The Secretary of the Navy/Chief of Naval Operations Chair in Oceanographic Sciences

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LONG-TERM GOALS

The overall long-term goals of this work are to facilitate interactions between the academic community and researchers supporting the operating fleet, to accelerate ongoing research, and to enhance the educational value of my teaching of undergraduate and graduate students.

OBJECTIVES

The general long-term research objective for this work is to advance understanding and predictive capabilities in three areas:

1) upper ocean physical, bio-optical, and biogeochemical responses to intense wind events including hurricanes and typhoons,
2) coastal optics, physical thermodynamics and dynamics, turbulence, internal gravity waves, sediment transport, and harmful algal blooms, and
3) the physical, bio-optical, and biogeochemical dynamics of ocean mesoscale eddies.

The overall educational objective is to contribute to the development of undergraduate and graduate students, especially those who will seek careers in the ocean sciences.

The overall transitional objective is to stimulate new interactions among academic and Navy laboratory ocean scientists who support fleet operations.

APPROACH

The approach for achieving the research goals is to utilize and build upon ongoing interdisciplinary research in the areas of coastal optics and physics, upper ocean response to hurricanes, and mesoscale eddies. Both field and modeling efforts are involved in these activities. One of the key efforts centers upon the ONR Radiance in a Dynamic Ocean (RaDyO) program described below. Other work utilizes data sets previously collected off Bermuda and Hawaii, which are also discussed below.

WORK COMPLETED

The Chair funding began in late September 2008. I have continued my work on the physical and biogeochemical responses of hurricanes with a graduate student, Jennifer Sirak, through Chair funding along with other members of my group. We are utilizing several data sets collected over the past several years from the Bermuda Testbed Mooring (BTM), located off Bermuda and near the Bermuda Atlantic Time Series (BATS) site. In addition, we are collaborating with other observationalists and modelers to better understand the relevant processes and develop improved parameterizations that are needed for better predictive capabilities. These efforts bear on various naval operations in adverse weather and sea-state conditions. A recent paper by Black and Dickey (2008) describes some of the recent hurricane research.

I am the lead PI for the ONR-sponsored Radiance in a Dynamic Ocean (RaDyO) program (Figure 1). A primary goal of RaDyO is to develop models capable of predicting the relationships among several optical properties and environmental factors as well as enabling improved models for imaging applications. In this work, we are studying the propagation of light across the air-sea interface and into and exiting the surface and upper ocean boundary layers. The first field experiment (benign sea-state conditions) was conducted in the Santa Barbara Channel in September 2008 and the second field experiment (high sea-state conditions) off Hawaii is presently underway (August-September 2009). Preliminary results from the former experiment are described in an overview paper that is being prepared at present and are summarized in a separate ONR report on the RaDyO activity. I have led both field efforts and coordinated the organization of data, special sessions at meetings, and editing special journal publications for the project. A comprehensive website for RaDyO (www.opl.ucsb.edu/radyo/) has been developed and expanded. Graduate student Francesco Nencioli contributed to the RaDyO experiment by collecting optical and physical data from R/P FLIP in the Santa Barbara Channel. Graduate student Jen Sirak, is presently collecting data from R/V Kilo Moana for RaDyO during the Hawaii experiment. RaDyO results will be valuable for fleet operations involving visibility and imagery aspects. An overview paper for the Santa Barbara Channel RaDyO field experiment is being drafted at present and I anticipate coordinating a collection of papers on RaDyO results for the Journal of Geophysical Research.

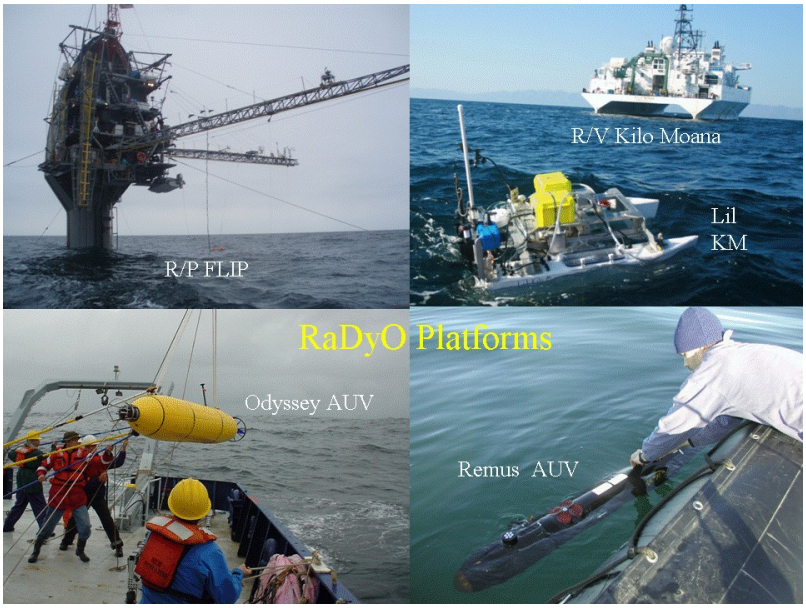

Figure 1. Platforms used for the RaDyO Santa Barbara Channel experiment, August 2008.

