Summer 1994

Circulation, Summer 1994

Center for Coastal Physical Oceanography, Old Dominion University

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Large Influences From Small Features: SUBMARINE CANYONS

Historically, circulation processes associated with submarine canyons that transect many continental shelves have not received much attention. The primary emphasis of most canyon studies has been on sediment transport, turbidity currents, and other short time scale processes. The few investigations of circulation in submarine canyons focused on tidal flow and internal wave processes.

In the early 1980's, interest developed in the circulation in canyons. This interest was the result of a study in a narrow canyon near Vancouver Island, British Columbia (Freeland and Denman, J. Marine Res., 40, 1,069--1,093, 1982), which showed that the canyon acted as a conduit moving water, which was originally deep and offshore, onto the shelf. The vertical and horizontal distances over which this upwelling occurred were much greater than those observed in classical wind-driven upwelling systems. Other observational studies (Hotchkiss and Wunsch, Deep Sea Res., 29, 415--442, 1982) indicated that deep circulation in canyons responded rapidly to changes in surface wind stress. Later observations were less clear about the effect of these canyons on the alongshore flow; in some cases, the coastal flow crossed the canyons apparently oblivious to their presence, while in other cases the alongshore flow was disrupted by pools of dense water that appeared on the shelf near the head of the canyons. This exchange between shelf and offshore waters has important implications for biological and chemical processes of continental shelf systems.

A consensus has formed among the cognoscenti on the dynamical processes responsible for the circulation within submarine canyons. The critical factor is that submarine canyons are narrow, in general, being 5 to 15 km in width, relative to the internal radius of deformation, which is a natural scale for horizontal gradients in rotating, stratified fluids. For canyons that are narrower than this scale (nearly always true), the influence of the Coriolis force is reduced and the flow converts from a geostrophic to a pressure-driven circulation. That is, as the system becomes narrow, the flow tends to be down the pressure gradient instead of transverse to the pressure gradient.

The remaining piece to the puzzle is the origin of the coastal pressure gradient. Almost all continental shelves have a large-scale flow parallel to the coast, which is driven by buoyancy flux from rivers or by large-scale winds. Since this flow is geostrophically balanced, there is a pressure gradient across the shelf, which is aligned, generally, with the axis of the canyons and can drive circulation in the canyons.

There have been several observational studies, based on current meters and hydrography, that have shown a correlation between flow on the shelf and circulation along the axis of a canyon. As is the case in oceanography, the correlations are not perfect, which indicates that other processes are at work. So, this description of the pressure-driven flow is, thus far, a general framework rather than a final answer.

JOHN KLINCK'S (associate professor of CCPO) interest in the dynamics of circulation in submarine canyons began with these observations, which indicated a multi-level circulation pattern. Current work on circulation dynamics uses 3-D numerical models to look at the interaction of alongshelf flow with an idealized canyon. The shape of the canyon is gaussian and the geometry (width, length, and depth) is appropriate for conditions on the eastern coast of the U.S. A series of numerical experiments considered several different choices of initial stratification and direction of coastal flow. The simulations were started from rest and the alongshore flow was built up over a period of six days. Simulations lasted up to 100 days, but the basic circulation pattern around the canyon developed by about 10 days.

The simulations show that the direction of the alongshore flow, and hence the direction of the cross-shelf pressure gradient, has the most important effect on the resulting circulation. When the pressure gradient drives offshore flow in the canyon, there is mild downwelling in the canyon but only a very weak exchange between the shelf and the deep ocean. However, when the pressure gradient drives onshore flow, there is strong upwelling and a persistent flux of deeper water up onto the shelf.

These simulations are useful in revealing processes associated with flow in submarine canyons, but additional dynamics

and forcing remain to be added to the circulation model. Future work will focus on transient coastal flow, wind forcing, and other influences on circulation in and near submarine canyons.

Notes From The Director

The Center is now entering its fourth year, and the sayings, ``The success has been great but the challenges are even greater" and ``May you live in interesting times," are both appropriate.

