Assessment of Coastal Processes Affecting Beach Morphology at Sandy Point State Park, MD

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Abstract

Meteorological data and current data were collected from 16-27 February 2018 and used to assess coastal processes affecting beach morphology at Sandy Point State Park, MD, an estuarine shoreline beach on the Chesapeake Bay. Beach morphology was assessed and measured using aerial drone surveys and field survey techniques. Beach sediments were collected to assess potential grain size sorting in response to physical forcing along the beach. Survey and grain size results were compared to coastal current measurements and meteorological forcing conditions to determine how these coastal processes may affect beach structure. Results will be used to make recommendations for future potential coastal engineering improvements to better manage beach conditions.

Study Area and Methods

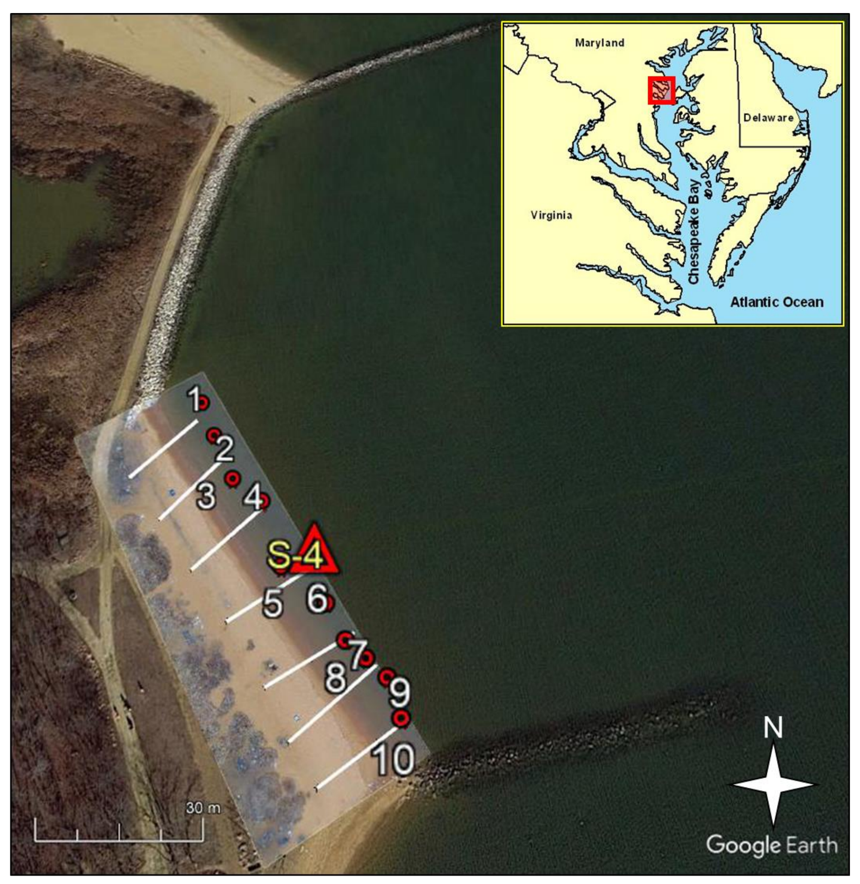

Figure 1. Map of study area at Sandy Point State Park, MD located on the western shore of the mesohaline Chesapeake Bay just north of the Chesapeake Bay Bridge. Shaded area is an ortho-mosaic created from an aerial drone survey on 27 March 2018. White lines are beach survey transects. The red triangle indicates the location of an S-4 current meter from 16-27 February 2018 and red dots (1-10) are locations of sediment samples collected on 16 February 2018.

A beach study was conducted from February – March 2018 on a small (~ 100 m), low-energy, northeast facing (approx. 045°) beach between two groins at Sandy Point State Park, MD (**Fig. 1**). On 16 February an S-4 current meter was deployed to collect current data ~ 10 m offshore on an aluminum mount ~ 1 m off the seabed (**Fig. 2A**). Sediments were collected from 10 points (1-10; **Fig. 1**) north-to-south just landward of the shoreface (**Fig. 2B**). Sediment samples were dried in the lab at 60 °C for > 48 hours and analyzed for grain size (in 6 classes) using dry mechanical sieving (*USGS, Poppe et al., 2000*). The S-4 was recovered on 26 February 2018. An aerial drone survey of the beach was conducted with a DJI Phantom 4 quadcopter on 27 March 2018 using methods of *Byers (2017) and* processed using Pix4D mapping software. A manual beach survey of 7 lines was performed on 27 March 2018 using a TopCon Laser Alidade and Total Station (**Fig. 2C**) .

