Winter 1996

Circulation, Winter 1996

Center for Coastal Physical Oceanography, Old Dominion University

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The Ocean Mesoscale

Because of the POLYGON, MODE, and POLYMODE programs of the early 1960's, oceanographers have known that mesoscale flows with space and time scales of 100 km and a few weeks are the principle causes for redistributing kinetic and thermal energy as well as other material properties in the ocean. Since that pioneering era, the working hypothesis of oceanographers has been that mesoscale features are basically isolated eddies or rings. This means, for example, north of the Gulf Stream one should find anticyclonically (warm core) rotating rings while south of the Gulf Stream cyclonically (cold core) rotating rings would be found. Furthermore, these eddies should be isolated from similar flow structures. This ``isolated eddy'' hypothesis has dominated both theoretical and experimental programs since the 1960's, even though the field programs from MODE and POLYMODE did not support the hypothesis.

CCPO scientists, A. D. KIRWAN, JR., professor, BRUCE LIPPHARDT, JR., research assistant professor, and JOHN HOLDZKOM II, graduate student, working with colleagues at NASA Goddard Space Flight Center, the Naval Research Laboratory (NRL), and the Rosenstiel School of Marine and Atmospheric Sciences (RSMAS) of the University of Miami, have begun uncovering evidence which challenges the isolated eddy hypothesis. The key to their work is a recent development in remote sensing analysis, the ``zebra'' palette. This approach superimposes on the standard false color ``rainbow'' palette, a fast color scale which can be tuned to the natural scales of variability of the sea surface temperature, thus producing much more spatial resolution of remote sensing images than heretofore achieved. Hooker et al. (1995a) describes the procedure in some detail. Figure 1, taken from their paper, compares the analysis of the same advanced very high resolution radiometer (AVHRR) data using the two palettes. It is clear that much more small scale information is available from the zebra palette (lower panel) than from a standard palette (upper panel).

Using this technique, Hooker and Brown (1994) reanalyzed the original AVHRR data for one of the most intensely surveyed rings in the world ocean. This ring was the subject of a special issue of the Journal of Geophysical Research (Vol. 90(C5), 8,801-8,979, 1985). Hooker and Brown showed that a small, intense cyclone, believed to be a transient disturbance in the original study, was actually present for at least 52 days and that the cyclone rotated about the larger anticyclonic ring while undergoing a repeating deformation cycle. Holdzkom et al. (1995) extended that analysis and showed that cyclonic activity was present with this ring for over six months, virtually the entire lifetime of the ring.

There is the possibility that the cyclonic activity associated with North Atlantic anticyclones, such as the one mentioned above, is the result of local interactions of the flow in the ring with the bottom topography. To test this, Hooker et al. (1995) examined historical AVHRR observations of several large cyclonically rotating rings in the Sargasso Sea. These are found in the middle of the Atlantic, far removed from topographic effects. To their surprise, they found small anticyclones rotating about the cyclones. Team members are making zebra palette analyses of AVHRR historical data from other parts of the world ocean to see how extensive pairings of cyclones and anticyclones really are. The preliminary results indicate a wide and bewildering zoo of complicated eddy structures that does not fit the simple model of isolated eddies.

There have been important theoretical developments as well. The first analysis by Hooker and Brown (1994) used a vortex model to account for the rotation and deformation cycles of cyclones around more intense anticyclones. Holdzkom et al. (1995) used a hydrodynamic lens model to account for the cyclonic activity and Hooker et al. (1995b) adapted a barotropic ``modon'' model from Mied et al. (1992) to show that a cyclone was necessary to account for the observed sea surface temperature pattern. Lipphardt (1994) extended the Mied et al. (1992) modon model to include baroclinic effects and studied the energetics of the anticyclone with the cyclone present. Lipphardt found the energy available to drive the circulation of the combined system was about an order of magnitude higher than previous studies of this ring. Furthermore, he showed that the resulting flow field could play a major role in exchange between the Middle Atlantic Bight and the North Atlantic.

These results suggest that not only is the isolated eddy hypothesis in question, but they have also identified a potentially

important mechanism for exchange between shelf regions and the abyssal ocean. This work has important consequences for parameterizations in predictive models of ocean circulation and in estimates of the energetics of the ocean. As part of this combined effort, CCPO scientists are now examining data from the Gulf of Mexico to see what role the coupling of cyclones and anticyclones plays in exchange between the shelf and abyssal Gulf.

