OS11U-12 1135h

An experimental approach to understanding bloom maintenance or decline

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Large chain forming centric diatoms, mostly Thalassiosira spp., are typically the biomass dominants during prolonged blooms in the North Water polynya, the largest recurring region of ice-free water in the Canadian Arctic Ocean. We used an experimental method based on semi-continuous cultures to investigate possible mechanisms responsible for bloom maintenance in this system. Specifically, our objective was to test whether a large-cell bloom could be maintained under an episodic advective regime with losses of all planktonic size-classes on the same scale as nutrient inputs. We compared this scenario to one of a community with nutrient recycling and substantial losses of only larger cells, for example by sedimentation or zooplankton grazing. We followed macro-nutrient utilization, along with production by bacteria, viruses and protists including phytoplankton. Over the 8 days of the experiment the eukaryotic community production in the recycled treatment was able to keep up with the imposed losses, but the community shifted to one dominated by dinoflagellates and ciliates. In the advective treatment, Thalassiosira spp. production continued to increase using the added nutrients and the production exceeded total community losses. There were no differences in net bacterial or viral production between treatments. This implies that advective processes underlie the persistent blooms of Thalassiosira in the North Water polynya, and other large-cell diatoms in similar oceanic environments.

OS12A HC: Hall III Monday 1330h

Recent Advances in Ocean and Freshwater Science Instrumentation

Presiding: **H L Clark,** National Science Foundation**; A Isern,** National Science Foundation

OS12A-100 1330h POSTER

Surface-Following Acousto-Optic Probe for Microbubble and Surface Layer Process Studies

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We have developed a surface-following spar buoy to investigate microbubble populations in relation to air-sea gas exchange processes and ocean colour. Primary bubble sensors are a prototype broadband sonar operating in two frequency bands (300-700 kHz and 1.5-4 MHz) and a special-purpose three-strobe digital camera with sub-micron resolution. Submerged and subaerial hyperspectral measure upwelling and downwelling irradiance. Ancillary sensors monitor water temperature, salinity, gas tension, tilt and axial acceleration of the spar. The onboard data acquisition system combines PC104 and passive-backplane PC technologies, running QNX and Windows-NT respectively. The probe was deployed from RV Endeavor, as part of the Hyperspectral Coastal Ocean Dynamics Experiment (HyCODE) in July-August 2001. Over 3 GBytes of data were collected, in wind speeds up to 20 knots. For HyCODE, the probe was operated from the ship with a 100-m long power/telemetry tether to the ship. Communications between the onboard computers (the central QNX-based node and a Windows-NT thin-client) and the probe-based computers were via Ethernet. Future intended developments of the surface layer microbubble probe include a hardwired moored configuration for longterm observations in the coastal zone, and an autonomous drifter configuration for short-term event-based studies.

OS12A-101 1330h POSTER

A Coastal-Water 10m Range PIV Turbulence and Stress Profiler

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A submersible Particle Image Velocimetry (PIV) system for measuring the velocity distribution and turbulence in the bottom boundary layer and part of the water column in the coastal ocean has been developed and deployed. PIV measures the instantaneous distribution of two velocity components within a sample area. The resulting 2-D vector fields enable us to calculate spatial turbulent spectra and distributions of Reynolds shear stresses (following a procedure described in another presentation - Nimmo Smith et al.), both of which are not contaminated by surface waves. The submersible PIV system has evolved over several years from an original configuration, using one camera with a limited sample area (0.2x0.2m), capable of profiling up to 1m above the sea bed, to a system utilising two higher resolution cameras, and a profiling range of 10m.

The present version of the submersible system comprises two 2Kx2K pixels, 12bits/pixel digital cameras operating simultaneously, each with a sample area of up to 0.5x0.5m. When the two sample areas are aligned horizontally in the same plane, and spaced 1m apart, they enable us to resolve turbulent scales ranging from 8mm (the vector spacing) to 1.5m. The light source of the PIV system is a pair of flashlamp-pumped dye lasers located at the surface, whose beams are transferred to each of the sample areas using two independent optical fibres. Submerged probes are used for expanding the beams into light sheets. In the present configuration we record two exposures within each frame of the digital cameras. To remove directional ambiguity a hardware based 'image shifter' creates a known fixed offset between exposures on the CCD array. Naturally occurring particles are used as tracers. The cameras can capture up to 4 frames/s, requiring a total image acquisition rate of 64Mb/s. The data is stored using ship-board hard disk arrays. Data analysis is based on calculating the auto-correlation function of the intensity distributions in subsections of the image. The calculated velocity distributions are then corrected for optical distortions in the original images. Errors associated with the out-of-plane component of the velocity are minimised by limiting the thickness of the light sheets (to 2.5mm), restricting the sample areas (to about 35cm square), and setting a minimum of the camera to light sheet separation of about 1m.

The components of the PIV system are mounted on a rigid sea bed platform, which enables us to align the sample areas with the direction of the mean current. The profiling range has been extended from very close to the bottom up to 10m above the bed. The elevation is controlled using a rugged, double-acting, telescopic hydraulic cylinder mounted vertically on a heavy tripod base. The instrumentation is mounted on a rigid framework suspended from a turntable at the top of the cylinder. The system also includes a CTD, transmissometer, precision pressure transducer, compass and video camera for monitoring the flow direction. During recent deployments we also installed airfoil turbulence probes and profiled the entire water column using ship-board CTD and ADCP. A 60m umbilical, containing hydraulic, power, fibre-optic, control and data lines, links the submerged instrumentation to the support vessel. The compact size of the platform when fully retracted, 3x2x2.75m, allows it to be deployed from a moderate-sized coastal research vessel.

This system has been deployed in the vicinity of LEO-15 twice during 2001 and once during 2000. Overall 1.2 TB of PIV data were collected. Sample results will be presented. More details are provided in (Nimmo Smith et al.).

Funded in part by NSF and in part by ONR.

OS12A-102 1330h POSTER

A Unique Approach to Long-Term Turbidity Measurements

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An extensive study to determine the fate of a mixed-sediment dredged material placement mound is underway at the Cape Fear River experiment site, off the North Carolina coast. A critical component includes assessing the mound and ambient turbidity levels, which are important to fish, larvae, and habitat. The approach has been a unique application of the DRL-Sediview method to obtain long-term (months to years) solids concentration data from an array of bed-mounted ADCPs at varying distances from the mound and river mouth. Initial calibration and verification of the technique has involved the LISST-100 and LISST-25 laser concentration and size sensors, an OBS optical concentration sensor, and bottle water samples analyzed by filtration and weighing. The results, including the first attempt to get mean particle diameter from the LISST-25, show a high level of consistency between the methods. This paper will describe the methods and present the multi-sensor results. Data of this kind are to be incorporated into fate and plume models that require suspended particle size as well as concentration.

OS12A-103 1330h POSTER

HydroScat-4: A New, Four-Wavelength Optical Backscattering Sensor for Both Profiling and Long-Term Mooring Applications

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The HydroScat-4 is the third and newest model in our line of HydroScat backscattering sensors. The HS-4 measures optical backscattering at four wavelengths, which can be chosen from a large set ranging from 420 to 880 nm. Wavelength options also include pairing a shorter-wavelength excitation source with a longer-wavelength emission receiver to measure fluorescence (hence this option is a combined three-wavelength backscattering sensor and fluorometer). Like the HS-6 and HS-2, the HS-4 is calibrated with a robust and well-tested method to provide measurements of the VSF at a nominal angle of 140 degrees which is converted to the backscattering coefficient [Maffione and Dana, 1997, Applied Optics, 36: 6057-6067]. It also retains the unmatched sensitivity (typically 0.0005 m1) and background-light rejection of the HS-6 and HS-2. Like those instruments, the HS-4 includes internal rechargeable batteries, internal data logging, and intelligent real-time interfacing. Moreover, it includes significant advances over current multi-wavelength optical backscattering sensors. For mooring applications the HS-4 incorporates a copper shutter system that prevents fouling of the optical windows. The instruments micro-computer automatically opens the shutter during data sampling, and closes it, covering the windows, during idle times. Considering all these capabilities, it is very compact, measuring only 5 in diameter by 12.6 long. The HydroScat-4 promises to be a uniquely powerful new tool for a wide range of research and ocean monitoring applications.

URL: http://www.hobilabs.com/products/hydroscat4/hydroscat4.html

OS12A-104 1330h POSTER

A Profiling Optical and Water Return (POWR) Package for In-situ Optical Characterization of Coastal Waters: Results From First Field use During the 2001 HyCODE Experiment at LEO-15

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To improve our understanding of the diverse processes controlling the inherent optical properties of the coastal ocean, the Naval Research Laboratory in Washington, DC has developed a Profiling Optical and Water Return (POWR) package. This multi-instrumented package was built on a modified Seabird Rosette frame by WET Labs, Inc. in Philomath, Oregon, and measures spectral absorption, attenuation, back-scattering, CDOM absorption, temperature, salinity, and stimulated chlorophyll fluorescence. Simultaneously, the package can collect up to eight 2.5-liter water samples for laboratory measurements such as chlorophyll concentration, CDOM concentration, pad absorption, and total suspended solids. Results from first field use during the 2001 HyCODE experiment at the LEO-15 site off New Jersey will be presented.

