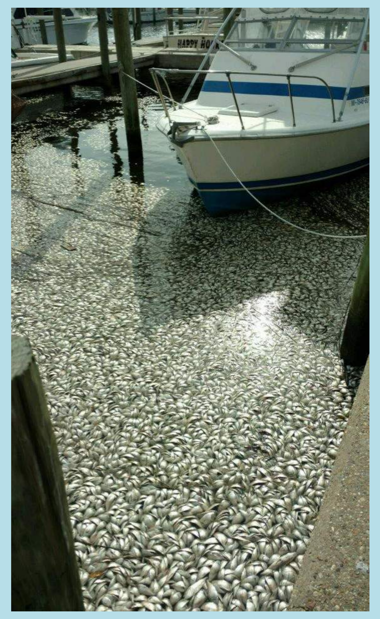
Advection of Karenia brevis blooms from the Florida Panhandle towards Mississippi coastal waters

Inia M. Soto[1], **M. Kemal Cambazoglu**[1*], A.D. Boyette[1], K. Broussard[2], D. Sheehan[3], A.M. Shiller[1], B. Dzwonkowski[4], S. Howden[1], L. Hode[1], P. Fitzpatrick[5], R. Arnone[1], P. Mickle[2], K. Cressman[2]

[1]The University of Southern Mississippi [2]Mississippi Department of Marine Resources [3]Alabama Department of Public Health [4]University of South Alabama, Dauphin Island Sea Lab [5]Mississippi State University

Introduction

- Harmful Algal Blooms (HABs) of the toxic dinoflagellate *Karenia brevis* pose a threat to coastal communities in the Gulf of Mexico.
- *K. brevis* blooms from the Florida Panhandle (FP) region are often advected westward towards the Mississippi-Alabama coast; however there is interannual variability in their presence and intensity in Mississippi coastal waters.
- *K. brevis* blooms in the Florida Panhandle were reported during the fall of 1996, 2000–2003, 2005, 2007 and 2015.
- While *K. brevis* blooms reached the western edge of Florida in all of those years, major blooms were also reported in coastal Alabama in 1996, 2007, and 2015 and coastal Mississippi during 1996 and 2015.

