Navigation and Localization in Spatiotemporally Evolving Environments

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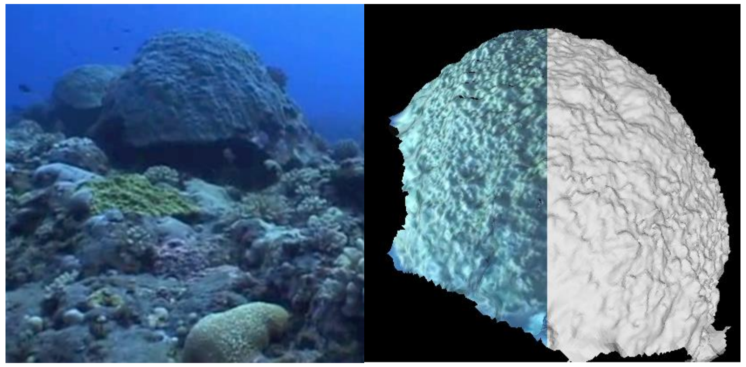
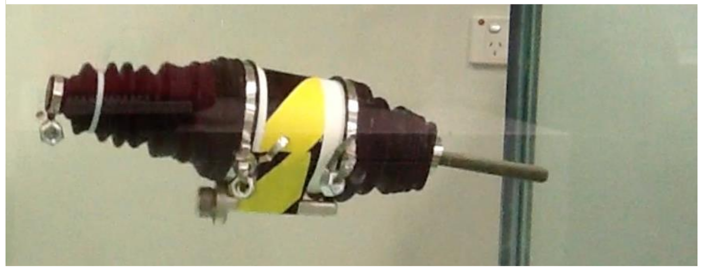
Robotic GNOME Lab at Fort Lewis College

- Robotic Guidance and Navigation for the Observation and Monitoring of the Environment (Robotic GNOME)
  - Nexus of Robotics, Sensor Networks and Environmental Monitoring
    - Research areas in robotic perception, conceptualization, planning and long-term navigation.
  - Creating robotic systems that operate for long periods, without human intervention, in complex spatiotemporally dynamic,real-world environments.





