

Africa Partnership Station

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LONG-TERM GOALS

The long-range goal of this research is to assist in the development of the ONR-sponsored Africa Partnership Station to be located in Accra, Ghana, Africa.

OBJECTIVES

1. Assist in guiding activities associated with coastal processes research conducted by the University of Ghana (PI Wiafe) during the second and third years of their 3-year funded program, and conducting workshops related to specific objectives.
2. Assist in the preparation, deployment, and operation of a directional wave buoy off the coast of Ghana for regional numerical modeling studies, collaborate in field activities, and conduct a joint UG-UNH workshop on data collection and analysis methods.
3. Assist in the development of a shallow water survey vessel for studies of the large scale coastal behavior along the Ghana coastline.

APPROACH

The ONR-sponsored project, which is being facilitated by CNE-C6F's Africa Partnership Station (APS) is presently in its second year of development. The overall goals of the program are to assist emerging West African nations in obtaining knowledge of and skills working in shallow coastal environments, developing a remote sensing capability, and creating a partnership where education and capacity building exercises are implemented in the host countries. The program is developing a shallow water component where various researchers from the U.S. and around the world provide in-depth training and expertise in nearshore processes including theoretical knowledge, numerical model

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development and execution, satellite imagery analysis, and field observation techniques, processing, and assimilation of data with models.

The proposed research builds upon activities conducted in 2008 & 2009, including ONR-sponsored nearshore processes workshops coordinated and carried out by the PI and collaborators (Dr. Dano Roelvink, UNESCO; Dr. George Wiafe and Mr. Selorm Ababio, UG; Dr. Augustus Vogel, U.S. Naval Forces Europe and Africa; Dr. Cheryl Hapke, USGS; Dr. Andrew Ashton, WHOI), and a 3-year ONR-funded proposal to UG (PI Wiafe) to begin development of oceanographic field capabilities within the APS.

The long-range goals of the Ghana partnership within the APS are to develop a regional observational network of sensors and expertise to support coastal research activities both within the country and extending cross-borders throughout the Gulf of Guinea. The thrust of the program will be coordinated by the University of Ghana in Accra, with laboratory and technical support in the Department of Oceanography and Fisheries, and with long-term plan - through university, governmental, and DOD support - to build, staff, and operate a facility directly on the coastline from which field operations and regional data collection would be based.

The coastal and marine environment of Ghana contributes significantly to the economic development and security of the country. Ghana has demarcated a 200 nautical mile Exclusive Economic Zone (EEZ) within the framework of the United Nations Convention on the Law of the Sea (UNCLOS). This has brought vast living and non-living resources under Ghanaian jurisdiction. Furthermore, shipping traffic continues to rise and associated problems with ballast water and potential oil spill raises concern for ecosystem health. The ability for monitoring the resource and the environment will contribute immensely to the management of the marine ecosystem.



Figure 1. Active erosion at Accra (left two panels), Anyanui (third from left), and Ada (far right) showing the effects of rapid beach erosion threatening major coastal roadways in the region.

The coastline of Ghana measures about 550 km and is generally a low-lying area not exceeding 200 m above sea level. It is bordered by a narrow continental shelf extending outwards between 30 and 90 km. Presently, there is an increasing rate of erosion along the coastline. Shoreline recession is caused by the interplay of several factors including prevailing wave regimes, damming of rivers, and removal of vegetative cover. In at least three sites visited during the workshop, the erosion is so rapid that major coastal roadways are being washed into the sea or threatened (Figure 1). Limitations in infrastructure to repair the roadway or use alternative routes (of which there are none presently constructed) make this a serious problem for local communities and commerce. Understanding the changes to the sediment transport that have occurred at these two sites is critical to forecasting changes along other parts of the coastline, most of which has shown a marked loss of overall sediment within

the past 2 decades (Figure 2) based on widely acknowledged anecdotal observations from UG researchers and the local populace.



Figure 2. Rocky coastline along the region just to the west of Ghana (left). This region was characterized by a wide sandy beach just a decade before, similar to adjacent beaches nearby (right).

