Sublethal Effects of Crude Oil on the Community Structure of Estuarine Phytoplankton

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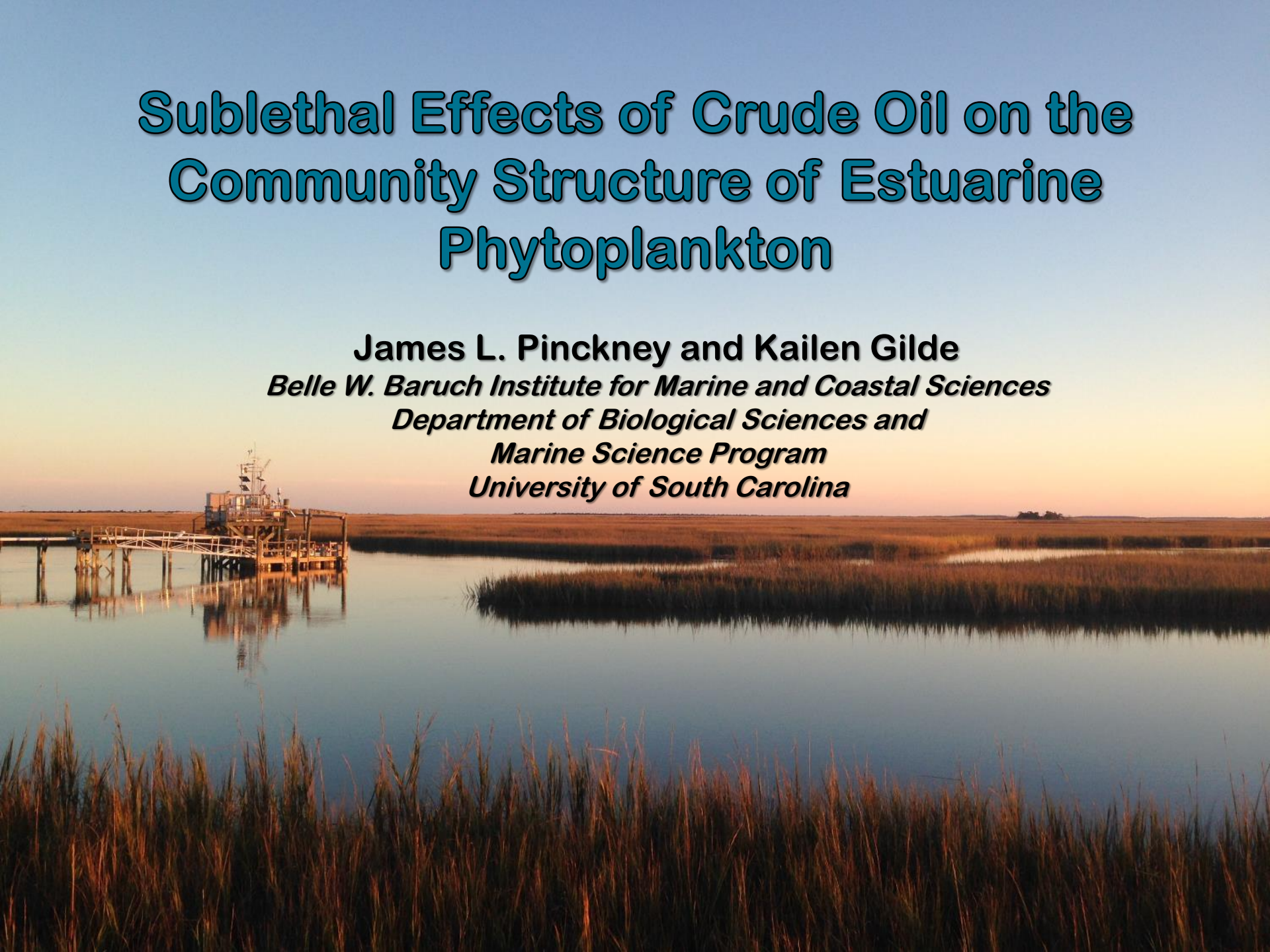

