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I.O.S.

GEOPHYSICAL STUDIES OF THE CONTINENTAL MARGIN AROUND THE GRAND BANKS

Internal Document 105

D.G. Roberts

September 1980

NATURAL ENVIRONMENT RESEARCH COUNCIL

INSTITUTE OF OCEANOGRAPHIC SCIENCES

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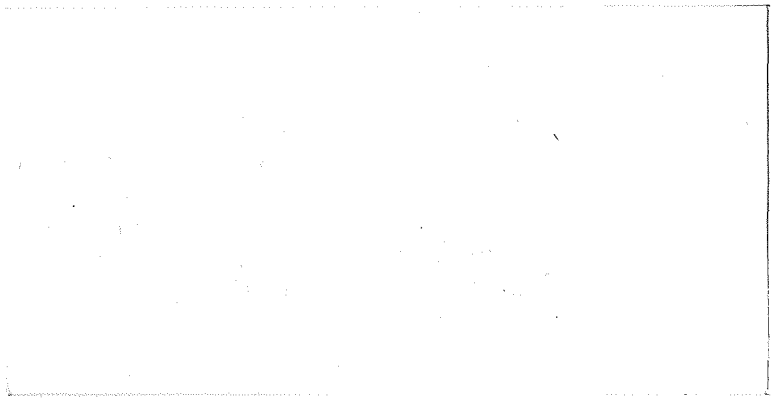

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Work carried out under contract to the Department of Energy

Institute of Oceanographic Sciences,
Brook Road,
Wormley,
Godalming, Surrey
GU8 5UB

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DATES

Sailed Bedford Institute of Oceanography, Halifax	8 July, 1980
Arrived St. John's, Newfoundland	30 July, 1980

SCIENTIFIC PERSONNEL

D.G. Roberts	Principal Scientist	IOS Wormley
M.L. Somers	GLORIA	IOS Wormley
D.G. Bishop	SRP	IOS Wormley
Mrs. P. Edwards	MIAS	IOS Wormley
A. Gray	Workshop	IOS Wormley
P.M. Hunter	Geophysics	IOS Wormley
D.G. Masson	Geophysics	IOS Wormley
P.R. Miles	Geophsyics	IOS Wormley
L. Parson	Geophysics	IOS Wormley
R. Phipps	Workshop	IOS Wormley
R.G. Rothwell	Geophysics	IOS Wormley
R. Walker	GLORIA	IOS Wormley
Ms. D. Jones	Computer	RVS Barry
S. Jones	Gravimeter	RVS Barry
G. Knight	Computer	RVS Barry
A.C. Grant	Observer	Geological Survey of Canada, Bedford Institute
G. Camp	Observer	Dalhousie University

SHIP'S OFFICERS

Capt. M. Bowen	Master
K. Avery	Chief Officer
M. Putnam	Second Officer
T. Boult	Third Officer
C. Latter	Chief Engineer
G. Batten	Second Engineer
J. Landry	Third Engineer
B. Entwhistle	Fourth Engineer
G. Kimble	Fifth Engineer
P. Sharp	Electrical Officer
B. Overton	Catering Officer
R.S. Bell	Radio Officer

SUMMARY OF CRUISE INTENTIONS

The principal objective of the cruise was to undertake a comparative study of the geology of the continental margin around the Grand Banks with that off Western Europe by means of an examination of the structural and sedimentary processes that have shaped the margin off eastern Canada. En route to the area, it was intended to make a further GLORIA traverse of the Nova Scotian margin thus making a mosaic of the GLORIA sonographs obtained from R.V. Starella during October 1979. The programme was to be executed using the following equipment:-

1. Multichannel seismic reflection profiling

Six channel seismic profiles were to be acquired using single or multiple airguns and the MSES 6-channel Geomechanique array and digital recording. Two EPC recorders operated at different filter settings were to provide monitor displays showing resolution and penetration.

2. GLORIA

It was intended to tow GLORIA at all times subject to weather conditions to examine the structural and sedimentary features of the slope and rise.

3. Wide angle reflection/disposable sonobuoys

Disposable sonobuoys were to be used to obtain velocity data in the thicker sedimentary sequences. Experiments using different firing rates were to be used to assess methods of improving signal quality.

4. 2 kHz seismic profiler

The 2 kHz seismic profiler will be used in conjunction with GLORIA to study sedimentary processes on the slope and rise.

5. On passage observations

Gravity, magnetics, the PES and short-range sonar (in narrow beam echo-sounder mode) will be operated throughout the cruise.

