Freshwater inflows in Galveston Bay: Primary productivity as an indicator of ecosystem function.

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Freshwater inflows in Galveston Bay

• An examination of the impacts of changes in freshwater inflow and bay circulation are priority areas for state agencies in Texas, particularly given increasing population density

  – An additional 3.5 million people predicted to arrive by 2040 in Texas, most of these will reside in coastal areas
Freshwater inflows in Galveston Bay

- With this rapidly expanding population, coastal municipalities, water regulators and managers are faced with the challenge of meeting human needs, potentially by freshwater diversions, while maintaining critical freshwater inflows to estuaries.
Freshwater inflows in Galveston Bay

- Beneficial freshwater inflows are those necessary for salinity, nutrient and sediment loading regimes adequate to maintain the productivity of economically important and ecologically characteristic species in Galveston Bay.
Freshwater inflows in Galveston Bay

Phytoplankton:
– are at the base of the food web
– are sensitive to changes in water quality on short time scales
– exhibit seasonal cycles which are related to changes in water temperature and salinity
– form blooms, which may be harmful either as a result of toxins produced or the accumulation of organic matter
Freshwater inflows in Galveston Bay

- Presenting findings of a year long monitoring program
  
  - January to November 2006 –
    that specifically examined changes in water quality, primary productivity and phytoplankton community structure in response to freshwater inflows in the Galveston Bay estuary.

- New program started February 2008 is ongoing…..
Freshwater inflows to Galveston Bay 2006 - Trinity River discharge

Daily Discharge in Trinity River USGS 08066500

♦ = sampling trips

Phytoplankton Dynamics Laboratory
State of the Bay – January 2009
Freshwater inflows in Galveston Bay

Dataflow
Dataflow – mapping Galveston Bay

• water quality and hydrology were measured using a high-speed, flow-through system developed for mapping physico-chemical parameters in shallow aquatic systems in a boat running closely gridded transects

• used to concurrently measure water temperature, conductivity, salinity, water clarity (beam transmittance), chlorophyll a (*in situ* fluorescence), dissolved organic matter (DOM; *in situ* fluorescence), and PAR

• an integrated GPS is used to simultaneously plot sample positions, allowing geo-referencing of all measurements for each variable.
Dataflow

Measure GPS coordinates, Temperature, Salinity/Conductivity, Beam Transmittance, Chlorophyll a, CDOM, Depth, and PAR at approximately 8 second intervals from a vessel running at 20 kts.
January 2006 - Galveston Bay

Galveston Bay, January 06

In vivo Chlorophyll a (µg L⁻¹)

- Trinity River
- Houston
- Pasadena
- Texas City
- Bolivar Peninsula
- Gulf of Mexico
- West Bay
- Galveston

Latitude (°N) vs Longitude (°W)
Temperature (°C)
In vivo chlorophyll a (ug L$^{-1}$)
Dissolved Organic Matter (ug L\(^{-1}\))
Transparency (%)
Phytoplankton responses to freshwater inflows in Galveston Bay

Phytoplankton Analyzer (PHYTO-PAM)
Phyto-PAM

• Phytoplankton - Pulse Amplitude Modulated (PHYTO-PAM) Fluorescence Analyzer

  • used to concurrently to map health, phytoplankton community composition & primary production

  • samples were collected from 41 fixed stations throughout the bay complex, which included 6 discrete stations

  • examined in the laboratory within 24 hrs
Cyanobacteria

- Biomass
- Yield (potential)
- Production
Diatoms & Dinoflagellates

- Biomass
- Yield (potential)
- Production
Annual changes in Phytoplankton Community Composition

Stations in Galveston Bay

Trinity River

Distance from river mouth (km)

Gulf of Mexico

Month

Diatoms/Dinoflagellates

Cyanobacteria

Values: 1.2, 1.15, 1.1, 1.05, 1, 0.95, 0.9, 0.85, 0.8, 0.75, 0.7, 0.65, 0.6, 0.55, 0.5, 0.45, 0.4, 0.35, 0.3, 0.25, 0.2, 0.15, 0.1
Phytoplankton responses to freshwater inflows in Galveston Bay

Discrete measurements
Discrete measurements

- at **6 fixed stations** spaced thru Galveston Bay,
- experiments & measurements included:
  - **Primary productivity**
  - **Phytoplankton community composition**
  - **Nutrients**
    - salinity, DOM, many more …
Monthly *gross primary production* rates \((gC \text{ m}^{-2} \text{ d}^{-1})\) measured in Galveston Bay during 2006 at 6 fixed stations.
Phytoplankton community composition in June 2006 at 6 fixed stations in Galveston Bay.
Phytoplankton responses to freshwater inflows in Galveston Bay

- Dataflow
- PHYTO-PAM
- Discrete measurements
Freshwater inflows in Galveston Bay

Next steps …

• multivariate multidimensional statistics will be used to determine which factor(s) are most important in driving changes in primary production and phytoplankton community composition

• long term annual studies to compare effect of high and low freshwater inflow years

• long term studies to examine effect of magnitude, pulse and duration of freshwater inflow in downstream processes
Freshwater inflows in Galveston Bay

Longer term goals ...

• develop process-based understanding of the linkages between the magnitude of freshwater inflows, sediment and nutrient loading on productivity for the Galveston Bay ecosystem

• work with circulation models to define how changes in freshwater inflows will affect discrete components of the bay
**Freshwater inflows in Galveston Bay**

*Longer term goals ...*

- continue mapping water quality parameters in Galveston Bay to:
  - examine how the bay responds to perturbations such as hurricanes, and
  - examine bay responses to change flows, for examples, shifts in flow regimes between the Trinity and San Jacinto rivers
Thank you for your attention

Questions ???

State of the Bay – January 2009
Freshwater inflows in Galveston Bay

- Findings of the research will be used to:
  - assess the importance of freshwater inflow events on water column processes and the downstream ecological impacts of changes to freshwater inflows on the productivity of the Galveston Bay estuary
  - develop intense process-based understanding of the linkages between the magnitude of freshwater inflows, sediment and nutrient loading on productivity for the Galveston Bay ecosystem
Phyto-PAM phytoplankton community composition

- Distinguishes between 3 major taxonomic groups:
  - 470 nm – green algae
  - 520 nm – diatoms & dinoflagellates
  - 645 nm – cyanobacteria
- Measures total signal
  - 665 nm – chlorophyll a
Phytoplankton community composition

Summer 2006

- Cyanobacteria
- Diatoms and dinoflagellates
- Green algae

Locations:
- Houston Ship Channel
- Trinity Bay
- Texas City Dike
- Smith Point
- West bay
- Rollover Pass
- Christmas Bay
- Offatt's Bayou

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- West bay
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Phyto-PAM health

- Measures variable fluorescence in photosynthetic organisms
- Use this as a proxy for the **physiological status** of phytoplankton, and so, primary production

- $F_v/F_m = 0.65 \, \text{😊}$
- $F_v/F_m < 0.4 \, \text{🙁}$
- $F_v/F_m \, 0.4 > & < 0.65 \, \text{🙁} \, \text{stressed}$
Fv/Fm 😊 - 0.4 > & < 0.65
- stressed

- concurrent study revealed phytoplankton are nutrient (N) stressed

Fv/Fm 😊 - rarely
Fv/Fm ☹ - occasionally, seasonal, spatial
Monthly nitrite plus nitrate (mM; blue) & orthophosphate (mM; orange) measured in Galveston Bay during 2006 at 6 fixed stations.