I.O.S.

INSTITUTE OF OCEANOGRAPHIC SCIENCES

R.R.S. JOHN MURRAY

CRUISE 8/78

12 July - 1 September, 1978

Meteorological Observations during JASIN 1978.

CRUISE REPORT NO. 76
1979

NATURAL ENVIRONMENT RESEARCH COUNCIL
INSTITUTE OF OCEANOGRAPHIC SCIENCES

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SCIENTIFIC PERSONNEL

(numbers in brackets indicate cruise legs)

T.H. Guymer	(1,2,3)	IOS(W)	Pr. Sci; Radiosondes
H.T. Bull	(3)	IC	Met. observer
Miss K.E. Campbell	(1)	UEA	Met. observer
D. Edge	(2,3)	IOS(W)	Radiosondes
Mrs. P. Edwards	(2,3)	IOS(W)	Met. observer
P. Kenward	(1,2,3)	IOS(W)	Radiosondes
J. King	(2)	MO	Radiosondes
D.A. Mansfield	(2)	IC	Met. observer
Miss R. Muir	(1)	IOS(W)	Met. observer
G. Parkes	(1)	IC	Met. observer
A. Thomas	(1,2,3)	IOS(W)	Radiosondes
Mrs. J. Tranter	(2,3)	IOS(B)	Met. observer
G. Vallis	(1)	IC	Met. observer

IOS(W) Institute of Oceanographic Sciences, (Wormley)

IOS(B) Institute of Oceanographic Sciences (Bidston)

IC Atmospheric Physics Group, Imperial College

UEA University of East Anglia

MO Meteorological Office

INTRODUCTION

During the period July to September JASIN 1978 took place, in which fourteen ships, three aircraft and thirty-five mooring systems were used to study air-sea interaction off the north-west coast of Scotland. More than fifty teams of investigators from nine countries participated. Cruise 8 represented John Murray's contribution to the program and was divided into three legs (A, B, and C) each approximately 2 weeks long and corresponding to the three observational phases of the experiment.

The main items of the scientific program were:-

(1) Radiosonde launches at intervals determined by weather conditions. On intensive days hourly launches were aimed for between 0600Z and 2100Z (all times in this report are GMT); apart from these a program of 6-hourly ascents was maintained.

(2) Automatic logging of 1-minute values of surface pressure, relative wind speed and direction, wet-and-dry bulb temperature, sea surface temperature, solar and net radiation.

(3) Hourly surface meteorological observations. The variables in (2), apart from radiation, were measured by an independent set of instruments as a back-up. Additional observations of precipitation, cloud type, wind and swell waves, and present weather were made. These reports were transmitted at 6-hourly intervals to aid forecasting for the JASIN area.

(4) Photographs of cloud cover using a 16mm time-lapse all-sky camera and 35mm cameras. Precipitation echoes on the radar display were also photographed.

(5) Operation of Ship-borne Wave Recorder at three or six-hourly intervals when on station and additional records during passes of SEASAT-A, a new oceanographic satellite, for which 'ground-truth' measurements were required.

(6) Intercomparisons of systems on all meteorological ships. These took place in prearranged formal intercomparison periods. Every opportunity was also taken for comparisons with other platforms on an opportunity basis.

following day, two while the ship was stationary and one while steaming. On the 22nd there was a formal intercomparison (number II) with other meteorological ships which included a pressure calibration and the tracking of sondes released from Meteor and John Murray. At 1500 we set course for Glasgow having completed the program for Phase O. The WMO observations and half-hourly navigation fixes ceased at 0700/23rd shortly before we passed St. Kilda where the course was altered to take us through the Sound of Islay. John Murray docked at Glasgow 1800/24th.

Leg 2 (for track plot see Fig. 2; also see activity diagrams)

Modifications were made to the aft platform during the in-port period which facilitated balloon launches. John Murray sailed from Glasgow at 1500/27th July and headed for the Fixed Intensive Array at 59°00'N, 12°30'W. A course along the coast of N. Ireland was taken to gain protection from a beam sea. In the early hours of the 29th a mooring, believed to be C5 adrift, was sighted and Meteor was informed. While in the vicinity of the FIA intercomparisons with Atlantis II., Meteor B2 and the C-130 were carried out. We then steamed to J1, our station for Phase 1. The next day was declared intensive and 12 sondes were launched; H3 was also checked. On 31 July, in calm, sunny conditions a line of discoloured water was observed extending from horizon to horizon. SST was measured along a line perpendicular to the feature and a water sample was taken. A search for the line on the following morning proved fruitless. Light winds enabled a balloon and sonde to be tethered to the ship whilst attempts were made to improve the humidity signal. This led to a permanent solution of the problems by the next day. A visit to H3 was also made on 2nd and on the return a pressure calibration was carried out.

Conditions were slow to change with drizzle at times as occluded fronts progressed very slowly westwards. The air temporarily became drier and colder overnight on the 1st/2nd

(i.e. outside possible intensive periods) but it was not until the 4th that conditions became suitable for intensive operations. The Porton psychrometer,, which had been giving wet bulb temperatures higher than dry bulbs, was checked on the evening of 6th; it appeared that the voltage output was too high at the sensor end. At 1935/6th we closed to within 0.1nm of J1 and checked the instrumentation. 1-minute readings of surface variables were taken for comparison followed by a pressure calibration against relative wind. The 7th August was declared intensive because of weather conditions and aircraft availability followed by a quiet day during which the C-130 and Electra made several overpasses. Before leaving station on the evening of the 8th, H3 was checked. Course was set for B4 to the north of the FIA and on arrival at 0530/9th surface measurements were taken for comparison. Discovery was engaged in a batfish survey just to the east during this period. An hour's steaming brought us to the FIA for Intercomparison III with Meteor and Endurer. After three hours of measurements the John Murray steamed for Glasgow spending until 1900 searching without success for the missing waverider C5. Berthing at Yorkhill Quay took place at 0900/11th August.

Leg 3. (for track plot see Fig. 3; see also activity diagrams)

During the port-stop checks were made on several instruments in the Porton Ship Meteorological System including a recalibration of the psychrometer one of whose potentiometers appeared to have loosened. The vessel set sail at 0800/17th August and proceeded via the Sounds of Islay, Mull and Sleat to the Butt of Lewis. A large Atlantic swell and strengthening southwesterly winds caused us to head for Faeroes Bank then to H3 arriving at 2100/19th. Intercomparison IV took place in deteriorating weather from 0900-1900 on the 20th and by the time of the final balloon launch from John Murray winds were 32Kt. This probably represented the upper wind speed limit for radiosonde launches. The rough seas prevented ships

(7) Calibration of pressure readings against the relative wind.

Operational aspects differed slightly between the phases. Phase 0 was intended as a period for the testing of equipment since the 200km triangle, regarded as a minimum requirement in the overall radiosonde program, was not planned to be in existence until Phase 1. However, useful data on the small-scale variability of surface meteorological parameters were obtained from an array formed with Hecla and two surface moorings, J1 and H3 (see Fig. 2 for locations). Occasional radiosondes were also launched. During Phase 1 John Murray was at J1 and carried out the full program of a corner ship but for Phase 2, when she occupied a station at the centre of the triangle, the requirement for 6 - hourly ascents was relaxed and only occasional soundings were made outside the intensive days. During this third leg the John Murray stood by ready to relieve any of the corner ships which were unable to maintain their series of primary measurements. This contingency plan was operated when Hecla left station on a medical evacuation on 25 August.

Weather conditions were mostly good. Winds were light or moderate for a large proportion of the time, strong winds hampering the program on 21 August only. There were fewer instances of cold-air outbreaks and well-defined fronts than to be expected from climatological statistics and precipitation, if any was generally in the form of drizzle. The predominant cloud cover was stratocumulus and stratus.

Most of the equipment functioned well. Some problems were encountered with the automatic logging of surface variables, particularly in Phase 0. Radiosonde humidity data were lost near saturation until an adjustment was made to the ground tracking equipment. More frustrating was the lack of an adequate Loran-C navigation system since Loran-C had been specified as the primary navigational aid for the experiment.

A set transferred from Discovery an hour before sailing did not work. Fortunately, an old receiver on the John Murray was made to function and continued to operate throughout. However, it was extremely tedious to read and gave inaccurate fixes. Had Decca not proved unexpectedly reliable, this could have been a limitation on the ship's program.

NARRATIVE

Leg. 1 (for track plot see Fig.2 ; see also activity diagrams)

John Murray sailed from Barry at 1110Z/12th July and proceeded to the JASIN area via the Irish Sea. Fog was encountered from 0600-1330 on the 13th and speed was reduced. The Porton psychrometer was rigged and gave readings in good agreement with the Assmann However, the Digiquartz pressure sensor was not working. Hourly surface observations were started at 1200/13th and half-hourly Decca and Loran fixes at 2000/14th. After arriving on station alongside Hecla ($60^{o}15'N$, $10^{o}30'W$) at midday on the 15th the Porton SST probe was deployed and appeared to operate satisfactorily. A Hecla scientist was able to rectify the pressure transducer fault and advise on the logging system which was functioning only intermittently.

The first attempt at a radiosonde launch was made on the 16th followed by a comparison with H3 and then a pressure calibration in which the vessel steamed into wind and down wind. A similar program was carried out on the following day but this time the pressure measurements were made while the ship was hove to on 8 different headings. On the 18th we steamed slowly upwind to a position 15 miles west of J1. A $1^{o}C$ change in SST was found. Having returned to station the booms holding the radiation balance meters were swung into position.

The SST probe was recovered on the 19th and was found to have leaked. It was not used again in the experiment. Preparations were made for a trial intensive day on the 20th when 10 sondes were launched and Hecla flew a tethered balloon for part of the time. Three pressure calibrations were carried out on the

from reaching their Phase 2 stations in time for an intensive day on the 21st resulting in its cancellation. However, one was held on 22nd in anticipation of frontal activity. The C-130 made on air-drop of spare chart rolls for the LO-CATE set and the opportunity was used for an intercomparison. At 2100 Discovery arrived to lay a radar marker (M1) at our station position which greatly facilitated navigation. A comparison of surface meteorological measurements and ship-borne wave recorders was also completed.

Since the next day was declared 'quiet' the opportunity was taken to steam to H1 where a spare Assmannpsychrometer was transferred to Endurer. The steerable, directional antenna was mounted and put into operation to minimise interference by other sondes. We returned to station and started intensive launches at 0600/24th. The following day was also intensive but at 2200 Hecla reported that she was leaving her station for a medical evacuation and John Murray immediately steamed to J1 to replace her and maintain the sequence of surface and upper air observations as provided for in the contingency plans. Only the midnight ascent was lost. While at J1 data were obtained from a radiosonde mounted on the bow to monitor variations in temperature and humidity and to compare with Assmannreadings. When Hecla returned at 1800 instead of returning directly to M1 we steamed to H1 to transfer spare sondes to Endurer. (It had been decided that the 27th was unsuitable for an intensive program). During the period of close proximity to Endurer several activities were carried out. An Endurer scientist came on board to measure the outputs of the Porton Anemograph so that faults on Endurer's system could be rectified. The variation of SST around both ships was measured from a Zodiac boat. In light wind conditions a tethered radiosonde was profiled through the lowest 200m up to cloud base and the data recorded. Intercomparisons were also carried out between the two ships and H1 before John Murray returned to M1 arriving at 1900/27th.