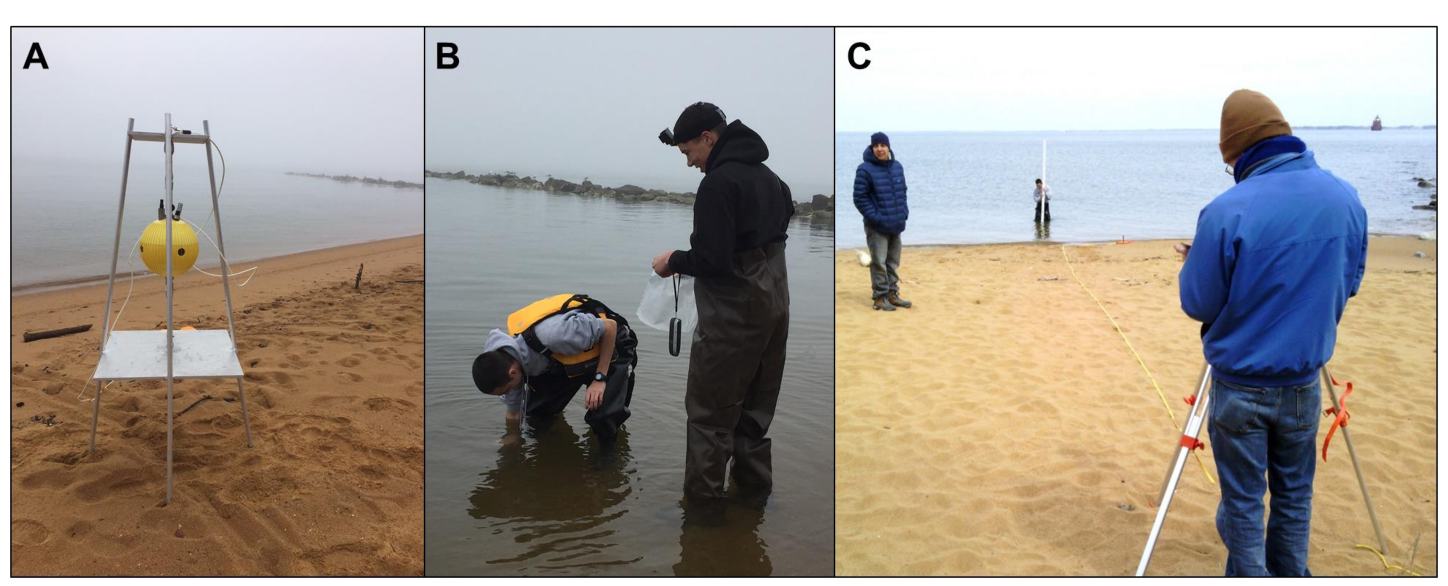

Figure 2. (**A**) The S-4 current meter with custom aluminum mount on the beach prior to deployment; (**B**) MIDN 1/C Barrios and MIDN 1/C Butler collecting beach sediments along the shoreface, and; (**C**) Mr. A. Keppel, Mr. L. Rodriguez, and MIDN 1/C Barrios conducting a beach survey.

