1975 SUBSEA CABLE ROUTE STUDIES

GRAND MANAN CHANNEL

HEAD HARBOUR PASSAGE AND FRIAR ROADS
NEW BRUNSWICK
CANADA

Submitted to

New Brunswick Electric Power Commission
Marysville, New Brunswick

by

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ABSTRACT

Three possible routes for a submarine power cable to link Grand Manan Island, New Brunswick with the mainland New Brunswick power grid, were the object of marine geophysical surveys in 1975. The areas studied were Grand Manan Channel, Head Harbour Passage and Friar Roads. The surveys were conducted by Geomarine Associates Limited of Halifax, Nova Scotia. The systems employed included: a combined, deep-tow side-scan sonar and 3.5 kHz seismic profiler, a surface-towed "boomer," seismic reflection system and low-frequency echo sounder. The revelations of these systems were "ground truthed" with seafloor sediment samples and photographs. The survey was supported by a precision radar-transponder navigation system.

Interpretation of the survey data involved the integration or cross-correlation of all information sources and resulted in the development of maps describing the bathymetry, surficial geology and thickness of unconsolidated sediment in the three channels studied. The bathymetry and sediment thickness data are further illustrated in cross sectional profiles of each channel.

The survey results indicate that Grand Manan Channel is flanked by precipitous and rocky submarine exposures representing the underwater extension of onshore bedrock features. These submarine outcroppings are onlapped by unconsolidated

sediments a short distance offshore. The unconsolidated sediment cover over most of the channel ranges between 10 and 40 ft (3 and 12 m) thick. These sediments consist of gravel with varying admixtures of sand and mud on the seafloor and of the same mixture but with an apparently increased mud content beneath the seafloor. Beneath the sediment cover over most of the channel, Triassic sedimentary strata form the bedrock. A field of sand waves has been mapped, paralleling the coast off Long Eddy Point on Grand Manan Island. Head Harbour Passage, between Deer Island and Campobello Island, was found to have two channels. The southeastern channel with a maximum depth of 340 ft (103.7 m) is virtually swept clear of sediments. The northwestern channel with a maximum depth of 240 ft (73 m) is found to be largely filled by fine-grained sediments. Friar Roads, which experiences strong tidal currents, is also largely swept clear of sediment. Head Harbour Passage and Friar Roads, as illustrated in cross sectional profiles, are typified by steep seafloor slopes composed largely of rock outcroppings.

Section 1 INTRODUCTION

Grand Manan Island, New Brunswick, at the mouth of the Bay of Fundy, supports a thriving fishing industry and a population of 2480 (1974 census). At present, the Island is supplied with power by a diesel generating station at Ingall's Head on Grand Manan operated by the New Brunswick Electric Power Commission. For economic reasons, the Power Commission wishes to link Grand Manan Island with the New Brunswick mainland power grid. To accomplish this, power cables will be laid across Grand Manan Channel to Campobello Island, thence overland to the western side of Campobello Island and finally across either Friar Roads or Head Harbour Passage, to Deer Island, where the New Brunswick power grid will be intersected (Fig. 1).

The laying of major submarine cables across Grand Manan Channel, with maximum depth 365 ft (111.3 m) and Head Harbour Passage 350 ft (107 m) or Friar Roads 280 ft (85 m), requires that a base of physical information be established to facilitate assessment of cable laying conditions, cable design and the cable security. The required information includes measurement of water depth, the mapping of seafloor geology and the investigation of sub-seafloor conditions. Geomarine Associates Limited of Halifax, Nova Scotia was retained to acquire and interpret the physical data for the

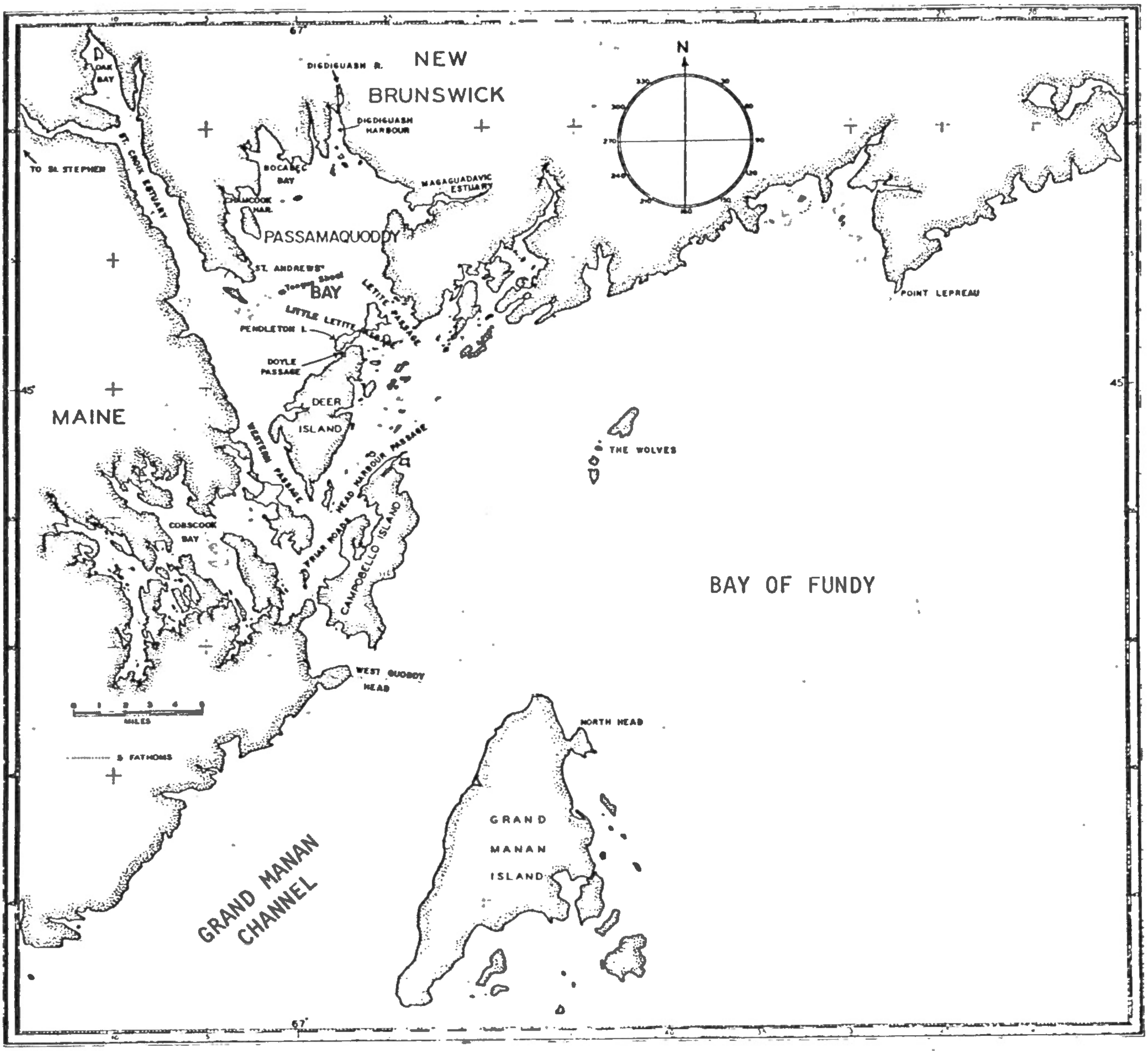


Figure 1 Southwestern New Brunswick

cable routes being considered. The field surveys were completed between September 15 and October 2, 1975.

The study of Grand Manan Channel conducted by Geomarine Associates Ltd was the second study of this proposed cable route. A previous study was completed in 1972 by Arctic Canadian Continental Shelf Exploration Services Ltd (ACCESS) of Toronto. In that study, a Klein Associates, Inc. Model MK-300 side-scan sonar was used to investigate the Channel and several potential cable landing sites. A Perry submersible (PS-2) was used to traverse sections of the cable route and observe seafloor conditions directly. The relatively lightweight and bulky early model side-scan sonar "fish" proved, because of water depth and tidal currents, difficult to maintain sufficiently close to the seafloor to obtain good records. Relevant to the present study, side-scan information was collected in Whale Cove, Grand Manan, considered a possible terminus for the cable. In the Geomarine survey of 1975, one informal line was run (by dead reckoning) along the coast from Long Eddy Point into Whale Cove. The interpretation of that line combined with a re-interpretation of the ACCESS data from Whale Cove is included as Appendix 1 in this report.

A power cable is presently in use between Deer Island and Campobello Island. This crosses Casco Island in Head Harbour Passage. Power was previously supplied to Campobello Island through a cable crossing Friar Roads between Campobello Island and Indian Island. The location of the existing and abandoned cable is shown on the hydrographic chart of the area (Fig. 26). Cables previously extended from Campobello Island to Grand Manan Island. In 1881 (Ingersoll, 1969), the first telegraph communication was established through a cable extending between Meadow Brook Cove on Campobello Island and Long Eddy Point on Grand Manan. A second cable, combining telephone and telegraph communications was later installed between Schooner Cove on Campobello Island and Whale Cove on Grand Manan. The location of these two cables was shown on earlier editions of Canadian Hydrographic Service Chart Number 4340 (representing surveys in 1948-49). The present edition, a portion of which appears in this report as Figure 16 , no longer shows the cables but the edition used by the ACCESS group in 1972 as a base map does show the old cable routes. The history of the cable's laying and survival could prove instructive in the present deliberations.

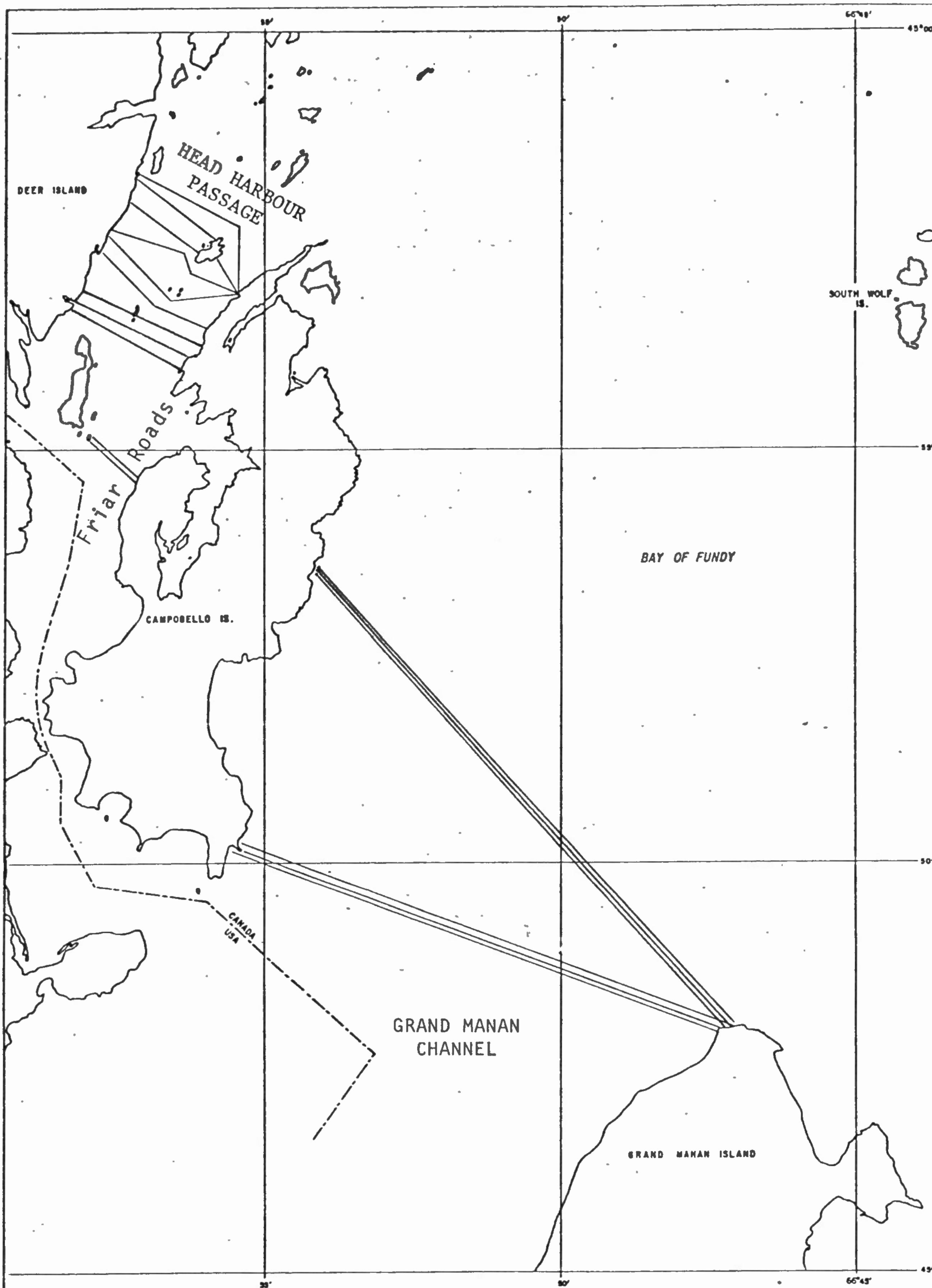


FIGURE 2. CABLE CROSSING ROUTES

1975 Survey

1976 Survey

Section 2 PRE-SURVEY ACTIVITY

The involvement of Geomarine Associates Ltd with the proposed cable route studies commenced on May 21, 1975 when Claude Gallant, N.B.E.P.C. Project Engineer requested that Geomarine conduct a brief literature search for information relative to the physical oceanography and marine geology of Grand Manan Channel and Head Harbour Passage/Friar Roads. The results of this review were considered at a meeting in Fredericton on May 29 and submitted in report form on June 3, 1975 (Ruffman, Geomarine Associates Ltd, 1975).

Following receipt on August 27, 1975, of N.B.E.P.C.'s order to proceed with the subject geophysical surveys, a planning meeting was held in Fredericton. In attendance were Mr. Claude Gallant (N.B.E.P.C.), Mr. Andy Biggar (Montreal Engineering Co. Ltd, consultants to N.B.E.P.C.), Mr. John Stewart (Vice President of Geomarine Associates Ltd, the prime contractor) and Mssrs. Ed Lancaster-Williams and William Latter (ComDev Marine - subcontractors for the supply of navigational systems and services). A number of revisions of the proposed survey track were completed.

On September 8, 1975, a reconnaissance of the survey areas was begun. Mssrs. Gallant, Mundle (N.B.E.P.C.), Stewart (Geomarine) and Williams (ComDev Marine) attempted a helicopter flight to the area but were turned back when fog was encountered along the Bay of Fundy coast. Shortly after noon, the group drove to Dipper Harbour and Chance Harbour to inspect fishing vessels which had been offered for charter. On departing this area, Gallant returned to Fredericton while Mundle, Stewart and Williams continued to Grand Manan Island. On Grand Manan, discussions were held with Ivan and Gleason Green of Ingall's Head concerning the charter of their vessel, M/V BONNY BROOK. The following day, Stewart returned to Halifax and Mundle and Williams commenced a search for existing survey control points. This reconnaissance was extended to Campobello and Deer Islands and completed September 11. The search for information relating to previously established control continued in the days immediately following, at the Bedford Institute of Oceanography.

A review of the 1972 report of side-scan sonar and submersible examination of Grand Manan Channel (ACCESS, 1972) was completed by Geomarine.

Section 3 SURVEY PERSONNEL

The following personnel were involved with the marine survey. The normal survey crew consisted of Party Chief, John Stewart (Geomarine Associates Ltd), Ed Lancaster-Williams and William Latter (ComDev Marine), Richard Blidberg and Ron Panton (O.R.E.), survey vessel skipper and crew and the client representative.

A. New Brunswick Electric Power Commission Representatives-

Claude Gallant - Project Engineer
N.B.E.P.C. Service Centre, Marysville

Bob Mundle - Assistant to Project Engineer
N.B.E.P.C. Service Centre, Marysville

B. Survey Vessels-

Ivan Green (Ingall's Head, Grand Manan Island)
Owner/Skipper of the M/V BONNY BROOK

Gleason Green (Ingall's Head, Grand Manan Island)
Owner/Skipper of the M/V BONNY MAID (employed one day) and crew aboard his son's vessel, the BONNY BROOK

Emery Guptill (Ingall's Head, Grand Manan Island)
Alternate Skipper of the BONNY BROOK (Grand Harbour, Grand Manan Island)

C. Navigation System-

Ed Lancaster-Williams - Hydrographer (ComDev Marine, Ottawa, Ontario)

William Latter - Senior Electronics Technician (ComDev Marine, Dartmouth, Nova Scotia)

D. <u>Geophysical Systems</u>-

Richard Blidberg - Electrical Engineer (Ocean Research Equipment, Inc., Falmouth, Massachusetts)

Ron Panton - Electronics Technician (Ocean Research Equipment, Inc.) Training Project - not charged to client

E. <u>Party Chief</u>-

John Stewart - Geologist (Vice President, Geomarine Associates Ltd, Halifax, Nova Scotia)

Section 4 SURVEY OPERATIONS LOG - SUMMARY

MOBILIZATION AND TESTING

Sunday, September 14, 1975 - Halifax - Saint John, N.B.

Travel, Halifax - Saint John, N.B. with half-ton truck (Stewart). Travel, Falmouth, Massachusetts - Bangor, Maine with van (Blidberg, O.R.E.).

Monday, September 15, 1975 - Mainland and Grand Manan, N.B.

Stewart drove from Saint John to St. Stephen, met O.R.E., cleared customs in one hour, met ferry at Black's Harbour and travelled to Grand Manan. Met and talked with Ivan Green.

Tuesday, September 15, 1975 - Grand Manan Island

Commenced mobilization of vessel: installation of winch for deep-tow side-scan, loading of heavy equipment at Seal Cove Wharf using heavy duty mast and winch.

Wednesday, September 17, 1975 - Grand Manan Island

Continue fabrication of winch baseplate and Elac transducer mount. Continue installation of other gear, start up and check out of gear. Assemble thermal generator gear and propane.

<u>Thursday, September 18, 1975 - Grand Manan Channel</u>

Stewart and Williams installed transponders at the Wolves and at West Quoddy Light between 0900 and 2200 hours. O.R.E. tested their equipment, ComDev installed and tested theirs. Problems with "boomer" and Autoplot exist.

<u>Friday, September 19, 1975 - Grand Manan</u>

Diode in "boomer" blown, Blidberg departs to meet plane with replacements in Saint John. Trisponder System tested out, Autoplot System tested off Long Eddy Point.

SURVEY: GRAND MANAN CHANNEL

<u>Saturday, September 20, 1975 - Grand Manan Channel</u>

Steam to Black's Harbour, pick up Blidberg of O.R.E. with boomer replacement parts. Tested systems, steamed for start of line at Owen Head. Completed Line 3.

<u>Sunday, September 21, 1975 - Grand Manan Channel</u>

Complete Line #2, shut down after heavy fog or other cause cut out reception of the Long Eddy transponder.

<u>Monday, September 22, 1975 - Grand Manan Channel</u>

Run Line #1A from Long Eddy Point to Ragged Point - some Trisponder interruption. Pause at end of Line 1 to re-arrange Trisponder/Autoplot and solve electrical interference problem. Re-run Line 3, run Line X enroute to re-start Line 3, following brief interruption due to Lister, diesel generator problem.

Tuesday, September 23, 1975 - Grand Manan Channel

Examined sand waves off Long Eddy Point. Ran two tie lines. Trisponder lost signal in thick fog. We geared up for seafloor sampling and completed three stations.

Wednesday, September 24, 1975 - Grand Manan Channel

Completed three camera stations and one grab station, attempted tie lines off Campobello, then ran reconnaissance line into Whale Cove from Long Eddy Point.

Thursday, September 25, 1975 - Move operations base North Head to Wilson's Beach

Stewart, Panton, Gleason Green and Em. Guptill steam to S. Wolf I., retrieve transponder. Blidberg drives ½ ton to Campobello, Mundle drives his car to Campobello, BONNY BROOK steams to Campobello. Latter and Williams co-ordinating on Deer Island.

SURVEY: CAMPOBELLO ISLAND TO DEER ISLAND

Friday, September 26, 1975 - Head Harbour Passage

Stewart and Mundle emplace transponders at CHOC and Leonardville Lt. Williams and Latter coordinating further control.

Saturday, September 27, 1975 - Campobello Island

Erected mast and transponder at Wilson's Beach. Encountered problems with the Trisponder System in the afternoon: a water-saturated antenna and possibly signal attenuation due to dense fog, also radar interference.

Sunday, September 28, 1975 - Head Harbour Passage

Check out Trisponder System, O.K., complete Lines 11, 12, 13, 14, 22, 21, 20, 23 by 1700 hrs. Can do no more until additional control is triangulated.

Monday, September 29, 1975 - Head Harbour Passage/Friar Roads

Morning spent in seafloor sampling from BONNY BROOK until interrupted by loss of coverage by Station WILSON (due to inadvertent rotation). Williams of ComDev triangulating onshore. Indian Island - Campobello Island partially completed by evening.

Tuesday, September 30, 1975 - Head Harbour Passage/Friar Roads

Completed Indian Island to Campobello Island crossing. Moved to Casco area, re-established Station LEONARDVILLE, complete work N.E. of Casco Island.

Wednesday, October 1, 1975 - Head Harbour Passage/Friar Roads

Complete 8 camera station to 1330 hrs., remove and re-erect two transponder stations (CHOC and LEONARDVILLE) at Head Harbour and Power Plant. Completed fill in lines N.W. of Casco Island by 1930 hrs.

Thursday, October 2, 1975 - Head Harbour Passage

Shuffled transponders to allow completion of lines S.E. of Casco Island. Completed survey by 1500 hrs. Picked up White Horse Island transponder, loaded ComDev gear and delivered ComDev personnel to Leonardville.

SURVEY COMPLETED; SURVEY MOVES TO LEPREAU

Section 5 MOBILIZATION

Mobilization of survey personnel and equipment commenced Sunday, September 14, 1975 with the departure of Geomarine personnel and equipment from Halifax and the departure of Ocean Research Equipment, Inc. personnel and geophysical systems from Falmouth, Massachusetts. These groups met at St. Stephen, New Brunswick on Monday, September 15 where Canadian and U.S. customs clearance was accomplished in one hour. The Geomarine and O.R.E. trucks then continued via Black's Harbour and the Ferry M/V GRAND MANAN to North Head, Grand Manan Island and thence to Ingall's Head. The following day, September 16, the M/V BONNY BROOK, chartered for the survey, sailed to Seal Cove on the south coast of Grand Manan Island. The vessel was tied alongside a wharf adjacent the machine shop of General Marine Services (1972) Ltd operated by Mr. Wiley McDowell. This wharf had a heavy duty mast and boom and geared hand-winch with wire rope and tackle which proved necessary for the transfer of the heavy side-scan sonar winch, diesel generator and other equipment. The General Marine Service (1972) Ltd Shop provided convenient and valuable services in the fabrication of a steel base plate for the side-scan winch and an outboard mount for the echo sounding transducer. The General Marine (1972) Ltd wharf is located in a narrow inlet at the head of Seal Cove. The inlet at this point dries at half-tide. Thus, it was necessary to ground the M/V BONNY BROOK at each low tide. While this required some care and vigilance, it meant that the distance from the wharf surface to the vessel at low tide was not the 20-25 ft (6.1-7.6 m) experienced where the vessel is afloat throughout the spectacular tidal range at Grand Manan. This fact permitted the loading of heavy equipment by means of the limited range tackle, without regard for tide level.

In choosing a location for the mobilization of survey equipment, we were presented with two alternatives. One was to mobilize from a "mainland" port such as Black's Harbour, N.B. The other alternative was to mobilize on Grand Manan Island. The major factor favoring the mainland location was the ease with which Saint John and the Saint John Airport could be reached if spare parts or unusual services were required. This practicality was of course, the major consideration against mobilizing on Grand Manan where one is completely dependent on a twice-daily ferry connection with the mainland in which accommodation for a vehicle is by no means guaranteed. In favor of Grand Manan was the proximity to the vessel owner's boat supplies, their local knowledge of supply sources, proximity to a machine shop and the necessity of ultimately establishing a base at North Head, Grand Manan, the closest port to the survey area.

The ComDev crew and equipment arrived on Grand Manan at mid-day on Tuesday, September 16. Mobilization of equipment was largely completed on Wednesday, September 17 and testing of equipment carried out on September 18. On this same day, Stewart and Williams, aboard the M/V BONNY MAID, installed transponders on South Wolf Island and at West Quoddy Light.

A malfunction in the "boomer" seismic system consumed spare components and required that Blidberg of O.R.E. go to Saint John Airport to meet a replacement part on Friday, September 19. It proved impossible to obtain passage for Mr. Blidgerg's vehicle on the Ferry M/V GRAND MANAN and Blidberg had to "hitch" a ride to Saint John and rent a car for the return trip to Black's Harbour. During this lost day, testing of the Trisponder System continued. On Saturday morning, September 20, the M/V BONNY BROOK and survey crew met Blidberg at Black's Harbour. The "boomer" malfunction was quickly repaired and the survey of Grand Manan Channel commenced.

Section 6 SURVEY EQUIPMENT - DESCRIPTION, EVALUATION AND RECOMMENDATIONS

Descriptions of the survey equipment are given below for the purpose of:

1. conveying an understanding of how the geological data of this report was acquired and
2. providing a reference for future phases of the subject cable-laying project or other marine projects contemplated by N.B.E.P.C.

The survey equipment items are considered below in terms of their physical and operating characteristics, their installation, operation and performance. Some recommendations are made for improvements in use of equipment.

Note that manufacturer's specification sheets are included as Appendix 3 . Survey equipment items considered are the following:

a. survey vessel
b. navigation system
c. side-scan sonar/3.5 kHz seismic profiler
d. "boomer" seismic reflection system
e. echo sounder
f. remote undersea camera
g. sediment grab sampler
h. support systems

6a. THE SURVEY VESSEL

The vessel employed for the survey was the M/V BONNY BROOK. This vessel was owned by Ivan Green of Ingall's Head, Grand Manan Island and built to a design by Ivan's father, Gleason Green who acted as crew-man during the survey. The vessel design is similar to the famous Cape Sable Island design of western Nova Scotia, but with some distinctive modifications (Plates 1 and 5). This same vessel was employed by N.B.E.P.C. and the ACCESS group in 1972 during a previous study of Grand Manan Channel (ACCESS, Ltd, 1972). The 1972 survey required that the M/V BONNY BROOK tow a 6 ton submersible to and from the survey area. The vessel's ability to cope with the deep-towing side-scan sonar vehicle of the 1975 survey was therefore unquestioned. The M/V BONNY BROOK performed admirably, causing no survey downtime. General specifications of M/V BONNY BROOK are:

Length Over All: 44 ft (13.4 m)

Beam: 13.5 ft (4 m)

Draft (as loaded for survey): 4.5 ft (1.4 m)

Propulsion: 118 h.p. Chrysler Nissan diesel

Accommodations: two bunks, starboard forepeak
large, propane stove/oven

Equipment: Radar: DECCA "Super 101"
Sounder: FURUNO FG 300 MK 3(recording)
Raytheon DE 726A (non-recording)
Radio Transceiver: Citizen's Band

The M/V BONNY BROOK is further equipped with a solid wooden mast and boom with lifting tackle, a hydraulically-powered lobster trap hauler and capstan combination and a custom design scallop-dragging system. The existence of the scallop-dragging apparatus was the major factor allowing the employment of the O.R.E. deep-towing side-scan sonar system in our survey. The scallop-dragging system normally consists of: (a) a low gallows frame (Plates 1 and 2) fixed to the deck amidships on the starboard side of the "house" and guyed with wire rope and turnbuckle to the stem of the vessel, (b) a hydraulic double drum winch, located in the house on the port side of the engine cover and (c) steel plates, attached to the vessel's frame beneath the floorboards, serve as an anchor for the winch (d) a steel plate attached to the vessel's gunnel serves as another anchor point for the winch (e) several scallop rakes and wire rope. Starboard side panels are removed from the house to permit the wire rope to pass from the winch through a steel block on the gallows frame and thence overboard (Plate 3). When scallop-dragging, the scallop rakes are brought to the surface with the scallop winch then lifted onboard by means of the aforementioned mast, boom and tackle. In our operations, the O.R.E. winch, weighing over 1500 lbs, replaced the scallop winch and was secured to the same anchor points (Plates 4 and 5) the hydraulically-powered capstan and mast, boom and tackle were employed to lift the side-scan "fish" aboard once it had been brought to the surface. While it is rather discomforting from the safety aspect to have a tow cable running through the vessel's "house," directly behind the helmsman and in front of the entrance to the "Cuddy," this location is dictated as the optimum towing point for scalloping. The doubly armoured electrical conducting cable of the side-scan sonar vehicle, has a strength rating many times that encountered in our operations. Assuming no effect on the steering qualities of the vessel, removal of the winch, cable and gallows frame to the open afterdeck would have required considerable extra steel fabrication and installation time, though it would have permitted installation of the navigation system in the "house" next to the helmsman - a location preferred to that in the "cuddy." This would be considered if the operation were to be repeated.

The only criticism of the vessel's operation is the extremely high noise levels of the engine and exhaust system. Apart from being unpleasant, the noise made communcation with the helmsman very difficult - a point which taxed the navigator heavily. Intercom systems were tried but proved ineffective under these circumstances. If the operation were repeated, we would strongly recommend that the survey crew members be given noise-supressing "headphones" and that the navigator and helmsman wear aviation-type headphone/microphone apparatus.

6b. SIDE-SCAN SONAR/3.5 kHz SEISMIC PROFILER

Side-scan sonar data and high-resolution seismic profiles were obtained with the deep-towing system, manufactured and operated by Ocean Research Equipment, Inc. of Falmouth, Massachusetts. This system was recommended in consideration of the extreme tidal currents which flow through Grand Manan Channel and Head Harbour Passage/Friar Roads. Towed systems deployed in these areas must be capable of operation in both the normally, high current velocities of the main channels, as well as in the extreme currents experienced in turbulent eddies caused by prominences of land and seafloor topography - Long Eddy Point on Grand Manan Island is aptly named.

The O.R.E. Model 1096 system combines two 100 kHz side-scanning transducers and an array of four 3.5 kHz downward-directed seismic profiling transducers in a heavy, streamlined fish (Plates 6 and 7). The "fish" weight can be adjusted to suit conditions by the removal or addition of lead ballast. This vehicle is towed at an optimum distance from the seafloor (minimum distance from the seafloor (30 ft, 10 m) by a doubly-armoured electrical-conducting cable. The complete 1096 system consists of the following components:

1. deep-tow vehicle containing two side-scan transducers, four 3.5-7.0 kHz transducers

and a pre-amplifier (weight approx. 350 lb, 159 kg)

2. armoured tow cable, 1000-2000 ft (305-610 m) in length partially faired with plastic ribbon

3. Electric winch, O.R.E. Model 116, powered by a 220 volt, 3 phase, 5 h.p. motor and fitted with slip rings and remote control cable to the recording console for continuous monitoring and control of "fish" depth

4. O.R.E. Model 140, 10 kw transceiver for seismic profiler

5. O.R.E. Model 170B, dual channel side-scan transceiver

6. O.R.E. Model 175A, split trace programmer

7. two Hydro Products/Gifft Model 4000 wet paper, graphic recorders (paper width, 19 inches, 50 cm)

8. spares

By means of the split trace programmer, the 19 inch (50 cm) wide paper of one graphic recorder is "split" in half and shared by the port and starboard-looking side-scan sonar outputs. The second graphic recorder is similarly "split" to accommodate the 3.5 kHz seismic sub-bottom profile on one half and the output from the higher-powered "boomer" seismic reflection system on the other. This ability to share identical recorders simplifies recorder maintenance and provides important flexibility for field recording should trouble with one recorder be experienced.

This heavy, deep-towed system has always, in our previous experience, been deployed from sea-going ships. The system's use from a 44 ft (13.4 m) wooden fishing vessel is immodestly considered a major success. Details of the system's installation on the M/V BONNY BROOK were previously given in a description of the survey vessel (see Section 6 (a)). Briefly, the 1500 lb (681 kg) winch was installed on the port side of the deckhouse, flanking the vessel's engine box. The tow cable was lead across the house to a block suspended from a low gallows frame on the starboard gunnel. The heavy "fish" was maneuvered in and out of the vessel with the aid of the vessel's hydraulic capstan, mast, boom and lifting tackle.

No problems accompanied the operation of the combined side-scan sonar/3.5 kHz seismic profiler system.

The transducers were successfully towed at the desired depths near the seafloor without appreciable deflection or interruption by strong currents. The extremely steep bottom slopes which typify Head Harbour Passage made it difficult to

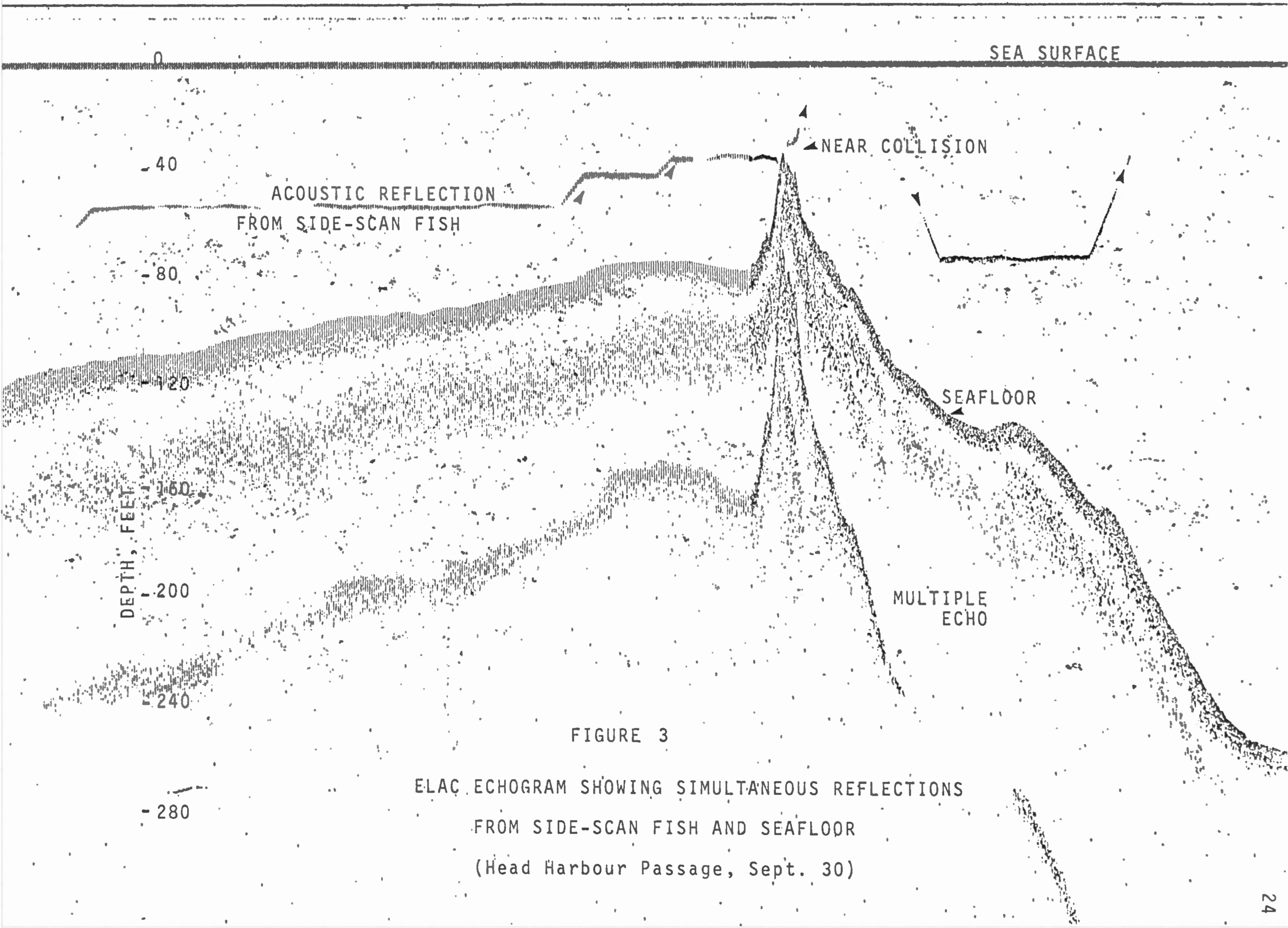


FIGURE 3

ELAC ECHOGRAM SHOWING SIMULTANEOUS REFLECTIONS
FROM SIDE-SCAN FISH AND SEAFLOOR
(Head Harbour Passage, Sept. 30)

obtain good records because frequent, major adjustments to fish depth were required in order to follow the bottom contours without causing collision and fish loss. These avoidance adjustments are dramatically illustrated in Figure 3 which illustrates an echo sounding record on which is superimposed the trace of an acoustic reflection from the side-scan fish. The adjustments in fish altitude and the record of a near-bottom collision are clearly evident.