Mesoscale eddies and their roles in biogeochemical cycling have been studied with my graduate student, Francesco Nencioli through Chair funding, collaborators, and other members of my group. This research involves data sets collected off Hawaii during the NSF E-FLUX experiment. Again, interdisciplinary modeling of these eddies is a major thrust of the research. Papers written on biogeochemical cycling are listed below (i.e., see Dong et al., 2009; Honda et al., 2009; Lomas et al., 2009, Nencioli et al., 2009a,b). This research is of interest to naval operations in the presence of mesoscale features in the ocean.

I have continued my leadership in optimizing interdisciplinary observing systems, which bear on naval applications. Papers in this area (see below) include Dickey et al. (2008, 2009) and Dickey (2009).

Educational efforts have included the mentoring of two graduate students, Francesco Nencioli and Jen Sirak, who are funded through the Chair. In addition, I continue to teach a large introductory oceanography class (200-300 students) and bring my research activities and experiences into the classroom.

IMPACT/APPLICATIONS

We anticipate several impacts. For example, RaDyO will include the examination of spectral time-dependent oceanic radiance distributions in relation to dynamic surface boundary layer (SBL) processes, construction of a radiance-based SBL model, validation of the model with field observations, and investigation of the feasibility of inverting the model to yield SBL light conditions. These activities bear on understanding and predicting impacts of SBL processes and ocean biogeochemistry and ecology on the underwater light field, imaging, and thus operational problems involving naval operations. The feasibility of obtaining ocean surface estimates using underwater camera data will be explored. The work in the areas of upper ocean responses to hurricanes and mesoscale eddies will be valuable for improving predictive models of fundamental oceanographic processes and are of naval interest.

TRANSITIONS

There are no transitions yet. However, we anticipate that major transitions will develop in the form of testing and commercialization of new sensors by RaDyO collaborators (e.g., MASCOT). We expect that the RaDyO project will accelerate interdisciplinary ocean measurement technology capabilities by 1) increasing the variety of optical variables which can be measured autonomously, 2) improving the robustness and reliability of interdisciplinary sampling systems, and developing more accurate predictive models of the optical and physical environment of the ocean. In terms of the hurricane and mesoscale eddy work, transitioning of observational methodologies and predictive model parameterizations is an expected outcome.

RELATED PROJECTS

There are several projects that taken place in the Santa Barbara Channel that relate to the RaDyO program. Spatial surface current data (using CODAR) were collected by Libe Washburn's UCSB group (http://www.icess.ucsb.edu/iog/realtime/index.php) and are useful for characterizing major current

features and passages of sub-mesoscale features and eddies; ship-based bio-optical data collected by the Plumes and Blooms Program (Dave Siegel, lead-PI; http://www.icess.ucsb.edu/PnB/PnB.html) facilitate interpretation of the RaDyO bio-optical data; surface hydrocarbon slicks and slick dynamics are being investigated (Ira Leifer and Jordan Clark, PIs; http://www.bubbleology.com/); and ship-based data collected by the Santa Barbara Channel Long-Term Ecological Research (LTER; Dan Reed, lead-PI; with focus on land-ocean margin; http://sbc.lternet.edu/) program. Mark Moline of Cal Poly collected physical and optical data in conjunction with the Santa Barbara Channel RaDyO field experiment and is now collecting data during the RaDyO Hawaii experiment. Satellite sea surface temperature and ocean color data were collected by our group, and Ben Holt (Jet Propulsion Laboratory, JPL) has collecting synthetic aperture radar (SAR) data. These remote sensing data sets along with others provide spatial context. By combining and synthesizing these data sets with ours, we will be able to describe and quantify the three-dimensional evolution of several key water quality parameters on time scales of a day to the interannual. Modelers working with us on these data sets include Charles Jones (UCSB), Leila Carvalho (UCSB), Charles Dong (UCLA), and Yi Chao (JPL).