NARRATIVE

The scientific party joining RRS Discovery Cruise 111 Leg 2 arrived in Halifax on July 2nd to meet Discovery on her arrival at Bedford Institute at 0930 L.T. on July 3rd. Scientific freight that included spare weighted hydrophone sections to replace those damaged during Cruise 109 was shipped on board and the scientific party were engaged in preparing the scientific gear for sea. On July 4th, Discovery was inspected by the Lieutenant-Governor of Nova Scotia and a reception was held on board during the evening for the Director and scientists of Bedford Institute and the senior officers of C.S.S. Hudson, Baffin and Dawson, which were also berthed at Bedford. On July 5th, the scientific party rebuilt the multichannel hydrophone using the spares freighted from the UK whilst Discovery awaited the arrival of vital spares for the V.E.B. generator. Several trans-Atlantic telephone calls were made to RVS and to British Airways in an effort to trace them and expedite their delivery. However, the spares were only delivered to the ship on the afternoon of July 7th, delaying departure by 36 hours. In view of bad weather on the afternoon and evening of July 7th, sailing was delayed until 0800 L.T. on July 8th.

RRS Discovery finally sailed from Halifax at 1230Z, July 8th (190) in light winds and sunshine. Shortly after clearing the estuary, the ship's Sperry autopilot steering motor failed

requiring hand steering. As the autopilot was essential for GLORIA surveys, the ship remained off Halifax lest a return to obtain spares be proven necessary. After one hour however the faults were identified as a defective bearing and scored armature. As both defects could be remedied on board, course was set at 10 kts towards the shelf edge to deploy GLORIA. At 1524Z, the PES fish was streamed but the PES recorder was found to be unserviceable because of a defective drive motor and was replaced with the spare. At 1612Z, logging commenced on the 1800 computer but only analogue recording of gravimeter data was possible because of a hardware fault in the interface. At 0030Z (191), speed was reduced to 4 kts to commence deployment of the geophysical gear. GLORIA was deployed at 0110Z and the airgun and IOS 2-channel hydrophone at 0255Z when speed was increased to 9.5 kts. In the interim, gravimeter logging commenced at 0118Z. After a short traverse downslope, course was altered to 063° at 0640Z to mosaic the slope parallel to the GLORIA traverse made from Starella in October 1979. At 2250Z the signal was lost on channel 1 of the IOS hydrophone and speed was reduced to 5 kts to recover the hydrophone. The loss of signal was caused by breakage of cores in the tow cable due to severe twisting. This and a similar problem on Cruise 110 may have been caused by leakage of oil from the array. By 0300Z (192), the 6-channel hydrophone and a 300 in^3 airgun were streamed and speed was increased to 6.5 kts. At 0445Z, the mosaic of the Starella traverse was completed and course was set to 038° to commence a survey of the Laurentian Fan and the southwestern margin of the Grand Banks. The upper slope adjacent to the Laurentian Channel was crossed during the day and at 0420Z (193), course was altered to 129° to run parallel to the southwestern margin of the Grand Banks. At 0810Z course was altered to 251°, to return across the slope. At 1200Z (193), the compass failed in GLORIA and at 1420Z speed was reduced to 5 kts because of poor visibility. Thick fog persisted throughout the night and at 0800Z course was altered to 070°. Yaw of the GLORIA vehicle because of the compass failure eventually forced recovery of GLORIA and the seismic gear at 1135Z (194). All gear was inboard at 1230Z, when Discovery hove to pending repairs to the GLORIA compass.

Although thick fog persisted throughout the afternoon and evening the opportunity was taken to occupy and reverse a refraction profile using disposable sonobuoys (Stations 10195A/B). Discovery remained hove to overnight in dense fog. A velocimeter dip was made between 1354 and 1548Z (Station 10196). At 2219Z (196) GLORIA was streamed together with the 2 kHz hydrophone. The 6-channel hydrophone was not streamed in order to retain maximum manoeuvrability in the thick fog. Course was set to reoccupy the recovery position of 1135Z (194) which was reached at 0012Z (196). At 0030Z, the fog cleared and speed was increased to 8 kts at 1120Z (196). Further traverses were made of the slope until 0600Z (197) when course was altered to 148° to occupy a series of oblique traverses across the slope. At 1500Z, thick fog again enforced a speed reduction to 5 kts. At 2042Z (197) a return oblique crossing of the slope was commenced on a heading of 206° and completed at 0625Z (198) when course was altered to 302°. A return crossing of the Laurentian Fan was commenced at 0750Z when course was set to 070°. At 1735Z (198) course was set to 180° and to 252° at 2030Z to cross the fan again. During the final crossing of the fan, thick fog enforced a speed reduction to 5 kts. At 2200Z, course was set to 000° to commence a series of traverses across the slope southwest of the Grand Banks and at 1250Z course was altered to 126° to cross the slope. Visibility deteriorated throughout the day until it was about a ships length at 2159Z (200) when GLORIA and the seismic gear were recovered. At 2231Z, Discovery hove to. By 1350Z (201), visibility had again improved and speed was increased to 4 kts to launch GLORIA and the 2 kHz hydrophone. The airgun was also deployed to assess the feasibility of using the 2 kHz array to receive airgun signals. The trial was unsuccessful and the airgun was brought inboard at 1620Z. At 1900Z, speed was increased to 8 kts to converge on the original traverse which was reached at 2015Z when course was altered to 125°. At 2057Z, speed was reduced to 4 kts to stream the 6-channel array, magnetometer and airgun in improved visibility.