CCPO successes have been documented in this publication for the past year, and they continue as more exciting projects are started and more faculty, students, and staff are brought onboard. But what are the ``challenges," and what are the ``interesting times"? They are the fact that the Commonwealth of Virginia, who asked us for a self-sufficiency plan that would take effect when funding ended in 1996, reduced our funding unexpectedly in the 1994-95 budget. Luckily the plan was well along, so we could start it earlier than anticipated. Old Dominion University has been very supportive of the plan and has developed new policy to allow our research center and others yet to be formed to prosper. The policy involves the creation of self-supporting research positions and other changes in resource allocation. The research positions are critical to CCPO's long-term success, and we have already established three positions.

I believe that CCPO and other research centers at Old Dominion University will thrive in this environment, and the University is to be complimented for its forward thinking during rough budget times.

Larry P. Atkinson Director, Center for Coastal Physical Oceanography

A New Face At CCPO

LOUIS (Lou) A. CODISPOTI, whom many of us know from his tenure as a Slover visiting scholar, became a member of the CCPO family on July 15. Lou is well-known in the oceanographic community and has spent the last two years working at the Office of Naval Research on loan from the Monterey Bay Aquarium Research Institute. He received his Ph.D. from the University of Washington in 1973.

Soon after Lou's arrival to CCPO, he left for Singapore to join the T. G. Thompson as chief scientist for the first leg of the NSF-funded JGOFS Arabian Sea process study, and he will participate in two additional Thompson cruises in the Arabian Sea during 1995. Lou will be able to continue his studies of the Arctic Ocean with support from the Office of Naval Research and will continue to assist and advise ONR on the Arctic Nuclear Waste program that he has managed for the last two years. He also participates in a bi-lateral research program between the National Institute of Oceanography in India and the United States.

Lou has many research interests, but his interest in the global nitrogen cycle and how it interacts with climate change is at the core of many of them. He has published papers and reports on coastal oceanography, paleoceanography, nitrogen cycling, carbon cycling, the oceanography of the Arctic Ocean, and instrument development. Lou has also served the oceanographic community in administrative capacities and as a member of advisory committees, such as the WOCE/DOE carbon dioxide science team and advisory committees for NSF's Arctic System Science Program. He also has interests in public education and in developing environmental courses for undergraduate non-majors.

Bridge Pilings Effects On Statification

The Chesapeake Bay Bridge-Tunnel (CBBT) Authority plans to construct a second span of their bridge-tunnel across the mouth of the Chesapeake Bay. As part of the permitting process, the CBBT Authority is required to produce an environmental impact statement describing the effects of this additional span on the ecology of the Bay. Their local consultant, Sverdrup Engineering of Virginia Beach, has contracted CCPO researchers, LARRY ATKINSON, GABE CSANADY, JERRY MILLER, and ARNOLDO VALLE-LEVINSON, to study the effects of the flow past the existing bridge pilings on the stratification of nearby Bay waters. Jerry and Arnoldo have recently completed intensive CTD surveys upstream and downstream from the bridge during spring and neap tides. Flow beneath the bridge was measured

with moored current meters during and between these surveys. The resulting data sets were examined for evidence of bridge-related changes in the Bay's stratification.

Tidally-forced flow beneath the existing trestle of the CBBT causes significant distortion of the ambient density field in the immediate vicinity of the trestle due to flow over the scour zone around the pilings. Effects are minimal a short distance away from the trestle. Estimates of piling-induced destratification based on direct observations of temperature, salinity, and currents near the pilings indicate that piling effects are less than naturally occurring destratification due to bottom and wind stresses. Loss of stratification during times of strongest flow past the pilings is a few percent.

The Mystery Photo

Who do these feet belong to? Hint: The feet belong to a distinguished oceanographer who frequently visits CCPO, but he/she is on faculty at another university.

If you think you know the mystery photo, please e-mail your response to carole@ccpo.odu.edu, or fax to Carole Blett, editor, CCPO Circulation, at (804) 683-5550. We are eager to hear everyone's responses, and we will publish the results when the mystery photo is revealed in the fall issue of CCPO Circulation, due to be published mid-November.