An intensive day was held on the 28th and on the 29th after recovering the radar marker we steamed to the FIA. Data were again gathered from a radiosonde on the bow. A short intercomparison with Meteor and B2 was carried out including a pressure calibration at a range of ship speeds and the John Murray left the JASIN triangle for the final time at 1500/29th. Three days sailing in calm conditions brought us, via the North Channel, to Barry.

NOTES ON EQUIPMENT AND OBSERVATIONS

RADIOSONDES (staff concerned: T. Guymer, P. Kenward, A. Thomas, D. Edge, J. King).

Upper air measurements of temperature, relative humidity and wind were made using a Beukers LO-CATE WL2 receiver to track VIZ radiosondes (usually type 1220 but occasionally 1205) which were equipped with premium hygristors. Loran-C signals from SL3M, SL3W and SL3Y were used throughout. An IOS-constructed data logging system enabled the data to be recorded in digital form at a frequency of 1 Hz. However, analogue chart records were obtained on all flights for both the 'meteorological' and wind data, allowing the calibration and phase-lock to be monitored and also permitting some data analysis in near real-time. The latter was useful in identifying interesting meteorological situations.

Radiosondes were calibrated up to four days in advance where possible using a baseline check box. During Phases 0 and 1 silica gel was placed inside to reduce the relative humidity. Baseline thermometers were calibrated against those from the other radiosonde ships during the in-port period between Phases 1 and 2. The sondes were carried aloft by 350g baloons filled with 70 cu.ft. of helium this being sufficient to ensure an ascent rate of 5-6 ms^{-1}. All flights used a single balloon, but on intensive days a release device (Max-Planck Institute, Hamburg) and parachute (Met. Office) were included in the rig so that at a predetermined height the sonde was released from the balloon and returned gently to the surface, still transmitting useful data and also clearing the air of radio transmissions. A special aft platform was constructed around the A-frame before the cruise to raise the elevation of the launch point

and to give increased protection to the balloon during filling. The arrangement worked extremely well, although minor modifications were necessary after Phase 0 because the opening through which the balloon was released was too restricted. Only 5 balloons out of over 150 burst during the project and on no occasion did the sonde hit the water during launch.

Details of all flights are given in Table 1. Eight intensive days were held, these being decided by the co-ordination team at Machrihanish in consultation with Principal Scientists on the meteorological ships. During Phase 1 John Murray launched 6-hourly sondes outside intensive periods but in Phase 2 this requirement was dropped. On intensive days the aim was to release all apart from the 06, 12, 18z flights at the 500 mb level since this was well above the top of any boundary layer present. Many of the releases activated prematurely due to leaks but some went too high possibly due to icing. The parachutes functioned extremely well with only one failure and gave a descent rate of about 4 ms^{-1}.

The John Murray was involved in several formal intercomparisons of radiosondes. Each ship in turn launched a sonde which was tracked simultaneously by the other ships. Owing to incompatabilities between the fast-sampling sondes used on Hecla, Meteor and Endurer and the WL-2 system we were able to record only the Loran-C phase differences. Some comparisons were also made with other systems on board John Murray. On 26 and 29 August a sonde was mounted on the bow to measure the ship's velocity and to compare temperatures with those recorded by the Assmann psychrometer. A tethered sonde was also flown up to 200 m in light winds on 27 August.

On early ascents it was noticed that the relative humidities indicated by the 1220 sondes were doubtful when at or near saturation. There was also a range of temperatures for which the chart record was very noisy. The problem was traced to the met. data converter board which required retuning when 1220 type sondes were used instead of the 1205s. Difficulties were also encountered with a weak SL3W signal which sometimes made it impossible to lock on before launch. Some improvement was gained by resiting the 100 KHz

antenna. At the beginning of Phase 2 transistors from reject 1205 sondes were used as replacements in the 403 MHz antenna coupler.

A failure within the drive mechanism of the chart recorders meant that they had to be run at their fastest speed. To replenish supplies an airdrop of spare chart rolls was made by the C-130 on 22 August. A further contingency plan was brought into operation when Hecla had to leave station for a medical evacuation. Speedy replacement by the John Murray meant the loss of only one of the 6-hourly series of ascents.

WAVE RECORDING (P. Edwards, J. Tranter, D. Mansfield, T. Bull)

The NIO Shipborne Wave Recorder, located in the gravimeter room of the John Murray was operated on many occasions during JASIN when the ship was on station and occasionally when on passage. During Phase 0 operation was not on a routine basis, records being required mainly to coincide with SEASAT passes or pressure calibration runs (total 6 hours). Throughout Phase 1 records were obtained every 3 hours for 30 minutes starting at 0230, 0530 GMT etc., with extra records for SEASAT passes (total 53 hours). After 21 August in Phase 2 the recorder was switched on every 6 hours at 0040, 0640 GMT etc., with occasional departures to cover SEASAT passes (Phase 2 total - 27 hours). For details see activity-time diagrams (Fig. 4).

Analogue traces were obtained and care was taken to ensure that accurate time marks were made and that ship movements were recorded. Generally the ship remained on a constant heading at speed less than 2 kt for the duration of each record where this did not conflict with other requirements. At 2030/22 August an intercomparison was carried out with Discovery's SBWR.

Inconsistencies were found in the annotations of records in Phase 0 which may mean errors in timing of a few minutes. Apart from this the main problem was in the pen occasionally lifting off the paper resulting in gaps in the record.

SURFACE OBSERATIONS (P. Edwards, J. Tranter, D. Mansfield, T. Bull, G. Parkes, G. Vallis, R. Muir, K. Campbell).

The John Murray was equipped with the Porton Ship Meteorological

System (PSMS) for automatic logging of surface wind, dry and wet-bulb temperatures, sea-surface temperature, pressure and radiation. In order to provide a back-up series of measurements and to provide additional quantitative information for defining the meteorological situation a team of observers maintained round the clock observations based on WMO standards. It was desirable that certain of the measurements be made at particular times in the hour with pressure as close to the hour as possible. After the first few days of Phase 0 the schedule in Table 2 was adopted and maintained for the rest of the cruise. During formal intercomparisons the WMO observations were made every half hour. Details of these and other intercomparisons are shown in Table 3. Data were also taken for SEASAT studies.

Logging

Outputs from each of the PSMS sensors were fed via a logging unit into a Wang desk top computer where 1-minute integrated values were stored. Every 6 minutes these 1-minute raw data values were logged on to cassette tape. It was general practice to change the tapes every 12 hours during the hour preceding 00 and 12 GMT. On some occasions this was not done and the tape then ran for a maximum of four more hours after which data were lost until the tape was replaced. It was also possible to print calibrated values of the variables at 1-minute intervals or averaged over any number of minutes, thus providing a check on the reliability of the measurements.

Periods during which data were taken are shown in the activity diagrams (Fig. 4). During Phase 0 there were a number of occasions when logging failed, possibly due to fluctuations in power supply, and reprogramming of the computer was necessary. Performance was much improved in the subsequent phases. Isolated spikes on all variables occurred and were attributed to radio interference.

The hourly observations were noted in a log specially designed for JASIN and 3-hourly values of selected quantities were plotted by hand. A description of the measurements and procedures is given below.

Winds

Two cup anemometers were clamped to one end of a horizontal boom mounted 1 metre forward of the foremast cross-trees and about 11 m above sea level. At the lower end of the boom were two wind vanes, one set so as to give directions relative to the ship's head, the other a self-referencing instrument giving direction relative to true north. Both, however, measured the apparent wind. This configuration was designed to give optimum exposure when the vessel was heading into wind. One of the anemometers and the self-referencing vane were connected into the PSMS. The outputs of the other instruments were fed into a Porton Anemograph where the data were displayed in two ways - meters and a paper-chart recorder (Rustrack). In the latter values were plotted at 2 sec. intervals and time-marks were made very 30 minutes. A 1-minute filter was generally applied to the winds but in Phase 0 a 10-minute filter was switched in. Unfiltered values were recorded during intercomparisons with buoys and in pressure calibrations.

For the hourly observations the anemograph meters were read together with the ship's heading from a gyro compass repeater and the speed off the Bergen log. This enables true winds to be computed. Conversion of the rest of the data to true winds should be possible using a chart record of ship's head. A comparison with Endurer on 23 August revealed a difference in wind direction of $\sim 15^{\circ}$ which was traced to a shift in the base of the wind vane (non self-referencing). Preliminary investigation suggests this occurred on 23/24 July.

Printouts of the self-referencing wind vane showed little variation in wind direction even when the ship was turned through 360°. The fault appeared to be in the vane itself and therefore it will probably not be possible to retrieve the data. Wind speeds from both systems did, however, appear to be reliable and encouraging agreement was achieved.

Pressure

A Meteorological Office pattern static head was mounted at the centre of the meteorological boom mentioned above and was connected by plastic tubing to a manifold in the gravimeter room. Three

pressure measuring devices were connected to the manifold; a Digiquartz transducer and two Precision Anenoid Barometers (PAB). The location was chosen to minimise the effects due to ship motion and to be close to the water-line.

The Digiquartz contained a thermistor since its output is temperature-dependent. Signals from both were carried by cables to the PSMS logger. During the passage out to station in Phase 0 it was discovered that the Digiquartz was giving unrealistically low readings. A Porton Down scientist on board Hecla transferred to the John Murray and was able to identify and cure two faults. The output voltage from the transducer was too low to drive the signal up the cable and an incorrect calibration constant had been used in the computer program. Once these had been rectified the pressures agreed to within a few tenths of a millibar with the PABs. Since significant variations with temperature were reported by Endurer an effort was made to monitor the temperature of the gravimeter room.

Calibration corrections were supplied with the PABs but these were inconsistent with observed differences between the instruments and only the raw data were recorded. PAB 2 appeared to have excessive free play in its adjustment so PAB 1 was taken as the primary data source. Both instruments were read as close as possible to the hour and pressure tendencies were taken from PAB readings during the previous 3 hours.

Several investigations into the effect of the relative wind on pressure measurements were made in the course of the cruise. The output of the Digiquartz, PABs and relative wind were taken every minute while the ship varied its heading and speed in a systematic manner. Details of the various runs are given in Table 4.

Air temperatures

Dry-and-wet-bulb temperatures were measured in the PSMS by an electrically aspirated psychrometer fitted with Rosemount platinum resistance thermometers, one covered by a muslin wick kept moist with distilled water. The sensors were protected from rain, spray and the effects of solar radiation and the psychrometer was suspended

from the foremast boom via a pulley system so that it could be lowered to deck-level for wick-changing and for checking the level of distilled water in the reservoir. It was prevented from swinging during lowering by using the signal cables. The wick was, in fact, not changed at all because of difficulties in fixing the clean one. However, the original wick was inspected regularly and washed with distilled water when necessary.

