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The Joint Air-Sea Interaction Experiment—JASIN 1978

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Abstract

In June the first of 17 ships and aircraft left their home bases to participate in the Joint Air-Sea Interaction (JASIN) Experiment. This paper summarizes the scientific and operational plans for the field experiment.

1. Background

A project to study the interaction of the atmospheric and oceanic boundary layers with the larger-scale motions of the sea and air was proposed in 1966 by the Royal Meteorological Society to the Royal Society as an appropriate United Kingdom contribution to the Global Atmospheric Research Program (GARP). It was envisaged that the project, to be called the Joint Air-Sea Interaction (JASIN) Project, would involve the intensive study (for about a month) of the atmospheric and oceanic boundary layers over an area in the North Atlantic ~150 km across, using buoys, ships, balloons, and aircraft to observe the structure of the layers and their interaction with the larger-scale synoptic features.

More than 10 years later, and after a series of preparatory experiments (Royal Society, 1971; Pollard, 1973), this initial United Kingdom proposal has led to an international experiment, JASIN 1978, whose primary aims are

1) to observe and distinguish between the physical processes causing mixing in the atmospheric and oceanic boundary layers and relate them to mean properties of the layers;
2) to examine and quantify aspects of the momentum and heat budgets in the atmospheric and oceanic boundary layers and the fluxes across and between them.

Management of the JASIN Project is the responsibility of the Air-Sea Interaction Subcommittee of the British National Committee for GARP. Although the project was nationally initiated, participation in JASIN 1978 is international (Table 1). JASIN is also recognized by the Joint Organizing Committee (JOC) as a component experiment of GARP and is a declared United Kingdom contribution to the International Decade of Ocean Exploration (IDOE) and the Long Term and Expanded Program of Oceanographic Research (LEPOR). Financial support is primarily on a national basis and the Project Office is partially supported by a grant from the NATO Science Council.

Plans for the main field experiment have been drawn up by the scientific participants at meetings in the United Kingdom in January 1975, September 1976, and

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TABLE 1. JASIN 1978—Participating institutes and primary involvement.

Institute	Investigators	Involvement
Australia		
Royal Australian Naval Research Lab.	I. S. F. Jones	Gradient Richardson number profiler.
Canada		
Bedford Institute of Oceanography	F. W. Dobson, J. A. Elliott, N. S. Oakey	Wave buoy, Octuprobe.
University of British Columbia	W. Large, S. Pond	Dissipation flux measurements.
Federal Republic of Germany		
Deutsches Hydrographisches Institut	H. Carlson	Wave-rider buoys.
Institut für Umweltphysik	B. Kromer, W. Roether	Gas exchange rates.
Karlsruhe Meteorologisches Institut	F. Fiedler	Turbulent eddy measurements within planetary boundary layer.
Kiel Institut für Meereskunde	R. Käse, H. Peters, G. Siedler, J. D. Woods, W. Zenk	K moorings, CTD profiles, current profilers, towed oscillating CTD probe.
Koln Institut für Geophysik und Meteorologie	E. Raschke, P. Speth	Radiation flux measurements, meteorological spar buoys.
Max-Planck Institut für Chemie	R. Jaenicke, W. Seiler	Atmospheric aerosol and trace gas flux measurements.
Max-Planck Institut für Meteorologie	E. Augstein, B. Brümmer, M. Dunckel	Flux measurements from tethered balloon, cloud and radar echo observations.
Seewetteramt	G. Olbrück	Radiosonde measurements.
Ireland		
University College, Galway	E. C. Monohan	Measurement of foam.
Netherlands		
Koninklijk Nederlands Meteorologisch Instituut	P. Kruseman, G. J. Prangsma	Large-scale hydrographic survey: CTD yo-yos and deep CTD casts, XBT drops.
Utrecht University	H. M. van Aken	
Soviet Union		
Institute of Atmospheric Physics	A. M. Oboukhov, Y. Yolkov *et al.*	Surface fluxes, turbulent spectra, and profile measurements from ship and towed gradient buoy.
Sevastopol Marine Hydrophysical Institute	B. A. Nelepo	Comprehensive upper-ocean measurements.
Sweden		
Göteborg	G. Kullenberg	Dye diffusion.
United Kingdom		
Department of Agriculture and Fisheries for Scotland	H. Dooley	D moorings, water bottle surveys.
Harwell Lab.	D. J. Stanley	Directional wave spectra from Seasat SAR.
Institute of Oceanographic Sciences	T. D. Allan, J. Crease, T. H. Guymer, R. T. Pollard, P. M. Saunders, P. K. Taylor, D. J. Webb	Seasat-A sea truth, radiosondes, towed oscillating CTD probe, drifting spar buoy, acoustic float tracking, pitch/roll buoys, I moorings.
Meteorological Office	G. J. Jenkins, P. Ryder, K. L. Webber	Radiosonde measurements, tethered balloon, flux measurements, dropsonde survey of fronts.
Meteorological Research Flight	S. Nicholls, C. J. Readings	Aircraft direct flux measurements.
Scottish Marine Biological Association	A. Edwards, D. J. Ellett, P. Tett	Large-scale hydrographic survey, CTD grid, E moorings, surface chlorophyll measurements.

