CONCEPTUAL REGIONAL SEDIMENT BUDGET FOR THE U.S. NORTH ATLANTIC COAST

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ABSTRACT

A Conceptual Regional Sediment Budget (CRSB) was developed for coastal beaches, bays and estuaries extending from Virginia to Maine, USA, as part of the North Atlantic Coast Comprehensive Study. Hurricane Sandy made landfall on October 30, 2012 near Brigantine, New Jersey, and generated severe beach erosion and property damage throughout this region. A CRSB is the first step in understanding sediment transport patterns and magnitudes, and aligning dredging and placement operations to take advantage of natural processes and identify sediment deficiencies in a regional system. Optimizing regional sediment management practices in this region is critical to (a) improve beneficial use of dredged sediments; (b) reduce the risks of future storm damage and enhance the environment; and (c) reduce costs in maintaining coastal infrastructure. Data from 1990-2013 indicated an average of 18.7 million cu yd/year was dredged within the North Atlantic region. A direct link to the CRSB geospatial map is available: http://1.usa.gov/1DoxAnQ; the map is hosted on the USACE geospatial portal at https://geoplatform.usace.army.mil/home.

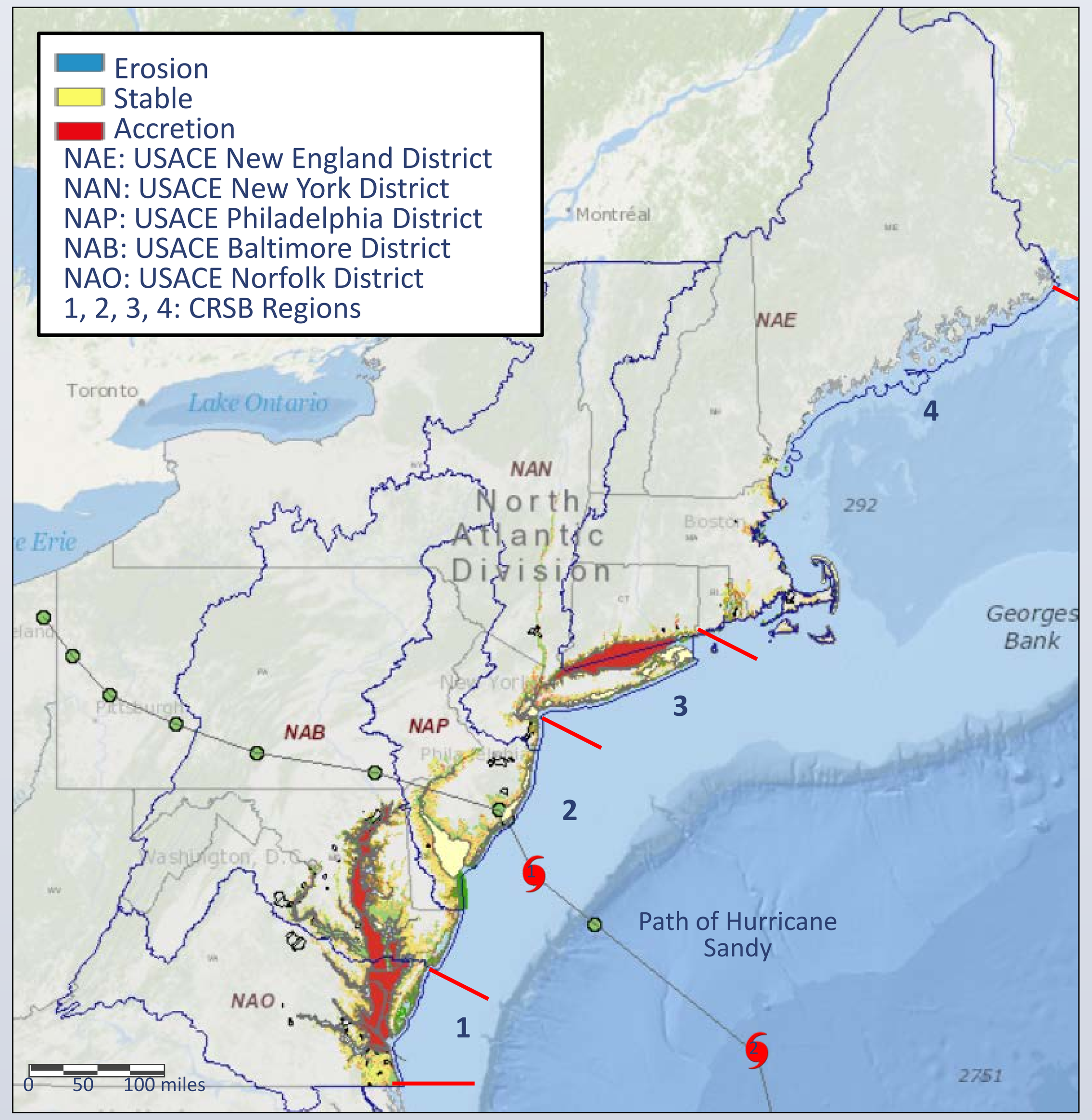

Fig. 1. Overview of Conceptual Regional Sediment Budget (CRSB) Regions and Path of Hurricane Sandy

METHODS

Conceptual Regional Sediment Budget

- Documents patterns and rates of sediment transport, dredging and placement, and volumetric change
- Developed in the Sediment Budget Analysis System (SBAS) for rapid dissemination and viewing

METHODS (concluded)

Conceptual Regional Sediment Budget (continued)

- The CRSB is an accounting of sediment sources, sinks and sediment-related engineering activities within a specific control volume (cell) or a series of cells over a given period of time
- Cells were defined by morphology, engineering activities, coastal structures or known sediment transport fluxes
- Sediment Budget equation, in volumes or volumetric rates of change:

$$\Sigma\, Q_{source} - \Sigma\, Q_{sink} - \Delta V + P - R = Residual \qquad (1)$$

