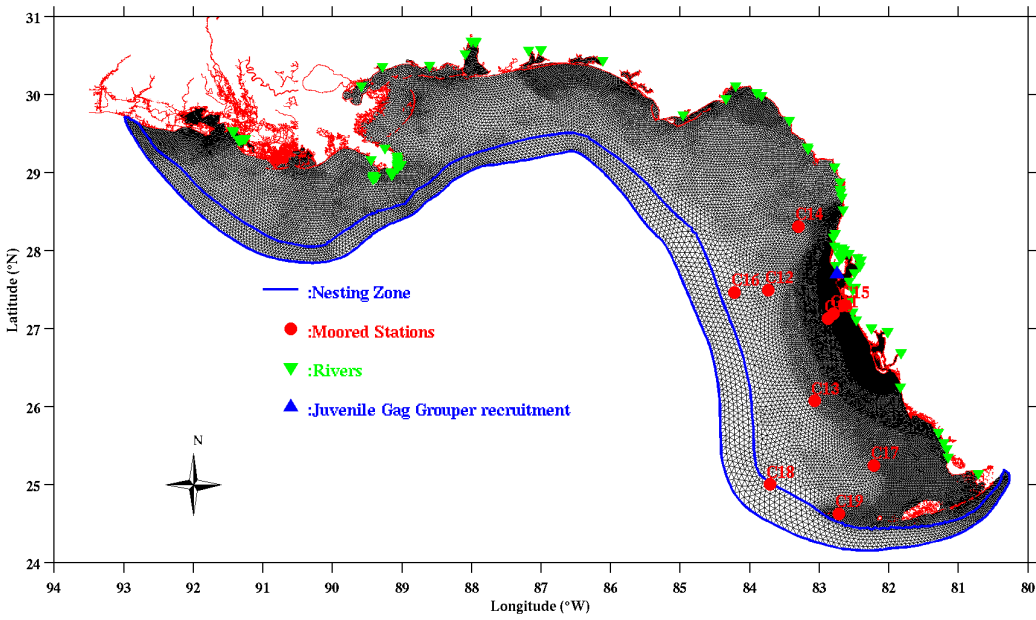
Use the list or the map to the left to access near-real time observations.

Access graphs and historical data by clicking on a station.

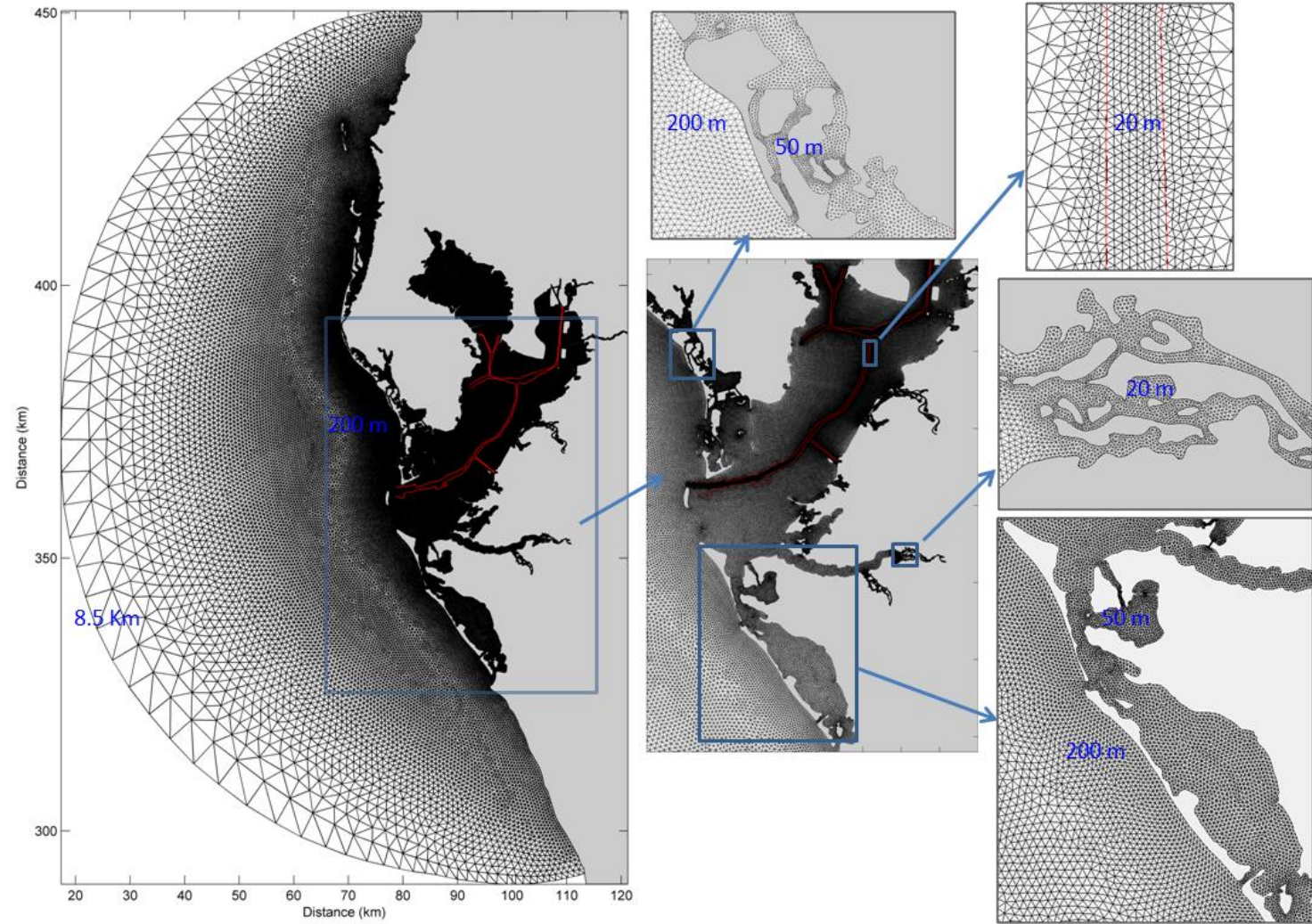


**Models: The West Florida Shelf is driven both by the deep ocean and by local forcing. The estuaries are driven by the WFS and by local forcing. Hence we must downscale from the deep ocean, across the shelf and into the estuaries**

