Intergovernmental Oceanographic Commission
Reports of Meetings of Experts and Equivalent Bodies

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

Hobart, Tasmania, Australia, 23-26 March 1993

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In this Series, entitled

Reports of Meetings of Experts and Equivalent Bodies, which was initiated in 1984 and which is published in English only, unless otherwise specified, the reports of the following meetings have already been issued

1. Third Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
2. Fourth Meeting of the Central Editorial Board for the Geological/Geophysical Atlases of the Atlantic and Pacific Oceans
3. Fourth Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' *(Also printed in Spanish)*
4. First Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
5. First Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
6. First Session of the Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
7. First Session of the Joint CCOP(SOPAC)-IOC Working Group on South Pacific Tectonics and Resources
8. First Session of the IODE Group of Experts on Marine Information Management
9. Tenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies in East Asian Tectonics and Resources
10. Sixth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
11. First Session of the IOC Consultative Group on Ocean Mapping *(Also printed in French and Spanish)*
12. Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ships-of-Opportunity Programmes
13. Second Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
14. Third Session of the Group of Experts on Format Development
15. Eleventh Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
16. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
17. Seventh Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
18. Second Session of the IOC Group of Experts on Effects of Pollutants
19. Primera Reunión del Comité Editorial de la COI para la Carta Batimétrica Internacional del Mar Caribe y Parte del Océano Pacífico frente a Centroamérica *(Spanish only)*
20. Third Session of the Joint CCOP/SOPAC-IOC Working Group on South Pacific Tectonics and Resources
21. Twelfth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of South-East Asian Tectonics and Resources
22. Second Session of the IODE Group of Experts on Marine Information Management
23. First Session of the IOC Group of Experts on Marine Geology and Geophysics in the Western Pacific
24. Second Session of the IOC-UN(OETB) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources *(Also printed in French and Spanish)*
25. Third Session of the IOC Group of Experts on Effects of Pollutants
26. Eighth Session of the IOC-UNEP Group of Experts on Methods, Standards and Intercalibration
27. Eleventh Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans *(Also printed in French)*
28. Second Session of the IOC-FAO Guiding Group of Experts on the Programme of Ocean Science in Relation to Living Resources
29. First Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
30. First Session of the IOCARIBE Group of Experts on Recruitment in Tropical Coastal Demersal Communities *(Also printed in Spanish)*
31. Second IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
32. Thirteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asia Tectonics and Resources
33. Second Session of the IOC Task Team on the Global Sea-Level Observing System
34. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean and Overlay Sheets
35. Fourth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
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39. Fourth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
40. Fourteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
41. Third Session of the IOC Consultative Group on Ocean Mapping
42. Sixth Session of the Joint IOC-WMO-CCPS Working Group on the Investigations of 'El Niño' *(Also printed in Spanish)*
43. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
44. Third Session of the IOC-UN(OALOS) Guiding Group of Experts on the Programme of Ocean Science in Relation to Non-Living Resources
45. Ninth Session of the IOC-UNEP Group of Experts on Methods Standards and Intercalibration
46. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico
47. First Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
48. Twelfth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
49. Fifteenth Session of the Joint CCOP-IOC Working Group on Post-IDOE Studies of East Asian Tectonics and Resources
50. Third Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
51. First Session of the IOC Group of Experts on the Global Sea-Level Observing System
52. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Mediterranean
53. First Session of the IOC Editorial Board for the International Chart of the Central Eastern Atlantic *(Also printed in French)*
54. Third Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico *(Also printed in Spanish)*
55. Fifth Session of the IOC-UNEP-IMO Group of Experts on Effects of Pollutants
56. Second Session of the IOC Editorial Board for the International Bathymetric Chart of the Western Indian Ocean
57. First Meeting of the IOC *ad hoc* Group of Experts on Ocean Mapping in the WESTPAC Area
58. Fourth Session of the IOC Consultative Group on Ocean Mapping
59. Second Session of the IOC-WMO/IGOSS Group of Experts on Operations and Technical Applications
60. Second Session of the IOC Group of Experts on the Global Sea-Level Observing System
61. UNEP-IOC-WMO Meeting of Experts on Long-Term Global Monitoring System of Coastal and Near-Shore Phenomena Related to Climate Change
62. Third Session of the IOC-FAO Group of Experts on the Programme of Ocean Science in Relation to Living Resources
63. Second Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
64. Joint Meeting of the Group of Experts on Pollutants and the Group of Experts on Methods, Standards and Intercalibration
65. First Meeting of the Working Group on Oceanographic Co-operation in the ROPME Sea Area
66. Fifth Session of the Editorial Board for the International Bathymetric and its Geological/Geophysical Series
67. Thirteenth Session of the IOC-IHO Joint Guiding Committee for the General Bathymetric Chart of the Oceans *(Also printed in French)*
68. International Meeting of Scientific and Technical Experts on Climate Change and Oceans
69. UNEP-IOC-WMO-IUCN Meeting of Experts on a Long-Term Global Monitoring System
70. Fourth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes
71. ROPME-IOC Meeting of the Steering Committee on Oceanographic Co-operation in the ROPME Sea Area
72. Seventh Session of the Joint IOC-WMO-CPPS Working Group on the Investigations of 'El Niño' *(Spanish only)*
73. Fourth Session of the IOC Editorial Board for the International Bathymetric Chart of the Caribbean Sea and the Gulf of Mexico *(Also printed in Spanish)*
74. UNEP-IOC-ASPEI Global Task Team on the Implications of Climate Change on Coral Reefs
75. Third Session of the IODE Group of Experts on Marine Information Management
76. Fifth Session of the IODE Group of Experts on Technical Aspects of Data Exchange
77. ROPME-IOC Meeting of the Steering Committee for the Integrated Project Plan for the Coastal and Marine Environment of the ROPME Sea Area
78. Third Session of the IOC Group of Experts on the Global Sea-level Observing System
79. Third Session of the IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials
80. Fourteenth Session of the Joint IOC-IHO Guiding Committee for the General Bathymetric Chart of the Oceans
81. Fifth Joint IOC-WMO Meeting for Implementation of IGOSS XBT Ship-of-Opportunity Programmes

IOC-WMO/IGOSS-XBT-V/3
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1. ORGANIZATION OF THE MEETING

1.1 OPENING OF THE MEETING

1 The Fifth Joint IOC-WMO Meeting for Implementation of the Integrated Global Ocean Services System (IGOSS) XBT Ship-of-Opportunity Programmes was opened by Commodore John Leech, Vice-Chairman of the Joint IOC-WMO Committee for IGOSS at 2:00 p.m., 23 March 1993, at the CSIRO Marine Laboratories in Hobart, Australia.

2 Commodore Leech welcomed the participants on behalf of Prof. Dieter Kohnke, Chairman of IGOSS. He noted that the primary activity of IGOSS is the collection and acquisition of near real-time oceanographic data. There is no point in developing sophisticated communications and data management systems if there is no data available. The ocean thermal data that forms the majority of data collected by the Ship-of-Opportunity Programme is essential to many users both in real time and in delayed mode. The applications of this data to scientific research and commercial use is expanding rapidly. The Ship-of-Opportunity Programme is one of the most important components in the IOC and WMO's work towards understanding and predicting the behaviour of the oceans. For this reason the meeting has a major role to play in the continuing development of marine science.

3 The IGOSS Ship-of-Opportunity Programme (SOOP) has been underway as an internationally co-ordinated effort since the first meeting of this group in Seattle, Washington, in 1985. The Programme evolved through the integration of various national and international efforts to support scientific and marine monitoring programmes. In particular the ocean thermal data requirements for the Tropical Ocean Global Atmosphere (TOGA) programme was a catalyst for using merchant ships to deploy XBT probes. Given the increasing interest in global ocean phenomenon, it became obvious that no country could undertake global monitoring, and also the necessary data coverage required more ships than are available within the oceanographic community. The only solution to the problem of collecting *in situ* observations was to use additional platforms such as commercial shipping. This approach has proven to be very successful as shown by the number of agencies and countries participating in the programme and represented at this meeting.

4 In Australia, a number of agencies are involved in the Ship-of-Opportunity Programme. In particular, the CSIRO Division of Oceanography is the instigator, organiser and main institution involved in the Australian effort. It is appropriate therefore that this meeting is being held in Hobart. The Bureau of Meteorology and the Royal Australian Navy also provide support.

5 The Royal Australian Navy has a long and unique involvement with both IGOSS and the Ship-of-Opportunity Programme. Back in the early 1980's, the RAN, through the Hydrographer, began its participation and became the first Navy that routinely transmits real-time BATHY messages resulting from the deployment of XBT's. This has resulted in an annual contribution to IGOSS of over 2,000 observations per year in what is generally a data sparse region.

6 In addition to this, the RAN through the Australian Oceanographic Data Centre (AODC) has contributed approximately 2,000 XBT probes to the CSIRO Division of Oceanography for use in their Ship-of-Opportunity Programme. AODC staff also greet the ships when they visit Sydney, providing additional probes, collecting the data and solving minor system problems. The RAN will continue this level of involvement with IGOSS.

7 The need for programmes, such as SOOP, is expanding. Furthermore, with the implementation of the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the World Ocean Circulation Experiment (WOCE), greater coverage and more regular sampling of the ocean's thermal structure are needed. To support this in Australia, efforts are already underway to develop strategies that will assist the implementation of the GOOS.

8 It is therefore important that this meeting addresses the crucial issues facing it and continues to build the observing networks and data processing, quality control and communications elements of the programme. The introduction of new instrument technologies and new manufacturers places an additional burden on existing systems. New approaches need to be found. For example, the Global Temperature and Salinity Pilot Project (GTSPP) is using a number of new techniques to successfully increase both the timeliness of data availability and the quantities of data available. Monitoring exercises have demonstrated considerable success. The standardization of quality control methods is also an important topic for discussion.

9 Dr. Angus McEwan, Chief of CSIRO Division of Oceanography, welcomed the participants to the marine laboratories on behalf of CSIRO and wished them an enjoyable stay in Tasmania.

10 Mr. Timothy Wright, IGOSS Operations Co-ordinator, on behalf of the IOC and WMO, welcomed the participants and thanked the Government of Australia and the CSIRO for hosting the meeting. He noted that there has been significant progress made in equipment, data quality control and monitoring methods. With the beginning of GOOS, it is now necessary to evaluate the role of IGOSS and to assess how well we are fulfilling the needs of the users of IGOSS data. It is very important that we provide the best information and services possible with our limited resources.

11 The List of Participants is given in Annex II of this Report.

1.2 ELECTION OF THE CHAIRMAN

12 Mr. Rick Bailey of CSIRO was proposed as Chairman by the Representative of the United States of America. The nomination was seconded by Representatives from Germany and France. The Meeting unanimously supported the nomination.

1.3 ADOPTION OF THE AGENDA

13 The Meeting reviewed the Agenda and decided to discuss items 3.1 and 3.2 together as item 3.1 and renumbered agenda item 3.3 accordingly. It also decided to consider agenda item 3.3 in conjunction with items 3.3.1 and 3.3.2. The Agenda, as adopted by the Meeting, is reproduced in Annex I.

1.4 WORKING ARRANGEMENTS

14 The Meeting adopted the work programme proposed by the local secretariat and agreed to adjust it as necessary.

2. REQUIREMENTS FOR SUB-SURFACE THERMAL DATA

15 The discussion on Agenda Item 2 was opened by Mr. Bailey.

16 Mr. Timothy Wright presented a review of the status and latest developments in the progress of the Global Ocean Observing System. He noted that the approach to GOOS would be the operational data collection, data analysis, exchange of data and products along with the technology development and transfer and capacity building required for a global system. The System would utilize both remotely sensed and *in situ* data which would be implemented through nationally-owned and operated services and facilities. The observations should be:

(i) Long-term;
(ii) Systematic;
(iii) Relevant to the Global System;
(iv) Cost-effective;
(v) Routinely made.

17 The modules of GOOS, of which IGOSS is a very important one, should represent the user interests and applications and be inter-related (i.e. share observations and facilities). The data should be made available to numerical models for predictions on all time scales for global, national and regional use.

18 The initial emphasis of climate monitoring, assessment and prediction would be the inter-annual variability, particularly the ENSO phenomenon. The phases of GOOS implementation are:

(i) The Planning Phase;
(ii) Operational Demonstration in each Module;
(iii) Gradual Implementation of the permanent system;
(iv) Continued Assessment and Improvement.

19 The national actions proposed are:

(i) Establish national committees;
(ii) Strengthen national ocean institutions;
(iii) Accelerate data collection activities;
(iv) Make existing and new data available;
(v) Establish National GOOS contact.

20 He also noted that as a component of the Integrated Global Ocean Observing system, the Ship-of-Opportunity Programme was making a major contribution and is a prime example of how the observations should be made and how the data should be shared. One of the best ways to support the development of GOOS is for national programmes to increase their support to programmes such as IGOSS and the Ship-of-Opportunity Programme.

21 Dr. Gary Meyers, CSIRO, presented the WOCE/TOGA XBT requirements. The impacts of Pacific ENSO events are evident, for example in the effects on Australian rainfall. The recently developed coupled ocean-atmosphere models, which are initialized by SOOP XBT data, along with wind and SST predict the rainfall effects with a high level of skill. The WOCE/TOGA Programme requires increased sampling in both the Indian, Atlantic and Southern Oceans. One of the more important parameters that also needs to be considered, is salinity to help estimate currents and transports. Salinity measurements are particularly needed in the North Atlantic to determine long term inter-decadal changes.

22 The Meeting thanked Dr. Meyers for his informative talk. The Meeting recommended that more salinity observations should be recorded on SOOP ships. In addition, the development of simpler methods to measure salinity and SST should be encouraged. Thermosalinographs have produced more, better quality data than the bucket method. In addition, the cost/benefit ratio of thermosalinograph sampling to bucket samples is significant. It was noted with pleasure that there are six thermosalinograph lines proposed or operating. The Meeting encouraged the real-time transmission of this data.

3. SHIP-OF-OPPORTUNITY ACTIVITIES PRESENT AND FUTURE

3.1 STATUS OF EXISTING, PLANNED AND PROPOSED LINES

23 Mr. Rick Bailey introduced this agenda item.

24 Reports were submitted by experts from the following Member States: Australia, Canada, Germany, France, United Kingdom and the United States. These reports are included in Annex III.

25 The Meeting recommended that the GOOS Planning Committees consider the SOOP and XBT sampling programmes as very high priority. With the end of the TOGA programme, there should be a plan to continue the surface and sub-surface sampling at the present levels until the GOOS objectives are firmly determined. The long-term time series should not be interrupted. The participants were asked to give an idea of their future plans. It was apparent that a lot of the programme would cease to operate at the end of 1994 unless a decision is made by the end of 1993 to continue to provide future funding for these programmes.

26 The sampling design strategies developed by the TOGA/WOCE community should continue to be adopted. National programmes were asked to provide line usage projection for the next two-three years (see Annex IV). TOGA operators were encouraged (if not already doing so) to extend TOGA lines to cover WOCE areas should funding permit.

27 It was noted by the Meeting that significant progress has been made in the co-operation of national navies such as Germany and Australia in releasing and declassifying data within two weeks. These developments will contribute significantly to the IGOSS database. The Meeting encouraged other countries to consider co-operation with IGOSS in this manner. The Meeting also appreciated the participation and insertion of fisheries bathythermograph data in real-time. It encouraged other fisheries activities to also participate in this manner.

28 Another most important factor is the co-operation of the crews and officers of the various merchant ships involved in collecting this data. It was recommended that some means of recognition by the IOC be provided for the outstanding work performed by the members of this part of the programme.

29 It was also recommended that operators of the lines should examine the delayed mode data as soon as received in order to discover any problems as soon as possible.

30 The Meeting supported proposals for future expansions in the Indian and South Atlantic Oceans to help fulfill the TOGA/WOCE requirements.

3.2 MANAGEMENT OF THE SHIP-OF-OPPORTUNITY PROGRAMME INCLUDING DATA FLOW MONITORING AND COMMUNICATIONS

3.2.1 Monthly Ship Visit Reports

31 Mr. Timothy Wright, IGOSS Operations Co-Ordinator, introduced this agenda item and gave the status of present monitoring activities being conducted. The role of the Operations Co-ordinator in assisting communications and monitoring of data flow problems through an international organization was addressed. He gave a presentation on IGOSS data monitoring. There are many monitoring efforts being undertaken. There needs to be co-ordination between the various types of activity. At the last meeting in Washington D.C. it was decided to revise the monthly ship report in order to provide a more meaningful format. We now have the beginning of a monthly report which approaches the objectives requested by the WOCE IPO to monitor the sampling on the TWI lines. However there are limitations and problems to this monitoring scheme. It is very difficult to develop an accurate algorithm to specify the location of an XBT drop by TWI line. The question of the width of a line or corridor for specification of drops was discussed. From the information that we have now, it was recommended that we examine our existing lines and ensure that we are optimizing our resources. The Meeting recommended that a delayed mode report would better serve this purpose and is most effectively issued on a six month basis. The proposed format is attached as Annex V.

32 It was proposed that a new real-time monitoring scheme be implemented to consist of data from the Specialized Oceanographic Centres (SOC) to determine whether the Global Telecommunications System (GTS) is successfully relaying data to the appropriate centres. The Meeting recommended that the SOCs be requested to send the number of drops to Mr. Noe by call sign for each ship that they received data for the month by the tenth of the following month in a specific format. The format is attached in Annex VI.

3.2.2 Global Temperature-Salinity Pilot Project

33 The Meeting noted the efforts of the Global Temperature Salinity Pilot Project and recognized the importance of this report as a tool in discovering problems in near real-time.

34 Mr. Bruce Sumner of the Australian Bureau of Meteorology gave a presentation on the GTS for real-time transmission of bulletin reports. It was noted that the most important aspects of monitoring this data is to know the national contact at the GTS centre serving a national programme. The importance of the switching tables and the fact that some centres are source sensitive was very illuminating. It is extremely important to go through the local GTS centres when trying to locate data transfer failures as these failures must be tracked down from the receiving centre back through the system towards the source.

35 The Meeting thanked Mr. Sumner for a very informative talk. It recommended that a local GTS expert be invited to future meetings to update the group and answer questions.

4. EQUIPMENT: INFORMATION ABOUT NEW DEVELOPMENTS (XBT'S, XCTD's, THERMOSALINOGRAPHS)

36 This agenda item was opened by Mr. Rick Bailey noting that, in addition to new equipment, there are also new versions of existing equipment that need to be examined. Presentations were given on the XCTD, thermosalinographs, multiple XBT launchers and new software.

37 Mr. Chris Noe discussed the latest developments of the INMARSAT-C transmission system. Standard C offers several advantages for the transmission of environmental data because it is low cost, allows many transmissions per day, is not limited by report length, and will be installed on most major commercial vessels by 1995. The Meeting was encouraged by the potential use of this system in the future.

38 Mr. Jim Hannon, Sippican, gave a presentation on the latest developments of the XCTD. He provided the following information:

XCTD Design Improvements

(i) Data telemetry that is sent up the BT wire has been changed to reduce noise and improve accuracy.

(ii) Conductivity cell electrodes have been modified to eliminate bubbles.

(iii) Calibration Baths use the MK-12 to minimize calibration noise.

(iv) MK-12 Software has been modified to operate with all high speed 486 PCs.

39 There are still problems in the development of the instrument and they are not yet ready for production. More tests incorporating several modifications will be held in the near future by Sippican and the TT/QCAS. The Meeting recommended that the TESAC (KKXX) message should be modified to designate the instrument type and fall rate equation for the XCTD. In addition, XCTD data should not be transmitted in real time until the instrument has been proven.

5. DATA QUALITY

5.1 QUALITY CONTROL: AUTOMATED SYSTEMS ABOARD SHIP

40 Mr. Rick Bailey, Chairman of the IGOSS Task Team on Quality Control for Automated Systems opened this agenda item with a brief overview of the history of the Task Team. He then made presentations on the following activities of the Task Team (see Annex VIII):

(i) The Bowing Problem;

(ii) Sippican MS-DOS IEEE Timing Problem:

(iii) XBT Fall Rate;

(iv) New XBTs, XCTD's, equipment, etc.

A scientific paper on the T7/T4/T6 XBT fall rate will soon be produced by the Task Team and published in the literature.

41 A recommendation to change the BATHY code has been drafted by the TT/QCAS for the JJXX BATHY message. The recommendation is included as Annex VII. A similar modification is required for the TESAC (KKXX) message. The TT/QCAS is working on this modification.

