SURFICIAL SEDIMENT INVESTIGATION
McNAB'S COVE
HALIFAX HARBOUR

by:

Geomarine Associates Ltd.
Halifax, Nova Scotia
Canada

for:

Ministry of Transport
Coast Guard Division
Dartmouth, Nova Scotia
Canada

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Project No. 77-4

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INTRODUCTION

In November, 1977, Geomarine Associates Ltd. was contracted by the Ministry of Transport, Coast Guard Division, to undertake a study of the surficial geology of McNab's Cove. The results of the study are to be used to define suitable emergency grounding areas for ships in distress. McNab's Cove is located on the west side of McNab's Island and opens out to the main channel of outer Halifax Harbour and is thus a suitable location for such procedures.

McNab's Island consists of a number of closely spaced drumlins oriented parallel to the axis of the harbour. Drumlin erosion and subsequent redeposition has caused the formation of a 1,200 m long sand spit and extensive sand beach area that form the southern wall of the cove. The cove is approximately 1,000 m wide by 700 m long. The shoreline progresses from a wide sand beach along the south and east edge of the cove to a narrow cobble beach on the north (Fig. 1).

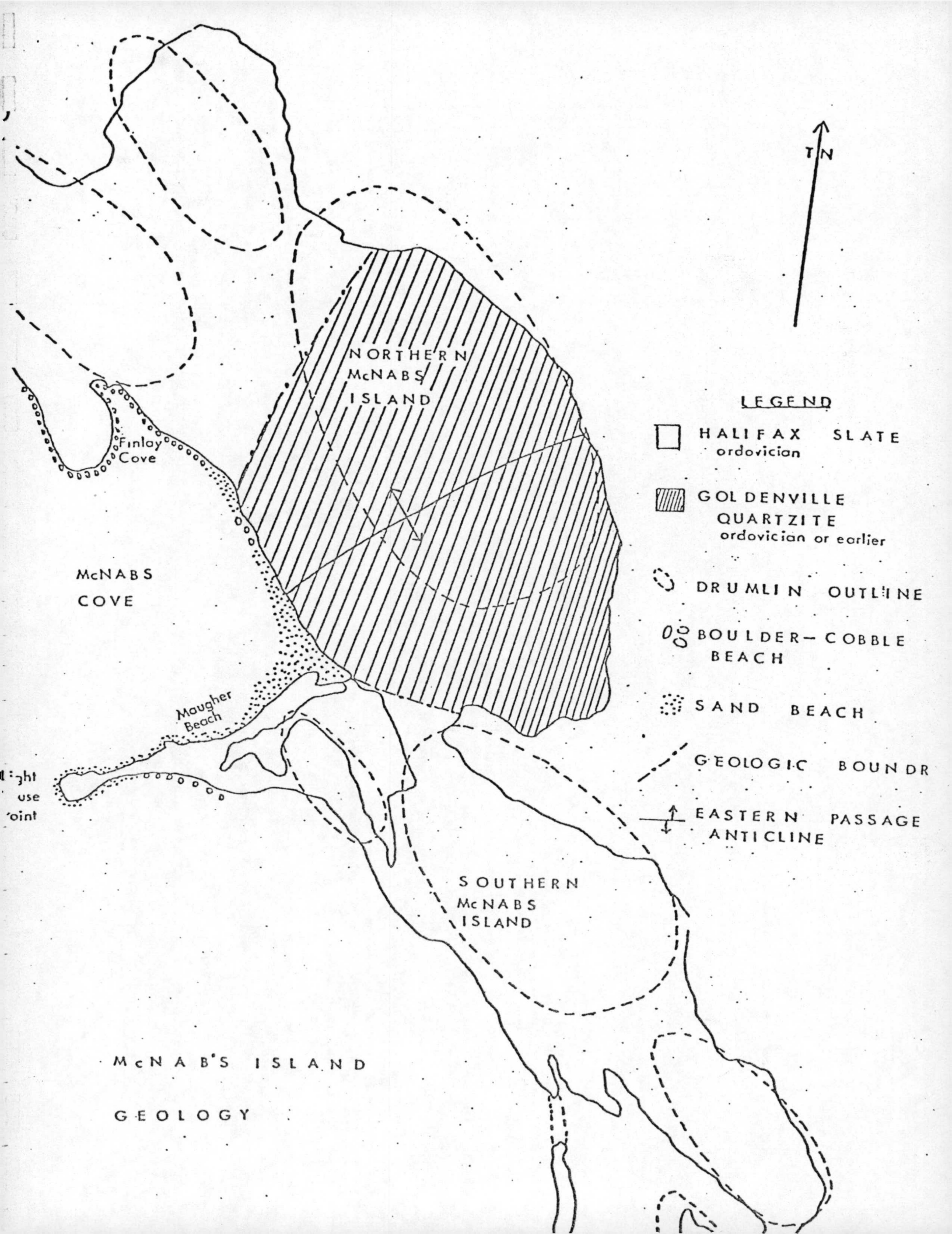
SURVEY PROCEDURE

The survey was conducted on November 10 and 11, 1977, from a 42 ft Cape Island type fishing craft owned and operated by Mr. Gus Henneberry, Sambro, Nova Scotia.

Using a Del Norte trisponder positioning system, arcs were run in a NW-SE direction. Slave trisponders were located accurately on hydrographic survey plugs at Ferguson Cove and Point Pleasant (Appendix B). Bathymetry data were provided by the ship's J.M.C. echo-sounder which produced a continuous profile on 6 in wide paper. An over-the-side-mounted O.R.E. 3.5 kHz profiler was used to obtain sub-bottom and textural information and was augmented by an O.R.E. side-scanning sonar system towed a few metres behind the boat.

FIGURE 1

McNAB'S ISLAND
ILLUSTRATING GENERALIZED GEOLOGY
(After Brisco, 1974)


N
NORTHERN McNABS ISLAND
Finlay Cove
McNABS COVE
Maugher Beach
SOUTHERN McNABS ISLAND
LEGEND
HALIFAX SLATE
ordovician
GOLDENVILLE QUARTZITE
ordovician or earlier
DRUMLIN OUTLINE
BOULDER–COBBLE BEACH
SAND BEACH
GEOLOGIC BOUNDR
EASTERN PASSAGE ANTICLINE
McNAB'S ISLAND
GEOLOGY

(Appendix A). No interruptions were encountered due to bad weather or gear failure.

DATA REDUCTION

Using the ranges to the boat from the slave trisponders, a track chart was computer-drawn by Servant, Dunbrack, McKenzie and MacDonald Ltd., Land Surveyors, at a scale of 1:2,000 on a 3° MTM grid. From the preliminary map anomalous fixes, caused by the interference of passing ships, were removed and a final track chart produced (Enclosure 1).