TABLE 1. (continued)

Institute	Investigators	Involvement
United Kingdom (contd.)		
University of Birmingham and Appleton Laboratory	E. D. R. Shearman, P. A. Bradley	Radar measurements of sea state.
United States		
Catholic University	T. W. Kao, S. C. Ling	Water droplet fluxes, aerosol studies.
Naval Postgraduate School	K. L. Davidson	Dissipation flux measurements.
Oregon State University	W. V. Burt, C. A. Paulson	B moorings, moored and towed thermistor chains.
Pacific Marine Environmental Laboratories	D. Halpern	H moorings.
Scripps Institution of Oceanography	R. E. Davis, R. H. Stewart	Vertical current structure, current shear measurements, rainfall measurements.
Sea-Air Interaction Lab.	F. Ostapoff, J. Proni	Towed acoustic profilers, laser altimeter.
University of California at San Diego	C. Friehe, J. La Rue	Aircraft fine-scale velocity and temperature measurements.
University of Rhode Island	D. L. Evans, R. Watts	Yvette velocity profiler, acoustic transducer towing.
University of Washington	J. A. Businger, K. B. Katsaros	Aircraft direct flux measurements, radiation measurements.
Woods Hole Oceanographic Institution	M. G. Briscoe, H. McComas, M. Orr	W moorings, CTD profiles, vector current meter, float tracking.

November 1977. (Full details may be found in publications of the Royal Society (1977, 1978), but few copies are available to the public.) Coordination of JASIN is carried out from the JASIN Project Office at the Institute of Oceanographic Sciences by the Project Director (H. Charnock), Scientific Coordinator (R. T. Pollard), Project Manager (A. E. Fisher), and Data Manager (T. H. Guymer) aided by a Project Assistant and Subject Coordinators drawn from the participants. It is a feature of JASIN that formal committees and management structure have been kept much smaller than in other recent large experiments such as the Barbados Oceanographic Meteorological Experiment (BOMEX), the Mid-Ocean Dynamics Experiment (MODE), and the GARP Atlantic Tropical Experiment (GATE). The organizers have relied heavily on the enthusiasm and cooperation of participants to cover many of the organizational aspects of the experiment, and we have not been disappointed.

2. The need for a collaborative experiment

The need for a large joint experiment arises from the complexity of the air-sea interaction problem. No individual can gather all the data he needs to investigate any single aspect of the interaction process, and the development of numerical models to simulate the behavior of the atmospheric and oceanic boundary layers has been hindered for many years by the lack of an adequate data base.

Over 50 principal scientists will collaborate in JASIN 1978, each a specialist in some aspect of the interaction problem. The strength of JASIN will lie in the individual's ability to analyze his own data in the light of the large body of complementary data collected by other participants.

3. Logistic summary of the field experiment

JASIN 1978 will take place for 2 months in the summer of 1978 in an area of deep water (North Rockall Trough) several hundred kilometers across off the northwest coast of Scotland (Fig. 1). More than 50 teams of investigators from 9 countries will participate, using 14 ships and 3 aircraft (see Fig. 2 for timetable). There will be 32 mooring systems deployed (Fig. 3), 10 of which will be within a 5 km square Fixed Intensive Array (FIA) area centered at 59°N, 12°30′W (Figs. 1 and 4).

The experiment will be divided into three phases (Table 2), comprising two intensive measurement periods during Phases 1 and 2, preceded by a preparatory testing period (Phase 0).

Within the phases there are shorter periods when intensive measurements or intercomparisons will be made with nearly all platforms involved in a particular part of the program in position (Figs. 5 and 6). Such periods are shown in Fig. 2.