At 2206Z, speed was increased to 7 kts. At 0140Z (202) course was altered to 090° to cross the 'Tail of the Bank' sedimentary basin and at 0300Z speed was reduced to 5 kts as the 'ice zone' was entered. The edge of the basin was crossed at 1000Z (202) and course was altered to 171° to traverse from the shelf edge to the 'J' anomaly ridge. At 1520Z (202), speed was reduced to 5 kts because of poor visibility and the airgun, 6-channel hydrophone and magnetometer brought inboard. At 1700Z (202) the 2 kHz hydrophone and airgun were streamed. Between 1715Z and 2320Z, a series of disposable sonobuoy stations were occupied downslope. During the course of these stations, visibility improved allowing us to stream the 6-channel hydrophone at 1838Z and the magnetometer at 2340Z. Between 2320Z (202) and 2400Z (203), a detailed survey was made of a series of channels and mud-waves adjacent to the 'J' anomaly ridge. Thick fog appeared however late in the evening of day 203 and the airgun, magnetometer and 6-channel hydrophone were brought inboard at 0058Z (204). At 0224Z, course was set to 057° to make the first of a planned series of traverses parallel to the east margin of the Grand Banks. Between 1032Z and 1130Z (204), collision avoidance action was necessary. At 1758Z, the airgun was streamed and disposable sonobuoy station 10200 occupied between 1822Z and 2045Z. During the course of this station, speed was reduced to 3 kts to avoid an approaching vessel, the Agalos Michele, which did not respond to signals in clear visibility. At 2200Z, the 2 kHz array was brought inboard and at 2206Z the 6-channel hydrophone and magnetometer were streamed and profiling began again. At 0130Z (205), thick fog was again encountered and during recovery of the array and magnetometer, speed had to be reduced to 3 kts to avoid collision with a vessel making 17 kts. At 0300Z, speed was increased to 5 kts and the 2 kHz array deployed. Thick fog persisted throughout day 205 and by 1212Z on day 206, had become so dense that GLORIA and the 2 kHz array were brought inboard and Discovery hove to pending an improvement in visibility. These conditions persisted overnight and showed no signs of improvement. In view of this, it was decided to occupy a series of reversed seismic

refraction profiles parallel to the slope using disposable sonobuoys. Prior to the start of the station, the PES fish was observed to be vibrating badly and it was recovered to check the strut bearings for wear. The PES fish and airgun were deployed at 1844Z and refraction station 10201 commenced at 1956Z using a 1000 in^3 airgun. Reversal of the line (station 10202) was completed at 0055Z (208) and course was set southeastward towards the next refraction profile. Station 10203 commenced at 1332Z and the reversed profile completed by 1900Z (208). Course was then set southeastward to occupy the last of the refraction profiles. Stations 10205 and 10206 were occupied between 2312Z and 0348Z (209). On completion of the stations, the airgun was brought inboard and a gravity traverse was made across the refraction profiles. Visibility improved steadily throughout the day and at 2124Z, GLORIA and the multi-channel hydrophone were deployed and at 2200Z (209) course was set to 006^{o} to transit the Flemish Pass. At 0635Z (210), thick fog was again encountered necessitating recovery of the airgun and multichannel hydrophone. The 2 kHz hydrophone was then streamed. Visibility improved by morning and speed was increased to 8 kts at 1340Z (210). Thick fog was again encountered at 2040Z (210) and speed was reduced to 5 kts. At 0020Z (211), course was altered westward to transit the upper slope of the Orphan Basin. Extremely dense fog persisted throughout the day and at 2300Z GLORIA, the 2 kHz array and the PES fish were brought inboard for our passage into St. John's. Visibility unexpectedly improved at 2400Z, and the night remained clear as did the following day enabling Discovery to dock in St. John's at 1800Z (212).