Student Profiles

ANA MARIA MARTINS received her B.S. in biology from the College of Sciences, University of Lisbon, in December 1986. After graduation, Ana held a research position for two years with the National Laboratory of Energy and Industrial Technology (LNETI), Lisbon. Ana joined the faculty at the oceanography department of the University of the Azores, Portugal, in 1989. In August 1989, she received a Fulbright scholarship and an AAUW fellowship to enroll in physical oceanography at ODU to study under the direction of Eileen E. Hofmann. In 1991, Ana received her M.S. and then entered into the Ph.D. program.

Ana's dissertation work is entitled, ``Winter Variability of CZCS Derived Winter Distributions on the Southeastern U.S. Continental Shelf." This study uses available CZCS data to obtain a description of the near-surface pigment distributions of the South Atlantic Bight (SAB) in terms of regional variability and dominant space and time scales. It will also provide parameter values that can be used to optimize atmospheric correction and pigment retrieval of CZCS and SeaWiFS imagery in the SAB.

After graduation, Ana plans to return to her home in Portugal, where she will return to her faculty position at the University of the Azores and continue her research.

YVETTE HERBERT SPITZ received a License in Physics and a License in Oceanology from Liege University, Belgium. Yvette worked as a research assistant at Liege University and then at the Management Unit for the Mathematical Models of the North Sea and Scheldt Estuary (MUMM). She moved to the United States in 1987, where she received her M.S. in physical oceanography from Florida State University, and then started Old Dominion University, where she is currently pursuing her Ph.D. in physical oceanography under the direction of John M. Klinck.

Yvette's dissertation is entitled, ``A Feasibility Study of Dynamic Assimilation of Tide Gauge Data in the Chesapeake Bay." In this study, the recovery of the circulation in the Chesapeake Bay is investigated by using a variational method, and tide gauge observations are assimilated into a vertically integrated 2-D shallow water model. The surface wind stress and bottom drag coefficients are adjusted to improve agreement with data.

Yvette hopes to obtain a university position in the United States. She is interested in continuing research using numerical modeling and data assimilation techniques and in mathematical modeling of ecosystems.

CCPO Is Represented At SCAR Sixth Biology Symposium

From May 30 to June 3, 1994, the SCAR Sixth Biology Symposium entitled, ``Antarctic Communities: Species Structure and Survival," was held in Venice, Italy. The symposium, which is held every four years, provides an international forum for presenting results from Antarctic research programs. CCPO was represented at the 1994 symposium by two graduate students (CATHY LASCARA and DAVID SMITH) and two faculty members (JOHN KLINCK and EILEEN HOFMANN). They presented studies of hydrographic and circulation distributions for the region west of the Antarctic Peninsula and studies of the distribution of Antarctic krill in this region as determined from acoustic measurements. These studies were based upon data collected as part of the Palmer Long-Term Ecological Research Program, which is based at Palmer Station on Anvers Island off the western Antarctic Peninsula.

E. E. HOFMANN, D. A. SMITH, B. L. LIPPHARDT, JR. and R. A. Locarnini of Texas A&M University, and R. C. Smith of the University of California, Santa Barbara, ``Circulation West of the Antarctic Peninsula."

J. M. KLINCK and R. C. Smith of the University of California, Santa Barbara, ``Heat Budgets and Implications for Circulation on the Continental Shelf West of the Antarctic Peninsula."

D. A. SMITH, E. E. HOFMANN, J. M. KLINCK, B. L. LIPPHARDT, JR., and R. A. Locarnini of Texas A&M University, and R. C. Smith of the University of California, Santa Barbara, ``Hydrography in the Region West of the Antarctic Peninsula."

C. M. LASCARA, E. E. HOFMANN, J. M. KLINCK, and R. M. Ross and L. B. Quetin, both of the University of California, Santa Barbara, ``Seasonal and Geographic Variability in the Distribution of Antarctic Krill, Euphausia superba, West of the Antarctic Peninsula."

L. B. Quetin and R. M. Ross, both of the University of California, Santa Barbara, and C. M. LASCARA, ``Fine-scale Distribution of Antarctic Krill, Euphausia superba, Within Coastal Waters Near Palmer Station off the Antarctic Peninsula."