Measurements will be made in a number of nested and partially nested regions, the most intensive mea-

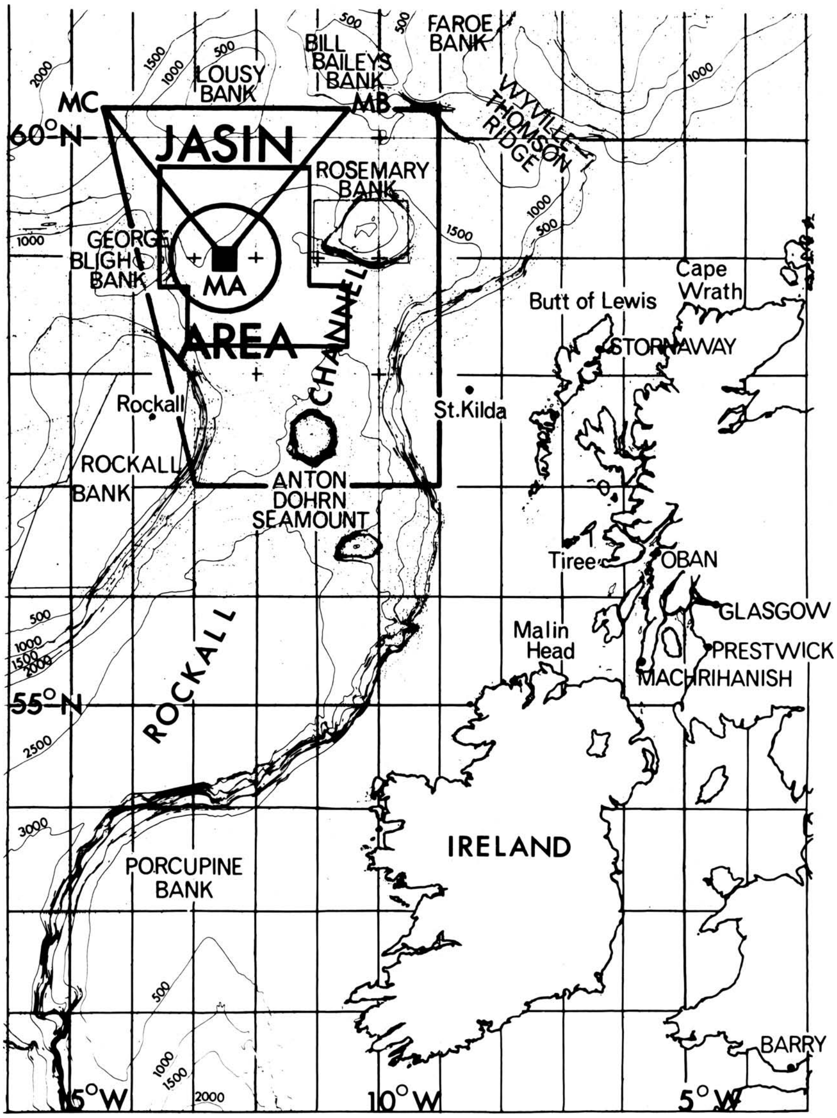

FIG. 1. The JASIN area in relation to the British Isles. Bathymetry is shown with depth in meters. Bases for ships (Glasgow) and aircraft (RAF Machrihanish) are also given. Five partially nested experimental areas are depicted: Large Scale Area, ~300 km square (the outer quadrilateral); Hydrographic Survey Area, 150 km square (the Z-shaped area); Meteorological Triangle, 180 × 180 × 220 km (triangle MA, MB, MC); Oceanographic Intensive Area, the 100 km diameter circle; and the Fixed Intensive Array, a 5 km square in the center of the OIA (59°N, 12°30′W).

surements being confined to the smallest regions. Five regions can be identified (Fig. 1):

1) Large Scale Area (LSA), ~300 km square;
2) Hydrographic Survey Area (HSA), 150 km square;
3) Meteorological Triangle, 180 × 180 × 220 km;
4) Oceanographic Intensive Area (OIA), a circle 100 km in diameter;
5) Fixed Intensive Array (FIA), 5 km square.

The field experiment will be coordinated from the Aircraft Base, RAF Machrihanish (Fig. 1). A team led by the Field Operations Coordinator (H. Charnock) will assess the program daily, aided by weather forecasts, ship status reports communicated on a regular schedule through Oban Radio (Fig. 1), and special analyses compiled by a JASIN forecaster and oceanographer at the base.

Harbor facilities for all ships requiring them will be centralized at Yorkhill Quay, Central Glasgow. This will be particularly used between phases as a center for scientific meetings and exchange.