The hourly temperatures were obtained using an Assmann psychrometer with a clockwork-driven aspirator to ventilate the bulbs. Before each reading the wick was moistened with distilled water taking care not to contaminate the dry-bulb; dirty wicks were replaced. The motor was wound and the instrument was suspended over the side of the ship into wind (usually from the bridge wing but occasionally, with a following wind, from the stern of the vessel). Readings were taken until a stable minimum value was achieved, usually after about five minutes, and these temperatures were recorded.

On the morning of 9 August the aspirator motor seized and while repairs were being effected the screen thermometers on the bridge deck were used. A comparison of all the thermometers used in the Assmann and SST measurements was made using a water bath and revealed differences of 0.3°C or less. On one or two occasions 5-minute readings of the Assmann were taken to compare with buoys or other ships. Both dry and wet-bulb temperatures appeared to vary in a sensible manner. Anomalously high values were sometimes observed in light relative winds, especially in sunshine.

The dry-bulb on the Porton psychrometer performed reliably, a systematic difference of 0.5°C between it and the Assmann being attributed to a known error in the calibration program. In contrast the Porton wet bulbs in Phase 1 showed an increase with time compared with the Assmann leading eventually to readings several degrees in excess of the dry-bulb. On return to port investigation showed that a potentiometer adjusting screw had slipped. It was resealed but similar behaviour was observed in Phase 2. Although absolute values of the wet-bulbs are suspect a simple calibration can probably be applied by comparing hourly values with those of the Assmann.

Sea surface temperature

The PSMS measurements were made using a resistance thermometer which was allowed to float on or just below the sea surface regardless of ship and wave motion. A flexible pole extended 2-3m horizontally over the side of the ship from the foredeck and lead weights were suspended from its end by a nylon line so that at all times they remained at least a metre below the surface even while the ship rolled or steamed slowly. A polystyrene float, to which the sensor was attached, was free to ride up and down this line following the movement of the surface. By suitable adjustment of the length of the power and signal cables and the way in which they were secured to the float a configuration was eventually found where the probe remained within a few centimetres below the sea surface even when streamed at ship speeds of 5 kt. Unfortunately the probe was found to have leaked on 19 July and although replacement sensors were available subsequent problems with the amplifier meant that the system was not used again. However, several hours of data were recorded while the ship was in the vicinity of J1 and Hecla.

SST was also measured by collecting surface water in a Meteorological Office rubber steaming bucket clear of the ship's hull and forward of engine outflows. The area near the hydrographic winch on the starboard side proved satisfactory but when samples were taken from various locations round the ship no significant variations were found. Measurements from a Zodiac boat at distances of up to 1 mile from the vessel showed a similar result. After the bucket had been pulled in a fast response mercury thermometer was immersed and after 30 seconds of continual stirring was read. On 31 July a line of discoloured water was observed and because the PSMS probe had failed a series of bucket readings was carried out at 30-60 second intervals while the ship steamed slowly across the feature to investigate changes in SST.

Radiation

Measurements of downward solar radiation and net all-wave radiation were made as part of the PSMS. A solarimeter was bolted to the bridge deck in an area where the effect of shadows would be minimised.

The solarimeter plate was gimbal-mounted so as to remain horizontal. On several occasions it was noticed that the output voltage was small and negative even when insolation was significant. However, during Phase 2 the output was monitored at hourly intervals and reasonable results were achieved. Two radiation balance meters were used, each mounted at the end of 3 m long booms projecting from the mooring over each side of the ship. The instruments were mounted in yokes in such a manner that they remained horizontal despite ship motion and the booms could be raised and hauled inboard in heavy seas to avoid damage (this did not in fact prove necessary). For much of the time the output voltage remained constant and is therefore suspect.

Clouds

Attempts were made to classify the clouds observed, according to WMO conventions with the exception that 'significant clouds' did not have to meet such rigorous criteria. Heights of cloud deduced from radiosonde humidity data were used where appropriate.

Visual observations were supplemented by photographic records. An all-sky camera, consisting of a Bolex H16SB cine camera mounted on a tripod above a parabolic mirror, was operated in time-lapse mode by an electronic timer connected via a solenoid to the shutter. Sampling intervals of about 10 minutes in Phase 1 and 2 minutes in Phase 2 were obtained (no all-sky photographs were taken in Phase 0). Apart from periods of precipitation the camera ran continuously from approximately 0800 to 1900, the date and time appearing on the first few exposures each day and the time of each frame being given by a watch which also appeared in the field of view. A single lens aperture of f11 was used which leads to underexposure of the evening skies.

Cloud photographs were also taken using 35 mm cameras. In Phases 0 and 1 these were on an occasional basis but were nearly hourly during the final phase.

Rainfall

Two rain gauges, each consisting of a funnel leading into a glass measuring cylinder with graduations appropriate to the diameter of the funnel, were used to quantify precipitation. One was attached

to a rail on the port bridge wing, the other to the top of the hydrographic davit on the starboard side of the bridge deck, at heights of 19 and 23 feet respectively. Neither exposure was ideal but the rainfall collected in both cylinders was comparable and even light drizzle was recorded. At high sea state (e.g. 20 August) there was evidence of spray contamination.

A Decca Radar TM 629 was used to identify the bearing and range of areas of precipitation up to about 20 miles from the ship. The radar appeared sensitive to light drizzle particularly when carefully tuned but occasionally did not show echoes when rain could be observed visually. When well-defined echoes were observed photographs of the display were taken with an Olympus 35RC camera set at f11. The shutter was kept open for 5 or 6 sweeps of the radar scanner.

Waves

Visual estimates of wind and swell waves were made every hour noting the amplitude (crest-to-trough), period and, in the case of swell, direction from which the waves were moving. All waves not moving with the local wind direction were classed as swell. Those which moved with the wind but whose height and period were too large to be driven by the local wind were also recorded as swell. A preliminary comparison of observed waves with that of the SBWR charts shows similar variation with time and estimates of wave height are about two-thirds of the maximum recorded in the relevant half-hour.

NAVIGATION, STATION KEEPING PROCEDURE AND ECHO SOUNDING

At all times when within 100 km of the JASIN area half-hourly uncorrected Loran and Decca fixes were taken. The scientific party were responsible for logging the Loran-C readouts (Master:SL3M, Slaves: SL3W and SL3Y) together with the North Scottish Decca (Red and Green). The bridge officers, using an independent Decca set, recorded the Red and Green lanes of the North Hebridean chain. Navigation round the JASIN area was by means of Decca. Half-hourly radar fixes on buoy J1 and Hecla were also taken in Phase 0 and on J1 alone in Phase 1. For the final phase radar fixes were taken on a marker laid for us by Discovery near the centre of the 200 km triangle at 59 46N 12 30W.

When keeping station at J1 the ship steamed into wind at minimum

speed until abeam of the buoy and then returned downwind for about 1 mile at 2-3 kt before repeating the pattern. This avoided disturbance of the airflow in which the meteorological instruments on the buoy were embedded. A similar procedure was adopted when navigating by the radar marker in Phase 2 except that the upwind leg was continued past the buoy until nearly out of radar range. Radiosonde launches were always made with the ship heading into wind.

Two echo sounders were employed. The SIMRAD was used during most of the passages to and from station when on the continental shelf. The Precision Echo Sounder (PES) was tried unsuccessfully in Phase 1. After repairs in port it was then operated with the hull transducer for selected periods in Phase 2.

ACKNOWLEDGEMENTS

It is a pleasure to acknowledge the helpful and interested co-operation of the Master, Captain P.H. Warne, and the officers and crew of the R.R.S. John Murray. The bridge officers are to be thanked for their transmission and reception of the special JASIN broadcasts which were an important part of the co-ordination plan.

Mrs. P. Edwards and Mrs. J. Tranter provided notes on many of the meteorological observations which formed the basis of one of the sections of this report.

T.H. Guymer

TABLE 1. RADIOSONDE FLIGHTS

Ascent No.	Date	Launch Time (z)	Mag. Tape	Entered cloud (mb)	Pressure tracked to (mb) Ascent	Descent (S-Surface)	Comments
Phase 0:							
1	July 16	1326	-		1013	-	Stopped transmitting after two minutes.
2	17	1141	1	951	38	-	1205 sonde
3	17	2057	1	942	214	-	
4	19	1146	2	947	205	-	
5	20	0703	2	859	322	-	
6	20	0905	2	680	495	1000	
7	20	1044	3	854	347	-	? Balloon leaking
8	20	1246	3	870	539	S	
9	20	1403	4	872	209	-	
9A	20	1550	4	-	965	S	Premature release
10	20	1650	4	915	683	S	
11	20	1852	4	903	640	S	
12	20	1957	5		572	S	Data not logged after 2007.
13	20	2140	5		-		Only T. transmitted
14	22	1413	5	898	209	-	Also tracked by Endurer
-	22	1220	-	-	-	-	Launched by Meteor
Phase 1:							
15	30	0659	5		253	-	
16	30	0825	5	Clear	439	-	Release failed. Tape recorder not connected
17	30	0953	6		-	S	Baroswitch jammed so only wind data
18	30	1050	6		512	999	
19	30	1248	6	Clear	650	S	
20	30	1403	7	Clear	783	S	
21	30	1515	7	Clear	487	S	
22	30	1625	7	?Clear	592	S	Tape recorder not on
23	30	1750	8	Clear	479	S	for ascent
24	30	1908	8	Clear	336	995	
25	30	2036	9	933	854	S	
26	30	2112	9		212	-	Slave A locked on NAVAID
27	31	0001	9	Dark	210	-	Noisy SL3W
28	31	0621	10		102	-	Noisy temp. High level 1220
29	31	1200	10	Clear	230	-	Maybe thin cumulus
30	31	1805	11	910 (thin)	208	-	1205
31	Aug 1	0006	11	Dark	920	-	Did not transmit reliably. Abandoned.
32	1	0102	11		210	-	Slave A locked 7 mins. after launch.