**The West Florida Coastal Ocean Model (WFCOM) nests the unstructured grid FVCOM in GOM HYCOM**

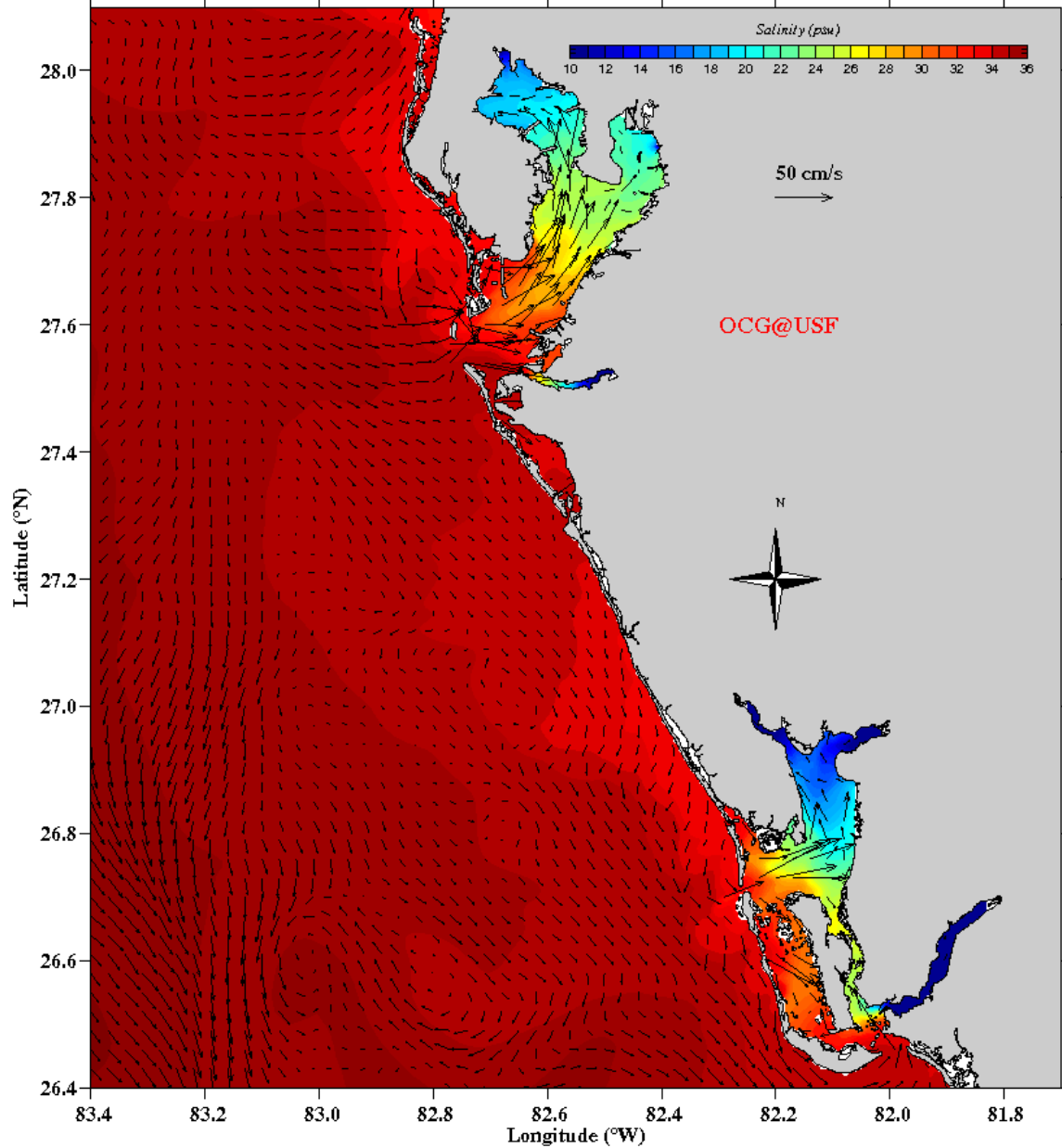


**The Tampa Bay coastal Ocean model (TBCOM) nests FVCOM in WFCOM**

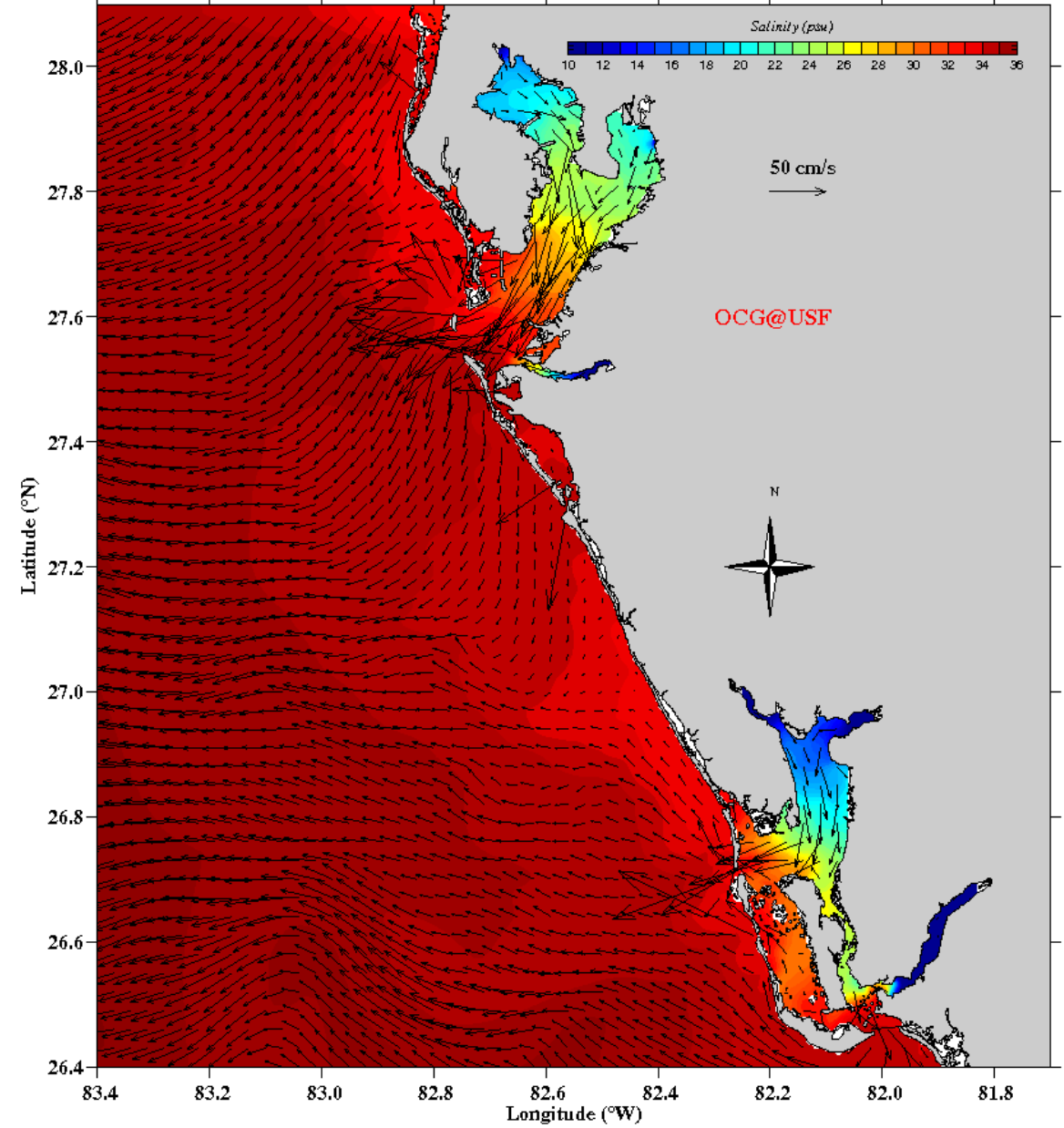


# West Florida Coastal Ocean Model (WFCOM) Nowcast/Forecast Examples

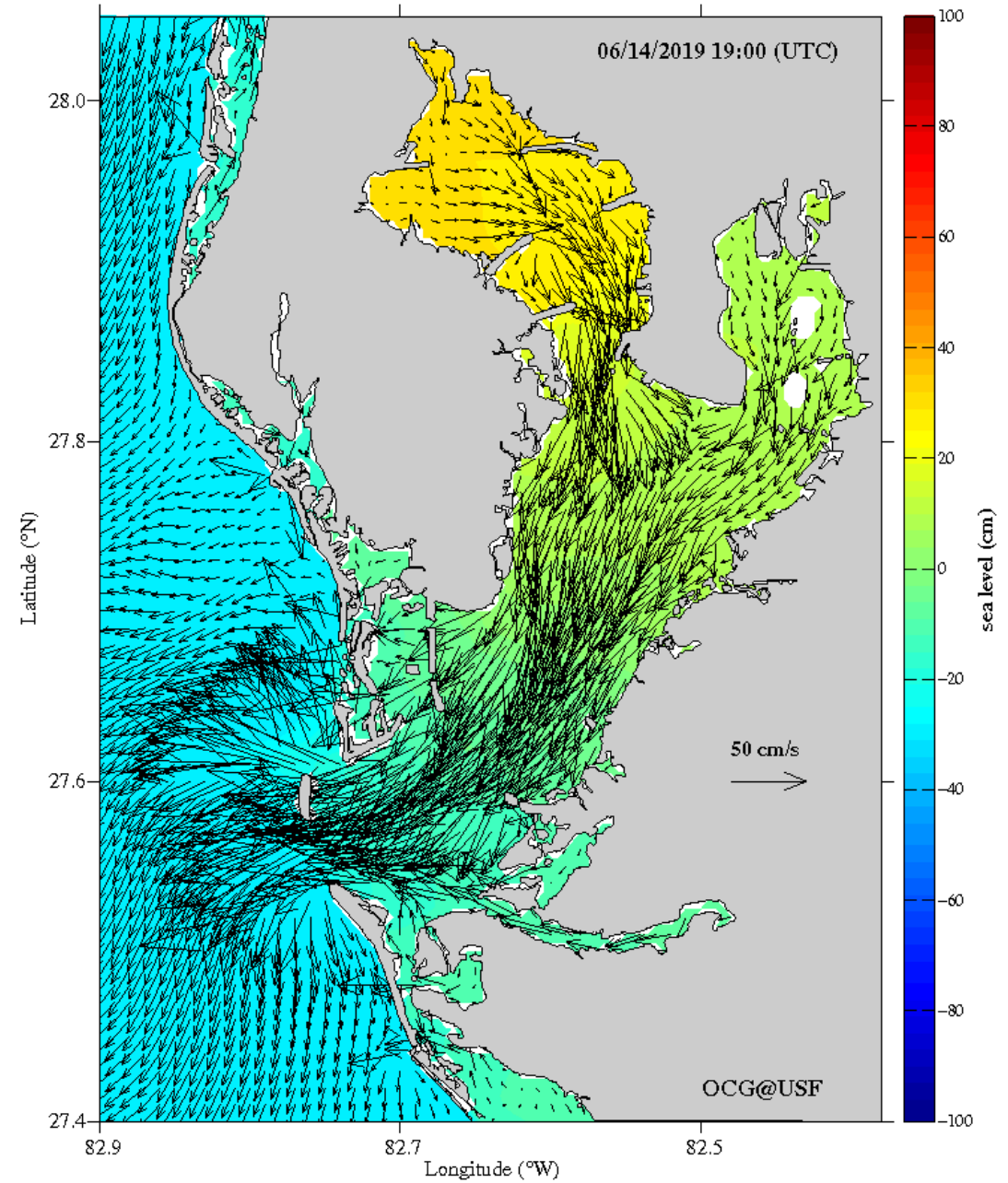