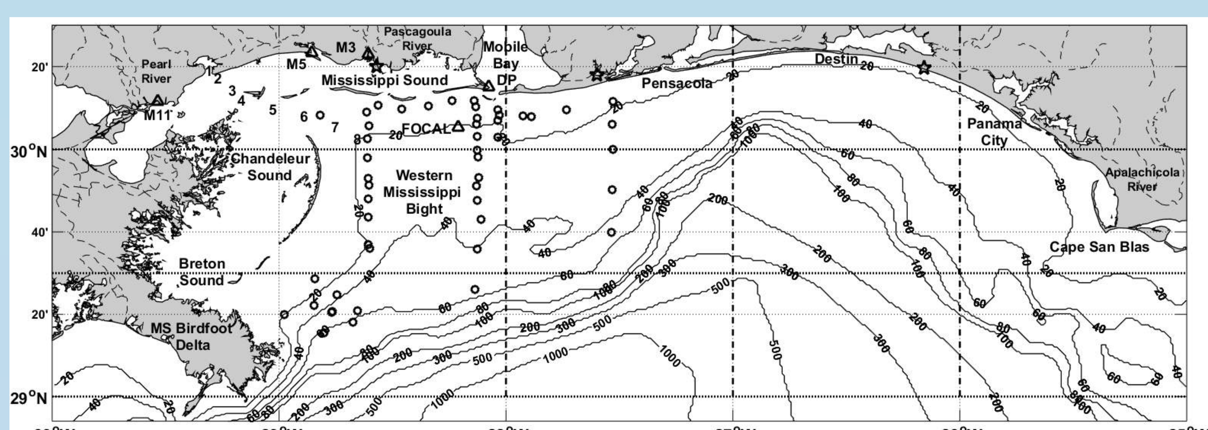


Menhaden mortality. Credits: Biloxi Small Craft Harbor, 2015

Objectives

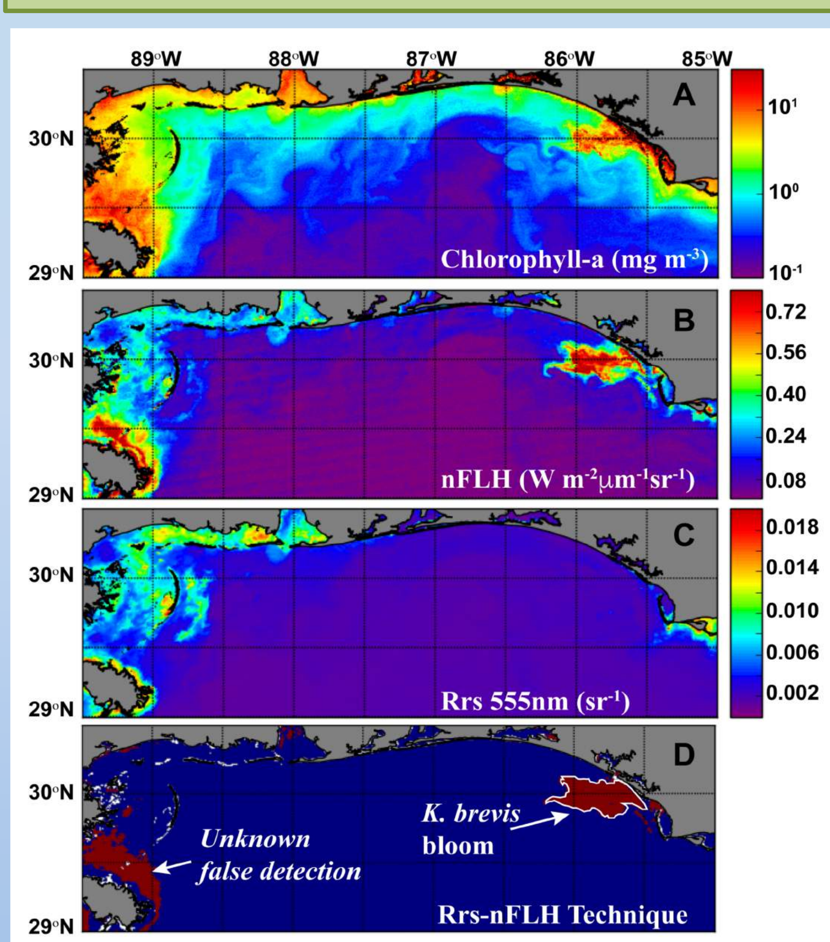
- Compare biophysical oceanographic conditions during two *K. brevis* blooms in the Florida Panhandle: one that preceded a major bloom in the western Mississippi Bight and Mississippi Sound (i.e., fall of 2015) and one that did not (i.e., fall of 2007).
- Identify mechanisms that may have led to a major bloom in Mississippi coastal waters in 2015 and not in 2007.

Study Area



The triangles represent the MDMR stations (M3, M5, M11), FOCAL station and NDBC Dauphin Island (DP). The circles represent the stations during the CONCORDE cruise. The numbers represent the NGI stations (1–8). The stars represent the High Frequency Radar stations. The dotted lines represent the East-West transects and the dashed lines the North-South transects.