TABLE 1. RADIOSONDE FLIGHTS (cont'd)

Ascent No.	Date	Launch Time (z)	Mag Tape	Entered cloud (mb)	Pressure tracked to (mb) Ascent	Descent	Comments
33	Aug. 1	0609	12		232	-	Lost lock on Slave A after half of flight
34	1	1153	12		651	-	1205. No refs so abandoned.
35	1	1243	12		961	-	Lost, T, RH after 5 mins.
36	1	1803	13	922	217	-	
37	1	2357	13		-		Intermittent met, winds O.K.
38	2	0035	13	Dark	214	-	
39	2	0604	14	951	208	-	
40	2	1154	14	990	203	-	
41	2	1821	15	978	210	-	First flight after adjusting met. data board.
42	3	0005	15	Dark	201	-	
43	3	0601	16	991	212	-	
44	3	1201	16	970	210	-	Navaid chart drive on 2"/min.
45	3	1811	16	996	221	-	
46	3	2335	17	1007	194	-	
47	4	0555	17	992	203	-	
48	4	0653	17/18	988	446	S	Tape ran out
49	4	0809	18	995	739	S	
50	4	0851	18	995	591	S	
51	4	0941	18	994	540	S	
52	4	1104	19	994	867	S	
53	4	1218	19		219	-	
54	4	1330	19	913	696	S	
55	4	1433	20	918	525	S	
56	4	1613	20	919	705	S	
57	4	1723	20	922	212	-	
58	4	1948	21	912	465	545	Noisy trace
59	4	2049	21	956	220	-	Lost Slave A lock during flight
60	4	2346	22	Dark	378	-	Signal lost due to 1223 interference
61	5	0603	22	884	202	-	
62	5	1158	22		158	-	1205 (Balloon burst 117mb)
63	5	1816	23	1000	173	-	1205 Temporary loss of signal
64	5	2340	23		225	-	1205 Unstable ref. at first
65	6	0603	24	994	581	-	1205 Transmission ceased.

TABLE 1. RADIOSONDE FLIGHTS (cont'd)

Ascent No.	Date	Launch Time (z)	Mag Tape	Entered cloud (mb)	Pressure tracked to (mb) Ascent	Descent	Comments
66	6	0737	24	977	218	-	1205
67	6	1153	24	955	208	-	1205. No Loran signals received
68	6	1342	25	950	217	-	1205
69	6	1806	25	953	213	-	1205
70	6	2346	26	965	250	-	1205 Lost Slave A temporarily
71	7	0615	26	980	212	-	1205
72	7	0728	26/27	983	363	S	Tape change during flight
73	7	0832	27	968	671	S	
74	7	0923	27	978	601	S	
75	7	1042	28	978	399	S	
76	7	1224	28	983	200	-	
77	7	1338	29	981	579	S	
78	7	1451	29	976	479	S	
79	7	1608	30	980	573	S	
80	7	1731	30	978	227	-	
81	7	1838	30		395	?591	Tracked ascent 80 descent by mistake for first 4 mins.
82	7	1957	31	986	541	S	
83	7	2143	31	983	207	-	
84	7	2350	33	-	198	-	No tape 32
85	8	0616	33	977	204	-	1205 Lost Slave A lock soon after launch.
86	8	0731	34	971	205	-	
87	8	1158	34	983	207	-	
88	8	1502	35	961	212	-	
89	8	1803	35	939	215	-	
90	9	0912	36	60 sec	-		1223 Launched from Endurer - (I/C III)
91	9	1017	36	120 sec	-		1223 Launched from Meteor
92	9	1200	37		-		1223 launched from Meteor (No met. data from 90-92)
Phase 2							
93	Aug. 20	1338	37	40 sec	-		1223 From Meteor 1st 5 min. not taped
94	20	1506	37		-		1223 From Endurer
95	20	1602	38		-		1223 From Hecla
96	20	1651	38		208		32kt. surface wind
97	21	1409	38		227	-	
98	22	0619	39	949	199	-	

TABLE 1. RADIOSONDE FLIGHTS (cont'd)

Ascent No.	Date	Launch Time (z)	Mag Tape	Entered cloud (mb)	Pressure tracked to (mb) Ascent	Descent	Comments
99	Aug. 22	0732	39	949	605	S	
100	22	0852	39	N	621	S	
101	22	0959	40	957	566	S	
102	22	1149	40	949	530	985	Interference by 1223
103	22	1335	41	955	213	-	
104	22	1438	41	943	391	1006	? delay in parachute opening.
105	22	1557	41	968	480	1004	Tape ran out
106	22	1714	42	936	548	1010	Sonde entangled with suspension
107	22	1835	42	945	199	-	
108	22	1943	42	953	752	S	
109	22	2037	43	928	215	-	
110	24	0612	43	939	216	-	
111	24	-			-		Sonde fell off into sea.
112	24	0737	43	925	515	S	Lost Slave A for 2 mins.
113	24	0850	44	960	250	931	Loran locked after launch
114	24	1014	44	900(975)	211	-	Also logged on tape as 113
115	24	1135	45	Clear	671	S	
116	24	1235	45	896	196	-	1st min. not recorded
117	24	1408	45	893	727	S	
118	24	1524	46	?Clear	452	987	
119	24	1628	46	Clear	450	988	
120	24	1756	47		220	-	
121	24	1853	47		600	1018	
122	24	2010	47	Clear	217	-	
123	25	0617	48		220	-	Between clouds
124	25	0726	48	No low cloud	432	1023	
125	25	0859	49	791	552	1022	
126	25	1016	49	783	559	S	
127	25	1151	50	809	218	-	
128	25	1305	50		629	S	Behind cloud at 887mb
129	25	1411	50	967	489	1023	
130	25	1522	51	1000	532	S	
131	25	1658	51		521	S	
132	25	1815	52	1000	210	-	
133	25	1953	52	924	625	S	
134	25	2059	52	1002	207	-	
135	26	0611	53	935	220	-	
136	26	1213	53		160	934	1205. Tracked after burst.
137	26	1803	55		529	-	1205. No Loran
138	26	1828	55	1000	217	-	

TABLE 1. RADIOSONDE FLIGHTS (cont'd)

Ascent No.	Date	Launch Time (z)	Mag Tape	Entered cloud (mb)	Pressure tracked to (mb) Ascent	Descent	Comments
139	Aug. 27	1934	57	749	211	-	
140	28	0615	57		215	-	Balloon burst at 215mb
141	28	0734	57/58	1006	479	S	Tape ran out on descent? Shift in calibration.
142	28	0851	58	1010	455	S	? met. trace on
143	28	1019	58	1009	519	S	descent.
144	28	1124	59	1006	763	S	
145	28	1233	59	1006	200	-	
146	28	1336	59	1011	489	S	? met. trace on descent.
147	28	1503	60	1010	966	S	Premature release
148	28	1532	60	1006	646	S	
149	28	1721	60	1016	499	S	
150	28	1858	61	1010	208	-	
151	28	2014	61	1009	409	S	? met trace on descent
152	28	2137	62	Dark	199	-	
153	29	0713	62	977	224	-	

TABLE 2 PROCEDURE FOR HOURLY METEOROLOGICAL OBSERVATIONS

Time	Observations
H-20 min	Clouds, present weather, bearing and distance of showers
H-15	Wind and swell waves, visibility, rainfall (empty gauges if necessary)
	Check wick on Assmann
H-12	Start Assmann
H-5	Read Assmann
H-4	SST by bucket measurements
H-3	Porton anemograph, gyro compass, Bergen log.
H-2	Print-out of PSMS started
H	Precision Aneroid Barometers
H + 1	Stop 1-min printouts of PSMS. Apparent wind checked

H = hour of day

Throughout the hour weather development was monitored and used to determine the past weather code.

TABLE 3 INTERCOMPARISONS WITH OTHER PLATFORMS

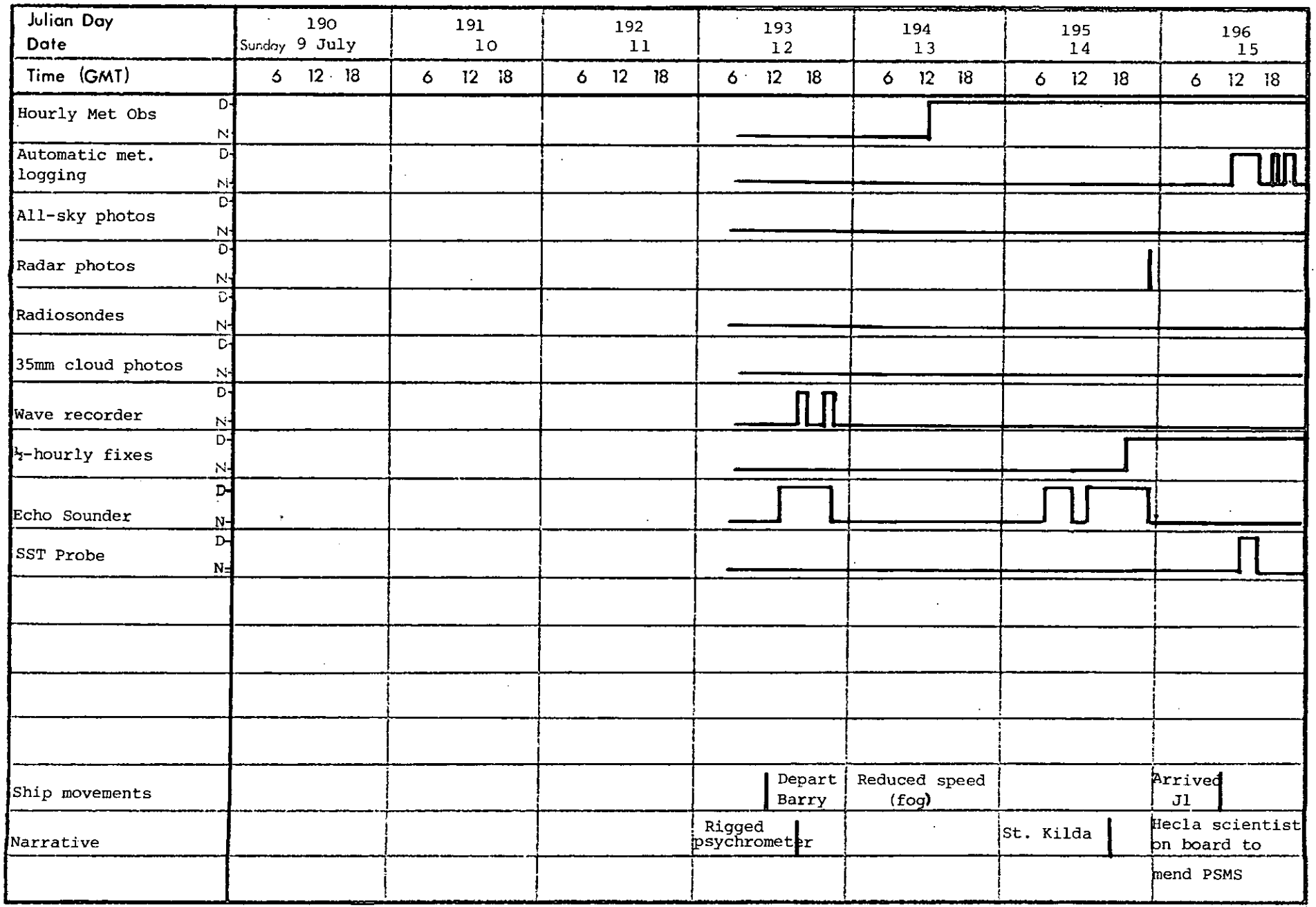
Date			
July 16	1340-1345	H3	Surface met.
	1539-1639	H3	Surface met.
22	0910-1500	Hecla,Meteor,Endurer	Surface met,radiosondes (I/CII)
29	1042-1230	B2,Meteor,Atlantis II	Surface met.
		C-130	SST,wind,temperatures
	1425	C-130	" " "
30	0957-1115	H3	Surface wind
Aug 2	1324-1355	H3	Surface met.
8	1100-1338	C-130,Electra	SST,wind,radiation
9	0544-0615	B4	Surface met.
	0900-1200	B2,Meteor,Endurer	Surface met,radiosondes (I/CIII)
20	0900-1900	J1,Hecla,Endurer,Meteor Vernadsky	Surface met, radiosondes (I/CIV)
22	1127-1142	C-130	Winds,temperatures
	2045-2142	Discovery	Surface met,shipborne wave recorder
23	1700-1730	H1,Endurer	Surface met.
26	0612-1810	J1	Surface met,sonde on bow
27	0842-1210	H1,Endurer	Surface met,SST,Tethered sonde
29	0745-0900	NASA C-130	Surface wind
	1500-1600	B2,Meteor	Surface met.