Introduction

- The ecological impacts of crude oil exposure have been widely studied, its effects on natural phytoplankton communities in salt marsh estuaries has not been well-documented.
- Past studies often used unialgal lab cultures, which cannot capture sublethal effects on phytoplankton community structure.
- Laboratory conditions may also alter the toxicity of the compounds tested and usually focus on the water accommodated fraction of oil (i.e., those compounds soluble in water).
- Whole crude can be more toxic than the water accommodated fraction alone

Objective

- Quantify the short term (2 day) responses of a natural estuarine phytoplankton community to low level exposures to crude oil (10 – 100 ppm by volume)

Hypothesis

- Phytoplankton exposures to low concentrations of crude oil will result in significant reductions in total biomass (Chl *a*) and alterations in the relative abundances of different algal groups

Experimental Design

- Water collected from North Inlet Estuary in February and March (salinity = 32)
- 2 Types of crude oil – LA, from Macondo spill
  TX, a mixture from Texas oil fields
- LA and TX crude oil additions of 10, 50, 100 µl l^{-1}, and Control (3 replicates)
  45 samples x 2 incubation dates = 90 total incubations
- Nutrients (20 µmol l^{-1} NO_3^- and 10 µmol l^{-1} PO_4^{3-}) added to all

Experimental Design

- *In situ* incubations for 36 h
- Filter samples (GF/F filters)
- HPLC analysis of photosynthetic pigments
- ChemTax - derived group abundances

Water Sample → **HPLC** Pigment Analysis →

Photopigments:
Chlorophyll *a*
Chlorophyll *b*
Chlorophyll *c*
Fucoxanthin
Zeaxanthin
Alloxanthin
Prasinoxanthin
Peridinin
Gyroxanthin
etc.....
(total of ca. 50+)

→ **ChemTax** →

Fairy Dust
Unicorn Horn

Algal Groups:
All Phytoplankton
Chlorophytes
Diatoms
Cyanobacteria
Cryptophytes
Prasinophytes
Dinoflagellates
Pelagophytes
Haptophytes
etc.....
(21+ groups)

