BIO-SENSING IN OCEAN OBSERVATION

Accomplishments and Ambitions for In-Situ, Autonomous, Real Time and Related Measurement, Sampling, and Sensing Systems for Biological, Ecological and Human-Health Variables as Part of Coastal Ocean Observing Systems

WORKSHOP REPORT

June 18, 19, 20, 2007
Sarasota, Florida

Organized and Hosted by

The Mote Marine Laboratory and
College of Marine Science, University of South Florida
Joint Center for Coastal Ocean Studies
&
The Florida Coastal Ocean Observing Systems Consortium

Sponsored by

Economic Development Corporation of Sarasota County
Florida Fish and Wildlife Conservation Commission
Florida Chapter, Marine Technology Society
Alliance for Coastal Technologies
Barney and Carol Barnett Fund
AMJ Environmental / YSI, Inc.
Ocean Optics, Inc.

Report Written and Compiled by Jyotika I. Virmani and Ernest D. Estevez

Summary

A workshop on bio-sensing in ocean observations was held June 18-20, 2007 at Mote Marine Laboratory in Sarasota, Florida. The meeting was organized and hosted by the Mote Marine Laboratory and College of Marine Science, University of South Florida Joint Center for Coastal Ocean Studies, and the Florida Coastal Ocean Observing Systems Consortium. Additional sponsorship was provided by the Economic Development Corporation of Sarasota County, Florida Fish and Wildlife Conservation Commission, the Florida Chapter of the Marine Technology Society, the Alliance for Coastal Technologies, the Barney and Carol Burnett Fund, AMJ Environmental/YSI, Inc, and Ocean Optics, Inc. Over hundred scientists, engineers, students, and other interested parties representing the academic, private and government sectors, attended from Canada and across the US to share theoretical approaches, prototypes, and operating systems for the purposes of improving networking and partnerships, and addressing stakeholder needs.

Workshop Rationale and Objectives

Hampering the development of Integrated and Sustained Ocean Observing Systems around the US is a lack of *in situ*, automated sensors for a broad range of ocean and public health conditions. Robust, reliable, and automated physical oceanographic and meteorological sensors have been commercially available for many years, and can collect and return near real-time data without requiring maintenance on a prohibitive schedule. However, an Integrated Ocean Observing System also requires chemical, geological and biological sensors. As Ocean Observing Systems are developed to address an assortment of societal needs, an assessment of existing biological sensors for automated ocean observing is needed. This workshop had three specific aims:

- To assess the current level of development of biological sensors for ocean observations
- To determine the needs of the biological oceanography sensor development community
- To identify future steps in transitioning from Research & Development to commercially available sensors

Workshop topics included platforms, sensors and applications, human health, harmful algal blooms, nutrients, acoustics, integration and synthesis, and a panel discussion on Technology Transfer and Commercialization. In the following summary, italicized references correspond to Workshop presentations for which abstracts are also included in this Report.

Goals for Sensor Development

Sensor development goals were discussed. Practical goals fall under the sensor requirements for an Ocean Observing System, including existing hurdles such as biofouling. A list of core variables provides the observation goals; autonomous sensors that can be deployed for extended periods of time are needed to observe these variables.

Ocean Observing System Sensor Requirements and Existing Hurdles

An Ocean Observing System requires broadly applicable automated *in situ* sensors that can sample frequently for rapid detection of changes in the variable. They also need to be portable, robust, provide good quality data, and eventually be converted to a real-time data relay mode. As part of an Ocean Observing System, the data will ultimately result in a forecasting capability via model validation and data assimilation. Workshop participants agreed that biological sensors need to be coupled to observations of other parameters (e.g. currents, temperature, salinity, wind, chlorophyll, oxygen) to understand ecosystems.

Existing problems in achieving these requirements were identified during the workshop. The primary hurdle was that sensors require frequent servicing or maintenance because of biofouling, a lack of robustness, or the limited longevity of wet chemistry reagents that cannot be in the field for too long. Other problems include large power requirements and therefore a large battery, and low data frequency. Also highlighted during the workshop was the need for biological sensors to have an automatic identification capability because traditional methods of lab-based analysis are too slow. For example, near real-time identification is needed to determine the source of a waterborne pathogen in a timely manner so related environmental problems can be managed effectively. Sensors also need an internal check on their effectiveness. Some manufacturers use internal checks for sensor drift. Another internal check should be on battery life to warn the user if the battery is dying. For example, in tracking fish such a feature would indicate whether the fish has swum out of range or the tag has lost power.

Other general obstacles in the development of an Ocean Observing System (not solely for biological sensors) were discussed. These include: adequate and sustained funding to include support for basic science as well as operational oceanography; a trained and adequate workforce needed for a 24/7 operational Ocean Observing System; adequate bandwidth for transmission of all the data; integrated data management, which includes storage capacity and QA/QC; and piracy. Basic science support is required to understand the system and to develop techniques to improve the efficiency of the observing system, both in the types and distribution of sensors.

Core Variables Measured by an Ocean Observing System

NOAA has identified a list of core variables requiring measurements by an Ocean Observing System. The variables can be categorized depending on the sensors that are available to measure them (Table 1). Workshop participants discussed the characteristics required for sensors to belong in these categories.

Sensors that observe variables in the green category generally measure physical and meteorological variables because these automated sensors are commercially available by multiple manufacturers and have been tested under various conditions. They are reliable over long periods (months to years) and can be deployed on moored buoys or non-stationary platforms. They are capable of returning near real-time data that meets research standards, which are generally considered the most stringent end-user requirements.

Sensors that observe variables in the yellow category need more frequent maintenance and cannot be deployed for extended periods and have not been tested in various oceanic environments. However, they are becoming commercially available and users other than the developers can operate these sensors with relatively minor training.

New and emerging technologies are the defining feature of those sensors that measure variables in the red category.

Sensor Category	Variables Measured
Green	Salinity, temperature, sea level, surface waves, surface currents, heat flux, momentum flux*, sea ice.
Yellow	Bathymetry and bottom character (e.g. benthic habitats), optical properties, dissolved nutrients (N, P, Si), dissolved oxygen, chemical contaminants.
Red	Fish species, fish abundance, zooplankton species, zooplankton abundance, phytoplankton species, phytoplankton abundance, waterborne pathogens.

*Momentum Flux (winds) is not on the NOAA IOOS list, but is a key variable.

Table 1: Core variables and the categories they fall into depending on the state of development of the sensor [*Luther*].

A reassessment of the variables in these categories based on the new technologies discussed at the 2007 Workshop is needed. For example, acoustic technologies, used for detecting fish abundance and fish diversity, are commercially available, widely tested, and can be deployed for long periods on multiple platforms.

Workshop Presentations Overview

General Platforms

Stationary pilings (NOAA C-MAN stations), lighthouses, and a USF buoy are platforms used in Florida Institute for Oceanography's SEAKEYS program in the Florida Keys [*Fajans*]. They carry hydrological and meteorological sensors, including nutrient sensors, and site visits are required every 2-3 weeks for maintenance and groundtruthing. To mitigate biofouling, a mesh cover for the sensors was developed in collaboration with Falmouth Inc, which allows the sensor to be left in the water for up to a month. Archived and near real-time data are available through NOAA/AOML's ICON (http://ecoforecast.coral.noaa.gov/), the USF COMPS (http://comps.marine.usf.edu/), and the NOAA/NDBC (http://www.ndbc.noaa.gov/) websites.

The Bottom Stationed Ocean Profiler (BSOP) [*Lembke et al.*], developed at the University of South Florida, is a free drifting vertical profiling platform. More than 90% of deployed BSOPs are recovered. It is portable and easy to deploy and can carry an array of hydrological sensors including dissolved oxygen and the BreveBuster™ [*G. Kirkpatrick et al.*]. Data are collected as the instrument moves vertically in the water, and is telemetered when the instrument surfaces. BSOPs can be deployed for several months.

A compact, low power, autonomous profiling platform is being developed by WET Labs, Inc. in collaboration with the University of Rhode Island and Oregon State University [*Barnard et al.*]. The profiler provides high vertical resolution physical and bio-optical data, and is designed to allow additional sensors. It can operate at various depths. Included are a core suite of sensors, a power system, a winch system, a telemetry module, a buoyancy module, and a controller. The profiler can be deployed for up to six months and optionally includes a bottom docking station and power reservoir.

Task-Specific Platforms

MARVIN [*Bendis and Neely*], developed by AMJ Environmental, is a stationary solar-powered surface platform used in some estuaries and rivers in Florida. It is capable of carrying an assortment of physical and chemical hydrological and meteorological sensors, and uses a water flow-through system that allows samples to be collected from multiple depths. A satellite airlink and communication modem allows near real-time data telemetry twice per hour. The data are available via Marvindata.org and the COMPS website (http://comps.marine.usf.edu/). As part of the instrumentation, MARVIN is configured to carry a nitrate analyzer [*Neely and Heil*]. This requires servicing every two weeks because of biofouling, especially in rivers, and because the chemical payload is limited and needs replacing. If that time is extended, the lowest nitrate reading is dropped. Also of concern is that agitations and interior temperatures affect the accuracies of the chemical payloads. An on-board fluorometer on MARVIN has shown that contributions to the fluorometric signal can occur from non-chlorophyll compounds and requires groundtruthing [*Neely et al.*]. The collocation of multiple sensors improves the interpretation of CDOM and Chlorophyll *a* fluorometric data [*English et al.*].

The Aquamapper AUV [*Ellison*], developed by YSI Environmental, Inc. and OceanServer Technology is a low-cost ($60K-$70K), easily deployable platform designed for water quality mapping. The platform size is flexible because the nose can be lengthened, allowing it to carry different water quality sensors. Associated software allows the user to enter way-points at which it surfaces and transmits data, which allows some flexibility in the sampling pattern, and an ability to get very highly resolved spatial data. An internal GPS will correct it if it drifts off the pre-set track. It can also undulate because it has a depth sounder and pressure inducer. The US launch is in 2007 and it will be available globally in 2008.

Also addressing water quality, a multi-parameter autonomous Water Quality Monitor (WQM) has been developed collaboratively by WET Labs, Inc. and Sea-Bird Electronics, Inc [*Orrico et al.*]. Measurements include conductivity, temperature, depth, dissolved oxygen, chlorophyll fluorescence, and turbidity. The use of multiple anti-fouling approaches suggests that the system can be deployed for up to 6 months without degrading the data quality.

The Environmental Sample Processor (ESP) [*Preston et al.*], developed at MBARI, is an autonomous ocean platform for molecular diagnostic tools. It conducts molecular biological analyses *in situ* in real-time over extended periods instead of bringing samples back to the lab. This allows a rapid response to environmental problems. It has an interactive mode: if the water sample returns a positive result, then a second sample will be archived and brought back to the lab for further tests. Deep-water pressure housing has been developed and the ESP has been tested at depths of up to 1000 m. The core ESP is a sample processing and archival, real-time probe array with a CTD and battery pack. The battery pack is the limiting element, allowing for one month deployment before servicing. The ESP provides power, fluids to chemistry assay for molecular analysis, and communication connections.

Different sampling modules can be added, including DNA probes. The ESP has successfully analyzed marine planktonic organisms including bacteria, Archaea, and small invertebrates. Lab techniques have been developed to rapidly detect and identify invertebrate larvae [*Jones et al.*]. Large volumes of water can be screened rapidly in the lab using the ESP. A PCR module and implementation of fiber optic microarrays are under development. Future plans include the addition of an external sensor to automatically trigger sampling, and to extend the depth capabilities to 4000 m. Several harmful algal species have also been detected during ESP deployments using the DNA probe arrays [*Doucette et al.*]. A second generation ESP has further allowed the detection of the algal toxin domoic acid. Combined with algal species detection, this is the first remote, integrated assessment of harmful algal cell abundance and toxin presence in coastal waters. Further tests on this are on-going.

An Unmanned Surface Vehicle (USV) has been developed by USF to aid in extensive seagrass restoration monitoring efforts (Dreger et al.). The USV is equipped with an underwater camera and GPS system, and operates in shallow water (<0.5m). Data and video feedback for distances greater than 0.5 miles are available via a wireless interface.

Sensors

The Alliance for Coastal Technologies (ACT; **http://act-us.info**) [*Luther*] tests commercially available sensors in different ocean environments against traditional methods of detection. The sensors are not tested against each other, but are tested against the manufacturers claims based on some mutually agreed upon standard. Tests that have been conducted to date include dissolved oxygen sensors, *in situ* fluorometers, turbidity sensors and nutrient sensors (underway). Biofouling is always an issue. Evaluations of test sensors that have been around for some time are available in a searchable database on the website. Demonstrations are also done for new sensors that have not yet been fully field tested. ACT holds targeted workshops on emerging sensor technologies.

Fluorescence techniques have been used to investigate phytoplankton physiology and primary production. The Fluorescence Induction and Relaxation System (FIRe) [*Gorbunov et al.*] is a newly developed low cost fluorescence fluorometer. It is more sensitive than the more commonly used Fast Repetition Rate fluorometers (FRRF) and has flexible measurement protocols. It has successfully been tested on gliders and moored platforms. Hand-held instruments have also been used to monitor corals.