From 15 to 22 July John Murray was close to Hecla and J1. This period constitutes I/C I.

TABLE 4. PRESSURE CALIBRATION RUNS

Date	Time(z)	Position	Measurements *	Comments
July 16	1835-1941	J1	Precision Aneroid Barometer (PAB) Digiquartz Transducer (DQ)	Steaming downwind and upwind at 7Kt.
17	1840-1920	J1	PAB, DQ.	Minimum speed on 8 headings.
21	1020-1130	J1	PAB, DQ	J. Murray steaming, Hecla stationary.
	2020-2040	J1	PAB, DQ	Stationary into and downwind
	2120-2140	J1	PAB, DQ	Stationary into/downwind
22	1034-1147	J1	PAB, DQ (6 minutes)	4 ships steaming downwind and into wind during I/C II
Aug. 2	1525-1611	J1	DQ	Minimum speed on 8 headings.
6	2016-2034	J1	DQ	Stationary, into and downwind
8	1842-1903	J1	DQ	Stationary, into and downwind.
9	1103-1200	B2	PAB 1, PAB 2 and DQ	Upwind/downwind at 7kt 4 ships during I/C III.
20	1017-1142	J1	PAB, DQ	Upwind/downwind at 5Kt.
	1208-1304	J1	PAB 1, PAB 2 and DQ	Minimum speed, head to wind (during I/C IV)
27	1131-1210	H3	DQ	Steaming at 2, 5 and 8kt. with Endurer (into wind)
29	1515-1600	B2	PAB, DQ	Into wind at 2, 5, 8kt. Meteor stationary.

* In all cases relative wind and ship velocity was recorded. Readings were usually taken at 1-minute intervals. Unless stated otherwise PAB 1 was read.



D=Data N=No data

Fig.4(a) Activity diagram, week commencing 9 July.

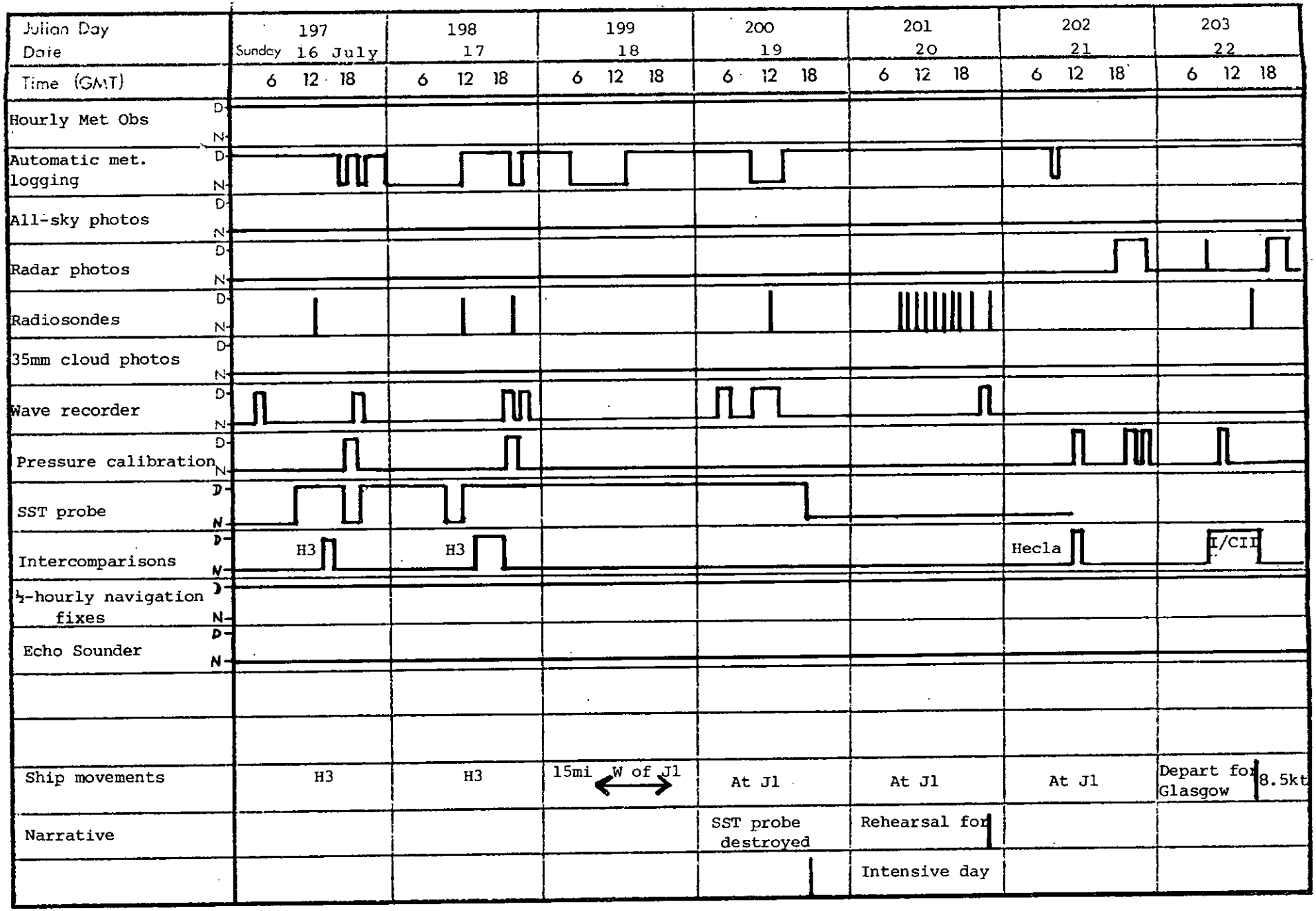


Fig.4(b) Activity diagram, week commencing 16 July.

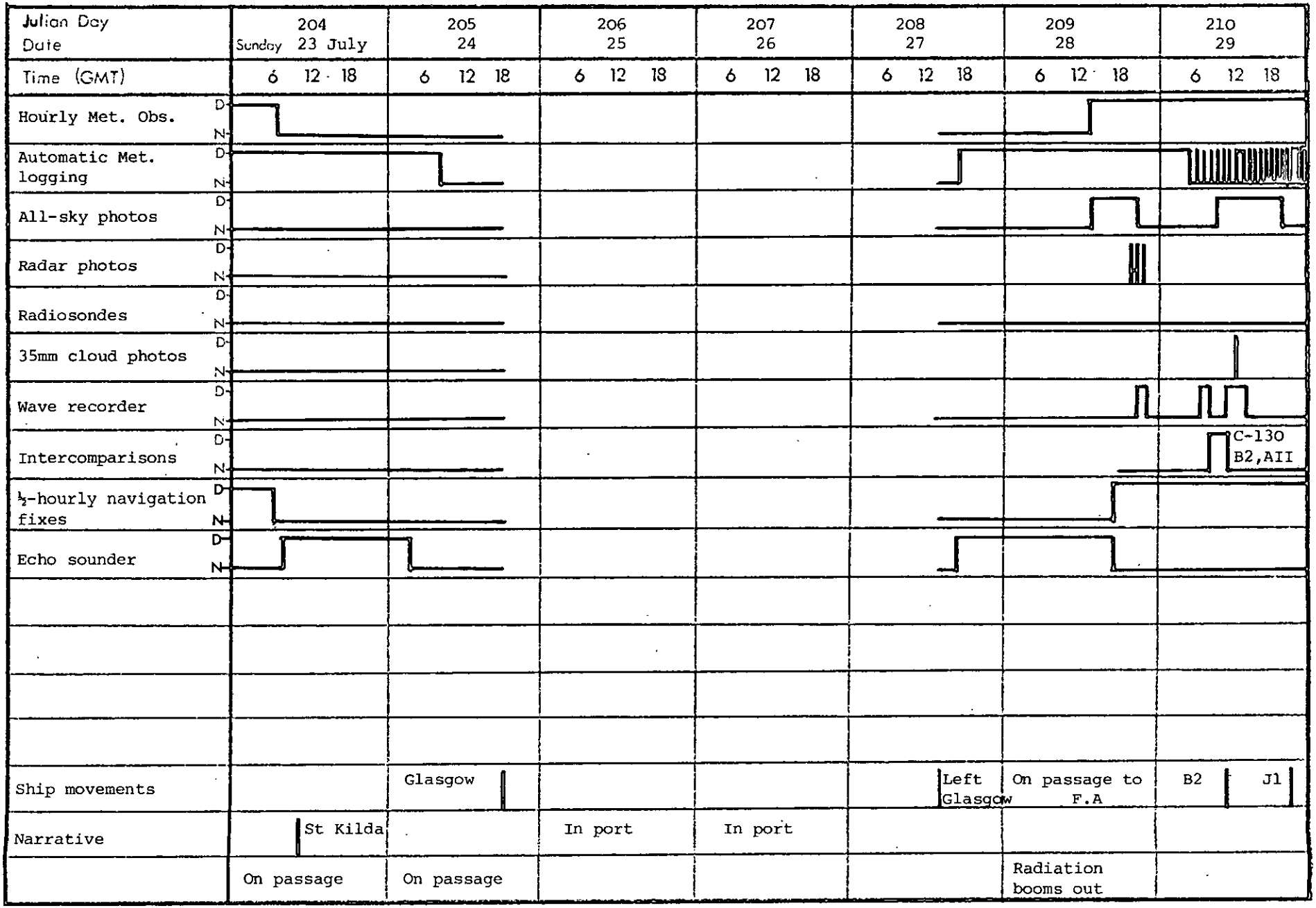


Fig.4(c) Activity diagram, week commencing 23 July.