WORK COMPLETED

All numerical modeling efforts for coastal changes require knowledge of the wave climate in the region. Presently, observations of surface waves on the Ghanaian shelf, and in the Gulf of Guinea in general, are not made. As part of the University of Ghana's efforts, a directional wave buoy was deployed on the Ghanaian shelf. As part of the work completed, assistance in the preparation, deployment, operation, and maintenance of the buoy was provided during a mooring workshop held at the University of New Hampshire in March 2010 (Figure 3).



Figure 3. (left panel) Typical vessel (50 Ft. R/V Gulf Challenger) used to deploy wave buoy's by the UNH mooring team. (right panel) Photo of a deployed 0.9 m diameter Datawell Directional Wave Buoy .

Through a DOD-sponsored research grant (PI Wiafe), the University of Ghana purchased a Datawell Directional Wave buoy and in August 2010 deployed it in 200 m water depth at the edge of the continental shelf off the coast of Ghana (Figure 4). The location ($4^{\circ} 13.65$ N; $1^{\circ} 38.65$ W), of the buoy at the point of the continental shelf directly off the central coast of Ghana is ideal for observing the surface wave field uninterrupted by offshore obstructions or bathymetric irregularities.

The buoy is equipped with Iridium satellite link for retrieving wave data 6 times per day. These data will be used to initialize swell wave models for the entire Ghanaian coastline under the assumption that the swell wave field is homogeneous over that distance. The deployment location of the wave buoy will allow wave predictions over the entire northern boundary of the Gulf of Guinea, as the wave buoy is in an ideal location to measure swell originating over a 180° window open to waves propagating away from storms everywhere in the Atlantic Ocean south of the equator, and directly along great circle routes from the Southern Ocean. Anecdotal wave climatology is not well documented for the Gulf of Guinea, and the buoy will provide the first long term observations in the region and allow regional modeling capabilities for wave prediction in the Gulf of Guinea encompassing many nations (and thereby promoting international collaborative efforts).

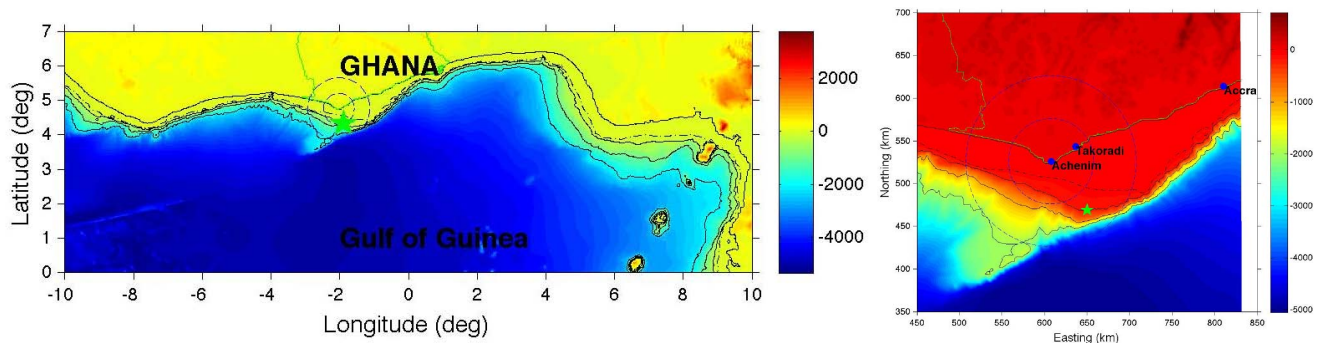


Figure 4. (left panel) Bathymetric map of the Gulf of Guinea showing the deployment location of the directional wave buoy (green star) off the Ghana coastline. (right panel) The location of the directional wave buoy off the coast of Ghana along the 200 m depth contour. The shoreline, 75 m (dash-dot line), 200 m, 1000 m, and 2000 m contours are shown. The color scale is elevation in meters relative to mean sea level.

RESULTS

The directional wave buoy was deployed in the Gulf of Guinea on the 200 m depth contour on 21 August 2010. The deployment was carried out by University of Ghana researchers with assistance from the Ghana Navy (Figure 5).



Figure 5. Deployment of the direction wave buoy in 200 m water depth. The buoy was deployed University of Ghana researchers aboard the Ghana Naval Ship GNS Anzone. Detailed bathymetric depths were surveyed by University of Ghana researchers onboard a Defender Class boats .