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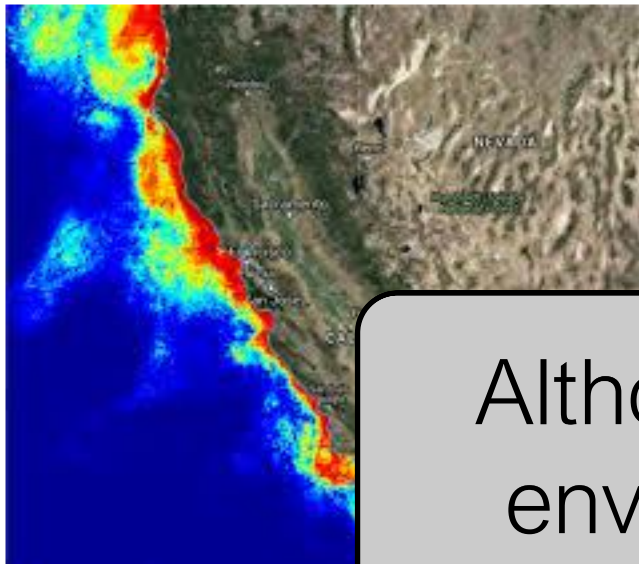
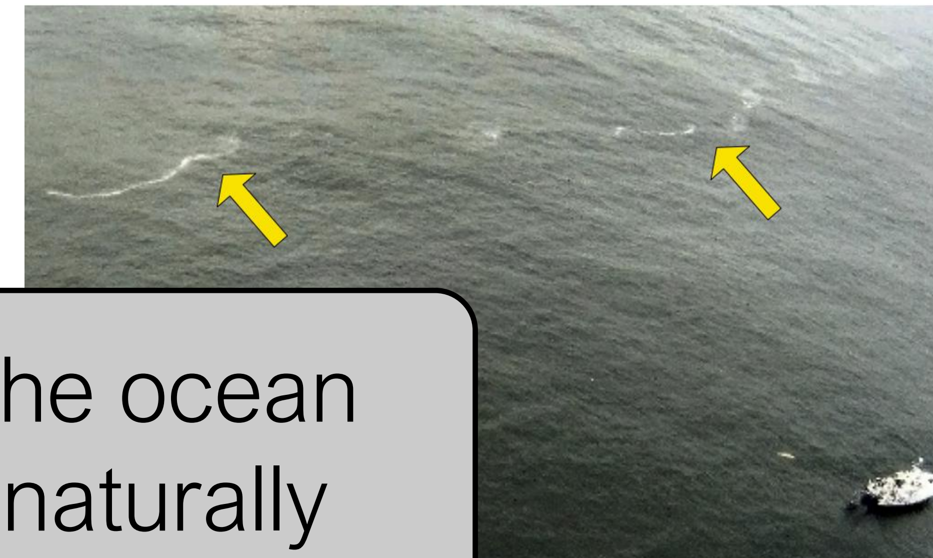
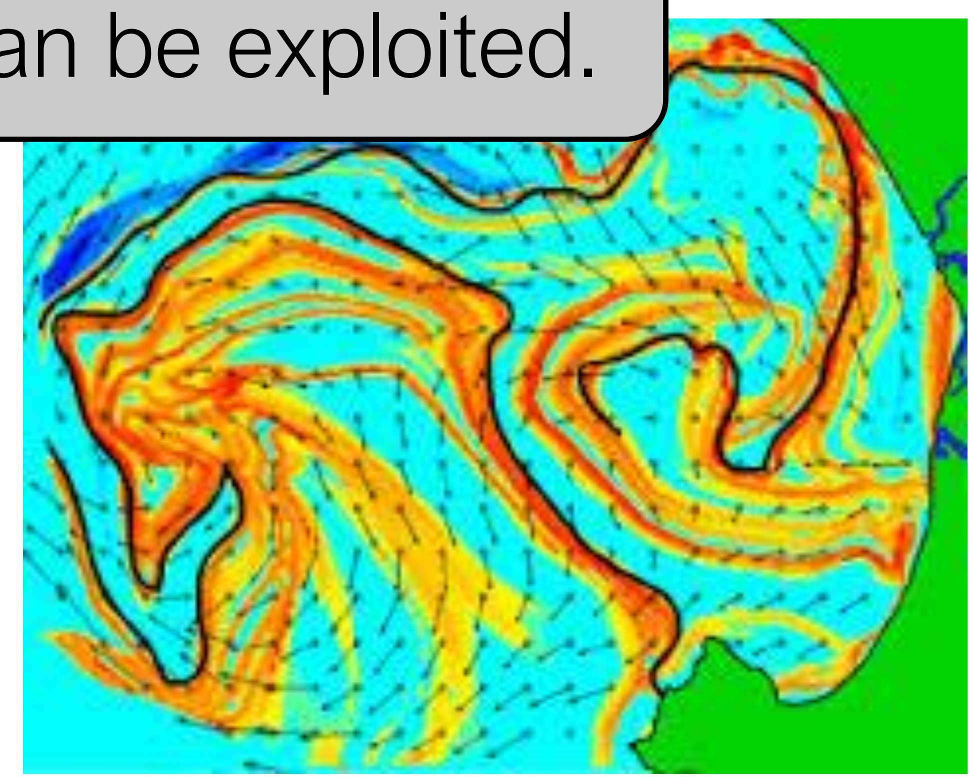
Algal Blooms, Ocean Fronts, and LCS



