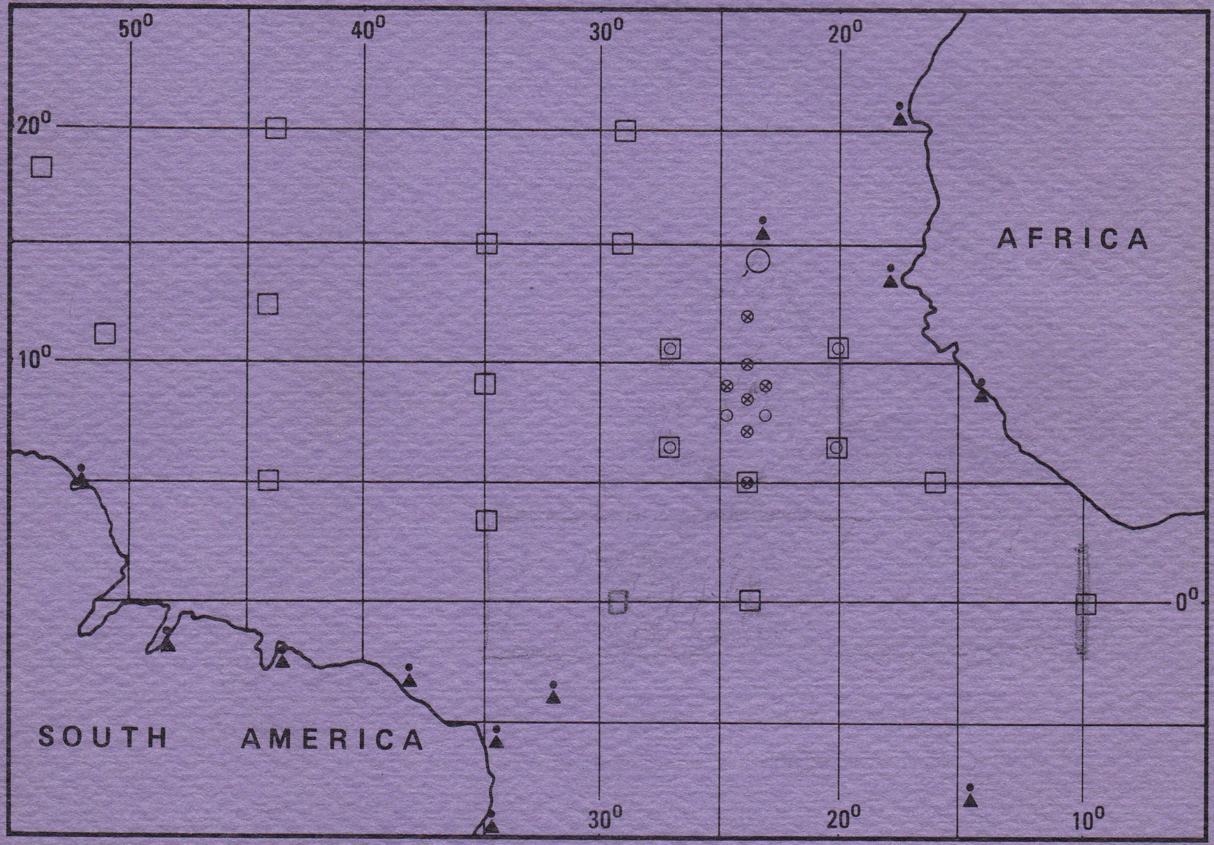
SCOR Proposal for a GATE Oceanographic Program



WORKING GROUP 43

SCIENTIFIC COMMITTEE ON OCEAN RESEARCH
INTERNATIONAL COUNCIL OF SCIENTIFIC UNION

June 30, 1973

PREFACE

SCOR Working Group 43 was set up in 1972 with the following terms of reference: "To develop plans for an oceanographic program to be associated with the GARP Atlantic Tropical Experiment; to propose means for its implementation and coordination". The group held its first meeting in Miami, Florida, U.S.A. on 5-10 February 1973 and prepared a report on an international oceanographic program for GATE. This report was accepted as a basis for the planning of the GATE oceanographic sub-program by the Tropical Experiment Board Meeting in Geneva, Switzerland on 19-21 March 1973. Following the recommendations given in the report, the SCOR Executive Committee during its meeting in Texel, Netherlands changed the terms of reference to read as follows: "To develop plans for an oceanographic program to be associated with the GARP Atlantic Tropical Experiment and to facilitate its implementation and coordination in cooperation with ISMG and IODE".

The second meeting of SCOR Working Group 43 was held in London, U.K. on 4-8 June 1973 in cooperation with the International Scientific and Management Group for GATE. The program presented here is an updated version of the Miami report. For the purpose of planning the ship distribution plan, Alternative A proposed by the ISMG and dated 11 April 1973 has been used. This does not imply preference of this plan over other alternatives but rather that it was convenient for planning because it includes in the B-area array the 100 km triangle of ships desirable for oceanographic and boundary-layer subprograms. In addition to the Miami report, programs on data management and analysis, aircraft measurements, routine oceanographic measurements and exchange of scientists and/or instruments are given in chapters 7 to 11.

Presently SCOR Working Group 43 has the following membership: V. A. Burkov/USSR, W. Düing/U.S.A., I. Galindo/Mexico, J. Gonella/France, C. Mann/IOC, G. T. Needler/Canada, F. Ostapoff/U.S.A., G. Siedler/F.R.G. (chairman), M. Sturm/G.D.R. and J. D. Woods/U.K.

In addition to the members of the group, the staff of the ISMG and many scientists from institutions participating in GATE have contributed to this document. The members of SCOR Working Group 43 express their appreciation for this assistance which was indispensable in preparing the report.

CONTENTS

1. INTRODUCTION

The primary objective of GATE, an improved understanding of tropical convection in cloud clusters and its interaction with the large scale circulation, is strongly dependent on accurate determination of the heat, moisture, and momentum fluxes across the air-sea interface on the B-scale (GARP Special Report No. 6 – GATE). An oceanographic program in GATE would be highly desirable for the independent – and in many cases more accurate – determination of these fluxes from appropriate budget measurements in the mixed layer. At the same time GATE will provide a unique opportunity for investigating the response of the oceans to atmospheric forcing on various scales. Although less directly related to the main atmospheric program, it should be recognized that oceanic response studies are central to the GARP objective of developing coupled ocean-atmosphere models for extended forecasting and investigations of climate. It is, of course, also the primary motivation for the oceanographic involvement in GATE. The concentration of mid-ocean platforms achieved during GATE will not likely be available again for many years, and it is therefore strongly recommended that the opportunity that GATE offers for studying the response of the ocean to the atmosphere be recognized and fully exploited in the planning of GATE.

Salinity and heat budget measurements are planned in the B-area and within one of the B-area grid triangles, which will be instrumented with a smaller network of oceanic instruments (C-scale). Oceanic response studies will include phenomena on the C-scale (interface, mixed layer and thermocline response, section 3), the B-scale (baroclinic adjustment, section 4) and A-scale (equatorial current system).

2. GENERAL RECOMMENDATIONS

The SCOR Working Group 43 recommends that:

2.1 This international oceanographic program be incorporated in GATE.

2.2 The coordination of the meteorological and oceanographic programmes be the responsibility of the ISMG; detailed logistic and scientific planning of the oceanographic programme should continue to be carried out by SCOR WG43 in close cooperation with the ISMG.

2.3 The enclosed map of optimum ship positions and survey tracks for the oceanographic programmes during phases I, II and III be considered as a basis for ship deployment compatible with the meteorological experiment.

2.4 Aircraft measurements required for the oceanographic programme be incorporated in the GATE aircraft programme.

2.5 The scientific programme of every ship in the B-scale and equatorial A-scale be directed on board by a qualified scientist with sea-going experience.

2.6 Provision be made for the assignment of scientific and technical personnel to ships of other nations as required by the oceanographic programme.

2.7 Oceanographic intercomparison be incorporated in the GATE programme for intercalibration tests.

2.8 IGOSS increase the density of observations in the GATE area during 1974 as specified in this document.

2.9 A strong surface radiation programme be established in support of the mixed-layer programme.

3. C-SCALE EXPERIMENT

An investigation of physical processes in the layer of the ocean disturbed by local atmospheric forcing (0-200 m).

3.1 General objectives

We seek to measure the detailed response of the ocean to local atmospheric disturbances occurring in a 100 km triangle during phase III of GATE. Special regard will be given to (a) surface waves, (b) internal waves, (c) mixed layer development, and (d) fronts in the thermocline. This high resolution experiment is designed to explore the physical mechanisms responsible for the overall change of structure to be measured in the oceanographic B-area experiment.

In planning the C-scale experiment we have considered a variety of theoretical models for the thermocline and the overlying surface layer. In all these models, changes in the vertical profiles of temperature and salinity are brought about by mixing due to one or more of the following:

a. surface waves

b. shear and static instability in the upper layer

c. shear instability at the top of the thermocline

d. internal quasi-geostrophic eddies and fronts

e. internal gravity waves.

Although these are often treated separately, from the point of view of thermocline models, a complete picture of the upper ocean also needs to take into account interactions between, in particular:

a. surface and internal waves

b. internal waves and quasi-geostrophic microstructure

c. surface waves and acceleration of the mixed layer

d. fronts and internal waves

e. internal waves and vertical current shear.

The relative importance of these contributions to mixing depends upon the weather, geographical location and season and upon the time and space scales being considered. Because our understanding of the physical processes associated with each of the contributions is still incomplete, the available theoretical models based on them are unsatisfactory. Despite quite different assumptions about the mixing process involved, the various models all yield plausible predictions concerning thermocline development in response to atmospheric forcing. This is not because the models are all equally valid, but because they are all insufficiently precise.

The C-scale experiment is designed to reveal the relative importance of the various mixing processes controlling the response of the thermocline. This will be achieved by measuring key parameters in each of the mixing processes and the surface wind, temperature, humidity field, and net radiation.

[The objective is to compare the observed response of the upper ocean (the changes in velocity, temperature and salinity distribution) with theoretical responses calculated on the basis of our physical measurements and the different thermocline models. The final goal is to parameterize these processes in a form suitable for coupled atmosphere-ocean numerical models.]

3.2 Surface Waves

Objectives

We propose to measure surface waves to test numerical methods of wave prediction needed for improved parameterization of air-sea momentum transfer and to provide one of the important inputs for groups concerned with the response of the upper layers of the ocean to meteorological forcing. The proposed array scales from 40 to 300 km correspond to the estimated response scales of different regions of the wave spectrum to the wind input. The array could also provide ground truth for testing remote microwave measurements of sea state from satellites (GEOSC) or aircraft.

Instrumentation

Seven pitch-roll buoys operated from ships and five wave-riders will be used for the surface wave measurements. Two receiving stations and ships (METEOR and HECLA) are needed to record the wave-rider data. These measurements will be supplemented by airborne laser wave profiles.

Operations

Both goals of the experiment require a network of wave stations covering approximately the same range of scale between about 40 and 300 km. The proposed array shown in the figure 1 coincides on the smaller scale with the oceanographic C-scale array and extends at large scales into the B-area array. Measurements will be made for ½ hour every 4 hours. To overcome spatial aliasing problems it would be desirable to augment the array measurements at discrete points with continuous wave profiles obtained with at least onel preferably two airborne laser instruments. The experiment is planned for three weeks during the third phase of GATE.

3.3 Coupling of internal waves to the mixed layer

Objectives

It is intended to study the coupling of internal gravity waves in the thermocline to the mixed layer and the wind field at the surface of the ocean. Recent experiments on cross-spectral properties in the internal gravity wave frequency band in other areas indicate that the following scales seem appropriate for a determination of the wavenumber spectrum: Vertically 2 to 200 m, horizontally 2 to 200 m or better 500 m. Correlations of internal wave energy in selected bands can possibly be detected over horizontal scales of a few km to the size of the C-array.

Instrumentation

Current/temperature meters will be used in deep-sea moorings. Surface buoys will carry meteorological sensors, especially wind meters.

Operations

We plan to measure the frequency and wavenumber spectrum of internal gravity waves in two dimensions at scales of some hundred meters in a two-leg mooring with approximately 20 instruments and to obtain frequency spectra at moorings 2-4, 10 and 30 kilometers apart with 3 to 6 instruments each (see Section 3.7). Spatial scales of 10 to 100 km should be covered when measuring wind speed and direction on surface buoys and the neighbouring ships. If possible, thermistor chain measurements should be carried out on selected triangular paths in the C-scale. A ship which is not committed to stay on a fixed position will be needed for the measurements and for servicing and controlling the buoys.

3.4 Mixed Layer development

Objectives
To measure the changing velocity, temperature and salinity structure of the mixed layer and pycnocline. To correlate this with surface wind, temperature and humidity measurements and mixing rates in the surface layer and at the top of the thermocline as deduced from the measured Richardson number profile.

Instrumentation
The full network of surface wave, wind, temperature and humidity and subsurface current, temperature and salinity measurements as listed in the table below (section 3.6).

Operations
The experiment is based on the routine schedule of measurements listed in paragraph 3.6. These will provide measurements at intervals of 1-2 hours at the corners of a nested series of triangles of sides 100 km, 40 km, 20 km, 5 km.