The echo-sounder records were digitized, corrected for tidal variation and transducer depth and posted (Enclosure 2). A velocity of 1,500 m/sec was assumed as the propagation speed of sound through water. Cross-over errors along the checklines were small, generally within .5 m, indicating both good navigation and precise depth measurements. The posted soundings were then contoured at a 2 m interval to arrive at a contoured bathymetry map (Enclosure 3).

Surface boundaries of bottom types and thicknesses of sediment over impenetrable reflectors were taken from the 3.5 kHz record and plotted on an overlay of the track chart. A velocity of 1,450 m/sec as the speed of propagation through soft, ungasified sediments was used based on Kepke's velocity measurements in Halifax Harbour and Bedford Basin (Kepke, 1977). Bottom type was interpreted using the sidescan sonar and 3.5 kHz profiler records. An isopach map was then produced at a 1 m contour interval for these penetrable sediments (Enclosure 4).

The digitized sediment thicknesses were added to the water depths to arrive at a contoured total depth to the hard reflector

(Enclosure 5). Tentative areas of suitability for grounding a ship of 200 m length with variable drafts of from 6 to 17 m were then demarked and selected profiles of the bottom made for these areas (Enclosure 6, Fig. 5).

RESULTS

Bathymetry

The cove generally has a smooth uniform bottom of shallow slope. The contours tend to follow the shape of the shoreline causing the slopes to converge toward the centre of the cove, producing a bowl-like bathymetry. There are exceptions to this general bathymetry. Most notable are the steep slopes on the southwest and northwest corners of the cove and the prominent shoal north of Maugher's Beach Lighthouse, an extension of Horseshoe Shoal. A slight rise of 1 m amplitude hooks out into the west central portion of the cove, and another more prominent rise affects the 6-10 m contours on the eastern side of the cove. The width of these rises is from 80-100 m. A narrow re-entrant of 3-4 m amplitude affects the 6-10 m contours on the eastern side of the map area. This is the seaward extension of a narrow channel which bifurcates Maugher's Beach.

Depths within the cove never exceed 18 m, but descend rapidly to a maximum depth of 32 m beyond the mouth of the cove in the harbour channel proper. The contours from 18 m and deeper do not follow the shape of the cove, but rather the axes of the harbour channel. Proceeding westward, the bottom rises gradually from 32 to 24 m and then quite sharply from 24 to 18 m as Middle Ground Shoal is encountered. A minimum depth of 10.4 m is recorded on the portion of the shoal in this map area.

Surficial Geology

Most of McNab's Cove is overlain by a mantle of fine-grained sediments. For the purpose of this study "fine-grained" sediment is defined as sediment that is acoustically penetrable using the 3.5 kHz profiler and therefore may include fine sands, silts and clays. Hard packed sands offer little or no penetration; while coarse sands, gravels, tills and bedrock are impenetrable. In the survey area, where penetration is achieved at all, it is clear and unambiguous indicating that the sediments have a high silt and/or clay component.

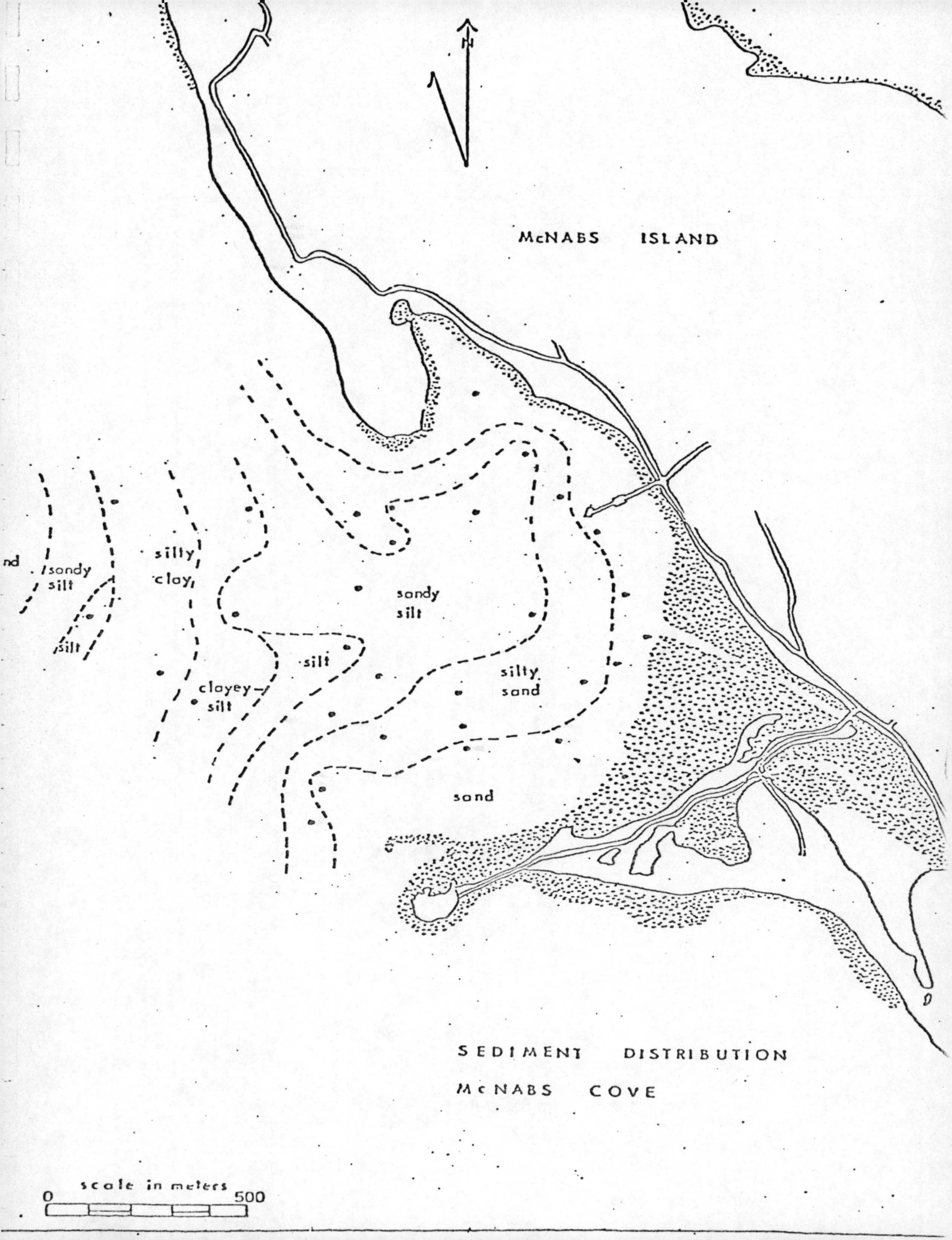
Based on bottom grab sample analyses, Brisco (1974) notes a normal progression of sand through silt going from the low water mark to the mouth of the cove, to silty clay in the harbour channel and back to silty sand over Middle Ground Shoal (Fig. 2). Grain size is depth dependent, with the finest sediments occupying the deepest areas and sand to cobbles forming or overlying the beach areas and shoals.

