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AN INTERPRETATION OF MULTIBEAM BATHYMETRY OFF EASTERN OAK ISLAND, MAHONE BAY, NOVA SCOTIA

by

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INTRODUCTION

This Geological Survey of Canada Open File presents multibeam bathymetric imagery from the seabed surrounding the eastern end of Oak Island, Mahone Bay, Nova Scotia (Figure 1). A preliminary interpretation of the image is also provided (Figure 2).

Oak Island has been the focus of a large number of groups, over the past 150 years, interested in exploring the island for buried treasure. Activity began in 1750 with the discovery of a depression on the island; this was interpreted to result from differential compaction of material filling an excavated shaft. Many attempts to open the former suspected shaft failed with the incursion of marine water into the pit. An elaborate flooding system was proposed to explain the water incursion, accompanied by discoveries of hypothesized flooding ducts in the shallow water off the east coast of the island.

A prolonged period of excavation, survey, construction of cofferdams, landscape modification and other activities continued on the island until the 1980's. In 1996, the Canadian Hydrographic Service undertook a survey of the shallow water area surrounding the eastern part of the island using the vessel Puffin, equipped with a Simrad EM 3000 multibeam mapping system. This survey was intended to map the bathymetry.

REGIONAL GEOLOGICAL SETTING

Goldthwait (1924) first mapped the surficial geology of the Mahone Bay region. He interpreted Oak Island as a composite of four drumlins, two large and two small, forming the island (Figure 1). The drumlins are oriented northwest-southeast. Stea et al., (1992) mapped the surficial geology of the Province of Nova Scotia including the Mahone Bay region and defined the regional setting of Oak Island as a stony till plain with drumlins. The drumlins are elongated hills consisting of multiple till layers. The stony till plain, with a sandy matrix, was derived from local bedrock sources. The drumlins were siltier as a result of incorporation of older till units during glaciation. The thickness of the till in the drumlins ranges up to 30 m. To the south, multiple till sequences of Lunenburg Bay consist of basal grey compact Hartlen Till, overlain by reddish Lawrencetown Till. This sequence is typical of the stratigraphy of many of the drumlins along the south shore of Nova Scotia.

Piper et al., (1986) studied Mahone Bay as part of a regional assessment of the marine geology of the nearshore of the south shore of Nova Scotia. Their mapping indicates that most of Mahone Bay is underlain by a continuous till sheet with drumlins. The south eastern half of Oak Island is underlain by Mississippian Windsor Group limestone and gypsum while the northwestern part of the island is underlain by Cambro-

Ordovician Halifax Formation slate.

MULTIBEAM BATHYMETRIC IMAGE AND INTERPRETATION

The bathymetric image (enclosure) is a colour-coded depth representation of the morphology of the seabed surrounding eastern Oak Island. It is shaded with artificial illumination to enhance relief. The image shows the natural relief of the seabed and the location and shape of features. Some features are natural, others are anthropogenic.

Bathymetry

Water depths range to greater than 15 m across the image. The deepest water occurs southeast of Oak Island. Projecting from the southeast area of the island are two shoals. An isolated shallow area further to the east of the northern shoal is an oval-shaped feature with an orientation and elongation similar to the drumlin field of Mahone Bay. The shoreline of the island dips uniformly seaward and meets the flat surrounding seabed at approximately 12 m. The north side of the island presents a steeper profile, and the flat seabed is encountered at a depth of approximately 6 m. A linear channel up to 12 m in depth separates the island from a shoal area to the northeast. This shoal is likely a submerged western continuation of Frog Island, northeast of Oak Island.

Surficial Geology

It is difficult to interpret the sediment type of the seabed based only on the bathymetric image without samples. We present a preliminary interpretation (Figure 2) based on textural information and roughness from the multibeam data, together with sediment information from southern areas of Mahone Bay (Piper et al., 1986). The shallow areas surrounding the island, which appear as an offshore extension, consist of a muddy facies of the Sable Island Sand and Gravel, with greater than 10% mud (King, 1970 and Fader and King, 1986). The deeper flat bottomed areas consist of the LaHave Clay formation that contains less than 15% gravel.