42 An evaluation of the fall rates for probes produced by other manufacturers has also been undertaken by members of the TT/QCAS. The modified Spartan T-7 is yet to be fully evaluated. The TT/QCAS is working on a comparison of Spartan and Sippican T-7s. Concern was raised that the Task Team was beginning to be asked to be a certifying body and not an evaluation body.

43 The Meeting recommended that the GOOS should consider a committee similar to the CIMO of the World Weather Watch to evaluate operational instruments and procedures.

44 The Meeting also recommended that manufacturers of equipment contact users when modifications are made or problems are found with equipment. Mr. Hannon mentioned that, when problems with equipment are discovered, a message is put on the Oceans Bulletin Board of OMNET.

45 Dr. Savi Narayanan reported on an evaluation of the performance of XBTs on the continental shelf off eastern Newfoundland which revealed that XBT temperature profiles could have significant depth offsets that vary randomly from profile to profile. This error appears to have been caused by a delay in starting the data flow from the probe to the computer after the probe impacts the water surface, and is unrelated to the drop equation error identified previously. When the profiles were adjusted by applying a uniform depth offset estimated from CTD data, the depth error was significantly reduced, in most cases, to levels within the manufacturer's specifications. An examination of the temperature profiles from a long-term monitoring station off Newfoundland (STATION 27) indicates that this depth offset could be a major contributor to the noise in the data.

46 The discussion following this presentation indicated that a mismatch of the e-prom chip in the XBT deck unit and the Sippican's software may be a major contributor to the start-up delay; the XBT systems distributed by Sippican when they first made the conversion from HP-based units to PC-based systems have been found to have a random start-up delay.

47 The Meeting recommended that the manufacturers of SOOP equipment should inform ALL CLIENTS when a problem is identified; electronic bulletin is not the best method to inform clients, since many small organizations such as National Sea in Canada may not have any reason to check the bulletins on a regular basis. Also, manufacturers should keep a list of the clients and send them newsletters summarizing such information.

5.2 QUALITY CONTROL PRIOR TO GTS INSERTION, MINIMUM REQUIREMENTS, THE QUIPS SYSTEM AND OTHER QUALITY CONTROL EQUIPMENT

48 Mr. Mike Szabados discussed the quality control monitoring used by the SEAS programme to monitor the real-time data. When the ships are visited, there are checks on the equipment, a spot check of the data and procedures. He provided a display of the NOS QC software and procedures. There is no means of flagging that QC has taken place at this time. Some data is quality controlled and some is not depending on its point of origin.

49 The Meeting recommended that no official WMO oceanographic bulletins should be taken from the GTS, modified and reinserted.

50 Dr. Alexander Sy reviewed his QC routine. He is developing a routine to despike profiles onboard vessels after data collection and quality control. It is an interactive system where data is edited on the computer screen. Coding and transmission errors are checked for data received from other German institutions. Delayed mode data is the main focus and it is quality controlled very carefully. The routines are similar to those used for CTD data. Data is sent to Dr. Jean-Paul Rebert at the TOGA/WOCE data centre in Brest.

51 Mr. Pierre Rual discussed the real-time and delayed mode QC performed by ORSTOM Noumea. Automatic onboard QC is made prior to the BATHY message transmission to ARGOS. ARGOS also screens the message for obvious errors at the reception level prior to insertion on the GTS. All incoming delayed mode data is manually quality controlled.

52 Mr. Rick Bailey reviewed CSIRO quality control procedures. QC of real-time data is performed onboard prior to satellite transmission using the same procedures developed by ORSTOM/ARGOS. When the data is collected from the ship and brought back to the lab, the full resolution XBT data is immediately processed. The data processing consists of a quality control procedure which checks for position/speed of vessel, common malfunctions, regional oceanographic features, and calibration probe temperatures. The data is also compared against Levitus and CSIRO track line climatologies. The data is edited to remove start-up transients to 3.9m, flagged for common malfunctions and oceanographic features, and classed by depth. Mr. Bailey demonstrated the CSIRO interactive/visual display QC processing system at the laboratories.

6. TEMA-RELATED COMPONENTS

53 This agenda item was introduced by Mr. Timothy Wright.

54 It is very important that developed countries support developing countries in training, education and mutual assistance. A very good example of this type of co-operation can be seen in the recent co-operation between the US and Nigeria in the development of an XBT programme and the sampling of a line between Nigeria and Brazil. The IOC through its contacts can be helpful in this type of co-ordination.

7. CLOSURE OF THE MEETING

55 The Meeting recommended that to ensure good participation at future meetings, the IOC should urge Member States to support the attendance of SOOP managers and operators, data centre and communications personnel, and experts by providing funds for travel and to co-ordinate this activity through the IOC. This is required to support the exchange of information concerning the important work performed by the programme in this important GOOS module.

56 The Chairman, Mr. Rick Bailey, expressed his thanks to CSIRO and its staff, and the Secretariat of the IOC for their excellent support and facilities for the meeting.

57 Mr. Timothy Wright, on behalf of the Secretariat, expressed the thanks of the IOC and WMO for Mr. Bailey's excellent chairmanship and to all the Representatives of Member States for making this meeting productive and successful in its tasks.

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   - 3.1 STATUS OF EXISTING, PLANNED AND PROPOSED LINES
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ANNEX II

LIST OF PARTICIPANTS

I. EXPERTS FROM MEMBER STATES

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ANNEX III

NATIONAL REPORTS ON SHIP-OF-OPPORTUNITY ACTIVITIES

The following pages contain national reports on ship-of-opportunity activities submitted by the following countries:

AUSTRALIA

CSIRO Division of Oceanography

1. INTRODUCTION

Australia's economic well-being is intimately linked to climate fluctuations, with periods of severe drought or extensive flooding having a negative effect on economic activity. The occurrence of such fluctuations is largely controlled by the temperature of ocean waters north of Australia. For example, the severe drought of 1982-83 was linked to sea surface temperature changes in the western equatorial Pacific Ocean (the 1982-83 El Nino). Australia's rainfall is also strongly affected by the sea surface temperature in the eastern Indian Ocean.

The geography of the "heat pool" to the north of Australia is characterised by changes in location of its temperature maximum over thousands of kilometres on seasonal and interannual time scales. Details of the geography are known to have statistical relationships to the occurrence of the abovementioned climate anomalies, but the physics underlying these relationships is not well understood.

Because of thermal inertia, temperature in the heat pool varies relatively slowly, and acts as a memory in the coupled ocean-atmosphere system. Consequently, ocean temperature can be used as a predictor of rainfall anomalies, either as direct input into statistical models or in the initialisation of numerical/dynamical coupled general circulation models. In either prediction scenario, model development must be preceded by process studies to identify the physics of ocean temperature change. An increase in the accuracy of climate predictions on seasonal to interannual time scales will have a significant impact on the ability of society and the economy to adjust to climate variation. Of particular importance will be the ability of primary industry to plan for anomalous conditions in coming seasons. In the longer term, improved information on regional climate change over decades is required by both government and industry. Accurate ocean models can also be applied usefully in shipping, fishing, air-sea rescue, and defence related activities.

1.1 Objectives

The main objectives of the CSIRO Ocean Observing Networks are to provide large-scale spatial and temporal data coverage of relevant ocean basins in support of several of the research projects within the CSIRO Division of Oceanography's Climate Research Program. The specific research goals are:

a) Document ocean temperature in the heat pool north of Australia, and to evaluate the relative importance of surface heat fluxes, advection, and mixing processes to the thermodynamics of the region. As part of this goal it is necessary to document the variability of the major geostrophic currents in the tropical Indian Ocean on seasonal and interannual time scales, and to evaluate their role in changing sea surface temperature.

b) Understand sea level's response to El Nino Southern Oscillation (ENSO) events by examining combined sea level and subsurface ocean temperature data in the eastern Indian Ocean and south west Pacific Ocean.

c) Measure the transport of mass, heat and salt in the surface layers by the major geostrophic currents in the eastern tropical Indian Ocean, south west Pacific Ocean and Southern Ocean, and to determine the role of these currents in climate change.

d) Form a basis for the design and development of an operational National Ocean Observing System as part of the proposed Global Ocean Observing System (GOOS).

2. VOLUNTARY OBSERVING SHIP NETWORK

In order to measure the transport of mass, heat, and salt in the surface layer of the ocean and the storage capacity of the surface layer for heat and salt, it is necessary to carry-out repeated measurements of global upper ocean variability. These must be taken at both intra- and inter-annual time scales, and the only feasible way to carry out this program is to use volunteer merchant ships that are frequent carriers on particular routes. The practical objective of the Volunteer Observing Ship (VOS) Network is to collect the full suite of in situ measurements of ocean temperature, salinity, and absolute velocity from volunteer ships on a routine basis. This is done in two ways, either as broadscale sampling through volunteer observers launching XBTs (expendable bathythermographs) and XCTDs (expendable conductivity, temperature, and depth instruments) to determine general circulation and upper ocean heat and salt content, or by high-resolution (high-density) sampling along exactly-repeated sections with scientists or oceanographic technicians on board to make the extra measurements required to determine large-scale velocity and geostrophic current transport variations in the ocean.

The CSIRO VOS Network using voluntary observers began operation in 1983. It is operated from a centre in Hobart, with ship-greeting activities in the major ports around the nation. It is the major observing network in the Indian Ocean. The high-density sampling program began in the Tasman Sea and Coral Sea region at the beginning of 1991, and in the Southern Ocean in the austral summer of 1992-93. The high-density sampling program is proposed to expand into the eastern Indian Ocean in 1994 (subject to funding).

The CSIRO activity is closely coordinated with major international research programs. In particular, the CSIRO program contributes significantly to the Tropical Ocean Global Atmosphere (TOGA) project and the World Ocean Circulation Experiment (WOCE) of the World Climate Research Program (WCRP). The CSIRO Division of Oceanography has taken a leading role in both TOGA and WOCE since their beginnings.

A corner-stone for both international projects has been the implementation of an international ocean observing network which can provide the observational data needed for process studies, and for model development and initialisation. Global coverage of the oceans is a key requirement for both projects, and a coordinated international effort has helped to achieve this goal. As a TOGA and WOCE contribution, the CSIRO Voluntary Observing Ship program is expected to continue to operate until at least the end of TOGA and WOCE (1995-97).

2.1 Coverage

Figure 1 shows the lines recently and presently in operation. Due to a permanent change in general merchant ship routing on line IX–9, this line continues to be only sampled north of the latitude of Sri Lanka as no regular shipping exists between Fremantle and Sri Lanka. The lines in the Southern Ocean (CS-1, CS-2, CS-3) are operated by Antarctic supply vessels, and operate only during the austral summer months. Lines PX-30/31, PX-34, PX-35 and CS-2 are high-density XBT lines.

Figure 2 shows the location of all XBT stations which have been processed, edited, and accepted at CSIRO from the start of the program in 1983 to the end of 1992. The total does not include XBTs that have failed (approx.7%). Figure 3 shows those XBTs accepted for 1992 only, whilst Table 1 gives the total number of XBTs (including failures), good XBTs, sections, and number of bathy reports sent over the Global Telecommunications System (GTS) in real-time for 1992. Wherever possible, lines are sampled at the sampling frequencies and spacings as determined by extensive optimal sampling studies[1,2,3], as adapted and recommended by the TOGA Implementation Plan (Feb, 1990).

Surface salinities are being collected with surface sample buckets along the high-density line PX-34.

2.2 Support and Cooperation

The field program has been a very large undertaking. Although viewed by the Division as necessary in the national interest, it has been too large for the Division to accomplish with its own resources. The strategy for funding from the outset has been to gain resources from several national and international agencies, while maintaining scientific direction and management of the program under the control of research oceanographers. This strategy has proven to be extremely successful, to the point that now nearly 4000 ocean soundings will be made each year.

Table 2 shows the contributors of XBTs to the CSIRO VOS Network during 1992. Unfortunately, the Royal Australian Navy (RAN) was only able to provide 500 of its projected support of 2000 XBTs during 1992 due to a supply shortage.

The Australian Bureau of Meteorology (BOM), the Australian Oceanographic Data Centre (AODC), and the CSIRO Division of Fisheries help the Division of Oceanography by forwarding supplies to participating merchant ships through personnel located in the major ports. The Australian Bureau of Meteorology also assists by paying for the cost of transmitting the bathy reports via satellite for insertion onto the GTS. This data is used in Bureau of Meteorology Research Centre (BMRC) objective mapping routines for the Pacific and Indian Oceans, as well as by the National Meteorological Centre (NMC) in the U.S.A. for initialisation of their climate prediction model.

Line IX-22/PX-1 1 is being operated in conjunction with the Japan Meteorological Agency (JMA). The high density line PX-30/31 is being operated in conjunction with the Scripps Institution of Oceanography (SIO). CSIRO and SIO each operate this line twice per year. Line CS-2 is operated in conjunction with ORSTOM, with XBTs and recording equipment supported by both the French Polar Institute (FPI) and the CSIRO. At present, no funding source has been identified for the continuation of lines CS-1 and CS-3 for austral summer 1993-94.

2.3 Equipment Design and Development

In recent years, CSIRO has extensively upgraded all of the equipment on its merchant ships to Sippican MK-9/Lap-Top configured XBT systems. The software was extensively re-written for the voluntary observer environment. Figures 4 and 5 show examples of the operator menu and temperature profile display respectively. The XBT systems are also interfaced to CLS ARGOS satellite transmitters to enable the relay of bathy data in near real-time. The data undergoes filtering and general quality control checks, as designed for the ARGOS XBT system, before it is sent via satellite for insertion onto the GTS for distribution to scientists and climate prediction centres around the world. A number of problems continue to plague the GTS and ARGOS relay station, but with the help of communication engineers at the BOM the problems are being overcome.

The prototype SIO XBT automatic-launcher has been installed on merchant ships utilised in the high-density program. This is a device which can automatically deploy up to six XBTs at predetermined times. CSIRO is modifying the software and hardware of the unit for eventual operation in the volunteer observer environment, and to also incorporate the Sippican MK-12 card to allow deployment of XCTDs in the future.

Deployment of a thermosalinograph on an high-density line has been delayed until 1994 due to other commitments. A sensor unit designed by the Division Of Oceanography has been especially modified for installation on merchant vessels. This unit has the capability for measuring temperature, salinity, dissolved oxygen, pH, and turbidity. CSIRO intends to work closely with ORSTOM in Noumea on this project, learning from their previous experiences of deploying thermosalinographs on merchant ships.

2.4 Equipment Evaluations

CSIRO will continue to test and evaluate equipment deployed for the research program to ensure its accuracy and integrity. All such tests and evaluations will be coordinated with and submitted to the Integrated Global Ocean Services System (IGOSS) Task Team for Quality Control of Automated Systems (TT/QCAS).

Work continues on evaluating the accuracy of XBTs and XBT data acquisition systems, including an evaluation of the fall rate equation of the XBT. This work has contributed to the work of the XBT Fall Rate Study Subgroup of the TT/QCAS, and a joint paper on the findings is soon to be published. A study is also underway on evaluating the accuracy and reliability of Sparton XBTs. CSIRO has participated in the evaluation of the Sippican XCTD, including field trials on the R.V. *Franklin* .

2.5 Volunteer Observer Relations

Considerable effort is put into maintaining good public relations with the voluntary observers and shipping companies. Each ship is visited on every return to an home Australian port so that new supplies can be forwarded, data collected, instrumentation checked, and most importantly, so that good public relations through feedback and attention to observer requirements are maintained. Also, each ship is visited by a scientist involved in the research program at least once per year, although generally more often than this. The success of the program is a measure of the generous and high level of quality support from the voluntary observers and the shipping companies.

2.6 Data Management and Quality Control

Quality Control (QC) of XBT data at the delayed mode stage is closely supervised by research oceanographers participating in the program. A flow chart of the QC procedures is shown in figure 6. The vertical profiles are checked on a voyage basis for common malfunctions, regional oceanographic features, drop to drop consistency along the ship track, and repeat drops of unusual features (which we encourage our observers to take). The data are also checked against a climatology based on the data collected by ships participating in the CSIRO Ship-of-Opportunity Program. An archive of profiles with unusual features observed along the different lines is used in the QC process. The features are checked with CTD data as opportunities arise.

An interactive editing routine has been set up on the in-house mainframe (UNIX System) computer to edit the data. QC decisions on common malfunctions and real oceanographic features are flagged on the data set . The data is further classed (1-4) by depth according to the type of flag associated with the data. Class 1 data is good data. Class 2 data has unusual features, but they are considered to be probably real. Class 3 data has features considered to to be most likely the result of instrument malfunctions and not real features. Class 4 data is obviously erroneous data.

The data is stored in three archives. The first archive contains the unedited, full resolution, raw data as collected from the merchant ships. The second archive consists of the edited, full resolution data (Class 4 removed). The third data archive has the data condensed to a 2 metre format (Class 3 removed). This third data archive is the archive used in scientific analysis, and for the transfer of data to other organisations and the global data centres on a yearly basis.

Quality control of the data is considered to start by providing the voluntary observers with continual feedback on why they are collecting the data as well as the results obtained. The two-way communication between observers and researchers inevitably leads to a more carefully collected and generally higher quality data set.

Plans are well underway between CSIRO, Australian Bureau of Meteorology (BOM), and the Australian Oceanographic Data Centre (AODC) concerning the formation of the WOCE Upper Ocean Thermal Data Assembly Centre (UOT/DAC) for the Indian Ocean. During 1992 training began of AODC staff in the data processing procedures developed and used by the CSIRO. Although the BOM and the AODC already jointly operate the Specialised Oceanographic Centre for the Indian Ocean and South Pacific region, the idea of the WOCE UOT/DAC is to involve research scientists in the quality control of XBT data to produce a "scientifically" quality controlled data set for WOCE. The principle quality control procedures developed by CSIRO are also to be implemented by the WOCE UOT/DAC's for the Atlantic and Pacific Oceans.

2.7 VOS Network Research Highlights

2.7.1 Seasonal Variation of Geostrophic Transport Relative to 400db in the Eastern Indian Ocean

Expendable bathythermograph (XBT) sampling to 400m depth began in 1983 on the routes from Shark Bay (Australia) to Sunda Strait and from Singapore to Torres Strait, and in 1986 on the route from Port Hedland to Japan. The data collected through 1989 have been used to estimate longterm mean and mean seasonal variation of geostrophic current transports relative to 400 db (using climatological temperature-salinity relationships). This area forms an important link between the waters of the Pacific and Indian Ocean, and is little understood.

The long-term mean, relative transport is 5.2 x 10^6 m^3/s westward on the Sunda Strait line. A comparison of this result to transports calculated from historical hydrographic data shows good agreement, and shows how the 400 m transports are related to circulation at deeper levels. Transport on the Torres Strait line is 4.9 x 10^6 m^3/s southward. A map of the individual currents on the three lines (see figure 7) indicates a coherent pattern of Indonesian Throughflow. Seasonally, the net westward relative transport through the Sunda line varies from 12 x 10^6 m^3/s in August/September, when easterly winds in the region are strong, to nearly zero in May/June, when eastward flow in the South Java Current is strong. The South Java Current has a distinct semiannual variation related to wind-forced, semiannual currents in the equatorial region. Southward transport on the Torres Strait line is strongest (10 x 10^6 m^3/s) in May/June at the time when westward transport on the Sunda Strait line is weakest. Thus the region between the Indonesian Archipelago and North-west Australia acts during the seasonal cycle as a buffer between the Pacific and Indian Oceans, accumulating upper layer water from the Pacific during the austral summer; then releasing it to the Indian Ocean during winter.

The results were compared with the Semtner and Chervin[4] ocean general circulation model and show excellent agreement on the Sunda line.

2.7.2 Transports of the Major Current Systems in the Tasman Sea

A key objective of the World Ocean Circulation Experiment (WOCE) is to estimate the mean and time variations of geostrophic mass transport and the associated fluxes of heat and salt. Observational studies have to include contributions from spatial scales ranging from the mesoscale to ocean gyres in order to accurately estimate the mean circulation. Whereas data from the large scale sampling networks can be useful, they are not sufficient. An high resolution network with closely spaced profiles (10 to 40 km) is required to resolve the narrow boundary currents adjacent to continental shelves and to minimise the aliasing of smaller scale features such as eddies and fronts (see figure 8). Depth coverage to at least 800m is required. Sampling of the salinity profile by expendable conductivity probes (XCTDs) is needed in addition to temperature profiles recorded by expendable bathythermographs (XBTs) to resolve large scale variations in the temperature/salinity relation.

