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Center for Coastal Physical Oceanography, Old Dominion University

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HF RADAR: Is It Ready for Prime Time?

One of the most exciting developments in oceanography is high frequency (HF) radar measurements of surface currents. These radars operate in the 10 to 100 meter wavelength band. Most of the ocean's surface wave energy is in this band. When HF radar illuminates the sea surface, a resonant backscatter, called Bragg scattering, is observed as reflection from ocean waves whose wavelength is exactly half of the radar pulse. Bragg scattering is readily detected in the backscattered radar spectrum. The intensity of the backscattered signal is related to the ocean wave spectrum and Doppler shifts of the Bragg scattering peaks are related to surface currents. Applications of this technology to current observations have received the most attention in recent years.

HF radar measurements of surface currents require two or more radar sites, scattering from hundreds of wave crests, and ensemble averaging of scattered returns. The precision and accuracy of current measurements using this approach depend on the resolution of the Doppler spectrum, system noise, geometry of the deployed antennas, and the presence of waves of appropriate wave length. These factors are not only site specific but may vary in time at specific locations. Nevertheless, scientists and engineers who work with this equipment have claimed accuracies of the order of 10 cm/sec with spatial resolution of order of 2 km or less, depending on the system and site specific factors. However, the question of precision and spatial resolution is still open. For example, the *Journal of Geophysical Research* (102(C8), 18,737-18,766, 1997) has two articles which give a detailed comparison of one type of HF radar with conventional measurements.

Although these measurements have been made successfully for over 40 years and commercial systems are now available, they have never been part of "main stream" oceanographic measurements. There are many reasons for this. First, there is a cultural gap between the pioneers of the technology, who were mostly engineers, and oceanographers who try to use. Also noted above, it is difficult to quantify the errors and resolution of the measurements. Also, the systems are expensive and difficult to operate. Finally, since the horizontal resolution available from HF radar is much

finer than traditional oceanographic measurements, most oceanographers have had little experience with observing currents and processes on these scales.

Recent developments suggest this situation is changing. Oceanographers at Oregon State University and the University of Hawaii recently have procured HF radar systems. This fall, a major experiment involving these radars will take place in Chesapeake Bay and adjacent coastal waters. Scientists from the University of Michigan, the University of Miami, the Naval Postgraduate School, and the Naval Research Laboratory will compare the current measuring capabilities of three different HF radar systems. It seems then that after nearly four decades of development, this technology is starting to emerge as an important measurement tool for oceanographers.

In order to explore methods for using HF radar observations in oceanography, a workshop was convened at CCPO on July 21-22, 1997. Scientists from Oregon State University; University of Southern Mississippi; the Naval Postgraduate School; HydroQual, Inc.; Ocean Physics Research Development; the Office of Naval Research; and Naval Facilities, Atlantic met at CCPO's facility, Crittenton Hall, to discuss the scientific and technical issues related to analyzing HF radar data and blending them with numerical models. **A. D. (Denny) KIRWAN, JR.**, meeting coordinator and professor at CCPO, opened the workshop by welcoming participants. He went on to discuss an operational scenario where HF radar would be used in Rapid Environmmental Assessment. Jeff Paduan of the Naval Postgraduate School provided a tutorial on HF radar and discussed a case study of its use in Monterey Bay. He also provided estimates on both the accuracy and resolution of these measurements. Denny then gave a short talk on the problems of blending this high resolution data with numerical models. The central issues are the radar data may provide a finer solution than most numerical models, but it generally covers only a portion of the model domain. **BRUCE LIPPHARDT, JR.**, research assistant professor, followed this with a discussion of preliminary results from attempts to blend the Monterey Bay radar and Lagrangian data from the Louisiana-Texas (LaTex) shelf with numerical models to produce maps of the surface currents. **GLEN WHELESS**, research assistant professor, gave a demonstration of visualization of data and model results from Chesapeake Bay and the LaTex shelf. Afterwards, Alan Blumberg of HydroQual discussed his attempt to blend all available data from the New York Bight and the Hudson River with the HydroQual model. Although this study did not use HF radar data, it illustrated nicely many of the issues that arise in attempting to use HF radar data with present generation models. Jim Lewis of Ocean Physics then described his experiences in assimilating the Monterey Bay HF radar data with a ``nudging'' technique into a small scale model of the Bay. A significant finding was that when he attempted to assimilate the data directly, large spurious horizontal divergences in the data degraded the assimilated product. However, when the data were first mapped using a spectral technique developed by CCPO scientists, the divergences were more realistic. The first day ended with Igor Schulman describing his work on specifying model radiation boundary conditions, optimization, and connecting large and small scale models.