OS12A-105 1330h POSTER

Ocean Response Coastal Analysis System (ORCAS)

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ORCAS is a system under development that combines ship-deployed and autonomous bottom-up profilers to provide coherent, fine-scale profiling of multiple oceanographic parameters in three dimensional space and time. The system is designed to be rapidly deployed to quantify biological, physical, chemical, and optical responses of coastal systems to episodic events of interest or opportunity, such as storms, harmful algal blooms, chemical spills, and the onset of hypoxia or anoxia. Major progress has been made in the development of the core technologies need for autonomous bottom-up profiling. Prototype versions of ORCAS were successfully tested in September 2001 in the Gulf of Mexico off Pensacola, FL. These prototype systems autonomously collected high resolution profiles of temperature, salinity, density, oxygen, chlorophyll fluorescence and light scattering. These profiles were collected from the bottom up. At the end of each cast, the profiler stayed at the surface only long enough to telemeter the data, collect a GPS fix, and receive any instructions regarding future casts. The autonomous profilers would then return to the bottom until the next profiling cycle. An overview of the system and data from the recent test deployment will be presented.

OS12A-106 1330h POSTER

Gauging Littoral Optics for the Warfighter (GLOW): A Project to Validate Diver Visibility Algorithms and Transition ORCAS Technology in Support of U.S. Navy Missions

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Ocean optics is a concern for U.S. Navy diver missions because of its impacts on underwater vision and diver vulnerability to detection. It is the responsibility of the Commander, Naval Meteorology and Oceanography Command(CNMOC) to provide such environmental information to the warfighter as an aid in mission planning and execution. To improve upon existing optics capabilities, CNMOC, the Naval Research Laboratory, and Planning Systems Incorporated initiated the GLOW project in 1998. One of GLOW's major thrusts has been to re-examine the Navy's traditional visibility algorithm that was originally developed using measurements from older instrumentation and applying a limiting case of contrast transmittance theory. To validate visibility range prediction methods, GLOW has been conducting a series of experiments using measurements obtained via state-of-the-art optics instrumentation and actual in-water observations of Navy divers. Results of GLOW experiments reveal that derived horizontal visibility predictions underestimate actual diver-observed ranges by as much as 50 percent. This year's experiments have shown the impact of additional parameters such as diver approach angle. Based on its test results, GLOW is developing an enhanced visibility algorithm that allows for varying incident solar irradiance, optical properties, approach angle, and target reflectance. To further algorithm development efforts, GLOW partnered in 1999 with the University of Rhode Island (P. Donaghay, lead) and others in the project Ocean Response Coastal Analysis System (ORCAS) under the auspices of the National Oceanographic Partnership Program. The GLOW team, including Navy divers from Explosive Ordnance Disposal Mobile Unit Twelve, is assisting project partners to test ORCAS with the goal of transitioning it to the operational Navy. ORCAS, described in detail in related presentations, shows great potential as a realtime tool for rapid environmental assessment in support of U.S. Navy missions.

OS12A-107 1330h POSTER

Characterization of a Prototype Point-Source Integrating-Cavity Absorption Meter (PSICAM)

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The measurement of the absorption coefficient of seawater and its components is of great interest for oceanography and the optical remote sensing of the ocean. Currently used methods for determining the absorption coefficient of water samples require corrections for the presence of scattering. The use of an integrating cavity, on the other hand, offers a method for determining the absorption coefficient that does not require scattering corrections. The Naval Research Laboratory has developed a point-source integrating-cavity absorption meter (PSICAM), where the light source is isotropic and located at the center of a spherical cavity having highly reflective walls. A prototype PSICAM was built by Labsphere Inc. of North Sutton, New Hampshire under NRL supervision. We have evaluated the performance of this prototype and compared the results to the pad absorption measurement and ac-9 and Histar spectral absorption and attenuation meters made by WETLabs, Inc.

OS12A-108 1330h POSTER

Monitoring the Coastal Sea Level from Land-Based GPS Receivers

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Altimetric measurements closer than 20 km from the coast suffer degraded accuracy with current spaceborne altimeters such as Topex/Poseidon, because of the land contamination for the 2 3 footprints near the coast. Here we explore the potential of ground-based, passive Global Positioning System (GPS) receivers on the coast to achieve nearly continuous sea level measurements in the coastal waters.

An experiment was conducted at Crater Lake (in Central Oregon) using a GPS receiver 480 meters above the lake to measure differential arrival times of direct and reflected GPS signals. The results show that the lake surface height can be estimated with 2-cm precision in 1 second. Time series analyses suggest that tropospheric and thermal noise fluctuations dominate the altimetric error. Estimating the differential delay from several simultaneously visible GPS satellites may enable tropospheric error estimation and correction. Thermal noise on the reflected signal will be reduced with fully polarimetric observations and larger antenna apertures.

Preliminary results of another GPS reflection experiment conducted in the open ocean environment (at the Platform Harvest, about 10-km off the coast of California) will also be presented. Our goal is to achieve a cm-level precision of the sea level determination by averaging over a few minutes. With further analysis and experiments, we plan to implement a coastal altimetry network for continuous cm-level monitoring, filling a performance deficit in spaceborne altimeters near the coast.

OS12A-109 1330h POSTER

The Salinity, Temperature, and Roughness Remote Scanner (STARRS)

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An advanced airborne system for remotely sensing sea surface salinity has successfully passed its initial sea trials and is ready for routine application in coastal and open ocean surveys. The Salinity, Temperature, and Roughness Remote Scanner (STARRS) employs a push-broom passive L-band microwave radiometer which senses the natural radiation emitted from the sea surface at a wavelength of 21cm. This radiation is a function of the complex dielectric properties of the sea surface which, at this wavelength, are a strong function of the electrical conductivity — the same quantity measured in-situ by standard CTDs. Sea surface temperature and roughness are secondary effects on radiation emitted at L-band. STARRS incorporates nadir-viewing dual-channel infrared and multi-frequency C-band radiometers to obtain independent measures of these secondary quantities. In the process of correcting for these secondary effects, SST and winds are estimated as well. Tertiary effects of cosmic and galactic radiation at L-band are handled in the salinity retrieval software and are computed as functions of GPS-based location and aircraft attitude as measured by fiberoptic gyroscope, the same data required for geolocation of the salinity estimates. With typical sampling scenarios, data of sufficient quality and quantity are generated such that 1x1km pixel averaged salinity values can be obtained with noise levels in the range of 0.1. Examples of data obtained during the NRL Coastal Buoyancy Jets program are described.

OS12A-110 1330h POSTER

TRMM Microwave SST

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The TRMM Microwave Imager (TMI) has produced passive microwave observations at 10.7, 19.4, 21.3, 37.0, and 85.5 GHz since December 1997. Accurate retrievals of sea surface temperature (SST) can be made in all weather conditions except rain. Microwaves penetrate clouds with little attenuation, giving an uninterrupted view of the ocean surface. This is a distinct advantage over infrared measurements of SST, which are obstructed by clouds. Errors in the microwave SST retrieval are mainly derived from inaccurate parameterization of wind effects. Comparisons with ocean buoys show a root mean square difference of about 0.57°C, which is partly due to the satellite-buoy spatial-temporal sampling mismatch and the difference between the ocean skin temperature and bulk temperature. The combination of 1-micron (infrared), 1-mm (microwave) and 1-meter (buoy) SSTs is yielding a better understanding of the ocean skin layer. Microwave SST retrievals are of adequate resolution and accuracy for a high-quality, long-term dataset for climate studies.

URL: http://www.remss.com

OS12A-111 1330h POSTER

Acoustically-tracked Neutrally-buoyant Lagrangian Drifters in Lake Champlain - a Feasability Study

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The first phase of a two-year pilot program to look at the feasibility of acoustically-tracked neutrally-buoyant Lagrangian drifters within Lake Champlain was completed in July 2000. A deep ocean, 780 Hz RAFOS system was used. Four sound sources were utilized within the central portion of Lake Champlain, each transmitting every hour. Initial proximity testing confirmed that the emitted sound posed no problem to the diving community. Testing of the glass floats at WHOI found them to be unstable within the upper 100 meters of the water column. They were never-theless still utilized for testing acoustic propagation within a shallow water environment. Two research vessels and free-drifting drogues equipped with a surface Argos transmitter and two glass floats (shallow and deep) were utilized to check signal correlation. Results indicated that acoustic shadows behind shoals and islands represent the largest problem for tracking, but can be obviated with an increase in the number of sources as well as their positioning. Maximum tracking distance may be greater than 25 km based on the unexpectedly high correlations at the end of the longest drogue track. Additionally, the 780 Hz system will be replaced by a much smaller and less expensive 1560 Hz system. Phase 2 of the program (summer 2002) will utilize six 1560 Hz sound sources. Presently, modifications and testing of a computer-controlled, self-ballasting SOLO float are being undertaken in order to create a smaller, lake version called the Lake Champlain Profiler (LCP). This also will be field tested in the spring of 2002.

OS12A-112 1330h POSTER

High Frequency Monitoring of Coastal Marine Environment Using MAREL Buoy

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The MAREL data buoy measures physico-chemical parameters in seawater on a continuous and autonomous mode. The water is pumped 2.5 m below the surface through a sampling pipe and flows through the measuring cell located in the floating structure. Technological innovations implemented inside the measuring cell atop the buoy allows a continuous cleaning of the sensor, while injection of chlorinated ions in the circuit prevents biological clogging. Specific sensors for temperature, salinity, oxygen, fluorescence, turbidity , pH and nitrates have been qualified to guarantee measurement precision over 3 months period without servicing. A bidirectional link under internet TCP-IP protocols is used for data, alarms and remote-controls transmissions with the land-based data centre. We present here one year records of the parameters gathered using a MAREL buoy moored in a coastal environment (Iroise Sea, Brest, France). The accuracy of the data provided by the buoy is accessed by comparison with measurements of seawater weekly sampled at the same site as part of the French network for monitoring of the coastal environment SOMLIT (Service d'Observation du Milieu LITtoral). Some particular events (impact of fresh water discharge due to intensive rains, short phytoplankton bloom) are also presented which demonstrated the interest of high frequency continuous monitoring in highly variable coastal environment with a reliable system.

