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BODS 15/2/73

9/61/72

CRUISE REPORT

M.V. HAWTHORN July 7th to August 4th, 1972

NORTH ATLANTIC SEISMIC PROJECT

Cruise Objective

M.V. Hawthorn was chartered to act as shooting ship for the project. A total of 68.5 short (2,000 lbs) tons of Geophex explosive was to be carried and 236 shots of 300,600 or 1200 lbs fired by slow burning fuse wherever possible at the optimum depth for generation of seismic energy. The area of operations extended from The Minch to Iceland - (see sketch map attached). The shooting was planned to take place between July 10th and July 28th. The ship was required to transmit information on the shooting operation to two ships engaged in recording the seismic arrivals at sea and to 29 temporary recording stations on land in the U.K.(8 stations), the Faeroe Islands (6 stations), and Iceland (15 stations). The time of the shots was to be determined to an accuracy of better than 1/20th sec., the position to better than $\frac{1}{2}$ n.m. and the water depth at each shot site to a few metres.

Personnel

Because of the danger inherent in the handling of explosives and the heavy physical labour involved in building the charges it was decided to carry enough people to operate a two team system for up to 18 hours a day. 24 hour working was not considered advisable because of lowered night time efficiency and loss of sleep for all those on board. It was therefore decided to carry 8 or 9 men, two teams of three each for the firing and two for the recording operation with one man, if available, on standby in case of sea-sickness, breakdowns etc. Mr. T. Vertue from Cambridge University agreed to assist with the early part of the project and to pass on his know-how concerning large charges to the other members of the party. The six members of the firing party to share the work after Mr. Vertue's departure were Mr. A.L. Crowe, an explosives safety officer from Hunting Engineering Ltd., - later replaced by Mr. B. Palmer from the same company.

G. Wilson, Durham
D. Asbery, Durham
G. Dresser, Durham
B. McEleavey, Durham
M. Beney, Technician from R.V.B.

Paul Holden, an undergraduate from Durham had volunteered to assist me with the recording, broadcasting and position fixing. He found working in the chart room unpleasant and after a few days changed with Beney. Unfortunately, Mr. Crowe was extremely seasick and was unable to give any assistance while at sea. He was dropped in the Faeroes on July 13th and replaced on July 15th by Justin Lewis - a new research student, previously on board M.V. Miranda. Asbery was also unwell for the first few days and it was not possible to regularly work the two shift system before leaving the Faeroes for the second time. After Vertue's departure on July 18th, G. Wilson and D. Asbery took charge of the two firing teams. After Mr. B. Palmer arrived on July 24th, Lewis took over broadcasting and recording duties, freeing the Senior Scientist of routine commitments.

Six seamen were on board, two being on watch at any one time. On 19 occasions on 16 separate days, four or five of them gave assistance in lifting explosives from the ship's hold or in launching or recovering the echosounder fish. A total of 26 hours was spent helping the Durham party. Captain Hardy was normally on the bridge during shooting operations with the 1st and 2nd mates on watch. Between them they took Radar fixes whenever possible and supervised the seamen when lifting explosive from the hold.

Modifications to ship

At the request of the Department of Trade and Industry, extra fire hoses were installed close to the hold containing the explosives and these were connected up and put on standby when explosives were being loaded. Posters forbidding smoking anywhere on deck were posted throughout the ship and this regulation was obeyed throughout.

The explosive magazine was built on the floor of the aft hold and was perfectly satisfactory if a little inaccessible being 20 ft below deck level. No special arrangements for getting the explosive from the hold to the deck were provided. In order to lift from the hold the ship's derrick had to be slung with its arm in a near vertical position. Consequently there was

50- 60 ft. between the block on the arm and the bottom of the hold and because of the large scope on the lifting cable it was difficult and dangerous to lift the explosives in anything but the calmest sea. It proved impossible to do this whilst underway and therefore we were unable to bring up the explosives during shooting operations. Our practice was to bring up sufficient explosive for one or two days' shooting while hove to in calm or sheltered water. Usually this took about two hours. The cargo net was much better than the heavy wooden tray provided - the latter crashed into the protecting rails around the hold when it was first used, bending them in the process.