Methods



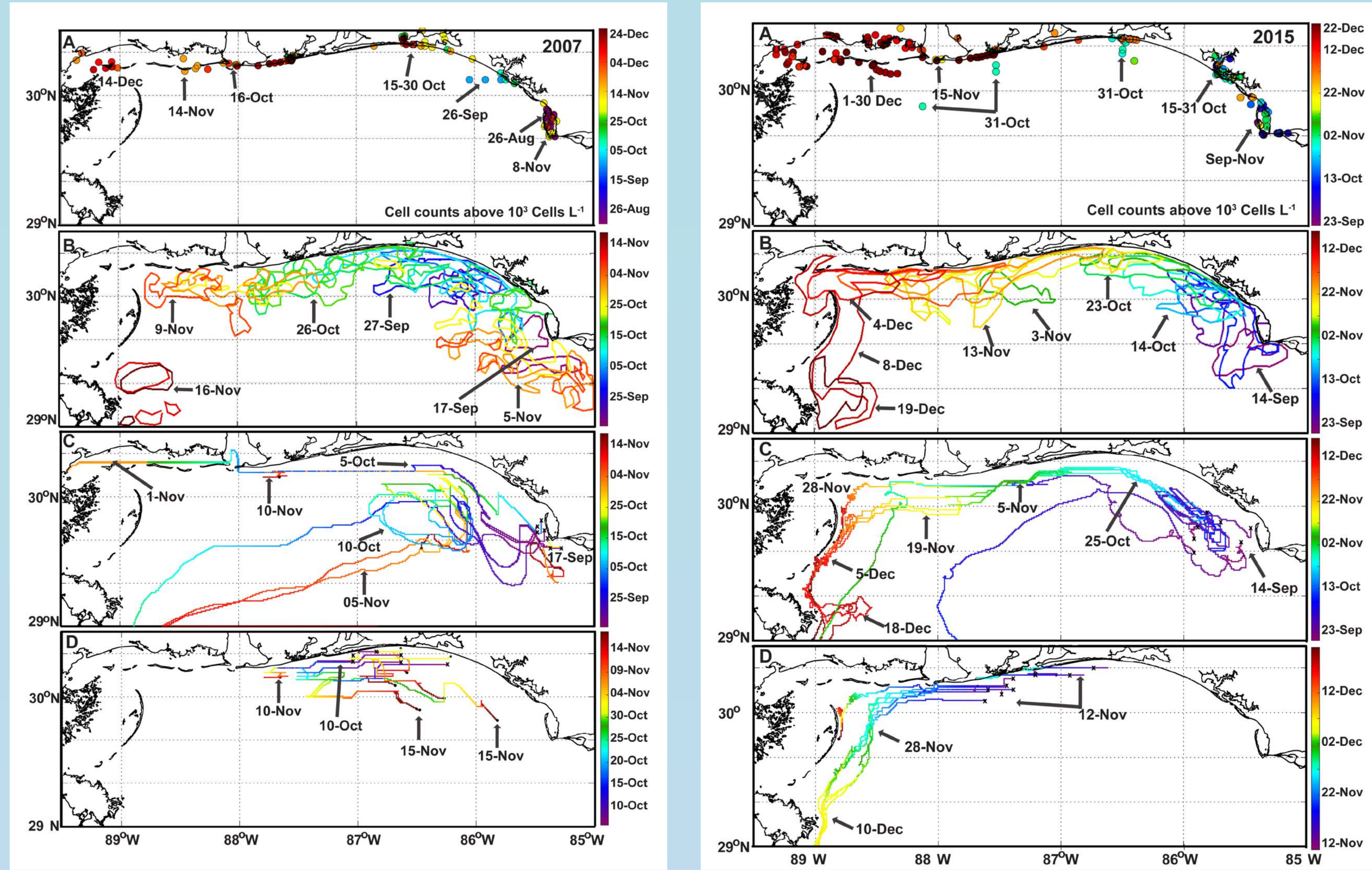
- A comprehensive database of *K. brevis* cell counts
- Nutrients database
- Passive Lagrangian Particle tracking (2m depth)
  - 2015 NRL-NCOM (1 Km, 3h)
  - 2007 NRL- IASNSF (6 Km, 6h)
- Physical oceanography/ Hydrographic data
  - Salinity - models and *in situ*
  - E-W and N-S transport - models
  - Sea surface Currents (High Frequency Radar)
  - Wind data from NOAA/NDBC station at Dauphin Island (AL)
  - River discharge (USGS)