Oceanographic observers have been repeatedly placed on commercial shipping to carry out the required high resolution sampling of the major current systems in the Tasman Sea region as part of WOCE Core Project 1. This sampling has been maintained quarterly since April 1991 on the sections Brisbane-Fiji-Auckland-Wellington-Sydney (called the "Tasman Box"). The high resolution XBT transects have provided snapshots of the synoptic geostrophic circulation which have a signal-to-noise ratio in the upper kilometre that is comparable to that of surveys carried out with research vessels. The XCTD is still being tested and is in its protracted infancy.

Data from the above transects and climatological temperature/salinity relations have been used to estimate the vertical profile of transport of the East Australian Current (EAC), a major western-boundary current, and the geostrophic mass divergence in the Tasman Sea Box. The main inflow is the EAC on the Brisbane-Fiji section (see figure 9). The main outflow is in a series of fronts north of New Zealand on the Fiji-Auckland section. A large part of the EAC first flows southward past Sydney, but then most of the flow recirculates northward across the Wellington-Sydney section to join the fronts north of New Zealand. The total flow in April 1991 showed a net divergence of mass which may be related to directly wind driven (Ekman) currents.

The ongoing research will examine the seasonal and interannual variations of the major currents in the region. Such currents are important in the transfer of heat in the climate system away from equatorial region, and thus variations in these currents have impacts on the variability observed in the climate system.

2.7.3 1991-92 ENSO Event

During the austral summer of 1991-92 an ENSO event was observed in the Pacific, the effects climate system being felt globally. The CSIRO VOS Network successfully observed the associated variations in the sea surface temperatures (SST) to the north of Australia in the heat pool region (see figure 10), and collected valuable data for ongoing research into the associated effects in the Indian Ocean. The data collected by the network and relayed via satellite was used by many scientists around the world in monitoring and predicting this particular ENSO event.

3. SEA-LEVEL NETWORK

For many years tide gauges have been operated along coasts and on islands to monitor changes in sea-level. The most obvious sea-level changes are the short period effect of tides and storm surges. On much longer time scales are the geological influences on sea-level, such as the emergence of land areas after ice age retreat and the slow movements of the tectonic plates. The intermediate region of the spectrum, however, contains the fluctuations in sea-level related to weather systems, changes in ocean circulation, and short term climatic variations such as El Nino-Southern Oscillation (ENSO) phenomenon. It is these phenomena that we wish to understand.

During 1984/85 the CSIRO Division of Oceanography extended an international network of sea-level gauges in the equatorial Pacific into the region to the north of Australia. The network has recorded year-to-year variations of mean sea-level of as much as 40 cm over large areas, as well as establishing the potential for monitoring ocean currents by means of sea-level differences. It is planned to maintain the CSIRO tide gauges for the 10-year duration of the Tropical Ocean and Global Atmosphere (TOGA) program (ie until the end of 1995). Discussions have begun with the Australian National Tidal Facility (NTF) and the University of Hawaii with regards to the continued maintenance and operation of the CSIRO established network beyond this time.

3.1 Coverage

Altogether there are 14 gauges in the CSIRO network (see figure 11). In the western Pacific, sea-level stations have been installed at 7 sites around Papua New Guinea: Port Moresby, Alotau, Lae, Madang, Wewak, Manus Island, and Kavieng. Sea-level stations have also been installed at Norfolk Island and Lord Howe Island in the Tasman Sea, Granville Harbour (west coast) and Spring Bay (east coast) of Tasmania, on the Cocos (Keeling) Islands, Christmas Island (Indian Ocean), and at Pelabuhan Ratu, South Java. Unfortunately the last station is no longer operational.

3.2 Recorders

The tide gauges (Leopold and Stevens analog-digital recorders) are similar to those which have been in use for at least 100 years. They employ a system in which a float senses the water level within a stilling well. This is simply a long tube with a small orifice at its base to allow the passage of water to and from the outside it acts as a high frequency filter to damp out wave motion. Tides can be measured over a range of 10 m with an accuracy of 1 mm and are recorded on punched paper tape at 15 minute intervals. Timing is controlled by a quartz crystal oscillator. The recorders are powered by rechargeable 12 volt dry cell batteries. A pressure gauge was installed in conjunction with the stilling well type gauge at Granville Harbour as part of a comparison study of the two types of systems. The sea level stations are serviced and re-levelled by CSIRO scientists and engineers at least once every two years, with the Papua New Guinea, Cocos and Christmas Island gauges being serviced during 1992.

3.3 Calibration

At each location a local tide observer is responsible for day-to-day maintenance and supervision of the gauge. The operator's main task is, a vital one in terms of ensuring high quality data, is to make regular comparisons of the instrument reading of sea-level with that indicated by an adjacent visual tide staff that has been fixed into the appropriate national levelling grid. We are indebted to the good work of the local tide observers, and also in many cases we are indebted to the support of their organisations which include local Marine and Harbours Boards and research institutions.

Electronic datum monitors have been designed and developed at the Division of Oceanography for later installation at the sea level stations pending further trials.

3.4 Data Processing

The observer sends the tape to Hobart each month for processing. As part of the processing the data are compared with predicted sea levels to reveal errors. These include datum changes, timing errors and missing data. After correction the data are low-passed filtered to remove the tidal signal (see Figure 9). As longer time series have built up it has become possible to identify seasonal and interannual fluctuations in the signal. Difficulties with the transfer of the data processing software to the new main-frame computer at the laboratories has caused delays in the processing of the 1992 data. It is hoped this will be rectified during 1993 when new data editing software is in place and the transfer complete. When this is achieved the annual transfer of the data to the Global Sea Level Centre in Hawaii will resume.

3.5 Sea Level Network Research Highlights

3.5.1 Sea -Level Response to the 1986-87 ENSO Event in the Western Pacific in the Vicinity of Papua New Guinea.

Sea-levels at the Papua New Guinea coast responded to the 1986-87 ENSO event much as would be expected for points on the inshore edge of a western boundary current driven by remote sea level disturbances (see figure 11). Sea-level estimates from tide gauges and adjacent XBT's were in good agreement, and so XBT data was used to supplement sea-level results; specifically, an estimate of the western boundary current as a function of depth was obtained.

The anomalous current transport through Vitiaz Strait varied by about 15 x 10^6 m^3/s during the event, with possibly more following the eastern New Ireland coast. The western boundary current response appears to be all located equatorward of the inflow feeding it. The boundary current followed the Trobriand Island ridge, rather than the main Papua New Guinea coastline, and appears to bifurcate along southern New Britain. A maximum response to the ENSO occurred south of New Ireland, where steric sea level appeared to vary up to 45 cm due to the ENSO event; this may be an inertial feature.

This research is important in understanding the thermodynamics of the heat pool in the western Pacific Ocean; an area which is crucial in the development of ENSO events.

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TABLE 1

1992 CSIRO Voluntary Observing Ship Line Summary

Line	CallSigns	#Sections	#Drops	#Good	#Xmitted*
PX-2	9VUU VJBQ	20	427	398	376
PX-5	VJDP VJDI	6	193	184	155
PX-30	A3CA	2	174	167	0*
PX-32	GYRW GYSA	7	86	75	33
PX-34	GYRW GYSA VNGL VNGZ	5	339	321	35*
PX-35	GYRW	2	102	101	0*
IX-1	S6FK	25	583	553	528
IX-9	9VBZ 9VWM	12	211	196	184
IX-12	GYSA GYSE GYRW	15	708	668	606
IX-22/ PX-11	VJDI VJDP	8	370	333	295
CS-1	VNAA	1	40	35	0*
CS-2	FHZI	2	116	53	?
CS-3	????	1	48	39	0*
TOTALS:			3397	3123	2212

NOTES:
* In some cases numbers transmitted are approximates only. Some high density XBT runs have not been able to transmit due to a lack of a transmitter and appropriate software. When high density lines have transmitted it is not guaranteed that all messages will reach the satellite, and hence GTS, as a result of the number of samples compared to the number of satellite overpasses.

CALL SIGNS:
9VUU = ANRO ASIA
VJDP = IRON PACIFIC
VJDI = IRON NEWCASTLE
VNAA = AURORA AUSTRALIS
A3CA = FUA KAVENGA
GYSE = NEDLLOYD TASMAN
GYRW = ENCOUNTER BAY
???? = ICEBIRD
VJBQ = ANRO AUSTRALIA
VNGL = IRON FLINDERS
VNGZ = IRON DAMPIER
FHZI = L'ASTROLABE
S6FK = SWAN REEFER
GYSA = FLINDERS BAY
9VBZ - AUSTRALIA STAR (EX MAHSURI)
9VWM = NEW ZEALAND STAR (EX MANDAMA)

TABLE 2

1992 XBT Support for CSIRO VOS Network

CSIRO	1800
Royal Australian Navy	500
NOS/NOAA	600
Japan	300
France	200
TOTAL	3400

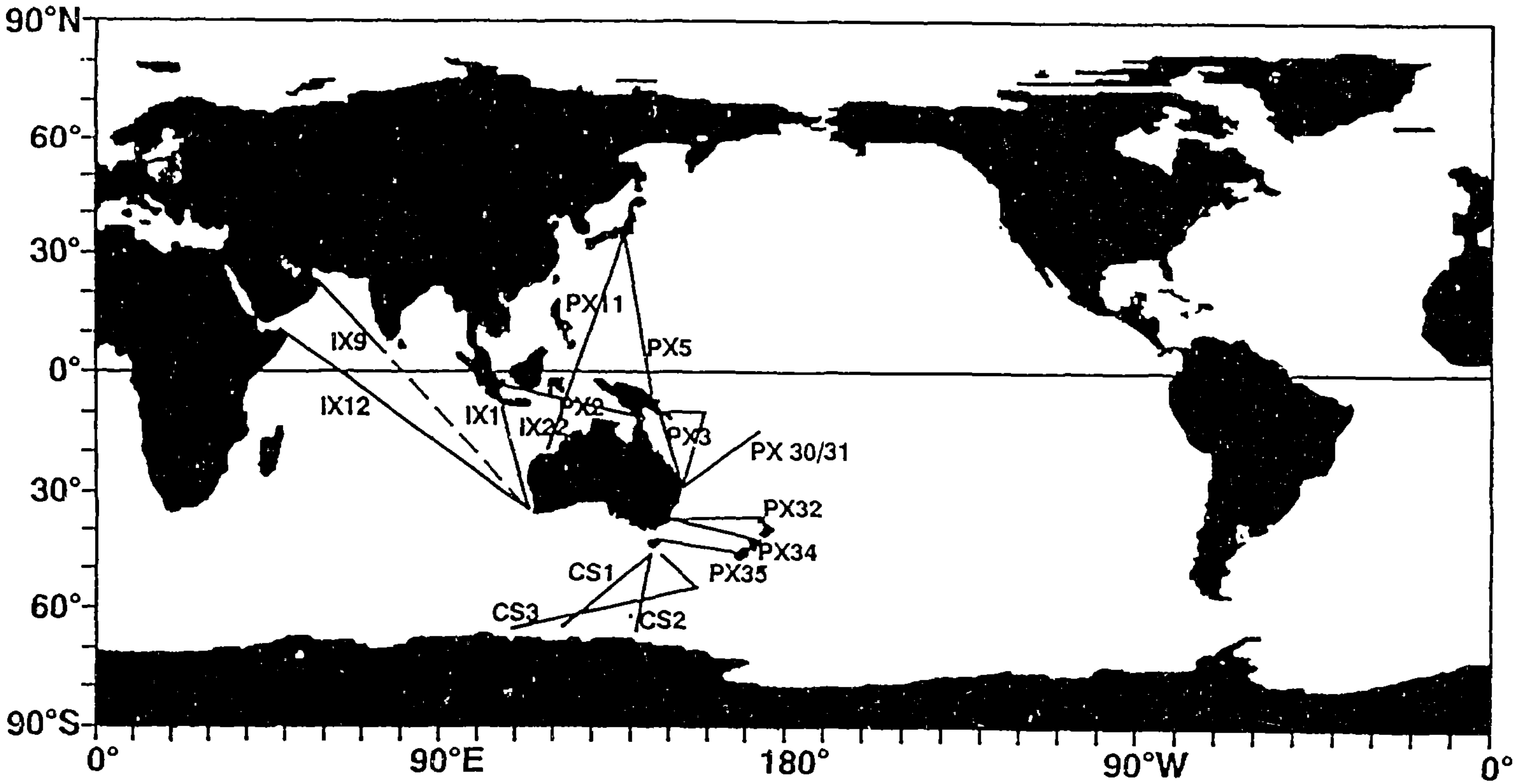
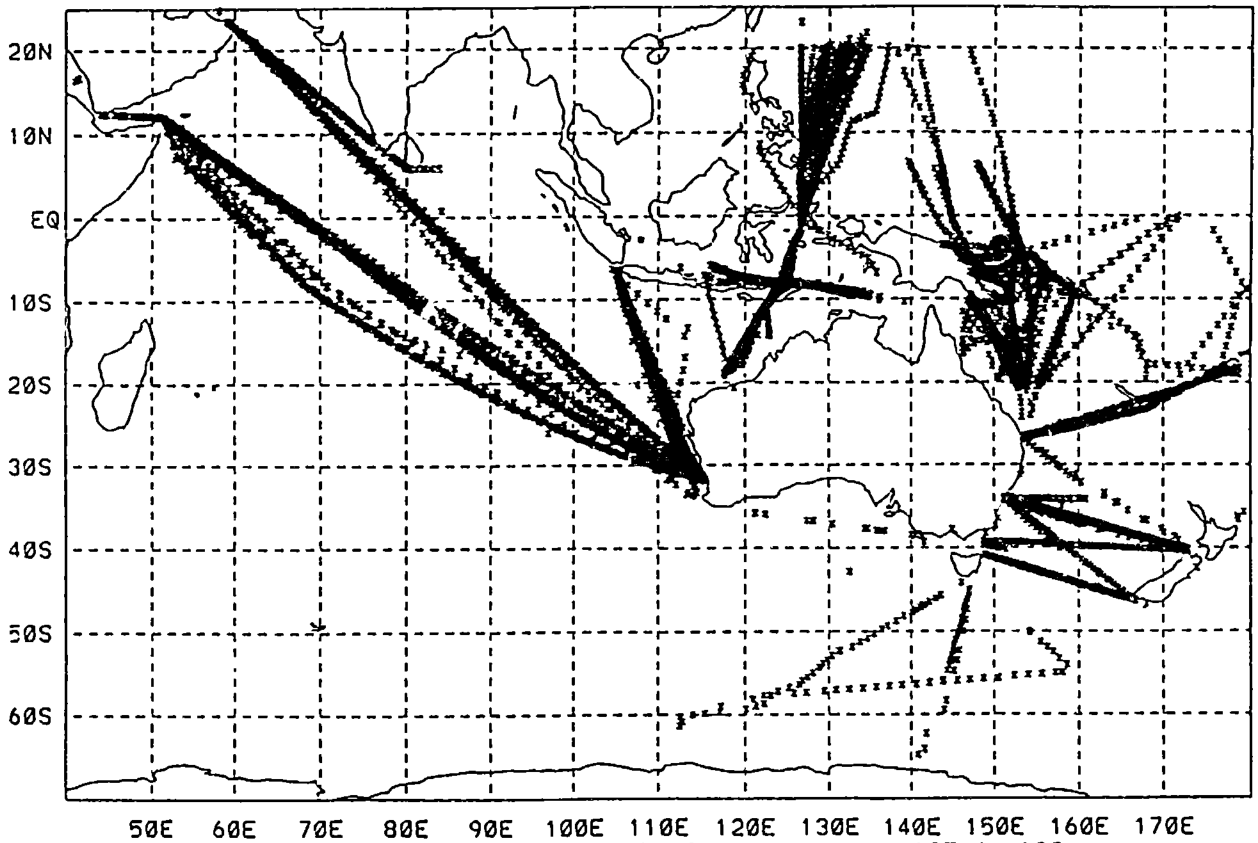


Figure 1. 1992 CSIRO Voluntary Observing Ship Routes

CSIRO XBT COVERAGE 1983 - 1992

Total Number of Successful XBTs = 19860



PER SHIP

ACT 10= 189
ACT 6= 252
AUST. PROGRESS=2830
NEDLLOYD TASMAN=1817
FUA KAVENGA= 167
IRON FLINDERS= 79
L ASTROLABE= 53
NIMOS=2155
SHEARWATER= 526

ACT 3= 211
AURORA AUSTRAL= 35
AUSTRALIA STAR=1057
ENCOUNTER BAY=1556
ICEBIRD= 39
IRON NEWCASTLE= 461
NZ STAR= 388
SWAN REEFER=2353

ACT 4= 198
ANRO AUSTRALIA=1844
ANRO ASIA= 795
FLINDERS BAY=1680
IRON DAMPIER= 155
IRON PACIFIC= 836
MERIDIAN= 138
SOUTHERN SURVEY= 46

Figure 2.

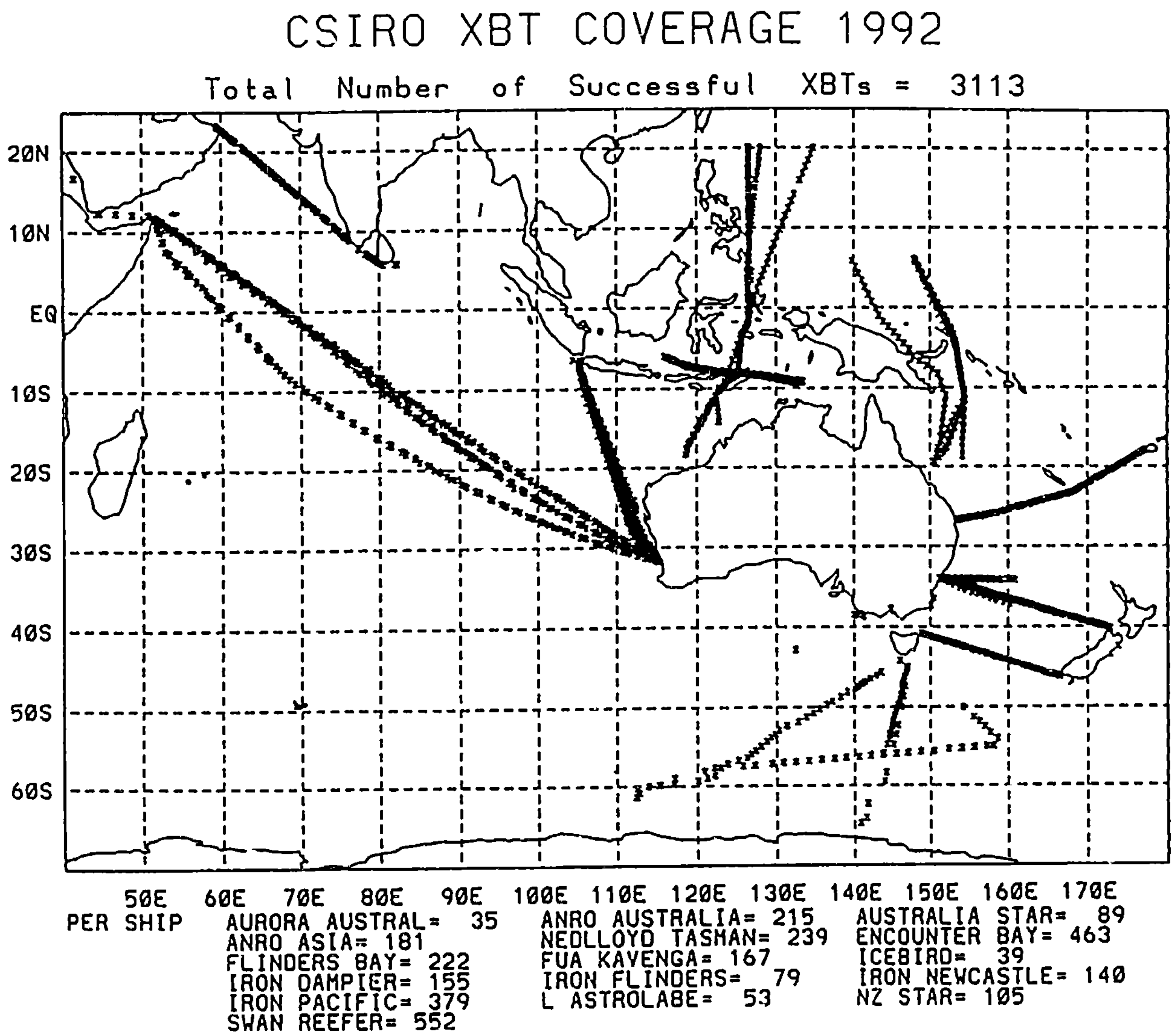

CSIRO XBT COVERAGE 1992
Total Number of Successful XBTs = 3113
20N
10N
EQ
10S
20S
30S
40S
50S
60S
50E 60E 70E 80E 90E 100E 110E 120E 130E 140E 150E 160E 170E
PER SHIP
AURORA AUSTRAL= 35
ANRO ASIA= 181
FLINDERS BAY= 222
IRON DAMPIER= 155
IRON PACIFIC= 379
SWAN REEFER= 552
ANRO AUSTRALIA= 215
NEDLLOYD TASMAN= 239
FUA KAVENGA= 167
IRON FLINDERS= 79
L ASTROLABE= 53
AUSTRALIA STAR= 89
ENCOUNTER BAY= 463
ICEBIRD= 39
IRON NEWCASTLE= 140
NZ STAR= 105

Figure 3.

