1998

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GR Cutter Jr.
Virginia Institute of Marine Science

Robert J. Diaz
Virginia Institute of Marine Science

Journal of Shellfish Research, Vol. 17, No. 5, 1443–1444, 1998.

NOVEL OPTICAL REMOTE SENSING AND GROUND-TRUTHING OF BENTHIC HABITAT USING THE BURROW–CUTTER–DIAZ PLOWING SEDIMENT PROFILE CAMERA SYSTEM (BCD SLED)

G. R. CUTTER, JR. and R. J. DIAZ
Virginia Institute of Marine Science
Gloucester Point, Virginia 23062

ABSTRACT The Jefferson Benthic Sled provides video sediment profile imagery of continuous cross-sectional data. Subsurface imaging is achieved by attaching a profile camera prism behind an agricultural plow that extends beneath the plane of the sled skids, slicing through the top 10 to 20 cm of sediment. The plowing video profile provides a high-resolution, real-time, remotely controlled view of the flat side of the plow furrow. Successful continuous profiles of up to 100 m have been collected. The equipment allows immediate characterization of benthic habitats, transition zones, sediment types, sediment oxidation layering, biological resources, and fisheries impact.

KEY WORDS: Sediment profile, underwater video, benthic habitat

INTRODUCTION

Sediment profile imagery has been improved from discrete point data to continuous cross-sectional data by the development of the Burrow–Cutter–Diaz plowing profile camera sled system (BCD sled). The camera plows through the sediments and provides a continuous sediment profile image. Uninterrupted sub-bottom video imaging is achieved by attaching a modified sediment profiling camera prism behind a plow blade that extends beneath the plane of the sled runners and slices through the top 30 cm of sediment. The BCD sled provides high-resolution, real-time imaging of the flat side of the plow furrow as it develops. Successful continuous profiles have been collected that span up to 100 m. Attachment of other equipment allows simultaneous delineation of benthic habitat and near-bottom water conditions. Using the plow-sled, we can immediately characterize benthic habitats, transition zones, sediment types, apparent sediment oxidation layer, and biological resources, assess bottom fisheries impact, and achieve concurrent ground-truthing of side-scan sonar survey data by deploying the plow-sled during sonar surveys.

SYSTEM

The BCD sled (Fig. 1) is configured to collect real-time video from the plowed furrow created by a camera system designed for continuous transect sediment profile imagery. Figure 1 depicts the main components of the plow-sled system: the plow blade and plowing profile camera prism casing with the prism window on one side, and the two sled runners. The runners ride along the sediment surface, and the lower half of the plowing camera casing travels through the surficial sediments. The plowing profiling camera prism is rotated 90° from the still image sediment profile camera system (Rhoads and Cande 1971, Rhoads and Germano 1982, Germano 1983, Rhoads et al. 1996). The plowing profile camera prism window is flush with the flat, vertical side of an underwater plowing device, and enables viewing the sediments in profile as the plow slices through the uppermost layers (30 cm) of sediment.