6c. "BOOMER" SEISMIC PROFILING SYSTEM

In the spectrum of seismic reflection profiling systems, "boomer" systems occupy an intermediate position of moderately high power and sub-bottom penetration and a moderately high degree of resolution. The "boomer" system used in the subject survey consisted of the following components:

1. EG&G catamaran with suspended electro-mechanical sound transducer
2. EG&G combined power supply, capicator bank and trigger unit
3. Hydrophone array - length, 25 ft (8 m)
4. Gifft-Hydro Products recorder
5. O.R.E. recording time delay unit
6. Del Norte filter.

The "boomer" transducer suspended beneath the partially-flooded catamaran (Plates 9 and 10) emits a characteristically short-duration acoustic pulse which is relatively free of reverberations and bubble pulses that typify "sparker" sound sources. The short pulse-length yields good resolution of seafloor and sub-seafloor reflections while the 200 to 300 joule power output yields good sub-seafloor penetration.

The "boomer" catamaran, weighing 200 lbs (91 kg) was towed astern a distance of 90 ft (27 m), 108 ft (33 m) behind the navigation point, on the port side of the survey vessel, while the 25 ft (7.6 m) long hydrophone array was towed with its leading end 75 ft (23 m) astern on the starboard side, 93 ft (28 m) behind the navigation point. For details of the towing distances relative to the navigation point, see Figure 4.

The hydrophone array or streamer was towed from a point midway between a large, surface-towed float and a weighted depressor. The streamer was towed at a depth of approximately 2 ft (0.6 m) below the sea surface. This towing depth is intended to cause cancellation of acoustic reflections from the sea surface. To partially compensate for the recording time difference between a feature detected by the hull-mounted echo sounder and the same feature recorded by the hydrophone array towing 100 ft (30 m) behind the echo sounder transducer, a variable recording time delay was used. The horizontal displacement of a given feature on the seafloor as recorded on the echo sounder and "boomer" seismic profile is thus minimized

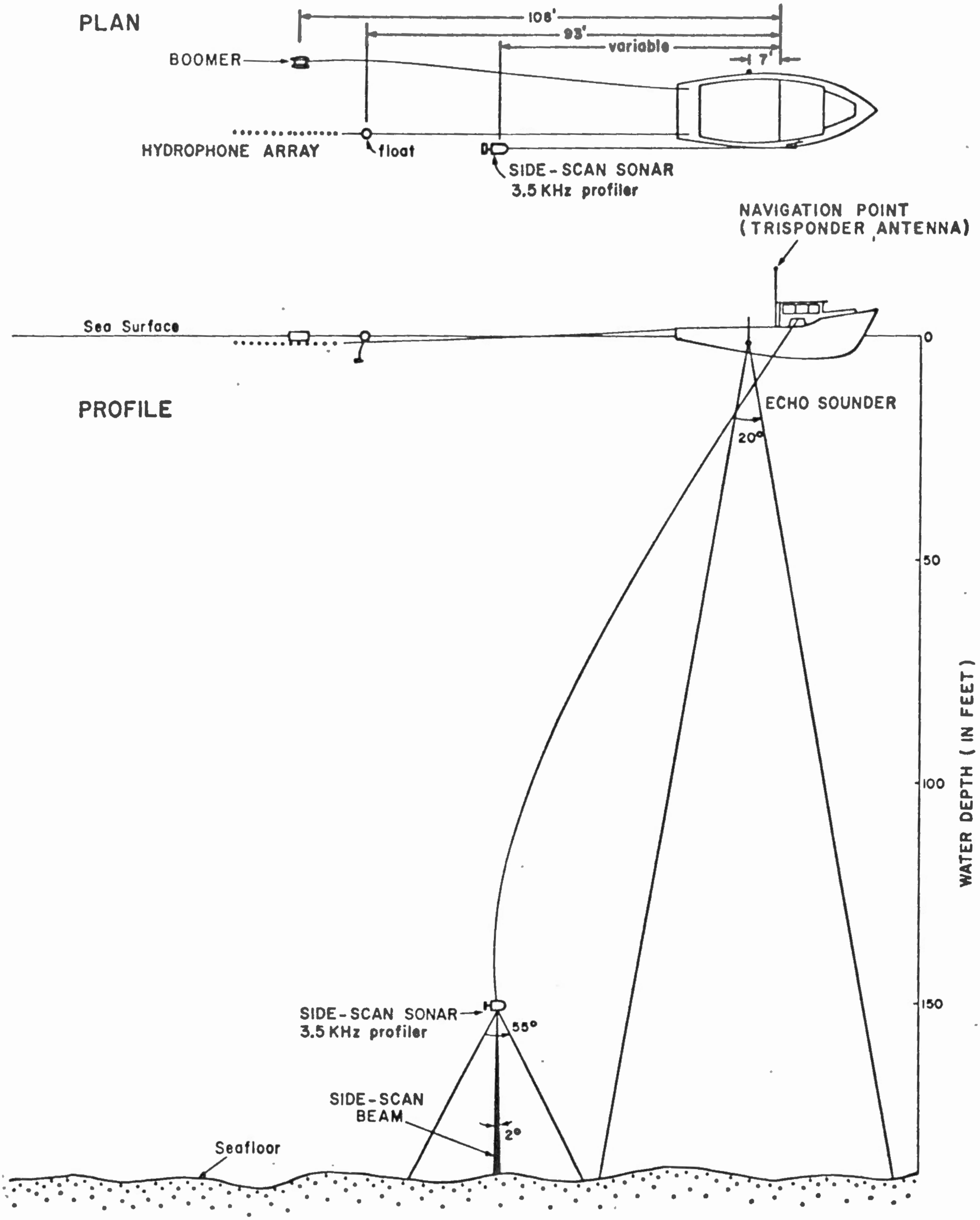


FIGURE 4. TOWING CONFIGURATION FOR SIDE-SCAN/3.5 KHz PROFILER, BOOMER SYSTEM AND ECHO SOUNDER.

though still observable. A similar recording displacement is also observable on the side-scan sonar and 3.5 kHz recordings and was similarly, partially compensated for.

The EG&G "boomer" power/trigger unit which had not been used previously proved in initial tests, to have a defective component which resulted in a series of "blown" diodes. Replacement components were received from EG&G and the system repaired September 20, the first day of surveying. Thereafter, the system operated continuously with no down time.

6d. ECHO SOUNDER

The Elac LAZ-17 survey sounder was employed in the survey. The system consists of a recording and control unit and an outboard, hull-mounted transducer. The operating frequency of the system is 50 kHz and the beam width 20°. The transducer was fixed at the bottom of an aluminum tube which was held by clamps, to a steel plate mounting unit (Plate 11). The system was mounted on the port side of the survey vessel 6.5 ft (2 m) behind the navigation point (Trisponder antenna). By loosening the clamps, the transducer could be raised for high speed travel or lowered for surveying. Transducer depth below sea surface was 1.5 ft (0.5 m). The recording/control unit was installed on a bunk in the cuddy. Power for the sounding system was supplied by two, 12 VDC automobile batteries (24 VDC total) which were on constant charge from a battery charger.

The system was very effective and operated continuously. The sounding system was calibrated twice daily by performing a "bar check." In this procedure, a flat steel bar, 5 ft (1.5 m) in length was lowered below the transducer and suspended momentarily at 10 ft (3 m) interval depths from -10 ft (-3 m) through -90 ft (-27 m). The reflection from the suspended bar was checked against the recorded depth. Reflections from sediment sampler or camera were commonly observed during their descent and ascent and the camera was often observable while "pogo sticking" across the bottom (Fig. 5). Where the camera is not observable, it appears likely that strong currents were responsible for deflecting the camera outside of the echo sounder's cone of "sonofication." Similar reflections were commonly observed echoing from the Shipek sediment grab sampler (Fig. 6).

6e. REMOTE UNDERSEA CAMERA

An Alpine Model 313F, remote deep-sea camera was employed to make direct observations of the seafloor and thus contribute to the interpretation of the side-scan sonograms. The camera system shown in Plate 12 consists of a frame in which are mounted a camera, a strobe and interconnecting electrical conductors. The camera and strobe are mounted in pressure cases. A lead weight is suspended from a magnetic

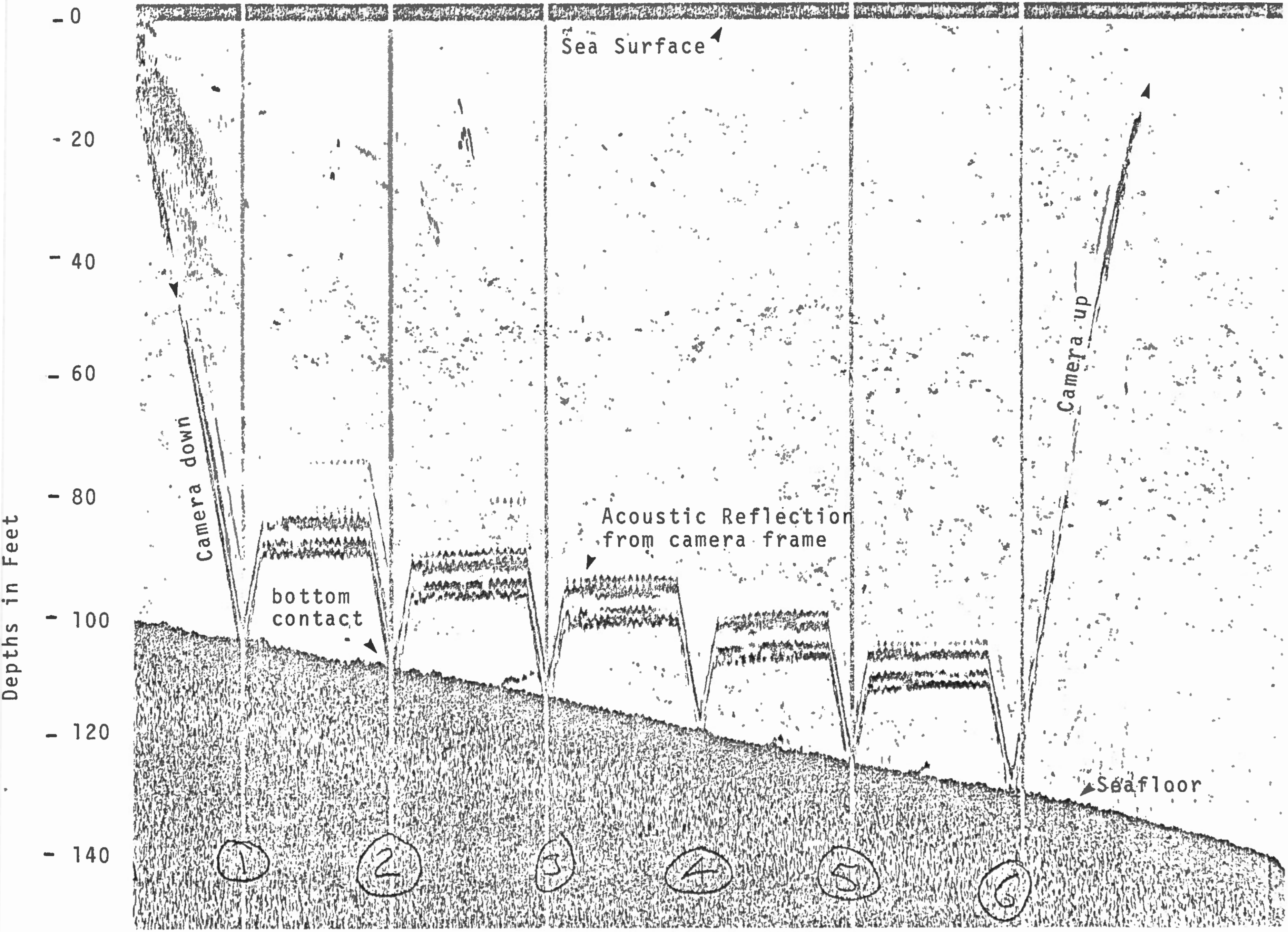


Figure 5 Echogram showing simultaneous reflections from remote, undersea camera and seafloor (Station 75/13/21, Head Harbour Passage).

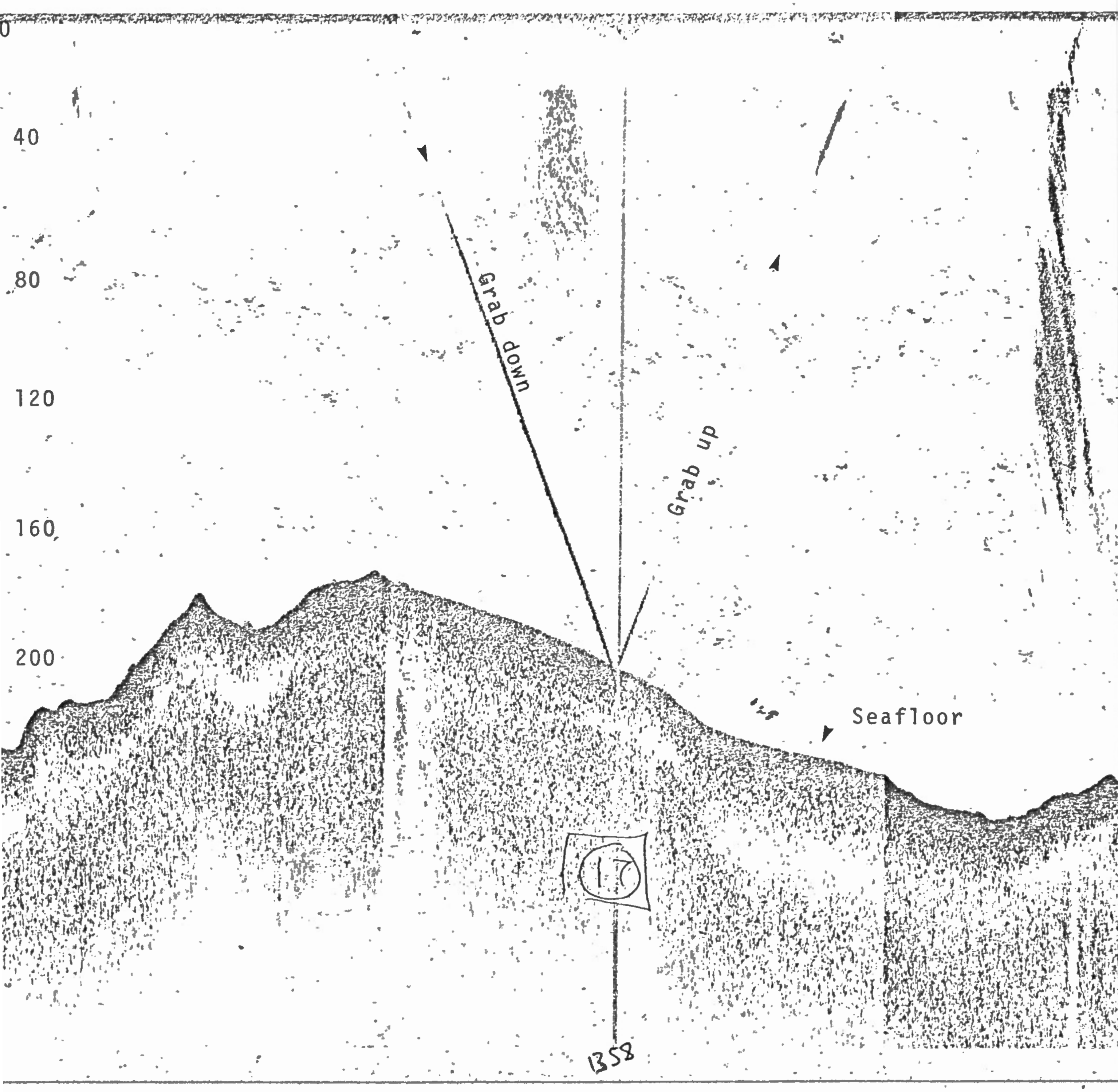


Figure 6 Echogram showing reflection from Shipek sediment grab. (Station 75/13/17, Friar Roads.) Depths in feet.

switch by a short length of wire rope below the camera frame. When the trigger weight touches the seafloor, the spring-loaded magnetic switch is activated, causing the camera shutter to open and the strobe to flash (Fig. 7). The cycle is completed when the 35 mm film is wound through a distance of one frame and the strobe capacitors are re-charged. At some camera stations, a compass was suspended in the lower left field of view to provide a reference for seafloor lineations.

During a camera station, the camera was alternately lowered to make bottom contact, then raised and suspended above the seafloor for 60 seconds to recycle; a process termed "pogo sticking." Acoustic reflections from the camera were commonly observed on echograms recorded during camera stations. This is illustrated in Figure 5.

The remote camera and sediment grab sampler were lowered to the seafloor on the end of the O.R.E. side-scan winch cable. To do this, the cable was disconnected from the side-scan fish, the electrical terminals taped back out of the way, and the cable lead through a cargo block suspended from the survey vessel's lifting boom. It had been originally planned to transfer 3/16 inch diameter wire rope to the trawl winch belonging to the M/V BONNY BROOK. The winch would have required installation on the afterdeck of the vessel as the side-scan winch occupied the normal location of the trawl winch. The use of the side-scan winch was volunteered by O.R.E.'s engineer, Dick Blidberg, to save mobilization time. The use of another winch would have saved wear on the O.R.E. cable fairing, would have eliminated the time required to rig and de-rig the side-scan cable and would have avoided a minor electrical problem experienced each time the side-scan fish was re-connected. The use of a separate winch for camera and sediment sampling apparatus is therefore recommended.

The contribution of seafloor photographs from Grand Manan Channel and Head Harbour Passage/Friar Roads, to the understanding of side-scan sonograms and to the visualization of seafloor conditions, is significant. The resolution of the photographs, however, leaves much to be desired. GAF 500 colour slide film (35 mm, A.S.A. 500) was used in Grand Manan Channel. The GAF laboratory in Toronto was requested to develop this film assuming an ASA of 1000. The results were very poor and considerable expense was required in trying to compensate for the poor results by printing selected slides on Cibachrome printing paper (Plates 19 thru 24). As we have had better previous experience in developing GAF 500 film through the same procedure we suspect that the film was not developed as for ASA 1000.

The employment of Kodak Tri X film in Head Harbour Passage and Friar Roads produced better results though the frames are somewhat over-exposed in part. We suspect that this over-exposure resulted from the prevailing, strong currents streaming the camera away from the vertical to the extent that the illuminating beam angle and thus the intensity of seafloor illumination was increased beyond normal. This partial over-exposure has not diminished the usefulness of the photographs though dramatic clarity is absent.

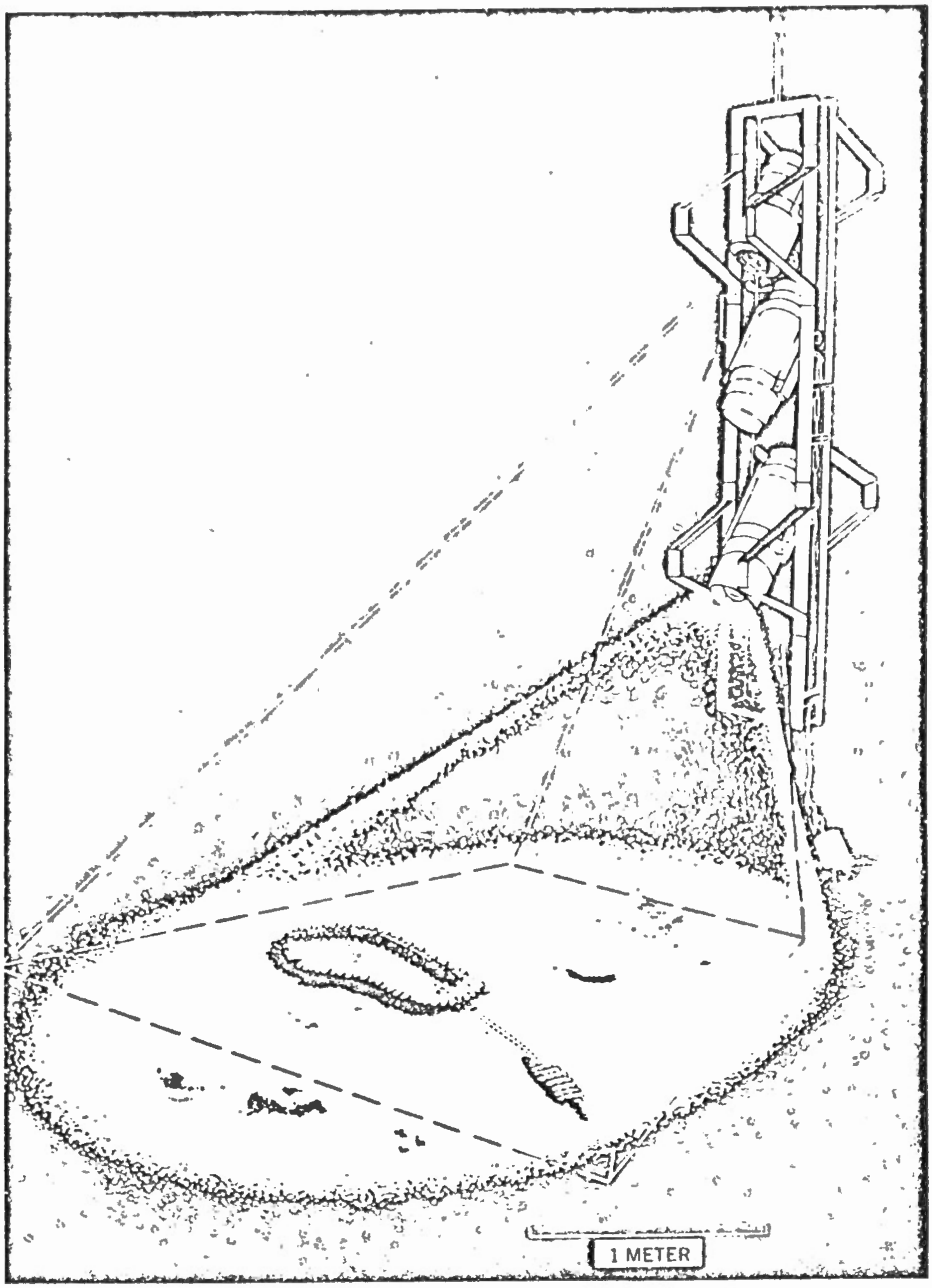
6f. SEDIMENT GRAB SAMPLER

A Shipek, Model 860 sediment grab (Plate 8 and Appendix 3) was used to obtain direct sampling evidence of seafloor conditions and thus complement the understanding and interpretation of side-scan sonograms. The use of survey vessel time for sampling was minimized by selecting desired sample locations by in-the-field examination of side-scan and seismic records. The alternate method is to sample at fixed intervals irrespective of the degree of seafloor textural variation or the location of anomalous conditions. The selective sampling program, though minimal, contributed significantly to interpretation of the survey information and would be recommended again.

6g. SUPPORT SYSTEMS

A number of equipment items supported the primary survey systems. The support equipment included the following:

1. A Kohler generator, Model 10CM081 (Plate 5) - supplied power for the side-scan winch (5 hp) and "boomer" seismic system



Deep-sea camera. Most of the photographs reproduced in this book were taken with cameras of this design. The upper pressure case contains a shutterless camera, the lower pressure case contains an electronic flash unit. The trigger weight is attached by a thin flexible wire to a switch located on the side of the camera frame. When the weight is released, the switch closes, triggering the electronic flash. This camera may be used with or without a sonic pinger. In this drawing, a pinger unit, allowing constant position control, is shown between the camera and light source. This camera and light source together, provided with sufficient power to take thirty photographs at a repetition rate of thirty seconds, weigh 150 pounds in water.[8]

Figure 7 Illustration of undersea camera operation.

- 35 amp
- 220 volt, three-phase AC
- 110 volt, single-phase AC
- powered by a Lister diesel engine: 3 cylinder, 18 hp, electric start
- weight: approximately 1500 lbs (681 kg)

2. A Honda generator - supplied power to O.R.E. recorders and ComDev Marine Autoplot system
   - 110 volt, 60 Hz
3. A Mite-Lite generator - standby
   - 110 volt, 60 Hz
4. A Telan Thermoelectric generator (Appendix 3) was used provide continuous power to two 12 VDC batteries (24 VDC total) in turn powering the remote transponder on South Wolf Island (Plate 13). The generator burns propane to produce electrical energy. Six 20 lb (9 kg) propane bottles were assembled with a gas manifold to supply the generator.
5. O.R.E., Inc. Model 116 electric winch (Plates 4 and 5) controlled the O.R.E. deep-towed side-scan sonar vehicle.
   - 5 hp electric motor (requiring 220 volt, three-phase power)
   - 2000 feet (610 m) of doubly-armoured electrical conducting cable with lower 400 feet (122 m) ribbon-faired.
   - slip rings allow electrical conduction during drum rotation

- remote up/down control for continuous monitoring and adjustment of "fish" depth from the recording console.
- Weight: approximately 1500 lbs. (681 kg).

6h. NAVIGATION SYSTEM

The following description of the navigation system consists largely of relevant excerpts from an operational review of the navigation system and horizontal control submitted by ComDev Marine Ltd and written by Mr. E. Lancaster-Williams (ComDev Marine, 1976).

The navigation system employed was the Trisponder/ Autoplot system, manufactured in Texas by Del Norte, Inc. and sold in Canada by ComDev Marine Ltd. Listed below are the system components as used in the 1975 survey:

1. The Trisponder, Model 202A
   - a Distance Measuring Unit (DMU)
   - one omnidirectional antenna (aboard the survey vessel)
   - three, 180^{o} (horizontal beam angle) remote transponders
   - eight, 12 VDC automobile batteries (two per antenna)

2. The Autoplot System

- Autoplot processor: interfacing unit between the D.M.U. and H.P. calculator
- Hewlett Packard 9820 programmable calculator with printer
- Hewlett Packard x-y plotter, Model 9862A

Following are brief explanations of the Trisponder and Autoplot operating principles, extracted from the ComDev Marine Ltd operations report (ComDev Marine Ltd, 1976).

"The Trisponder 202A is an automatic distance measuring system providing ranges of the survey vessel from two fixed locations [transponders] on shore. The Auto Plot System converts these ranges to grid coordinates and displays the position of the vessel on an X-Y plotter on which the required survey lines have been preplotted. The survey launch is steered in such a manner as to maintain the plotter pen on the preplotted track."

"The Auto Plot System reads the 1 second updated Trisponder ranges and converts these ranges into a grid position based on the coordinates of the two remote stations. With the rapid update of ranges, an instantaneous position of the survey" "vessel is obtained, and the direction of progress is readily seen. This system is ideal for use where a straight survey line is required, rather than a track that follows a range arc on one of the remote stations."

"The Auto Plot System analyses the present position of the survey vessel against the last recorded fix and when the distance since the previous fix, or the time elapsed since the previous fix meets the predicted parameters, a new fix is initiated. A fix mark is generated to mark the echogram and any other peripheral recorders connected to the system."

"Theoretical Factors Affecting Trisponder Range

A. Atmospheric Conditions Affecting the Radar Horizon

Radar waves are bent from a straight line in passing through the atmosphere (see Fig. 8A). The amount of bending depends on the difference in density and amount of water vapor at various levels of the atmosphere."

"The distance to the radar horizon is approximately 6% greater than to the optical horizon under 'standard' conditions. This phenomena occurs since radio waves undergo a greater downward bending than light waves."

"In air whose surface dewpoint is higher than, or equal to, the sea-surface temperature, evaporation takes place from the sea into the air above it. Unless the air is very unstable," "this evaporation produces a shallow layer of air, some tens of feet high, immediately above the sea surface, within which water vapor content decreases rapidly with height. This occurrence results in the partial trapping of near-horizontal rays from the radar, and has the effect of increasing radar ranges compared with 'standard' conditions. The conditions described above are more typical then 'standard' and occur widely over oceans."

"Accentuated downward bending occurs when temperature decreases with height less rapidly, and/or when water vapor content decreases with height more rapidly than in the 'standard' atmosphere. Either of these conditions (known as 'temperature lapse' and 'humidity lapse' respectively) will result in extended radar detection ranges. (See Fig. 8B). If both occur simultaneously, the effect is even more pronounced. This effect is known as 'super-refraction'."

"If the bending downward is very large throughout a certain layer above the earth's surface, radar rays leaving the antenna nearly horizontal in this layer may be wholly or partially trapped within the layer. They will be guided around the earth's surface as far as the layer exists, to distances in excess of the 'standard' range. The region within which the rays are trapped is known as a 'radio duct.' Fig. 8C shows how a radio duct can extend considerably the coverage of a"

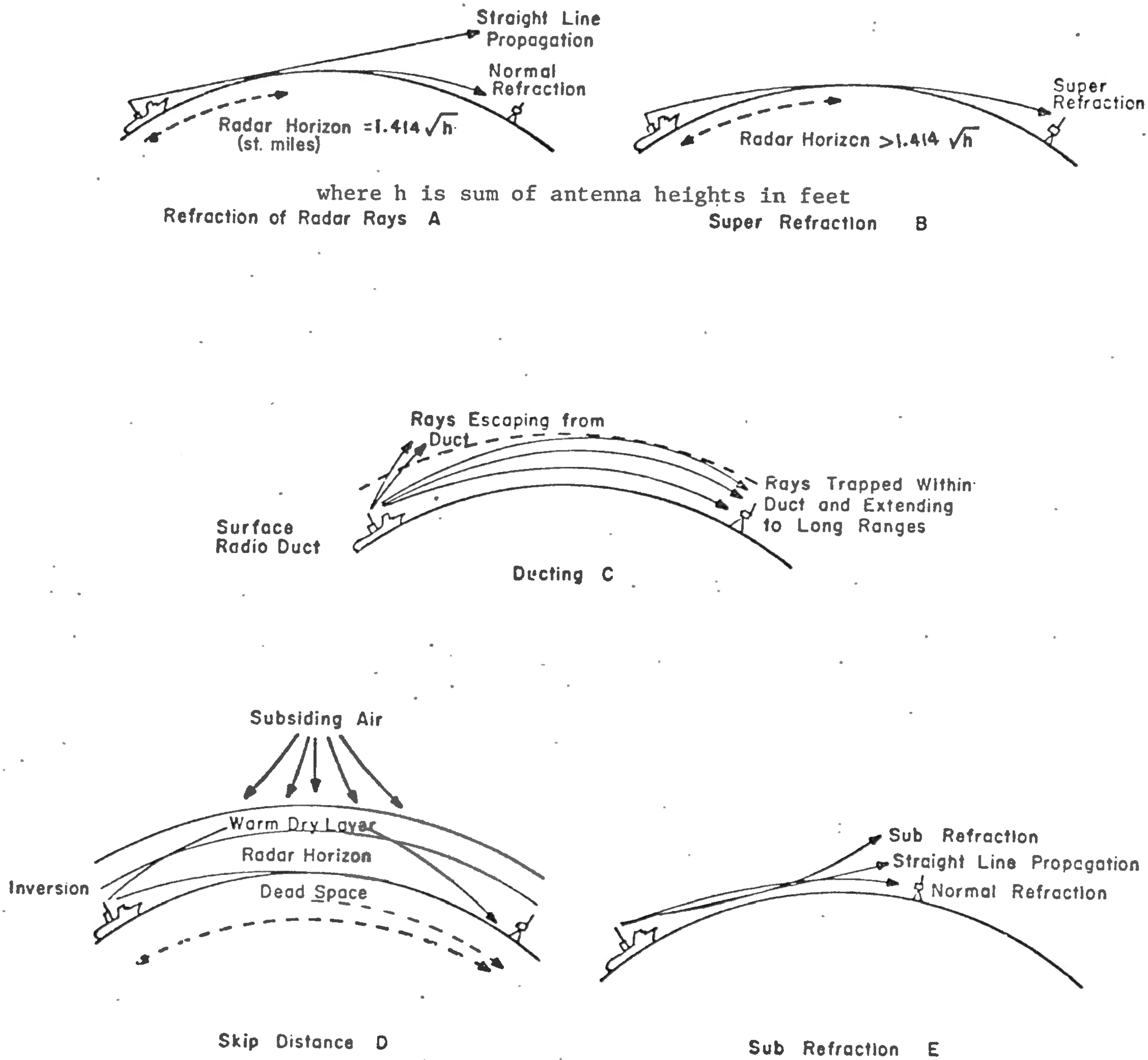


FIGURE 8 CONDITIONS AFFECTING TRISPONDER RANGES

"radar whose antenna is situated within it."

"When warm and dry air from a land mass flows over a colder sea, a temperature inversion becomes established and there is also much evaporation into the lower layers of the air. Radio ducts are formed almost as soon as the air moves over the sea, and marked super-refraction may be the rule rather than the exception. Small intense ducts extending from 50 to 100 ft above the sea surface may result in considerable super-refraction. These occur most frequently in sub-tropical latitudes, but also are experienced quite often in temperate latitudes, particularly in summer."

"Another weather phonomenon which tends to increase radar range is 'subsidence.' This is a gradual sinking downward and spreading outward of air at high levels, which is most frequently found in regions of high barometric pressure such as anti-cyclones or ridges. The subsiding air becomes warmer and drier than the air below, and a temperature inversion is established as well as a large humidity lapse. This combination is very favourable to duct formation, and the nearly horizontal rays entering the inversion layer may be bent downward to such an extent that they are returned to the surface at very long ranges (Fig. 8C). The distance from the radar antenna to the nearest point at which an indirect ray returns to the surface is known as the 'skip distance' and" "the phonomenon is known as 'skip effect.' If super-refraction associated with a radio duct is absent, there will be a blind zone between the zone of reception of the direct rays and that of the indirect rays. This is shown in Fig. 8D and explains why ranges are sometimes detected at great distances, then disappear to be re-detected at normal distances."

"Detection ranges are reduced when meteorological conditions are such that:

a. evaporation does not take place. When the surface dewpoint of the air is higher than the sea surface temperature, sea fog generally will occur.

b. The fall in temperature with height is very rapid. This is conducive to good visibility, but may reduce detection ranges."

"The effect of these conditions on radar rays which are nearly horizontal is to cause straight-line propagation or to bend the rays upward (see Fig. 8E) giving reduced detection ranges of targets on or near the surface. This phenomenon is known as 'sub-refraction'."

B. <u>Detection Range</u>

"To obtain a given trisponder range, assuming the necessary power and receiver sensitivity is present, the heights of the Master Transponder and the Remote Transponder" "must be taken into account. The heights of the antennas may be any feasible ratio, but should obstructions exist between the Master and Remote, either the heights of the antennas must be raised or another remote station used."

"Another factor affecting detection range is the Fresnel Zone clearance. In essence, this clearance is that necessary above the grazing surface of a flat land or ocean above an obstruction such as hills or mountain peaks. A third factor affecting detection range is ground reflections. These reflections can cause a very important effect on the received wave. In the simplest case, the reflection causes attenuation and phase shift along the indirect path. When the wave from the direct path and indirect path converge at the receiving antennas, these two waves combine. If the combination of phase shift at the reflecting point and indirect path geometry cause a 180^o reversal of the reflected signal with respect to the direct path - a null will be experienced. The distance of a null from the remote station can be changed by altering the height of either antenna, but in these cases, it is often simpler to have an alternative station to provide coverage in these areas."

"All radio navigation systems using radar frequencies are affected by the above factors, but the advantages of high accuracy and reliability far outweigh the disadvantages."

"Operational Factors Affecting the Trisponder System

During the survey operations, several problems came to light that were peculiar to this project. The boomer and deep-tow side-scan sonar were connected to a separate power supply to the navigation equipment, but throughout the project, enough noise was picked up from the boomer to cause the navigation system to be disrupted. Various remedies were attempted which temporarily helped but did not eliminate the noise problem." [The source of this disruption was apparently in the cables connecting the Distance Measuring Unit to the Autoplot Processor. With the cable disconnected, the Trisponder functioned properly (William Latter, ComDev Marine Ltd, personal communication).]

"The Trisponder antenna on the survey vessel was mounted on a separate mast and located above the interference zone of the radar antenna and as far out on the boat's beam as possible to minimize the arc that was blocked by the vessel's mast. Owing to the height of this mast, it was impractical to mount the antenna unit on the top of the mast. In any case, the rolling motion of the boat would adversely affect the ranges at that height. During the survey operations, the blocking of the Trisponder antenna by the mast did restrict the reception of one of the remote stations from time to time. In foggy weather, the radar was required for safety reasons, and when close inshore [e.g., in Head Harbour Passage] ," "the Trisponder signals tended to be swamped by the radar signals reflected off the cliffs, reducing the effective navigation coverage under these conditions."

"The Trisponder antenna on the survey launch proved to be defective under the conditions of excessive atmospheric moisture. Condensation inside the antenna built up to the point where the propagation of signal was blocked. A spare antenna was dispatched from Ottawa, but after drying out and field repairs, the new unit was not required."

"During the survey operations, the boomer caused an intermittent build up of feed back noise which created havoc with the trisponder ranging and initiated spurious fix marks on all the records. At such times, the navigation system was isolated from the rest of the equipment and the geophysical records were marked by hand. With the extra amount of work this created, this was a retrograde solution, but no operational time could be spared to find a better solution for this problem."