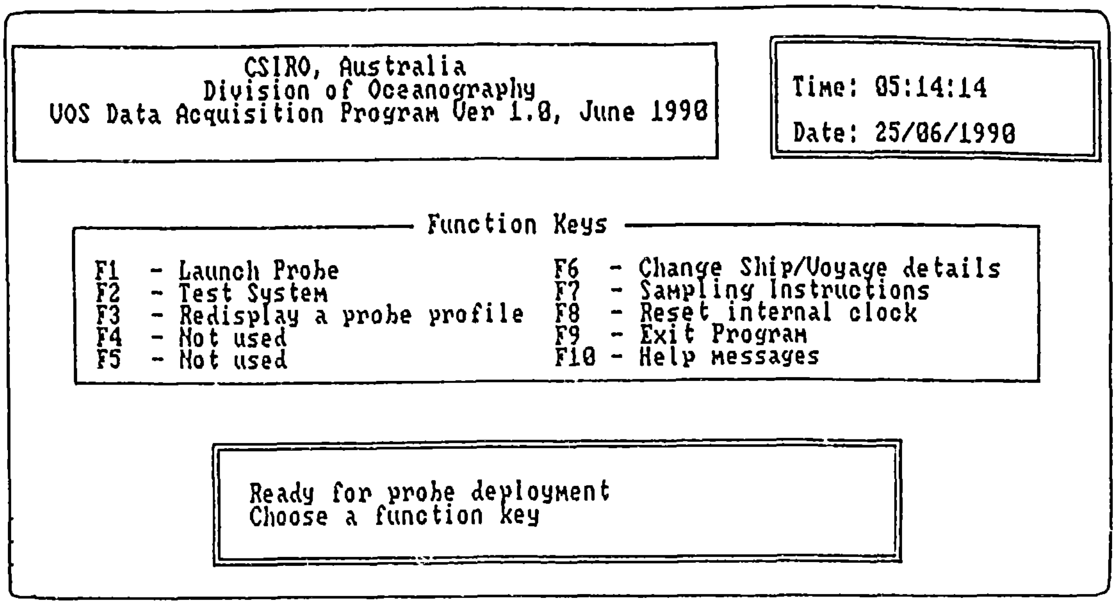


Figure 4. CSIRO XBT Data Acquisition System - Function Menu

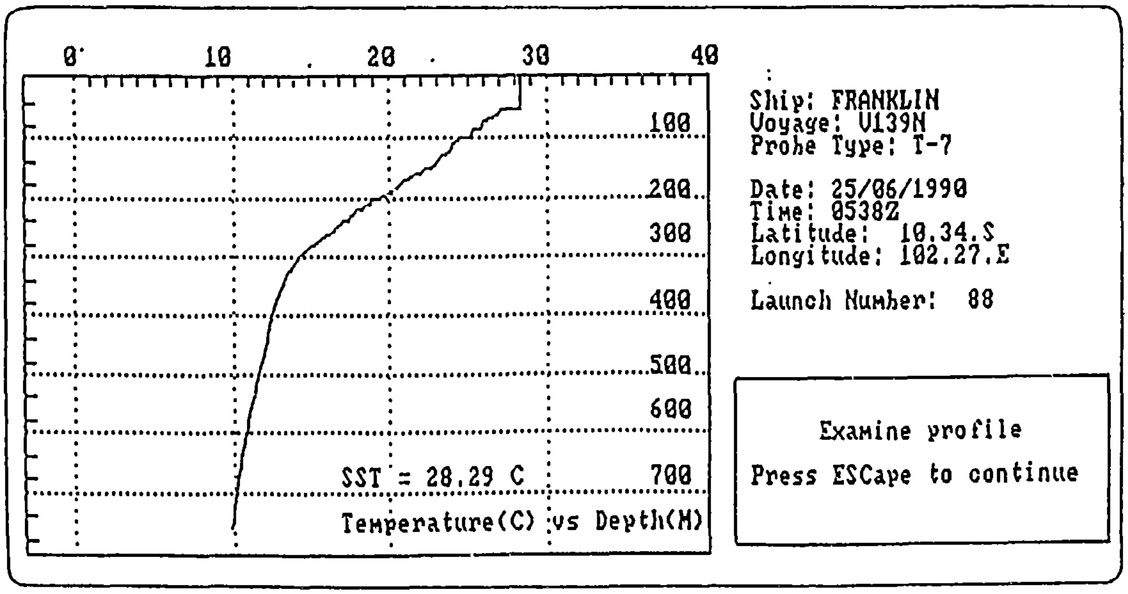


Figure 5. CSIRO XBT Data Acquisition System - Profile Display

XBT Data Processing

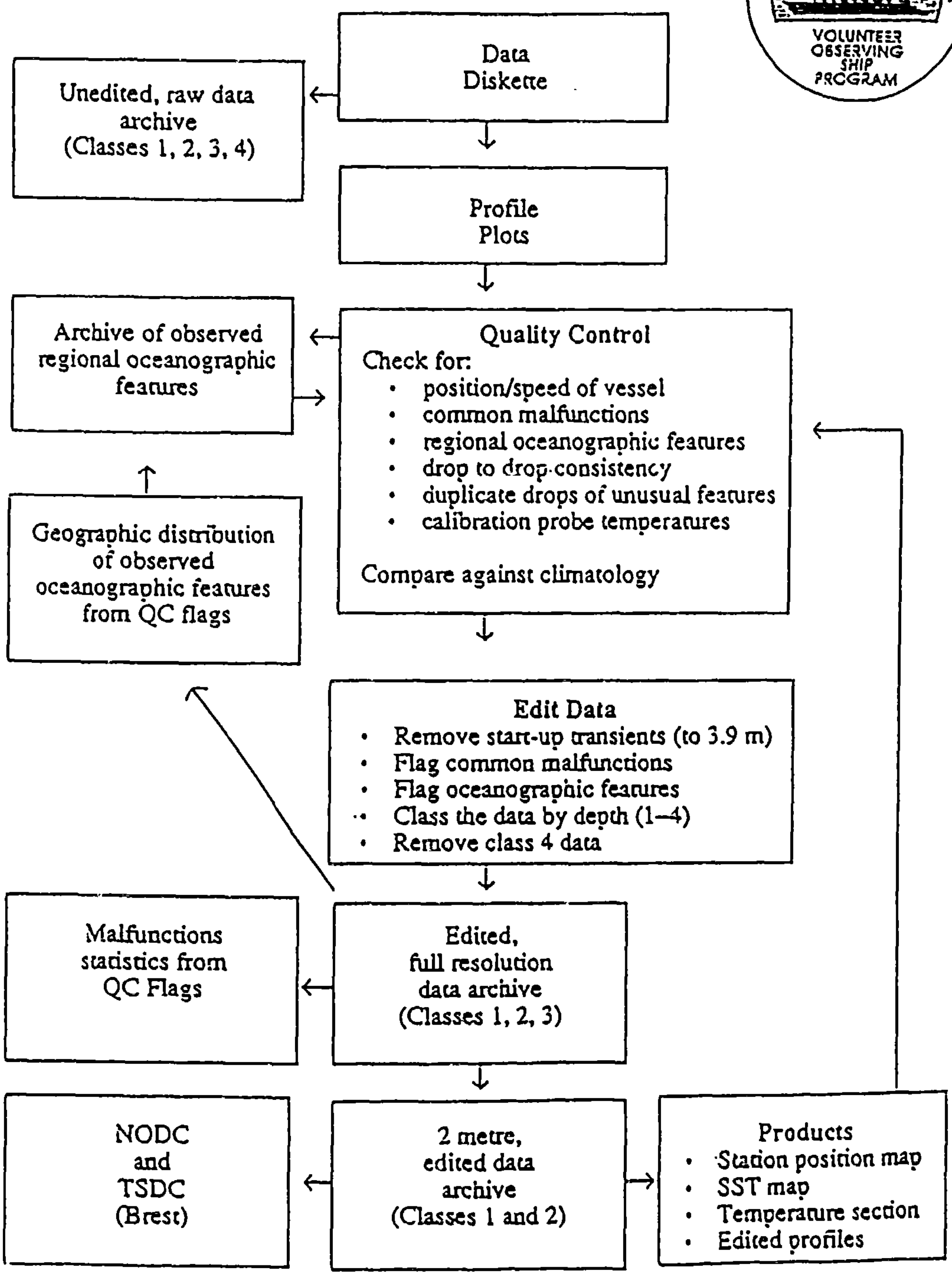


Figure 6. CSIRO XBT Data Processing Flow Chart

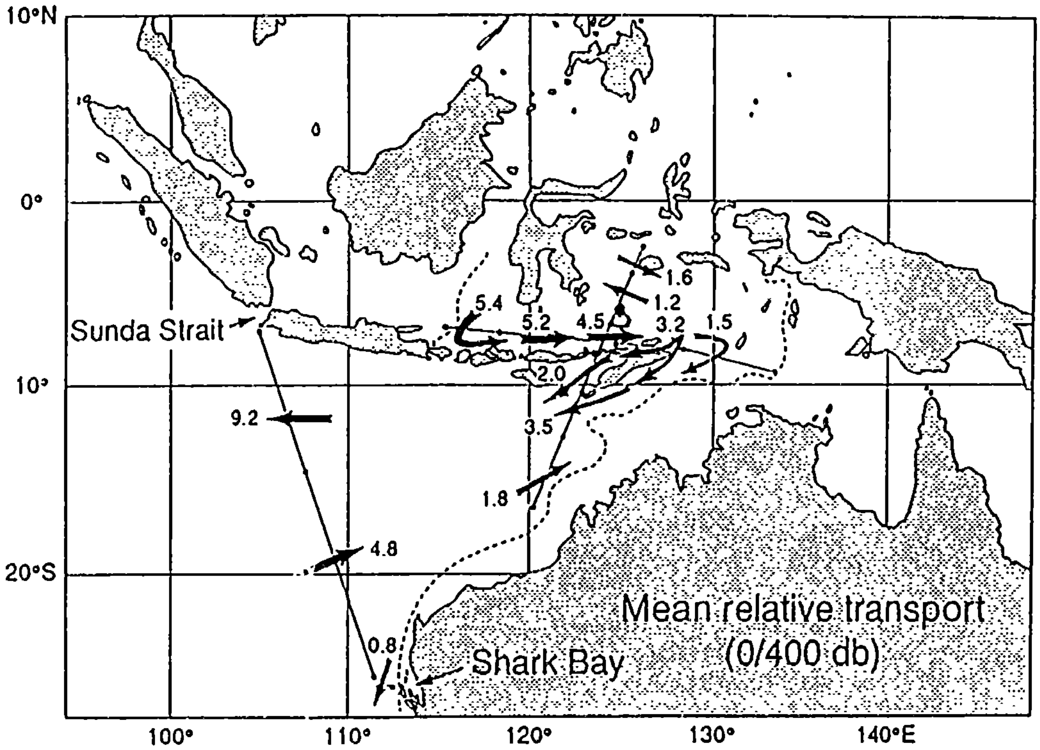


Figure 7. Geostrophic volume transports relative to 400 db in 10^6 m^3/s

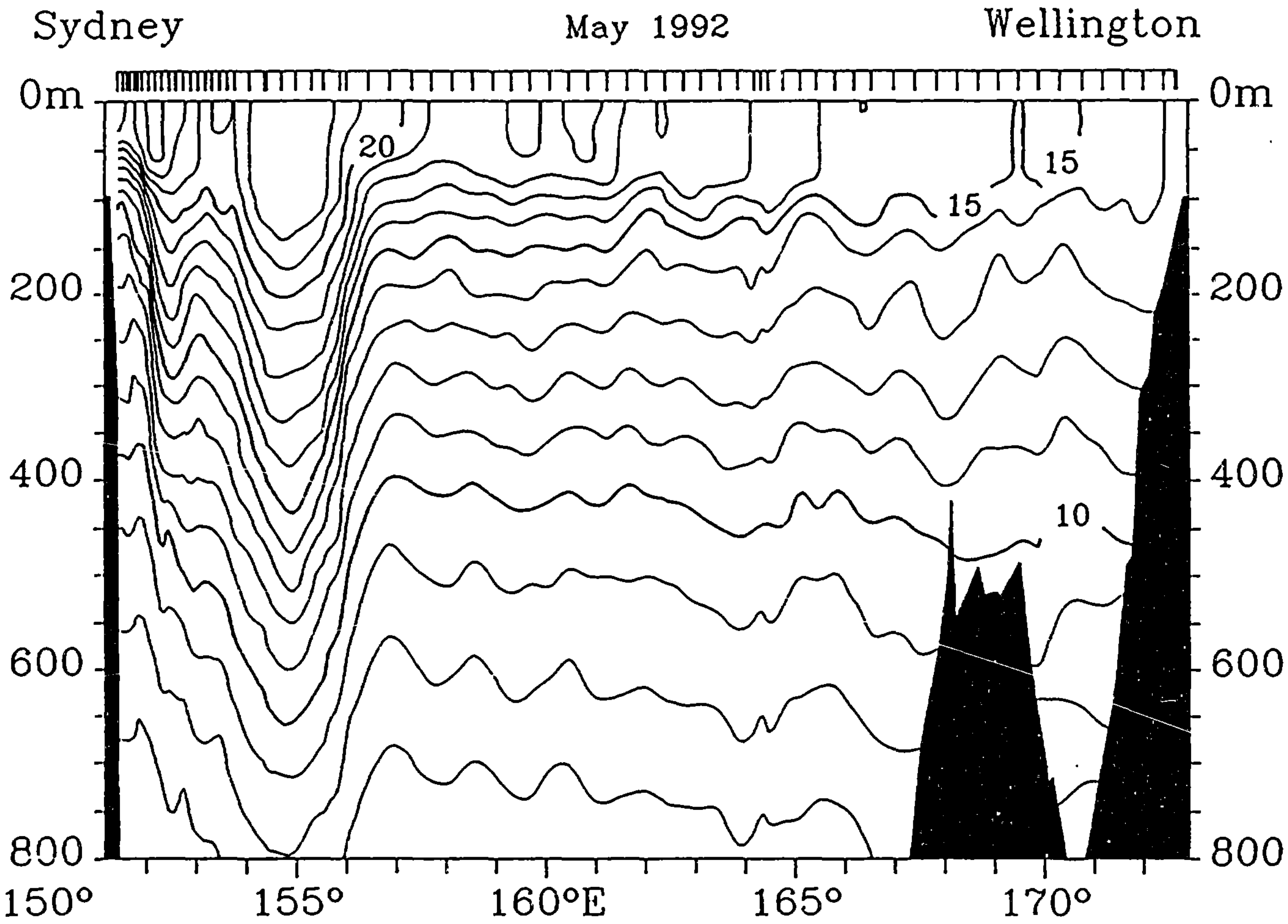


Figure 8. High-density XBT temperature section on line PX-34.

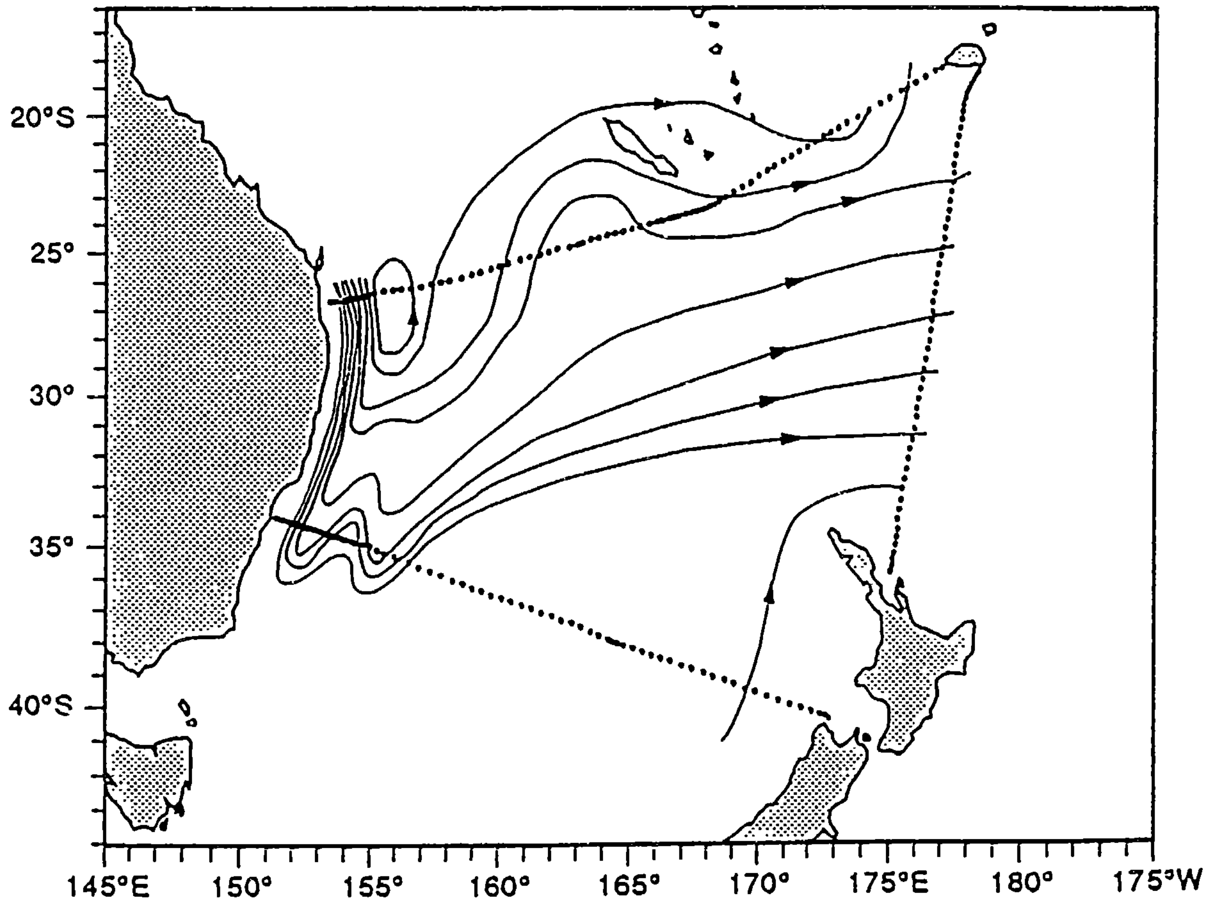


Figure 9. 1991-92 mean circulation of water warmer than 12^0 C relative to 800m (contour interval 2 x 10^6 m^3/s)