4. Scientific summary of the field experiment

It is impossible in a short article to do justice to the many individual experimental contributions to JASIN. Some flavor of them may be gleaned from Table 1. Here we can only mention some of the major aims and components of the experiment, which can for convenience be split into meteorological and oceanographic programs, the two being closely linked by the need to determine the fluxes across the air-sea interface.

a. Meteorological program

In middle and high latitudes the marine atmospheric boundary layer is characterized by great variability in both air mass type and structure, knowledge of which is still small. The meteorological program attempts to

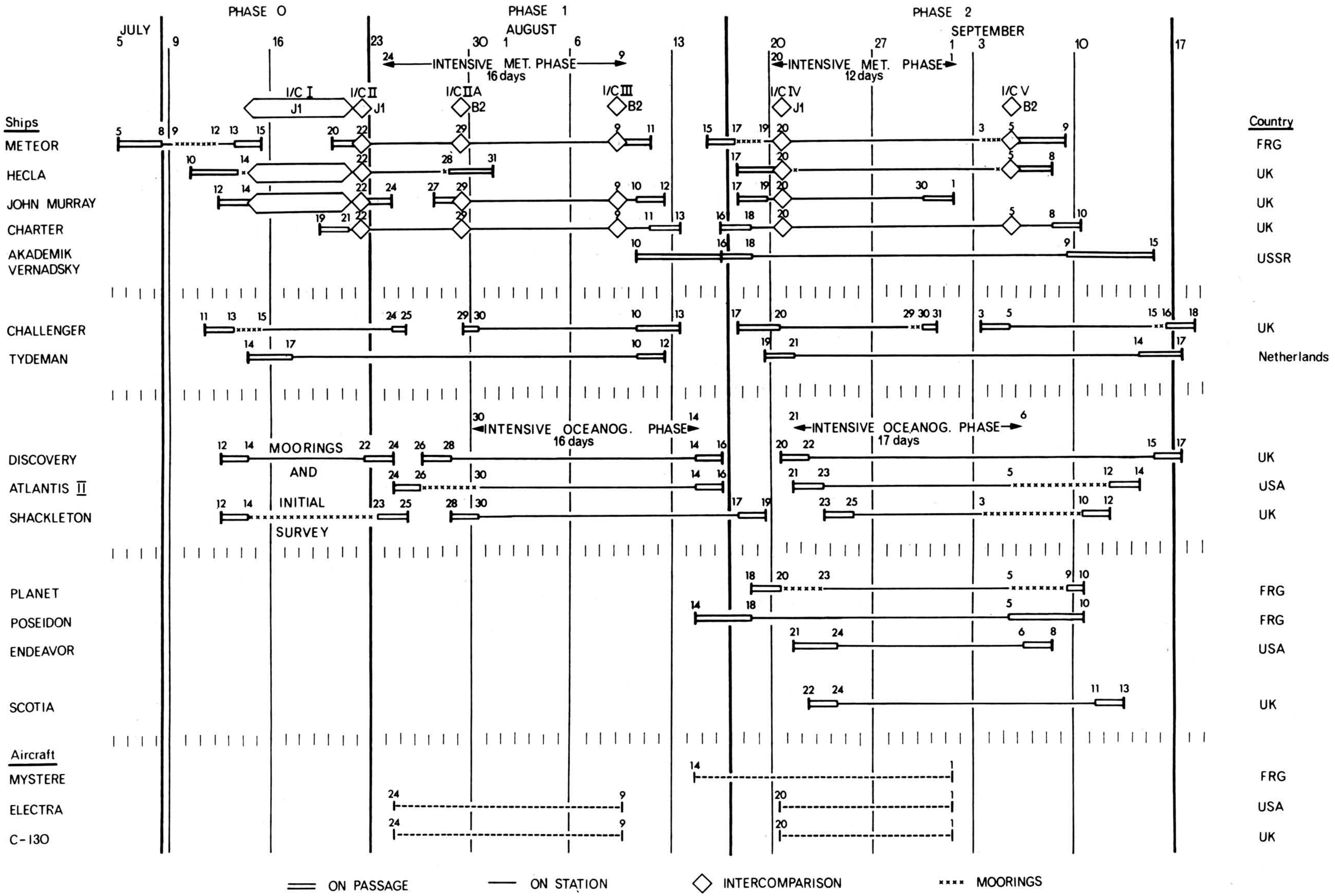

FIG. 2. JASIN 1978 ship and aircraft timetable. Phases 0, 1, and 2 are delineated by thick vertical lines. Intensive meteorological and oceanographic periods within the main phases are shown. Intercomparisons (e.g., I/C I) will take place near the mooring (e.g., J1) shown. Moorings are shown in Figs. 3 and 4.