There are several collaborative efforts that we have already in place for the hurricane/typhoon and mesoscale eddy research planned here. For example, we have been working with Steve Babin (JH/APL), Jerry Wiggert (USM), Maureen Conte (BIOS), and James Carton (U Maryland) on color changes in the wakes of hurricanes. Yi Chao and Fei Chai plan to do model simulations of our hurricane data sets and one of my graduate students, Jen Sirak, is focusing her efforts in this area. Another of my graduate students , Francesco Nencioli, is working with Charles Dong (UCLA) on interdisciplinary mesoscale modeling.

Finally, we plan to facilitate new interactions between the academic community and Navy laboratories. Potential collaborations may be generated with several Navy researchers including Bob Arnone (NRL), John Kindle (NRL), Rick Gould (NRL), Kevin Mahoney (NAVOCEANO), Jeffrey Bowles (NRL), William Snyder (NRL), Bill Shaw (NPS), Thomas Herbers (NPS), Curt Collins (NPS), Jeff Paduan (NPS), Jennifer Prentice (NAVAIR), Karen Patterson (NAVOCEANO). During the first year, I contributed a paper to the SPIE meeting in Orlando and interacted with several of the individuals mentioned above.

PUBLICATIONS

Black, W. J., and T. D. Dickey, 2008, Observations and analyses of upper ocean responses to tropical storms and hurricanes in the vicinity of Bermuda, J. Geophys. Res., doi:10.1029/2007JC004358.

Dickey, T.D., E.C. Itsweire, M. Moline, and M.J. Perry, 2008, Introduction to the Limnology and Oceanography Special Issue on Autonomous and Lagrangian Platforms and Sensors (ALPS), Limnol. Oceanogr. 53(2), Part 2: 2057-2061.

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Dickey, T., M.-C. Alboussiere, M. Banner, P. Bhandari, T. Boyd, L. Carvalho, G. Chang, Y. Chao, M. Cimono, H. Czerski, M. Darecki, C. Dong, D. Farmer, E. Firing, S. Freeman, J. Gemmrich, N. Hall-Patch, B. Holt, J. Hummon, J. Jaffe, S. Jiang, C. Jones, G. Kattawar, L. Lenain, M. Lewis, Y.

Liu, L. Logan, D. Manov, K. Melville, M. Moline, R. Morison, F. Nencioli, S. Pegau, B. Reineman, I. Robbins, R. Roettgers, H. Schultz, D. Siegel, L. Shen, M. Shinki, M. Slivkoff, M. Sokolski, P. Sutherland, F. Spada, N. Statom, D. Stramski, M. Twardowski, S. Vagle, R. Van Dommelen, K. Voss, L. Washburn, J. Wei, H. Wijesekera, O. Wurl, S. Yildiz, Y. You, D. Yue, R. Zaneveld, and C. Zappa, An introduction to the Radiance in a Dynamic Ocean (RaDyO) Santa Barbara field experiment: Physical and optical setting, to be submitted to Journal of Geophysical Research.

Dong, C, T. Mavor, F. Nencioli, S. Jiang, Y. Uchiyama, J. C. Williams, T. Dickey, M. Ondrusek, H. Zhang, D. Clark: 2009, An oceanic cyclonic eddy observed on the lee side of Lanai Island, Hawaii, accepted b Journal of Geophysical Research.

Honda, M.C., K. Sasaoka, H. Kawakamu, K. Matsumoto, S. Watanabe, and T. Dickey, 2009, Application of underwater optical data to estimation of primary productivity, submitted to Deep-Sea Research I.

Lomas, M., D. Steinberg, T. Dickey, C. Carlson, N. Nelson, R. Condon, and N. Bates,Increased ocean carbon export in the Sargasso Sea is countered by its enhanced mesopelagic attenuation, submitted to Biogeosciences.

Nencioli, F., C. Dong, T. Dickey, L. Washburn, and J.C. McWilliams, 2009a, A vector geometry based eddy detection algorithm and its pplication to a high resolution numerical model product and high-frequency radar surface velocities in the Southern California Bight, submitted to Journal of Atmospheric and Oceanic Technology.

Nencioli, F., Chang, G., Twardowski,M. and T.D. Dickey, 2009b, Optical characterization of an eddy-induced diatom bloom west of the Island of Hawaii, accepted by Biogeosciences.

HONORS/AWARDS/PRIZES

Professor Dickey was named a Secretary of the Navy/Chief of Naval Operations Chair in oceanography in 2008.

Professor Dickey was named Outstanding Professor by University of California Santa Barbara Residence Hall Association and Office of Residential Life (2009).