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Figure Caption

Comparison of Rainbow and Zebra Palettes Rendering of a Warm Core Ring in the Middle Atlantic Bight during April 1982. Original appeared in Hooker et al. (1995a). This imagery was processed at RSMAS using the DSP software package developed by O. Brown and R. Evans.

Community Interactions

Thomas Jefferson High School

On November 6, 1995, CCPO was pleased to host four students from Thomas Jefferson High School for Science and Technology (TJHSST), Alexandria, VA. The students, Halden Fitzgerald Jensen, Michelle Tsai, David Perkins, and Kristen Ankerbrandt, are in TJHSST's program for gifted science and mathematics students and are completing their fourth year of science and calculus. The students are of Dr. John Fornshell's Oceanography Technology Laboratory class at TJHSST. Through Dr. Fornshell's direction, the students are working on various projects in oceanography, to include submarine acoustics, polar sea studies, remote sensing, coastal physical oceanography, and hydrography.

During the students' visit, CCPO scientists gave presentations and talked to the students individually about their varied interests. The CCPO scientists included: LIZ SMITH, research assistant professor, who showed how to study the oceans using satellites and high technology data distributed on CD ROM; BRUCE LIPPHARDT, research assistant professor, introduced drifters, showed drifter data and how to gather that data from the Internet; GLEN WHELESS, research assistant professor, presented visualizations of numerical model output with virtual reality; ARNOLDO VALLE-LEVINSON, research assistant professor, presented the effects of Hurricane Felix on the hydrography of the lower Chesapeake Bay; and EILEEN HOFMANN, professor of oceanography, gave a slide presentation on research in Antarctica.

Not only was it educational and fun for the students, but it was also fun for CCPO scientists who enjoy interacting with young and coming scientists.

Photo captions: TJHSST students: (l-r) David Perkins, Michelle Tsai, Kristen Ankerbrandt, and Halden Jensen CCPO scientist, Eileen Hofmann, speaks to students about her experiences in Antarctica.

Notes From The Director

Since the publication of our last newsletter, CCPO has grown by adding two more key people to its family. You will see both of them profiled in this issue. GLENN COTA brings expertise to CCPO in ocean optics that will nicely complement our research faculty. CCPO was founded with the vision of providing an interface between academia and commerce, and the addition of GARY MAGNUSON is the first formal step in that direction. Gary will be responsible for connecting us to the maritime commercial world.

We welcome both Glenn and Gary to CCPO, to Old Dominion University, and to Hampton Roads. During the short time they have been onboard, one notices the stimulus added by such new talents.

Larry P. Atkinson Director, Center for Coastal Physical Oceanography

A New Face At Ccpo

Glenn F. Cota

GLENN F. COTA became a member of the CCPO family on November 15, 1995. Glenn, a biological oceanographer, is best known for his work on primary production and photophysiology in polar ecosystems. He received his Ph.D. from Dalhousie University in 1983 with Drs. Gordon Riley and Peter Wangersky as his co-supervisors. Larry Atkinson, director of CCPO, is also a Dalhousie alumnus and was one of Dr. Wangersky's students.

Before coming to CCPO, Glenn worked for the Canadian Department of Fisheries and Oceans in the Arctic and then extended his polar studies to the Antarctic while working at the University of Southern California and the University of Tennessee. He has maintained close ties with Canadian colleagues, and much of his work has been in the Canadian Arctic.

His research interests include bio-optics and remote sensing, primary production and photophysiology, physical-biological interactions, biogenic gas emission, nutrient and carbon cycling, and contaminate transport. His studies have focused on high latitude systems with support provided by U.S. (ONR, NASA, NSF, and DOE) and Canadian (DFO and EMR) agencies. Algal physiology and bio-optics investigations have involved both sea ice and planktonic systems. Glenn's physiological work has examined either the release of organohalogen and sulphur gases or photophysiological acclimation. Ice algae were shown to be a globally important source of organohalides, particularly bromoform, which play an important role in tropospheric ozone depletion. He has published a series of papers on primary production, nutrient uptake, and photophysiology of ice algae and phytoplankton. More recent work on the bio-optics of sea ice (ONR) and the water column (NASA) is presently being written up.

Glenn is an investigator for the ONR's Sea Ice Electromagnetics ARI, and he is a member of NASA's SeaWiFs Science Team and Bio-Optical Algoritum Development Subgroup. Additionally, he is a member of Japan's NASDA ADEOS/OCTS Science Team.