A hard, acoustically impenetrable horizon is seen to underlie this mantle where penetration is not stopped by gas in the soft sediments. This hard reflector is exposed on the bottom in several places. The hard exposures are generally associated with topographic highs, with finer sediments being ponded in and infilling the intervening topographic lows. The exposures form two parallel lines separated by a NW-SE trending depositional basin.

Within the cove the northern and northeastern periphery within the 12 m contour is predominantly hard-bottomed as is the outer edge of Horseshoe Shoal north of the Maugher's Beach Light. This exposure is bounded at its deep end by the 16 m contour. Outside the cove a large exposure occurs between the 32 and 26 m contours on a direct line between Horseshoe Shoal and Middle Ground Shoal, and another on Middle Ground Shoal lies above the 24 m contour.

FIGURE 2

SURFICIAL SEDIMENT DISTRIBUTION
(After Brisco, 1974)


N
McNABS ISLAND
nd
sandy silt
silty clay
silt
sandy silt
silt
clayey silt
silty sand
sand
SEDIMENT DISTRIBUTION
McNABS COVE
scale in meters
0
500

Gas Horizon

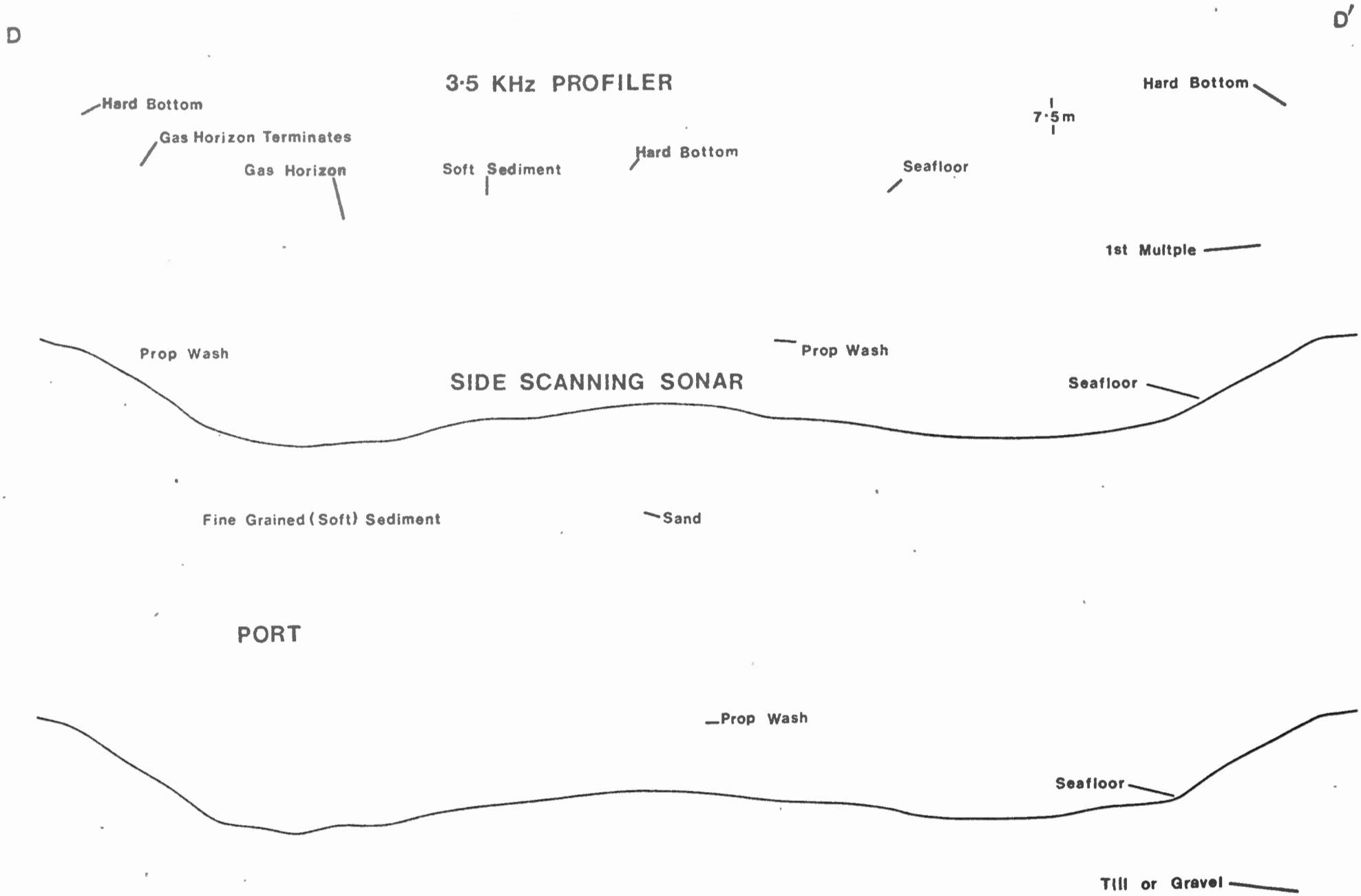
The determination of soft sediment thickness is hampered by the existence within much of the depositional basin of accumulations of methane gas. This gas is formed in situ by bacterial degradation of organic compounds. The gas forms a flat, featureless horizon, impenetrable to the 3.5 kHz profiler. The impenetrability, "may be due to dispersive wave propagation in gassy sediment, perpendicular to vertical incidence," (Kepke, 1977).

In general, the acoustic reflector terminates by dipping sharply down against the basin margin or where the underlying hard reflector rises to within a few metres of sediment surface (Plate 1). This need not always be the case, and along the southern edge of the unit in this map area the boundary is not distinct. This gas-induced acoustic reflector is a fairly common feature of ponded, fine-grained marine deposits, occurring in depositional basins in Outer Halifax Harbour, Northwest Arm, St. Margaret's Bay and Mahone Bay (Figs. 3 and 4).