3.5 Fronts in the thermocline

Objectives
To make repeated quasi-synoptic surveys of fronts in the C-scale with horizontal resolution of less than 1 km and vertical resolution less than one meter. Special attention will be paid to structural features associated with vertical circulation at fronts and its response to atmospheric forcing.

Instrumentation

Aircraft:	airborne radiation thermometer digital data logging digital telemetry to ship (100 km range)
Roving Ship:	digital telemetry link with aircraft and data logger Neil Brown CTD – with Batfish (?) XBT Protas (free fall shear microstructure probe)
Fixed Ships:	Rapid STD and current meter profiles on demand when front passes any one of the three ships.

Operations
Daily airborne radiation thermometer (ART) flights to cover the whole C-area (5 hours on station); data to be telemetered to DISCOVERY for Sea Surface Temperature map analysis. DISCOVERY will then survey selected fronts, making XBT, CTD and batfish sections and dropping Protas at selected points. Two other roving ships from Canada and USA will collaborate with a joint towed STD programme. The three fixed ships will be requested to increase the frequency of their STD and current profiling if it is suspected that a front is passing through their station. The ship survey will be repeated regularly throughout the period of the C-scale experiment.

3.6 (i) Specific Requirements

SHIP	POSITION	INSTRUMENT	DEPTH	SAMPLING	PHASE	COMMENTS
PLANET	100 km N METEOR	Bathysonde	700-1000 m	4 h	III	
			200 m	1-2 h	III	
		PVCT profiler	100 m	1 h	III	
(GATE ship 27)		Hydrocast	1000 m	as needed	III	
		Thermistor chain (Bergen type)	11 levels to 50 m	5 min	III	
		Pitch Roll Buoy (H2)	surface	½ h every 4 h	III	
		XBT	450 m	back-up for bathysonde	III	
RESEARCHER	100 km NE METEOR	(Plessey) STD	1000 m	4 h	III	
			200 m	1-2 h	III	
(GATE ship 28)		PVCT profiler	100 m	1 h	III	
		Pitch Roll Buoy (H3)	surface	½ h every 4 h	III	
METEOR	$8^{o}30'N$ $23^{o}30'W$	Bathysonde	700-1000 m	4 h	II & III	
			200 m	1-2 h	II & III	
(GATE Ship 1)		PVCT profiler	100 m	1 h	III	
		Hydrocast	1000 m	as needed	III	
		Thermistor chain (Bergen type)	11 levels to 50 m	5 min	III	
		Pitch Roll buoy (H1)	surface	½ h every 4 h	III	
		Receiver for wave rider No. 5		½ h every 4 h	III	
		XBT	450 m	back-up for bathysonde	III	
DISCOVERY	Mobile	Neil Brown CTD		as required		
		XBT		as required		
		Hydrocast		as required		
		Batfish	0-200 m	as required		
		Protas (shear microstructure)	0-200 m	as required		

3.6 (i) Specific Requirements (contd.)

SHIP	POSITION	INSTRUMENT	DEPTH	SAMPLING	PHASE	COMMENTS
DISCOVERY (continued)	Mobile	Receiver for ART data Towed thermistor chain (Kiel) (?)		during flights 3-4 days continuous towing (to bottom of thermocline)		
GILLIS	GATE ship 5	Pitch Roll buoy (H4)	surface	½ h every 4 h	III	
USSR	GATE ship 4	Pitch Roll buoy (H5)	surface	½ h every 4 h	III	
OCEANOGRAPHER	GATE ship 7	Pitch Roll buoy (H6)	surface	½ h every 4 h	III	
HECLA	GATE ship 29	Pitch Roll buoy (H7) Receiver for wave rider buoys	surface	½ h every 4 h	III	
US (?)	Roving	STD Porpoising STD Buoy	0-300 m 0-50 m surface	every ½ h continuous	II & III	not definite
CANADA * (GATE ship 28)	Partly mobile	Towed STD (Batfish)	0-200 m	as required	III	

* This programme is possible if the Canadian ship is given a position such that it may leave station for up to ten days during Phase III. Such a position has been requested.

3.6 (ii)

MOORINGS	POSITION	INSTRUMENT	DEPTHS	SAMPLING	PHASE	COMMENTS
Current Meter Moorings (E1)	Corners of 20 km sided triangle centred on F1 apex South	6 VACM's 7	straddling mixed layer and thermo-cline	2½ min		IOS/U.K. Laid by DISCOVERY
		wind temperature humidity	surface	10 min		
(E2)		6 current meters	straddling mixed layer and thermo-cline	2½ - 10 min		NOAA (Halpern) Laid by ?
		wind/temperature (?) humidity (?)	surface	10 min		
(E3)		6 current meters	straddling mixed layer and thermo-cline surface	2½ - 10 min		NOAA (Halpern) Laid by ?
		wind/temperature (?) humidity (?)	surface	10 min		
Two-leg Moorings (F1)	Center of C Array	20 current meters (VACMs & Bergen) wind speed and direction (Bergen)	0-200 m surface	2½ min or 10 min	II & III	IfM KIEL Laid by METEOR
One-leg Moorings (F2)	Near F1	6 current meters wind speed and direction	surface	10 min		IfM KIEL Laid by METEOR
Triton buoy (AOML ship) (F3)	Near C	air temperature, humidity, wind speed and direction (?)	3 levels	?	II & III	

3.6 (ii) (contd.)

MOORINGS	POSITION	INSTRUMENT	DEPTHS	SAMPLING	PHASE	COMMENTS
Triton buoy (continued)		current shear (requires servicing every 6 days)	?	?		
7 Buoys (F4)	60 km W of RESEARCHER	wind speed, direction, air and wet bulb temperature, rain rate, water temperature	surface and down to 10 m	1¼ to 10 min (?)	III	Wayne Burt
Pitch Roll Buoys						
(H1)	METEOR	Pitch Roll buoy	surface	½ h every 4 h	III	
(H2)	PLANET	Pitch Roll buoy	surface	½ h every 4 h	III	
(H3)	RESEARCHER	Pitch Roll buoy	surface	½ h every 4 h	III	
(H4)	GILLISS	Pitch Roll buoy	surface	½ h every 4 h	III	
(H5)	Canadian Ship	Pitch Roll buoy	surface	½ h every 4 h	III	
(H6)	OCEANOGRAPHER	Pitch Roll buoy	surface	½ h every 4 h	III	
(H7)	HECLA	Pitch Roll buoy	surface	½ h every 4 h	III	
Wave Rider Buoys						
(G1)	60 km NE of METEOR	Wave rider buoys	surface	½ h every 4 h	III)	
(G2)	50 km NNE of METEOR	Wave rider buoys	surface	½ h every 4 h	III)	METEOR or HECLA
(G3)	50 km NE of METEOR	Wave rider buoys	surface	½ h every 4 h	III)	
(G4)	30 km NE of METEOR	Wave rider buoys	surface	½ h every 4 h	III)	Received on METEOR
(G5)	40 km SW of METEOR	Wave rider buoys	surface	½ h every 4 h	III)	
Cyclosondes						
(D1)	Corners of 40 km Triangle centered on C	Cyclosonde	200 m	1 cycle every ½ h	III	AOML ship to service every 6 days
(D2)		Cyclosonde	200 m		III	
(D3)		Cyclosonde	200 m		III	
Met Package	On every mooring (total of approx. 10)	Surface wind, temperature (?), humidity (?)	surface	10 min	III	

3.6 (iii)

AIRCRAFT	POSITION	INSTRUMENT	RESOLUTION Along Track	RESOLUTION Between Track	FREQUENCY	PHASE
Dedicated flights	throughout C-scale area	(1) airborne radiation thermometer (ART), digital recording, digital data transmission to ship (X,Y,T) every sec.	100 m	5 km or 2 km	1 sec for 5 hours 1 sec for 5 hours	3 flights in Phase II Daily in Phase III
		(2) laser altimeter	1 - 5 m	—		Daily in Phase III
Opportunity flights	In B-area outside C-triangle	(1) and (2) as above	as above	—	2 minute run down wind followed by 2 minute run up wind. 4 times per flight	Throughout Phase III as aircraft flights are available.

3.7 Map of C-Scale Platforms

D1, D2, D3 : Cyclosonde buoys

E1, E2, E3, F2 : Current meter moorings

F1 : Two-leg current meter moorings

F3 : Triton buoy

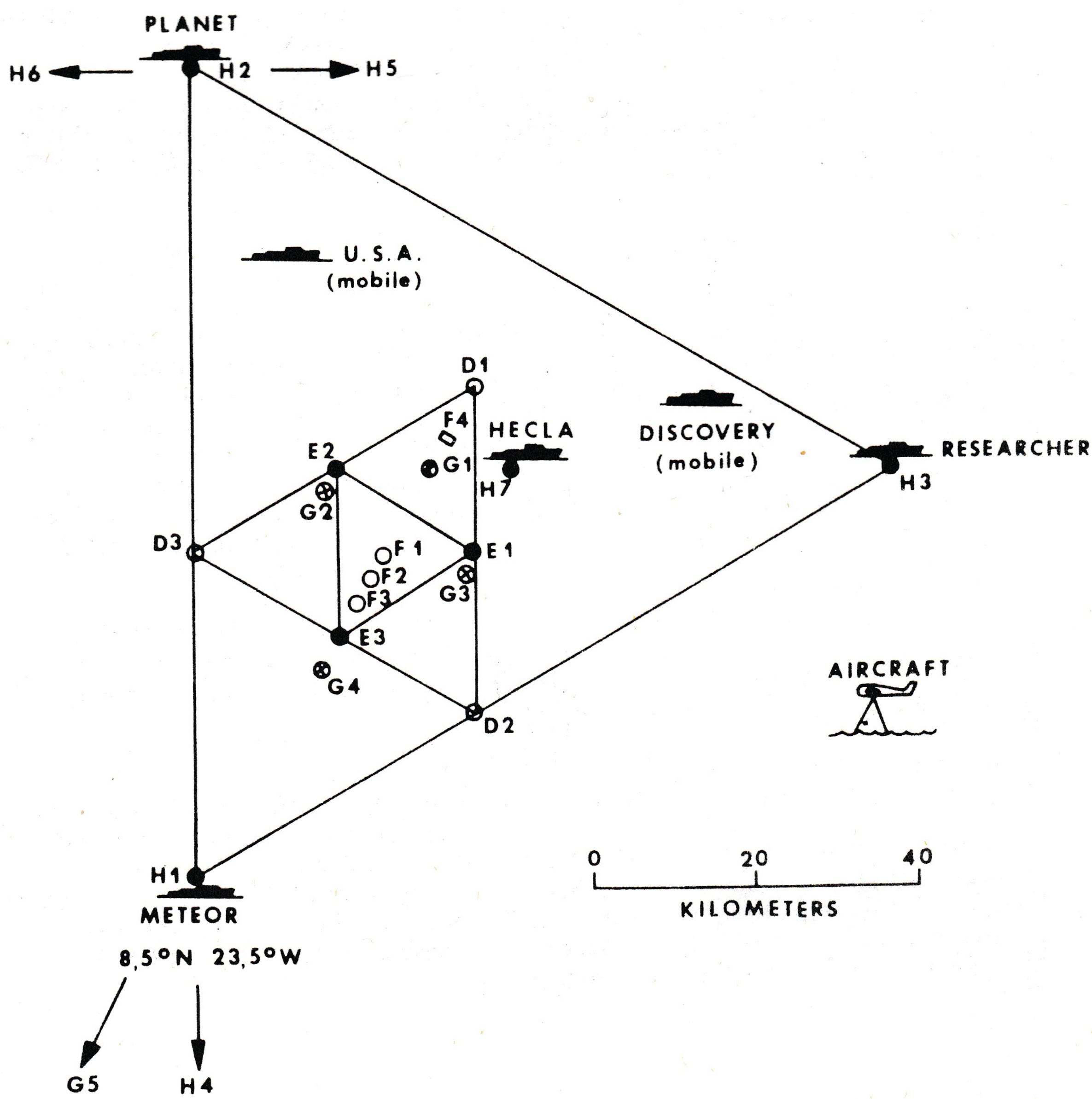
F4 : Wayne Burt buoys on a 6 km scale, possibly laid near F1 or F2

G1-G5 : Wave rider buoys

H1-H7 : Pitch and roll buoys

(Arrows indicate position outside this area)

Figure 1



4. B-AREA EXPERIMENTS

Investigation of the response of the ocean to atmospheric forcing on the B-array Scale.

4.1 General Objectives

Changes of the upper ocean on the time scale of a few weeks and space scales of individual cloud cluster events, are important both as elements of the meteorological observation programme, and as observations of the rate of water mass modification and dynamic adjustment of the North Equatorial current system and its associated cold ridge in the upper main thermocline. The programme proposed here consists of four intensive surveys of the mixed layer topography, and salinity and temperature distributions, complemented by a programme of regular hydrographic observations at B-area stations, and by associated current measurements during the various experimental phases. The former constitutes the Mixed Layer Budget Study, while the second is discussed here as the Main Thermocline Response Experiment. While each of them, in terms of execution and analysis, constitutes a closed experimental unit, these tasks complement each other closely. The budget analysis depends crucially on the possibility of achieving a reasonably accurate estimate of the mean horizontal divergence in the mixed layer, and thus on an accurate estimate of the vertical motion field at the top of the thermocline. Based on the reasonable assumption that the main thermocline adjustment is nearly adiabatic such an estimate will be a direct product of the response analysis. Secondly, since the mean frictional mass convergence in the atmosphere should be equal to the mean frictional mass divergence in the ocean, the vertical velocity estimate together with the salt budget will provide an indirect estimate of the relation between total rainfall and Ekman layer convergence in the atmosphere, i.e. of a crucial element in the CISK hypothesis.