The Shadowed Particle Profiling and Evaluation Recorder (SIPPER) and an associated software package called the Plankton Image Classification and Extraction Software (PICES) has been developed at the University of South Florida [*Remsen*]. Traditional methods of zooplankton sampling are not practical on observing platforms, and fragile and gelatinous samples tend to be undersampled and are difficult and expensive to archive. The low power, high storage SIPPER/PICES system provides *in situ* detection and automated rapid analysis and identification of marine plankton. It can be towed so water can flow through it, or it can be in a stationary mode and water can be pumped through. It has the capability of continuous imaging (10^6 images per day) and an attached CTD allows concurrent temperature and salinity measurements. PICES has 73% classification accuracy on more than 25 groups of plankton. In addition to the sensor and software, a low cost (<$10K) tow-body has been developed for data telemetry. *In situ* testing includes sampling on AUVs, the BSOP, and on fixed platforms and it can be used on archived lab samples. Biofouling currently prevents longer term deployments.

A new Fiber-optic Oxygen sensor (FOXY) has been developed by Oregon State University, Woods Hole Oceanographic Institution, and Ocean Optics, Inc. [*Reimers et al.*] to measure the partial pressure of oxygen in water. Using fiber optics instead of more traditional electrochemical designs makes this sensor robust and stable. This includes the ability to compensate for drift, *in situ* calibration, and an increased immunity to biofouling. Prototype tests are completed and oceanographic tests are in progress.

An underwater phosphate sensor for deployments has been developed by WET Labs, Inc., SubChem Systems, Inc., and the University of New Hampshire [*Zaneveld et al.*]. The sensor uses micropumps in a unique flow system. Results of tests show the sensor can be deployed for over a month.

Utilizing Sensors

Deployment of a Pulse Amplitude Modulation (PAM) fluorometer allowed an *in situ*, high-resolution assessment of a large bleaching event in the Caribbean [*Manzello et al.*]. Concurrent hydrological observations showed temperature as the primary factor for bleaching stress for the corals being monitored. NOAA’s hotspots program uses sea surface temperatures from satellites to assess where bleaching may occur and automated bleaching alerts are emailed onto the Coral listserve. However, damage occurs before corals appear white and, in addition to heat, bleaching stressors include light and oxygen. Although little can be done in the short-term about bleaching, *in situ* observations that assess coral health (not just temperature) are required so bleaching alerts can be issued in a timely manner for reef management. A number of coral sites are being monitored as part of the NOAA/AOML ICON program and *in situ* data are available at http://ecoforecast.coral.noaa.gov/.

Integration of *in situ* TSI sondes, a low cost unmanned multi-instrument surface vehicle (USV), near real-time wireless multi-instrument data acquisition, and geospatial analysis and data display are used to demonstrate the advantages of technological and analytical improvements in sampling rivers and estuaries [*Casper et al.*]. These supersede traditional methods which require large amounts of time and manpower to collect samples and process the data. In addition, the new techniques cover large areas and show variability which may be missed by hand-collected point samples.

Using the relatively new time depth recorders (TDRs) in conjunction with satellite tags, data on the behavior of inter-nesting turtles can be used to provide guidance on how best to protect them from harmful human activities (e.g. boaters) [*Sobin and Tucker*]. Satellite tags of loggerhead turtles have also shown the migratory patterns of these creatures in the Gulf of Mexico, as well as their location relative to other hazards such as offshore dredging, harmful algal blooms, and tropical storms [*Tucker*]. Tagging endangered green sea turtles and using a combination of mark-recapture, satellite tracking, and molecular genetic techniques may be used to identify locations of seagrasses and algae cover in the western Everglades [*Hart*]. These remote areas are difficult to reach, and the benthic habitat is unknown.

Harmful Algal Blooms

An *in situ* instrument to detect various taxonomic classes of phytoplankton (BreveBuster™) [*G. Kirkpatrick et al*.] has been developed at Mote Marine Laboratory. The BreveBusters are being used to detect harmful algal blooms on the west Florida shelf. At the moment, 15 BreveBusters are assembled and 8 are in fabrication. Over the past two years these sensors have been tested on various platforms including shipboard, moorings, gliders and the BSOP. As part of an integrated ocean observing system, a full HAB observatory would combine the *in situ* BreveBuster with new molecular probe species-detection technology (e.g. the ESP [*Doucette et al.*]), satellite remote sensing, and models to observe and forecast the temporal and 3-dimensional spatial distribution of HAB species along the west coast of Florida.

A classification technique for detecting and monitoring *Karenia brevis* blooms has been developed based on the optical backscattering coefficients of a bloom, which are low compared to those generally observed in chlorophyll-rich coastal/estuarine waters [*Cannizzaro et al.*]. Satellite or *in situ* optical data may be used. The technique shows a ~80% success rate.

Microalgal species can be identified using a bead suspension array [*Scorzetti et al.*]. This allows for simultaneous detection of toxin and potential toxin producing species in phylogenetically diverse communities. Initially 8 species have been identified, but the method can be expanded to an unlimited number of species.

An automated *in situ* productivity analyzer shows that maximum net production and community respiration rates occur during *K. brevis* blooms [*Hitchcock and Langdon*]. The analyzer measures oxygen, temperature and irradiance. Samples are replenished daily at dawn to yield a diurnal cycle of net community productivity.

Addressing Public Health

A real-time beach condition system [*B. Kirkpatrick et al.*] was developed by Mote Marine Laboratory to address the needs of the public in a region that is affected by harmful algal blooms that cause respiratory problems. Traditional media coverage of red tide is too broad and some beaches may report adverse affects whilst others do not. In Sarasota and Manatee Counties (Florida), mandatory lifeguards on all beaches are outfitted with a Blackberry ™ and are trained to submit information via a simple form on the conditions at the beach. The counties have mandated this as part of the lifeguard duties. The beach condition report can be accessed by the public from the SO COOL server website (**http://coolgate.mote.org/beachconditions/**) or via phone (941-388-5223). Manatee County has paid to get this system on their beaches. In addition to red tide notification, the lifeguards also report surf condition and what beach flag is flying (e.g. red = high surf; purple = marine hazard). This system will be expanded to the south (Collier County) where there is a problem with macro-drift red algae. The NOAA HAB Bulletin also uses the data for validation of their report. A goal for the NOAA HAB IOOS program is to forecast beach impacts 24-48 hours ahead of time and these data go to NOAA for forecast model improvements.

Traditional approaches to beach monitoring (for example) are too slow and there is no ability for source tracking or pathogen detection capability without lots of microscope time and expertise. Rapid detection of biological parameters is required in order to address environmental public health needs. This has resulted in increasing use of molecular methods [*Goodwin*]. By pairing engineers and scientists with end-users, rapid, quantitative technologies with multi-target capabilities are being developed that begin to address end-user needs. Still needed is an automated microbe identification capability and better source tracking markers. Potential emerging technologies of use in this area are the Autonomous Genosensor and the Environmental Sampling Processor, which are in the testing stages and are not yet widely available.

An electrochemical assay has been developed for the simultaneous detection of fecal-indicating bacteria, human source-tracking markers, bacterial pathogens, and a viral pathogen [*LaGier et al.*]. The assay is designed for a hand-held, commercially available instrument and can rapidly screen samples (3-5 hours). To transition this to an automated, portable sensor to rapidly detect harmful microorganisms in Ocean Observing Systems, a PCR chip and a reconfigurable fluidic processor [*Farmer et al.*] have been developed by the University of

South Florida, in collaboration with the University of Miami and NOAA/AOML. The chip is designed to allow easy integration into a portable, semi-automated microbial sensor. Future steps include developing a fully automated system.

Nutrients

Unless nutrients are observed on appropriate time and space scales, hypotheses about the role of nutrients in ecosystem processes cannot be tested and the efficacy of management practices cannot be evaluated. An Adaptive and Integrated nutrient Monitoring System (AIMS) was developed at the University of Maryland [*Kelly et al.*]. This system integrates Autonomous Nutrient Monitors (ANMs; Nitrate, Phosphate, and Ammonium) with water samplers, multi-parameter sondes, telemetry and an automated data processing system, and the recent addition of a urea sensor developed in collaboration with EnviroTech LLC. The system can be deployed for one to two months without requiring maintenance. Test results agree with hand collected samples and show temporal variability that is not sampled by traditional method. Nutrient sensors need to be deployed with other hydrographic sensors and telemetry systems to maximize scientific and policy impacts. Autonomous nutrient sensors that can be deployed for long periods are not yet commercially available and well tested, but with modern instruments, spares, trained staff, and declining prices, they soon will be.

Episodic high nutrient events may not be captured by discrete measurements, and require a more flexible sampling approach. Such nutrient features on the west Florida shelf can occupy more than 1000 square miles. A lab (or ship) based high-resolution high-sensitivity analyzer [*Masserini et al.*] is used to measure nitrate, nitrite and ammonium in surface oceans. Concurrent CTD samples provide information on the source of high nutrient events.

Acoustics

The Ocean Tracking Network (OTN) [*Jackson et al.*] is a pilot project for the IOC Global Ocean Observing System. Using acoustic transmitters, tagging technology and satellites, the OTN will span 14 ocean regions and connect all 7 continents. Global research themes include: the biology and behavior of migrating marine life; ocean physics modeling; impact of climate change on marine life and ocean physics; resource management; and international social and legal framework for oceans**.** New analysis tools and data management to handle the large quantities of information will be developed and will include a standardized global data structure. Partners have agreed to track, observe, maintain and upload the data. Over 30 MOUs have been signed, including Mote Marine Laboratory who will take the lead for the Florida to Cuba acoustic line. The acoustic tags vary in size; the largest tags will last up to 20 years. The tags are surgically implanted into the animals and will constantly transmit data on an individual code. The tags will also record temperature and salinity. Archival tags are different from acoustic tag and will have to be retrieved afterwards. The latest generation of receivers can last for 5 years and the transmission range from each animal is ~1km.

Hydrophones are the most robust biological sensor available and can collect data continuously from a large range of animals from shrimp to whales [*Mann and Locascio*]. Platforms include hard-wired hydrophones, autonomous dataloggers, drifting platforms (e.g. BSOP), ROVs, gliders, and animal-borne tags. The instruments are usually placed on pre-existing sites that have been chosen by physical or geological oceanographers. In addition to the sensor challenges listed earlier, a specific challenge for passive acoustics is to identify the sound producer. A species database needs to be built up.

There are approximately 1,200 species of fish in Florida waters, and about ~30% are sound producers, so about 400 species need to be included in a species database for Florida [*Gilmore*]. Identifying the sound source will take time but a library of these sounds with analyses is needed so a call recognition system can be developed. The Chinese have been listening to sound sources for more than 2000 years in order to hunt fish for food. The Latin Americans were also doing this in South America and there is also a possibility that Native Americans also listened to the sound of fish. An Ocean Observing System should include observations of spawning sites to really integrate the biology, but wherever a site is placed, knowledge and a need for ground truthing of the fauna is required.

The Long-term Acoustic Recording System (LARS) combines hydrophones with a data logging device and can be calibrated and deployed for up to a year on two packs of 4 batteries because it has low power consumption [*Locascio and Mann*]. It is fully programmable and logs data to a compact flash memory. Associated analysis software shows fish sound production on long time scales; the majority of sound production is associated with spawning and courtship behavior. There is a paucity of biological data on Ocean Observing Systems and hydrophones are a perfect fit. An integrated suite of measurements are required to fully understand the ecosystem.

Goliath grouper, *Epinephelus itajara*, is protected in US state and federal waters, however, obtaining a visual census of abundance is difficult in conditions of low visibility [*Frias-Torres et al.*]. A high-resolution dual-frequency sonar (DIDSON) system has been used to detect juveniles in mangrove shorelines. This system can record the shape, size and movement of the fish.

Integration and Synthesis

One goal of an Ocean Observing System is the ability to provide forecasts. Models need to be developed in conjunction with observations. An example of this is WAVCIS, an operational wave and storm surge monitoring system with capability for near real-time monitoring off the Louisiana coast [*D'Sa et al.*]. Decommissioned oil platforms off the Louisiana coast are used as observing platforms. Measurements include waves, currents, water depth, salinity, turbidity, air and sea temperature, wind speed and direction, barometric pressure, and visibility. MODIS X-band direct broadcast reflectance data and other NASA satellite products are also used. MODIS Terra/Aqua gives total suspended matter. An ocean circulation 3D model will use these data to develop a high-resolution forecast system for the Gulf coast.

Government funding for oceanographic research has shifted due to a variety of reasons [*Langebrake*]. For example, approximately 70% of NSF funds are allocated to infrastructure and only 30% are going to science; ten years ago it was the opposite. Other factors have resulted in a decrease in funds for the sciences, and an increase for other areas (e.g. homeland security). This shift in resources and technology developed for other areas can be used for scientific research. An example of such a recently developed system includes a high resolution AUV for mapping and surveillance. Also available are DOD funded open source databases for ocean going ships. The UK is developing a number of systems similar to those being developed in US.

Workshop Concluding Remarks

A panel discussion on Technology Transfer and Commercialization consisted of five panelists representing five different types of institutions: SRI International, Ocean Optics, Inc., Dalhousie University, Monterey Bay Research Institute, and Mote Marine Laboratory. The panel/audience discussion highlighted the need for a source of funding to help transition prototype sensors to the commercial arena.

Regarding sensor development, many private companies have scientists and engineers. In academic arenas, individual researchers can collaborate with private companies, or with engineering departments within the same institution to produce a prototype. However, there is a need for more information from the top down. As sensors are developed it would be useful to have specifications to aim toward in order to provide the best sensor to fit into the existing suite of instruments that are available for ocean observations. This should include information on connections, dimensions, power capabilities etc. Some standardization would be helpful in developing a uniform Coastal Ocean Observing System for the US.