Where Q_{source} and Q_{sink} are the sources and sinks of sediment to the control volume, respectively; ΔV is the volume change within the cell; P and R are the placement and removal of sediment within the cell, respectively; and *Residual* is the degree to which the cell is balanced; non-zero *Residuals* were retained in the sediment budget to indicate conflicts in information or a lack of data

- Confidence levels were assigned to each morphologic zone based on whether a sediment budget was available (high); only general information existed for volume change, sediment pathways or magnitudes (medium); or only qualitative observations of morphology from aerial imagery were available to provide general sediment transport pathways (low)
- Dredging information from the U.S. Army Corps of Engineers' Dredging Information System (DIS) from 1990 through July 2013 was analyzed to provide representative average annual infilling rates for USACE navigation channels
- No placement data were available in DIS and were not included in the CRSB unless documented in the literature
- Regions were delineated based on geology and present-day morphology (Fig. 1)
- The Composite Exposure Index (CEI) was developed as part of the North Atlantic Coast Comprehensive Study as an indicator of the vulnerability of coastal populations in the North Atlantic region
- The CEI combined three sets of information: infrastructure and population (80 percent weighting), social vulnerability (10 percent weighting), and environmental exposure (10 percent weighting)
- The CRSB was overlain with the CEI and vulnerable regions with high CEI and erosion or high CEI and low confidence (e.g., no data) were identified so that these areas could be better managed in the future

RESULTS

Region 1: Virginia /North Carolina Border to Chincoteague Inlet, Virginia including Chesapeake Bay and Tributaries

- Sediment is transported towards the bay from the Atlantic coast and into the bay from the Susquehanna River and other rivers (Fig. 2, left); sediment is deposited in the bay and lower portions of the tributaries
- DIS dredging data were available for 31 navigation channels and harbors for both contract and USACE dredges; USACE Baltimore and Norfolk Districts dredged **6.3 million cu yd/year** of littoral sediment within this region.