OS12A-113 1330h POSTER

Recent Experience with the WHOI/McLane Moored Profiler

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In development and testing over roughly the last 10 years, the WHOI Moored Profiler (MP) and the commercial version of the device, the McLane Moored Profiler (MMP), have recently become operational with the establishment of a shared-use instrument pool at the Woods Hole Oceanographic Institution. The MP and MMP vehicles use a small traction drive to travel up and down a conventional subsurface mooring line on a pre-programmed schedule carrying sensors to sample water properties (temperature and salinity thus far) and currents versus depth at high vertical resolution. Maximum operating depth is 6500 m (5000 m for the MP) and with careful deployment, moorings can be designed so that the Profilers sample within 50 m of the surface. Range of the vehicles is approximately one million meters of profiling on a battery pack. Typically, Profilers are programmed to burst sample with several profiles acquired in rapid succession followed by wait periods of one day or more. Data are presently stored internally; a real-time data telemetry link is in development.

We report results from recent year-long deployments of MP's in the Labrador and Weddell Seas and shorter-term deployments of MP's and MMP's off Bermuda, on the U.S. continental slope, and on the Hawaiian Ridge. At present, a total of 10 WHOI-owned Profilers are deployed around the world in addition to MMP systems purchased by other users. An overview of the ongoing WHOI experiments will be given along with information about accessing instruments from the WHOI pool. We gratefully acknowledge the support for prototype development and testing provided by the National Science Foundation, the Office of Naval Research, the National Oceanic and Atmospheric Administration, the Vetlesen Foundation and the WHOI Director's discretionary fund.

OS12A-114 1330h POSTER

An Autonomous Vertical Profiler for use in Nearshore Waters

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The Great Lakes Environmental Research Laboratory has developed an autonomous vertical profiler for use in nearshore waters. The motivation for its development was the need to study the effects of inertial internal waves on the benthic nepheloid layer in Lake Michigan. At present the profiler makes observations of water temperature and transparency as a function of depth, but additional sensors could be added. The profiler was designed to make vertical profiles once an hour for at least three weeks in depths up to 100m.

The profiler is constructed from standard 1.1 cm (7/16") thick PVC pipe 14 cm (5.5") in diameter with machined, spherical end caps. It is 2.2m long, weighs 40 kg in air, and is neutrally buoyant in water. A drive pulley powered by an electric motor propels the profiler up and down the mooring cable. Upward and downward excursion is limited by mechanical stops attached to the cable. The profiler is controlled by a data logger and records data to a 15 mega-byte compact flash disk memory card. The profiler ascends and descends at a rate of 15 cm/sec, sampling continuously at about 2 Hz to provide sub-meter sample resolution. Two separate alkaline battery packs are used: the one for the motor consists of eight 12-volt stacks wired in parallel, while the stack for the controller consists of a single 12-volt stack. This allows the controller to operate the unit until the complete exhaustion of the motor battery pack. The motor sits inside the housing with its shaft parallel to the length of the PVC pipe, so a 90-degree gear coupling to the drive pulley is required. During development we encountered several problems with the motor binding under load because of this arrangement. This problem was finally resolved by not rigidly mounting the motor and gearing mechanism, but instead allowing for some play in the shaft coupling. A better design would be to use a larger diameter PVC pipe and mount the motor perpendicular to it so that the motor and the drive pulley are on the same shaft. Total cost of the profiler (not including the sensors) was approximately $5000.

The profiler was successfully deployed at a site in 56 m of water in southern Lake Michigan on July 31, 2001 and retrieved in mid-September. The profiler made over 500 successful profiles before the batteries were depleted. Observations were made between 1 meter above the bottom and approximately 15m below the surface. The observations clearly show that the thickness of the benthic nepheloid layer changes with the phase of the internal inertial waves.

MON

OS12A-115 1330h POSTER

HydroDAS: Multi-Instrument Data Acquisition, Integration and Control System for Oceanographic Platforms Such as Profilers, Moorings, and Towed or Autonomous Vehicles

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HOBI Labs has developed an extremely versatile, compact, low-power, oceanographic multi-instrument integration and control system called HydroDAS. HydroDAS can simultaneously distribute power through 12 independently-switched outputs, and communicate with any combination of up to 11 serial digital, 16 analog, and 4 frequency-output instruments. Additional instruments can be integrated into the system by daisy-chaining HydroDAS units. HydroDAS supports a wide range of system configurations. It can operate autonomously, for example as a mooring controller, handling power distribution from external batteries and storing data in its expandable flash memory. In these applications, the HydroScript programming language provides complete control over the data collection schedule and allows adapting to almost any instrument protocol. HydroDAS can also be used for real-time control and data handling in a profiling package, receiving power and handling bi-directional integrated data in real time over 2-conductor cables several km long. A sophisticated Windows host program allows users to easily connect to and address individual instruments. The host program can store merged data into a single archive file, or store the data in individual files in the instruments native format. Moreover, the data stream of each instrument can be directed to serial ports for real-time display by the instruments host program. These functions are supported by any recent Pentium-based laptop computer with the addition of an inexpensive USB multi-port adapter. HydroDAS has been in operation on a mooring in Monterey Bay for over one year, and is routinely used in a multi-instrument profiling package that operates over a UNOLS 3-conductor winch cable. Other applications can include towed or autonomous vehicles.

URL: http://www.hobilabs.com/products/hydrodas_pages/hydrodas.html

OS12A-116 1330h POSTER

A Smart Submersible Chemical Analyzer for Moored Profiling and Deployment on Other Autonomous Remote Monitoring Platforms

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An in situ nutrient analyzer has been developed for autonomous observations of fine-scale nutrient gradients in the water column. The compact MiniNutrient Analyzer is a key new technology in the ORCAS remotely moored, bottom-up profiling system being developed in collaboration with the URI Graduate School of Oceanography. The sensitive MiniNutrient analyzer is designed to provide high-resolution vertical profiles of nutrients in real-time (1 reading per second) at trace concentration levels (nanomolar to micromolar).

The MiniNutrient Analyzers are comprised to two modules 1) a four channel spectrophotometric reagent delivery and optical detection module and 2) a reservoir for reagents and standards. A variety of nutrients and trace metals can be determined with this instrumentation using methodologies for continuous flow analysis and spectrophotometric detection that have been optimized for rapid in situ measurements. A new generation of flow-through spectrophotometric absorption cells was developed for the MiniNutrient analyzer. The 15 cm long ChemStar cells have a 1 mm internal diameter that dramatically decreases the volumetric requirements of the analyzer. This reduction in volume, in turn, dramatically reduces the energy requirements, reagent use, and overall package size. The instrument operation, as well as data acquisition and transfer, are controlled by an on-board processor. Techniques have been developed that allow the in situ calibration necessary for un-attended autonomous operation. These developments place the size and power requirements of the analyzers to the point where they can be incorporated into remote, battery powered platforms such as moored bottom-up profilers or autonomous underwater vehicles. The instruments capabilities for the determination of nitrite, nitrate, and iron have been demonstrated in the laboratory and during ORCAS field tests.

URL: http://www.subchem.com

OS12A-117 1330h POSTER

In Situ Mapping of Horizontal and Vertical Nutrient Gradients in Narragansett Bay, RI

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Natural and anthropogenic events can lead to remarkable spatial and temporal variability in marine nutrient distributions. Dissolved inorganic nutrients, like nitrate and nitrite, may significantly enhance or limit phytoplankton growth in estuarine waters. Strong nutrient gradients are often associated with marine eutrophication, hypoxia, and harmful algal blooms in coastal waters. Unfortunately, traditional techniques for sampling and analysis of nutrients have a limited capability to define estuarine nutrient gradients. We have developed a submersible towed chemical profiling system that allows us, in real-time, to define spatial nutrient gradients with high resolution. The XZ-Profiler consists of 1) a fast-response nutrient analyzer, the SubChemPak Analyzer, 2) a CTD system with oxygen, pH, (Sea-Bird Electronics), 3) a suite of bio-optical sensors (WET Labs, Inc.) and, 4) an Acrobat light weight tow vehicle (Sea Sciences, Inc.).

The XZ-Profiler was recently deployed in upper Narragansett Bay and the Providence River, RI to investigate estuarine nutrient gradients and phytoplankton dynamics. The sensitive SubChemPak Analyzer was configured for simultaneous determination of dissolved nitrite, nitrate, and iron. The real-time, two-dimensional, multi-parametric data collected during this survey revealed steep vertical and horizontal concentration gradients in upper Narragansett Bay that would have been poorly defined, or perhaps missed, by traditional water sampling techniques. Nutrient, chlorophyll, pH and oxygen distributions in the study region were strongly influenced by the localized discharge plume from the Fields Point Sewage Treatment Plant.

URL: http://www.subchem.com

OS12A-118 1330h POSTER

A Profiling Mooring for Fine-scale Biogeochemical Observations of the Water Column

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A "bottom-up" profiling mooring was developed to provide autonomous observations of fine-scale distributions of physical, chemical and bio-optical properties in the water. The profiler consists of an intelligent winch with integrated battery pack mounted to a positively buoyant frame with a master controller/data handler, a wireless data transceiver, and an instrumentation suite. Two versions of the profiler were deployed in Pensacola Bay Florida, in September 2001. A "mini" profiler consisted of a minimal sensor package that includes a CTD, a dissolved oxygen probe, a fluorometer, and a scattering sensor. A larger "maxi" profiler includes all the measurements of the mini profiler and also provides additional interfaces for an in-water spectrophotometer, a multi-nutrient analyzer, and a downwelling irradiance sensor. Initial results demonstrate the mini profilers' ability to track in-water events over space and time.