4.2 Mixed Layer Budget Study

Objectives

It is intended to determine budgets of mass, salt, and heat storage in the mixed layer over the B array area for three periods during GATE. These will be based on four surveys coinciding with the deployment of the B-scale vessels. Since shower activity causes large amplitude salinity fluctuations on spatial scales of ten to twenty kilometers, spatial aliasing can only be avoided by sampling with much higher resolution than the basic B-array mesh. This will be achieved by using vessels moving to or from their stations in the regular GATE experiment. Advection will be estimated on the basis of zonal extension beyond the B array and by geostrophic surface transport estimates.

Instrumentation

All vessels involved in the mapping operation should be equipped with either BT's or XBT's and to take surface bucket salinity samples, supplemented if possible, with continuous surface salinity recorders. One vessel (Canadian) will be equipped with a high resolution TS porpoising towed instrument.

Operations

In order to achieve matching with the meteorological observation periods, the mapping exercises will be performed during deployment after the first intercalibration period, enroute to Dakar after the first experiment phase, during deployment for the third experiment phase, and enroute to the intercalibration site at the end of GATE. Mapping tracks are detailed in Sections 4.4 and 4.5. The tracks are chosen as a compromise between conserving steaming time and reducing aliasing by crossing the east-west elongated salinity anomalies at a reasonable angle.

A detailed test of the applicability of depth estimates for salinity anomalies based on bathythermograph records will be provided during phase III by a detailed TS profile study performed by the Canadian ship with Batfish.

4.3 Main Thermocline Response Experiment

Objectives
It is intended to study the response of the main thermocline to the observed meteorological forcing events on time scales longer than the inertial period. Dynamic response analysis based on surface stress estimates from individual cloud cluster events will be performed; also quasi-geostrophic interpretation of the smoothed hydrographic time series and associated current meter data will provide the best possible estimate of the frictional divergence in the surface layer.

The interior analysis will also provide an estimate of the effective thickness of the momentum boundary layer which may be much greater than the diffusion boundary layer depth due to momentum transfer by internal waves. It thus provides a long term, large scale integrated test of one of the major effects under study in the C scale experiment.

Instrumentation
All B and AB scale vessels should take STD's or hydrocasts to 1000 m depth. Continuous STD's should be taken as far as possible and current meters used as are available.

Operations
In order to reduce aliasing by internal gravity wave motions at tidal and adjacent frequencies, density measurements should be obtained every four hours and if possible not less frequently than every six hours. In order to use the salinity gradient at the Antarctic Intermediate Water core as a tracer of deep meridional displacements, routine hydrographic measurements should extend to a depth of 1000 m.

Direct current measurements are a necessary complement to the hydrographic data collection. In the southern part of the B-area adequate current meter coverage is foreseen from moorings deployed by the USSR vessels and in the center by those used by the C-scale experiment. Additional moorings will be sought with a view to extending current meter coverage to at least 13^{o}N, and to ensure longer continuous time series for analysis in the inertial frequency band.

4.4 Ship Requirements

(a) *Observations on Station (Fig. 6)*
Ships at stations 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 20, 21 for period on station during Phases I, II and III.

Ships at stations 27 and 28 for period on station during Phase III.

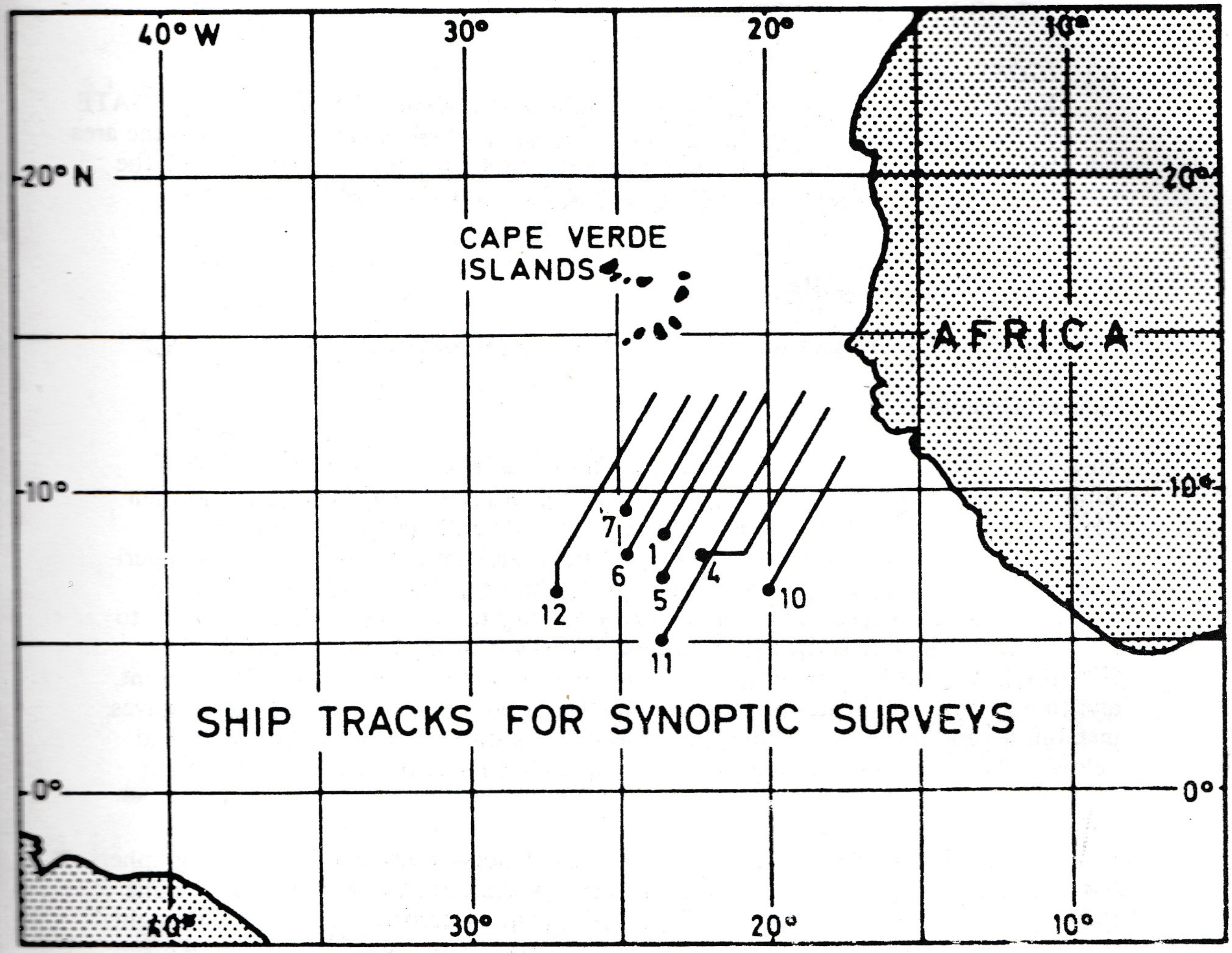
Observations of temperature and salinity to 1000 m at 4 hour intervals. Either by STD or Hydro-cast.

(b) *Synoptic Surface Mapping*
Ships to follow tracks designated below; at beginning and end of Phase I, end of Phase II, and end of Phase III (see Figure 2).

Measurements: Surface salinity and temperature to 300 m every 10 km along track.

Note: a) Ships not equipped to measure salinity collect samples for analysis in Dakar.
b) Ships equipped to do so should measure surface salinity continuously.

Figure 2



Ship Tracks* for end of Phases I, II and III for period of measurement are as follows:

Ships at stations 1, 5, 6, 11: Commencing at array position steer 30°N to 13°N.

Ship at station 4: Commencing at array position steer east to 21°W and then at 30°N to 12.5°N.

Ship at station 7: Commencing at array position steer north to 9.5°N and then at 30°N to 13°N.

Ship at station 10: Commencing at array position steer 30°N to 11°N.

Ship at station 12: Commencing at array position steer north to 7.5°N and then at 30°N to 13°N.

At the beginning of Phase I measurements should be taken along all tracks while steering in the reverse direction.

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* these tracks have been set with the realization that ship positions are not final at this time and that all ships may not be equipped with the necessary equipment. It is requested that the ISMG arrange similar or better coverage to the B-area making best use of the available ships and equipment.

Beginning and End Phase III
Ship at station 3 (Canadian) carry out survey of thermocline fine structure, T/S, in B-area (Batfish).

(c) *IGOSS*
Requested to increase density of observations in the GATE area (other than GATE ships) during 1974. This might be done by equipping ships passing through the area with XBT's and facilities for collecting surface water samples. In the area of the B-array the density of observations should be as for GATE ships.

5. EQUATORIAL EXPERIMENT

A study of the Equatorial Current System and its relationship to the atmosphere.

5.1 General Objectives

Measurements of the Equatorial Current System have revealed that its structure is subject to considerable variations. To clarify the nature of these variations and their dependence on the surface winds measurements on a spatial and time scale much greater than that which can be covered by a single ship are necessary. Such an experiment must obviously coincide with a meteorological one that will furnish detailed wind data. GATE affords a unique opportunity for the oceanographic experiment to be described below. It is the aim of the experiment to study the dynamics of the Equatorial Current System with particular emphasis on the Equatorial Undercurrent, and to determine the scales of transient equatorial phenomena such as trapped waves, instabilities and meanders. Though a number of separate experiments are described below it should be kept in mind that they are all interrelated and that they are not independent.

The experiment described below is of considerable interest not only to oceanographers but also to meteorologists. Variations in the band of anomalous cold water all along the equator, a consequence of upwelling in the Equatorial Undercurrent, are thought to affect the atmospheric circulation both in the tropics and in mid-latitudes. This hypothesis of Bjerknes has been confirmed by the numerical experiments of Rowntree and Miyakoda. They found that the disappearance of this band of cold equatorial water can after only ten days have a profound effect on the atmospheric circulation in mid-latitudes. The experiment to be described here will study the factors which influence this band of cold water.

5.2 Hydrographic Description of the Equatorial Current System

Objectives
It is intended to measure the mass transport of the various equatorial currents across 24^{o}W and to determine their temporal variations during the three phases of GATE.

Instrumentation
STD's and/or hydro-casts.

Operations
The R/V TRIDENT will make a detailed section of temperature and salinity along 24^{o}W starting at 10^{o}N and proceeding to 5^{o}S. On the return leg, a similar section will be made along 20^{o}W.

All stationary vessels along 24°W are requested to make STD or hydrographic casts to a depth of 100 m every four hours during all three phases of GATE. The data obtained in the above manner will be supplemented by measurements from buoys as described in section 5.4.2.

5.3 Dynamics of the Equatorial Undercurrent

Objectives
The aim is to measure the zonal pressure gradient along the equator in order to determine whether it is the primary source of momentum for the Undercurrent. Velocity measurements will make it possible to assess the significance of various terms in the equations of motion.

Instrumentation
Current meters, STD's, or hydrocasts.

Operations
All ships positioned on the equator are requested to make STD's to a depth of 1000 m every four hours during all three phases of GATE. Should STD's be unavailable so that only measurements with hydrocasts at discrete depths are possible, then the measurements should follow the following schedule:

> Hydrocasts are to be made every four hours. The vertical spacing should be the following: 0, 20, 40, 50, 60, 70, 85, 100, 125, 150, 175, 200, 300, 400, 500, 600, 800, 1000 meters.

All ships stationed on the equator are also requested to measure the shear of the current to a depth of 1000 m every six hours. If this is not possible during all three phases of GATE, it should be attempted during phase II at least.

5.4 Spatial and Temporal Scales of the Undercurrent

5.4.1 Three Dimensional Current Profiling Array

Objectives
It is intended to study the time-dependent three dimensional structure of the equatorial current system with particular emphasis on the Equatorial Undercurrent. In particular, we expect to obtain information on the response of this current system to wind fluctuations on a local scale as well as on a larger horizontal scale (e.g. effects of shifts of the ITCZ). The study will allow us to resolve variations of the Undercurrent and the adjacent equatorial currents on a horizontal scale up to 1000 kilometers, a vertical scale ranging from several meters to several hundred meters and on a time scale from 4 to 30 days.

Instrumentation
Taut-wire radar reference buoys will be planted at various positions. Three vessels will conduct relative vertical profiles of horizontal currents. By using radar range and bearing from the reference buoys, the relative profiles will be converted into absolute profiles. Temperature measurements using XBT's will complement the programme.

Operations
It is proposed to work during three weeks with four vessels (Humboldt, Columbus, Iselin, Anton Dohrn, Capricorn) in an array which will be divided into three sub-arrays of linear configuration. Taut-wire radar reference buoys will be planted at the indicated positions, and the three vessels will carry out relative current profiling, using radar range and bearing to convert the obtained relative profiles into absolute profiles. Each

subarray is so designed that one round trip with one profile at each reference buoy can be completed within two days. It is intended to repeat these round trips during three weeks, thus hopefully yielding 10 quasi-synoptic pictures. The current profiler will also provide temperature and conductivity profiles of limited accuracy. In addition, each vessel will carry out a dense temperature section (XBT) on the return leg every second day.