The cruise was bedevilled by thick fog throughout. The graph (Figure 2) shows that visibility was less than 0.1nm for 55% of the cruise and that periods of good visibility were brief. In these conditions, the scientific work had to be restricted. Although it was possible to tow GLORIA, speeds had to be kept to 5 kts and to avoid restricting the manoeuvrability of the ship, no multi-channel profiling could be done. It was not possible to

work elsewhere as on occasion the fog bank extended from Newfoundland to New York and for 750 miles eastward into the Atlantic. That some scientific work was carried out was due entirely to the dedication of the Master who remained on the bridge for about twenty-one days. It is a personal pleasure for me to record my thanks to the Master and the officers for their efforts in these trying conditions and by no means least to the scientific party for their hard work despite frustrating circumstances. I also wish to thank Dr. Longhurst, Director of Bedford Institute, Dr. R. Howarth and Dr. A.C. Grant of the Atlantic Geoscience Center for their help and hospitality at Bedford Institute.

PROJECT REPORTS

1. Survey of the margin of the Grand Banks

During this season's work, it was originally intended to examine the margins south and east of the Grand Banks. In the event, severe and persistent fog considerably curtailed operations. Use of the multichannel seismic system was restricted to the very few periods of good visibility to allow maximum manoeuvrability of Discovery. The thick fog did not permit survey speeds to exceed 5 kts and it was necessary to stop operations completely on several occasions. It was not possible to shift the area of operations to that scheduled for 1981 as thick fog was also present to the north. The fog extended on occasion from well to the northeast of Newfoundland to New York.

Despite the fog, a large part of the margin southwest of the Grand Banks was examined using GLORIA, gravity with partial seismic reflection coverage. In this area, the GLORIA results were excellent and clearly show the large scar left by the Grand Banks earthquake. It is hoped that the results will contribute to an understanding of fan development on continental margins.

During the latter part of the cruise, the fog hindered operations even more and only reconnaissance GLORIA traverses proved possible east of the Grand Banks. During periods when GLORIA observations were not possible because of thick fog, refraction lines were occupied using disposable sonobuoys and a 1000 in^3 airgun. These lines were particularly successful and the results will be used in gravity interpretation of the structure of the continental slope.

D.G.R.

2. GLORIA

The vehicle was launched at 0115 GMT on day 191. The sound propagation conditions were good and the weather fair. On day 193 the vehicle compass failed, but as the sea was calm and the results seemed not to be suffering for lack of beam steering it was decided to carry on without the compass. When forced to slow down to less than 5 kts for fog on day 194 the sonographs started showing signs of yaw and the vehicle was recovered for repairs to the compass. On inspection it was found to be working again so all connections were checked, all contacts cleaned and the vehicle sealed up again. From then the compass worked but on each launch it took some time to stabilise and settle down. The vehicle had to be recovered twice more before the final lift at the end of the cruise, fog rather than any malfunction being the cause on both occasions.

The system did show minor faults on occasion indicative of having been out of the UK and heavily used over the last 2 years, but no serious malfunctions occurred which could not be quickly repaired. The most persistent and irritating fault was the intermittent reduction of signal level showing up as random dark streaks on the records. On this cruise the Port-side suffered most heavily but the cause is still elusive.

Some 48 tapes were recorded, which allowing for some partially filled tapes, accounts for some 14 days of full recording.

Much of the survey had to be conducted at 5 kts due to poor visibility and the poorer directional stability of the vehicle at this speed inevitably had its effect on the records. Notwithstanding this the results were for the most part of very good quality.

M.L.S.

3. Seismic Reflection Profiling

On leaving Halifax, the IOS 2-channel array and 300 cubic inch airgun were deployed at 0250Z (191) and towed at 9.5 kts. After 20 hours of profiling, channel 1 went open circuit. Inspection from the aft deck showed that the tow cable was badly twisted. On recovery of the array, it was found that the twisting extended over the entire length of the cable, and the front spring section had lost some of its oil and was partially twisted. It was decided that the most probable cause of the failure was loss of oil in the spring section making it go unstable. This combined with increased drag from a flooded buoy was sufficient for the spring section to rotate in the water and thereby pass the twist up the cable. I strongly recommend that if the SRP system is to be used at high speeds again, that we try using, or perhaps invest in, a single channel, 30 metre Geomechanique array.

At 0254Z (192) the multichannel array was deployed and towed at 6.5 knots increasing later to 7 knots. This system was used for the remainder of the cruise. Owing to prolonged periods of dense fog, only 120 hours of track were recorded, at speeds varying from 4 knots to 7 knots depending upon the density of the fog. Because of calm seas the array was extremely quiet, resulting in high quality data.

During the off-period of the SRP, the digital recording system was used to record one of the Sonobuoy stations towing a 1000 cubic inch airgun. This was highly successful.