The trolleys provided for moving the explosive aft were very efficient as was the tilting platform on which the charges were built prior to fusing. No intercom from this area to the bridge was provided, although requested, but fortunately the electricians on board in Liverpool were able to supply a field telephone which sufficed.

Charge Firing

The Geophex was left in its cardboard box, six of which were banded together to make a 300 lbs unit, using either steel or plastic banding tape. Initially large charges were made by linking two or four of these 300 lbs units together but after aquaflex was found to be unreliable, the larger charges were made as single units to avoid the linking. These were bound together as tightly as possible but even so would not be very rigid under pressure. Slow burning fuses of 6',8' and 9' were used for the 600 lbs shots normally fired in deep water (> 100m) and 4' or 6' for the 300 lbs shots fired in shallow water. Marker floats attached to the charge were laid for most shots within 12 n.m. of the coast. These consisted of one or two blocks of self-extinguishing expanded polystyrene foam contained by polypropylene netting. It had been intended to use these as buoys to support 1200 lbs charges at optimum detonation but after the lack of success in firing these charges this idea was dropped and the 600 lbs charges fired instead during free fall.

Living and Working conditions

There were two causes for complaint concerning living conditions. Firstly the water available in the midships accommodation was polluted with diesel oil and as a result most of the party were unable to drink tea, coffee

or cocoa and some people found it unpleasant to shower or clean their teeth in it. Secondly, only one toilet out of four worked throughout the cruise, sometimes this was the only one working and occasionally the others would spill over when blocked. The food and service left little to be desired and considering the cooking facilities available for the number aboard (21-22) were very good.

Working conditions were satisfactory when the weather was good but because all the weight was in the bottom of the ship the ship rolled considerably in even a moderate swell making building the largest charges (1200 lbs) rather dangerous. The difficulty was in preventing the charge sliding sideways off the platform prior to 'drop'. The space available in the chart room for the recording instruments and for plotting was somewhat restricted and barely adequate for more than two people plus the officer of the watch. The rolling was particularly noticeable there and in bad weather, some people felt ill there whereas they were alright in other parts of the ship. There were times during the first days of the project when even sleeping was difficult and consequently some of the party became unduly tired.

Equipment performance

A number of equipment failures occurred, which it is worth recording in case of future projects. Firstly the plug connecting the echosounder tow cable to the recorder cable was damaged. The plug provided as spare was the wrong size. The repair effected by M. Beney was electrically satisfactory but eventually broke mechanically and was only remade with some difficulty. The echosounder recorder (MS38) required early repairs to the sweep rate lever, and later "frigging" to get the transmission mark on the left of the sweep. The hired MK.21 Decca receiver appeared satisfactory when installed in the ship in Liverpool but soon showed a tendency for the red decometer to move erratically as if the drive was slipping. This fault cleared itself before the project started but reappeared towards the end of the project (on July 28th). From then on the lane identification signal had to be used for the fractional lane reading with consequent loss of accuracy. The LORAN C receiver worked well throughout though it lost signal lock almost every time the ship's Radio Transmitter was used for giving shot warnings. The ship's radio transmitter was replaced with the standby set in Liverpool prior to sailing in order that the recommended intership frequency of 2421 KH2 could be used. A day before the

shooting operation commenced this transmitter failed and the ship's own transmitter had to be replaced. It was not possible to install the 2421 crystal in this set without sacrificing the British calling frequency crystal 2381 or adversely affecting the output at other frequencies. It was therefore decided to use the normal intership frequency of 2301 provided in the ship's set. Attempts to repair the standby transmitter were made by a radio technician in Thorshavn on July 13th but it wasn't until the ship's own transmitter failed while in Thorshavn on July 17th that the common fault was located - a faulty capacitor - reported to be of inferior quality by the technician. The aerial arrangements on the ship were not very satisfactory - a completely new receiving aerial was fitted because the existing one had several breaks in it, new insulators were fitted on the transmitting aerial (they were absent at one end!) and a new connection to the deckhead insulator made. After retuning ,the aerials worked well.