5.4.2 Measurements from Anchored Buoys

Objectives
Time series of currents and temperature by unattended buoys are desirable for all aspects of the programme because they will enable us to say more about the statistical significance of phenomena observed in the more intense, but shorter, work periods. This is important for several programme elements; for example, the programme described in section 5.3 and in section 5.4.1, where the effect of tidal aliasing will be investigated in relation to the high resolution current profiling. Moored instruments are the only means to obtain information on phenomena with time scales longer than a few days or weeks. In particular, they are important to study planetary equatorial waves generated by easterly atmospheric waves and to investigate propagation and spatial structures of density and velocity fields of these waves in relation to the stationary equatorial current system.

Instrumentation
A large number of buoys capable of recording current and temperature will be provided by various participating nations as listed in section 5.5.

Operations
Individual buoy positions are given in section 5.5. In general these locations will be in the neighbourhood of those vessels which will deploy them.

5.4.3 Intense Hydrographic Section Along the Equator

Objectives
The limited number of stationary ships along the equator are not sufficient to determine the zonal pressure gradient accurately. An intensive section along the equator is necessary to supplement this.

Instrumentation
One STD, one porpoising STD (Batfish).

Operations
The DISCOVERY will measure the salinity, oxygen and temperature to a depth of 1000 m every ½^{o} longitude between 30^{o}W and 21^{o}W.

The CHAIN will tow a porpoising STD all along the equator from 40^{o}W into the Gulf of Guinea, making a meridional section every 5^{o} longitude.

5.4.4 Equatorial Measurements with Pressure Gauges

Objectives
Time series of pressure obtained from bottom-mounted and island pressure gauges will be obtained to study pressure fluctuations associated with currents and tides at the equator. These series, when correlated with the velocity and density measurements, will help define the time-dependent dynamics of the equatorial currents. Tides will be obtained from the records in a region of particular importance in the global theory of tides.

Instrumentation
Five deep-sea pressure gauges will be mounted on the bottom. A shore gauge will be place on St. Paul's Rocks.

Operations
The deep-sea pressure gauges will be set on the ocean floor on the equator at 21°W and 26°W during all three phases of GATE. They will obtain half-hourly measurements of bottom pressure and temperature. The shore gauge at St. Paul's Rocks, 30°W, will make comparable pressure measurements.

5.5 Table of specific requirements

SHIP	POSITION	INSTRUMENTS	DEPTHS	SAMPLING	PHASE	COMMENTS
Acad. Kurchatov	00^{o}, 30^{o}W	Hydrocasts	as per sect. 3.1.3	4 h	I, II, III	
		BT	250 m	4 h	I, II, III	
	$0^{o}45'$S, 30^{o}W $0^{o}15'$S, 30^{o}W $0^{o}15'$N, 30^{o}W $0^{o}45'$N, 30^{o}W	4 Moored buoys with current & temp. sensors	open	1 h	I, II, III	
USSR	00^{o}, 10^{o}W	Hydrocasts	as per sect. 3.1.3	4 h	I, II, III	
		BT	250 m	4 h		
	$0^{o}40'$S, 10^{o}W $0^{o}0'$ 10^{o}W $0^{o}40'$N, 10^{o}W	3 Moored buoys with current & temp. sensors	open	1 h	I, II, III	
USSR	05^{o}N, 24^{o}W	Hydrocasts	as per sect. 3.1.3	4 h		
		BT	250 m	4 h	I, II, III	
	4^{o}N, 24^{o}W 3^{o}N, 24^{o}W 2^{o}N, 24^{o}W	3 Moored buoys with current & temp. sensors	open	1 h	I, II, III	
Col. Iselin	1^{o}N 1^{o}S, 26^{o}W	XBT's computer to decode Aanderaa tapes	450 m	1 round trip along ref. buoys every 2 days, every 20 miles	II	
Anton Dohrn	1^{o}N 1^{o}S, 21^{o}W	XBT's computer to decode Aanderaa tapes	450 m	1 round trip along ref. buoys every 2 days, every 20 miles	II	

5.5 Table of specific requirements (contd.)

SHIP	POSITION	INSTRUMENTS	DEPTHS	SAMPLING	PHASE	COMMENTS
Anton Dohrn (continued)	$0^{o}40'S$, $21^{o}W$	2 or 3 moored buoys with current and temp. sensors	open	15 min	II	
Trident	$10^{o}N$ $5^{o}S$, $24^{o}W$	STD, XBT				
	$5^{o}S$ $10^{o}N$, $21^{o}W$	0_2, current shear	1000 m	every 30 miles	II	
		3 moored buoys with current and temp. sensors	open	15 min	II	
Chain	Mobile	porpoising STD	80 m		I	
Discovery	Mobile along the Equator	STD current shear	1000 m	as required	II	
Alex. von Humboldt	$1^{o}N$-$1^{o}S$, $18^{o}W$	current profilers STD	1000 m	10 miles	II	
Capricorn	$1^{o}N$-$1^{o}S$, $16^{o}30'W$	current profilers STD	1000 m	10 miles	II	

6. SHIP POSITIONS WITH OBSERVING CAPABILITIES

(See following page for definition of symbols and notation)

COUNTRY/ NAME (1)	POS. NO. (2)	U/A OBS. (3)	Sfc OBS. (4)	RAD. OBS. (5)	B/L OBS. (6)	OCEANO. OBS. (7)	OTHER (8)	PHASE (9)
U.S.S.R.								
Prof. Vize	2	R	S	Rs,RB	TB,F	B,T,S,C	Comp.R3,5kw	All 3
Prof. Zubov	11	R	S	Rs,RB	TB,F	B,T,S,C	Comp.R3,5kw	All 3
Ernest Krenkel	17	R	S	Rs,RB	–	B,T,S,C	Comp. – 5kw	All 3
Acad. Kurchatov	24	R	S	Rs,RB	X	B,T,S,C	Comp. – X	All 3
Passat	9	R	S	Rs,RB	–	B,T,S,C	X, – ,X	All 3
Musson	10	R	S	Rs,RB	–	B,T,S,C	Comp. – ,X	All 3
Volna	12	R	S	Rs,RB	–	B,T,S,C	– , – ,X	All 3
Acad. Korolov	16/8	R	S	Rs,RB	–	B,T,S,C	– , – ,X	All 3
Acad. Vernadsky	26	R	S	Rs,RB	–	B,T,S,C	– , – ,X	All 3
Prilev	13	R	S	Rs,RB	TB,F	B,T,S,C	– , – ,X	All 3
U.S.A.								
Researcher	3/28	O	S	Rs	TB,F	STD,B,T,S,C	Comp.R5, X	All 3
Gilliss	5	O	S	Rs	TB,F	STD,B,T,S,C	Comp.R5, X	All 3
Oceanographer	7	O	S	Rs	TB,F	STD,B,T,S,C	Comp.R5, X	All 3
CG Cutter	8	O	S	Rs	X	STD,B,T,S,C	X	All 3
Chain	E	–	X	–	–	STD, XBT, Towed STD,C	–	2
Col. Iselin	E	X	X	Rs	X	STD,C	X	2
USA (?)	E	X	X	Rs		STD,C	X	2
F.R.G.								
Meteor	1	O	S	Rs,RB	TB,F	STD,B,T,S,C	– ,R3,X	All 3
Planet	27	O	S	Rs	F	STD,B,T,S,C	R3	3
Anton Dohrn	E	O	S	Rs	F	STD,B,T,S,C	–	2
FRANCE								
Marion DuFresne	4	O	S	Rs	–	STD,T,S	X	1, 2
Capricorn	25	O	S	Rs	X	X,B,T,S,C	X	1
Riviere Class	–	O	S	Rs	–	X	X	3
Charcot	19	O	S	Rs	–	STD,B,T,S,C	X	3
U.K.								
U.K. No. 1	6	O	S	Rs	X	X,X,T,S,X	X	All 3
U.K. No. 2	22	O	S	Rs	X	X,X,T,S,X	X	All 3
Hecla	29	–	S	X	TB	STD,T,S,C	X	3
Discovery	E/C	X	S	Rs	F(?)	STD,B,T,S,C	Comp. X	2, 3
CANADA	19/3	O	S	Rs	X	STD,T,S	Comp.	All 3
BRAZIL								
Sirius	20	O	S	X	–	X	X	All 3
Adm. Saldanha	21	O	S	X	–	X	X	All 3
MEXICO								
Virgilio Uribes	14	O	S	Rs	–	STD,T,S,C	–	All 3
COLOMBIA								
San Andres	18	O	S	–	–	T,S	–	All 3
NETHERLANDS	15	O	S	X	–	X	X	All 3
PORTUGAL	23/25	O	S	X	–	X	X	All 3
GDR								
Alex. von Humbolt	E	X	S	–	–	STD,T,S,C ⊙	X	July/ Aug.

DEFINITION OF NOTATION AND SYMBOLS USED IN SECTION 6: SHIP POSITIONS

Column Number	Definition
(1)	Name of country
(2)	*Position number used:* E = Equatorial position C = C-scale
(3)	*Upper-air observations:* R = Radar wind plus radiosonde O = OMEGA winds plus radiosonde X = Capability unknown
(4)	*Surface Meteorological Observations:* S = Standard marine meteorological observations X = Capability unknown
(5)	*Radiation Observations:* Rs = Surface radiative fluxes RB = Balloon radiometersondes X = Capability unknown
(6)	*Boundary-layer Observations:* TB = Tethered balloon at constant levels or vertical profiling system F = Surface flux measurements made either aboard ship or on a buoy nearby X = Capability unknown
(7)	*Oceanographic Measurements:* B = Oceanographic buoy near ship T,S = Water temperature and salinity sampled at selected levels (non-profiling system) STD = Salinity/temperature/depth profiling device C = Water currents measured X = Capability unknown ⊙ = Contribution of current meters possible to other nations mooring buoys
(8)	*Other Capabilities:* Comp. = Computer on-board R3,R5 = 3 cm or 5 cm radar, respectively 5kw = Power of on-board radio-transmitter for communications X = Capability unknown
(9)	*Phase:* 1,2,3 = GATE observational periods All 3 = Ship participating during all periods