Apart from a few short breaks due to fog, the 2 kHz system worked successfully for the whole cruise.

During the periods when the multichannel array was out, one channel was used to display the 2 kHz signal. This has one major disadvantage, and that is the spacing of the array elements causes grating lobes which give a double image of the signal on the recorder making interpretation of the data very difficult. This problem will be solved when we insert a custom built 2 kHz section into the long SRP arrays.

D.G.B.

4. Disposable Sonobuoys

Twelve disposable sonobuoys were deployed and all were successful. Sonobuoy preparation and deployment was from midships forecastle deck port side using the reception ariel mounted on the bridge navigation lights. Eight sonobuoys were used to occupy four reversed refraction lines, one on the Laurentian Fan and three on the N.W. margin of the Newfoundland Basin. The Newfoundland Basin lines showed at least three strong refracted arrivals together with good wide angle reflection penetration from the thick sediments using a 1000 cu. in. airgun source. The earlier lines were run using a 300 cu. in. source. Nearly all sonobuoy lines were run at speeds between 3.5 and 5 knots permitting controlled operation of the sonobuoy system, with airguns towed at estimated depths of 25 to 30 metres. This produced a lower frequency source compatible with the thick sediments and the requirement for strong refracted arrivals. As SRP was often not operating during these stations, the firing rate could be set in accordance with gun size and average ground speed. A firing rate of 3¼ secs. was found to provide the best data coverage at speeds of 4.5 kts. The results of these controls on the sonobuoy operations were monitor records and tape recordings consistently above average in quality out to the limit of radio contact. The reversed refraction lines illustrated particularly that if the cruise operations can allow controlled sonobuoy lines, then the data quality improves significantly. Preliminary

interpretation of the monitor and replay records shows a marked improvement in the refracted arrival events. The first three stations were recorded using crystal tuning. This was abandoned following low power transmission and poor S/N. Manual tuning was consistently good. During SRP down-time, a sonobuoy station was replayed and digitised successfully on digital tape 37. The digitisation was made at normal console record speed with a bandwidth of 40 to 100 Hz.

Details of the sonobuoy deployments are given in the station position table.

P.R.M.

5. Magnetometer

The magnetometer was used very little during the cruise. The RVS fish first streamed was found to be noisy although the computer sampling provided a smooth field. This fish was replaced by Wormley fish 'B' with the new outboard cable and the noise disappeared as anticipated. Computed magnetic anomlay values were noticed to have the large negative values from incorrect IGRF reduction that was rectified during Cruise 107. The leg from Panama to Halifax was also incorrect but Cruise 110 data was correct. An off-line IGRF reduction program computed the same erroneous anomalies for Cruise 111 legs 1 and 2, and put a sample of Cruise 110 data incorrect when that was tested. It was concluded that at some point the software had been rebuilt in error without incorporating software designed by J. Sherwood during Cruise 107. J. Sherwood was to be asked in St. John's to correct the data and ensure that the problem could not repeat itself.

P.R.M.

6. Side-scan sonar

The short range side-scan sonar could not be fully deployed because of damage to the ram during Cruise 109.

The sonar was used however as a narrow beam echo-sounder throughout the cruise in depths up to 4300m. In depths of 1000m-2000m, the sonar was used in side-scan mode.

D.G.R.

7. 1800 Computer

For the majority of the cruise, the computer performed its functions well, the problems being caused by peripheral failures. The only total breakdown occurred when a system disk corrupted as it was being copied to its back-up. The corruption did not affect the data stored on that disk, but because of program corruption the system was restarted on an emergency copy of the system disk. Four hours of data were lost at this time.

During the cruise it was noticed that the gravimeter interface occasionally picked up 'bits'. This caused a large shift in the logged gravity values, but since the shift was constant, at the end of each day a standard number was subtracted from the shifted gravity values and the anomaly recalculated.

The regional field of the magnetic anomaly is suspected to be incorrectly calculated. The associated programs have been checked against older listings and are consistent with them. The programs were rebuilt to make sure the problem was not caused by program corruption, but when tested on old, correctly calculated data, the data was corrupted. There were no obvious logic errors in the programs, but as there was no independent method of calculating the regional field, this problem could not be investigated further.

Throughout the cruise, the data were edited and plotted on a daily basis, according to the standard criteria.

D.J./G.K.

8. Meteorological Data

Comparisons were made at least once daily between the Meteorological Office instruments used by the ship's officers for the Selected Ship observations and the scientific meteorological sensors. The former are spot visual readings; the latter are data-logged at two minute intervals, being mean and filtered versions derived from one second sampling. Despite the differences in sampling techniques the two sets of instruments gave satisfactory comparisons.

