Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes

Seattle, USA, 9-13 September 1985

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In this Series

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984, the reports of the following meetings have already been issued:

- Third Meeting of the Central Editorial Board for the Geological/ Geophysical Atlases of the Atlantic and Pacific Oceans
- Fourth Meeting of the Central Editorial Board for the Geological/ Geophysical Atlases of the Atlantic and Pacific Oceans
- Fourth Session of the Joint IOC-WMO-CPPS Working Group on the investigations of «El Niño»
- First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in relation to Living Resources
- First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
- First Session of the Joint CCOP (SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
- First Session of the IODE Group of Experts on Marine Information Management
- Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Testonics and Resources
- First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in relation to Non-Living Resources
- Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and intercalibration
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SC-85/WS/80

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1.1 OPENING OF THE MEETING

The Joint IOC-WMO Meeting for Implementation of the Integrated Global Ocean Services System (IGOSS) XBT Ship-of-Opportunity Programme was opened by Mr. G.H. Holland, Chairman of the Joint IOC-WMO Working Committee for IGOSS, at 10:00, 9 September 1985 at the NOAA Northwest Ocean Service Center in Seattle.

Mr. Kelly Sandy, Director of the NOAA Western Regional Center, welcomed the participants to the Center and wished them a pleasant stay in Seattle.

Mr. J. Withrow, IGOSS Operations Co-ordinator on behalf of IOC and WMO, thanked the government of the USA, particularly NOAA, for hosting the Meeting and for providing such excellent conference facilities. He remarked that the Meeting constituted a good mixture of scientists and operators of ship-of-opportunity programmes and was confident that the Meeting would achieve the intended objective. His confidence was also based on the fact that operators of nearly 90% of the ships of opportunity presently being undertaken were participating in this Meeting.

The List of Participants is given at Annex II to this Report.

1.2 ELECTION OF THE CHAIRMAN

The Meeting unanimously elected Mr. G. Withee as Chairman of the Meeting.

1.3 ADOPTION OF THE AGENDA

The Agenda as adopted by the Meeting is reproduced at Annex I.

1.4 WORKING ARRANGEMENTS

The Meeting accepted the work programme proposed by the local secretariat and agreed to adjust it as necessary, including the establishment of working groups to address specific questions.

2. REQUIREMENTS FOR SUB-SURFACE THERMAL DATA

2.1 REQUIREMENTS FOR SUB-SURFACE THERMAL-STRUCTURE DATA

Mr. Alexiou of the IOC Secretariat led the Meeting through the CCCO requirements document entitled World Climate Research Programme Requirements for Ship-of-Opportunity Subsurface Thermal Structure Data (SC-85/WS/63). The discussion focused on the scientific requirements and the need to update these on the basis of studies that have become available since the report was drafted. Warren White, of the Scripps Institute of Oceanography had recently completed some analyses that had a bearing on the Pacific requirements, and agreed to draft changes to the report reflecting findings of the most recent work of others as well as his own.

The following salient changes were recommended:

(i) A statement was added to stress the fact that this set of requirements is not expected to resolve questions associated with time dependence of intense currents.

(ii) Definitions were provided for each specification; i.e., spatial (horizontal and vertical) resolution, time resolution, sampling density, mapping accuracy, data accuracy.

(iii) Modifications were made to some values of the specified parameters.

It is important to underscore the point made in the original document that requirements will continue to evolve as more data are accumulated and analysed. They cannot be considered as static values. Thus, as the scientific requirements evolve, the required ships of opportunity XBT tracks can also be expected to change. Another section of this report addresses the updating of the XBT ship tracks by the Meeting. The definitions of terms used and scientific guidelines are given in Annex III.

2.2 OTHER REQUIREMENTS

The Meeting recognized the extensive quantity of IGOSS data provided by platforms other than ships of opportunity and therefore the need to recognize these other data sources when addressing the total context of ocean data requirements.

The Meeting was not in possession of sufficient information to make meaningful comments on needs in far northern, far southern or semi-enclosed waters but recognized that significant needs do exist in those areas. The Meeting noted that scientific research and Antarctic re-supply vessels are considered ships of opportunity for IGOSS purposes and stressed the need for enhanced data collection and exchange via these vessels within the Southern Ocean.

The Meeting briefly discussed the need for IGOSS sub-surface thermal data to delineate ocean fronts and eddies. Strong ocean currents are often not directly associated with surface thermal gradients, but with sub-surface temperature gradients. When strong winds from winter storms oppose these currents, anomalous, or "killer" waves are generated which annually result in substantial ship damage or sinkings. Likewise, cold-core eddies as large as 100 km across lose their surface thermal expression but maintain surface currents as strong as 2-3 knots. Knowledge of these derived currents is important to safety of shipping and search-and-rescue operations. Sub-surface thermal data are also important to many commercial fishing applications and for fisheries management research. The Meeting noted that Member States will choose to fund ship-of-opportunity programmes based on a variety of reasons, including support for international projects such as TOGA. For this reason, the Meeting decided, when dealing with proposed ship-of-opportunity lines, to offer an opinion as to which programme the proposed line is particularly applicable to.

The Meeting noted the definition of real-time IGOSS data as those ocean measurements, particularly sub-surface temperature, that are available for exchange between Member States (via the WMO Global Telecommunication System (GTS)) within 30 days after observation.

3. SHIP-OF-OPPORTUNITY ACTIVITIES

3.1 EXISTING (OPERATIONAL) LINES

Reports were presented on the existing ships of opportunity XBT programmes, their objectives, usefulness, difficulties encountered, etc. It was recalled that the total BATHY/TESAC reports exchanged over the GTS in 1984 totaled about 42,000. At the same time, it was noted that there were many more observations being made than were inserted onto the GTS for global distribution. The Meeting agreed that every effort should be made to increase the input into the GTS, particularly in view of the emerging TOGA requirements for rapid data collection and exchange. This is further supported by the fact that the operational XBT data return constitutes a far larger portion of existing data sets than the non-real-time digitized data. Brief descriptions of the existing ship-of-opportunity XBT programmes were given by the participating managers (see Annex IV). The Meeting recommended that all countries consider the importance of rapid dissemination of meteorological and oceanographic data for solution of environmental and economic problems.

3.2 PLANNED AND PROPOSED LINES

The Meeting then reviewed the results of the joint IOC-WMO questionnaire on the ship-of-opportunity programmes being operated, planned and proposed, which were further complemented by the participants. The complete ships of opportunity lines thus presented are shown in Annex. VII in a tabular form as well as on maps.

When considering ships of opportunity XBT coverage, the Meeting recognized the need to obtain a complete picture of the sub-surface thermal data coverage through all the observational platforms. These should include such platforms as ocean weather vessels en route to and from station and research ships. The cruise patterns of some of these ships are regular and well-established. The Meeting proposed that a world-wide map. of these observational programmes, including section surveys, etc., be prepared.

It was noted that, although naval authorities in some countries still oppose dissemination of oceanographic data from the territorial waters of their countries, good progress is being made in full exchange of data. Naval oceanographic institutions in many countries have both military and civil missions. Military vessels engaged in routine patrols or other non-sensitive missions can serve a secondary purpose of collecting and reporting oceanographic data through the GTS. XBT observations are presently being reported from supply vessels of the US Navy, and patrol vessels of Peru.

Many observations of sub-surface temperature and salinity are being made globally by STD casts aboard research vessels but in some cases are not being reported in real time via TESAC messages. The delay in reporting some of these profiles may be years to even decades and thus not useful to IGOSS or other research activities. The increased availability of research vessel data may permit the direction of ship-of-opportunity resources into undersampled oceanic regions. Therefore the Meeting recommended that IOC and WMO encourage research institutes to report STD data through IGOSS, and to programme their STD systems to format messages for reporting in real time.

Pacific Lines

Several past and present large scale network programmes in the Pacific (NORPAX, ERFEN, EPOCS, TOGA) have provided a solid basis for development of the most extensive programme in IGOSS. The major established Ship-of-Opportunity (SOO) programmes in the Pacific are TRANSPAC in the mid-latitude North Pacific, several routes managed by the Fleet Numerical Oceanography Center (FNOC), and the SURTROPAC programme of ORSTOM and SIO in the tropical Pacific.

More recently, efforts have been made to establish sampling programmes from vessels transiting regularly between the coast and offshore islands of Latin America or other coastal vessels in association with the ERFEN programme. The first of these, that between Guayaquil and the Galapagos Islands, has been in operation since mid 1983, and others have been started off Paita and Callao. Experience on these coastal routes is leading to interest and capability among the ERFEN countries in establishing SOO activities on merchant vessels calling at Latin American ports. The first of these is an Ecuadorian vessel transiting between Japan and Guayaquil and Valparaiso.

There is a need, however, to improve coverage by adding new lines in presently undersampled regions, particularly in the southeast and deep north Pacific, and the far western Pacific. Several new lines were identified as having potential to fill these needs (see Annex VII).

(i) Line P-17 is to be implemented in the western Pacific as either a FNOC or a joint FNOC-SIO ocean thermal structure monitoring effort. Ultimately, three ships will be outfitted with XBT launchers/recorders and enough XBT probes to make two observations each day the ship is in deep water (>100 fms.).

(ii) A monitoring section along a "N-S" line is required in the Central Pacific. P-30 is a Joint FNOC-IOS ocean thermal structure monitoring effort to meet this requirement. P-30 is oriented NE-SW to provide two observations per day in this undersampled area.

(iii) Line P-18 running north-south across the entire eastern Pacific has been arranged for the SIO-ORSTOM programme, but requires equipment and supplies.

(iv) For the route identified as P-19, Chile offered several ships operating between South American ports, but for which full assistance is required. Some of these ships also travel to Japan, but via California, and these cover the Pacific on routes that are already well observed.

(v) ORSTOM plans to initiate observations from a French vessel operating between Tahiti and Valparaiso (line P-29), and will require only probes.

(vi) ORSTOM also has arranged for observations on a route between Tahiti and New Zealand (line P-28) for which equipment and supplies are required.

(vii) Although full particulars are not available, there are some remaining opportunities to improve sampling on lines extending a few hundred kilometres out from the coast of South America (Route P-26). Arrangements have been made for a line out from Ilo, Peru, for which equipment and probes are needed. The possibility of routes between Chilean coastal cities and offshore islands is being investigated, as is one between Manzanillo, Mexico and Isla Clarion. Relatively dense sampling on such short lines perpendicular to the coast is valuable for interpretation of sparse and randomly spaced observations from ships traveling along the coast.

(viii) SIO and ORSTOM are proposing to equip and service up to three vessels traveling between Panama and India/Indonesia along a low-latitude track (P.38) which has not yet been well established. This would be the only zonally oriented section at low latitude in the Pacific and it would pass through many sparsely sampled areas.

These additions will increase the number of voluntary observing ships in the Pacific to about 130, making it the ocean basin most well observed on a regular basis. Some parts of the southeast Pacific remain less than well sampled, however. Additional routes from Peru and Chile to the Far East are still needed.

Indian Ocean Network

The Meeting recognized that the Indian Ocean is poorly sampled and that any implementation of the proposed lines (60% of the total network) will be welcomed. It was also noted that there is a strong need for new lines in the energetic circumpolar Antarctic area.

Due to the fact that several proposed lines would converge in the La Reunion/Mauritius area, co-ordination between these two points is highly recommended.

The Meeting noted that a number of additional ship-of-opportunity lines were required in the Indian Ocean to meet present requirements for data as given in the draft TOGA Implementation Plan. The Meeting felt that Member States of the region should make additional efforts to initiate these lines because of the importance of sub-surface thermal observations to the understanding of the oceanography of the basin and the monsoon of the region. In particular, because of the strong oceanographic capabilities of India, the Meeting suggested that India be encouraged to initiate efforts to operate several of the required lines. Also, it suggested that India be encouraged to make data available for international exchange from its ongoing or planned research and operational projects in the Indian Ocean.

The Meeting also noted the difficulties encountered by using radio facilities and the INSAT geostationary satellite for data transmission purposes. The use of polar-orbiting satellites in real-time mode as a data collection system (i.e., ARGOS) was recognized as being useful for the availability of future data sets.

Atlantic Network

The Meeting considered the potentially available networks and made the following specific comments:

A1 and A2 - observing that these lines were polewards of the North Atlantic Front, where deep convection is a regular winter feature and the thermocline is deeper than 500m over large areas, the Meeting urged operators to use the deepest available probes; similarly they were urged to consider regular salinity measurements.

A5 and A7 - one planned, the other proposed, were both of importance for determination of seasonal and interannual variability; in the same way, A-11 was needed for information on equatorial currents, thermocline development and in conjunction with the TOGA programme. The Meeting emphasized that all sections between 20oN - 20oS were of great value to that programme and it noted that the total benefit was greater than the sum of the individual parts.

A6 - part of this line may be duplicated and operators may wish to consider their positions jointly.

A10 - was thought to be valuable for TOGA boundary conditions. Data from this line are not being reported in real time and, view of the unique value of these observations for TOGA, the Meeting suggested that the release of some data in real-time, but within the limitations imposed by the IGOSS BATHY/TESAC code, might be re-considered by the operator.

A4 and A5 - were both in data sparse areas and the occupation of these lines would serve the interests of both IGOSS and TOGA. The Meeting recommended their support by IGOSS.

A26 - again passed through an area which is insufficiently sampled at present. The Meeting recommended IGOSS support because of the importance of the circumpolar current and deep sea water-mass formation to WOCE.

A27/I7; A5/P17 - The United States (NOAA/NOS) indicated their intention to pursue instrumentation of two ships offered by Uruguay. The route identified by the Meeting as A27/I7 (between Montevideo and the Persian Gulf) was deemed particularly significant because it covered data sparse areas of the Southern Ocean, as well as providing some coverage in the Indian Ocean.

The Meeting placed the same value on line, A26/P19 proposed by Chile and solicited support for these lines.

4. REQUIREMENTS VERSUS RESOURCES

It was apparent from the results of the questionnaire that the disparity between requests for assistance and resources available to meet these requests is imbalanced largely in favor of the former. In any case, the Meeting saw a need to establish criteria for selecting important lines and agreed that the primary consideration would be those lines from which observations will be put on GTS operationally; i.e., either radio-transmitted ashore or forwarded within 30 days for insertion onto the GTS. In addition, the general criteria which were considered important for any selection should include the following:

(i) In terms of programmatic consideration

(a) Data sparse areas

(b) Specific programme needs, such as those of TOGA and WOCE

(c) Support to global operational programmes, such as long-range weather forecast, short-term climate prediction, ocean circulation

(d) Fisheries

(e) Ocean processes, such as upwelling and eddies.

(ii) In terms of ships of opportunity

(a) Ships' experience in observing programmes, such as those acquired as WMO's Voluntary Observing Ships.

(b) Adequate communication facilities aboard ships, particular preference being given to those ships equipped with an INMARSAT terminal (Ship Earth Station).

(c) Easy contact with ships' owners.

(d) Favorable working relationship with the ship's crew.

The following co-operative efforts were set forth at the Meeting:

(i) Canada and Thailand agreed that when suitable arrangements have been made, they would work together to initiate the generation of BATHY/TESAC messages from two Thai research vessels.

(ii) France and Canada agreed to co-operate in the preparation of hardware for ARGOS transmission of BATHY/TESAC data from the Indian Ocean.

(iii) The USA (FNOC) and Canada agreed to pool efforts along certain Atlantic and Pacific Ocean routes. FNOC's role would be to provide either XBT hardware or probes or both to ships recruited and managed by Canada.

(iv) The USA (NOAA/NOS) has initiated bilateral discussions with China for the purpose of deploying a SEAS unit on a Chinese vessel operating on a trans-Pacific route.

(v) The USA indicated that it intended to co-operate with Uruguay in the outfitting of two Uruguayian vessels for Atlantic/Indian Ocean routes.

(vi) France (ORSTOM) and the USA (SIO) agreed to co-operate on the initiation of several more lines in the Pacific.

(vii) Canada (IOS) and the USA (FNOC) agreed to jointly support one line in the central Pacific.

D. Cutchin of the Scripps Institute of Oceanography analysed the relative costs of three methods of sub-surface thermal-structure data collection. The three representative methods chosen were ships of opportunity deploying XBTs, drifting buoys with thermister chains and aircraft dropping AXBTs (Expendable Airdropped Bathythermographs). Dr. Cutchin referred to previously published data on the various decorrelation space and time scales for the Pacific Ocean for each system, then calculated the cost per statistically independent temperature profile based upon the decorrelation scale and his estimates of standard equipment and operation costs. While recognizing that the method of observation may be dictated by the requirements of the particular experiment or programme, his analysis showed that ships of opportunity provided an extremely cost-effective method of data collection. Disregarding other arguments and comparing the three methods on a cost-per-independent- bathythermograph-profile basis, the ship-of-opportunity method yielded costs almost an order of magnitude below the airdroppable XBT method, with the drifting-buoy method intermediate between the two. The ship-of-opportunity programme costs are effective due in large measure to the good will of the ships' crews and owners.

Dr. Cutchin also described additional possible observations of interest to meteorologists and oceanographers, which were being implemented, planned or discussed for ships of opportunity. These included automated upper-air soundings, plankton sampling, acoustic doppler current measurements, continuous surface measurements of temperature and salinity, the use of on-board navigational or dedicated (CODAR) radar for wave and current measurements, in addition to the more conventional bathythermograph and marine weather reports. He presented data showing sub-surface current shears that he had obtained from interpreting the acoustic return signal from an operational doppler current profiler coupled to a doppler speed log.

The Meeting was encouraged by presentations showing the advancing state of the art in salinity measurement, and, coupled with that, the ability to make salinity measurements in some parts of the ocean. With this in mind, the Meeting recommended that the need to establish a salinity ship-of-opportunity programme be brought to the attention of the Joint IOC-WMO Working Committee for IGOSS at its Fourth Session by the Chairman of the Joint Working Committee. Annex VII gives a brief description of such a proposed programme.

5. IGOSS XBT SHIP-OF-OPPORTUNITY MANAGEMENT

The Meeting agreed that international management of the ship-of-opportunity system is both worthwhile and necessary. The international management would complement the national or institutional management without interfering or encroaching upon the latters' responsibilities. Many aspects of the role of the national and international managers were reviewed and discussed.

Based on a suggestion by the Chairman of the Joint Working Committee for IGOSS, the Meeting recommended that the IOC and WMO assume additional International Co-ordination responsibilities and suggested that the Terms of Reference of the IGOSS Operations Co-ordinator might be expanded to include the responsibilities enumerated in Apendix IX. In order to undertake this role the co-ordinator would have to be in possession of an adequate inventory containing information on the individual programmes. This must include the ship, call-sign, route, frequency, programme details, dates of commencement and the programme or national contact. He would also need access to data management information from one or more of the centres recovering the IGOSS data from the GTS on a weekly, biweekly or monthly basis.

The international co-ordination would be by exception; that is, missing data from the plan would be noted and the appropriate national or institutional manager informed. Further follow-up would be necessary if the problem was outside the responsibility of the local manager. A regular bulletin of the ship-of-opportunity status, including lists of potentially available ship-lines would be distributed initially on a annual basis. It was stressed that the successful co-ordination could be achieved only if co-operation with the national and programme managers was assumed and data products were available from national data centres. The IGOSS Co-ordinator reported that he already received data products on a monthly basis from Japan, Canada and F.R.G. Doug McLain of NOAA, Southwest Fisheries Center offered a global product fron the NOAA's National Ocean Service at Monterey, California.

The Meeting also agreed that it would not be realistic to assume that the Operations Co-ordinator could produce a regular news bulletin for wide distribution, but it was considered possible, through the use of word-processing facilities and electronic mail, to keep national and programme managers informed of the ship-of-opportunity status. The programme managers themselves must undertake to transmit any c[illegible]es in their individual programme back to the Operations Co-ord[illegible]or. It was also agreed that much use could be made of existing publications for reporting and distributing information. In this connection, the use of the monthly WWW Operations Circular was also suggested.

In view of the foregoing, the Meeting accepted Annex IX.

Further use of the existing list of the WMO Voluntary Observing Ships for designation of oceanographic ships of opportunity was considered to be a useful recommendation to make to the WMO. This designation however requires a good information submission system and the Meeting requested that IOC and WMO study this question.

Finally the importance of feedback from programme managers to the operators of the ships themselves was stressed. Motivation was an important recurring aspect of the whole programme. Several methods, each with its own respective merit were discussed; they included certificates (national or international), plaques, presentation XBT's (offered by Sippican on a limited basis), logos, flags or pennants and a brochure explaining the programme's merits in laymen's terms. Mr. Holland agreed to raise all these possibilities at the Fourth Session of IGOSS in November 1985.

The Meeting stressed that, while it was concerned with data from regular ships of opportunity lines, there are numerous other measurement programmes that are concerned with the measurement of sub-surface temperature. Some of these other programmes include fisheries ships, research ships, Coast Guard vessels and other military vessels. In order to get an accurate picture of the total amount of data to be gathered, these other programmes must be included.

As a matter of interest, Dr. W. White presented his proposal for a data management scheme for sub-surface thermal data for TOGA. The Meeting found the proposal interesting but was reminded that further discussion is required between TOGA and the Working Committees for IGOSS and IODE, such that the two Committees can accommodate the requirements of the TOGA.

The introduction of a variety of new automated BATHY/TESAC digital collection/transmission systems without graphic display or operator review emphasizes the importance of establishing a set of standards which can be used by manufacturers to improve the consistency of data submitted into the IGOSS system. The Meeting recommended that the IGOSS Subgroup on Operations and Technical Applications be tasked to investigate both real-time and non-real-time digital techniques in use today with the purpose of establishing standards and maintaining configuration management. Several possible standards proposed by D. McClain of the National Marine Fisheries Service, NOAA, are given in Annex X and these are brought to the attention of the Sub-group.

The Meeting recognized that the availability of adequate ship-shore communication facilities would be a crucial factor for the successful implementation of future SOO XBT programmes; the problem will become particularly acute in terms of costs and transmission if the XBT lines in the tropical zone are implemented as projected. Many ship-shore communication possibilities are now available and these may be adequately used for SOO programmes. Various communication capabilities are summarized in Annex XI.

