Environmental Characterization of Mine Countermeasure Test Ranges: Hydrography and Water Column Optics

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Grant Number: N00014-01-1-0040

LONG-TERM GOALS

We wish to observe the hydrographic factors that regulate optical changes in near-shore water columns and support companion laser imaging system tests. The physical, biological and optical oceanographic data developed under this project will be used as input to optical and environmental models to assess the performance characteristics of laser imaging systems. Our long-term goals concern the ability of optical imaging systems to detect man-made objects placed on the seafloor, and the effects of biological fouling to confound the discrimination of objects from the environmental background.

OBJECTIVES

We proposed to characterize the physical, biological and optical fields present during deployments of the Streak Tube Imaging Lidar (STIL, Arete Associates) and two Laser Line Scanner systems (EOID, Raytheon Corp. and AQS-14, Northrop-Grumman). Our environmental characterization efforts were closely coordinated with Dr. Charles Mazel (measurements of benthic optical properties) and Dr. Ken Voss (measurements of the benthic bi-directional reflectance distribution function, water column point spread function and scattering phase function). Our data would also be valuable for sensor characterization and evaluation of sensor performance models.

APPROACH

Our field efforts centered on: 1) deployments of upward looking ADCP and near-bottom CTD/optics moorings along a transect within the test range, 2) ship based underway surface measurements of physical, biological and optical properties, 3) ship based station profiling and discrete water sampling as a function of depth for physical, biological and optical properties of the water column and 4) acquisition of 1km resolution satellite images for sea surface temperature and albedo (AVHRR) and ocean color parameters (SeaWiFS) in order to describe mesoscale oceanographic conditions present during the tests.

Report Documentation Page

Report Documentation Page	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE **30 SEP 2002**	2. REPORT TYPE	3. DATES COVERED **00-00-2002 to 00-00-2002**

4. TITLE AND SUBTITLE **Environmental Characterization of Mine Countermeasure Test Ranges: Hydrography and Water Column Optics**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Bigelow Laboratory for Ocean Sciences,,180 McKown Point,,W. Boothbay Harbor,,ME, 04575**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

We wish to observe the hydrographic factors that regulate optical changes in near-shore water columns and support companion laser imaging system tests. The physical, biological and optical oceanographic data developed under this project will be used as input to optical and environmental models to assess the performance characteristics of laser imaging systems. Our long-term goals concern the ability of optical imaging systems to detect man-made objects placed on the seafloor, and the effects of biological fouling to confound the discrimination of objects from the environmental background.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

WORK COMPLETED

Field work off Panama City, FL, was performed aboard R/V Edwin Link from August 12 to 24, 2001. This year has been spent processing and distributing data to our project partners, rectifying data quality issues and production of a final data report for submission to the modelers.

13 days of bottom mounted ADCP/CTD/optics records at ten minute intervals (two sites)

41 ac9/CTD profiles at main transect site

41 discrete Niskin bottle casts for particulate and dissolved absorption, pigments and TSS

23 profiles of spectral downwelling irradiance (E_d) and upwelling radiance (E_u)

1 standard deviation experiment for Joint Environmental Model inputs

12 days of SeaWiFS ocean color coverage in the month of August, 2001

1 sensor inter-calibration experiment of Boothbay Harbor, ME.

To summarize the data processing accomplished this year:

two complete, intercalibrated 18 parameter mooring data sets

all CTD, ac9Plus and PRR600S data binned to 0.25m and expressed as altitude above bottom

chlorophyll, TSS, particulate and dissolved absorption dataset completed

ac9Plus and PRR600S standard deviation experiment processed and evaluated.

RESULTS

General results of the field measurements have been reported previously. A major concern for the system performance modelers was the presence of a near-bottom turbidity layer of variable thickness and concentration throughout the experiment. We were asked to recalculate our profile data as altitude above the bottom rather than depth in order to assist the modelers in the calculation of attenuation length as an environmental characteristic of their imaging runs. We also incorporated our near-bottom optical mooring measurements (0.36m altitude) to discern patterns in the nature of the turbidity layer. Figure 1 shows 532nm time series data for moorings and ac9 casts, surface ac9 values are relatively constant while near-bottom attenuation is highly variable and up to an order of magnitude higher than surface values. Figure 2 shows the companion absorption and scattering values from only the ac9 casts, scattering presumably due to resuspension of bottom sediments was responsible for the observed increases in attenuation. While on board ship, we performed a series of three optical profiling casts to determine the standard deviation of parameters as a function of environmental conditions consistent with our operational protocols. The Standard Deviation Experiment included the ac9Plus, MicroCTD and PRR600S. Three casts were performed in quick succession on a calm seas/clear sky day with all operational protocols followed (power-up, cleaning, immersion and recovery). The PRR600S data were presented as sensor dark current prior to lowering on deck, 5m data, surface data, maximum depth data, surface data and sensor dark current after recovery on deck and depth. The data were averaged and the standard deviation determined for all records logged at a fixed depth. Standard deviation of calculated vertical attenuation coefficients were calculated from the three casts since fixed depth measurements do not allow calculations of ‘k’. The same procedure was followed for ac9 casts, results for both up and down casts are shown in Figure 3. In general, standard deviations were well below 10% in the upper layers where variability was low, but increased with depth as the profiling instruments encountered the 'turbidicline' that occurred near the bottom. Even though the three casts were accomplished in about a half hour, internal wave or surf action in the shallow water column caused the boundary layer to move vertically resulting in higher standard deviations within this vertical region. These standard error estimates of the environmental parameters were to be used in evaluation of environmental and system performance models.