K. Gary Magnuson

Recognizing the evolving roles and relationships of academic and research institutions with the private sector and its immediate community, CCPO is pleased to announce that R. GARY MAGNUSON has joined its staff to assist in outreach efforts with the maritime and governmental interests of the Norfolk region. Gary will be working with Larry Atkinson, Anne West-Valle, and other CCPO staff, to establish lines of communication and develop an outreach plan to promote the application of CCPO research. The pursuit of mutually beneficial projects by CCPO with the Norfolk maritime community is the aim of this planned effort.

Unlike many here at CCPO with graduate degrees in oceanography, and marine, biological, computer, and mathematical science, Gary is a self-declared "generalist" with an undergraduate degree from Wittenberg University of Ohio in political science and a Masters in public administration from the University of Colorado, with an emphasis in intergovernmental relations. Complementing his academic achievements are his twenty years of work experience in Washington, DC as a legislative assistant for former U.S. Representative John Krebs (D-California), Assistant Director of then California Governor Edmund G. (Jerry) Brown's Washington Office, Executive Director of the Coastal States Organization (a representative association for the governors of the 35 U.S. coastal states and territories), Vice President of the Center for Marine Conservation, and Director of Constituent Affairs for the National Ocean Service, National Oceanic and Atmospheric Administration (NOAA). Before going to Washington, Gary held administrative positions with Councils of Governments in Fresno, CA and Denver, CO.

For many years, Gary has also been active in the ocean and coastal community, holding responsible positions with The Coastal Society, the Women's Aquatic Network, the American Shore and Beach Preservation Association, and the Secretary of Interior's OCS Policy Committee, NOAA's Coastal Ocean Policy Roundtable, and the National Petroleum Council as an advisor.

Gary resides in Vienna, VA with his wife, Janis, his two teenagers, Ryan and Kristin, and his Golden Retriever, Zack. A candidate for the Town of Vienna Planning Commission, Gary keeps life in balance by playing tennis and racquetball, managing and coaching baseball, staying active in local politics, and escaping to the beach when possible.

CCPO'S Fugitive List

JERRY MILLER and all his oceanography books are missing from his CCPO office. Word has it that Jerry has been spotted at his new position at the Naval Research Laboratory, Stennis Space Center, Mississippi. He is an oceanographer for the Mesoscale and Finescale Ocean Physics Section of the Ocean Sciences Branch. There he will be doing research on numerical modeling and observational experiments on the Chesapeake plume, and he will continue collaborative research with Brazilian colleagues. Good luck, Jerry, with your new position!

Everyone has been asking why graduate student, DAVID SMITH, did not show up at February's Ocean Sciences Meeting held in San Diego. It wasn't that David was too chicken to present his paper on the distribution of circumpolar deep water west of the Antarctic Peninsula; it was because he and his wife, Robin, were expecting their second child. Baby girl, Alison, arrived the last day of the meeting, February 18. Congratulations David and Robin!

Chaos: Beware!

Mathematical modeling has become an indispensable tool in understanding physical phenomena. Most geophysical fluid phenomena are extremely complicated. The art of the mathematical modeling of any one particular phenomenon is to focus on a limited number of questions associated with the problem and try to simplify the mathematical equations describing the phenomenon to answer these questions. To a greater or lesser degree, the mathematical model will have a limited ability to describe the phenomenon.

One question which is often of importance is how well the model will predict future behavior. One limitation of any model's predictive ability is chaos. Dynamical chaos is behavior that is not periodic, not forced by random inputs, and exhibits sensitive dependence on initial conditions. Until fairly recent (well into the '70s), this limitation was not recognized, except by some especially prescient people such as Poincare (1899) and much later, Lorenz (1963).

Presently, JOHN KROLL, associate professor of the Department of Mathematics and CCPO, is investigating the development of chaos in a particular simplified model of an oceanic flow. This model, first investigated by De Szoeke (1986), is a two-layer ocean over varying topography with the density in the upper layer less than that in the bottom layer. The equations describing this system are partial differential equations called the quasi-geostrophic equations. No attempt is made to find all possible solutions of this system because the equations are quite difficult, so more simplification is done.

It can be shown that flow with a constant current velocity, , in the top layer and no flow in the bottom layer is an exact solution. The ratio of the bottom topography to the depth, , is assumed very small. A solution which is a correction of order of the constant solution can then be found. The most interesting result of this solution is that two given wave solutions, each stable in time when alone, can be unstable (grow in time) under certain conditions when put together as they interact with each other and the topography. They grow until limited by nonlinear interactions in the model. Figure 1 shows the typical variation of the amplitude of one of these waves with time. Clearly the motion is predictable.