The Meeting agreed that the follow-up on the final report of the Meeting should include:

(i) distribution to the National Representatives for IGOSS, CCCO and others concerned;

(ii) distribution to ship-of-opportunity XBT programme managers for updating;

(iii) report to the Fourth Session of the Joint IOC-WMO Working Committee for IGOSS;

(iv) distibution to Member States of IOC and WMO inviting their further participation or their support for implementing planned and proposed lines.

6. CLOSURE OF THE MEETING

Following the review and adoption of the draft Summary Report of the Meeting, the Chairman thanked all the participants for their co-operation and valuable contributions. He paid a special tribute to the staff of the local Secretariat whose supporting work contributed greatly to the success of the Meeting.

Mr. J. Lyons, on behalf of all participants, congratulated Mr. G.W. Withee on the excellent manner in which he conducted the Meeting and thanked him for the leadership.

The Meeting was closed at 13.00 h. on Friday 13 September 1985.

ANNEX I

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ANNEX II

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ANNEX III

DEFINITION OF TERMS AND SCIENTIFIC GUIDELINES

The present strategy for measuring interannual changes in the heat content of the tropical Pacific, as determined in the TOGA scientific plan, is based upon a network design analysis conducted by White et al (1982), whose work was confined to a much smaller data base than is available now. Until new network design studies are completed, however, requirements for measuring large scale heat content variability will continue to be based upon the earlier work. These requirements involve parameters of space/time resolution, instrument accuracy, mapping accuracy, and the sampling density required to achieve these requirements. They depend upon knowledge of the regional decorrelation time/space scales and signal-to-noise ratios, all of which are functions of depth and region.

In the following tables that list these requirements on a regional basis, the definitions of the column elements are given as follows.

Decorrelation scale is the minimum distance/interval in the time/space domain over which a parameter at one time/space location is not correlated with the paramater of another time/space location.

Horizontal resolution is that required to resolve one half the space decorrelation scale.

Time resolution is that required to resolve one half the time decorrelation scale.

Vertical resolution is that required to resolve depth at least to the inflection points in the column profile.

Sampling density is the number of observations per resolution element required to reduce the mapping error to half the signal standard deviation. It assumes a signal-to-noise ratio of unity.

Mapping accuracy is specified to be half the signal standard deviation; the signal standard deviation is a function of depth in the column and location within the region.

Data accuracy is defined as that value that brackets the maximum error of the recorded data when all degrading performance factors are accounted for.

Tropical Pacific

Horizontal spatial resolution	2o lat by 10o long
Vertical spatial resolution	*Significant points (0-450m)
Time resolution	two months
Sampling density	4 observations/resolution element
Mapping accuracy	+/- .5 s
Data accuracy	+/- .25o C

The foregoing Table refers to the tropical Pacific, excluding the narrow equatorial band 5o N - 5o S, where the decorrelation time scale of variability has been observed to be much smaller than in the 5o - 20o region. Gill and Biggs (1985) have analyzed the present network design of XBT programme in this equatorial region and determined that the following measurement requirements were necessary to detect equatorial long waves in the thermal structure.

Equatorial wave guide Pacific

Horizontal spatial resolution	1o lat by 10o long
Vertical spatial resolution	significant points (0-450m)
Time resolution	two weeks
Sampling density	1 observation/resolution element
Mapping accuracy	+/- .5 s
Data Accuracy	+/- .25o C

In the extra-tropical Pacific, poleward of 20o latitude, White and Bernstein(1) established the decorrelation time/space scales and signal-to-noise ratios of large scale interannual variability in heat content; this allowed the measurement requirements to be established as follows:

Extra-tropical Pacific

Horizontal spatial resolition	5o lat by 20o long
Vertical spatial resolution	significant points (0-450m)
Time resolution	two months
Sampling density	4 observations/resolution element
Mapping accuracy	+/- .5 s
Data accuracy	+/- .25o C

Tropical Atlantic 20o N - 20o S

Horizontal spatial resolution	2o lat by 10o long
Vertical spatial resolution	significant points (0-450m)
Time resolution	two months
Sampling density	4 observations/resolution element
Mapping accuracy	+/- .5
Data accuracy	+/- .25oC

Equatorial Atlantic 5o N - 5o S

Horizontal spatial resolution	1o lat by 20o long
Vertical spatial resolution	significant points (0-450m)
Time resolution	one month
Sampling density	2 observations/resolution element
Mapping accuracy	+/- .5
Data accuracy	+/- .25oC

Extra-tropical Atlantic 20o N - 60o N 20o S - 60o S

Horizontal spatial resolution	5o lat by 20o long
Vertical spatial resolution	significant points (0-450m to 50o N and 0-750m north of 50o)
Time resolution	three months
Sampling density	3 observations/resolution element
Mapping accuracy	+/- .5
Data accuracy	+/- .25oC

Tropical Indian Ocean North of 20o S

Horizontal spatial resolution	2o lat by 10o long
Vertical spatial resolution	significant points (0-750m)
Time resolution	one month
Sampling density	4 observations/resolution element
Mapping accuracy	+/- .5
Data accuracy	+/- .25oC

Monsoon Region North of 10o S and West of 80o E

Horizontal spatial resolution	2o lat by 2o long
Vertical spatial resolution	significant points (0-750m)
Time resolution	two weeks
Sampling density	1 observation/resolution element
Mapping accuracy	+/- .5
Data accuracy	+/- .25oC

Extra-tropical Indian Ocean 20o S - 60o S

Horizontal spatial resolution	5o lat by 20o long
Vertical spatial resolution	significant points (0-750m)
Time resolution	two months
Sampling density	3 observations/resolution element
Mapping accuracy	+/- .5
Data accuracy	+/- .25oC

* Significant points as defined in the IGOSS Guide to Operational Procedures for the Collection and Exchange of Oceanographic Data (BATHY and TESAC)

(1) White, W.B. and R.L. Bernstein, 1979. Network design of an XBT programme in the mid-latitude North Pacific, J. Phys. Oceanogr., 9, .

ANNEX IV

SUMMARY OF SHIP-OF-OPPORTUNITY PROGRAMMES

Canada - Pacific

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Institute of Ocean Sciences
Pat Bay, B.C.
Canada

Recognizing the importance of the equatorial pacific during the TOGA period, IOS Pat Bay, B.C. will continue strong interaction with the Scripps Institute in maintaining 3 ships on the Vancouver-Sydney line and upgrade to SEAS-equivalent units. We will make furhter efforts in recruiting the Alcan bauxite supply ships to the trans-equatorial route.

We will continue our efforts in reporting the experimental surface salinity programme to IGOSS.

THE BIO CAPE RACE-REYKJAVIK LINE

F.W. Dobson
Ocean Circulation Div.
BIO
(Canada Dept. of Fisheries
and Oceans)

During the CAGE Feasibility Study [1] it became clear not only that measuring the storage of heat in the North Atlantic Ocean would be a necessary part of understanding the meridional transfer of heat by that ocean, but also that it was feasible to do so to within known error limits with a carefully-designed ship-of-opportunity XBT programme using deep (>750m) probes. The Bretherton, McPhaden and Kraus study [2] concluded that such a programme should last at least 5 years, contain a minimum of 7 lines sampled at least three times per year on a 175 km spacing.

Because of interest in the CAGE idea, and because we wished to gain a better understanding of basin-scale variability in the upper km of the ocean in the waters polewards of the "Polar Front" representing the boundary between Arctic-derived and Gulf Stream derived waters (Figure 1, from Dietrich et al [3]), we chose as our contribution a line from Cape Race to Reykjavik, which we sample 4 times per year at a spacing of 60 km east of 38 W and 120 km west of that line (Figures 2, 3). It uses 64 T-7 probes a year: 16 per cruise.

Scientific interest in this line goes beyond the specific objectives of a N. Atlantic heat content study; it had to in order to justify its initial existence. Sampling four times per year provides a good estimate of the annual cycle, which is large and hence important to basic-scale air-sea interaction and even perhaps to atmospheric dynamics. The 80 km spacing E of 38 W permits us to sample the position of the N-S loop of the Labrador Current/N. Atlantic Current loop NE of the Grand Banks (Figure 3), and of eddy statistics in the area. From 38-20 W, the line will add to the very sparse archive (in winter there is almost nothing). With occasional CTD surveys and periodic meteorological forcing estimates, the line will provide seasonal information on the temporal and spatial extent of deep mixing due to convective overturning, and on the process of ventilation at high latitudes.

We are still discussing whether we can learn more about high-latitude dynamics; that won't be resolved until we know if we can share data with other lines in the area.

We are very much interested in extending our experiment, both locally in the North Atlantic, and to do the CAGE heat content study if possible. Without that extension, our own work is much less useful (and hence less justifiable) scientifically. Our first concern is to find a concurrent line which gives us information at right angles to our own. We hope to work with LCDR MacAndrew and the UK Naval Hydrographic Office on their line from C. Farewell to the Faeroes. Together, the two lines can be used to define 2-D variability in the North Atlantic Front, for example.

The heat content study would require us to join forces with lines from many countries (UK, Germany, France, Portugal, USA). As we see it, the scientific justification, besides those of CAGE and WOCE, will be based on elucidation of the dynamics of climate-scale and basin-scale variability in the heat content of the ocean, in terms of surface forcing (from large- scale atmospheric analyses) and, possibly, of the dynamics of the ventilated thermocline.

References

[1] Bretherton, F.P., Burridge, D.M., Crease, J., Dobson, F.W., Kraus, E.B. and T.H. Vonder Haar (1982) The "CAGE" Experiment: A Feasibility Study. World Climate Programme Report Series, No. 22. WMO, Geneva. 95 pp.

[2] Bretherton, F.P., McPhaden, M.J. and E.B. Kraus (1984) Design Studies for Climatological Measurements of Heat Storage. J. Phys. Oceanogr., 14, 318-337.

[3] Dietrich, G., Kalle, K., Krauss, W. and W. Siedler (1975) General Oceanography: 2nd Ed., in English. Wiley, NY, 626 pp.

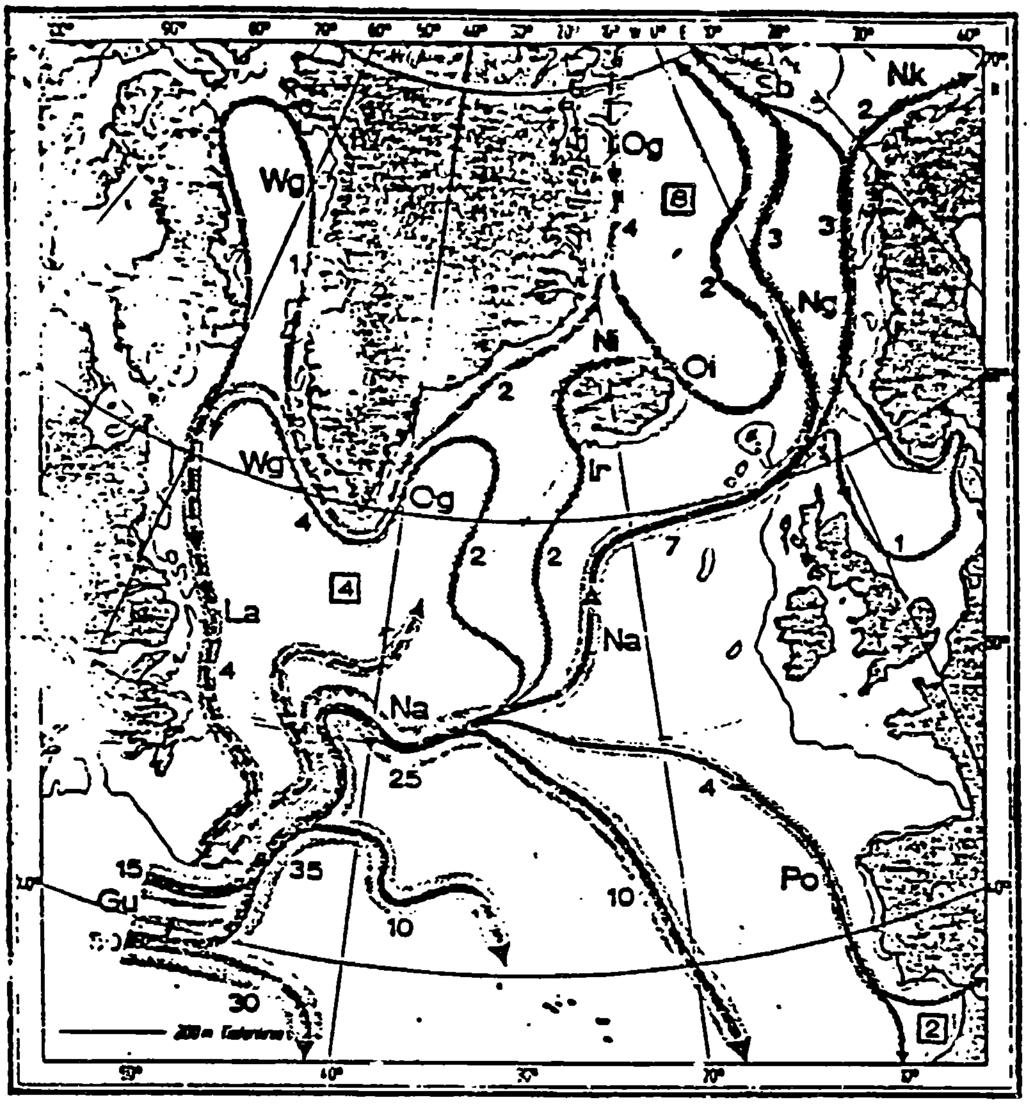

Fig. 1

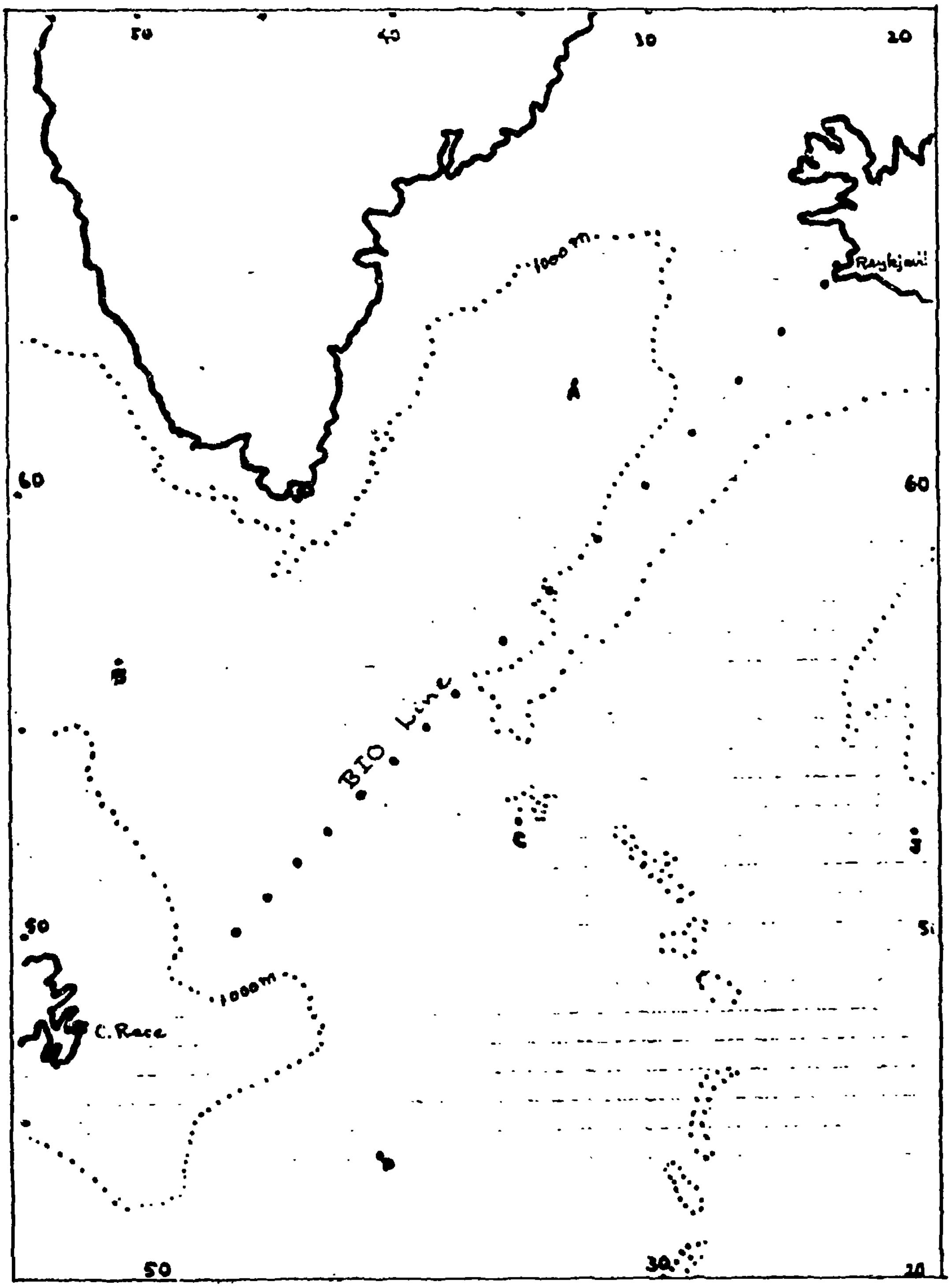
50
40
30
20
60
60
50
50
30
20
1000m
1000m
Reykjavik
BIO Line
C. Race
A
B
C
D

Fig. 2

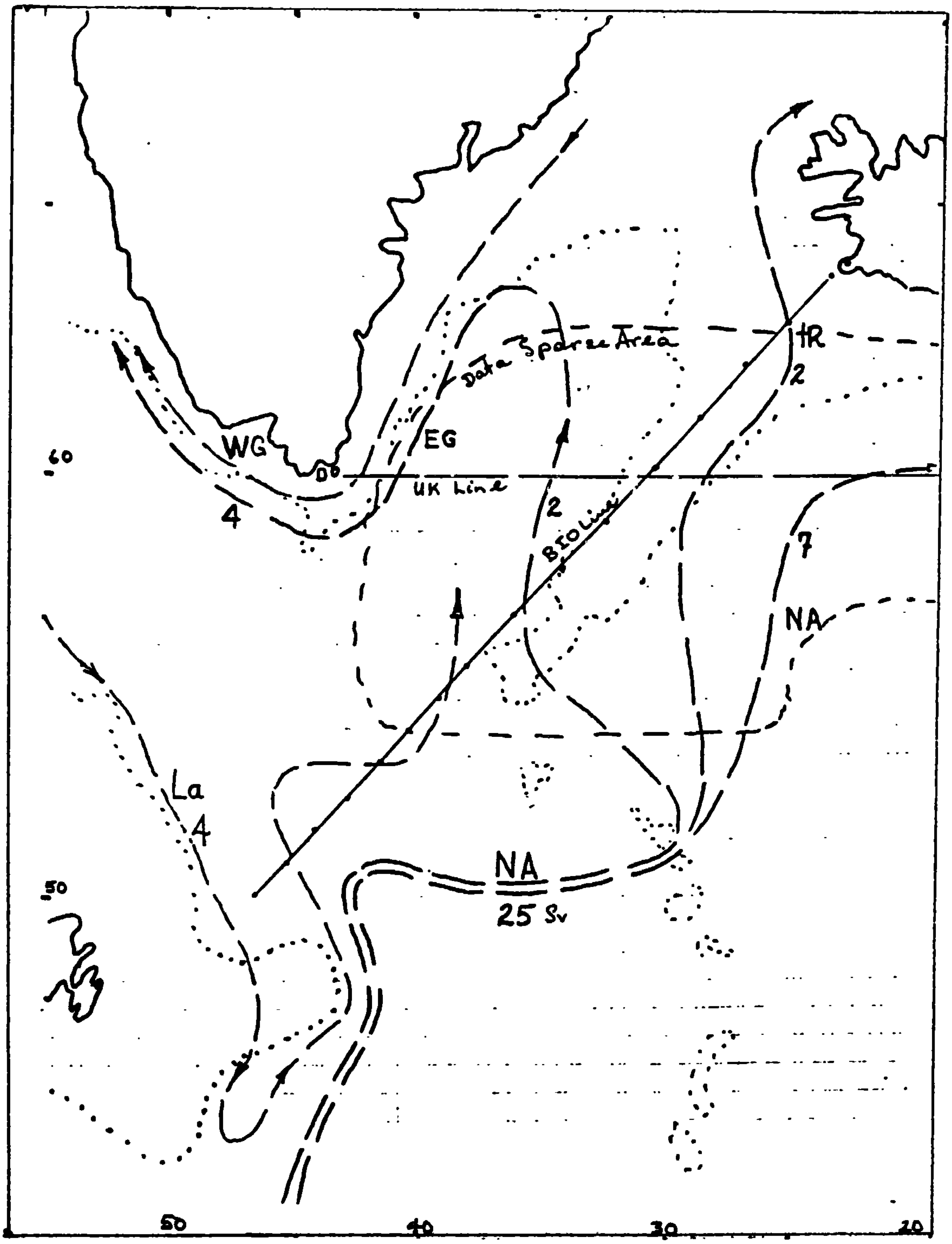
Data Sparse Area
IR
2
WG
EG
60
DS
UK Line
4
2
BIO Line
7
NA
La
4
50
NA
25 Sv
50
40
30
20

Fig. 3

Ecuador

Pinto and Hansen

Observations being made on two vessels. M/V Bucanero transits the line from Guayaquil to Galapagos with a nominal 3-week cycle time. We presently sample outbound leg only because of short turnaround time in Guayaquil, but can (did) sample in both directions during El Nino. M/V Isla Floriana transits Guayaquil-Callao-Valparaiso, and Guayaquil-Yokahama with a nominal two-month cycle time. When merited by traffic, this ship is expected to transmit data via GOES. Recent data collections are shown in Figure 1. On the initial run XBT sampling was done from Isla Floriana all the way to Japan, but in the future it is planned to limit sampling to the region south of 20oN unless specifically requested by the TOGA Programme office or the National Ocean Service to sample farther west. The responsible institution in Ecuador (INOCAR) is proposing expansion of the programme to a third vessel.