The three cylinder Lister generating set gave trouble - firstly by emitting thick smoke and sparks - eventually diagnosed as a faulty injector and corrected by the chief engineer - secondly by the main on-off power switch burning out and finally by a pipe carrying excess fuel away from the injector bursting and causing the sump to fill with diesel oil. After the first fault arose it was decided to take the spare injector off Miranda but this was unfortunately lost overboard in transit and the standby set on Miranda had to be cannibalised to replace this. Eventually the set on Miranda was transferred to Hawthorn on July 18th and was used to provide a replacement for the burst pipe.

Of the equipment brought by Durham, the Ultra Violet recorder gave most trouble. It is thought this was caused by the DC power supply used. When the damaged components were replaced the instrument was run off a car battery which was floated across a 10 amp battery charger and only switched on for shots. Despite this the 25 amp load soon reduced the voltage output of the 120 AH battery to such a level that the U.V. lamp was very difficult to strike. Inability to start the lamp caused the recording of a number of shots to be missed but fortunately all shots throughout the project were recorded on magnetic tape. The electronic clock used for timing the shots ran down its batteries much more rapidly than expected and as a result before this was fully appreciated and corrected the drift rate may have been higher than is desirable.

Cruise Narrative

July 7th

The ship sailed for Greenock in the early evening of Friday July 7th, the shipyard workers having worked right up to the last minute. The midships toilet had not been repaired but all major items seemed satisfactory. The spare banding machine ordered the previous day from a firm in Manchester had not arrived so Mr. Wilson was left ashore to collect it and take it to the ship in Greenock. On passage to Greenock the Durham recording equipment was set up and tested (because of the last minute work going on prior to sailing, including installation of A.C. mains, Decca, Loran, Field Telephones, this was not possible prior to sailing).

July 8th-9th

The ship docked in Greenock (James Watt Dock) on Saturday evening and started loading the explosives at 0800 on Sunday with Securicor in attendance. The ship's agent was not present and no papers stating the quantities of each item supplied were available. After talking with the I.C.I. representative, Mr. Jeans, it was soon apparent that there was only 122,000 lbs delivered, whereas we were expecting 137,000 lbs. After spending most of the morning consulting I.C.I. and R.V.B. as to how this had happened and how it could best be rectified it was decided that rather than hold up the start of the project while the remaining explosive was brought to the ship (a difficult matter to arrange at short notice on a Sunday) it would be better to sail as soon as the explosives were loaded and collect the remainder at the most convenient port that I.C.I. could arrange. The ship sailed therefore at 1400 on July 9th for a position in the North Minch where it was hoped to fire some trial shots.

July 10th

On leaving the Firth of Clyde a heavy swell was encountered and instead of making the passage in 24 hrs (at 10 kts) it took 35 hrs and the plans for trial shots on July 10th were abandoned. Several members of the party were ill throughout July 10th. Attempts were made to find a good receiving site for the L.F. radio receiver tuned to M.S.F. Rugby but without conspicuous success. This radio has a built in aerial which seemed exceedingly directional. The background noise level seemed to be very high, especially in bad weather. From time to time throughout the 10th, Hawthorn spoke to M.V. Miranda and Durham and also sent a cable to Russian Research Vessel Mikhail Lomonosov

giving the program for the first day's shooting. Test radio transmissions were sent out at 1330 on the 10th and again at 0600 and 0630 on the 11th.