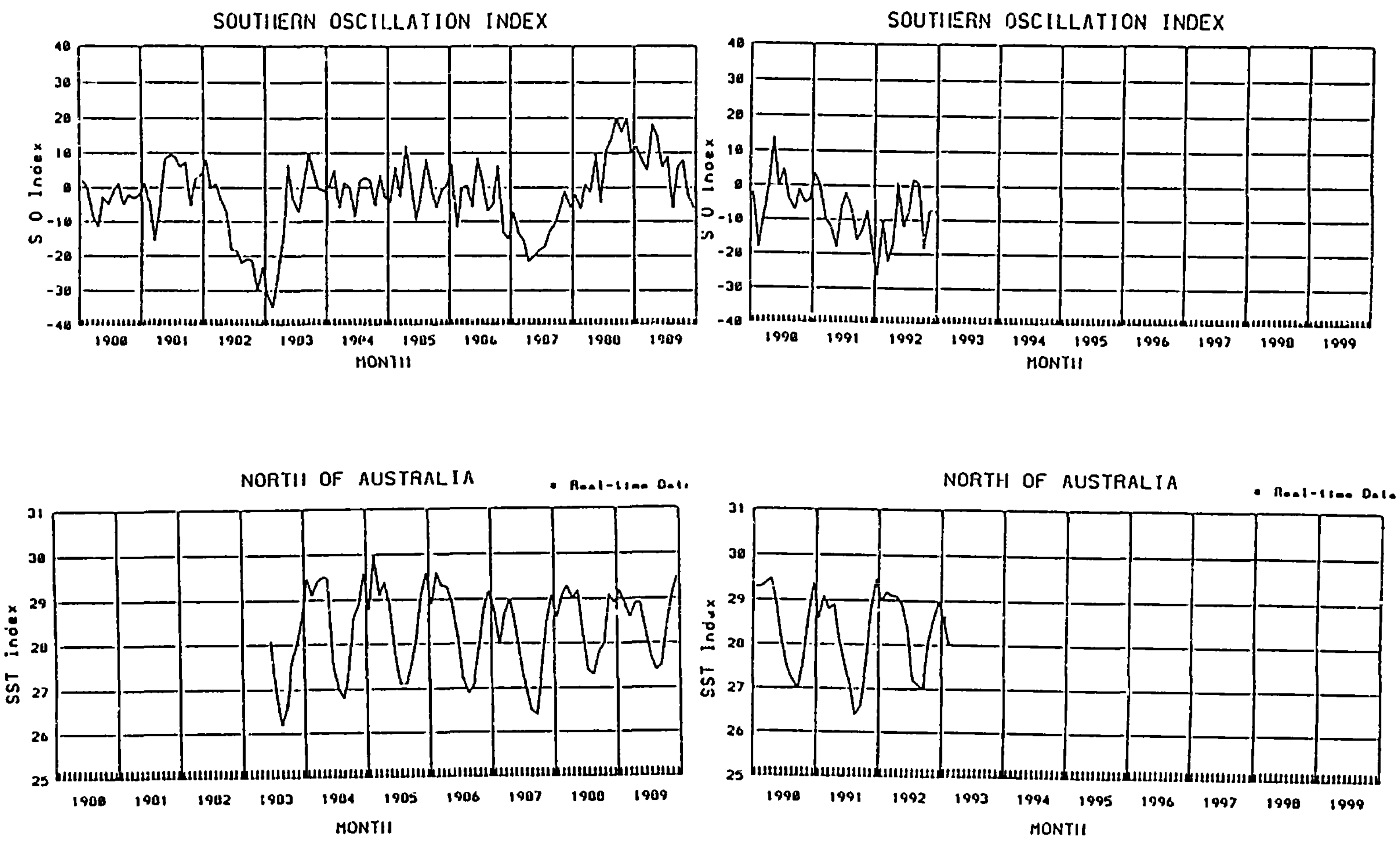


Figure 10. Southern Oscillation Index (SOI) (difference between atmospheric pressure at Darwin and Tahiti) and XBT Sea Surface Temperature (SST) Index for the north of Australia .Note the correlation between low SSTs and low SOI indices which are indicative of ENSO events.

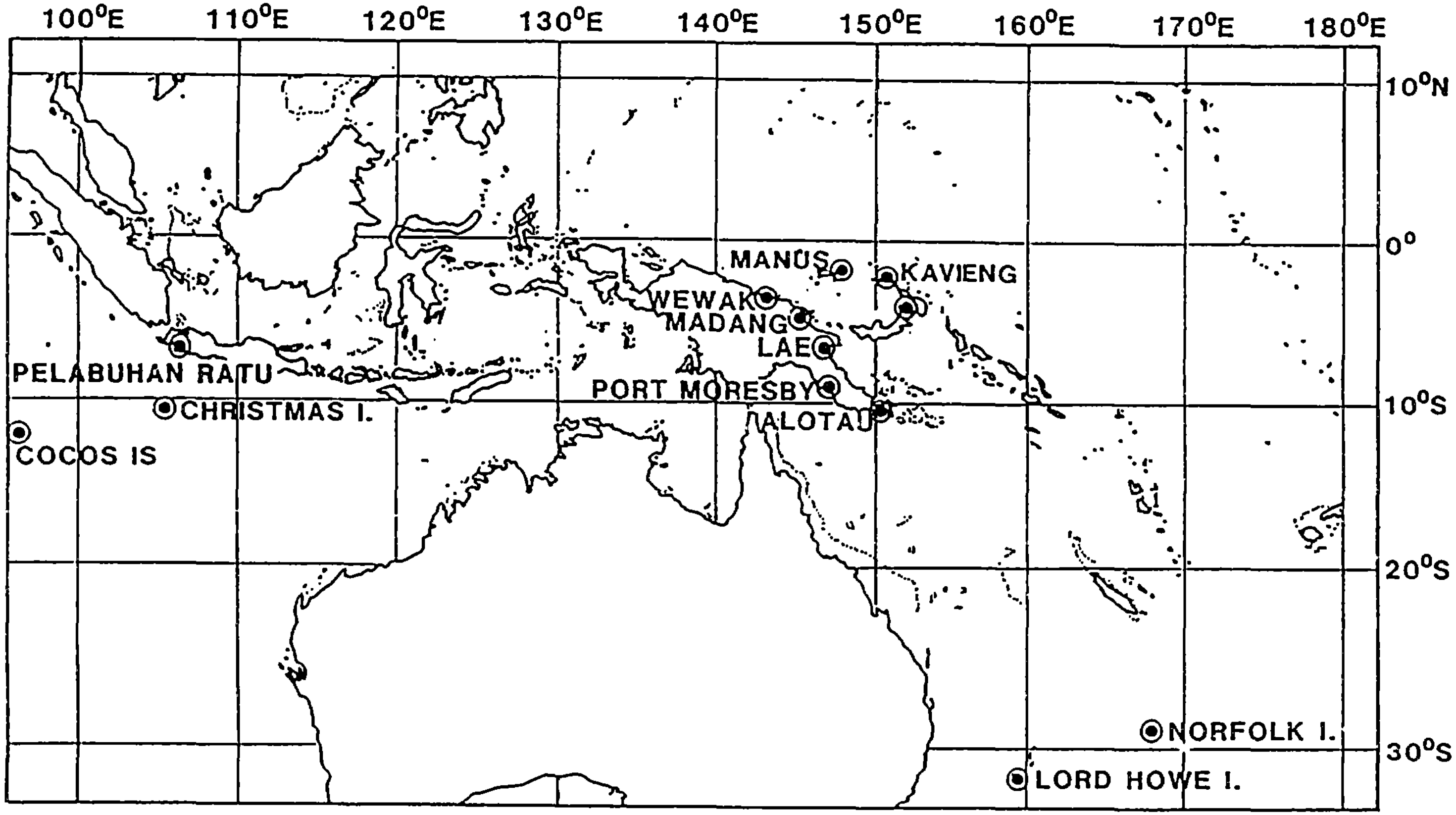


Figure 11. CSIRO Sea-Level Network.

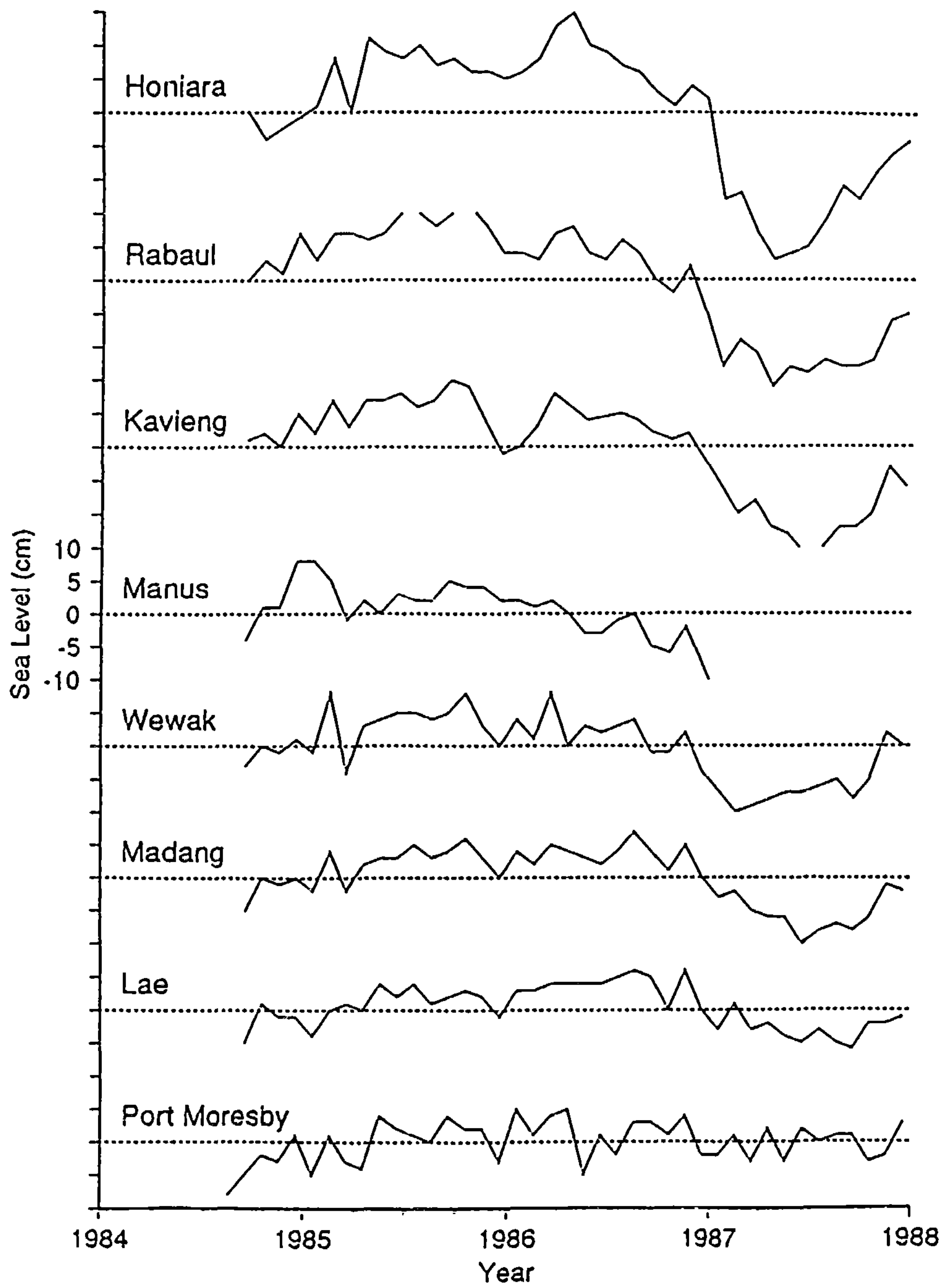


Figure 12. Monthly mean sea-level anomalies (in cm) at selected sea-level stations around Papua New Guinea showing the 1986-87 ENSO event (lower sea-levels).

CANADA

There are four government research laboratories in Canada, contributing physical oceanographic data in real time or delayed mode: Institute of Ocean Sciences, Sidney, BC; Bedford Institute of Oceanography, Dartmouth, NS; Maurice Lamontagne Institute, Mont-Joli, Quebec; and the Northwest Atlantic Fisheries centre, St. John's, NF. These regional laboratories send IGOSS messages to the Marine Environmental Data Service (MEDS) in Ottawa, Ontario, for archival and for distribution. MEDS is also a node for the international data network, and an active participant in the Global temperature-salinity Pilot Project.

Institute of Ocean Sciences

IOS conducts about half a dozen physicaL oceanographic cruises per year involving CSS Ricker and CSS Tully. CTD data collected from these cruises are submitted to MEDS in near-real-time, where they are checked and placed on GTS. At present IOS does not have a ship-of-opportunity program for physical oceanographic data.

The ocean chemistry group at IOS (Dr. C. S. Wong) in collaboration with Kimoto Electronics Co. of Japan and Guildline Instruments in Canada has recently initiated a ship-of-opportunity program for sampling CO_2. One of the objectives of this project is to develop an underway system for sampling surface waters for T, S, nutrients, CO_2 and ozone using ship-of-opportunity. They are also attempting to develop a protocol for on-board automatic analysis of salinity to overcome the problems associated with sensor fouling and stability.

Bedford Institute of Oceanography

Dr. F. W. Dobson at BIO is a collaborator on the ship-of-opportunity XBT program for the study of heat storage in the N. Atlantic ocean. As part of this project, he has been collecting XBT data, with probes supplied by the UK Naval Hydrographic office, along a line between St. John's and Reykjavik (2800 km, 16 probes) in spring, summer, fall and winter using MV Skogafoss. Unfortunately, processing difficulties have kept him from delivering IGOSS data for the last 1 1/2 years, but that problem is now overcome and data will be submitted in delayed mode. There is also a new initiative to put an observer on board on skogafoss to take surface salinity and CO_2 measurements. Fred Dobson is also a member of the TOGA/WOCE XBT/XCTD programme Planning Committee.

BIO also conducts a number of physical oceanographic cruises every year using primarily CSS Hudson and CSS Parizeau. The survey area includes the continental shelf and the adjacent waters off the east coast of Canada, and the WOCE line that runs from Labrador to Cape Farewell. CTD data collected from these cruises are sent to MEDS in near-real-time.

Maurice Lamontagne Institute

MLI's field activities are in the St. Lawrence estuary and the adjacent Gulf, and in Hudson and James Bays; CTD data are submitted to MEDS.

Northwest Atlantic Fisheries Centre

As part of the physical oceanographic and fisheries research activities at NAFC, a large quantity of CTD and XBT profiles is collected every year from the continental shelf off Newfoundland and Labrador. These files are processed and sent to MEDS.

The trawlers-of-opportunity program, initiated in 1989, to develop an automated environmental data acquisition/transmission system, is now in its final phase. This system is a stand-alone system that can be installed on ships-of-opportunity to collect, process and transmit, XBT profiles and meteorological information. It can also display the information either on the controllers monitor, or on a separate display unit for the convenience of the ship's crew. A number of commercial and government vessels have been using the system quite successfully. Details are given in a technical report.

FRANCE *

France participated in this program as usual and principally by using TOGA funds. In one hand the different Orstom Centers did their best in order to cover tropical area of each ocean and in an other hand the Australian-French collaboration went on, on the WOCE approach, particurlarly by developping section in Southern Ocean beyond 40° South.

Therefore, activities will be presented on each ocean.

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* This report was prepared by:

J.P REBERT In charge of TOGA center Brest (ORSTOM).
P. RUAL In charge of XBT Pacific (ORSTOM).
J.R. DONGUY In charge of XBT Austral (ORSTOM-CSIRO).
T. LUDJET French Responsible for IGOSS-OTA (METEO-FRANCE).
J. POITEVIN French representative for IGOSS
Head Marine forecasting section (METEO-FRANCE).

Atlantic and Indian Oceans.

Tables I to V were prepared by J.P. REBERT (responsible of TOGA Center,Brest).

- Figure I presents TOGA lines covered by France.
- Figure II presents data distribution of XBT observations.
- Table I presents daily available data distribution.
- Table II presents by ship callsign, number of XBT, time period and TOGA lines.
- Table III and IV present by ships and lines all the contributions.
- Table V presents the summary of ORSTOM Atlantic and Indian oceans contribution for the period considered.

Pacific Ocean.

Informations were produced by P. RUAL

- Figure III presents all the lines covered. On each line are wrotten the numbers of ships and the numbers of sections.
- Table VI presents by ship callsign, the number of measurements and sections.
- Table VII presents by TOGA lines, ship number and section number.
- Figure IV presents the sections on which thermosalinograph observations were assured.
- Table VIII presents the summary of thermosalinograph observation made since 1989.

Southern Ocean.

Figures V and VI were produced by J.R. DONGUY.

Figure V presents the lines covered in collaboration between Australia and France. Solid lines present lines made by ASTROLABE and MARION DUFRESNE ships and doted lines present lines made by AURORA AUSTRALIA and ICE BIRD ships.

French program began during southern summer 1992-1993. XBT measurements were made each 6 hours at the beginning and at the end of the summer between Hobbart and Dumont d'Urville by the deck officers of the Astrolabe and Marion Dufresne and each 2 hours during the summer by scientists;

85 bathythermic measurements (0-800m)of good quality were collected.

Figure VI presents the vertical distribution of temperature and on this figure we can see main fronts and convergence areas.

During 1993 this program would be extended on the South part of India Ocean using Marion Dufresne, XBT measurements would be made four time a year on lines La Reunion-Crozet-Amsterdam-La Réunion during southern winter when there are few available data.

GTS - Specialised Oceanographic Center

- Figure VII presents geographical position of data which are transmitted through GTS.
- Figure VIII presents the part of geographical position of data, which passed through GTS, made by France.

Daily quality control of the received are made at the SOC.

Monthly, a data file is produced to be sent to Brest TOGA Center. So during 1992, 26490 data profiles have been sent to it.

