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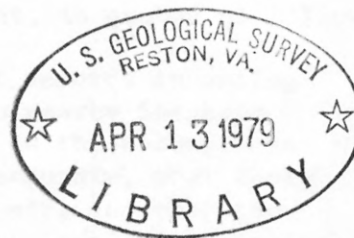
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Depth Determination of Colvocoresses Reef, Indian Ocean

(EC-68-Landsat)

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United States Department of the Interior

GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092
National Center, #522

April 9, 1979

Memorandum for the Record (EC-68-Landsat)

By: EROS Coordinator, Topographic Division

Subject: Depth determination of Colvocoresses Reef, Indian Ocean

Abstract

The depth to the subject reef has been estimated at a nominal 10 m by three independent analyses based on Landsat and (in two cases) comparisons to measured depths of submerged features in the same area. Fathometer readings made in 1979 confirm the 10-m reading.

Text

Reference is made to EC-43-Landsat dated November 4, 1976, which reported the discovery of an uncharted feature in the Chagos Archipelago, now known as "Colvocoresses Reef." This reef (latitude 4°53' S. and longitude 72°37' E.) provided a unique opportunity to test the capabilities and limitations of remote sensing systems such as Landsat with respect to water depth determination.

Three independent depth determinations were made and described as follows:

(1) Colvocoresses (USGS) examined 1:1,000,000-scale positive transparencies and prints of E-2450-04330-4 dated April 16, 1976, and E-2432-04334-4 dated March 29, 1976, which showed that the radiometric response from both Colvocoresses Reef and Speakers Bank were consistent and not materially effected by temporal anomalies. His official report to NASA of July 29, 1977, which is a part of EC-55-Landsat, is quoted as follows:

"This office has examined two separate Landsat records in analog form and compared the radiometric response to nearby Speakers Bank which was boat surveyed in 1837. Based on the assumptions that the survey was reasonably complete and accurate, that depth has not materially changed in the past 140 years, and that the reef and bank have similar reflective characteristics, the nominal depth of Colvocoresses Reef is estimated at 10 m. However, small elements of the reef might lie at somewhat lesser depths."

This depth estimate was based entirely on visual estimation of image tone aided by a small mask of opaque paper used to eliminate the contrast effects of adjacent features.

(2) Sheila Martin (USGS) analyzed the imagery in negative transparency form with a microdensitometer. A copy of her report which estimates 11 m is enclosed.

(3) Fabian Polcyn (Environmental Research Institute of Michigan) prepared a map during 1978 of the reef based on a computer printout which depicts depth zones in various colors with the 10 to 15 m zone being dominant. Polcyn used computer compatible tapes and derived his depth zones as a function of the radiometric signals. A copy of Polcyn's map is enclosed and it is understood that he used empirical formulas rather than the comparison to other features of "known" depth as used by Colvocoresses and Martin. Some "noise" can be seen in the map in the form of apparent small shallow areas. Polcyn is preparing a report on his work.

On January 17, 1979, HMS Vernon as part of the (British) Joint Services Chagos Research Expedition ran five fathometer transects across Colvocoresses Reef. Copies of the transect recordings have been delivered to the Defense Mapping Agency Hydrographic/Topographic Center and to the undersigned. The echosounder used was calibrated against a leadline which showed 21 m equivalent to 25.5 m on the leadline. Interpretation of the transect recordings and tide corrections will undoubtedly be made by concerned agencies, but from cursory examination they indicate a nominal depth to the reef, which is quite flat, of 10 m.

Rodney V. Salm, a graduate student at Johns Hopkins University who is studying coral reefs, participated in the expedition and furnished reports (pers. comm., 1979) and the transect recordings. Salm indicated that a serious effort was made to find the shallowest part of the reef which turned out to be 9.5 m. He indicated that the reef had a generally uniform surface and that several dives were made to it in spite of the presence of a large number of sharks. Salm also stated (pers. comm., 1979) the color-coded depth maps of Chagos by Polcyn proved quite accurate except over reef flats and turbulent areas.