While it cannot be stated with certainty, several lines of evidence indicate that "soft" sediment thicknesses are greater beneath the gas horizon than those measured where the gas horizon does not exist. In almost all instances, the onset of the gas horizon is accompanied by a deepening of the underlying hard reflector with a corresponding thickening of the sediment thickness. The thickest measured accumulations of sediment occur around the periphery of the gas horizon. The thickness isopachs trending parallel to and increasing toward the gas horizon boundary indicate that the horizon overlies a deeper sub-surface basin. Also, where an isolated sub-bottom high approaches to within 2-4 m of the sediment surface, the gas horizon is interrupted. Finally, all studies done noting the occurrence of the gas horizon locally in St. Margaret's Bay (Piper and Keen, 1976), Mahone Bay (Barnes, 1976) and Halifax Harbour

PLATE 1

Section of sidescan sonar and 3.5 kHz profiler record indicating various bottom types existing within McNab's Cove. (For location, see Enclosure 6.)


D
D'
3·5 KHz PROFILER
Hard Bottom
Gas Horizon Terminates
Gas Horizon
Soft Sediment
Hard Bottom
Seafloor
Hard Bottom
7·5m
1st Multiple
Prop Wash
Prop Wash
SIDE SCANNING SONAR
Seafloor
Fine Grained (Soft) Sediment
Sand
PORT
Prop Wash
Seafloor
Till or Gravel
STARBOARD
Sand

