The Influence of the 2005 Hurricane Season on Water Quality in Florida Bay and Surrounding Coastal Waters

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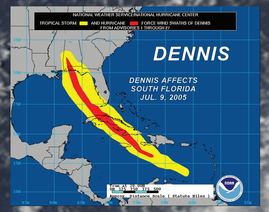
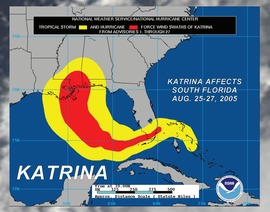
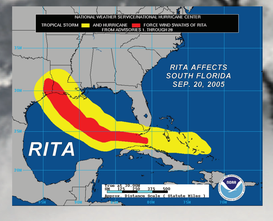
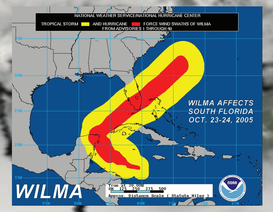








The 2005 Atlantic hurricane season was one of the most active ever recorded. Of the 27 named storms, four hurricanes: Dennis, Katrina, Rita, and Wilma (shown in the panels above) directly affected south Florida and the surrounding coastal ocean. Synoptic events, such as the passage of tropical cyclones, can have a significant impact on water quality in areas where coastal waters are relatively shallow such as Florida Bay, the Southwest Florida Shelf, and the Florida Keys reef tract.

As part of a long-term study funded by the National Oceanic and Atmospheric Administration's Coastal Ocean Program (COP), scientists from NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML), the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS), and other institutions monitor the physical, chemical, and biological properties of south Florida coastal waters on a regular basis. Scientists utilize bimonthly regional hydrographic surveys, monthly bay surveys (Florida and Biscayne), moored instrumentation, Lagrangian drifters, and remote sensing techniques to gain a more comprehensive understanding of how regional flow patterns and the resulting spatial distribution of water properties are influenced by offshore processes in the Gulf of Mexico and the Straits of Florida, and by freshwater input through direct precipitation and coastal runoff from the south Florida watershed. These water properties (salinity, chlorophyll concentration, turbidity, dissolved organic matter, etc.) and their spatial distribution are a direct measure of the condition of south Florida coastal ecosystems.

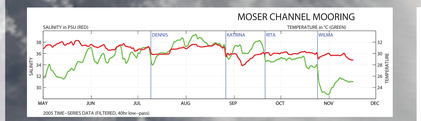
The affects of Dennis, Katrina, Rita, and Wilma on flow fields and water property composition/distribution, as seen through the moored instrumentation time-series, shipboard surveys and Lagrangian drifter trajectories associated with this ongoing monitoring program are illustrated below.

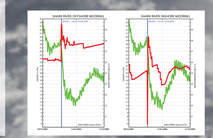
Moored Instrumentation

The passage of each of the four tropical cyclones (Dennis, Katrina, Rita, and Wilma) can be seen in the current velocity, temperature, and salinity time-series for SE ADCP A and MID-BAY/FLBAY moorings and in the temperature and salinity records for MOSER CHANNEL mooring.

Following each storm, a drop in water temperature is evident. However, uniformity in salinity response is not necessarily the case and varies based on storm dynamics (track, magnitude, translation speed, and associated precipitation) and on the proximity to areas of riverine discharge. Hurricanes Dennis, Katrina, and Rita produced a decrease in salinity at the moorings shown. Due to its trajectory, Hurricane Wilma drove high salinity, offshore waters towards the southwest Florida coast resulting in a temporary increase in salinity, most noticeable at SE ADCP A and SHARK RIVER.

Current velocity records show that the predominant signal on the southwest Florida shelf is the east/west tidal component. Depending on the timing of a hurricane's passage, direct wind forcing associated with the storm will either work with or against tidal components resulting in either the dampening of the tidal signal (subtractive) or in unusually strong current velocities (additive). During Hurricanes Dennis and Rita, both SE ADCP A and MID-BAY/FLBAY show the former. Hurricane Katrina produced an intensified current at SE ADCP A; however at MID-BAY/FLBAY, wind forcing and tide worked against one another, resulting in a diminished tidal signal. Hurricane Wilma generated strong currents at both locations roughly three times the magnitude of normal tidal maxima (40-50 cm/s vs. 130-150 cm/s).