Sea level history information from an area off Halifax (Stea et al., 1993) suggests that a similar environment and post glacial history probably affected the Mahone Bay region. The low sea level stand markers are found at a depth of 65 meters below present day sea level. It is highly likely that the entire seabed around Oak Island was sub-aerial some time during the last ~12,000 years and was transgressed as sea level rose following the last glaciation. The process of marine transgression eroded prexisting glacial materials (drumlins and till) armouring their surfaces with gravel and boulders. Fine-grained sediments are transported to deeper water for deposition. Piper et al., (1986) note landward migration of sand in the Mahone Bay region during the transgression.

Anthropogenic Features

The interpretation of the origin and nature of seabed features from multibeam data alone is also difficult. In other areas where significant anthropogenic features occur, interpretation requires additional seismic reflection, sidescan sonar, samples and visual observations for feature confirmation (Courtney and Fader, 1993, and Fader and Buckley, 1997). None of this additional data is available for the inner area of Mahone Bay, therefore, the interpretation presented here is preliminary. Care must also be exercised in differentiating survey artifacts from real data. This is particularly true in the case of the Simrad EM 3000 mapping system used in this survey. It was undergoing acceptance trials and modifications at the time of the survey. Additionally, environmental operating conditions such as waves, currents, vessel wakes, and tides introduce artifacts into the

data.

Three gravel (boulder) ridges trend to the southeast from the southeast corner of the island parallel to the orientation of the drumlins (northwest/southeast). Normally, boulder ridges and berms represent former beaches and are oriented parallel to the coast and bathymetric contours. The features on the image are normal to the shoreline. A large number of unknown objects are identified across the image. Most are interpreted as large boulders, but some may be anthropogenic objects.

A series of small isolated circular depressions occurs at the southwest part of the image. They may represent pockmarks formed by venting gas or water, or may be sinkholes resulting from subsidence over subsurface Windsor limestone bedrock. An unusual large depression with a linear positive feature in the centre, occurs in the southwest area of the image. The depression is similar to features observed in other areas where seabed sediment scour, or a lack of deposition, occurs around large obstacles such as shipwrecks and bedrock ridges. Two parallel, linear, slight depressions are found on the mud bottom at the southeast area of the image. They may represent artifacts from data levelling problems or large linear scours in the mud attributed to unknown anthropogenic processes.

A rectangular depression occurs on the seabed near the northeast shore. It is directly across from another large depression formed in hard materials on the opposite side of the linear channel. The origin of both features is unknown, however, the nearshore Oak Island feature likely represents a data processing artifact.

ACKNOWLEDGEMENTS

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Captions.

Figure 1. Index of study area in Mahone Bay, Nova Scotia. Drumlin map from Goldthwait, 1924. Oak Island is depicted as consisting of 4 individual drumlins.

Figure 2. A preliminary interpretation of the multibeam bathymetric image. The seabed in the nearshore is largely interpreted to consist of gravel covered till and is an offshore extension of the drumlins.

Enclosure. Depth colour-coded, multibeam bathymetric image of the seabed east of Oak Island, Nova Scotia.