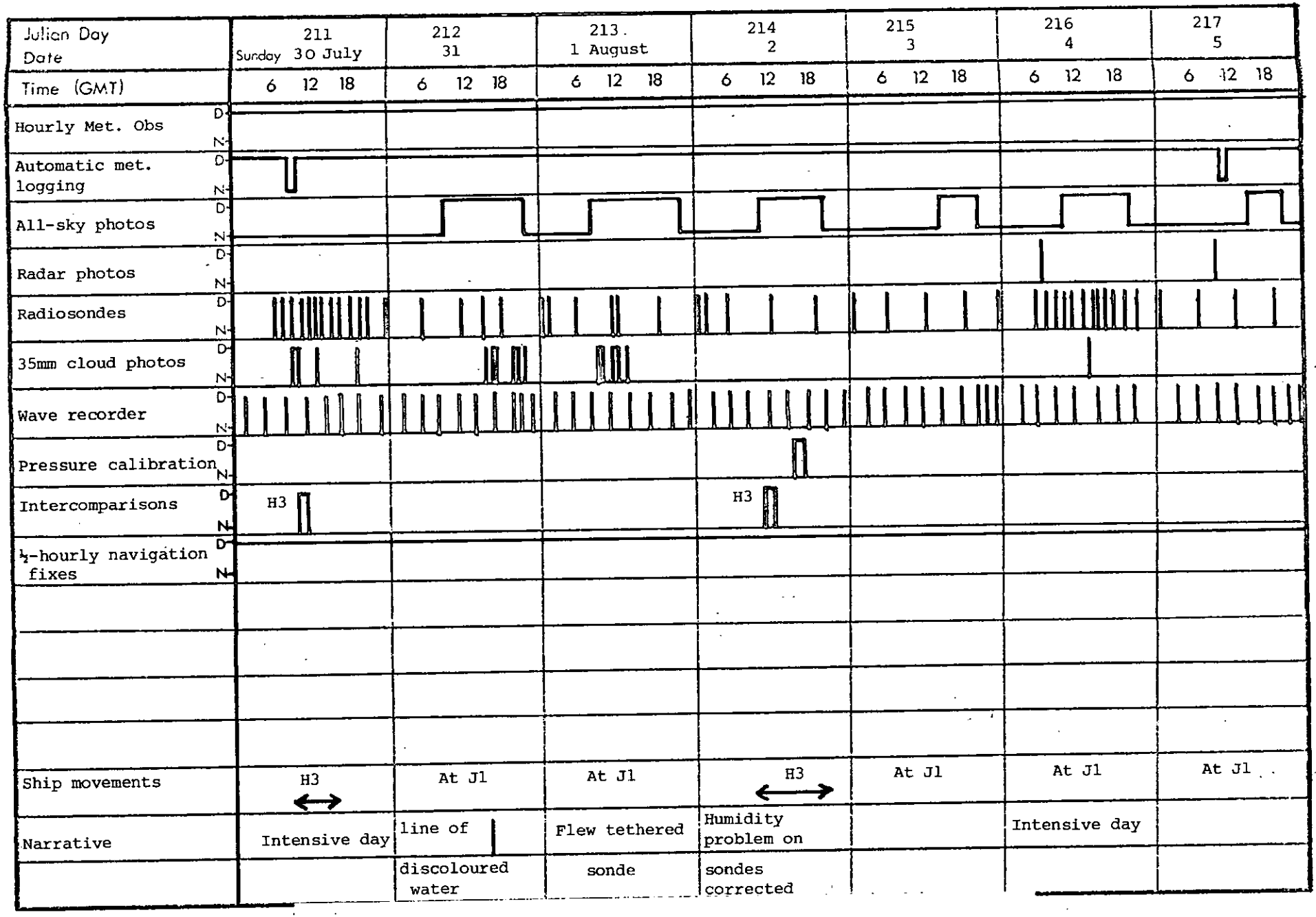


Fig.4(d) Activity diagram, week commencing 30 July.

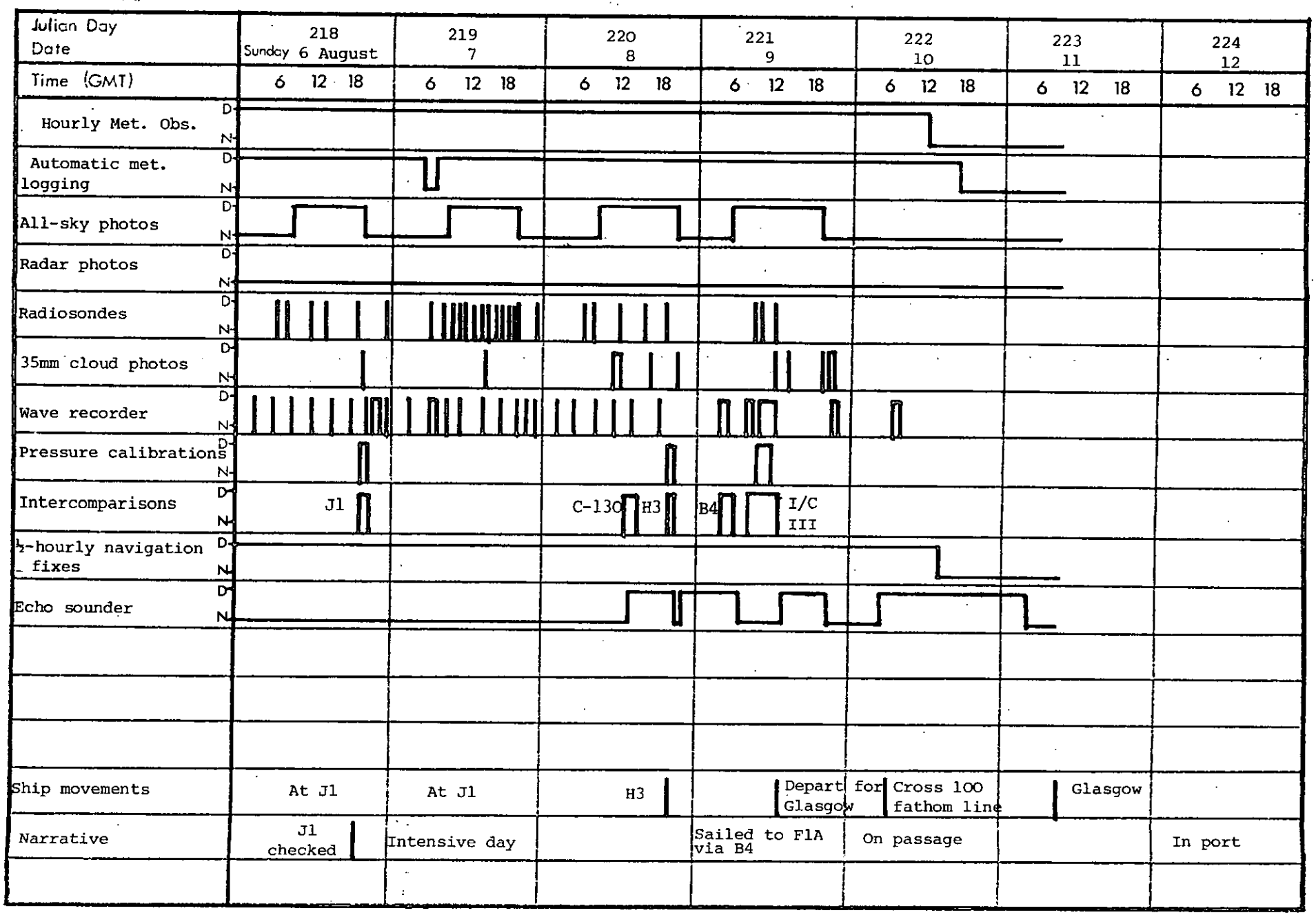


Fig.4(e) Activity diagram, week commencing 6 August.