Figures 6 and 7 show sample observations obtained from the wave buoy. Wave observations indicate a persistent, energetic long period swell (around 11-14 sec) originating in the Southern Ocean and impacting the coastline at about a 25 degree incidence angle in 200 m water depth, and a variable, local wind-driven sea (between 5-7 sec). Root-mean-square wave heights are between 1.5 and 2 m.

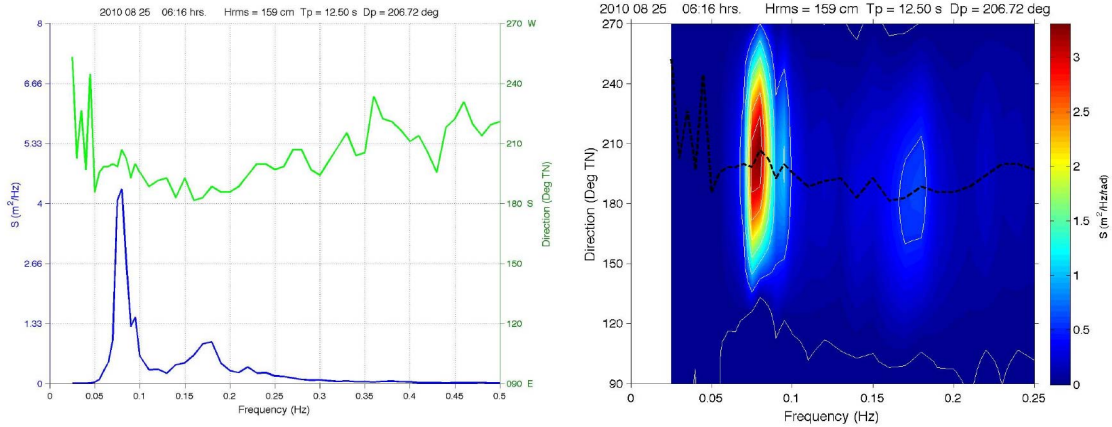


Figure 6. (left panel) Wave spectrum and dominant wave direction at each frequency observed on 25 August 2010 at 0616 hrs GMT showing long period (13 second) swell originating in the Southern Ocean and higher frequency, local wind-driven seas 25 degrees to the south of the swell. (right panel) Color contour plot of the directional wave spectrum. Dashed line depicts dominant wave direction.

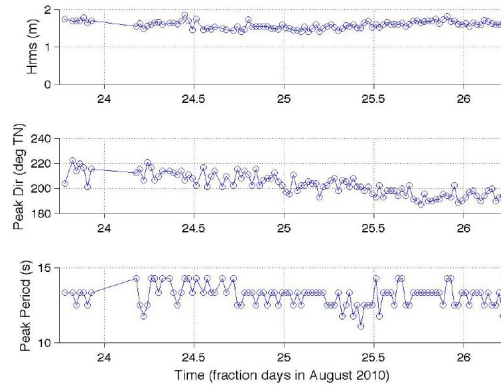


Figure 7. Wave heights (upper panel), and spectral peak wave direction (middle panel) and period (bottom panel) observed with the wave buoy in late August 2010.

To facilitate UG research efforts within the framework of the APS, improved internet access is required through upgraded infrastructure to UG in general, and in particular to the Dept. of Oceanography and Fisheries. This need has already been identified and some efforts are being put forward to ensure that this happens. Increased bandwidth will facilitate exchange of research results,

allow for data mining from global sources, the timely acquisition of satellite imagery, as well as direct Iridium link to the wave buoy.

IMPACT/APPLICATIONS

The training and buoy deployment serve to continue development of capabilities in coastal processes research in West Africa. Wave buoy observations will allow wave climatology in the region to be better understood, and to initialize wave models for predicting sediment transport.

TRANSITIONS

Capacity building exercises will continue within the program, including instructional workshops and development of observational capabilities for shelf and surf zone processes.

RELATED PROJECTS

Ongoing partnership with other U. S. Naval and oceanographic entities in the US (UNH, WHOI, USGS, RSMAS, NPS), Ghana (Univ. Ghana), Europe (UNESCO), and in neighboring regions.