July 11th

Three trial shots of 25, 25 and 100 lbs were fired before the first scheduled shot at 0845. The ship was rolling heavily and the geophone coil was frequently forced against its stops. In order to be sure of not damaging the ship it was decided to use a length of fuse with a burning time of at least 3 min. for the first few 300 lb. shots. At 10 knts. this allowed Hawthorn to get half a n. mile away, which, for 300 lb shot is six times the distance considered safe in deep water. It was expected that in shallow water greater shock would be felt. After four shots it was felt the fuses could be shortened. The burning time of 1 min. 40 secs. allowed the ship to reach at least three times the deep water safe distance when the charge fired. The water depth in the area was 80-120 m. The effect on the ship was greater and eventually the fuses in the automatic steering control blew. The captain requested we use longer fuses which we did. Shooting finished for the day at 2115.

July 12th

Line C was continued the following day in the Faeroes-Shetland channel using larger (600 lbs) charges on $2\frac{1}{2}$ min. fuses. This burning time allowed the ship to reach at least three times the safe distance before detonation. It had been hoped to fire 1200 lbs. charges on this section of the line but after three poor detonations out of four on the 11th and one at the start of the 12th it was decided to reduce to 600 lbs after these charges were found to fire successfully when allowed to free fall on the $2\frac{1}{2}$ min. fuses. With the ship rolling heavily the 1200 lbs charges were much more difficult to build and restrain than the 600 lbs ones. Eventually even the 600 lbs units became unmanageable and after only 9 shots it was decided in view of this and the acute sea sickness of Mr. Crowe to head for Thorshavn. Conditions on board M.V. Hawthorn at this time were apparently completely different from those on M.V. Miranda, largely because of differences in ballasting and the fact that Hawthorn was travelling full speed with the sea on the quarter. While steaming past Russian Vessel Mikhail Lomonosov 17 charges of 25 or 50 lbs were dropped to make a shallow refraction profile (split). The ship arrived in Thorshavn at 0700 on July 13th, Mr. Crowe was landed, the ship's two Radio Transmitters received attention and repairs

were effected to the Durham Ultra Violet recorder. The ship sailed at 2000 to resume line C on the following day, starting as close to Thorshavn as possible.

July 14th

Unfortunately on arrival in the area of the first few shots the sea state was such that the captain considered it completely unsafe to carry out firing operations there. The position of these shots were therefore moved into more sheltered waters and firing commenced at 0900. More small shots were fired while passing Lomonosov and at her request the position of one of her two seismometer marker buoys fixed by Decca and Loran. The last shot of line C was completed at 2110 G.M.T. after a little delay caused by concern over the state of the Lister generator.

July 15th

The chief engineer repaired the generator but in case of future trouble it was decided to ask for the spare injector on Miranda to be brought across at the same time as a replacement for Mr. Crowe. Due to careless handling the injector was lost in transfer from the dinghy to Hawthorn. Due to this and a switch failure on the generator, shooting did not start until 1330. It continued until 2235 when Hawthorn was alongside Lomonosov at the N.E. end of line CB.

July 16th

Shooting in the opposite direction on line CB started the followingg day at 1010 as soon as Miranda had taken up her hew recording position close to Lomonosov. A spare injector was successfully transferred from Miranda to Hawthorn in the middle of a short split profile and firing continued until 0105 July 17th with three breaks of about an hour each while Miranda moved back on station.

July 17th

Both British ships spent the day in Thorshavn and Lomonosov lay outside. At the invitation of the Russian Scientists a party of about 16, including all of the Danish and German parties in the Faeroes, went aboard the Lomonosov to be shown the Russian equipment and to be entertained! The invitation was returned and four Russians were shown round Hawthorn and Miranda. In the course of the day the U.V. spares and banding equipment arrived.

July 18th

The spare generator from Miranda was transferred to Hawthorn before she left the harbour at 0900 to bring explosives on deck. Shortly afterwards the ship's transmitter was found to be dead and there was a long delay while the engineer came out, found the fault, repaired it and then found an identical fault in the standby set. The ship eventually sailed at 1400 and having passed through magnificent fiord scenery Line C was continued commencing at 1950 and continuing until 0005 on July 19th.