Phase 1 — Distribution of GATE Ships

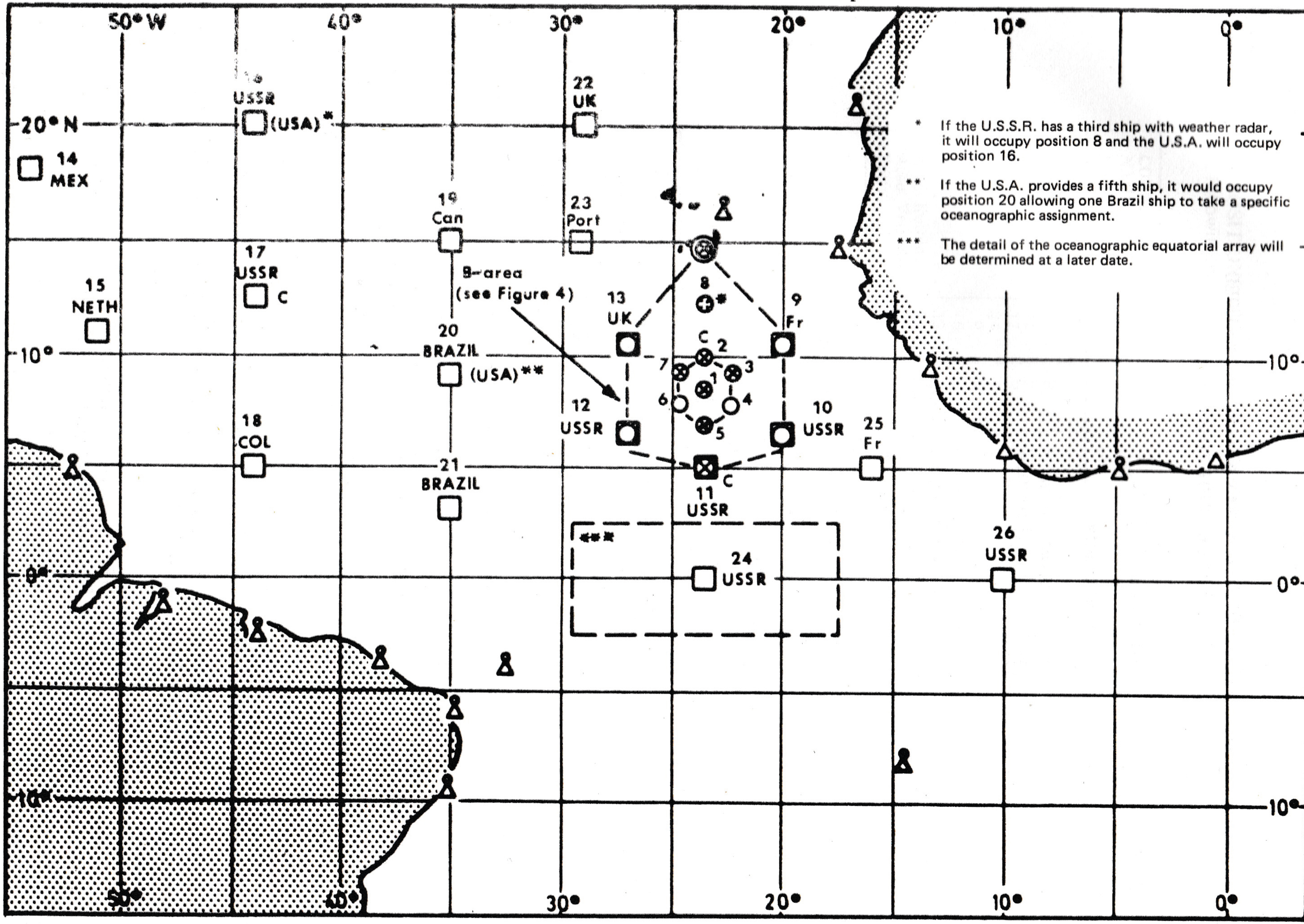
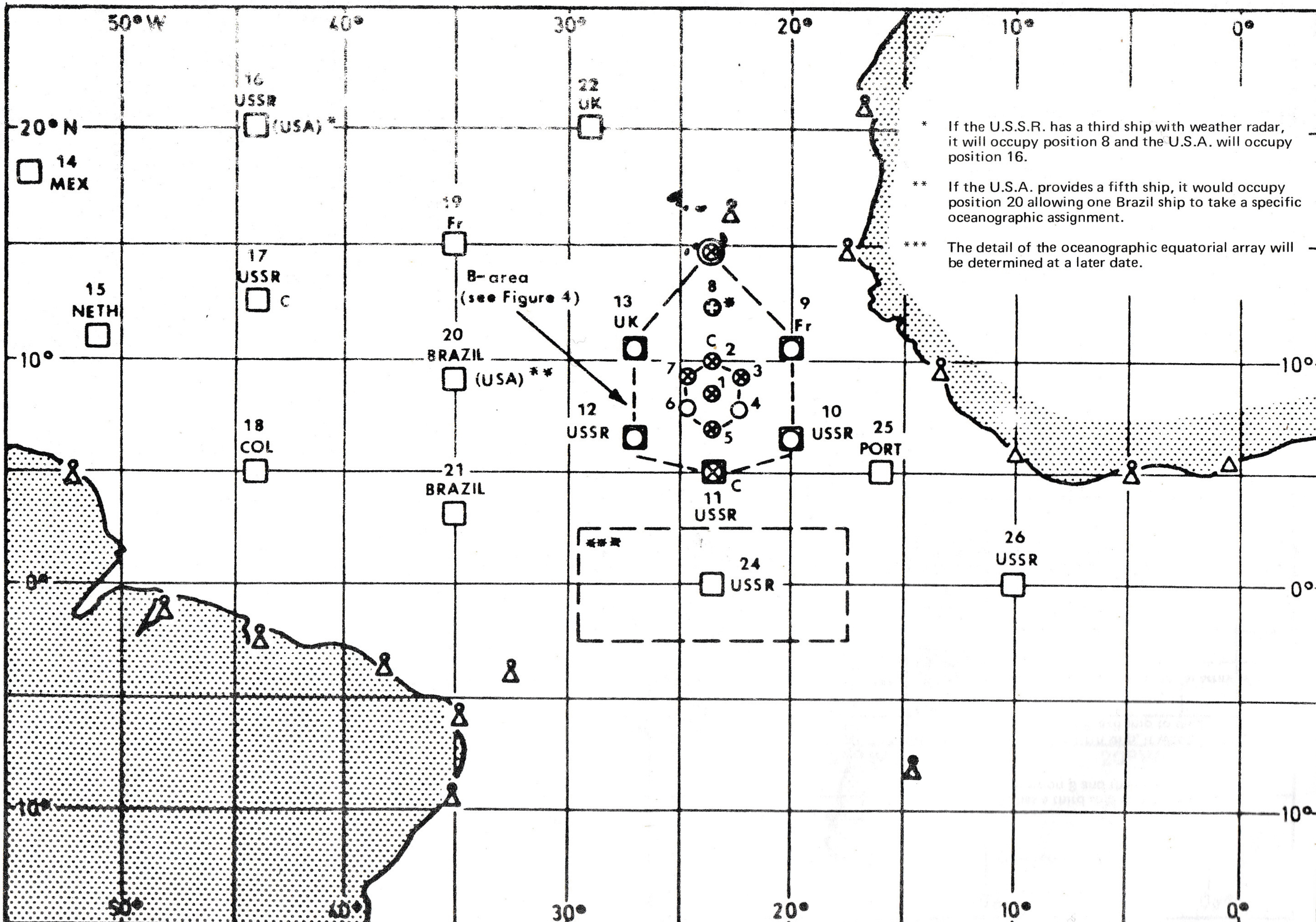


Figure 3 – Proposed Ship Distribution for the A-Scale Area, Phase 1

Note: See Figure 6 for definition of symbols used to designate types of ship positions.

Phase 2 — Distribution of GATE Ships



* If the U.S.S.R. has a third ship with weather radar, it will occupy position 8 and the U.S.A. will occupy position 16.

** If the U.S.A. provides a fifth ship, it would occupy position 20 allowing one Brazil ship to take a specific oceanographic assignment.

*** The detail of the oceanographic equatorial array will be determined at a later date.

Figure 4 — Proposed Ship Distribution for the A-Scale Area, Phase 2

Note: See Figure 6 for definition of symbols used to designate types of ship positions.

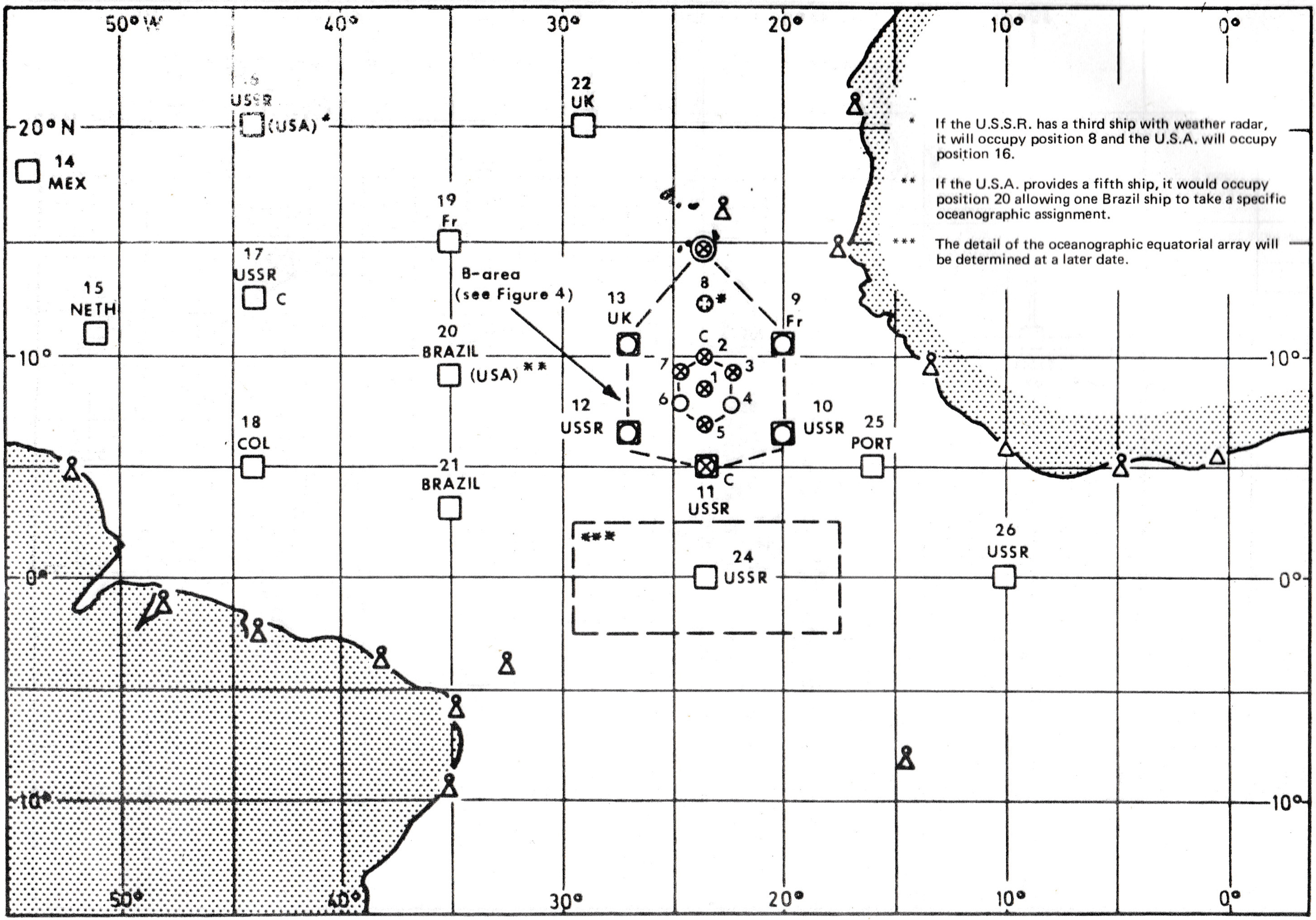


Figure 5 — Proposed Ship Distribution for the A-Scale Area, Phase 3

Note: See Figure 6 for definition of symbols used to designate types of ship positions.

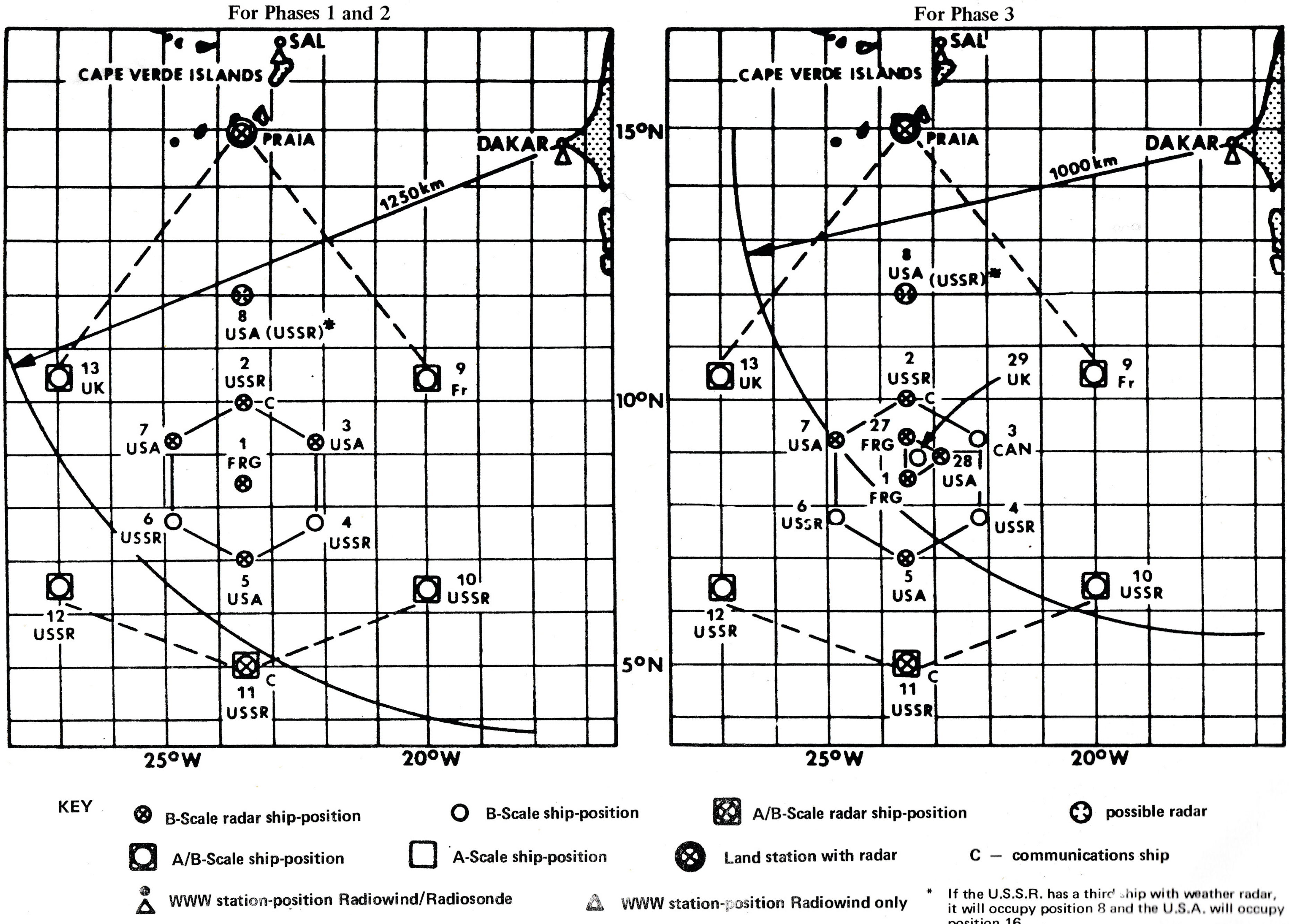


Figure 6 — Proposed Ship Distributions for the B-Scale Area

7. OCEANOGRAPHIC DATA MANAGEMENT AND ANALYSIS

7.1 Introduction

Two distinct tasks were identified which are needed to fulfil the oceanographic scientific requirements:

(1) Ability to assemble, process, quality control and internationally validate all oceanographic data, to process requests for particular data sets and to provide the data from full archives – An oceanographic sub-programme data centre function.