OS12A-119 1330h POSTER

New Insights from High Resolution and Long-Term Chemical Measurements with the MBARI In Situ Ultraviolet Spectrophotometer (ISUS): Optical Nitrate and Bisulfide Determinations

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Recent advances in the development of In Situ Ultraviolet Spectrophotometers (ISUS) now make it possible to rapidly collect UV spectra with wavelength resolution better than 1 nm for extended periods of time. Many dissolved compounds of interest to oceanographers and limnologists, e.g., nitrate, nitrite, bisulfide, bromide, iodide, thiosulfate, and organic material, absorb UV light. Each of these compounds has a unique absorption spectrum, which allows individual components in complex mixtures to be quantified using numerical methods to deconvolve the spectra.

The MBARI ISUS has been successfully deployed in a variety of diverse environments and operational modes. Profiling data will be shown from deployments on an Autonomous Underwater Vehicle (AUV) within Monterey Bay and in the Arctic, towed undulating vehicles off Monterey Bay (Sea Sciences Acrobat) and off the Oregon coast (Chelsea SeaSoar), and vertical casts on a CTD/Rosette system. Data from long-term (6 month) mooring deployments in the equatorial Pacific and Monterey Bay, as well as real-time seafloor observations above a cold seep in the Monterey Bay using a Remotely Operated Vehicle (ROV), illustrate the dynamic capabilities of ISUS to characterize a broad range of important environments.

Characterization of spatial and temporal variability of dissolved chemicals is greatly enhanced by the ability to measure concentrations directly with no chemical manipulation and with a temporal resolution of approximately 1 second. In this poster, we will focus on the new scientific insights that are derived from these data sets.

OS12A-120 1330h POSTER

SCIMS - A Semi-Autonomous System for Sampling and Extraction of Surfactants in the Sea-Surface Microlayer

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Sea surface films affect the air-sea exchange of heat, mass, and momentum. The occurrence, spatial distribution, concentration and composition of sea surface films are not well known. A new survey tool, SCIMS (Slick Chemical Identification and Measurement System), that detects the presence of surface microlayer films and allows mapping of their spatial and temporal distributions, has been developed. SCIMS consists of a surface microlayer skimmer that is coupled to a fluorometry package and an automated extraction interface. It is used in conjunction with an ion trap mass spectrometer to study microlayer film accumulations and their specific composition. Deployed on a remotely-piloted catamaran, SCIMS processes the skimmer flow stream, carrying out cyclical, microscale solid-phase extraction, concentration, desalting, and elution of microlayer surface-active organics for short-term archiving in an autosampler-compatible vial array. The time-series 'snapshots' of the extracted microlayer are then processed by a shipboard ion trap mass spectrometer to develop the surface compositional profile of the area surveyed by the skimmer, with a temporal resolution of about ten minutes. SCIMS also provides real-time measurements of microlayer and subsurface colored dissolved organic matter (CDOM) fluorescence with 1-second resolution. The remote vehicle is a thirteen-foot catamaran supporting an instrument platform on which the SCIMS package, GPS unit, battery banks, and solid-state chargers are mounted. Twin radio-controlled electric motors and servo-driven rudders provide propulsion and steering. In addition to SCIMS, the vehicle carries a flux measurement system consisting of a 2-D sonic anemometer and relative humidity gauge mounted on a 3-meter mast as well as subsurface temperature and conductivity probes. Communications and real-time control of SCIMS operations are made via wireless LAN components mounted on the catamaran and the support vessel. In deployments, the vehicle has proved to be highly maneuverable in winds up to 6 m/s. Endurance is about 6 hours and limited mainly by the current drain of the propulsion system. Examples of time-series surface film enrichment and mass spectra collected during two recent field deployments will be presented.

OS12A-121 1330h POSTER

Spectrophotometric pCO2 Measurements Based on a Long Pathlength Liquid-Core Waveguide in the South Atlantic Bight

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We developed a spectrophotometric pCO2 sensor based on a long pathlength liquid-core waveguide. This fiber-optic sensor is configured to measure pCO2 across the air-sea boundary. The heart of the sensor is a low refractive index (RI) amorphous fluoropolymer tubing (Teflon AF), which serves as both a CO2-permeable membrane and a long pathlength liquid-core (an acid/base indicator with carbonate buffer solution) waveguide to detect pCO2. A spectrophotometer detects the light intensities at the wavelengths of indicator acid and base peaks in spectrum plus a reference wavelength when CO2 molecules in sample water or air diffuse through Teflon AF membrane and its indicator core establishes pH equilibrium. The intensities at three wavelengths are then converted to the sensor's response by using intensity ratios. Good reproducibility and stability are achieved by using this multiple-wavelength technique. The sensor has two pronounced features: fast response (about 2 min. to reach 99% response) due to high permeability of the Teflon AF, and high precision (2 to 3 atm in the pCO2 range of 200 to 500 atm) because of the long pathlength (20 cm). The precision was limited by the quality of the spectrophotometer we used. The small sample volume needed for CO2 measurement makes the sensor particularly suitable for the study of CO2 variation on small spatial and temporal scales.

The sensor was evaluated during an underway survey of surface seawater pCO2 along a transect off the Georgia coast in December 2000. The results were comparable to the standard shower head equilibrator plus infrared detector method. The surface water pCO2 decreased quickly in the offshore direction from 520 to 270 atm. The corresponding air-sea CO2 flux calculation reveals that in the offshore direction, the surface seawater varied from a weak source (about 15 mmol m-2 day-1) to a strong sink of CO2 (about 70 mmol m-2 day-1) relative to the atmosphere. Overall, this area acted as a net sink for atmospheric CO2 during this survey. The weak source of CO2 is believed to be a result of salt-marsh output along the GA coast. Several possible mechanisms are discussed to explain the low pCO2 offshore and the net sink for atmospheric CO2.

OS12A-122 1330h POSTER

Continuous, Real-Time Determination Of Hyperspectral Absorption Of Colored Dissolved Organic Material

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Rapid characterization of CDOM over relevant time and space scales is important for characterization of coastal processes. Water just offshore in the 'coastal zone' can vary rapidly both in space and time between 'blue', clear water to dark, loaded water. Standard methods for determining the absorption of CDOM are laborious and susceptible to interference, and are therefore not conducive to providing the temporal and spatial resolution desired. To improve spatial and temporal resolution and to minimize variability due to sampling, storage and analysis techniques, a real-time, automated system was developed based on a liquid waveguide capillary cell and a fiber-optic spectrometer. New technologies in sample handling and optical characterization incorporated in the automated system reduced user involvement and greatly increased spatial and temporal coverage. The CDOM mapper was tested during two summer seasons at the Rutgers University LEO-15 study site and during the ECOHAB: Florida process cruise in October 2001. Concurrent discrete water samples were collected, filtered and stored at regular sampling stations for laboratory analysis of CDOM absorption. Additionally, vertical profiles of CDOM absorption were conducted using a commercial, hyperspectral absorption meter during the ECOHAB: Florida cruise. Contour maps of CDOM absorption spectra in surface waters generally showed strong cross-shelf gradients. The LEO-15 results contained small-scale features in the mapped absorption that indicated boundaries where terrestrially derived water met oceanic water. Similarly, in the ECOHAB: Florida results there were distinct boundaries between bloom and non-bloom waters. The results to be presented suggest that the CDOM mapper may be applicable to routine high- resolution (time, space and spectral) characterization of CDOM absorption.

OS12A-123 1330h POSTER

Interpretation of Observations of Trans-spectral Phenomena Acquired Using Hyperspectral Sensors Aboard a Remotely Operated Vehicle in Exuma Sound

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Hyper-spectral (512-channel) optical data acquired during a relatively deep (102m) dive of our ROSEBUD Remotely Operated Vehicle (ROV) in the clear waters of Exuma Sound, Bahamas provided the opportunity to investigate the trans-spectral shift of photonic energy (inelastic scattering) as a function of water depth. Results show a convolution of several spectral processes (e.g. absorption, scattering) involving water molecules, dissolved material and particulates as well as trans-spectral (inelastic) processes involving fluorescence by water molecules (Raman), dissolved material and chlorophyll.

The spectral signatures of these convolved causes and effects allow deconvolution with a hyperspectral approach. Intrinsic to the deconvolution was the ability to position the vehicle at depths where Raman fluorescence dominated at red wavelengths. Results show that the calculated Raman absorption coefficients are generally consistent with historical values (i.e. 0.9E-4 at 525 nm excitation) and that an angstrum exponent of 5 is more appropriate than the often cited value of 4.

OS12A-124 1330h POSTER

Laser-Induced Fluorescence Measurements of Natural and Anthropogenic Organic Compounds in Coastal Marine Sediments

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High-resolution, in situ techniques are needed to investigate the biogeochemistry of natural and anthropogenic organic compounds in coastal marine sediments due to their high spatial and temporal variability in these dynamic regions. Fluorescence provides a direct, fast, high-resolution technique for characterizing and quantifying fluorescent compounds such as natural humic substances and anthropogenically-derived polycyclic aromatic hydrocarbons (PAHs). However, using fluorescence to quantify organic compounds on solid environmental media usually encounters considerable analytical difficulties due to the high degree of heterogeneity in solid matrices.