CHESTER (Chet) GROSCH, professor at CCPO, led the discussion on the second day by posing seven issues that arose during the presentations from the previous day. These are:

1. The need to characterize error/noise bands in the data.
2. The need to extract and use wave information contained in the data. In some Rapid Environmental Assessment scenarios, the wave spectrum may be more important than the current data.
3. The basic radar data product is backscatter spectra. These are affected by temporal and spatial inhomogenities in the wind field. This suggests temporal/spatial moving averages might be used to advantage.
4. There is a need to establish the role of models and boundary conditions, especially when they contain coarse scale information over larger regions than the radar data. How can we include traditional oceanographic data with model boundary data?
5. There appears to be a need to perform both temporal and spatial filtering of the HF radar data. Here the approach described by Bruce Lipphardt may be useful.
6. There is a need to perform sensitivity tests for spectral fitting of the data. HF radar data will have scales that are incommensurate with many models. Is this good or bad? If good, how can we take advantage of this? If bad, how do we overcome this problem?

Following this, there was a general discussion of the advantages and disadvantages of various analysis methods and assimilation strategies. Manny Fiaderio of the Office of Naval Research summed this all up by reminding everyone of George Veronis's law: "Do not assimilate data into a model that the model cannot simulate."

Notes from the Director

DENNY KIRWAN'S article on HF radar for sensing surface currents makes us realize just how much progress we have made in the past few decades. I am just old enough to have known oceanographers who really used the Ekman current meter like the one displayed at CCPO. For you younger oceanographers, the Ekman meter dropped small balls in bins situated on a compass at the rate proportional to the current speed. By counting the number of balls in each bin and knowing the time interval, one obtained current direction and speed information. While those meters were elegant in workmanship, the information produced was valuable at the time but very limited.

Now with HF radar, we have the prospect of routinely measuring surface currents over wide areas at spatial lengths and temporal frequencies that are well within our requirements. While the application to physical oceanography is clear as is the application to military and port operations, I think the real breakthrough may be when we combine this type of information with the difficult problems of fisheres recruitment and multi-disciplinary problems.

It seems that it would be wise to get some of these systems installed semi-prermanently at several locations around the world where the data can be demonstrated, used, and turned into information that can be used by a wide variety of users. It seems clear to me that we are only beginning to see the great potential for this technology.

Larry P. Atkinson
Director, Center for Coastal Physical Oceanography

The CCPO Family

Pictured are: *First row (l-r):* Mike Fougerousse, John Holdzkom, Lisa Varner, Beverly Scott, Kris Holderied, Cathy Lascara, Glen Wheless; *Second row (l-r):* Arnoldo Valle-Levinson, Lisa Ayers, Carole Blett, Lou Codispoti, Julie Morgan, Marjy Friedrichs, Tonya Clayton; *Third row (l-r):* Kou-Chuin Wong, Lorraine Heilman, Kate Bosley, Cristobal Reyes, James Koziana, Larry Atkinson, Shelly Paraso, Bettina Fach, Chester Grosch, Ricardo Locarnini, Kurt Clemente; *Back row (l-r):* Steve Gaurin, Jun She, David Ruble, Denny Kirwan, Glenn Cota, Tom Royer, Bruce Lipphardt, Vince Kelly, Chunyan Li.

CCPO family members who where absent on CCPO picture day include: Eddie Haskell, Heather Haskell, Eileen Hofmann, John Klinck, Gary Magnuson, David Smith, Elizabeth Smith, Warren Taylor, and Anne West-Valle.

