Follow this and additional works at: http://digitalcommons.odu.edu/ccpo_circulation
Part of the Oceanography and Atmospheric Sciences and Meteorology Commons

Recommended Citation
http://digitalcommons.odu.edu/ccpo_circulation/4

This Book is brought to you for free and open access by the Center for Coastal Physical Oceanography at ODU Digital Commons. It has been accepted for inclusion in CCPO Circulation by an authorized administrator of ODU Digital Commons. For more information, please contact digitalcommons@odu.edu.
Every summer, the bottom waters in the central portion of Chesapeake Bay experience low dissolved oxygen (hypoxia) or the complete lack of dissolved oxygen (anoxia) for extended periods of time. Nutrients that enter the Bay fuel the growth of algae during the spring and early summer months. When the algae die and sink to the bottom, their decomposition utilizes oxygen. The strong density gradient between the fresh surface waters and salty bottom waters prevents oxygen introduced at the surface from mixing down into the bottom waters, leading to hypoxic or anoxic conditions. There is considerable evidence showing that hypoxic volumes began increasing during the early 1980s and remain above pre-1980s levels today. It is generally accepted that the increased nutrient loads that are delivered to the Bay have fueled increased algal growth leading to more extensive low-oxygen conditions. Yet, studies that directly correlate nutrient loads to inter-annual variations in hypoxic volume often fail to explain the majority of the variability.

Through funding by the National Science Foundation, I have been investigating how physical forces modulate dissolved oxygen in Chesapeake Bay and contribute to the unexplained inter-annual variability in hypoxic volume. During the summer of 2011, I conducted an intense field campaign to document the interactions between physical processes and dissolved oxygen concentrations. This work included extensive ship-based surveys, as well as moored instrumentation maintained at a mid-Bay cross-section from mid-May through mid-September. (cont’d. on page 2)
When the moorings were deployed in mid-May, bottom dissolved oxygen concentrations had already dropped to near hypoxic levels. Bottom waters remained largely devoid of dissolved oxygen throughout the summer until Hurricane Irene moved up the coast in late August. As the hurricane came closer and wind speeds increased, oxygenated waters arrived first at bottom waters along the western shore and progressed eastward during the storm. This is clearly not just direct vertical mixing, but the combination of vertical mixing with wind-driven circulation. Because of the track of Hurricane Irene, the winds over Chesapeake Bay were almost entirely from the north throughout the storm. Thus, the Ekman transport was directed toward the west, causing downwelling along the western shore bringing oxygenated waters from the surface to the bottom along the western shore.

In contrast, upwelling of bottom water had to occur along the eastern shore to replace the surface waters driven to the west. Thus, low oxygen bottom water was forced to the surface. The bottom sensor at Mooring D was destroyed during the storm, but the surface sensor reveals a large decrease in oxygen concentration as the storm intensified, consistent with upwelling at this location. The strong surface mixing rapidly oxygenated the low-oxygen water that upwelled along the eastern shore. When the winds began to abate, this newly oxygenated water sloshed back to west, providing an influx of oxygen to bottom waters. The fact that the bottom dissolved oxygen concentrations did not begin to increase at Mooring C until wind speeds began to decrease is consistent with oxygenated water from the eastern shore sloshing back to the west.

While Hurricane Irene provides a dramatic example of how low-oxygen waters slosh back and forth as part of the mixing process, this also occurs during weaker winds typical of summertime conditions. Figure 2 shows the across-estuary distribution of dissolved oxygen collected by ship-based surveys that were roughly one day apart during the summer of 2011.

The survey conducted on June 12 followed a period of moderate winds from the south. Following the survey on the 12th, the winds reversed and blew from the north with peak speeds of roughly 20 knots. Following the wind event from the south, the oxygenated surface waters are displaced toward the east, with low-oxygen water upwelling onto the western shoal. There is even a hint that this low-oxygen water has been mixed with surface waters along the western shore. The picture is reversed after the winds from the north on June 13, with oxygenated surface waters deflected toward the western shore and low-oxygen water upwelling along the eastern shore. (cont’d. on page 7)
My trip began on a hot, humid Friday afternoon at the end of July. Five airports, 6,000 miles, and 30 hours later, I arrived in Punta Arenas, Chile, one of the southernmost cities in the world. With snow on the ground and temperatures below 0°C, it already felt like Antarctica. The research cruise was part of NOAA Fisheries’ U.S. Antarctic Marine Living Resources (AMLR) program. AMLR cruises have been conducted for over 25 years on the Antarctic Peninsula, with sampling stations from south of King George Island to the east of Elephant Island. However, this was the first AMLR winter cruise. It was also the first time the cruise was onboard the NSF’s ice breaker R/V Nathaniel Palmer. Therefore, one of the main objectives was to become familiar with the ship operations and the icy conditions of the study area.

