NOAA Office of Ocean Exploration

FINAL REPORT
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Title: Benthic Ecosystem Characterization of the Charleston Bump

Area of Operation: Charleston Bump, 31°30'N, 71°00'W

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II. Summary

1. Abstract

To learn more about the bottom dwelling organisms of the Charleston Bump, we explored the benthic invertebrate communities of the Charleston Bump and nearby shelf areas utilizing a manned submersible, and attempted to determine how aspects of the local hydrographic regime drive benthic productivity, species diversity and patterns of distribution. We 1) used videographic surveys and collection devices to characterize the epifaunal and infaunal invertebrate communities of the several different habitat types found on the slopes of the Bump, 2) emplaced 'clod cards' to characterize the near-bottom hydrographic environment and its relationship to benthic community structure, and 3) collected hydrographic data at a variety of scales to elucidate how the bump affects hydrodynamics of the shelf area. We also formed a team with a K-12 teacher who participated in our cruise and collaborated to develop research-based lesson plans and materials that specifically address National and South Carolina standards. This report details our finding and products, reviews work that was not completed or was different from our original objectives, and reviews our budget expenditures.

2. Purpose of Project

To learn more about the bottom dwelling organisms of the Charleston Bump, we proposed to explore the benthic invertebrate communities of the Charleston Bump and nearby shelf areas utilizing a manned submersible, and to preliminarily examine how aspects of the local hydrographic regime drive benthic productivity, species diversity and patterns of distribution. During our explorations, we proposed to 1) use videographic surveys and collection devices to characterize the epifaunal and infaunal invertebrate communities of the several different habitat types found on the slopes of the Bump; 2) emplace 'clod cards' to begin to characterize the near-bottom hydrographic environment and its relationship to benthic community structure, and 3) collect hydrographic data at a variety of scales to elucidate how the bump affects hydrodynamics of the shelf area. We also proposed to organize teams of K-12 teachers and students to participate in cruises and develop research-based lesson plans and materials that specifically address National and South Carolina standards.

3. Approach

A. Characterization of the Benthic Community

At the end of the two week cruise, we had collected numerous benthic invertebrates and sediment samples, and had run videographic transects at all stations visited. Collected organisms were divided between ourselves and collaborators from George Sedberry's team. We took most of the echinoderms and all of the sediment samples that had been collected using the submersible's sucker. All organisms were preserved in 80% ethyl alcohol and transported to the Stancyk lab on the USC campus. Samples were archived and annotated in a spreadsheet held at the Southeastern Taxonomic Research Center in Charleston, in combination with samples collected by the Sedberry group.

B. Clod Cards

Experiments to deploy, recover and evaluate clod cards to estimate relative current speed and mixing rates between exposed planar regions and beneath overhangs and ledges were undertaken. We deployed a total of 5 clod cards in three different locations in water depths ranging from 460 to 560 m and were able to relocate and recover all sets. This included both short-term (24 h) and long-term (7 d) deployments**.** All clod cards were stored and processed in the Styles lab at the University of South Carolina.

C. Hydrogaphy

Full water column current speed and direction were acquired from a low (78K Hz) and high (150K Hz) frequency Doppler profiler permanently mounted on the *R/V Seward Johnson's* outer hull. Both instruments sampled nearly continuously during the 11-day survey portion of the cruise. During the day, the ship maintained station over the dive site so that measurements are viewed as time series at a single point. Night operations involved cross-stream transects to provide fuller coverage of Gulf Stream variability. In a few instances, weather conditions forced us towards the northwest, which had the fortuitous result of expanding our ADCP surveys to include portions of the mid-shelf and the transition between the western edge of the Gulf Stream and the much shallower continental shelf. Data were managed and processed in the Styles lab at the University of South Carolina

D. Educator Collaboration and Outreach

We were accompanied on our cruise by a K-12 science coordinator, who worked chiefly with Dr. Sautter in assembling research-based educational materials. They also designed several standards-based exercises. In addition, all of the scientists, in collaboration with Dr. Sautter and her *Project Oceanica* team, designed photo- documentaries about various aspects of the science performed on the Charleston Bump. Together with another NOAA-funded project (SC Sea Grant Rising Tide Project), lesson plans and laboratory exercises were planned for a USC-based web page.