We have developed a time-resolved, laser-induced fluorescence system for studying organic compounds in situ in coastal marine sediments. The system is designed to deliver UV laser radiation via fiber optics to a probe placed directly in the sediments and to detect the resulting emission spectrum at various nanosecond delays after the laser pulse. Additionally, we have found that reflectance and surface area are the most influential matrix factors affecting fluorescence response, and therefore a comprehensive but simple calibration method has been developed to correct for matrix variations. A good linear correlation (R2=0.91) has been found between corrected 0 nsec delay fluorescence and total organic carbon (TOC) for 57 sediments from four US estuaries. While a scatter plot of corrected 32 nsec delay fluorescence and total extractable hydrocarbons for selected samples from contaminated sites indicates a nice linear correlation (R2=0.92), fluorescence also correlates well with total PAHs (the sum of 16 EPA priority PAHs) and some individual PAHs (e.g. pyrene) for the same sample set. In addition, 32 nsec delay fluorescence has been used successfully to predict the vertical profile of total extractable hydrocarbons in a sediment core from Savin Hill Cove mudflat in Boston Harbor, MA. Corrected fluorescence indicates a subsurface maximum between 1940 and 1970, agreeing with the pollution history of Boston Harbor. All the results indicate that with appropriate matrix-correction methods, the fiber-optic, time-resolved, laser-induced fluorescence system can be used for fast, high-resolution and in situ determination of TOC and PAHs in coastal marine sediments under realistic environmental conditions.

OS12A-125 1330h POSTER

The DGT–A Device for Measuring Dissolved Trace Elements in Fresh and Ocean Water?

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Water column sampling and biotic sampling (e.g., NOAA's Mussel Watch Project) are two common methods for determining pollutant concentrations and trends in the coastal ocean and the streams that flow to the ocean. Shortcomings associated with water column sampling include: 1) the ambiguity regarding the definition of dissolved versus particulate phases (usually operationally defined as what passes through filters with pore sizes varying between 0.2 to 1 μm), 2) each sample represents only a "snapshot" in time, and 3) often toxic pollutant concentrations are less than the detection limit. Biotic sampling addresses these problems to some degree, however, interspecies, intersite, and even interseasonal comparisons at a single site are frequently unreliable. Moreover, it is difficult to determine what portion of the bioaccumulated pollutant is associated with the dissolved and particulate phases. The inadequacies of water column and biotic sampling, particularly dissolved species, suggest that an in situ, time-integrating, passive sampler would be useful for measuring pollutant concentrations and trends in the aquatic environment. In the last 5 years, a passive sampler has been developed that is reported to work in ocean and fresh water using diffusive gradients in thin films (DGT) to measure labile trace elements. DGTs have the added advantage that they obviate such techniques as flow injection analysis (FIA) to preconcentrate low-level pollutants and to circumvent seawater matrix problems associated with ICP-MS analysis. We deployed DGTs in the Ala Wai Canal, a subtropical urban estuary in Honolulu, Hawaii. Additional DGTs were deployed at two freshwater stations within the largest subwatershed of the Ala Wai Canal. This study compares the time-integrated results of dissolved trace elements obtained from DGTs with the results of our discrete sampling program conducted over the last 3 years during base-flow and stormflow conditions with the objective of determining if DGTs are acceptable sampling devices for these diverse environments. Our preliminary analysis of the data appears promising suggesting that DGTs may be reliable for providing time-integrated dissolved trace element concentrations in both fresh and ocean waters.

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OS12A-126 1330h POSTER

In Situ Sulfur Speciation Using Au/Hg Microelectrodes as an aid to Microbial Characterization of an Intertidal Salt Marsh Microbial Mat

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Sulfur speciation was determined *in situ* in a mid-Atlantic salt marsh microbial mat using a solid-state gold-amalgam voltammetric microelectrode. Chemical constituents were measured in real time with no sample manipulation or processing. A transition from O_2 to partially oxidized sulfur species (polysulfides, thiosulfate, and elemental sulfur) to H_2S was detected through the mat. Metal oxidation (Fe and Mn) of hydrogen sulfide did not occur in the mat, where microbially mediated processes are responsible for H_2S oxidation. The $\sim$7 mm thick mat was frozen *in situ* and cryomicrotome-sectioned into 20-micron sections for visual and molecular biological analyses of the microbial community. The upper 3.16 mm of the mat was dominated by a filamentous morphotype while the lower 3.59 mm was dominated by a rod morphotype. The shift between the two morphologies corresponded to a zone of transition between $S_8/S_2O_3{}^{2-}$ and $S_x{}^{2-}$.

OS12A-127 1330h POSTER

Advances in Fluorescence Imaging of the Sea Floor

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Many seafloor organisms and substrates fluoresce, and images of that fluorescence can provide a view of the benthos that is significantly different than that provided by black and white or color reflected-light imaging. Recent field studies have shown that fluorescence imaging can reveal the presence of organisms that are

otherwise too small or too well camouflaged to be seen, and that the spectral imagery data can be used to classify seafloor features by functional group. Fluorescence may provide insight into physiological state and/or process. A variety of approaches to in situ fluorescence imaging now exist, in varying degrees of technological complexity and maturity. Techniques include: viewing by the human eye, 35 mm film photography, daytime conventional and digital photography, multispectral digital photography, multispectral intensified video and two approaches to laser-induced fluorescence imaging. Each technique has its own capabilities and constraints, but all face the same challenges posed by the variability of fluorescence excitation and response in natural scenes. This presentation will provide a summary of the sources of fluorescence on the sea floor, the principles of fluorescence imaging, recent developments in fluorescence imaging techniques, and examples of practical scientific applications of the imagery.

OS12A-128 1330h POSTER

New Developments in Imaging and Deployment of the Video Plankton Recorder

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The Video Plankton Recorder (VPR) is an underwater video microscope that images plankton and seston in the size range of 100 microns to 5 centimeters. The VPR system previously has included up to four analog video cameras and has been towed at 2-8 knots by various sized research vessels. Smaller self-contained VPRs have been deployed on CTD casts, MOCNESS tows, and on an autonomous bottom mounted winch. New developments in VPR technology have included: 1) a new three-axis undulating towfish, 2) a high-resolution 10-bit digital camera (1K×1K pixels at 30 frames/sec) for the towed VPR, 3) improved image analysis and display software, and 4) deployment from an autonomous underwater vehicle (AUV).

The three-axis towfish is designed to be towed at speeds up to 10 knots using vessels ranging in size from 15 to >100m in length. The new towfish can be launched off the stern of the vessel and then flown off to the side out of the wake using a tail rudder, while maintaining a horizontal image volume using two independent tail flaps. The new towfish greatly increases the horizontal resolution of the VPR. A 1-meter separation between camera and strobe reduces flow disturbances to the image volume. The new digital camera increases the high magnification imaged volume by over an order of magnitude and improves the contrast. New software has been developed that automatically sorts the plankton images and plots the distributional patterns in real time. The VPR also has been incorporated into the REMUS AUV as a first step in mapping 2 and 3-dimensional taxa-specific plankton distributions autonomously from remote areas. An analog VPR together with strobe and digital video recorder were developed as a modular unit that is inserted into the REMUS body. This unit together with the REMUS' on-board CTD and ADCP allow for autonomous mapping of plankton, hydrography, and currents. These new VPR developments enable rapid interactive and remote autonomous mapping of planktonic taxa.

OS12A-129 1330h POSTER

Measuring Zooplankton With the Laser-OPC: the Next Generation of OPC

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Optical Plankton Counters have been in service for over 10 years and have provided scientists with a wide range of measurement variability and flexibility. It has been mounted a a variety of platforms: Batfish, moorings, Scanfish, inside nets, V-fins, MOCNESS and BIONESS, and a variety of custom vehicles. OPC measurements have included total plankton biomass, size distributions and isolated size ranges which include, for example, only Calanus spp.. The next generation of OPC, the LOPC, uses a thin-ribbon laser beam and provides advantages of 1) reduced coincidence (X10), 2) smaller size, 3) measurement of shape profile of sizes >1mm, 4) lower detection sizes (100 microns) and 5) measurement of flow. Intercomparisons are made with plankton net profiles using and LOPC mounted inside a net of 74 micron mesh. The LOPC demonstrates higher size discrimination capability of plankton, particularly in the sze ranges corresponding to Calanus spp. where their shape profiles are simultaneously measured. By adding a wider (5X) tunnel to body, the LOPC becomes an efficient tool for measuring euphausiids by providing their shape profiles in real-time. Other LOPC deployment methods are presented, particularly the Moving Vessel Profiler where the LOPC is towed at speeds of 12-14 kts.

OS12A-130 1330h POSTER

An Optical Biosensor for Marine Microbial Process Studies: Development Phase II

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Progress in the design and development of a compact and portable fiber optic biosensor is presented. When fully operational this renewable system will detect hybridization of nucleic acids on the surface of an optical fiber to quantitatively assay for the abundance and expression of specific genes in mixed microbial communities.

Current prototypes use a flow cell to expose the sensing fiber to target molecules extracted from sampled bacterial cells. The flow cell permits exposure of a probe-coated surface to sample extracts, alternating with wash and regeneration solutions. Its small size is amenable to either temperature or chemical-composition control of hybridization stringency. Our current, third-generation prototype uses a microbore capillary (ID =1mm, OD, 1.040 mm) as the flow cell. The inside surface of the sensing capillary is coated with probe molecules and the fiber-optic waveguide is coupled to the end of the fluid filled capillary. The excitation source is an inexpensive 3 mW solid-state laser diode operating at a wavelength of 532 $\pm$ 1 nm. Hybridization is detected by an array of fibers coupled to a compact photomultiplier, as a fluorescence signal that preferentially departs the capillary at 90^{o} to the capillary axis. A competitive hybridization approach is used to measure the abundance of unlabelled sample rRNA or rDNA. As of this date, the biosensor sensitivity is at least 0.001 μg/ml. We hope to improve this sensitivity by more than an order of magnitude.