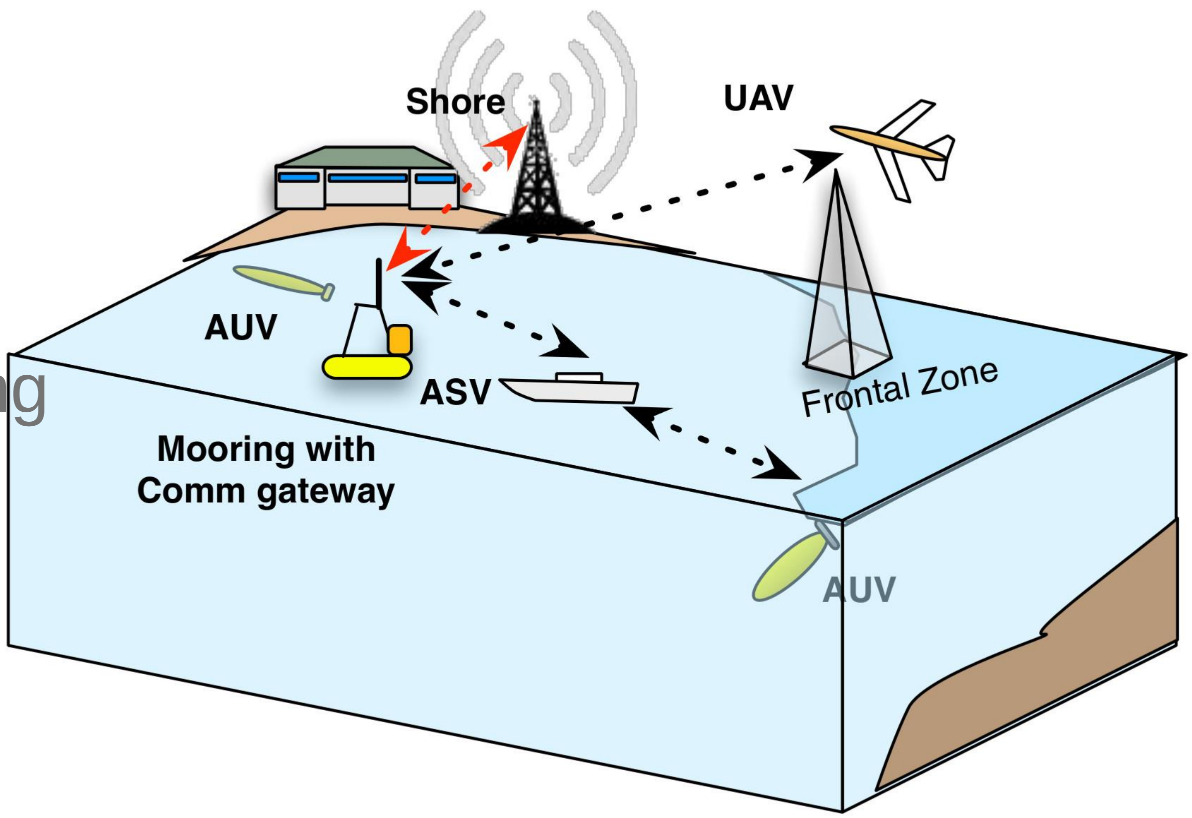


Although these events, and the ocean environment in general, are naturally stochastic and aperiodic, they do exhibit coherent structure that can be exploited.



Background

- Overarching Research Question
  - **Where and when do we sample?**
- To answer this question, we require robotic assets to:
  - perceive a dynamic, real-world feature of legitimate scientific interest, and
  - position, track and follow this feature using multiple, heterogeneous, autonomous platforms.



Research Overview

- Development of stochastic planning strategies for AUVs that are able to adapt to a spatiotemporally evolving environment to effectively execute planned missions in dynamic, cluttered, and/or uncertain environments.

- Examine the trade-offs of communication of data during mission execution across various heterogeneous assets, including the scenario when one asset is a human on shore.

- Derive representations of aquatic features from overhead (satellite) imagery, physical and biological models, bathymetry, and minimal sparse samples that enable computation of planning and sampling strategies devoid of a world reference model.