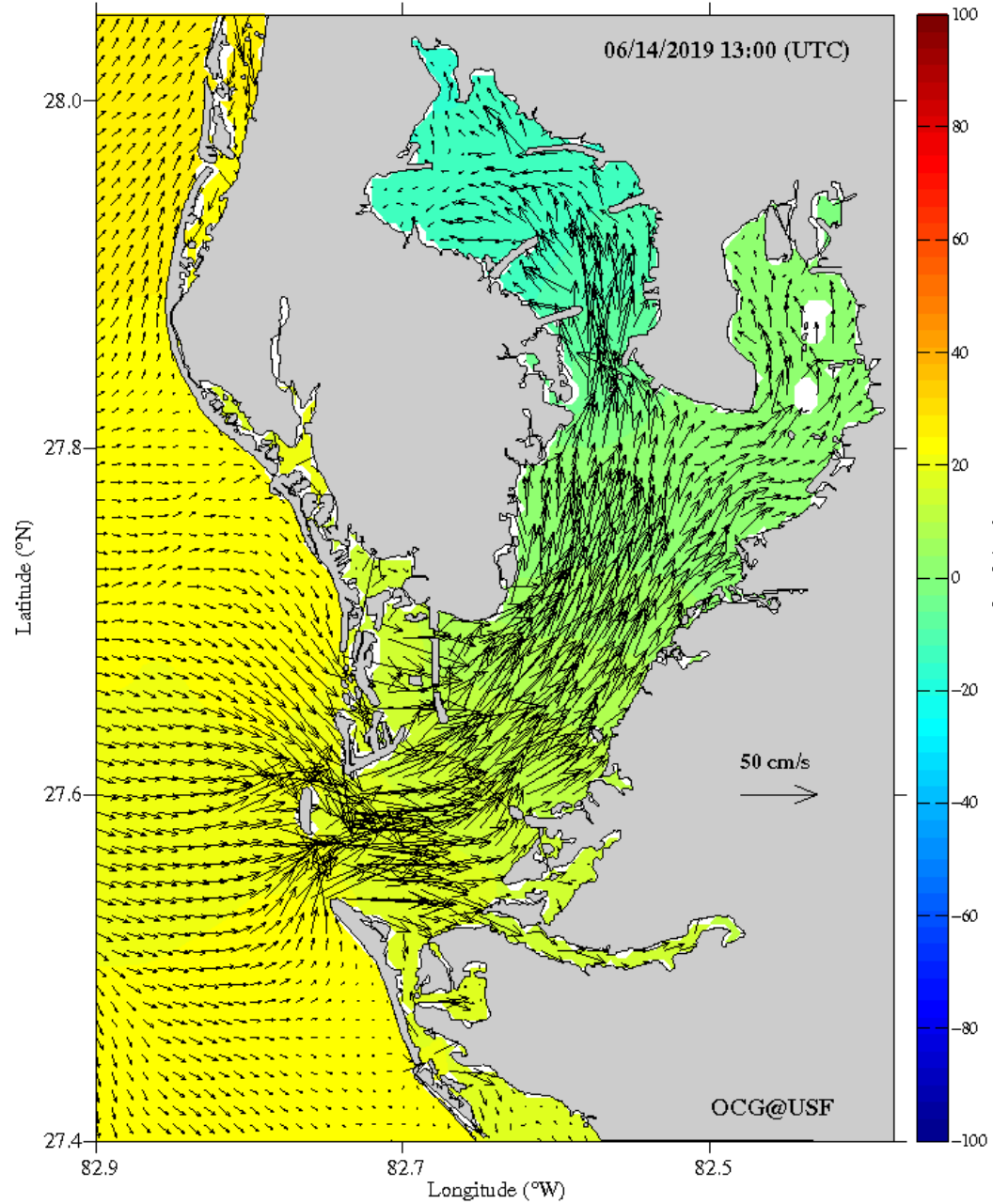
WFCOM surface current and salinity at hour 13 on 06/14/2019



WFCOM surface current and salinity at hour 19 on 06/14/2019



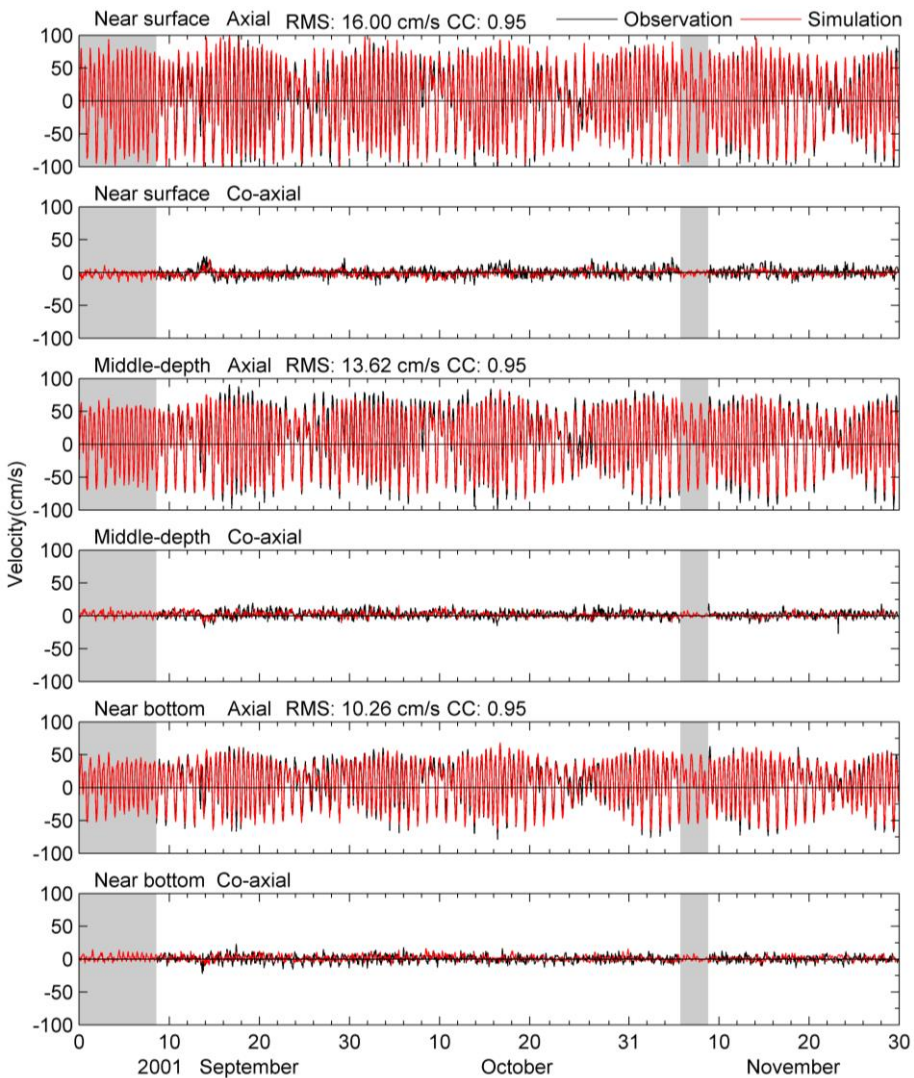
# Tampa Bay Coastal Ocean Model (TBCOM) Nowcast/Forecast Examples