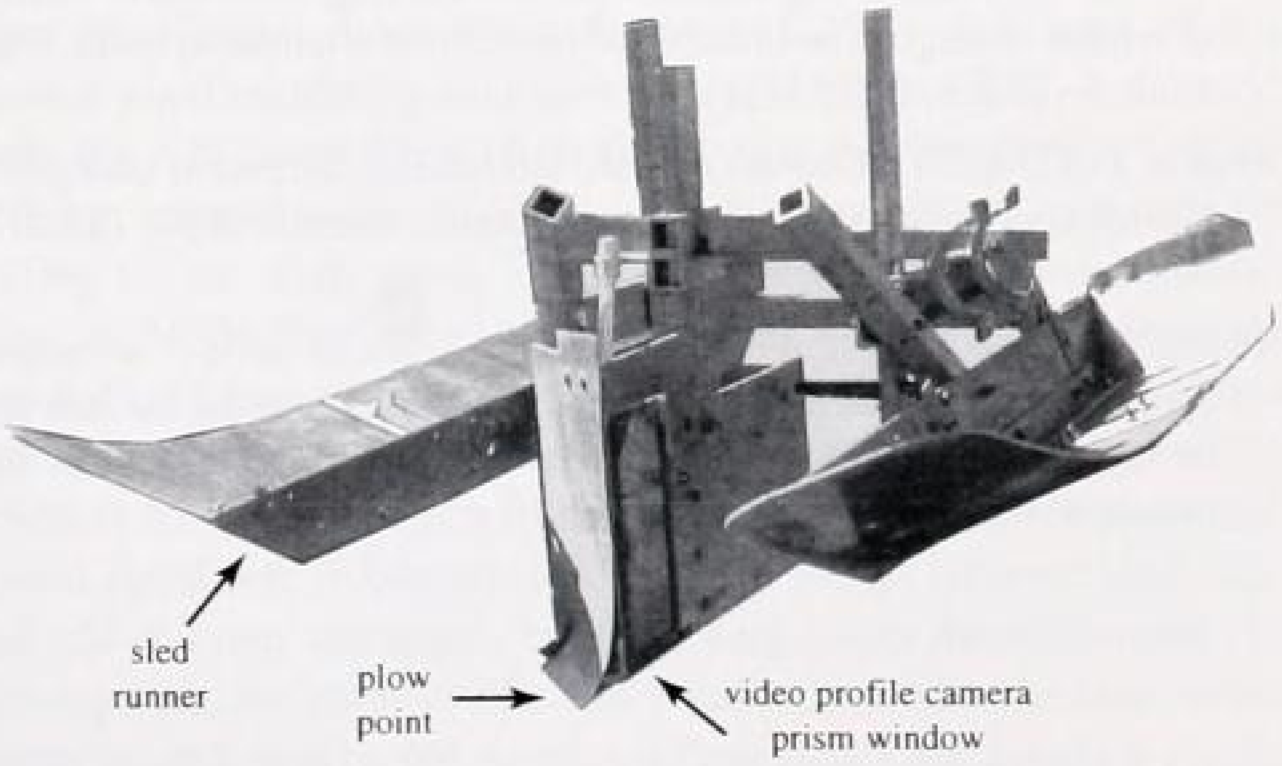

Figure 1. Burrow–Cutter–Diaz plowing profile camera sled.

The video system and lighting are powered by 12 V battery pack system in an underwater housing. Remote viewing is achieved, presently, through a 150-m long underwater cable. Sled tow transects are continuously logged on the vessel as Global Positioning System (GPS) coordinates. A hydrographic sensor system may be attached to the sled to provide simultaneous continuous acquisition of water depth, temperature, salinity, dissolved oxygen, and pH.

DATA OUTPUT

Composite images, such as the example in Figure 2 (top), from the plowing camera are compiled from digitized versions of Hi-8 video sequences recorded from the vessel during deployment. Additional video and still cameras may be affixed to the sled and to provide close-up plan-view or oblique-view images of the sediment surface. The combination of images, continuous sediment profile imagery, and surface-view images, produces a high-resolution optical analog to acoustic side-scan sonar and sub-bottom profiler images. Postprocessing of digitized video images allows quantification of microtopography, fauna, and sediment attributes in terms of transect data and analyses similar to those described by Malatesta et al. (1992).

The top image in Figure 2 is a mosaic of several video frames acquired from a short section of one sled transect. This reconstruction of the bottom is accomplished by manual registration of adjacent digitized video images using visual surface and subsurface features. Several image features contain information about the substrate properties and the benthic biological community. For example, the sediment–water interface, or seafloor geometry, is visible as the green to yellowish-brown color transition. The yellowish-brown sediment layer represents the apparent color redox-