Community Outreach

Students Visit from Millersville University, Pennsylvania

Students attending a course in biological oceanography at the Marine Science Consortium (Wallops Island, VA) took time out from their busy schedule to visit CCPO for several hours on June 23, 1997. The class, taught by Dr. Julie Ambler of Millersville University, comprised of 13 students from four Pennsylvania state universities. **CATHY LASCARA**, CCPO assistant research professor, spoke with the class concerning several research projects underway at CCPO which focus on physical and biological interactions in the Chesapeake Bay. The group also received a demonstration of water-level nowcast predictions for Chesapeake Bay by **KATE BOSLEY**, a NOAA research scientist at CCPO.

Of course, no visit to CCPO is complete without a tour of the Virtual Environments Laboratory. The students thoroughly enjoyed their ``interactive immersion'' into the Chesapeake Bay Virtual Environment (CBVE), where they experienced, firsthand, the effects of winds, tides, and freshwater discharge on the circulation of the lower Bay. The CBVE application, developed by **GLEN WHELESS** and **CATHY LASCARA**, embraces the virtual world paradigm

as a new means of environmental information processing in which visualizations are projected using high-resolution, large-screen, stereographic computer display systems.

Based on the enthusiastic response of the class, it is apparent that the integration of Virtual Reality (VR) technology with oceanographic applications provides a powerful outreach tool.

Students Visit from Bloomsburg State College, Pennsylvania

On August 4, 1997, Dr. Cynthia Venn of Bloomsburg State College visited CCPO and the Department of Oceanography with 11 students from her wetlands ecology course. This course is taught at the Marine Sciences Consortium (supported by several Pennsylvania colleges) at Wallops Island.

The visit was at the invitiation of **LOUIS (Lou) CODISPOTI**, CCPO research professor, who had given a lecture at Wallops the previous week. Lou gave the students an overview of CCPO and then put the students in the capable hands of **CATHY LASCARA**, research assistant professor, and **VINCE KELLY**, graduate research assistant. Cathy gave a well-received demonstration of the "ImmersaDesk," and Vince took the students on a tour of the Department Oceanography and of the new Oceanography Building. While at the Department, **DAVE BURDIGE**, associate professor of the Department of Oceanography, met with the students to tell them about his research and about opportunities for graduate study in marine sciences at Old Dominion University.

A Birthday Surprise

LOU CODISPOTI surprised **LARRY ATKINSON** on Larry's 56th birthday, August 6, 1997. Lou and his wife, Codie, arranged to have 50 flamingos planted on Larry's front lawn at 4:00 the morning of his birthday. When Larry went outdoors to get the morning newspaper at 6:00, he found he had acquired 50 new lawn ornaments. Way to go, Lou and Codie! Nice PJs, Larry.

Alumni News

CCPO's primary goal is to provide education, training, and experience necessary to prepare students for achieving their prospective career and research aspirations. CCPO takes great pride in its students, and that pride extends beyond graduation when alumni embrace a life outside of graduate school. Below is a brief summary of a few of our alumni since the inception of CCPO in 1991. These summaries show how alumni have applied the knowledge and skills they gained during their undergraduate and graduate studies and are already facing challenges, fulfilling goals, and reaping professional rewards.

Margaret Dekshenieks, 1996

After receiving her Ph.D., **Margaret Dekshenieks** began a postdoctoral position at the University of Rhode Island's Graduate School of Oceanography. This position provides Margaret with a myriad of research opportunities. First, field efforts are focused in two separate marine environments. In a fjord system in the San Juan Island chain, Margaret and colleagues are investigating the biological and physical processes determining thin phytoplankton layer formation, and, on Georges Bank, they are working on a project designed to investigate the correlation between the fluorescence of aquatic humic substances and zooplankton abundance. Second, in the field of programming and data analysis, Margaret developed several programs which automate the data analysis process. Upon returning from field studies, the raw data from instruments (which measure both biological and physical properties (ADCP, ac9, aa9, CTD, SAFIRE etc.)) can be immediately and efficiently merged and post-processed by these programs. Finally, data sets collected by Margaret and her group, both in the field and in associated laboratory studies, are unique and can be used as a basis for modeling studies. Margaret has developed particle transport models based on the physical and biological data derived from the fjord study. Additionally, she is in the process of developing a physiologically-based model, which calculates the effects of variations in turbulence on phytoplankton abundance.