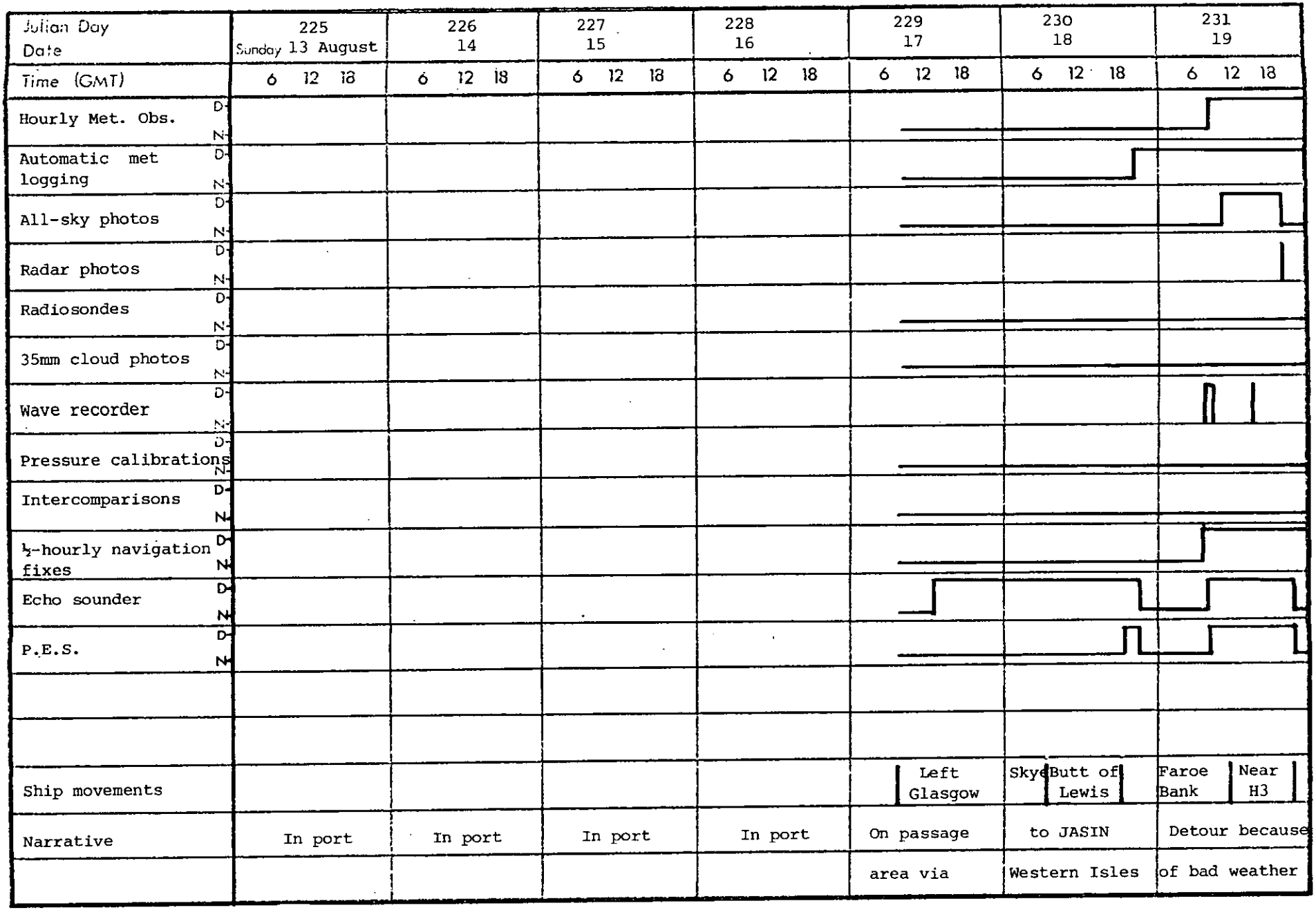


Fig.4(f) Activity diagram, week commencing 13 August

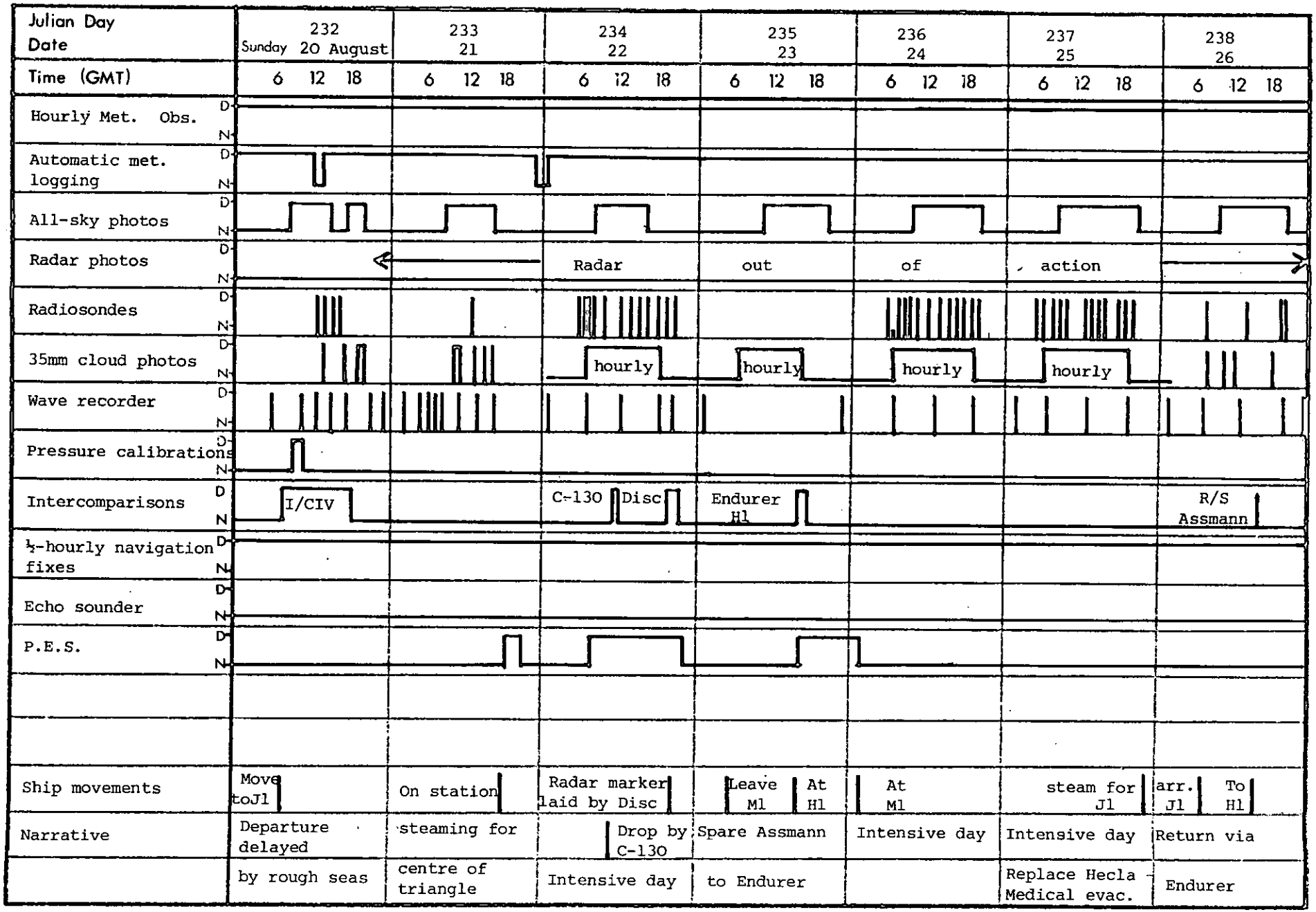


Fig.4(g) Activity diagram, week commencing 20 August

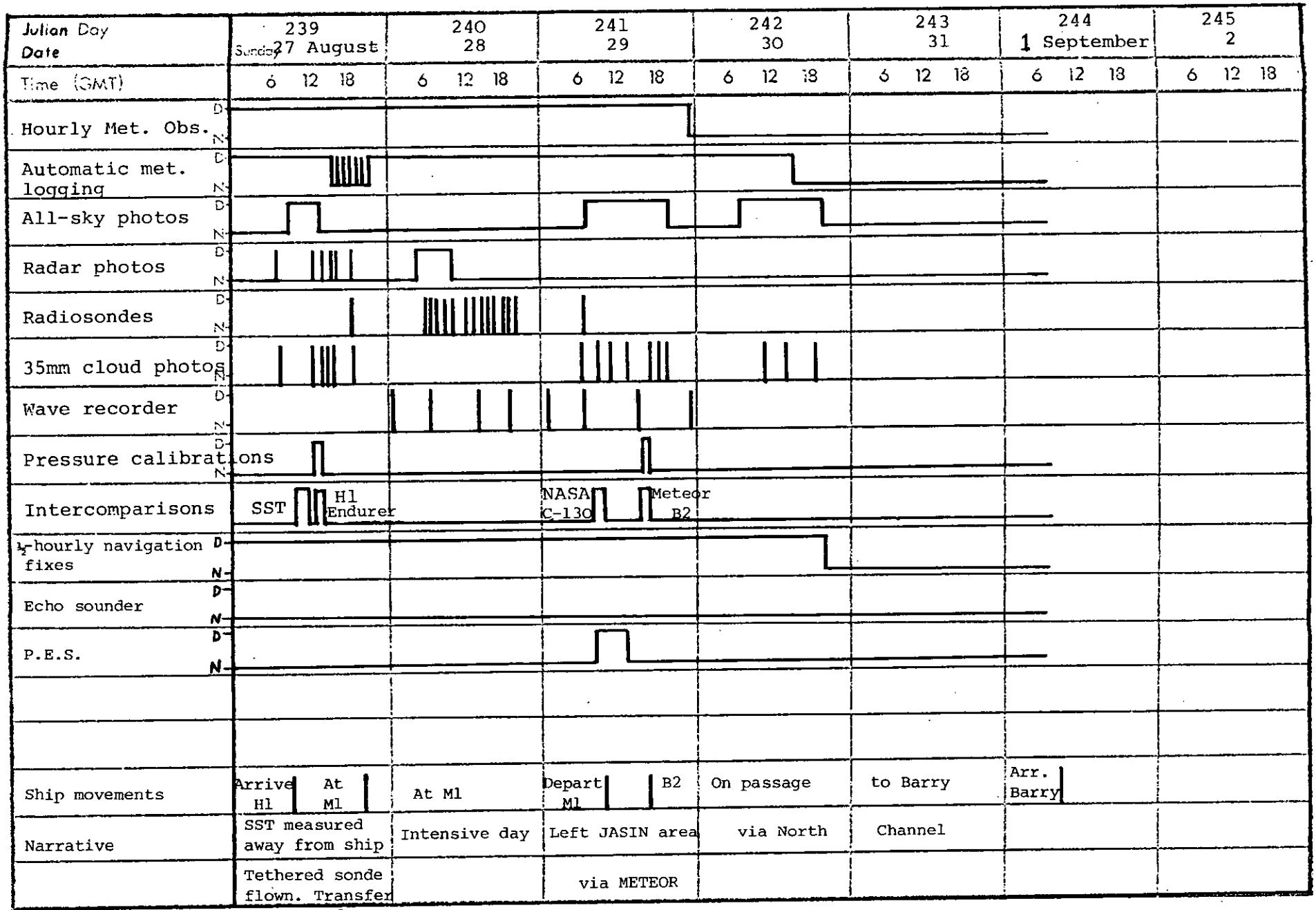


Fig.4(h) Activity diagram, week commencing 27 August

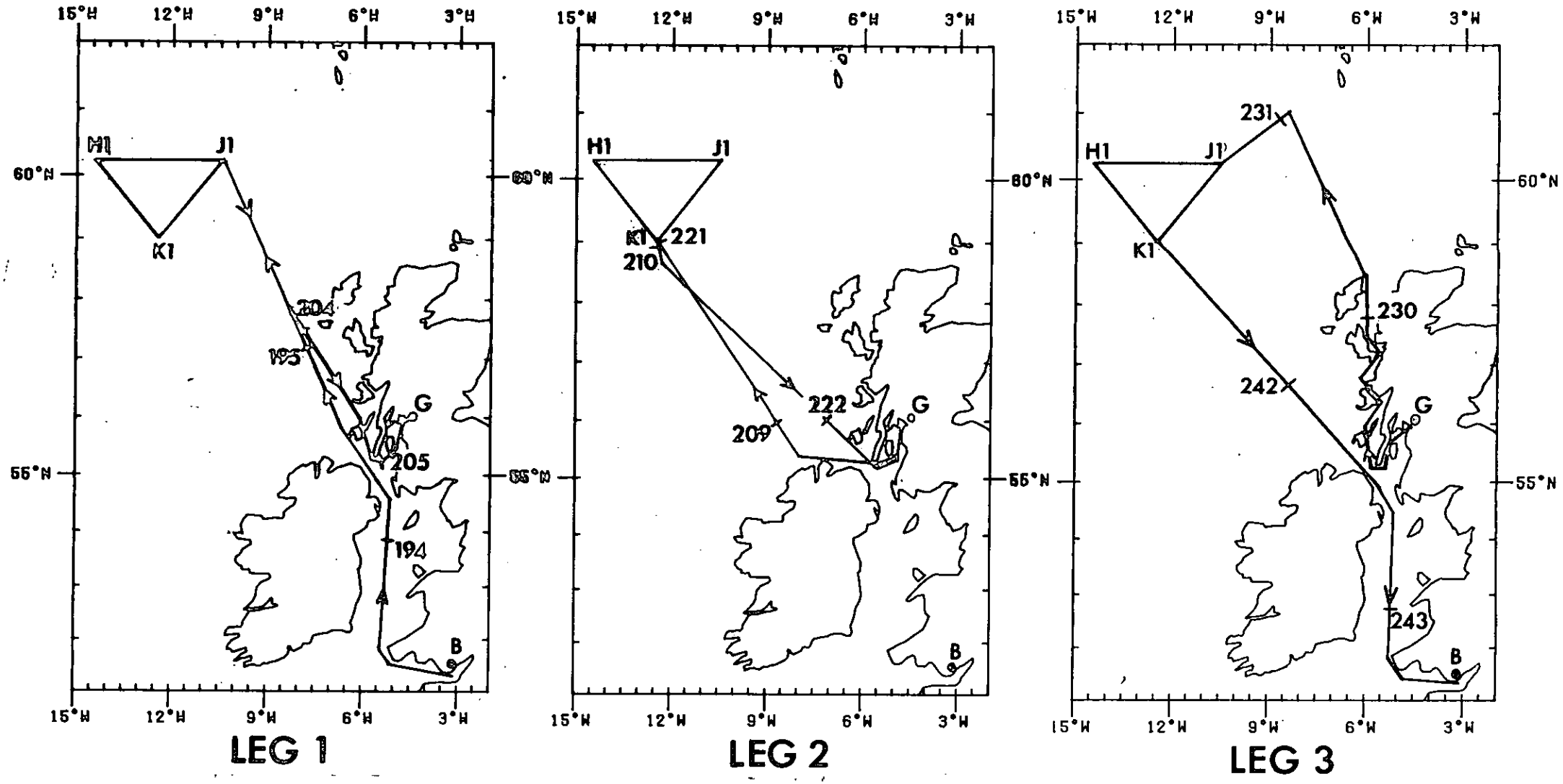


Fig. 1. John Murray Cruise 8/78 - General Track Charts - 12z positions are shown when on passage, numbers denoting Julian day (for date/Julian day conversion see Fig. 4). Movements within the JASIN 200km triangle, H1, J1, K1 are shown in Fig. 2 (legs 1 and 2) and Fig. 3 (leg 3). Glasgow (G) and Barry (B) are also marked.