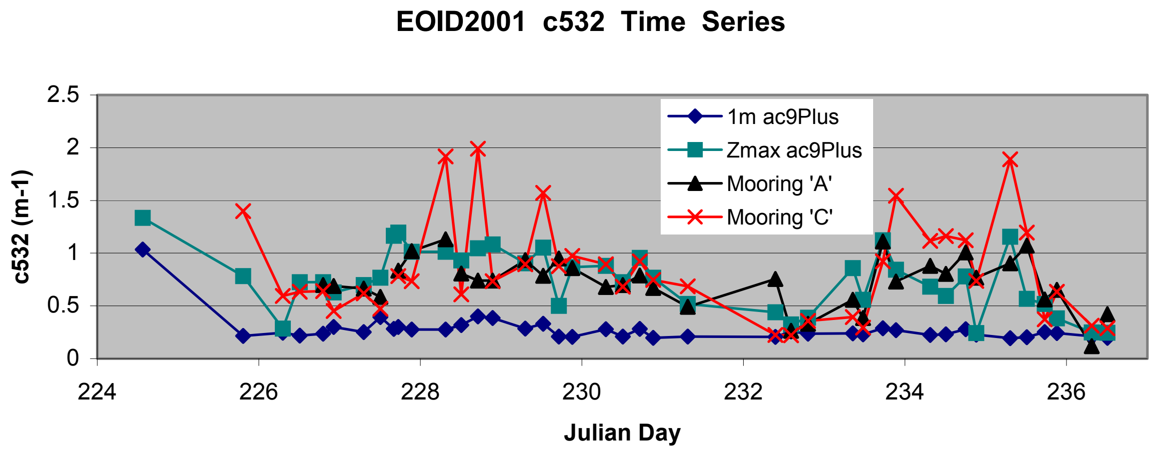

Figure 1. Time series of c532 (m^{-1}) At the EOID test range from profiles and moorings. Near-bottom attenuation within the turbid layer measured at the maximum depth of the ac9 casts and 0.36m off the bottom by moorings A and C is higher and more variable than surface attenuation.

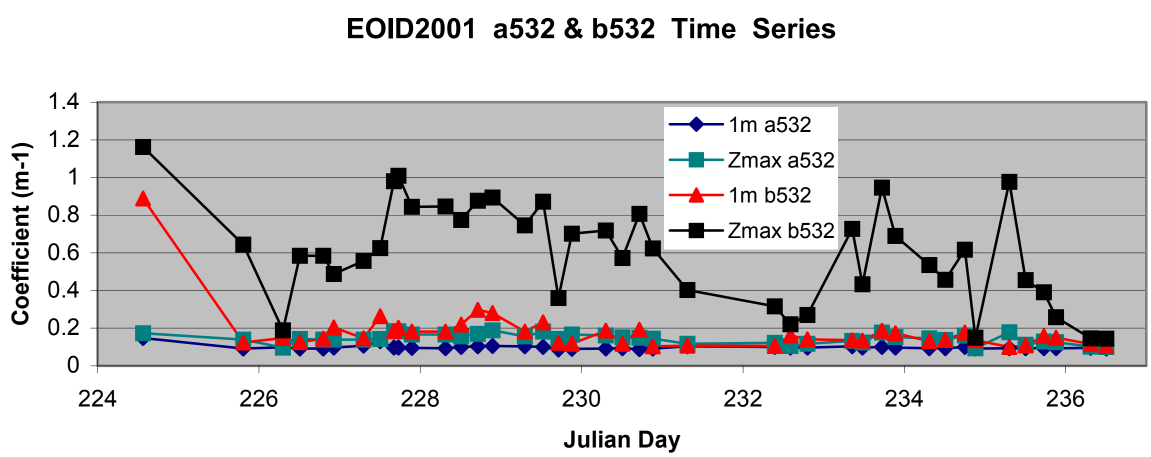

Figure 2. Time series of absorption and scattering coefficients at 532nm from ac9 profiles at the EOID test range. Increased scattering (factor of 4 to 5) due to resuspension of benthic sediments in the near-bottom layer was responsible for increases in attenuation seen in Figure 1. Absorption in both the surface and near-bottom layers were comparable to scattering in the surface layer.

IMPACT/APPLICATIONS

This work is an important aspect of the transition of laser imaging systems to the fleet for mine countermeasure operations. Our environmental data will contribute significantly to the models that will evaluate and predict sensor performance in a wide variety of operational scenarios. These models require accurate water column optical property data in order to quantify image quality parameters.