For this cruise, the sampling stations were located mostly around Elephant Island, one of the few areas with low ice concentrations adequate for navigation. The chief scientist for the cruise was Dr. Christian Reiss, a former OEAS-ODU graduate student, who is now with NOAA.

My job was with the CTD-water sampling group. We collected water samples from the Niskin bottles attached to the rosette to examine for micronutrients and salinity analysis. I also ran water samples through the salinometer and did some processing of the data that was being collected. Polar research is not my area of expertise, so it was interesting to interact with the scientists that are experts in this field. The other groups worked on krill sampling, lipids extraction, acoustics, bird and mammal observation, and phytoplankton. The following days were pleasant and uneventful.

The Palmer began heading north to Punta Arenas and in three days, we were back on land enjoying the sun. After a couple of weeks in Chile visiting my family, I returned to the hot, humid weather of Norfolk, which I had really missed. I’m very grateful to Dr. Christian Reiss for the invitation to the cruise and to Dr. Eileen Hofmann, CCPO, for allowing me to have this opportunity. Without any doubt, this research cruise was one of the best and most rewarding experiences of my life.
There is increasing recognition that human activities are important drivers of change in the world’s ocean and that humans are in turn affected by ecosystem changes. This recognition has motivated changes in the traditional approaches used to study marine ecosystems (Figure 1). Many of the research programs now being planned include explicit components directed at understanding socio-economic effects and interactions, and their feedbacks to marine ecosystems. This evolution in how marine ecosystems are viewed is at the forefront of international global environmental change research and is being incorporated into planning for future research efforts. One such effort, Future Earth, is being planned as a 10-year international research initiative that is focused on developing the knowledge for responding to the risks and opportunities of global environmental change and moving toward global sustainability.

Addressing the many important issues of human-ocean interactions requires a community of scientists who can work at the interface of natural and human systems (trans-disciplinary research) a community that does not now exist. The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project, a global environmental change research program co-sponsored by the International Geosphere-Biosphere Programme and the Scientific Committee on Oceanic Research, has undertaken initiatives that are intended to foster the development of this community. Two recent activities have focused on providing trans-disciplinary training. The first was a summer school in 2012 that was focused on human-nature interactions in the marine world, which brought together scientists from the disciplines of resource economics, social science, marine ecosystem modeling, climate modeling, and Earth system modeling. The second will occur in January 2013 as part of the IMBER IMBIZO (a Zulu word meaning a gathering) series.

The IMBIZO consists of workshops that explore the linkages and interactions between humans and ecological and biogeochemical systems in the continental margins and open ocean. The IMBIZO will bring together scientists from a range of natural and social sciences. The IMBER Human Dimensions Working Group, which is focused on the two-way interactions between human and ocean systems, provides the longer term view and focus for developing human-natural science linkages.

The need for sustainable and secure sources of food, water, energy and other ecosystems services is transforming the way marine ecosystem research will be done. Participation in research initiatives that are being planned for the future will require marine scientists to have familiarity with social science and economic concepts, and vice versa.

Fig. 1 Schematic showing characteristics and process within the biophysical and human social fishing systems of marine social-ecological systems, and their interactions and connections (figure from Perry et al., 2010, in: Marine Ecosystems and Global Change).
Late in the spring semester of last year, I saw an announcement posted for an internship sponsored by the Virginia Sea Grant. They were looking for two students to board the NOAA Ship *Okeanos Explorer* (Figure 1) to collect acoustic data in the Northwest Atlantic for future scientific research. With the backing of ODU’s oceanography department, I knew I had a favorable chance of being selected for this great opportunity. In less than a month’s time, I was offered the internship, selected from hundreds of worthy applicants.

At the time, I still considered myself as being fairly new to the oceanographic community. With a background in physics, one of my major interests is in continuous mediums. The importance of the earth’s oceans and how they impact the planet is what drew me to this field. Oceans provide the foundation for the most extensive food web in the world, affect climate patterns, and provide a source of renewable energy. Currently, my studies focus on energy transfer within a density stratified water column. Many factors determine how well the process takes place and on some instances, the oceanic bottom must be taken into consideration.