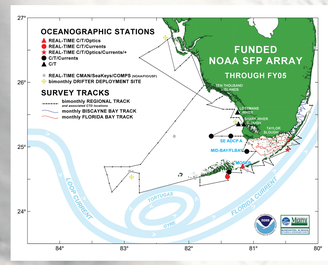


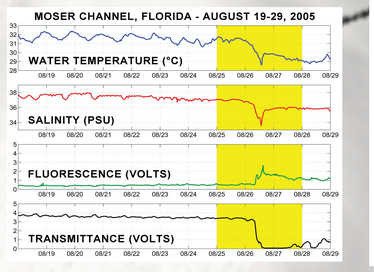


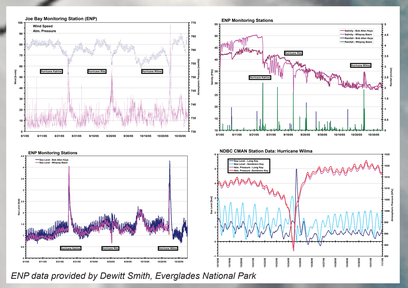
Above and left: Temperature and salinity time-series are shown from MOSER CHANNEL and SHARK RIVER.

Lower left: East/west (u) and north/south (v) current velocity components, temperature, and salinity time-series are shown for SE ADCP A and MID-BAY/FLBAY.

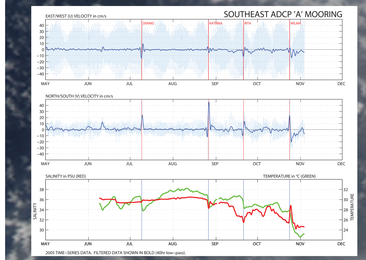
Lower right: Current magnitude and direction are shown for the time period covering each of the four hurricanes at sites SE ADCP A and MID-BAY/FLBAY.

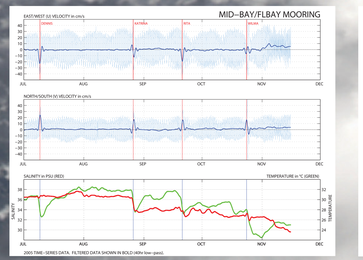


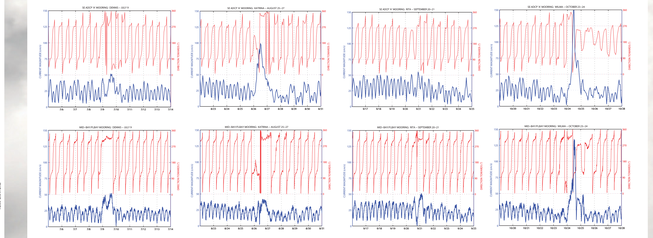




ENP data provided by Dewitt Smith, Everglades National Park







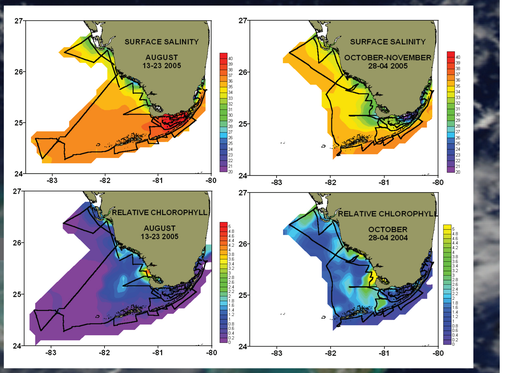
Above: MOSER CHANNEL temperature, salinity, fluorescence, and transmittance time-series document the passage of Hurricane Katrina. The record shows a marked decrease in salinity due to direct precipitation and extensive runoff through canals and rivers around the region. An increase in chlorophyll concentration and water turbidity (decreased transmittance) was also recorded, likely due to the resuspension of sediments caused by wind driven mixing.