The top 4 factors that are currently limiting sensor development are funds, biofouling, physical size, and power requirements. Every manufacturer is working on trying to solve biofouling. ACT had a workshop on biofouling and found that there is no consensus on how to tackle this problem.

There is a critical role for science and engineering in an Ocean Observing System that serve societal needs. Scientific discovery and ecosystem based understanding and subsequent innovation is needed in order to improve ocean observing, both in the sensors being produced and in the location of deployment and frequency of collection. The biology is used to do the sensing, and the sensors are used to look at the biology.

On a larger level a need exists for ocean observations that extend beyond the waters of the State or the US. This will require partnerships and capacity building. An example of such an international effort is the OTN. OTN money is budgeted for the acoustic tags for countries where the biology is important, but who may not otherwise be able to afford them. Another example is GOMA, who intends to place red tide sensors off Mexico because it is of interest to the Gulf as a whole. The difficulty of putting instruments in foreign waters is overcome by forming partnerships. The data collected should be available to everyone. IOOS and GOOS are looking at data warehousing and archiving that provides open access. Some concern was expressed that European countries have limited access to their data.

Workshop Follow-Up Items Identified by Participant Discussion

- Write a workshop report. This has the potential to be used by federal agencies to get funding. It could help motivate program managers and call for RFPs etc. The report should be available via the website (preferably as a PDF).
- Set up a listserve for those who attended the workshop to facilitate communication
- Set up a website for connecting the community represented by people at this workshop. This includes scientist, engineers, private companies involved with sensor development, and people who are looking for sensors (e.g. Seakeepers).
- Encourage companies (many are small) to register with ACT so they are included in the list of companies. ACT and Sea Technology both have lists of instrument manufacturers. This will provide a one-stop location for people who are looking for companies that are involved with sensor development.

- Need to keep the communication avenues that began with this workshop open. Two possibilities for next year are a 2nd Biosensing in Ocean Observations Workshop, or a session at one of the larger meetings. We have missed the deadline for the Fall 2007 AGU and the 2008 Ocean Sciences meeting, but could be a session at the International Coral Reef Conference in July 2008. The advantage of a session in a larger meeting is that we can get more people involved, but with concurrent and multiple sessions there is often no time to talk as a group that cross-cuts traditional ocean science and engineering disciplines. The advantage of a workshop is the opportunity to talk and exchange information and move forward as a community.
- Find out what is going on in sensor development in other parts of the world, e.g. Europe. ECOOT (**http://www.noc.soton.ac.uk/ecoot/**) is the European equivalent of ACT.

WORKSHOP COMMITTEE

Coordinators:

Jyotika Virmani, Coordinator, Florida COOS Consortium, jyotika@marine.usf.edu
Ernie Estevez, Director, Mote Center for Coastal Ecology, estevez@mote.org

Mote Marine Laboratory

Damon Gannon, damon@mote.org
Barbara Kirkpatrick, bkirkpat@mote.org
Gary Kirkpatrick, gkirkpat@mote.org
Tony Tucker, tucker@mote.org

USF College of Marine Science

Kent Fanning, kaf@seas.marine.usf.edu
Mark Luther, luther@marine.usf.edu
David Mann, dmann@seas.marine.usf.edu
RobertWeisberg, weisberg@marine.usf.edu

Acknowledgements

The Committee gratefully acknowledges the assistance of Rusty Holmes, Traer Price, Vicki Wiese, Paula Clark, Wayne Yingling, Henry Luciano, Larry Lesnett, Brett Blackburn, Deborah Voutselas, Nadine Slimak, Sandra Vargo, Joe Nickelson, Jeff Hughes, and James Green.

AGENDA

LOCATION: All events other than the dockside demonstrations will be on the 3rd floor of the Keating Marine Education Center, Mote Marine Laboratory

Monday, June 18, 2007

4:00 pm Organizing Committee Meeting

5:30 pm Exhibits, Vendors and Poster set-up

6:00 pm Reception sponsored by Alliance for Coastal Technologies and Florida Chapter, Marine Technology Society

Tuesday, June 19, 2007

8:00 am Registration; Continental Breakfast sponsored by Ocean Optics, Inc. (Powerpoint presentations loaded onto computer during this time)

8:30 am Call to Order & Announcements - *Dr. Ernest Estevez, Co-Coordinator*

8:35 am Welcoming Remarks –
Dr. Glen Shen, Executive Vice-President for Research, Mote Marine Lab
Diane Andrews, Business Development Manager, Economic Development Corporation of Sarasota County

8:50 am Introduction of the Organizing Committee and Workshop Session Chairs – *Dr. Jyotika Virmani, Co-Coordinator*

8:55 am **Session 1: Platforms** – Session Chair, *Mark Luther*

9:00 am MARVIN, a Novel Floating Platform for Large Sensor Arrays – *Brian Bendis, AMJ Environmental/YSI, Inc.*

9:15 am SEAKEYS: 17 Years of Successes, Failures and Challenges – *Jonathon S. Fajans, Florida Institute of Oceanography*

9:30 am Use of Coastal Profiling Platforms for Coastal Monitoring on the West Florida Shelf – *Chad Lembke, University of South Florida*

9:45 am A New Paradigm for Water Quality Monitoring – Man-Deployable, Water Quality Mapping AUV for the Masses – *Robert Ellison, YSI Environmental, Inc.*

10:00 am	The Environmental Sample Processor (ESP) – A Robotic Instrument for Applying Molecular Probe Technology Remotely Under the Sea – *Christina Preston, Monterey Bay Aquarium Research Institute*
10:15 am	Short Break
10:25am	**Session 2: Sensors & Applications** –Session Chair, *Kent Fanning*
10:30 am	Development of Fluorescence Induction and Relaxation (FIRe) Sensors for Gliders and Ocean Observatories to Monitor Photosynthetic Processes in Marine Ecosystems – *Maxim Y. Gorbunov, Rutgers University*
10:45 am	Use of Sandwich Hybridization and the Environmental Sample Processor (ESP) for Rapid Characterization of Larvae: High-Throughput Lab Analysis and *In Situ* Detection – *William J. Jones, Monterey Bay Aquarium Research Institute*
11:00 am	The Alliance for Coastal Technologies: Sensor needs for Coastal Ocean Observing Systems – *Mark E. Luther, University of South Florida*
11:15 am	High-Resolution, Near Real-Time Photosynthetic Response of a Coral Reef during 2005 Caribbean Bleaching Event – *Derek Manzello, University of Miami*
11:30 am	Combining *In Situ* Imaging Systems with Automated Identification Software for Monitoring Biological Processes in Aquatic Environments – *Andrew Remsen, University of South Florida*
11:45 am	Fiber Optic Oxygen Sensor for Sea Water Monitoring – *Mahmoud Shahriari, Ocean Optics, Inc.*
12:00 pm	Lunch sponsored by the Florida COOS Consortium
1:00 pm	**Session 3: Human Health** – Session Chair, *Damon Gannon*
1:05 pm	Ocean Observing Systems and Public Health: The Florida Beach Conditions System – *Barbara Kirkpatrick, Mote Marine Laboratory*
1:20 pm	Bio-Sensing to Monitor the Coastal Ocean for Threats to Human Health – *Kelly D. Goodwin, NOAA/AOML*
1:35 pm	**Session 4: Harmful Algal Blooms** – Session Chair, *Barbara Kirkpatrick*

1:40 pm	Light Absorbance-Based Taxonomic Discrimination of Phytoplankton in the Eastern Gulf of Mexico; Instruments, Platforms, Operations and Performance – *Gary J. Kirkpatrick, Mote Marine Laboratory*
1:55 pm	Autonomous, Sub-Surface Detection of the Algal Toxin Domoic Acid on board the Environmental Sample Processor – *Christina Mikulski, NOAA/National Ocean Service*
2:10 pm	Short Break
2:20 pm	**Session 5: Nutrients –** Session Chair, *Merrie Beth Neely*
2:25 pm	Technological Maturity puts Autonomous Nutrient Monitoring on the Precipice of Wide Scale Acceptance – *Vince Kelly, University of Maryland*
2:40 pm	High Resolution Instrumentation for Monitoring Episodic Nutrient Events – *Robert Masserini, University of South Florida*
2:55 pm	Comparison of Nitrate Sensor Data from Two Caloosahatchee River Stations, Fort Myers, FL, USA – *Merrie Beth Neely, FWC/Florida Fish and Wildlife Research Institute*
3:10 pm	**Session 6: Acoustics –** Session Chair, *David Mann*
3:15 pm	The Ocean Tracking Network: An Implementation Update – *Daniel L. Jackson, Dalhousie University*
3:30 pm	Passive Acoustics in Ocean Observatories – *David Mann, University of South Florida*
3:45 pm	Defining Limits in Identifying Marine Organisms Using Passive Acoustic Monitoring Systems – *R. Grant Gilmore, Jr., Estuarine, Coastal and Ocean Science, Inc.*
4:00 pm	Examples and Interpretation of Passive Acoustic Data Collected in Coastal Environments of Southwest Florida – *James Locascio, University of South Florida*
4:15 pm	**Session 7: Integration & Synthesis –** Session Chair, *Gary Kirkpatrick*
4:20 pm	Developing a Gulf Coast Monitoring and Decision Support System Using NASA Remote Sensing Data and a Coastal Circulation Model – *Eurico D'Sa, Louisiana State University*
4:35 pm	Technology for Ocean Observation: Bridging the Gap between Science and Defense – *Larry Langebrake, SRI International*

4:50 pm Posters and Dockside Demonstrations

5:30 pm Posters & Mixer sponsored by AMJ Environmental/YSI, Inc.

Wednesday, June 20, 2007

9:00 am Panel Discussion: Technology Transfer and Commercialization –
Daniel Jackson, Dalhousie University
Joe Jones, Monterey Bay Aquarium Research Institute
Jorge Macho, Ocean Optics, Inc.
Glen Shen, Mote Marine Laboratory
Carol Steele, SRI International (Moderator)

10:00 am General Workshop Discussion on 'Biosensing in the Oceans: the Next Steps' (*Jyotika Virmani*, *Moderator)*, Future Planning Meeting, & Brunch sponsored by Mote Marine Laboratory

11:50 am Wrap-Up Comments – *Ernest Estevez*

POSTERS

The Development of Autonomous Moored Profiler Platforms for Coastal Environments (*Andrew Barnard, WET Labs, Inc.*)

Detection of *Karenia brevis* Blooms on the West Florida Shelf from Sea and Space (*Jennifer P. Cannizzaro, University of South Florida*)

Blending Sensor Technology, Robotics, and Geospatial Analysis Reveals Important Reach-Scale (10-100m) Heterogeneity in Coastal Rivers (*Andrew F. Casper, University of South Florida*)

Unmanned Surface Vehicles for Seagrass Monitoring (*Karen Dreger, University of South Florida*)

The Use of a Colored Dissolved Organic Matter (CDOM) Fluorometer in High CDOM Waters (*David English, University of South Florida*)

Thermocycling Flow-Cell Development for PCR-Based Electrochemical Detection (*Andrew S. Farmer, University of South Florida*)

Species-Specific Detection of Micro-Algae with High Throughput Suspension Array Analysis (*Jack W. Fell, University of Miami*)

Using Dual-Frequency Sonar to Detect Juvenile Goliath Grouper, *Epinephelus itajara*, in Mangrove Habitats (*Sarah Frias-Torres, University of Miami and NOAA/National Marine Fisheries Service*)

Electrochemical Detection of Microbial Contaminants (*Kelly D. Goodwin, NOAA/Atlantic Oceanographic and Meteorological Laboratories*)

Using Sea Turtles to Find Seagrass: Tracking Juvenile *Chelonia mydas* with Satellite Telemetry in the Southwest Coastal Everglades, Florida, USA (*Kristen M. Hart, US Geological Survey*)

In Situ, Automated Measurements of Net Community Production in Sarasota Bay, Florida (*Gary L. Hitchcock, University of Miami*)

Evaluation of the Phytoflash Instrument vs. Traditional Sampling Techniques in the Caloosahatchee River, FL (*Merrie Beth Neely, Florida Fish and Wildlife Research Institute*)

WQM: A New Water Quality Monitor for Long-Term Deployments (*Cristina Orrico, WET Labs, Inc.*)

Diving Behavior of Internesting Female Loggerhead Turtles (*Caretta caretta)* and Risks of Boat Impact (*Jake Sobin, Duke University*)

Satellite Tracking of Loggerhead Turtles during Inter-Nesting Movements, Post-Nesting Migrations, and Foraging Residency (*Anton D. Tucker, Mote Marine Laboratory*)

An Underwater Reagent Based Phosphate Sensor for Long-term Deployments (*J. R. V. Zaneveld, WET Labs, Inc.*)

ABSTRACTS

All abstracts are listed by session and then by alphabetical first author name.