"Conclusions

On past projects this navigation system has worked well with various geophysical equipment. However, during this project, the cramped conditions on the launch undoubtedly contributed to a high degree to the problems we experienced" "in the field. It was impossible to isolate systems from one another to prevent signal crossover in the cables and the close proximity of the boomer was a constant source of electrical noise."

"This project has made it clear that on future projects of this multidisciplinary nature, the selection of the vessel and layout of equipment must be given a great deal more thought in the planning stage to both screening and isolation of electrical systems."

Additional Comments

Several constructive comments may be added to the foregoing discussion of Trisponder/Autoplot operational problems by Williams. These follow.

It has been the experience of the author in previous surveys that the ComDev Trisponder has not been affected by electrical interference from "sparker" seismic reflection systems with greater power output than the "boomer" employed in the present survey. In the instances cited, vessels of similar or smaller size were used and no unusual electrical shielding or grounding systems were found necessary.

Geomarine Associates Ltd has not previously employed the Autoplot System. ComDev Marine Ltd used both the Autoplot System and an identical EG&G "boomer" seismic system in the 1974 survey of proposed cable routes across the Northumberland Strait, apparently without encountering similar problems.

That survey, however, was conducted from the 60 ft (18 m) long steel vessel, M/V SUPPLY VENTURE. Presumably such a vessel would provide greater isolation for the sensitive navigational system components subject to electrical fields emanating from the seismic source. It may be deduced that the sensitive element of the navigation system was the Autoplot System and not the Trisponder. Two solutions may be suggested for consideration in planning future surveys of this type:

1. employ a larger steel vessel or,
2. design simple methods of isolating "boomer" seismic system electrical fields and/or by "insulating" the Trisponder/Autoplot System from electrical interference.

In fact, only the second alternative makes sense in the present instance for reasons of economy and since the subject survey and following survey for N.B.E.P.C. at Point Lepreau required work in very shallow water. Appreciating the sensitivity of the navigation instruments to electrical interference, it should be possible to use improved shielding or interconnecting cables, improved grounding systems and possibly a grounded shielding cover on the seismic power/trigger unit. We have recently been informed by Mr. William Latter of ComDev that during a similar survey in the Magdalen Islands, conducted by Geomarine Associates Ltd, which followed the two N.B.E.P.C. survey, the problem of electrical interference was largely eliminated by inserting diodes in the transfer signal lines going to the D.M.U. from the Autoplot Processor.

Unpredicted loss of signal (possibly due to the skip effect) and weakening of signals under non-ideal weather conditions occurred on occasion at the western end of Grand Manan Channel.

The unusual weakening of signals at ranges well within the capable range (50 km) of this Trisponder System is now attributed to the fact that the base unit, on the survey vessel, suffered from lowered sensitivity; (William Latter, ComDev, personal communication). This diminished sensitivity was discovered in shop tests following the field season and is tentatively attributed to damage caused by high powered radar transmission from a source on the same elevation and only a short distance away. Protective diodes in the radar frequency receiver may, in this way, suffer damage and cause a diminishment in Trisponder sensitivity. The diminished sensitivity in combination with the deleterious effects of fog and precipitation on range is therefore tendered as the explanation of signal weakening and loss under those conditions. The future deployment of a spare base unit would insure against such possibilities.

To eliminate problems of anomalous signal loss due to the "skip effect" or refraction, we suggest that the deployment of additional transponders would provide alternate locations from which to range. The additional cost of leasing and installing these transponders would most certainly be offset by savings in operational time for the other survey equipment and crew. If we project this discussion to consideration of future cable-laying problems, we would again recommend the Trisponder/Autoplot System or similar radar transponder system for positioning but would suggest that two additional transponders be employed - possibly at a second point on Grand Manan Island, southwest of Long Eddy Point and at Nancy Head or Owen Head on Campobello Island.The deployment of extra transponders for alternative ranging in Head Harbour Passage with its steep, treed coastline and numerous obstructing islands, is strongly recommended should this cable route be chosen.

Friar Roads would pose no surveying problem although some transponder sites, more appropriately sited relative to the crossing, would provide more complete coverage.

Section 7 DATA REDUCTION AND INTERPRETATION METHODS

The process of data reduction and interpretation in surveys such as presently under consideration is, to a very important degree, a process of integrating complimentary information from several sources. Thus, the successful mapping of bedrock exposures on the seafloor, for instance, often depends on the skilfull integration of information from echo sounding profiles, from seismic reflection profiles, from side-scan sonograms and from the information of seafloor samples and photographs, etc. These processes depend on the extraction and manipulation of numerical data from records (e.g., soundings) and on the still somewhat artful interpretation of other records which, in the present state of the art, yield no numerical data e.g., the acoustic patterns of side-scan sonograms and seismic, sub-seafloor reflection correlations.

7a SURVEY TRACK PLOTS

Fix positions consisting of ranges between survey vessel and onshore transponders, were converted to Universal Transverse Mercator (U.T.M.) coordinates, using the corrected remote transponder locations. These corrected locations resulted from the horizontal control re-survey described in Appendix 2 which followed the geophysical survey. The conversion of positional data and plotting of a track chart at scale 1:12,000 (1 inch = 1000 ft) was completed by ComDev Marine Ltd.

7b HYDROGRAPHY

Echo sounding profiles or echograms were digitized (that is, depths scaled off) at positions corresponding to each fix and at positions midway between fixes. In addition, soundings were digitized at points corresponding to changes in bottom slope, e.g. high points and low points, where these occur between the regular digitizing interval. Note that during the survey, the echo sounder was calibrated by means of a "bar check" at the beginning and end of each day and the depth of the transducer below sea-surface, automatically compensated for. The method of bar checking was described in Section 6 (d).

The digitized or numerical sounding data was next reduced to the Canadian Geodetic datum elevation at Saint John, New Brunswick, using Canadian Hydrographic Service Secondary Port tidal height predictions for North Head, Grand Manan Island and Wilson's Beach on Campobello Island. These tidal height predictions are published in the Canadian Hydrographic Service Tide and Current Tables, 1975.

The reduced soundings were posted on the survey base map (scale 1:12,000) and contoured with contour interval 10 ft.

The reduced soundings corresponding to transverse-channel survey lines were finally plotted as seafloor depth-profiles at a vertical scale of 1:240 (1 inch = 20 ft) and horizontal scale, the same as the mapping scale, 1:12,000 (1 inch = 1000 ft). This vertical scale results in an exaggeration in the vertical sense by a factor of 50 times (50x). These scales were dictated by (1) practical limits to map size, (2) by a desire to plot both Grand Manan Channel and Head Harbour Passage/Friar Roads profiles at a comparable scale (3) by the requirement that seismic data be added beneath the seafloor profile and (4) by the normal constraints under which the chosen horizontal scale must relate to data density (that is, if we increase the horizontal scale to 1:6000, we must also increase the data density by a factor of 2 to give an accurate presentation).

The hydrographic aspects of post-survey data analysis was completed largely by ComDev Marine while John Stewart of Geomarine Associates contoured the posted soundings to produce maps of bathymetry for the proposed routes.

Please note that Diazo prints of original track plots or sounding maps (paper or plastic film) inherently exhibit a distortion, relative to the original, as a result of the printing method.

7c SEISMIC REFLECTION PROFILES

The seismic reflection profiles consist of deep-towed 3.5 kHz system profiles and surface-towed "boomer" profiles. Sub-seafloor reflections in the seismic profiles were correlated along each line and from line to line. Depth of the deepest observable reflector below the seafloor, tentatively correlated as the bedrock surface, was measured, plotted and contoured. This map (Enclosure 4) constitutes an illustration of the thickness of unconsolidated sediment. The relatively high frequency, 3.5 kHz profiles, provide very valuable qualitative indications of the acoustic penetrability of the seafloor sediments - from impenetrable bedrock exposures to acoustically transparent mud. The 3.5 kHz profiles also allow a higher degree of resolution of sediment thickness where sediment cover is thin and unresolvable by the more powerful boomer system. Notice that the "datum" from which 3.5 kHz profiles are measured is the depth of the deep-tow vehicle. Thus, when the towing depth is altered, the profile is affected during the raising or lowering period. This sometimes confusing aspect of deep-tow profiles is shown in Figure 34. The "datum" of the boomer profiles is the sea surface and does not change appreciably. In the absence of definitive data on the velocity of sound in the sediments being surveyed, a velocity of 1500 m/sec (the velocity of sound in water) was employed.

7d SIDE-SCAN SONOGRAMS

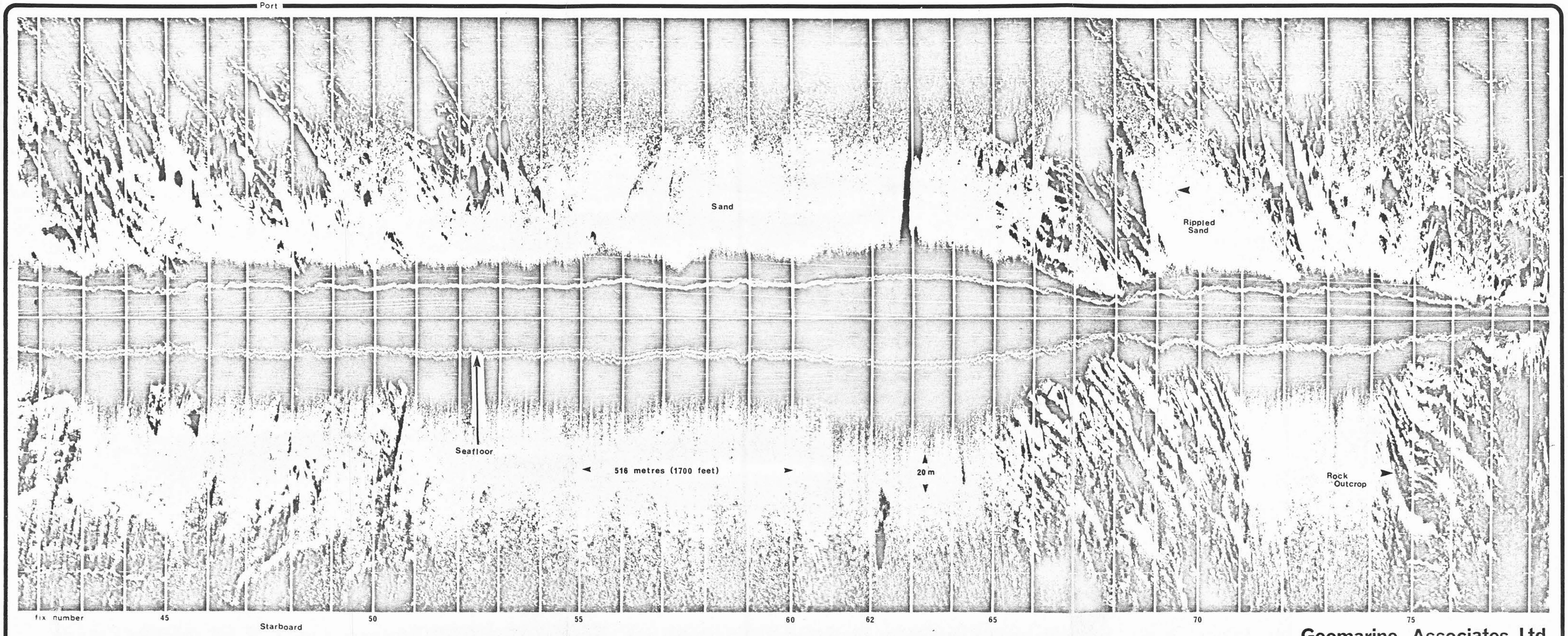
The deep-towed side-scan sonar system yields a detailed, graphically visual "plan view" of the seafloor up to 500 ft (150 m) on each side of the towed vehicle (total width swept - 1000 ft (300 m)). The patterns of acoustic reflections and shadows, as with the natural illumination of aerial photography, permit the identification and mapping of bedrock outcroppings and other seafloor features. Variations in the acoustic reflectivity of surficial sediments permits an interpretation of sediment grain-size variations. As well, morphological features such as sand waves, bedrock stratification and jointing are commonly evident. The transfer of information from side-scan sonograms to a map illustrating surficial geology is usually a difficult task because of the highly detailed image of geomorphologic boundaries and seafloor textures commonly observed. The only way to convey such detail is through photographic processes involving anisotropic scale changing and continuous-strip photographic reproduction of side-scan sonograms, to construct a "photo-acoustic" mosaic. Instead, the most elemental method of translating side-scan sonogram data to a map was employed to yield a simplified representation of seafloor surficial geology in the survey area. This method consisted of translating geomorphological boundaries as observed on the sonograms to a copy of the track chart by determining the approximate point of intersection of a given boundary and the survey vessel track. Geomorphological boundaries, as observed between side-scan lines, were drawn through visual approximation of their course and shape as observed from two or more lines.

Note that the O.R.E. side-scan system employs a conventional survey recorder. A Split Trace Programmer facilitates recording of port and starboard-side reflections on this single recorder. However, this process requires that the sonograms of port and starboard side be oriented similarly rather than in the opposite sense required for correct visual effect. Thus, one must mentally turn the port side (left hand) record through 180^{o} so that a mirror image of the seafloor reflection occurs symmetrically arranged about a centre line representing Time Zero (T_0) for an outgoing pulse from the towed vehicle. A side-scan sonogram with the orientation of port and starboard records rectified is included as Figure 9 . This figure also illustrates the typical elements of a side-scan sonogram and an interpretation of commonly occurring features.

7e SEAFLOOR SAMPLES AND PHOTOGRAPHS

The location of seafloor sediment samples is plotted on the maps of surficial geology. These samples were washed and visually examined. A brief description of each sample is included as Table 1 (Grand Manan Channel) and Table 3 (Head Harbour Passage) and Table 4 (Friar Roads).

Remote seafloor photography stations consist of a series of bottom-contacts (corresponding to photographs) at which the position of the survey vessel was recorded. This series of positions, constituting a single photography station, is also plotted on the maps of surficial geology. A description of the results of each camera station accompanies sample descriptions in Tables 1, 3 and 4. Representative photographs from each station are included later in this report.



Side Scan Sonar Record Line I Outer Harbour – Halifax

Geomarine Associates Ltd.
P.O. Box 41 (5112 Prince Street)
Halifax, Nova Scotia, Canada

Section 8 THE GRAND MANAN CHANNEL CABLE ROUTE

Grand Manan Channel, at the mouth of the Bay of Fundy, is bounded by Grand Manan Island, New Brunswick on the southeast and by Campobello Island, New Brunswick and Washington County, Maine, on the northwest and west. The route of the proposed power cable extends from the vicinity of Ragged Point on Campobello Island to Long Eddy Point on Grand Manan Island (Fig. 2), a distance of 6.2 nautical miles (7.1 statute miles or 11.5 km).

8a PHYSICAL SETTING

The western coast of Grand Manan Island is strikingly marked by 200-350 foot (62-109 m) high cliffs of basalt (Fig. 10 These basalts (extrusive volcanic rocks) are Triassic in age (Fig. 11) and part of a sequence of volcanic and sedimentary rocks which underlie most of the Bay of Fundy. This western coast of Grand Manan Island is interpreted as fault-bounded by King and McLean, in their 1975 map 812H, describing the bedrock geology of the Scotian Shelf and adjacent areas, a portion of which is included here as Figure 12. The Triassic sedimentary rocks of the Bay of Fundy are interpreted by King and McLean to extend through Grand Manan Channel to the Murr Basin, southwest of Grand Manan Island. As will be described below, seismic information from the present survey

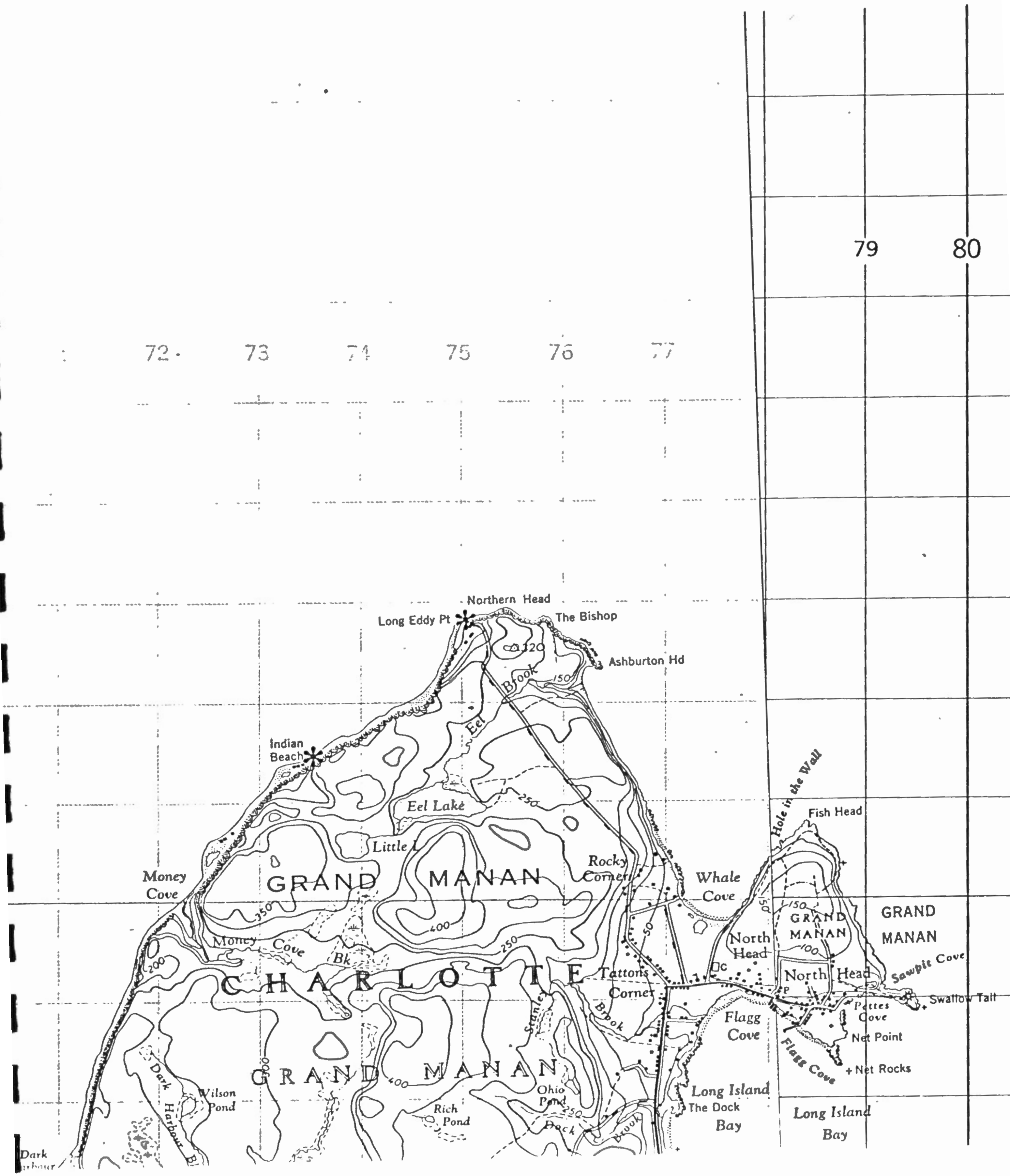


Figure 10 Topography of northeastern Grand Manan Island (contour interval, 50 ft, scale 1:50,000) Topographic map 21 B/10.

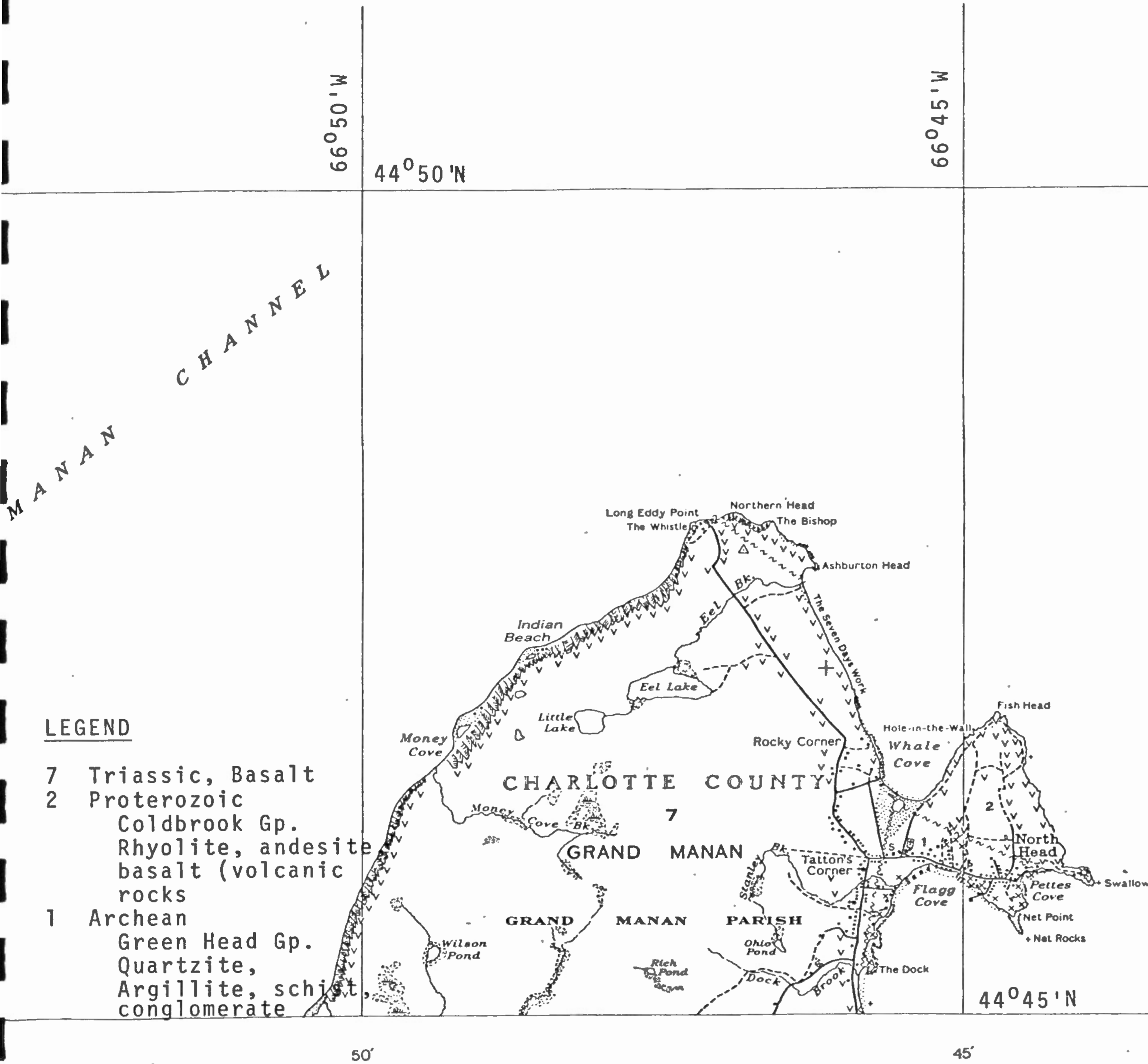


Figure 11 Geology of Grand Manan Island. Scale 1 inch = 1 mile (1:63,360), portion of GSC Map 964A.

Figure 12 Regional marine geology, scale 1:1,000,000, portion of Map 812H.

Legend: TRs = Triassic sedimentary strata

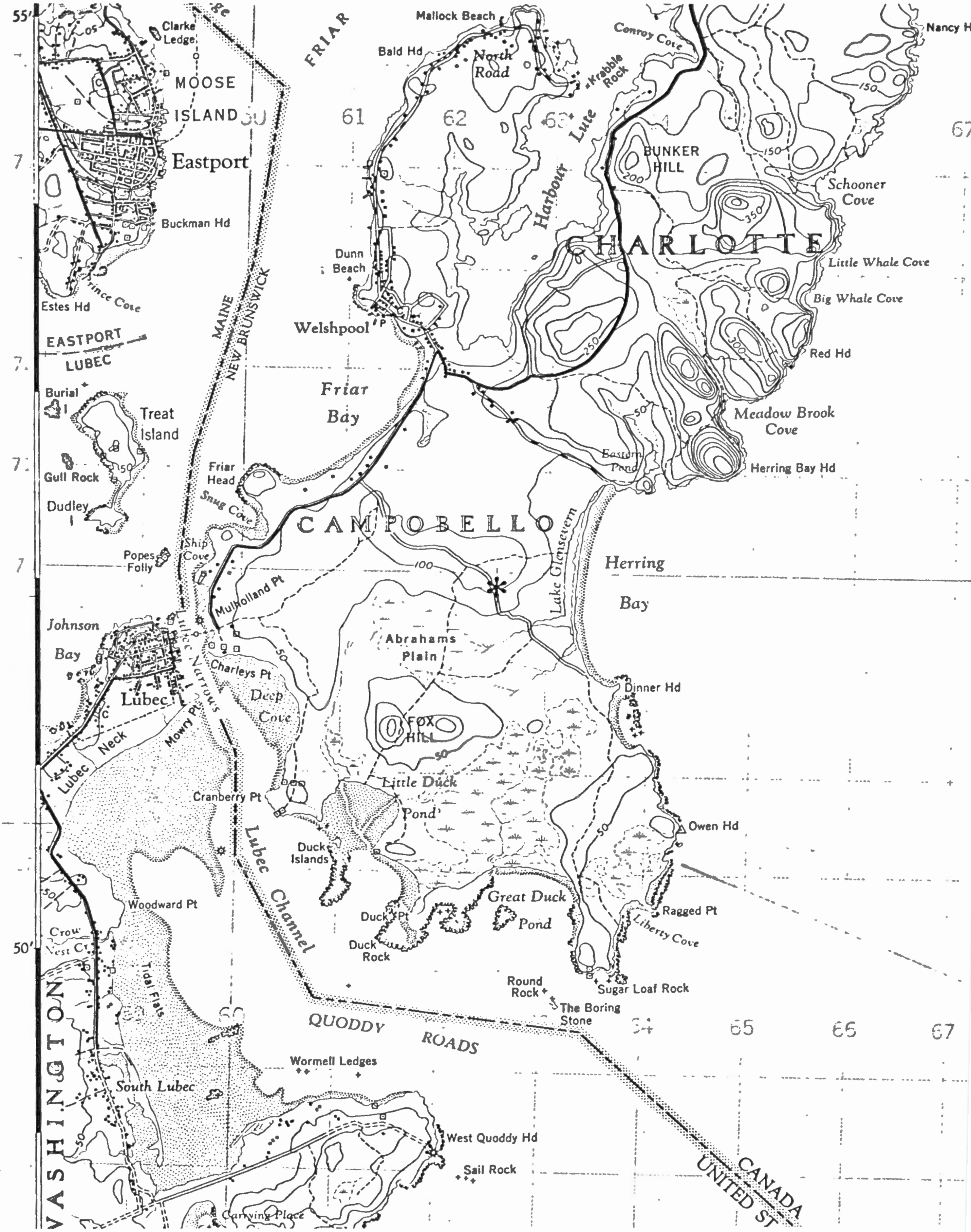
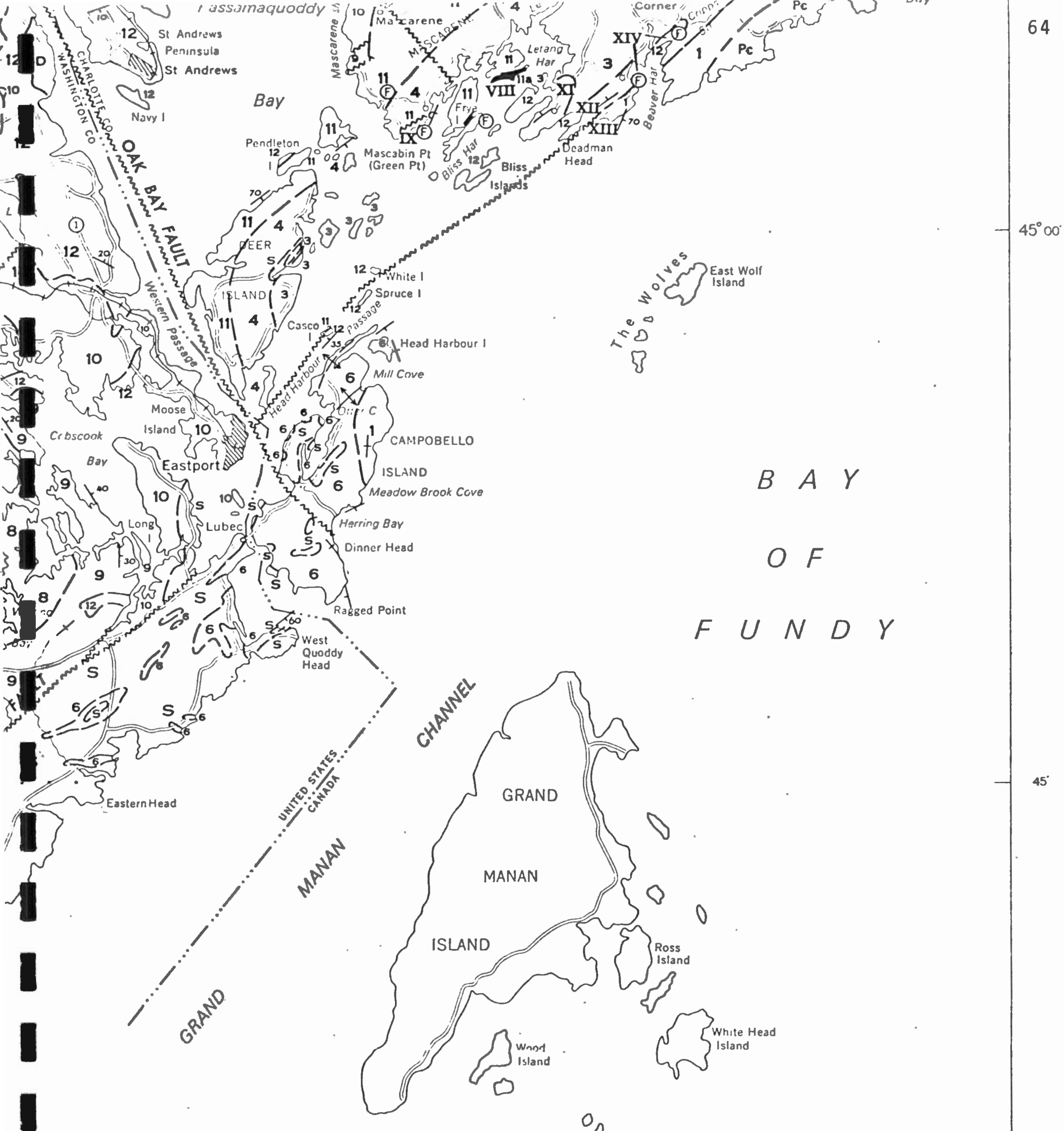


Figure 13 Topography of southwestern Campobello Island (contour interval, 50 ft), scale 1:50,000. Topographic map 21 B/15W.



LEGEND

12	Upper Devonian - Perry Fm.
11	Pembroke/Quoddy Fm Undifferentiated
6	Silurian - Quoddy Fm
5	Silurian - Unfidderentiated
4	Pre-Silurian or Silurian - Formation B
3	Pre-Silurian or Silurian - Formation A

FIGURE 14

GEOLOGY, PASSAMAQUODDY BAY AREA
(Cumming, 1967)

also suggests the presence of Triassic sedimentary rocks beneath surficial, unconsolidated sediments of Grand Manan Channel.

Campobello Island, in the vicinity of Ragged Point is typified by relatively low elevations, the maximum height of land being approximately 50 ft (15 m) (Fig. 13). The bedrock in this area consists of Silurian (Palaeozoic) rocks assigned to the Quoddy Formation (Cumming, 1967). The Quoddy Formation consists of slates, shales and cherty argillites and volcanic rocks; rhyolites, andesites, basalts, volcanic tuffs and breccias (Fig. 14).

8b BATHYMETRY

The regional bathymetry of the Grand Manan area is illustrated in Figure 15. A description of the bathymetry of Grand Manan Channel coinciding with the proposed cable route follows. Note that depths referred to are relative to Geodetic datum. Refer to Figures 16 and 22 and (Enclosure 2); maps of contoured bathymetry.

At the Grand Manan Island end of the cable route, off Long Eddy Point, the seafloor plunges spectacularly from the beach to a depth of 200 feet (61 m). Slightly south of Long Eddy Point, this steep foreshore plunge is inferred to ameliorate considerably at about 140 feet (43 m). The steep foreshore slopes are considered a submarine continuation of the precipitous basalt cliffs of Grand Manan Island. From the base of this steep section, the seafloor slopes more gently down to a depth of approximately 310 ft (95 m). As will be described below, a deposit of well-sorted coarse sand and fine gravel occupies this area and appears to smooth seafloor topography. From approximately the 310 ft (95 m) contour, the seafloor undulates with little relief down to the axis of a trough approximately one-third of the way across the Channel. The trend of the trough axis is approximately NE-SW; parallel to the trend of Grand Manan Channel. The depths in the axis of the trough average between 350 and 370 ft (107 and 113 m). The maximum depth attained is 375 ft (114 m). Westward from this trough, the Channel floor undulates gently with average depth approximately 330 ft (101 m) and the maximum relief 20 ft (6 m). A second trough, approximately two-thirds of the way across the Channel, is bounded by the 340 ft (104 m) contours. The maximum depth attained is 364 ft (111 m). Again, the axial trend of this trough parallels the Grand Manan Channel axis. From the centre of this trough, the seafloor slopes upward in a very gentle and regular incline with little relief. At a point, approximately marked by the 110 ft (34 m) contour, a slope break occurs and the seafloor rises with greater inclination, but still smoothly, to at least the 70 ft (21 m) contour. It is anticipated that between this zone and shore, seafloor inclinations increase. This area could not be safely

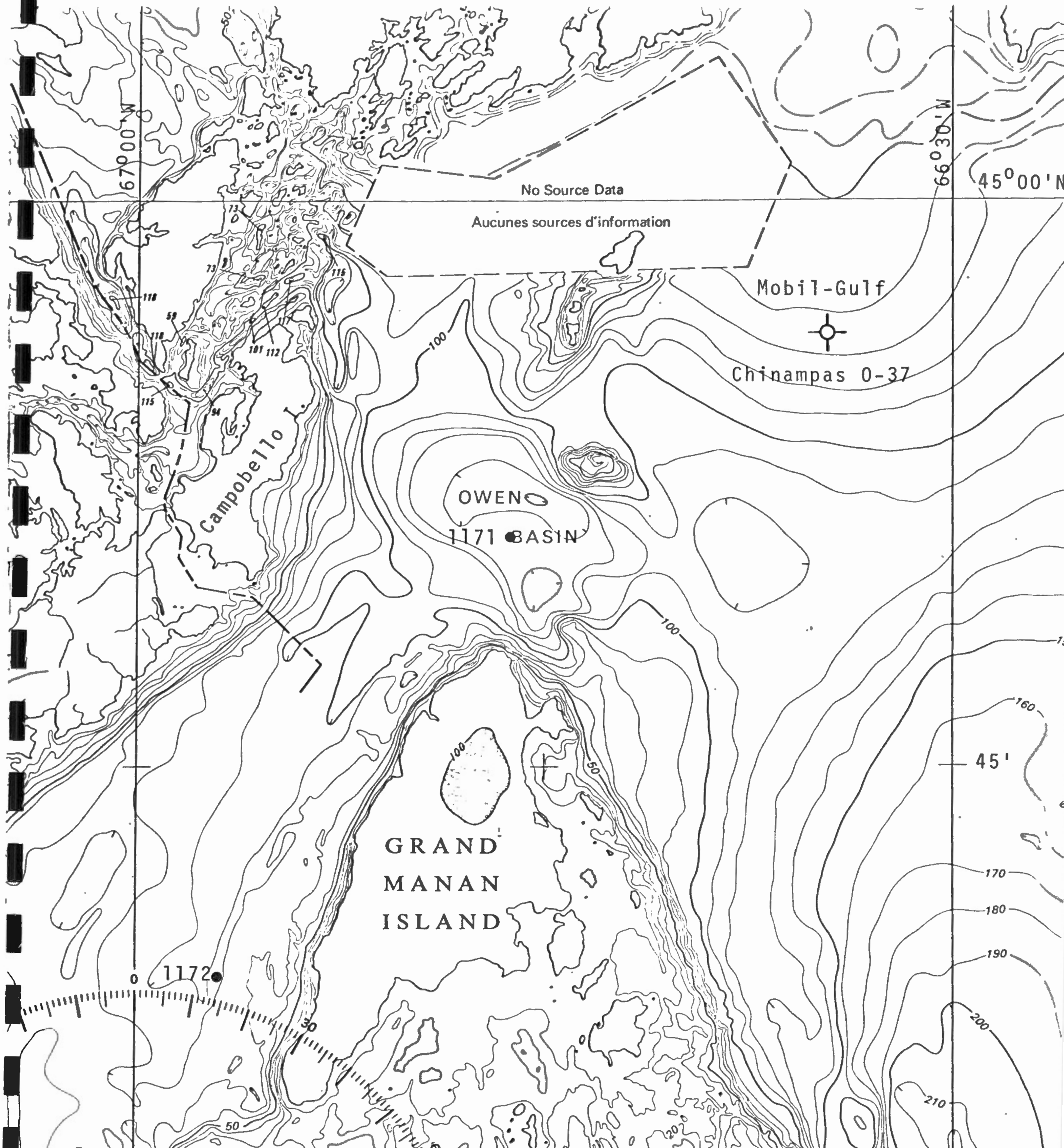


Figure 15 Regional bathymetry, scale 1:250,000, contour interval 10 m, Nat. Res. Map 15146A.