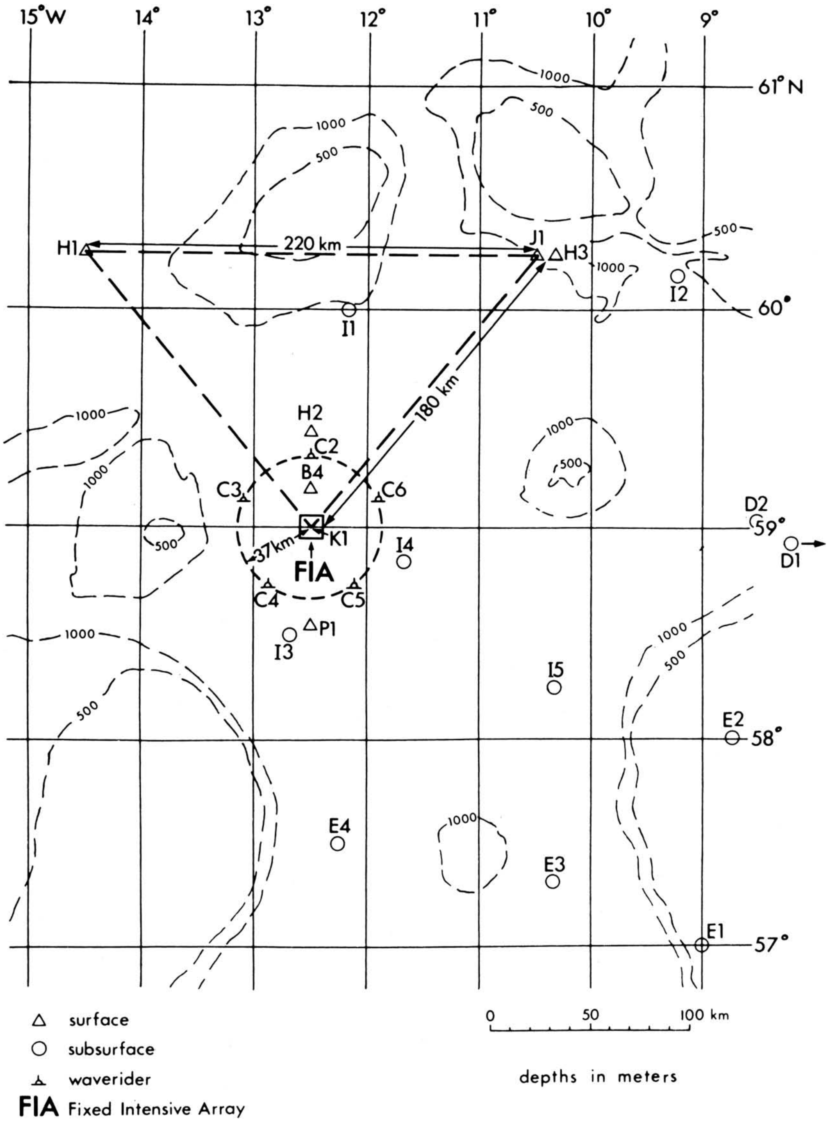

FIG. 3. Moorings to be set in JASIN 1978 in the Large Scale Array. H1, J1, and K1 are the buoys at the corners of the meteorological triangle. The E, H, I, and K moorings carry current meters, and the B, H, and P moorings carry surface meteorological instrumentation.

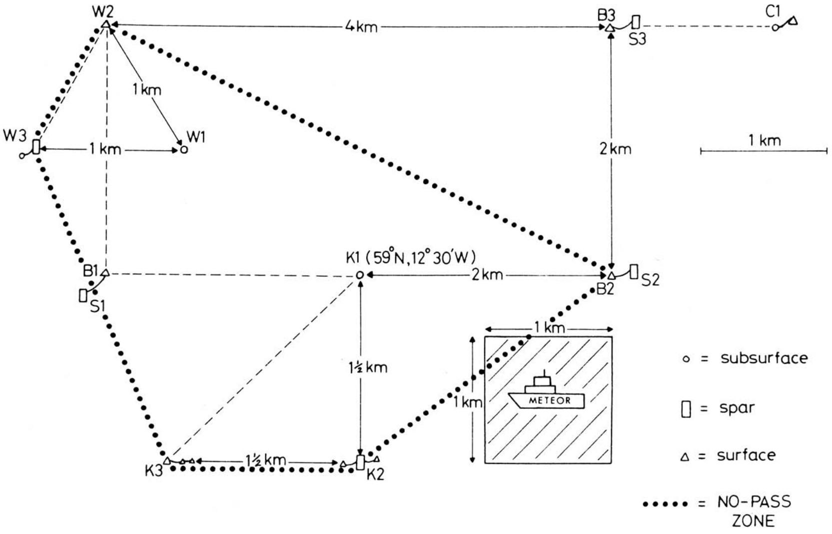

FIG. 4. Moorings to be set in JASIN 1978 in the Fixed Intensive Array (FIA). C1 is a waverider buoy. All other surface buoys carry wind sensors, B and S moorings carry full meteorological packages, and K1, K2, and W moorings carry current meters (23 on W1).