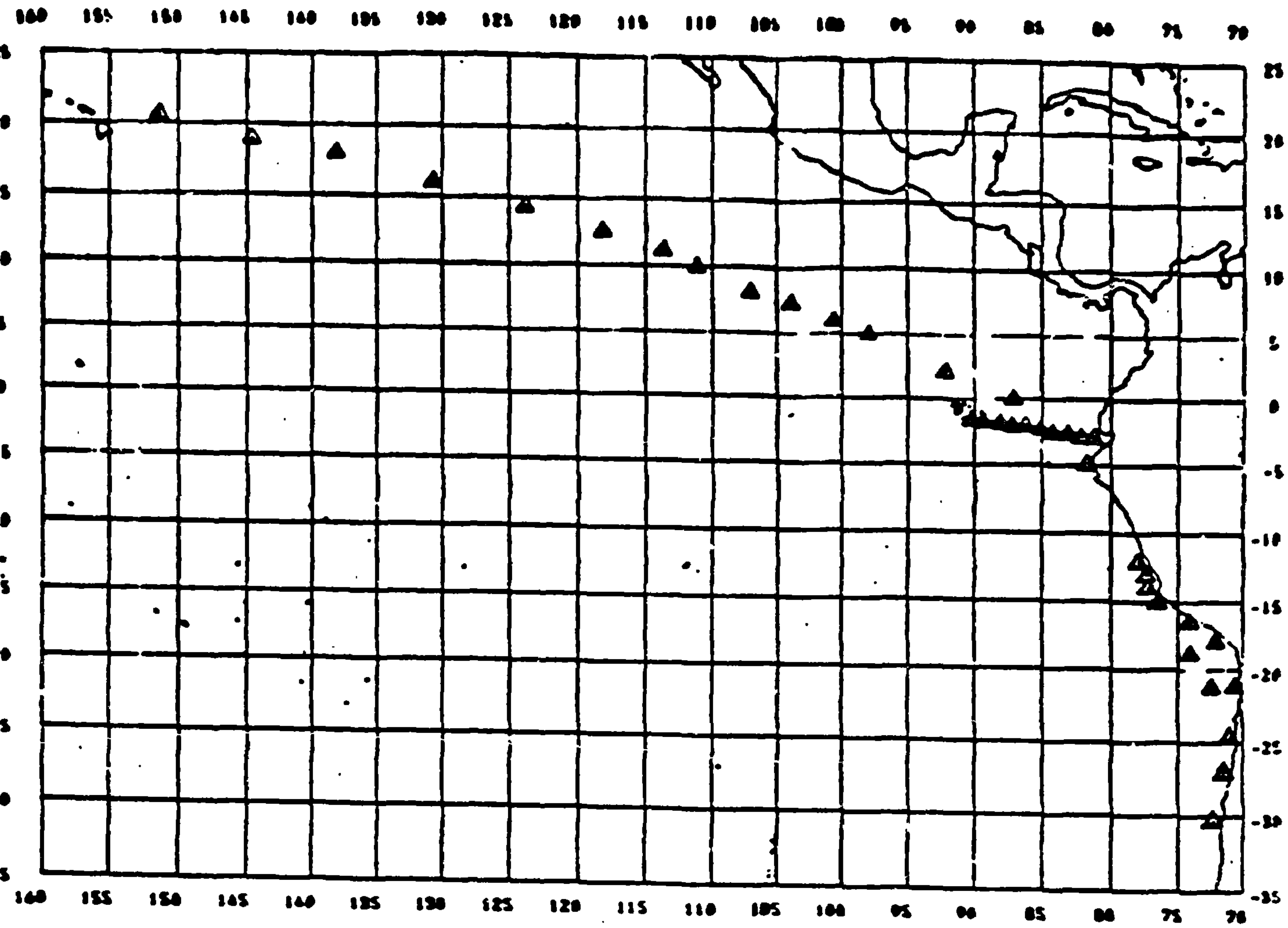

Figure 1. XBT's transmitted by satellite from Ecuadorian vessels.

France

Y. Tourre

ORSTOM

France has been running systematic observing programmes with merchant ships in the 3 oceans since as early as the mid fifties (particularly for the monitoring of sea surface temperature and salinities). In the Eastern Atlantic Ocean, the observations were conducted along the African coastline. In the Indian Ocean, the main operating line was Djibouti- Madagascar-Mascarene Islands, while in the Pacific Ocean, in the early sixties, ships sailing between Noumea and Sydney were used. ORSTOM Centres have been the main investigators in those early observing programmes.

Those observations have been intensified since then, through different research programmes, involved in the studies of seasonal and interannual variabilities of thermal structures and circulations of the 3 oceans, such as: MESTRA (French Meteorology/ORSTOM), FOCAL/SEQUAL, SURTROPAC (French/USA), Sinode (MNHN, TAAF), TOGA. In the last programme which started in January 1985 France will have an observing programme in the tropical areas of the 3 oceans for the next 10 years.

At present there are five operational merchant ship lines in the Pacific Ocean, namely: Noumea-Hong Kong; Noumea-Japan; Noumea-California; Noumea-Tahiti-Panama; Tahiti-California. The frequency approximately is once a month.

In the Atlantic Ocean there is a continuous observing line between Africa and Brazil (post-Focal operation).

In the Indian Ocean, the Sinode programme uses the R/V Marion Dufresne, 4 times a year between Somalia and La Reunion.

In order to fill out gaps in the Southern parts of the Pacific ocean, Eastern part of the Atlantic Ocean, and all over the Tropical Indian Ocean, the following lines are being planned and proposed:

Noumea-New Zealand and Tahiti-New Zealand (Pacific Ocean), West Africa- South Africa (Atlantic Ocean) lines are planned.

In the poorly sampled Indian Ocean, a triangle made with lines between Somalia-Indonesia-La Reunion is being proposed.

Federal Republic of Germany

D. Kohnke

The IGOSS representative of the Federal Republic of Germany introduced his country's contribution to the ship-of-opportunity programme. He informed the session that four institutions in Germany have equipped ships with XBT systems. XBT lines are operated between Europe and South America, between Europe and the Caribbean, and between North America and Dakar (Senegal). One line is operated in the Red Sea. In addition to the ships steaming on lines, a fishing guard vessel is making XBT measurements in the North Atlantic Ocean. The XBT data from the lines to South America, through the Red Sea, and from the fishing guard vessel are quality controlled and then transmitted via the GTS.

Besides these more regular XBT observations, most of the German research vessels make XBT measurements on the way to, and in their area of operation. In this context, he mentioned, in particular, that XBT measurements are made, normally in lo latitude intervals, on board the polar research vessel "Polarstern" on her way from Europe to Antarctica, and back. Most of these XBT "research data" are also entered onto the GTS.

For the future, it is planned to gradually up-grade the measuring systems by automatic digitization and data transmission facilities.

Peru

D. Hansen

Programme has been established for collection of XBT data on lines running about 200 km out from the coast, using vessels of the Peruvian Navy and Coast Guard. Sampling is being done monthly at Callao (11oS), and quarterly at Paita (5oS). It is planned to add a quarterly line at Ilo (17o.5S) soon. Opportunities exist for sampling also from shipping routes between Callao or San Juan and Japan, and Callao and Los Angeles. These can be activated as soon as the sampling equipment is available. Finally, Peruvian institutions are conducting several cruises each year usually on the lines shown in Figure 2. Some XBT sampling have been obtained on these cruises, but not as systematically as could be done. Peru needs a GOES transmitter system for these vessels also to make the most of the opportunity.

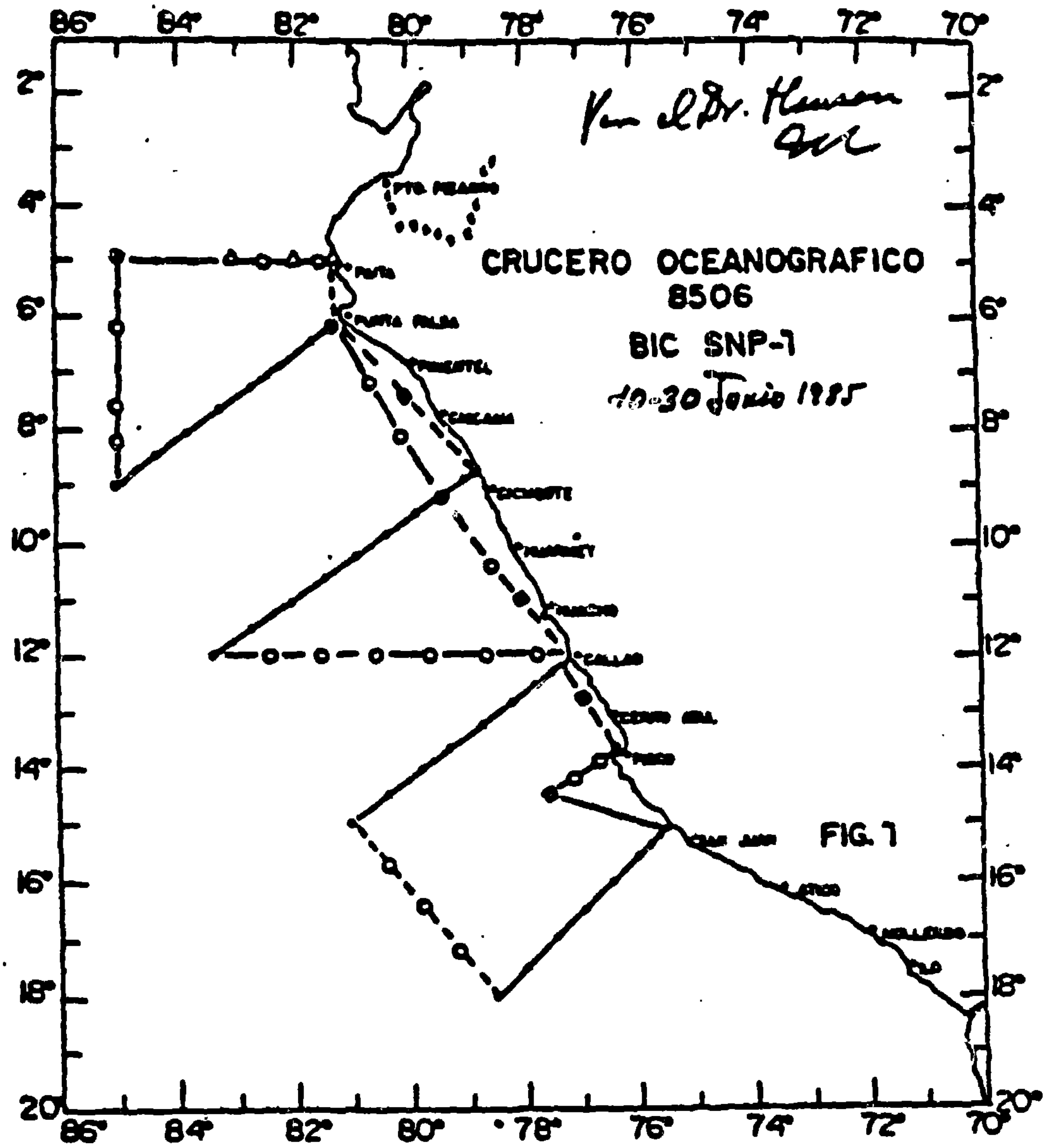

Figure 2. Cruise track tranisted by Peruvian research vessels several times a year.

UK Programme

T. McAndrew

The UK reports that one ship-of-opportunity was being operated, in conjunction with the Danish Governmental Shipping agency, between the Pentland Firth and Cape Farewell on an approximately monthly cycle. It was intended to continue this season, along about 60oN, for the foreseeable future; some difficulties in transmitting observation onto GTS had been encountered and it was hoped to resolve these soon.

The UK (Institute of Oceanographic Sciences, Meteorological Office and Hydrographic Office) are actively considering a modest expansion of the UK's ship-of-opportunity programme. To this end a method of selecting appropriate ships, using movement reports compiled by Lloyds, had been devised by IOS and was described in a short paper (Gould and Fisher 1985) which was presented to the group. Provision of probes and recorders for additional ships had not yet been approved and route selection will ultimately depend upon available resources.

United States of America

VOLUNTEER OBSERVING SHIP PROGRAMME

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The largest volunteer ships observing programme in the Pacific is operated by Scripps Institution of Oceanography together with the French ORSTOM (Office Recherche Scientifique et Technique Outre Mer). Their joint network consists of over thirty ships which fly the flags of Japan, Australia, Germany, the Phillipines, Panama, Korea, France, the US and other nations. These ships annually deploy 10,000 XBTs according to a scientifically designed sampling strategy.

Since 1979 about one third of the ships have been equipped with inexpensive computerized XBT recording systems of the type designed by Oregon State University and now manufactured in France. Since 1982 one of the ships, the M/V Lillooet, has been automatically transmitting XBT data via an inexpensive ARGOS-based system also designed by Oregon State University. Work by SIO, CRSTOM and the Canadian IOS is continuing on more sophisticated and even less expensive SEAS-type systems which incorporate elaborate shipboard data displays and data transmission via GOES.

Volunteers who take oceanographic or meteorological data are usually unaware of the content of their observations and how they fit into the larger oceanic or atmospheric picture. This is a serious deficiency because it contributes to the problems of poor volunteer performance and data errors. In order to partly remedy this deficiency, Scripps VOS programme has developed a display programme module which could be installed on volunteer ships. At this point it is only a programme module - a part of a larger programme - and is not immediately ready to be put on a ship.

The programme is written for a Commodore-64 computer which sells for about $250.00 (US) including CRT monitor and data tape recorder. it could be used in place of the more expensive HP-85 computer which is normally used in SEAS systems. In addition to low cost the C-64 computer has very good high resolution graphics.

The sample display programme draws a climatological picture of the depths of the 25o, 15o and 10o isotherms along the major shipping tracks in the central tropical Pacific (Figures 1, 2). Actual data, obtained from either XBTs or a data tape record of XBT drops, is then dotted over the top of the climatology. The depths of the actual 25o and 15o isotherms are indicated by white dots and the depth of the 10o isotherm by black dots. A ships' officer who is using this system could easily:

* see if his XBT measurement were revealing any unusual oceanic conditions such as those which occur during El Nino.

* identify XBT drops which were clearly in error.

* determine how many observations should be taken in what areas.

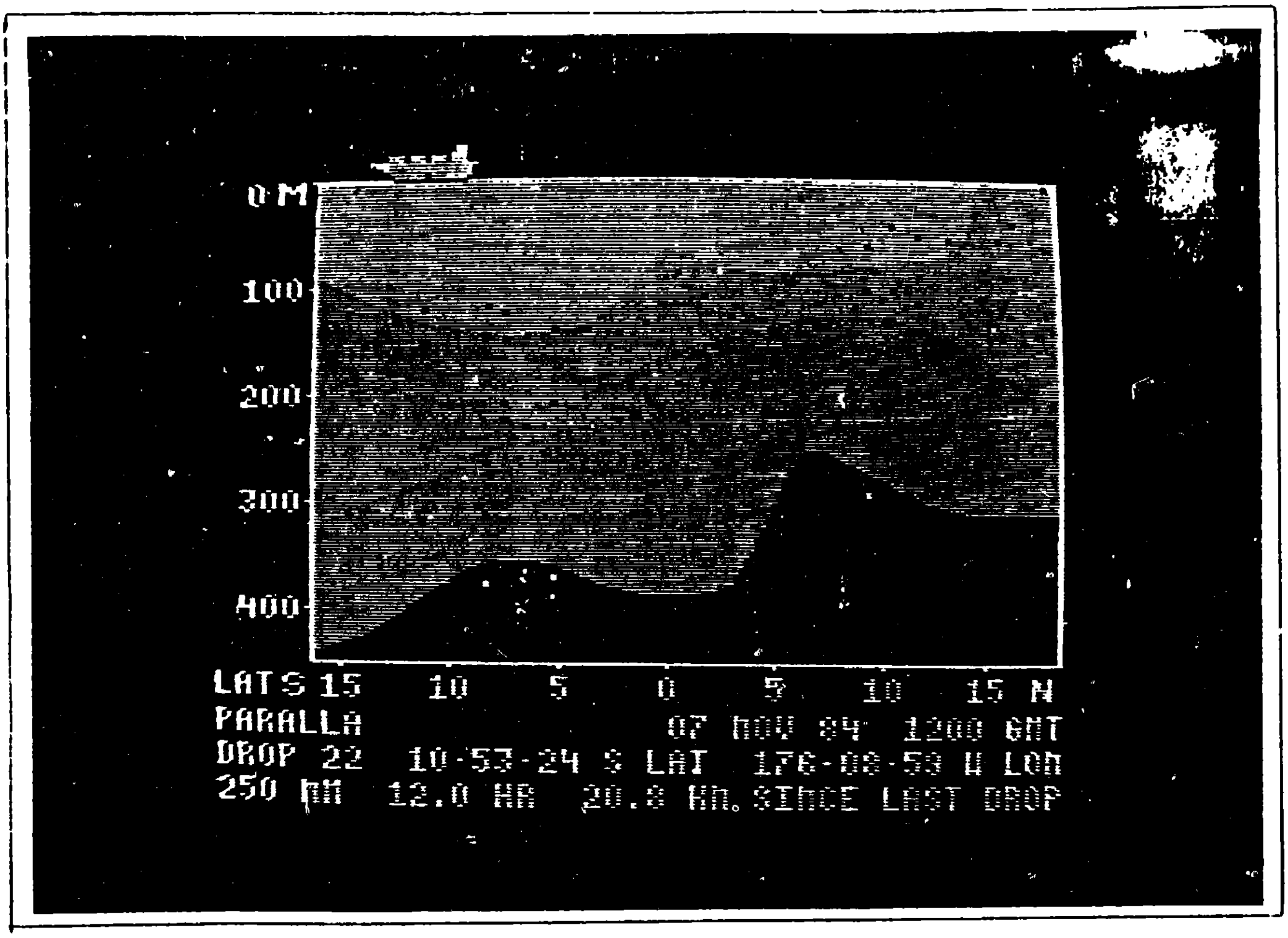


FIGURE 1

Sample program for displaying actual XBT data (dots) against thermal structure climatology (shaded areas).