Air temperatures, both dry and wet bulb, agreed to 0.4°C or less. The dry and wet bulb readings were frequently the same, as about 50% of the cruise was spent in fog, with a horizontal visibility of one nautical mile or less, frequently much less. The range of dry bulb temperatures was from 9.2°C to 22.3°C.

Sea temperatures indicated by two different bulb sensors agreed less well, probably due to different response rates, as sea temperature fluctuated rapidly and changed as much as 2°C in one hour. Differences between the two instruments were up to 0.7°C but there were no systematic differences. The range of sea temperatures was from 8.3°C to 22.3°C.

The two anemometers gave reasonable agreement in true wind speed and direction. Winds were between ten and twenty knots for much of the time, with a maximum two minute mean wind speed of 33 knots.

The Meterological Office pressure aneroid barometer on the bridge read a mean 0.4 mb higher than the electronic barometer in the gravimeter room. The barograph on the bridge usually gave slightly different values from both.

The solarimeter gave reasonable looking values.

There is no reason why the meteorological data for the whole cruise should not be acceptable, having also been screened daily by the computer staff and found to be free from noise.

Air-sea temperature differences were usually small and often less than 2.0°C, but there was no obvious correlation between the sense or magnitude of these differences with the incidence of fog, nor of wind speed. The fogs were due to warm moist southerly air and were very widespread, according to the weather forecasts.

P.E.

9. Coding of visibility observations made by the Officer-of-the Watch on RRS Discovery

Meteorological observations are made by the officer of the watch for two log books, viz the Meteorological Office Selected Ship 6 hourly observations, and the Ship's Log 4 hourly observations which are made at the change of the watch.

A scale for coding 'visibility' is printed in both log books. The Met. Office code is as per MET.O.694A (revised 1 January, 1979). The Ship's Log refers to the International Met. Code, "see A.L.R.S. Vol. III". Both codes are given overleaf (Table 2). It can be seen that, except for code numbers 90 and 99, the corresponding Ship's Log code numbers are one unit lower than the Met. Office Log code numbers, e.g. a visibility distance of 2.2 nautical miles is given coding 96 in the Met. Office code and coding 95 in the Ship's Log code.

This means that the officer of the watch has to use two different code tables for visibility, which is confusing and might lead to mistakes. It seems logical to change the Ship's Log codes to correspond with the Met. Office codes.

P.E.

