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Integrated CHIRP Sub-Bottom Profiler and Dual-Frequency Sidescan Sonar

Understanding sediment dynamics in aquatic systems is a critical component of the Corps' mission. For example, the volume of sand in a nearshore profile has significant impact on shoreline stability, and the type of sediment characterizing the seafloor impacts not only the type and distribution of benthic habitats but also influences sediment transport. Traditional sediment characterization techniques, such as estimates of sediment volume derived from repeated bathymetric mapping or characterization of aquatic habitats by sidescan sonar alone, neglect the subsurface geology and thus provide an incomplete picture of a region. To address this gap, Coastal Observation & Analysis Branch (under the Coastal Field Data Collection Program) has acquired an Edgetech 2000-CSS: a Compressed High Intensity Radar Pulse (CHIRP) sub-bottom profiler integrated with a dual simultaneous frequency CHIRP sidescan sonar (Figure 1).

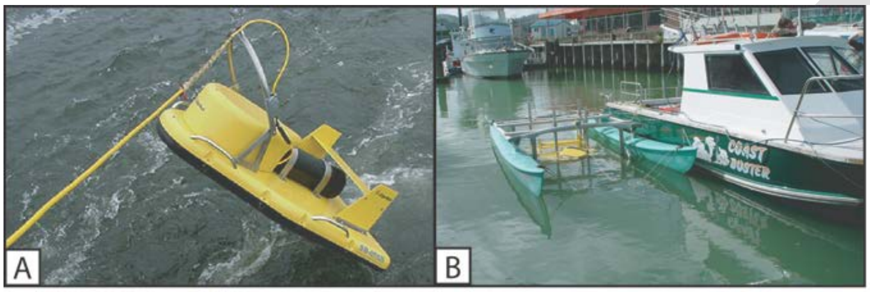

Figure 1: (A) Edgetech 2000-CSS. (B) Edgetech mounted on a 12-foot catamaran. Catamaran mount allows for towing of the ~600lb towfish with a small vessel of opportunity, and in depths limited only by the towing vessel's draft.

Nearshore Sediment Habitat and Sediment Stratigraphy

Sidescan sonar generates spatial maps of surficial sediment type (e.g. rock, sand, mud) via variations in the reflection of high-frequency acoustic pulses off of the seafloor. The Edgetech 2000-CSS has a dual-frequency side-scan sonar (300khz/600kHz) allowing simultaneous characterization of surficial bottom type (Figure 2).

Sub-bottom profiling is a geophysical technique that allows for rapid data collection of shallow (<50m depth) geologic features and lithologic information in submerged environments. Subsurface density variations correlate to stratigraphic changes (e.g. a layer of sand overlying a layer of mud), and are imaged as discrete reflectors below the seafloor (Figure 3). Unlike single-frequency profilers, a CHIRP sub-bottom profiler produces a wide range of acoustic frequencies in a single pulse, allowing for resolution of geologic features as small as 8-20cm, yet penetrating up to 20m in sand, and even deeper in more mixed substrates. The integrated sidescan sonar allows for detailed seafloor surface mapping, and the simultaneous collection of both data allow for a complete quantification of the seafloor type, sediment resources, and sediment dynamics of a region.