Now what happens if the uniform current velocity is made to vary slightly in a smooth oscillatory manner, i.e., much less than , where is a given frequency? Figure 2 is typical for greater than zero. The motion is no longer periodic and in fact looks chaotic. Note that the system is forced in a simple smooth manner but exhibits a random-like response. It can be shown to fulfill the criteria stated above for dynamical chaos. Moreover, this system becomes immediately chaotic for any finite value of , so the smallest variation of causes chaos. In the real world, there is no current that is absolutely constant, thus, this model is an unreliable predictor.

Actually, things are not quite that bad. There are degrees of chaos. For very small values of , the time it would take for an error in prediction caused by chaos to become significant may be much longer than any length of time of interest. Also, at least in this model, the addition of friction makes the system less prone to become chaotic. The system is then no longer immediately chaotic for any infinitely small variation of the current.

What has been found to be true for this model is also true for many other similar models. The cautionary tale is this: the slight variation of a quantity, known to be almost constant and modeled to be constant, may be extremely important.

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Figure 1. Amplitude vs. time (not chaotic).

Figure 2. Amplitude vs. time (chaotic).

Upwelling Near Cabo Frio

The Brazil Current originates at about as the South Equatorial Current encounters the eastern coast of South America. From there, it gains in strength as it flows southward along the continental shelf break towards Cabo Frio (). At Cabo Frio, the coastline and the current turn westward past Rio de Janeiro and then southwestward through the South Brazil Bight (SBB). Cabo Frio is an active upwelling region widely known for its rich fisheries resources and Rio is ... well Rio, with its beaches among other beautiful things.

Brazil's National Council for Scientific and Technological Development, their equivalent of NSF, recently gave JERRY MILLER, research assistant professor, a visiting scholar award under their Human Resources for Strategic Areas program. This award permitted Jerry to travel to Brazil's National Institute for Space Research (INPE), their equivalent of NASA, and work with Drs. Joao Lorenzzetti and Jose Stech on numerical modeling of flow around Cabo Frio. This is an extension of Jerry's ongoing collaboration with Brazilian scientists at the Oceanographic Institute of the University of Sao Paulo (IOUSP), which focuses on Brazil Current dynamics in the SBB.

An intense cold current originating near northern Argentina, more than 1000 kilometers south of the SBB and extending northward along the mid-shelf to near Rio, has been documented by INPE and IOUSP researchers. This current is thought to not occur every year; however, it is apparently the pathway by which penguins which are native to the

Patagonian shelf (ca.) sometimes arrive at the Tropic of Capricorn and occasionally appear on Copacabana and Ipanema beaches. Cold upwelled waters from Cabo Frio generally flow westward and may temporarily maintain the habitat required by the interloping penguins. The effects of seasonal wind variations, the Brazil Current, and the unusually strong (25 knots) sea breeze on upwelling at Cabo Frio will be investigated as the project continues.

Second Annual Open House

The Department of Oceanography will be holding its Second Annual Open House on Saturday, April 20, 1996, from 10:00 a.m. to 3:00 p.m. The event is open to the public and admission is free.

Following the success of the First Annual Open House (CCPO CIRCULATION, Summer 1995), many of the same activities will be offered. Visitors will be able to peer through microscopes, make fish print t-shirts, ride on a submarine replica, learn about on-going research in oceanography, and take computer quizzes about the oceans.

Science teachers will be able to register to win a trip for their class aboard Old Dominion University's ship, R/V HOLTON, and children can register to win a Department of Oceanography t-shirt.

The event will be held on West 47th Street (across the street from ODU's main campus) in Norfolk. Parking is available at the intersection of 46th Street and Hampton Boulevard. For more information, please contact ANNE WEST-VALLE at (804) 683-5558.

Adk's Words Of Wisdom

``A person who keeps company with glaciers comes to feel tolerably insignificant by and by ..." Mark Twain

Courtesy of Professor Barry Lyons, University of Alabama

Just The Facts...

Appointments

L. P. ATKINSON, co-chair of the Joint Subcommittee on Environmental Information for Select Outer Continental Shelf (OCS) Area Under Moratoria, established by the U.S. Department of Interior's Minerals Management Service (MMS).