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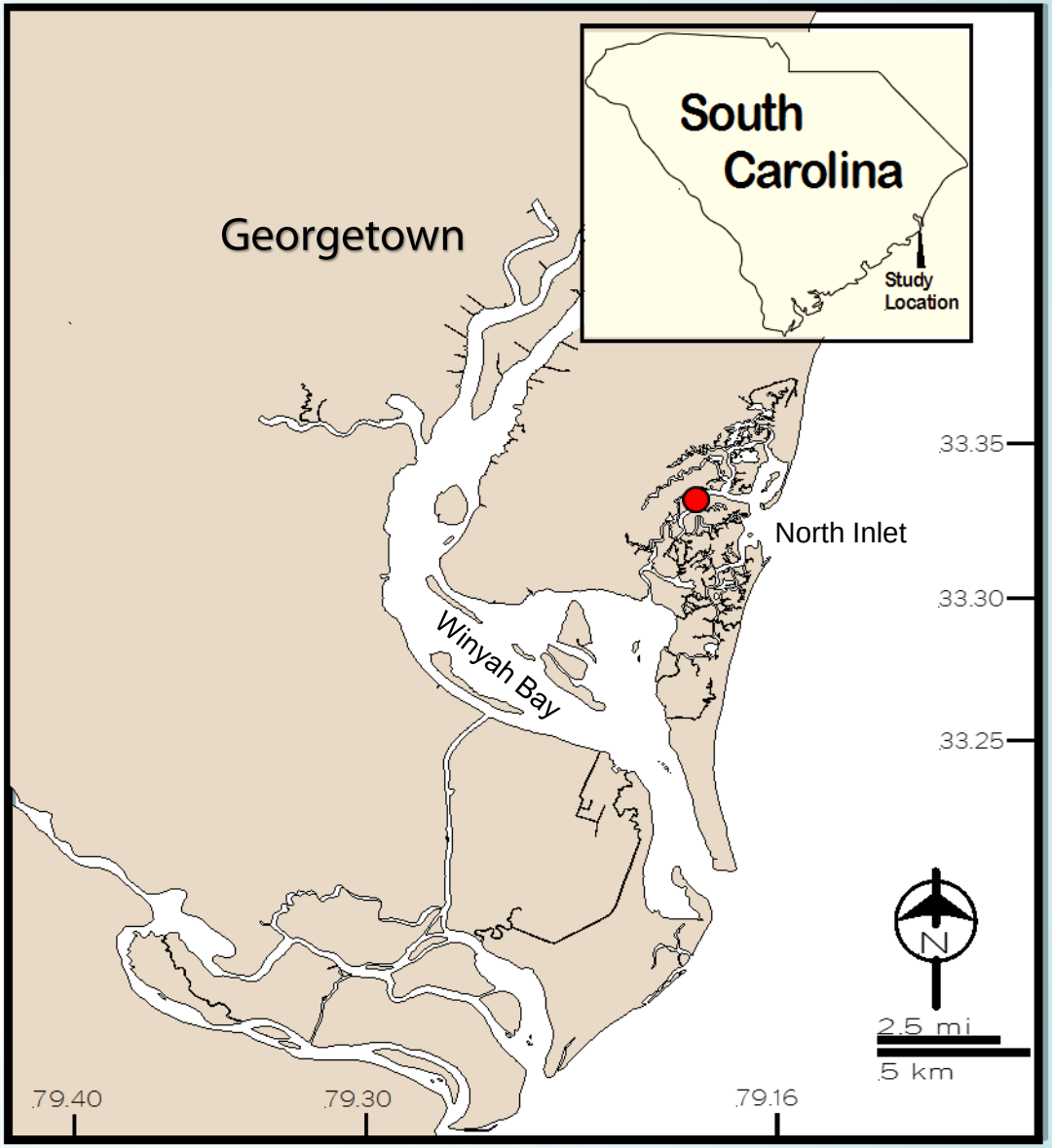
North Inlet – Winyah Bay