July 19th

After bringing more explosives on deck shooting commenced at 1035 and continued along Line A until 0005 July 20th.

July 20th

After waiting for Miranda to take up her new position, shooting started at 1110 and continued until 2245 after which the ship proceeded to Neskaupstadur in Eastern Iceland.

July 21st

The ship berthed 0800 and the party went ashore. During the day operators of the Icelandic and Durham recording stations visited the ship.

July 22nd

The ship sailed at 1800 and at the request of the Icelandic organiser for N.A.S.P. 12 50 lbs shots were fired across the edge of the Icelandic "Shelf".

July 23rd

Additional shots on Line A were shot from 1400 to 1740 and from 2140 to 2320. Five attempts were made to use Aquaflex to link the fuse to the charge but all failed.

July 24th

Mr. Palmer from Hunting Engineering was picked up by Pilot boat, explosives brought on deck and shooting of Line B commenced 1135 after waiting for Lomonosov to lay a second bottom seismometer. Shooting continued until 2135.

July 25th

Line B was started at 0740 and continued until all 6' fuses were used up at 1525. A course was set for the Firth of Forth where more fuse and the balance of the explosive was due to be delivered.

July 26th was spent on passage. Recordings made earlier in the trip were checked. The ship anchored off Inch Keith for the night.

July 27th

We came alongside Crombie pier about 1230 B.S.T., loaded explosives, fuses and detonaters and sailed 1530 for Aberdeen to collect bunkers.

July 28th

Arrived Aberdeen about 0600 and left 0830. Explosives brought on deck before starting line E at 1450. Line complete at 2220. Three misfires occurred as a result of trying to use Aquaflex to fire the charges. The safety fuse collected at Crombie Pier would not fire the charges. The weather was good.

July 29th

Line B was continued at 0835 and completed at 1305. Line D was started at 1535 and continued until 2155 in ideal conditions. The coastguard in Wick was informed of all unexploded charges in British waters.

July 30th

Line D was continued at 0700 and finished at 1710.

July 31st

Line F was started at 0700 and finished at 0940. The ship then headed for Liverpool and as soon as radio reception was good enough the NASP control centre was informed of the completion of the project.

August 1st and 2nd

On instruction of the ship's owners, Hawthorn proceeded to Barry. On passage the woodwork in the explosives magazine was dismantled and some tape recordings of the shots played back.

August 3rd

Hawthorn arrived in Barry Roads 1730 B.S.T. and took aboard three welders

to partially dismantle the magazine in order that ballast could be unloaded the following day in Newport. Two representatives of the ship's owners stayed the night on board and Beney, Lewis and Holden left to spend the night ashore.

August 4th

The ship arrived in Newport at 1230 B.S.T. and after Customs and Immigration clearance the Durham party left at 1500.

Conclusions

Much useful experience was gained in the course of the cruise which it is felt worthwhile to record for future reference.

Personnel

In case of sea sickness, tiredness or other ailment it is important at all times to have a standby for all vital aspects of the work. In particular it is now felt that at least two geophysicists with some experience at sea should have been carried. Only Vertue, Asbery and G. Wilson have previous experience and they were all heavily committed as explosive technicians and therefore unable to assist on the bridge.

Ship

The vessel was barely adequate for the work. It transpired after we sailed that she had quite a number of loose rivets and therefore we had to err on the side of safety when chosing fuse lengths, particularly in shallow water where the effect on the ship is less predictable than in deep water. The radio transmitter was not sufficiently powerful nor was it designed for virtually continuous use - hence, probably, the failure of the set and its standby and the resulting need to change to a noisier frequency. In future when more modern sets will have to be carried by law it is recommended that two sets should be fitted in order that ordinary link calls can be made at the same time as the seismic work. On Hawthorn it was difficult to make link calls without long breaks from seismic work while waiting "turn".