E. E. HOFMANN, C. M. LASCARA, B. L. LIPPHARDT, JR., J. M. KLINCK, D. A. SMITH, and R. A. Locarnini of Texas A&M University and R. C. Smith of the University of California, Santa Barbara, ``Seasonal Changes in the Hydrographic Structure of the Upper 100 m of the Water Column."

ADK's Words Of Wisdom

``Every computer program has at least one line of unnecessary code. Every computer program has at least one undetected bug. Iterate to a one line program." Adapted from J. Von Neumann.

Distinguished Visitor

LEONID M. IVANOV, Chief of Laboratory in the Nuclear Hydrophysical Department, Marine Hydrophysical Institute, Sevastopol, Ukraine, visited CCPO from May 8 through June 5, 1994. Dr. Ivanov has published extensively in both Russian and Western literature on the transport of scalars in oceanic eddy fields, Ekman transport processes, and inverse methods for assimilation of oceanographic and geochemical data into numerical models.

For the last five years, Dr. Ivanov has collaborated with CCPO scientists, principally A. D. Kirwan, Jr., on assimilation of Lagrangian data into numerical models and on the distribution in the Black Sea of radioactive tracers released by the Chernobyl incident. Two papers resulting from this collaboration were recently published in the Journal of Geophysical Research, Vol. 97(C6), 9,733--9,742 and 9,743--9,753, 1992. Also, one paper has been accepted for publication in the Journal of Environmental Radioactivity on the fate of radioactive from Chernobyl in the Black Sea. Drs. Ivanov and Kirwan have also been studying methods for assessing the predictive capability of numerical models of ocean circulation.

This past visit to CCPO was Dr. Ivanov's third visit to the U. S. and to CCPO, and Dr. Kirwan has also made three visits to the Ukraine for ongoing collaboration with Dr. Ivanov.

CCPO'S Link To WWW

The World Wide Web (WWW) is becoming one of Internet's fastest growing methods of information distribution. The WWW system works by using a series of Hypertext links to link sites all over the Internet. To get more information on a subject, you simply click on the link, and your WWW browser will go fetch the information for you. CCPO has joined the WWW, with the assistance of CCPO's systems engineer, BOYD FLETCHER, as a way to disseminate information about the Center's educational and research activities. The Center's WWW Uniform Resource Locator (URL) record is http://www.ccpo.odu.edu/. The current information provided by our WWW service includes:

- a description of the Center and its computing facilities;
- profiles on faculty, visiting faculty, and staff;
- information on Old Dominion University's undergraduate and
- graduate programs in oceanography; and
- on-line versions of CCPO Circulation.

In the future, we hope to provide abstracts of papers and information on the datasets used in our research. At the Center, we are now using Mosaic from the National Center for Supercomputing Applications to access WWW. Mosaic is a graphical WWW browser that works under the X Window System (Unix machines), Microsoft Windows (x86 PCs), and System 7 (Apple Macintosh). If you have one of these platforms, have access to the Internet, and would like to use Mosaic, it can be obtained via ftp from ftp.ncsa.uiuc.edu.

Just The Facts...

Graduates

Ph.D.: CAITLIN P. MULLEN, dissertation title, ``Flow Kinematics and Dynamics of the Gulf Stream from Composite Imagery,'' August 1994, Advisor: A. D. Kirwan, Jr. Dr. Mullen has accepted a position at the U. S. Naval Academy, Annapolis, MD.

Ph.D.: SUNNY YU WU, dissertation title, ``On the Low-Frequency Current and Temperature Fluctuations Along the Shelf Break in the South Atlantic Bight,'' August 1994, Advisor: Larry P. Atkinson. Dr. Wu has a position at the Horn Point Environmental Laboratory, University of Maryland, Cambridge, MD.

Appointments

J. J. HOLDZKOM II, accepted into the NASA Summer School for High Performance Computational Physics, NASA/Goddard Space Flight Center, Greenbelt, MD, July 11--29, 1994.

Presentations

M. M. DEKSHENIEKS, E. E. Hofmann, E. N. Powell, and J. M. Klinck, ``Effect of Environmental Conditions on the Population Structure of the Oyster: A Modeling Study,'' The 1994 Chesapeake Research Conference, Norfolk, VA, June 1-3, 1994.