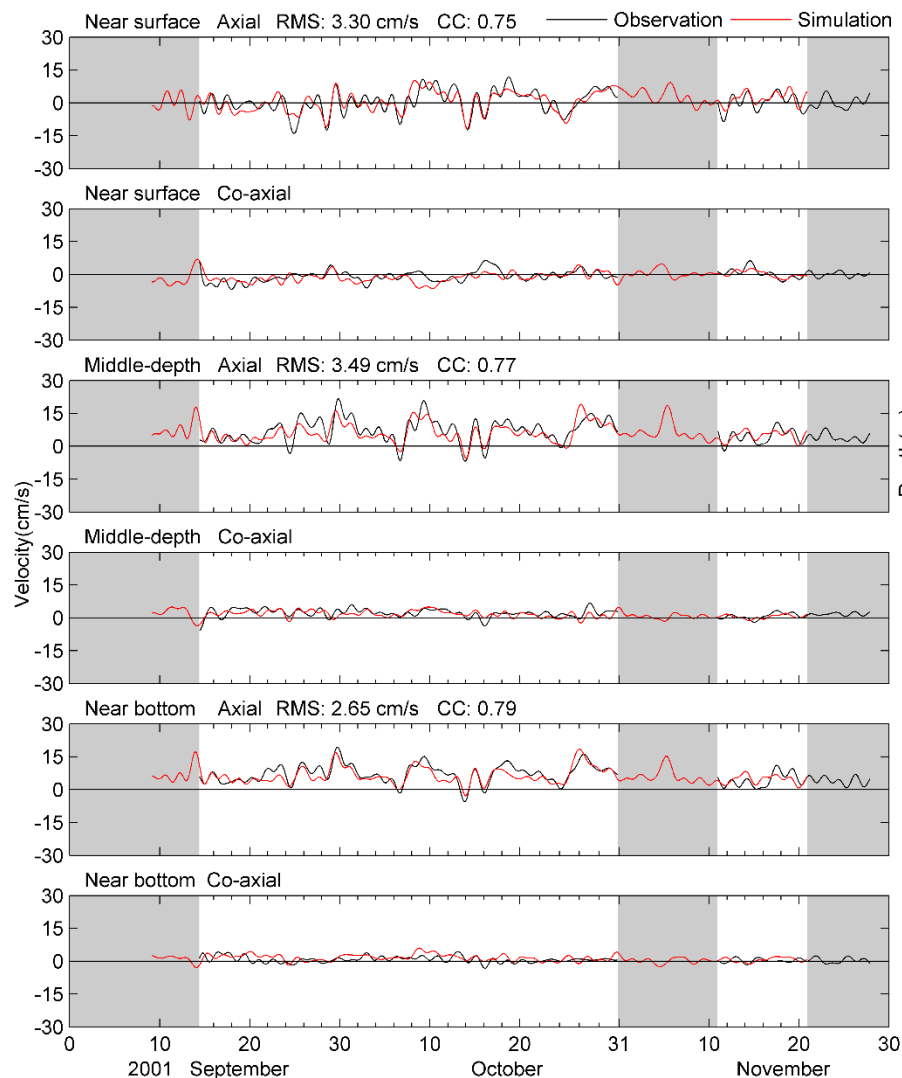
# TBCOM: Is it Accurate? Yes!

The present N/F has not been fully assessed yet. Nonetheless, the previous hindcast version run for the three month interval, Sept.-Nov. 2001 was compared with currents under the Skyway Bridge, as shown below.

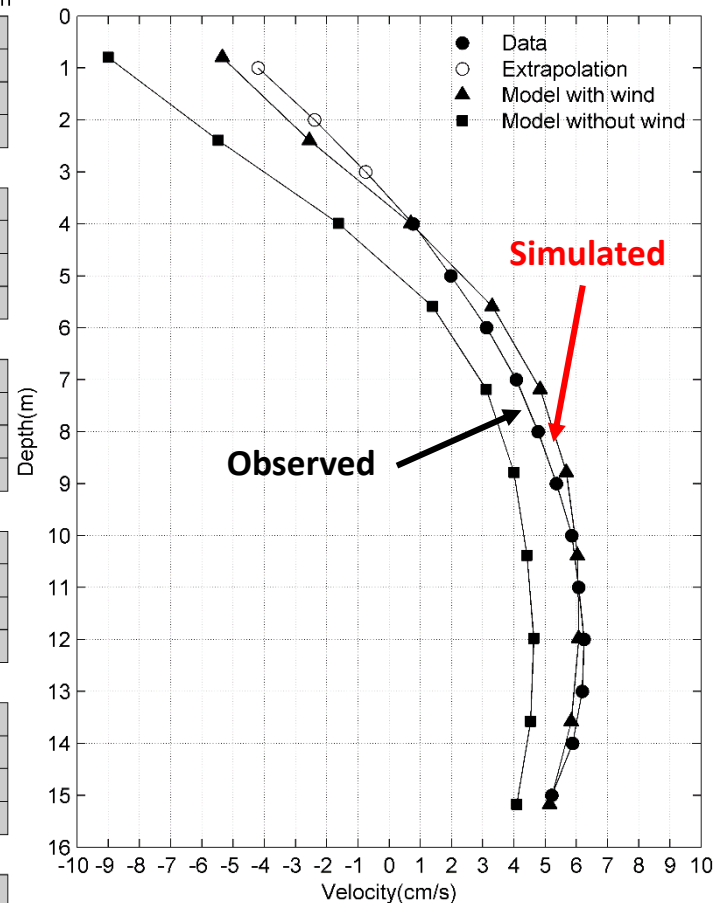
### Axial and Co-axial Currents Observed and Simulated



### Low-pass filtered Axial and Co-axial Currents Observed and Simulated



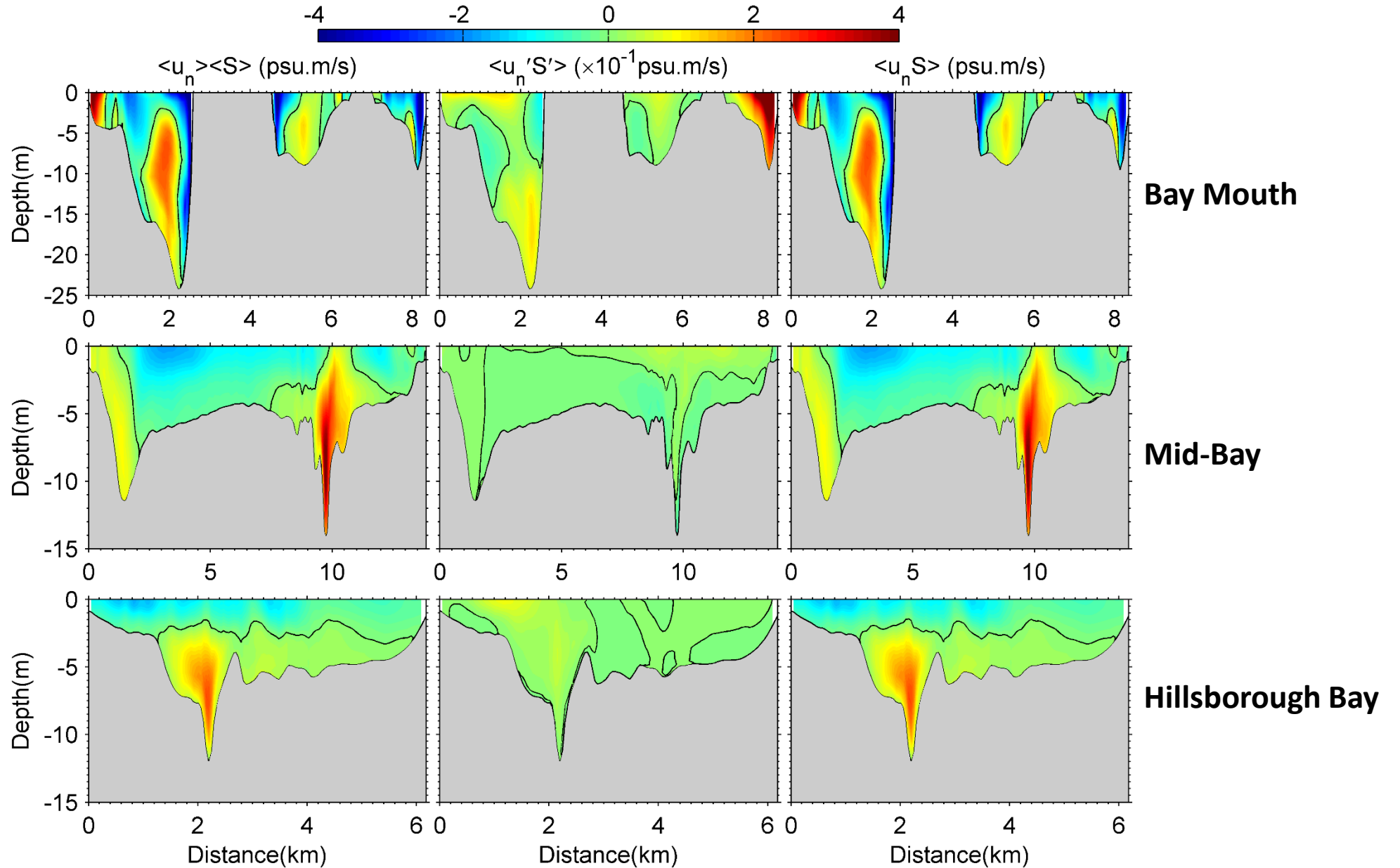
### Record-length-averaged Axial Currents W/O Winds