This exercise confirms previous indications that Landsat can be used for water depth determination under suitable conditions and with local ground truth for calibration purposes. Although the Landsat data used was of the high-gain (3X) mode, this does not prove or disprove the relative merits of the two gain settings available on Landsat.

Obviously neither remote sensing from space nor a series of ship transects can provide full assurance that no lesser depths occur, but it is believed that sufficient data now is available to permit the designation of depth to Colvocoresses Reef. I'd suggest 10 (m) approx. or $10 \pm 1(m)$ as suitable designations.

The expedition reports when fully analyzed will undoubtedly contribute a great deal more as to the use and limitations of Landsat for the charting and analysis of such an area.

It now appears that Landsat has opened the door to the definitive mapping of the shallow seas which goes well beyond nautical charting. At present, such charts are the only available graphics of most shallow sea areas.

Alden P. Colvocoresses
Alden P. Colvocoresses

Enclosures



United States Department of the Interior

510 National Center
GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

August 5, 1977

Memorandum for the Record

From: Sheila E. Martin

Subject: Microdensitometer Study of Colvocoresses Reef

An attempt was made to estimate the depth of Colvocoresses Reef by comparing density profiles of Speakers Bank with profiles of the newly discovered and unsurveyed reef. Three assumptions were made: (1) Speakers Bank and Colvocoresses Reef have similar reflectance characteristics; (2) both have remained relatively stable over the last 140 years since the first Survey was made; and (3) soundings shown on the revised (August 1976) Chagos Archipelago nautical chart are correct.

Two 1:1,000,000-scale negatives of band 4 high-gain Landsat 2 images were scanned on the Joyce-Loebl Microdensitometer: E-2432-04334-4 (29 March 76) and E-3450-04330-4 (16 April 76). Rub-on dots were placed on the negatives to locate the exact areas that were scanned. Twelve scans were made across Speakers Bank, 5 of which crossed Colvocoresses Reef.

Atmospheric haze, scan lines, film granularity and resolution limits at 1:1,000,000-scale were factors that caused problems in distinguishing signal from noise. The best separation was obtained using a 5 μ m by 200 μ m effective scanning slit.

After the negatives were scanned they were placed on a Bausch and Lomb Zoom Transfer Scope. An attempt was made to match the imagery to the revised nautical chart to record positions of the 12 scan lines and correlate density readings with soundings. Unfortunately the cartographic renditions of Speakers Bank and Colvocoresses Reef were too general and did not conform to the imagery. This problem made it impossible to positively transfer the positions of the 12 scan lines onto the revised chart, and consequently made any correlation of density profiles with soundings somewhat unreliable. In fact Speakers Bank is depicted as a completely closed reef, while the Landsat image shows at least 4 openings on the western side.



The central portion of Colvocoresses Reef and the upper northwest portion of Speakers Bank gave correspondingly high density peaks (see figure 1c, 1d). Since 11 meters is the shallowest sounding shown in the northwest portion of the revised map and is also in the same location on the original chart, one could estimate that the central portion of Colvocoresses Reef lies at a depth of 11 meters. However, since 11 meters is the average depth of Speakers Bank on the revised chart, there should be high density peaks on each scan line across Speakers Bank equivalent to the one in the northwest corner if the soundings are correct and we assume that densities can be related to depth. Since this does not occur, it could mean that the revised soundings are suspect, or that portions of Speakers Bank and Colvocoresses Reef are shallower than 11 meters.

For bathymetry via remote sensing to have validity, densitometer studies should be conducted on repetitive imagery of well-documented test sites, prior to estimating depths in unknown areas. This was attempted in this case, since it is believed that the Chagos Archipelago represents a typical area with respect to nautical charting status. It will be interesting to see what depths an actual survey reveals.