4. Findings

A. Characterization of the Benthic Community

Organisms

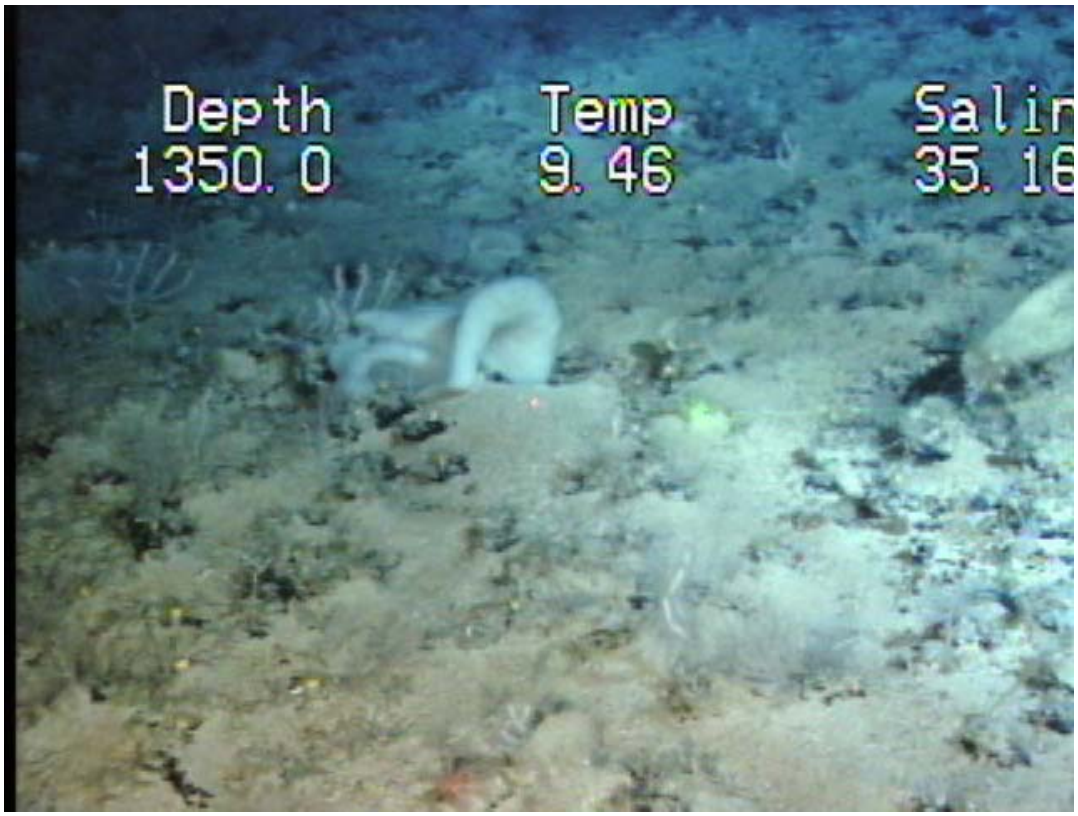
We collected 21 species of echinoderms in all classes, but the collection was dominated by asteroids, of which we obtained 12 species. All of the echinoderms have been identified and archived at the Southeastern Taxonomic Research Center in Charleston. All other invertebrates were retained and identified by staff at SERTC – see Sedberry Final Report for OE project Number: NA03OAR4600097.

We also collected 16 separate samples of sediment, ranging in volume from 1 to 5 liters. These samples have been completely sorted by undergraduate assistants. All organisms larger than 1 mm were retained, including corals, polychaetes, bivalves, and arthropods. Once sorted, organisms were sent to experts on the Sedberry team or sent towill be identified on site or sent to experts and collaborators at the Southeastern Taxonomic Research Center in Charleston..

