

2.5 Aquatic Microbial Observing Systems (AQU)

The overarching theme of the Center's Aquatic application area is the creation and application of a new genre of wireless sensing systems that will provide real-time monitoring capabilities of chemical, physical and biological parameters in freshwater and coastal ecosystems. Temporal and spatial measurements at high-resolution are essential to understand the highly dynamic nature of aquatic ecosystems and the rapid response of microbial communities to environmental driving forces.

Our unique approach to aquatic sensing and sampling, Networked Aquatic Microbial Observing Systems (NAMOS), employs coordinated measurements between stationary sensing nodes and robotic vehicles (surface robotic boat and more recently autonomous underwater vehicles) to provide in-situ, real-time presence for observing plankton dynamics (e.g. chlorophyll concentration, dissolved oxygen), and linking them to pertinent environmental variables (e.g. temperature, light, nutrients, etc.). Sensing and sampling capabilities of the autonomous vehicles are carried out through the development of adaptive protocols, directed through the network. These systems enable the generation and testing of novel hypotheses regarding the processes that control the distribution, growth and demise of aquatic microbial populations.

Laboratory studies within the Aquatic Application provide a testbed for the development and testing of hardware and software for novel sensing/sampling approaches, and for detailed experimental studies of aquatic microorganismal behavior (growth, vertical migration, trophic interactions). Our laboratory work continues to involve the development and testing of novel sensors/samplers, the development of supporting software and hardware, and the testing of these novel approaches in 'artificial water columns' used to simulate natural planktonic environments. The development of new sensors, or new detection protocols, has also been a minor component of this project. This work has been performed in coordination with other CENS groups whose primary objective is the development of innovative sensors.

Three projects have been developed during the past year that have involved the development and deployment of sensor networks to examine microbial plankton dynamics in the coastal ocean of southern California. Two of these projects involve the establishment of a sensor network within King Harbor, City of Redondo Beach. Like many coastal municipalities, Redondo Beach has struggled to maintain high levels of coastal water quality in the face of an increasing chemical and biological contaminants originating from the activities within their own communities, or via the transport of various contaminants from inland sources via storm drains, rivers or effluent pipes. Efforts by municipalities to provide responsible environmental stewardship of their coastal waters are often thwarted by a lack of water quality data and inadequate scientific understanding. The NAMOS established in this harbor during past funding cycles has been employed to provide sensing capabilities to support observational and experimental studies of the harmful algal blooms in the harbor, and for studies of vertical migratory behavior and

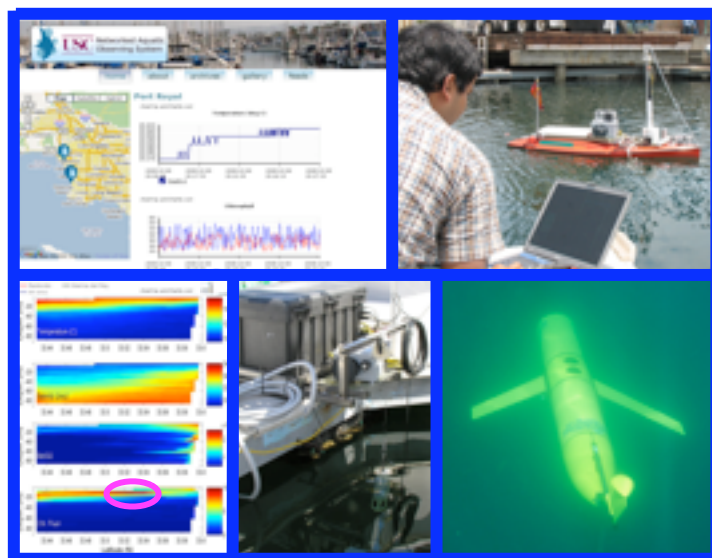


Figure 1. Networked Aquatic Microbial Observing Systems (NAMOS) encompass the design, construction and deployment of sensor networks that employ stationary buoys or pier-based sensor packages (bottom, middle), robotic boats (top, right) and autonomous underwater vehicles (bottom, right) to provide spatially and temporally dense measurements. Near-real time web-based displays of the data (top, left and bottom, left) allow rapid response to emerging environmental events such as harmful algal blooms.

photoadaptation of the phytoplankton within the harbor. The NAMOS developed for King Harbor has recently been expanded to Marine Del Rey, another highly urbanized marina in the Greater Los Angeles area.

The third project is relatively new and entails the construction of mobile sensor networks in open coastal waters of southern California. This project involves deployments of autonomous surface and underwater vehicles, and the development of hardware and software for coordinated activities of these underwater robotic vehicles. The work includes the development of algorithms and approaches for transmitting sensed information to shore-based facilities, assimilating the information into predictive models of coastal ocean physics, and using the resulting predictions of feature dynamics to retask the underwater vehicles to optimize their activities (setting new tasks, way points, etc.). This work is being realized through attempts to characterize high-nutrient freshwater discharges into the coastal ocean, and the blooms of planktonic algae that are often stimulated by these inputs.

The sensing network research in the open coastal ocean represents a larger-scale implementation of a distributed sensing system. This component of the Aquatic Application is being conducted in conjunction with a NOAA-funded Monitoring and Event Response for Harmful Algal Blooms (MERHAB) program entitled Rapid Analysis of Pseudo-nitzschia & Domoic Acid, Locating Events in near-Real Time (RAPDALERT). The project uses CENS hardware, software, and overall approaches in coastal waters near LA Harbor to study the environmental factors leading to toxic algal blooms caused by phytoplankton species that produce the powerful neurotoxin domoic acid. This project brings together CENS- and non-CENS investigators to develop and deploy a network of coastal sensor buoys, and employs autonomous underwater vehicles whose movements and activities are controlled by information gathered by the static sensor buoys, in a manner analogous to the present control of the robotic boat in our NAMOS project. The advancements in vehicle control accomplished through CENS constitute major advancements in our ability to characterize rapidly evolving biological events in the coastal ocean.

Knowledge transfer and outreach of the Aquatic Application research group has been accomplished through a variety of activities. Partnerships have been established with the Southern California Coastal Water Research Project, a joint powers agency charged with studying water quality in the Southern California Bight. The NAMOS group also collaborates closely with the Southern California Coastal Ocean Observing System, a regional component of the national Ocean Observing System. Our partnership with the City of Redondo Beach provides the City with vital information to improve the City's abilities to decide on an appropriate course of action to prevent or ameliorate harmful algal blooms. Our group has also participated in public outreach and education programs hosted by the City (Redondo Beach Clean Waterfront Festival held October 11, 2008). A collaborative effort has also been developed with the West Basin Municipal Water District to examine the impact of harmful algal blooms on water desalination processes. Finally, our NAMOS research group has hosted film crews from the History Channel and Nova Channel, and provided numerous interviews to newspapers, radio and television on the impacts of harmful algal blooms on coastal ecosystems and marine animal populations, and new technological approaches for studies these harmful events.