LEGEND 1171 ● - U.S. Geol. Survey sample location (see Table 2).

Figure 16 Hydrography of Grand Manan Channel, soundings in fathoms - scale 1:60,000, C.H.S. Cha[redacted] D7[redacted]40.

surveyed because of the strong tidal currents around Ragged Point and the danger to the towed sub-surface side-scan sonar unit.

8c MARINE GEOLOGY

The following description of the geology of Grand Manan Channel derives from the cross examination of all available information sources; side-scan sonograms, 3.5 kHz and boomer seismic reflection records, bathymetric data and seafloor samples and photographs. The results of this integrated interpretation are illustrated in maps of surficial geology (Enclosure 3 , Figure 23) and thickness of unconsolidated sediment (Enclosure 4 , Figure 24) and in three cross sectional profiles of Grand Manan Channel (Enclosures 5 , 6 and 7 , Figure 25).

We reiterate that no geophysical systems available produce numerical and absolute determinations of seafloor and sub-seafloor characteristics. Our maps and descriptions of these characteristics, therefore, represent our best interpretation of existing conditions based on the study and cross correlation of all information sources. We are highly confident that all aspects of the interpretation relevant to the laying and burying of a power cable are correct. However, qualifications of some aspects of our interpretation are contained in the following description of seafloor geology.

Referring to Enclosure 3 (Fig. 23), the map of surficial geology along the proposed cable route, it is apparent that the foreshore zones of relatively steep bottom slopes, flanking both Grand Manan Island and Campobello Island, are occupied by bedrock exposures. On the west side of Grand Manan Island, the cliff-forming Triassic basalts are assumed to continue underwater, forming steep, sediment-free submarine slopes. Similarly, the Silurian, Quoddy Formation slates, shales and volcanic rocks exposed in the vicinity of Ragged Point on Campobello Island, continue underwater and are exposed, or covered, by a thin, patchy veneer of sediment. The distribution pattern of this seafloor outcropping suggests undersea continuity of the shoreline lineation characterizing the coastline between Herring Cove and Owen Head. (This lineation may represent the continuation of the Oak Bay Fault, Fig. 14.)

Unconsolidated sediments onlap the seafloor exposures of bedrock. There appears to be very little variation in the composition of seafloor sediments across the whole of Grand Manan Channel. The best indirect evidence of this is found in the monotony of the side-scan sonograms which display exceptionally little variation in reflectivity related to varying seafloor composition. Direct indications of the nature of this monotonous seafloor is found in photographs and samples. The grab samples and camera stations are plotted on the map of surficial geology (Enclosure 3, Fig. 23), and station results summarized in Table 1 below.

Additional to the results of the Geomarine Survey, two stations with samples and photographs taken by the United States Geological Survey have been located. Dr. John S. Schlee (personal communication) of the U.S.G.S.states that the photographs from these stations "show a fair admixture of shell fragments and some gravel in with sand and mud." The position of the two stations is shown in Figure 15 and a description of the stations summarized in Table 2 .

The available surficial evidence suggests that the seafloor over most of Grand Manan Channel typically consists of a poorly sorted mixture of sediments ranging in grain size from mud (silt and clay) to cobbles and boulders. One notable feature of the main Grand Manan Channel seafloor is revealed by all side-scan sonograms from the area: the texture,or micro topography of surficial sediments,displays a strong linearity (Fig. 17) which is clearly a pattern induced by the strong ebb and flood tidal currents which surge through the Channel. The linear pattern may

TABLE 1

SUMMARY OF SAMPLE AND PHOTO STATION RESULTS

GRAND MANAN CHANNEL
(1975)

Station	Type	Results
75/13-1	Grab	One large cobble, several very coarse pebbles. N.B. some stiff clay was found on grab sampler handles
75/13-2	Grab	One large cobble (130 mm dia) several pebbles
75/13-7	Grab	Coarse sand of rock and shell fragments and rounded pebbles up to 64 mm (7 cm max dia)
75/13-3	Grab	Coarse sand consisting of rock fragments and shell debris and fine to medium gravel consisting mainly of shell debris up to 2 cm max dimension
75/13-4	Camera	Plates 19 & 20, photos display well-sorted shell debris as sampled at station 75/13-3. Crest of a sand wave observed in Frame 10A.
75/13-5	Camera	Plate 21, mottled light and dark seafloor of uncertain composition, several cobbles observed. Mottling may be due to churning effect of burrowing organisms sampled in Grab Sample 75/13-2.
75/13-6	Camera	Plate 22, numerous cobbles. Probable dense growth of benthonic organisms.

TABLE 2

UNITED STATES GEOLOGICAL SURVEY SAMPLES

GRAND MANAN PASSAGE

(after Schlee, 1975)

Grab/Camera Station	Latitude	Longitude	Depth	Description	% Gravel	% Sand	% Silt	% Clay
1171	$44^{o}51.0$'N	$66^{o}46.3$'W	141 m 462 ft	grey, sticky clay overlain by 2 cm brown sandy clay	7.0	4.6	20.9	57.5
1172A	$44^{o}39.6$'N	$66^{o}57.0$'W	100 m 328 ft	greenish-brown silty mud with very small amount of gravel to 2 cm dia.	12.5	29.3	20.8	37.4
1172B	$44^{o}39.6$'N	$66^{o}57.0$'W	100 m 328 ft	lumps to 4 cm. dia. indurated clay	-	-	-	-

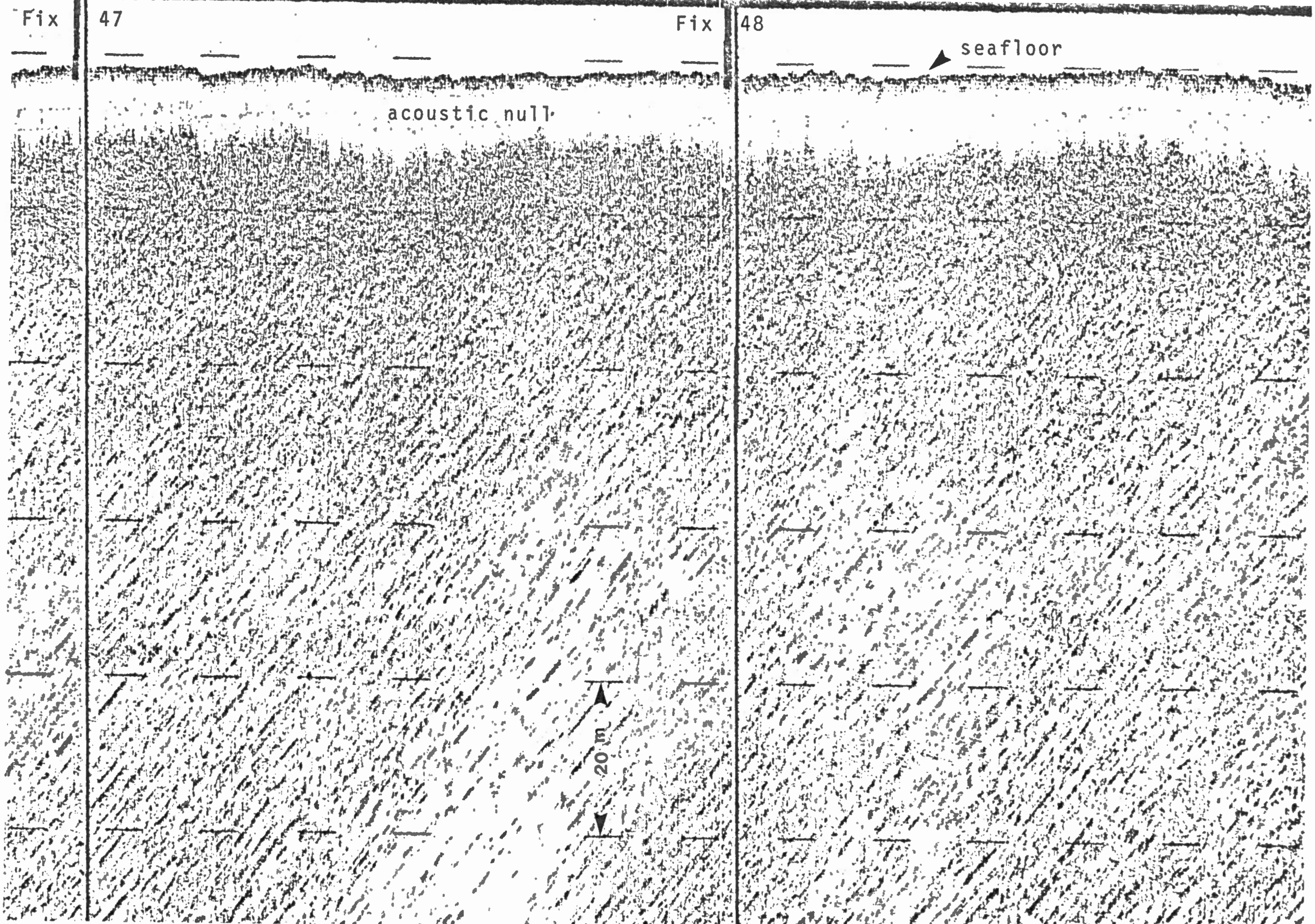


Figure 17 Lineated side-scan sonogram of Grand Manan Channel, Line 3b (starboard side of sonogram only).

represent "crag and tail"-like erosion and sedimentation. That is, fine sediments carried in traction by currents fall from suspension when current velocities suddenly drop in the "lee" of cobbles and boulders. Thus, the cobble or boulder becomes an immovable protrusion or "crag" behind or in the "lee" of which is deposited a streamlined "tail" of sediments. The orientation of this streamlining would, of course, parallel the current direction. The lineations of the side-scan sonograms parallel the axis of Grand Manan Channel and the direction of current ebb and flood through the Channel. This explanation assumes a dominant current direction. Whatever the explanation, the lineated seafloor clearly represents a pattern of ridges and furrows in the surficial sediments whose long axis coincides with the direction of major tidal current ebb and flood and whose origin is a direct result of these strong currents.

The side-scan sonograms from "Line 1 & 3 extension" recorded by the ACCESS group in 1972 show a similar linear-patterned seafloor in Grand Manan Channel.

An important exception to the general uniformity of the Grand Manan Channel sediments is an elongate deposit lying near the base of and paralleling the steep submarine foreshore off Long Eddy Point on Grand Manan. The surficial sediments of this deposit are a well-sorted coarse sand to fine gravel-sized mixture of shell fragments with a minor rock fragment component (Sample 75/13/3 and Camera Station 75/13/4; Plate 19). Side-scan sonograms and echograms reveal the presence of numerous sand waves which, with the relatively high degree of sediment sorting, reflect the existence of strong tidal currents around Long Eddy Point. These persistent strong currents around this protrusion obviously account for the name given to the point. The maximum sand/gravel wave amplitude measured is 10 ft (3 m). On the map of unconsolidated sediment thickness (Encl. 4, Fig. 24). This deposit, lying due west of Long Eddy Point, is shown as attaining a thickness in excess of 60 ft (18 m). The evidence suggests that the surficial sediments of this deposit are in a state of dynamic equilibrium in response to the "Long Eddy" current. It remains to consider whether a power cable might suffer abrasion or otherwise be affected by the transient migration of these sediments to a degree which would suggest changes in cable design or route selection.

The thickness of unconsolidated sediment is mapped in Enclosure 4 (Fig. 24) and further illustrated in the cross sectional profiles (Encls. 5, 6 and 7, and Fig. 25). Please note that in computing thickness, the velocity of sound in the unconsolidated sediments is assumed to be identical to that in sea water: 4800 ft/sec or 1500 m/sec. In the absence of specific velocity measurements and in consideration of the uncertainties as to the specific composition of the sediment column, it is conventional to make this assumption.

The western half of Grand Manan Channel has a thin and uniform blanket of unconsolidated sediment overlying the deepest observable reflector which is considered to be bedrock. The average thickness of sediment is about 20 ft (6 m) in this section. The eastern half of the Channel displays much greater variability in sediment thickness, ranging between 10 and 40 ft (3 and 12 m) along the proposed cable route excepting the previously described Long Eddy current deposit where a thickness of 60 to 70 ft (18 to 21 m) is found. North of Long Eddy Point and the proposed cable route, the thickness of sediments increases dramatically, exceeding 100 ft (30 m) in thickness as bedrock depth below the seafloor increases. The data in general suggest a thickening of sediment to the north all along the proposed route. If burial of the cable is deemed judicious, the northern edge of the survey coverage appears to offer greater assurance that shallow, sub-seafloor protrusions of bedrock will not be encountered. Such a choice of route would also be favoured if it is decided to land the cable at Whale Cove instead of Long Eddy Point.

The surficial or seafloor sediments have been previously described as consisting, in general, of a poorly-sorted mixture of mud, sand and gravel. No samples of sub-seafloor sediment have been taken. Thus we must deduce composition from indirect evidence, namely, from the acoustic reflection characteristics of the subsurface sediments. In this respect, two character types have been recognized, one occupying the western half of Grand Manan Channel and the other, the eastern half. The two units have an indistinct and gradational boundary between them. The distribution of the units and the location of their mutual boundary is illustrated in the map of surficial geology, Enclosure 3 (Fig. 23).

Unit 1. The sediments of the western half of Grand Manan Channel appear, on the basis of limited surface sampling and photography, to be similar to the sediments of the eastern half. The unconsolidated sediment substratum is transparent to 3.5 kHz energy which readily penetrates the sediment column to reflect strongly from the upper surface of the bedrock (Figs. 18 and 19). Experience and theory indicates that 3.5 kHz energy cannot penetrate well-sorted gravel, will only penetrate a few feet in sorted sand, but readily penetrates sediments with increasing proportions of mud (silt and clay). Considering (a) the relative ease of

3.5 kHz penetration to bedrock over the western half of the Channel, (b) the occurrence of a firm mud on the handle of the grab sampler at station 75/13/1, and (c) the observation of pebbles and cobbles in seafloor photographs from the area, it is concluded that the unconsolidated sediment column, in comparison with the seafloor sediments, contains a higher percentage of silt and clay as a matrix and lesser proportions of sand, gravel and cobbles. The preponderance of gravel and cobbles at the seafloor as indicated by photographs and samples, suggests that these are a lag deposit, that is, a concentration of coarse-grained material left in place after fine-grained sediments have been swept away by currents. The seafloor in this way becomes armoured to some degree against further erosion.

Unit 2. The sediments of the eastern half of Grand Manan Channel are surficially similar to those of the western half. However, the acoustic penetration of the 3.5 kHz appears less and the resolution of the bedrock surface on the boomer reflection records is indistinct where bedrock lies at shallow depths below the seafloor, comparable with bedrock depths of the western section of the Channel (Figs. 20 and 21). We interpret the diminished penetration of the 3.5 kHz profiler and the indistinct resolution by the boomer of the bedrock surface over the eastern half of the Grand Manan Channel to reflect, in comparison with the sediments of the western channel, a diminished proportion of mud and increased proportion of sand and gravel in the subsurface unconsolidated sediments.

The sediments in the basin north of the eastern end of Grand Manan Channel, previously alluded to, appear on the "boomer" reflection records, to be well stratified - an observation suggestive of deposition in water (as opposed to subglacial deposition). It may be speculated that this basin, possibly a southern extremity of the Owen Basin, has acted as a sink in the bedrock surface into which sediments eroded from the shallow, southern section of Grand Manan Channel have settled. The 3.5 kHz profiles contain no distinct reflections from the internal stratification shown to be present by the "boomer" profiles. If it is accepted that the stratified sediments of this basin were water born, then consideration of the comparative penetrations of the boomer and 3.5 kHz profiles suggests that the deposit contains a high proportion of sand and/or fine gravel and consequently a low proportion of mud.

The underwater continuation of bedrock, exposed on the shorelines of Grand Manan and Campobello Islands has been described previously in the discussion of surficial

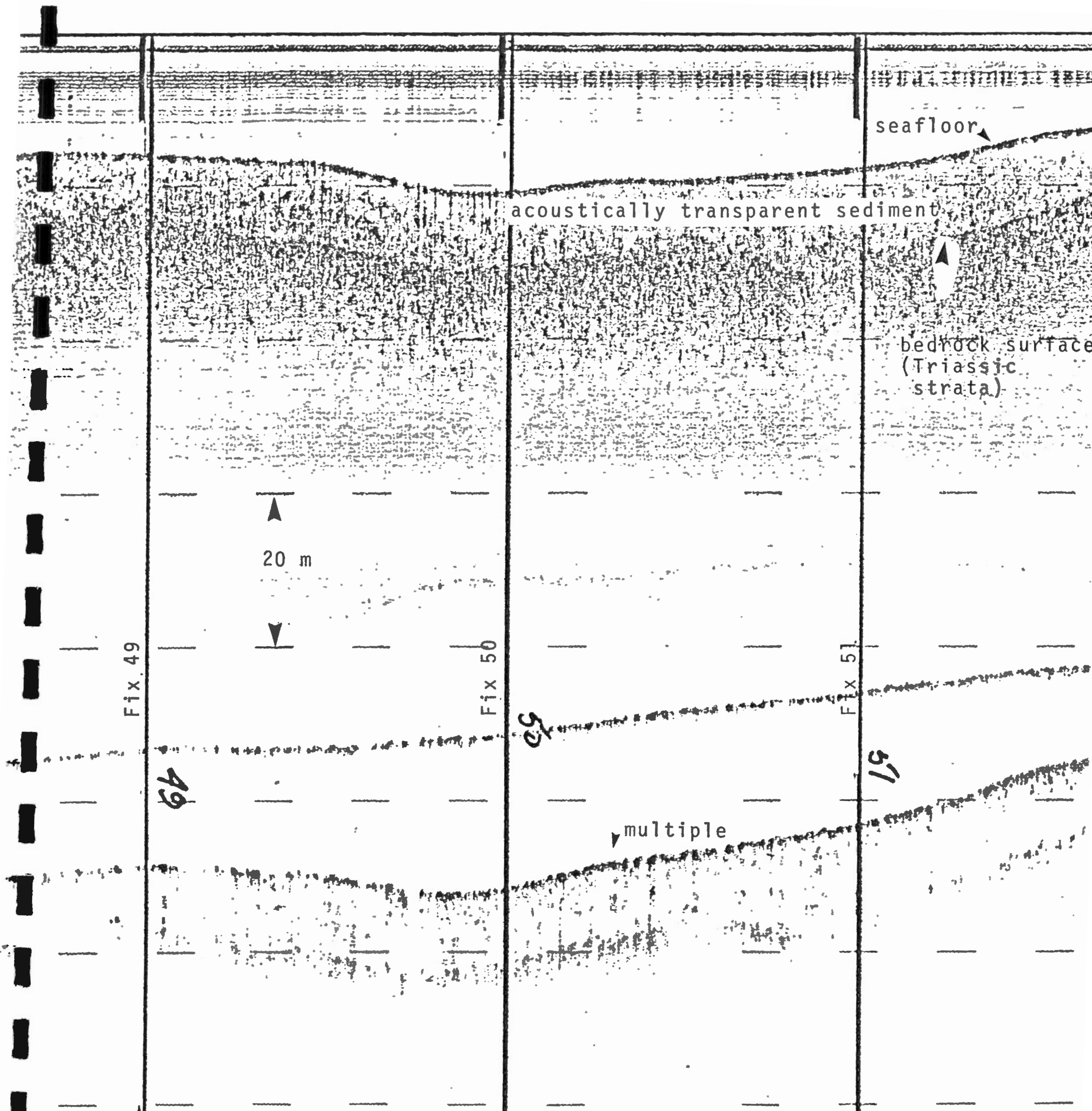


Figure 18 3.5 kHz seismic profile, western Grand Manan Channel, Line 1c. Recorded simultaneously with boomer profile of Figure 19. Note apparent transparency of unconsolidated sediments to 3.5 kHz energy.

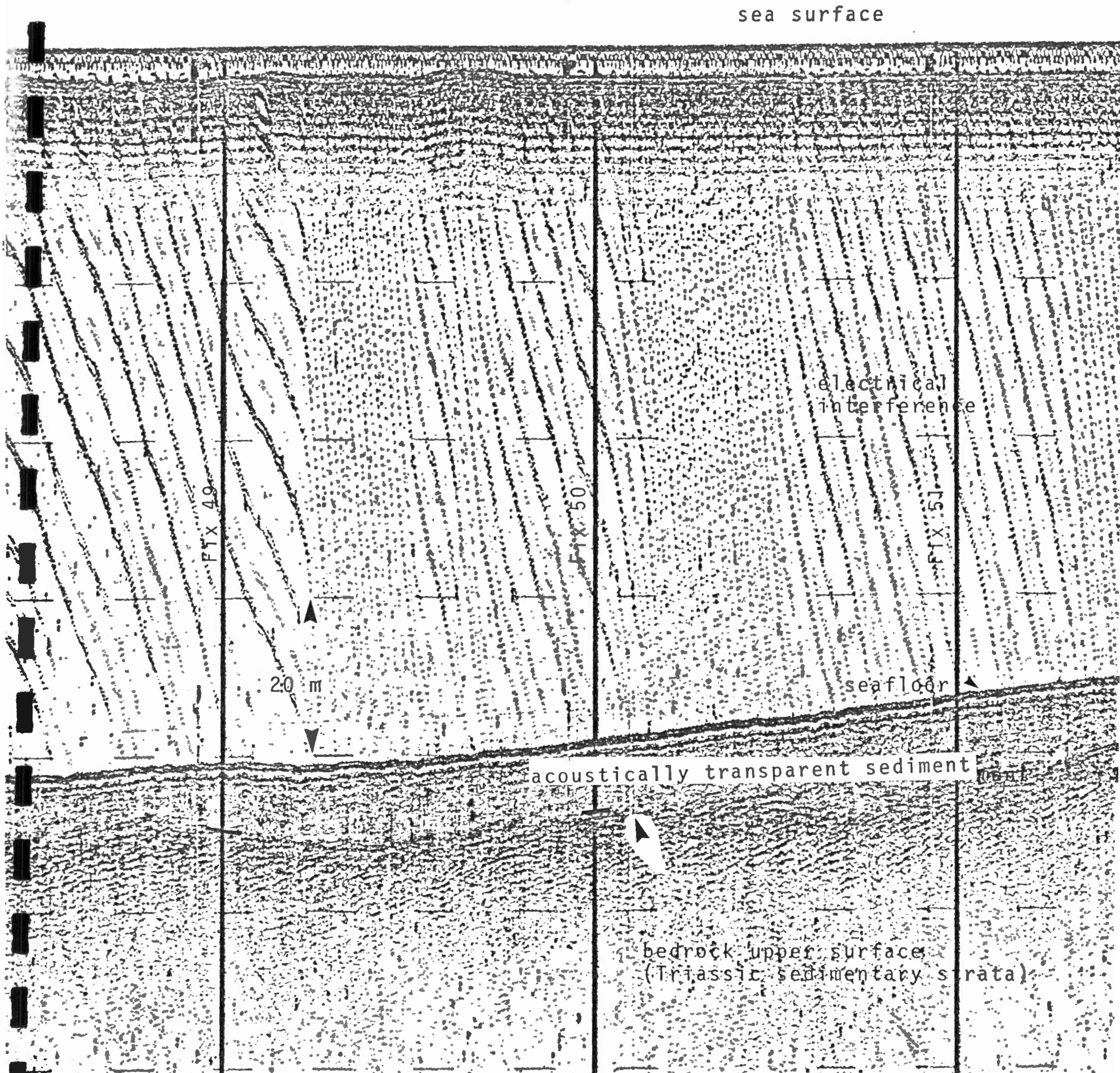


Figure 19 Boomer profile, western Brand Manan Channel, Line 1c. Note apparent acoustic transparency of western Grand Manan Channel unconsolidated sediments (compare with Figure 21.)

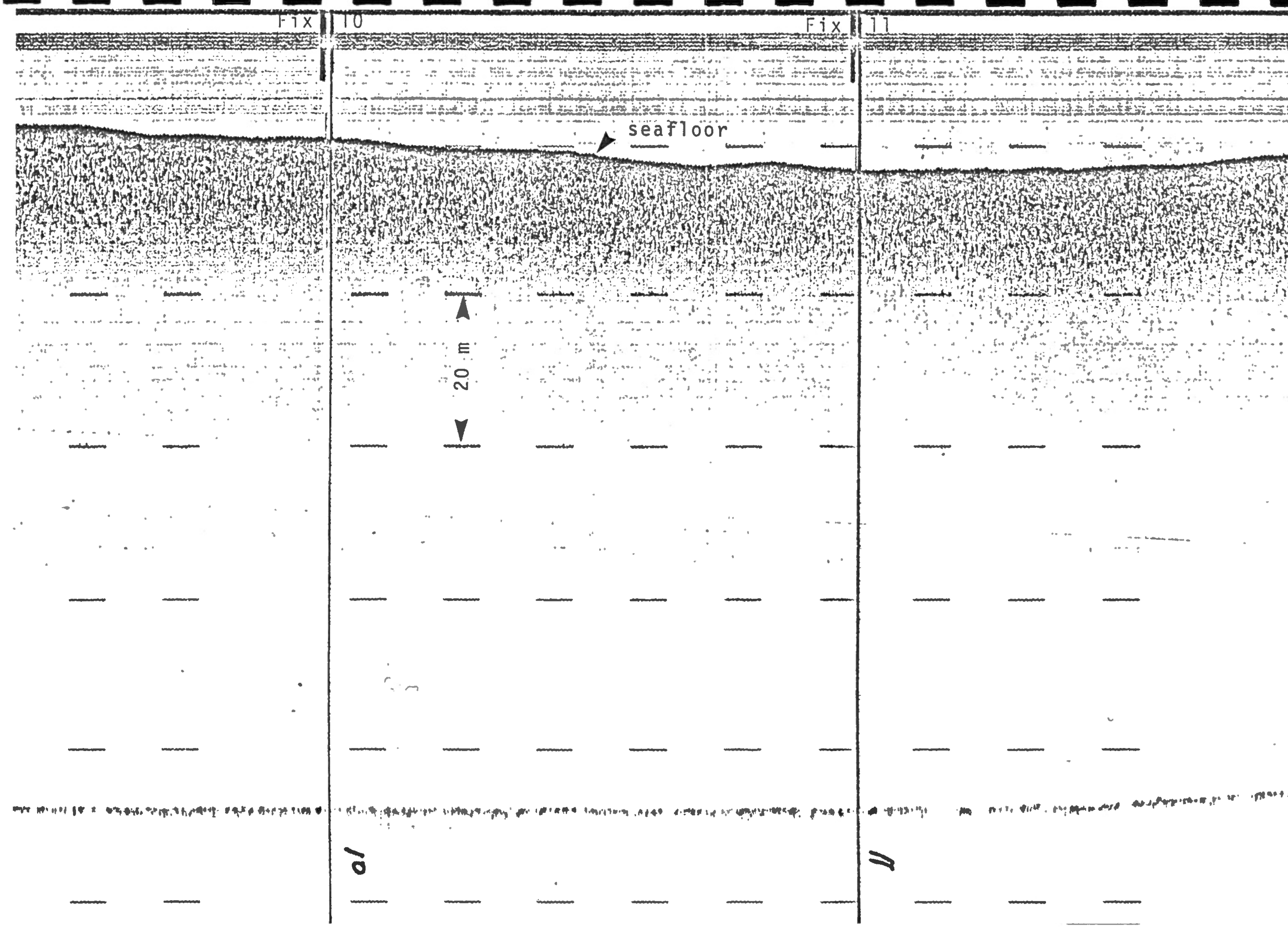


Figure 20 3.5 kHz seismic profile, eastern Grand Manan Channel, Line 6, recorded simultaneously with boomer profile of Figure 21. Note apparent opacity of unconsolidated sediments to 3.5 kHz energy (compare with Figure 18).

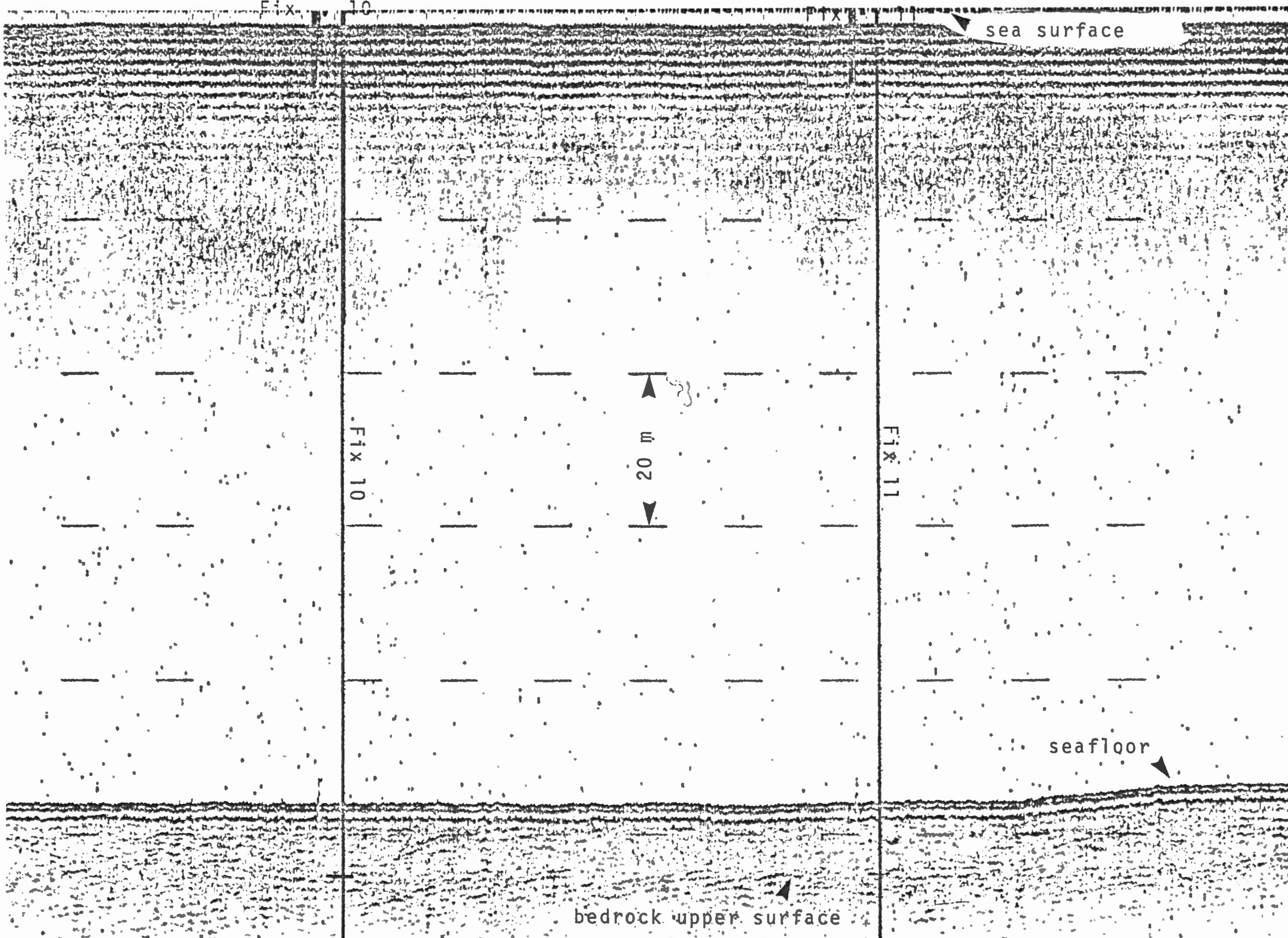


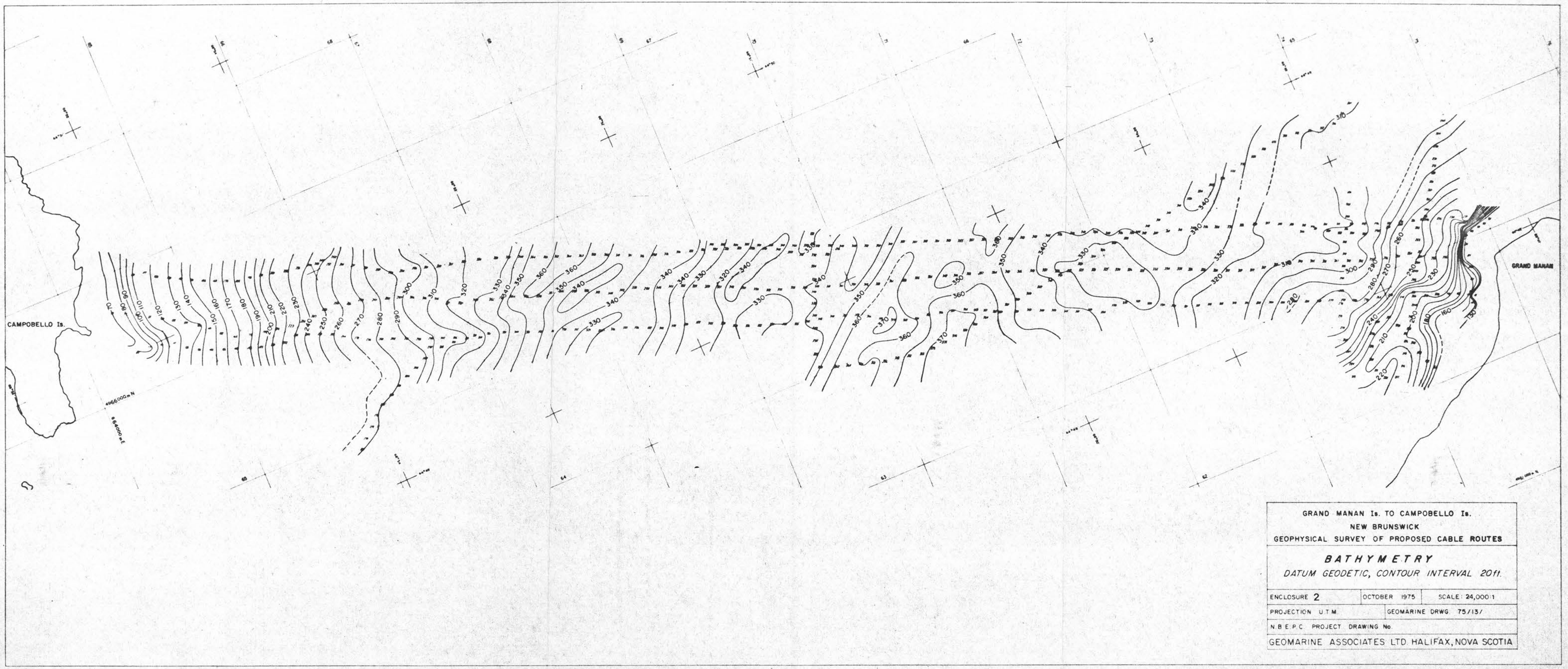
Figure 21 Boomer profile, eastern Grand Manan Channel, Line 6. Note apparent lack of acoustic transparency of unconsolidated sediments (compare with Figure 19).

geology since these bedrock extensions are exposed on the seafloor. The extent of these bedrock units beneath the sediment cover cannot be determined with certainty. In the case of the Grand Manan foreshore, the Triassic basalt appears to be fault-bounded (King and McLean, 1975) and is thus expected to terminate its westward extent (at depths relevant to this investigation) abruptly near the base of the steeply sloping foreshore. The Silurian Quoddy Formation slates, shales and extrusive volcanic rocks of southern Campobello Island likely terminate less abruptly, presumably continuing beneath the unconsolidated sediment cover for some distance until they are onlapped by the bedrock strata which form the deepest observable reflector across most of Grand Manan Channel - the Triassic sedimentary rocks. The contact between these bedrock units was not observed.

The extent of the Triassic strata underlying Grand Manan Channel is mapped largely through inference by King and McLean and shown in their map 812H, a segment of which is reproduced in this report as Figure 12 . On the basis of a single seismic line extending from the Murr Basin to the Owen Basin and therefore crossing the proposed cable route, King and McLean observed the Triassic strata dipping southwestward into a synclinal or basinal structure west of Grand Manan Island with apparent strike (the direction perpendicular to the direction of dip) running across the Channel (NW-SE).

In the boomer profiles of the present survey, internal bedrock reflections from dipping strata are commonly observable. These Triassic strata consistently have an apparent dip toward Grand Manan Island (i.e., toward the SE) at a low angle from the horizontal. Considering the apparent dip directions of SW and SE observed on two sets of seismic lines approximately perpendicular to one another, and assuming similar angles of dip on the two sets of lines, a true dip direction of south may be inferred for a first approximation.