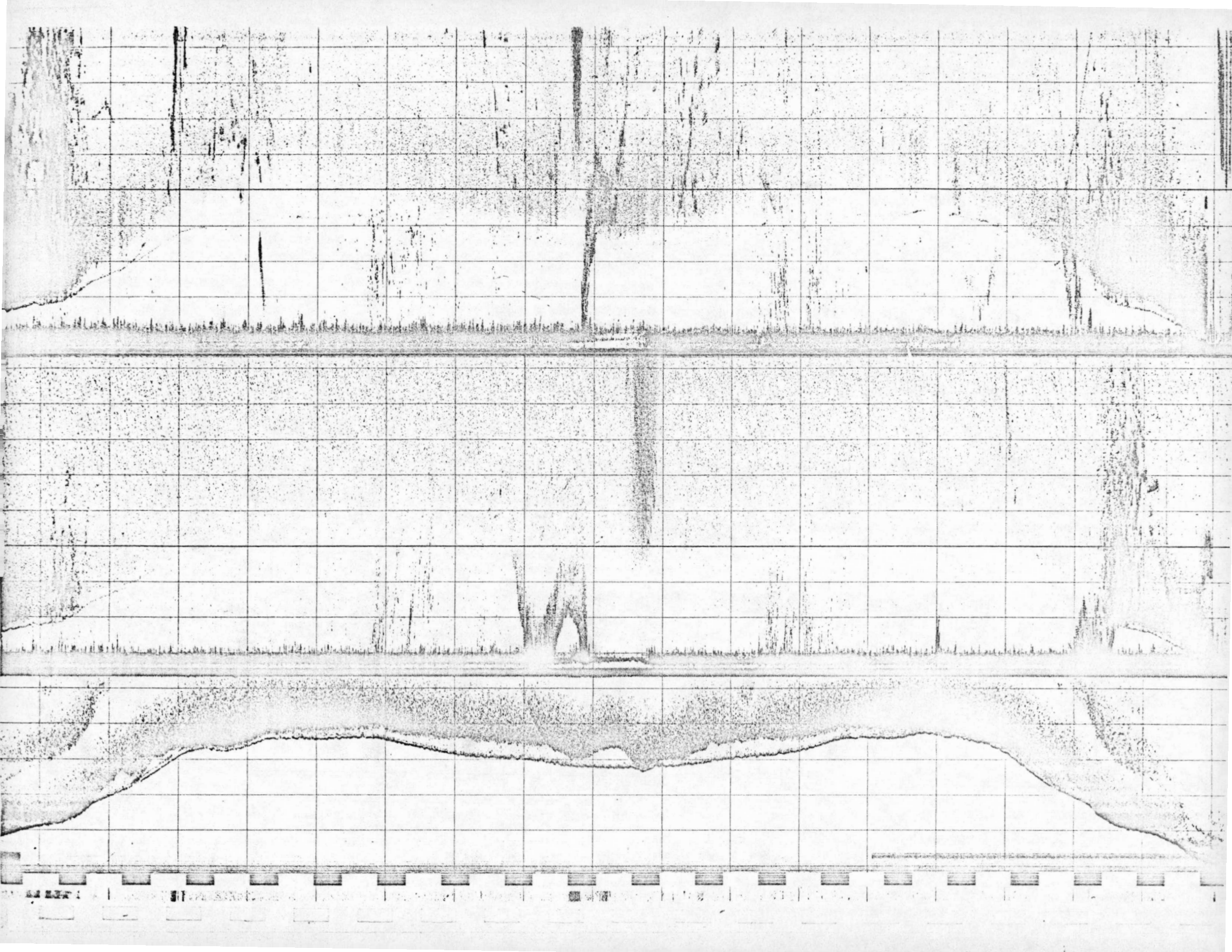


FIGURE 3

EXTENT OF GAS HORIZON IN HALIFAX HARBOUR

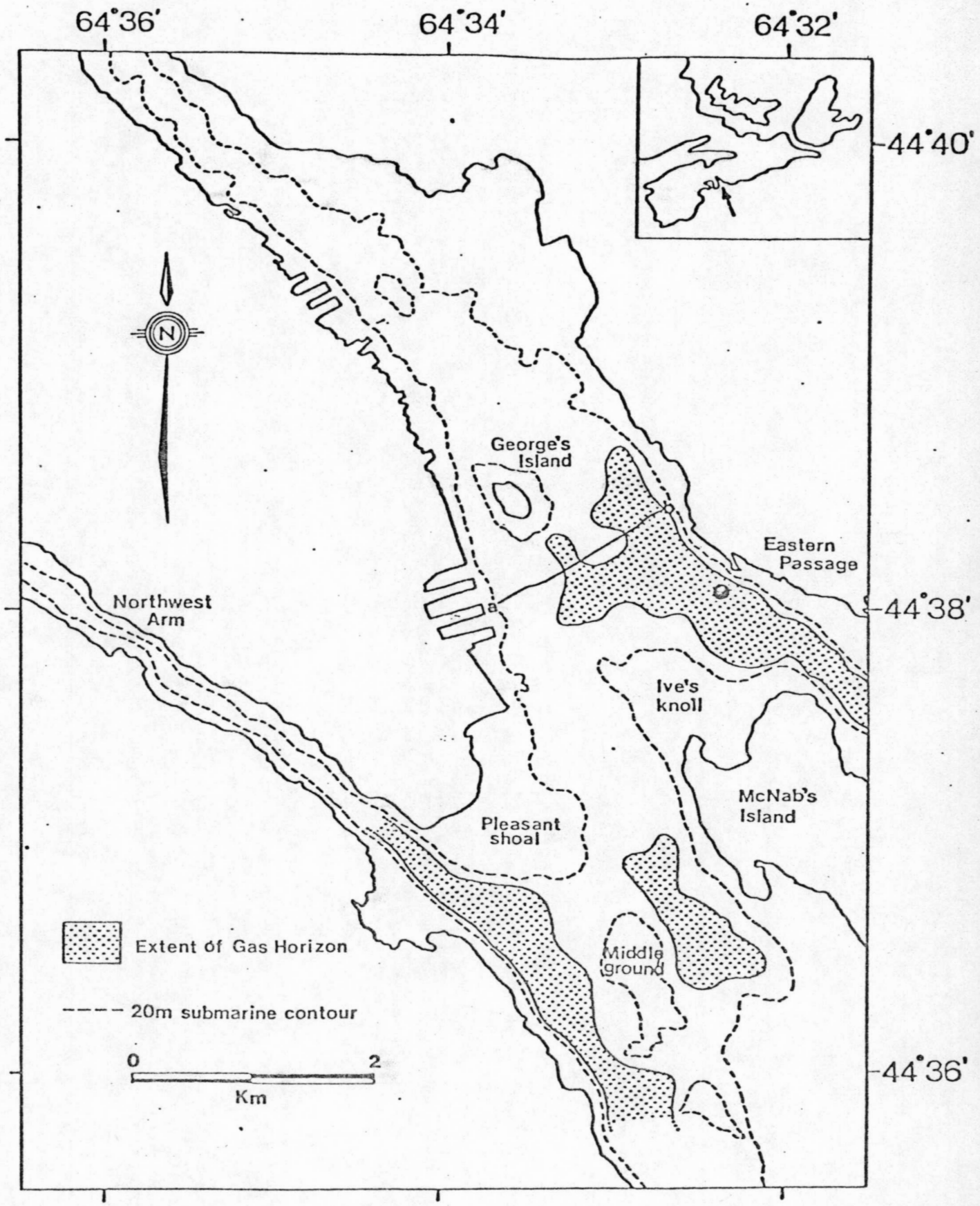
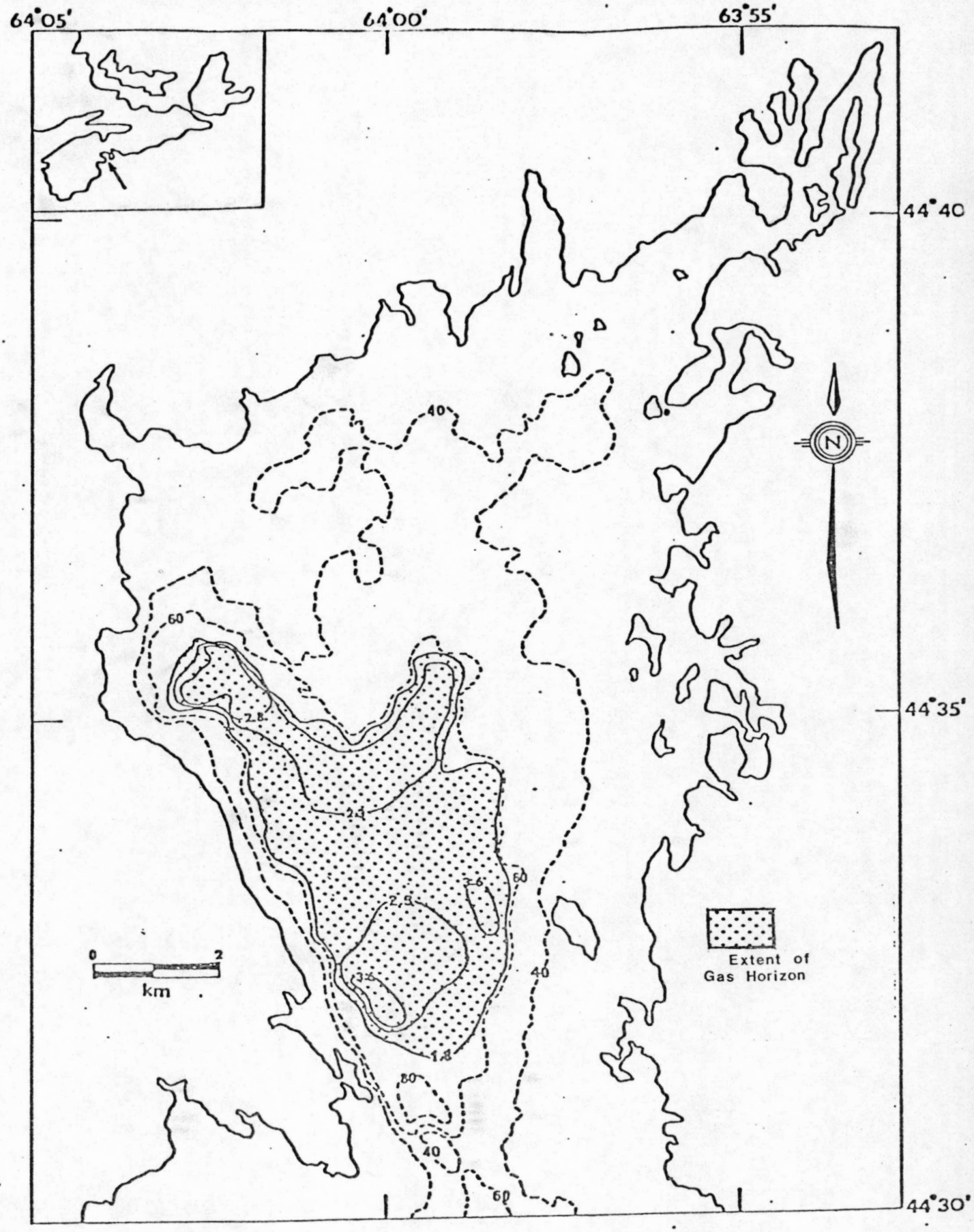

64°36'
64°34'
64°32'
44°40'
44°38'
44°36'
N
George's Island
Eastern Passage
Northwest Arm
Ive's knoll
McNab's Island
Pleasant shoal
Middle ground
Extent of Gas Horizon
20m submarine contour
0
2
Km

FIGURE 4

EXTENT OF GAS HORIZON IN ST. MARGARET'S BAY


64°05'
64°00'
63°55'
44°40
44°35'
44°30'
N
40
60
2.8
2.4
2.6
2.9
3.0
1.8
80
40
60
40
0
2
km
Extent of
Gas Horizon

(Kepke, 1977) find that the horizon occurs only in the deeper portions of basins where accumulation of fine-grained sediments is greatest.