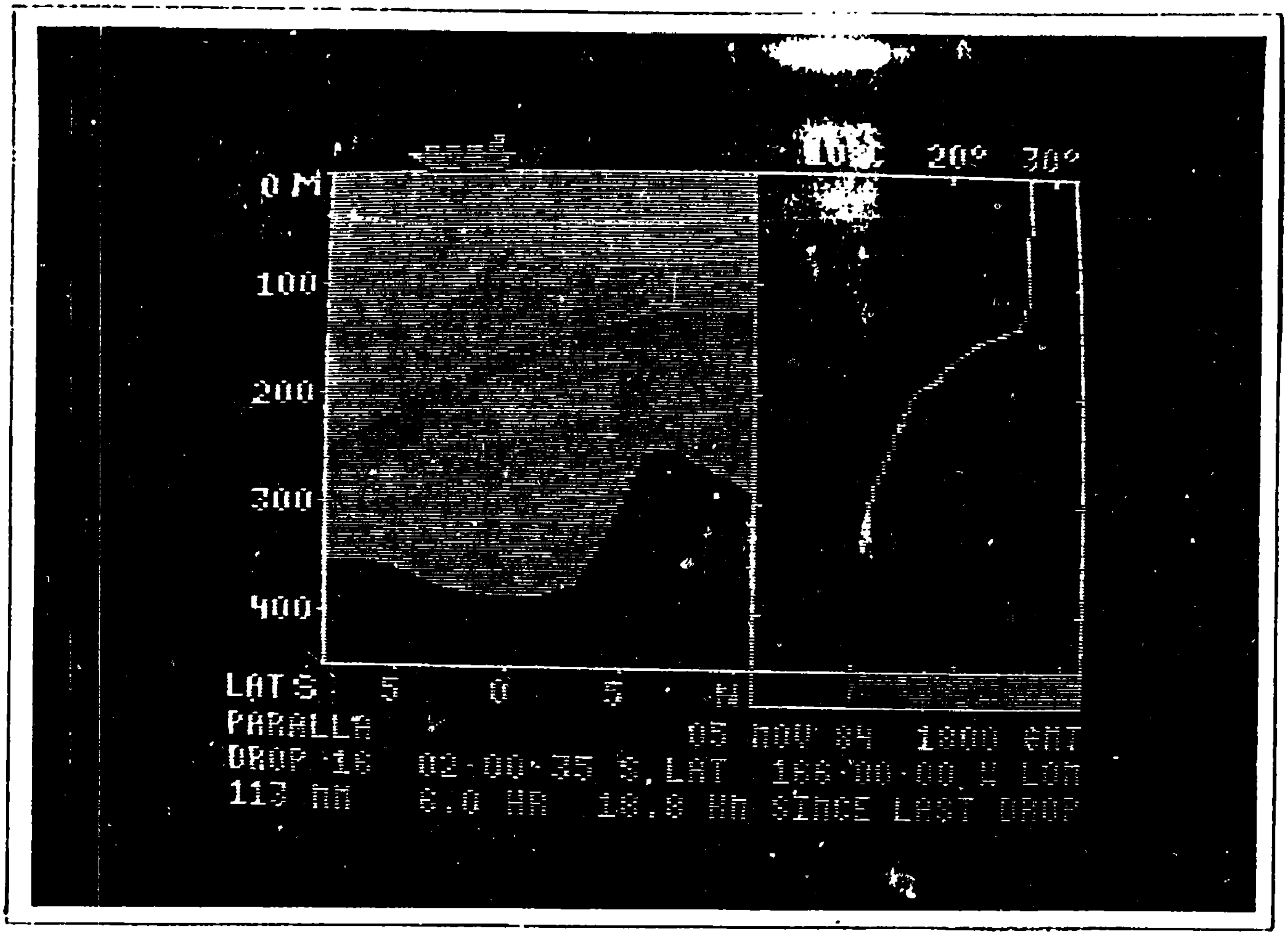
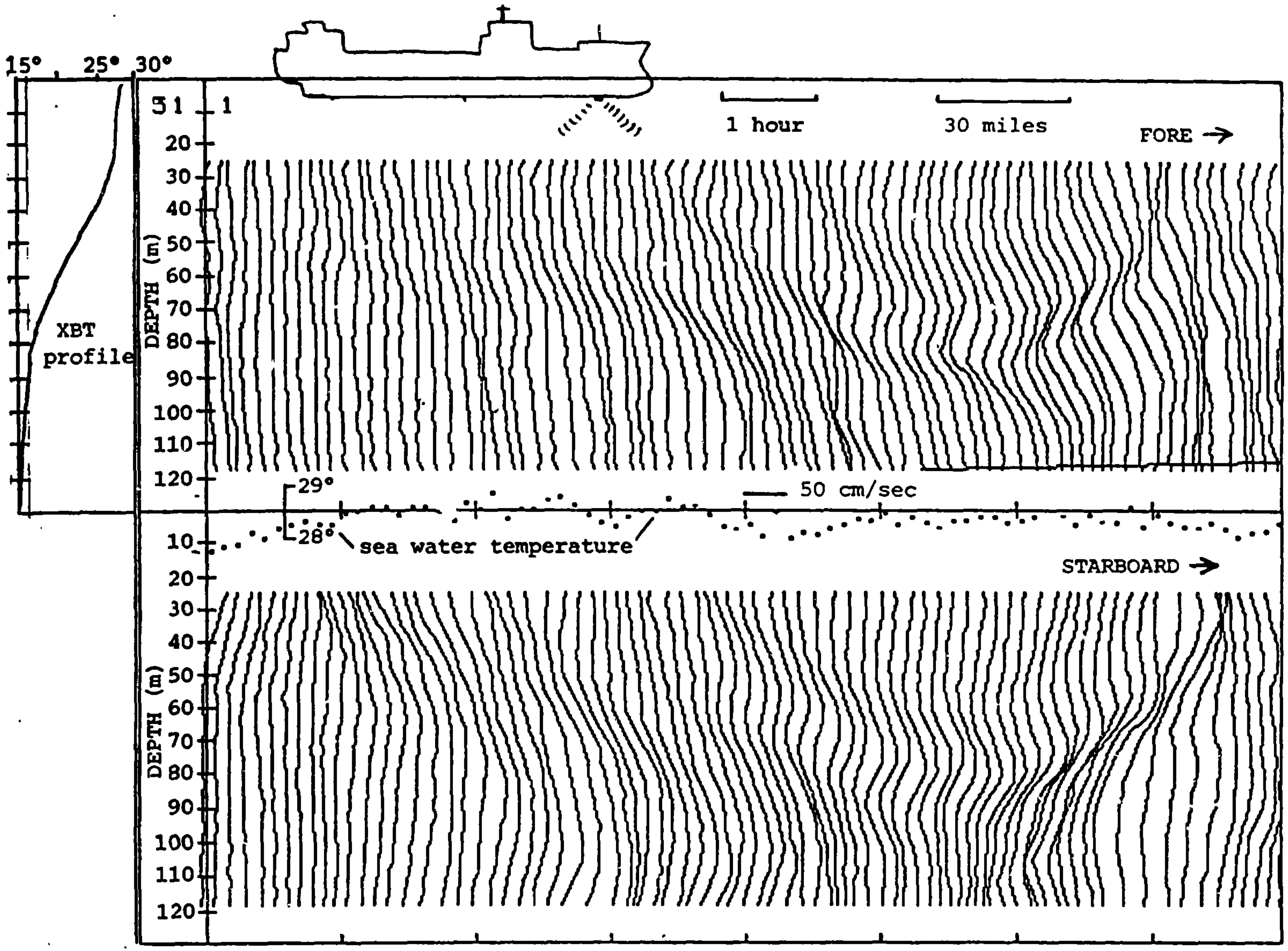


FIGURE 2

Another type of display from
the sample program.

Scripps' VOS Programme has just completed the installation and successful testing of an Ametak-Straza acoustic Doppler current profiler on the 42,000 draft EXXON tanker Jamestown. A sample of the current profiles obtained by the Jamestown is shown in Figure 3.

Scripps' VOS Programme is presently supported by the US TOGA Office, NOAA-NOS, and the Fleet Numerical Oceanography Center. Very substantial shiptime and officer services contributions are also made to the programme by fifteen private shipping companies.



Acoustic Doppler section, January, 1985, taken aboard the EXXON *Jamestown* in the Gulf of Tehuantepec.

FIGURE 3

THE NATIONAL OCEAN SERVICE DISTRIBUTION OF SHIPBOARD ENVIRONMENTAL DATA ACQUISITION SYSTEMS (SEAS)

Steve Cook

As of September 1985, the NOS had purchased 83 SEAS units; 30 manual and 53 semi-automated, of which 24 had been deployed (see Table 1). The manual SEAS units allow for the hand entry of surface meteorological observations and when installed on ships with already existing XBT systems also allow for the entry of digitized subsurface data. The semi-automated systems provide the same function for the entry of surface meteorological observations and also automatically digitizes XBT data and formats that data into the internationally accepted JJXX code. Both the manual and semi-automated systems transmit these quality controlled data via the GOES satellite system in a timely manner.

Plans are to outfit all mainline NOAA vessels with semi-automated systems as soon as they become available. There are presently 9 NOAA vessels and 15 other outfitted and operational (see Table 1). After these initial installations, other vessels will be outfitted in a prioritized fashion concentrating on those areas where observations are presently scarce or have a low reporting frequency.

SHIP	AREA OF OPERATION
NOAA Ship CHAPMAN	Atlantic
NOAA Ship DAVID STARR JORDAN	Pacific
NOAA Ship DELAWARE II	Atlantic
NOAA Ship DISCOVERER	Pacific
NOAA Ship McARTHUR	Pacific
NOAA Ship OREGON II	Atlantic
NOAA Ship RESEARCHER	Atlantic
NOAA Ship SURVEYOR	Pacific
NOAA Ship WHITING	Atlantic
USGS S.P. LEE	Pacific
EPA R/V PETER ANDERSON	Atlantic
M/V BUCCANEER	Pacific
M/V ALFRED NEDLER	Atlantic
M/V ARCO RESOLUTION	Atlantic
M/V EDGAR M. QUEENY	Atlantic
M/V ISLA FLOREANA	Pacific
M/V OCEANDER	Atlantic
F/V SEA HAVEN	Pacific

Table 1. Deployment of NOS semi-automated SEAS units as of September 1985. Note there are also 6 manual units deployed and operational all of which are in the Pacific

CO-OPERATIVE OCEANOGRAPHIC OBSERVATIONS PROGRAMME

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1. Concept - The Fleet Numerical Oceanography Center (FNOC) makes global analyses of the ocean's subsurface temperature. To support these analyses FLENUMOCEANEN has developed a Co-operative Oceanographic Observations Programme (COOP) over the past 15 years (Saur and Stevens 1972). The observational programme is now being expanded under a joint Navy/NOAA agreement dealing with ocean observations from ships of opportunity. Various NOAA activities, including National Marine Fisheries Service (NMFS), National Ocean Services (NOS), and the Tropical Ocean Global Atmosphere (TOGA) research programme of Environmental Research Laboratories now contribute to the programme.

Many different types of ships and routes are used to acquire a global coverage of widely spaced "BATHY" observations. Primary emphasis is placed on merchant ships on transocean routes since these navy ships spend much of their time in deep ocean waters. In addition, some Navy and research vessels are recruited and supplied with bathythermograph units when they are transitting sparse data areas between ports or when operating in remote and seas. Fishing vessels (primarily tuna seiners) are also recruited and provide good coverage in fishing areas.

2. Network - The COOP observational network consists of about 100 ships making Expendable Bathythermograph (XBT) observations. Technicians of the US Navy's Meteorological Oceanographic Equipment Programme (MOEP) meet many of the ships. The COOP relies on co-operative arrangements with other oceanographic programmes to meet and service ships. Some of these co-operating programmes are:

1) The TRANSPAC programme of the Scripps Institution of Oceanography in La Jolla, CA.,

2) The SURTROPAC programme operated by the French ORSTOM laboratory in Noumea, New Caledonia,

3) The tropical Atlantic research programme operated by the Deutches Hydrographiches Institut in Hamburg, Germany,

4) The Antarctic/Antarctic Programme of the United States Coast Guard, and

5) NOAA research vessels.

Normally, the shipboard observers space the XBT soundings twelve hours apart and manually encode a CW radio message of the temperature at depth for each sounding. Figure 1 shows an example BATHY observation taken, encoded and transmitted by radio from the containership M/V MEDNIA in the North Atlantic. Position data in reports from fishing vessels are sometimes coded as range and bearing from reference points as the fishermen do not wish to reveal their positions to other fishermen.

Figure 2 sketches the basic architecture of the COOP network. Outlined are routes transited by ships participating in the COOP and other Volunteer Observing Ship (VOS) programmes that are supported as part of the COOP. Each route is named for the main "parent" compant or VOS programme whose ships monitor that particular area of the ocean. Since most of the observations are in the Northern Hemisphere we are attempting to increase coverage in the Southern Hemisphere to obtain a more uniform global coverage.

3. <u>Hardware</u> - Most of the COOP observations are made using XBT probes and Sippican analog strip chart recorders, although some observations are still made using Mechanical Bathythermograph (MTB) equipment. Deep (760 m) are sometime used to detail the deepened thermocline structure, such as the North Atlantic in winter. Recently Sippican stopped manufacture of the strip chart recorders and thus we must convert to modern microcomputer based hardware. With FNOC and NOAA funding support, we have developed special software for the Hewlett Packard 85 microcomputer and Sippican MK-9 XBT interface for convenient use on merchant ships. We are now installing microcomputer based XBT recorders on other ships.

Figure 3 is an example printout of an automated bathythermograph observation using the HP85 microcomputer system. Temperature readings are automatically stored at one meter intervals on a data cassette as the XBT probe descends to its maximum depth. The temperature values are plotted as a vertical profile and used to compute significant temperature values as a function of depth. The position, time, and significant temperature values are used to automatically prepare a BATHY message for radio transmission to shore.

The NOS of NOAA has purchased about 80 microcomputer based Shipboard Environmental Data Systems (SEAS) for use on NOAA research vessels and in VOS programmes. These systems are similar to the FNOC microcomputer XBT systems but will have GOES satellite radio transmitters for automatic data transmission to shore. Transmission of the report via the GOES satellite can occur within minutes after the observing time and at greatly reduced error rates, relative to present CW radio transmission. Figures 4 and 5 show examples of errors in the data presently received. The figures show data from the Pacific for December 1984. A prime source of present data errors is due to the manual broadcast and handling of the messages.

BATHY (RADIO REPORT)
NAVOCEANO FORM 2080/1 (6-80)   08 0600AUG81

SHIP OF ORIGIN	RADIO CALL SIGN	GROUP COUNT	FILING (DTG) DATE TIME (GMT)	FORWARDED (TOD) DATE TIME (GMT)	RELAYED BY SHORE RADIO STATION CALL SIGN
MEONIA	OXON			08 0940	NAR

Transmit ONLY to a U.S. Government Radio Communication Station authorized to accept the bathythermograph message.

TO: FLENUMOCEANCEN MONTEREY CA JJXX

YYMMJ	GGgg /	QcLaLaLaLa	LoLoLoLoLo	INDICATOR GROUP	ZoZoToToTo
08081	0600/	74611	02851	88888	00206
ZZTTT	ZZTTT	ZZTTT	ZZTTT	ZZTTT	ZZTTT
15200	20190	28180	35170	40165	50158
55155	67150	78146	80143	99901	00143
30140	55138	90136	99902	00135	20134
50132	80130	99903	00128	50125	99904
00120	50115				

(All messages must end with Ship Radio Call Sign) ⟶ RADIO CALL SIGN OXON

DRAFTER [signature]   RELEASING OFFICER [signature] VIA NMR

Figure 1. Radio log sheet for reporting manually encoded real-time BATHY reports of subsurface temperature. This report was made by the containership M/V MEONIA at 0600Z on August 8, 1981 at 46°11'N, 28°45'W in the North Atlantic. Reports are often normally made by CW in Morse Code by high frequency radio to coastal stations and are relayed by teletype to analysis centers and to the Global Telecommunications System (GTS).

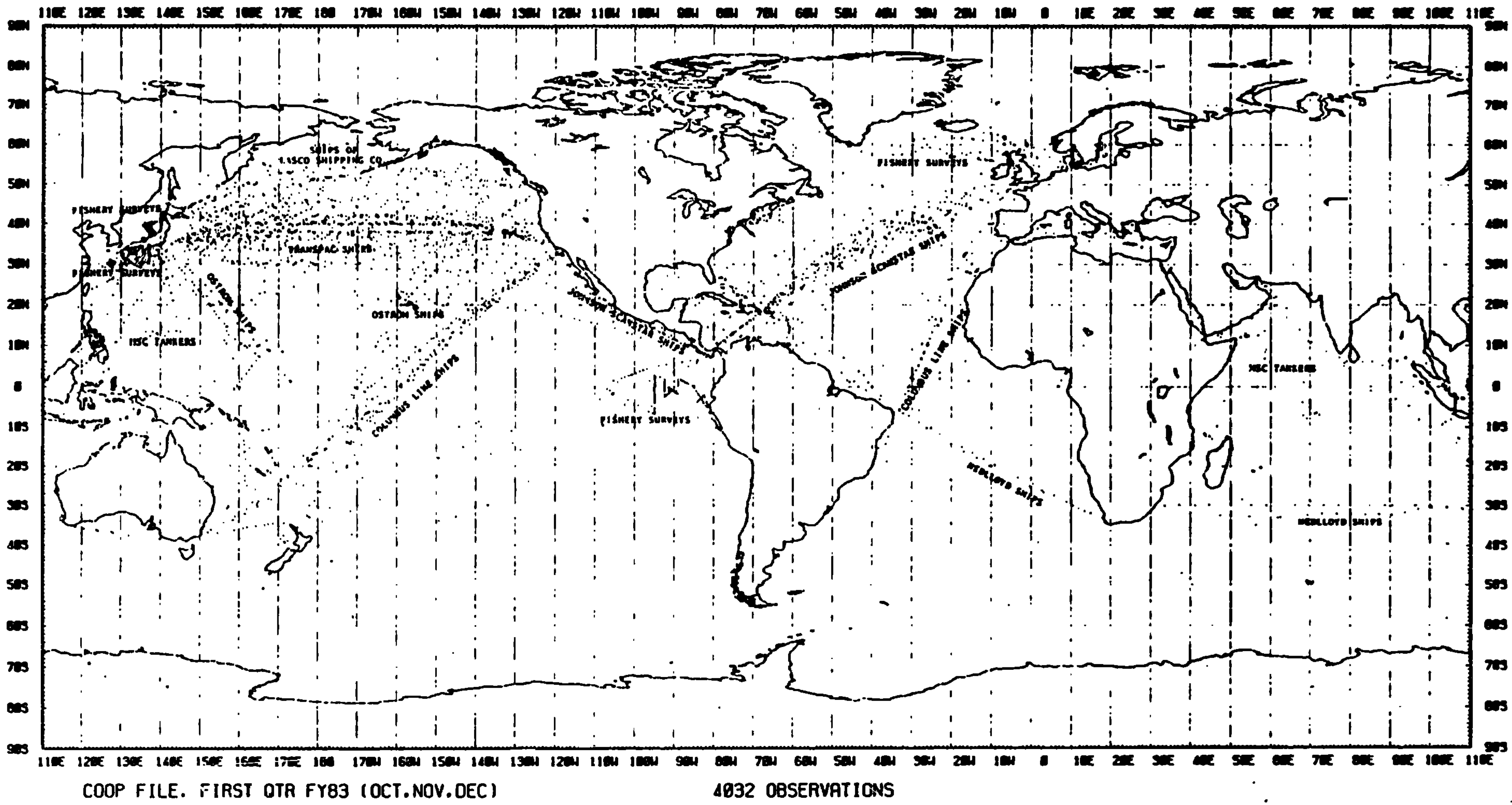


Figure 2. Volunteer observing ship programs and routes in FNOC Cooperating Oceanographic Observations Program. Map shows locations of 4032 real-time radio messages received by FNOC in October to December 1983.

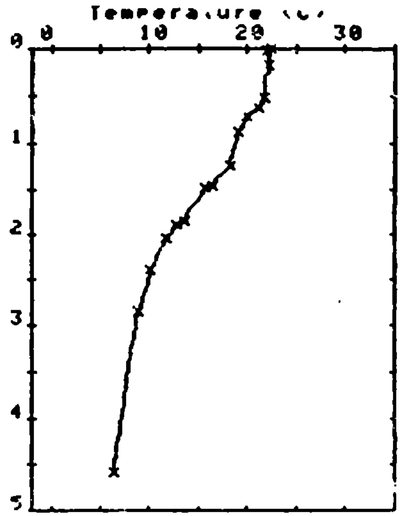
```
              Latitude  24 11 4 N
             Longitude  130 28 8 W
                  Time  14 02
                  Date  06 07 85
 Observer Initials          ROSE

Prelaunch:
Contact = 60.8
Offset  =  6 9 Slope =  .9831
RECORDING XBT    FILE # 2
              Sequence        0002

Since last BT:
     Time (hrs)              24.7
     Course (deg)           233 3
     Distance (n mile)      474.4
     Speed (knots)           19 2

Significant Points:
```

Depth	Temp
0	22 46
3	22.07
17	22.26
52	21.75
62	21.20
72	19 98
89	19.09
125	18 24
146	16.41
150	15 70
185	13.57
190	12 79
205	11.66
235	10 17
285	8.38
459	6 46




```
BATHY MESSAGE:

JJXX  06075 1402/ 72411 13029

88888 00225 03221 17223 52217

62212 72200 89191 99901 25182

46164 50157 85136 90128 99902

05117 39102 85089 99904 59065

DGVK
```

Figure 3. Sample printout from Sippican MK-9 / Hewlett Packard 85 microcomputer digital XBT system programmed by FNOC and NMFS for use on volunteer observing ships. The HP85 program checks that the time and position values entered by the operator are within reasonable ranges; note the latitude value was flagged as out of range and re-entered. The program then computes time, course, distance, and speed since the previous observation and if the speed is negative or unreasonably large, asks the operator to check the time and position. After the XBT cast, the program computes, prints, and plots significant data points and formats a radio message. The actual data values are stored at one meter intervals on a magnetic tape cassette for later archival ashore.

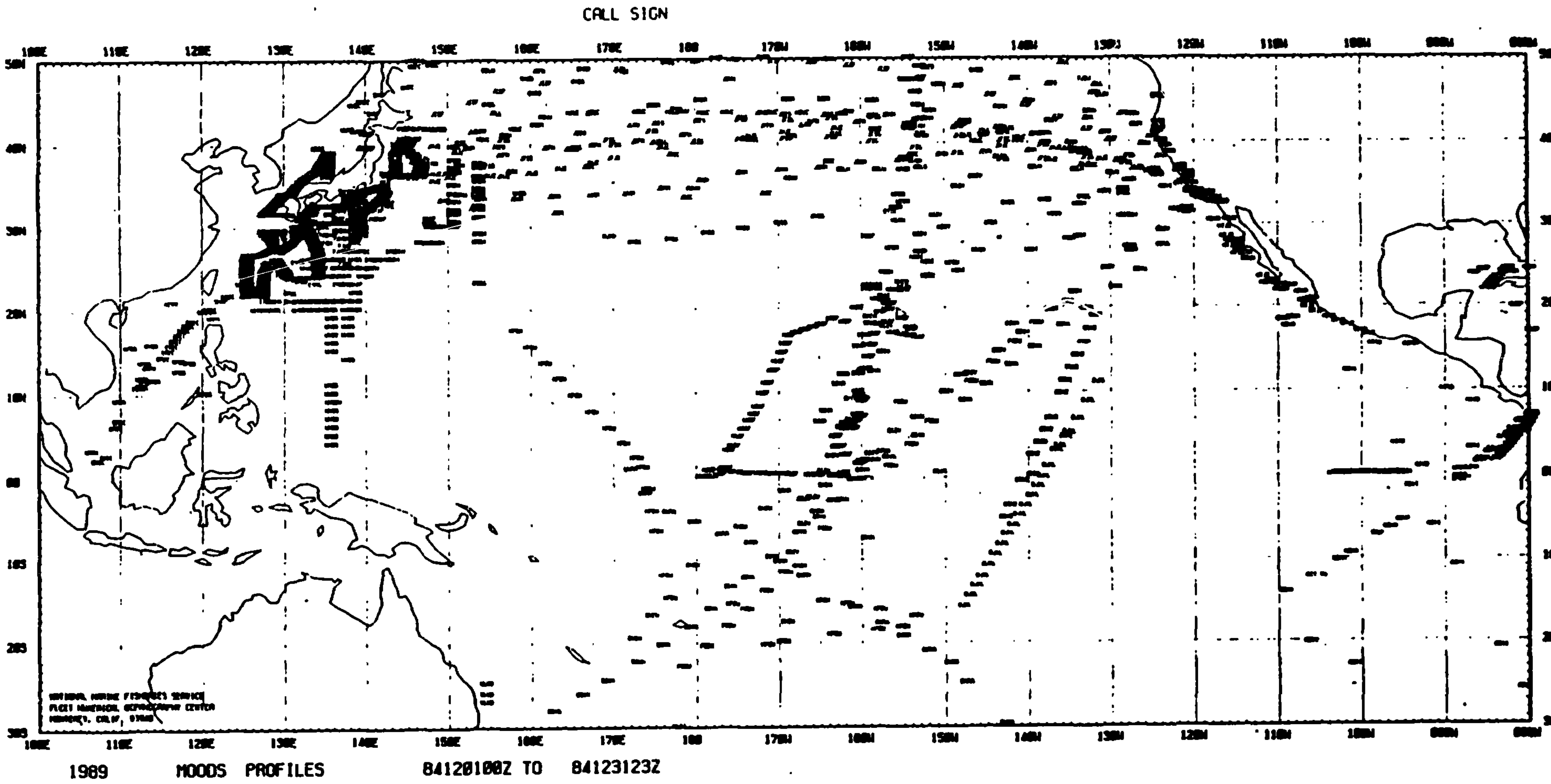


Figure 4. Map of international radio call signs of 1989 real-time messages received by FNOC in Demember 1984 for the Pacific. Call sign maps are very useful in tracking ships and correcting bad position values in real-time message data.