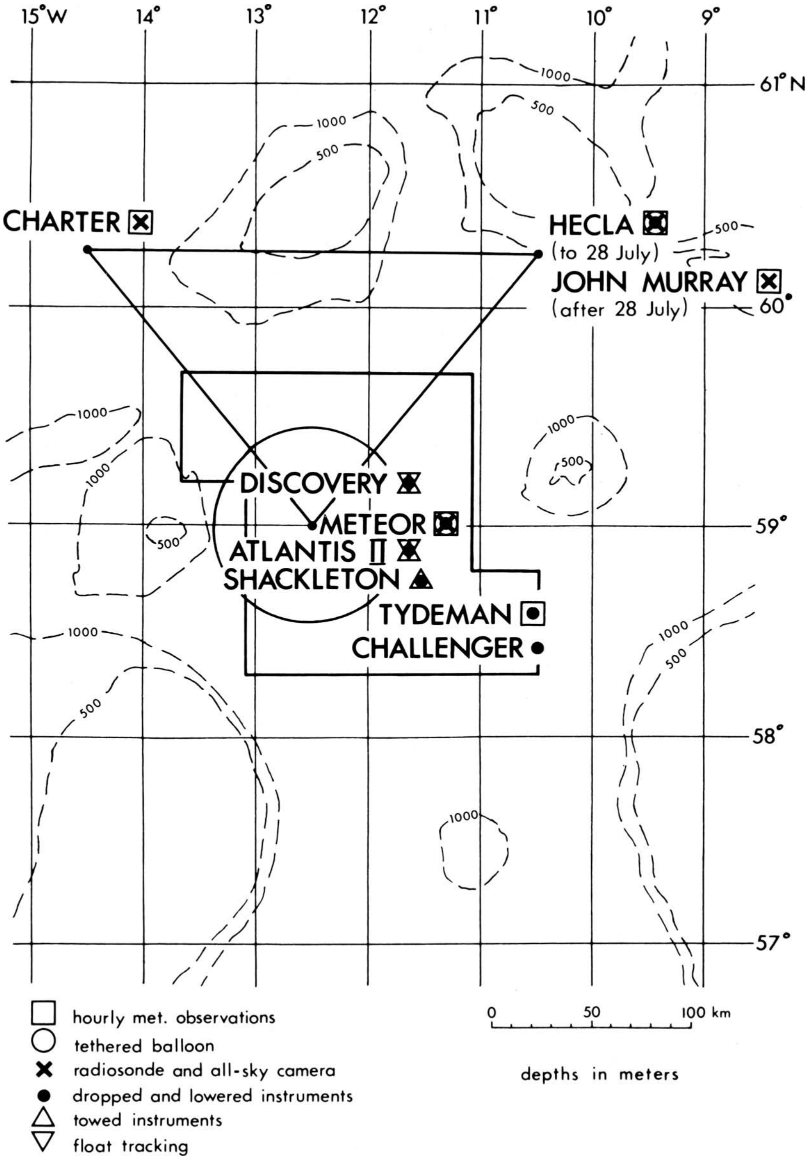

FIG. 5. Positions of ships in the main experimental areas (Fig. 1) during Phase 1. Symbols indicate main tasks of each ship.

span this variability, to relate the thermodynamic and dynamic structure and the evolution of the boundary layer to the large-scale meteorological fields in all conditions as far as is possible with available instrumentation. The array of ships and buoys is designed to quantify the effects of advection and baroclinicity as well as measuring the local fluxes.

TABLE 2. Phases of JASIN 1978.

Phase	Dates	No. of Ships	No. of Aircraft	Main Purpose
0	8 July–22 July	8	0	Set moorings, test equipment, first surveys.
1	23 July–16 Aug.	10	2	First measurement period.
2	17 Aug.–16 Sept.	14	3	Second measurement period, recover all instrumentation.

An important aspect of the experiment is to obtain information concerning the interaction of the boundary layer with mesoscale structures that may be embedded in it or extend beyond it depending on the degree of disturbance the atmosphere displays. The atmospheric state may be classified as follows:

1) *Undisturbed conditions.* This situation occurs when there is a relatively shallow (<1.5 km) inversion capped boundary layer present with no clouds or clouds only associated with the inversion such as stratocumulus and cumulus humilis. In this case the mesoscale structures such as plumes, helical rolls, and convective cells are effectively part of the boundary layer structure.
2) *Moderately disturbed conditions.* When the organized convection penetrates through the boundary layer and extends well beyond it, the interaction between the boundary layer and the