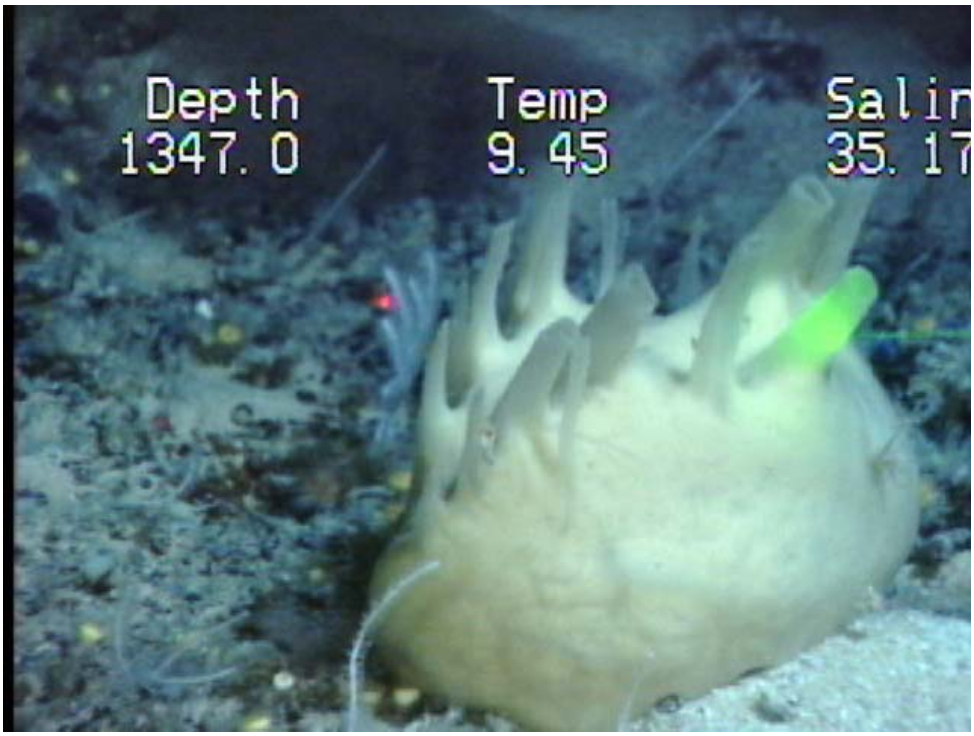
Video surveys

Every submersible dive involved at least one, but usually more, videotaped transects across the sea bottom. We duplicated all of these tapes and archived in the Helmuth lab at the University of South Carolina. An undergraduate hired during our one-year extension reviewed all tapes in order to isolate particularly useful sections. Initial viewing indicated strong patterns of organism orientation relative to currents, such that filter feeders appeared to be oriented in the same way in areas of high or unidirectional current. Because of the volume of material, a subset was analyzed.This study investigated the sponge population at Sherwood Valley, a site at 400 m depth. After developing a data collection protocol using image capture technique, sponges were classified according to morphological characteristics and counted(figure 1). Measurements were taken of their size and distance relative to other sponges via ImageJ software. Comparisons of data were made between frames, but statistical analysis suggested no clear correlation between changing depth at the site and variations in sponge density, distance between sponges, or their height-to-width ratio. The site's depth range was only IO meters, however, and temperature, substrate, and salinity were uniform at the site and did not produced any effect effect on the sponge community. At the single site of Sherwood Valley at least, variations in morphology or distribution were not attributable to changes in physical factors on an intrasite basis, although long-term current measurements might have provided data on primary current direction that could have influenced the entire community.

A great deal of video analysis remains to be done, but there are no funds or personnel available to carry out the work. Remaining analysis would involve precise measurements of organism orientation relative to currents at other sites, comparison of faunal composition with different substrates at different sites, and quantification of



Still #	Time	Depth (m)	Frame (m)	Sponge	Morphology	Orient. (deg)	Width (m)	Height (m)	To #2 (m)
1	0:14	411.48	1.64	1	White bonnet	140	0.16	0.08	0.16
				2	White bonnet	120	0.18	0.16	



Still #	Time	Depth (m)	Frame (m)	Sponge	Morphology	Orient. (deg)	Width (m)	Height (m)
3	8:56	410.57	0.53	1	Yellow chimney	135	0.31	0.29

Figure 1. Typical framed of sponges and orientation measures from video survey.

organism distribution relative to substrate and current regimes in sites where those could be quantified. Attempts to correlate organisms in the sediment samples discussed above with videotape evidence of current direction were not successful because current data could not be obtained for most sites.