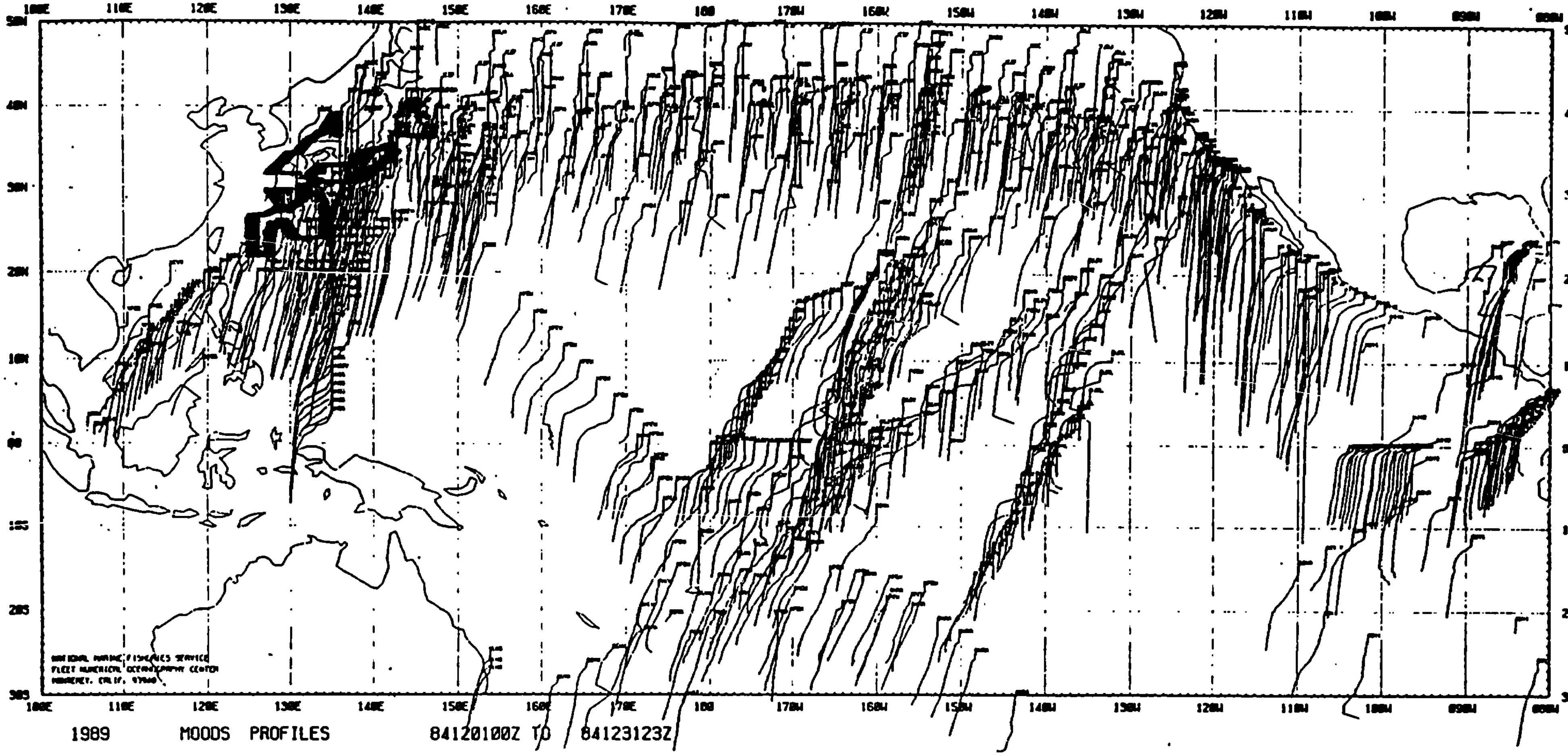


Figure 5. Map of international radio call signs and temperature profiles of same real-time messages as in Figure 4. Profile maps are a very useful quick check on the quality of the data. Note the presence of positive tails at end of some of the profiles and unreal spikes in other profiles.

A major emphasis of the NOS SEAS programme is to increase the number and quality of marine weather reports. All of the SEAS systems will automatically report weather observations and about half will be able to automatically make and digitize XBT observations as well. More and better weather reports will benefit FNOC as well as NOAA.

Recently NOAA and others have developed drifting ocean buoys that make weather reports and which can be instrumented to make subsurface temperature observations. These buoys are based on the US "drifter design" used during the First Global GARP Experiment (FGGE). The new "drifters" have a much longer lifespan (12 to 18 months) than those of FGGE (6 to 12 months). An automated buoy is very cost effective when compared to the present manually observed and transmitted weather reports and XBT soundings from ships. We plan to try to obtain several such drifting buoys in the coming year for use in areas such as the Southern Pacific where shipping and observations are sparse.

4. <u>Data Processing</u> - COOP XBT observations provide ocean thermal structure data in two modes, real-time and delayed. The real-time radio messages are sent from the ship to a shoreside communication station, then on to FNOC and the National Meteorological Center (NMC) in Washington, D.C. An example data bulletin (shown as Figure 6) was received in FNOC at 0811Z on 8 August 1981, and is composed of BATHY messages from three ships participating in the COOP, the containerships M/V FALSTRIA and the tanker USNS COLUMBIA. After receipt, the BATHY messages are edited manually but this is a laborous and error-prone process. To speed editing and to reduce errors, NOS and TOGA are funding Compass Systems, Inc. (CSI) to develop software for Zenith microcomputer systems to edit radio messages at both FNOC and NMC using interactive graphic displays. At FNOC, the radio messages are archived on magnetic tapes each month and are eventually merged with other subsurface temperature sets. NMC collects the radio messages during a specified time period, assembles them into bulletin formats, then enters the bulletin onto the circuits of the Global Telecommunications Systems (GTS) and stores copies of the radio message bulletins for the National Oceanographic Data Center (NODC).

At the end of each ships voyage, the XBT strip charts and log book position data are mailed to either FNOC or NODC for delayed mode processing. At each center, the strip charts are manually digitized and the data archived on magnetic tapes. Tapes are exchanged on a regular basis between NODC and FNOC. With NOS and TOGA funding, CSI is programming Zenith microcomputers to digitize XBT strip charts at both FNOC and NODC. The new systems use GTCO digitizing tablets and replace obsolete Calma and Altec digitizing tables at both centers. The systems will allow sharing of software between NOAA and the Navy, and will insure comparability of strip chart digitizing between NODC and FNOC.

Digital data cassettes from SEAS type system are read at FNOC using an HP85 microcomputer, quality checked and archived. We are co-operating with NODC in cassette reading by providing them with the software to read and edit cassette data. In the next year, we will work with NODC to expand the capabilities of the cassette read software to read all four formats of cassettes (original Sippican MK-9, FNOC one meter data, NOS Sutron SEAS, and NOS Bathy Systems SEAS).

```
@4414
NNNN
 ****TSCREEN MSG  16 UNCLAS                    (  BG     A                           )00

PTTUZYUW RULGSGG1928 2200940-UUUU--RUWJAGE.
ZNR UUUUU
P 080600Z AUG 81
FM SS MEONIA//OXON//
TO RUWJAGE/FLENUMOCEANCEN MONTEREY CA
BT
UNCLAS
JJXX  08061 0600/ 74611 02854 88888 00206 13200 20190 28180 35170
40165 50148 55155 67150 78146 80143 99901 00143 30140 55138 90136
99902 00135 20134 50131 60130 99903 00128 50125 99904 00120 56115
OXONS
BT
@1928
NNNN
 ** *TSCREEN MSG  17 UNCLAS                    (  BG     A                           )00

PTTUZYUW RULGSGG1933 2200945-UUUU--RUWJAGE.
ZNR UUUUU
P 080100Z AUG 81
FM SS FALSTRIA//OYBG//
TO RUWJAGE/FLENUMOCEANCEN MONTEREY CA
BT
UNCLAS
JJXX  08081 0004/ 72441 11219 88888 00215 10162 15167 20162 35160
50157 60150 70143 80140 99902 10141 99904 30142 OYBGS
BT
@1933
NNNN
 ****TSCREEN MSG  21 UNCLAS                    (  BG     A                           )00

PTTUZYUW RULSSGG7474 2201046-UUUU--RUWJAGE.
ZNR UUUUU
P 081017Z AUG 81
FM USNS COLUMBIA
TO RUWJAGE/FLENUMOCEANCEN MONTEREY CA
BT
UNCLAS //N03160//
JJXX 08081 0800/ 74040 04816 88888 00243 20 40 30231 40211
50183 90187 99901 50178 60163 80160 99902 10160 20150 90140
99903 50179 90172 99904 50170 NCFX
BT
@7474
NNNN
   END OF BT72FIL   MESSAGES, 8108081:              11022
```

Figure 6. Printout of FNOC programme TSCREEN of received BATHY messages from containerships M/V MEONIA and M/V FALSTRIA and tanker USNS COLUMBIA.

Data from both strip charts and cassettes are processed by the same software and quality control procedures. The ship's course and speed are computed between adjacent XBT drops to check the reported position and time data. Figure 7 is a plot of the cruise track that is produced by the software that commutes the speeds between observations. The data are plotted semi-automatic DISPLAY plots are seen in Figures 8 and 9 using data from the voyage of the containership M/V COLUMBUS VICTORIA between the US westcoast and Australia. Figure 8 is computed from day/time and consecutive latitude and longitudes, each number along the route identifies an XBT station. Also shown are the corresponding sea surface temperature observations along the ship track. The southbound leg of the voyage is shown on the left while the return leg is on the right. The validity of the temperature data are visually checked by computer plotting each profile and then contouring the vertical temperature sections (Figure 9).

Data digitization from the cassettes is faster, cheaper and more accurate than manual digitization of strip charts. We estimate that 6.0 hours are needed to manually digitize and quality control 46 traces as compared to 3.25 hours for automated digitization of 61 traces.

All subsurface temperature profiles are stored at FNOC as the Master Oceanographic Observations Data Set (MOODS, Bauer 1985). MOODS tapes are co-housed at both FNOC and at NODC. The MOODS contains merged records of both the radio messages and the delayed mode observations, not only from the COOP but also other contributors such as the Integrated Global Ocean Station System (IGOSS). The programme that merges the real-time and delayed mode data files checks for duplicate records and duplicate records exist, the delayed mode observation is considered the primary observation and its radio message counterpart is flagged as a duplicate.

The MOODS format was developed for the COOP to store ocean profile data in an efficient manner. Three primary criteria for the design of the MOODS format were:

1) allow storage of large ammounts of subsurface profiles in a very compact form to minimize number of magnetic tapes to be handled,

2) be sortable using standard sort software (on Control Data computers), and

3) be easy to update.

All COOP data have been converted to MOODS format and all available other data have been converted and added to the MOODS data set. All available files from NODC, Japanese, British, French, Australian, and other sources were used. The combined MOODS data set has been merged and sorted by month, latitude and longitude. This data set has been in use for several years by the COOP. The MOODS format and data set are used operationally by other FNOC programmes for handling of real-time BATHY messages and for climatological purposes. In addition, the MOODS format and data set are being considered for use

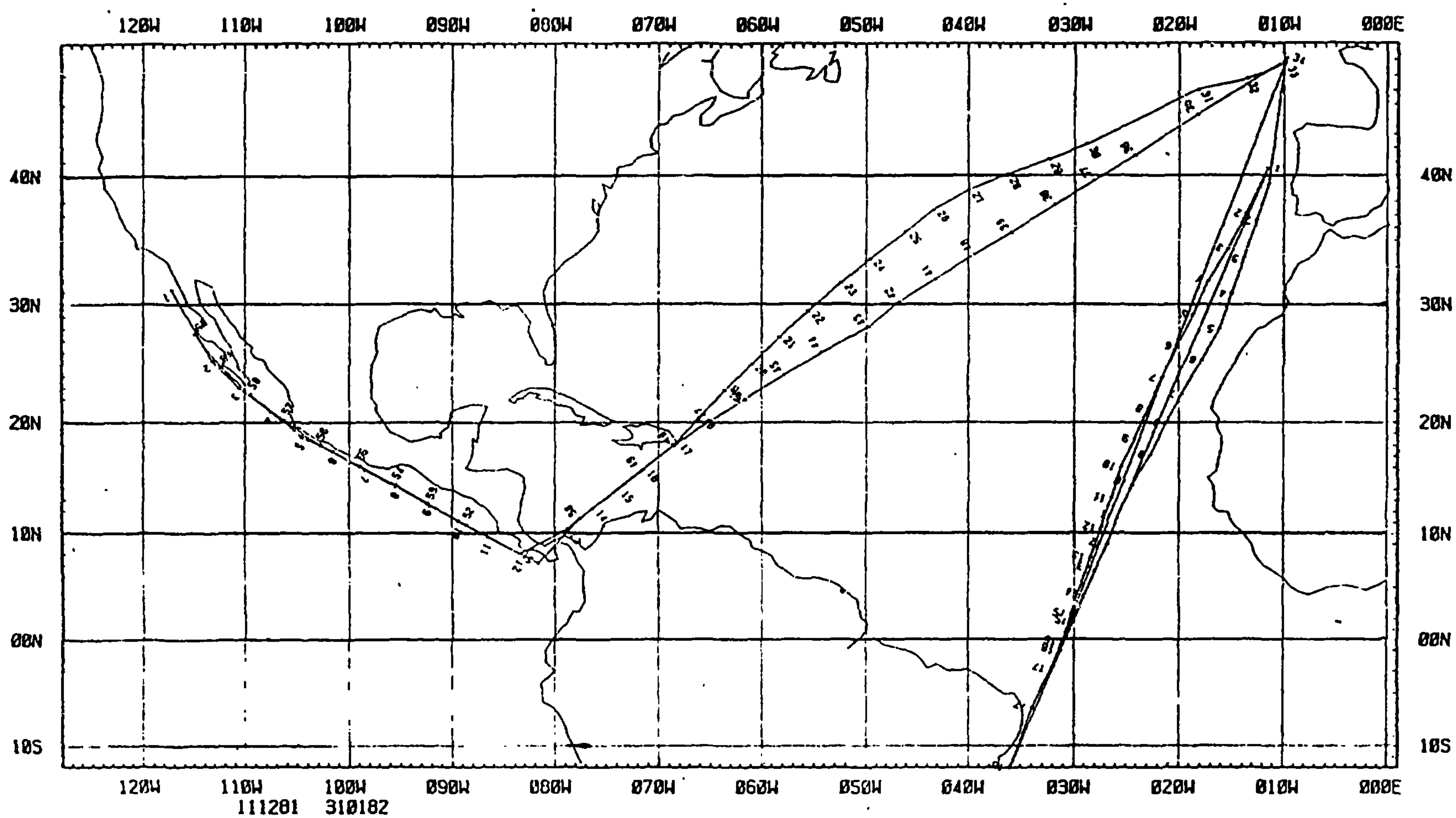


Figure 7. Cruise track plot of locations of XBT drops of ships cooperating in FNOC COOP program. Cruise track plots are computer plotted to check positions of XBT observations. The numbered dots indicate positions where XBT probes were dropped.

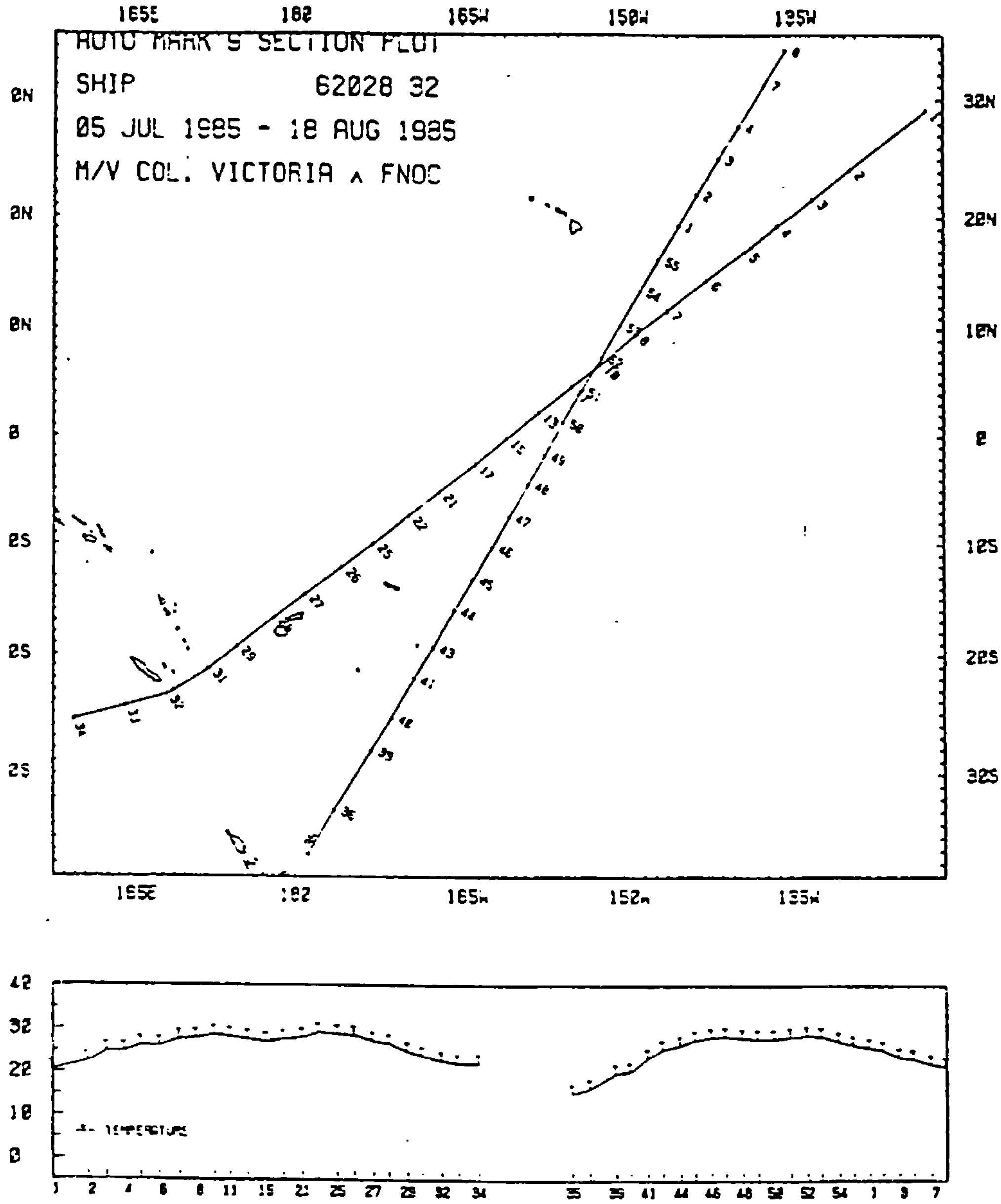


Figure 8 Cruise track and sea surface temperature plots produced semiautomatically by FNOC program DISPLAY from digital XBT cassette data recorded during July-August 1985 on the containership M/V COLUMBUS VICTORIA enroute from US west coast to Australia and return from New Zealand. Lower panel shows the sea surface temperature recorded on this route (southbound leg on the left and northbound leg on the right)

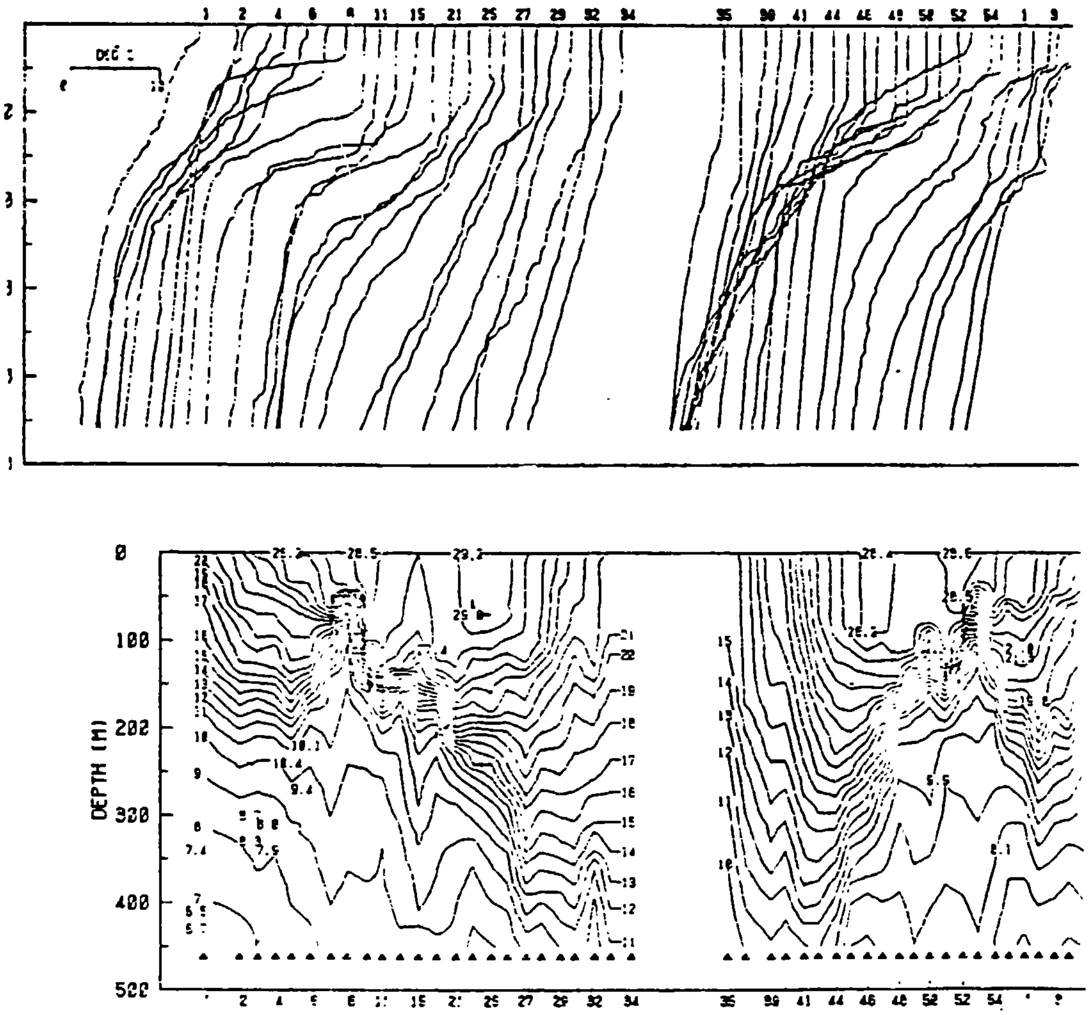


Figure 9. Vertical temperature profiles and contour section of M/V COLUMBUS VICTORIA data shown in Figure 8 and plotted semiautomatically by FNOC program DISPLAY. Vertical profile charts and contour sections are useful to identify erroneous temperature values in XBT section data. Note that the characteristic thermal structures across the equator are reversed in the southbound and northbound legs of the voyage.

as a standard within the Navy for all ocean profile data. Moods software and data files are being used for other laboratories as well, including: NAVOCEANO, NORDA (Teague et al. 1985), Applied Physics Laboratory of Johns Hopkins University (Sinex 1985), NOAA Environmental Research Laboratories in Boulder, CO., Pacific Marine Enviromental Laboratory, Scripps Institution of Oceanography, University of Miami, NOAA Geophysical Fluid Dynamics Laboratory, Pronceton University and Dynalysis Corp.