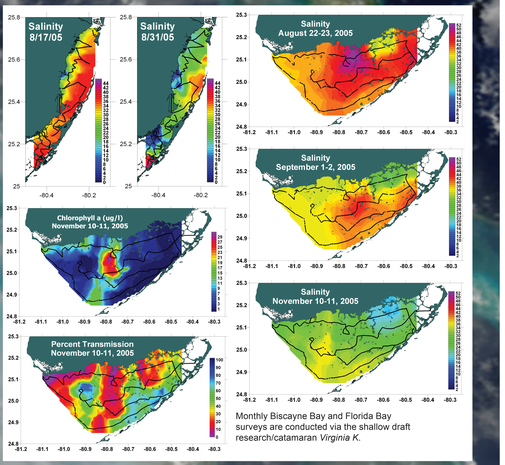
Above right: Everglades National Park (ENP) Monitoring Station data (including wind speed and atm. pressure from Joe Bay; and salinity, rainfall, and sea level from Bob Allen Keys and Whipray Basin) recording hurricane passages. CMAN data (atm. pressure and sea level) from Long Key and Sombrero Key are shown for Hurricane Wilma.

Shipboard Surveys

Flow-through data collected during regional surveys in August and October/November (upper right) show that following the passage of Hurricane Dennis, south Florida coastal waters in Florida Bay and on the southwest Florida shelf are of high salinity and low chlorophyll. The subsequent passages of Hurricanes Katrina, Rita, and Wilma result in near-shore salinity decreases in Biscayne and Florida Bays and along the rivers of the southwest Florida coast. The October/November cruise shows increased chlorophyll fluorescence on the shelf with a very strong signal near the mouths of Lostmans and Shark Rivers. This may be due to post storm nutrient rich runoff discharged from rivers along the southwest coast or the resuspension of sediments and related microphytes caused by strong wind driven mixing associated with the hurricane passages. Sample analyses are presently underway.

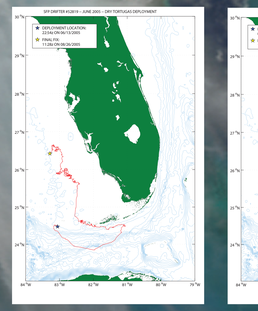
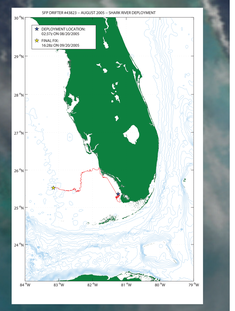
Monthly surveys of Biscayne and Florida Bays (lower right) show high salinities in both bays prior to Katrina's passage. A rapid response survey conducted in the week following the storm shows freshwater runoff along the western edge of Biscayne Bay and in the northeast corner of Florida Bay. Following Rita and Wilma's passage, the November survey shows continued freshening of Florida Bay and a large chlorophyll signature in the central region of Florida Bay. This signature may be caused by sediment resuspension as the shallow bay waters were mixed via hurricane wind forcing, or by the influx of offshore source material carried into the Bay with the storm surge associated with Hurricane Wilma (this surge can be seen in CMAN and ENP monitoring station time-series data shown below). Additionally, the high sediment load suspended in the water column by the hurricanes inhibited light transmission through most of Florida Bay during the November survey conducted nearly three weeks after Wilma's passage.





Monthly Biscayne Bay and Florida Bay surveys are conducted via the shallow draft research/catamaran *Virginia K.*

Drifter Deployments

Lagrangian surface drifters are deployed in south Florida coastal waters on a bi-monthly basis. These satellite-tracked drifters enable scientists to monitor regional flow patterns of the coastal ocean in real-time. Deployments have typically been made at the mouth of the Shark River north of Cape Sable, and at Riley's Hump in the Dry Tortugas. Drifters are now also being deployed near Charlotte Harbor.

Two drifter trajectories (right) show evidence of hurricane passages. The June 2005 Dry Tortugas deployment (drifter #53819), originally caught up in a gyre, is driven north by Hurricane Dennis and dies during the rough sea state associated with Hurricane Katrina. The August 2005 Shark River deployment (drifter# 43823) meanders near its deployment site before being carried northwest towards Marco Island by Hurricane Katrina. The drifter dies during Hurricane Rita.