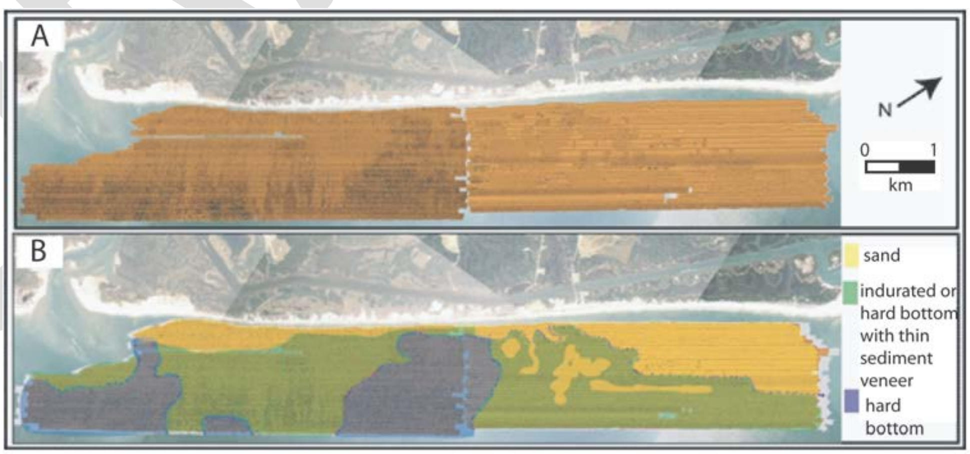

Figure 2: Sidescan sonar map of the Onlsow Beach, NC nearshore region. (A) The complete sidescan mosac. (B) Interpreted surficial habitat map. From *Wadman and McNinch, 2011.*

Variations in Nearshore Sediment Volume and Associated Shoreline Change

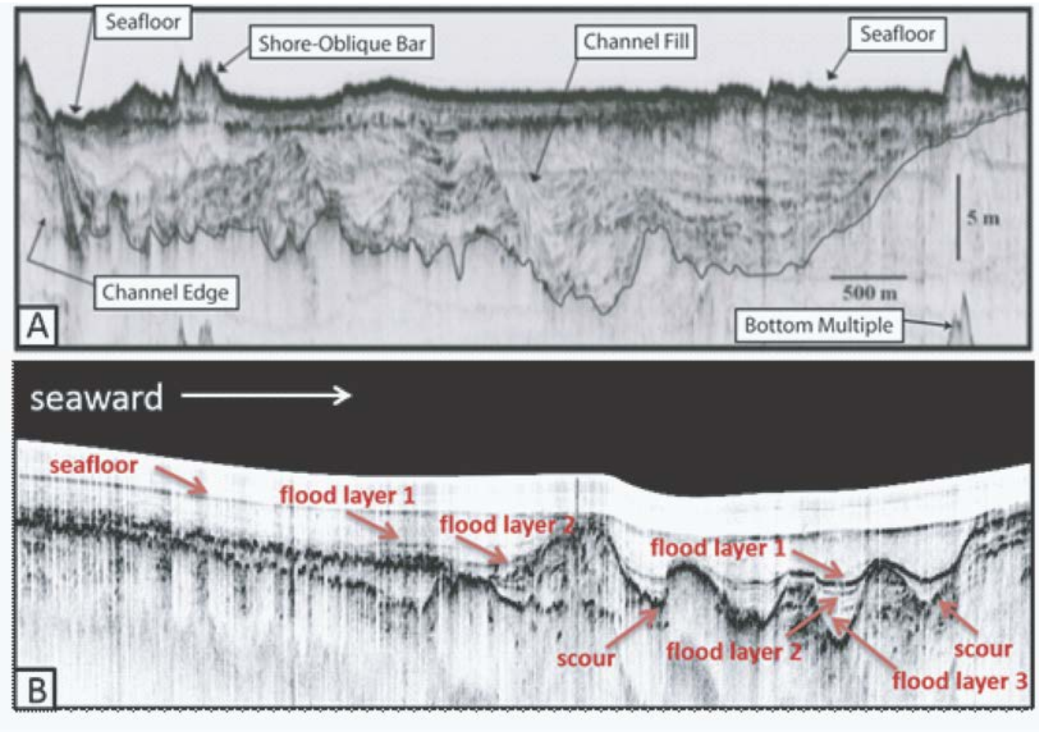

Figure 3: Examples of chirp subbottom profiles. A) Alongshore seismic line off of Kitty Hawk, NC showing the buried Paleo-Roanoke River valley. From *Browder and McNinch, 2006.* (B) Seismic data collected along the axis of the Waipaoa River, New Zealand, showing scour from flood events and subsequent deposition of mulitple layers of post-flood mud. From *McNinch and Wadman, 2009.*

