Anomalous Accretion Along Outer Cape Cod Shoreline Possibly Linked with Aeolian Transport Associated with Parabolic Dune Field

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www.coastalstudies.org
Outer Cape Parabolic Dune Field

Photo Source: MassGIS, 2005
Formation of Provincetown Hook

Zeigler et al., 1965
Glacial sediment
Deposited before 15,000 years BP

Modern sediment
Deposited after 15,000 years BP

Giese et al., 2007
Dune Field Development

- Dune field formed at the end of the late 17th century due to human settlement and related land cover changes.

- Parabolic dunes: arms anchored by vegetation and the center portion advances based on wind and climate.

- The dunes appeared to broaden and migrate seaward over time.

- National Park effort to re-vegetate dunes 20-30 years ago.

Photo Source: Peter Rosen
Dune Migration Study

- Strong winter dry westerly-northwesterly wind drives the dunes movement and sediment source.

- Rate of dune movement affected by amount of moisture (Forman et al., 2008).
Cape Cod Outer Coast

Photo Source: Cape Cod National Seashore
Cahoon Beach, Wellfleet

Photo Source: Cape Cod National Seashore
Historic Examples

Coast Guard Station
Moved from Chatham to
Race Point, Provincetown
Recent Examples

Highland Light Move, 1996
Truro, Massachusetts
Current Examples

Photo Source: Christopher Seufert Photography
North Beach, Chatham

Photo Sources: Cape Cod Times (January and March, 2008)
February 3, 2008
February 3, 2008
Prepared to Move
January 27, 2009

Photo Sources: Cape Cod Times (January 28, 2009)
Marindin Surveys

- **Survey of Outer Cape Cod Coast from Chatham to Provincetown in late 1800s**

- **229 on and offshore survey lines recorded in Coastal Geodetic Survey Annual Reports, 1889 and 1891.**

- **Locations reoccupied in 1950s by Zeigler et al.**

- **Average rate of erosion approximately 1 meter/year, varied over distance along shoreline.**
Project Objectives

- Develop a current model of sediment erosion, transportation and deposition of outer Cape Cod coastline.
- Understand and predict the formation and destruction of coastal landforms on Cape Cod.
- Provide valuable information for future management and planning strategies.
Data Sources

- Marindin’s late 1800’s origins, elevations and depths.
- Lidar data from 2005.
- GPS Surveys 2008-9 of marine/terrestrial boundary.
Study Methods

- Create GIS data layer of Marindin’s origins and transects in ArcView 9.3.
- GPS field work to gather the current marine/terrestrial boundary.
- Lidar data (airborne laser mapping technology) data for onshore portion.
- Offshore boat fieldwork to gather bathymetric data.
- Plot data in Matlab and compare current to late 1800s.
- Calculate the volume change and flux rate over time.
Flux Along and Across Shore

Rate of Erosion = $\Delta Q_x + \Delta Q_y$

$Q_y$: Net alongshore sediment flux in $+y$ direction
$Q_x$: Net cross-shore sediment flux in $+x$ direction
$V$: Volume between (e.g.) 1888 & 2008 surveys
Convert Origins and Azimuths

Convert origin latitude/longitude to North American Datum 1927 by subtracting -0.6 from latitude (Giese and Adams, 2007).

Convert NAD27 latitude/longitude to NAD83.

Convert latitude/longitude NAD83 to UTM, meters Zone 19N.
Create Azimuth Lines for Navigation

- Extend Marindin’s lines along same azimuth to 20 m depth.
- Data lines from NOAA charts available from MassGIS.
GPS and Boat Survey Fieldwork

- Terrestrial/Marine boundary location.
- Bathymetric data.
GPS of Terrestrial/Marine Line
Raw Depth Data Collected 2008

- Offshore data snapped to nearest azimuth line.
- Corrected for tides and sea level (in progress).
Results of Raw Data
Mean annual volume loss: 22.3 m$^3$/m
Intersect Marindin’s Lines with GPS
## Comparison of Landform Location

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Marine/Terrestrial Boundary Change Along Outer Cape Cod Coast

Mean Annual Change (m/y)

Transect Number
Lidar Coverage of Dune Field
Marine/Terrestrial Boundary Change Along Outer Cape Cod Coast

Transect Number

Mean Annual Change (m/y)
M163

Distance from Origin (m)

Elevation / Depth (m)

-25
-20
-15
-10
-5
0
5
10
15
20
25
0
500
1000
1500
2000
2500

1890s
2005
2008
Interpolated
Conclusions

- An apparent anomalous zone of shoreline growth was located off the outer Cape Cod coast.

- This growth was linked with the location of the parabolic dune field.

- The dune sand is thought to be a sediment source for the shoreline in this area.

- The contribution of the dunes to the overall system is a cross-shore element to consider in the development of a sediment model for the outer Cape Cod shoreline.
Acknowledgments

- Cape Cod National Seashore
- Provincetown Center for Coastal Studies
- Volunteers
- Cape Cod Five Cent Bank