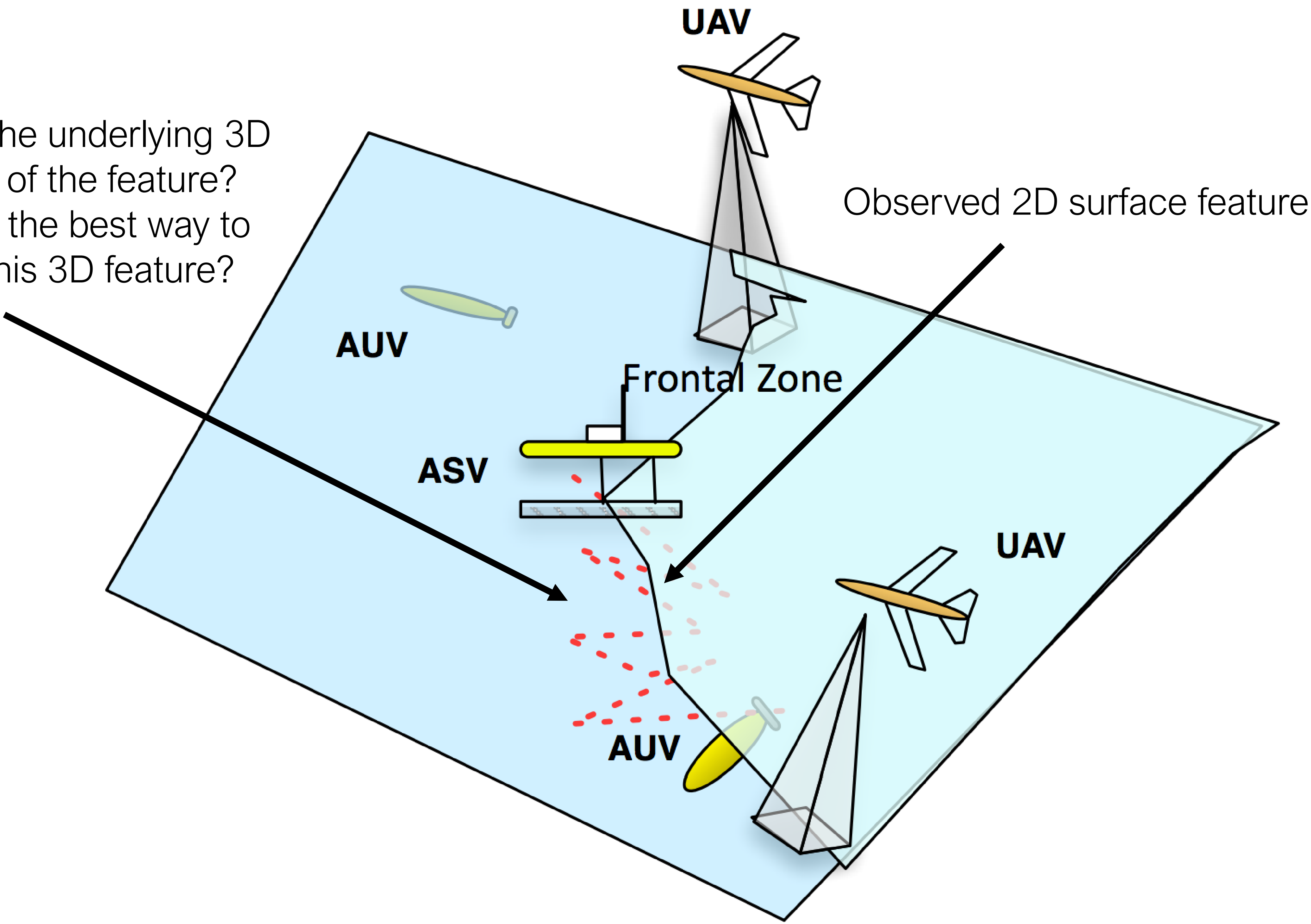
- Experimentally validate the proposed strategies using a combination of laboratory experiments and full-scale field trials.

Research Contributions

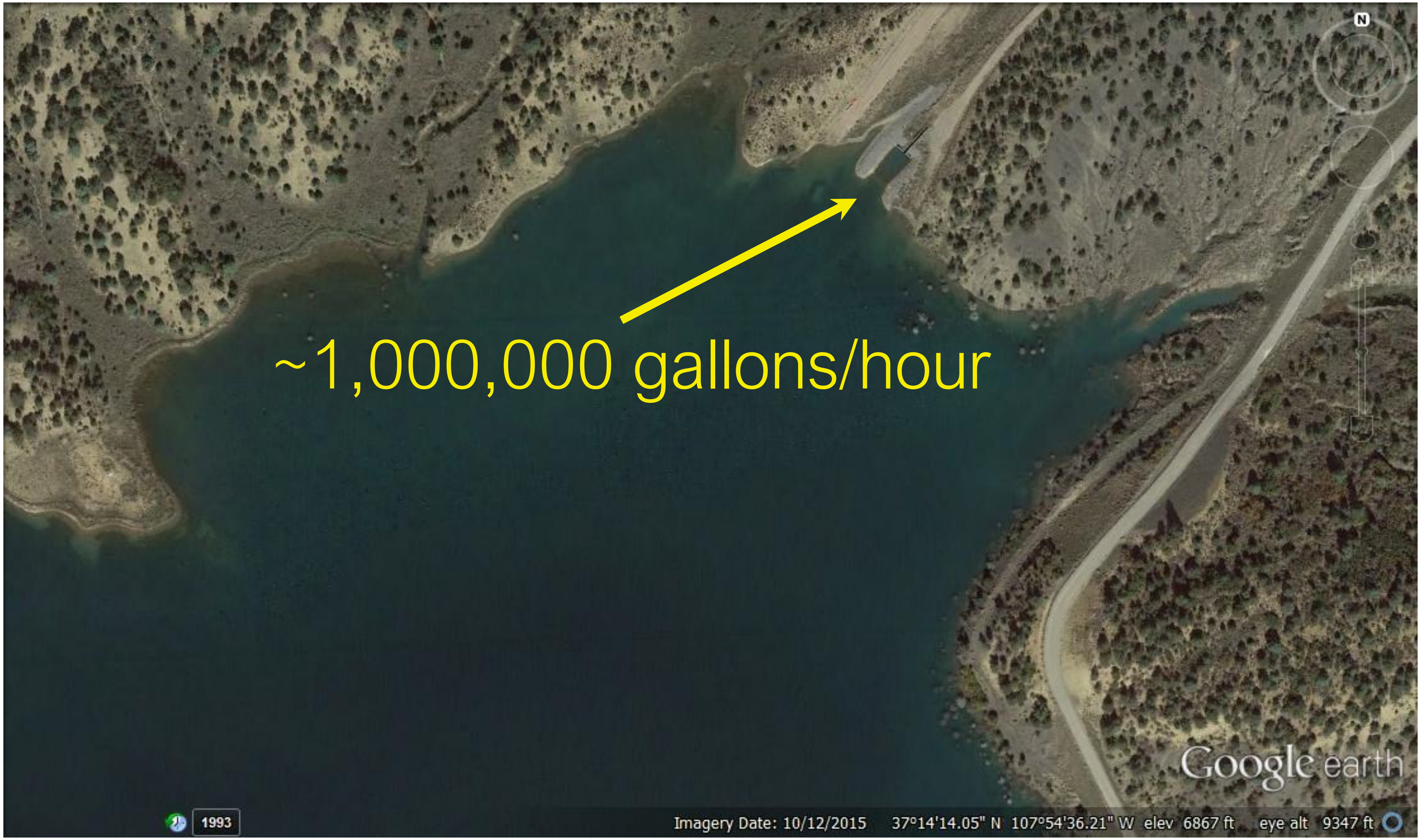
- Utilize priors (ocean models, data from previous sampling, etc.) to inform planning and the design of sampling strategies.
  - Develop methods to create a 3D prediction of interesting features from 2D overhead imagery.
  - Provides a heuristic of the scenario so that heavy autonomy does not have to live on-board…only updates to the predicted representation
  - The idea is to execute more exploit versus explore in aquatic sampling
- Augment dead-reckoning navigation with in-situ methods to increase navigation and localization capabilities of underwater vehicles.
  - Combine dead-reckoning with Augmented Terrain-Based Navigation via an online localization algorithm