SESSION 1: PLATFORMS

MARVIN, a novel floating platform for large sensor arrays

Brian Bendis[1] and Merrie Beth Neely[2]

[1]AMJ Environmental/YSI, Inc., 222 14th Ave South, St Petersburg, Florida 33701
[2]FWC/Florida Fish and Wildlife Institute, 100 8th Ave SE, St Petersburg, Florida 33701

Resources (time, personnel) and logistics frequently limit researchers' ability to design an ecosystem study that obtains enough samples to fully represent the study area. Often, few data points are used to represent trends over long time periods or large geographic areas. AMJ Environmental, a division of AMJ Equipment Corp was contracted by the Florida Marine Research Institute to design and build a platform that would hold equipment to continuously record data, thereby increasing temporal sampling resolution. MARVIN is a solar powered system designed for convenient maintenance, portability and application flexibility. A CSI datalogger controls the sampling intervals of the sensors, stores data, and controls data telemetry. Various sensors are connected to a flow-through system that takes discrete water samples from multiple depths. The onboard sensor array includes a YSI 6600 sonde, Sontek ADCP, Vaisala meteorological package, LiCor PAR sensors, a YSI 9600 Nitrate monitor, and a Turner Designs PhytoFlash. During maintenance of MARVIN, water samples collected by an ISCO water sampler are collected to verify instrument readings as well as for phytoplankton counts. This high-frequency water quality data is being analyzed to better understand how the complex water quality of the river affect HABs, TMDLs, seagrasses and the general health of the estuary.

A New Paradigm for Water Quality Monitoring – Man-Deployable, Water Quality Mapping AUV for the Masses

Rob Ellison[1]

[1]YSI Environmental, Inc., 1725 Brannum Lane, Yellow Springs, Ohio

YSI & OceanServer Technology partnered to develop the first autonomous underwater vehicle specifically designed for water quality mapping. Several of the features that make this man-deployable vehicle unique include the intuitive mission planning software, 12 hour run times with remote RF communication, and the complete on-board water quality sensor suite that samples at a frequency of 1Hz. The result is detailed maps of water quality parameters at a fine spatial resolution that does not require a boat and only one technician's time. Water quality monitoring programs can use the vehicle to sample difficult to reach or shallow areas, expand monitoring frequency and spatial resolution, and fill in the gaps of

fixed point monitoring programs. Local and federal agencies will find the vehicle well suited for rapid response applications, monitoring sensitive locations, as well as for mapping low oxygen zones of algae blooms. The vehicle has been extensively tested in a number of coastal and estuarine environments. An overview of the vehicle and the results from several field trials in estuarine environments will be presented.

SEAKEYS: 17 Years of Successes, Failures and Challenges

Jonathan S. Fajans[1]

[1]Florida Institute of Oceanography, Keys Marine Laboratory, P.O. Box 968, Long Key, Florida 33001

The SEAKEYS (Sustained Ecological Research Related to Management of the Florida Keys Seascape) program began in 1991 with six enhanced, satellite-linked NOAA C-MAN monitoring stations spanning the 220 mile-long Keys coral reef tract and Florida Bay. A seventh station was added in Northwest Florida Bay in 1999 and a new station at Carysfort Reef is scheduled to be built later this year. The purpose of SEAKEYS is to provide scientists and resource managers with long-term oceanographic data to help connectivity modeling, to document unusual events, and to discriminate natural variation from human disturbances. The program now boasts one of the longest running regional data sets in U.S. coastal waters. Since construction, the stations have been continuously upgraded to pace changing technologies and user needs. Long-term deployment of light and chlorophyll monitors continues to be a challenge in areas where fouling organisms are abundant. The stations have recorded notable data during hurricanes and seasonal weather and oceanographic events. In partnership with NOAA AOML and USF COMPS, the data are downloaded to the web in near-real time and significantly benefit a wide range of user groups including federal agencies, commercial forecasters, the dive, fishing, and cruise ship industries, seaplane and ferry boat charters, as well as marine researchers. Efforts are ongoing to implement the latest cost effective technology while ensuring that the needs of the user groups continue to be met.

Use of Coastal Profiling Platforms for Coastal Monitoring on the West Florida Shelf

Chad Lembke[1], Robert H. Weisberg[1], Robert Byrne[1], Andrew Farmer[1], Randy Russell[1], James Patten[1], and Graham Tilbury[1]

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701

The Bottom Stationed Ocean Profiler (BSOP) is a free drifting profiling platform designed for work in coastal environments. Similar to the deep water ARGOS profilers, the profilers sample the water column and telemeter the information back to the users for periods of up to

several months. Over the past several years the reliability and robustness of the system has been demonstrated in extensive testing and data collection on the West Florida Shelf. While all BSOP units are equipped with CTDs, in the past year fluorometers and dissolved oxygen sensors have been incorporated and deployed offshore. Moderate scale arrayed deployments are planned for synoptic spatial and temporal mapping of oceanographic and biological parameters.

The Environmental Sample Processor (ESP) – A Robotic Instrument for Applying Molecular Probe Technology Remotely Under the Sea

<u>Christina Preston</u>[1], Chris Scholin [1], Scott Jensen[1], Brent Roman[1], Eugene Massion[1], Roman Marin III[1], , Dianne Greenfield[1], William Jones[1], Greg Doucette[2], Tina Mikulski[2], Kristen King[2], Kevin Wheeler[1], Doug Pargett[1], Mike Parker[1], Mark Brown[1]

[1]Monterey Bay Aquarium Research Institute, Moss Landing, California 95039
[2]Marine Biotoxins Program, NOAA/National Ocean Service, Charleston, South Carolina 29412

The objective of our work is to develop methods and instrumentation that allows molecular biological analyses to be conducted in real-time, below the ocean surface, autonomously and interactively if desired. Here, we present results of studies that explore this concept utilizing an instrument known as the Environmental Sample Processor (ESP; **http://www.mbari.org/microbial/esp**). While moored in shallow-water, the ESP has successfully automated application of 3 different classes of DNA probe arrays, targeting marine planktonic organisms ranging from bacteria, archaea, harmful algae, to small invertebrates, and a competitive ELISA for the algal neurotoxin domoic acid, in field deployments lasting 20 days (**http://www.mbari.org/microbial/esp/esp_technology.htm**). In addition, a sample collection module and deep-water pressure housing was developed for deploying the ESP to 1000m. Future capabilities of the ESP will support higher fidelity analyses (e.g. qPCR, microarrays), allow external sensors to trigger sampling and analytical events, and permit sampling from surface to 4000m. Deployment of autonomous integrated sensor systems that include interactive molecular biological experiments are possible in the near term (**http://cmore.soest.hawaii.edu/cmore_theme3.htm**; **http://www.mbari.org/microbial/ESP/esp_deep.htm**). These same core techniques and technologies being developed for oceanographic research purposes are also applicable to developing new paradigms for carrying out routine water quality testing (**http://www.sccwrp.org/about/rspln2006-2007.html#d2**; **http://www.rsmas.miami.edu/groups/ohh/**).

SESSION 2: SENSORS & APPLICATIONS

Development of Fluorescence Induction and Relaxation (FIRe) Sensors for Gliders and Ocean Observatories to Monitor Photosynthetic Processes in Marine Ecosystems

Maxim Y. Gorbunov[1], Oscar Schofield[1], Paul Falkowski[1], Geoff MacIntyre[2], Scott McLean[2]

[1]Institute of Marine and Coastal Sciences, Rutgers University, 71 Dudley Road, New Brunswick, New Jersey 08901
[2]Satlantic Inc., Richmond Terminal, Pier 9, 3481 North Marginal Road, Halifax, Nova Scotia, B3K 5X8, Canada

Over the last decade, variable fluorescence technique (pump-and-probe and Fast Repetition Rate, FRRF, fluorometries) provided unprecedented insight into the factors controlling phytoplankton physiology and primary production in the ocean. The use of the FRRF became an integral part of most biological oceanographic programs, but its broader applications are limited by the complexity and high cost of the available instrumentation. To help overcome these problems, we have developed a new instrument, called Fluorescence Induction and Relaxation (FIRe) System, to measure a comprehensive suite of photosynthetic characteristics in phytoplankton and benthic organisms. The compact design, low power consumption, and network capability make the FIRe System a potentially robust sensor for long-term monitoring programs in coastal zones and the open ocean. Here we report and discuss adaptation of the FIRe technology to Autonomous Vehicles such as Gliders and moored platforms.

Use of sandwich hybridization and the Environmental Sample Processor (ESP) for rapid characterization of larvae: high-throughput lab analysis and *in situ* detection.

W. J. Jones[1], C. Preston[1], R. Marin III[1], C. Scholin[1], and R.C. Vrijenhoek[1]

[1]Monterey Bay Aquarium Research Institute (MBARI), 7700 Sandholdt Road, Moss Landing, California 95067

Considerable difficulties exist in sampling, detecting, identifying, and quantifying marine invertebrate larvae from mixed planktonic samples. We have developed a molecular technique for laboratory-based detection of larval invertebrates in natural marine samples based on the sandwich hybridization method developed by Scholin *et al.* to detect and quantify harmful algal species. We have extended the scope of the nucleic-acid–based sandwich hybridization technology to include the detection of larvae of shallow water invertebrates (barnacles, mussels, crabs, and polychaetes). The benchtop application allows rapid (~1 hour) identification of specific targets from a crude lysate made from a natural

water sample. The ESP automates application of custom DNA probe arrays to detect target species and transmits results to shore via radio modem in near real-time. Coupled with concurrent salinity, temperature, and chlorophyll measurements, the ESP provides a unique approach to identifying important factors controlling the distribution and recruitment of marine larval invertebrates.

The Alliance for Coastal Technologies: Sensor needs for Coastal Ocean Observing Systems

Mark E. Luther[1]

[1] College of Marine Science, University of South Florida, 140 Seventh Avenue South, St. Petersburg, Florida 33701

The Alliance for Coastal Technologies (ACT; see http://act-us.info) was established to foster the development and application of new coastal ocean sensor technologies to address the needs of coastal decision makers. New sensor technologies are required to make observations of biological and geochemical parameters that are needed for many management issues in a long-term, sustained, environmentally relevant manner. The coastal component of the US Integrated Ocean Observing System (IOOS) is being implemented as a federation of Regional Coastal Ocean Observing Systems (RCOOS's), tied together by a National Backbone. This structure explicitly recognizes that many (most) management issues are local or regional in scope and that a regional presence is required to maintain such an observing system and to connect with the end users of information products from the system. While several regions are making headway in establishing prototype RCOOS's, most are restricted to observations or models of physical variables, because that's what we know how to do in an automated fashion. Bio-optical sensors, automated genetic sensors, and nutrient sensors are under development and are utilized in a few pilot projects; however, monitoring for human health by regulatory agencies still requires human-intervention techniques such as manual cell counts. ACT facilitates the transition of new sensor technologies from research to operations through targeted workshops and verification trials of emerging technologies. Recent examples include trials of dissolved oxygen sensors, chlorophyll fluorometers, turbidity sensors, and nutrient sensors.

High-Resolution, near real-time photosynthetic response of a reef coral during 2005 Caribbean bleaching event

Derek Manzello[1], Jim Hendee[1], Erik Stabenau[2], and Mike Jankulak[1]

[1]NOAA/AOML/OCD, 4301 Rickenbacker Causeway, Miami, Florida 33149
[2]National Park Service, Everglades National Park, South Florida Natural Resources Center, 40001 State Road 9336, Homestead, Florida 33033

Monitoring the fluorescence yield of corals provides an early indication of the onset of coral bleaching, prior to when subjective determination of changes in coral color can be observed with the potential to greatly improve bleaching forecasts. Field deployment of a pulse amplitude modulation (PAM) fluorometer before the 2005 Caribbean-wide bleaching event allowed in situ, high-resolution assessment of the photosynthetic efficiency of the endosymbiotic algae within two species of reef-building coral in near real-time before, during and after bleaching. Fluorescence data were measured concurrently with a suite of environmental variables (temperature, irradiance (PAR and UV), wind speed etc.) both above and below water (1 and 3 m). Multiple stepwise regression analysis showed that temperature alone explained > 75% of the variance in fluorescent yield for a colony of *Siderastrea siderea*; highlighting temperature as the proximate causative factor of bleaching stress in this species during this event.

Combining *In Situ* Imaging Systems with Automated Identification Software for Monitoring Biological Processes in Aquatic Environments

Andrew Remsen[1]

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue South, St. Petersburg, Florida 33701

Zooplankton are key mediators of fisheries recruitment, particle flux and biomass production in the aquatic environment. They can also act as sentinel organisms for signs of environmental change due to their small size, rapid generation times, lack of commercial exploitation and non-linear population response to changes in their environment. The last twenty years has seen the development of a variety of *in situ* imaging systems capable of continuously sampling the fine-scale distribution of zooplankton, phytoplankton and suspended particles from the centimeter scale to across ocean basins. These instruments collect biological data at the same rate and resolution as many environmental sensors, allowing for more powerful analysis of relationships between plankton and their environment. These instruments also provide the capability to sample fragile and delicate organisms that previously have been undersampled and ignored in many aquatic environments. One challenge has been how best to analyze the incredibly large image datasets these sensors collect. To this end, machine learning methods have been applied to the task of rapidly identifying plankton and suspended particle images in near real time. At the USF Center for Ocean Technology, we’ve developed both an underwater imaging system called the Shadowed Particle Profiling and Evaluation Recorder (SIPPER) and an associated software package called the Plankton Image Classification and Extraction Software (PICES) that allows for rapid analysis and identification of the plankton in an aquatic system. This system can be used both as a traditional towed sampling tool for surveying large areas of the ocean and used in a fixed location to vertically profile the water column. Example data collected by this system will be presented and future work on this system will be discussed.