TABLE 1: STATION POSITION LIST

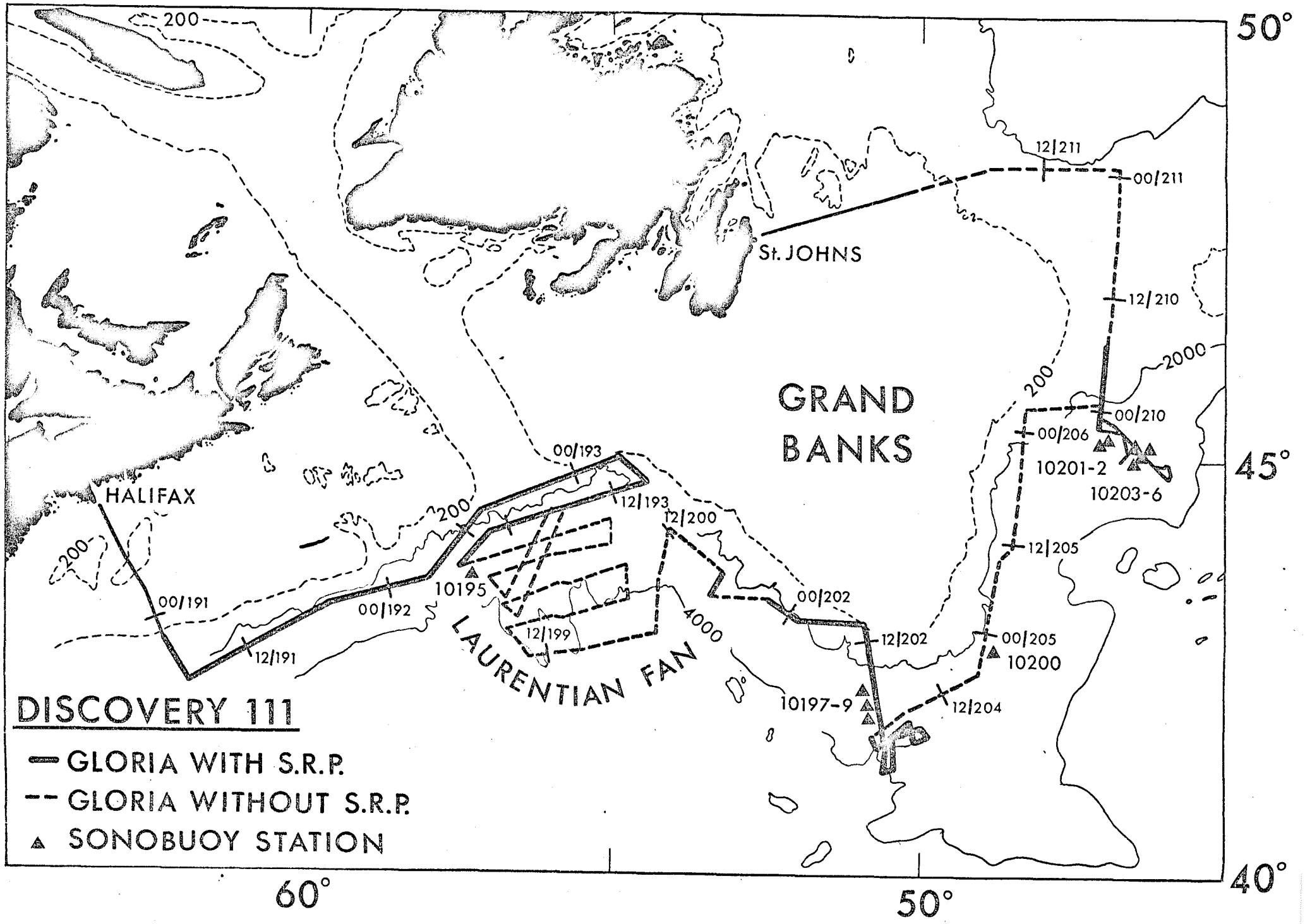
STATION NO.	TYPE	DAY	START	LAT.	LONG.	DEPTH U. METRES	END	LAT.	LONG.	DEPTH	COMMENTS
10195A	DSB	194	1734	43°42.6	57°13.1	3520	1948	43°35.6	57°13.7	3606	(Reversed line)
10195B	DSB	194	2027	43°35.4	57°14.7	3510	2230	43°42.2	57°18.5	3510	(Reversed line)
10196	V	196	1354	43°44.1	57°24.0	1800	1548	43°44.3	57°23.1		
10197	DSB	202	1715	42°14.9	50°42.3	2905	1855	42°06.1	50°39.6	3239	
10198	DSB	202	1916	42°03.8	50°38.7	3326	2045	41°53.5	50°35.4	3691	
10199	DSB	202	2201	41°45.3	50°33.6	3884	2324	41°36.4	50°30.6	4088	
10200	DSB	204	1822	42°28.0	49°00.0	2922	2030	42°38.6	48°56.4	2739	
10201	DSB	207	1956	45°34.4	47°19.8	2040	2200	45°27.4	47°26.4	2260	(Reversed line)
10202	DSB	207	2231	45°27.5	44°27.7	2265	0055	45°35.8	47°19.3	2236	(Reversed line)
10203	DSB	208	1332	45°09.1	46°33.4	3444	1620	45°00.9	46°43.2	3574	(Reversed line)
10204	DSB	208	1656	44°59.9	46°43.7	5380	1900	45°08.1	46°32.8	3510	(Reversed line)
10205	DSB	208	2312	44°57.5	46°04.6	3613	0100	44°50.7	46°10.5	3622	(Reversed line)
10206	DSB	209	0142	44°49.8	46°12.5	3611	0350	44°58.9	46°00.6	3626	(Reversed line)