Lancers XBT ORSTOM en 1992

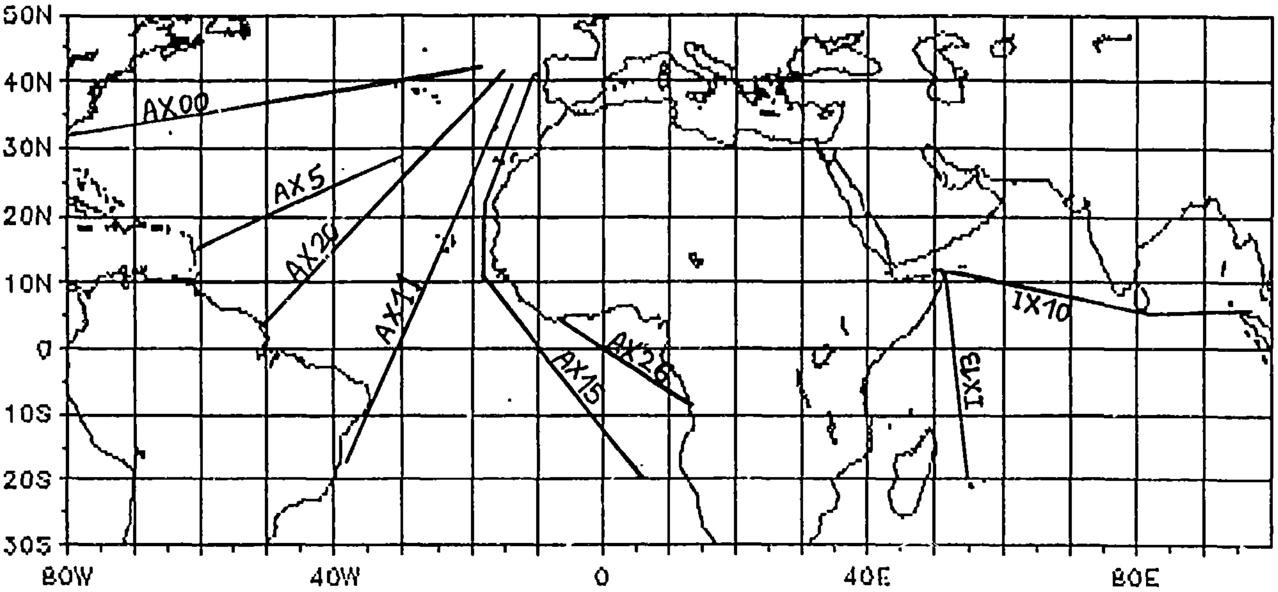


Figure I

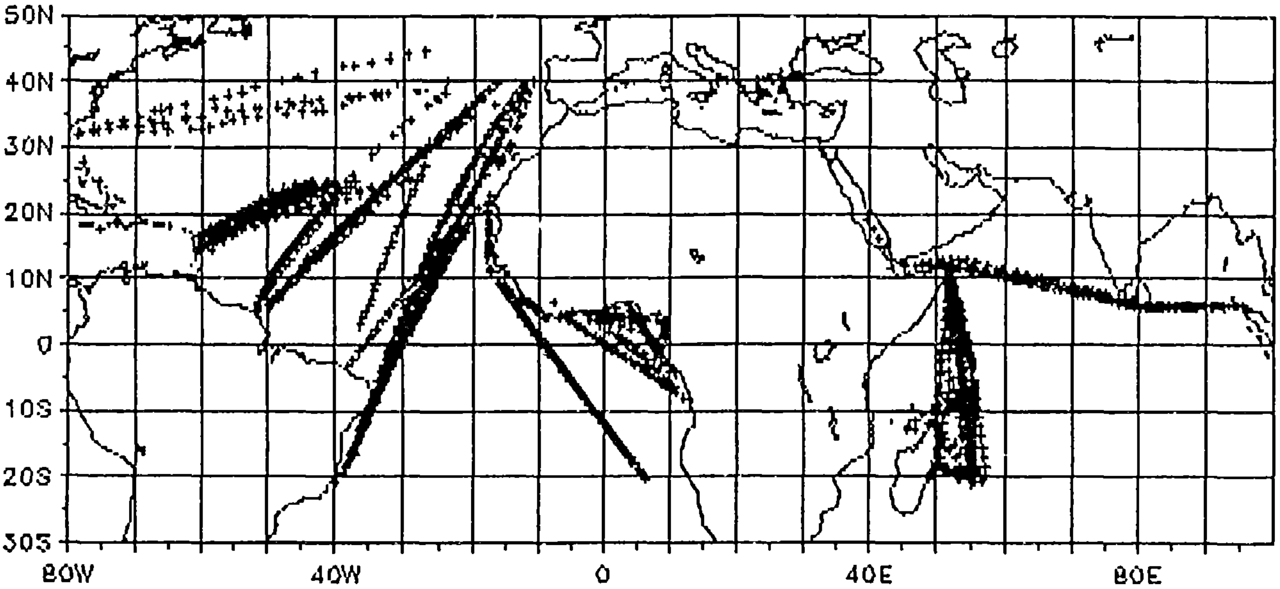


Figure II

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
DEC																											1	3	7	7	7
JAN	5	3	4	5	7	6	3	3	4	4	4	4	6	6	4	5	9	12	11	4	4	5	6	5	7	9	7	2			
FEV	3	4	4	4	4	3	4	4	3	5	3		3	8	11	18	11	15	16	12	13	13	7	5	6	3		2	3		
MAR	3	3	7	6	3		3	4	4	8	1		9	15	16	21	10	11	10	14	11	11	11	7	10	16	5	4	4	2	
AVR	1	4	4	11	8	6	10	8	11	10	19	16	10	5	4	5	4	4	4	2	12	6	5	5	10	5	4			3	
MAI	1	6	9	13	14	16	17	15	8	9	16	15	14	14	5	7	8	8	1	1	7	6	14	15	14	10	8	7	4	1	2
JUIN		3		3	7	6	8	8	8	10	2	1	6	6	9	3	8	4	4	5	6	6	6	4	5	14	8	8	6	5	
JUIL	6	1	10	4	4	8	6	5	18	12	16	15	10	4	2	7	10	11	7	9	8	8	12	8	4	4	4	4	5	1	
AOU	1	4	4	2	1	4	5	7	10	9	5	11	12	14	16	11	9	9	7	11	6	4	7	8	9	7	6	6	5	1	2
SEP	6	9	11	16	25	20	16	8	10	13	20	19	21	25	19	20	8	1	1	5		3	1			1	5	2	4	13	
OCT	10	10	16	10	9	5	7	5	11	13	15	10	8	11	11	8	7	5	4	3	2	3	3	2	6	8	8	7	4	3	8
NOV	12	4	5		1	13	16	14	10	12	8	8	13	7	8	6	4	2	6	6	5	3	17	15	14	19	13	6	10	6	
DEC	6	7	7	14	14	13	12	5	9	7	4	2	7	7	7	6	3	3	5	2		6						2	2	6	8
JAN	7	12	6	3	5	4	2	3	1	5	3	5	4	4	4	3															

Total = 2713 (2617)

Tableau I

1992

	Croisière	N. lancers	Date début	Date fin	Lignes TOGA
DIDA	AA9201	34	24/12/1991	08/01/92	AX20
	AA9202	27	27/02/92	26/03/92	AX20
	AA9203	35	04/05/92	14/05/92	AX20
	AA9204	10	21/07/92	23/07/92	AX20
	AA9205	43	22/08/92	07/09/92	AX20
	AA9206	48	06/10/92	28/10/92	AX20
	AA9207	46	20/11/92	02/12/92	AX20
FGPT	CY9201	34	30/09/92		AX20
	CY9202	48	23/11/92	18/12/92	AX20, AX11
FNZB	GB9206	23	01/11/92	08/11/92	AX26
TUMG	GB9207	24	19/12/92	07/01/93	AX26, AX15
FNQB	IM9201	44	08/01/92	21/01/92	IX3
	IM9202	46	13/03/92	09/04/92	IX3, AX15
	IM9203	45	10/05/92	12/06/92	IX3, AX15
	IM9204	33	09/07/92	24/07/92	AX26
FNQD	IR9201	40	01/02/92	20/02/92	IX3
	IR9202	55	11/04/92	09/05/92	IX3, AX15
FNJT	KO9201	39	14/02/92	13/05/92	IX10
	KO9202	27	13/06/92	15/07/92	IX10
	KO9203	46	12/08/92	17/09/92	IX10
	KO9204	38	14/10/92	17/11/92	IX10
FNGS	LF9201	27	29/12/91	19/01/92	AX11
	LF9202	53	14/02/92	20/03/92	AX11
	LF9203	57	03/04/92	07/05/92	AX11
	LF9204	57	21/05/92	02/07/92	AX11
	LF9205	45	17/07/92	18/08/92	AX11
	LF9206	49	01/09/92	05/10/92	AX11
	LF9207	40	19/10/92	20/11/92	AX11
	LF9208	63	05/12/92	16/01/93	AX11
C6IO5	ND9201	38	04/03/92	30/03/92	IX3, AX15
	ND9202	51	03/05/92	31/05/92	IX3, AX15
	ND9203	24	06/07/92	10/07/92	IX3
	ND9204	50	31/08/92	17/09/92	IX3
	ND9205	48	27/10/92	15/11/92	IX3
	ND9293	32	10/07/92	30/07/92	IX3, AX15
FNDK	PD9201	37	23/11/92	07/12/92	IX3
FNQC	RD9201	48	05/12/92	06/01/93	IX3, AX15
FNXW	RH9201	12	09/02/92	16/02/92	AX26
	RH9202	10	22/03/92	27/03/92	AX26
	RH9203	18	21/06/92	03/07/92	AX26
	RH9205	8	30/09/92	11/10/92	AX26
	RH9206	6	19/11/92	27/11/92	AX26
FNZB	RL9201	32	03/02/92	23/03/92	AX15, AX26
	RL9202	32	02/06/92	22/06/92	AX15, AX26
	RL9205	27	04/09/92	23/09/92	AX15, AX26
FNOM	RN9202	42	17/06/92	28/08/92	IX10, AX00
	RN9203	34	27/09/92	05/12/92	IX10, AX00

	Croisière	N. lancers	Date début	Date fin	Lignes TOGA
FNPA	RS9201	43	13/01/92	26/03/92	IX10, AX00
	RS9202	1	01/07/92		
	RS9203	31	11/08/92	18/10/92	IX10, AX00
FNCZ	SC9201	26	17/01/92	28/01/92	AX5
	SC9202	31	13/02/92	25/02/92	AX5
	SC9203	22	15/03/92	23/03/92	AX5
	SC9204	23	11/04/92	19/04/92	AX5
	SC9205	24	11/05/92	18/05/92	AX5
	SC9206	24	06/06/92	15/06/92	AX5
	SC9207	25	04/07/92	13/07/92	AX5
	SC9208	22	01/08/92	10/08/92	AX5
	SC9209	27	04/09/92	15/09/92	AX5
	SC9210	25	03/10/92	11/10/92	AX5
	SC9211	23	30/10/92	08/11/92	AX5
	SC9212	7	29/11/92	04/12/92	AX5
FNQM	SD9201	13	06/02/92	22/02/92	AX26
	SD9202	43	04/04/92	27/04/92	AX15, AX26
	SD9203	34	18/05/92	25/05/92	AX15, AX26
	SD9204	51	11/07/92	12/08/92	IX3, AX15
	SD9205	56	11/09/92	07/10/92	IX3, AX15
	SD9206	41	08/11/92	27/11/92	IX3
3EET4	SF9201	40	21/01/92	21/02/92	AX11
	SF9202	41	16/03/92	14/04/92	AX11
	SF9203	48	23/06/92	21/07/92	AX11
	SF9204	46	13/08/92	15/09/92	AX11
	SF9205	46	08/10/92	10/11/92	AX11
	SF9206	35	03/12/92	04/01/93	AX11
FNED	UT9201	36	18/02/92	16/03/92	IX3, AX15
	UT9202	47	21/04/92	17/05/92	IX3, AX15
	UT9204	57	18/08/92	16/09/92	IX3, AX15

Tableau II

Récapitulatif par navire et par ligne TOGA

Code radio	Navire	Total
DIDA	Ariana	243
FGPT	Cygne	82
FNZB (TUMG)	Grand Bassam	47
FNQB	Ile Maurice	168
FNQD	Ile de la Réunion	95
FNJT	Korrigan	150
FNGS	La Fayette	391
C6IO5 (FNWC)	Nathalie Delmas	243
FNDK	Patricia Delmas	37
FNQC	Renée Delmas	48
FNXW	Saint Roch	54
FNZB	Saint Roland	91
FNOM	Renoir	76
FNPA	Ronsard	75
FNCZ	Delmas Surcouf	279
FNQM	Suzanne Delmas	238
3EET4	Seas Eiffel	256
FNED (3EKW9)	Utrillo	140

Tableau III

Ligne TOGA	Total
IX3	564
IX10	222
AX00	78
AX5	279
AX11	671
AX15	320
AX20	301
AX26	273

Tableau IV

Les réseaux ORSTOM Atlantique et Indien en 1992 récapitulatif

navire	c. radio	LIGNE ppale	charges en 92	lances en 92	donnees SMT	XBT reussis	Nombre de visites
ANGO	FNOM	AX15	108	99	10	48	3
ARIANA	DIDA	AX20	276	264	132	209	7
CYGNE	FGPT	AX20	132	84	0	82	3
DELMAS SURCOUF	FNCZ	AX7	312	321	233	279	12
GRAND BASSAM	TUMG	AX26	24	24	9	24	1
ILE DE LA REUNION	FNQD	AX15	108	157	23	95	4
ILE MAURICE	FNQB	IX3	156	180	140	168	4
KORRIGAN	FNJT	IX10	216	218	8	150	5
LA FAYETTE	FNGS	AX11	396	415	232	364	7
NATHALIE DELMAS	FNWC	AX15	60	53	0		1
NATHALIE DELMAS	C6IO5	IX3	288	222	167	243	5
PATRICIA DELMAS	FNDK	IX3	48	40	21	37	2
RENEE DELMAS	FNQC	AX15	0	0	19	48	1
RONSARD	FNPA	AX15	108	106	0	75	4
SAINT ROCH	FNXW	AX26	144	90	28	54	8
SAINT ROLAND	FNZB	AX26	72	99	54	91	7
SEAS EIFFEL	3EET4	AX11	288	288	193	256	6
SUZANNE DELMAS	FNQM	AX15	300	265	180	238	7
UTRILLO	FNED	AX15	84	80	46		3
UTRILLO	3EKW9	IX3	60	114	37	140	2
*** Total ***			3180	3135	1747	2652	93

Le taux de réussite des tirs XBT pour l'ensemble de ces océans est donc d'environ 84%. Il n'est pas possible de faire un compte exact par océan, en raison du fait que plusieurs navires parcourent des lignes qui traversent les deux océans.

Le nombre de données transmises sur le SMT est celui des données SMT reçues au Centre TOGA. Il peut donc differer de celui des données reçues à Météo France du fait que la zone est limitée aux latitudes inférieures à 30°.

Tableau V

TIRS XBT RETENUS - ANNEE 1992 : 3056 tirs

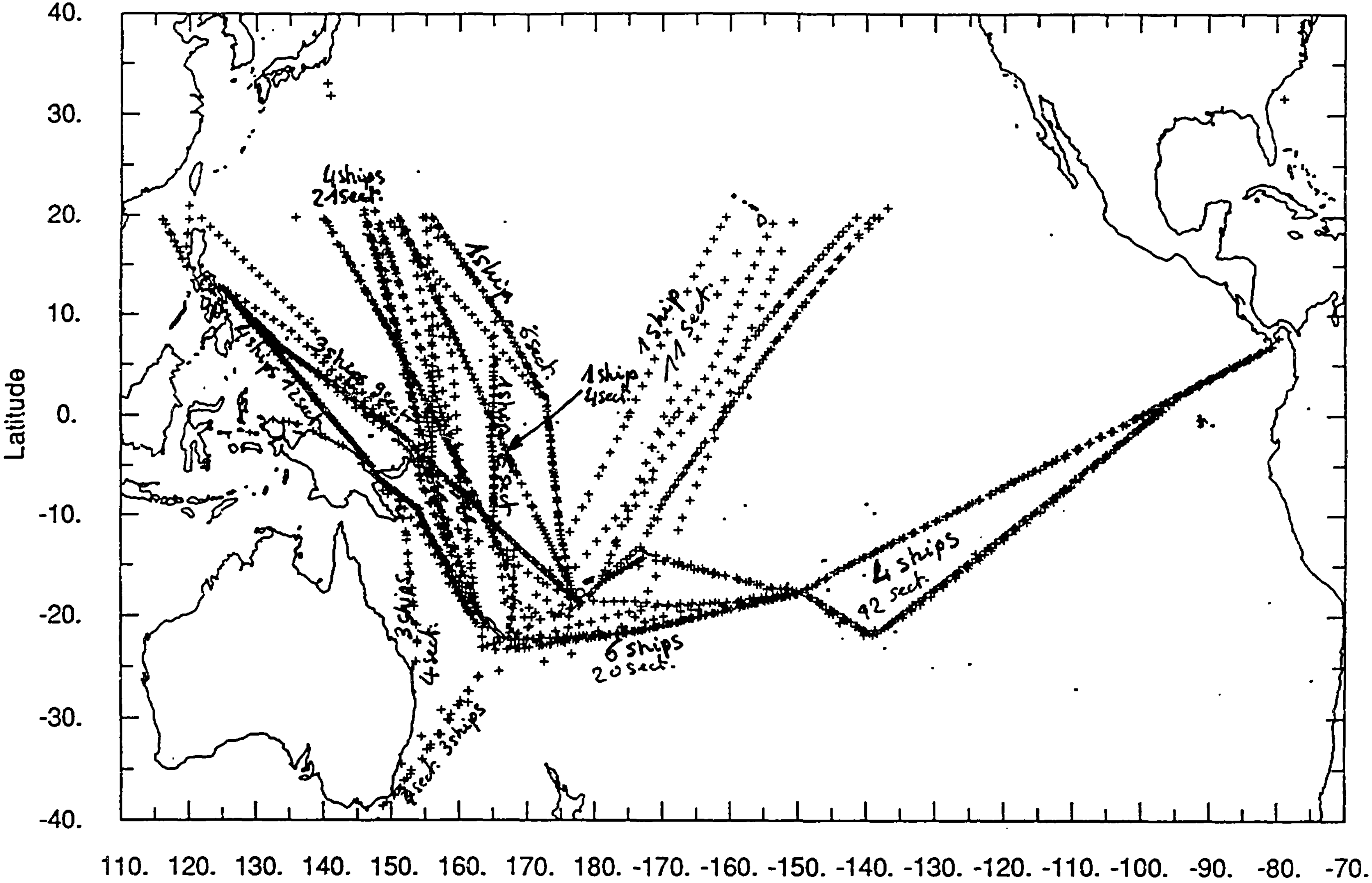


Figure III

edite le : 16/ 3/1993

Bateaux		Lignes	Nb de profils banque TOGA
ACT10	C6HL	PX31	71
COLOMBIA STAR	C6HL8	PX31	278
EXPLORER	ZDAZ6	PX5 PX51 PX3 PX31	374
FORTHBANK	GQEK	PX5 PX51 PX3 PX31	138
MARINER	ELIS8	PX5 PX51 PX3 PX31	382
NAVIGATOR	ELIL9	PX5 PX51 PX3 PX31	443
NOROIT	FITA	PX45 (165°E,156°E)	268
PACIFIC ISLANDER	HPEW	PX5 PX52 PX4 PX12	526
RABELAIS	FNZO	PX17 PX12 PX3 PX31	272
RACINE	FNZP	PX17 PX12 PX3 PX31	237
RIMBAUD	FNZQ	PX17 PX12 PX3 PX31	257
VOYAGER	ZDBE9	PX5 PX51 PX52 PX53	302
		TOTAL	3550

$$\text{Rendement} = 92\ \% = \frac{\text{bons tirs}}{\text{Nb total de tirs}}$$

Tableau VI.

Line #	Ship	Sections
PX12	6	20
PX17	4	12
PX3	3	4
PX31	1	11
PX4	1	6
PX45	1	6
PX5	4	21
PX51	4	12
PX52	1	4
PX53	3	9

Tableau VII.

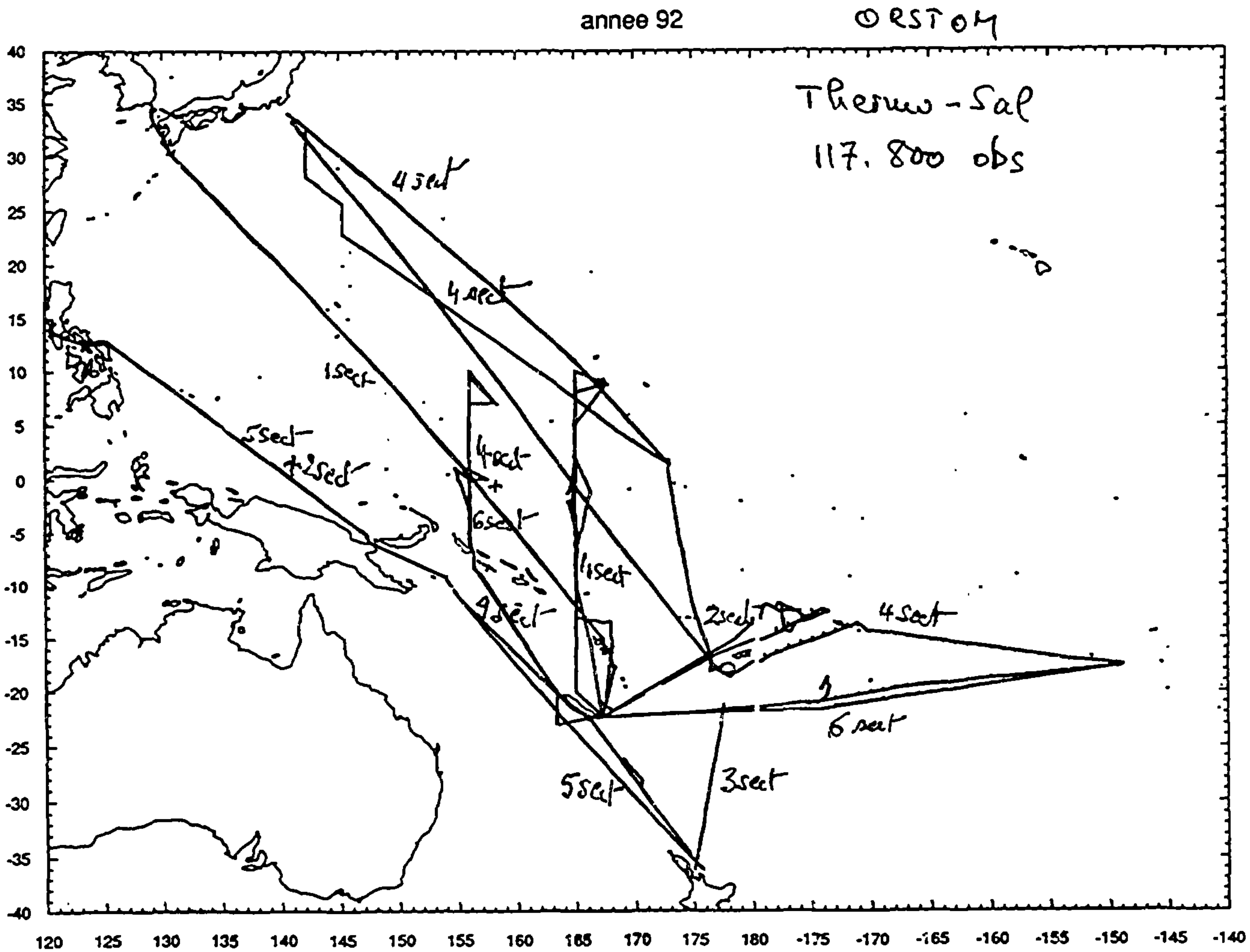

annee 92
ORSTOM
Thermo-Sal
117.800 obs
4 sect
4 sect
1 sect
5 sect
+2 sect
4 sect
6 sect
1 sect
4 sect
2 sect
4 sect
6 sect
5 sect
3 sect
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
120
125
130
135
140
145
150
155
160
165
170
175
180
-175
-170
-165
-160
-155
-150
-145
-140