Dorlisa Hommel, 1992

Dorlisa (Lisa) Hommel has had the good fortune to have had three very different employment opportunities, all in the Washington, D.C. area, and all working with great people. The first was helping to develop a world-class oceanographic database at NOAA/NESDIS/NODC in Dupont Circle (which Lisa says is a great area of D.C. to work or play). Her second employment opportunity was at the Naval Research Laboratory (NRL), where she was introduced to Synthetic Aperature Radar as a means of studying the coastal ocean by working with images of the Gulf of Mexico. Lisa now works for NOAA/NESDIS in beautiful scenic Suitland, MD. She is currently working with near-real time weather data operating system from TIROS satellites.

William Indest, 1992

William (Bill) Indest is currently a systems engineer at Objectivity, Inc., an object-database software vendor based in Mountain View, CA. His first home brewing experience helped decorate the basement walls with hoppy stout. His daughter, Camille, and wife, Marci, are eagerly anticipating an addition to the family in November. His family still allows him a set of keys to their Fairfax, VA domicle.

Ajoy Kumar, 1995

Ajoy Kumar is a postdoctoral associate with the Remote Sensing Group at Rosenstiel School of Marine and Atmospheric Science (RSMAS), University of Miami. His research involves the analysis and improvement of retrieval algorithm from satellite-derived sea surface temperature. Ajoy said he "enjoys the work and association with a close knit of well experienced scientists." He also likes living in Miami because of the variety of people and cultures from various parts of the world, especially from Latin America, and the beautiful beaches. Miami's sunny and hot climate reminds Ajoy of his home country, India. Last December, he went to India to get married. His wife, Vrinda, is also from India, and she recently arrived in the U.S. to live with Ajoy.

Bruce L. Lipphardt, Jr., 1995

Since receiving his Ph.D. in 1995, **Bruce Lipphardt, Jr.** stayed at CCPO doing postdoctoral research and collaborating with **A. D. Kirwan, Jr.** and **C. E. Grosch**. Since completing his dissertation, Bruce has worked on developing a method for merging oceanographic data from a variety of sources, including both observations and models. This method can be used to produce maps of scalar fields (like temperature) or vector fields (like ocean currents). In addition, the method provides a useful basis for assimilating ocean observations from disparate sources into numerical models. Bruce also enjoys mountain biking, and he is restoring a 1972 Corvette convertible. Someday he may even drive it.

Julie McClean, 1993

Julie McClean is a research assistant professor in the Oceanography Department at the Naval Postgraduate School (NPS), Monterey, CA. She has been at NPS since graduating from ODU, first as a postdoctoral researcher, and then in her current position to which she was promoted in August 1995. She is part of a team (NPS, LANL, NCAR) funded by the DOE/CHAMMP program to develop high resolution ocean models for climate studies. Her contribution to this effort is to use many different types of data to verify model behavior and physics. In addition, Julie is the PI of an NSF grant comparing high resolution ocean models with WOCE data, and she is a co-PI on a NASA grant with a goal of using a combination of data and models to understand seasonal to decadal climate changes. Julie was married in 1994 and lives in Monterey with her husband, Toby, stepson Nathan, and Zack, a black Labrador.

John Moisan, 1993

John Moisan is currently in his fifth year as a postdoc in the Physical Oceanography Research Division at the Scripps Institution of Oceanography. While there, he has been working with both Drs. Peter Niiler (SIO) and Mark Abbott (Oregon State University (OSU)) on modeling both the upper ocean's heat budget and biogeochemistry. John has also been working with another CCPO alumna, Yvette Spitz, (now at OSU) to model the JGOFS time-series data sets. John's wife, Tiffany, who is an ODU Department of Oceanography alumna (M.S.), has just passed her Ph.D. qualifying

exams in Marine Biology at Scripps. At the start of 1998, both John and Tiffany will be moving to Southampton, New York, where John will begin his new position as assistant professor of physical oceanography at Long Island University. A large moving van will be needed, as both Tiffany and John have amassed a large collection of tropical plants and orchids during their stay in California. They will be making their move back east with their terrapin turtle, "Terrie," and their two cats.