By comparison with the typical Triassic strata intermittently exposed onshore around the Bay of Fundy, the Triassic strata which form the bedrock surface beneath the unconsolidated sediments of Grand Manan Channel are inferred to consist of interstratified red shales, sandstones and conglomerate. Since the bedrock surface as interpreted, approaches the seafloor no closer than 7 ft (2 m) and in general, is considerably deeper over most of the Channel, and since no evidence of outcroppings between survey lines was observed on side-scan sonograms covering a swath 500 ft (150 m) on each side of the lines, it is unlikely that bedrock will be encountered in cable laying or burying. It should be stressed, however, that the 1000 ft (305 m) seismic line spacing does not permit unequivocal statements to that effect.



GRAND MANAN Is. TO CAMPOBELLO Is.
NEW BRUNSWICK
GEOPHYSICAL SURVEY OF PROPOSED CABLE ROUTES

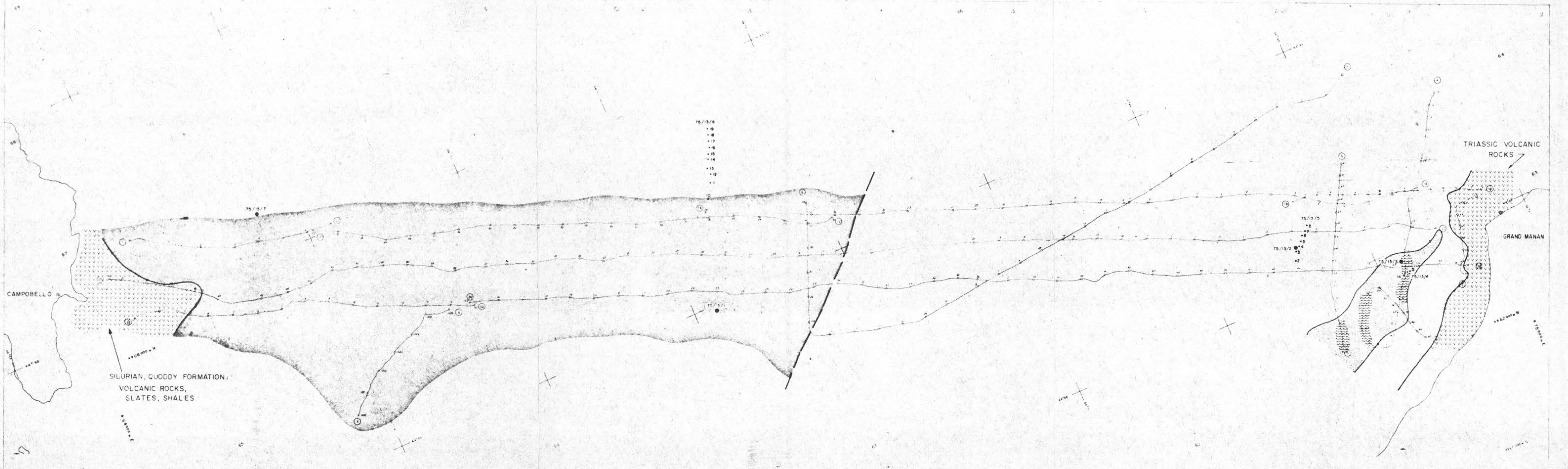
BATHYMETRY

DATUM GEODETIC, CONTOUR INTERVAL 20ft.

ENCLOSURE 2	OCTOBER 1975	SCALE: 24,000:1
PROJECTION U.T.M.	GEOMARINE DRWG. 75/13/	
N.B.E.P.C. PROJECT DRAWING No.		

GEOMARINE ASSOCIATES LTD. HALIFAX, NOVA SCOTIA

FIG. 22



LEGEND

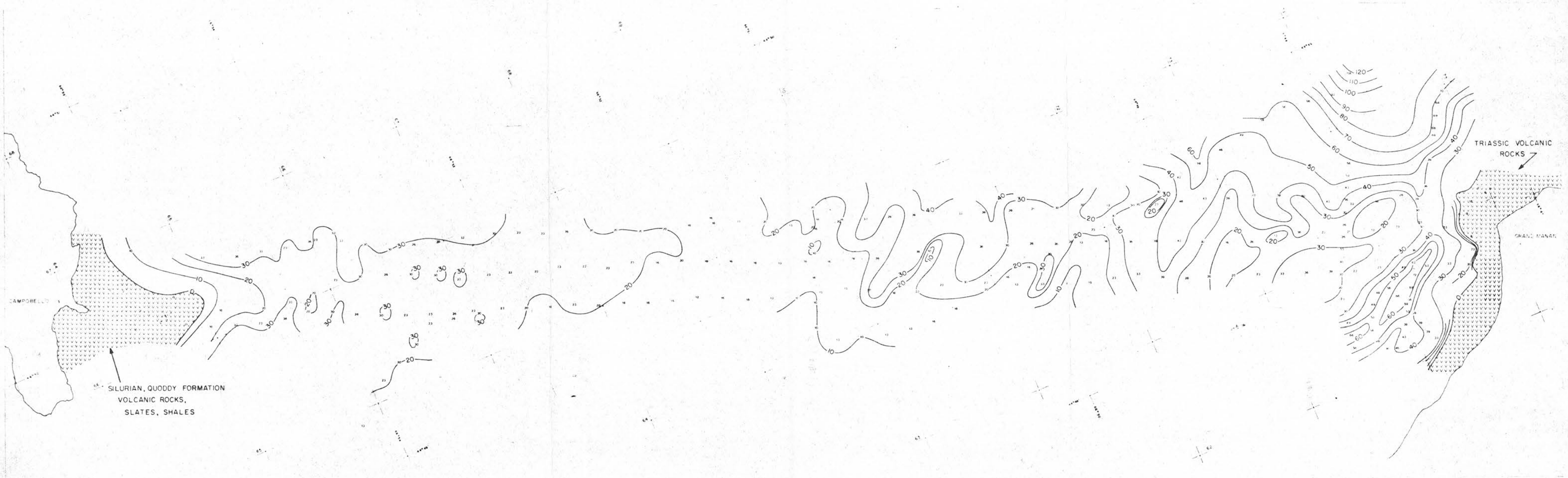
- POORLY SORTED MIXTURE OF COBBLES GRAVEL, SAND, MUD SOFT SUBSTRATUM *(HIGH MUD CONTENT)* INDICATED BY HIGH DEGREE OF ACOUSTIC TRANSPARENCY
- SURFICIAL SEDIMENTS SIMILAR TO WEST HALF OF GRAND MANAN CHANNEL, BUT DIMINISHED AÇOUSTIC TRANSPARENCY SUGGESTS DENSER SUBTRATUM *(LOWER MUD CONTENT)*
- 75/13/2 SEDIMENT SAMPLE STATIONS
- 3 ... 6 75/13/4 REMOTE SEAFLOOR PHOTOGRAPHY STATION; SERIAL FIXES INDICATED
- BEDROCK *(EXPOSED OR COVERED BY THIN VENEER OF SEDIMENT)*
- COURSE SAND TO FINE GRAVEL, SHELL DEBRIS
- SAND WAVES *AXIAL TREND APPROX. EAST-WEST*

GRAND MANAN Is. To CAMPOBELLO Is.
NEW BRUNSWICK
GEOPHYSICAL SURVEY OF PROPOSED CABLE ROUTES

SURFICIAL GEOLOGY

ENCLOSURE 3	OCTOBER 1975	SCALE 24,000:1
PROJECTION U.T.M.	GEOMARINE DRWG 75/13/	
N.B.E.P.C. PROJECT DRAWING No		
GEOMARINE ASSOCIATES LTD. HALIFAX, NOVA SCOTIA		

FIG. 23



LEGEND

UNCONSOLIDATED SEDIMENT THICKNESS VALUE IN FEET (VELOCITY OF 4800 FT/SEC ASSUMED)

GRAND MANAN Is. To CAMPOBELLO Is.
NEW BRUNSWICK
GEOPHYSICAL SURVEY OF PROPOSED CABLE ROUTES

THICKNESS OF UNCONSOLIDATED SEDIMENT

CONTOUR INTERVAL: 10 Ft.

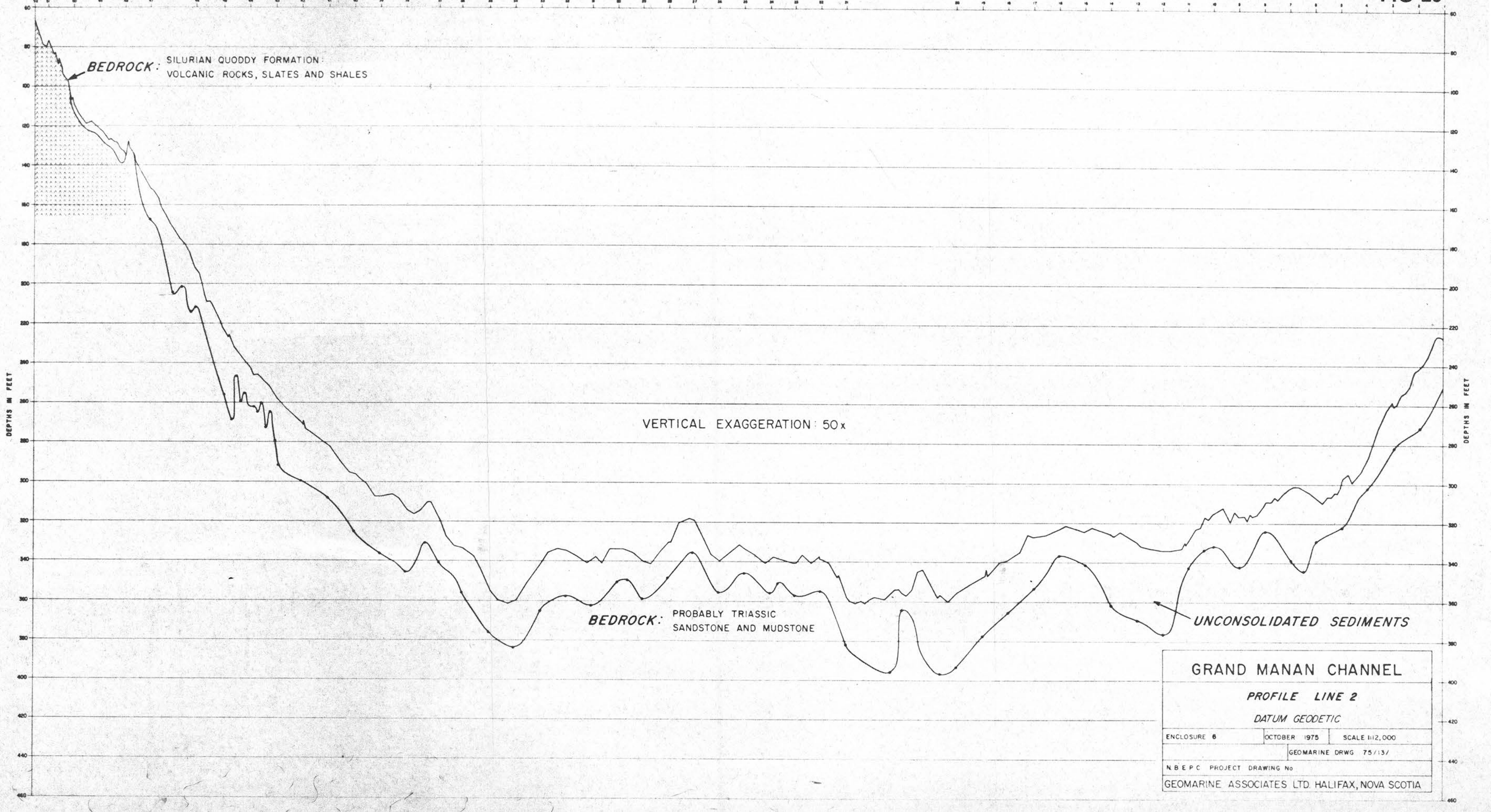
ENCLOSURE 4	OCTOBER 1975	SCALE 24,000:1
PROJECTION U.T.M.		GEOMARINE DRWG 75/13/
N.B.E.P.C. PROJECT DRAWING No		

GEOMARINE ASSOCIATES LTD. HALIFAX, NOVA SCOTIA

FIG. 24

Line 2

FIG 25


BEDROCK: SILURIAN QUODDY FORMATION:
VOLCANIC ROCKS, SLATES AND SHALES
VERTICAL EXAGGERATION: 50x
BEDROCK: PROBABLY TRIASSIC
SANDSTONE AND MUDSTONE
UNCONSOLIDATED SEDIMENTS
DEPTHS IN FEET
DEPTHS IN FEET
GRAND MANAN CHANNEL
PROFILE LINE 2
DATUM GEODETIC
ENCLOSURE 6
OCTOBER 1975
SCALE 1:12,000
GEOMARINE DRWG 75/137
N.B.E.P.C. PROJECT DRAWING No
GEOMARINE ASSOCIATES LTD. HALIFAX, NOVA SCOTIA

Section 9 THE HEAD HARBOUR PASSAGE AND FRIAR ROADS CABLE ROUTES

Head Harbour Passage lies between Campobello Island and Deer Island, New Brunswick (Fig. 2). Existing power cables extend from a point on Campobello Island north of Wilson's Beach, across Head Harbour Passage to Casco Island (Plate 14) and thence to Leonardville (Plate 15) on Deer Island. This cable route is shown on Canadian Hydrographic Service Chart 4373 and U.S.N.O.A.A. Chart 13328, portions of which are included in this report as Figures 26 and 27 .

A power cable crossing Friar Roads, between Campobello Island, Cherry Island and Indian Island and between Indian Island and Deer Island Point, was previously in service. This cable, according to Mr. Claude Gallant of N.B.E.P.C. (personal communication), was fouled by drilling crews during soil investigations for the International Joint Commission on Passamaquoddy Bay Power Development. While the cable is no longer in use, its location is also shown in Figure 26 . The routes of the existing and previously existing cables are both being considered for the proposed power cable to Grand Manan Island.

Figure 26 Hydrography of Head Harbour Passage/Friar Roads C.H.S. Chart 4373, scale 1:36,400.

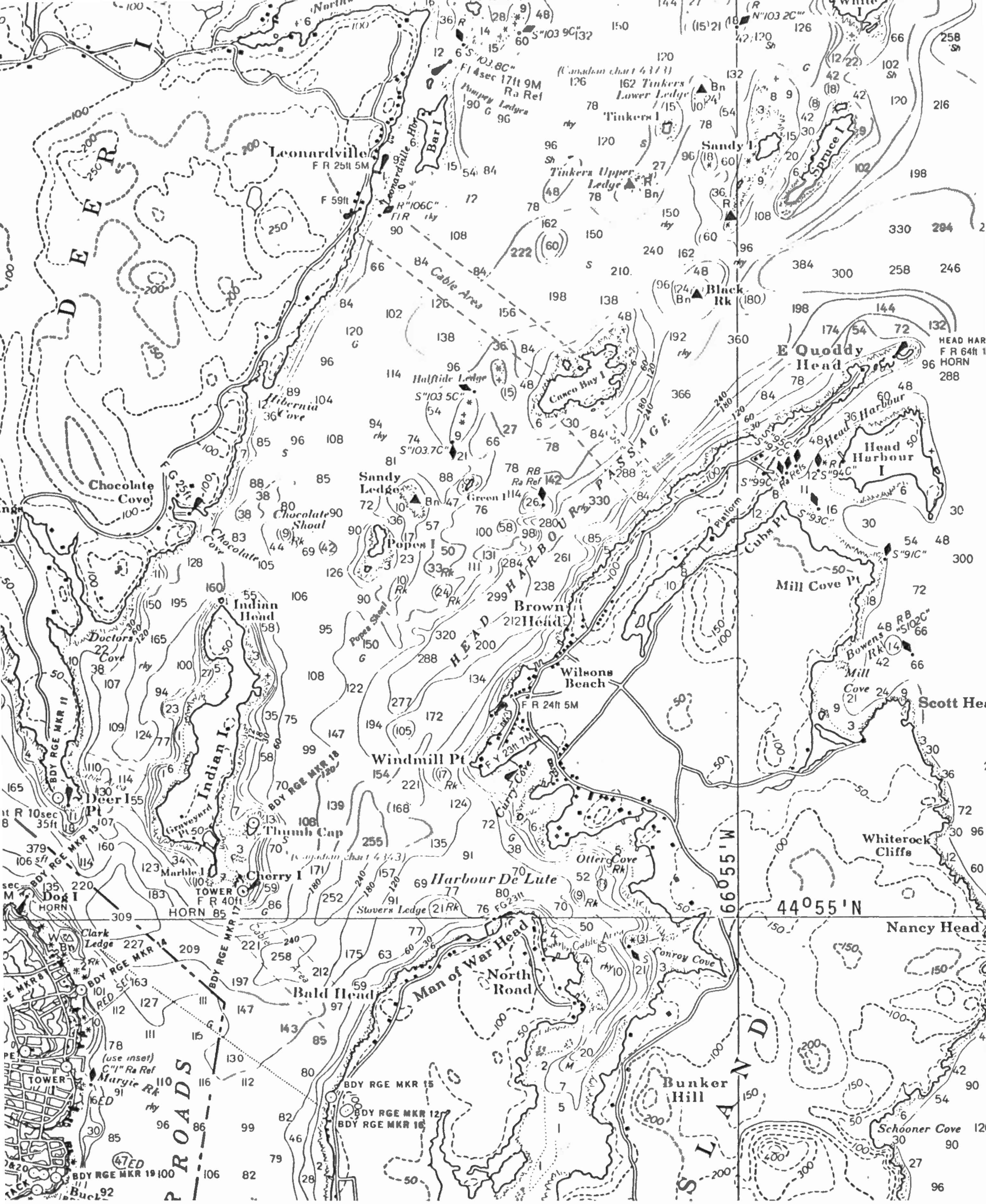


Figure 27 Hydrography, Head Harbour Passage and Friar Roads, contour interval, 60 ft, scale 1:40,000. USNOAA Chart 13328.

9a PHYSICAL SETTING

The shorelines of Campobello Island and Deer Island, flanking the northern end of Head Harbour Passage, are marked by low cliffs 25-50 ft (7.7-15.2 m) high (Fig. 28). Occasional indentations contain small beaches. Casco Island, in mid-passage, is wooded and low on the southwestern end, but has rather steep, if low, rocky cliffs on its northeastern end (Plate 14). Numerous small islands; Popes Island, Green Island (Plate 17) and shoals; Halibut Ledges, Half Tide Ledge, Black Rock, to the northeast and southeast of Casco Island, mark a high trend in the seafloor topography of which Casco Island is the most prominent expression.

At Friar Roads, the shoreline of Campobello Island has wooded cliffs of 25-100 ft (7.7-30.5 m) elevation (Fig. 28). Indian and Cherry Islands (Plate 18), in mid-channel, are relatively low and largely wooded with low cliffs at the shoreline. Deer Island Point, now part of a New Brunswick provincial park, is low in elevation and largely cleared.

The geology of Head Harbour Passage provides an explanation for many of the topographic features observed. Two geological maps of the area have been published (Cumming, 1967 and Alcock, 1946). Sections of these are included as Figures 14 and 29 . The trend of structural folds and faults closely parallel the long axis of Head Harbour Passage and have clearly controlled the geomorphological development of the land masses in the area. As will be shown below, the submarine bedrock topography features exhibit the same trends as onshore and are probably also controlled by the structural geology of the area.

9b BATHYMETRY

The bathymetry of the possible cable routes in Head Harbour Passage and Friar Roads is best understood by reference to Enclosure 10 (Fig. 31). (Note that depths referred to are relative to Geodetic Datum at Saint John, New Brunswick.)

Considering first the Head Harbour Passage route, and referring to the map of bathymetry, it is immediately apparent that there is a major difference in seafloor morphology on either side of Casco Island. On the eastern side, a narrow and steep-sided channel trends in a northeast-southwest direction, paralleling the shoreline of Campobello Island. Depths in excess of 340 ft (104 m) are found in the axis of this trough. As will be shown in the consideration of sediment distribution below, the walls of this trough are largely devoid of sediment which is generally restricted to the floor of the trough.

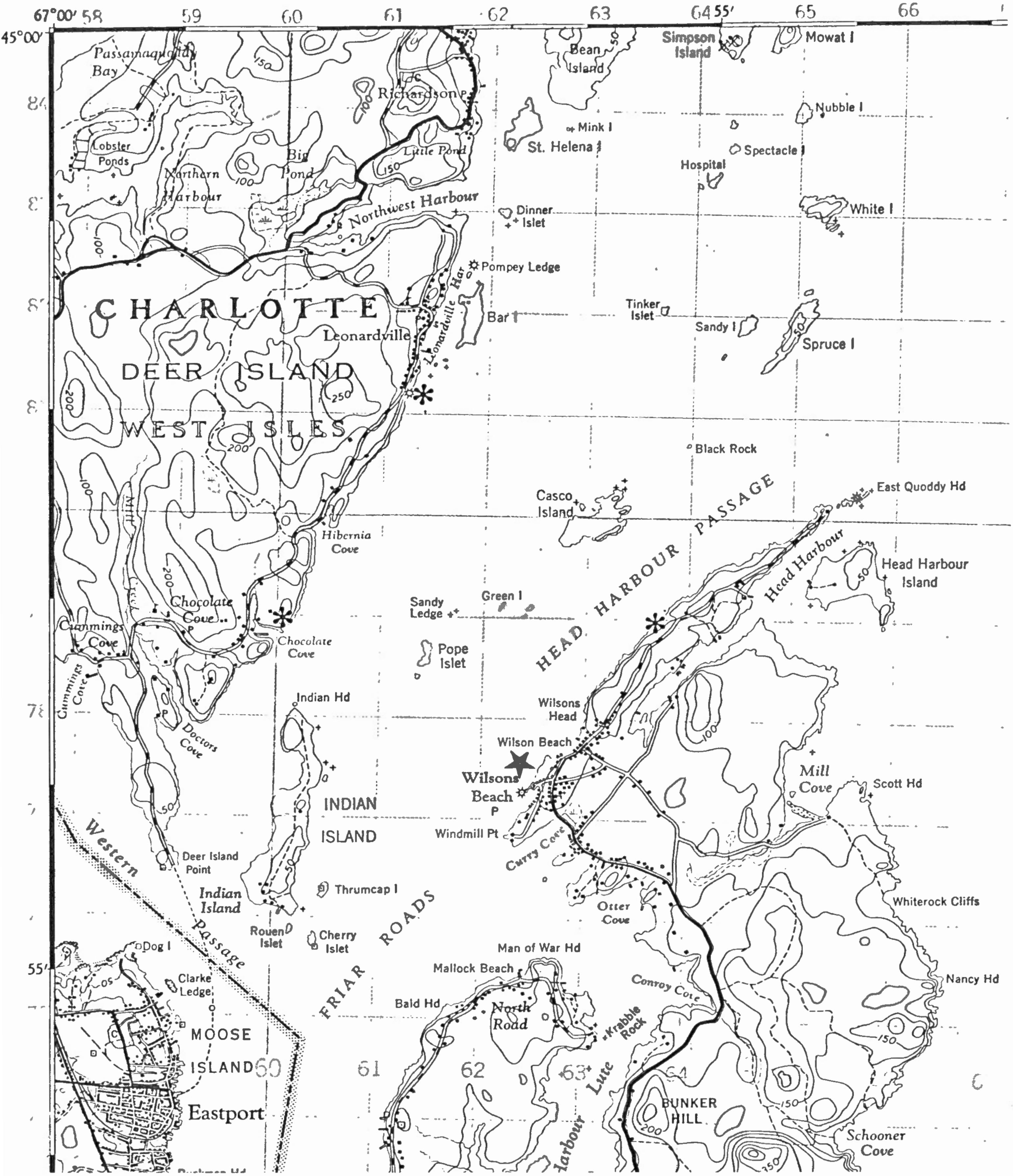
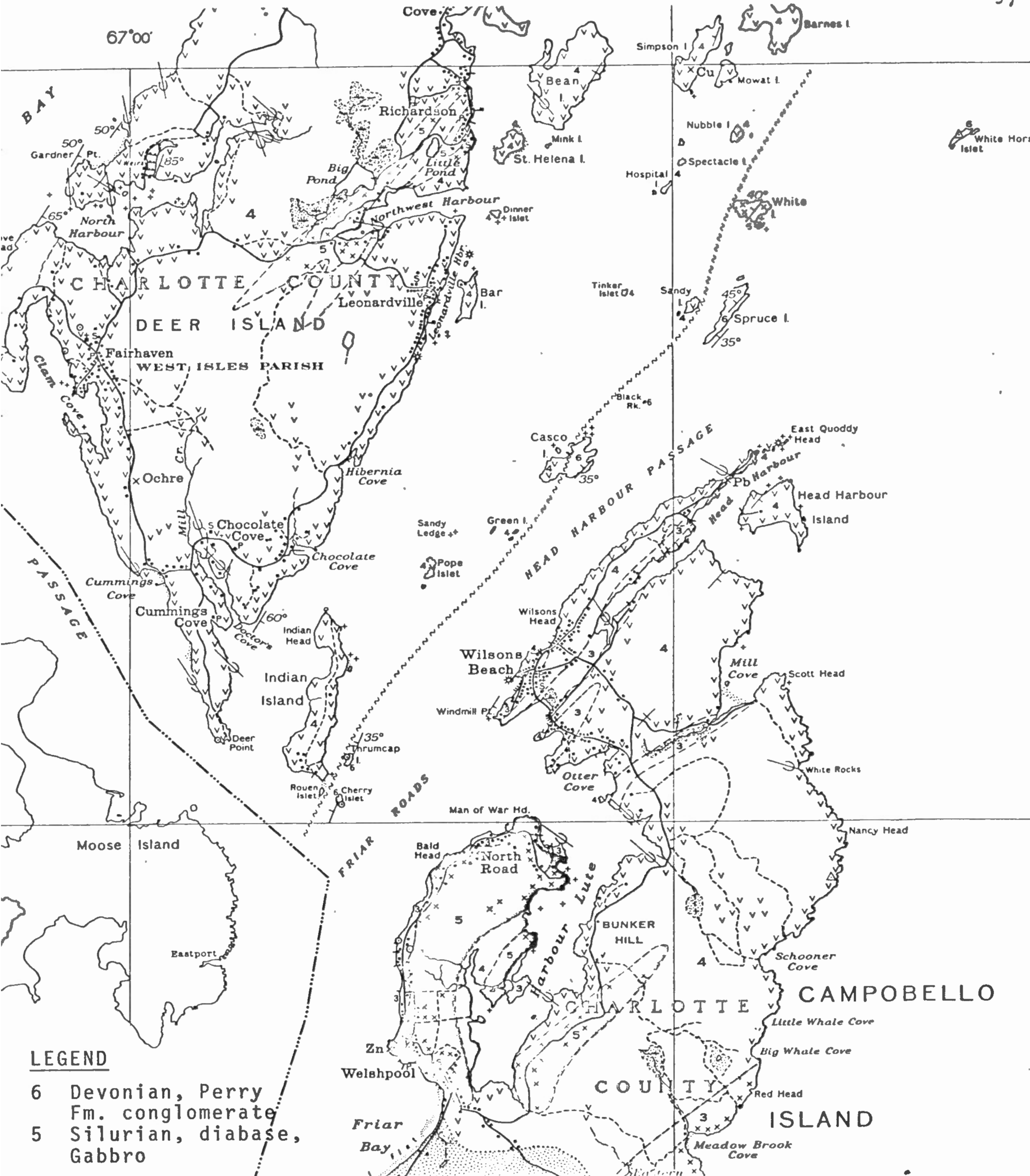


Figure 28 Topography of the Head Harbour Passage, Friar Roads area. Contour interval, 50 ft, scale, 1:50,000, Topographic Map 21 B15/W.



LEGEND

6 Devonian, Perry Fm. conglomerate
5 Silurian, diabase, Gabbro
4 Silurian, volcanic rks. slates, shales
3 Silurian, shales, slates, volcanic rocks

Figure 29 Geology of the Head Harbour Passage Friar Roads area. Scale, 1" = 1 mi (1:63,360), portion of G.S.C. Map 964A.

In contrast with the channel of the eastern side of Casco Island, the western channel is considerably more shallow. Half Tide Ledge, the Halibut Ledges and Green Island, form a complex of bedrock protrusions. A relatively broad trough with an average depth of about 160 ft (49 m) extends from a point due north of Casco Island, in a westerly direction toward Deer Island. The relatively shallow water depth of this trough (as compared with the trough on the eastern side of Casco Island) is the result of infilling of a much deeper trough in the bedrock by sediments.

The bathymetry of the potential cable route at the southern end of Head Harbour Passage across Friar Roads, between Campobello Island and Cherry Island/Indian Island is comparatively simple. The seafloor slopes regularly from each shoreline, forming a broad, U-shaped channel with a maximum depth of approximately 280 ft (85 m). The channel floor is largely swept clear of sediments by the strong tidal currents which ebb and flood into Passamaquoddy Bay through Western Passage.

9c MARINE GEOLOGY

The horizontal distribution of sediments and rock outcrop on the seafloor is illustrated in the map of Surficial Geology, Enclosure 11, (Figure 32).

Considering first the Head Harbour Passage route, it is evident that the shoals of the area are formed of bedrock protrusions. East and south of Casco Island, sediments are restricted to the narrow floor of the Channel and to the narrow, bathymetric re-entrants in the shoals flanking Casco Island. Unfortunately, the trends of these sediment-floored re-entrants is transverse to the intended cable route and they cannot be used as a natural trench in which to lay the cable.

The Channel north and west of Casco Island is largely covered by sediment with the exception of Half Tide Ledge, the Halibut Ledge complex and a relatively large area south of Bar Island.

Side-scan sonograms, samples and photographs afford a description of the sediments at the seafloor. The location of grab sample and camera stations is shown on the map of Surficial Geology as are notable textural features revealed by side-scan. A description of grab and camera station results is summarized in Table 3 .

TABLE 3

SUMMARY OF SAMPLE AND PHOTO STATION RESULTS

HEAD HARBOUR PASSAGE

Station	Type	Results
75/13/8	Grab	Fine gravel, very coarse sand 1-4 mm, well-sorted. Shell debris 70% rock fragments 30%.
75/13/9	Grab	90% gravel: pebbles, 4 cm max. dia, shell fragments. 10% coarse sand containing shell debris and rock fragments, minor mud component.
75/13/10	Grab	No sample
75/13/11	Grab	Small sample: gravel 80% (rock fragments up to 5 cm max dimension) coarse sand (shell debris and rock fragments) minor mud fraction.
75/13/12	Grab	Same as 75/13/11, angular gravel 80%, coarse sand, 20%.
75/13/13	Grab	Small sample; several large pebbles, fine gravel (9 cm max dimension) and coarse sand, shell debris.
75/13/14	Grab	Angular rock fragments (13 cm max dimension) coarse sand (rock fragment and shell debris) 10%
75/13/20	Camera	Plate 23 photos display moderately well-sorted, gravel-sized shells and shell debris
75/13/21	Camera	Resolution of seafloor too poor to permit valid observations. Bottom appears to be composed of gravel-sized material
75/13/22	Camera	Plate 24 Poor resolution. Photo suggests the presence of several cobbles lying on a relatively fine-grained sediment.

Table 3
(continued)

Station	Type	Results
75/13/23	Camera	Plate 25 three photos indicate fine gravel-sized rock fragments on a generally fine-grained bottom. Few shells present.
75/13/24	Camera	Photos blurred too badly to distinguish seafloor features (current agitation?)
75/13/25	Camera	Plates 26 and 27 three photos reveal cobble and gravel seafloor.

The surficial sediments of the channel between Leonardville and Casco Island are generally poorly-sorted, the typical sample consisting of angular and rounded gravel-sized (up to 5 cm maximum dimension) rock fragments, mussel shells and shell debris, a considerable coarse sand fraction and a minor mud (silt and clay) component. The photos from Camera Station 75/13/23 (Plate 25) probably typify the seafloor in this basin and show the mixture of fine and coarse sediments.

The exception to these poorly-sorted sediments is found where strong currents, often associated with nearby bedrock protrusions, have concentrated hydraulically similar material in fields of ripples or waves.

Sample 75/13/8 probably typifies the material from these areas. The sample consists of well-sorted very coarse sand and fine gravel-sized shell debris and rock fragments. This material closely resembles the sediment recovered from the sand wave fields off Long Eddy Point on Grand Manan Channel. The major areas of sediment ripples and waves are shown on the map of Surficial Geology (Enclosure 11). A spectacular field of sand/gravel waves which resemble barchan dunes of terrestrial deserts is observed on side-scan sonograms (Figure 30) from an area northwest of Green Island. These are also shown in Enclosure 11. This "dune field" and flanking sand waves is

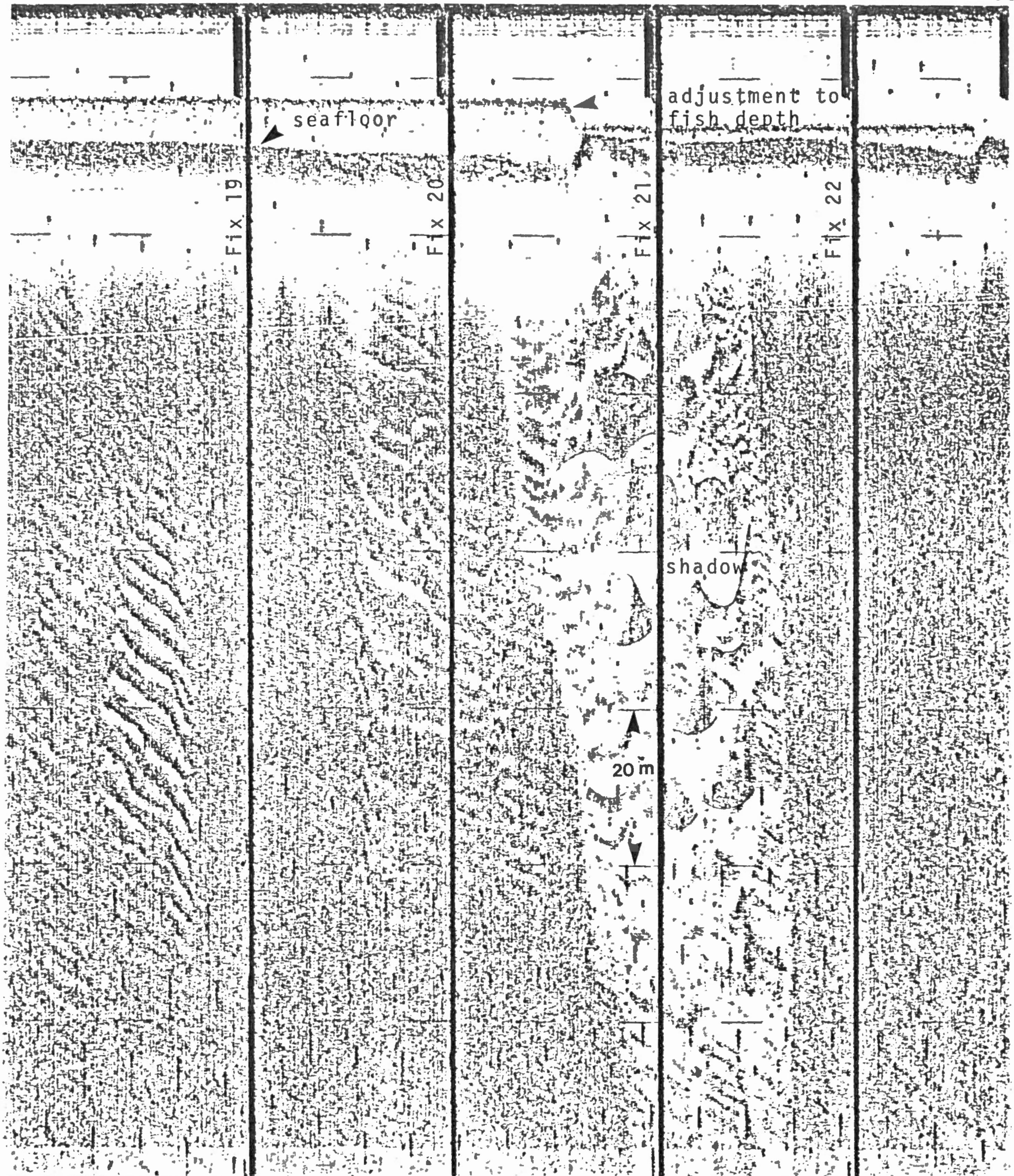


Figure 30 Side-scan sonogram showing sand "dunes" and associated sand waves. Head Harbour Passage, Line 11 (starboard side only).

probably indicative of channelized current flow between bedrock protrusions; Halibut Ledges to the north and Sandy Ledge to the south (Fig. 26).

The photos from station 75/13/25 (Plates 26 & 27) indicate the presence of coarser-grained material on the seafloor in the channel south and east of Casco Island. This is compatible with the current-swept nature of this southeastern channel.

The seafloor sediments of the Campobello Island to Cherry Island crossing are in general, coarse-grained as expected from an area swept by strong currents. The seafloor photographs of Camera Stations 75/13/18 and 75/13/19 Plates 28 and 29 show a bottom composed largely of gravel. In this regard, sample number 75/13/16 , which contains a high percentage of firm brown mud is anomalous. The firmness or compaction of the mud may indicate that the mud is from a streamlined "tail" in the lee of a cobble or boulder "crag," behind which a drop in current velocity allows deposition of the mud. Similarly, the mud may have come from a depression in the seafloor in which a current velocity drop caused deposition of the mud. The description of sample and seafloor photos from Friar Roads is summarized in Table 4.