Figure IV

Voyage	début	fin	nbre observations
mari9001	01-11-90	04-12-90	5180
mari9002	18-12-90	30-12-90	3258
mari9101	02-01-91	18-02-91	5109
noro9101	08-02-91	06-03-91	7135
noro9102	11-03-91	06-04-91	6622
mari9102	01-03-91	03-05-91	7813
mari9103	02-05-91	03-08-91	6 791
noro9104	18-07-91	14-08-91	17 417
noro9105	20-08-91	15-09-91	5 990
suro8901	03-12-89	27-12-89	5 061
voya9101	11-12-91	13-12-91	721
mari9104	23-08-91	25-09-91	1 775
voya9102	13-12-91	27-01-92	6 593
noro9201	18-01-92	16-02-92	7 447
noro9202	21-02-92	17-03-92	6 593
noro9203	06-05-92	15-05-92	2 926
alis9201	05-05-92	31-05-92	8 260
paci9201	11-05-92	06-07-92	12 426
noro9204	18-06-92	27-06-92	2 206
voya9201	13-02-92	13-06-92	13 637
alis9202	20-07-92	21-07-92	1 145
voya9202	11-06-92	11-08-92	6 670
paci9202	07-07-92	03-09-92	10 290
paci9203	10-09-92	03-11-92	11 015
noro9205	05-08-92	31-08-92	6 591
noro9206	05-09-92	02-10-92	6 995
paci9204	19-11-92	08-01-93	8 182
voya9203	11-08-92	13-11-92	6 403
paci9301	12-01-93	10-03-93	11 842
noro9207	02-12-92	01-03-93	21 134
		total	**223 227**

Tableau VIII *fichiers, dates extremes et nombre d'observations*

On peut annoncer la distribution (approximative) suivante des données par année:

1989:	5 061
1990	8 438
1991	60 857
1992	117 786
1993:	25 976

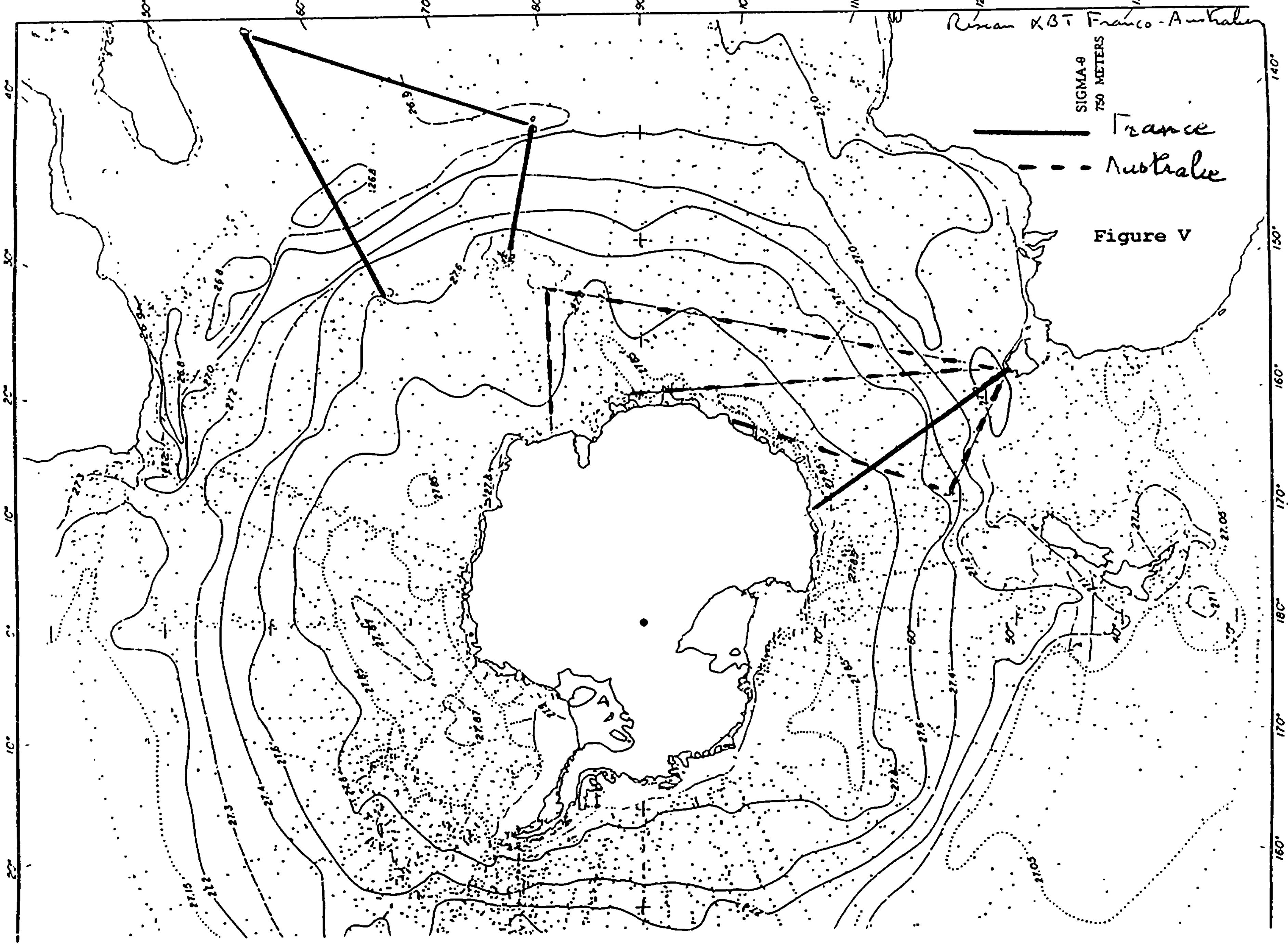

Réseau XBT Franco-Australien
SIGMA-θ
750 METERS
France
Australie

Figure V

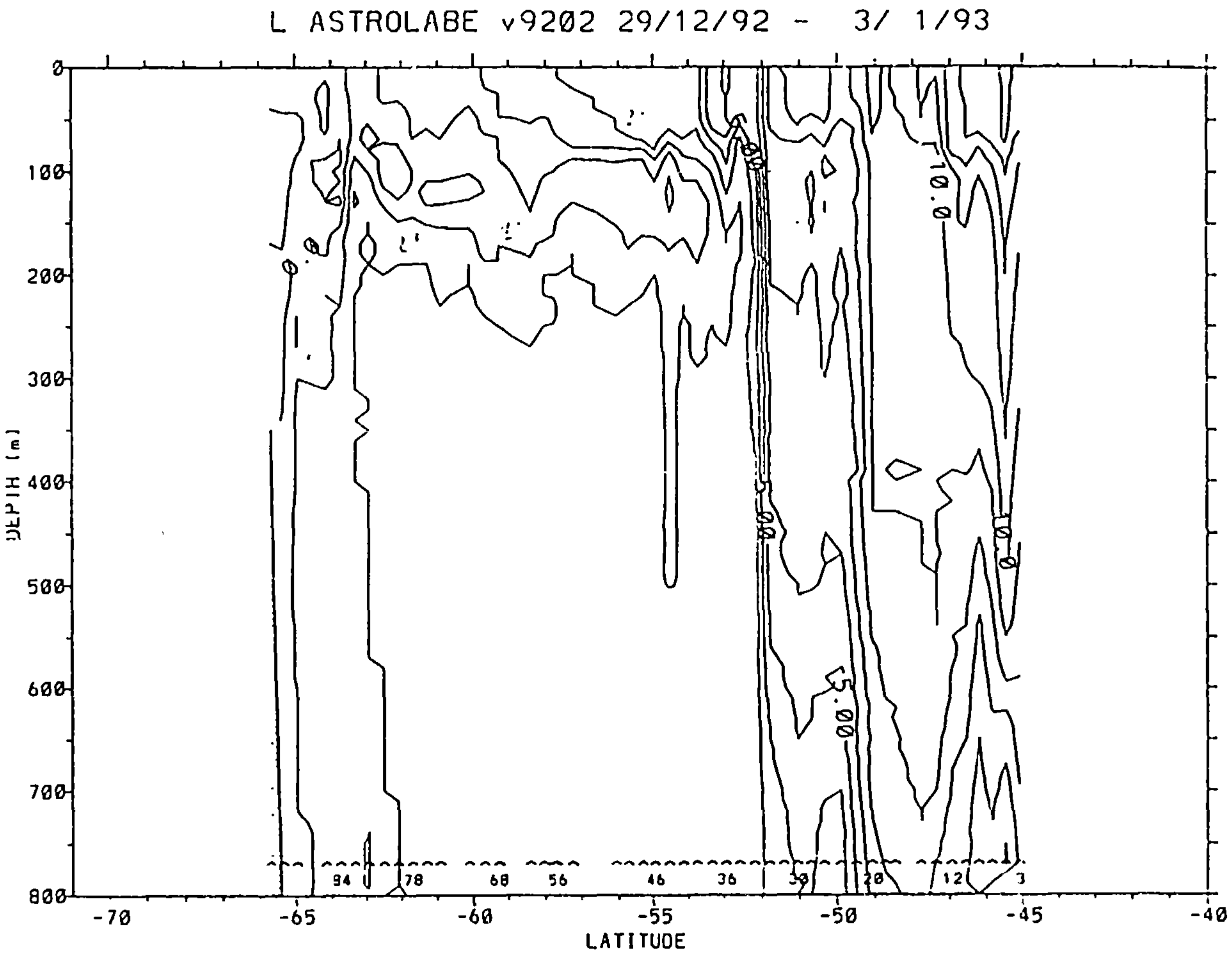

L ASTROLABE v9202 29/12/92 - 3/ 1/93
DEPTH (m)
0
100
200
300
400
500
600
700
800
-70
-65
-60
-55
-50
-45
-40
LATITUDE
10.0
5.00
94
78
68
56
46
36
30
20
12
3

Figure VI

METEO-FRANCE/SMISO FRENCH MET OFFICE/IGOSS

Pointage des observations recues durant l'annee 1992

Messages : BATHY/TESAC Total : 45257

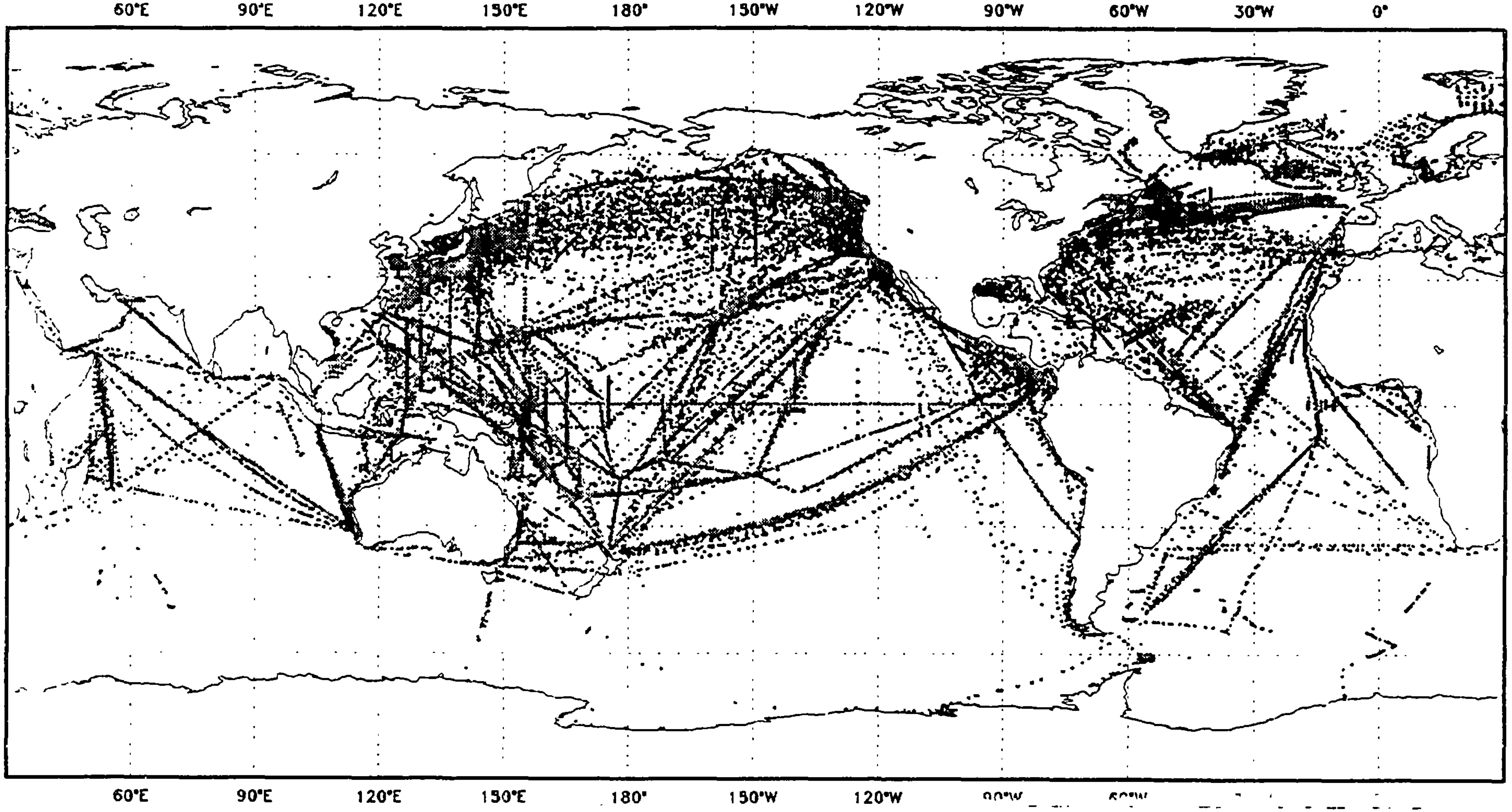


Figure VII.

METEO-FRANCE/SMISO FRENCH MET OFFICE/IGOSS

Pointage des observations effectuees par les navires francais

durant l'annee 1992

Messages : BATHY Total : 4215

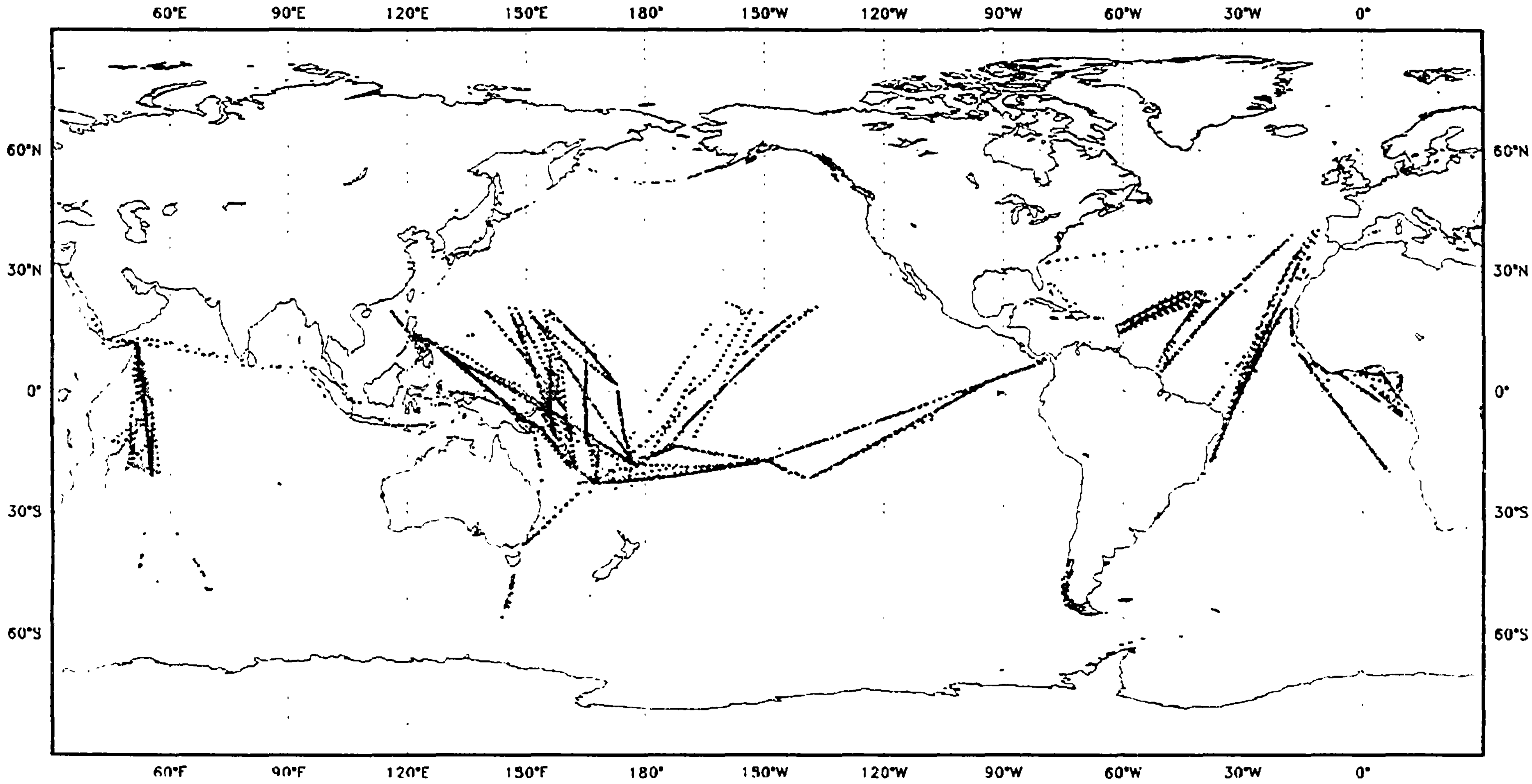


Figure VIII.

GERMANY

Bundesamt für Seeschiffahrt und Hydrographie

Overview

As in previous years, German ship-of-opportunity (SOO) activities are focussed on the Atlantic Ocean. Several German institutions are involved. Both the Institut für Meereskunde, Kiel (IfM Kiel) and the Bundesamt für Seeschiffahrt und Hydrographie, Hamburg (BSH; formerly DHI) each operate two lines on a regular basis. These lines are part of the German contribution to WOCE and should be operational at least until the end of the German WOCE field phase (1995). In addition, several research vessels, e.g. "Meteor", "Valdivia", "Polarstern", and "Walther Herwig", carried out XBT measurements while en route. It must be stressed that most of these SOO activities are PI-driven, and thus depend on specific scientific programmes rather than on being an official German contribution to IGOSS. Technical and organizational information about these lines is summarized in the Table. Real-time and quality controlled data are inserted into GTS by the BSH with a delay of about 3 days to 1 week.

Observing Network

Line AX-3 is operated by the BSH. The sampling strategy for this line is designed to meet both WOCE requirements and the PI's own scientific objectives. It crosses the subarctic North Atlantic close to the endpoint/startpoint of the thermohaline-driven "Conveyor Belt". The stability of the North Atlantic part of the "Conveyor Belt" has recently been questioned in paleoclimatic investigations and by results from numerical ocean models. Many pronounced processes and features are candidates for global change indications. Besides investigating heat content variability and, possibly, heat flux, another focus of attention is the statistical analysis of specific regional features concerning

1. the temporal and spatial variability of the North Atlantic current system,
2. the thermal front between the Labrador Current and the North Atlantic current,
3. and winter convection in the eastern part of the North Atlantic.

The programme is funded by the German Ministry of Science and Technology.