Results

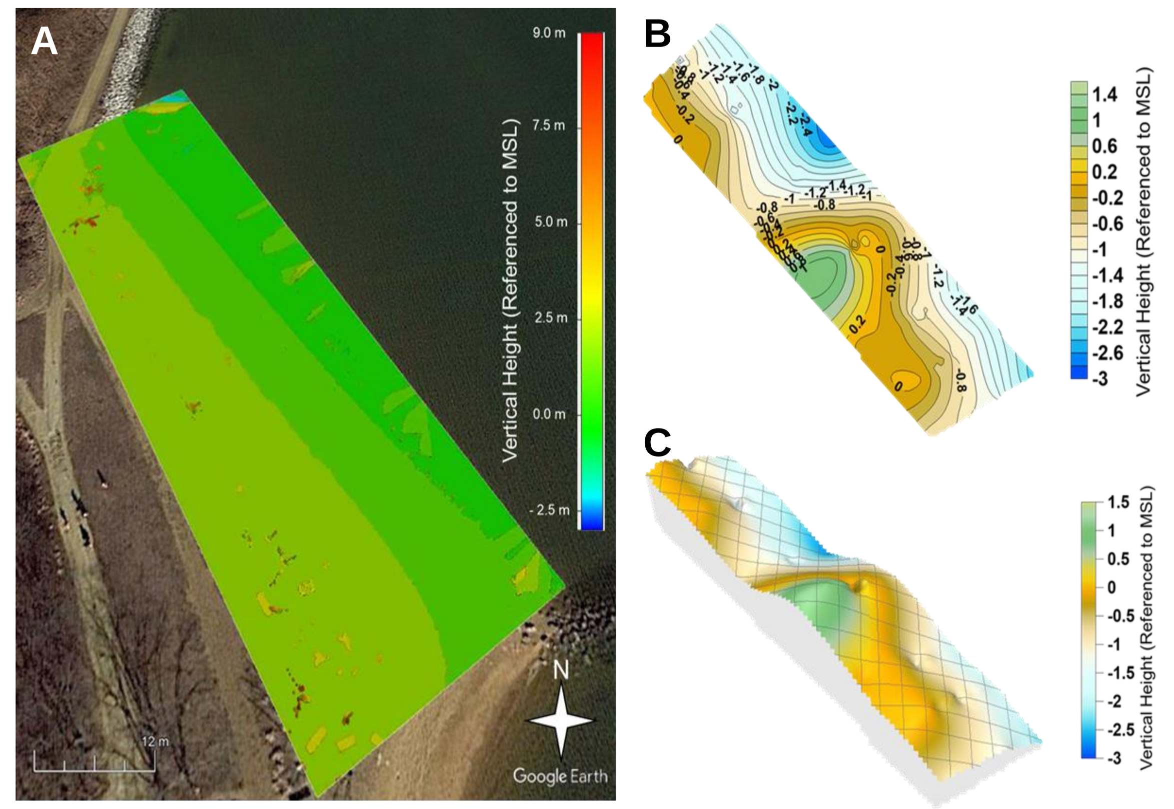

Figure 3. (**A**) A DSM of the beach developed from aerial drone images using Pix4D mapping software; (**B**) 2-D topographic contour map of the beach from beach survey lines; and; (**C**) A 3-D elevation model of the beach from beach survey lines. The 2-D contour map and 3-D elevation model were made using Surfer v11 software with a Kriging interpolation method. All elevations are referenced to mean sea level (MSL).

Figure 3A shows a Digital Surface Model (DSM) of the beach that clearly shows a 2-3 m down slope elevation change from the beach to the shoreline and slightly higher elevations in the south side of the beach. A 2-D contour map of the beach (**Fig. 3B**) developed from the survey lines show the same general features but reveals more detail in topography showing slightly elevated topography in the mid-beach area extending out past the waterline. The 3D elevation model developed from the beach survey (**Fig. 3C**) shows this feature in more detail and reveals differences in beach morphology from north to south along the shoreline down to the shoreface.