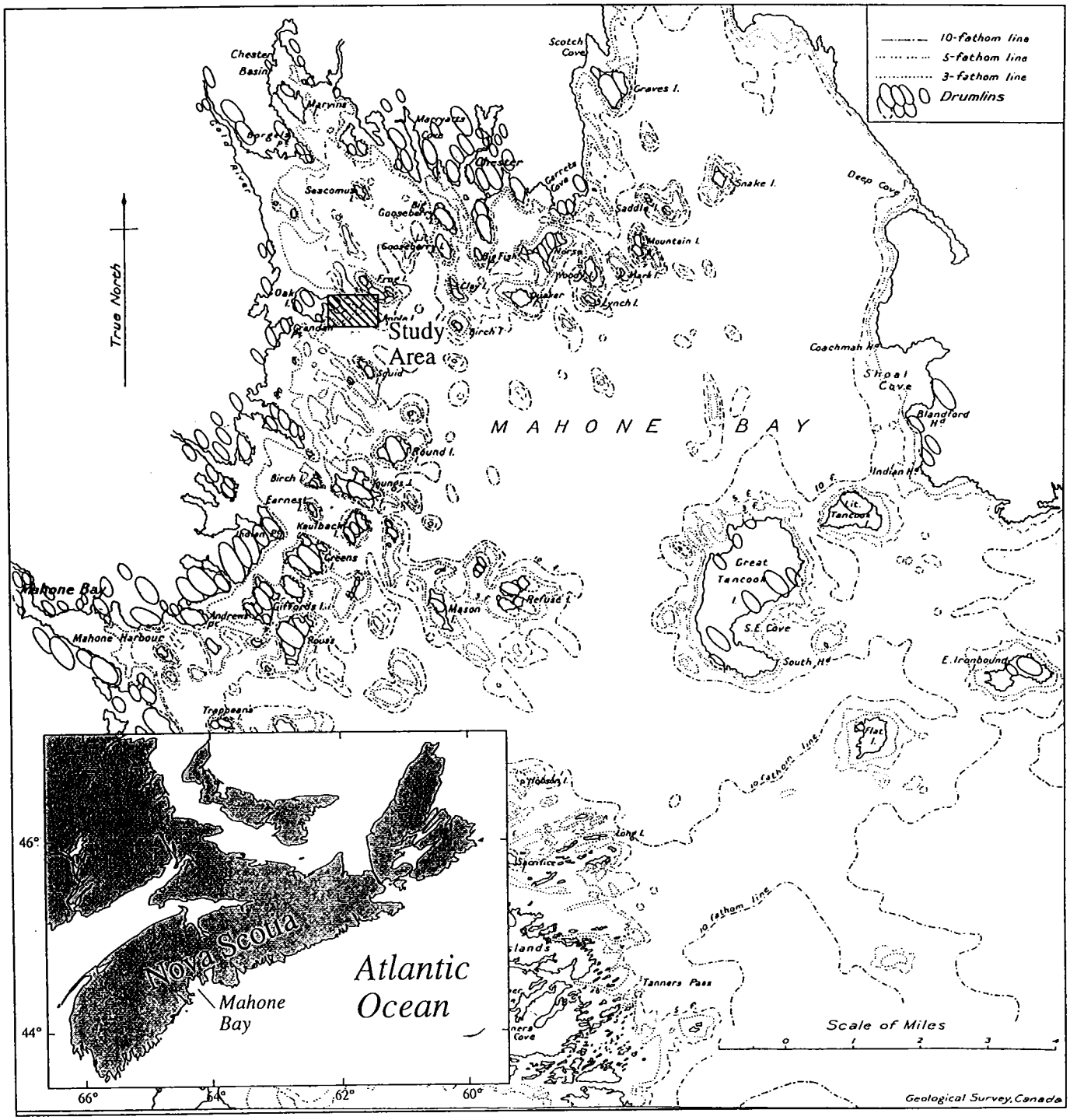

10-fathom line
5-fathom line
3-fathom line
Drumlins
True North
Study Area
MAHONE BAY
Mahone Bay
Mahone Harbour
Chester Basin
Scotch Cove
Graves I.
Snake I.
Deep Cove
Saddle I.
Mountain I.
Coachman Hd.
Shoal Cove
Blandford Hd.
Indian Hd.
Great Tancook I.
S.E. Cove
South Hd.
E. Ironbound
Flat I.
Long I.
Tanners Pass
10 fathom line
Scale of Miles
0 1 2 3
Geological Survey, Canada
Nova Scotia
Atlantic Ocean
Mahone Bay
46°
44°
66°
64°
62°
60°