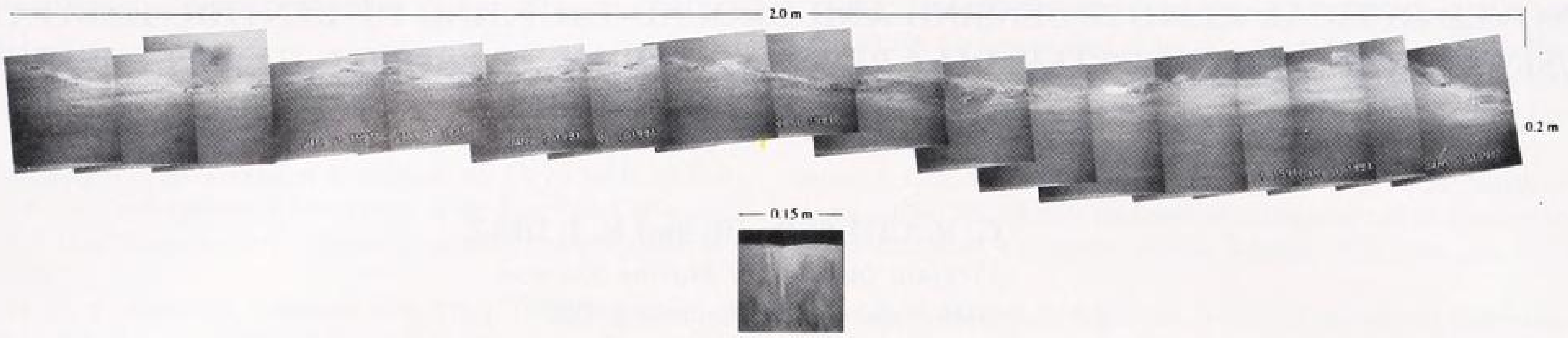

Figure 2. Plowing profile camera image mosaic (2-m wide) above, and standard profile camera image (0.15-m wide) below.

potential discontinuity (Rhoads and Germano 1982, Diaz and Schaffner 1988).

ANALYSIS

Geostatistical methods (Journel and Huijbregts 1978) are applied for analysis of the composite plow image features (Fig. 2, top). Sedimentary and biological habitat features are measured according to Diaz and Schaffner (1988) and Rhoads and Germano (1982, 1986), but at uniformly spaced distance intervals, or lags. Superposition of a grid over the images, such as in Figure 2 (top) and measuring parameters at each intersection with a vertical gridline produces a series of measurements of the same feature over a range of distance scales. This allows the data to be treated as regionalized variables for the study area rather than a single-valued datum for a sample point, such as is obtained from standard sediment profile image (Fig. 2, bottom). This approach provides data that can be used to quantify the spatial behavior of the parameter, in addition to allowing calculation of over-all mean parameter values for any desired section of the bottom. Habitat features and habitat delineations are accomplished using the geostatistical data obtained from the plow images, and assuming correlations between the sediment profile imagery parameters and habitat properties according to the relationships demonstrated by Bonsdorff et al. (1996).

SYSTEM APPLICATIONS

The primary applications of the BCD sled include benthic habitat delineation and mapping, assessment of benthic living resources, disturbance impact assessment, ground-truthing for side-scan sonar surveys, water quality model parameter evaluation, and thin-layer disposal monitoring.

DEVELOPMENTS

Installing a level or inclinometer in the prism will relate fore–aft inclination angle, allowing bottom image transect reconstruction using sled-tilt angles observed during deployment. The compilation image is analogous to a very detailed acoustic sub-bottom profile images.

Additional video and still cameras may be affixed to the sled to provide close-up plane-view or oblique-view images of the sediment surface. The combination of images, continuous sediment profile imagery and surface-view images, produces a high-resolution optical analog to acoustic side-scan sonar and sub-bottom profiler images. Resolution is now limited by the video signal and video-digitizer. The real-time and assembled plowing video profile images should be very useful to side-scan sonar ground-truthing efforts, enabling rapid determination of sources of variation in the broad-scale acoustic reflection patterns.

ACKNOWLEDGMENT

This is contribution number 2194 of the Virginia Institute of Marine Science.

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