We are also working on a programmable fluid and data handling system, which will allow for automation of measurements, increased sample reproducibility, and reduced sample-processing time. Our goal is a biosensor with sufficient sensitivity to detect: 1) specific bacteria (rRNA targeted); 2) a specific gene associated with a metabolic function (DNA targeted); or 3) the expression of a specific gene associated with a metabolic function (mRNA targeted) in small, easily processed samples, even when the genes are not particularly abundant.

OS12A-131 1330h POSTER

The Use of Flow Cytometry to Anaylze Large Phytoplankton Cells (>5um) Measured During the CoOP WEST Project in Northern California.

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Coastal upwelling systems are generally dominated by larger phytoplankton cells (>5um diatoms) during episodic bloom events. In order to examine these populations, flow cytometry was used as a tool, along with microscopic counts to quantify these phytoplankton bloom communities between near-shore and offshore areas along the northern California coast (CoOP-WEST - Wind Events and Shelf Transport Project). The instrument we are using is a Cytobuoy (Dubelaar Research Instruments Engineering, The Netherlands), which was originally designed for in situ autonomous deployment. The Cytobuoy measures forward light scatter, side scatter, and three fluorescence characteristics: yellow fluorescence (549-588nm), orange fluorescence (607-646nm) and red fluorescence (665-685nm) using a green laser for pigment excitation (532nm). The data buffer is 64 kilobytes for each of the 5 detectors and typically contains between 1500-4500 particle pulses, while samples are processed at a fixed sampling rate of 0.273ml/min. The unique feature with this instrument is its ability to characterize the larger phytoplankton cells (1-256um), versus the traditional flow cytometers, which specialize in the small picoplankton cells (Synechococcus sp. and Prochlorococcus sp.). The Cytobuoy was used during our second field season (2001), which featured strong upwelling pulses followed by short periods of relaxation events. The data shown here will include a time series set of measurements made at the central mooring site (D2) over the period of one month (17 May 14 June 2001). We were able to resolve the phytoplankton community size structure from 1.8um up to over 100um - as well as able to distinguish solitary phytoplankton cells from chain forming diatom cells. Phytoplankton fluorescent signals, fluorescent ratios, distribution and species identification will be discussed.

OS12A-132 1330h POSTER

Challenges in Sampling Plankton Structure and Composition at Critical Scales in the Coastal Ocean

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Application of high resolution optical and acoustical techniques has shown that plankton can form temporally and spatially persistent structures at far finer scales than could be sampled just a few years ago. These techniques have also demonstrated that plankton biomass at a given depth can change over very short time scales in response to both physical processes (lateral advection, internal waves, frontal circulation) and organism behavior (vertical migration). These results raise the question of whether the plankton composition also varies at similar finescales? To address this question, we have examined the spectral characteristics of scattered light and sound collected by high-resolution profilers. Observed differences in spectral signatures imply that the phytoplankton and zooplankton size structure and taxonomic composition are also changing at over the similar temporal and spatial scales as the biomass. Testing this hypothesis requires the development of rapid, high-resolution sampling methods which utilize real-time environmental and biological sensing to direct collection of the samples needed for detailed species level taxonomic analyses. Such samples also will be critical to conducting biological process studies needed to understand the biological importance of finescale structures and the mechanisms that control their dynamics.

OS12A-133 1330h POSTER

The Role of the Autonomous Vertically Profiling Plankton Observatory (AVPPO) in the FRONT Project, Block Island, NY

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The Autonomous Vertically Profiling Plankton Observatory (AVPPO) is designed to collect data on the vertical position and taxonomic composition of the plankton together with ancillary environmental data on spatial scales of microns to 100 m in high-energy Shelf regions of the ocean. The profiler consists of a Video

Plankton Recorder (VPR), a wavelet encoding VCR, transmissometer (AC-9), fluorometer, down and upwelling spectral radiometers, conductivity and temperature sensors, and a computer to act as a controller and data logger. A buoyant package containing the VPR and environmental sensors rests in a bottom-mounted winch housing. Throughout a profile data are transmitted to shore via a cellphone modem and displayed on a real-time website. Since October 2, 2001 AVPPO has been profiling to the surface and telemetering data four times per day with the exception that on one day a week it conducts 24 profiles. Between October 2 and November 7, 2001 we have 288 profiles of hydrography and plankton distribution from the FRONT site. Typically, a highly stratified water column with fresher, warmer surface water typically extends to a depth of 25 m and becomes more well mixed at tidal frequencies. Hydrographic features clearly define distinct plankton communities existing above the pycnocline, dominated by the copepod Acartia sp, and below the pycnocline, dominated by the copepods Calanus sp. and Temora sp. Between October 22 and 26, however, a thermal and salt inversion was evident above 25 m with a distinct warm, salty water intrusion extending between 18 and 25 m in depth. This intrusion carried a plankton community unlike any previously noted either before or after the event. A variety of small plankton and dinoflagellates dominated the intrusion. The source of the intruding water mass is unknown but appears to carry organisms endemic to offshore Shelf water.

OS12A-134 1330h POSTER

Development of an AUV to Measure Bioluminescence in the Coastal Ocean

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During the summer of 2001 a modified REMUS (Remote Environmental Measuring UnitS, WHOI) AUV, measuring physical, optical and biological properties, was incorporated into a multiplatform adaptive sampling experiment at LEO-15 (Long-term Ecosystem Observatory) off the southern coast of New Jersey. The REMUS is the first of its kind in that it is the only hand deployable AUV capable of quantifying bioluminescence. Modifications to the AUV have greatly increased its applications in the field of oceanography. In addition to CTD and ADCP sensors, a new nosecone has been developed which incorporates an internal bathyphotometer (bioluminescence sensor), an external fluorometer and an external turbidity sensor. Vehicle performance, including comparisons of goal to realized velocity, heading and depth will be examined for deployments in the nearshore environment. The vehicles high temporal and spatial resolution sampling capabilities enable it to measure biological, optical and physical parameters on scales relevant to complex coastal environments. An example of this was the characterization of a tidally-driven frontal feature and the associated effect on the biological and optical loads. In an attempt to optimize AUV flight paths in quantifying small-scale features in the coastal ocean, an assessment of different sampling strategies will also be demonstrated.

OS12A-135 1330h POSTER

Life and Death in Fishy Nights: Nocturnal Predator Prey Interactions in Fish

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Non-visual predator prey interactions of nocturnal fish have been rarely studied in detail. We have shown previously that nocturnal piscivorous European catfish follow the swim path of their prey before capturing it. Ablation experiments now reveal that this behaviour is guided by the lateral line while unimpaired chemoreception is not essential. All these results were obtained in aquaria under lab conditions.

In order to investigate whether wake following is also frequently employed under more natural conditions an new technique was developed. In a larger outdoor facility with structures and areas of different water depth the swim paths of fish equipped with miniature radio transmitters was telemetrically followed. Neuronal network analysis was utilised to determine 3D positions from the derived signals.

Wake tracking is potentially an important mechanism for many organisms in aquatic systems.

OS12A-136 1330h POSTER

Digital Holographic Cinematography of the Flow Field Around Freely Swimming Copepods

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Holography overcomes the very limited depth of field of conventional focal plane imaging techniques, especially at high magnification. By recording the interference pattern generated by particles backlit with a collimated coherent light source, an in-line hologram preserves not only the shape of the particle, but also its depth location. Consequently, a single in-line hologram can be used for generating a series of in-focus planes at different depths. Using a readily available He-Ne laser and a 1000x1000 pixel digital CCD camera, this technique is used to record a holographic movie of a flow field containing a freely swimming copepod. The depth of the sample volume is 30 mm and the copepod is located at a distance of 25 mm from the camera plane of focus. The entire flow field can be reconstructed in spite of recording with a microscope objective with a depth of focus of less than 0.1 mm. Digital image reconstruction of different planes is performed numerically using the far field diffraction approximation. A comparison of the reconstructed image to focal plane imaging of a certain plane confirms that the images are similar. The differential movement of 15 micron seed particles between sequentially recorded images is used to determine the flow fields within each of the reconstructed planes. The results clearly show the feeding current generated by the copepod, and the movement of the swimming appendages generating these currents. Different currents in other planes within the sample volume are also reconstructed. Inherently, holography is significantly less accurate in measuring "out of plane motion," i.e. in a direction parallel to the optical axis of the recording beam, compared to in-plane motion. To obtain accurate measurements of all three velocity components, we simultaneously record on the same hologram two perpendicular views of the same sample area. The simple procedure is based on inserting a mirror aligned at 45 degrees to the incident beam in the sample volume. In the region that the incident and reflected beams overlap, each particle is illuminated twice in perpendicular directions. The resulting two views enable us to perform accurate three dimensional particle tracking. Preliminary results showing the flow field around freely swimming copepod within this system are presented.