(2) Provision of software and support facilities to enable scientists or groups of scientists visiting the centre for short periods to access and manipulate any subset of data flexibly and rapidly – A scientific analysis function.

The SCOR WG43 could see two alternatives:

(1) A single facility accept responsibility for both tasks,

(2) The oceanographic subprogramme data centre be responsible for providing full archiving and data dissemination facilities, and separate institutions be responsible for providing in-house scientific facilities.

There was a strong feeling that no single institute exists that would be able to provide both services in time for GATE. Centres experienced in archiving and disseminating data may not have support facilities as sophisticated as are required for the various components of the oceanographic programme, and it was felt that such facilities could not be set up from scratch in 18 months. Therefore, the SCOR WG43 in conjunction with ISMG representatives considers the second alternative the more practical approach. From informal discussion among representatives from existing facilities it was concluded that this may be possible. Proposals for a selection of the Oceanographic Subprogramme Data Centre and of analysis institutions are made in the following paragraphs.

7.2 Oceanographic Subprogramme Data Centre

At the meeting of the Tropical Experiment Board Meeting (TEB-IV) in March 1973 the French delegation stated that France was interested in possibly providing national support for an oceanographic subprogramme data centre in that country. A French expert, Dr. G. Peluchon, was therefore invited to the meeting of SCOR WG43 in London, June 1973, to describe the facilities at the Bureau National des Données Océanographiques, CNEXO-COB, Brest, France.

It was concluded from these discussions that the oceanographic data centre function could be proposed for a facility such as exists in Brest. However, it was realized that some additional staff and other resources would be required. A preliminary estimate of the additional support was given as 1 – 2 scientists and 2 – 3 programmers (or equivalent manhours from a number of people) and possible a second shift operation at the Brest computer centre. The staff augmentation would be necessary by the fall of 1973 to begin preparations of new software. The possible second shift computer operation would be needed for processing GATE oceanographic data following the field phase in 1974. It was the understanding of SCOR WG43 following discussions at TEB-IV, that the funding of the Oceanographic Subprogramme Data Centre would originate from national sources.

A summary of the type of work proposed for the Oceanographic Subprogramme Data Centre is given in the following paragraph.

7.3 Requirements for the Oceanographic Subprogramme Data Centre

Functions of the Oceanographic Subprogramme Data Centre:

A. Assemble and process international intercomparison data;

B. Prepare intercomparison data sets for analysis by groups of experts;

C. Send analysed intercomparison data sets to WDCS and subprogramme users;

D. Assemble all oceanographic observations and background information in accordance with J.;

E. Process, quality control and validate subprogramme observations;

F. Prepare basic international data sets containing validated observations and distribute to subprogramme data users and WDCs;

G. Prepare special data sets and charts*;

H. Prepare documents with explanations to data sets and inventories and methods used for data processing and validation;

I. Send data sets, documents and inventories to users, other subprogramme data centres and WDCs as requested and specified by the GATE Data Management plan.

J. All data exchange would be in internationally agreed formats and according to internationally agreed data exchange practices for GATE.

7.4 Scientific Analysis Institutions

SCOR WG43 recognised that the oceanographic subprogramme consists of a number of closely interrelated, interactive scientific problems. Scientists experienced in specific types of data need to come together to investigate interactions between their particular fields and to synthesize their results. For example, wind, surface wave, internal wave and current fields must be combined to study the total momentum budget. Therefore it is mandatory that mechanisms be established to allow such collaboration. After the common data base has been established in the Oceanographic Subprogramme Data Centre, the data should be made available to specialist establishments for further scientific analysis.

Institutes in three countries have been identified at which expertize directly relevant to the oceanographic programme has been developed. It is recommended that they be designated as analysis institutes for specific scientific problems, namely,

in the United Kingdom, to focus on internal waves, thermocline and mixed layer modelling;

in the Federal Republic of Germany, to focus on surface gravity waves and surface wave prediction;

in the United States of America, to focus on the equatorial experiment and thermocline response studies.

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* Special data sets and charts are required as "background" or for general use by oceanographic users and meteorological subprogramme users. Examples of these products are sea surface temperature maps (A and B scales), descriptive maps and vertical sections of the mixed layer, specially prepared displays of surface meteorological and near-surface oceanographic parameters, etc. Specific requirements for such products will be compiled and specified in the GATE Data Management Plan according to subprogramme needs.

It is recognized that, if these countries agree to provide scientific analysis facilities, their institutes may require additional funding to upgrade their capabilities in order to provide the services envisioned. The main requirement is for versatile software allowing easy retrieval of any subset of the available data. In addition, quick turnaround (not more than a day) is required even for fairly large jobs.

The designation of institutes as scientific analysis institutes does not imply that only at them will the respective scientific studies be carried out. It merely says that they will provide analysis facilities capable of handling certain types of data and provide the scientific environment for a coordinated international interactive analysis phase.

7.5 International exchange of GATE data

7.5.1 Introduction

SCOR WG43 felt that it was extremely desirable that a common format be agreed for national and international exchange of both oceanographic and meteorological validated data. After examination of formats presently under consideration as formats for international exchange of oceanographic data, the working group concluded that, while they may be adequate for standard oceanographic data, they are not versatile enough to handle data from specialized oceanographic or meteorological instruments.

It was recognised that data exchange will be on many different media – the GTS, cards, analogue records, magnetic tapes, etc. However, it was felt that most of the data exchange, certainly between the National Processing Centres, Subprogramme Data Centres, World Data Centres, and wherever possible between any users with computer and magnetic tape facilities, would be on the medium of computer magnetic tapes. The working group recommends that the specifications given in 7.7 be incorporated into a universal format for all exchanged magnetic tapes.

7.5.2 Magnetic tape specifications and format for data exchange

(a) tapes to be either 7-track, 556 b.p.i., even parity, or 9-track, 800 b.p.i., odd parity as agreed by the two exchanging parties.

(b) 7-track tapes to be in BCD (binary coded decimal), 9-track tapes to be in EBCDIC (extended BCD).

Where possible, IBM codes should be used, otherwise a table of the codes used should be supplied.

(c) the tape structure to consist of four types of physical record separated by inter-record gaps and blocked into files usually separated by end-of-file marks (EOFs, sometimes called tapemarks) in the sequence

```
file 1      tape header record
            EOF
file 2      file header record type one
            file header record type two
            data record  )
                         )
                         )
                         )
                         )  as many as required
                         )
                         )
            data record  )
            EOF
```

files 3,4, etc.

	EOF
file n	file header record type one
	file header record type two
	data record
	EOF) double EOF signifying end of
	) information on this tape
	EOF)

(d) all EOFs except the two at the end can be omitted if the recipient of the data so desires.

(e) all records to be 2400 bytes (characters) in length (padded with blanks or zeros where necessary to make up the length).

(f) the tape and header records to be blocked conceptually into 80 byte units, so that header information can be easily copied from punched cards, if desired.

(g) the type of record to be identified by the first character in it, i.e.

- '0' – tape header record
- '1' – file header record type one
- '2' – file header record type two
- '3' – data record

(h) the tape header record to contain the tape name (the same name as on the physical label written on the tape spool) and information identifying the institute which wrote the tape, the type of computer, code conversion table, etc.

(i) a file to be defined as all those data that conveniently constitute one data set. A single STD dip, one radiosonde ascent, ART data from a single aircraft flight, the time series from a single current meter, are examples.

(j) if a file is too long to fit onto one magnetic tape, it can be continued on further reels. The tape header record contains information to show if a file is the continuation of a file on a preceding tape, or if the file is continued on a following tape. The EOF after the tape header record is present on all tapes (except as provided by (d)), but the file header records are not repeated on continuation tapes.

(k) each data file to be fully self-described by the header records that begin it. In particular, header record type one to contain details of the format of all data records. (In FORTRAN, this would be the format statement used to write one data record.) Header record type two to contain information on each parameter in the data set.

(l) each data record to consist of a number of data cycles. All sampling instruments sample in a sequence that is regularly repeated. One repetition of the basic sequence constitutes a data cycle.

For example:

(time, temperature) – from an XBT or MBT

(pressure, temperature, humidity) – from a radiosonde (time, direction, direction, direction, speed) – from a velocity meter sampling one parameter more frequently than another.

The parameters may or may not all be sampled simultaneously. If the sampling is sequential, as in the last example, each parameter has a time lag associated with it which is the time lag from the time specified in the data cycle, and these lags are to be specified in file header record type two. In general, pressure or some other variable may be the independent variable, and this variable must be the first element of the data cycle. The lags specified in file header record type two are then in the same units as the independent variable.

If the lags are all zero, parameter one need not be an independent variable.

(m) in FORTRAN, it is recommended that only A, I, F and X formats be used, E and D formats are not always compatible between different installations. The parameter scaling factors (see file header record two) may be used to avoid E and D formats.

(n) care must be taken that the word lengths of the computers used are sufficient for the resolution needed by each parameter. Again, use of the scaling factors may alleviate this problem.

(o) suggested record formats followm in which

A means alphanumeric
I means integer
F means fixed point format

7.5.3 Tape header records

Byte No.	No. of bytes	Format	Description and comments
1	1	I	'0' – tape header record identifier
2-13	12	A	tape name
14-15	2	I	year (within century)) date and time at which date was first written to
16-17	2	I	month)
18-19	2	I	day)
20-21	2	I	hour)
22-23	2	I	minute)
24-25	2	I	second)
26-28	3	I	country of origin – code number
29-38	10	A	country of origin – plain language
39-49	11	I	institute or data center that wrote tape – code number
50-69	20	A	institute or data center that wrote tape – plain language
70-78	9	A	type of computer used
79-80	2	I	card count
81	1	I	'0' – tape header record identifier
82-93	12	A	– name of preceding tape (if file continued from another tape) – blank (if not continued)
94-105	12	A	– name of following tape (if file is continued on another tape)
106-158			unspecified
159-160	2	I	card count
161,241, 321, etc.			'0' – tape header record identifier
239-240, 319-320 etc.			card count
			further information required by data centers, etc.

File Header Record Type One

Byte No.	No. of bytes	Format	Description and comments	
1	1	I	'1' file header record type one identifier	
2-13	12	A	file name	
14-15	2	I	year within century	date and time at which file was created
16-17	2	I	month	
18-19	2	I	day	
20-21	2	I	hour	
22-23	2	I	minute	
24-25	2	I	second	
26-29	4	A	source ('BUOY', 'SHIP', 'A/C', 'SAT.' etc.)	
30-78	49	A	details of platforms given in 26-29 (e.g. for a ship, ship name, or official code, cruise, ship heading and speed at start of observation)	
79-80	2	I	card count	
81	1	I	'1' file header record type one identifier	
82	1		'+' for North '–' for South	latitude at start of observation
83-84	2	I	degrees	
85-86	2	I	minutes	
87-88	2	I	seconds	
89	1		'+' for East '–' for West	longitude at start of observation
90-92	3	I	degrees	
93-94	2	I	minutes	
95-96	2	I	seconds	
97-100	2	I	year within century	date and time at start of observation
101-102	2	I	month	
102-104	2	I	day	
105-106	2	I	minute	
107-108	2	I	second	
109-111	3	I	millisecond	
112-121	10	F	depth (metres). depth at start of observation	
122-131	10	F	pressure (mb) pressure at start of observation	
132-141	10	F	time between samples (seconds) – relevant for evenly time sampled data	
142-143	2	I	number of parameters in each data cycle	

File Header Record Type One, continued

Byte No.	No. of bytes	Format	Description and comments
144-153	10	I	number of data cycles in the file (if known) otherwise blank or zero
154	1		'+' East deviation) Magnetic '–' West deviation) deviation
155-156	2	I	degrees) at start) position
157-158	2		unspecified) and time of
159-160	2	I	card count) observation
161	1	I	'1' file header record one identifier
162-221	60	A	format description (first part)
222-238			blank
239-240	2	I	card count
241	1	I	'1' file header record type one identifier
242-301	60	A	format description (continued, if necessary)
302-318			blank
319-320	2	I	card count
231,401 etc.		I	'1' file header record type one identifier
399-400, 479-480 etc.			card count
			all other space up to 2400 is available for further information (coded or plain language) on the platform, observing programme, institute, instrument package, sensors etc., in addition to what is already coded in this header record and file header record two.