Detection and delineation of *K. brevis* blooms

- MODIS-Aqua 1km imagery
- Detection using the Remote Sensing Reflectance- Fluorescence Line Height detection technique (Soto, et al., 2015. *Remote Sens. Environ.* 170)
- Delineation of the best scenarios (Soto, et al., 2016. *J. Appl. Remote Sens.* 11(1):012002)

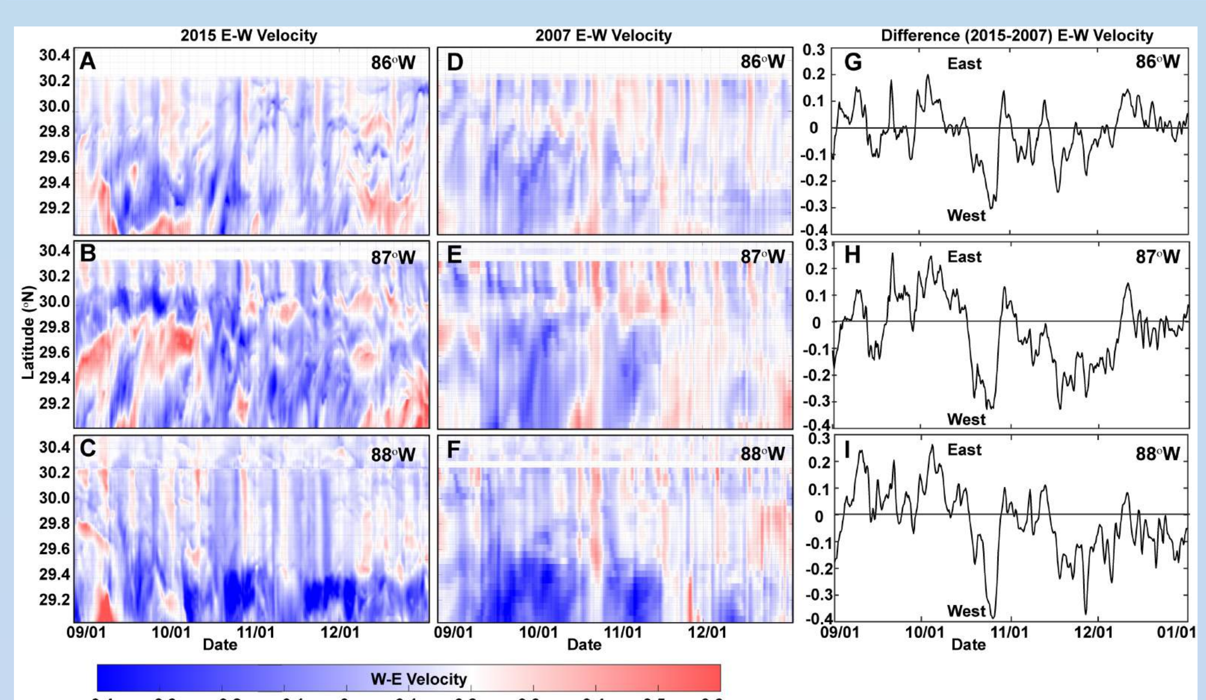
Results: Bloom dynamics (cell counts, satellite delineations and Lagrangian particles)

In 2007, the *K. brevis* bloom began late August in the Florida Panhandle and reached the Mississippi Bight (MB) in November for only few days. The cell concentrations did not exceed 6×10^4 cells/L^{-1}. Only one Lagrangian particle reached the MB during the first release and no particles reached the MB during the second particle release. In 2015, the bloom began early September and reached the MB and Mississippi Sound (MS). The bloom lasted the month of December with concentrations above 1 million cells/L^{-1}. The Lagrangian particles followed the same patterns observed in the satellite imagery.