Sheila E. Martin
Research Cartographer
Branch of Photogrammetry

Attachment 1

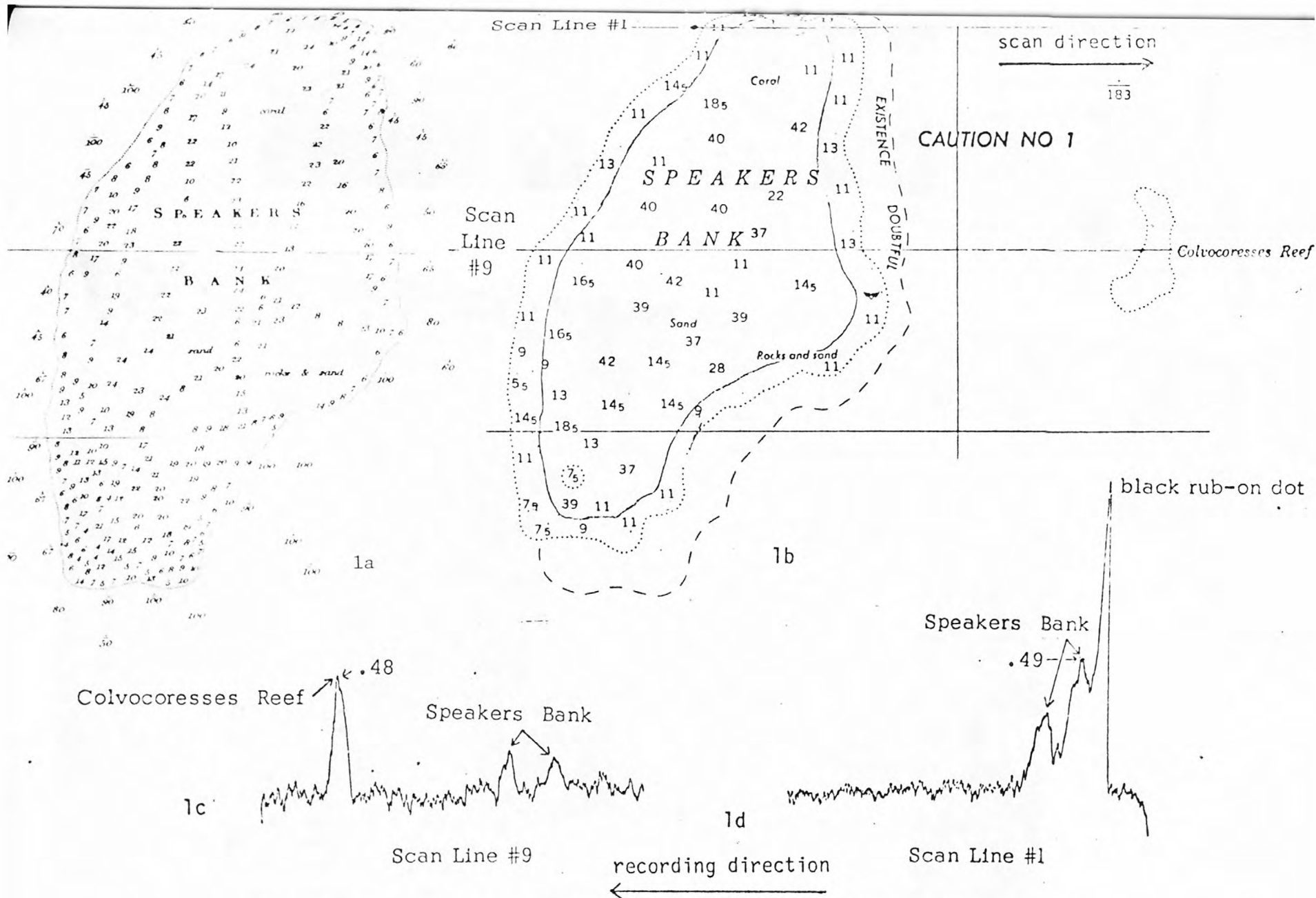
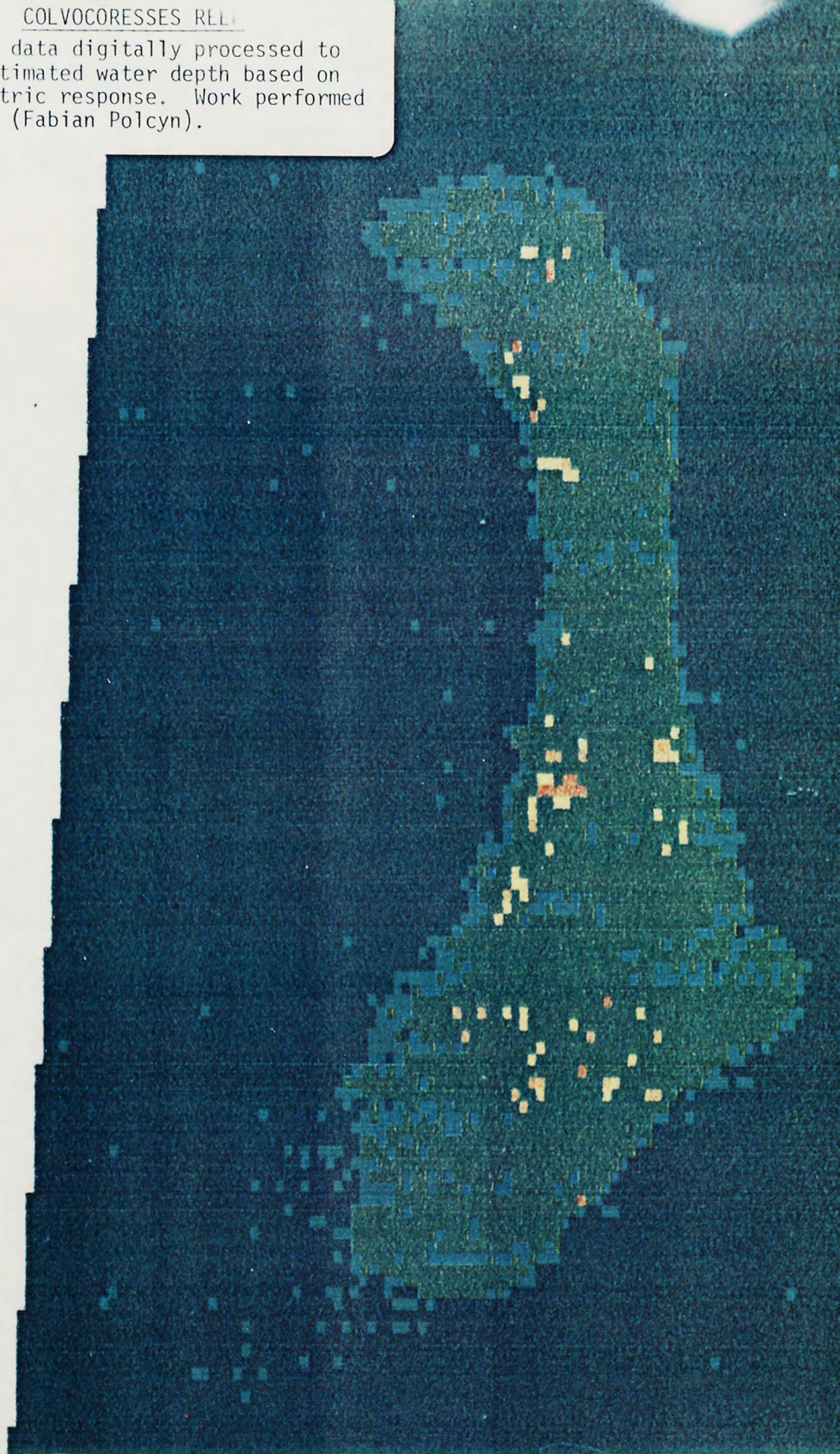


FIGURE 1. 1a = Original version of Speakers Bank (soundings in fathoms);
 1b = Speakers Bank (soundings in meters) and Colvocoresses Reef
 as shown on revised chart; 1c, d = Density profiles across
 Landsat negatives of Speakers Bank and Colvocoresses Reef.

Landsat data digitally processed to show estimated water depth based on radiometric response. Work performed by ERIM (Fabian Polcyn).

LAND**0-2'** *m***2-4****4-6****6-8****8-10****10-15****15-20****>20**

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