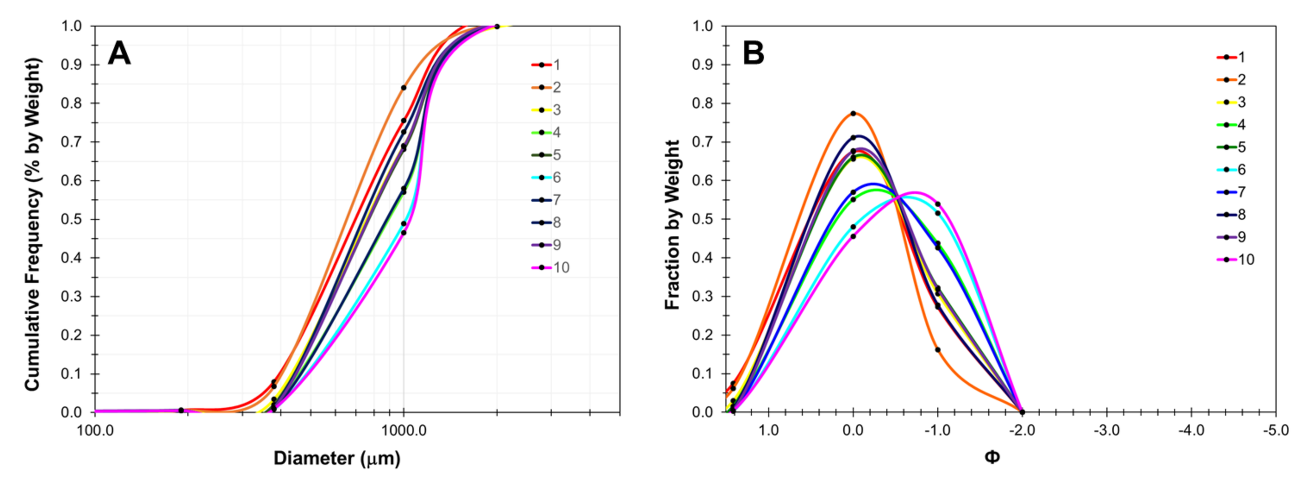

Figure 4. Results of grain size analysis for 10 sediment samples collected north-to-south (1-10) along the beach displayed as: (**A**) cumulative frequency (% of total weight) vs. diameter (μm) and (**B**) fraction by weight vs. phi ($\phi = -\log_2(d_{50}$ in mm)) for each size category. Sediments were separated into 6 size classes according to the Udden-Wentworth scale: gravel and very coarse sand, coarse sand, medium sand, fine sand, very fine sand, and mud (<63 μm).

Figure 4A and **B** shows the cumulative frequency and the fraction by weight of grain size classes measured in each sediment sample. Results reveal a shift to a higher fraction of smaller grain sizes from south-to-north along the beach. **Table 1** shows the median diameter (d_{50}) estimated for each sediment sample with a more positive ϕ indicative of a smaller median grain size.

Table 1. Median diameter (d_{50}), mean phi ($\phi = -\log_2(d_{50}$ in mm)), and size classification for sediment samples estimated from the cumulative frequency curve (**Fig. 4B**).

Sample	Median Diameter (d_{50} in μm)	Phi (Φ)	Udden-Wentworth Size Classification
1	763.50	0.39	*Coarse Sand*
2	724.80	0.46	*Coarse Sand*
3	818.10	0.29	*Coarse Sand*
4	920.50	0.12	*Coarse Sand*
5	828.80	0.27	*Coarse Sand*
6	1014.20	-0.02	*Very Coarse Sand*
7	912.60	0.13	*Coarse Sand*
8	801.64	0.32	*Coarse Sand*
9	825.50	0.28	*Coarse Sand*
10	1048.30	-0.07	*Very Coarse Sand*

Discussion

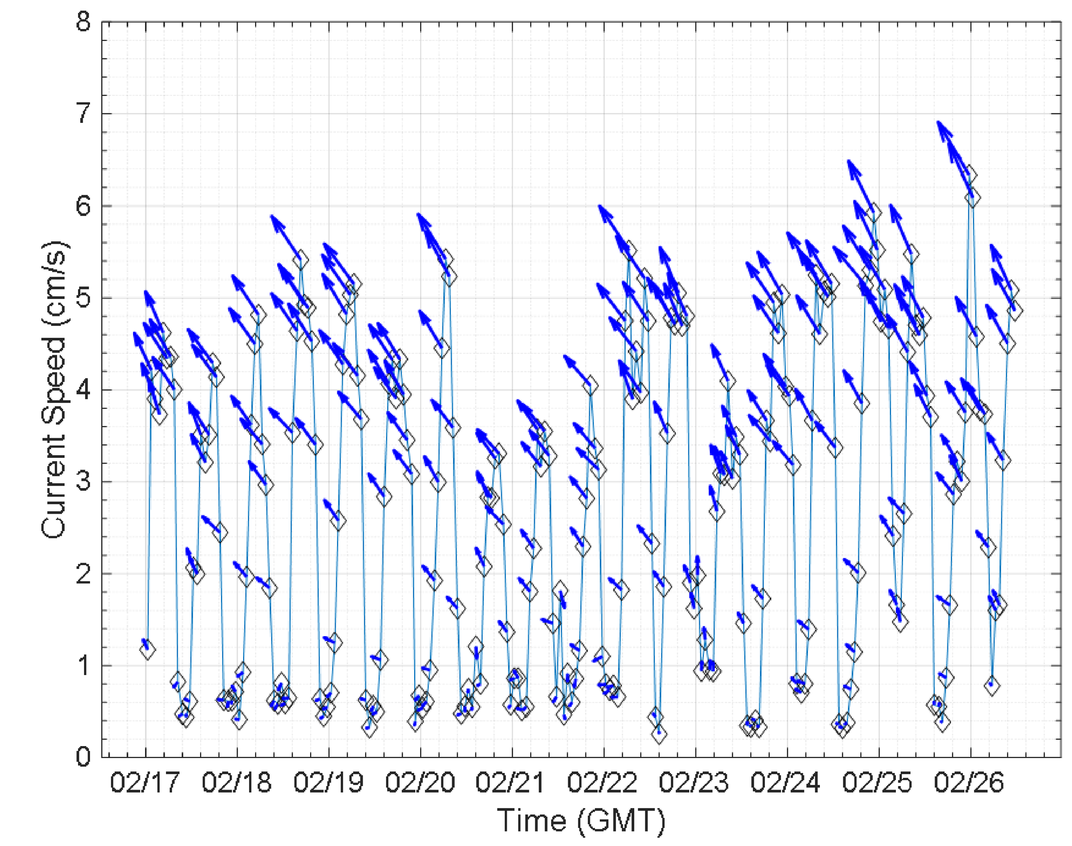

Figure 5. Hourly-averaged current speed (cm/s) and direction measured by the S-4 offshore of the beach at Sandy Point State Park from 17-26 February 2018. Blue quivers show current direction referenced to true north.