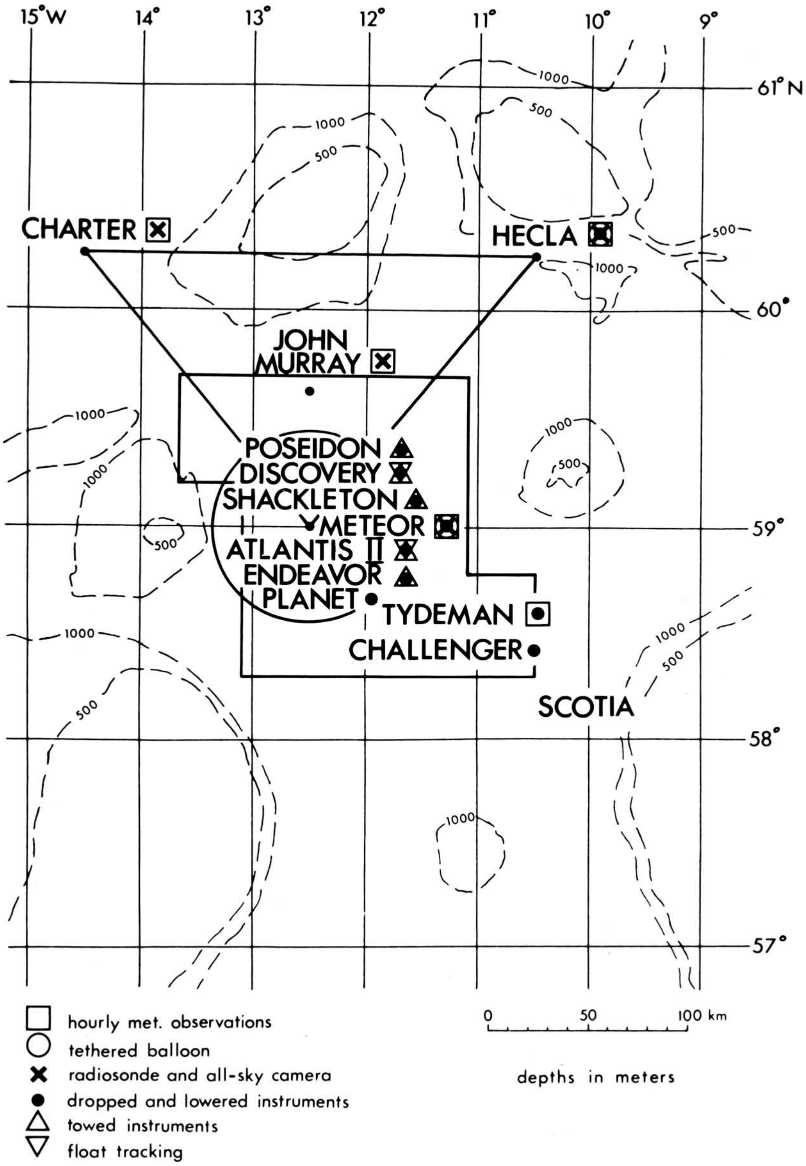

FIG. 6. Positions of ships in the main experimental areas (Fig. 1) during Phase 2. Symbols indicate main tasks of each ship.

mesoscale system becomes much more complex. The plan is to study cases in this category that can be clearly identified from satellite pictures or by other means.

3) *Fronts.* A special effort will be made to study the structure of the boundary layer before, during, and after frontal passages. The fronts to be selected must be well defined and pass the array in a relatively short time.

Instrumentation to be used in support of these goals includes radiosondes, tethered balloons, three gust probe equipped aircraft, and surface measurements on ships and buoys.

Radiosonde launches using LO-CATE wind measuring sondes from ships at the corners (and center) of the meteorological triangle (Figs. 5 and 6) will be made at 3 or 6 h intervals for most of the experimental period. On ~15 intensive days, each meteorological ship will launch at least 12 radiosondes between 0600 and 2100 GMT at ~1 h intervals. Intensive days will be chosen by the Field Operations Coordinator after assessing the weather forecasts in approximately the following ratios:

1) stable atmosphere from the sea surface, 0%;
2) suppressed convection, 45%;
3) moderate convection, 35%;
4) fronts, 20%.

On most intensive days, 3 aircraft (2 in Phase 1) will fly generally in formation at different heights, repeatedly surveying the 100 km box and 50 km L patterns contained mostly within the meteorological triangle (Fig. 1).

Measurements to be made include direct fluxes, radiation, surface waves by photography and laser altimetry, and sea surface temperature. Instrument intercomparisons will be made on passage, supplemented by dedicated aircraft flights if necessary.