Desired Scenario

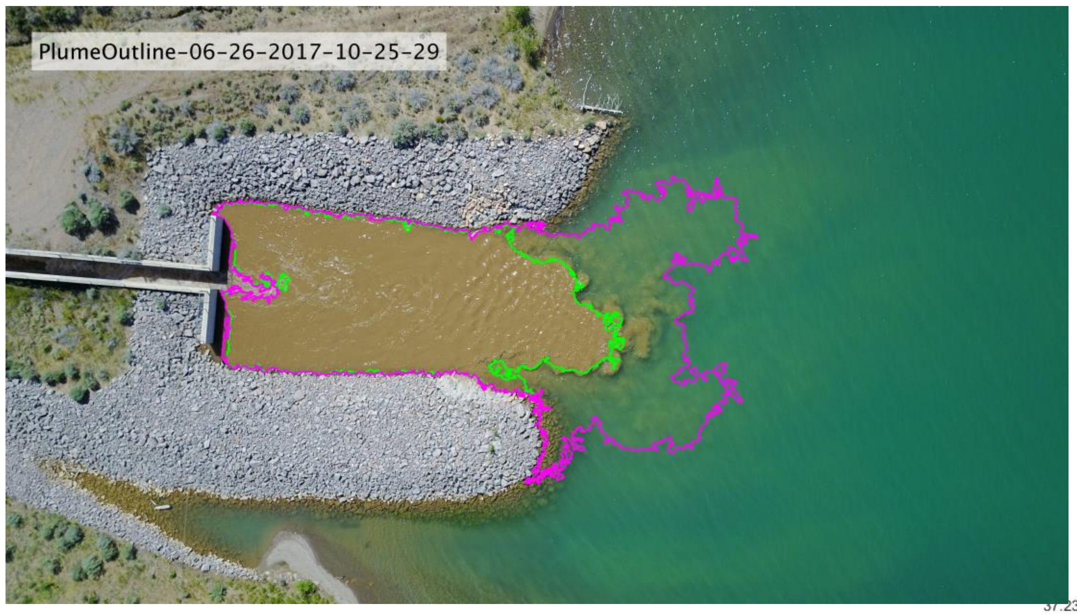
1. What is the underlying 3D structure of the feature?
2. What is the best way to sample this 3D feature?