L. P. ATKINSON, chair of the Chesapeake Research Consortium (CRC) Board.

Graduates

Ph.D.: S.K. LEE, dissertation title, ``Seasonal Variability of Heat and Mass Transport Process in the Upper Tropical Atlantic Ocean: A Numerical Model Study," December 1995, Advisor: G. T. Csanady.

Ph.D.: A. KUMAR, dissertation title, ``Observation of Shelfwater Overrunning the Southern Slope Sea," December 1995, Advisor: G. T. Csanady.

Grants/Contracts Awarded

L. A. CODISPOTI, ``Management and Scientific Services in Support of the U.S. JGOFS Arabian Sea Process Study," subcontract from the University of Miami, 285,405, NSF.

G. F. COTA, ``Arctic Ice Algal Bio-Optics and Sea Ice Sediments," 145,339, ONR.

E. E. HOFMANN and J. M. KLINCK, ``*Crassostrea virginica* Pathogens in Chesapeake Bay Oyster Populations: A

Dual Disease Simulation Model of Parasite-host Interactions Over a Large Spatial Scale" 50,204, Virginia Graduate Marine Science Consortium.

E. E. HOFMANN, ``Long-Term Ecological Research on the Antarctic Marine Ecosystem: An Ice-Dominated Environment," 62,550, University of CA, Santa Barbara/NSF.

Presentations

M. M. DEKSHENIEKS, E. E. Hofmann, J. M. Klinck, and E. N. Powell, Haskin Shellfish Research Laboratory, ``The Effects of Environmental Change on the Spatial Distribution of the Eastern Oyster: A Modeling Study," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996. This was an invited presentation.

M. A. M. FRIEDRICHS; E. E. Hofmann; L. M. Lawson, East Tennessee State University; and Y. H. Spitz, Oregon State University, ``Assimilating Noisy Data into a Marine Ecosystem Model," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

E. E. HOFMANN and T. Powell, University of California, Berkeley, ``The Environment Affects Biological Systems," The National Academy of Sciences International Conference on Ecosystem Management of Sustainable Fisheries, Monterey, CA, February 19-24, 1996.

E. E. HOFMANN, M. M. Dekshenieks, J. M. Klinck, and E. N. Powell, Haskin Shellfish Research Laboratory, ``Physical and Biological Structuring of Oyster Populations," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

E. E. HOFMANN, ``An Overview of Physical-Biological Models for Marine Ecosystems," guest lecturer in the course, A Systems Approach to Biological Ocean Science, University of New Hampshire, February 29, 1996.

J. J. HOLDZKOM II, A. D. Kirwan, Jr., and C. E. Grosch, ``Modeling Submesoscale Processes by a Particle Method," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

A. K. KIRWAN, JR. and B. L. LIPPHARDT, JR., ``Quantitative Utilization of Lagrangian Data," HydroQual, Inc., Mahwah, NJ, December 1, 1995.

A. K. KIRWAN, JR.; B. L. Lipphardt, Jr.; P. P. Niiler, Scripps Institution of Oceanography; and W. R. Johnson, Minerals Management Service, Herndon, VA, ``Circulation on the Louisiana--Texas Shelf Inferred from SCULP Drifter Data," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

J. M. KLINCK and G. H. WHELESS, ``The Influence of Stratification, Inlet Width and Tides on Ocean-Estuary Exchange," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

J. E. KROLL, ``Nonlinear Wave Interactions in a Two-Layer Zonal Baroclinic Shear Flow Model," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

C. M. LASCARA and E. E. Hofmann, ``Modeling the Growth Dynamics of Antarctic Krill," 1996 Ocean Sciences Meeting, San Diego, CA, 12-16, 1996.

L. M. Lawson, East Tennessee State University, E. E. Hofmann, and Y. H. Spitz, Oregon State University, ``Time Series Sampling and Data Assimilation in a Simple Marine Ecosystem Model," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

B. L. LIPPHARDT, JR.; A. D. Kirwan, Jr.; L. H. Kantha and J. K. Choi, both at CCAR/University of Colorado; P. P. Niiler, Scripps Institution of Oceanography; and W. R. Johnson, Minerals Management Service, Herndon, VA, ``How Useful are Lagrangian Observations for Assessing the Predictive Skill of a Gulf of Mexico Model?" 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

J. L. MILLER, ``Seasonal Variation of Delaware Plume Effects at the Entrance to Chesapeake Bay," Brazilian National Space Agency, Instituto Nacional de Pesquisas Espaciais, Sao Jose dos Campos, Brazil, December 13, 1995.