# Does TBCOM Provide Important Water Quality/Ecology Insights: Yes

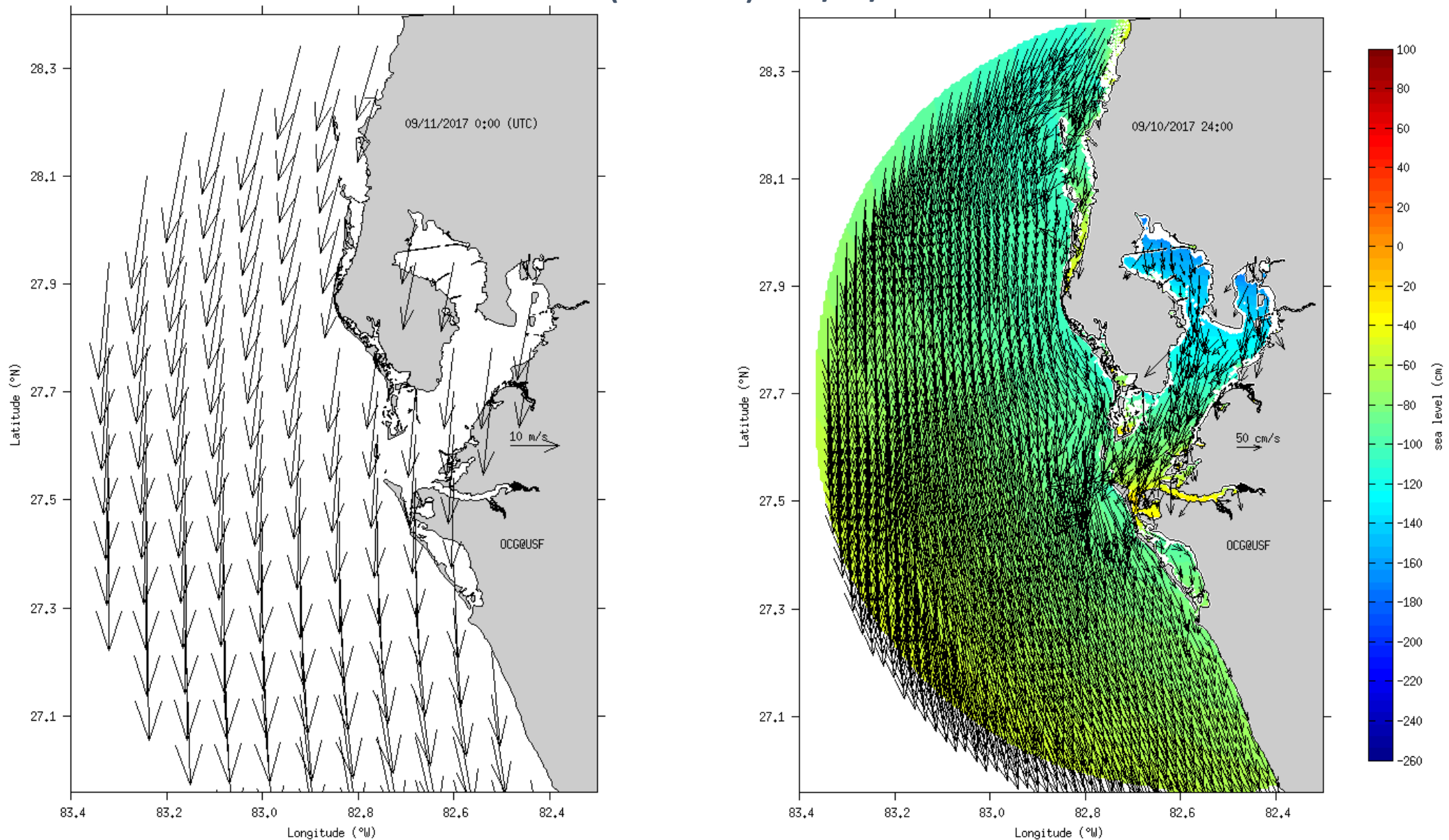
## Salt flux through various cross-sections



# TBCOM Application Example 1: Hurricane Irma

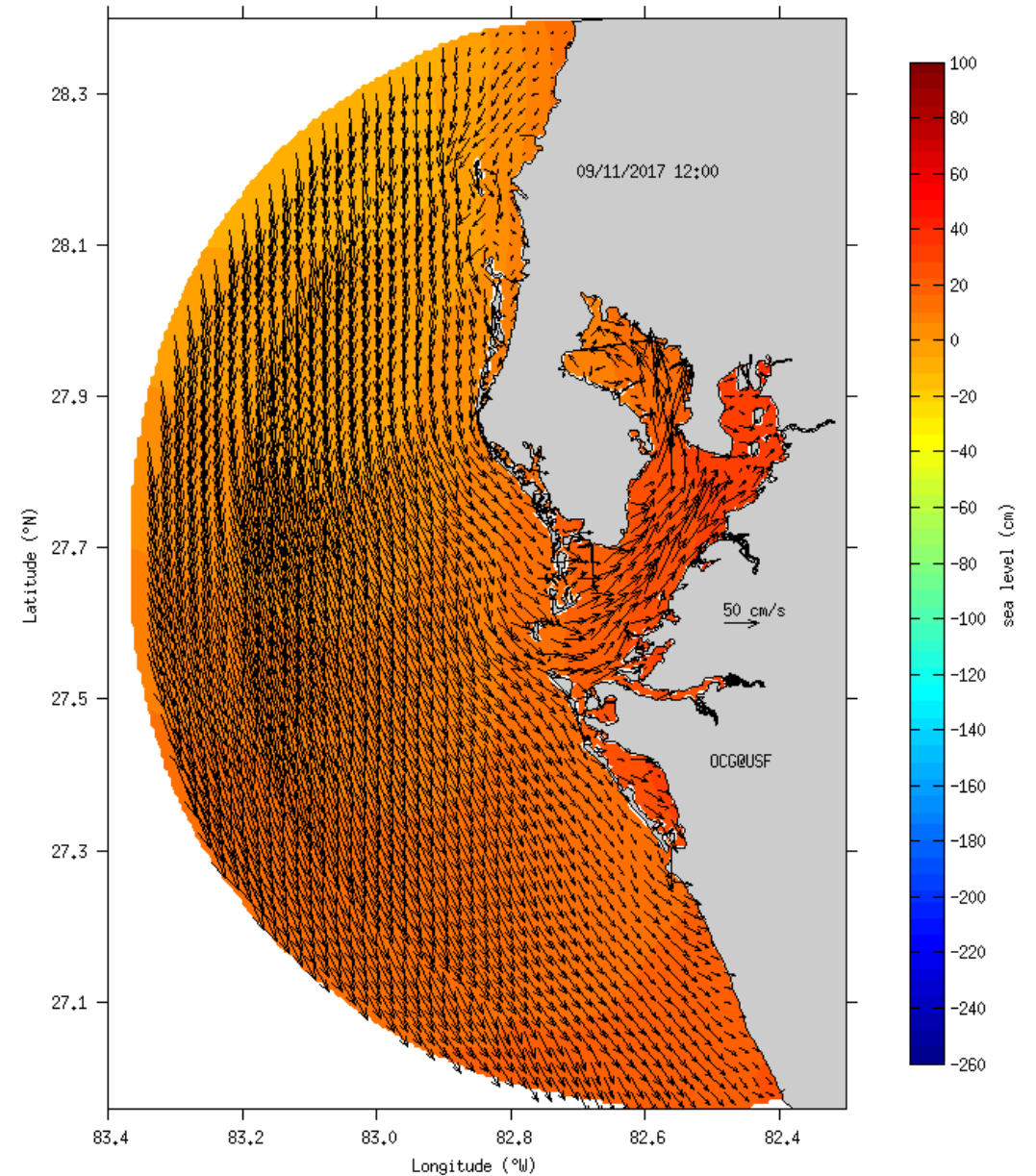
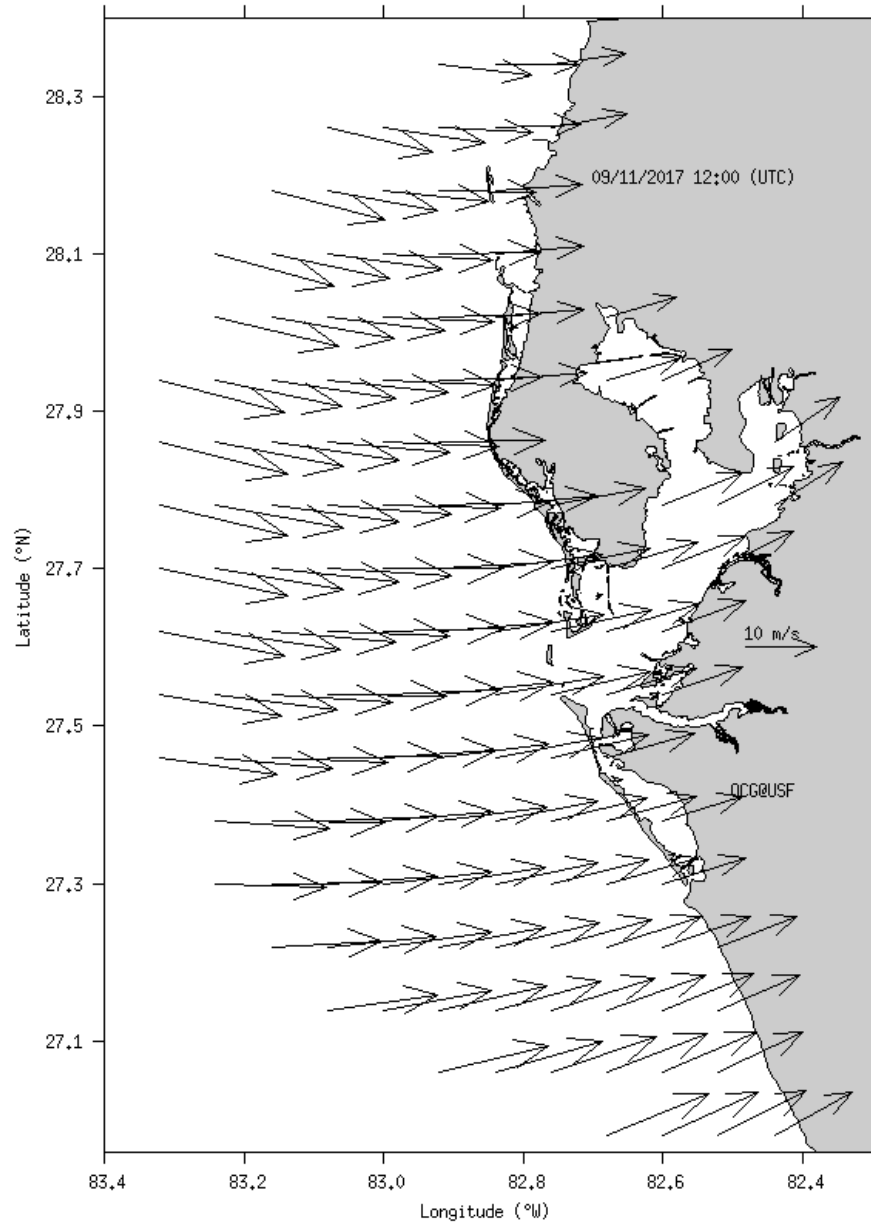
TBCOM Domain Winds, Surface Currents and Sea Level