As a central element of the air-sea interaction program, surface meteorological parameters will be sampled by a wide variety of devices on ships and buoys. Near-surface fluxes will be estimated from these measurements and will also be directly measured from 2 tethered balloons and low-flying (30–50 m) aircraft.

b. Oceanographic program

Many factors influence the development of the upper ocean boundary layer, including the wind, surface heating and cooling, the surface and internal wave fields, the stability of the underlying thermocline, frontal and intrusive structures in the thermocline, mesoscale deep ocean eddies, and tides. Each factor separately can produce substantial variability on much the same vertical scales, up to the mixed layer depth, and on horizontal scales from a few meters to hundreds of kilometers.

Because of the complexity of these phenomena and because of the difficulties of making measurements in the surface layers in the presence of surface waves, our understanding of the upper-ocean structure is poor.

In JASIN, many investigators will deploy specialized instrumentation to observe the individual phenomena in the surface layers. Our aim, through careful comparisons and joint analyses of the different data sets, is to identify as far as possible the contributions of each of the phenomena to the creation and maintenance of the structure of the mixing layer and seasonal thermocline.

Moorings spanning the entire LSA (Fig. 3) will examine the response of the ocean to atmospheric forcing on the scale of the North Rockall Trough. Hydrographic surveys will be confined to the Hydrographic Survey Area (Fig. 1) and will be carried out by the *Challenger* and *Tydeman* with assistance from *Shackleton*. *Challenger* will make casts to the bottom at the corners of 15 km triangles, repeated once to reduce tidal noise. A grid of triangles at 45 km separation will be surveyed once on each leg of *Challenger*'s cruise. *Tydeman* will carry out yo-yo dips to ~200 m of 1 h duration on a 22.5 km grid, with a few casts to the bottom coordinated with *Challenger* and *Shackleton* to ensure that the Hydrographic Survey Area is surveyed with deep casts approximately every 5 days.

The small-scale measurements, which form the core of the oceanographic program, will be confined to the OIA (Fig. 1) and will involve intensive surveys of areas up to ~20 km square either fixed or drifting within the OIA, carried out by up to 7 ships (Figs. 5 and 6).

The highest concentration of instruments will be the FIA (Fig. 4) of moorings, which is designed to study the structure and propagation of surface-generated internal waves, the structure of the mixed layer and upper thermocline on scales from meters to kilometers, and the surface fluxes of momentum and heat on scales of a few kilometers. Ship measurements to be made near the FIA include conductivity temperature depth (CTD) yo-yoing from up to 3 ships simultaneously, CTD profiles every 4 h from *Meteor* (hourly in Phase 2), drifting vertical current meter measurements, several oceanographic profiling systems, and freefall dissipation and microstructure instruments.

Mobile measurements will be conducted in the OIA in a Lagrangian fashion, either in the vicinity of a drifting spar buoy carrying sensors to measure current shear or following dye injected at the mixed layer/thermocline interface. With mean currents of 10–20 cm/s expected, such measurements will, in general, be 10 km or more away from the FIA, and for safety reasons, towed instruments are not allowed within the FIA. Instruments to be operated include 2 towed profiling CTDs, a towed thermistor chain, 2 acoustic sounders, and Swallow floats (Table 1). Instrument intercomparisons and joint exercises involving more than one ship making coordinated measurements are an integral part of the experiment.

Six waveriders around a 37 km circle within the OIA and at its center (Fig. 3) will operate throughout the experiment. Four pitch/roll buoys will be frequently deployed from *Discovery* and *Atlantis II*. Measurements will be coordinated with aerial photographs of the surface from a C-130, laser profilometer measurements from an Electra and, if possible, with altimeter and synthetic aperture radar measurements from Seasat-A. If Seasat-A is launched in time, it is hoped that JASIN will provide valuable ground truth for many of its sensors.[1]

5. Data management

To facilitate exchanges of data and joint analysis, a data catalog and General Interest Data Sets completed during the field experiment will be circulated to all participants by the Data Manager within two months of the end of the Phase 2. In addition, cruise reports will be circulated to all participants by each principal scientist, and more detailed Special Interest Data Sets will be circulated by the Data Manager on request.

Updates to the data catalog will be circulated every three months. Participants can make their progress and findings known to coparticipants through reports in the *JASIN Newsletter* and at meetings for data exchange and discussion, the first of which will be held in May 1979. It is expected that results from JASIN will begin to appear in the published literature before the end of 1979.

Acknowledgments. Much of this article has been condensed from the JASIN planning documents of the Royal Society. The contributions of all participants to these documents and to the planning of the experiment are gratefully acknowledged.

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[1] *Editor's note:* Seasat–A was launched 26 June. For more information, see "News and Notes" (p. 1355).