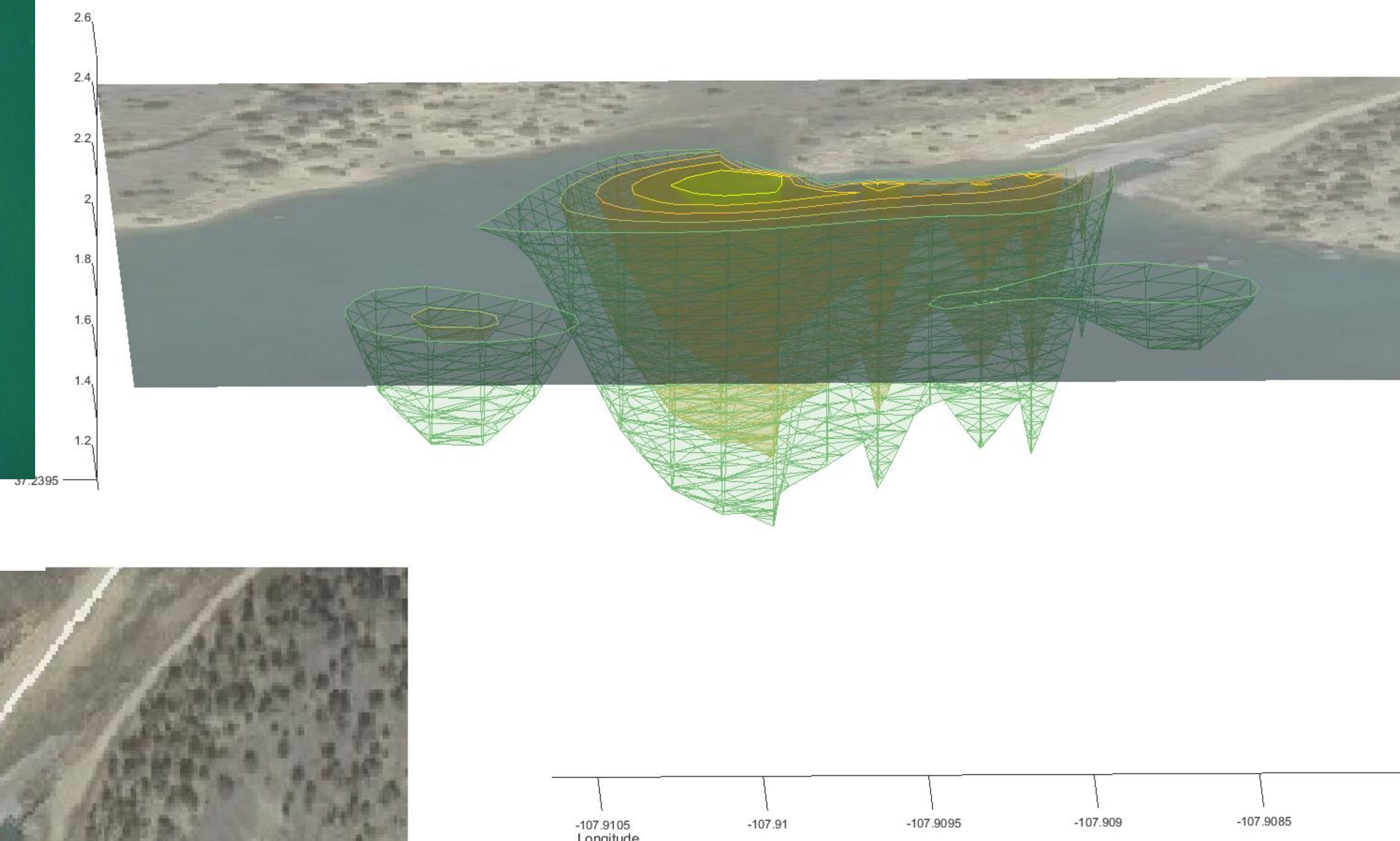


Lake Nighthorse Testing Facility



3D Plume Contours





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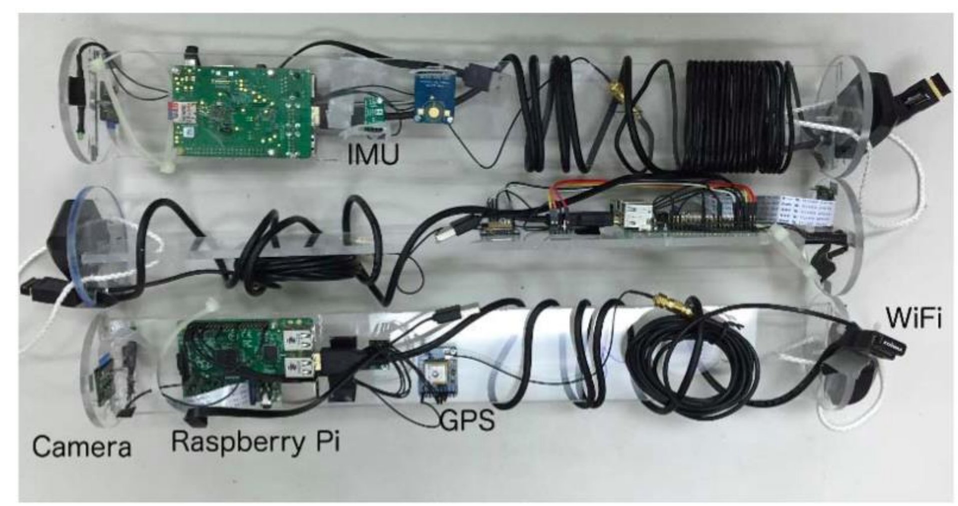
Robotic Assets

- Aerial vehicles
  - Synoptic view
  - RGB Cameras
- 2 Clearpath Heron ASVs
  - YSI Sonde
  - 8 Gulpers
  - RGB Cameras
  - Side-Scan Sonar
  - WHOI Micormodem
- Communication Buoy
  - WHOI Micormodem
  - FreeWave 900 MHz radio
  - WiFi
- EcoMapper AUV
  - YSI Sonde
  - Side-Scan Sonar
  - DVL (up and down)
  - WHOI Micormodem
  - FreeWave 900 MHz radio
  - WiFi
  - RGB Cameras
- Drifting Nodes
  - RGB Camera
  - WiFi
  - IMU



Lake Nighthorse – Durango, CO

Lake Nighthorse – Durango, CO

Additional Access

Other Infrastructure

Fort Lewis College GNOME Robotics About Data Reservoirs Other Sites

Fort Lewis College GNOME Robotics About- Data- Reservoirs- Other Sites-

Buoy

The buoy is a static data collection instrument designed and constructed by the GNOME Lab. It is equipped with two sets of sensor arrays that are placed are different depths. A cellular connected microcontroller is utilized to publish data to the internet in real-time. The device is powered by a