Belle W. Baruch Institute for Marine and Coastal Sciences

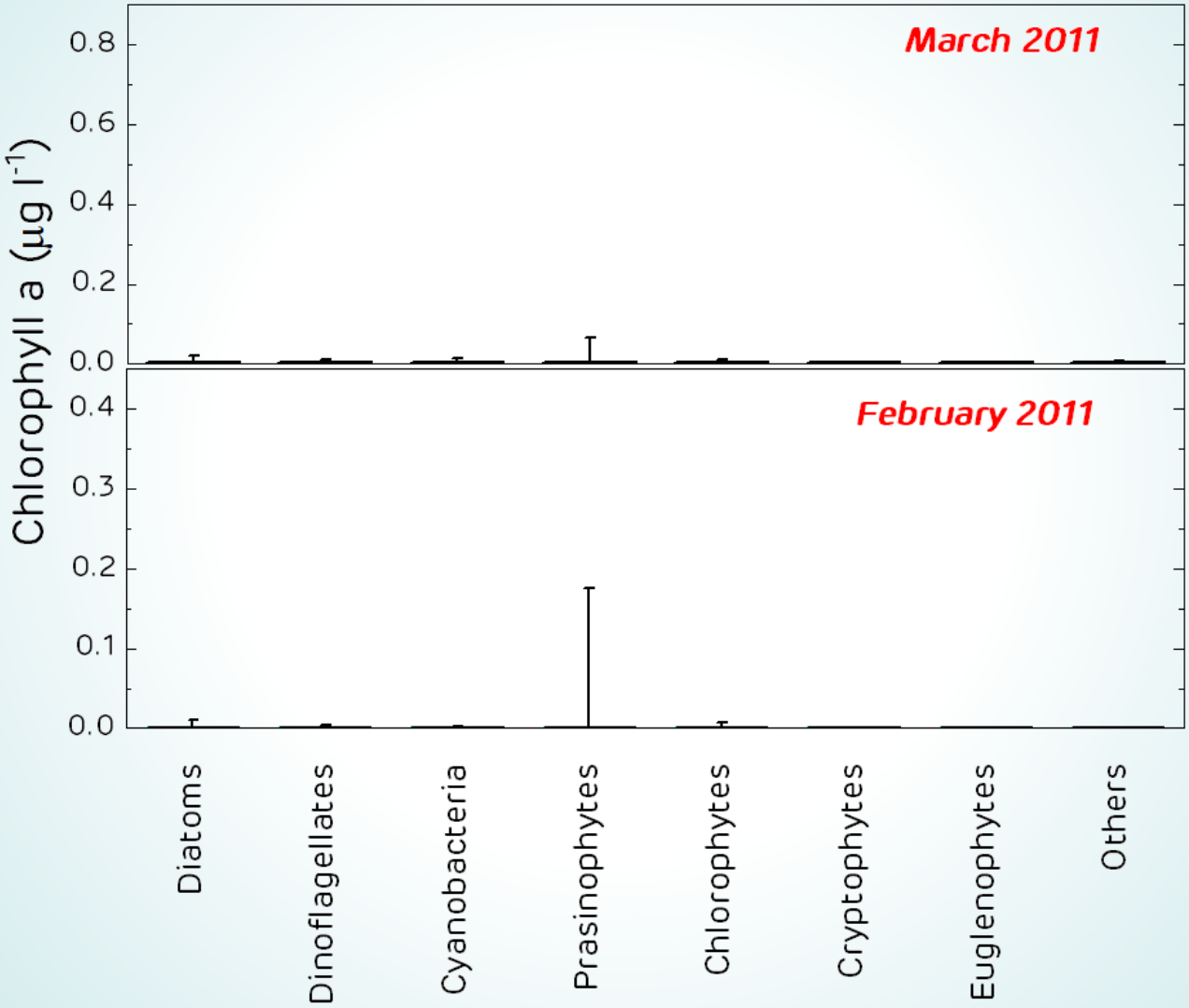
National Estuarine Research Reserve

Georgetown, SC

Clambank Landing

