Title

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CENS **Center for Embedded Networked Sensing**

Trajectory Design and Implementation for Multiple Autonomous Underwater Vehicles Based on Ocean Model Predictions

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Introduction: AUV Trajectory Design based on Ocean Model Predictions

Trajectory Design based on Model Predictions

- **Single or Multiple Vehicle Applications**
- **Paths are not predetermined patterns, but adaptive strategies**
- **Effective tracking of ocean features**
- **Gather specific *in situ* data based on the type of feature**
- **Improve model skill via near real-time data assimilation**
- **Increases the likelihood of the vehicle sampling in a point of scientific importance**

Ocean Prediction Tool

- **Regional Ocean Modeling System (ROMS)**
  - Split-explicit, free-surface, topography-following-coordinate oceanic model
  - Model research and execution is carried out by the JPL under a contract with the National Aeronautics and Space Administration (NASA)

Oceanography Application and Motivation

- **Harmful Algal Blooms**
  - Large concern for coastal communities in southern California
  - Generally occur from nutrient-rich, freshwater runoff into the ocean
  - Wish to track, monitor, observe and predict their generation and evolution

Problem Description: Observe, Track and Monitor a Dynamic Ocean Feature

Problem Statement

- **Given**
  - One or many mobile ocean sensor platforms (AUVs)
    - Autonomous Underwater Vehicles
  - Evolving ocean feature of scientific interest
    - Freshwater plume
  - Complex ocean model and prediction tool
    - ROMS
- **Goals**
  - Design a set of trajectories that track the centroid, boundary and additional areas of interest within a freshwater plume, based upon a ROMS prediction.
  - Use the collected in situ data to increase model skill and improve future predictions, as well as provide ocean scientists with meaningful measurements to adequately predict or asses the potential for a harmful algal bloom to occur.

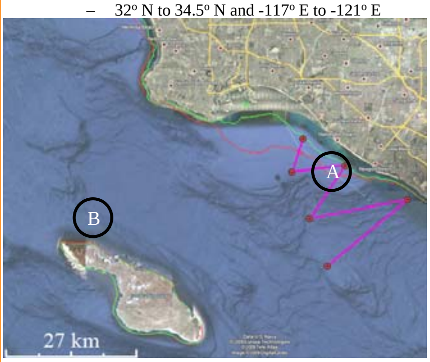
Proposed Solution: Trajectory Design Based on a Regional Ocean Model

Summary

- **Identify a feature of interest**
  - Remote sensing tools
- **Predict the evolution of the feature by use of ROMS**
  - 12-16 hour prediction
- **Input prediction to trajectory generation algorithm and create a sampling mission**
  - Centroid tracking
  - Boundary tracking
- **Execute the mission with available AUV(s) and collect data**
- **Assimilate collected data into ROMS and generate updated prediction**
- **Iterate process until the feature is out of range, or no longer of interest**

Area of Study

- **Southern California Bight (SCB)**
  - 32º N to 34.5º N and -117º E to -121º E

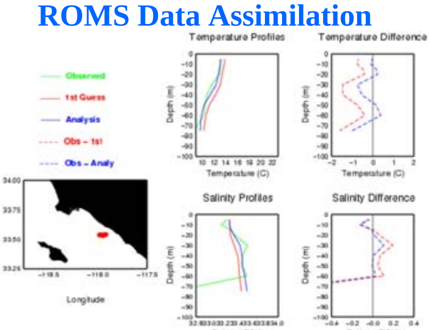


- Preset survey pattern (Feb. 17 - Apr. 17, 2009)
- 20 m isobath
- 30 m isobath
- Implementation region

Webb *SLOCUM* Glider

- **Autonomous glider**
- **Buoyancy driven**
- **Long-term deployments**
  - Up to one month
- **Slow operational velocity**
  - ~ 0.75 km/hr

ROMS Data Assimilation

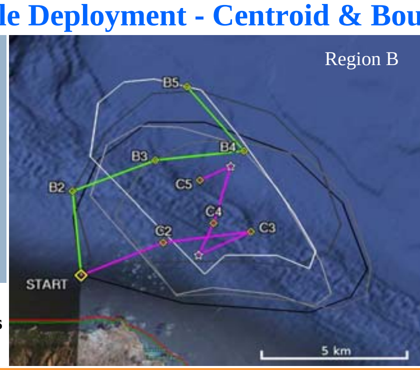


Single Vehicle Deployment Centroid Tracking

- Delineated plume
- Planned trajectory
- 20 m isobath
- 30 m isobath
- #1,3,5 - Sampling location (centroid)
- #2,4,6 - Sampling location (extra)
- Glider surfacing location

Multiple Vehicle Deployment - Centroid & Boundary Tracking

- **24 hour ROMS prediction**
- **Lagrangian surface drifters**
- **Provided by JPL**



- Centroid tracking trajectory
- Boundary tracking trajectory
- Feature boundary t=0
- Feature boundary t=4 hr
- Feature boundary t=8 hr
- Feature boundary t=12 hr
- Feature boundary t=16 hr
- Sampling location
  - B# - boundary
  - C# - centroid
- Sampling location (extra)