Much software has been developed to process and display MOODS format data. Figure 10 shows an example of the final result of the data digitization process, using a manual version of programme DISPLAY with data from the rollon-rolloff ship M/V CHANG ZHOU across the North Pacific. The same plots as shown in Figures 8 and 9 are seen in Figure 10 but in a more compact form. We produced a set of DISPLAY plots for VOS equatorial crossings in the 1970's under EPOCS funding (Favorite and McLain, 1982) and hope to produce more in the future under the TOGA programme. Time series changes of subsurface temperature from the MOODS file can be analysed and displayed as in Brainard and McLain (1985).

5. Data Coverage - COOP contributes, as a programme, most of the data contained in the radio message file and a good percentage of the digitized file: 35% for the international message file and about 15% for the digitized file. These percentages are valid only for data disseminated via the circuits of the Global Telecommunications System (GTS).

Figures 11a and 11b illustrate the distribution of data from two files of a five year data set, 1979 through 1984. These files were taken from the MOODS of FNOC. Figure 11a presents the delayed mode (digitized strip chart and cassette data), while Figure 11b depicts the real-time or radio message file. These maps extend only from 50N to 50S because the data were extracted for the TOGA research programme. Note that the radio message file is nearly seven times larger than that of a digitized file at any point in time. Several reasons account for this:

a. Propriatory nature of the original data sets
b. Regulations governing data transmittal to RNODCs
c. Timeliness of data exchanges between RNODCs
d. Priority of processing the original data sets
e. delay in acquiring the original data sets at FNOC

While the number of radio messages received for a given time period is fixed, the number of digitized profiles available for that time period will grow as additional data are required.

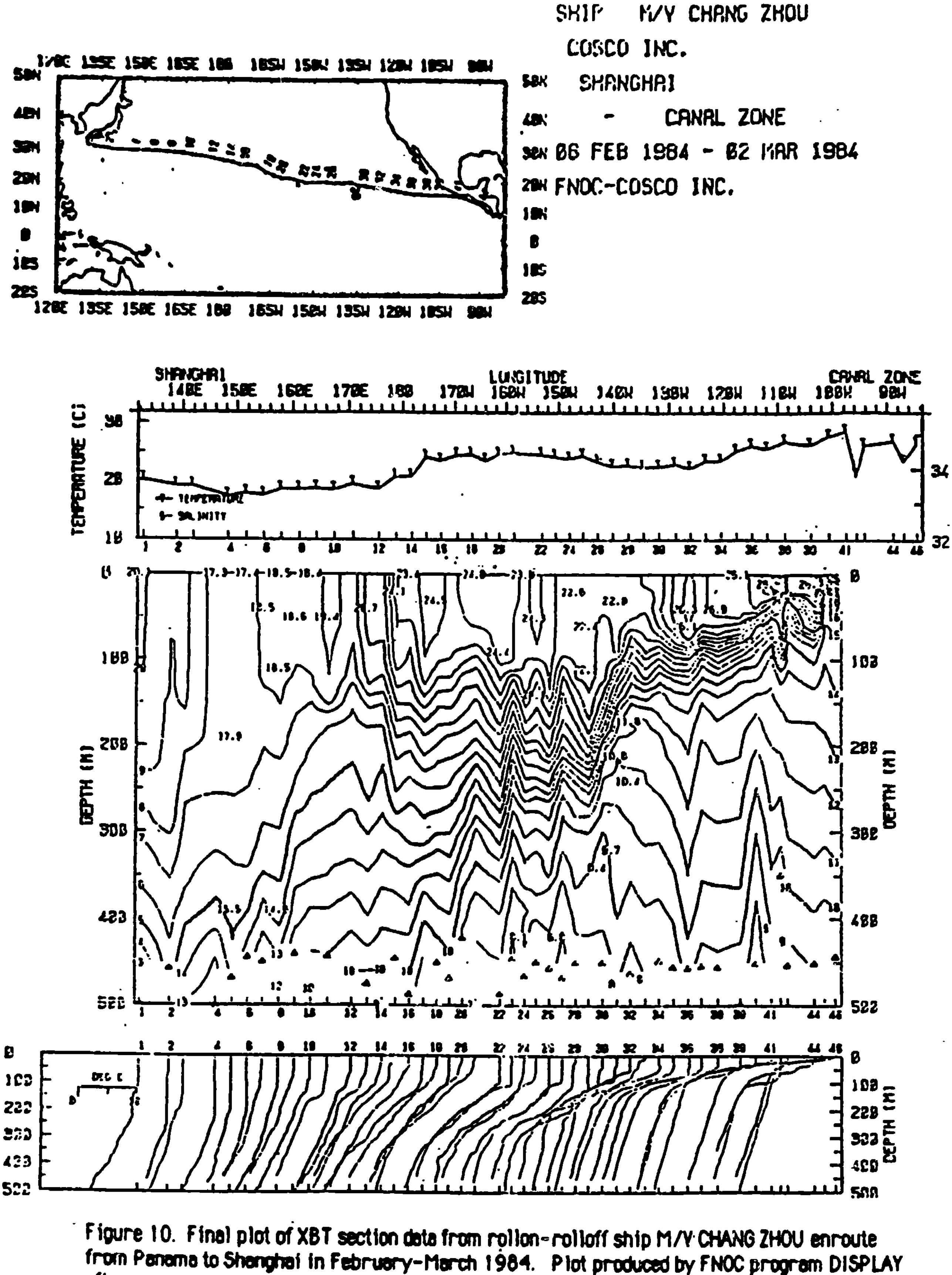


Figure 10. Final plot of XBT section data from rollon-rolloff ship M/V CHANG ZHOU enroute from Panama to Shanghai in February-March 1984. Plot produced by FNOC program DISPLAY after voyages are split into legs and checked for data errors. The upper panel shows locations of XBT drops, the second panel shows the sea surface temperature along the route, the third panel shows the vertical contour section, and the lower panel shows the temperature profiles. Plots such as this represent final product of XBT data digitizing process.

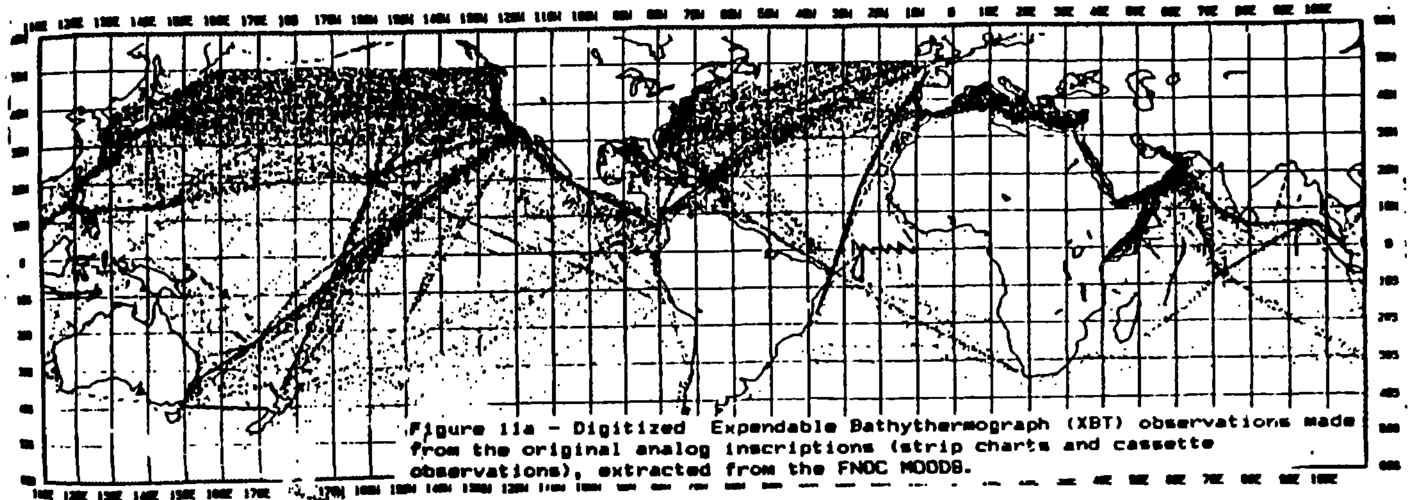


Figure 11a - Digitized Expendable Bathythermograph (XBT) observations made from the original analog inscriptions (strip charts and cassette observations), extracted from the FNOC MOODS.

DIGITIZED BATHY OBS.. ALL MONTHS 1979 THRU 1984 82746 OBSERVATIONS

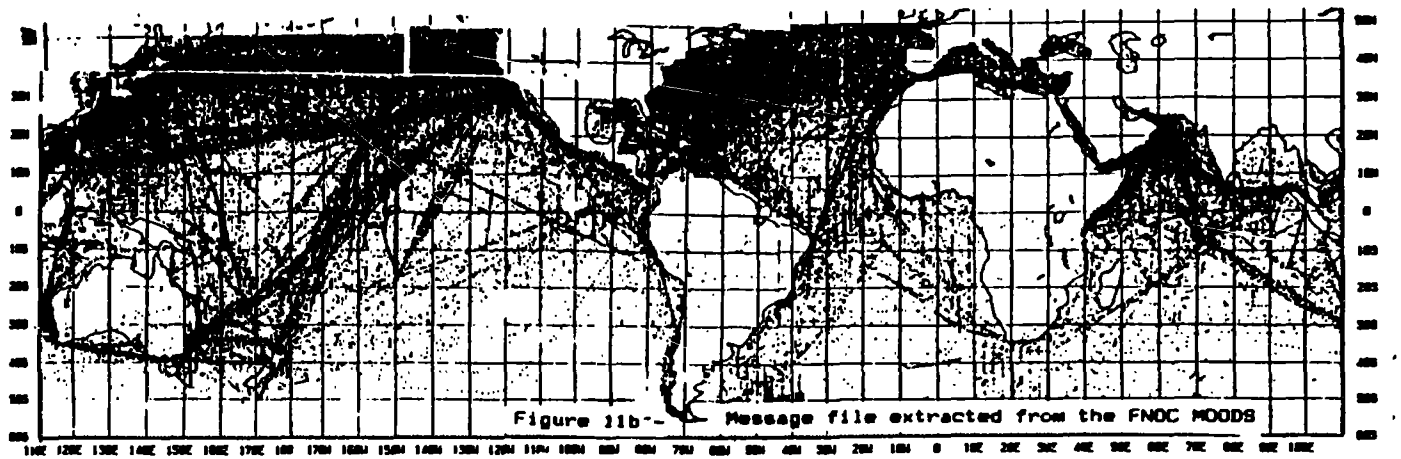


Figure 11b - Message file extracted from the FNOC MOODS

BATHY/TESAC MESSAGE FILE. ALL MONTHS 1979 THRU 1984 429011 OBSERVATIONS

Figure 11

6. Quality Control - Many of the data received in real-time by FNOC have obvious errors such as unreasonable values and unreal gradients of temperature. Some of the errors are due to the XBT probe failure but most are probably due to manual digitizing errors or transmission errors. Reduction of these errors is a major reason for automation of the XBT observations and satellite transmission using the GOES or ARGOS. Currently, a major task is to develop computer software that will further identify and correct other errors that are found in messages. The operational FNOC subsurface temperature analysis and ship tracking programmes reject bad reports but do not save information as to which reports are rejected. Only those reports which fail format tests or do not pass gross temperature and gradient tolerance limits are flagged as bad and edited. The bad reports are manually corrected and re-entered daily into the system using a punch card system. At the end of each month, the profiles are plotted to identify other errors. Figures 3 and 4 show the radio message data for December 1984 in two formats useful for quality control. These are:

a. International Radio Call Sign (IRCS) Maps - Indentifies ships engaged in monitoring along specific routes. Often shows transposition errors of latitude/longitude that might not be detected otherwise.

b. IRCS/Thermal Structure Profile Maps - Visual quality control identifies subtle profile errors, such as spikes or tails on the temperature profile. These errors pass the temperature and gradient test limits in the operational FNOC analysis programmes but are obviously in error. maps.

Many of the errors seen in these maps are being generated by the automated digital shipboard systems. We need to improve the software of these shipboard digital systems to recognize and correct errors before the messages are transmitted as the messages are automatically relayed by NMC globally via the GTS without further editing. Thus any errors present in the messages must be discovered and corrected by each user of the GTS. As an example of automatic message corrections, in the FNOC HP85 software we compute ship speed and course since the previous observation. If the speed of the ship is unreasonable, the programme asks the operator to check the position (Figure 3). Others errors from the digital systems include unreal temperature tails at the end of the profile. Normally the ships' mates delete such tails when manually digitizing a BATHY message, but the software in the digital systems does not recognize the error and the tails are transmitted. Since there are now several different digital hardware and software systems in use (FNOC Sippican-HP, Sippican-HP-Sutron, NOS Bathy Systems-HP-Synergetics, and Scripps-OSTROM Oregon State-Commodore), it would seem desirable to try to develop standard software that could function on all similar hardware (i.e., all HP85-based equipment) that would contain improved error recognition codes.

After receipt of the BATHY messages at FNOC, a number of improved quality control tests could be made. We are beginning to develop some of these now with TOGA and NOS funding Compass Systems, Inc. One scheme is to capture the information in the operational shiptrack and temperature analysis programmes as to which messages were accepted and which were rejected. The rejected messages could then be examined in detail. There is a pressing need to expand the IGOSS-GTS data formats to include data edit flags so that corrected messages can be retransmitted. As an initial step towards this, CSI is developing data edit flags to allow exchange of corrected messages between FNOC and NMC. A second improvement is the replacement of the present manual punch card format editing at FNOC with a microcomputer based system. As mentioned above, CSI will install similar software for Zenith microcomputers at both NMC and FNOC to allow improved editing of messages. Sharing of software by NMC and FNOC will save costs and insure that data editing is comparable at the two centers. Finally, computerized audits of message traffic between FNOC and NMC will be improved to find sources of message loss in transmission.

7. Conclusion - The goal of the combined Navy-NOAA global VOS programme is to provide a comprehensive real-time and historical archive of all available ocean profiles. Salinity as well as temperature is required because of the importance of salinity in determining water density and in defining ocean fronts and boundries. To accomplish these goals, we need to improve our instrumentation, data transmission, editing, archival, and analysis systems. Some possibilities for such improvements include:

(1) Expansion of co-operative agreements with other programmes to increase global coverage,

(2) Use of retrievable mini-STD devices to eliminate XBT probe costs and to obtain salinity as well as temperature profiles,

(3) Reporting of underway surface temperature and salinity along a ship's track to allow better definition of surface features,

(4) Development of standards for digital XBT hardware and software to allow greater commonality between systems and to include improved error correction codes,

(5) Upgrading of all systems to include satellite transmitters for faster and more accurate reporting,

(6) Improvement of editing of historical and real-time profiles,

(7) Improvement of analysis products and data distribution methods.

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Favorite, J.A. and D.R. McLain. 1982
Expendable bathythermograph sections across the Central and Equatorial Pacific Ocean, 1972-82. Unpublished manuscript. Pacific Environmental Group, National Marine Fisheries Service, NOAA, Monterey, CA. 93940.

Saur, J.F.T. and P.D. Stevens. 1972.
Expendable bathythermograph observations from ships of opportunity. Mon. Wea. Rev. 16(1):1-8.

Sinex, C.H. 1985
The environmental data base at APL. In: Proceedings of 1985 Symposium; Ocean Data: Sensor-to-User. Marine Technology Society, Gulf Coast Section. p. 213-225.

Teague, W.J., R.L. Pickett, and D.A. Burns. 1985
Editing the Master Oceanographic Observation Data Set (MOODS). In: Proceedings of 1985 Symposium; Ocean Data: Sensor-to-User. Marine Technology Society, Gulf Coast Section. p. 294-297.

Director, Fleet Application Department
M. Shank, Naval Oceanographic Office

This paper describes past and current US Naval Oceanographic Office Ship-of-Opportunity activities. An XBT programme was conducted from 1969-74 aboard passenger cruise ships between New York and Bermuda to study both horizontal and vertical temperature variability of the Gulf Stream region. Major interests concentrated on identifying water masses, ocean fronts, and cold and warm core eddies. Over 100 sections, each consisting of approximately sixty 760 meter XBTs were obtained. It is stressed that obtaining measurements from passenger cruise ships offers several advantages:

(a) Regular schedules and repetitive tracks result in observations ideal for studying temporal variability.

(b) Excellent navigation systems providing good position fixes.

(c) Observers are easily obtained and readily motivated to obtain good quality data.

(d) Costs are minimal.

It is recommended that the potential value of these ships for obtaining ship-of-opportunity time-series observations be fully explored.

Further, ship-of-opportunity observations were made by Exxon tankers in the Indian Ocean transiting along the African east coast during 1975 and 1979. These observations were made to study the Somali current and adjacent eddies associated with the southwest monsoon. Observations were made utilizing 460 meter XBTs taken approximately every three weeks spaced approximately 25 km apart and were reported over the GTS.

The present programme consists of three sections across the equatorial Atlantic between 10o S and 10o N. SXBTs (460 meters) are taken at 20' latitude spacing resulting in 61 observations per section. These monthly sections have been taken by trained observers since January 1980 to the present, but are not transmitted over the GTS. Both the Indian Ocean and Equatorial Atlantic programmes were conducted by John Bruce in conjunction with the Woods Hole Oceanographic Institution and the National Science Foundation.

ANNEX V

LIST OF SHIP-OF-OPPORTUNITY CONTACT POINTS

Argentina

Jorge Luis Albertani
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Montes de Oca 2124
1271-Capital Federal-Republica Argentina

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Australia

Canada

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Dept. of Fisheries and Oceans
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Canada B2Y 4A2

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Valparaiso
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France

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F.R.G.

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Koh Teck Cheong
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Malaysia

Mauritius

S. Ragoonaden
Meteorological Service
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Vacoas
Mauritius

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Montevideo
Uruguay

ANNEX VI

VOLUNTEER OBSERVING SHIP MONITORING PROGRAMS

Operational:

* Standard WMO surface weather and SST observations
* XBT/MBT/EBT thermal structure networks
* ASAP upper air soundings
* CO2 sampling (intermittent)
* Plankton sampling
* Acoustic Doppler current profiling (temporary)
* Surface salinity

Experimental:

* X-band radar for wind stress
* CODAR for wave climate and surface currents
* Continuous SST

Potential:

* Continuous SST via radiomenter
* Continuous SSS
* Continuous wind velocity
* XCP (expendable current profilers)
* XCTD (expendable conductivity/temperature profiliers)
* Standard, high precision CTD/bottle casts
* Acoustic tomography
* Deployment and re-seeding of drift buoys arrays
* LIDAR profiling of atmospheric boundary layer
* Continuous rainfall rates
* EM-TTM

ANNEX VII

GLOBAL SHIP-OF-OPPORTUNITY PROGRAM CHARACTERISTICS

Table 1	Indian Ocean	Operational	Ship-of-Opportunity	Lines
Table 2	Indian Ocean	Planned	Ship-of-Opportunity	Lines
Table 3	Indian Ocean	Proposed	Ship-of-Opportunity	Lines
Figure 1	Indian Ocean	X	Ship-of-Opportunity	Lines
Table 4	Atlantic Ocean	Operational	Ship-of-Opportunity	Lines
Table 5	Atlantic Ocean	Planned	Ship-of-Opportunity	Lines
Table 6	Atlantic Ocean	Proposed	Ship-of-Opportunity	Lines
Figure 2	Atlantic Ocean	X	Ship-of-Opportunity	Lines
Table 7	Pacific Ocean	Operational	Ship-of-Opportunity	Lines
Table 8	Pacific Ocean	Planned	Ship-of-Opportunity	Lines
Table 9	Pacific Ocean	Proposed	Ship-of-Opportunity	Lines
Figure 3	Pacific Ocean	X	Ship-of-Opportunity	Lines

Table 1 Indian Ocean Ship-of-Opportunity Lines

Operational

Country	Route	Frequency Year	Vessel (Call Sign)	Assistance Required	Agency
Australia	Freemantle Singapore(I1)	8 8	M.V. Anro Australia (VJBO) M.V. Anro Asia (9VUU)	None	CSIRO Div. of Oceano.
US	Freemantle Durban(I2)	to be comm.	Nedlloyd Kembla Nedlloyd Kimberley Nedlloyd Kingston Nedlloyd Kyoto	None	FNOC
France	Somalia(I3) La Reunion	4	Marion-Dufresne	None	MNHN TAAF
RFG	Gulf of Suez(I4) Bab El Mandeb	12	CMS Ubena (DHCU)	None	IFMH

Table 2 Indian Ocean Ship-of-Opportunity Lines

Planned

Country	Route	Frequency Year	Vessel (Call Sign)	Assistance Required	Agency
Thailand	Gulf of Thailand to(Ill) Andaman Sea (2 R/V)(14)	7 7	H.S.F.T. H.S.F.O.	Probes Launchers Recorders Training	Dept. of Fish.