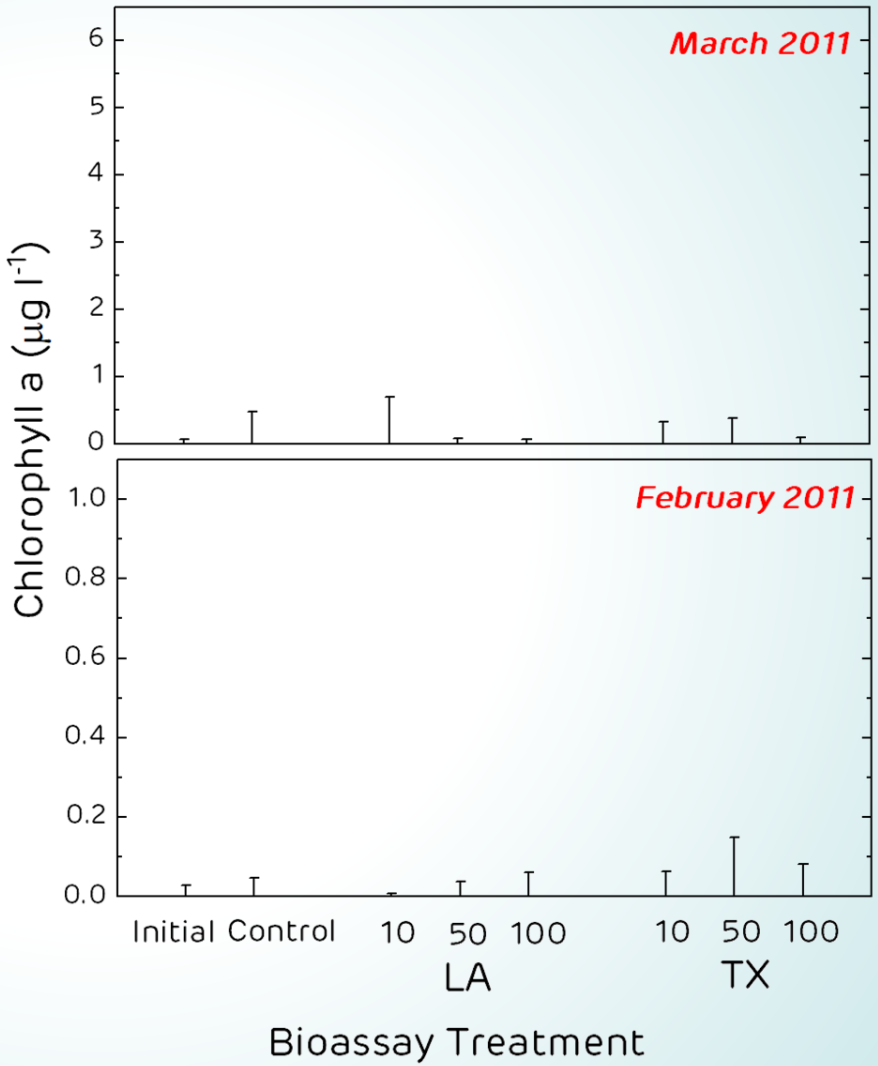


Initial Community Composition



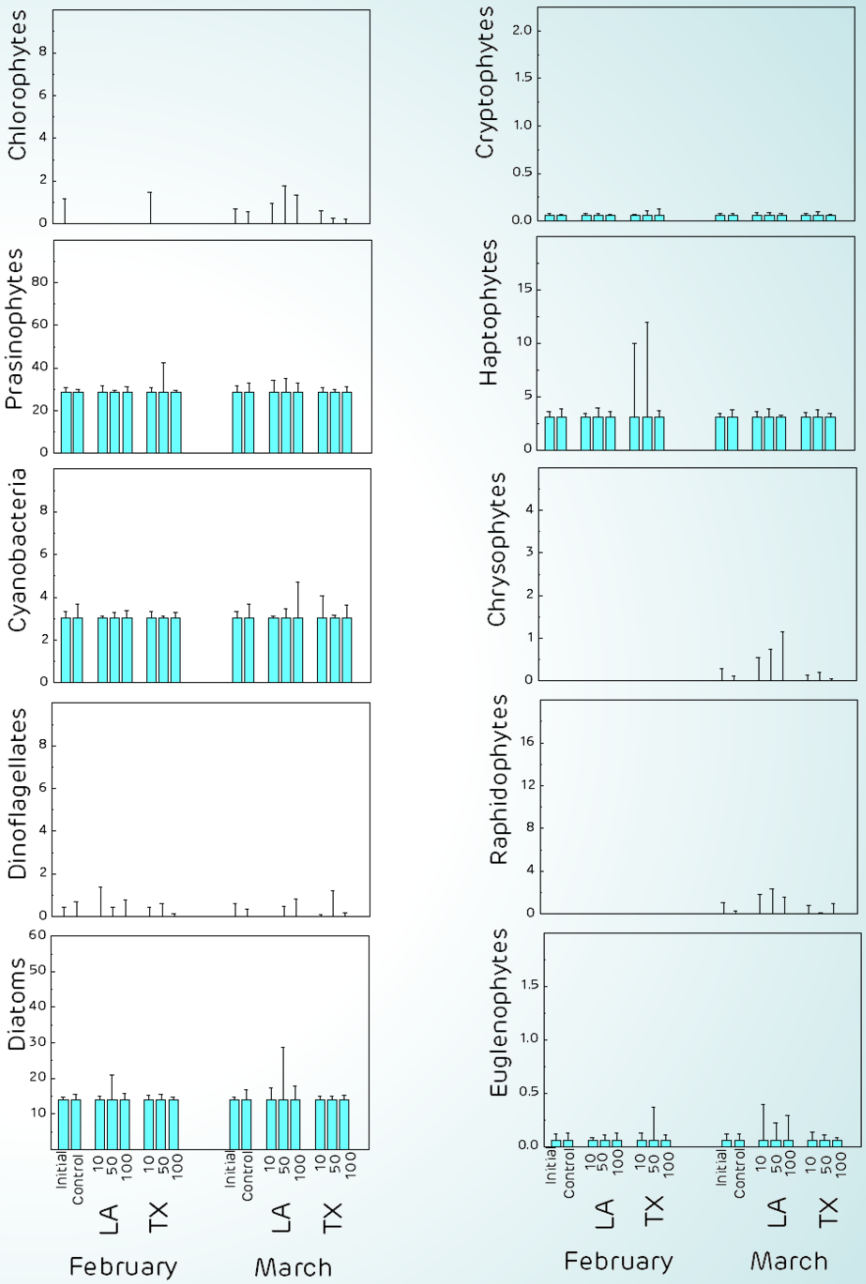
Total Community Response to Oil Additions