The thickness of unconsolidated sediment as determined from the 3.5 kHz and "boomer" reflection profiles is plotted in

TABLE 4

SUMMARY OF SAMPLE AND PHOTO STATION RESULTS

FRIAR ROADS

Station	Type	Results
75/13/15	Grab	Small sample. Several rounded pebbles 5 cm max. dimension, fine (shell fragment) gravel minor coarse sand and mud fraction
75/13/16	Grab	Firm brown mud containing mussel shells and several gravel-sized rock fragments.
75/13/17	Grab	Mussel shells and shell debris, coarse shell debris, sand and minor mud component
75/13/18	Camera	Plate 28.Five photos clearly reveal coarse-grained gravel, seafloor supporting an abundance of benthonic fauna.
75/13/19	Camera	Plate 29 Five photos are essentially identical to those of 75/13/18.

Enclosure 12 and contoured in Enclosure 13 (Fig. 33). Note that a velocity of 1500 m/sec (the velocity of sound in sea-water) was used for the determination of sediment thickness in the absence of specific velocity measurements.

The most notable feature of the sediment thickness map is the revelation of deep, sediment-filled troughs in the bedrock surface of Head Harbour Passage between Casco Island and Deer Island. This situation is in contrast with the relatively thin and restricted sediment deposits in the passage between Casco Island and Campobello Island, and between Campobello Island and Cherry Island. It is apparent that the main mass of water passing through Head Harbour Passage, flows along the southeastern channel and not through the northwestern channel. No doubt, the linear series of shoals and islands between Indian Island and Spruce Island (Fig. 27) act to restrict the flow to the southeastern channel which is as a result, largely sediment-free. The northwestern channel then experiences lower current speeds and sediment deposition is possible.

Another remarkable feature of the unconsolidated sediment column in the passage between Casco Island and Deer Island is its characteristic acoustic transparency. Not only do the "boomer" reflection profiles readily penetrate to bedrock, but the 3.5 kHz profiler penetrates to bedrock with equal ease (Figs. 34 and 35). The degree of 3.5 kHz penetration is a good qualitative indicator of sediment bulk density; the more dense the sediment, the shorter the depth of penetration. In the spectrum of sediment densities and corresponding 3.5 kHz penetration, mud (silt and clay), the least dense, allows the greatest degree of penetration while compacted sand or gravel is impenetrable. Thus, the high degree of penetration exhibited by the sediments under consideration is indicative of a very high mud content in the sub-surface. The general absence of sediments with a substantial mud content on the seafloor, as indicated by samples and photographs, suggests that the fine-grained sediment (mud) has been winnowed away leaving a lag deposit of coarser sediments behind. This lag deposit then acts as an armour against further erosion. Presumably, the bedrock troughs have in the past, acted as sinks for the deposition of sediment. One may speculate that as the troughs filled, a level of equilibrium would be reached above which the action of currents would prohibit further deposition.

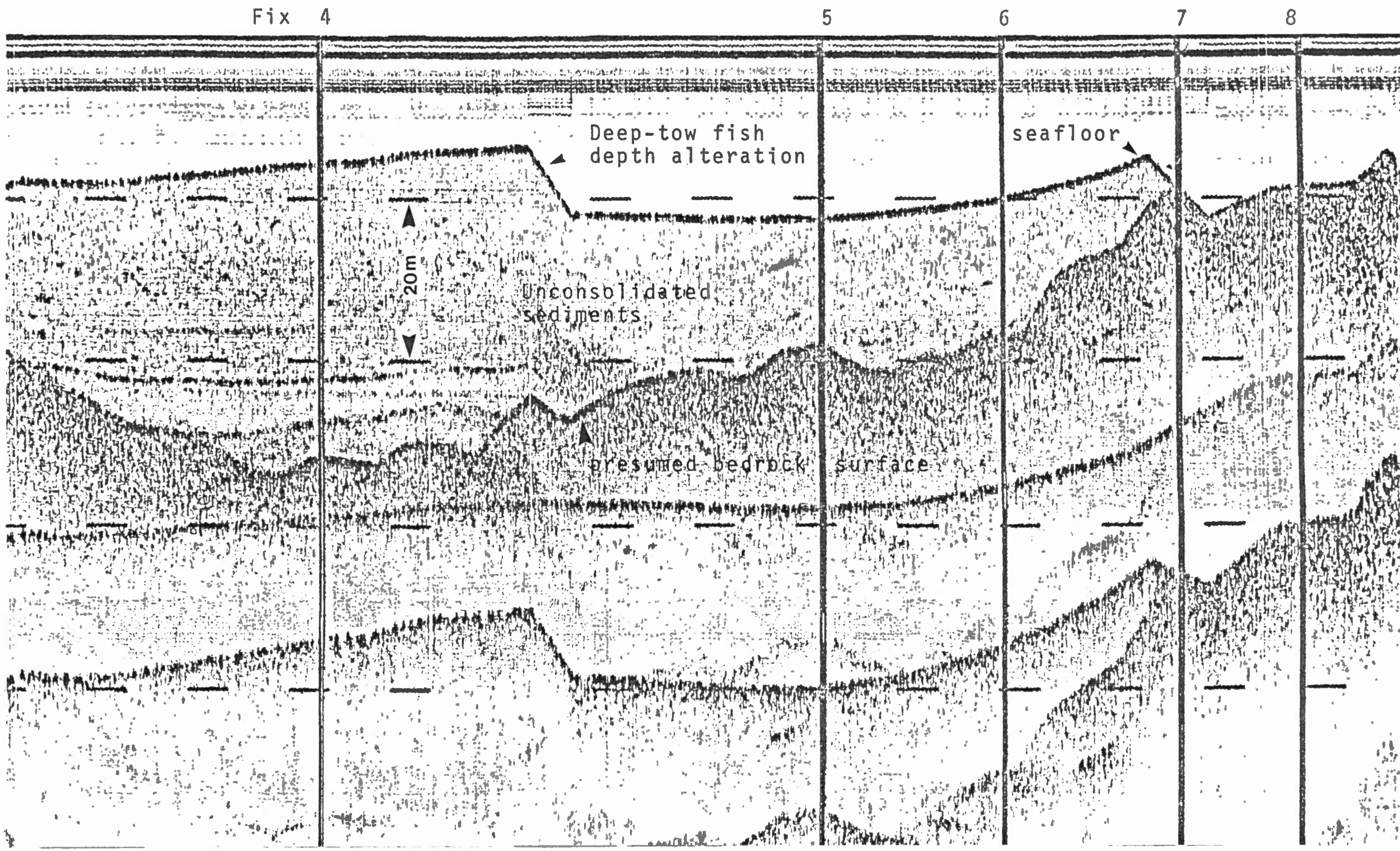


Figure 34 3.5 kHz seismic profile, Line 22a, Head Harbour Passage. Note high degree of acoustic transparency to 3.5 kHz energy exhibited by the sediments (compare with Figure 35).

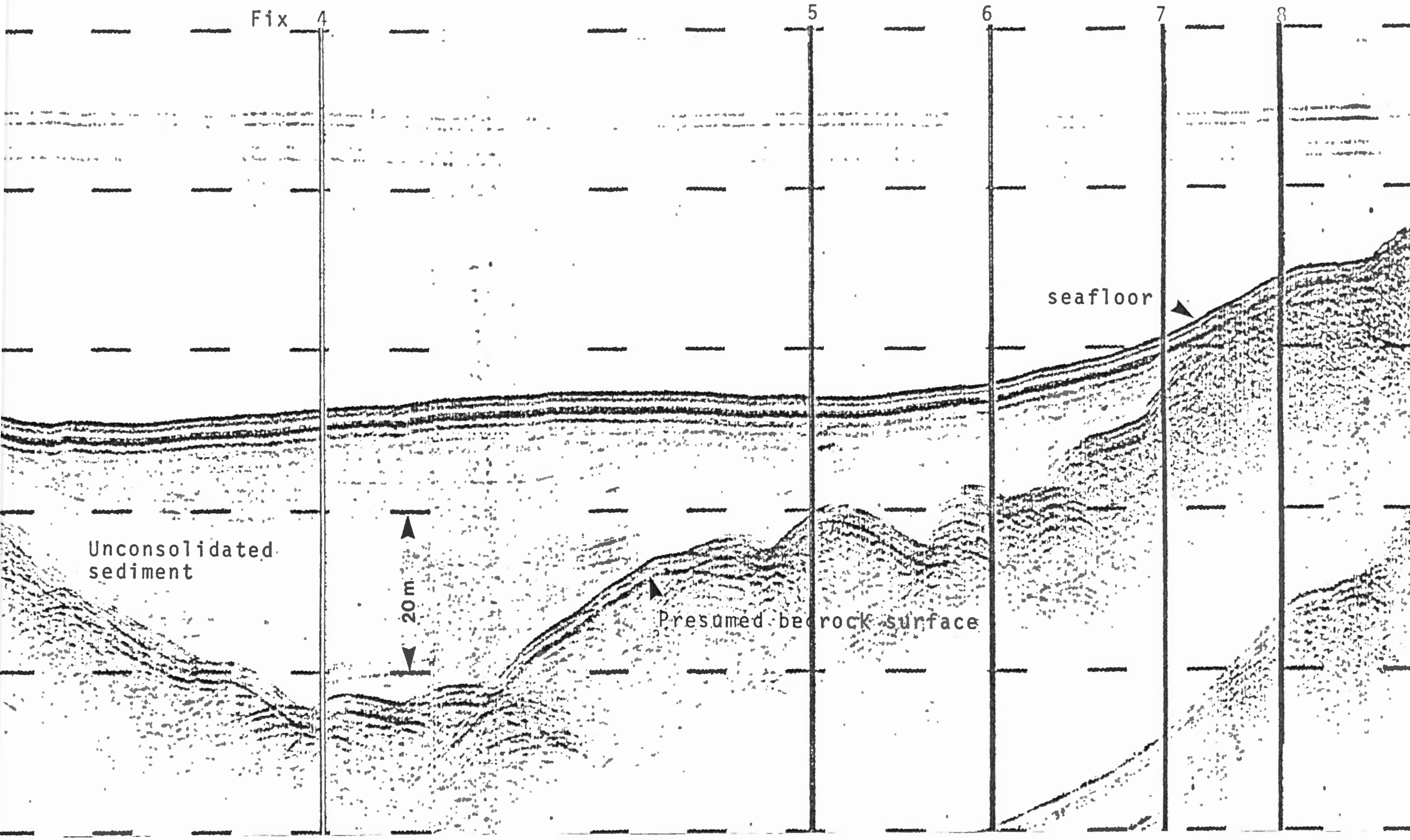
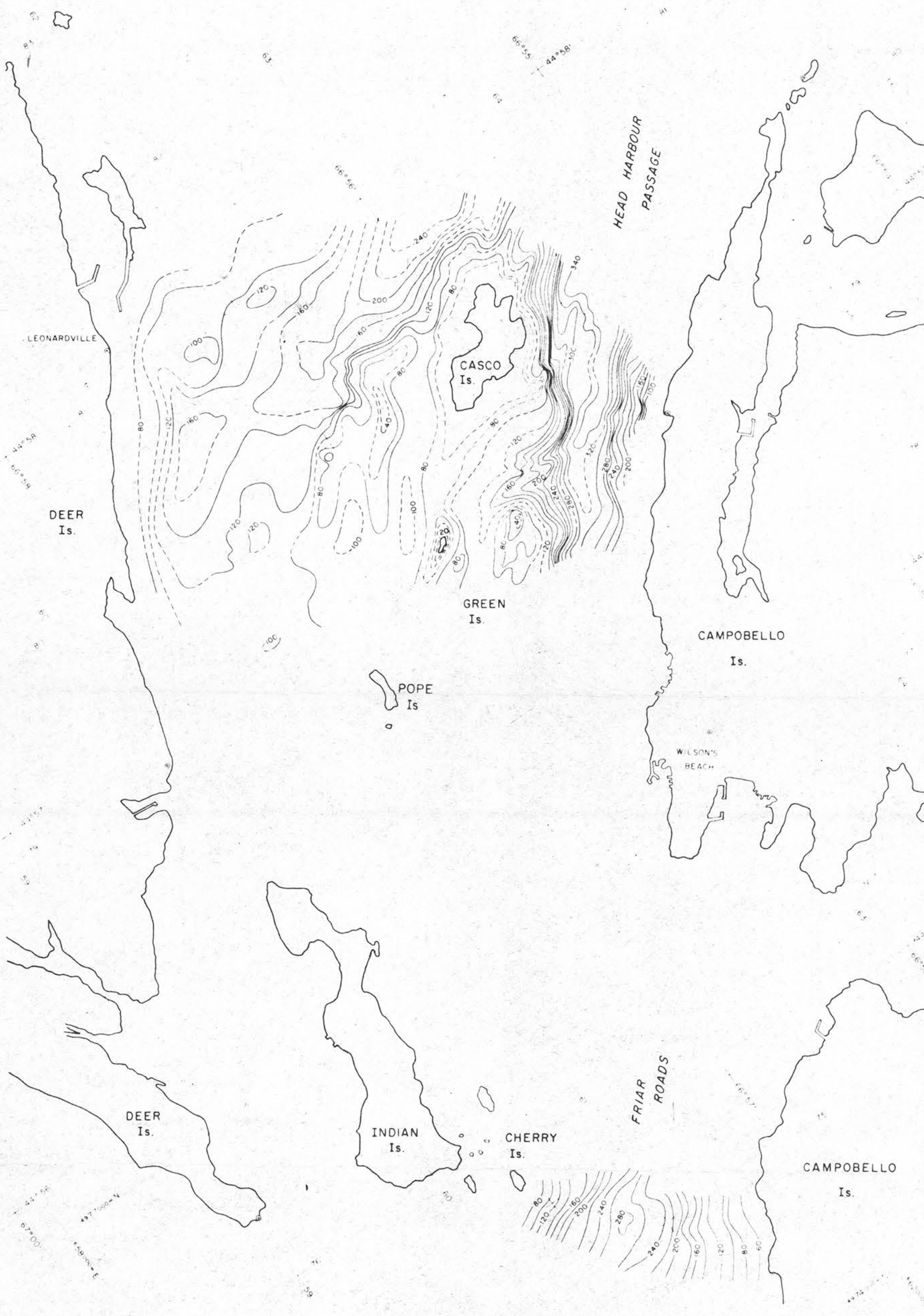


Figure 35 "Boomer" seismic profile, Line 22a, Head Harbour Passage. Note acoustic transparency of unconsolidated sediment (compare with Figure 34).



HEAD HARBOUR PASSAGE AND FRIAR ROADS
NEW BRUNSWICK
GEOPHYSICAL SURVEY OF PROPOSED CABLE ROUTES

BATHYMETRY
DATUM GEODETIC CONTOUR INTERVAL 20ft

ENCLOSURE 10	OCTOBER, 1975	SCALE 1 : 24,000
PROJECTION U.T.M.	GEOMARINE DRWG 75/13	
N.B.E.P.C. PROJECT DRAWING No		
GEOMARINE ASSOCIATES LTD. HALIFAX, NOVA SCOTIA		

FIG.31

LEGEND

ONSHORE GEOLOGY

- DEVONIAN, PERRY Fm. RED SANDSTONE AND CONGLOMERATE
- SILURIAN (*UNDIFFERENTIATED*) VOLCANIC ROCK, SHALES, SLATES
- FAULT

OFFSHORE GEOLOGY

- BEDROCK (*EXPOSED OR PARTIALLY COVERED BY A VENEER OF SEDIMENT*)
- SEDIMENT: MUD, SAND, AND GRAVEL
- CURRENT - INDUCED SAND RIPPLES
- CURRENT-INDUCED SAND DUNES
- 75/13/15 SEDIMENT SAMPLE STATIONS
- 3 .. 6 75/13/19 REMOTE SEAFLOOR PHOTOGRAPHY STATION; SERIAL FIXES INDICATED

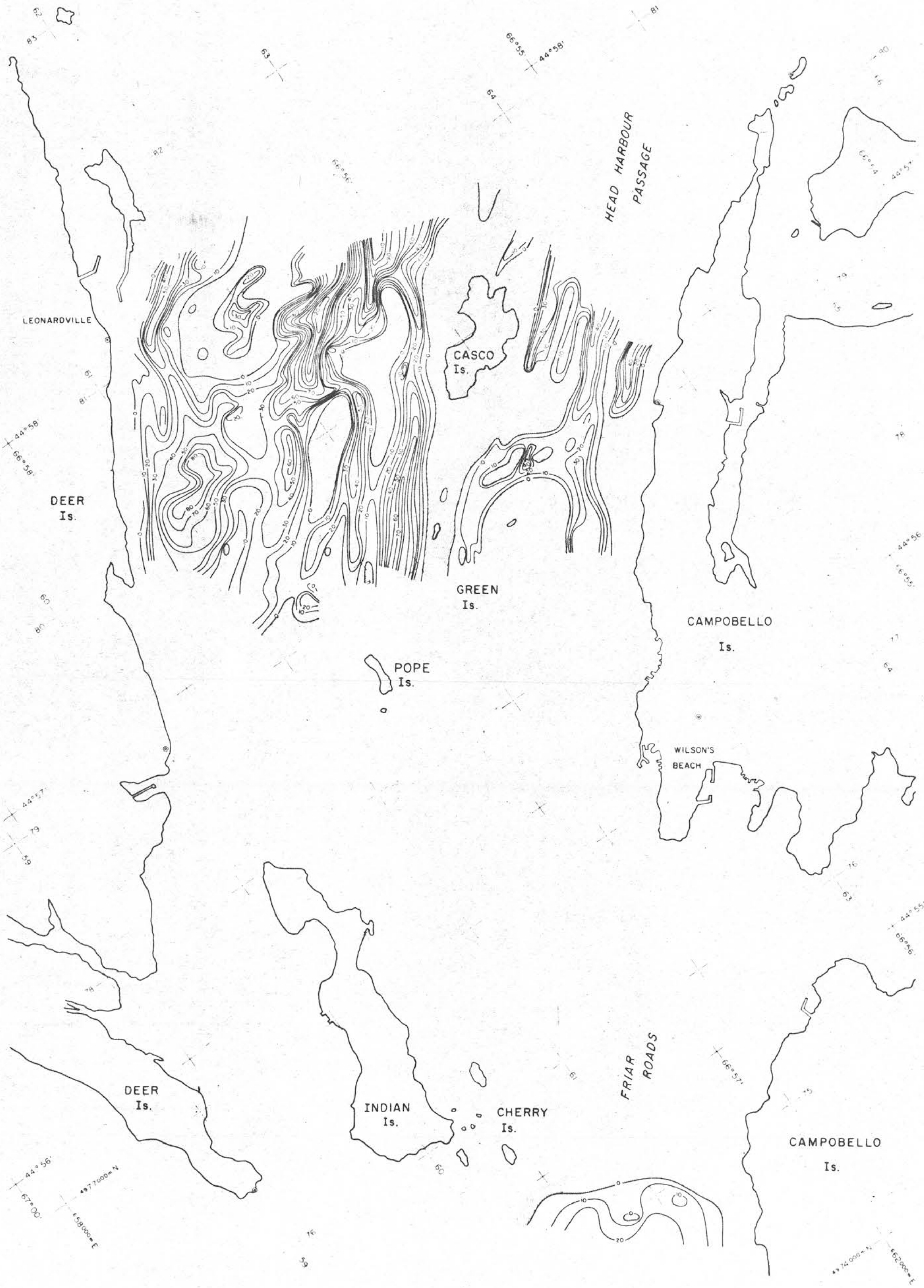
HEAD HARBOUR PASSAGE AND FRIAR ROADS
NEW BRUNSWICK
GEOPHYSICAL SURVEY OF PROPOSED CABLE ROUTES

SURFICIAL GEOLOGY

ENCLOSURE 11	OCTOBER 1975	SCALE 1:24,000
PROJECTION: U.T.M.	GEOMARINE DRWG 75/137	
N.B.E.P.C. PROJECT DRAWING No.		

GEOMARINE ASSOCIATES LTD. HALIFAX, NOVA SCOTIA

FIG. 32



LEGEND

BEDROCK (EXPOSED OR COVERED BY A VENEER OF SEDIMENT)

HEAD HARBOUR PASSAGE AND FRIAR ROADS NEW BRUNSWICK GEOPHYSICAL SURVEY OF PROPOSED CABLE ROUTES		
THICKNESS OF UNCONSOLIDATED SEDIMENT *CONTOUR INTERVAL: 10 Ft.*		
ENCLOSURE 13	OCTOBER 1975	SCALE 24,000:1
PROJECTION U.T.M.	GEOMARINE DRWG 75/137	
N.B.E.P.C. PROJECT DRAWING No.		
GEOMARINE ASSOCIATES LTD. HALIFAX, NOVA SCOTIA		

FIG. 33

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ACKNOWLEDGEMENTS

Geomarine Associates Ltd and the author gratefully acknowledge the assistance of those who participated in the field program. The skill and patience of the survey vessel crew, Ivan Green, Gleason Green and Emery Guptill contributed substantially. Their advice on local marine conditions also proved immeasurably valuable. The assistance of Wiley McDowell of General Marine Service (1972) Ltd during mobilization was appreciated. The persistent efforts of Bill Latter and Ed Williams of ComDev Marine in dealing with the navigational and control aspects of the survey is gratefully acknowledged. Similarly, we thank O.R.E. engineer, Dick Blidberg and technician, Ron Panton for their support as operators of the side-scan sonar and seismic profiling systems. Finally, we would acknowledge the calm support and encouragement extended by the representatives of the New Brunswick Electric Power Commission, Bob Mundle and Claude Gallant, the project engineer.

PLATES

Plate 1 M/V BONNY BROOK (center), North Head. Note gallows frame, adjacent the house.

Plate 2 Gallows frame with ribbon-faired side-scan sonar cable in place.

Plate 3 Gallows frame and ribbon-faired side-scan sonar cable, during towing operation. Helmsman standing to the left.

Plate 4 O.R.E. side-scan sonar tow winch and ribbon-faired cable looking to port with engine box in foreground.

Plate 5. Loading operations at Seal Cove. "Boomer" catamaran is in the air, 220 volt diesel generator in foreground, O.R.E. winch and electronics in background. Crew members are Gleason Green (foreground), Dick Blidberg (left) and Ron Panton (right).

Plate 6 O.R.E. deep-tow side-scan sonar/3.5 kHz profiler fish - off Northern Head, Grand Manan "The Bishop" rock in the background.

Plate 7 O.R.E. side-scan/3.5 kHz profiler fish. Side-scan transducers extend from holes in the housing.

Plate 8 Shipek sediment grab. Contact with seafloor allows cylindrical weight to fall on trigger, causing spring-loaded bucket to rotate, scooping up a sample.

Plate 9 "Boomer" catamaran with transducer visible beneath. Seal Harbour. Crew member is Ron Panton.

Plate 10 "Boomer" catamaran, underway.

Plate 11 ELAC echo sounding transducer (submerged) and mounting assembly.

Plate 12 Geomarine's remote deep-sea camera. Camera is at top of frame, strobe at bottom of frame. Compass protrudes into camera field of view from the base of the frame.

Plate 13 Transponder station on South Wolf Island. Transponder is mounted on tripod. Thermal generator and propane supply are shown at center left and center. Crew member is Ed Williams.

Plate 14 Southeast coast of Casco Island in Head Harbour Passage. Outcrops of Perry Formation conglomerate form the cliffs.

Plate 15 N.B.E.P.C. Head Harbour Passage power cable landing on Deer Island, south of Leonardville.

Plate 16 Leonardville Light on Deer Island.

Plate 17 Green Island, in Head Harbour Passage, from the northeast.

Plate 18 Cherry Island in Friar Roads. Perry Formation conglomerates form the shoreline. Buildings appear to house generators for the navigation beacon.

Plate 19 Seafloor Photo Station 75/13/4 (GAF 500 film believed to have been improperly developed) Flash No. 3, Grand Manan Channel, Depth 199 ft (60.6 m). Coarse sand to fine gravel-sized shell debris in the sand wave deposit off Long Eddy Point. (Frame 1A-2).

Plate 20 Seafloor Photo Station 75/13/4 (GAF 500 film believed to have been improperly developed) Flash No. 11, Grand Manan Channel, depth 202 ft (61.5 m). Crest of a sand wave composed of coarse sand to fine gravel-sized shell debris, Long Eddy Point. (Frame 10A-11.)

Plate 21 Seafloor Photo Station 75/13/5, Flash No. 5. Grand Manan Channel, depth 798 ft (90.8 m). Seafloor mottling may result from biological growth on cobbles or from biological churning of seafloor. Several cobbles observed. (GAF 500 film believed to have been improperly developed.) (Frame 4A.)

Plate 22 Seafloor Photo Station 75/13/6, Flash No. 11. Grand Manan Channel, depth 332 ft (101.2 m). Note numerous cobbles. Cobbles and pebbles partially obscured by biological growth. (GAF 500 film believed to have been improperly developed.) (Frame 10.)

Plate 23 Seafloor Photo Station 75/13/20 (GAF 500 film believed to have been improperly developed), Flash No. 3, Head Harbour Passage. Depth 104 ft (31.7 m). Moderately well-sorted shell debris, gravel-sized. (Frame 10A.)

Plate 24 Seafloor Photo Station 75/13/22 (GAF 500 film believed to have been improperly developed), Flash No. 1, Head Harbour Passage. Depth 106 ft (32.3 m). Several cobbles observable, surrounded by finer-grained sediment. (Frame 1A.)

Plate 25 Seafloor Photo Station 75/13/23, Flash No. 2, Head Harbour Passage. Depth 97.0 ft (29.6 m). Poorly-sorted mixture of pebbles, shells and finer material.

Plate 26 Seafloor Photo Station 75/13/25, Flash No. 1, Head Harbour Passage. Depth 280 ft (85.4 m), cobble and fine gravel mixture, supporting considerable biological growth.

Plate 27 Seafloor Photo Station 75/13/25, Flash No. 3, Head Harbour Passage. Depth 300 ft (91.5 m). Cobble and fine gravel mixture, supporting considerable biological growth.

Plate 28 Seafloor Photo Station 75/13/18, Flash No. 4. Gravel bottom supports abundant benthonic fauna. Depth 274 ft (83.5 m).

Plate 29 Seafloor Photo Station 75/13/19, Flash No. 1. Gravel bottom supports abundant benthonic fauna. Depth 264 ft (80.5 m).

APPENDICES

APPENDIX 1

INFORMAL STUDY OF WHALE COVE, GRAND MANAN ISLAND

Whale Cove, Grand Manan is considered an alternate to Long Eddy Point as a landing site for the Grand Manan Channel cable. Plate 30 is a photo of Whale Cove from the North. Whale Cove was studied by the ACCESS Group (ACCESS, 1972) in a previous survey. A Klein side-scan sonar system was towed along a number of survey lines. During the 1975 survey by Geomarine Associates Ltd, a single line was run from Long Eddy Point into Whale Cove. This informal line was run essentially on dead-reckoning because the Trisponder System installation had not been set up to serve the Whale Cove area. References to geographic features of the shoreline were recorded and the position of the line reconstructed from this information. The ACCESS and Geomarine lines were plotted on a base map, Enclosure 16 (Figure 36). This base map is derived from an enlargement of C.H.S. Chart as used by the ACCESS Group in 1972. A brief study of the Kline side-scan sonograms and of the O.R.E. side-scan sonograms, 3.5 kHz and "boomer" seismic profiles collected in 1975 was completed. The depth of the deepest observable reflector on seismic records, presumed to be bedrock, was measured and contoured as thickness of unconsolidated sediment. Features of the seafloor as observed on side-scan sonograms were interpreted and plotted in Enclosure 17 (Figure 37) along with unconsolidated sediment thickness contours.

The sediments at the entrance to Whale Cove are acoustically transparent to 3.5 kHz energy, indicating a substantial mud content in the sub-surface material. Flanking the submarine bedrock exposures, the sediments are commonly ripple-marked. This suggests their composition as sand.

A notable feature of the smooth sediment seafloor in central or outer Whale Cove is the abundance of bottom-trawl otterboard markings. These are best seen on the O.R.E. side-scan sonograms of 1975. The apparent popularity of Whale Cove for this mode of fishing indicates that consideration must be given to protecting the cable in this area if Whale Cove is chosen as the landing site.

Plate 30 Photo of Whale Cove taken from the North.

APPENDIX 2

REVIEW OF EXISTING HORIZONTAL CONTROL AND ADDITIONAL CONTROL SURVEY

The following is a (verbatim) report submitted by ComDev Marine Ltd and written by Mr. Edward Lancaster-Williams who acted as navigator during the geophysical surveys.

T A B L E   O F   C O N T E N T S

Introduction

Owing to the necessity to commence and complete the cable crossing surveys before the deterioration of sea and weather conditions towards the end of the survey season, there was insufficient time to carry out the necessary control work prior to the mobilisation of the survey in the field. Time permitted only a brief reconnaissance to be made of the area to determine likely locations for the Trisponder remote stations.

These locations were chosen to give good coverage in the survey areas, and were on known control stations wherever possible. Existing control stations in the survey area originates from six different agencies, and the co-ordinate values of these stations are not necessarily correlated with the values of neighbouring stations.

During the survey, discrepancies were noted between the positions of the survey vessel when using different combinations of Trisponder remote stations indicating in this case, errors in the co-ordinate values used.

On completion of the marine work it was therefore imperative that a programme of horizontal control observations should be carried out in order to tie the trisponder locations together in a single self checking network.

Section 1.

The Existing Horizontal Control

The existing horizontal control in the area originates from six different agencies: -

1) Geodetic Survey of Canada (G.S.C.)
2) Canadian Hydrographic Service (C.H.S.)
3) Topographic Survey (TOPO.)
4) New Brunswick Provincial Survey (N.B.P.S.)
5) International Boundary Commission (I.B.C.)
6) New Brunswick Electric Power Commission (N.B.E.P.C.)

These agencies each establish control stations to suit their individual needs, and the majority of stations were not suitable for the requirements of this survey. During the reconnaissance, previously selected stations proved to be unsuitable or irrecoverable.

It was hoped during the initial planning stage for this survey to make full use of previously co-ordinated lighthouse structures for the majority of the trisponder locations with a commanding view over the survey area, and with a readily available power supply at most structures to keep the batteries charged. However, the CHS had not been recently in the area and only approximate positions were available from government agencies.

A revised selection of trisponder locations was made, making use of the control stations available, and establishing new stations where required. The following stations were used during the survey: -

Long Eddy Lt. Ho.	Grand Manan	Co-ordinates from NBEPC
Wolves 18107	S. Wolf Island	" " GSC
Whitehorse	Whitehorse Is.	" " GSC
Head Harbour Lt. 18127	Campobello Island	" " GSC
16781	Campobello Island	" " NBPS
16755	"	" " "
16761	"	" " "
16765	"	" " "
Notice Board	"	New Station
Leanordville Lt.	Deer Island	New Station
Choc (1110)	"	Co-ordinates from CHS
Deer Island Pt. Lt.	"	New Station

The following stations were reconnoitred but not used.

Station	Source	Remarks
Campobello		
E. Campobello 18109	GSC	Inaccessible to vehicular transport.
Han	CHS	Not found.
Head Harbour Lt. 18127	GSC	Wrongly positioned.
Frians Head	IBC	Not found.
Owen	CHS	Not found.
W. Campobello 18111	GSC	Found, but blocked by trees.
1700	NBEPC	Not found.
Campobello	IBC	Found, but not of use.
16782	NBEPC	Destroyed.
Grand Manan		
Indian 1131	CHS	Destroyed.
Post 48 Dark Harbour	Topo	Destroyed.
Grand Manan	IBC	Not found.
Ash 1118	CHS	Not found.
Bishop 1119	CHS	Not found.
Grand Manan 09101	GSC	Found, but blocked by trees.

DEER ISLAND

MONUMENT RECORD

SURVEYS AND MAPPING BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

FILE CODE 44-66 NW

MONUMENT CHOC (1110)

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE			
FIELD OFFICER		LATITUDE	44 56 52.738		
TYPE OF SURVEY	Triangulation	LONGITUDE	66 58 14.531		
SOURCE	Hydrographic	DATUM	N.A. 1927		
MONUMENT TYPE	Rock Post	UTM NORTHINGS	4,975,958.09	✓	
DATE PLANTED	1948	UTM EASTINGS	660,089.12	✓	
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS	134.0'		
THEODOLITE		LEVELLING METHOD			

CHOC (1110)

Description: The station is situated on a summit just north of Chocolate Cove, Deer Island, N.B. It is marked by a Canadian Hydrographic rock post cemented in a granite boulder. This station can readily be reached by boat to the wharf in the cove and from the shore across from the wharf there is a path that leads to the summit where the station is located.

MONUMENT RECORD

SURVEYS AND MAPPING BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

#18106

FILE CODE: 44-66 NW

MONUMENT WHITEHORSE

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE			
FIELD OFFICER		LATITUDE	44 59 30.760		
TYPE OF SURVEY	Triangulation	LONGITUDE	66 52 20.916		
SOURCE	Geodetic	DATUM	N.A. 1927		
MONUMENT TYPE	Bronze Tablet	UTM NORTHINGS	4,984,032.83		
DATE PLANTED	1918-1962	UTM EASTINGS	667,710.09		
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS	100.0		
THEODOLITE		LEVELLING METHOD	(Trig)		

Whitehorse

Description: Located on the summit of a small gull island in Passamaquoddy Bay, situated halfway between the eastern end of Campobello Island and Bliss Island. Reached by launch from any of the harbours in the bay, the nearest being Head Harbour, three miles distant on the island of Campobello. Marked by a bronze tablet surrounded by a triangle and stamped with the station number 18106. A reference arrow is cut in a nearby outcrop of rock. Note: There was a wooden tripod over the station mark in 1962.

Elevation: 100.0' (TRIG)

MONUMENT RECORD

FILE CODE 44-66 NW

SURVEYS AND MAPPING BRANCH

#18107

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MONUMENT WOLVES

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE			
FIELD OFFICER		LATITUDE	44 56 11.987		
TYPE OF SURVEY	Triangulation	LONGITUDE	66 44 05.109		
SOURCE	Geodetic	DATUM	N.A. 1927		
MONUMENT TYPE	Bronze Tablet	UTM NORTHINGS	4,978,193.68		
DATE PLANTED	1918-1962	UTM EASTINGS	678,738.18		
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS	None		
THEODOLITE		LEVELLING METHOD			

Wolves

Description: Located on the southern end of South-West Wolf Island in Charlotte county, N.B. The island is the most southerly of a group known as "The Wolves", off the eastern end of Grand Manan Channel, Bay of Fundy. Reached by launch from any of the harbours in the bay, the nearest being Welchpool on Campobello Island from which it is distant about 17 miles. The point of 145.88 feet from the centre of the lighthouse tower on a rounded outcrop of grey granite. The station is coincident with a previous station of the U.S. Coast and Geodetic Survey. Marked by a copper bolt surrounded by a triangle, and stamped with the station number 18107 in 1962. Note: The top of the tablet has been removed. The stem marks the station.

MONUMENT RECORD

FILE CODE 44-66 NW

TOPOGRAPHICAL SURVEY
SURVEYS AND MAPPING BRANCH
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

18127

MONUMENT. HEAD HARBOUR L.

MAP SHEET	21-B-15				
PROVINCE	N.B.	DATE	Aug., 1961		
FIELD OFFICER		LATITUDE	44 57 29.50		
TYPE OF SURVEY	Triang.	LONGITUDE	66 54 01.22		
SOURCE	Geodetic	DATUM	N.A. 1927		
MONUMENT TYPE	L.H.	UTM NORTHINGS	4,980,233.8		
DATE PLANTED	1918	UTM EASTINGS	665,610.7		
FIELD BOOK NO.		ZONE	19		
AIR PHOTO NO.		ELEVATIONS			
THEODOLITE		LEVELLING METHOD			

Head Harbour L.H.

Description: Situated on the outermost rock of East Quoddy Head, northeast of Campobello Island, Charlotte County, N.B.