Caitlin Mullen, 1994

Caitlin (Cass) Mullen is currently a member of the research staff of Arete Associates in Crystal City, VA as a physical oceanographer. Arete is a Navy government contractor which conducts research in the oceans. Some of Cass's work has involved the analyses and comparison of TOPEX/Poseidon altimeter data with in situ buoy data and the analyses and processing of all ADCP data collected from field experiments. She is also a member of the Field Experiment Team, which includes Arete's Dive and Data Analyses Teams. Cass enjoys the research and challenge of her employment at Arete; however, she has unspeakable comments regarding the commute to work from her home in Annapolis, MD every morning at 0530. She is the head coach of the United States Naval Academy's Women's Softball team and continues to jog everyday. In 1996, Cass was a NASA Astronaut Candidate Finalist. She will continue to pursue her dream of becoming an astronaut.

Andry Ratsimandresy, 1994

Immediately after graduating with a Master's degree from ODU, **Andry Ratsimandresy** went back to his country of origin, Madagascar, to visit his parents before beginning his Ph.D. studies. He spent one month in Madagascar having a good time with his family, and, at the same time, he spent some time visiting the coast and talking to people involved in marine research, especially those in fisheries and physical oceanography. This increased his interest and goals of finding future funding for a project on physical oceanography around the island. Andry is now pursuing his Ph.D. in physical oceanography at the Universidad de Las Palmas de Gran Canaria, Spain. His research assistantship is with a physical oceanography participating in an European Union funded research project. In addition to his assistantship and working on his research thesis, he is the assistant computer manager responsible for data processing and the project cruise database. Andry says his work is very interesting, as "we are now having oceanographical cruises almost every 1-1/2 months. During those cruises, we get data from XBT, CTD, and ADCP."

Yvette Spitz, 1995

Yvette Spitz is currently at Oregon State University, College of Oceanic and Atmospheric Sciences as a research associate (postdoctorate). She is working under the direction of Mark Abbott on parameter estimation for physical-biological models using the variational adjoint method. Additionally, she is developing a physical-biological model for the Southern Ocean, and she is involved in a five-year project with two universities and the Ministry in Belgium to study the eutrophication in the North Sea. Yvette is getting ready to start a project with John Allen, also of Oregon State, on Circulation and Ecosystem modeling for the Oregon Shelf in the framework of COOP/GLOBEC. In Yvette's spare time, she enjoys horseback riding on the scenic Oregon trails.

Puzzler

The purpose of the *Puzzler* is to record thought-provoking questions and problems that have appeared on comprehensive, qualifying, and candidacy exams. Readers are encouraged to submit their own favorites, as well as to attempt to answer all questions. All communications should be directed to: **wizzard@ccpo.odu.edu**. Wizzard will acknowledge the sources of all questions/problems used and will publish selected thought-provoking (not necessarily correct) answers to previous submissions.

The first puzzler question, **Question 97.1** was introduced in the last issue of *CCPO CIRCULATION* (Vol. 4, No. 3). Wizzard will first answer Question 97.1 before posing **Question 97.2** to the reader.

Answer to Question 97.1: The elastic energy stored in the spring is ultimately converted to heat when acid is released

into the box. Wizzard assigns a grade of A+ to wayne@kai.com, who also noted correctly that light (photons) can be generated as well. wayne also is reminded that it is rude to correct the spelling of a family name just to make it conform to the common noun, "wizard." Wizzard also assigns a grade of A to smichael@tec.army.mil. smichael is advised to submit answers promptly as no credit is given for late answers.

Wizzard assigns a grade of B+ to lou@ccpo.odu.edu, who got the right answer but then added that entropy would not be affected. Wizzard suggests that the dissolved compressed spring has higher entropy production than does the dissolved umcompressed spring.

Question 97.2 is a problem submitted by Benoit.Cushman-Roisin@Dartmouth.edu. A similar question was also posed by Professor R. O. Reid during A. D. Kirwan's oral candidacy exam.

Question 97.2: Consider a stably stratified ocean at rest and let molecular diffusion run its course until the ocean has a uniform temperature. The potential energy of the final state is not the same as the initial stratified state. Is it greater or less, and where did the potential energy come from or go to?