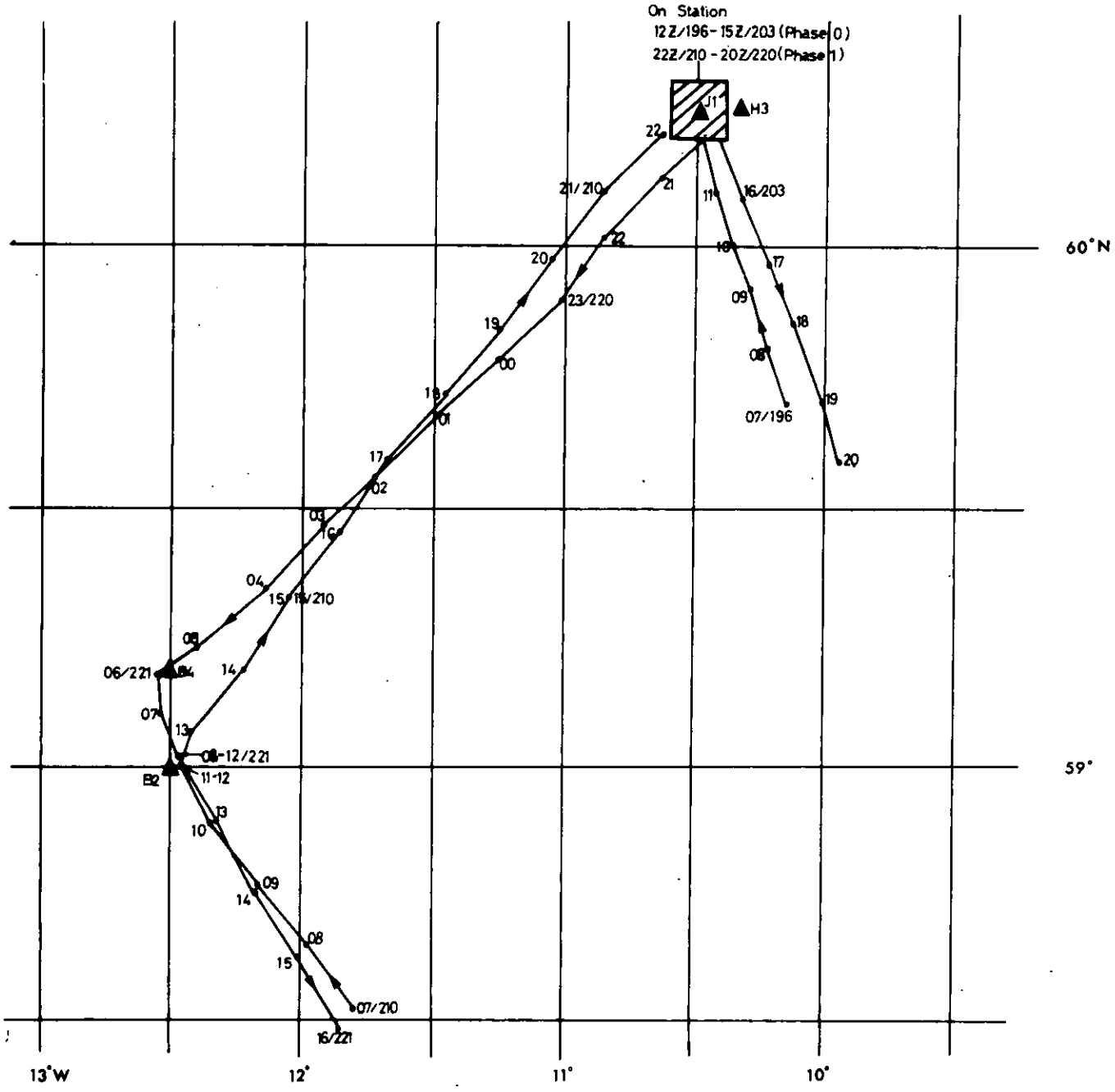


Fig. 2 Track chart (JASIN area, legs 1 and 2).
Solid circles indicate hourly positions when steaming.
Numbers alongside circles indicate Time (GMT)/Julian Day.
Hatched areas show where the vessel remained within a few miles of station for long periods.

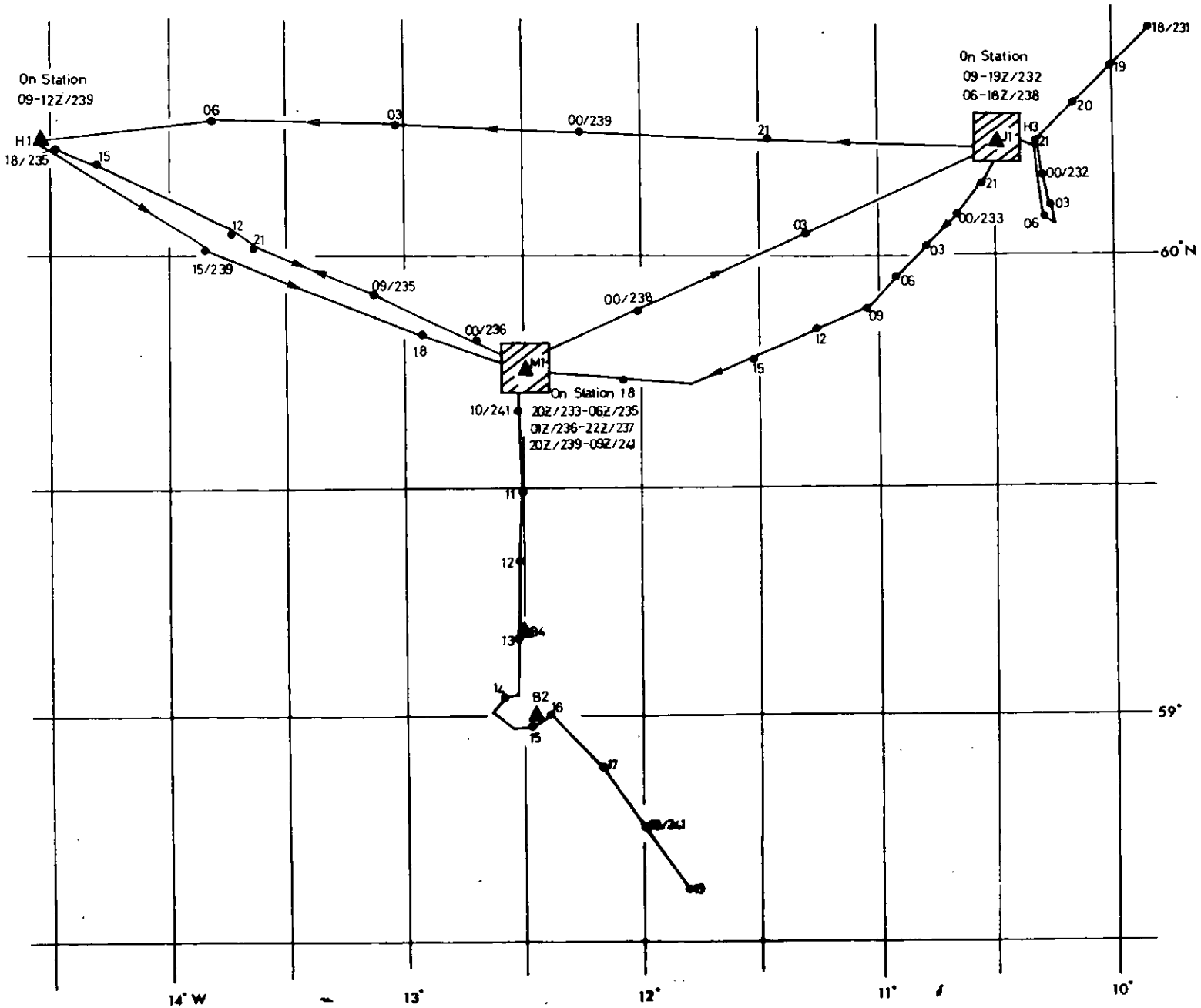


Fig. 3 Track chart (JASIN Area, leg 3).
As for Fig. 2

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RRS DISCOVERY

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39	APR - JUN 1971	40
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43	OCT - NOV 1971	47
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45	FEB - APR 1972	50
46	APR - MAY 1972	55
47	JUN - JUL 1972	52
48	JUL - AUG 1972	53
49	AUG - OCT 1972	57
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51	NOV - DEC 1972	54
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54	JUN - AUG 1973	2
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56	OCT - NOV 1973	4
57	NOV - DEC 1973	6
58	DEC 1973	4
59	FEB 1974	14
60	FEB - MAR 1974	8
61	MAR - MAY 1974	10
62	MAY - JUN 1974	11
63	JUN - JUL 1974	12
64	JUL - AUG 1974	13
65	AUG 1974	17
66	AUG - SEP 1974	20
68	NOV - DEC 1974	16
69	JAN - MAR 1975	51
73	JUL - AUG 1975	34
74/1+3	SEP - OCT 1975	35
74/2		33
75	OCT - NOV 1975	43
77	JUL - AUG 1976	46
78	SEP - OCT 1976	52
79	OCT - NOV 1976	54
82	MAR - MAY 1977	59
83	MAY - JUN 1977	61
84	JUN - JUL 1977	60
86	SEP 1977	57
87	OCT 1977	58
88	OCT - NOV 1977	65
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* REPORTS 1 TO 3 WERE PUBLISHED AND DISTRIBUTED BY THE ROYAL SOCIETY FOLLOWING THE INTERNATIONAL INDIAN OCEAN EXPEDITION

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