RESULTS (continued)

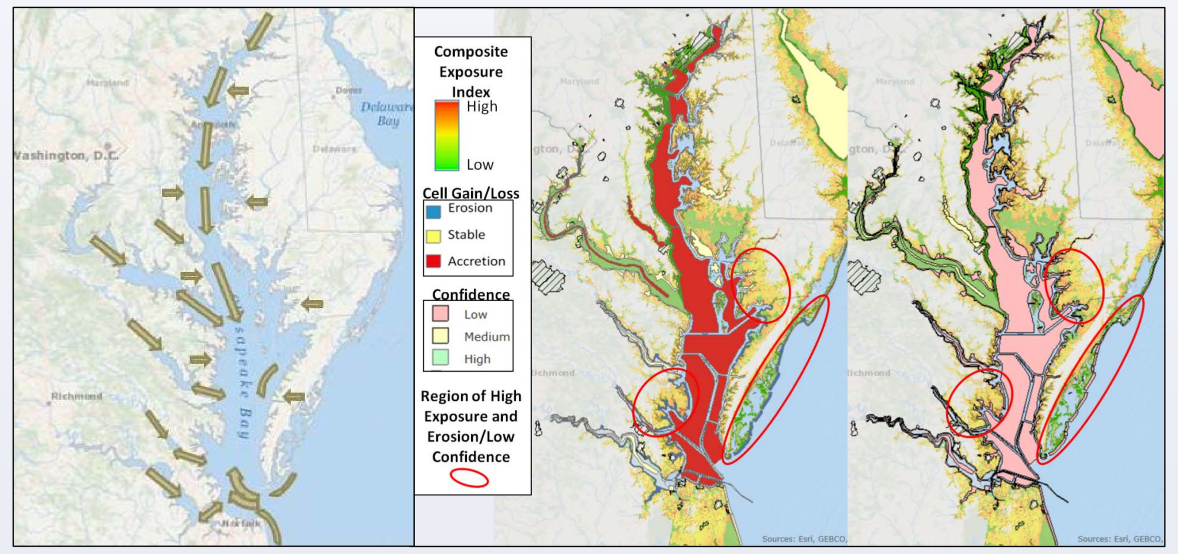

Fig. 2. Region 1 CRSB. Sediment pathways (left); cell gain/loss (center) and cell confidence (right); regions with high CEI and erosion or high CEI and low confidence are identified by red ovals.

Region 2: Chincoteague Inlet, VA to Sandy Hook, NJ

- Net sediment transport patterns for Region 2 are shown in Fig. 3 (left), with two nodal zones located approximately at the Delaware-Maryland border and between Barnegat Inlet and Shark River Inlet, New Jersey
- Dredging data for 19 navigation channels and harbors within the DIS for both contract and USACE dredges; DIS data indicated that **7.3 million cu yd/year** of sediment was dredged within Region 2.