Table 3 Indian Ocean Ship-of-Opportunity Lines

Proposed

Country	Route	Frequency Year	Vessel (Call Sign)	Assistance Required	Agency
France	Somalia La Reunion(I3)	36	to be comm.	Probes	ORSTOM MNHN
	Somalia Sri Lanka(I5)	36	"	Probes	"
	Sumatra La Reunion(I6)	36	"	Probes	"
Uruguay	Montevideo Persian Gulf (I7)(A4)	6 6	Rou Lavalleja (CXIJ) Rou Rivera (CXFN)	Recorder Launcher Probes Training	Armada Nacional
Chile	Japan Persian Gulf (I10)	4	Vina del Mar (CBVM)	Recorder Launcher Probes Training	Empremar
Mauritius	Mauritius Bombay(I8)	4	to be comm.	Recorder Launcher Probes Training	Ireland Blyth and Rogers & Co.
Australia	Freemantle Dubai(I9)	8	Australian Star (GXXY) New Zealand Star (GX07)	Probes	CSIRO Div. of Oceano.

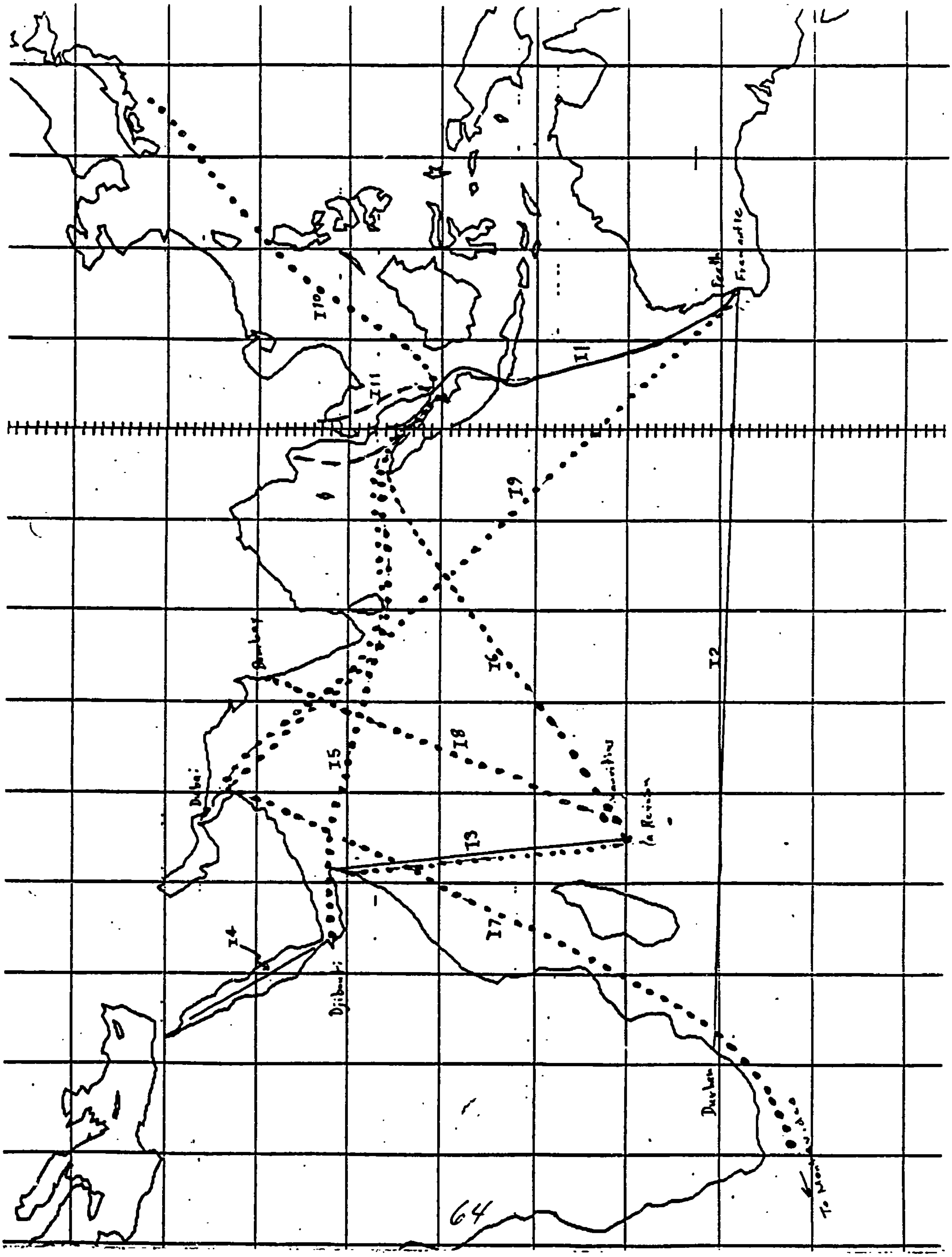

I10
I11
I1
Perth
Fremantle
I9
I6
I2
I8
I5
Bombay
Dubai
Mauritius
La Reunion
I3
I7
I4
Djibouti
Durban

Table 4 Atlantic Ocean Ship-of-Opportunity Lines

Operational.

Country	Route	Frequency (trips/yr)	Vessel (Call Sign)	Assistance Required	Agency
Argentina	A3	1	Amirante Irizar	None	
Canada	A1	4	Bakkafoss	None*	BIO
France	A6	24	Layafette +2		
Germany	A6	4	Monte Rosa	None	DHI
	A6	4	Saxon Star	None	DHI
	A6	4	Monte Sarmiento	None	DHI
	A8	6	Caribia Express	None*	IFM Kiel
	A9	3	Port Harcourt	None*	IFM Kiel
	A10	3	"	None*	IFM Kiel
	A11 (Dakar-Matadi)	3	"	None*	IFM Kiel
UK	A2	12	Nivi Ittuk (OXYL)	None*	UK NHQ
US	A12	52	Oleander	None	NMFS
	A13	12	Yankee Clipper	None	NOS
	A14	24	Edgar M. Queeny	None	NOS
	A15	24	Stena Hispana	None	
	A16/P13	NK	Variable	None	FNOC
	A17/P13	NK	Exxon Jamestown	None	SIO
	A18	NK	Mormac	None	FNOC
	A19	NK	Various	None	
	A20	NK	Various	None	
	A21	NK	Various	None	

Table 4 Atlantic Ocean Ship-of-Opportunity Lines, Cont.

Operational

Country	Route	Frequency (trips/yr)	Vessel (Call Sign)	Assistance Required	Agency
US	A22	NK	Mauricia de Olivia	None	
	A23	NK	Atlantic Causeway	None	
	I2/A24/P13/P7			None	FNOC
		6	Nedlloyd Kimberly		FNOC
		6	Nedlloyd Kembla		FNOC
		6	Nedlloyd Kingston		FNOC
		NK	Nedlloyd Kyoto		FNOC

Table 5 Atlantic Ocean Ship-of-Opportunity Lines

Planned

Country	Route	Frequency	Vessel (Call Sign)	Assistance Required
Argentina	A4/I7	14	Various	Full
France	A7	NK	NK	None
Germany	A6	NK	Cervantes	None

Table 6 Atlantic Ocean Ship-of-Opportunity Lines

Proposed

Country	Route	Frequency	Vessel (Call Sign)	Assistance Required
Argentina	A5	5	(NK)	Full
Chile	P6/A26/I10	4	Vina Del Mar	Full
Uruguay	A5 A27/I7	12	Ron Lavalleja Ron Rivera	Full
Chile	A27/P19	6	Anakena Angol	Full Full
	A28/P19	6	Anakena Angol	Full Full

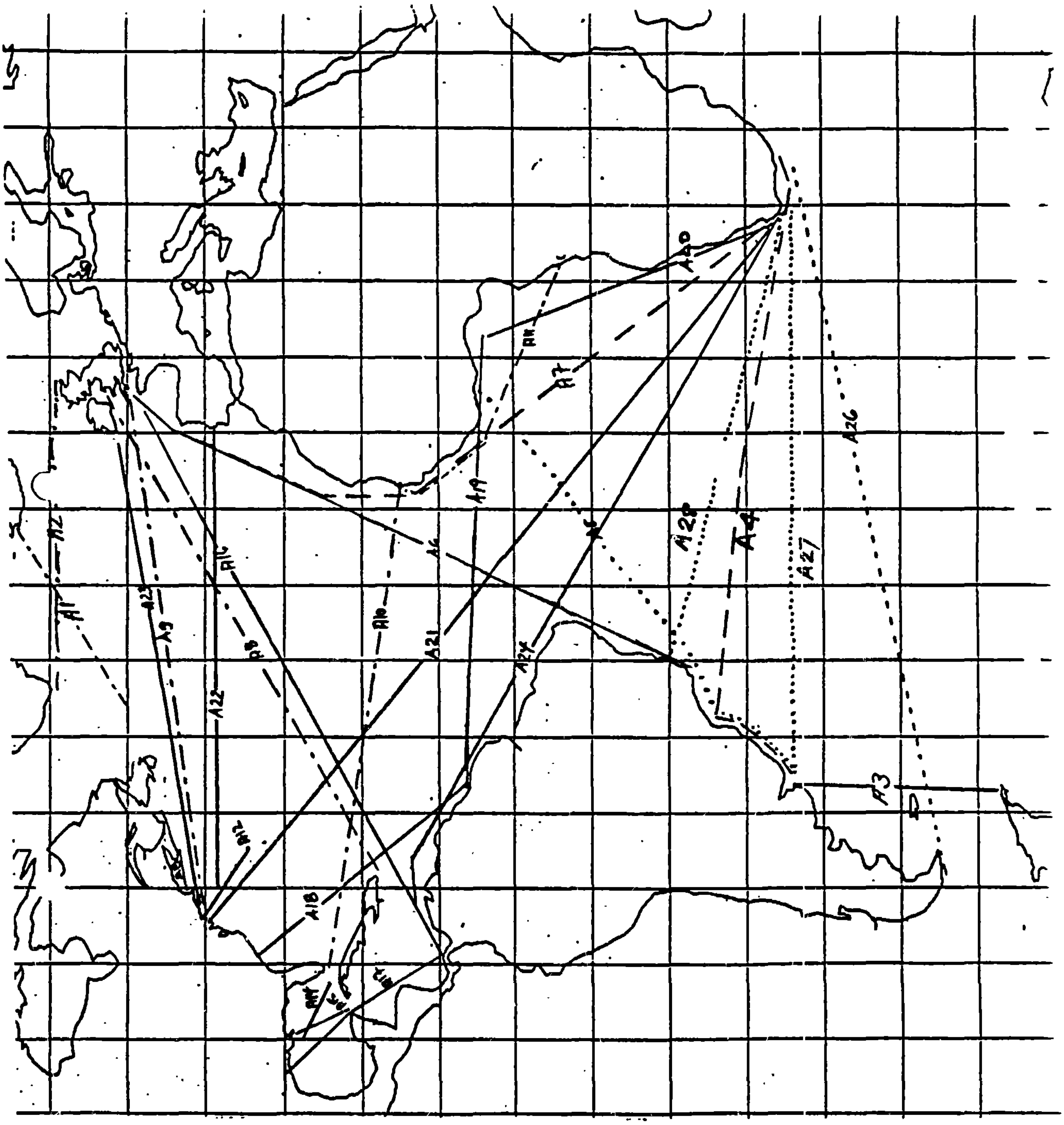

A3
A4
A20
A21
A22
A26
A27
A28

Table 7 Pacific Ocean Ship-of-Opportunity Lines

Operational

Country	Route	Frequency (trips/yr/vessel)	Vessel	Assitance Required	Organ.
Canada	Tokyo-Vancouver (P6)	12	Richmond Bridge	None	IOS/SIO
			Hakone Maru	None	IOS/SIO
			Tokyo Maru	None	IOS/SIO
	Vancouver-Sydney, Aust. (P3)	6	Lillooet	None	IOS/SIO/ ORSTOM
			Dilkara	None	IOS/SIO/ ORSTOM
Australia	Hobart-Japan	12	M.V. Meridian	None	CSIRO
	Freemantle-Singapore	8	M.V. Anro Australia	None	CSIRO
	Brisbane-Port Morsby/Honiara (P22)	12	M.V. Nimos	?	CSIRO
	Sydney-Panama (P12)	12	Act IV (GOVL)	None	CSIRO/ U.Sydney
			Act VI (GOVN)	None	CSIRO/ U.Sydney
			Act III(GZKA)	None	CSIRO/ U.Sydney
France	New Caledonia-Japan (P1)	5	Pacific Islander South Islander	2 xmitters	Orstom/ SIO
	Australia-Noumea-Hawaii-California (P3)	12	Lillooet, Paralla, Dilkara	1 xmitter	Orstom/ SIO
	New Caledonia-Tahiti-Panama (P5)	6	Rodin, Rostrand, Rousseau	3 xmitters	Orstom/ SIO
	Singapore-Japan (P11)				Orstom
	Tahiti-California (P4)	12	Polynesia	1 xmitter	Orstom/ SIO
	New Caledonia-Hong Kong (P1)	6	Jebsen Southland	1 xmitter	Orstom/ SIO
Ecuador /US	Guayaquil-Galapagos (P14)	24	M/V Bucanero	None	INOCAR
	Guayaquil-Japan- (P8)	12	M/V Isla Floreana	None	INOCAR
	Guayaquil-Chile				

Table 7 Pacific Ocean Ship-of-Opportunity Lines, Cont.

Operational

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required	Organ.
US	Long Beach-Hong Kong-Taiwan (P6/9)	12	Weser Express	None*	SIO
	Long Beach-Hong Kong-Taiwan (P6/9)	12	Elbe Express	None*	SIO
	US West Coast-Japan-Hong Kong-Taiwan (P6/9)	6	Korean Fir	None	FNOC
	US West Coast-Japan-Hong Kong-Taiwan (P6/9)	6	Korean Pride	None	FNOC
	US West Coast-Japan-Hong Kong-Taiwan (P6/9)	6	Pacbaron	None	FNOC
	US West Coast-Japan-Hong Kong-Taiwan (P6/9)	6	Pacbaroness	None	FNOC

Table 7 Pacific Ocean Ship-of-Opportunity Lines, Cont.

Operational

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required	Organ.
US	US West Coast-Japan-Hong Kong-Taiwan (P6/9)	6	Pacduke	None	FNOC
	US West Coast-Japan-Hong Kong-Taiwan (P6/9)	6	Pacduchess	None	FNOC
	US West Coast-Australia-New Caledonia-Pago Pago-Hawaii (P3/21)	12	Columbus Victoria	None	FNOC
	US West Coast-Australia-New Caledonia-Pago Pago-Hawaii (P3/21)	12	Columbus Virginia	None	FNOC
	US West Coast-Australia-New Caledonia-Pago Pago-Hawaii (P3/21)	12	Columbus Wellington	None	FNOC
	Gulf of Alaska		Justine Foss	None	NOS
	Trans-Pacific (P6/9)	6	Pacmerchant	None	FNOC
	Trans-Pacific (P6/9)	6	Pacstar	None	FNOC
	US West Coast-Panama-Europe (P13)	6	Annie Johnson	None	FNOC
	US West Coast-Panama-Europe (P13)	6	Antonia Johnson	None	FNOC

Table 7 Pacific Ocean Ship-of-Opportunity Lines, Cont.

Operational

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required	Organ.
US	US West Coast-Panama-Europe (P13)	6	Axel Johnson	None	FNOC
	US West Coast-Panama-Europe (P13)	6	Margaret Johnson	None	FNOC
	US West Coast-Panama-Europe (P13)	6	Columbia Star	None	FNOC
	US West Coast-Panama-Europe (P13)	6	San Francisco	None	FNOC
	San Francisco-Hawaii Alaska-Hawaii (P15)	3	Chevron California	None*	SIO
	Los Angeles-Tahiti (P4)	12	Polynesia	Trans.	SIO ORSTOM
	Hawaii-Micronesia Philippines-PNG (P10)	4	Micronesian Independence	Trans.	SIO ORSTOM
	Hawaii-Micronesia Philippines-PNG (P10)	4	Micronesian Commerce	Trans.	SIO ORSTOM
	Santa Barbara-Panama-Houston (P13)	12	Exxon Jamestown	Recorder Probes Trans.	SIO
US	California-Japan (P6)	12 RT	Hira Maru	None*	SIO
	California-Korea (P6)	12	Pacific Trader	None*	SIO
	California-Korea-Japan (P6)	12	Alaska Maru	None*	SIO
	Los Angeles-Seattle-Korea-Hong Kong (P6)	12	Hotaka Maru	None*	SIO
	California-Japan (P6)	12	Hakusan Maru	None*	SIO
	Seattle-Japan (P6)	12	Hakone Maru	None*	SIO
	California-Japan (P6)	12	Lionsgate Bridge	None*	SIO

Table 7 Pacific Ocean Ship-of-Opportunity Lines, Cont.

Operational

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required	Organ.
US	California-Japan (P6) California-Japan-Hong Kong	12	Hiei Maru	None*	SIO
	US West Coast-Japan (P6)	12	Shin Kashu Maru	None*	SIO
	US West Coast-Japan (P6)	12	Hikawa Maru	None*	SIO
	California-Japan-Hong Kong (P6)	12	Yamahsin Maru	None*	SIO
	Seattle-Japan (P6)	12	Tokyo Maru	None*	SIO
	Seattle-Japan (P6)	12	Richmond Bridge	None*	SIO
	California-Japan-Hong Kong (P6)	12	Pacific Arrow	None*	SIO
	US West Coast-Japan (P6)	12	Queensway Bridge	None*	SIO
	US West Coast-Japan (P6)	12	Asia Maru	None*	SIO
	US West Coast-Japan (P6)	12	American Maru	None*	SIO
	US West Coast-Korea (P6)	8	Pacific Sunshine	None*	SIO
	East Coast-Panama-Australia (P12/29)	6	Columbus Canterbury	None	FNOC
	East Coast-Panama-Australia (P12/29)	6	Columbus Louisiana	None	FNOC
	Worldwide (P7)	6	Nedlloyd Kembla	None	FNOC
	Worldwide (P7)	6	Nedlloyd Kimberly	None	FNOC
	Worldwide (P7)	6	Nedlloyd Kingston	None	FNOC
	Worldwide (P7)	6	Nedlloyd Kyoto	None	FNOC
	New Caledonia-Japan (P2)	5	Pacific Islander South Islander	2 xmitters	SIO/ORSTOM
	Aust-Noumea-Hawaii-California (P3)	6	Lillooet, Paralla Dilkara	1 xmitter	SIO/ORSTOM
	New Caledonia-Tahiti -Panama (P5)	6	Rodin, Rostrand, Rousseau	3 xmitters	SIO/ORSTOM
	New Caledonia-Hong-Kong (P1)	6	Jebsen Southland	1 xmitter	SIO/ORSTOM

Table 8 Pacific Ocean Ship-of-Opportunity Lines

Planned

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required	Organ.
France	Tahiti-Valparaiso (P29)	?	?	Probes	Orstom
US	Trans-Pacific (P6/9)	8	Pacprincess	None	FNOC
	Trans-Pacific (P6/9)	8	Pacprince	None	FNOC
	Trans-Pacific (P6/9)	8	Pac Emperor	None	FNOC
	Trans-Pacific (P6/9)	8	Pac King	None	FNOC
	Trans-Pacific (P6/9)	8	Pac Monarch	None	FNOC
	Los Angeles-Tahiti (P4)	12	Moana Pacific	Recorder Launcher	SIO ORSTOM

Table 9 Pacific Ocean Ship-of-Opportunity Lines

Proposed

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required	Organ.
Canada	Tokyo-Vancouver (P6)	12	(2 additional ships)		
	Vancouver-Sydney, Aust. (P3)	6	(2 additional ships)		
	Brisbane-Kitimat, B.C. (P27)	?	?	Probes	
Australia					
	Port Hedland-Japan (P23)	12	Australian Prospector		CSIRO
	Freemantle-Singapore	12	Anro Asia		CSIRO
Malaysia	Port Kelang-Singapore Kaoshiung-Keelung-Nagoya-Kobe-Tokyo (P27)	12	Bunga Melati	Recorder Launcher Probes Training	