Oil additions resulted in reduced growth of the phytoplankton community relative to the Control



Algal Group Responses to Oil Additions

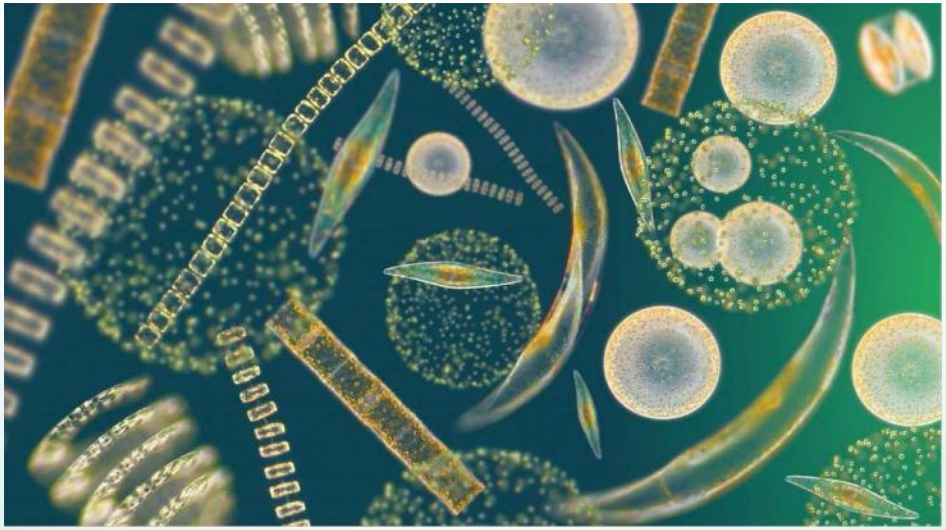
Values are the percent mean (± 1 SD) of total Chl a relative to the initial water sample



Response Summary

Responses to increasing concentrations of oil (0 to 100 ppm)

- Diatoms – maintained or increased abundance
- Chlorophytes & Cyanobacteria – moderate increase
- Cryptophytes & Dinoflagellates – normal growth at low levels, inhibition at high levels
- Euglenophytes & Chlorophytes – enhanced growth
- Prasinophytes – in Feb, no difference from Control. In Mar, inhibition