solar panels, and is capable of operating for multiple months without requiring user input. Note: If water quality data or location is not being displayed, than the device is currently offline.

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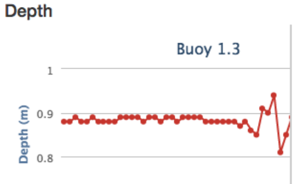
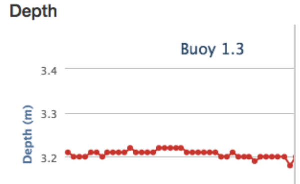
PROVISIONAL DATA SUBJECT TO REVISION

Graphs

Depth



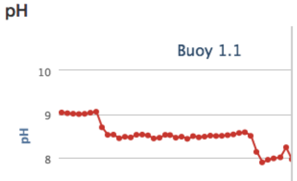
Depth



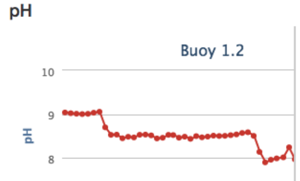
Depth

These two measurements show the two different depths at which the buoy is collecting data. The graphs in the respective columns are indicative of their depth of measurement.

pH



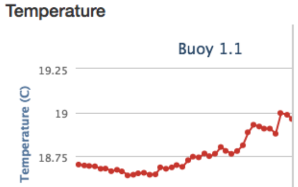
pH



pH

pH is a measurement of how basic or acidic the water may be, pH ranges anywhere from 1-14 and is unitless.

Temperature



Temperature

Temperature

The temperature sensors display the temperature of the body of water in Celsius (°C).

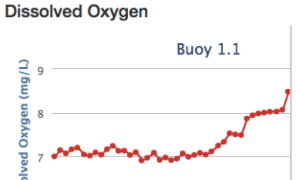
Salinity

Salinity

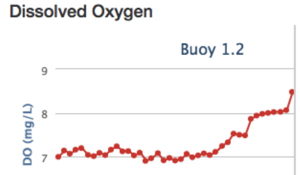
Salinity

Salinity represent the saltiness of the water. The measurement detects the amount of salt in grams per kilogram of water (g/kg).