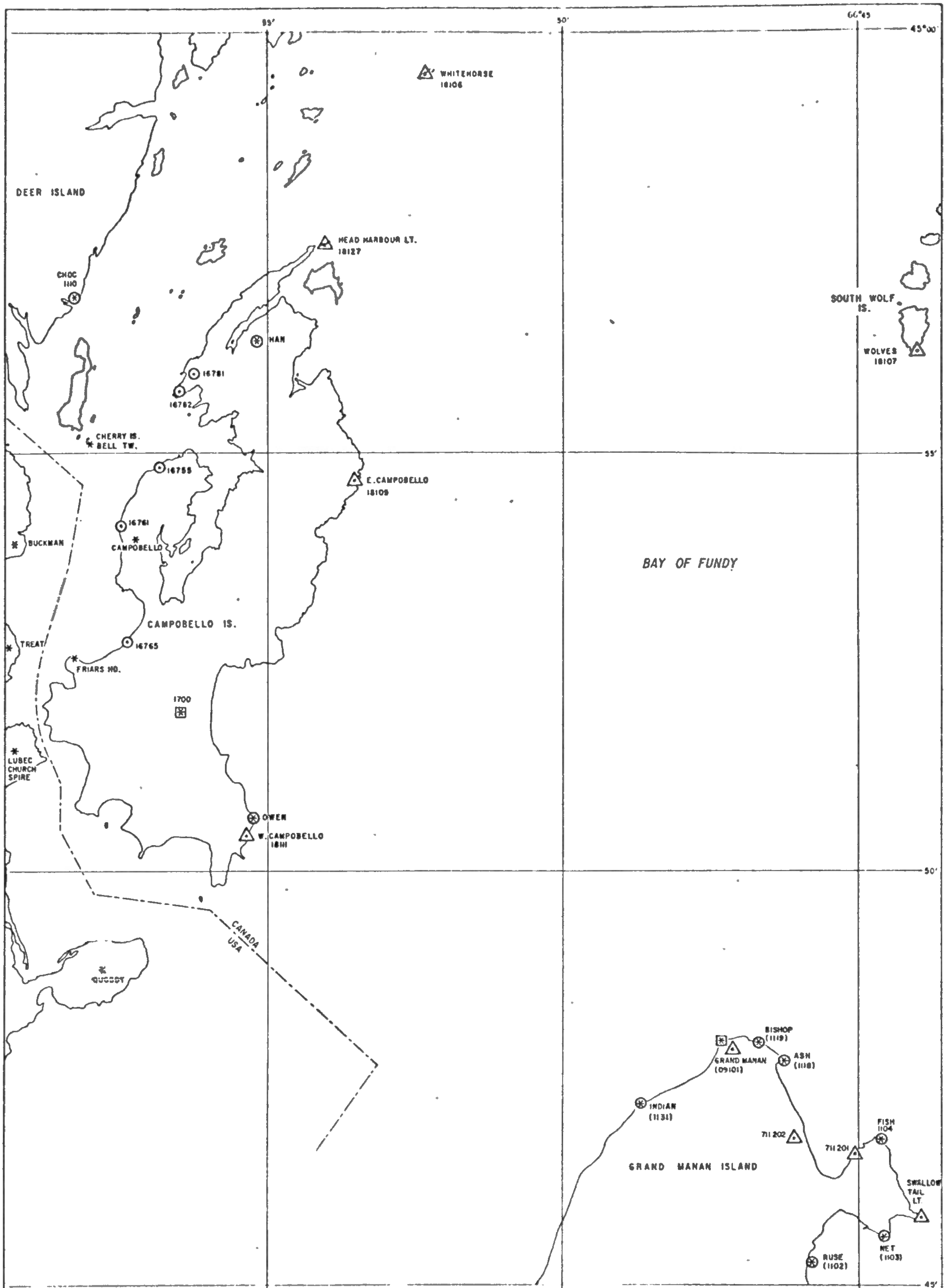


Fig. A. PERTINENT KNOWN CONTROL STATIONS

△ G.S.C. ⊛ HYDROGRAPHIC

⊙ N.B ⊡ TOPOGRAPHIC

* I.B.C. ⊠ N.B.E.P.C.

Section 2.

Methodology

It was planned to base the observed network of horizontal control on a series of interlinked geometrical figures that would be self-checking for gross errors. A base line between two GSC first order control stations, Wolves and Whitehorse, was established. Upon the accuracy of these positions depended the scaling and orientation of the network. The braced quadrilateral taking in stations Whitehorse, Wolves, Long Eddy and Head Harbour Lt. Ho. provided a mathematically rigorous method to tie Long Eddy into the network, without incurring an appreciable depreciation in accuracy over the long distances. The western end of the network tied into three known stations, Choc, 16781, and 16755, to give comparison between this present work and past work by other agencies.

Angular measurements were taken at each of the trisponder locations to prominent station marks erected at the unmarked stations, using a 1 second theodolite. At most of these locations, a false station had to be established, and considerable care was taken in order that little error was introduced by such an offset. All theodolite observations were carried out using the methods and techniques accepted by the Geodetic Survey of Canada to achieve at least third order accuracy of work or better.

The base line distance was measured by tellurometer to confirm the base line length, and several other key distances were measured also, to provide a check on the final calculated distances.

In the past, the stations used that had been established by the different agencies, were probably not tied into an all embracing network. For this reason, it was decided to use the co-ordinate values of this present work for the survey, rather than the existing values. It can be seen in Section 5 that the difference in the values will not affect the plotting of the work. During this control work, access to the offshore islands and transportation between Deer Island and Campobello was achieved by the use of local fishing boats.

The control work was progressed with the minimum of down time possible, but 3½ days down time was experienced due to bad weather or unfavourable visibility conditions.

Section 3

Equipment And Personnel

The additional control observations were carried out by the following personnel:-

E.J. Lancaster-Williams - Surveyor in charge

M. Lambert - Assistant

The following equipment was used:-

1 Kern DKM 2-A and tripod

1 CA1000 Tellurometers and tripods

1 Hire car

6 Station Markers

Section 4

Chronology

15 October

1200 Personnel arrived St. John's airport.

p.m. Moved into 45th Parallel Motel, Deer Island.

16 October

Low visibility, thunder and rain all day.

Arranged hire of local fishing boat.

17 October

Erected survey marker at Choc.

Completed observations at Wolves and Whitehorse.

M. Lambert landed at Wilsons Beach, Campobello.

18 October

Low visibility and rain all day.

19 October

Completed observations at Choc and Leonardville on Deer Island.

20 October

a.m. E.J.L. Williams transferred to Campobello.

Completed observations at Notice Board.

p.m. Low visibility and rain all afternoon.

<u>21 October</u>

Strong winds and haze prevent productive work.

<u>22 October</u>

a.m. Completed observations at Head Harbour Lt.

p.m. E.J.L. Williams transferred to Grand Manan.

Haze and oncoming dusk prevent observations at Long Eddy.

<u>23 October</u>

a.m. Completed observations at Long Eddy.

p.m. Returned to St. John's Airport and returned to Ottawa.

Section 5

Summary of Observations and Adjustment

Description of Stations Co-ordinated

WOLVES

Bronze tablet No. 18107 established by GSC, situated 145.88 ft. SW of South Wolf Island Light House.

WHITEHORSE

Bronze tablet No. 18106 established by GSC, situated on the summit of Whitehorse Island.

HEAD HARBOUR LT. HO.

Centre of Light.

LONG EDDY LT. HO.

Centre of Light.

LEONARDVILLE LT. HO.

Centre of Light.

CHOC

Bronze tablet No. 1110 established by CHS, situated on a summit just north of Chocolate Cove.

DEER ISLAND PT. LT.

Centre of Light.

STATION 16781

Bronze tablet No. 16781 established by New Brunswick Provincial Survey, situated on the summit of a small hill behind Wilsons Beach Church.

NOTICE BOARD

The SW support of a NBEPC Notice Board warning of Submarine Cables.

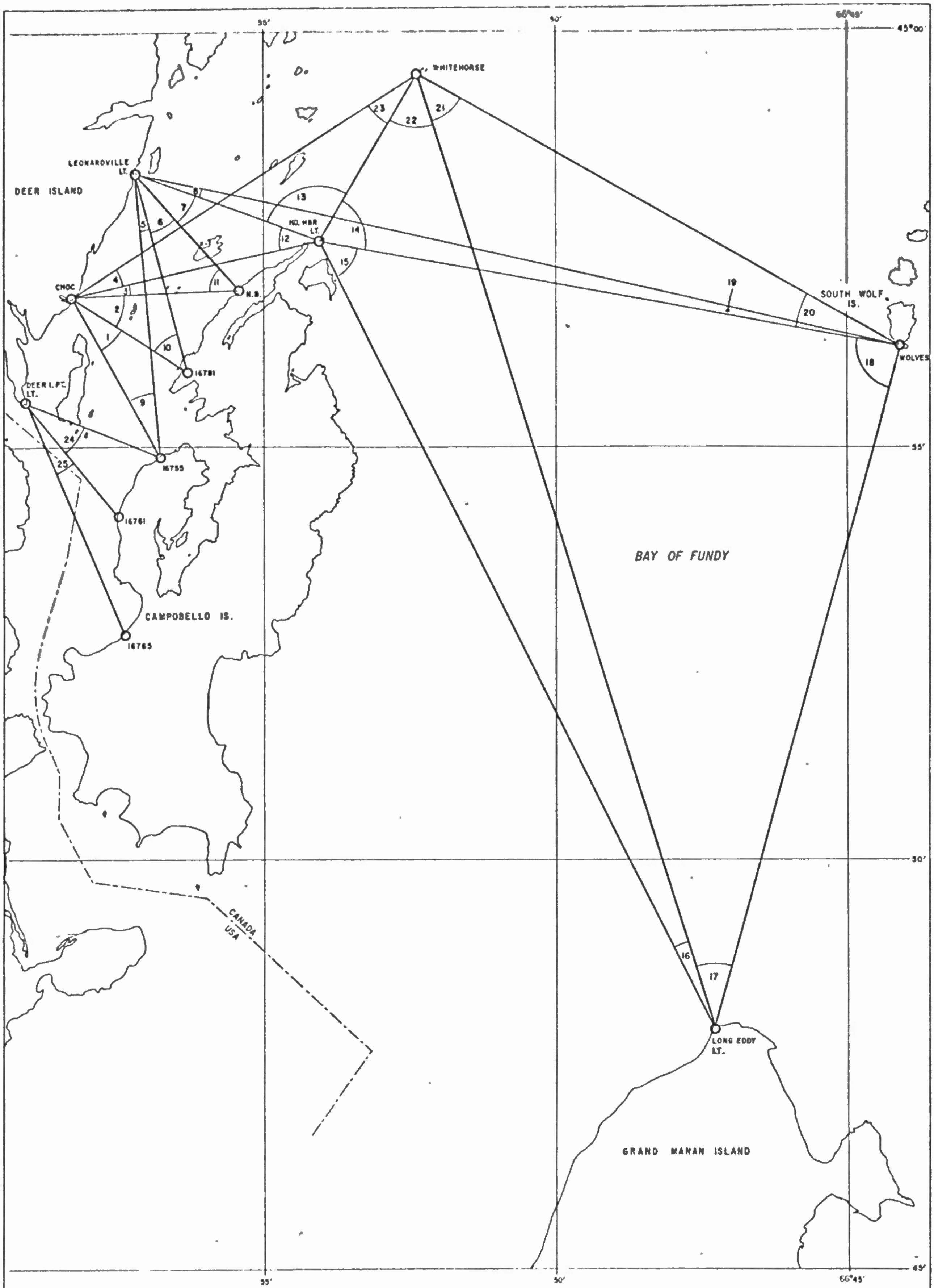


Fig. B. NETWORK OF ADDITIONAL HORIZONTAL CONTROL

CONDITION EQUATIONS USED FOR LEAST SQUARES ADJUSTMENT

A) (14) +(22) -(18) -(17) = 0

B) (15) +(16) -(20) -(19) -(21) = 0

C) (14) +(15) +(16) +(17) +(18) +(19) +(20) +(21) +(22) - 360 = 0

D) (8) +(13) +(14) +(19) -180 = 0

E) (7) +(12) -(11) -(3) = 0

F) (6) +(7) +(12) -(10) -(2) -(3) = 0

G) (5) +(6) +(7) +(12) -(1) -(2) -(3) -(9) = 0

H) (5) +(6) +(11) -(1) -(2) -(9) = 0

I) (6) +(11) -(2) -(10) = 0

J) (5) +(10) -(1) -(9) = 0

L) (4) +(12) +(13) +(23) -180 = 0

K) Sin(14) Sin(21) Sin(18) Sin(16)/Sin(15) Sin(17) Sin(20) Sin(22) = 1

Summary of Observed Angles, Corrected for False Station, & (t-T)

Angle No.	Corr. Observed Angle	Least Squares Correction	Final Adjusted Angles
1	30 43 44.1	+0.6001	30 43 44.7001
2	31 54 28.4	+2.9005	31 54 31.3005
3	11 51 50.4	-1.0981	11 51 49.3019
4	20 58 43.5	-0.3927	20 58 43.1073
5	14 44 33.5	-1.2003	14 44 32.2997
6	26 13 22.5	-2.9005	26 13 19.5995
7	27 43 47.4	+1.0981	27 43 48.4981
8	3 26 14.6	+0.4727	03 26 15.0727
9	20 07 33.0	+0.6001	20 07 33.6001
10	36 06 43.1	+2.9005	36 06 46.0005
11	41 48 01.7	-3.9985	41 47 57.7015
12	25 55 57.8	+0.7053	25 55 58.5053
13	105 39 55.2	+0.0801	105 39 55.2801
14	69 44 12.7	-2.1256	69 44 10.5744
15	52 36 28.9	-0.4674	52 36 28.4326
16	9 29 37.3	-1.0103	09 29 36.2897
17	32 32 01.8	-0.5948	32 32 01.2052
18	85 21 54.8	-0.7275	85 21 54.0725
19	1 09 38.6	+0.4728	01 09 39.0728
20	19 14 28.5	-2.5302	19 14 25.9698

Summary of Observed Angles, Corrected for False Station, & (t-T) Cont'd

Angle No.	Corr. Observed Angle	Least Squares Correction	Final Adjusted Angles
21	42 51 41.6	-2.8475	42 51 38.7525
22	48 09 47.2	-2.4967	48 09 44.7033
23	27 25 23.5 *	-0.3927	27 25 23.1073
24	26 50 38.2	-------	26 50 38.2
25	15 25 36.5	-------	15 25 36.5

* Calculated

Summary of Calculated Co-ordinates

STATION	TRIAL CO-ORDINATES		FINAL CO-ORDINATES	
WOLVES 18107	4,978,193.68N	678,738.18E	4,978,193.68N	678,738.18E
WHITEHORSE 18106	4,984,032.88	667,710.09	4,984,032.88	667,710.09
LONG EDDY LT.	4,962,867.0	675,338.2	4,962,833.41	675,108.60
HEAD HARBOUR LT.	4,980,233.8	665,610.7	4,980,196.22	665,590.07
LEONARDVILLE LT.	(4,981,220.0	661,230.0)	4,981,226.82	661,216.13
CHOC	4,978,958.09	660.089.12	4,978,958.99	660,088.63
NOTICE BOARD	(4,979,060.0	663,790.0)	4,979,011.04	663,766.13
16781	4,977,277.47	662,876.30	4,977,278.22	662,875.11
16755	4,975,282.96	662,057.29	4,975,285.53	662,056.10
DEER ISLAND PT. LT.	4,976,407.2	659,002.0	4,976,414.50	658,994.29
16761	4,974,006.45	661,230.48		
16765	4,971,494.13	661,550.65		

Owing to Trisponder Stations being offset from the calculated positions listed above, the co-ordinates of the trisponder stations are as follows.

TRISPONDER SITE	NORTHINGS	EASTINGS
WOLVES	4,978,193.68	678,738.18
WHITEHORSE	4,984,032.88	667,710.09
LONG EDDY	4,962,834.52	675,106.42
HEAD HARBOUR LT.	4,980,200.45	665,582.31

Cont'd

TRISPONDER SITE	NORTHINGS	EASTINGS
LEONARDVILLE LT.	4,981,226.35	661,217.52
CHOC	4,978,959.48	660,088.44
NOTICE BOARD	4,979,011.04	663,766.13
16781	4,977,278.49	662,875.26
DEER ISLAND PT.	4,976,413.87	658,992.57

Summary of Measured Distances

DISTANCE	CORRECT OBS. GRID DIST.	CALC. GRID DISTANCE
WOLVES-WHITEHORSE	12,478.125	12,478.583
CHOC-NOTICE BOARD	3,678.634	3,677.868
LEONARDVILLE-HEAD HARBOUR LT.	4,492.669	4,493.716
LONG EDDY LT-HEAD HARBOUR LT.	19,802.778	19,800.747
WHITEHORSE-HEAD HARBOUR LT.	4,383.412	4,383.428
DEER PT-16765	5,544.590	5,544.819
DEER PT-16761	3,286.316	3,286.221

Section 6

Conclusions

The least squares adjustment of the horizontal Control network applied corrections to the observed angles to make the network geometrically correct. The measured distances give an indication of the accuracy of the adjusted network. However, these distances were measured soley to provide a check, and are "coarse" readings. To bring the distance measurement into the same order of accuracy as the angular measurements, an average of many "fine" readings would have to be taken, and then a least squares adjustment by variation of co-ordinates would have been applied.

The accuracy of the final co-ordinate values may be approximately ascertained by the analysis of the worst case.

The longest observed line is Whitehorse to Long Eddy, being 22453 m. long. The largest error in the braced quadrilateral is 2.85 secs of arc.

Applying such an offset over that distance gives a subtended distance at Long Eddy of 0.31 m. It is therefore probable that the co-ordinates have an accuracy better than 1 metre.

Attention is therefore drawn to the differences of co-ordinates of the following stations to those published:-

1. <u>Head Harbour Lt. House</u>

Published GSC values	4,980,233.8N	665,610.7E
Calculated values	4,980,196.22N	665,590.07E
Differences	37.58	20.63
Distance Difference	42.87m.	

2. <u>Long Eddy Lt. House</u>

Published NBEPC values	4,962,867.0N	675,338.2E
Calculated values	4,962,833.41N	675,108.60E
Differences	33.59	229.60
Distance Difference	232.04m.	

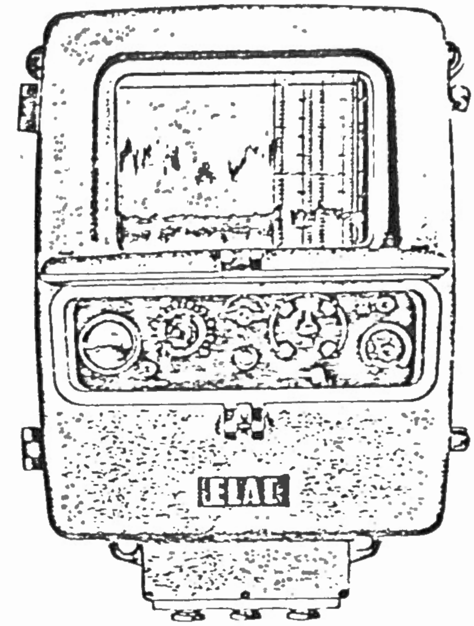
It was these errors that resulted in the requirement of additional Horizontal Control in the survey area.

APPENDIX 3

SURVEY EQUIPMENT SPECIFICATIONS

ELAC

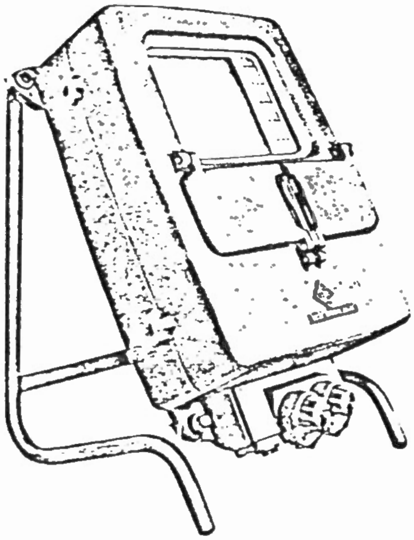
ECHOGRAPH SUPERIOR LAZ 17



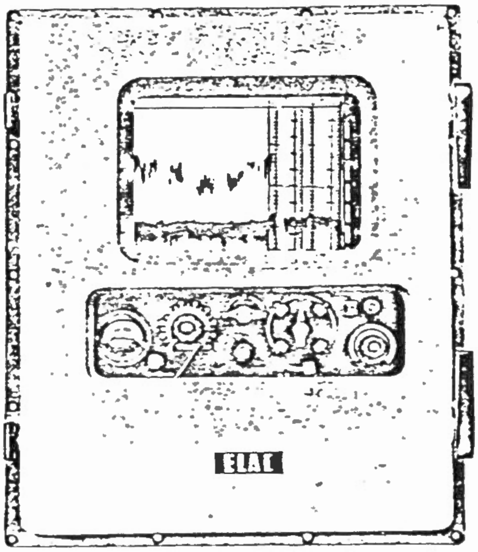
The ELAC Echograph SUPERIOR LAZ-17 is an ultrasonic echosounder giving a permanent graph indication on dry recording paper. The paper is fed horizontally from right to left with a fine-stepped and widely variable speed. The stylus moves vertically from the top to the bottom of the paper. Therefore, this results in the most comprehensive type of indication. The recording shows the pulse output as a „zero-line" at the upper edge of the paper. The echoes of plankton, fish and wrecks as well as the bottom are indicated below this as would be seen naturally.

The particular depths of water are read directly from a transparent calibrated scale in front of the paper. A large window of 19 × 26 cm (7.5 × 10.25") allows visual indication of the record at any time. The ELAC recording paper is of superior quality and gives clean indications of the echoes according to their strength in tones from light grey to black.

The unique design of the LAZ-17 allows the unit to be easily modified to meet various requirements by a simple exchange of single modular assemblies. Moreover, the LAZ-17 can be combined with other ELAC sounders and fishfinders such as the Echometer LAZ-22 or the Fishlupe LAZ-61.



LAZ 17 on mounting frame



LAZ 17 for console mounting

TECHNICAL DATA (We reserve the right to change the data in the light of future development)

STANDARD UNIT	Main- and Intermediate Ranges (fathoms)	Scale of first range in.-fath.	Soundings p. minute	Paper Feed mm / min.	Power Consumption (approx.)
CASTOR	0– 13,5 9– 22,5 0– 27 18– 45 0– 54 36– 90 0– 108 72– 180	1 ≙ 1.81	540 270 135 68	0–480 0–240 0–120 0– 60	130 W
BELLATRIX	0– 42 28– 70 0– 84 56– 140 0– 168 112– 280 0– 336	1 ≙ 5.83	160 80 40 20	0–160 0– 80 0– 40 0– 20	130 W
ATAIR ATAIR-SUPER	0– 42 28– 70 0– 84 56– 140 0– 168 112– 280 0– 336 224– 560	1 ≙ 5.83	160 160 80 40	0–160 0– 80 0– 40 0– 20	130 W
ATAIR-SPECIAL	0– 42 28– 70 55– 95 0– 84 56–140 110–190 0–186 112–280 220–380 0–366 224–560 440–760	1 ≙ 5.83	160 80 40 20	0–160 0– 80 0– 40 0– 20	130 W
ARCTURUS	0– 42 28– 70 0– 84 56– 140 0– 168 112– 280 0– 336 224– 560	1 ≙ 5.83	160 160 80 40	0–160 0– 80 0– 40 0– 20	2 kW
DENEB	0– 165 110– 275 0– 330 220– 550 0– 660 440–1100 0–1320 880–2200	1 ≙ 23.2	80 40 20 10	0– 40 0– 20 0– 10 0– 5	2 kW
DENEB-SPECIAL	0– 230 145– 375 0– 460 290– 750 0– 920 580–1500 0–1840 1160–3000	1 ≙ 29.3	60 30 15 8	0– 30 0– 15 0– 8 0– 4	2 kW
ENIF	0– 495 330– 825 0– 990 660–1650 0–1980 1320–3300 0–3960 2640–6600	1 ≙ 69.2	30 15 8 4	0– 13 0– 6,5 0– 3,25 0– 1,6	2 kW

Recording Paper:	Electrosensitive dry paper, width 204 mm (8") length / roll 25 m (76').
Marking:	By push-button on the control panel; automatic timing device and remote marker can be fitted upon request.
Operating voltage:	For 220 volts single-phase A. C. straight connection. For 12 volts up to 220 volts D. C. via static or rotary converter, either internal or external. For 110 volts, 115 volts or 127 volts single-phase A. C. via transformer.
Transducer:	Nickel, single package, permanently polarized (only one transducer for both transmitting and receiving), with 10 m or 20 m of cable. For steel hull ships, a casing of tested ship's steel is supplied. For wooden hulls, a mounting plate and hull stuffing tube is supplied.

We not only manufacture ELAC-echosounders to the highest specification for both performance and reliability, but have also taken care that sufficient spareparts and qualified service is available on all coasts at any time.

WITH ELAC-ECHOSOUNDERS, YOU SAIL AND FISH WELL ON THE SEVEN SEAS

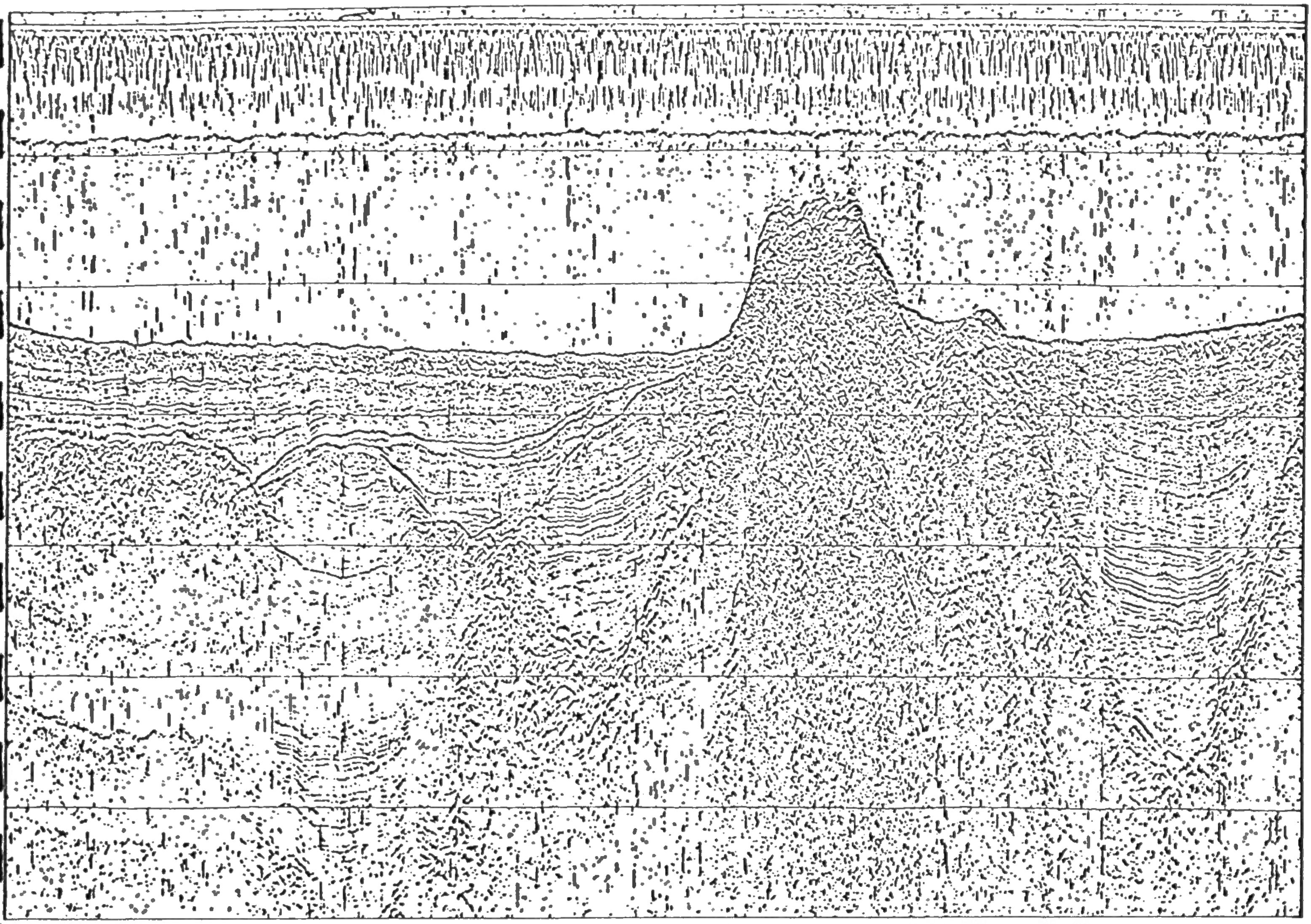
ELAC

23 KIEL 1

W.-GERMANY

1065. E (5. 20. 10. 72)

UNIBOOM™ SEISMIC PROFILING CAPABILITY



EG&G: FIRST IN COASTAL ZONE SEISMIC PROFILING

On the continental shelf, in the coastal zone, for near-surface geological surveys of every kind, the EG&G UNIBOOM Seismic Profiling System is the first choice of engineers and scientists. The reasons are good and clear.

The UNIBOOM SYSTEM is unique. It utilizes a single, broad band acoustic pulse with resolution approaching 15 cm (½ foot)... and it eliminates the heavy cavitation pulse common with standard sparkers.

Instead of the heavily-obscured, difficult-to-interpret recordings the conventional instruments produce...the UNIBOOM SYSTEM presents the investigator with a sharply-detailed record. The bottom echo appears as a precise, crisp trace...free of ambiguity. The sub-bottom interfaces below are delineated in clear, single, fine line patterns. Analysis and identification of the geological characteristics of the sub-bottom becomes a much easier matter.

The UNIBOOM system means high resolution penetration of marine bottom materials to a depth of 75 meters or more, even hard packed sand and gravel -- sediment types that defy useful penetration by ordinary systems in the 3.5-12kHz range.

It is easy to see why EG&G UNIBOOM Seismic Profiling Systems are playing vital roles in so many government, institutional, industrial and scientific programs, today: geological reconnaisance to mineral exploration, offshore platform foundation studies, harbor development and cable/pipline surveys, to name a few.

It is good reason for you to investigate the advantages of...

UNIBOOM™ SYSTEM CAPABILITY SPECIFICATIONS

Model 230-1 UNIBOOM Unit Pulse Boomer

Pulse Character

Energy Level:	@ 100 watt-seconds	@ 200 watt-seconds	@ 300 Watt-seconds
Duration:	0.2 milliseconds	0.2 milliseconds	0.2 milliseconds
Source Level:	95 db ref. 1 microbar at 1 meter	104 db ref. 1 microbar at 1 meter	107 db ref. 1 microbar at 1 meter
Spectrum:	700 Hz to 14 kHz	500 Hz to 10 kHz	400 Hz to 8 kHz
Repetition Rate:	6 pulses/second	4 pulses/second	2 pulses/second

Catamaran

Improved design features free flooding lower halves of floats for reduced buoyancy, increased inertia and less sensitivity to wave action.

Dimensions:	84 cm[W] x 59 cm [H] x 158 cm [L] [33" x 23"x62"]
Weight:	90 kg [200 lbs.]
Cable Length :	25 meters [80 ft.]
Towing Speed:	2 to 8 knots

Model 234 Energy Source

Input Power Requirements:

Voltage:	115 ± 15 VAC, 45 to 65 Hz	230 ± 30 VAC, 45 to 65 Hz
Peak Current:	100 Amperes	50 Amperes
Average Current:	30 Amperes	15 Amperes
Average Power:	2.2 Kilowatts	2.2 Kilowatts

Trigger:

Pulse Amplitude:	+ 5 to + 15 volts into 700 ohms
Pulse Width:	5 to 20 μ s [50% points]
Rise Time:	Less than 5 μ s

Manual Trigger also provided;

Charging Voltage: 3.5 Kilovolts Nominal

Output Energy:

100 Joules Nominal[16 μ f Capacitor]-Maximum Discharge Rate 6 pps
200 Joules Nominal[32 μ f Capacitor]-Maximum Discharge Rate 4 pps
300 Joules Nominal[48 μ f Capacitor]-Maximum Discharge Rate 2 pps

Life Expectancy: 10 million discharges without component replacement at any output energy specified.

Dimensions: 51 cm [W] x 48 cm [H] x 56 cm [D] [20" x 19" z 22"]
Weight: 73 kg [160 lbs.]
Safety Features: Cover Interlock •Dump Relay•Shunt Resistors•Circuit Breaker

Model 265 Hydrophone

Input Power:	transistor battery
Sensitivity:	-70 db/volt/microbar
Bandwidth:	100 Hz-10 kHz
Maximum Tow Speed:	15 knots
Tow Depth:	0—30 meters (0—100 ft.)
Output Connection:	BNC Connector
Tow Cable	
Length:	30 m [100 ft.]
Diameter:	1.25 cm [½"]
Breaking Strength:	115 kg. [250 lb.]

Active Section:	
Number of Elements:	8
Length:	4.6 m [15 ft.]
Diameter:	25 mm [1"]
Weight:	3.2 kg [7lbs.]
	neutral buoyancy
Preamplifier	
Gain:	40 db
Output Impedance:	2k ohms
Tail	
Length:	9.1 m [30 ft.]
Diameter:	6 mm [¼"]

FOR FURTHER DETAILS OR INFORMATION REGARDING A DEMONSTRATION,CONTACT:

EG&G ENVIRONMENTAL EQUIPMENT DIVISION
151 Bear Hill Road, Waltham, Mass. 02154•Tel: (617) 890-3710•TWX: (710) 324-7648•TELEX: 92-3429
• Cable: EGGINTER

O. R. E. SUB-BOTTOM PROFILING SYSTEM, MODEL 1036

Description:

The O. R. E. Model 1036 multi-frequency, Sub-Bottom Profiling System is an easily handled, portable unit capable of obtaining high resolution sub-bottom profiles while operating at vessel speeds up to 12 knots.

The system includes the following components:

1. O. R. E. Model 136, 3.5 kHz - 7.0 kHz, Towed Transducer Vehicle and Faired Cable Assembly.
2. O. R. E. Model 140, 10 kw Transceiver with continuously adjustable frequency from 1 kHz - 12 kHz and automatic bottom tracking Time Varying Gain.
3. Standard 19" wet or dry paper **Precision Graphic Recorder.**
4. O. R. E. Model 115 Hand Powered Winch, designed to accommodate faired cable.

Additional Models available include:

Model 1032 with 3.5 kHz - 7.0 kHz, two or four element, light-weight transducer array, adapted for over-the-side mounting on small boats.

Model 1038 with 1.4 kHz, four-element Towed Transducer Vehicle, for deeper penetration.

Features:

- Continuously variable frequency from 3.5 kHz to 7.0 kHz (Model 1036 and Model 1032) permits the operator to trade off penetration and resolution while observing the record.
- Adjustable keying allows the operator to select the transmitted pulse length to optimize penetration and resolution.
- Programmed range gating allows expansion and examination of bottom structure in fine detail.
- Special techniques eliminate transducer mechanical ringing permitting clear records to be obtained in water as shallow as five feet.
- Output power is adjustable to 10 kw, far higher than other systems, providing increased penetration and shorter pulse lengths, for higher resolution.
- Time Varying Gain triggers automatically at first bottom echo to optimize penetration without masking bottom reflection. Both TVG rate and delay are adjustable.
- Winch permits easy handling by one man. Entire unit is skid mounted, air shippable.

Applications:

The Model 1036 System, and its Model 1032 and 1038 variations, establish a new level of performance which make it possible to obtain useful information on sub-bottom structure for a number of important applications:

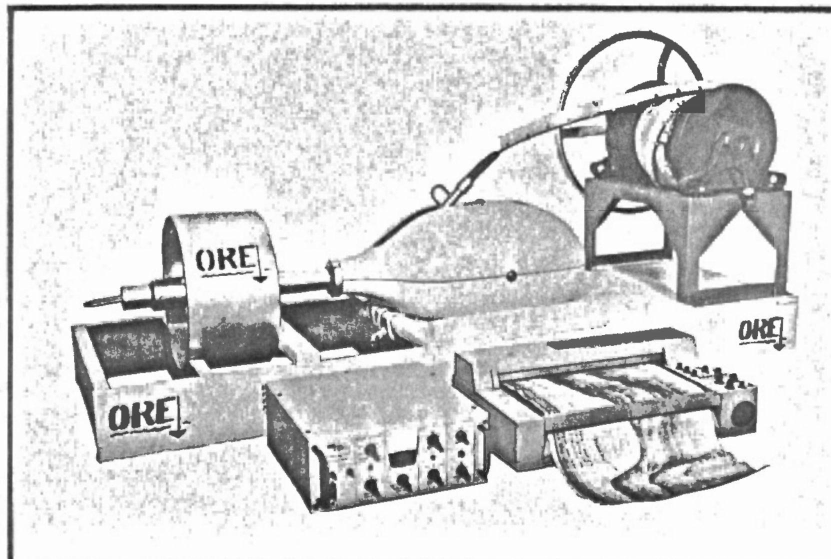
OIL EXPLORATION — Used to supplement the usual high energy seismic sources, the O. R. E. System can provide high resolution records of the first several hundred feet of sub-bottom.

CONSTRUCTION SITE SURVEY — The O. R. E. System may be used in conjunction with widely spaced corings, to obtain accurate profiles of large areas, rapidly, and at low cost.

PRE-DREDGING SURVEY — The Profiler provides an efficient, economical tool for speedy estimation of dredging problems and costs.

SAND AND GRAVEL INVENTORY — With its high power and low operating frequencies, the O. R. E. Profiling System provides sufficient penetration to map deposits of coarse sand and gravel.

POLLUTION STUDIES — Available in a lightweight configuration for over-the-side mounting on small boats, the Profiler provides a convenient tool for surveying disposal areas and for predicting future deposition of water-borne sediments.