FIGURE 1

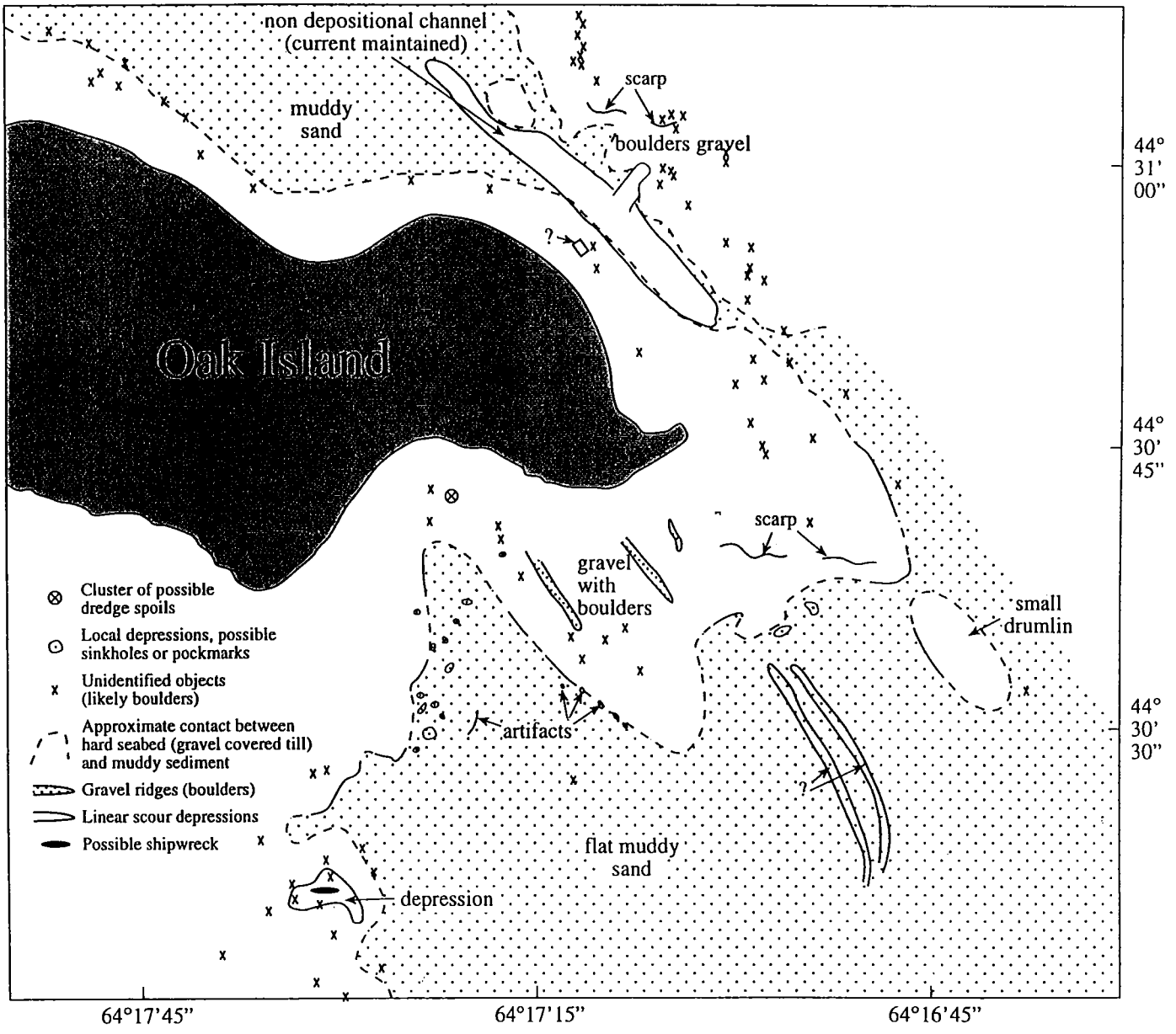
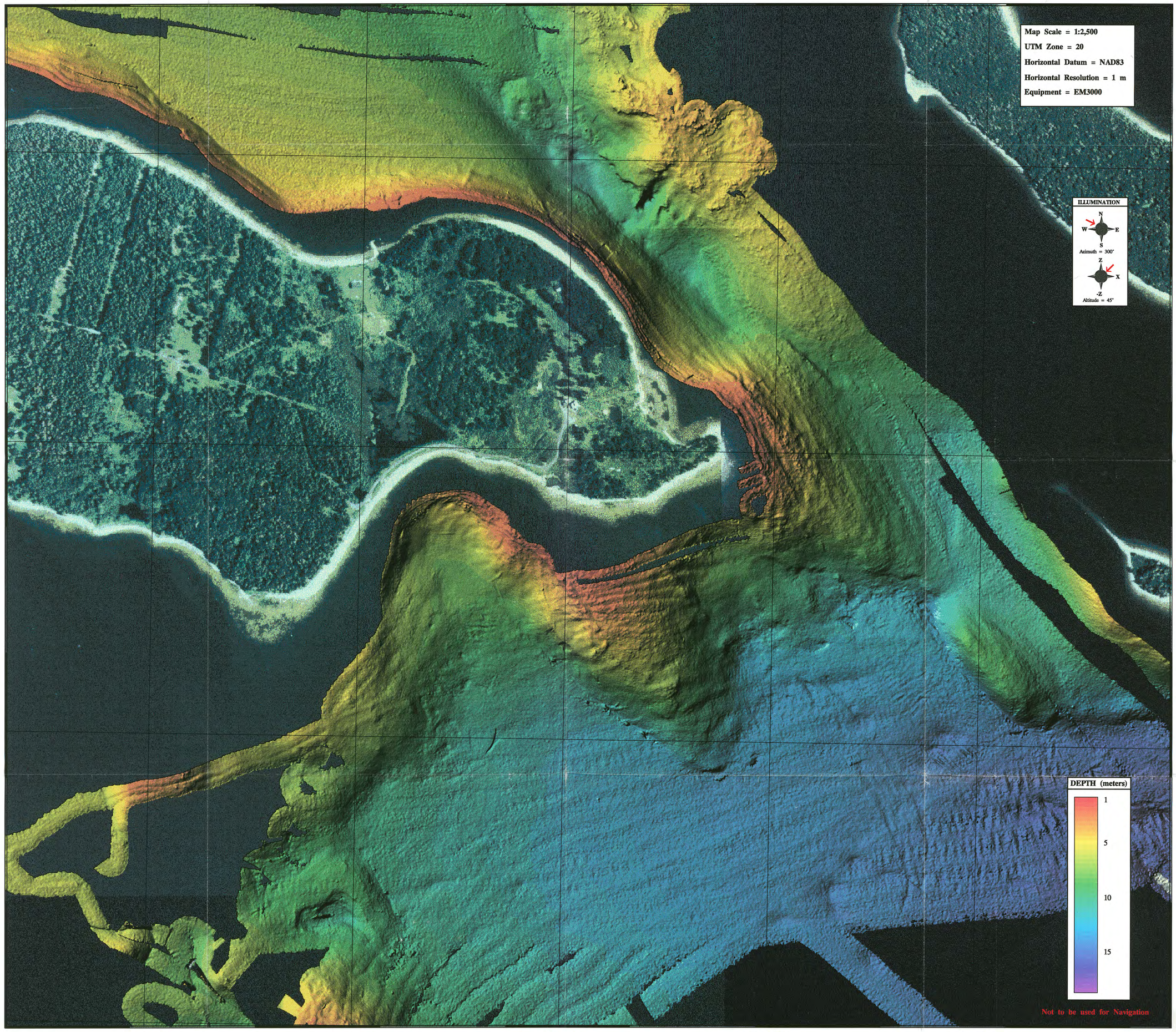

non depositional channel
(current maintained)
muddy
sand
scarp
boulders gravel
Oak Island
scarp
gravel
with
boulders
small
drumlin
artifacts
flat muddy
sand
depression
Cluster of possible dredge spoils
Local depressions, possible sinkholes or pockmarks
Unidentified objects (likely boulders)
Approximate contact between hard seabed (gravel covered till) and muddy sediment
Gravel ridges (boulders)
Linear scour depressions
Possible shipwreck
44° 31' 00"
44° 30' 45"
44° 30' 30"
64°17'45"
64°17'15"
64°16'45"

FIGURE 2

Multibeam Bathymetry
OAK ISLAND, NOVA SCOTIA
July 1996

396769 396969 397169 397369 397569 397769 397969 398169 398369 398569

4930280
4930080
4929880
4929680
4929480
4929280
4929080
4928880
4928680m



44:31:0
44:30:45
44:30:30

-64:17:45 -64:17:30 -64:17:15 -64:17:0 -64:16:45

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