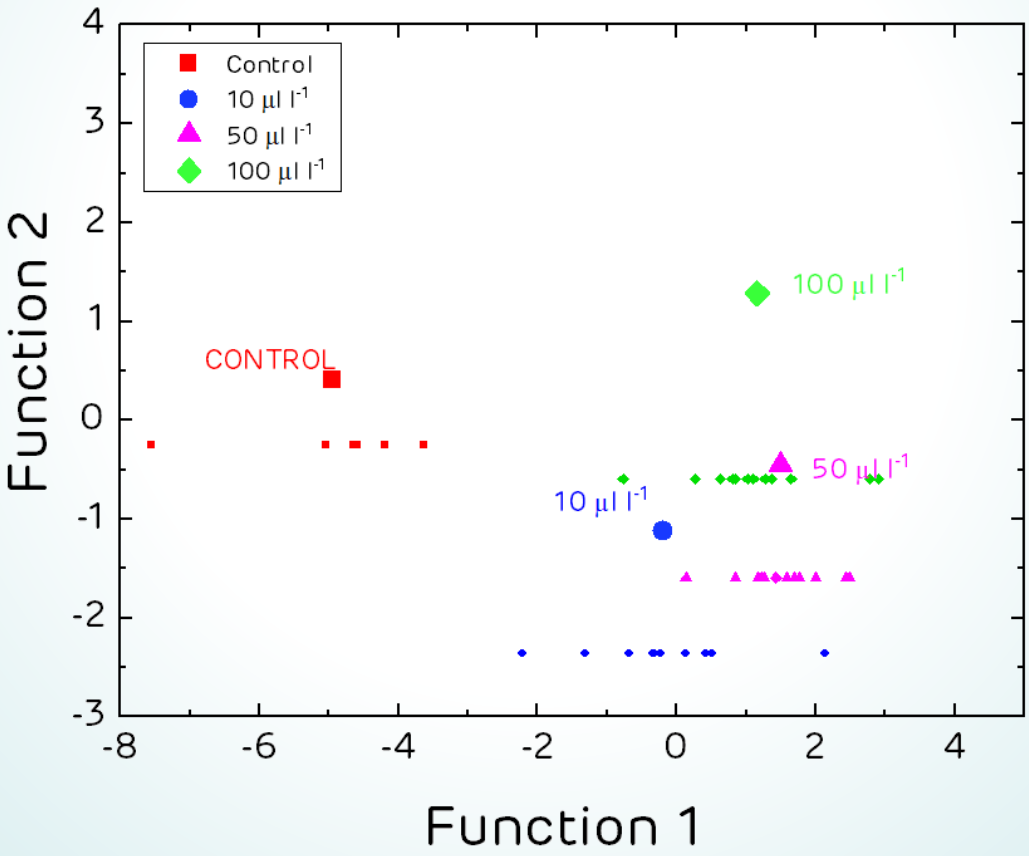


Discriminant Analysis

- A statistical method used in situations where you want to build a predictive model of group membership based on the observed characteristics of each case
- Used to separate (or discriminate) a set of groups using several predictors (independent variables)
- Algal group abundances can be used as independent variables
- Similar samples will be grouped together
- Can visualize if there is a difference in community composition