File Header Record Type Two

Byte No.	No. of bytes	Format	Description and comments
parameter 1 in each data cycle			
1	1	I	'2' file header record type two identifier
2-13	12	A	abbreviated name of parameter
14-16	3	I	parameter code
17-28	12	A	units
29-30	2	I	units code ('01' for metric standard units wherever possible)
31-40	10	A	sensor type and manufacturer's number
41-48	8	F	scale 1 (*)
49-56	8	F	scale 2 (+)
			scales used to reduce the number of bytes needed to record the parameter. To recover the parameter in the units given in 17-28, multiply the recorded parameter value by scale 1 and then add scale 2, i.e.
			param. (physical units) 1 param. (recorded units) * scale 1 + scale 2
56-64	9	F	lag in independent variable (see note (1)) (zero for parameter 1)
65-71	7	F	attribute 1
72-78	7	F	attribute 2
			unspecified attributes pertaining to each parameter. For example, on a package with instruments at several different heights, one attribute could be the height of each sensor.
79-80	2	I	card count
parameter 2			
81-160	same format as bytes 1 to 80		
parameter 3			
161-240	same format as bytes 1 to 80		
parameter 30			
2321-2400	same format as bytes 1 to 80		

Data Record

Byte No.	No. of bytes	Format	Description and comments
1	1	I	'3' data record identifier
2-5	4	I	no. of data cycles in this record
6-15	10	I	no. of data cycles before the first data cycle in this record
16-20	5	I	data record count
21-2400	2380		data cycles in the format specified stored in the sequence (data cycle 1), (data cycle 2) . . . . . . (data cycle n) where n (specified in bytes 2-5) is not greater than the largest number of complete data cycles that can be stored in 2380 bytes.

7.5.4 Table of Expected Data

The enclosed table was compiled from various discussions in the three oceanographic experiment areas – C-scale studies, B-area studies and equatorial studies. A summary of the expected data by experiment area is given below and followed by an explanation of the information to be found in the Table of Expected Data.

A Summary of Expected Data

Item	No. of expected observations (Individual measurements)		Amount of Expected Data (Data words)
C-scale studies			
1. Ocean currents	0.8m*	....	2.7m*
2. Current spectra	N/A**	....	3.0m
3. Wave measurements	8.6m	....	(42.0m)***
4. Wave spectra	N/A**	....	1.0m
5. Sea surface temperature	0.4m	....	1.7m
6. STD (Horizontal and vertical profiles)	31.7m	....	336.9m
7. Water temperature profiles	1.1m	....	9.0m
8. Laser Wave profiles	.6m	....	1.9m
9. Air temperature, Air-sea temperature difference, wind profiles etc.	7.7m	....	7.2m
10. Shear microstructure	.6m	....	4.0m
C-scale TOTAL	= 51.5m		= 367.4m
B-scale Studies			
1. STD profiles	2.7m	....	8.1m
2. Temperature profiles	.1m	....	.2m
3. Surface salinities	.05m	....	.1m
B-area TOTAL	= 2.85m		= 8.4m
Equatorial Studies			
1. S,T,D profiles	1.0m	....	2.8m
2. Temperature profiles	.2m	....	.3m
3. Current profiles (from drifting ships)	.01m	....	.02m
4. Current shear temperature, temperature gradient and salinity profiles	.2m	....	1.0m
5. Temperature and current at selected levels (Buoys and one ship)	.7m	....	2.2m
6. Near-bottom water pressure	.004m	....	.01m
Equatorial TOTALS	= 2.1m		= 6.3m

*m = Number of data words as observations in Millions according to the definitions given in 7.6 and 7.7 below. An S,T,D cast to 1000m and with 1 metre resolution would have 1000 observations.
** = N/A is not applicable.
*** = The high resolution wave measurements are not expected to be exchanged. Wave measurements are not included in the totals given here.

Oceanographic Programme Totals:

56m Observations (individual measurements)
382m Data Words

Explanation of the information presented on the Table of Expected Data

Column No.		Explanation
(1)	Experiment Area	Name of Oceanographic experiment area
(2)	Obs. Name	Name of observation
(3)	Instrument Name	Name of the instrument
(4)	Platform Name	Name of the platform(s) that will use the instrument or provide operational support
(5)	Max. No. of instruments	The maximum number of instruments planned for use in GATE
(6)	OPs. mode	Short description of the operational mode in which the measurements are planned for GATE
(7)	Obs. Frequency	The frequency of observation planned for GATE
(8)	Parameters in one Data Cycle	The number of parameters included in one data cycle. For example, an S,T,D, profile would have three – salinity and water temperature at a given depth.
(9)	Additional Information	Some additional information used in the estimates of expected data
(10)	Data cycles per obs.	The number of data cycles in one observation
(11)	Data cycles per day	The number of data cycles acquired in one day
(12)	Ops. days	Number of planned days of operation for the instrument
(13)	Total No. of Data Words	The total number of expected data words (in millions of words). Calculated from columns (8) and (10) – (12).

TABLE OF EXPECTED DATA

Experiment area (1)	Obs. Name (2)	Instrument Name (3)	Platform Name (4)	Max. No. of Instruments (5)	Ops. Mode (6)	Obs. Freq. (7)	Parameters in one Data Cycle (8)	Additional info. (9)	Estimated Processed Data: Data cycles per obs. (10)	Data cycles per day (11)	Ops. day (12)	Total No. Data words (13)
C-scale studies	1. Ocean current at depth	A.VACM	Moored buoys	27	Time series at 5-10 levels at each buoy	32/hr	5	27 levels total	1	32x24 x27	25	2.6m
		B. Aanderaa current meter	Moored buoys	15	Time series at 15 levels	6/hr	4	15 levels	1	6x24 x15	25	.2m
		C. Cyclo-sonde	–	3	–	–	6	–	–	48x80	21	1.5m
	2. Current spectra	Computed from (1) above	–	–	–	–	–	–	–	–	–	3.0m
	3. Wave measurements	A. Pitch and roll	Moored buoys	8	Time series	2/sec for 8 hr period each day	4	1	1	2x 3600 x8x8	21	37m*
		B. Wave Rider	Moored buoys	5	Time series	2/sec for 8 hr period each day	1	1	1	2x 3600 x8x5	21	4.5m*
	4. Wave spectra	Computed from (3) above	–	–	–	–	–	–	–	–	–	3.0m
	5. Sea Surface temperature	A. ART	GATE Aircraft	1	Survey mapping	–	4	–	1	$2x10^4$	21	1.7m

TABLE OF EXPECTED DATA (contd.)

Experiment area (1)	Obs. Name (2)	Instrument Name (3)	Platform Name (4)	Max. No. of Instruments (5)	Ops. Mode (6)	Obs. Freq. (7)	Parameters in one Data Cycle (8)	Additional info. (9)	Estimated Processed Data: Data cycles per obs. (10)	Data cycles per day (11)	Ops. day (12)	Total No. Data words (13)
C-scale (contd.)	6. STD Profiles	A. CDT	GATE Ship	1	Profile on stations to 200 m	—	4	1 meter res. to 200 m	1	30x60 x60 x10	15	64m
		B. STDs	GATE Ship	4	Profile on stations to 200 m	5 consecutive casts 6/day	4	1 meter res. to 200 m	1	5x6x 200x 4	21	2m
		C. Towed CTDs	GATE Ship	3	Survey mapping	—	6	—	1	10^6	15	270m
	7. Water temperature profiles	A. Thermistor chain	GATE Ship	1	—	1/sec	10	10 levels	1	60x60 x24	—	8.6m
		B. XBTs	GATE Ship	1000 unit	Profile on station to 200 m	—	2	1 meter resolution	1	200 (per unit)	—	.4m
		C. AXBT	GATE Aircraft	100 units	Profile on station to 200 m	—	2	1 meter resolution	1	200 (per unit)	—	.04m
	8. Wave measurements	Laser Wave Profiler	GATE Aircraft	1	—	—	3	Measurement every meter for 300 km	1	3x 10^4	21	1.9m
	9. Air Temp.	—	Ship & buoys in (1) above	3	—	6/ min	1	—	1	6x60 x24 x3	21	.5m

TABLE OF EXPECTED DATA (contd.)

Experiment area (1)	Obs. Name (2)	Instrument Name (3)	Platform Name (4)	Max. No. of Instruments (5)	Ops. Mode (6)	Obs. Freq. (7)	Parameters in one Data Cycle (8)	Additional info. (9)	Estimated Processed Data: Data cycles per obs. (10)	Data cycles per day (11)	Ops. day (12)	Total No. Data words (13)
C-scale (contd.)	10. Air-Sea Temp difference	—	Same as (9) above	3	—	6/ min	1	—	1	6x60 x24 x3	21	.5m
	11. Wind profiles	—	Ship	3	—	6/ min	10	—	1	6x60 x24 x3	21	5.4m
	12. Wind at constant levels	Tethered balloon	Ship	10	—	6/ min	2	—	1	6x60 x24 x3	21	1.1m
	13. Shear micro structure	Protas	—	1	—	—	6	—	1	10x 3000	21	4.0m
B-scale studies	1. STD	A.STD	B-scale ships (7)	7	Profile on fixed stations to 1000 m	6/ day	3	—	1	6x7x 1000	63	7.5m
		B. Nansen casts	B-scale ships (8)	*	18 levels on fixed stations to 1000 m	6/ day	3	—	1	6x8x 18	63	.2m
	2. Temperature profiles	A.BTs	10-A and B-scale ships	4000 units	Each ship cruises an average track line of 450 nm between operational phases	At 5m stations on track line, 4 BTs are taken	2	—	1	4000 x30	—	.2m
	3. Surface salinities	A. Bucket samples	10-A and	4000 samples	Taken along with BTs	Same	2	—	1	4000 x10	—	0.8m

TABLE OF EXPECTED DATA (contd.)

Experiment area (1)	Obs. Name (2)	Instrument Name (3)	Platform Name (4)	Max. No. of Instruments (5)	Ops. Mode (6)	Obs. Freq. (7)	Parameters in one Data Cycle (8)	Additional info. (9)	Estimated Processed Data: Data cycles per obs. (10)	Data cycles per day (11)	Ops. day (12)	Total No. Data words (13)
B-scale (contd.)	4. Surface salinities	A. Continuous sfc. instrument	2 GATE ships	1.4×10^4 samples	Same as BTs but digitize every ¼ nm	Continuous	2	—	1	1.44×10^4	—	.03m
Equatorial studies	1. STD profile	A. STDs (vertical sampling)	6 GATE ships	6	Stations along tracklines or at fixed stations	≈ 6/day	3	1 m. res. to 1000 m	1	1000 x6x6	21	2.2m
		B. STD (Horizontal sampling)	1-Ship (Chain)	1	Long E-W trackline with short N-S trackline every so often along equator	—	3	Towed at constant density surface at ≈90 m	1	—	—	.6m
		C. Nansen Casts	3-ships	—	Same as (1A) above	≈ 6/day	3	18 levels	1	3x18 x6	21	.02m
	2. Temperature profiles	A. MBTs	3-ships	—	Same as (1A) above	≈ 6/day	1	1 m. res. to 250 m	1	3x250 x6	21	.1m
		B. XBTs	2 Ships	—	Same as (1A) above	≈ 6/day	2	1 m. res. to 1000 m	1	2x 1000 x6	21	.5m
	3. Current profiles made from drifting ships	A. Current meters	Iselin Anton Dohrn Capricorn Humboldt	4	At stations along N-S tracklines in equatorial area	≈ 25 in 21 day period	3	10 m. res. to 1000 m	1	4x 100 x25	—	.02m
	4. Profile of of current T, $\Delta T/\Delta D$, S	Free-fall device	Discovery	1	Roving trackline in equatorial area	≈ 6/day	5	30 cm res. to 500 m	1	1x 1500 x6	21	1m

TABLE OF EXPECTED DATA (contd.)

Experiment area (1)	Obs. Name (2)	Instrument Name (3)	Platform Name (4)	Max. No. of Instruments (5)	Ops. Mode (6)	Obs. Freq. (7)	Parameters in one Data Cycle (8)	Additional info. (9)	Estimated Processed Data: Data cycles per obs. (10)	Data cycles per day (11)	Ops. day (12)	Total No. Data words (13)
Equatorial (contd.)	5. Temperature and current at selected levels	A. Current meters & temperature devices	USSR buoys (6 total)	5-current 5-temp.	Moored buoys with 5 current levels and 5 temperature levels	≈24/ day	2	10 selected levels	1	1x10 x24 x6	60	.15m
		B. Meter for current and temp.	FRG	3 buoys with 4 meters each	Moored buoys with 4 levels each	≈20/ hour	3	4 selected levels	1	1x4 x20 x24 x3	21	.06m
		C. Meter for current and temp.	USA	3 buoys with 5 meters each	Moored buoys with 5 levels each	≈20/ hour	3	5 selected levels	1	1x5 x20 x24 x3	60	.4m
		D. Meter for current temp.	Trident	1	Current at selected levels from ship	≈20/ hour	3	3 selected levels	1	1x3 x20 x24 x1	60	.26m
	6. Near-bottom water pressure	Deep sea pressure gauges	3 locations	3	Moored to bottom	≈1/ hour	2	Near-bottom	1	1x 24x3	60	.009m

8. AIRCRAFT PROGRAMME

8.1 Introduction

Measurements of sea surface temperature and surface waves by low flying aircraft are a central element of the international programme for GATE. These measurements have been identified (see 3.2, 3.5, 3.6) as having immediate relevance to existing meteorological models and they should therefore feature centrally in the GATE oceanographic subprogramme.

8.1.1 Sea surface temperature (SST)

Regular sea surface temperature measurements by aircraft are needed:

1. To increase the total number of SST measurements and their spatial distribution and hence to obtain more representative mean values of the SST.