Project is sponsored by NSF and ONR

URL: http://www.me.jhu.edu/∼lefd/shc/shc.htm

OS12A-137 1330h POSTER

A Wide-Dynamic Range Profiling Radiometer for Measuring Downwelling UV Irradiance Underwater

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The potential for increased ultraviolet (UV) exposure resulting from ozone depletion has fueled interest in obtaining accurate in-water measurements of UV irradiance. In the water column, the flux in the UV becomes a vanishingly small signal that must be measured in the presence of a much larger visible component. In addition, the flux of UV in natural waters may be influenced greatly by changes in solar elevation and or from focusing/defocusing by surface waves. For these reasons, an instrument that accurately measures the flux of UV in air will not work as well when submerged, and a number of elements must be optimized to produce instruments for use underwater. In response, Biospherical Instruments Inc. has produced the PUV-2500 Profiling Ultraviolet Radiometer. The system is designed to collect time series or vertical profiles of UV and Photosynthetically Active Radiation (PAR: broadband 400-700 nm) irradiance underwater to depths of 350 meters. The PUV-2500 is designed to measure downwelling irradiance with a response capability exceeding nine decades of dynamic range, as well as pressure/depth, and water temperature. The instrument combines a UV optimized cosine collector with a high-speed data acquisition system and advanced electronics in a compact, rugged design. The standard optical configuration is equipped with seven highly stable solid-state filter-photodetectors with center wavelengths at 305, 313, 320, 340, 380, 395 nm, PAR for measurements of downwelling irradiance and a single photodetector for measurements of chlorophyll upwelling Natural Fluorescence.

Highly versatile because of its small size and lightweight design, the PUV-2500 can be used in traditional vertical profiling mode (surrounded by a lowering frame and supported by its own cable) or, by employing our new free-fall design option, in free-descent mode, thereby avoiding problems caused by ship shadows.

MON

OS12A-138 1330h POSTER

Devout Observations of the Water Column and of the Bottom Boundary Layer

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Abstract: An autonomous profiling vehicle was used to collect long-term oceanographic data. Thousands of profiles were completed by the small (<10 liters) vertically profiling device for a period of over a year. The collected data includes CTD, Fluorescence, and PAR. Cold bottom boundary layer fingers were observed and are tidally linked. High temporal resolution data is adequate to show the vertical migration of an isotherm in an internal wave field. The instrument supports long-term physical and biologically important observations related to coastal and nearshore dynamics including tide and surface gravity wave amplitudes. The addition of radio transmission for data recovery and GPS for geographical position greatly reduce the logistics associated with long-term data sets. Data from deployments as shallow as 4 meters are presented.

OS12A-139 1330h POSTER

New Atmospheric Instrumentation for Ocean Buoys

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We have developed and tested three instruments that can be autonomously deployed on ocean buoys to collect time-series data sets on the chemical composition of the atmosphere near the ocean surface. These instruments include (1) an aerosol sampler/analyzer, (2) a rain water collector/iron analyzer and (3) an ozone analyzer. The aerosol instrument is capable of collecting 20 samples on filters over periods of days to weeks to months. The sensor is an x-ray fluorescence spectrometer (XRF-S) which can make quantitative and non-destructive measurements of the elemental concentrations of filter-embedded aerosols. Specifically, we are interested in determining the atmospheric concentrations of particulate Fe, Ca, Si, K and S in real time. Fe and Si are excellent indicators of mineral dust, S has both biogenic, seasalt and anthropogenic sources and Ca and K have mineral and seasalt sources. The second instrument collects rainwater and makes in situ colorimetric measurements of dissolved Fe (II) and total reducible Fe concentrations using two long-pathlength spectrometers. The third instrument uses a dual beam photometer to measure precise concentrations of ozone, an important trace gas in the atmosphere. Ozone data from buoys can provide useful information on the long-distance transport of anthropogenic emissions across ocean basins. This poster will provide engineering details of the three instruments as well as time-series data from tests on a buoy in local waters.

OS12A-140 1330h POSTER

Instumentation for in Situ and Autonomous Monitoring of the Marine Carbon Dioxide System

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To provide a greater understanding of the oceanic carbon cycle we have developed new instrumentation to operate in challenging environments. The challenge has been physical - to obtain long term measurements of the carbon dioxide system under ice or in the deep ocean; or logistical to measure seawater over long time periods from ships of opportunity and large scale mesocosm studies in natural systems. We describe colorometric and spectrophotometric instrumentation for the measurement of seawater pH and pCO2 and detail there utilization in many fields of ocean research. Shipboard pH measurements have a precision of 0.0065 pH units with a measurement frequency of 20 samples per hour. The method has been adapted for measurements from moorings and CTD to 4000m. Seawater pCO2 instrumentation from moorings has been used for year-long underice measurements in the Labrador Sea and in studies of coccolithophore carbon dynamics in a North Atlantic Eddy. Both underway seawater pH and pCO2 are measured from a ship of opportunity in the Nordic Seas and on monthly transects across the North Atlantic from Denmark to Greenland. An additional experiment has used the instrumentation in mesocosm studies to monitor the carbon dynamics of natural phytoplankton assemblies under varying atmospheric carbon dioxide scenarios.

OS12A-141 1330h POSTER

Comparison of Monte Carlo Model Predictions with Tank Beam Spread Experiments Using a Maalox Phase Function Obtained with Volume Scattering Function Instruments.

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The volume scattering function (VSF) is an inherent optical property (IOP) fundamental to the characterization of light attenuation in aquatic environments. It is a difficult IOP to measure in situ because light scatter relative to propagation direction is highly peaked in the forward direction, thus, measurement across the necessary angular range from 0-180 degrees requires a method that is sensitive over a dynamic range spanning at least 4 to 5 orders of magnitude. Immediate Navy requirements for a means of accurately measuring the VSF include evaluating LiDAR (light detection and ranging) system performance and underwater visibility studies.

We compare Monte Carlo simulations with the results of simple laboratory experiment using a measured Maalox (an over the counter antacid consisting of aluminum and magnesium hydroxides) phase function. Both the forward beam intensity distributions and angular backscatter results are presented. Maalox phase functions were measured in the small forward angle direction from 0.1 to 17 degrees with a custom table top VSF instrument and from 5 to 170 degrees using an in situ VSF instrument, HydroBeta, developed by HOBI Labs, Inc. The accuracy of the table top instrument was verified by comparing measurement of the VSF for various sized NIST traceable standard polystyrene microspheres under conditions of single scattering with Mie theory predictions.

Excellent agreement between HydroBeta and several previous independent measurements of Maalox yields confidence in the instrumentation's measurement capability. Field data was collected with the HydroBeta during the HyCODE summer 2001 experiment off the coast of Tuckerton, New Jersey. In situ VSF profile data are required as inputs to LiDAR Performance Prediction Models. The next step is to analyze the influence of variability in the water column VSF in the observed range of clear to turbid coastal regimes in conjunction with concurrently measured LiDAR returns.

OS12A-142 1330h POSTER

An Autonomous Ozone Instrument for Atmospheric Measurements from Ocean Buoys

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Atmospheric ozone is both a necessary oxidant and (at high concentrations) a pollutant. Because of its adverse health effects, there are numerous monitoring stations on land but none over the oceans. We have built an ozone instrument for deployment anywhere at sea from ocean buoys, to study ozone chemistry over the oceans, intercontinental transport of pollution, diurnal and seasonal cycles of ozone, and for baseline and long-term time series measurements of ozone in remote locations. The instrument uses direct (Beer's Law) absorption of UV radiation in a dual-path cell, with ambient and ozone-free air alternately switched between the two paths, to measure ozone. The instrument has been packaged for deployment at sea, and tested on a 3-meter discus buoy with other instruments in coastal waters. We will show the details of the instrument, laboratory and buoy test data from its first deployment, evaluation of its performance, plans for improvements, and plans for future science missions.

OS12A-143 1330h POSTER

Bottom Stationed Ocean Profiler

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Stratification provides a major influence on the littoral zone ocean circulation. This is true for all regions of the continental shelf from the shelf break to the inner-shelf. Ship surveys are costly, slow, and manpower intensive. A more convenient, cost effective, and timely means is required. We are developing a set of profiling floats for the continental shelf that park on the bottom when not in use. The concept is to have a complete continental shelf array of such floats that profile and telemeter their data via satellite on a regular basis, for use in mapping fields and assimilating these fields into nowcast/forecast models. By parking on the bottom between cycles, each profiler will be able to maintain station on scales comparable to the large-scale field resolution. These floats will have immediate application to the WFS models and field programs that require such data. In view of the need for such data on all continental shelves, we would envision extensive use of this technology elsewhere. Other applications could include: Low cost, low maintenance, surveillance of the coastal waters of hostile nations; Ability to monitor temperature gradients, currents, optical characteristics and chemistry; and Unique capability for monitoring coastal physical/chemical responses to storms.

Our Bottom Stationed Ocean Profiler (BSOP) is a drifting sensor package designed for use in the littoral environment. It follows from previous drifting system developments (Davis, et al. 1992); the significant difference being the ability to hold general position by stationing on the sea floor. The profilers are equipped with a transmitter for relaying data, a buoyancy adjustement system, a power supply, an emergency abort device, and controlling electronics including microcontroller. Nominally outfitted with a CTD the BSOP goal is to provide relatively inexpensive, synoptically sampled, near real-time profiles for mapping large-scale material property fields and assimilation of these data into models. Other applications with advanced chemical, biological, physical, and optical sensors easily accomodated and are in development for broad-based adaptive sampling. The goal is to have a versatile system with interchangeable/programmable applications, while striving for modest cost to enable large-scale deployments.

OS12A-144 1330h POSTER

Self-shading of Buoyed Radiometers in Optically Shallow Water

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Upwelling radiance measurements made with instruments designed to float at the sea surface are shaded both by the instrument housing and by the buoy that holds the instrument. The amount of shading is wavelength dependent and is affected by the local marine and atmospheric conditions. For optically shallow waters, the effect of water depth and bottom albedo on this shading can be significant. Radiance measurements made with such instruments should be corrected for this self-shading error before being applied to remote sensing calibrations or remote sensing algorithm validation. We present results of Monte Carlo simulations that quantify the self-shading of a commercially available buoyed radiometer for various water depths and bottom types, and we also provide an algorithm to correct for the self-shading effect. The approach can be easily adapted to the dimensions of other instruments.