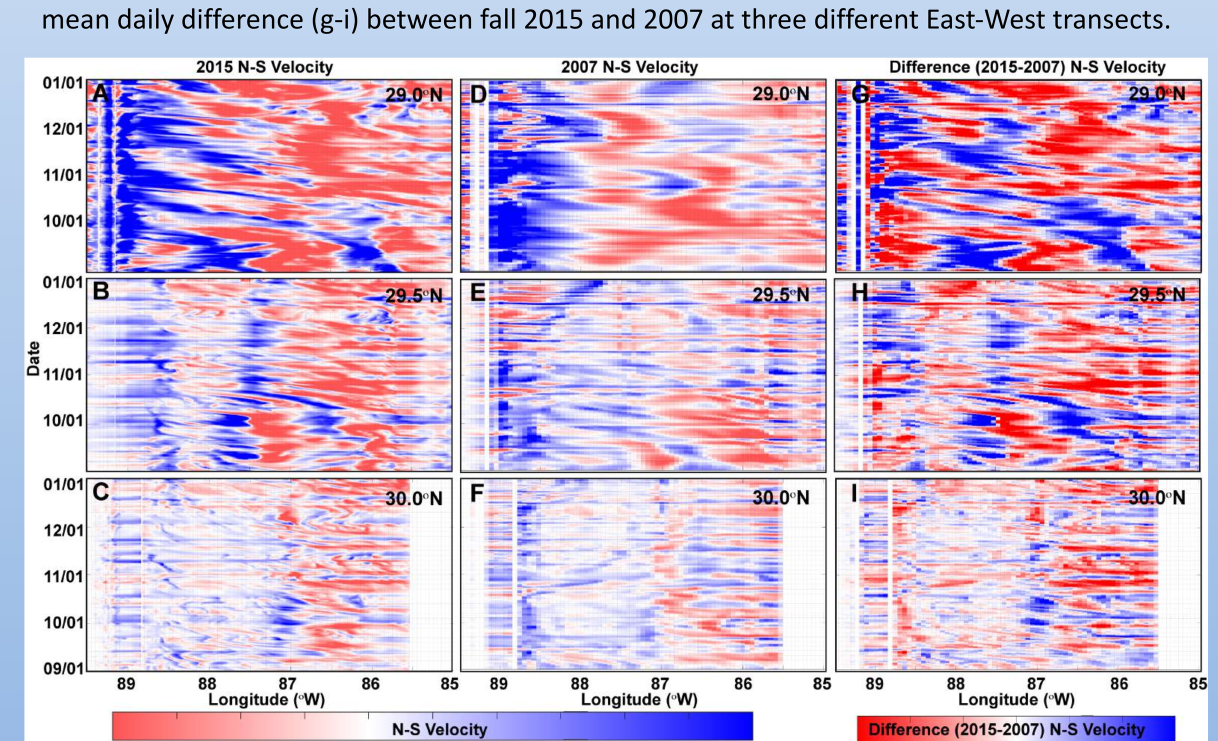


Karenia brevis bloom dynamics for 2007 (left panel) and 2015 (right panel). a) Map of *K. brevis* cell counts above 10^3 cells L^{-1}. b) MODIS-Aqua *K. brevis* delineations. c) First set of Lagrangian particles released 17 September 2007 and 23 September 2015 inside the first bloom delineation. d) Second set of Lagrangian particles released 17 November 2007 and 12 November 2015. The color represents the date.

Results: Sea surface currents and winds



Hovmöller diagram of daily mean u-velocity component for fall 2007 (a-c) and 2015 (d-f) and mean daily difference (g-i) between fall 2015 and 2007 at three different East-West transects.



Hovmöller diagram of daily mean v-velocity component for fall 2007 (a-c) and 2015 (d-f) and mean daily difference (g-i) between fall 2015 and 2007 at three different North-South transects.

In 2015, two main events of stronger westward currents were observed from 17-28 October 2015 before the passage of Tropical Cyclone Patricia's remnants and 14 November to 8 December 2015 especially west of Pensacola.