These observations lead to the conclusion that there must be an accumulation in excess of 2-4 m of fine-grained, organic rich sediment in order that a gas horizon may exist.

Sediment Thickness

The thickness of soft sediments measurable over the gas horizon varies from 0-2 m within the cove, but increases to as much as 5 m in the harbour channel, possibly reflecting the different biological and physical regimes of the cove and harbour.

The greater part of the cove lying east of the gas horizon is covered by a thin blanket of soft sediment which seldom exceeds 2 m thickness and is most often less than 1 m thick. Sediment thickness increases abruptly at the periphery of the gas horizon as the eastern shoulder of the sub-surface basin is encountered, and thicknesses of from 4-6 m are recorded.

On the southwestern or outer end of the cove and in the harbour channel, sediment accumulation occurs as deposits ponded between Maugher's Beach, Horseshoe Shoal, Middle Ground Shoal and the hard bottom exposure north of Horseshoe Shoal. Accumulation increases with proximity to Maugher's Beach and is greatest immediately northwest of Maugher's Beach Light, where a thickness of 11 m is measured. As with the inner cove, sediment thicknesses also increase as the gas horizon is approached and thicknesses of 3-6 m occur along the horizon boundary.

Site Suitability

Among the factors to be considered in assessing the suitability of the cove for beaching vessels are:

a) length and draft of vessel;
b) slope of bottom;
c) bottom type;
d) thickness of suitable bottom type.

Using as a guideline a vessel 200 m long with a minimum and maximum draft of 6 m and 17 m the suitability of the cove was examined and profiles of three tentative beaching locations were made (Fig. 5, Enclosure 6). Each profile is specific to ships of a certain range of drafts.

Profile A-A^1 could accommodate ships of 17 m draft; Profile B-B^1 ships of 16 m to 10 m draft; and Profile C-C^1 ships of 8 m to 6 m draft. The adequacy of Profile B-B^1 is based on the assumption that the gas horizon is covering a substantially thicker deposit which is probable but must be verified by a followup coring program. It is the sole area in the cove, however, where the combination of a uniform gentle slope from 16-10 m depth and possibility of substantial soft sediment thickness occurs. It should thus be carefully considered. In Profile A-A^1 the slope is gentle enough and sediment thickness great enough over the gas horizon that a ship of 17 m draft could be completely grounded without striking a hard bottom.

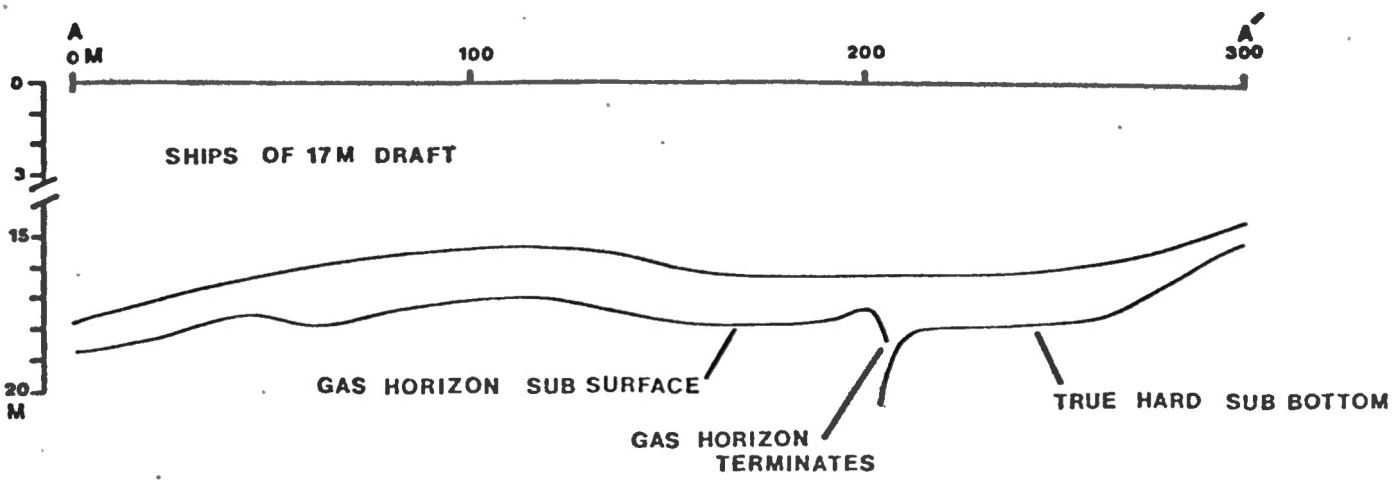
Decreasing depth is accompanied by increasing slope and decreasing sediment thickness. This presents a problem in finding a suitable location to beach ships of 8-6 m draft. It is possible that an extension of Profile B-B^1 inshore may prove that this line is also suitable for craft of these drafts. Alternatively, Profile C-C^1 is the most favourable site in the inner cove for beaching ships of these drafts.

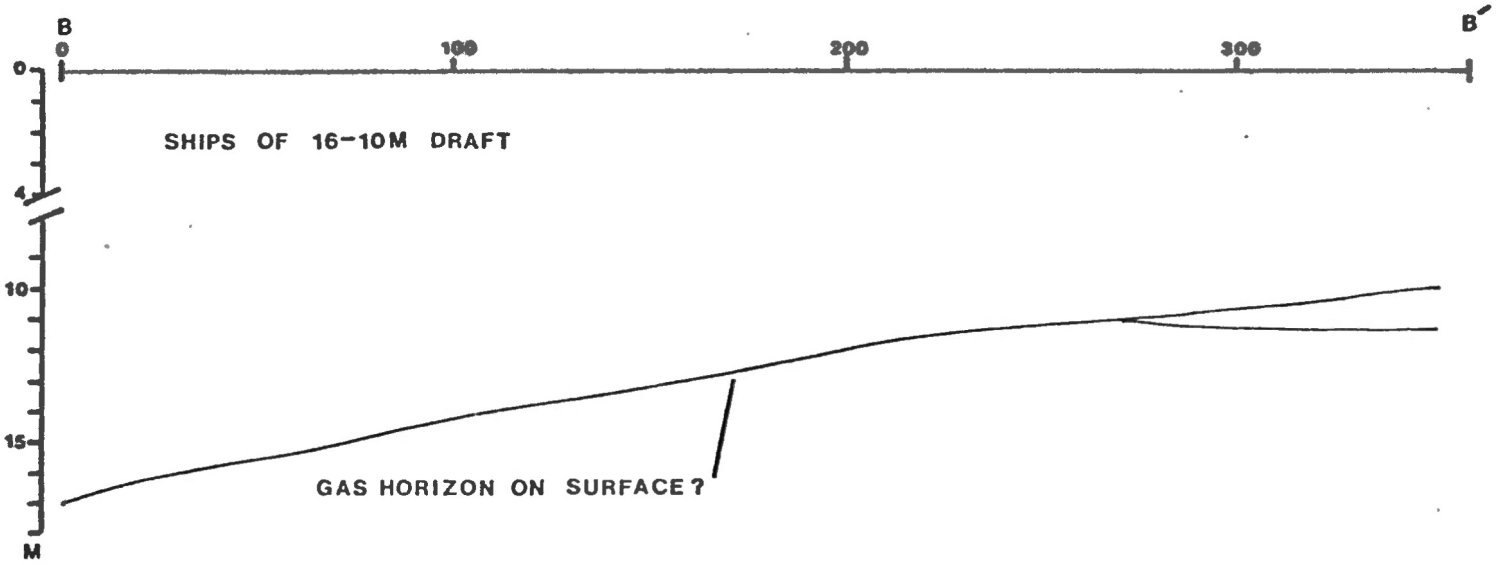
Areas of suitability were outlined by discarding areas of steep slope such as the outer edges of the cove and areas where soft