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OCEAN RESEARCH EQUIPMENT, INC. P.O. Box 709 FALMOUTH, MASS. 02541 (617) 548-5800 TELEX 929-445

Specifications:

Transducer Array

Model 136

Frequency	3.5 kHz to 7.0 kHz
Maximum Power	10 kw at 1% duty cycle
Beamwidth	55 degrees at 3.5 kHz 40 degrees at 5.0 kHz 30 degrees at 7.0 kHz
Source Level	114 db ref. 1 μb. at 1 yd.
Vehicle Weight	270 pounds in air
Dimensions	60″ x 18″ x 14″
Cable	74 feet armored conducting cable lower 24 feet faired.

Model 132

Same transducer specifications in four-transducer configuration, but mounted on pivoting over-the-side bracket rather than in towed vehicle.

Model 138

Frequency:	1.4 kHz
Maximum Power	10 kw at 1% duty cycle
Source Level	116-118 db ref. 1 μb. at 1 yd.
Beamwidth	55 degrees
Vehicle Weight	950 pounds in air
Length	96 inches

O. R. E. Model 140 Transceiver

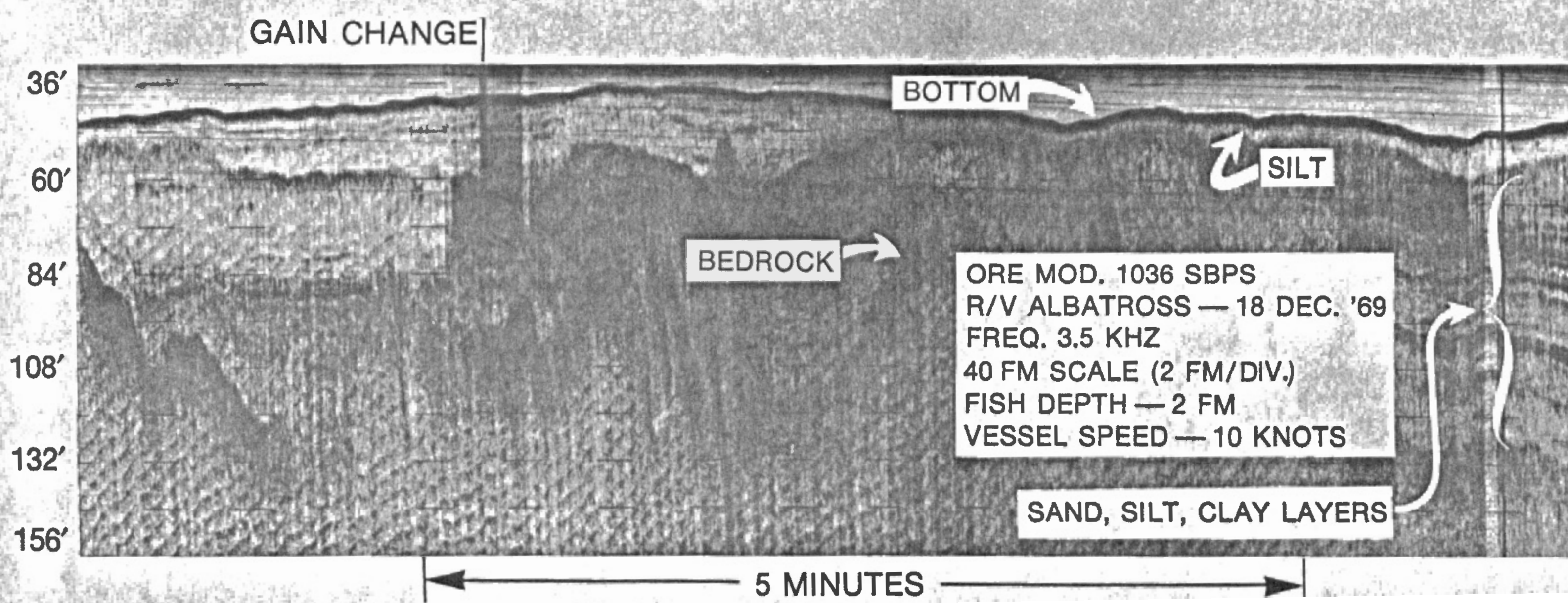
Power Output	10 kw
Transmit Frequency	Adjustable 1-12 kHz
Pulse Length	Adjustable .2 to 10 Ms.
Repetition Rate	Adjustable 1 to 10/seconds
Receiver Frequency	Adjustable 1-12 kHz
Receiver Bandwidth	Adjustable
Time Varying Gain	Adjustable rate and delay Automatic bottom tracking
Power Requirements	115 VAC ±10% 57-63 Hz, consumption 200 watts nominal.
Dimensions	17″ x 17″ x 7″ Weight — 50 pounds

Recorder

Standard 19″ wet or dry paper recorder available on request.

O. R. E. Model 115 Winch

Operation	Hand-powered, 2-speed
Capacity	Designed to handle O. R. E. Faired Cable. Maximum capacity 150 feet, 50 feet faired.
Dimensions	30″ x 15″ x 26″ Weight — 300 pounds



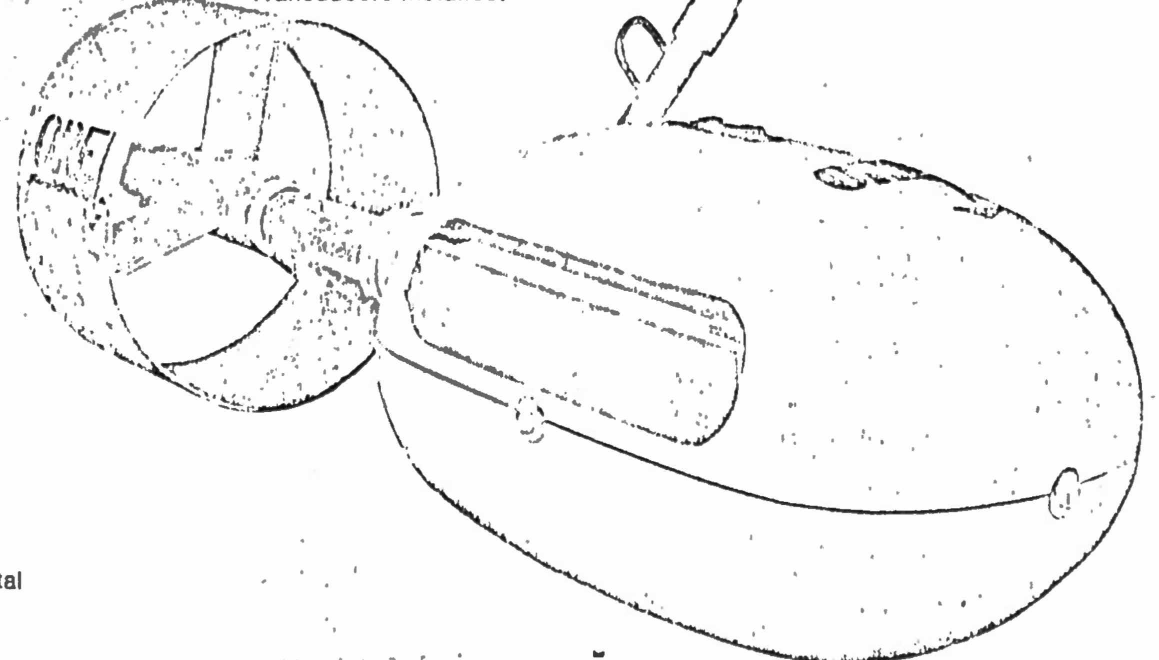
New O. R. E. Side-Scan Sonar Adapter, Model 1096

Converts O. R. E. Sub-Bottom Profiler to Dual System for Split-Trace Recording of Horizontal Seabed Topography and Sub-Bottom Structure.

Advantages

- Simplified operation — one fish, one cable, one recorder.
- More economical to own and operate than two separate systems.
- Positive position correlation between side-scan and sub-bottom profiles.
- Switch on shipboard transceiver selects left or right side scan transducer. Also available with 3-trace option for simultaneous display of left, right and sub-bottom profiles.

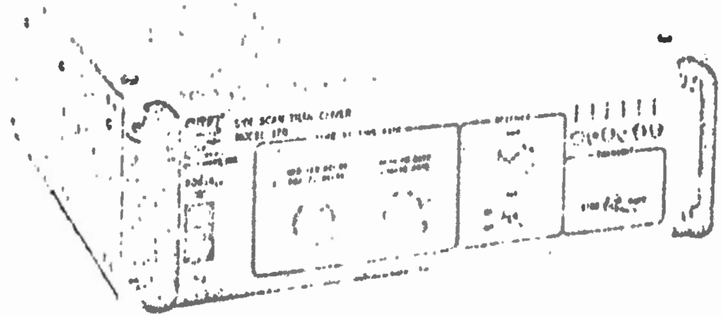
1.) Model 136 Towed Sub-Bottom Profiling Vehicle with Model 196 Side-Scan Transducers Installed.



Specifications:

Operating Frequency	96 kHz
Pulse Duration	0.1 Milliseconds
Horizontal Beamwidth	2 degrees (total)
Vertical Beamwidth	30 degrees (tilted down 10 degrees from the horizontal
Source Level	+125 db re 1 μbar at 1 yd.
Range	Up to 1,000 ft. each direction
Maximum Towing Depth	2,000 ft.
Transducers (Model 196)	Two Units, each 3" x 1.5" x 16"
Transceiver (Model 170)	5¼" x 19" x 19", rack mountable, wt. 35 lbs.
Input Voltage	115VAC, 50-60 Hz
Input Power	75 watts
Cable	Armored 4 conductor, 100 ft. or 1,000 ft. lengths. Other lengths available.

Specifications subject to change without notice.



2.) Model 170 Side Scan Transceiver

ComDev | Marine

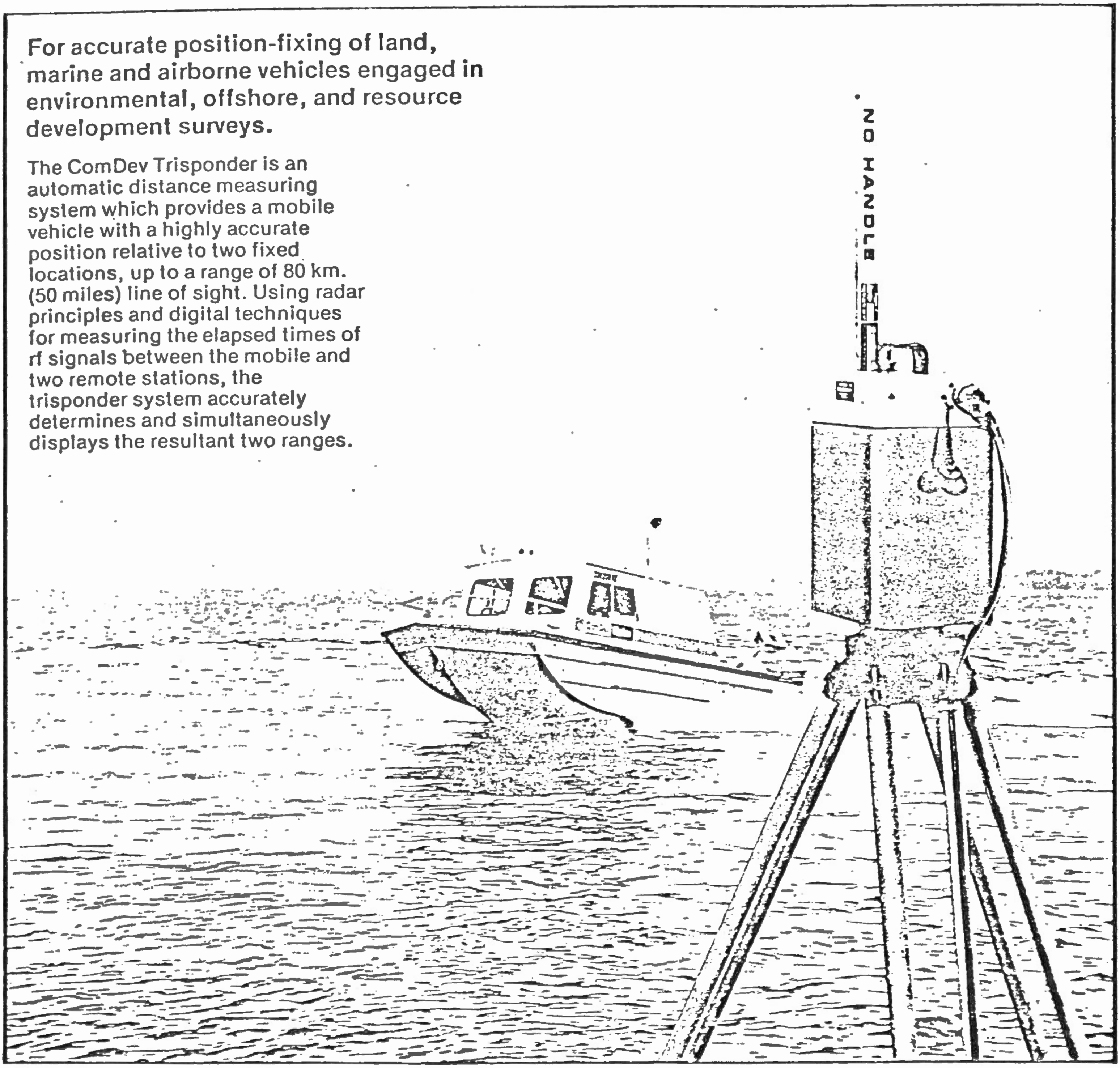
Navigation
Systems &
Services

ComDev Trisponder

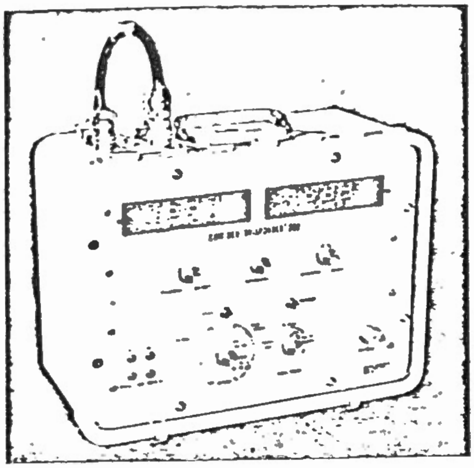
Model 202-MS05

For accurate position-fixing of land, marine and airborne vehicles engaged in environmental, offshore, and resource development surveys.

The ComDev Trisponder is an automatic distance measuring system which provides a mobile vehicle with a highly accurate position relative to two fixed locations, up to a range of 80 km. (50 miles) line of sight. Using radar principles and digital techniques for measuring the elapsed times of rf signals between the mobile and two remote stations, the trisponder system accurately determines and simultaneously displays the resultant two ranges.

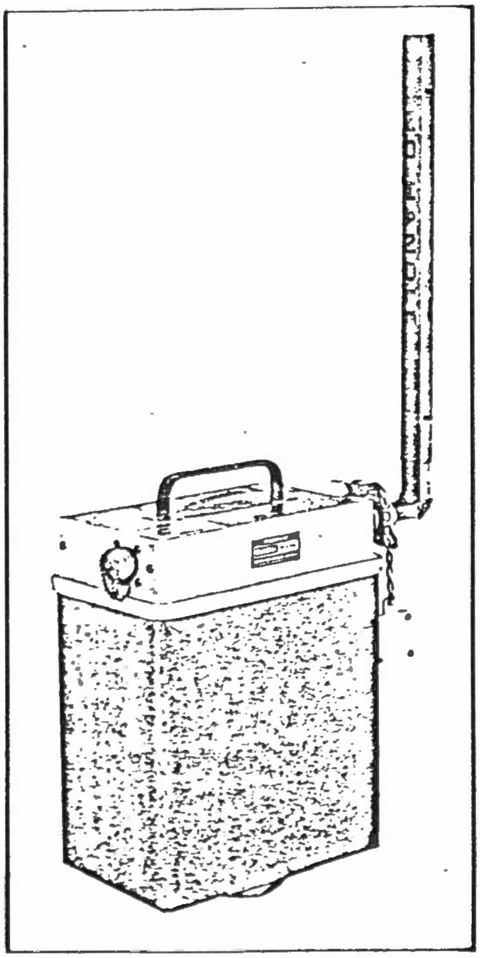


Unit Specifications



Distance Measuring Unit

Range:	Line-of-sight to 80km
Accuracy:	±3 metres
Resolution:	1 metre
Display:	Two 5-digit ranges displayed simultaneously in metres.
Calibration:	Adjustment of preset controls over a measured range.
Outputs:	BCD 1248 code, +5V logic level. (ASCII available as option))
Power Supply:	22 to 32V DC 40 Watts
Size:	40 x 27 x 36cm (16 x 12 x 8½ in.)
Weight:	11½ kg. (25 lb.)
Housing:	Rugged aluminum transit case. Waterproof - cover on. Splash proof - cover off.

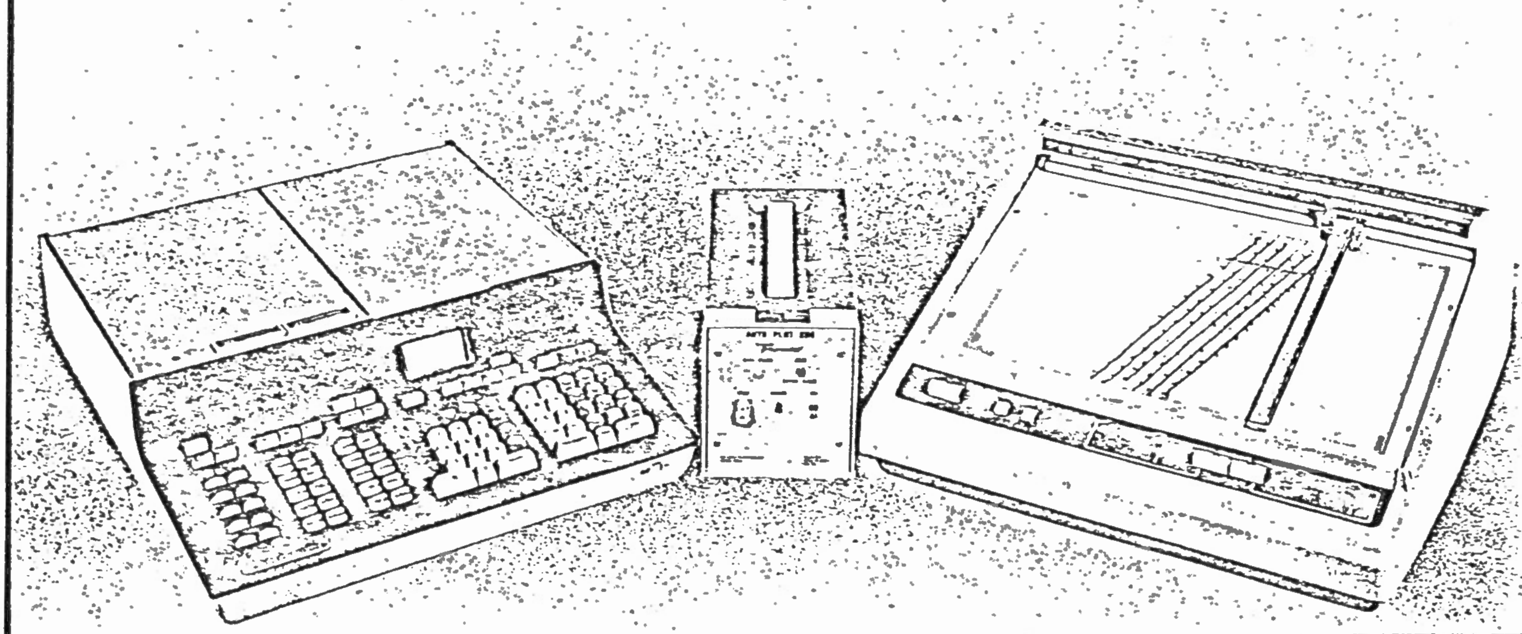


Transponder Model 212 - Mobile or Remote

Transmitter:	Magnetron tunable 9,200 - 9,475 mHz
Pulse Power:	1,000 watts (60dBM) 75% rated
Receiver:	Superheterodyne - Solid State
Antenna Connector:	UG40/U with quick disconnect clamp.
Environmental:	Weather proof for marine use; temperature range -35°C to 70°C (-28°F to 158°F)
Power Supply:	22 to 32V dc
Power Consumption:	8 watts standby; 17 watts operating
Automatic Call-up:	Operate: 30-90 seconds after interrogation Standby: 40 minutes after last interrogation
Automatic Power Control:	Shuts down transponder when battery voltage falls below 22V.
Size (less antenna):	15 x 27 x 36cm (6 x 10½ x 14 in.)
Weight:	6½ kg (14 lb.)

Autoplot System

Provides conversion of range/range data to XY co-ordinates in UTM or a local grid system, for on-line track plotting or off-line preplotting. The HP 9810 or 9820 programmable calculator and the HP9862A XY plotter with ComDev software and Interface provide a flexible computerized plotting system.



Antenna-Remote — 87°/5°, 16db vertical slotted array. 180°/5°, 15db vertical slotted array.

Automatic Position and Recording System — Provides printed record of Trisponder range data at selected intervals of 1 sec. to 1 hr. Optional printout of time and BCD data e.g., depth, temperature etc.

Trisponder Data Logger — Housed in a splash proof transit case, this rugged unit provides a printout of Trisponder range data, time, event and auxiliary input, on command or a preselected intervals.

Left/Right Track Indicator — Enables a mobile station to steer a course parallel to any selected line of position. L/R display is by a remote analog meter.

Aircraft Transponder Mounting System — Mobile Transponder mount securely attaches transponder to helicopter anc electrically raises unit for landing or extends transponder in an inverted vertical attitude for operation.

RF Link Simulator — Transponder operation can be simulated for testing Distance Measuring Units. Digital outputs representing ranges, can be individually selected.

Field Link Simulator — A field version of the RF Link Simulator with fixed range outputs.

Portable RF Detector — Received signals are converted to audio to confirm transmission at mobile, remote station.

Remote Display Unit — Provides a remote display of range data from the Trisponder D.M.U.

Signal Strength Indicator — Provides a relative signal strength indication of the selected remote transponders, displayed in a O-9 notation, representing 0-40db signal level

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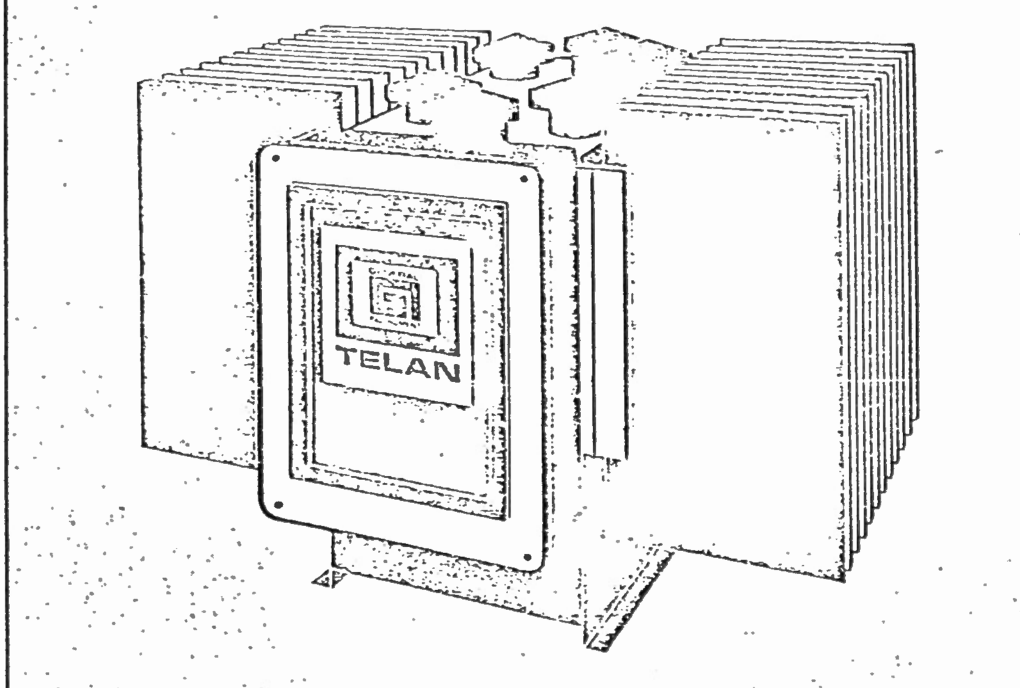


THERMOELECTRIC GENERATORS

FOR RELIABLE REMOTE POWER

GENERAL INSTRUMENT

GENERAL INSTRUMENT CORPORATION
THERMOELECTRIC DIVISION

DESCRIPTION:

GI TELAN generators are highly reliable, long-duration sources of electric power (1 to 300 watts for periods up to 5 years) in remote locations. They fill a need not met by batteries or engine-driven generators.*

TELAN generators convert heat from the combustion of propane, butane or natural gas directly into electricity by thermoelectric means, a very simple and, therefore, reliable source of electrical energy. The design emphasis in the TELAN line is on *reliability* in *remote locations* at *low costs.* The listed features demonstrate this design emphasis.

FEATURES

1. **CATALYTIC BURNING (PROPANE, BUTANE AND NATURAL GAS)**
   Since there is no flame, flame-out problems are eliminated. Fuel or air flow can be interrupted for 3 minutes and the combustion will continue spontaneously when system is restored.

2. **MATCH OR ELECTRIC IGNITION**
   No longer is battery power required for ignition. Electrical ignition is optional for remote starting.

*Consider TELANs to be watt-year energy sources, batteries watt-hour sources and engine generators kilowatt-hour devices.

3. **NO MOVING PARTS**
   Fuel is injected by its own pressure thru a jet into a venturi, which ingests the needed air.

4. **ALL SOLID-STATE ELECTRONICS**
   The thermoelectric power generating modules and the DC-DC converter transistors are all highly reliable semiconductor devices.

5. **COMPLETELY WEATHERPROOF HOUSING**
   Weatherproof housing is <u>standard</u> for all TELAN generators.

6. **OPERATE CONTINUOUSLY**
   TELAN units produce a constant power continuously, eliminating failures due to components required to sense and control a varying power output. (For varying loads, a small storage battery supplies the demand power; the TELAN unit supplies average power).

7. **MODULAR CONSTRUCTION**
   You need buy only as many identical power assemblies in single housings as required. You never buy more power than you need.

8. **SIMPLE OPERATION**
   TELAN units can be operated by unskilled personnel. Maintenance is also very simple; no special training required.

WHEN TO USE TELAN GENERATORS

TELAN generators are the lowest-cost source of reliable remote power when:

1. Power level is between 1 and 300 watts.
2. Power is required for at least 3 months.
3. The location is remote (at least ¼ to 1 mile from a power line).
4. Reliability is a prime consideration.

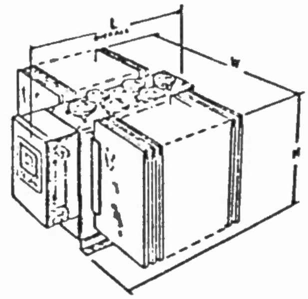
To make conservative comparisons with other power sources under consideration, estimate the costs for a TELAN unit at $350.00 plus $20.00 per watt for initial costs and $3.60 per watt-year for fuel (use average power consumption, not maximum demand power). The units will require no regular maintenance, so maintenance costs are negligible.

In most cases the economic cross-over with primary batteries is between 1 and 2½ watts and with engine generators at 200 to 500 watts.

TELAN units are seldom economically justifiable at less than 3 months operating time but at times longer than 3 months and in 2 to 300 watt range, they will be the least expensive power source.

Power lines cost from $1,000 to $10,000 per mile, depending on terrain. Therefore, in some cases a TELAN unit could save costs if only ¼ mile from a power line.

(continued)



SPECIFICATIONS *Table 1*

ELECTRICAL SPECIFICATIONS								FUEL								
Without Converter				With Converter [3][5]				Propane & Butane			Natural Gas		Size & Weight			
Generator Model	P[2] Watt	E Volt	I Amp	Converter Model	P[2] Watt	E Volt	I Amp	W·hr/lb[4]	lb/Wk	$/Yr	W·hr/MCF[4]	MCF/Wk	H In	W In	L In	Wt Lbs
TELAN-PA1	6.2	.65	9.6	PC1-12 PC1-24	4.2	12 24	0.35 0.18	130	8.2	20			17	11	18	28
TELAN-U1P[1]	9	.90	10	UC1-12 UC1-24	6.5	12 24	0.54 0.27	140	11	29	3000	.5	17	11	18	28
TELAN-U2P[1]	18	1.8	10	UC2-12 UC2-24	14	12 24	1.2 .6	140	22	55	3100	1.0	17	23	13	42
TELAN-U3P[1]	27	2.7	10	UC3-12 UC3-24	21	12 24	1.8 .9	145	31	81	3100	1.4	17	23	21	58
TELAN U4P[1]	36	3.6	10	UC4-12 UC4-24	28	12 24	2.4 1.2	150	40	110	3300	1.8	17	23	21	73
TELAN-U5P[1]	45	4.5	10	UC5-12 UC5-24	36	12 24	3.0 1.5	150	50	130	3300	2.2	17	23	29	87
TELAN-U6P[1]	54	5.4	10	UC6-12 UC6-24	43	12 24	3.6 1.8	150	61	158	3600	2.6	17	23	29	100
TELAN-U7P[1]	63	6.3	10	UC7-12 UC7-24	50	12 24	4.2 2.1	150	71	185	3600	3.0	17	23	37	114
TELAN-U8P[1]	72	7.2	10	UC8-12 UC8-24	57	12 24	4.8 2.4	150	81	210	3600	3.4	17	23	37	130
TELAN-U9P[1]	81	8.1	10	UC9-12 UC9-24	65	12 24	5.4 2.7	150	91	235	3600	3.8	17	23	45	144
81 to 300 W				69 to 300 W				TELAN units can easily be operated in series to obtain power to 300 W. Ask GI engineers or reps for recommendation or request "TELAN Application Handbook" TEG-12.								

(1) P indicates generator will be shipped with jets for Propane. Substitute "B" for Butane or "N" for Natural Gas jets. Jets can be changed in the field if fuel is changed after generator is installed.

(2) Warranty power at room temperature (70°).

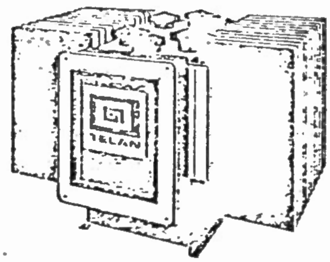
(3) Solid state DC-DC converter with variable voltage limiter. Specify 12 or 24V; variable range 12 to 16V and 24 to 31V.

(4) Without DC DC converter.

(5) The rectifiers in TELAN DC-DC converters prevent the battery from discharging into the generator. When a unit without converter is used to charge a battery a blocking diode must be included to prevent battery discharge thru the TELAN unit.

All generators include gas regulator set to accept 10-30 psi; complete with weatherproof housing and weatherproof electrical convenience box.

GENERAL INSTRUMENT



GENERAL INSTRUMENT CORPORATION
THERMOELECTRIC DIVISION

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Hicksville, New York 11802 516-681-4300

Other Brochures Also Available:

DECAP-Thermoelectric Generators For Cathodic Protection, TEG-10

TEMAR-Thermoelectric Power Sources For Buoys, TEG-6

TELAN-Application Handbook, TEG-12

APPENDIX 4

OPERATIONS SUMMARY

GRAND MANAN AND PT. LEPREAU PROJECT

OPERATIONS SUMMARY

Sunday, September 14, 1975 - Halifax-St. John, N.B.

Travel, Halifax-St. John, N.B. with half-ton truck (Stewart). Travel, Falmouth, Mass. - Bangor, Maine with van (Blidberg - O.R.E.)

Monday, September 15, 1975 - Mainland and Grand Manan, N.B.

Stewart drove from St. John to St. Stephen, met O.R.E., cleared customs in 1 hour, met ferry at Blacks Harbour and travelled to Grand Manan. Met and talked with Ivan Green.

Tuesday, September 16, 1975 - Grand Manan Island

Commenced mobilization of vessel: installation of winch for deep-tow side-scan, loading of heavy equipment at Seal Cove Wharf using heavy duty mast and winch.

Wednesday, September 17, 1975 - Grand Manan Island

Continue fabrication of winch baseplate and ELAC transducer mount. Continue installation of other gear, start up and check-out of gear. Assemble thermal generator gear and propane.

Thursday, September 18, 1975 - Grand Manan Passage

Stewart and Williams installed transponders at the Wolves and at West Quoddy Light between 0900 and 2200 hours. O.R.E. tested their equipment, ComDev installed and tested theirs. Problems with boomer and AUTOPLOT exist.

Friday, September 19, 1975 - Grand Manan

Diode in Boomer blown, Blidberg departs to meet plane with replacements in St. John. Trisponder System tested out, AUTOPLOT system tested off Long Eddy Point.

Saturday, September 20, 1975 - Grand Manan Passage

Steam to Blacks Harbour, pick up Blidberg of O.R.E. with boomer replacement parts. Tested systems, steamed for start of line at Owen Head. Completed Line 3.

Sunday, September 21, 1975 - Grand Manan Passage

Complete Line #2, shut down after heavy fog or other cause cut out reception of the Long Eddy transponder.

Monday, September 22, 1975 - Grand Manan Passage

Run Line #1A from Long Eddy Point to Ragged Point - some Trisponder interruption. Pause at end of Line 1 to rearrange trisponder/AUTOPLOT and solve electrical interference problem. Re-run Line 3, run Line x enroute to re-start Line 3, following interruption due to LISTER diesel generator problem.

Tuesday, September 23, 1975 - Grand Manan Passage

Examined sand waves off Long Eddy Point. Ran two tie lines. Trisponder lost signal in thick fog. We geared up for seafloor sampling and completed three stations.

Wednesday, September 24, 1975 - Grand Manan Passage

Completed three camera stations and one grab station, attempted tie-lines off Campobello, then ran reconnaissance line into Whale Cove from Long Eddy Point.

Thursday, September 25, 1975 - Enroute North Head to Campobello

Stewart, Panton, Gleason Green and Em. Guptill steam to S. Wolf I., retrieve transponder. Blidberg drives ½ ton to Campobello, Mundle drives his car to Campobello, Bonny Brook steams to Campobello. Latter and Williams coordinating on Deer Island.

Friday, September 26, 1975 - Head Harbour Passage

Stewart and Mundle emplace transpinders at Chalk and Leonardvillè Lt. Williams and Latter coordinating further control.

Operations Summary
(continued)

Saturday, September 27, 1975 - Campobello Island

Erected mast and transponder at Wilsons Beach. Encountered problems with the Trisponder system in the afternoon: a water-saturated antenna and possibly signal attenuation due to dense fog, also radar interference.

Sunday, September 28, 1975 - Head Harbour Passage

Check out Trisponder system, O.K., complete Lines 11, 12, 13, 14, 22, 21, 20, 23 by 1700 hrs. Can do no more until additional control is triangulated.

Monday, September 29, 1975 - Head Harbour Passage

Morning spent in seafloor sampling from Bonny Brook until interrupted by loss of coverage by Stn. WILSON (due to inadvertent rotation). Williams of ComDev, triangulating onshore. Indian Island - Campobello I. partially completed by evening.

Tuesday, September 30, 1975 - Head Harbour Passage

Completed Indian Island to Campobello Island crossing. Moved to Casco area, re-established stn: LEONARDVILLE, complete work N.E. of Casco Island.

Wednesday, October 1, 1975 - Head Harbour Passage

Complete 8 camera stations to 1330 hrs., remove and re-erect two transponder stations (CHOC and LEONARDVILLE) at Head Harbour and Power Plant. Completed fill in lines N.W. of Casco Island by 1930 hrs.

Thursday, October 2, 1975 - Head Harbour Passage

Shuffled transponders to allow completion of lines SE of Casco Island. Completed survey by 1500 hrs. Picked up White Horse Island transponder, loaded ComDev gear and delivered ComDev personnel to Leonardville.

Friday, October 3, 1975 - Point Lepreau

Survey crew and vessel move to Dipper Harbour, transponders established in Duck Cove.

Saturday, October 4, 1975 - Point Lepreau

Completed pre-plotting chores. Attempted work but encountered high swells, confused sea and increasing wind. Abandoned attempt to work.

Sunday, October 5, 1975 - Point Lepreau

Ran survey lines all day in Duck Cove.

Monday, October 6, 1975 - Point Lepreau

Abandoned thought of work at sea because of strong wind and high seas. Stewart, Latter and Williams moved transponders on shore.

Tuesday, October 7, 1975 - Point Lepreau

Waiting on control work by N.B.E.P.C. surveyors onshore. Recover and move transponders.

Wednesday, October 8, 1975 - Point Lepreau (Duck Cove)

Completed lines in Duck Cove, moved three transponders to Indian Cove in preparation for tomorrow's survey.

Thursday, October 9, 1975 - Indian Cove

Completed survey in Duck Cove

Friday, October 10, 1975 - Point Lepreau

Demobilize survey vessel

Saturday, October 11, 1975 - Dipper Harbour

Survey crew departs New Brunswick