Problem Description: Understanding/controlling aquatic microbial population development

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.

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 microorganisms, 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 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.
  – 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
  – With-in-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.