Sub-bottom data are critical for a quantitative understanding of sediment dynamics in a region by, for example, allowing detailed mapping of the migration of sand lenses or waves over a more stable substrate, determining the volume of sand in the nearshore environment or in an offshore resource (Figure 4), or for analyzing the volume and types of sediment infilling a dredged harbor or channel. Sub-bottom data can also yield insight into structural controls on drainage systems by identifying where subsurface channels still influence modern drainage patterns (i.e. channel memory in macrotidal regions). When integrated with sidescan sonar data, these data can be used to identify the distribution and thickness of seafloor habitats and further understand the evolution of aquatic systems. Finally, the data can further be used to optimize collection of borehole data in order to characterize a region. For roughly the same cost as a bathymetric survey, a stratigraphic map of sediment layers can be created for a region of interest. The resulting geologic map is then used to identify optimal borehole locations to further evaluate the geologic properties of that region. In general, significantly fewer boreholes are needed to characterize a region, compared to studies without geophysical maps. This reduction in costly borehole collection and analysis frequently represents a significant cost savings, and the seismic data further reduce concerns about potential spatial variability between adjacent boreholes.

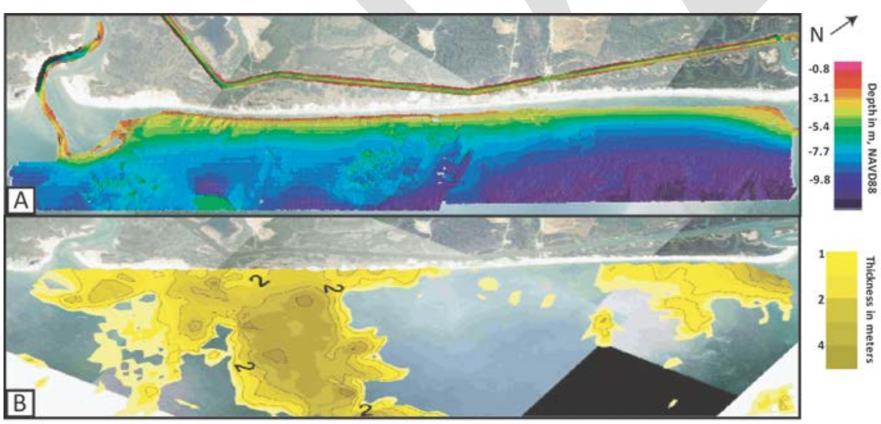

Figure 4: (A) Bathymetry of the Onslow Beach nearshore, MCB Camp Lejuene, NC. (B) Isopach map of sediment thickness in meters, reflecting cross- and alongshore variability in sand volume. Variations in volume are not apparent from bathymetry data alone. From *Wadman et al., 2014.*

Examples

Cross- and alongshore variations in the total nearshore volume of transport-relevant sand, as defined using chirp seismic data, have been shown to be strongly related to decadal-scale shoreline change rates along the Outer Banks of NC (e.g. McNinch, 2004; Browder and McNinch, 2006; Miselis and McNinch, 2006; Schupp et al., 2006; Wadman and McNinch, 2011) as well as along Fire Island, NY (Miselis et al., 2016). Along the northern Outer Banks in particular, nearshore sand volumes as defined by chirp profiles provided greater prediction accuracy of heightened shoreline erosion than did simply estimating sand availability along a more traditional, depth of closure-defined datum (Miselis and McNinch, 2006). At Onslow Beach, sidescan sonar data were integrated with chirp sub-bottom data to provide a three-dimensional picture of nearshore habitat type and sand volume (Wadman and McNinch, 2011).

Specifications/Features/System Requirements

The Edgetech 2000-CSS is comprised of:

1. Full-spectrum subbottom control and amplifier

2. Topside controller with dual monitors

3. A four-transducer SB-512i CHIRP towfish with a frequency range of 500Hz – 12kHz, integrated with a 300/600kHz dual simultaneous frequency CHIRP sidescan sonar

4. Communication/tow cable

5. Optional catamaran towing vessel for use by small vessels in water depths of <2m (dependent on towing vessel draft; Figure 1).

6. A single-beam and/or interferometric swath bathymetry system can be simultaneously operated on the same vessel as the Edgetech 2000-CSS to provide a complete nearshore map.

Distribution

ERDC's Coastal and Hydraulic Laboratory's Field Research Facility is the base for the Edgetech 2000-CSS, and scientists there should be considered the POC for specific questions with respect to project design and cost.

Documentation & Support

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