2400 UT (2000 DST) on 9/10/17



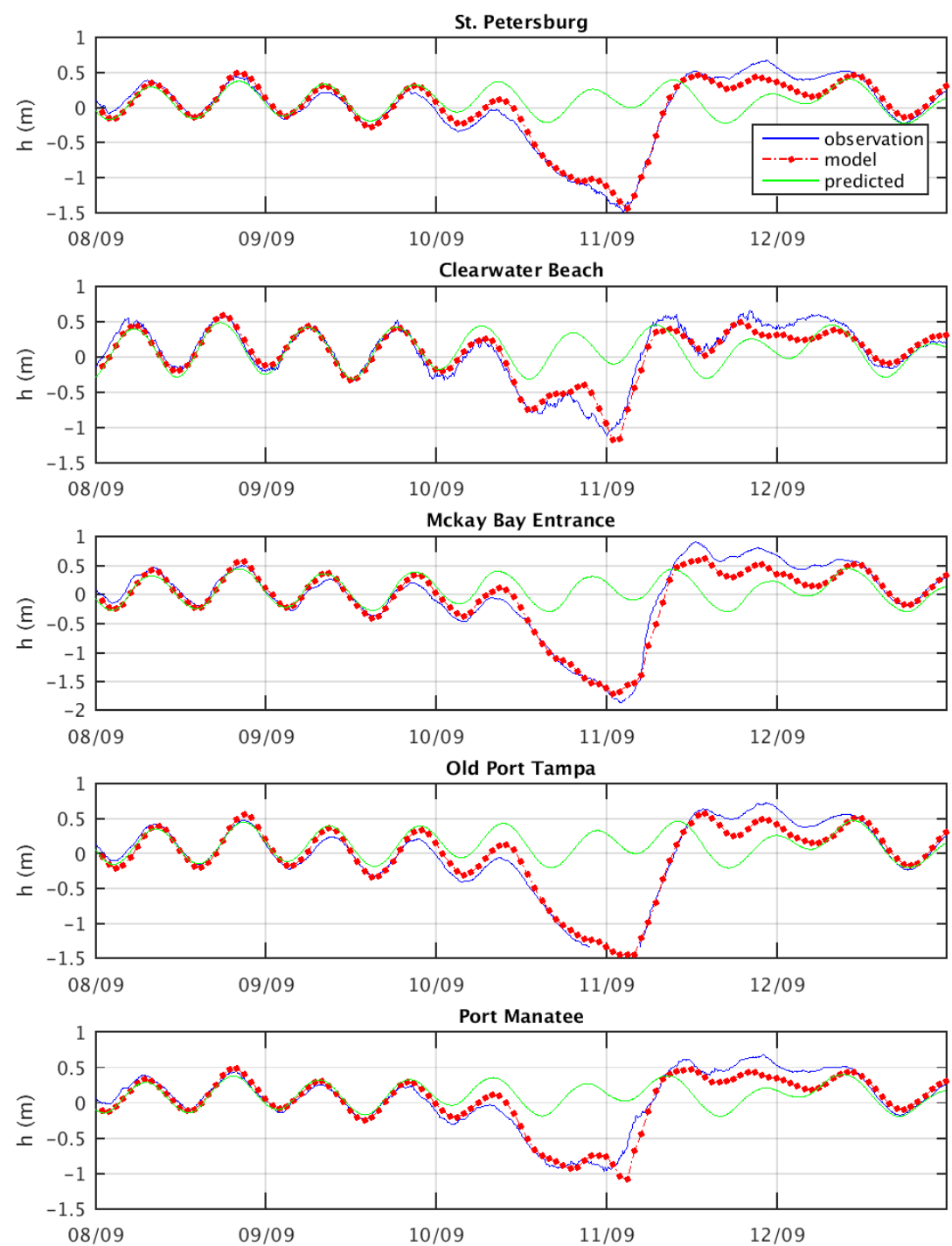
# TBCOM Domain Winds, Surface Currents and Sea Level

## 1200 UT (0800 DST) on 9/11/17



# The Hindcast Hurricane Irma Sea Level Comparisons with Wind Speeds Increased by a Factor of 1.6

From top to bottom are comparisons between sea levels **predicted by tides**, **observed** and **modeled** for stations at St. Petersburg, Clearwater Beach, Mackay Bay, Old Port Tampa and Port Manatee (all relative to mean sea level).