A. D. KIRWAN, JR., ``Ocean Eddies: The Inside Story,'' presented to the Department of Physics, College of William and Mary, Williamsburg, VA, May 17, 1994.

A. D. KIRWAN, JR., J. J. Holdzkom, II, C. E. Grosch, and M. Zubair and N. Kausar of the Computer Science Department, ``Particle in Cell Simulations of Oceanic Flow,'' The International Conference on Nonlinear Dynamics and Pattern Formation in the Natural Environment (ICPF), Noordwijkerout, The Netherlands, July 3-8, 1994.

A. D. KIRWAN, JR., B. L. Lipphardt, Jr., and R. P. Mied of the Naval Research Laboratory, Washington, DC, ``The

Dynamics of Steady, Rotating Baroclinic Multipole Vortex Systems," The International Conference on Nonlinear Dynamics and Pattern Formation in the Natural Environment (ICPF), Noordwijkerout, The Netherlands, July 3-8, 1994.

E. N. Powell, E. E. Hofmann, J. M. Klinck, and M. M. DEKSHENIEKS, ``Perkinsus Marinus: Triggering Mechanisms for Epizootics," The 1994 Chesapeake Research Conference, Norfolk, VA, June 1-3, 1994.

Y. H. SPITZ and J. M. Klinck, ``Recovery of Circulation and Forcing in the Chesapeake Bay by Assimilation of Tide Gauge Observations," The 1994 Chesapeake Research Conference, Norfolk, VA, June 1-3, 1994.

A. VALLE-LEVINSON, ``Water Exchange in the Lower Chesapeake Bay," The 1994 Chesapeake Research Conference, Norfolk, VA, June 1-3, 1994.

G. H. WHELESS, ``Estuary/Shelf Exchange Variability Due to Synoptic Scale Wind Events and Freshwater Runoff: Implications for Biological Recruitment," The 1994 Chesapeake Research Conference, Norfolk, VA, June 1-3, 1994.

Awards

C. E. GROSCH, The Group Achievement Award, for Dr. Grosch's part in the ICASE Fluid Mechanics Group ``for development of important insights into basic fluid mechanical phenomena and theoretical analysis tools which have contributed to major advances in flow prediction and control including laminar flow control," presented by NASA/Langley Research Center, Hampton, VA.

C. P. MULLEN, National Research Council Research Associateship Fellowship Award, as Resident Research Associate at National Oceanic and Atmospheric Administration (NOAA/NESDIS), Washington, DC.

Publications

D. Bhagavathi, ODU Computer Science Department, C. E. GROSCH, ODU Computer Science Department and CCPO, and S. Olariu, ODU Computer Science Department, ``A Greedy Hypercube-Labeling Algorithm," *The Computer Journal*, 37(2), 124-128, February 1994.

C. E. GROSCH, ``Reacting Compressible Mixing Layers: Structure and Stability," *Combustion in High-Speed Flows*, pp 131-190, J. Buckmaster, et al. (eds), 1994 Kluwer Academic Publishers, The Netherlands.

E. N. Powell of Texas AM University, J. M. KLINCK and E. E. HOFMANN, and S. M. Ray of Texas AM University, ``Modeling Oyster Populations. IV: Rates of Mortality, Population Crashes, and Management," *Fishery Bulletin*, Vol. 92, 347-373, 1994.

M. TONER and A. D. KIRWAN, JR., ``Periodic and Homoclinic Orbits in a Toy Climate Model," *Nonlinear Processes in Geophysics*, Vol. 1(1), 31-40, May 1994.

C. P. MULLEN and A. D. KIRWAN, JR., ``Surface Flow Structure of the Gulf Stream from Composite Imagery and Satellite-Tracked Drifters," *Nonlinear Processes in Geophysics*, Vol. 1(1), 64-71, May 1994.

A. VALLE-LEVINSON and R. E. Wilson of State University of New York at Stony Brook, ``Effects of Sill Processes and Tidal Forcing on Exchange in Eastern Long Island Sound," *J. Geophy. Res.*, Vol. 99(C6), 12,667--12,681, June 1994.

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