Fiber Optic Oxygen Sensor for Sea Water Monitoring

Clare Reimers[1], Mike Purcell[2], Mahmoud Shahriari[3]

[1]COAS, Oregon State University, 104 Ocean Admin Bldg, Corvallis, Oregon 97331
[2]Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543
[3]Ocean Optics, Inc., 830 Douglas Avenue, Dunedin, Florida 34698

The development of chemical and biological sensors is a requirement before physical, chemical and biological processes can be observed simultaneously and fully understood in the natural context of the oceans. Dissolved oxygen, as one of the chemical species that interacts most with marine life and that is greatly affected by the atmosphere and physical variations in temperature, salinity and pressure, is usually the most sought after biochemical parameter. Unfortunately as an in situ measurement, dissolved oxygen is notoriously difficult to monitor over long periods of time. The characteristics of an oxygen sensor that are key to a reliable long term-performance are stability (that results from ruggedness, selectivity and compensation for drift), immunity to befouling, and in situ calibration. The majority of oxygen sensors that have been used by oceanographers over the last two decades are electrochemical designs that do not possess these characteristics. The primary objective of this paper is to present advanced fiber optic sensor-based oxygen monitoring system that can meet these critical performance measures. The system has already been taken through a prototype demonstration phase. With this work we have improve some features and then prove the instrument's long-term performance and utility under challenging oceanographic applications.

SESSION 3: HUMAN HEALTH

Bio-Sensing to Monitor the Coastal Ocean for Threats to Human Health

Kelly D. Goodwin[1]

[1]NOAA/AOML, 4301 Rickenbacker Causeway, Miami, Florida 33149

To address public health needs, technology developers aim to devise bio-sensing technologies that can be incorporated into coastal ocean observing systems. Targets that indicate or pose a threat to human health include HAB species, fecal-indicating bacteria, pathogens, toxins, and source tracking markers. Detection of genetic signals is a promising means to provide rapid and accurate monitoring of coastal water quality. A variety of approaches are under development to allow for target identification using molecular signatures (DNA, RNA, immunological). Some molecular detection approaches have already been deployed on *in situ* sensing platforms. In addition to satellite and in-situ measurements, coastal ocean observing observations may be generated from rapid laboratory methods or handheld biosensors, particularly for threats occurring in the very near shore. An overview of the development and application of a sampling of technologies will be presented.

Ocean Observing Systems and Public Health: The Florida Beach Conditions System

Barbara Kirkpatrick[1], **Robert Currier**[1], **Kate Nierenberg**[1], **Andy Reich**[2], **Lorraine C. Backer**[3], **Lora E. Fleming**[4,5], **Gary Kirkpatrick**[1]

[1]Mote Marine Laboratory, Sarasota, Florida 34236
[2]Florida Department of Health, Tallahassee, Florida, 32399
[3]National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia, 30329
[4]Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, Florida, 33149
[5]School of Medicine, University of Miami, Miami, Florida, 33136

With over 50% of the US population living in a coastal county, the impacts the ocean and coastal environment have on people is substantial. These impacts are both positive, such as tourism and recreation opportunities, as well as negative impacts such as exposure to marine toxins.

Florida's west coast is an example of a coastal community needing public health information from a beach observing system. The west coast experiences annual blooms of the toxic dinoflagellate, *Karenia brevis.* Wind and wave action cause the toxins produced by *K. brevis* to become part of the marine aerosol. Asthmatics who inhale the toxins report increase upper and airway lower symptoms and have measurable changes on pulmonary function. Real time

beach reporting for these toxic aerosols may improve asthmatics and coastal residents' quality of life
A real time beach conditions reporting system has been designed and implemented in Sarasota and Manatee Counties, Florida. This system is based on reports from lifeguards at 8 public beaches. The lifeguards staff these beaches year round, 7 days a week making them ideal sentinels. The lifeguards provide subjective reports on a variety of beach parameters.

A key component of the observing system was to create an easy reporting pathway for the lifeguards to minimize time away from their primary duties. The system provides a PDA for each of the 8 beaches. The data is transferred to a website hosted on the Mote Marine Laboratory SO COOL server. The user can select the beach of interest and a pop up window provides the most recent report for that beach with a date/time stamp.

SESSION 4: HARMFUL ALGAL BLOOMS

Autonomous, sub-surface detection of the algal toxin domoic acid onboard the Environmental Sample Processor

G. J. Doucette[1], C. A. Scholin[2], C. M. Mikulski[1] , R. Marin III[2] , S. Jensen[2], B. Roman[2], D. Greenfield[2] , K. L. King[1] , J. Feldman[3], G. Massion[2] , C. T. Elliott[4]

[1]Marine Biotoxins Program, NOAA/National Ocean Service, Charleston, South Carolina 29412
[2]Monterey Bay Aquarium Research Institute, Moss Landing, California 95039
[3]Jet Propulsion Laboratory, Pasadena, California 91125
[4]Queen's University Belfast, Belfast, BT9 5AG, Northern Ireland

Over the past decade considerable effort has been directed toward development of remote, in-situ diagnostic capabilities for harmful algal bloom (HAB) taxa, their genes, gene products, and metabolites. The ability to detect targets such as HAB species and their toxins in real or near-real time will immediately benefit researchers studying HAB/toxin dynamics and coastal resource managers responsible for monitoring bloom populations as well as mitigating their socioeconomic impacts. The Environmental Sample Processor (ESP; **www.mbari.org/microbial/ESP <http://www.mbari.org/microbial/ESP>**) was developed for the autonomous, sub-surface application of molecular diagnostic tests and during initial deployments has successfully detected several HAB species using DNA probe arrays. Since toxin production and thus the potential for public health and ecosystem effects can vary widely with algal physiological status, the concurrent detection of algal toxins onboard the ESP is essential. We recently fielded methods for extracting the algal toxin domoic acid (DA) and testing of samples using immuno-based toxin arrays during deployments of a second generation ESP instrument. Through application of species- and toxin-specific arrays, known toxic diatoms of the genus /Pseudo-nitzschia/ spp. and DA were detected concurrently onboard the ESP in Monterey Bay, CA, USA, representing the first remote, integrated assessment of algal cell abundance and toxin presence in coastal waters. Present efforts are aimed at refining the sensitivity and calibration of the DA assay in order to obtain more accurate estimates of a bloom's toxicity and potential impacts. Ultimately, integration of multiple ESPs with ocean observing systems will enhance our monitoring, prediction, and management capabilities for HABs.

Light Absorbance-Based Taxonomic Discrimination of Phytoplankton in the Eastern Gulf of Mexico; Instruments, Platforms, Operations and Performance

G. J. Kirkpatrick[1], D. F. Millie[2], M. A. Moline[3], R. H. Weisberg[4], R. S. Wilhelm[5], C. A. Heil[6], S. E. Lohrenz[7], R. P. Stumpf[8], O. M. Schofield.[9]

[1]Mote Marine Laboratory, Sarasota, Florida 34236
[2]Florida Institute of Oceanography, St. Petersburg, Florida 33701

[3]California Polytechnic State University, San Luis Obispo, California
[4]College of Marine Science, University of South Florida, St Petersburg, Florida 33701
[5]FL-DOACS Division of Aquaculture, Tallahassee, Florida 32301
[6]FWC/Fish and Wildlife Research Institute, St. Petersburg, Florida 33701
[7]Dept. of Marine Science, University of Southern Mississippi, 1020 Balch Blvd., Stennis Space Center, Mississippi 39529
[8]NOAA National Ocean Service, 1305 East-West Highway code N/SCI1, Silver Springs, Maryland 20910
[9]Rutgers University, 71 Dudley Road, New Brunswick, New Jersey 08901

In an effort to fill a critical need for detection and tracking of the Florida harmful alga *Karenia brevis* in the Eastern Gulf of Mexico we are deploying a network of *in situ* instruments capable of taxonomic discrimination of phytoplankton to the class level. The discrimination process compares the particulate absorbance spectrum of the sampled 'unknown' community to a spectrum library of 'known' taxonomic classes yielding a multiple regression, least squares estimate of the community structure. Recent modes of deployment include shipboard, moorings, channel markers, piers and autonomous underwater vehicles. Our phytoplankton observatory incorporates fourteen of these *in situ* instruments referred to as BreveBusters™. Data from this array of instruments are received at the Sarasota Operations of the Coastal Ocean Observation Laboratories (SO COOL) for analyses, visualization and dissemination. Deployment and operation of these resources over the past two years has demonstrated the utility of a HAB observatory on the central west coast of Florida. Future operation of this observatory, in conjunction with satellite remote sensing and new molecular probe-based species-detection technology, will provide long-term delineation of the 3-dimensional distribution of HAB species along the Florida west coast.

SESSION 5: NUTRIENTS

Comparison of Nitrate Sensor Data from Two Caloosahatchee River Stations, Fort Myers, FL, USA

Merrie Beth Neely[1] and Cynthia A. Heil[1]

[1] FWC/Fish and Wildlife Research Institute, St. Petersburg, Florida 33701

YSI 9600 Nitrate monitors were continuously deployed at two stations within the Caloosahatchee River, FL from 2006 to the present. The Caloosahatchee River is a managed waterway connecting Lake Okeechobee and the Gulf of Mexico. Nitrate measurements were made hourly from the surface and bottom at two stations within the river. The average water depth at each site was between 3 and 4 meters. The upper river station has been deployed longer and is located near a coal-burning power plant and Interstate 75. This site varies in salinity from 0-21 psu and the water has a tremendous amount of Colored Dissolved Organic Matter and Particulate Organic Matter. The water at this station is representative of the influences of agricultural riparian watersheds, Lake Okeechobee releases, the power plant and the interstate on this river system. The second site is located near the mouth of the river where it meets the Gulf of Mexico and is estuarine in nature. This site has much clearer water as the CDOM is diluted with Gulf water and it is heavily influenced by urban watersheds on both sides of the river. The benefits and challenges of this type of data collection will be summarized.

Technological Maturity puts Autonomous Nutrient Monitoring on the Precipice of Wide Scale Acceptance

V. Kelly[1], L. A. Codispoti[1], P. M. Glibert[1], and J. Alexander[1]

[1]University of Maryland Center for Environmental Science, Horn Point Lab, 2020 Horns Point Road, Cambridge, Maryland, 21613

Advances in integrated electronics have for many years greatly enhanced our ability to make "standard" hydrographic measurements. More recently, they have been utilized in the development of Autonomous Nutrient Monitors (ANMs) which is significant because:

1. Nutrients play a dominant role in the regulation of aquatic system productivity.
2. The tidal, meteorological, natural and anthropogenic controls on nutrients act at time scales that are very difficult to resolve without ANMs.

Most ANMs employ wet chemistry and as such are considerably more complex than "plug and play" type instruments. However, improvements in ANM technology and user skill have recently allowed high data return rates. Our group has collected several one and two month records that show hourly to yearly time scale variability and favorable agreement with hand collected nutrient samples. We have integrated our ANMs (Nitrate, Phosphate and Ammonium) with multi parameter sondes, water samplers, telemetry and automated data

processing systems to produce an Adaptive and Integrated nutrient Monitoring System (AIMS) and recently developed a urea monitor with assistance from EnviroTech LLC that adds urea to the menu of parameters. We will present data from deployments in Chesapeake Bay that show high variability occurring over short time scales.

High Resolution Instrumentation for Monitoring Episodic Nutrient Events

Rob Masserini[1], **Kent A. Fanning**[1], **and Kristan Uhlenbrock**[1].

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701

Three powerful hurricanes (Charley, Frances, and Jeanne) that crossed peninsular Florida in the late summer and early autumn of 2004 produced dramatic changes in coastal nutrient chemistry. In the same West Florida coastal waters where surface ammonium concentrations are usually no more than 200-400 nanomolar at their highest, a region approximately 1500 square nautical miles in area showed surface ammonium concentrations that ranged up to 1500 nanomolar, or over 20 times normal background levels (50 nanomolar). Salinities in this region were 1-2 PSU lower than normal at the same times, implying the possibility of freshwater runoff as the source of the fixed nitrogen. Episodic nutrient fluxes, such as this, are difficult to capture with discrete measurements. Two different approaches were taken to capture nutrient events on varying scales. A ship based high-resolution high-sensitivity analyzer coupled to a pumping system was used to delineate the ammonium-enriched regions on the West Florida Shelf, and a mooring based high-resolution low-sensitivity UV-nitrate sensor was used to observe temporal variability within the Caloosahatchee River. Monitoring of sporadic nutrient fluxes with high resolution instrumentation can advance our understanding of complex ecological marine systems, elucidating, for example, cyclic processes affecting riverine nutrient fluxes with markedly different periodicities.

SESSION 6: ACOUSTICS

Defining Limits In Identifying Marine Organisms Using Passive Acoustic Monitoring Systems

R. Grant Gilmore, Jr.[1]

[1]Estuarine, Coastal and Ocean Science, Inc., 5920 First St. SW, Vero Beach, Florida 32968

A variety of investigators have published detailed descriptions of new biological sounds from aquatic environments since hydrophones were first used to document underwater biological sounds in the mid 20th century. There is historical precedence in publishing sound misidentification to source. We make some recommendations on the biological value of accurate sound source identification for ocean and coastal observatories. We present techniques/technologies that have been used for verifying diagnostic sounds produced by aquatic soniferous species. Biological sound source identification to species is clearly needed for accurate bio-acoustic monitoring programs to be effective. Verification methodologies include captive recordings, in situ photography, video and sonar imaging using various mobile and stationary platforms, as well as, having an intimate knowledge of the targeted fauna. An accessible and constantly updated aquatic sound library for regional investigators should be considered to aid future bio-acoustic studies.