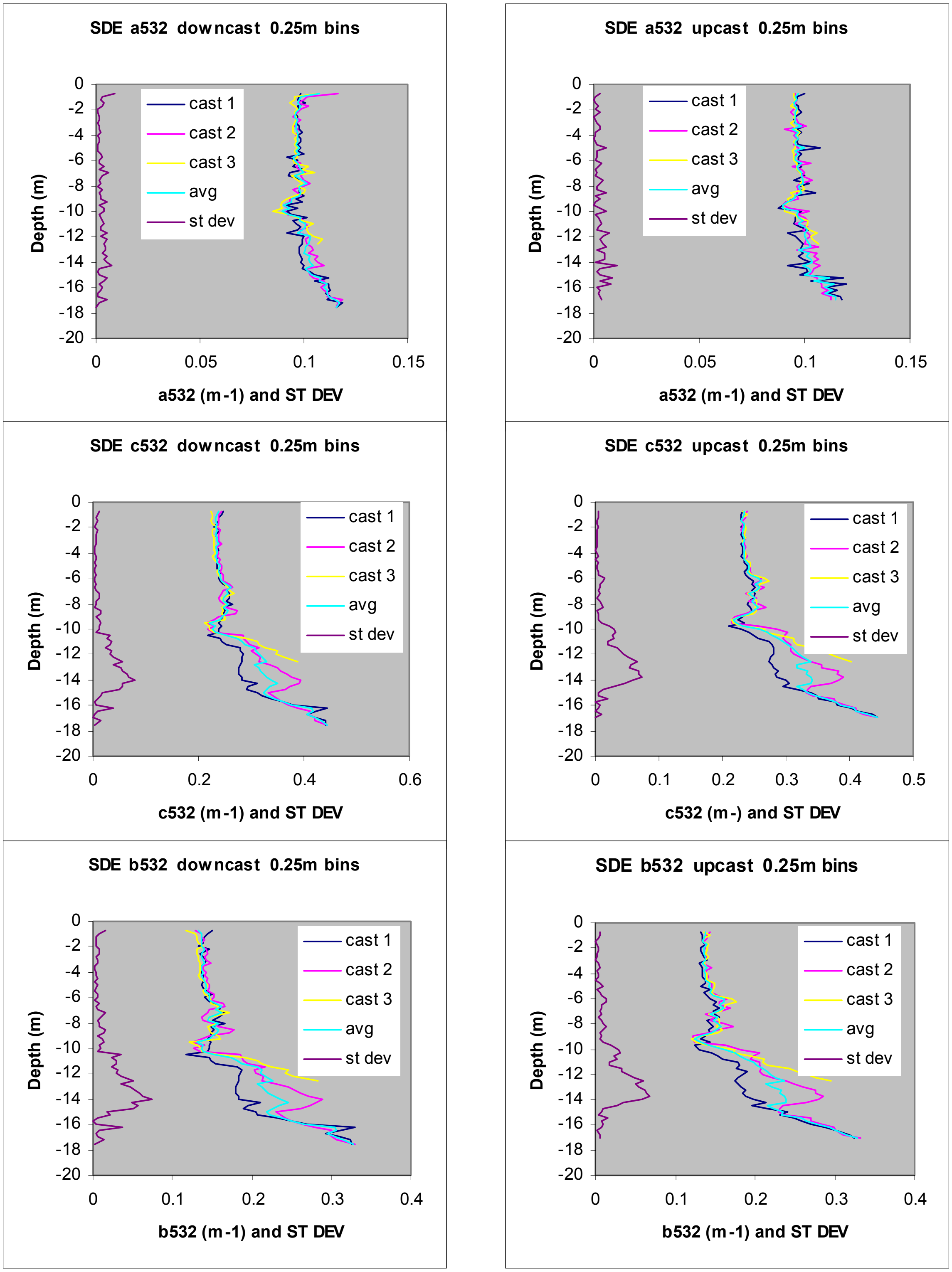

Figure 3. Standard Deviation Experiment data from the three casts with averages and calculated standard deviations. Standard deviation increased within the turbidity boundary layer for b and c.

TRANSITIONS

The complete dataset has been transitioned to the Electro-Optic Identification (EOID) Research program as part of the Joint Environmental Model and System Performance Model plans. All data of appropriate formats have been submitted to ONR's World Ocean Optics Database at APL, Johns Hopkins University and NASA's SeaBASS ocean color database.

RELATED PROJECTS

This project was closely coupled with the work of Mazel (Psicorp, Inc.) and Voss (University of Miami) for the environmental characterizations in collaboration with a large group from the Navy's Coastal System Station, Panama City, FL. Metron, Inc. (Reston, VA) was responsible for data management as well as environmental and performance model development. Other modelers included Strand (CSS, Panama City) and the laser imaging system vendors (Arete, Raytheon and Northrop-Grumman).

PUBLICATIONS

D'Sa, E.J., J.B. Zaitzeff, C.S. Yentsch, J.L. Miller and R. Ives. 2001. Rapid remote assessment of salinity and ocean color in Florida Bay. In: The Everglades, Florida Bay and Coral Reefs of the Florida Keys: An Ecosystem Source Book. J.W. Porter and K.G Porter (eds.), CRC Press, NY, pp. 451-460.

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