CCPO Seminar Series: Fall 1997

During the academic year, CCPO invites several distinguished scientists to prese nt seminars on topics related to coastal oceanography. The lectures take place in Room 109, Crittenton Hall, Old Dominion University on Mondays at 3:30 p.m. **Eileen Hofmann**, professor of oceanography, coordinates the lecture series with the assistance of **Beverly Scott**, office services specialist. Below is a schedule of lectu res for the fall semester 1997. For more information or to be included on the maili ng list for lecture announcements, please contact Beverly at (757) 683-4945 or beverly@ccpo.odu.edu. Specific lecture topics are announced one week prior to each lecture.

Date	Lecturer	Institute
September 8, 1997	**Eileen Hofmann**	*Center for Coastal Physical Oceanography*
September 15, 1997	**Grant Gross**	*Chesapeake Research Consortium*
September 22, 1997	**A. D. Kirwan, Jr.**	*Center for Coastal Physical Oceanography*
September 29, 1997	**Robert Diaz**	*Virginia Institute of Marine Science*
October 6, 1997	**Joan Cleveland**	*Office of Naval Research*
October 13, 1997	**Ricardo Locarnini**	*Center for Coastal Physical Oceanography*
October 20, 1997	**Richard Barber**	*Duke University Marine Laboratory*
October 27, 1997	**Paul Bissett**	*Naval Research Laboratory*
November 3, 1997	**Eddie Haskell**	*Center for Coastal Physical Oceanography*
November 10, 1997	**Jim O'Donnell**	*University of Connecticut*
November 17, 1997	**Mike Fogarty**	*Chesapeake Biological Laboratory*
November 24, 1997	**Charles Hopkinson**	*Marine Biological Laboratory, Woods Hole*

Student Profile: EDDIE HASKELL

A. G. EDWARD HASKELL graduated summa cum laude with a B.S. in marine science from Long Island University (LIU) in 1994. During Eddie's junior year at LIU, he spent 10 weeks aboard a 125' gaff rigged schooner during the school's SEAmester program. He followed that with a tropical marine biology class that took him to Tonga and Fiji. From there, Eddie spent four months in an internship at the Australian Institute of Marine Science, studying the genetic variability of corals. The research in Australia resulted in Eddie's first publication.

After receiving his B.S., Eddie spent a year working as an analytical chemist before matriculating to ODU as a non-thesis master's student under the guidance of **Fred Dobbs**, assistant professor of the Department of Oceanography. Eddie spent the summer following his first year at ODU working for **Arnoldo Valle-Levinson**, assistant professor, and Lou Codispoti, research professor, performing computer data analysis. Eddie enjoyed working on the computers so much that he decided to alter course and work on a thesis with Professor **Eileen Hofmann**. Eddie's studies involve using a time-dependent biological model to investigate the interactions of phytoplankton, copepod, and doliolid populations associated with Gulf Stream bottom intrusion features on the outer southeastern U.S. continental shelf.

During the previous school year, Eddie not only had his classes and research to occupy his time but he was also president of the Oceanography Graduate Student Organization, a substitute teaching assistant, and he worked on projects that will hopefully result in his next two publications.

Eddie's other interests focus heavily on outdoor activities including, but not limited to: rock climbing, hiking, biking, skiing, and camping. After graduation, Eddie intends to continue his education by pursuing his doctorate at the University of Rhode Island.

Kris Holderied Wins Tennis Championship

Congratulations to graduate student, **KRIS HOLDERIED** (pictured to the right). Last month, Kris won the Old Dominion University Summer Intramural Singles for Women Tennis championship. Go Kris!

Just the *facts* . . .

Appointments

E. E. HOFMANN, Editorial Board of *Journal of Marine Research*.

Grants/Contracts Awarded

G. F. COTA, "Labrador Sea Validation Cruise in Support of OCTS/SIMBIOS," $40,000, NASA.

E. A. SMITH, "Studying the Earth's Environment from Space: Classroom and Laboratory Activities with Instructor Resources," NASA Mission to Planet Earth," $83,990, co-PI is LCDR M. Alfultis, United States Coast Guard Academy.

Presentations

G. F. COTA, "Remote Sensing of Ocean Color in the Arctic: Algorithm Development Validation," First SIMBIOS Science Team Meeting, Solomons, MD, August 6-8, 1997.