The Ocean Tracking Network: An Implementation Update

Daniel L. Jackson[1]**, M.J.W. Stokesbury, and R.K. O'Dor.**

[1]Dalhousie University, Life Sciences Centre, Halifax, Nova Scotia, Canada B3H 4J1

Media coverage of the founding meeting in June 2006 for the Ocean Tracking Network (OTN), referred to it as "the Internet for fish." With the OTN now designated as a Pilot Project for the IOC's Global Ocean Observing System the analogy is apt because, as with the Internet, a global group of users is pressing for standards and protocols to allow universal storage and sharing of a broad spectrum of information. The OTN aims to deliver a picture of the complex interactions of physics and biology that are the world's oceans, a picture that scientists and managers need in order to protect and restore ocean productivity. This presentation will summarize recent developments in the implementation of the OTN. In 2008, researchers collaborating in the OTN plan to install curtains of acoustic receivers from Florida to Cuba, and Cuba to the Yucatan Peninsula of Mexico. These curtains will link to and connect local projects with the "Atlantic Arena". In the OTN project the "Atlantic Arena" acoustic tags will be used with archival tags and satellite technology to provide a powerful tool for gathering information necessary for the proper conservation and management of Large Marine Ecosystems.

Examples and Interpretation of Passive Acoustic Data Collected in Coastal Environments of Southwest Florida

James Locascio[1] and David Mann[1]

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701

Biologically generated sounds are pervasive in coastal waters of southwest Florida. While sound production is attributed to a variety of organisms and behavioral contexts the majority of sound production is associated with courtship and spawning behavior in fishes. The development of passive acoustic technologies including hydrophones, datalogging devices and analysis software have allowed us to measure patterns in fish sound production on time scales not previously possible. Time series data collected in southwest Florida are presented as examples of the application of passive acoustic methods for estimating periods and locations where spawning behavior of sonic fishes occurs.

Passive Acoustics in Ocean Observatories

David Mann[1] and James Locascio[1]

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701

Hydrophones are one of the most robust sensors for obtaining behavioral data on a wide range of soniferous animals. Many marine animals ranging from small invertebrates, like snapping shrimp, to large whales produce sounds that can be detected by hydrophones. This presentation will focus on the types of sounds that are produced by marine animals and various ocean observatory platforms that can be used to study them. These platforms include hard-wired hydrophones, stand alone acoustic dataloggers, drifting buoys, and the animals themselves. The talk will also cover some of the challenges of dealing with these large datasets and propose strategies for automatic detection and classification of sounds.

SESSION 7: INTEGRATION & SYNTHESIS

Developing a Gulf Coast Monitoring and Decision Support System Using NASA Remote Sensing Data and a Coastal Circulation Model

Eurico D'Sa[1], Mitsuko Korobkin[1] and Dong-Shan Ko[2]

[1]Department of Oceanography and Coastal Sciences & Coastal Studies Institute, Louisiana State University, Baton Rouge, Louisiana 70803
[2]Naval Research Laboratory, Stennis Space Center, Mississippi 39529

Coastal regions in the northern Gulf of Mexico such as the Louisiana, Mississippi, and Texas coast are being increasingly impacted by energetic meteorological events and human induced changes to the ecosystem. As part of a NASA funded project we plan to use NASA remote sensing data and a 3-D coastal circulation model in combination with field information presently available from a suite of coastal monitoring stations along the Louisiana coast (LSU's WAVCIS system) to develop a monitoring and a decision support system for the Gulf coast through assimilation of several NASA Earth science products such as winds, sea surface temperature, sea surface height and ocean color products. The output of a Naval Research Laboratory nested coastal model (NCOM) of the Gulf coast will be integrated to provide high resolution forecast of 3-D ocean currents, temperature, salinity and sea level variations for near-shore coastal waters. A preliminary assessment of NASA remote sensing data and products is to be undertaken as part of verification and validation and will be evaluated in the context of their spatial, temporal, latency, continuity requirements, and their integration with field data and model outputs.

Technology for Ocean Observation: Bridging the Gap between Science and Defense

Larry Langebrake[1]

[1]SRI International, 140 Seventh Avenue South, St. Petersburg, Florida 33701

Government funding has historically provided the fiscal foundation for oceanographic research. A number of factors including political pressures, national needs, the global economy, energy costs, etc. have tipped the scales in regard to funding applied science versus funding for "other needs". This shift in resource allocation has begun to negatively impact the scientific community's ability to pursue important research. The same pressures that have negatively impacted science have, to an extent, boosted activity in other areas, e.g. defense and homeland security. This gap in resource allocation can in several cases be bridged; thus, providing opportunity to exploit technology developed for non-scientific needs for application in scientific research. Presented are examples and specific opportunities where this exploitation could be pursued to the benefit of oceanography.

The Development of Autonomous Moored Profiler Platforms for Coastal Environments

Andrew Barnard[1],Casey Moore[1], Bruce Rhoades[1], Dan Whiteman[1], Alex Derr[1], John Koegler[1], P. Donaghay[2] , J. Sullivan[2], J.A. Barth[3] and M. Levine[3]

[1]WET Labs, Inc. P.O. Box 518, 620 Applegate Street, Philomath, Oregon 97370
[2]University of Rhode Island, Narragansett, Rhode Island 02882
[3]COAS, Oregon State University, 104 Ocean Admin Bldg, Corvallis, Oregon 97331

High resolution, 4-D environmental characterizations of the physical and bio-optical structure of the near shore and coastal oceans are needed in order significantly improve our understanding of the complex biogeochemical processes in these regions. Observing systems envisioned for the US coastal regions require reliable, affordable, autonomous monitoring stations to provide early warning indicators of events and trends. There is a need for the development of intelligent, reliable, high resolution, moored profiling systems. We are developing a compact, low power, autonomous, scalable, bottom-up profiling platform to support a variety of long-term coastal applications, where real-time, high vertical resolution physical and bio-optical data are required. The profiling system is based on a winch on board design, allowing for all system components to be completely self-contained. The scalable architecture allows the profiler to be modularly expanded to operate in a variety of water depths as well as to include additional sensors. A core sensing suite of physical and optical instruments, a power system, a winch system, a telemetry module, a buoyancy module, and a system controller form the primary components. The profiler has a deployment duration of up to six months, and optionally includes a bottom docking station and power reservoir.

Detection of *Karenia brevis* blooms on the West Florida Shelf from Sea and Space

Jennifer P. Cannizzaro[1], David C. English[1], and Kendall L. Carder[1]

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701

Harmful algal blooms of the ichthyotoxic dinoflagellate, *Karenia brevis*, regularly occur along the Gulf of Mexico, negatively impacting local tourism and shellfish industries and posing a threat to human health. Mitigation of these adverse effects is possible with an accurate means for early detection and bloom monitoring. Previous efforts using shipboard data (1999-2001) collected from the west Florida shelf (WFS) have shown that optical backscattering coefficients measured inside *K. brevis* blooms (>10^4 cells l^{-1}) are relatively low compared to those observed in chlorophyll-rich, coastal/estuarine waters. Based on this difference, a classification technique for detecting and monitoring *K. brevis* blooms was

developed that requires chlorophyll concentration, Chl, and particulate backscattering data. Such data can be measured *in situ* or estimated from remote-sensing reflectance data, $R_{rs}(\lambda)$, (e.g. satellite) using ocean color algorithms. Recent refinement/validation efforts show that 85% and 79% of *K. brevis* bloom data are successfully classified using independent *in situ* and Moderate Resolution Imaging Spectroradiometer (MODIS) data, respectively. This indicates that this HAB detection technique can successfully be applied to Chl and backscattering data (both measured and derived) provided by optical sensors located on a variety of ocean-observing platforms (e.g. ships, moorings, AUVs, gliders, aircraft, satellites, etc.) improving real-time HAB detection and monitoring capabilities in the Gulf of Mexico.

Blending Sensor Technology, Robotics, and Geospatial Analysis Reveals Important Reach-Scale (10-100m) Heterogeneity in Coastal Rivers

Andrew F. Casper[1,2], Michael L. Hall[3], Robert Stetson[2,4], Robyn Conmy[3], Paula Coble[3], Barnali Dixon[1,2,4] and Eric T. Steimle[1,2,3]

[1]Center for Science & Policy Applications for the Coastal Environment;
[2]Environmental Science, Policy and Geography Program;
[3]College of Marine Sciences;
[4]Geospatial Analytics Laboratory;
University of South Florida-St. Petersburg, 140 7th Ave. South, St. Petersburg Florida 33701

Historically, extensive monitoring of coastal and estuarine waters has been hampered by the limitations of using a small number of discrete grab samples to characterize large areas. Two of the main limitations to improving the assessment of these systems have been the large amount of time and manpower resources needed to analyze the increased numbers of grab samples and whether point sampling can be representative of spatially large and heterogeneous systems. We demonstrate how technological and analytical advances may substantially improve this situation. One such advance is the recent proliferation of remote sampling platforms ranging from autonomous underwater vehicles to the guided surface vehicles we demonstrate in this study. These all allow faster, cheaper, and more extensive coverage from deployments than reliance on shore line or ship based sampling can. A second improvement has been in how large datasets are analyzed and displayed. Specifically there has been a shift towards mainstream acceptance and application of GIS/Geospatial statistical approaches instead of the traditional inferential statistical descriptions (comparison of means/standard deviations). We present examples of the integration *in-situ* YSI sondes, an inexpensive unmanned multi-instrument surface vehicle (USV), near real-time wireless multi-instrument data acquisition, and geospatial analysis and data display.

Unmanned Surface Vehicles for Seagrass Monitoring

Karen L. Dreger[1], Mike Hall[2] and Dr. Eric T. Steimle[1]

[1]University of South Florida-St. Petersburg, Environmental Science and Policy Department, 140 Seventh Avenue S., St. Petersburg, Florida 33701
[2]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701

The last few years have seen an increased demand for accountability in restoration projects. Part of this demand is met by establishing monitoring programs to determine if the restoration was successful and to help determine the cost benefit, USF has developed an unmanned surface vehicle (USV) that will help alleviate some of the rigorous demands placed on managers faced with extensive monitoring projects. The USV is equipped with an underwater camera with a GPS overlay system, operates in shallow water (<0.5m) and the on-board wireless interface provides continuous data and video feedback at distances greater than ½ mile. Monitoring with the USV allows for increased accuracy returning to the original study site and provides a convenient way to collect data in high volumes in minimal time.

The Use of a Colored Dissolved Organic Mater (CDOM) Fluorometer in High CDOM waters.

David English[1], Kendall Carder[1], and Ernst Peebles[1]

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701

A CDOM fluorometer was deployed on the FWRI MARVIN platform in the Caloosahatchee River for several multi-week periods in 2005 and 2006. These deployments provide an example of the value of ancillary data in the accurate assessment of CDOM fluorometer data. Both in situ CDOM validation measurements and temperature (water and air) measurements can improve the interpretation of CDOM fluorometry. High CDOM concentrations, which are often found in Florida's rivers during the rainy season, can have a significant effect on fluorometric Chl_a measurements. In regions where high CDOM waters mix with low CDOM waters, CDOM estimates are recommended for correct interpretation of Chl_a fluorometric data.

Thermocycling Flow-Cell Development for PCR-Based Electrochemical Detection

Andrew S. Farmer[1], Kelly D. Goodwin[3], Stanislav Ivanov[1], Jack Fell[2], and David Fries[1]

[1]College of Marine Science, University of South Florida, 140 Seventh Avenue S., St. Petersburg, Florida 33701
[2]RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149
[3]NOAA/AOML, 4301 Rickenbacker Causeway, Miami, Florida 33149

Molecular microbiologists have been developing assays to achieve rapid detection of harmful microorganisms in coastal waters and have developed a need for miniaturized, portable sensors. To meet these needs, the developments here show a thermocycling PCR chip and a reconfigurable fluidic processor. Data shows the ability of the chip to cycle through and maintain common nucleic acid amplification temperatures. The chip has an embedded resistive heater. This heater was patterned on copper-laminated Liquid Crystal Polymer (LCP) using maskless photolithography techniques. The flow cell was etched into polycarbonate with a CO2 laser. These layers were bonded together with SU8 under constant heat and pressure. The fluidic processor is a simple 24volt solenoid valve and peristaltic pump configuration. The reconfigurability of the processor is used for prototype testing during fluidic management system development and will allow for rapid integration of the PCR chip with a commercially available electrochemical device into a portable, semi-automated, microbial sensor.

Species-Specific Detection of Micro-Algae with High Throughput Suspension Array Analysis

G. Scorzetti[1], L. E. Brand[1], G. L. Hitchcock[1], K. S. Rein[2], and J. W. Fell[1]

[1]RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149
[2]Florida International University, Miami, Florida 33199

High throughput identifications of microalgal species in complex communities can be accomplished with a bead suspension array that combines the specificity and reliability of nucleic acid hybridization analysis with the speed and sensitivity of Luminex xMAP analyzer. We developed a 14-plex array from sequence analysis of the LSU D1/D2 rDNA for the simultaneous detection of toxin and potential toxin producing species in phylogenetically diverse communities. The analysis includes species of *Karenia, Heterosigma, Heterocapsa, Prorocentrum, Protoceratium, Alexandrium, Karlodinium* and *Scrippsiella,* with a potential for expansion to an unlimited number of species.