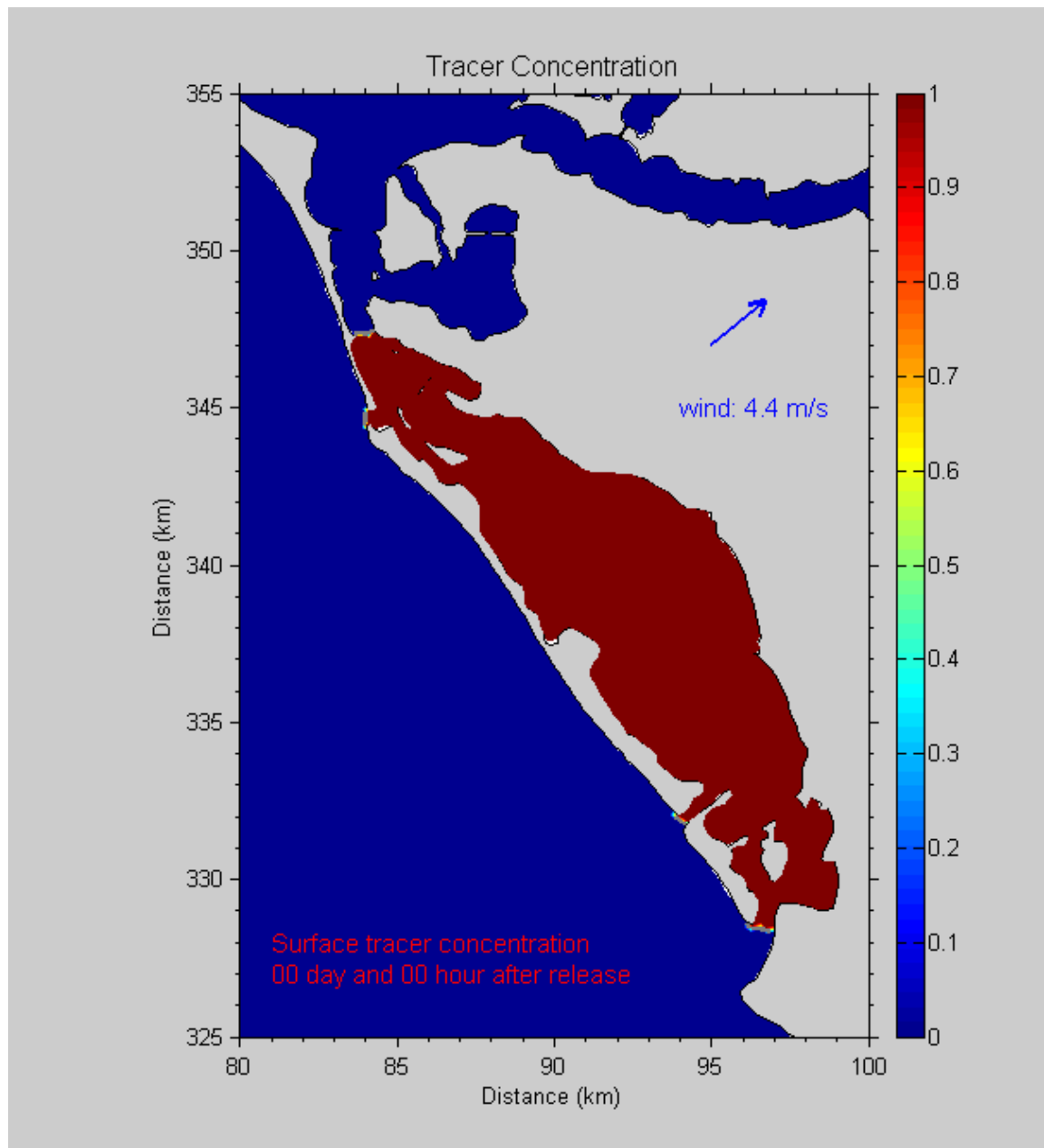


# Other Circulation Modeling Applications

- **Environmental intelligence for boating, fishing, beach-going**
- **Flushing of water bodies**
- **Dispersal from point sources**
- **Tracking of harmful spills**
- **Search and Rescue**
- **Forensic Science studies**
- **Support for Coastal Engineering Projects**

# Flushing of a Water Body: Sarasota Bay Example for 9/1-9/15, 2001

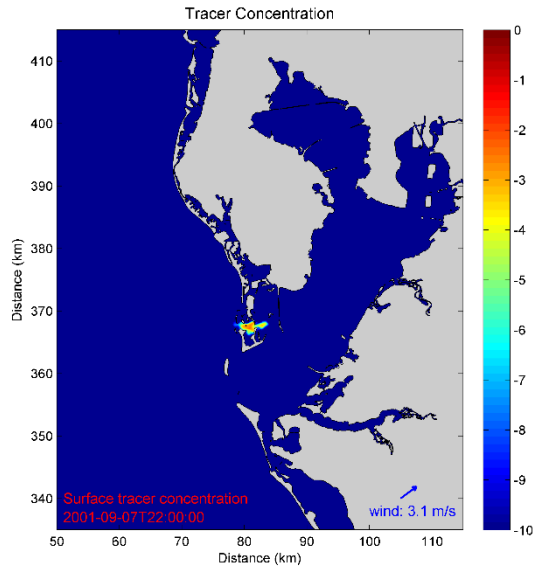
Inlet connectivity impacts all material properties within the bay and how different regions flush or fail to flush.



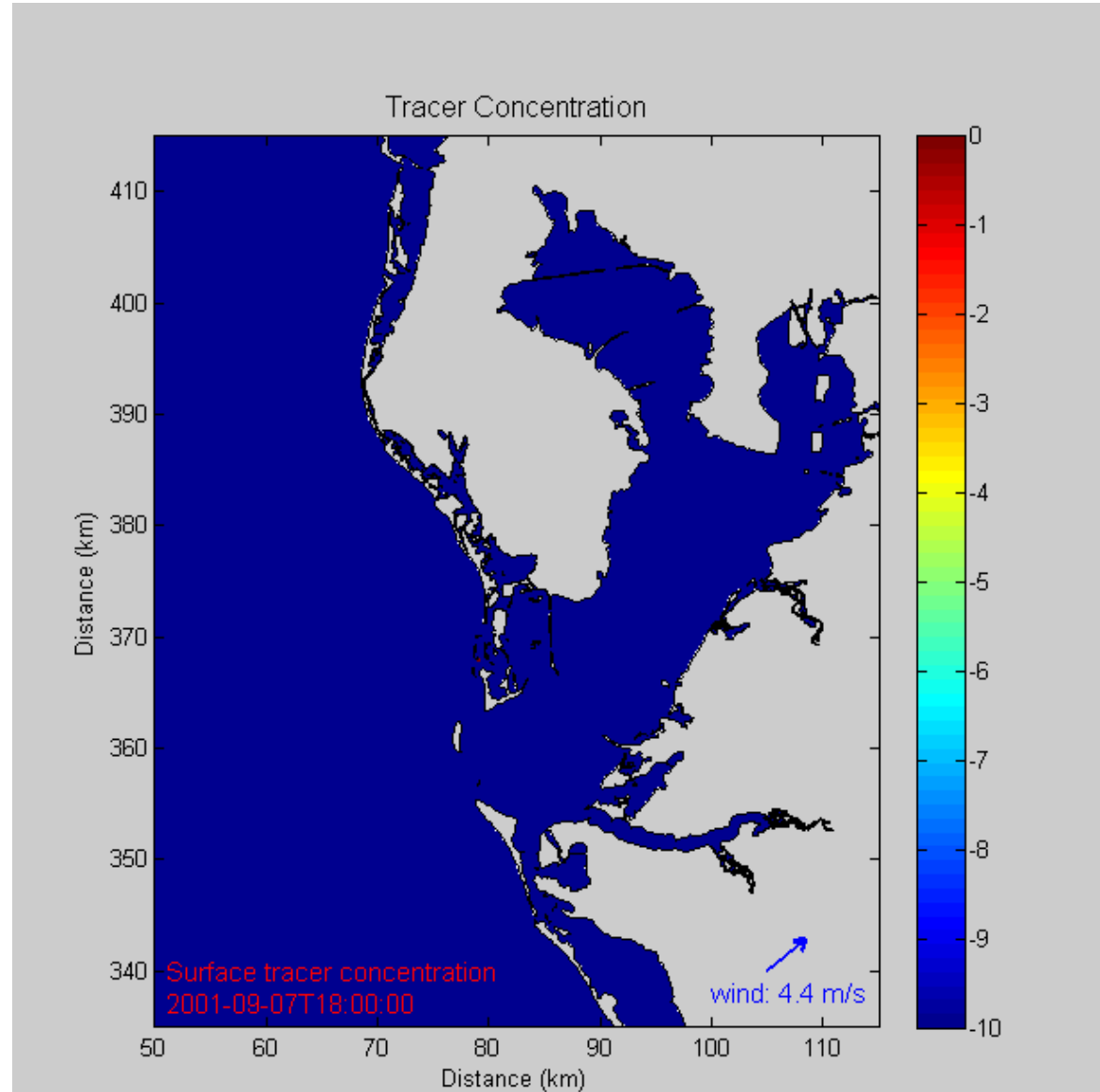
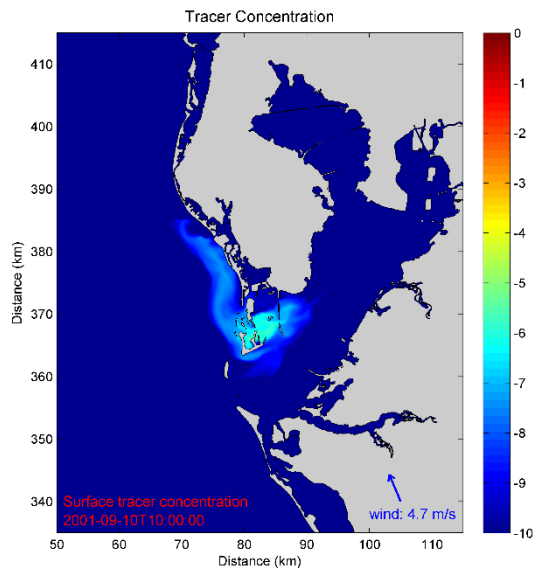
# Tracer Concentration from a Point Source at Bunces Pass.

Spotted Sea Trout preferentially spawn at Bunces Pass. Why did they evolve to do that?