The beach studied at Sandy Point is a low-energy beach and has been recently graded and altered. It is also an engineered beach influenced by the two groins to the north and south ends. Topography and results of grain size analysis suggest some limited longshore transport of sediments and trapping of finer sediments from south-to-north. This conclusion is supported by the currents measured offshore by the S-4 current meter during this study. Measured currents were relatively small but consistently show a current direction of ~310-330° (**Fig. 5**). These results are interesting since the Sandy Point beach is an estuarine beach subject to surface currents from river flow from north-to-south. This suggests that other physical factors such as wave action may be resulting in some movement of sediment. **Figure 6** shows wave direction and significant wave height for December 2017 (no data available for February 2018) with an average wave direction towards 320.5°. This represents an angle of ~10° to the shoreface. This could explain the observed northerly currents and sediment sorting observed at the beach.

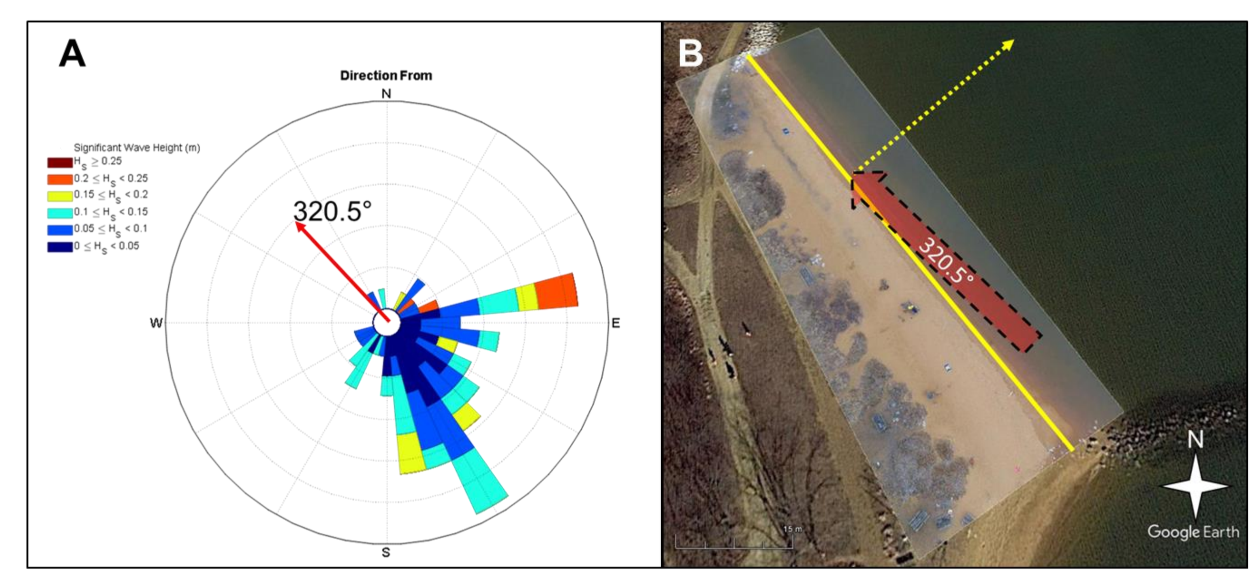

Figure 6. (**A**) Wave direction and significant wave height data for December 2017 from the NOAA Annapolis Buoy (Chesapeake Bay Interpretive Buoy System; https://buoybay.noaa.gov/locations/Annapolis) and (**B**) Diagram of average wave direction referenced to shoreface at the Sandy Point beach.

Conclusions

- ***Beach surveys, grain size analysis, and measurement of longshore currents at a Sandy Point beach suggest limited longshore transport of sediments and possible trapping of finer material from south-to-north***
- ***Factors other than freshwater flow, such as wave action, may be resulting in transport of sediments and changes in beach morphology***
- ***Future long-term studies should focus on changes in beach morphology in response to different forcing factors and sea level rise at this beach and other low-energy coastal beaches***

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