Using dual-frequency sonar to detect juvenile goliath grouper, *Epinephelus itajara*, in mangrove habitats

Sarah Frias-Torres[1,2], Jiangang Luo[1], and Joseph E. Serafy[1,2]

1. RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149
2. NOAA-NMFS Southeast Fisheries Science Center, 75 Virginia Beach Drive, Miami, Florida 33149

The goliath grouper, *Epinephelus itajara*, is the largest grouper in the Atlantic Ocean. Juveniles inhabit fringing red mangrove (*Rhizophora mangle*) shorelines, whereas adults inhabit coral reefs, patch reefs, reef ledges, and artificial structures. Due to commercial extinction, the species has been protected in U.S. state and federal waters since 1990. Underwater visual census of juvenile distribution and abundance are critical to evaluate population recovery and essential fish habitat, but limited due to low visibility along mangroves. Here we examine a high-resolution dual-frequency sonar (DIDSON) system for detecting juvenile *E. itajara* in mangrove shorelines. DIDSON uses multiple narrow hydroacoustic beams (96 at 1.8 MHz and 48 at 1.0 MHz) to produce high-resolution, nearfield image streams. It can record the shape, size and movement of targets (i.e. fish), and function under low visibility conditions. A paired DIDSON – digital underwater camera system was used to survey the mangrove shorelines of Niles Channel, in the Lower Florida Keys. Calibration occurred by recording juvenile goliath grouper both with DIDSON and video under high visibility conditions. The specific profile obtained during calibration was used to record and detect juveniles with DIDSON under low visibility conditions. On-going and future research directions using this system are discussed.

Electrochemical Detection of Microbial Contaminants

Michael J. LaGier[1], Andrew Farmer[2], J. Fell, C. Sinigalliano, and Kelly D. Goodwin[3]

[1]RSMAS, University of Miami, 4600 Rickenbacker Causeway, Miami, Florida 33149
[2]College of Marine Science, University of South Florida, 140 Seventh Ave. S., St. Petersburg, Florida 33701
[3]NOAA/AOML, 4301 Rickenbacker Causeway, Miami, Florida 33149

Electrochemical biosensors may provide a means to achieving rapid, on-site monitoring of coastal waters for microbial contaminants. A multi-target electrochemical assay developed for simultaneous detection of fecal-indicating bacteria, human source-tracking markers, bacterial pathogens, and a viral pathogen was tested with a variety of samples (coastal water, beach sand, yard sediment, sewage). The assays are designed for hand-held, commercially available instrumentation and can be used to rapidly (3-5 hours) screen environmental samples for the presence of microbial contaminants. In addition, progress has been made to integrate the PCR and electrochemical steps of the assay through engineering and microfabrication of a PCR chip and a reconfigurable fluidic processessor to allow for semi-automated detection and to pave the wave to fully automated platforms.

Using sea turtles to find seagrass: Tracking juvenile *Chelonia mydas* with satellite telemetry in the southwest coastal Everglades, Florida, USA

Kristen M. Hart[1]

[1]US Geological Survey, Florida Integrated Science Center, 600 Fourth Street South, St. Petersburg, Florida 33701

Green sea turtles (*Chelonia mydas*) are a federally listed endangered species. Threats to their survival include loss of nesting beach habitat, loss of eggs to nest predators, mortality due to by-catch in commercial fishing, and disease. Whereas the ecology and movements of adult green turtles is reasonably well known, relatively little is known about the habitat needs and movements of juveniles and subadults. We recently initiated a green sea turtle tagging study on juvenile and subadult *C. mydas* in the Big Sable Creek (BSC) mangrove complex of the southwest coastal Everglades National Park (ENP) to determine habitat use in BSC and visitation patterns to ENP. A 5-year sightings record of green turtles in the remote stretches of the study site is comprised of 50+ individual records, and we postulate that these difficult-to-access areas may provide previously unknown foraging and possibly nursery grounds for this endangered species. We are currently establishing activity and habitat-use patterns through the combined use of mark-recapture, satellite tracking, and molecular genetic techniques, and here we present tracks of tagged turtles to suggest locations of seagrass and algae cover in the western Everglades where benthic habitat has not yet been mapped.

In situ, automated measurements of net community production in Sarasota Bay, Florida.

Gary L. Hitchcock[1] **and Christopher Langdon**[1]

[1]Marine Biology and Fisheries, RSMAS, University of Miami, 4600 Rickenbacker Cswy, Miami, Florida 33149

The trophic status of a community or ecosystem is described by the net community production (NCP) with positive values corresponding to net autotrophy and negative values indicating net heterotrophy. An automated, in situ productivity analyzer has been deployed on the West Florida coast to measure rates of net oxygen evolution at 5 minute intervals in 4 liter samples incubated in a polycarbonate enclosure. Oxygen concentrations are measured with a pulsed electrode; temperature and irradiance can be simultaneously recorded by a Tattletale microcontroller. Samples are automatically replenished each day at dawn, so the cycle of oxygen production during the day and dark respiration at night yield NCP. Deployments in Sarasota Bay from May to December 2006 indicated that maximum net production and community respiration rates occurred in September during a bloom of *Karenia brevis*. Oxygen production values during the day (dawn-dusk) attained 100 µmol O_2

l^{-1} d^{-1} when *Karenia* abundance varied from 5 x 10^5 to > 10^6 L^{-1}. Dark (night) community respiration yield a 24 hour NCP of 20 - 40 µmol O_2 l^{-1} d^{-1}. In the majority of daily records NCP were positive, indicating that the plankton community in *Karenia brevis* blooms are predominantly autotrophic.

Evaluation of the Phytoflash Instrument vs. Traditional Sampling Techniques in the Caloosahatchee River, FL

Merrie Beth Neely[1], Cynthia A. Heil[1], Sue Murasko[1], and Brian Bendis[2]

[1]FWC/Fish and Wildlife Research Institute, 100 8th Ave SE, St Petersburg, Florida 33701
[2]AMJ Environmental/YSI, Inc., 222 14th Ave South, St Petersburg, Florida 33701

The installation of the MARVIN II platform at Redfish Point near the mount of the Caloosahatchee River provided an opportunity to compare the new Phytoflash in-situ fluorometer against the YSI9600 multiprobe fluorometer and traditional extracted chlorophyll *a* measurements. The platform was installed on January 9th and the Phytoflash unit was deployed January 17th, 2007. This comparison highlighted the contribution of colored dissolved organic matter (CDOM) to this particular estuarine system and the need for groundtruthing of fluorometric instruments where significant contributions to the signal can occur from non chlorophyll compounds. These commercially available fluorometers can be a welcome addition to a suite of sensors to more accurately evaluate the photosynthetic capacity of phytoplankton communities in rivers and estuaries, particularly where episodic cyanobacterial blooms are of concern.

WQM: A New Water Quality Monitor for Long-Term Deployments

Cristina Orrico[1], Casey Moore[1], Andrew Barnard[1], Alex Derr[1], Dave Romanko[1], Carol Janzen[2], Norge Larsen[2], and Dave Murphy[2].

[1]WET Labs, Inc. P.O. Box 518, 620 Applegate Street, Philomath, Oregon 97370
[2]Sea-Bird Electronics, Inc., 1808 136th Place NE, Bellevue, Washington 98005

We describe a collaborative effort to develop and implement an integrated water quality monitoring package that provides continuous and simultaneous multi-parameter measurements, including conductivity, temperature, depth, dissolved oxygen, chlorophyll fluorescence, and turbidity. The “Water Quality Monitor” (WQM) features autonomous operation and multiple anti-foulant approaches, and is intended for long-term deployments (months) in potentially high-fouling coastal environments. Results from field trials in coastal regimes are used to assess the WQM performance. WQMs were deployed at Seattle, WA from August 15, 2006 to January 15, 2007 and at Yaquina Bay, OR from September 13, 2006 to January 23, 2007. Temperature, salinity, dissolved oxygen, turbidity and chlorophyll fluorescence were highly coherent among multiple instruments deployed between 131 and

154 days, including measurement stability. Particularly important is the stability of the dissolved oxygen instrument measurements as compared to Winkler titrated water samples. Results indicate that we achieved 3- 6 months of high quality data without signal degradation using copper and bleach injection anti-foulant technologies, thus extending the usual time needed between instrument services. In this poster we discuss the WQM performance based on long-term deployments, careful calibration and in-field sample comparisons and assess its application for monitoring in coastal regimes.

Diving behavior of internesting female loggerhead turtles (*Caretta caretta*) and risks of boat impact.

Jake Sobin[1] and Tony Tucker[2]

[1]Nicholas School of the Environment and Earth Sciences, Duke University, Durham, North Carolina 27708
[2]Mote Marine Laboratory, Sarasota, Florida 34236

New scientific technology such as time depth recorders enables researchers to study the dive behavior of sea turtles in their natural habitat. Data on dive behavior of internesting turtles provides needed insights on how to better protect nesting turtles from human interactions. An 20 year trend of increasing boat impacts on stranded sea turtles reported by the Florida Sea Turtle Stranding Network establishes that risks of boat strike are rising steadily. An ongoing study will be conducted during summer 2007 with loggerhead turtles tagged at Casey Key Beach in southwest Florida to evaluate the dive behavior of females during the internesting period in the context of boat impact risks. Relative risk from boat traffic, water temperature, and daily activity of swimming female loggerhead will be documented with the use of time depth recorders (TDRs). The study aims will test a hypothesis that female loggerheads spend more time in the upper portion of the water column later in the nesting season as sea surface temperature rises. In addition to vertical use of the water column, females will be simultaneously tracked with satellite tags (platform terminal transmitters or PTTs) to provide latitude-longitude. These data help to establish whether protective measures are warranted, such as boating restrictions and time closure areas to minimize hazards of boat strikes on female loggerhead turtles.

Satellite Tracking of Loggerhead Turtles during Inter-Nesting Movements, Post-Nesting Migrations, and Foraging Residency

Tony Tucker[1]

[1]Mote Marine Laboratory, Sarasota, Florida 34236

As highly migratory animals, sea turtles face threats in a range of oceanic habitats that they traverse during each nesting migration. We deployed satellite tags on thirteen nesting female

loggerheads at a major rookery in the Gulf of Mexico to establish their spatial ecology in relation to potential threats. The path analysis yielded valuable insights into the extent of movements within the internesting period, along divergent post-nesting migrations, and for home ranges established at a foraging residency. We compare track paths in relation to local zones of potential hazard, including offshore dredging, boat traffic near inlets, and harmful algal blooms.
Four females undertook relatively short (50-288 km) and coastal migrations that were largely unaffected by current systems. Eight females undertook long migrations (613-1235 km) that were international or an open ocean path that crossed major currents. One female was an outlier with an entirely uncharacteristic internesting and post-nesting migration that requires some additional scrutiny base on her displacement during a tropical storm.
We evaluated the track paths with respect to remotely sensed oceanographic data. Turtles headed SE encountered a following stream with the Florida Current, those headed SW encountered two cross-currents from the Gulf of Mexico Loop Current, and those heading NW encountered a counter flow of the Loop Current.

An Underwater Reagent Based Phosphate Sensor for Long-term Deployments

J. R. V. Zaneveld[1], M. Levin[1], A. Barnard[1], J. Koegler[1], I. D. Walsh[1], C. Moore[1], A. Hanson[2], P. Egli[2], T. K. Gregory[3], J. R. Morrison[3]

[1]WET Labs, Inc. P.O. Box 518, 620 Applegate Street, Philomath, Oregon 97370
[2]SubChem Systems, Inc., 665 North Main Road, Jamestown, Rhode Island 02835
[3]University of New Hampshire, Durham, New Hampshire 03824

We have developed an underwater phosphate sensor for long term deployments. The sensor uses four micropumps that deliver two reagents, ambient water, and a phosphate standard. The instrument contains a unique flow system that allows mixing for the very small quantities of reagent used. Per sample the instrument uses 65 microliters of each reagent. Comparisons with dilution series are very good. The instrument shows a precision of around 25 nanoMolar. Battery power and reagent supply are sufficient for 1000 samples, without recharging reagents. The color change is measured in a miniature reflective tube absorption meter. Results from deployments in Yaquina Bay, OR show long term endurance of more than a month.