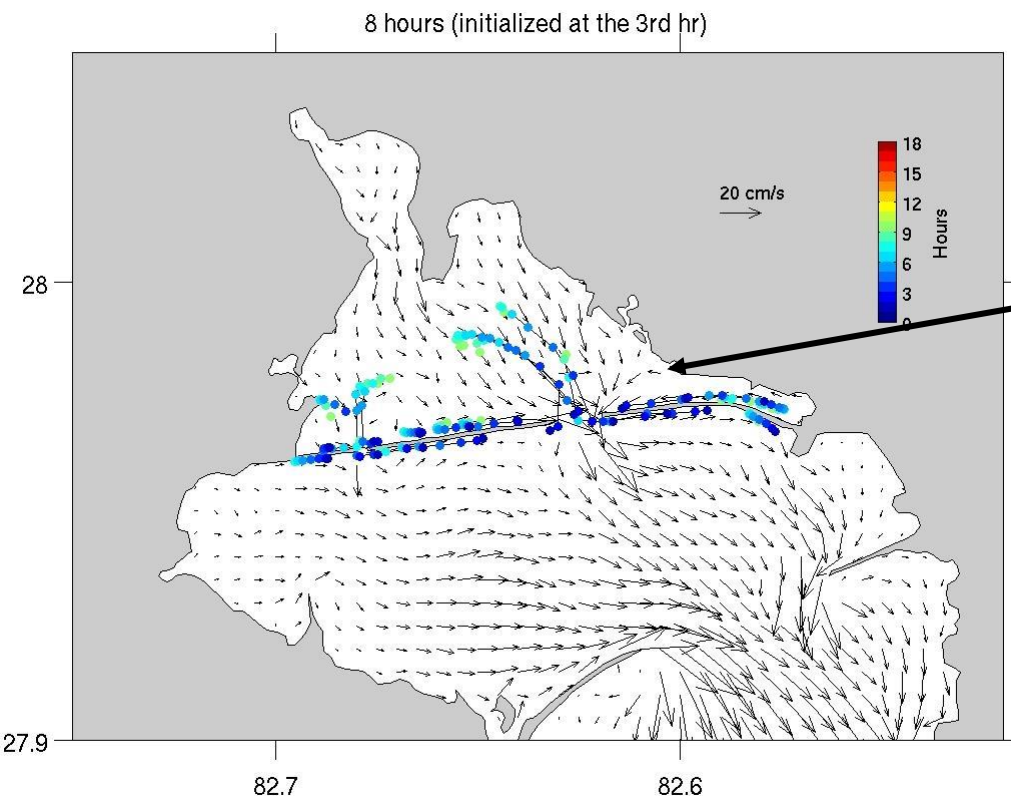
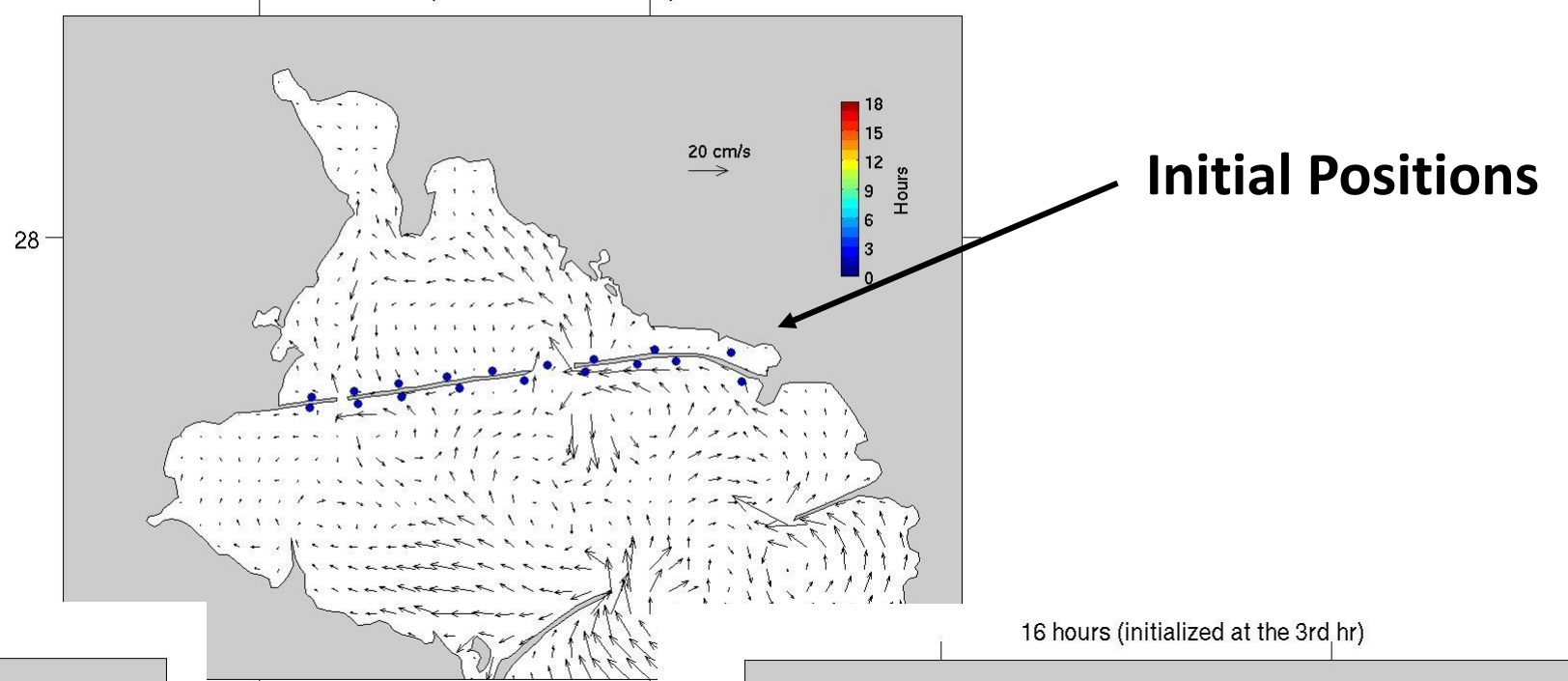
3 hr.



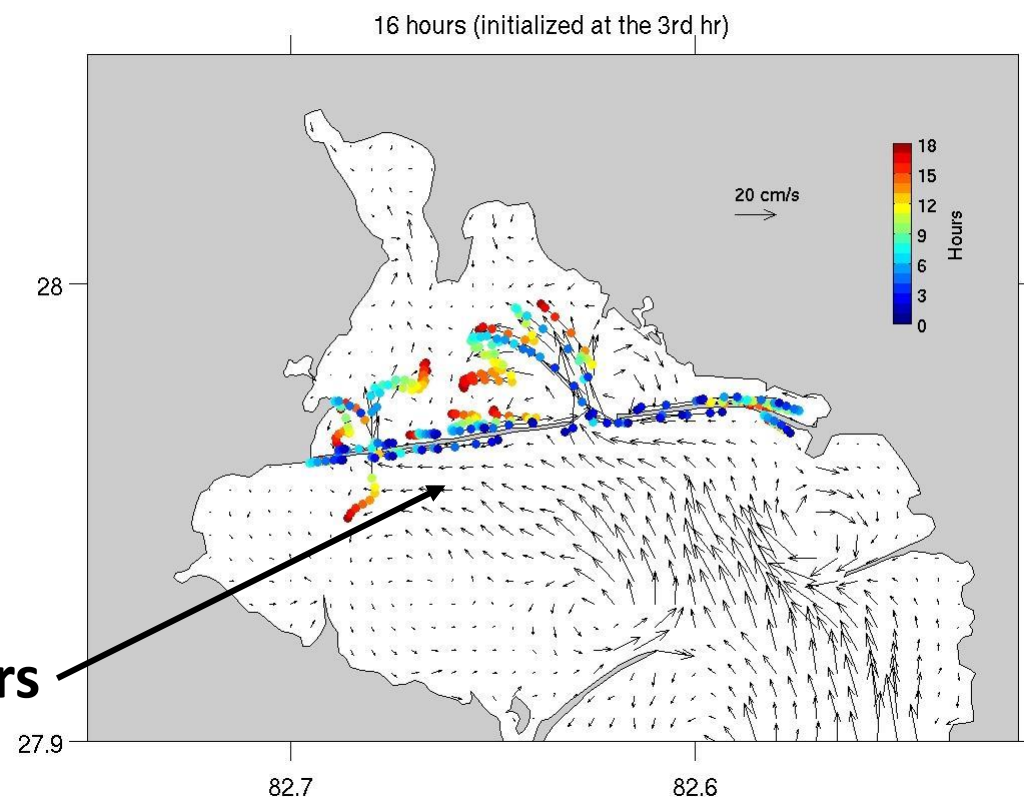
33 hr.



**Potential Search and Rescue Scenario: Where would a swimmer go if carried from the Courtney Campbell Causeway by the currents beginning at a certain phase of the tide?**



**After 8 hrs**



**After 16 hrs**



# Conclusions

- The ocean circulation controls the water properties in which organisms reside and make their livings, and this is fundamental to anything of an ecological nature on Florida's west coast and elsewhere.
- Observations and models of the west Florida coastal ocean circulation are publically available at:
  - <http://comps.marine.usf.edu>
  - <http://ocgweb.marine.usf.edu>
- Applications of these observing and modeling tools exist for a variety of societal relevant topics (e.g., **Red tide**, Fisheries, Oil tracking, Hurricane storm surge), and publications are available upon request.
- We remain interested in addressing other matters of societal concern.