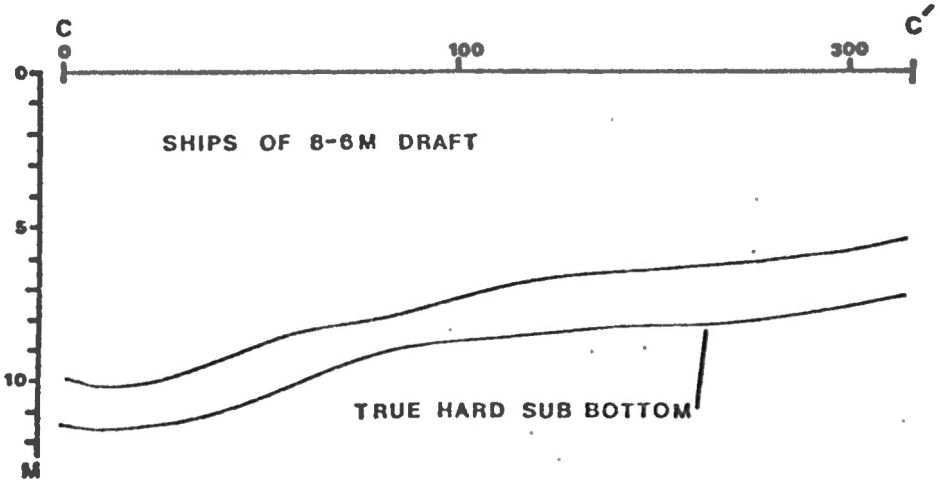
FIGURE 5

PROFILES OF TENTATIVELY SUITABLE BEACHING
SITES FOR SHIPS OF VARIOUS DRAFTS
(For locations of profiles, see Enclosure 6)

HORIZONTAL SCALE 1:2000
VERTICAL SCALE 1:250
VERTICAL EXAGGERATION X8







sediment thickness was less than 1 m. By overlaying the bathymetry on the bathymetry-plus-thickness map it was then possible to outline the area where a ship of 17 m draft, for instance, would first strike bottom and where, if it continued to plough into the bottom without riding up, it would strike the underlying hard reflector. These limits have been shown in Enclosure 6 for two cases, a 17 m draft ship and a 6 m draft ship.

It must be borne in mind that depths here have been reduced to chart datum and the effects of tide must be considered for any particular case. Because bottom slope and sediment thickness vary irregularly, the extent of suitable beaching sites will also vary irregularly with tide, which in Halifax Harbour may be as much as 2 m above chart datum.

CONCLUSIONS

1) Areas of hard versus soft bottom have been defined within McNab's Cove.

2) Contoured bathymetry reduced to chart datum provide total depth and bottom slope information.

3) Combined bathymetry and soft bottom sediment thickness information yield data pertinent to site selection.

4) Working examples of tentative groundings have been illustrated in the report and charts.

RECOMMENDATIONS

This report provides important data necessary to site selection for grounding vessels. Follow-up bottom sampling is an important step

to confidently choose final site location. Two methods of utilizing the information contained in this report are as follows:

1) Apply sea state, tidal height and ship characteristics to the enclosed charts as situations arise. Back-up bottom sampling to verify soft bottom thickness is a prerequisite to ensure proper degrees of safety.

2) From the charts produced, select one or more fixed grounding "lanes" and prove their final suitability by bottom sampling for hardness and thickness determinations. Proper placement of range markers on the island would indicate grounding lanes.

REFERENCES

Brisco, C. D. 1974. Concentration and Distribution of Oil Pollutants in McNab's Cove, Nova Scotia. Unpubl. B.Sc. (Hon.) Thesis, Dalhousie University, 18 pp.

Barnes, N. E. 1976. Geology of Eastern Mahone Bay. Unpubl. M.Sc. Thesis, Dalhousie University, 125 pp.

Keen, M. J. and D. J. W. Piper. 1976. Kelp, Methane and an Impenetrable Reflector in a Temperate Bay. Can. J. Earth Sci., 13, pp. 312-318.

Kepke, P. E. 1977. Preliminary Investigation of Free Gas as the Control of a Sub-Bottom Acoustic Reflector in the Fine Grained Sediments of Halifax Harbour and St. Margaret's Bay, Nova Scotia. Unpubl. M.Sc. Thesis, Dalhousie University, 86 pp.

APPENDIX 1

EQUIPMENT SPECIFICATIONS

APPENDIX 2

CONTROL POINTS USED FOR POSITIONING TRISPONDERS

NOVA SCOTIA DEPARTMENT OF LANDS AND FORESTS

CONTROL SURVEY MONUMENT RECORD

NOVA SCOTIA PLANE CO-ORDINATE SYSTEM

COMPUTED FROM TRAV. NO. 394 ; DATE JAN 1976 STATION 6040

COORD. EAST(X) 1242602.92 FEET CMER.=64.5 LATITUDE 44 37 3.6703
COORD.NORTH(Y) 16214468.41 FEET LONGITUDE 63 34 4.9566

HEIGHT (TOP OF MARKER) 27.25 FEET CONVERGENCE 0-39-16.6

UTM COORDS IN METERS EAST 454931.42 NORTH 4940421.70 ZONE 20

STATION	GRID AZIMUTH	DISTANCE	FACTOR
INFORMATION FOR ZONE WITH CENTRAL MERIDIAN 64.5			
6046	78 34 55.5	6912.09	0.999965
4307	154 23 13.5	4943.86	0.999957
6047	57 34 17.9	12836.87	0.999967
5803	181 37 9.3	3382.34	0.999977
6009	246 40 44.3	2448.64	0.999944
12147	74 34 57.7	6716.07	0.999970

NOVA SCOTIA 3° TRANSVERSE MERCATOR PROJECTION ZONE..... C.M.....