J. L. MILLER, ``Seasonal Variations of Delaware Plume Effects at the Entrance to Chesapeake Bay," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

D. A. SMITH, E. E. Hofmann, J. M. Klinck, C. M. Lascara, and R. C. Smith, University of California, Santa Barbara, ``Palmer LTER: Distribution of Circumpolar Deep Water West of the Antarctic Peninsula," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

A. VALLE-LEVINSON, ``Enhanced Stratification Produced by the Passage of Hurricane Felix off the Chesapeake Bay Mouth," MAPOM, Stony Brook, NY, November 2, 1995.

G. H. WHELESS, C. M. LASCARA, A. VALLE-LEVINSON, D. P. Brutzman, Naval Postgraduate School, and W. Sherman, National Center for Supercomputer Applications, ``The Chesapeake Bay Virtual Ecosystem Model: Interacting with a Coupled Bio-Physical Simulation," a GII Testbed Virtual Reality application presented on the Immersadesk at Supercomputing '95, San Diego, CA, December 3-8, 1995.

G. H. WHELESS and J. M. Klinck, ``Tidally-Driven Ocean-Estuary Exchange Through an Inlet Onto a Sloping Shelf: A Numerical Study," 1996 Ocean Sciences Meeting, San Diego, CA, February 12-16, 1996.

Publications

L. P. ATKINSON and S. Hankin, NOAA/PMEL, ``Common Data Formats," Oceanography, Vol. 8(3), 100-101, 1995.
R. J. Ferek, P. V. Hobbs, L. F. Radke, and J. A. Herring, all four from University of Washington; W. T. Sturges, University of East Anglia, United Kingdom; and G. F. COTA, ``Dimethyl Sulfide in the Arctic Atmosphere," *Journal of Geophysical Research*, Vol. 100(D12), 26,093-26,104, December 1995.

R. C. Smith, University of California, Santa Barbara; K. S. Baker, Scripps Institution of Oceanography; W. R. Fraser, Montana State University, E. E. HOFMANN; D. M. Karl, University of Hawaii at Manoa; J. M. KLINCK; L. B. Quetin, B. B. Prezelin, and R. M. Ross, all three at University of California, Santa Barbara; W. Z. Trivelpiece, Montana State University; and M. Vernet, Scripps Institution of Oceanography, ``The Palmer LTER: A Long-Term Ecological Research Program at Palmer Station, Antarctica," *Oceanography*, Vol. 8(3), 77-86, 1995.

E. J. D. Campos, Universidade de Sao Paulo, Brazil; J. L. MILLER; T. J. Muller, Universitat Kiel, Germany; and R. G. Peterson, Scripps Institution of Oceanography, ``Physical Oceanography of the Southwest Atlantic Ocean," *Oceanography*, Vol. 8(3), 87-91, 1995.

S. B. Hooker, NASA Goddard Space Flight Center; J. W. Brown, Rosenstiel School of Marine and Atmospheric Science; A. D. KIRWAN, JR.; and G. J. Lindemann and R. P. Mied, both of Naval Research Laboratory, Washington, DC, ``Kinematics of a Warm-Core Dipole Ring," *Journal of Geophysical Research*, Vol. 100(C2), 24,797-24,809, December 15, 1995.

J. M. KLINCK, ``Circulation Near Submarine Canyons: A Modeling Study," *Journal of Geophysical Research*, Vol. 101(C1), 1,211-1,223, January 15, 1996.

E. N. Powell, Rutgers University, J. M. KLINCK, E. E. HOFMANN, E. A. Wilson-Ormond and M. S. Ellis, both of Texas AM University, ``Modeling Oyster Populations. V. Declining Phytoplankton Stocks and the Population Dynamics of American Oyster (*Crassostrea virginica*) Populations," *Fisheries Research*, Vol. 24, 199-222, 1995.

J. L. McClean, Naval Postgraduate School, and J. M. KLINCK, ``Description and Vorticity Analysis of 50-Day Oscillations in the Western Tropical Region of the CME Model," *Journal of Physical Oceanography*, Vol. 25(11), 2,498-2,517, November 1995.

J. Moraga O, Universidad Catolica del Norte, Chile; A. VALLE-LEVINSON; and J. L. Blanco, Instituto de Fomento

Pesquero, Chile, ``Hydrography and Dynamics of the Upper Layer in the Southeastern Pacific Coastal Zone (30S)," *Invest. Pesq. (Chile)*, Vol. 38, 55-73, 1994.

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