SEABED MORPHOLOGY OFF SOUTHERN LONG ISLAND: STUDIES OF ARTIFICIAL REEFS AND IMPLICATIONS FOR WIND FARMS

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High resolution multibeam surveys to collect topographic and backscatter data at 300kHz were conducted in August 2001 and January 2005 on a set of artificial reefs along the south shore of Long Island, NY. The January 2005 cruise also included bottom photographs and groundtruthing of sediment characteristics with grab samples. The surveys of the reefs along the south shore demonstrated lateral variability in the surface sediment characteristics. Rates of morphological change can be determined where there were multiple surveys. In addition, a dramatic change in the texture of the bottom, which corresponds to biogenic structures is clearly visible in a large portion of the Fire Island Reef survey area. The presence of these biogenic structures in the geomorphology highlights the need to look at mesoscale temporal and spatial variability of the seabed and the role of the seabed as benthic habitats at more than one time in the year. This is particularly true in areas of proposed 'industrial' activity, so that important decisions are not made on insufficient data. Artificial reefs are particularly interesting because the surveys document variability in the seabed around very large anthropogenic structures on the seafloor, some of which are similar in scale to the proposed windmills. The mobility of sediment and the movement of bedforms can also be seen. The obviously active dynamics of the seafloor suggest that one needs to understand how active the seafloor is when placing such structures, and trying to assess their impact on the environment. (Fig. 1)

Figure 1. Map of Study Area and Wind Farm Sites

Two artificial reefs, Hempstead Town Reef and Fire Island Reef, are located close to the proposed wind farm site. (Fig. 1) Hempstead Town Reef is located approximately 6 km west of the proposed wind farm site in water depths of 13 to 22 m, while Fire Island Reef is located 7 km east of the proposed wind farm in water depths of 17 to 23 m. The depth of the proposed wind farm is 16 to 24 m. Hempstead Reef was only surveyed once, while Fire Island Reef was surveyed twice. Changes over 3.5 years in fauna, and seabed morphology of Fire Island Reef can be seen in the multibeam data.

General characteristics of study area:

As is generally understood, most of the south shore of Long Island is fairly flat and composed of predominantly sandy glacial outwash. The offshore lands were flooded at the end of the last ice age, and exposed to the reworking of currents and waves. Many studies have described the region's past and characteristics, including the general characteristics of the south shore of Long Island. The generally coarse nature of the offshore sediments reflects the high energy environment in this area. The area is also typified by a wavy morphology that can be clearly seen on nautical charts and maps, with a wavelength or scale of approximately 800 m to 1 km. This wavy morphology corresponds to layers of thicker "modern" sand deposits, described by Schwab et al. (2000), as being one to a few meters thick in this region. The Fire Island Reef survey survey shows a portion of some of these large waves. (Fig. 2)

Figure 2. Fire Island Reef January 2005. Contours in meters. Depth decreases towards the top of the figure.

Data was collected at a fairly high resolution over Fire Island Reef, an area approximately, (2.7 x 2.0 km) 3000 x 2200 yards in size (NY-DEC website). (To give you an idea of the scale of this are, this is larger than the dimensions of Stony Brook's main campus, but less than twice the size of the main campus.) The artificial reefs are being used to create habitat for certain fish and other animals by providing a hard substrate. The reefs have been created and maintained by the New York State Department of Environmental Conservation (NYS-DEC). Fire Island reef contains many different large objects, such as old barges, boat hulls, concrete cesspool rings, dry docks, surplus armored vehicles, tires tied together, rock, and rubble (NYS-DEC website.) The areas around the surveyed reefs are generally sandy, with many sand dollars and some shellfish present as can be seen in grabs and bottom photos such the one in Fig. 3.

Figure 3. Example of Fire Island Reef showing a sandy bottom with ripples and sand dollars.

Wind Farm:

The Long Island Power Authority (LIPA) has proposed a wind farm off of Long Island. The proposed site of the wind farm is situated just outside of the 3-mile limit of state waters, in federal waters near Jones Beach on Long Islands South Shore. This location is in approximately 20m of water, which is close to the maximum depth at which wind farms have thus far been built, anywhere in the world (MMS, 2006). The proposed turbines are rather massive structures in their own right (Army Corps-NY District website). Large piles, 18.7 ft (5.7m), wide are to be driven approximately 100 ft (30.48 m) into the sea floor. The windmills would extend 443 ft (135 m) from the mean low-water mark to the tallest peak of the blades. The pilings would be surrounded by a set of scour mattresses on the seafloor, approximately 4 ft (~1m) thick and 49x49 ft (~15 x15m) square. A substation would also be installed. The process of installing these structures and laying the associated cables are two of several potentially disruptive effects of the structures.