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Direct Measurements of the Water-following Characteristics of Surface Drifters

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The water-following capabilities of two commonly-used surface drifters, the CMOD (without case) and the CODE, and a new drifter design (MICROSTAR) were assessed by making direct measurements of the effects of wind and waves on their movements.

The surface drifters were equipped with acoustic velocimeters and with GPS receivers, without changing significantly their hydro-dynamical characteristics (e.g., size, buoyancy and drag area). The velocimeters measured the relative water flow at 1-2 locations near the body of the drifter with an accuracy of about 1 cm/s and with sampling frequency of 1 Hz. The GPS receivers provided high accuracy ($\sim$ 1 m) position data at 1 Hz. All the data were recorded on a datalogger and memory board inside the drifters. The three drifters were deployed in the vicinity of a waverider buoy in Monterey Bay on 5, 6, 7, 8, 11 and 12 December 2000. The waverider buoy provided significant wave height and wave direction data every 30 min. Each day, the drifters remained in the water for 3-5 hours before they were recovered. The ship used for the deployment/recovery operations was fitted with a meteorological station to collect wind data close to the drifters with a sampling interval of 10 min. Wind speeds when the drifters were in water ranged in 0.5 - 8 m/s whereas significant wave height varied between 0.8 and 2.5 m.

Over the 3-5 hour drift, the drifters deployed at the same location dispersed by less than 500 m (relative separation) with an obvious tendency of the CMOD to move more downwind that the others. The relative

speeds measured by the acoustic velocimeters and averaged over 10 min intervals were as large as 10 cm/s for the CMOD with r.m.s. variability of about 15 cm/s. For the CODE and MICROSTAR drifters, the 10-min averaged slips were bounded by 5 cm/s and their typical r.m.s. variability was 5 cm/s. Substantial values of shear between the top and bottom of the CODE and MICROSTAR drifters $\sim$ 1 m apart) were measured (up to 5 cm/s).

Regression were performed between the 10-min averaged relative flow data, the wind and wave observations. It was found that the CMOD drifter slips downwind (0.3% of wind speed) and to the right of wind (0.9%). The slip of the CODE and MICROSTAR drifters has no significant trend in the downwind direction whereas it increases like 0.1-0.2% of the wind speed in the cross-wind direction (to the right). The regressions of slip versus wave height did not provide significant linear trends, mostly because of the short range of wave heights and the dominance of wind effects, but a general tendency of upwave motion can be noted for the CODE/MICROSTAR drifters. Finally, regressions of shear (velocity at the top minus velocity at bottom) versus wind and wave data revealed that the shear is downwind and to the right of the wind (compatible with Ekman spiral!), and increases with wind speed with a slope of 0.3-0.5% of the wind speed. Regressions against wave data were inconclusive, although most estimates of shear were downwave (compatible with Stokes drift!).

In brief, the CODE and MICROSTAR were demonstrated to follow relatively well the surface water with an accuracy of about 1 cm/s in 10 m/s winds. In contrast, the CMOD design (without case) was shown to slip downwind by about 0.3% of the wind speed.

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Evaluation of a 75 kHz RDI Ocean Surveyor Shipboard ADCP by Comparison With an RDI 150KHz Narrow Band ADCP

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During a recent transit from Florida to Rhode Island, simultaneous single-ping data were recorded from two acoustic Doppler current profilers on the R/V Endeavor: an old 150-kHz narrow bandwidth (NB) model, and a new 75-kHz model (Ocean Surveyor: OS) with a flat phased-array transducer, operating alternately in narrow bandwidth (OSN) and broad bandwidth (OSB) modes. In calm weather the NB, OSN, and OSB data showed nearly perfect agreement, but the range of the OSN (up to 800 m) was about twice that of the NB, and the OSB range was about 85% of the OSN range. As weather worsened, the returns from all three degraded, with reduced depth range and with occasional pings returning no valid velocity estimates. Reduction in data return was most severe in the OSB, least severe in the NB. Performance degradation was associated with a velocity bias towards zero in both the OSB and OSN relative to the NB; we believe this problem can be solved with improved single-ping editing and averaging algorithms. Beam sidelobes were 12-15 db higher in this OS than in the NB.

URL: http://currents.soest.hawaii.edu/reports/endeavor_report/index.html

OS12A-96 1330h POSTER

Simultaneous Turbulence Measurements of Suspended Sediment Concentration and Velocity with an Acoustic Doppler Velocimeter

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To analyze erosion processes, we deployed a pair of acoustic Doppler velocimeters *in situ* which simultaneously measured velocity (proportional to the Doppler shift) and suspended sediment concentration (proportional to the acoustic backscatter intensity) at turbulent time scales. The instruments were located within one meter of the cohesive sediment bed of a partially stratified estuary. Pumped and filtered water samples provided empirical calibration to convert acoustic backscatter intensity to suspended sediment concentration. We estimated the uncertainty of these acoustically-derived suspended sediment concentration measurements by applying statistical theory and comparing the acoustic measurements with optical backscatter sensors. These simultaneous, high frequency measurements of velocity and suspended sediment concentration enable investigation of (1) the high frequency variability in suspended sediment concentration correlated with coherent turbulent structures, (2) the inverse relationship between salinity stratification and erosive flux, and (3) the replacement of empirical erosion models with direct measurements as the bottom boundary condition in suspended sediment modeling.

OS12A-97 1330h POSTER

Comparison of Surface Current Measurements by Different HF Radar Systems With Each Other and With ADCP Current Measurements

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The ground-wave HF radar method of ocean surface current measurement can be implemented in several different ways, using compact or distributed array antennas, single or multiple operating frequencies and beamforming or MUSIC signal processing. On Monterey Bay during autumn, 2000 (NOPP ICON project) and off Chesapeake Bay in autumn, 1997 (Chesapeake Bay Plume Outflow Experiment, COPE-3) different HF radar systems observed the same ocean region. In COPE-3 relevant ADCP current measurements were also available. We have used these data sets to compare measurements from different systems with each other and with ADCP measurements. The complex correlation method of Kundu is used where the (u,v) current components are transformed to a complex number (u + iv). Three models are used to characterize the relationship between the quantities being compared (X and Y), namely: Y = X + e0, Y = X + b0 + e1 and Y = aX + b1 + e2. Here, es are noise, b0 is a bias, a is a scaling factor and b1 an offset. Comparison studies on Monterey Bay used current measurements from SeaSonde (compact antennas, single frequency, MUSIC processing) and Multifrequency Coastal Radar, MCR (distributed antennas, multiple frequencies, MUSIC and beamforming processing) systems located near Santa Cruz (Long Marine Laboratory) and Moss Landing (Moss Landing Marine Laboratory) California. Both a small region comparison around the M1 buoy in Monterey Bay and an area comparison over Monterey Bay were used. The small area comparison showed a very high (0.95) correlation between the two radar systems using either MUSIC or beamforming processing with the MCR system. The error between the two radar systems was some 3 or 4 cm/s. As a larger region is examined, the error between the two systems increases for regions where the look geometry and/or signal to noise ratio are less favorable. However, a large region of Monterey Bay has an error between the two systems of less than 10 cm/s. The error between the two systems is composed of both systematic (a and b) and random (e) errors as noted above. We discuss potential sources of systematic error that are not corrected in these studies, e.g. the use of different operating frequencies and antenna pattern corrections. In summary we find that surface current measurements by the SeaSonde and MCR systems are consistent. Systematic errors between the two systems can probably be reduced by compensation for different operating frequencies and antenna pattern corrections.

OS12A-98 1330h POSTER

High Frequency Radar Measurements of Currents in Lake Michigan as part of the Episodic Events Great Lakes Experiment

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Over the past decade, High Frequency (HF) radar has become an important tool for mapping the waves and currents of the coastal ocean. During this time, its use over fresh water has been limited due to propagation loss and the dynamic conditions of fetch-limited water bodies. During the Episodic Events Great Lakes Experiment (EEGLE) two Multifrequency Coastal Radars (MCR's), operating between 4.8 MHz and 21.8 MHz, were installed on the southeast shore of Lake Michigan in concert with several meteorological stations and in-situ current measurement devices. Data from the 1998 through 2000 observations demonstrate HF radar as a useful current measurement tool over fresh water to a range in excess of 15 km when wind speeds at the center of the lake exceed 5 m/s. The measurements provide sufficient spatial and temporal detail to discern small changes in the flow field as a result of various physical forcing mechanisms such as wind and thermal front development. In addition, the measurements compare well with both in-situ instrumentation in the form of ADCPs and surface met buoys. Finally, the results are compared to preliminary hind-cast output from the Lake Michigan Princeton Ocean Model (POM) showing a strong correlation between the measurements and model hindcast.

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How Accurate are Total Vector Surface Currents from a Single HF Radar Site?

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When used as intended, high frequency (HF) radars resolve orthogonal velocity components of ocean surface currents by working in pairs. However, power outages or equipment failures occasionally render individual radars inoperative, leaving the user with surface current measurements from only one site. Since individual HF radars measure currents in polar coordinates, i.e. in range and bearing, it is possible to compute total vector surface currents from one HF radar by choosing an area close to the radar, which is large enough to contain nearly orthogonal velocity measurements. Total vector surface currents computed in this way may be used to fill gaps in time series, or to provide estimates of currents nearer to shore than is usually possible with a two-site HF radar configuration. A long term deployment of as many as 5 CODAR-type HF radars in the Santa Barbara Channel and Santa Maria Basin, off the central coast of California, coincides with the deployment of an array of moored and bottom mounted current meters. These current meters provide comparison data for evaluating total vector currents computed from individual CODAR HF radars.

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