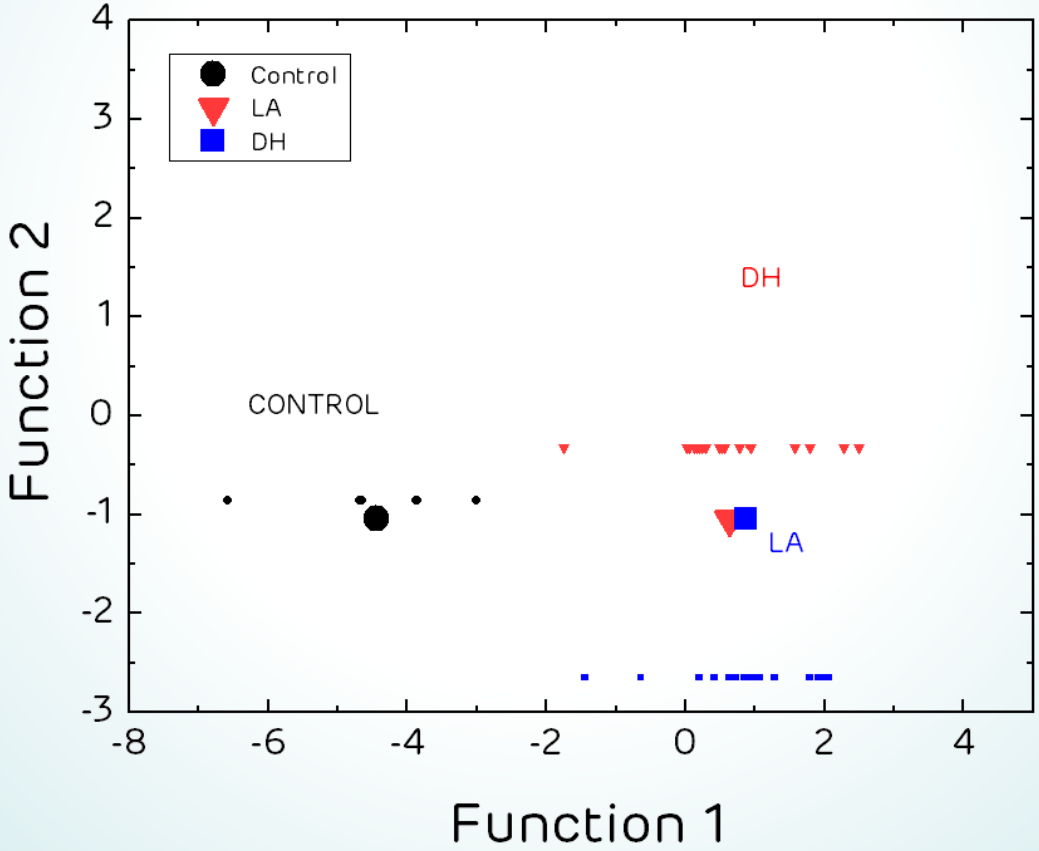
Discriminant Analysis for Exposure Levels

- Function 1 explains 80.6% of the variance
- Function 2 explains 15.8% of the variance
  Cumulative total = 96.4%
- 85.4% of samples were correctly assigned to groups



Discriminant Analysis for Crude Oil Source

- Function 1 explains 76.5% of the variance
- Function 2 explains 23.5% of the variance
  Cumulative total = 96.4%
- 100% of samples were correctly assigned to groups



Discriminant Analysis Results

- Additions of crude oil at all concentrations resulted in a shift in phytoplankton community composition
- Community responses were different for the two crude oil sources

CONCLUSIONS

- Increasing exposure concentrations of phytoplankton to crude oil results in decreases in phytoplankton biomass (Chl *a*)
- Algal group responses range from positive to negative growth
- Crude oil exposure at any concentration results in a shift in phytoplankton community composition
- Phytoplankton responses will vary depending on the community composition at the time of oil exposure
- Alterations in phytoplankton community composition have implications for biogeochemical cycling and trophodynamics of coastal ecosystems

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OTHER STUDIES

- Phytoplankton responses to oil exposure will depend on:
  - temperature
  - type of crude oil
  - phytoplankton species
  - exposure concentration
  - oceanic vs. coastal vs. estuarine communities
  - salinity
  - nutrient status
  - many other factors

- *Low concentrations of oil exposure can have sublethal effects*

- *Forecasting phytoplankton responses nearly impossible*

- *Safe to say that community composition will change with potential cascading impacts on higher trophic levels*

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Sunrise at Oyster Landing, North Inlet Estuary