Dissolved Oxygen

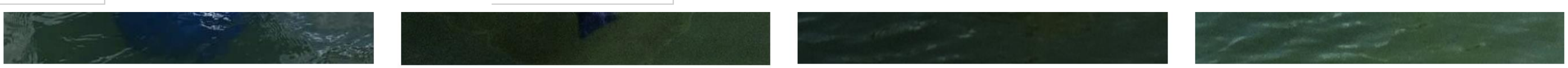


Dissolved Oxygen

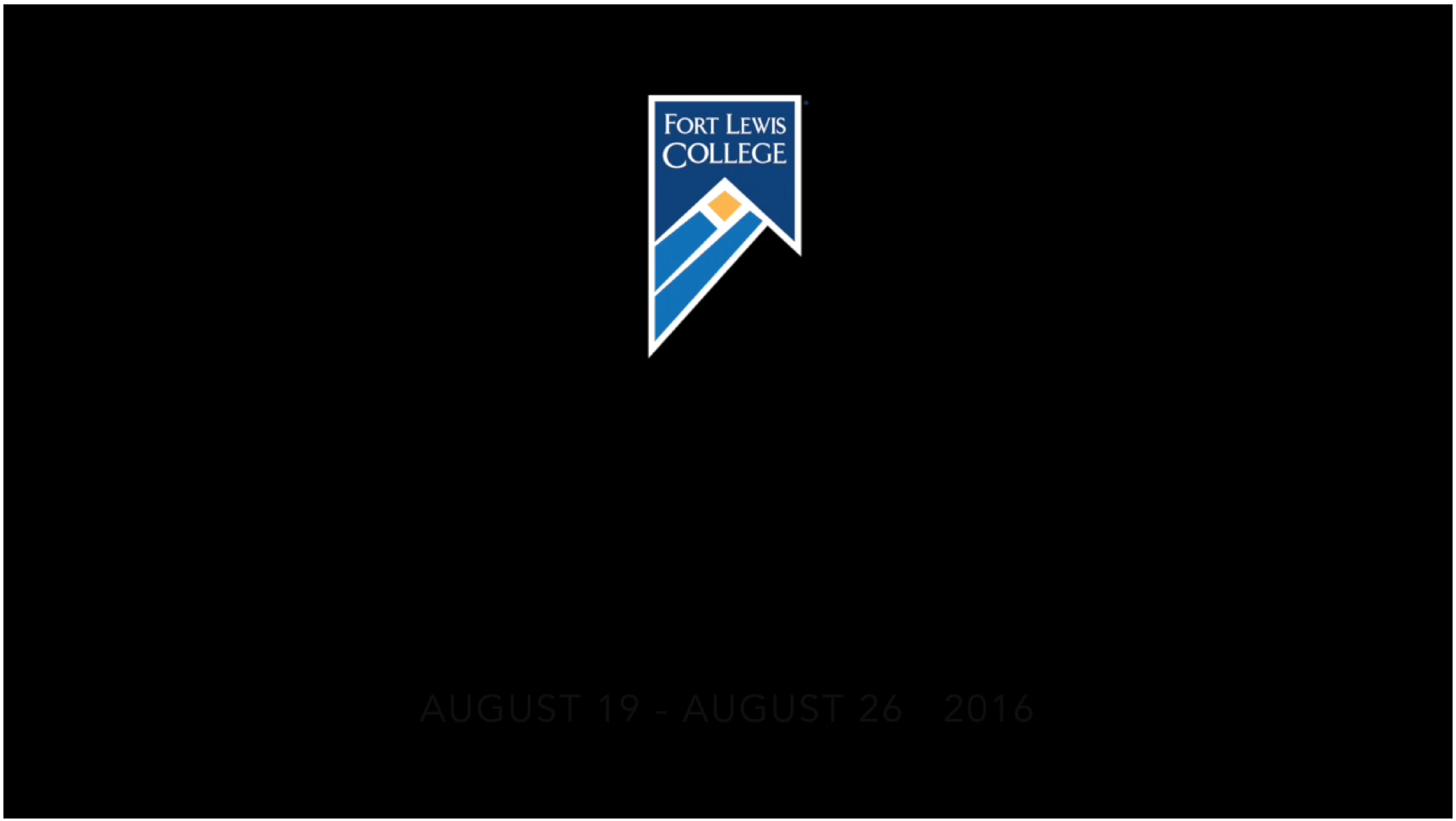


Dissolved Oxygen

Oxygen can enter bodies of water through either the atmosphere or plantlife and dissolve afterwards. Temperature and the amount of moving water can affect these levels. Dissolved Oxygen is measured in milligrams per liter (mg/L).



Other Infrastructure



Discussion Topics/Questions

- What is t
- How do w
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- What inf
- Who cou