The use of a derrick or crane for lifting explosives at sea is not to be recommended. A better arrangement would be a slide with sidewalls up - which a netful of explosive could be dragged by winch.

Vessels used for the purpose should have Decca receivers already fitted and tested at sea. A simple log for estimating speed would be a considerable advantage.

Explosives

No definite explanation for the poor detonation of the 1200 lbs charges was found. The first few charges were made up by Mr. Vertue according to Cambridge practice with 4 blocks of 300 lbs linked by 200' of Aquaflex to a slow burning fuse. The only difference was that the charges hit the bottom before detonation and that a mooring was attached. At first it was thought that the charges were breaking apart either on impact with the sea bed or the sea surface or through interaction with the mooring. After the fourth 1200 lb charge (which was directly fused and had no mooring) fired successfully on the seabed it was concluded that for the earlier shots the Aquaflex had failed in some way, possibly through interaction with the mooring. Attempts to fire charges using Aquaflex were made later in the project but without consistent success even in shallow water (50-100m). All possible methods of sealing and securing the Aquaflex to the Geophex were tried in order to identify the reason for the failures. It was eventually concluded that the Aquaflex was affected by pressure in such a way that it only detonated down to a certain depth. The maximum depth of a charge successfully fired by Aquaflex is estimated to be 100 m, but failures occurred in only 50 m.

Direct fusing was found to be satisfactory for charge depth of at least 150 m. Leaving the explosive in the cardboard boxes facilitated building of the larger charges and resulted in a sinking rate such that charges of 600 lbs could be allowed to free fall to close to their optimum detonation depth while allowing the ship to reach a safe distance. In view of the observed variability in burning times, and hence of sink rates, it would have been preferable to use a longer fuse and a mooring to control the depth of shot. A better method of packaging the charges other .than simply banding them together was thought desirable if moorings were to be employed, a possible method being to pack the individual charges into old oil drums.

Regarding the safe firing of charges in shallow water the following burn times were found satisfactory in all water deeper than 50 m