DSB Disposable sonobuoy

V Velocimeter dip

TABLE 2: VISIBILITY CODES

CODE NUMBER	MET. OFFICE SCALE	SHIP LOG SCALE	
	nautical miles	yards	nautical miles
90	less than 0.03	less than 55	less than 0.03
91	0.03	less than 220	less than 0.1
92	0.1	550	0.3
93	0.3	1,100	0.5
94	0.5	2,200	1.1
95	1.1		2.2
96	2.2		5.4
97	5.5		10.8
98	11		27
99	more than 27		more than 27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40°
60°
50°
200
200
200
2000
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00/211
12/210
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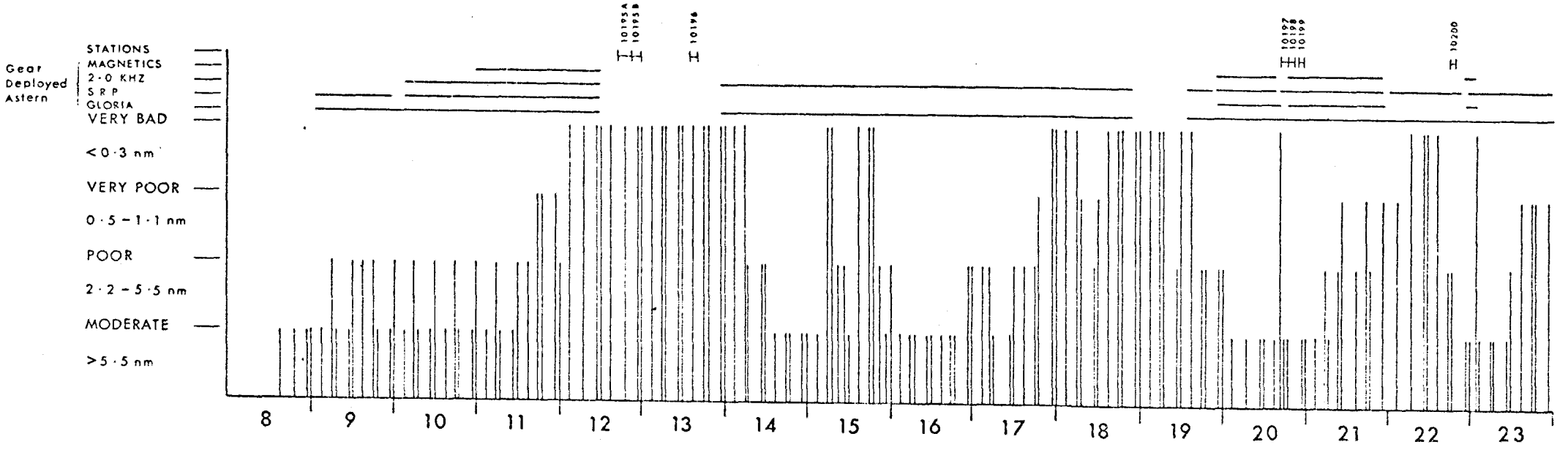
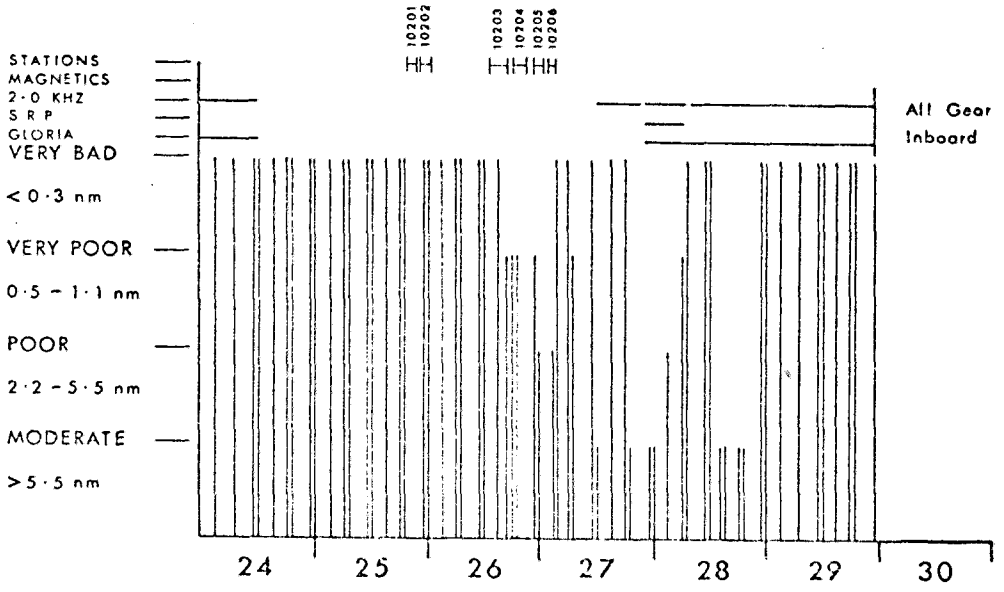
00/205
12/204
12/202
00/202
12/200
12/193
00/193
12/199
12/191
00/191
00/192
ST. JOHNS
HALIFAX
GRAND BANKS
LAURENTIAN FAN
10195
10201-2
10203-6
10200
10197-9
DISCOVERY 111
GLORIA WITH S.R.P.
GLORIA WITHOUT S.R.P.
SONOBUOY STATION

HORIZONTAL VISIBILITY INDEX

DISCOVERY CRUISE III, LEG 2



JULY 1980



JULY 1980

USING ALL OBSERVATIONS (n = 216)

MODERATE	29 %	
POOR	20 %	
VERY POOR	10 %	51 % 1·1 N. MILE OR LESS
VERY BAD	41 %	