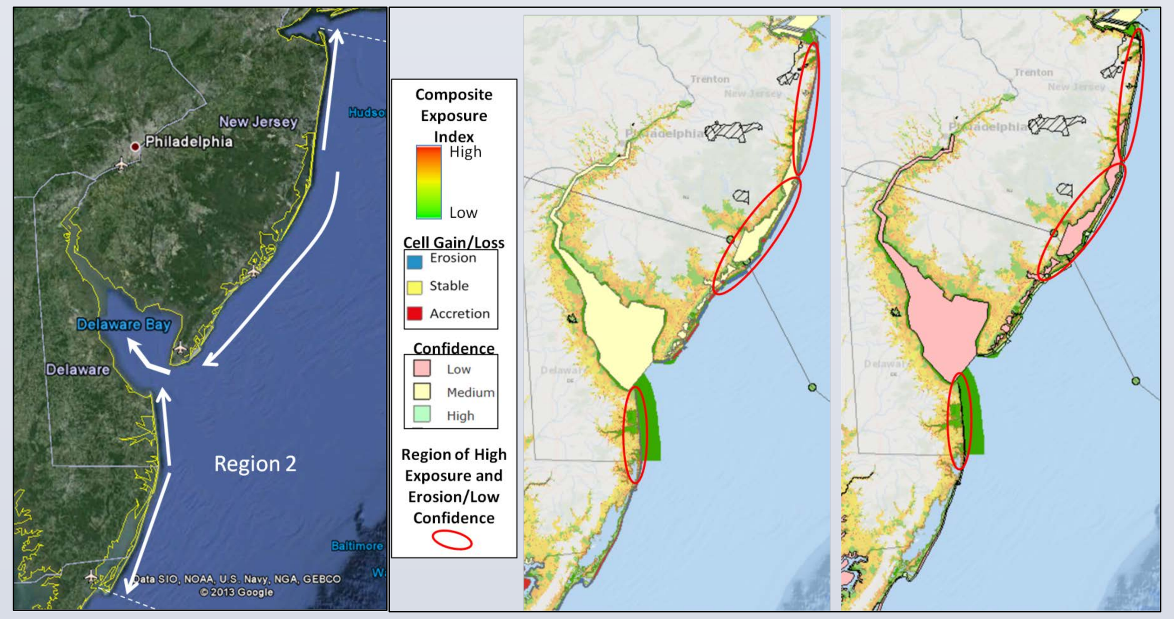

Fig. 3. Region 2 CRSB. Sediment pathways (left); cell gain/loss (center) and cell confidence (right); regions with high CEI and erosion or high CEI and low confidence are identified by red ovals.

Region 3: Sandy Hook, New Jersey to Connecticut-Rhode Island Border

- Net sediment transport is from east to west along the south shore of Long Island, directed towards the inner New York Bight and the Lower Bay (Fig. 4, top); rivers provide sediment and net transport is directed towards the west with local reversals along the north shore of the Sound (Connecticut coast)
- Along the northshore of Long Island, net transport is also to the west with local reversals; Long Island provides minimal fluvial sediment input to the Sound
- Dredging data were available for 23 navigation channels and harbors within the DIS for both contract and USACE dredges; several channels had only one dredging event, and as a result, it was not possible to compute an average annual shoaling rate at these sites.

RESULTS (continued)

Region 3 (concluded)

- Dredging data indicated that the USACE New York and New England Districts dredged **4.9 million cu yd/year** of littoral sediment within this region
- Three harbors in Connecticut contributed 86,677 cu yd/year to the total