The proposed location for the wind farm covers an area that is almost 2x6 miles (~ 3km by 10km) in extent. In addition to living resources, this area may also have other economic interests. The area of the proposed wind farms, on these large sand ridges in federal waters, has also been studied as a good location for sand mining in the past (MMS website). The Army Corps of Engineers has until recently been in charge of applications for development of off-shore wind farms, but that responsibility has been transferred to the Minerals Management Service, MMS, a federal agency in the Department of the Interior, as of August 2005 (MMS website).

Bedforms and structures:

The artificial reef surveys give an excellent illustration of how the seafloor changes in such a high energy environment and what one might expect to occur around a very large object on the seafloor. A type of change that is clearly shown in the reef surveys is the migration and alteration of bedforms in this sandy environment. (Fig 4a, b). Bed-form migration is not induced by artificial reefs but is natural occurance. One can see the movement of a few meters of some of these features, suggesting movement towards west or northwest at about 5m in 3.5 years. (The artificial reef structures, such as large barges, provide nice benchmarks to compare the movement of these features.) There are also moats or depressions around some of the reef structures, and the depressions around them appear to have changed between surveys (Fig 4a, b). In contrast, there are other seabed features (e.g., an experimental artificial reef on top of one of the ridges constructed from waste ash blocks) that do not appear to have created moats. The reason for this variability is not yet known.

Figure 4a.

Figure 4b.

One of the most striking changes in seabed character between the two surveys at Fire Island Reef is the presence of a large area of lumpy topography in the northwest portion of the survey area in January 2005 (Fig 6a, 6b). Grab samples and bottom photographs demonstrate that this lumpy topography is caused by polychaetes of the species *Asabellides oculata* (Fig 5a, 5b, 6a, 6b, 7, 8a, 8b). These may not be very large organisms individually, but they grow in these clusters creating mounds that are up to 0.8 m in height and tens of meters wide.

Figure 5a. Example of the edge of a Polycheate mound. The tubes that the organisms build to live in stick up out of the sediment into the water column. One can see that the tubes of individual organisms can stick up several centimeters vertically.

Figure 5b. Polychaetes cover the seabed. In contrast to Fig. 5a, the organisms are not in a dense mound. (Image is a little washed out due to close camera flash.)

These polycheates may be an important part of the benthic ecosystem during the winter. The presence and importance of mats of *Asabellides oculata*, have also been noted in other places (Clapp et al., 2002, Diaz et al, 2004). In general, bedforms, sediment type, and the presence or absence of biogenic structures, such as polychaete tube-mats have been shown to be important aspects of fish habitat and the marine ecology (Diaz et al., 2004). *Asabellides oculata* in particular, is a documented food source for fish, such as winter flounder and scud (Burlas et al., 2001). Biogenic structures such tube-mat fields also seem to be used as shelter by juvenile or young fish (Diaz et al., 2003). In fact one study found that “Asabellides tube mats had about twice as many fishes relative to bare sandy habitat” (Diaz et al., 2003).

Figure 6a. Shaded relief map showing a planar view of the lumpy texture visible in polycheate area during January 2005

Figure 6b. Shaded relief map showing a planar view of the smooth texture visible in polycheate area during August 2001

Figure 7. Angled view of the texture change visible in the bathymetry of the polycheate area between August 2001 and January 2005.

Polychaetes:

Six grab samples were taken and analyzed from the Fire Island Reef survey area. The polychaete tube mats are found in an area with a higher percentage of mud (i.e., silt and clay). There was approximately 2-3% mud in the polychaete area compared to less than 1% mud elsewhere. The survey also shows large areas of higher acoustic backscatter. A

sample in the high backscatter area has a higher percentage of gravel, 4.3% compared to 0% at FI _2 in the polychaete mound area. This gravel-sized sediment is composed of rounded predominantly light grey rock fragments, including many large quartz and feldspar grains. The maps of backscatter in the two different years, indicate a decrease in the backscatter of the polychaete area from 2001 to 2005. This decrease in backscatter may be due to the growth of the mounds in 2005. The mounts probably act to trap fine grained sediment.

Figure 8a. A January 2005 Backscatter map with locations of grab samples, and contours

Figure 8b. August 2001 Backscatter map and contours

Key to figure

Conclusion:

This study shows that the inner continental shelf at water depths of 17 to 23 m is a dynamic environment in terms of both sedimentary environment and benthic habitats with significant seasonal and other temporal variability. The presence of a dynamic environment both in terms of biology and sediment transport water at depths similar to the proposed wind farm site suggest that additional studies will be needed to understand the potential impacts of these large features in this inner-shelf environment.

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