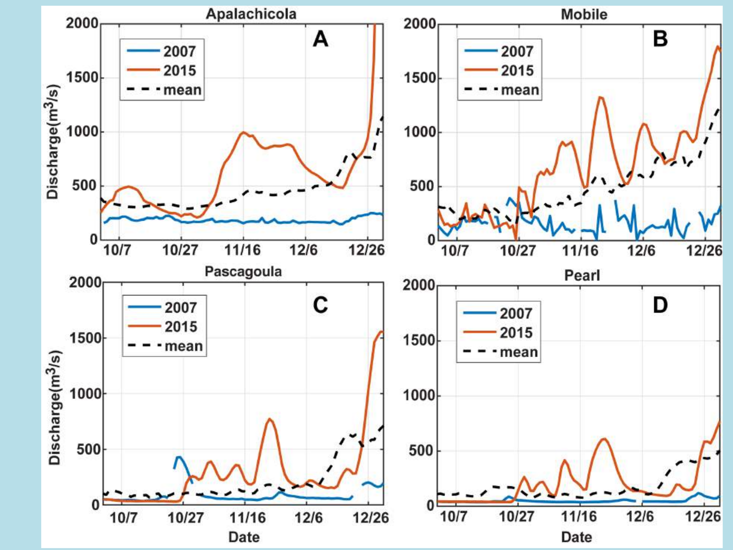
In 2007, westward currents were observed until the first week of November on all transects; after that, a shift toward weaker and predominantly eastward currents was observed until January.

Wind data from the Dauphin Island station showed that the number of consecutive hours of winds favorable for offshore waters flowing into the Mississippi Sound was nearly twice as much for fall 2015 in comparison to 2007.

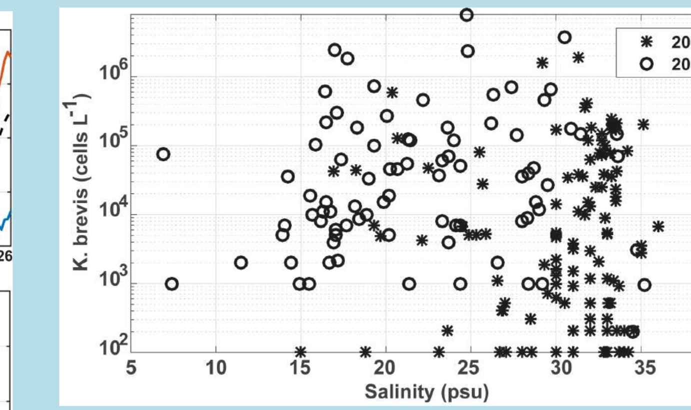
Mean current fields from HFR confirmed the model predictions, suggesting strong mean westward-northwestward flow from October to December for 2015 and only in October for 2007 (results not shown).

Average sea surface circulation patterns during fall (September–November, 2010–2016) were predominately west-southwestward in the northern MB west of Mobile Bay and westward from the Florida Panhandle towards Mobile Bay.