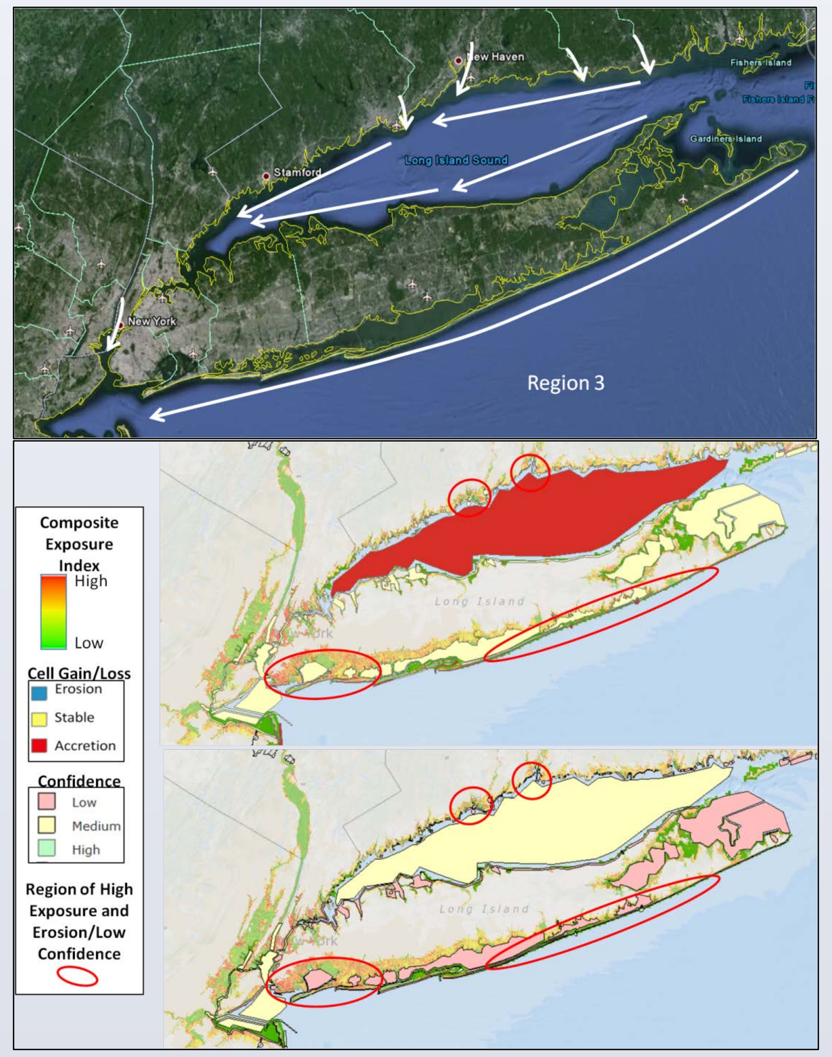

Fig.4. Region 3 CRSB. Sediment pathways (top); cell gain/loss (center) and cell confidence (bottom); regions with high CEI and erosion or high CEI and low confidence are identified by red ovals.

Region 4: Connecticut - Rhode Island Border to Northern Border of Maine

- Complicated paraglacial geological terrain, with end moraine islands, drowned glacial valleys, sand spits, salt marshes, and bedrock outcrops
- Paraglacial coasts are located in regions formerly covered by extensive glacial ice sheets and still retain extensive surface cover of easily-erodible glaciogenic sediments
- Unlike Regions 1-3, with barrier spits that extend for 10s or 100s of miles, New England's beaches are much shorter and usually bounded by a topographic feature such as a headland or channel
- New England contains a large number of Federal channels and harbors, many of which date back to the Colonial Era; today many of these harbors only serve pleasure craft and have not received regular dredging in recent decades
- Based on data from 1990 to July 2013, for sites with at least three dredging events, the DIS data indicated that ten channels were dredged for an annual average of **193,000 cu yd/year** of littoral sediment within this region

RESULTS (concluded)

Region 4 (concluded)

- CEI is only shown for a portion of Region 4 in Fig. 5 (lower right); there were no areas having both high CEI and erosion or high CEI and low confidence identified; CEI were not available for the remainder of Region 4

Fig.5. Region 4 CRSB. Sediment pathways (top); cell gain/loss (lower left) and cell confidence (lower right).

CONCLUSIONS

- 990 cells created in CRSB; 660 cells (67%) did not have data
- Dredging data averaged **18.7 million cu yd/year**, with contributions for Regions 1-4 of 6.3, 7.3, 4.9, and 0.2 million cu yd/year
- Recommendations for better characterization and management of sediment resources within the study area included:
  - o A database on dredging and placement activities including sediment type (sand, fines) and of longer duration could provide information on gross transport rates and river input to the regions
  - o Dredged sediment is a valuable resource for placement on adjacent beaches, building wetlands in the back bay, creating habitat, and other activities that improve the resiliency of the coastal environment
  - o Damage occurred from both ocean-facing and bayshores during Hurricane Sandy; there is a great potential for strategic placement of sediment on bayshores to reinforce bay and estuary resiliency

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