300 lbs	1m 40 sec.
600 lbs	2m

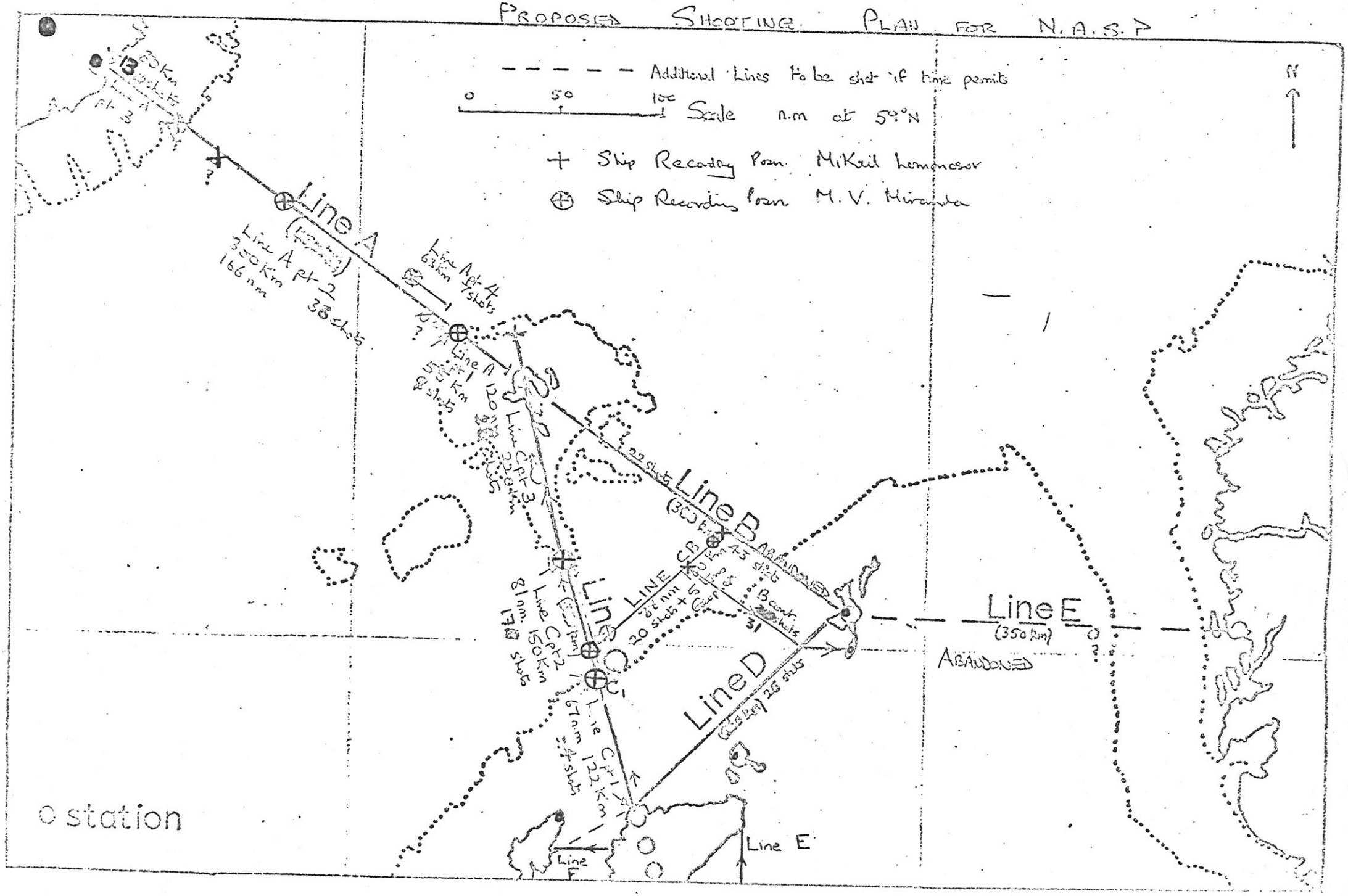
Attempts to use safety fuse in shallow water were unsuccessful and jointed oceanographic fuse in shallow water was unreliable.

Recording equipment

A communications receiver should be available for receiving W.W.V. Time Signals. Neither the ship's receiver nor Durham's short wave receiver could pick up this station. A Rugby LF receiver which can be fed from an external aerial would probably be preferable to one with a highly directional built-in aerial. An ultra violet recorder capable of running off 240v A.C. should in future be used with some other form of visual monitoring device as back up. A less sensitive geophone than the Hall Sears should be used and galvanometers having a flat frequency response up to 1 KH_Z should be used to make it easier to differentiate the water wave from ground waves, which, in shallow water, can arrive earlier. The Durham time encoder should be run off an accumulator on trickle charge with the display tubes permanently lit and simultaneously displaying seconds and minutes. N.E.R.C./ R.V.B. log-books should be available and used by the ship's officers as well as the scientific party.

Despite the many and varied problem s encountered the cruise was a success and I would like to thank all those who contributed to this.

J.Sunderland - Senior Scientist
August 15th, 1972


PROPOSED SHOOTING PLAN FOR N.A.S.?
Additional Lines to be shot if time permits
0 50 100
Scale n.m at 59°N
Ship Recording Poss. MiKail Lomonosov
Ship Recording Poss. M.V. Miranda
N
Line A
(350 km)
Line A Prt 2
350 km
166 nm
38 shots
Line A Prt 4
63 km
Line A Prt 3
120 km
Line C Prt 3
Line C Prt 2
150 km
Line B
(350 km) 45 shots
ABANDONED
Line C Prt 1
122 km
Line D
(67 km) 25 shots
Line E
(350 km)
ABANDONED
Line F
station