2. To measure the horizontal variability of sea surface temperature on scales of 100 metres to 100 km.

3. To detect, map and track sharp horizontal temperature gradients at the surface outcrops of fronts.

The scientific requirements for sea surface temperature measurements are

1. Together with other measurements of sea surface temperature to accurately fix the temperature at the sea surface for heat budget calculations carried out independently for the atmosphere and ocean.

2. To permit estimates of the horizontal advection term in upper ocean heat budget calculations.

3. To measure the two dimensional spectra of sea surface temperature variability as a test of oceanic turbulence theories.

4. To correlate the sea surface temperature variation with convective activity in the atmospheric boundary layer.

5. To correlate the detailed structure of the surface outcrop of fronts with their internal structure measured by the roving ships.

8.1.2 Wave measurements

Since ocean waves strongly influence transport processes across the air-sea interface, measurements of surface wave spectra constitute an essential element in many studies of the oceanographic and meteorological programmes. Extensive measurements of ocean waves are also required to test numerical models of wave prediction, which may ultimately need to be incorporated in coupled ocean-atmosphere models.

An array of 7 pitch-roll buoys and 5 wave-rider buoys will provide continuous wave-spectra data at scales varying between 40 and 300 km. However, these instruments alone may be insufficient to resolve aliasing problems during intensive, largely variable gusting conditions. Moreover, an extension of the wave observations to the full B-area would be desirable for wave-prediction tests. This can be achieved through laser-altimeter measurements from aircraft. A rapidly moving platform will be able to complement the time-continuous, discrete-space measurements of the wave array with spatially-continuous, although time-intermittent sections through the wave-field structure.

At least two laser altimeters will be needed for operations in two observational modes: (a) spatially dense series of recordings in the C-scale area to supplement the wave-array measurements at scales between 20 and 100 km. This cannot be combined with the standard meteorological surveys and will need a specific oceanographic flight. The wave-measuring programme can be coordinated with ART measurements in the C-scale area; (b) A series of wave measurements in the general B-scale region outside the C-scale area. These measurements can be coordinated with the meteorological programme for low-flying aircraft by introducing short down-wind, up-wind excursions (2 mins. each leg), each excursion yielding one wave spectrum. Apart from the two (U.S.) laser systems already committed, it would be desirable to equip airplanes with further wave measuring devices (e.g. radar altimeters) if these can be made available.

8.2 Flight plans

8.2.1 Flights dedicated to oceanography

(but available on a non-interference basis for other low level measurements, e.g. for the boundary layer subprogramme).

Flight plan 1 (general mapping)	:	A creeping line ahead with 5 km spacing between tracks. This plan should extend 10 km all round beyond the C-scale triangle which has nominal 100 km sides. Orientation of the tracks to be related to the wind direction.
Flight plan 2 (detailed survey of a front)	:	A high resolution creeping line ahead with 2 km spacing between tracks and extending over approximately 30 tracks of 50 km length each. The centre of this high resolution pattern and its orientation to be related to fronts mapped on previous flights.

Variation of flight plans to be at the discretion of the chief scientist on board in consultation with aircraft captain.

8.2.2 Flights dedicated to meteorology ~~link~~ including an oceanographic programme for part of the flight

The aim is to provide occasional oceanographic flights (laser altimeters and radiation thermometer) in the B-area outside the C-scale triangle. The proposed method is to add to all flights below cloud base up to four additional patterns per flight, each comprising reciprocal runs up and down wind for two minutes each. The total additional flying time will be approximately half an hour per flight. A more detailed analysis relating the proposed oceanographic measurements to the GATE aircraft plan will be submitted later.

Flight frequency

Dedicated flights	–	three flights before start of Phase III, one per day during Phase III
Opportunity flights	–	as available
Flying hours	–	dedicated flight 10 hours per flight
	–	opportunity flight ½ hour per flight

8.3 Instrumentation

8.3.1 Sea surface temperature

(a) An infrared thermometer (Barnes PRT-5 or equivalent) resolving and if possible calibrated to ±0.1°C, with a horizontal resolution of 100 metres.

(b) A second, identical instrument pointing upwards to monitor downward infra-red radiation from clouds. This should either look directly upwards through a window in the top of the fuselage or horizontally through a side window onto an external mirror.

(c) Suitable data logging equipment for both instruments with quick look facility for immediate replay at the end of the flight.

8.3.2 Surface waves

Two complete systems supplied by NOAA AOML, Miami, comprising laser altimeter, inertial navigation system and data logger (analogue and/or digital). Total weight each per system 200 kg; dimensions 1½ m standard 19" rack per system.

8.3.3 Aircraft requirements for laser altimeter

All aircraft likely to be used for these measurements should be fitted with the necessary racks and mounting frames (to be supplied by NOAA AOML), and a suitable downward viewing hole (5" diameter; open or glass). Assuming these racks etc., are available the total instrumentation can be mounted in 2-3 man hours.

8.4 Navigation

Aircraft navigation during oceanographic flights should be related to the central ship of the C-scale triangle. Relative accuracy between fixes onto this ship should be better than 1 km.

8.5 Scientific Personnel

At least one scientist will be provided to operate each laser altimeter during all oceanographic flights. It is assumed that a second scientist will be available for the normal aircrew to operate the radiation thermometer.

A scientific team at Dakar is required to control the oceanographic aircraft programme and to prepare and transmit sea surface temperature maps.

8.6 Communications

8.6.1 Voice: aircraft to ship

The scientists on the aircraft should be able to talk to the scientists on the C-scale and roving ships during ART flights.

8.6.2 Data: aircraft to ship

The aircraft should be able to transmit ART data to the roving ships during each flight. This might be carried out in real time or, perhaps better, in a compressed-data mode, at the end of each sea surface temperature survey (i.e. by replaying the data tape at, say, 16 times the recording speed). The necessary data rate is approximately one cycle per second (latitude, longitude and temperature).

8.6.3 Data: Dakar to ships

Sea surface temperature maps produced at Dakar should be transmitted in facsimile to C-scale ships after each flight.

8.7 Data analysis during experiment

There is no requirement for analysis of the surface wave data during the experiment.

The sea surface temperature data should be reduced to an isotherm map for each flight within a few hours of the completion of the flight. These maps are needed for day to day planning of the roving ship programmes. The maps should be produced (a) on board one of the roving ships, based on data transmitted to the ship during the flight, (b) at Dakar, based on replay of the data tapes recorded in the aircraft. It is recognised that these operational SST maps will be based on quick look data, lacking some of the corrections to be applied in the post-experiment data analysis.

9. ROUTINE OCEANOGRAPHIC MEASUREMENTS OF ALL SHIPS

Routine oceanographic measurements made by all GATE ships will provide essential background information for the higher resolution experiments. All routine oceanographic data (listed below) are to be archived at the GATE oceanographic data centre. Selected data are to be transmitted in "real time" over the meteorological circuit.

9.1 Four-hourly observations

9.1.1 Sea surface temperature

(a) By bucket, following the standard meteorological procedure. The required accuracy is ±0.1°C.

(b) If other continuous measurements of temperature are available, e.g. radiation thermometer temperature, intake temperature, these data should be logged every quarter hour.

9.1.2 Sea surface salinity

Surface salinity should be determined if possible.

(a) Surface salinity can be taken from surface bucket samples, and computed using titration or conductivity measurements. Data are to be taken every four hours, the required accuracy is at least ±0.1 o/oo.

(b) If continuous measurements of surface salinity are available, the records should be digitized and logged every quarter hour.

9.1.3 Profiles (STD, MBT, XBT)

STD, MBT or XBT measurements are desired where feasible.

(a) Frequency every four hours.

(b) If possible, 5 dips in rapid succession every four hours to reduce aliasing.

(c) Record the results in terms of mean values of T, S at intervals not to exceed 1 metre to the following accuracies:

T : 0.1°C; S : .02 o/oo

(d) The recommended STD lowering rate should be small enough to resolve sharp vertical gradients.

(e) MBT and XBT profiles accuracy to ±0.1°C.

(f) Digitize graphical records such that data should not deviate from the trace by more than 0.1°C.

(g) Record layer depth every four hours. The layer depth is the depth of the top of the thermocline, normally identified by a sharp increase in vertical temperature gradient.

9.1.4 Wave Data

(a) If the ship carries a wave recorder, wave height should be recorded for 10 minutes every four hours. Digitize data at a rate of maximum resolution.

(b) If no wave recorder is available, wave observation should be logged every four hours according to standard procedures.

9.1.5 Standard meteorological observations

WMO Standard.

9.2 Real time transmission of data (One/day)

The following observations are to be transmitted once per day with the routine Meteorological observations:

(a) Sea surface temperature

(b) Sea surface salinity

(c) Mixed layer depth, where feasible.

9.3 Real time charts

Daily charts of sea surface temperature, sea surface salinity and layer depth should be prepared and transmitted by facsimile to all ships. This may be carried out at the GOCC Dakar or on board one of the U.S.S.R. ships.

10. INTERCOMPARISON

10.1 Introduction

The many ships from various countries with different instrumentation require a carefully carried out intercomparison programme. This is recognised in the operations plan for GATE INTERNATIONAL SEA TRIAL (ICSU/WMO Bracknell, Geneva, May 1973).

The intercalibration programme will permit the data validation on the national and international level and assure that the data from the various platforms and instruments is made as compatible for further analysis as possible.

The basic data set of the oceanographic subprogramme may be grouped as follows:

1. NANSEN/ROSETTE samplers
2. STD/CTD
3. MBT/XBT
4. Current meter data
5. Surface meteorological data from buoys
6. Wave observations
7. Special instrumentation such as thermistor chains, batfish
8. Surface drifting buoys
9. Tide data

Since there are about 20-25 oceanographic ships involved in the B-area and equatorial experiments, and since in most cases it did not seem practical to assume that instruments could be transferred at sea from ship to ship, the recommended intercomparison procedures were developed on the basis of feasibility, practicality and necessity.

Some of the instruments are so specialised that a meaningful intercomparison can only be obtained through involved and time-consuming procedures. Therefore, a selection of instruments has been made to be subjected to intercomparison. These are primarily the sensors from which data on temperature, salinity and pressure are obtained. It is necessary to obtain water samples during the intercalibration meeting as often as possible.

The salinity intercalibration should follow the following procedure: one ship such as the *Oceanographer* collects large water samples (order of 30-50 litres) and distributes samples of each catch to every ship having salinometers or titration equipment. Each ship then will determine the salinity according to their procedures and transmit the results to the Oceanographic Subprogramme Data Centre.

10.2 Recommendations

(a) It is recommended that each ship will calibrate its CTD or STD using a rosette sampler and thermometers or reversing bottle mounted above the instrument head on each lowering. In addition the internal consistency of each ship's thermometer set should be checked by pairing of thermometers on the bottles and changing the pairs several times throughout the operation.

In order that there be consistency between temperatures measured on different ships, each ship to provide a set of two or three thermometers to be calibrated prior to GATE at a common facility and that these thermometers be paired with the rest of the ships thermometer sets on each cast and statistics completed on the differences between these standard thermometers and the normal set.

In order that there be consistency between the salinity determination of various nature, before coming into Dakar one or more ships should collect 30-50 litre water samples at 0, 20, 40, 200, 400, 600, 800 and 1000 metres, and the salinity of these samples be determined by all ships using their usual techniques. Each nation should also distribute samples of their standard and sub-standard waters to other nations for salinity determination.

Recognising that not all of the hundreds of reversing thermometers can be inter-compared in the field, it is necessary that a sufficient number of reversing thermometers of different types be intercompared in the field often enough to be statistically significant. ISMG will develop the operation plan for such intercomparisons.

(b) A pressure tank be possibly provided in Dakar for the purpose of calibrating MBT's. In addition, each ship should compare their BT profiles against STD and/or Nansen cast data periodically. Emphasis is placed on the intercomparison of MBT's under natural conditions, hence all MBT's should be made available to designated ship(s) for in situ comparison tests. The results should be provided as soon as possible to GOCC in Dakar.

(c) During each wave observation flight by aircraft several overflights be made over ships equipped with pitch and roll buoys for intercomparison purposes.

(d) Every effort be made to calibrate and intercalibrate the surface meteorological instrumentation packages to be deployed on buoys. Specifically, it is recommended that

(1) before GATE and after GATE the test facilities of the US National Buoy Data Centre be made available for calibration purposes;

(2) before and after Phase III space be provided in Dakar for intercomparison purposes. It is considered essential that air conditioned space be provided in Dakar for storage, servicing and intercomparison purposes;

(3) the boundary-layer subprogramme panel be involved in developing intercalibration procedures.

(e) Special instruments such as batfish, thermistor chains and profilers be intercompared on an ad hoc basis, and should be the responsibility of the principle investigators. It should also be the responsibility of the principle investigators to provide calibration results from before and after the field experiment for validation purposes to the Oceanographic Subprogramme Data Centre.

11. EXCHANGE OF SCIENTISTS AND/OR INSTRUMENTS

SCOR WG43 considers that all means be provided to achieve the scientific objectives of the GATE oceanographic subprogramme. One important aspect may be the exchange of scientists and instruments on platforms of other nations because of their unique positions and capabilities. Therefore, it is desirable to establish a mechanism through SCOR to facilitate such exchanges, if feasible, of scientists and/or instruments to optimize the achievement of scientific goals and to further international cooperative scientific studies.