B. Clod Cards

Experiments to deploy, recover and evaluate clod cards to estimate relative current speed and mixing rates between exposed planar regions and beneath overhangs and ledges were highly successful. We deployed a total of 5 clod cards in three different locations in water depths ranging from 460 to 560 m and were able to relocate and recover all sets. This included both short-term (24 h) and long-term (7 d) deployments. Units placed in sheltered regions (behind boulders, underneath ledges) possessed the lowest rates of dissolution, signifying relatively low current speeds and weak turbulence. Units placed on the top of exposed outcrops and low relief rock beds had the highest dissolution rates signifying greater current speeds and turbulence. The presence of current-generated ripples also provided evidence of flow speeds strong enough to mobilize coarse sand in exposed areas. The clod card results unequivocally confirm one of our initial hypotheses that benthic habitats on the Bump experience diverse flow conditions that may influence particle delivery and help to explain the spatial distribution of benthic organisms. The fact that we were able to return to 3 different sites also demonstrates that we can effectively navigate the swift currents and rocky terrain of the Bump.

C. Hydrographic Data

The time series measurements indicate strong along axis currents (> 1 m/s) throughout the water column in the center of the Gulf Stream. This was confirmed by concurrent submersible flow speed measurement that indicated swift currents approaching 1 m/s at the bottom over some dive sites. Measurements at the shelf break indicated a possible subsurface jet traveling opposite to the Gulf Stream. In addition to ADCP profiles, a total of 16 CTD casts using the *R/V Seward Johnson's* rosette were conducted during the 11-day survey period. The spatial distribution encompassed the region of the Gulf Stream and adjacent shelf in the vicinity of the Charleston Bump. The results showed a well-defined bottom mixed layer that extended 30 km laterally across the swiftest portion of the Gulf Stream (Figure 2). Bottom temperatures were around 10 ^{o}C and mixed layer depth was approximately 100 m thick in the central part of the Gulf Stream. Isotherms tilted upwards towards the shelf edge in agreement with historical observations of the stream in this region (Glenn, S. M. and C. C. Ebbesmeyer. 1994. The structure and propagation of a Gulf Stream frontal eddy along the North Carolina shelf break. *J. Geophys. Res*., 99, 5029-5046). Salinity varied less than 2 ppt between the surface and bottom and subsurface isohalines also tilted upwards towards the edge of the continental margin. The salinity maximum (36.6 ppt) occurred at about 150 m depth and a minimum of 35.2 ppt was seen in the bottom mixed layer.

The measured velocity profiles were compared to the calculated velocity profiles to produce a statistical model of vertical variability in Gulf Stream flow. Depth-independent estimates of the geostrophic current were computed from cross-stream sea surface height anomaly (SSHA) data obtained from the TOPEX and Jason-1 satellite altimeters. These estimates provide the boundary condition for the flow estimates obtained from the thermal wind equation calculations. On the basis of these comparisons, a data-calibrated model emerged that generated a decadal time series of Gulf Stream transport for this area of the South Atlantic Bight (SAB) and can accurately compute the local depth-integrated volume transport using historical SSHA data. The mean geostrophic transport for the period 1992-2004 is 37.5 Sv ± 7.7 Sv.

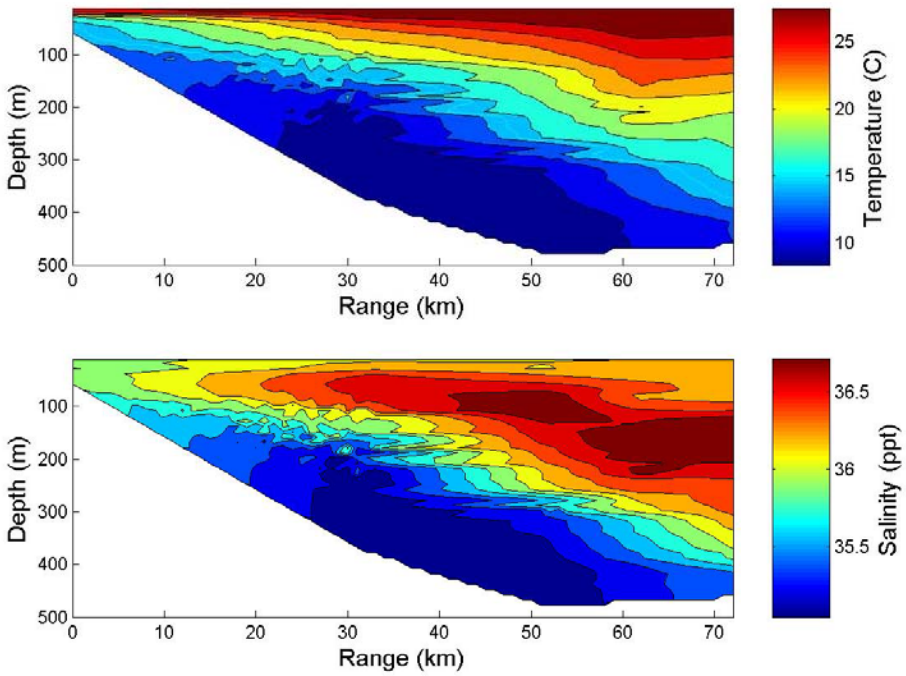


Figure 2. Salinity and temperature cross-section from the shelf edge into the middle of the Gulf Stream.