David Packer, a marine ecologist from NOAA and the National Marine Fisheries Service, was the primary investigator aboard the NOAA ship *Okeanos Explorer*. He is particularly interested in habitats that may house deep sea corals. We worked closely to determine which areas of investigation consisted of a “hard bottom”. He explained that corals are typically found at these locations. We used the intensity of the backscatter data collected as a determinant of which areas would be of greater interest. My team was only one part of a series of explorations that had a main focus of categorizing habitats that house a wide variety of organisms in order to help create protective policies for those regions (Figure 2). As an intern, I was required to produce a poster that captured the essence of the expedition to help educate the public and future interns about the research performed by NOAA. The overall experience was great and I would recommend it to anyone studying the ocean.

Aboard the NOAA Ship *Okeanos Explorer*, I was able to collect bathymetric data that maps the lower bounds of the oceanic medium. I observed the geophysical structures that affect ocean circulation and saw how the movements help to shape the structures themselves. My assignment was to process and filter raw data, collected acoustically below the ship’s hull. I knew the information I gathered would be beneficial to the scientific community, as well as assist in the safety of maritime and military navigation.
Edited Journal Issues


Publications


Presentations


The sloshing back and forth of the low-oxygen water is important because it brings low oxygen water up towards the surface. This lateral sloshing is largely driven by winds that blow along the axis of the Bay (north-south). In contrast, winds that blow across the Bay (east-west) create significantly less lateral water movement. As a result, across-estuary winds are less effective at supplying oxygen to hypoxic bottom waters. Using the moored oxygen sensors deployed during the summer of 2011, the total hypoxic area measured at the cross-section was estimated. The time rate of change in the hypoxic area was then averaged both as a function of wind speed and wind direction (Figure 3).

Under weak winds, hypoxic area generally increased, independent of direction. However, as wind speed increased, winds from the south decreased hypoxic area the most. In contrast, winds from the west always increased hypoxic volume. This result is consistent with the analysis of a 60-year time series of hypoxic volume that I recently published (Scully, M. 2010, *Journal Physical Oceanography*, 40, 1435-1440). In this paper, I found that inter-annual variations of hypoxic volume were strongly correlated to the total time that winds blew from the west during the summer. But this paper could only speculate about reasons for this correlation. The measurements collected during the summer of 2011 are consistent with my previous analysis and provide a detailed explanation for why summer wind direction is so important to water quality in Chesapeake Bay.
# Center for Coastal Physical Oceanography
## Spring 2013 Seminar Series

During the academic year, CCPO invites distinguished scientists to present seminars, which take place in Room 1202 on the first floor of the Engineering & Computational Sciences Building, Old Dominion University. Lectures begin at 3:30 p.m., with a reception prior at 3 p.m. Eileen Hofmann, professor of oceanography, coordinates the seminar series. Specific topics are announced one week prior to each seminar; abstracts can be found at www.ccpo.odu.edu/seminars_spring2013.html.

<table>
<thead>
<tr>
<th>DATE</th>
<th>SPEAKERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 21</td>
<td>No Seminar - Martin Luther King Jr. Day</td>
</tr>
<tr>
<td>January 28</td>
<td>Kunio Sayanagi, Hampton University</td>
</tr>
<tr>
<td>February 4</td>
<td>Jennifer Francis, Rutgers University</td>
</tr>
<tr>
<td>February 11</td>
<td>Nicholas Nidzieko, UMCES Horn Point Laboratory</td>
</tr>
<tr>
<td>February 18</td>
<td>Stefanie Mack, CCPO</td>
</tr>
<tr>
<td>February 25</td>
<td>Willett Kempton, University of Delaware</td>
</tr>
<tr>
<td>March 4</td>
<td>David Bruce, NOAA; Joe Rieger, Elizabeth River Project; Tommy Leggett, Chesapeake Bay Foundation</td>
</tr>
<tr>
<td>March 11</td>
<td>No Seminar - ODU Spring Break</td>
</tr>
<tr>
<td>March 18</td>
<td>Guillaume Martinat, CCPO</td>
</tr>
<tr>
<td>March 25</td>
<td>Oscar Schofield, Rutgers University</td>
</tr>
<tr>
<td>April 1</td>
<td>Walker Smith, VIMS</td>
</tr>
<tr>
<td>April 8</td>
<td>Frank Rack, University of Nebraska-Lincoln</td>
</tr>
<tr>
<td>April 15</td>
<td>Gangfeng Ma, Department of Civil and Environmental Engineering, ODU</td>
</tr>
</tbody>
</table>