Table 9 Pacific Ocean Ship-of-Opportunity Lines

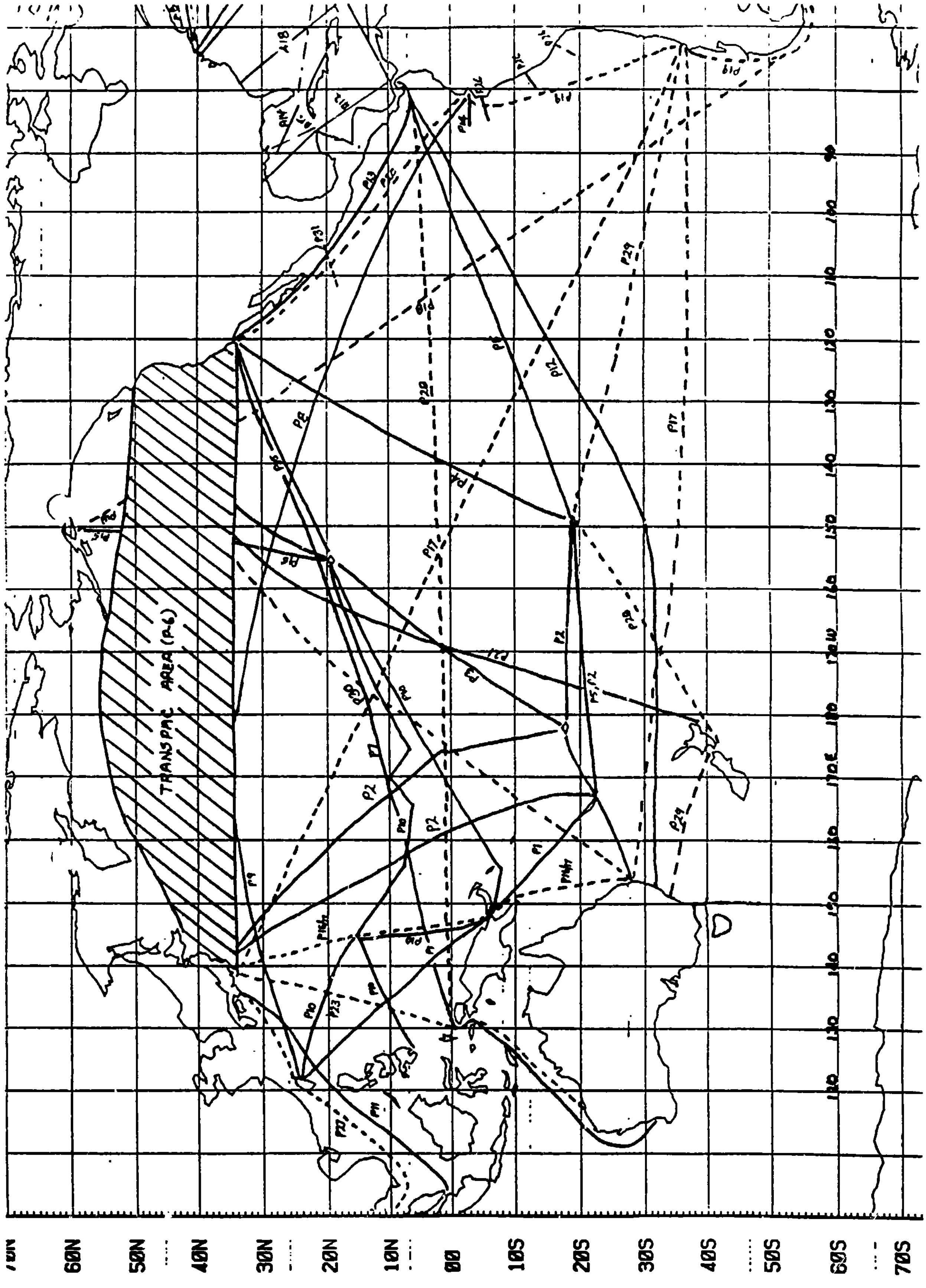
Proposed

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required
Chile	Valparaiso-Buenos Aires-Rio de Janeiro-Cape Town-Durvan-Buenos Aires-Valparaiso-Callao-Valparaiso (P19)	3	M/N Anakena	Recorder Launcher Probes Training
	Valparaiso-Buenos Aires-Rio de Janeiro-Cape Town-Durvan-Buenos Aires-Valparaiso-Callao-Valparaiso (P19)	3	M/N Angol	Recorder Launcher Probes Training
	Valparaiso-Antofagasta-Callao Guayaquil-Panama-Bristol (UK) Panama-Guayaquil-Callao-Valparaiso (P19)	4	Maipo	Recorder Launcher Probes Training
	Valparaiso-Antofagasta-Callao Guayaquil-Panama-Bristol (UK) Panama-Guayaquil-Callao-Valparaiso (P19)	4	Rubens	Recorder Launcher Probes Training
	Valparaiso-Guayaquil-Los Angeles-Yokohama-Los Angeles-South American ports-Valparaiso (P19/6)	4	Malleco	Recorder Launcher Probes Training
France	Tahiti-New Zealand (P28)	12	?	Recorder Launcher Probes

Table 9 Pacific Ocean Ship-of-Opportunity Lines, Cont.

Proposed

Country	Route	Frequency (trips/yr/ vessel)	Vessel	Assistance Required	Organ.
Chile	Valparaiso-Guayaquil-Los Angeles-Yokohama-Los Angeles-South American ports-Valparaiso (P19/6)	4	South Diamond	Recorder Launcher Probes Training	
US	Panama-Indonesia (P38)	18 RT		3 Recorders Probes	SIO ORSTOM
US	Valdez-Cape Horn (P18)	12 RT		3 Recorders Probes	SIO ORSTOM
Chile	Quintero-Huasco-Long Beach-Japan-Persian Gulf-Quintero (P6/19)	4	Vina del Mar	Recorder Launcher Probes Training	
	Valparaiso-Antofagasta-Callao-Guayaquil-Panama-Le Havre-Amberes-Rotterdam-Bremen-Hamburg (P19)	4 4	Valparaiso Presidente Banez	Recorder Launcher Probes Training	
	Valparaiso-Antofagasta-Callao-Guayaquil-Panama-Le Havre-Amberes-Rotterdam-Bremen-Hamburg (P19)	4	Presidenta Gonzales Videla	Recorder Launcher Probes Training	
	Valparaiso-Long Beach-Japan Korea-Japan-Long Beach-Valparaiso-(P19/6)	3	M/N Aranco	Recorder Launcher Probes Training	
	Valparaiso-Long Beach-Japan Korea-Japan-Long Beach-Valparaiso-(P19/6)	3	M/N Antofagasta	Recorder Launcher Probes	
	Valparaiso-Long Beach-Japan Korea-Japan-Long Beach-Valparaiso-(P19/6)	3	M/N Atacama	Recorder Launcher Probes	


TRANSPAC AREA (P-6)
60N
50N
40N
30N
20N
10N
00
10S
20S
30S
40S
50S
60S
70S

ANNEX VIII

SALINITY OBSERVATIONS

Doug McLain and Mike Miyake

In the past, IGOSS has concentrated on subsurface temperature profiles and the data are vital to understand changes in ocean circulation. In many areas of the ocean, however, subsurface temperature profiles do not well describe the density structure and salinity data are required. Similarly, on the surface, temperature observations are often insufficient to describe ocean fronts and boundaries. Many such features are better seen in salinity data than in temperature data. Substantial sampling of surface salinity and temperature from ships of opportunity is already being performed by ORSTOM in the Atlantic (MESTRA) and the Pacific Oceans (SURTROPAC). A next step in IGOSS is to begin thinking about how to make more salinity observations.

To inexpensively obtain salinity observations, two experimental salinity programmes are proposed: (1) vertical profiles and (2) horizontal, underway observations. Data from these programmes would be reported in real-time as TESAC and SHIPTRAK messages respectively. Initials tests would be made in the Gulf of Alaska - Bering Sea area because of the strong salinity gradients there and the failure of T-S relations to adequately determine density from temperature data alone.

A possible salinity profile device suitable for use on ships of opportunity is a mini-STD built in Canada and being tested along the British Columbia coast by the Institute of Ocean Sciences in Sydney, B.C. The device measures conductivity, temperature, and pressure and costs less than $5,000.00. The unit is about 4 inches in diameter and about 15 inches long. The unit can be calibrated to various accuracies but accuracies to +/- 0.05oC, +/- 0.05 0/00, and +/-0.1 m may be expected. In operation, the unit can be lowered by any available winch and cable system as the data values are sampled at programmable intervals and stored internally in random access memory. IOS is testing lowering the unit while underway and finds it possible to lower the unit to over 500m at speeds of 5 knots. Thus the unit could function similarly to a mechanical bathythermograph, reducing XBT probe costs as well as observing a salinity profile. Some software development has been carried out to make the STD units operational for IGOSS purposes with satellite link. The data is outputed to a Radio Shack TRS-80 Model 100 microcomputer to allow the operator to automatically generate TESAC messages. An initial experiment would be to install the mini-STD on several fishing boats along the coast and make trial profiles.

The second proposed experimental salinity programme is collection of underway surface temperature and salinity measurements. IOS has installed an underway TS log on the Friendship between the west coast and Japan. The data show abundant detailed structure, with fronts, boundaries, and filaments of high and low salinity water.

Additional vessels in the northeast Pacific would be equipped with underway T/S recorders as a test. Associated microcomputer equipment would control the observations, flag errors, format SHIPTRAK messages, and report the data via satellite. Initial maps of surface salinity would be made and distributed to interested scientists at research and fishery laboratories in the region. Research on the data could include study of variability of frontal temperature and salinity features, possible associated currents and convergence/divergence patterns, and comparison with fish migration routes.

ANNEX IX

RESPONSIBILITIES FOR THE INTERNATIONAL IGOSS OPERATIONS CO-ORDINATOR

1. To keep track of the ship-of-opportunity programmes wherever and whenever they occur.

2. To exchange information with the ship-of-opportunity programme managers as frequently as necessary by electronic mail, correspondence, telephone or visits.

3. To maintain a status report on existing lines, frequencies, call signs and other pertinent details and to communicate this information to programme managers at regular intervals.

4. To compare the data flow onto the GTS against the potentially available data and inform the the appropriate programme managers of any discrepancies.

5. Review ship-of-opportunity data for any recurring problems with transmission, quantity or quality of data and inform the appropriate programme manager of problem areas.

6. To advise national and international organizations as to the availability of, and requirements for ships of opportunity.

7. To arrange for regular reports to the international community at large on the status of the ship-of-opportunity programme and of interesting events and developments through the use of existing publications much as the WWW monthly bulletin and the TOGA TOPICS publication.

8. To make recommendations to the Joint Working Committee for IGOSS on improvements to the ship-of-opportunity network and data observations based on communications with the various programme managers.

In order to carry out the above tasks, the international co-ordinator will require assistance from national authorities and ship-of-opportunity programme managers in terms of information and responsiveness to identified problems. He will require regular and informed access and analysis of the data flow onto the GTS on a global and regional basis. This can only be achieved through the assistance of national and programme data centers.

He will require the expert assistance of scientists and programme managers in terms of contributions of articles and publications describing developments, changes and analyses of the ship-of-opportunity network.

ANNEX X

STANDARDS FOR DIGITAL SYSTEMS

In the past, many sub-surface temperature profiles were made in a relatively standard way due to the physical design and near-universal acceptance of the Sippican analog strip chart recorder. Now in the transition from analog to microcomputer-based recorders, IGOSS needs to start developing hardware and software standards for the new systems. Already in the United States, there are two designs of "SEAS" systems (Sippican 15P MK-9/HP-85/Sutron and Bathy Systems/HP-85/Synergetics) as well as the original Sippican MK-9 and FNOC modified MK-9 software. Oregon State University has developed XBT systems based on Commodore microcomputers which are now being used operationally by France and the United States. Co-ordination, maintenance and repair of these systems on many different vessels will become an increasing problem as the number of XBT systems increase globally.

Several possible standards for these systems are possible:

(1) Use of electronic industry standard interfaces between components of digital systems. The most common industry-standard is the RS 232 C serial interface and could be adopted as standard.

(2) Assurance that all programme codes be freely available and changeable to accommodate changing needs. Some of the programming for the United States SEAS systems is not in the "public domain" and not listable to the operator and thus cannot be modified. In particular, the algorithms for picking the significant data points and formatting the real-time messages should be standardized.

(3) Development of standard formats for data storage on ships of opportunity Proliferation of data storage formats can only lead to increasing confusion.

(4) Development of more "user-friendly" codes for shipboard digital systems. The amount of information required to be entered for each observation should be minimized (such as not asking the operator for the ship name for each observation). Different versions of the software should be abailable so that printed outputs and user-prompts are in the native languages of the crews on the ships.

(5) Automatic checking of the ship's speed since the previous observation. If the speed of the ship is unreasonable, the system should alert the operator to check the position or time data.

(6) Automatic checking of the temperature data to recognize, modify, or correct unreasonable temperature data due to XBT wire stretch or insulation failures. Profiles that contain erroneous temperature spikes or "tails", are being, transmitted and relayed globally via the GTS. Temperature spikes caused by the XBT wire touching the ships' hulls should be eliminated in a standard way.

ANNEX XI

SHIP-SHORE COMMUNICATIONS FOR USE IN SHIPS-OF-OPPORTUNITY XBT PROGRAMMES

International Maritime Mobile Service (coastal radio stations)

At present this is the most commonly used ship-shore communication means for the collection of marine meteorological reports as well as BATHY and TESAC reports from ships. These reports are defined by the ITU Radio Regulations as "meteorological radiotelegrams" and bear a paid service indicator "OBS". In this way, they enjoy an appropriate priority handling and in many countries a tariff reduction. Costs for the reception of reports are paid by the receivers, i.e. National Meteorological Services or in rare cases by National Oceanographic Services. Reports received at National Meteorological Centres (NMCs) are inserted onto the WMO Global Telecommunications System (GTS) for global exchange.

The weakness of this service is the increasing traffic congestion, particularly in HF bands and difficulties in clearing ships' messages in a timely fashion. The network of coastal radio stations accepting BATHY/TESAC reports is not adequate in certain sea areas, particularly in the tropical belt and southern hemisphere. The number of coastal radio stations accepting weather and BATHY/TESAC reports is as follows:

Number of Coastal Radio Stations Accepting Weather Reports and BATHY/TESAC Reports

		Weather Reports only	BATHY/TESAC
Region I	(Africa)	53	11
Region II	(Asia)	44	21
Region III	(South America)	26	6
Region IV	(North and Central America)	61	52
Region V	(South-West Pacific)	29	4
Region VI	(Europe)	100	21
	Total	313	116

INMARSAT

INMARSAT (International Maritime Satellite Organization) was formed to provide the satellite system to improve maritime communications and started its operation in February 1982. The reliability of this mobile satellite communications services is now well proved. In September 1985 about 4,000 ships are equipped with INMARSAT communication terminals termed "Ship Earth Stations (SESs), a number increasing by about 80 per month. Twelve INMARSAT Coast Earth Stations (CESs) are in operation, of which five accept ships' weather reports only and two accept both ships' weather reports and BATHY/TESAC reports, these are CESs at Santa Paula and Southbury (both USA) (see Appendix for the system configuration and global coverage).

The trend is that the traditional ship-shore communications through coastal radio stations are shifting toward the INMARSAT communications, particularly for long-distance high-sea communications. Also in September 1985, about 350 voluntary observing ships are equipped with SESs and transmit weather reports through INMARSAT by telex. The experience so far has shown a greater efficiency of transmission, particularly when a special addressing code 41 (meteorological messages) is used. It is expected that the same will apply to oceanographic reports (BATHY/TESAC reports) in the near future. The charging practice is the same as the traditional Maritime Mobile Service, i.e. the recipient of the reports bears the cost of messages. However, in order that INMARSAT may be used widely for the collection of BATHY/TESAC reports the number of CESs accepting these reports should increase.

Geostationary Meteorological Satellites

Certain geostationary meteorological satellites have data collection capabilities from mobile platforms. Automatic observing and transmission systems, such as SEAS developed in the USA, installed aboard ships employ these capabilities for the transmission for bathythermal reports. The great advantage of such communication means is the realiability, no transmission congestion and no cost for reception.

Argos System

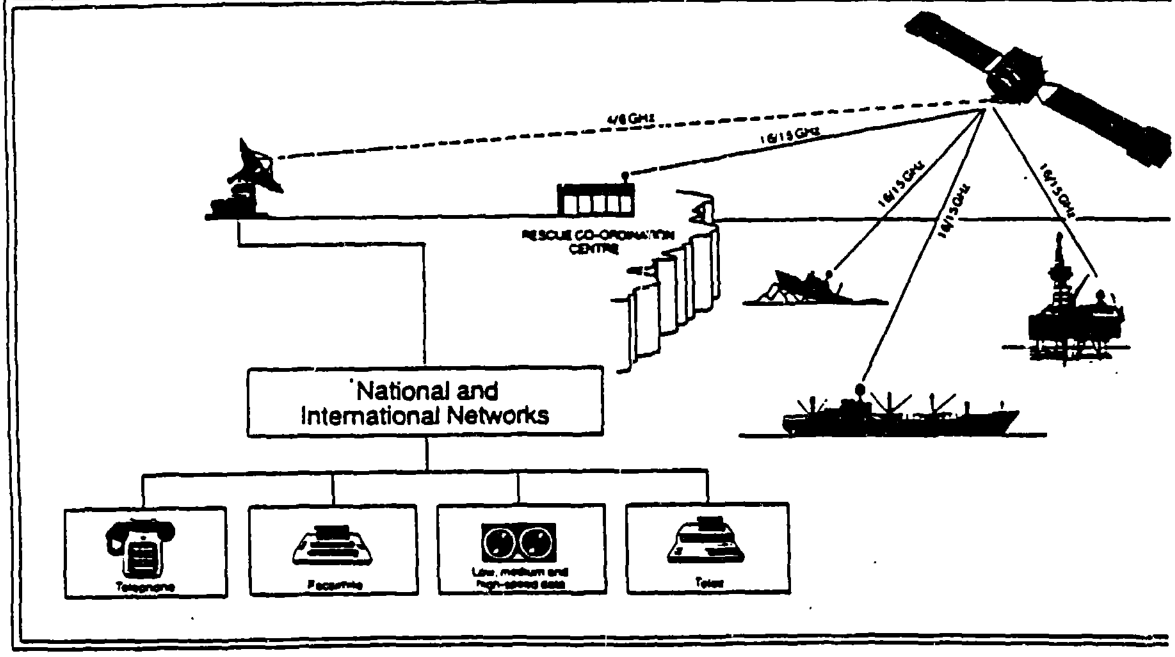
The Argos system is primarily designed to locate fixed or mobile platforms and to collect environmental data from these platforms. The system is a co-operative programme between the Centre National d'Etudes Spatiales (CNES, France), The National Aeronautics and Space Administration (NASA, USA) and the National Ocean and Atmospheric Administration (NOAA, USA). The system is expected to provide an operational service for the entire duration of the TIROS/NOAA satellite programme, that is until 1990 at least.

Within the WMO and IOC programmes, the Argos system has been used for the collection of ships' weather reports and drifting buoy data in code forms FM 13-VIII SHIP and FM 14-VIII DRIBU. Service Argos will improve its programme also to accept bathythermal reports in code form FM 63-VIII BATHY. On the other hand, an inexpensive Argos-based system designed by Oregon State University has been used since 1982 for automatically transmitting XBT in the Pacific Ocean XBT programme (see D.L. Cutchin and others, Annex IV).

The cost of transmission is included in the annual tariff for deploying an Argos Platform Transmittal Terminal (PTT) for which the full service (platform location and data collection) costs 2,400 French francs, in the case of a ship-of-opportunity only the data collection service is required and this costs one-fifths of the full service, i.e. US $ 60 a year by contracting with Service Argos through the Joint Tariff Agreement sponsored by WMO and IOC.

INMARSAT

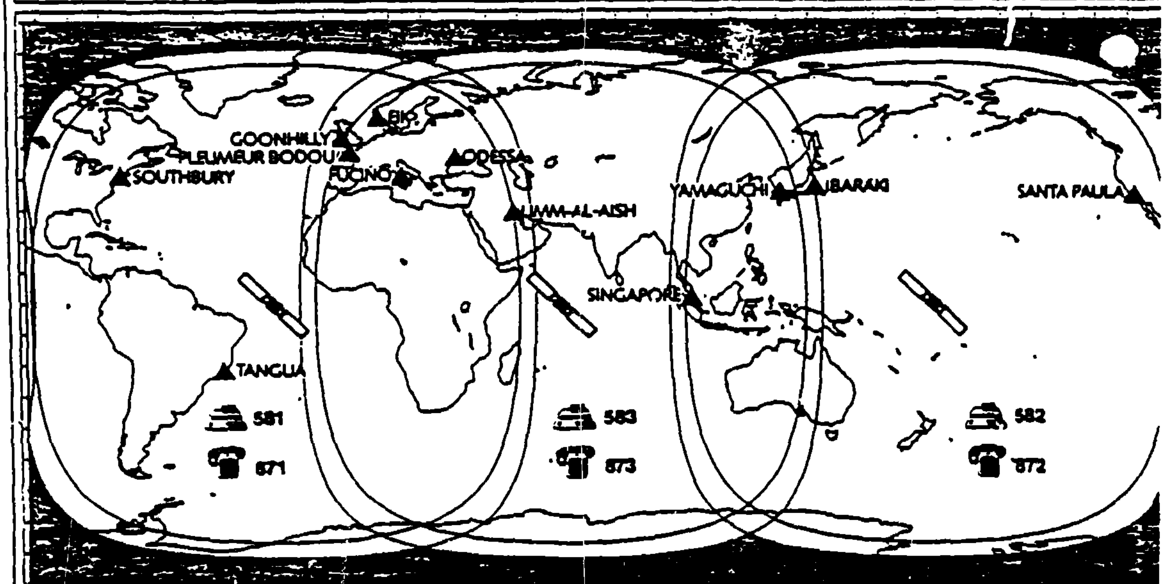
FIGURE 1 SYSTEM CONFIGURATION



INMARSAT

FIGURE 2 GLOBAL COVERAGE

Satellite coverage at 0° and 5° angles of elevation of ships' antennas



OCEAN REGION CODE (TELEX) OCEAN REGION CODE (TELEPHONE)
SATELLITE LOCATION: AOR 26° W, IOR 63° E, POR 177.5° E ▲ COAST EARTH STATIONS IN OPERATION JANUARY 1986