D. Educator Collaboration and Outreach

We were accompanied on our cruise by a K-12 science coordinator, who worked chiefly with Dr. Sautter in assembling research-based educational materials. They are continuing to work on standards-based exercises, and presented some of their results at the South Carolina Marine Educators Meeting in spring 2005 and 2006. In addition, all of the scientists, in collaboration with Dr. Sautter and her Project Oceanica team, produced numerous photodocumentaries about various aspects of the science performed on the Charleston Bump. These may be viewed at
http://oceanica.cofc.edu/CharlestonBump2003/Photodoc.htm

The primary exercise for students is "Taxonomy of The Charleston Bump- an educational activity for middle and high school students", by Connie Leverett & Dr. Leslie Sautter Four other photo galleries have been completed, including an extensive explanation of the echinoderms of the Bump, by Drs. Leslie Sautter & Steve Stancyk. These may be viewed at
http://oceanica.cofc.edu/CharlestonBump2003/PhotoGallery/photogallerybump03.htm

E. Presentations, publications and other products

Web sites: See above

Presentations: Hooker, D., R. Styles, S. Stancyk, L. Sautter and B. Helmuth, 2004. A comparison of the geostrophic balance and current measurements in the Gulf Stream. Southeastern Ecology and Evolution Conference, Georgia Institute of Technology, Atlanta, GA

Publications: Hooker, D., R. Styles, S. Stancyk, L. Sautter and B. Helmuth, 2004: Long-term estimates of geostrophic transport in the Gulf Stream, Eos Transactions of the American Geological Union 85, Fall Meeting Supplement., Abstract F1017.

Unpublished Senior Thesis: Pravatiner, Joan. 2005. The effect of physical factors on sponge distribution and morphology at the Charleston Bump's Sherwood Valley. Senior Thesis, Univ. of South Carolina Honors College. 64p

III. Evaluation

1. Accomplishments

Although we accomplished most of our field objectives, having our cruise teamed up with another research team also working on the Charleston Bump complicated the research considerably, and prevented us from examining transects repeatedly, or making current measurements. Depending upon which team member was in the sub, some objectives of one team or the other were neglected. I would strongly recommend against putting two research teams on the same cruise unless each was given its full complement of dives with its own team members.

There was also some misunderstanding between groups about who would retain and identify collected invertebrate specimens. One of our objectives was to capture sediment samples from either side of sponges in a strong current area, but in the end all the sponges and associated sediment collections went to the other group, as did all of the other invertebrates except echinoderms.

We were very successful in demonstrating that clod card experiments allow inexpesive non-quantitative comparisons of currents in different local areas within a transect, and our hydrographic data led to a comprehensive characterization of the local hydrographic regime.

We were able to produce numerous photodocumentaries and photo galleries about the Bump and life on board a research vessel, and we developed lesson plans that are useable by middle school teachers.

2. Expenditures

	Planned Expenditures	Actual Expenditures
Personnel	10,000	16,358
Fringe	50	151
Travel	2,300	1,359
Equipment	00	00
Supplies	5,766	1,019
Indirect	8,243	7,192
Data Processing	00	1,811
Services	00	919
Total	28,809	28,809

There were no special problems with the budget, except that we did not need as many funds for travel or supplies as we had anticipated. However, there were unanticipated charges for services and processing of hydrographic data. At the end of the grant period, we retained $5748. We received a no-cost extension to allow us to spend this surplus to hire one undergraduate student and one graduate student to help complete the videoanalysis and sediment sorting and identification. We were able to complete the sorting and to produce a report and a senior thesis on sponge distribution. We also used this student labor to complete our remaining photodocumentaries and research-based educational materials. At the end of the no-cost extension period, we had completed the project and expended all of the funds.

Prepared by: Stephen E. Stancyk 1 December 2006