DESCRIPTION

DATE.....1966....

TYPE (S.) C. A. R.

AREA..HALIFAX....

AIR PHOTO.....

MAP SHEET.11P/12a..

PICTURES.....

SKETCHED BY.TOPO...

TOWER HEIGHT.....

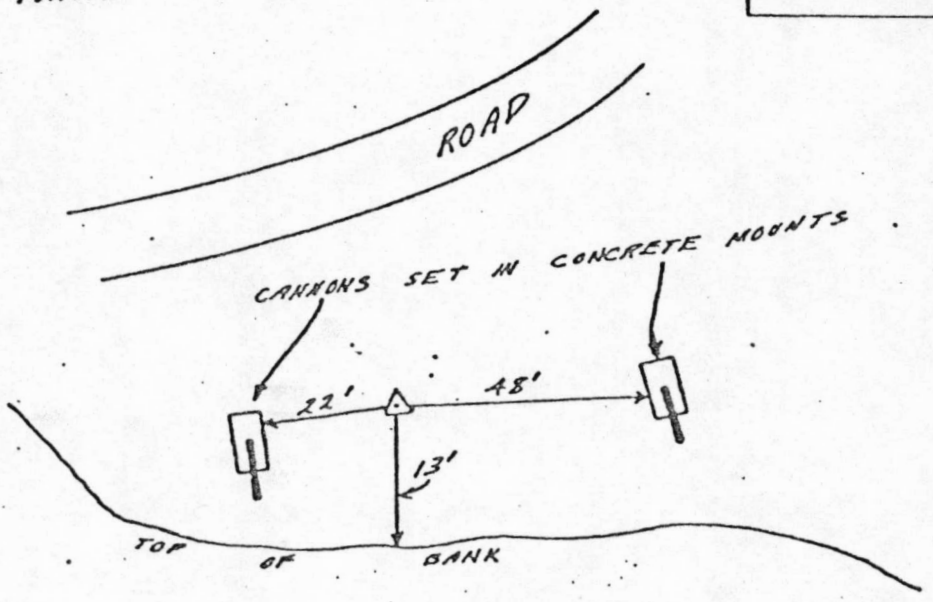
REOCCUPIED DATE

....

....

SOUTHERLY POINT OF POINT PLEASANT PARK.

MONUMENT 6040



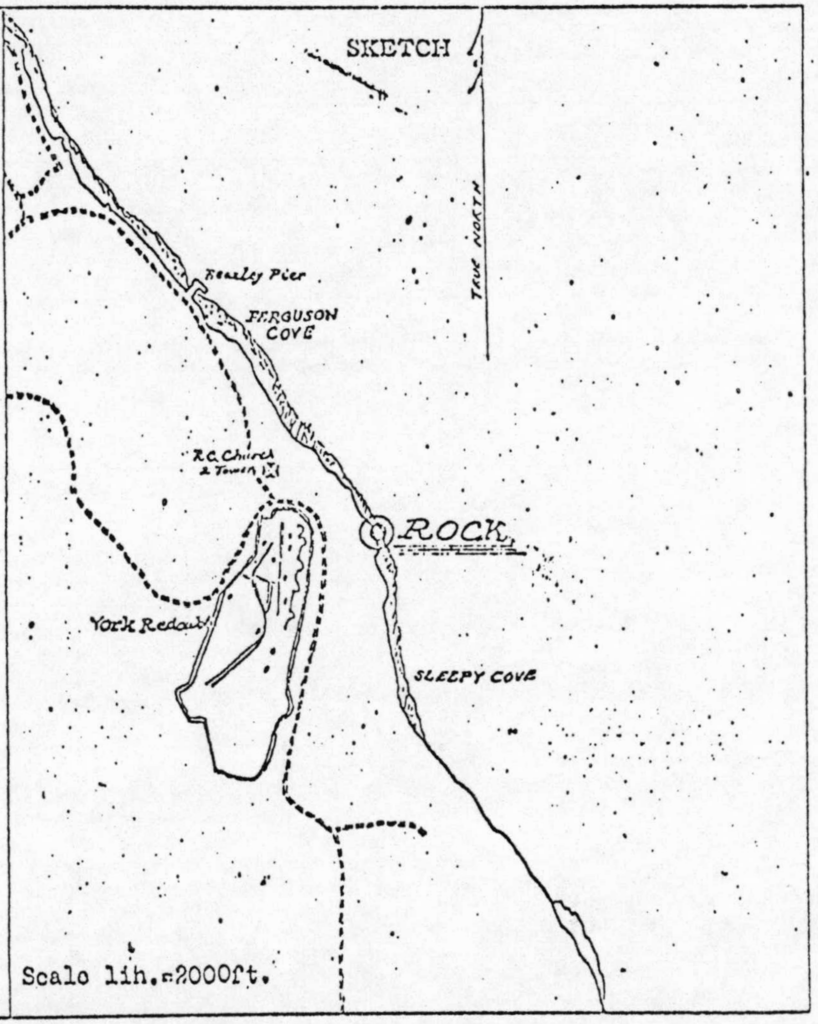
A1-63-4

Recovered, 1969 [illegible]

Entrance to Halifax Harbour

PHOTOGRAPH

Top of plug missing Aug 72 R. Burke



Station Name ROCK

Station Number 378

Chart No. 4316

Locality Ferguson Cove Halifax Harbour

Latitude 44°35'53.98" N .968

Longitude 63°33'08.57" W .553

Datum N. America 1927

Type of Post Cemented in bedrock

Elevation 6ft.

Calculation File No. 10161 [illegible]

Field Book File No. [illegible]

Field Sheet File No. 1762 & 1763 G14

Planted by D.H. Charles

Date Planted Oct. 1947

Officer-in-Charge G.E. Lowe

1977 MAK

Marking: As below

HYDROGRAPHIC SERVICE - CANADA -
378
1947

DESCRIPTION

This station is situated on the western shore of Halifax Harbour, just below Fort York Redoubt. It is marked by an Hydrographic rock post cemented in bedrock about 12ft. east of an abandoned concrete searchlight station. This station can be reached by boat, landing on the shore near the station or at Beazley Pier in Ferguson Cove or by automobile, taking the highway that leads from the Arm Bridge in Halifax to Ferguson Cove.

G.E. Lowe

F, 3133