WORKSHOP PARTICIPANTS & CONTRIBUTORS

NAME		AFFILIATION	E-MAILS
Jeff	Alexander	Horn Point Lab, University of Maryland Center for Environmental Science	
Audra	Ames	Marine Desalination Systems	aames@mdswater.com
Diane	Andrews	Economic Development Corporation of Sarasota County	dandrews@edcsarasotacounty.com
Bill	Arnold	FWC/Fish and Wildlife Research Institute	Bill.Arnold@MyFWC.com
Lorraine	Backer	Centers for Disease Control and Prevention	
Andrew	Barnard	WET Labs, Inc.	
Jack	Barth	COAS, Oregon State University	
Brian	Bendis	AMJ Environmental/YSI, Inc.	bbendis@ysi.com
Larry	Brand	RSMAS, University of Miami	
Heather	Broadbent	College of Marine Science, University of South Florida	heather@marine.usf.edu
Amy	Brossard	US Geological Survey	abrossar@usgs.gov
Mark	Brown	Monterey Bay Aquarium Research Institute	
Robert	Byrne	College of Marine Science, University of South Florida	byrne@marine.usf.edu
Jennifer	Cannizzaro	College of Marine Science, University of South Florida	jpatch@marine.usf.edu
Ken	Carder	College of Marine Science, University of South Florida	kcarder@marine.usf.edu
Andrew	Casper	Environmental Science & Policy Program, University of South Florida	afcasper@stpt.usf.edu
Paula	Coble	College of Marine Science, University of South Florida	coble@marine.usf.edu
Louis	Codispoti	Horn Point Lab, University of Maryland Center for Environmental Science	
Josh	Coldiron	Eckerd College	coldirjc@eckerd.edu
Robyn	Conmy	College of Marine Science, University of South Florida	rconmy@marine.usf.edu
Andrew	Crowder	Florida Institute of Oceanography	agcrowder@keysmarinelab.org
Robert	Currier	Mote Marine Laboratory	
Alex	Derr	WET Labs, Inc.	
Barnali	Dixon	University of South Florida	
Kellie	Dixon	Mote Marine Laboratory	lkdixon@mote.org
Percy	Donaghay	University of Rhode Island	
Greg	Doucette	NOAA National Ocean Service	
Don	Draper	Daytona Beach Community College	DraperD@dbcc.edu
Karen	Dreger	University of South Florida	kdreger@mail.usf.edu
Eurico	D'Sa	Dept. of Oceanography & Coastal Sciences, Louisiana State University	ejdsa@lsu.edu
Erin	Dykes	Florida Department of Environmental Protection	Erin.Dykes@dep.state.fl.us
Peter	Egli	SubChem Systems, Inc.	
C.	Elliott	Queen’s University Belfast	
Rob	Ellison	YSI Environmental, Inc.	rellison@ysi.com
David	English	College of Marine Science, University of South Florida	denglish@marine.usf.edu
Ernest	Estevez	Mote Marine Laboratory	estevez@mote.org
Stephanie	Fahrny	Dept. of Oceanography, Florida State University	fahrny@ocean.fsu.edu
Jon	Fajans	Florida Institute of Oceanography	jsfajans@keysmarinelab.org

Paul	Falkowski	Institute of Marine and Coastal Sciences, Rutgers University	
Kent	Fanning	College of Marine Science, University of South Florida	kaf@marine.usf.edu
Andrew	Farmer	College of Marine Science, University of South Florida	afarmer@marine.usf.edu
J.	Feldman	Jet Propulsion Laboratory	
Jack	Fell	RSMAS, University of Miami	jfell@rsmas.miami.edu
Lora	Fleming	RSMAS & School of Medicine, University of Miami	LFleming@med.miami.edu
Sarah	Frias-Torres	RSMAS, University of Miami	sfrias@rsmas.miami.edu
David	Fries	College of Marine Science, University of South Florida	dfries@marine.usf.edu
Damon	Gannon	Mote Marine Laboratory	damon@mote.org
Angela	Gellatly	WET Labs, Inc.	angela@wetlabs.com
Maribeth	Gidley	Oceans and Human Health Center, University of Miami	gidleyml@yahoo.com
Pat	Gilbert	Horn Point Lab, University of Maryland Center for Environmental Science	
Sherryl	Gilbert	ACT & College of Marine Science, University of South Florida	sgilbert@marine.usf.edu
R. Grant	Gilmore	Estuarine, Coastal, and Ocean Science, Inc.	rggilmorej@aol.com
Kelly	Goodwin	NOAA AOML	Kelly.Goodwin@noaa.gov
Maxim	Gorbunov	Institute of Marine and Coastal Sciences, Rutgers University	gorbunov@marine.rutgers.edu
T.	Gregory	University of New Hampshire	
Dianne	Greenfield	Monterey Bay Aquarium Research Institute	
Norman	Guinasso, Jr.	College of Geosciences, Texas A&M University	norman@gergx.gerg.tamu.edu
Michael	Hall	College of Marine Science, University of South Florida	mhall@marine.usf.edu
Alfred	Hanson	SubChem Systems, Inc.	
Kristen	Hart	US Geological Survey	kristen_hart@usgs.gov
Cynthia	Heil	FWC/Fish and Wildlife Research Institute	
Jim	Hendee	NOAA AOML	Jim.Hendee@noaa.gov
Karl	Henderson	Mote Marine Laboratory	
Michael	Henry	Mote Marine Laboratory	mhenry@mote.org
Gary	Hitchcock	RSMAS, University of Miami	g.hitchcock@miami.edu
Robert	Hueter	Mote Marine Laboratory	rhueter@mote.org
Carlton	Hunt	Batelle	huntc@BATELLE.ORG
Stanislav	Ivanov	College of Marine Science, University of South Florida	sivanov@marine.usf.edu
Daniel	Jackson	Dalhousie University, Life Sciences Centre	Dan.Jackson@Dal.Ca
Mike	Jankulak	NOAA AOML	
Carol	Janzen	Sea-Bird Electronics, Inc.	
Jon	Jarrell	YSI Environmental, Inc.	jjarrell@ysi.com
Scott	Jensen	Monterey Bay Aquarium Research Institute	
Jim	Jeansonne	NOAA/Office of Response and Restoration	Jim.Jeansonne@noaa.gov
Mike	Jones	Sarasota County Government	mjones@scgov.net
W. Joe	Jones	Monterey Bay Aquarium Research Institute	jones@mbari.org
Kristen	Kaufman	Southwest Florida Water Management District	Kristen.Kaufman@swfwmd.state.fl.us
Vince	Kelly	Horn Point Lab, University of Maryland Center for Environmental Science	vkelly@hpl.umces.edu
Kristen	King	NOAA National Ocean Service	
Barbara	Kirkpatrick	Mote Marine Laboratory	bkirkpat@mote.org

Gary	Kirkpatrick	Mote Marine Laboratory	gkirkpat@mote.org
Dong-Shan	Ko	Naval Research Laboratory, Stennis Space Center	
John	Koegler	WET Labs, Inc.	
Mitsuko	Korobkin	Dept. of Oceanography & Coastal Sciences, Louisiana State University	
Danielle	Krip	Mote Marine Laboratory	dkrip@dal.ca
Michael	LaGrier	RSMAS, University of South Florida	
Christopher	Langdon	RSMAS, University of South Florida	
Larry	Langebrake	SRI International	larry.langebrake@sri.com
Norge	Larsen	Sea-Bird Electronics, Inc.	
Chad	Lembke	College of Marine Science, University of South Florida	clembke@marine.usf.edu
Murray	Levine	COAS, Oregon State University	
James	Locascio	College of Marine Science, University of South Florida	locascio@marine.usf.edu
Steve	Lohrenz	Department of Marine Science, University of Southern Mississippi	
Jiangang	Luo	RSMAS, University of Miami	
Mark	Luther	College of Marine Science, University of South Florida	luther@marine.usf.edu
Jorge	Macho	Ocean Optics, Inc.	Jorge.Macho@oceanoptics.com
Geoff	MacIntyre	Satlantic, Inc.	
David	Mann	College of Marine Science, University of South Florida	dmann@marine.usf.edu
Derek	Manzello	RSMAS, University of Miami	dmanzello@rsmas.miami.edu
Damien	Marigliano	College of Marine Science, University of South Florida	dmarigliano@marine.usf.edu
Roman	Marin III	Monterey Bay Aquarium Research Institute	
Fabien	Martinez	College of Marine Science, University of South Florida	fmartinez@marine.usf.edu
Robert	Masserini	College of Marine Science, University of South Florida	masserin@marine.usf.edu
Eugene	Massion	Monterey Bay Aquarium Research Institute	
Scott	McLean	Satlantic, Inc.	
Lynn	Melton	Ocean Optics, Inc.	lynn.melton@oceanoptics.com
Christina	Mikulski	NOAA National Ocean Service	Tina.Mikulski@noaa.gov
Eric	Milbrandt	Sanibel-Captiva Conservation Foundation	emilbran@sccf.org
Michael	Miller	Mote Marine Laboratory	millerm@mote.org
David	Millie	Florida Institute of Oceanography	
Mark	Moline	California Polytechnic State University	
Casey	Moore	WET Labs, Inc.	
Geoff	Morrison	The International Seakeepers Society	morrison@seakeepers.org
John	Morrison	University of New Hampshire	
Sue	Murasko	FWC/Fish and Wildlife Research Institute	
Dave	Murphy	Sea-Bird Electronics, Inc.	
Merrie Beth	Neely	FWC/Fish and Wildlife Research Institute	Merrie.Neely@MyFWC.com
David	Niebuhr	Mote Marine Laboratory	david.niebuhr@mote.org
Kate	Nierenberg	Mote Marine Laboratory	
Ari	Nissauka	Mote Marine Laboratory	ari@mote.org
Douglas	Nowacek	Dept. of Oceanography, Florida State University	nowacek@ocean.fsu.edu
Ronald	O'Dor	Dalhousie University, Life Sciences Centre	

Cristina	Orrico	WET Labs, Inc.	
Tim	Ourbak	College of Marine Science, University of South Florida	tourbak@marine.usf.edu
Doug	Pargett	Monterey Bay Aquarium Research Institute	
Michael	Parker	Monterey Bay Aquarium Research Institute	
James	Patten	College of Marine Science, University of South Florida	jpatten@marine.usf.edu
Brad	Pederson	Mote Marine Laboratory	pederson@mote.org
Ernst	Peebles	College of Marine Science, University of South Florida	epeebles@marine.usf.edu
Joanna	Phillips	Falmouth Scientific, Inc.	jphillips@falmouth.com
Tom	Piazze	University of South Florida	piazza@spadmin.usf.edu
Christina	Preston	Monterey Bay Aquarium Research Institute	
Matt	Previte	YSI Environmental, Inc.	mprevite@ysi.com
Mike	Purcell	Woods Hole Oceanographic Institution	
Gary	Raulerson	Sarasota Bay Estuary Program	gary@sarasotabay.org
Andy	Reich	Florida Department of Health	
Clare	Reimers	COAS, Oregon State University	
Kathleen	Rein	Florida International University	
Andrew	Remsen	College of Marine Science, University of South Florida	aremsen@marine.usf.edu
Bruce	Rhoades	WET Labs, Inc.	
Marc	Rippen	SRI International	marc.rippen@sri.com
Brent	Roman	Monterey Bay Aquarium Research Institute	
Dave	Romanko	WET Labs, Inc.	
Randy	Russell	College of Marine Science, University of South Florida	rrussell@marine.usf.edu
Oscar	Schofield	Institute of Marine and Coastal Sciences, Rutgers University	
Chris	Scholin	Monterey Bay Aquarium Research Institute	
Gloria	Scorzetti	RSMAS, University of Miami	
Joseph	Serafy	NOAA NMFS Southeast Fisheries Science Center	
Mahmoud	Shahriari	Ocean Optics, Inc.	Mahmoud.Shahriari@oceanoptics.com
Glen	Shen	Mote Marine Laboratory	glenshen@mote.org
Rebecca	Shuford	NOAA IOOS	Rebecca.Shuford@noaa.gov
Chris	Simoniello	Florida Sea Grant	simo@marine.usf.edu
Christopher	Sinigalliano	NOAA AOML	Christopher.Sinigalliano@noaa.gov
Matthew	Smith	College of Marine Science, University of South Florida	msmith@marine.usf.edu
Jacob	Sobin	Nicholas School of the Environment & Earth Sciences, Duke University	jacob.sobin@duke.edu
Eric	Stabenau	National Park Service, Everglades National Park	
Kevin	Stallings	North Carolina University	kdstalli@ncsu.edu
Carol	Steele	SRI International	carol.steele@sri.com
Eric	Steimle	University of South Florida – St. Petersburg	esteimle@stpt.usf.edu
Robert	Stetson	University of South Florida – St. Petersburg	
Shannon	Stillwagon	Nekton Research, LLC	SStillwagon@NektonResearch.com
Michael	Stokesbury	Dalhousie University, Life Sciences Centre	
Mark	Strom	NOAA Fisheries, Northwest Fisheries Science Center	Mark.Strom@noaa.gov
Rick	Stumpf	NOAA National Ocean Service	

James	Sullivan	University of Rhode Island	
Graham	Tilbury	College of Marine Science, University of South Florida	gtilbury@marine.usf.edu
Tony	Tucker	Mote Marine Laboratory	tucker@mote.org
Libby	Tyner	College of Marine Science, University of South Florida	ltyner@marine.usf.edu
Kristan	Uhlenbrock	College of Marine Science, University of South Florida	
Jyotika	Virmani	Florida COOS Consortium	jyotika@marine.usf.edu
Robert	Vrijenhoek	Monterey Bay Aquarium Research Institute	
Carrie	Wall	College of Marine Science, University of South Florida	cwall@marine.usf.edu
Ian	Walsh	WET Labs, Inc.	
Beth	Weinstein	Ocean Optics, Inc.	beth.weinstein@oceanoptics.com
Robert	Weisberg	College of Marine Science, University of South Florida	weisberg@marine.usf.edu
Kevin	Wheeler	Monterey Bay Aquarium Research Institute	
Dan	Whiteman	WET Labs, Inc.	
Sherman	Wilhelm	Florida-DOACS Division of Aquaculture	
Steven	Wolfe	Florida Department of Environmental Protection	Steven.Wolfe@dep.state.fl.us
Ron	Zaneveld	WET Labs, Inc.	ron@wetlabs.com