CENS Aquatic Research: Overview

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Introduction: Aquatic Microbial Observing Systems

- Aquatic microorganisms impact human health (risk of exposure) and industries, such as fisheries and tourism.
- The problem is becoming worse with human encroachment in coastal areas.
- The conditions under which aquatic microorganisms develop are not understood.
- Methods for detecting microorganisms are too slow and complex for timely intervention.

Problem Description: Understanding/controlling aquatic microbial population development

Scientific Goals

- Understanding ecology of aquatic microorganisms.
- Developing better tools for studying them.

Technology/Applications Goals

- Detection and prediction of harmful events involving proliferation of aquatic micoorganisms, e.g., algal blooms.
- Intervention to mitigate the consequences of harmful events.

Requirements

- Continuous (sensing) presence in the environment.
- Real-time data acquisition and analysis.
- Chemical, physical, biological measurements.
- Correlation of of environmental conditions with microorganismal abundances.
- Spatial and temporal scales relevant to the organisms.

Proposed Solution: Adaptive, sensor-guided sampling and detection of microorganisms

Projects (details in additional posters)

- Adaptive Sampling for Marine Microorganism Monitoring
- Detection and Identification of Marine Microorganisms, using immunological techniques (Ab-Ag interactions):
  - Flow cytometry.
  - Force sensing using Atomic Force Microscopy (AFM).
  - Nanowire sensors with electrical readout.

Navigation algorithms

- Experimental demonstration of an efficient, distributed algorithm for adaptive sampling.
- Experimental demonstration of a bacterium-inspired algorithm for robot navigation and homing with minimal computational requirements.

Field instrumentation and network design and construction

- Design and prototype development of an underwater mote-based submarine robot for experiments in adaptive sampling
- Design and prototype development of a robot boat for surface operations in the field
  - Outfitted with basic sensors for pertinent environmental parameters
  - Equipped for sensor directed navigation
  - Equipped for sensor guided sample collection
- Design and prototype development of a wireless sensor network for small-scale sensing in aquatic ecosystems
  - Construction of 10 static nodes (presently underway) for sensing physical/chemical environmental parameters
  - Within-network data synthesis and decision making for directing a mobile sampler (boat)
  - Transmission of data to shore-based station

Experimental studies in laboratory test bed

- Artificial stimulation of a 'brown tide' (bloom of *Aureococcus anophagefferens*) in a thermally stratified column, and demonstration of predation effects.
- Monitoring the daily vertical migration of a red tide dinoflagellate in a thermally stratified column.

Microorganism sensing, identification, enumeration

- Development of a novel biological detection method for the harmful brown tide alga (BTA): immuno-based flow cytometry. Now used routinely in our labs for detection and counting of BTA.
- Development of methods for attaching BTA-directed antibodies to surfaces. This is useful for functionalizing the tips of AFMs that are used in force sensing, functionalizing other sensors, etc.
- Identification of BTA immobilized on a surface by using force-distance curves obtained with an AFM with a functionalized tip. This detection technique is sensitive to a single cell.
- Fabrication of nanowire and carbon nanotube sensors.
- Demonstration of nanowire sensing principles for BTA.

Future directions

- Emphasize field deployment:
  - James Reserve fresh water Lake Fulmor
  - Santa Catalina Island Thompson's fresh water reservoir
  - Long Island, NY coastal lagoons
- Continue lab work in support of field deployment.
- Discontinue detection and identification research using AFMs and nanowires because they will not be applicable to field deployments in the near future.