G. F. COTA and W. T. Sturges, University of East Anglia, Norwich, England, "Biogenic Bromine Production and Tropospheric Ozone Depletion in the Arctic," Arctic System Science, Ocean-Atmosphere-Ice Interactions meeting, Virginia Beach, VA, May 8-10, 1997.

S. Sathyendranath and T. Platt, both of Bedford Institute of Oceanography, Nova Scotia; **G. F. COTA**, V. Stuart, Bedford Institute of Oceanography, Nova Scotia; and G. A. Borstad, Borstad Associates Ltd., "Modelling and Interpreting Ocean-Colour Data," First Workshop on MOS-IRS and Ocean Colour, DLR Institute of Space Sensor Technology, Berlin, Germany, April 24-30, 1997.

M. A. M. FRIEDRICHS, "Physical Control of Biological Processes in the Equatorial Pacific," Woods Hole Oceanographic Institution, COFDL Seminar Series, Woods Hole, MA, June 13, 1997.

M. A. M. FRIEDRICHS, "Physical Control of Phytoplankton Biomass and Primary Production in the Central Equatorial Pacific: An Ecosystem Modeling Study," JGOFS Steering Committee Meeting, Williamsburg, VA, June 18, 1997.

M. A. M. FRIEDRICHS and **E. E. Hofmann**, "A Data Assimilative Ecosystem Model of the Equatorial Pacific," U. S. JGOFS SMP Workshop, Snowbird, UT, July 29, 1997.

J. M. KLINCK, **E. E. Hofmann**, **D. A. Smith**, and **C. M. Lascara**, "Hydrography, Heat and Salt Budgets on the West Antarctic Peninsula Continental Shelf," the Gordon Research Conference on Coastal Ocean Circulation, New London, NH, June 15-19, 1997.

A. VALLE-LEVINSON, K.-C. Wong, University of Delaware, and K. M. M. Lwiza, SUNY at Stony Brook, "Fortnightly Variability in the Transverse Structure of the Salinity and Flow Fields in a Coastal Plain Estuary," the Gordon Research Conference on Coastal Ocean Circulation, New London, NH, June 15-19, 1997.

Publications

A. H. Devol, University of Washington; **L. A. CODISPOTI**; and J. P. Christensen, Ocean Associates, "Summer and Winter Denitrification Rates in Western Arctic Shelf Sediments," *Continental Shelf Research*, 17(9), 1,029-1,050, 1997.

G. F. COTA and W. T. Sturges, University of East Anglia, United Kingdom, "Biogenic Bromine Production in the Arctic," *Marine Chemistry*, 56, 181-192, 1997.

C. E. GROSCH, J. M. Seiner, NASA Langley Research Center, Hampton, VA; M. Y. Hussaini, Florida State University; and T. L. Jackson, NASA Langley Research Center, Hampton, VA, ``Numerical Simulation of Mixing Enhancement in a Hot Supersonic Jet," *Physics of Fluids*, 9(4), April 1997.

A. D. KIRWAN, JR., R. P. Mied, Naval Research Laboratory, and **B. L. LIPPHARDT, JR.**, "Rotating Modons Over Isolated Topography in a Two-Layer Ocean," *Z. angew. Math. Phys.*, 48, 535-570, 1997.

ADK's Words of Wisdom

"I am never content until I have constructed a model of the subject I am studying. If I succeed in making a model, I understand; otherwise I do not."

Quoted by: Lord Kelvin

Contributed by Alejandro Souza, University of Wales. Dr. Souza was inspired to send us Lod Kelvin's quote after reading Larry Atkinson's quote of Mellor from *Notes from the Director* in the last issue of *CCPO Circulation* (Vol. 4, No. 3).

It is not uncommon to see a scene like this at CCPO. Here **Denny Kirwan** is walking on the floating dock located behind CCPO's waterfront facility. On this beautiful summer day, it is obvious that Denny is in deep thought. Sometimes we wonder what he is thinking. Is he pondering his next words of wisdom or is he thinking about how he is going to apply HF radar to his research? Maybe he is trying to figure out how to keep his dog, Roxanne, from chasing the neighborhood cat. Whatever it is, one hopes that he doesn't get distracted and slip off the dock into the water.

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