Results: River discharge and salinity

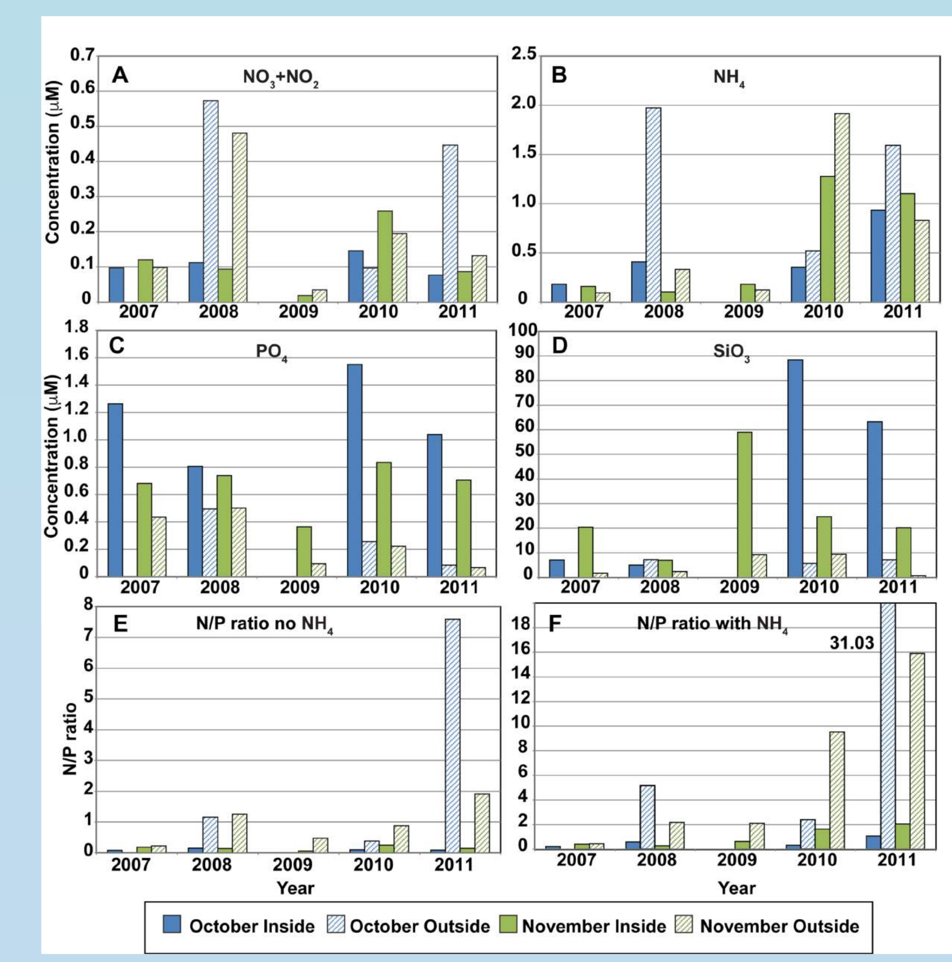


River discharge was anomalously high towards December 2015; and below the mean during fall 2007.



- In 2007, 85% of *K. brevis* cell counts (above 100 cells/L^{-1}) were found at salinities above 25, while only 28% were found at similar salinities in 2015.
- In 2015, *K. brevis* was found at salinities from 7 to 25, even at areas of high cell count concentrations (>105 cells L 1).

Results: Nutrients



Historical nutrient data from the NGI cruises for the fall showed very low NO3 + NO2 concentrations (<0.1 mM), variable NH4 concentrations (0.1 to 1.3 mM), and elevated PO4 concentrations (>0.6 mM) inside the Mississippi Sound throughout the 5-year study.

Nutrient concentrations were greater and more variable at stations outside the Mississippi Sound.

The data (not shown) collected during the CONCORDE cruise in 2015 allowed us to determine the nutrient response right after a heavy rain event. Relative to the historic NGI baseline data, NO3 + NO2 concentrations doubled after the event, but PO4 did not change. The molar nitrogen/phosphate ratios were still very low even after the rain event, although a slight increase was observed towards the western side of the Mississippi Bight.

Conclusions and remarks

Two major differences were observed during fall 2007 and 2015:

- intense westward - northwestward flow in 2015 that persisted until the beginning of December. This allowed for continuous advection of a persistent bloom in the Florida Panhandle, which increased the time for possible adaptation of K. brevis to lower salinity environments.
- elevated river discharge during fall 2015, which probably contributed a large nutrient flux to a region that generally seems to be nutrient-limited during this time of year.

Blooms of K. brevis may reach the Mississippi Coast more often than was previously thought; however, conditions may not always be favorable for bloom intensification.

Field monitoring, satellite imagery and circulation models may be sufficient to forecast future blooms in Mississippi coastal waters; other parameters such as nutrients data are necessary to understand the dynamics and duration of these blooms.

This research was made possible by a grant from The Gulf of Mexico Research Initiative. Data are publicly available through the Gulf of Mexico Research Initiative Information & Data Cooperative (GRIIDC) at https://data.gulfresearchinitiative.org