From the start of the programme in 1988, measurements have been taken monthly by the German container vessel "Köln Atlantic" on her way due east. An upgraded Bathy System Seas unit is used for data acquisition and transmission. So far, the line has been kept operational almost without interruption. Minor problems were solved immediately thanks to the help of Jim Farrington of NOAA. As of February 1993, 70 sections had been collected; most have a resolution better than 40 nautical miles (Fig. 1). In co-operation with the Russian State Oceanographic Institute, Moscow, two additional sections (spatial resolution up to 5 nm) were carried out by R.V. "Professor Multanovsky" in December 1992 and January 1993 (Fig. 2).

Temperature measurements, if sampled frequently enough, can give an idea about space and time scales. But because of the variable T/S relationship in dynamically active regions like the western North Atlantic, XBTs alone do not satisfactorily meet the requirements for the investigation of heat flux or other important climate-relevant processes. XCTD probes were therefore used as soon as they became available. The first ocean crossing XCTD section was probably carried out by CMS "Köln Atlantic" from Feb 22 to Feb 26, 1992 (Fig. 3). The section was repeated in July 1992. 2 repetitions per year are planned provided XCTD reliability problems can be solved. XCTD versus CTD comparisons carried out in the North Atlantic on board R.V. "Valdivia" in September 1992 (Fig. 4) showed that XCTD probes do not yet meet the manufacturer's specification and, most importantly, showed serious errors in XCTD performance (Sy, 1993). In addition, plans are underway for SSS measurements along this line to monitor the plume of Greenland meltwater runoff which spreads south in the surface layer of the sea in summer. A prototype thermosalinograph which has been developed by Ocean Sensors, USA, and which is designed to be attached to the vessel's water production facilities has not yet been tested at sea, however.

Line AX-11 was established as the first German SOO line in 1981 by DHI (now BSH). Both the data acquisition system and data management are the same as for line AX-3. The measurements are carried out by the German container vessel "Monte Rosa" on her way due north (Fig. 5). From July 1991 until November 1991 she was taken off the Europe - Brazil service. Thereafter measurements could be continued without interruption (Fig. 6).

Lines AX-17/18 and AX-21 were set up by IfM Kiel as part of WOCE in 1989. The scientific objective is to investigate
1. the annual and interannual variability of heat storage in the upper ocean and
2. in particular, the eddy activity of the Subtropical Gyre.
This programme is funded by the German Ministry of Science and Technology.

In the past, M.V. "Paul" and M.V. "Tilly", on their irregular service between Santos/Buenos Aires and Cape Town/Matadi, carried out measurements (Fig. 7) using T-5(20 kn) probes at a drop rate of 6 drops per day. Both vessels were taken off the Atlantic service at the end of 1991. It was difficult to find a substitute for these vessels, and the programme was only taken up again a year later by South African M.V. "Horizon" in September 1992 (Fig. 8). A second vessel, M.V. "Frontier", joined this programme in March 1993. Both vessels are equipped with a Nautilus Marine Service data acquisition system designed for real-time data transmission via METEOSAT.

As in the past, efforts have been made to collect data from data-sparse areas. R.V. "Polarstern" from Alfred-Wegener-Institut (AWI) is now equipped for routine XBT measurements and real-time data transmission. During the 1992/93 Antarctic research season, she transmitted BATHY messages along her way to and from Antarctica (Fig. 9). If funds are available, XBT measurements will be carried out again by R.V. "Polarstern" during her next Antarctic season. AWI scientists report about data quality problems occurring randomly at low temperatures. They assume that the Nautilus controller is the error source. Remarkable XBT real-time data contributions in 1992 came from the South Atlantic (R.V. "Meteor") and the subpolar North Atlantic (R.V.

"Valdivia"). Finally, the BSH succeeded in getting quality controlled BATHY messages from the German Navy. As a result of the new policy of détente between East and West, the Navy decided to declassify their data 14 days after collection. A regional overview of all BATHY messages submitted to GTS is given in Fig. 10.

Further activities and GTS data exchange

To comply with the IGOSS request for more TESAC messages, XCTD data from line AX-3 were transmitted via GTS as a test. We also linked a module to our CTD acquisition software which encodes the CTD bottle readings into TESAC form to be transmitted to shore by telex or telefax. This procedure has only been used for WHP cruises because of the higher data quality standards of WOCE CTDs. To support production of the BSH's weekly North Sea SST map (IGOSS, 1991), several vessels have been equipped with Pt100 contact thermometers (Sy and Ulrich, 1989). All SST data received at the BSH are inserted into GTS in the form of TRACKOB messages (Fig. 11). Finally, plans have now been realized for real-time linkage to GTS of selected stations in the BSH's automatic measuring network in German coastal waters in the North Sea and Baltic Sea.

Over the last 20 years, the BSH has participated actively in IGOSS and acts as the German input and output GTS hub for real-time oceanographic bulletins. Fig. 12 shows that the BSH contribution to the IGOSS real-time data flow has been relatively continous over the last 20 years. We hope to contribute in the same way in the future. New hardware and software for real-time data acquisition and distribution became operational at the BSH in 1990. Since then the volume of our IGOSS output data has increased significantly. A trackplot of the output for BATHY messages in 1990 is given in Fig. 13 and one of TESAC messages is given in Fig. 14.

References

IGOSS (1991): Integrated Global Ocean Services System Products Bulletin, June 1991. IOC/WMO, 18 pp.

Sy, A. und J. Ulrich (1990): North Atlantic Ship of Opportunity XBT Programme, 1989 - Data Report. Wiss.-Techn. Berichte aus dem Deutschen Hydrographischen Institut, 1990-2, 89 pp.

Sy, A. (1993): XCTD measurements in the North Atlantic: Report on XCTD performance data. Summary Report on a meeting of the IGOSS Task Team on Quality Control of Automated Systems, Geneva, 19-21 Oct. 1992.

<u>Table:</u> SOO lines operated by German institutions

	Europe-N.America	Europe-Brazil	S.America - Cape Town	
TWI #	AX-3	AX-11	AX-17	AX-18
Ship	"Köln Atlantic"	"Monte Rosa"	"Horizon" "Frontier"	"Horizon" "Frontier"
Callsign	DAKE	DGLM	J8GG4 J8GC9	J8GG4 J8GC9
Programme	WOCE	IGOSS/WOCE	WOCE	WOCE
Start	5/1988	1981	5/1989	9/1989
Finish	1995 ?	open	1995 ?	1995 ?
Frequency	8/yr	8/yr	6/yr	6/yr
Density	12/d	6/d	6/d	6/d
Probes	T7/T5 XCTD (2/yr)	T7	T7/T5	T7/T5
Equipment	SEAS II Bathy S.	SEAS II Bathy S.	Nautilus PC, DCP	Nautilus PC, DCP
Agency	BSH	BSH	IfM Kiel	IfM Kiel
Real-time	METEOSAT	METEOSAT	METEOSAT	METEOSAT

In addition, several research vessels will carry out XBT measurements irregularly while en route (braodcast mode):

R.V. "Meteor"	DBBH
R.V. "Polarstern"	DBLK
R.V. "Walther Herwig"	DBFP
R.V. "Gauss"	DBBX
R.V. "Valdivia"	DESI

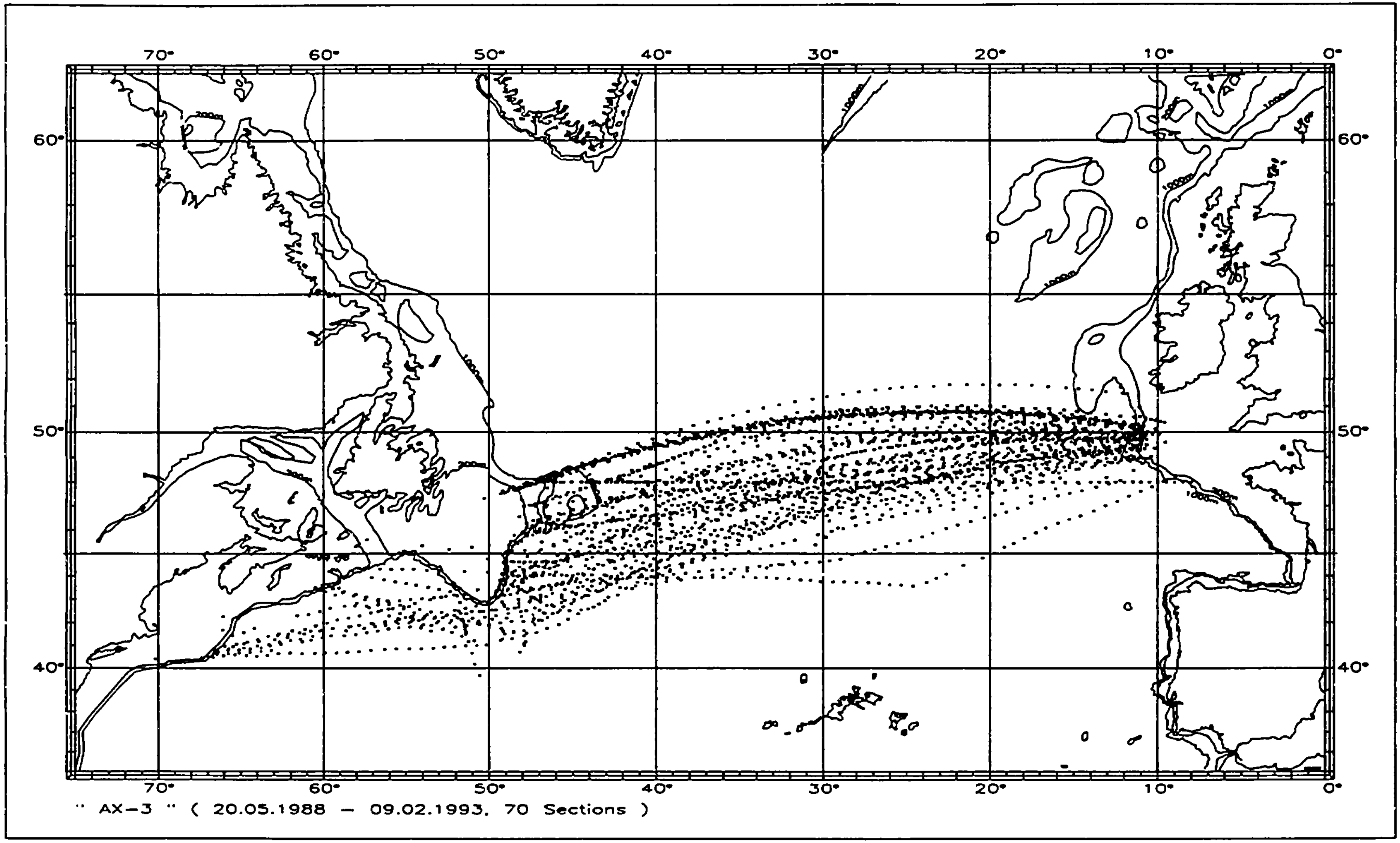
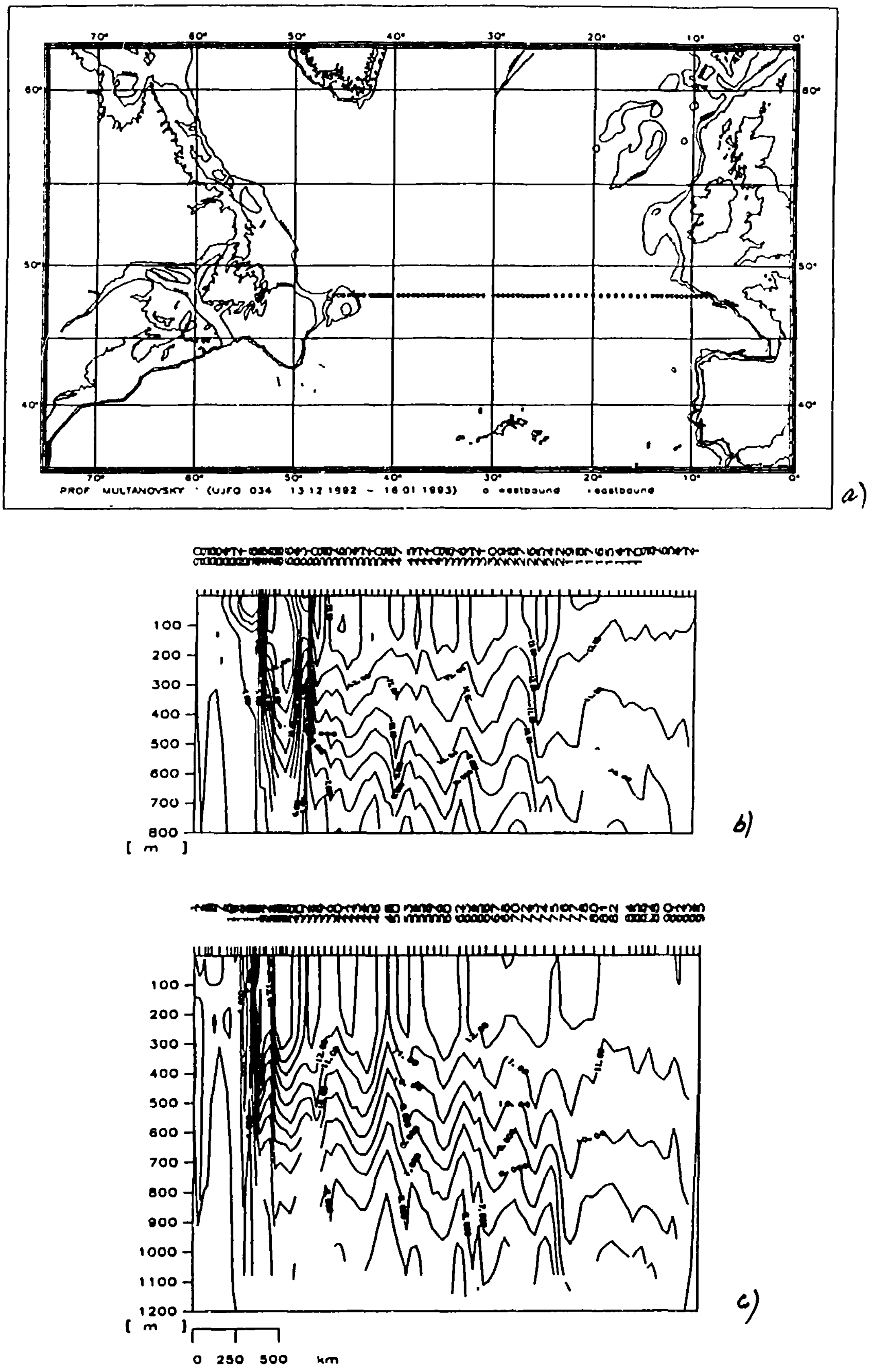


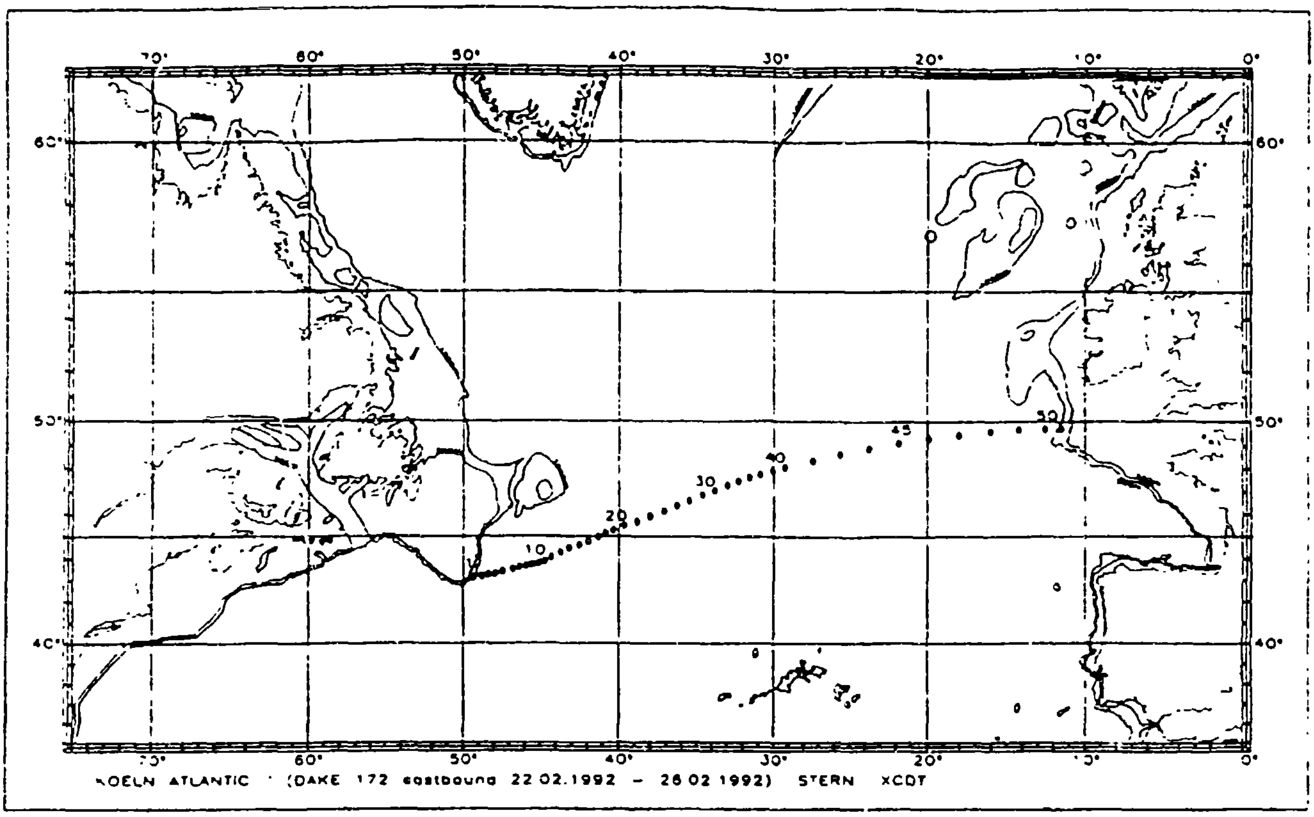
Fig. 1: XBT data distribution of BSH high density line AX-3 from May 1988 to February 1993



<u>Fig. 2:</u> a) XBT measurements across the North Atlantic along 48 °N carried out by RV. "Professor Mulatanovsky" in December 1992 and January 1993

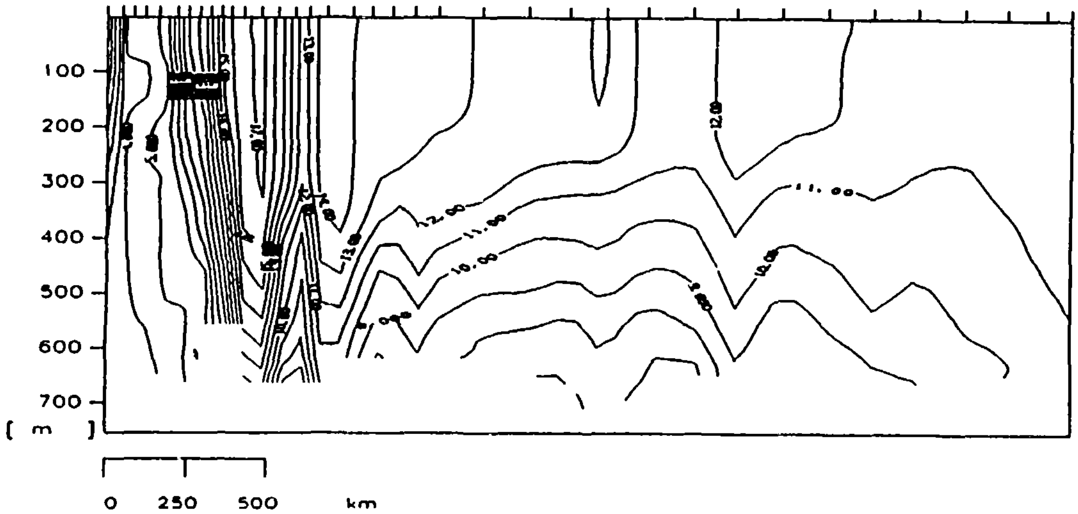
b) Temperature section December 1992 using T-7 probes

c) Temperature section January 1993 using T-5 (Fast Deep) probes



a)

<u>Fig. 3:</u> a) XCTD section carried out by CMS "Köln Atlantic" in February 1992
b) XCTD temperature
c) XBT (T-5 "Fast Deep") temperature for comparison. XBTs were launched from the bridge's wing.
d) XCTD salinity
e) XCTD density



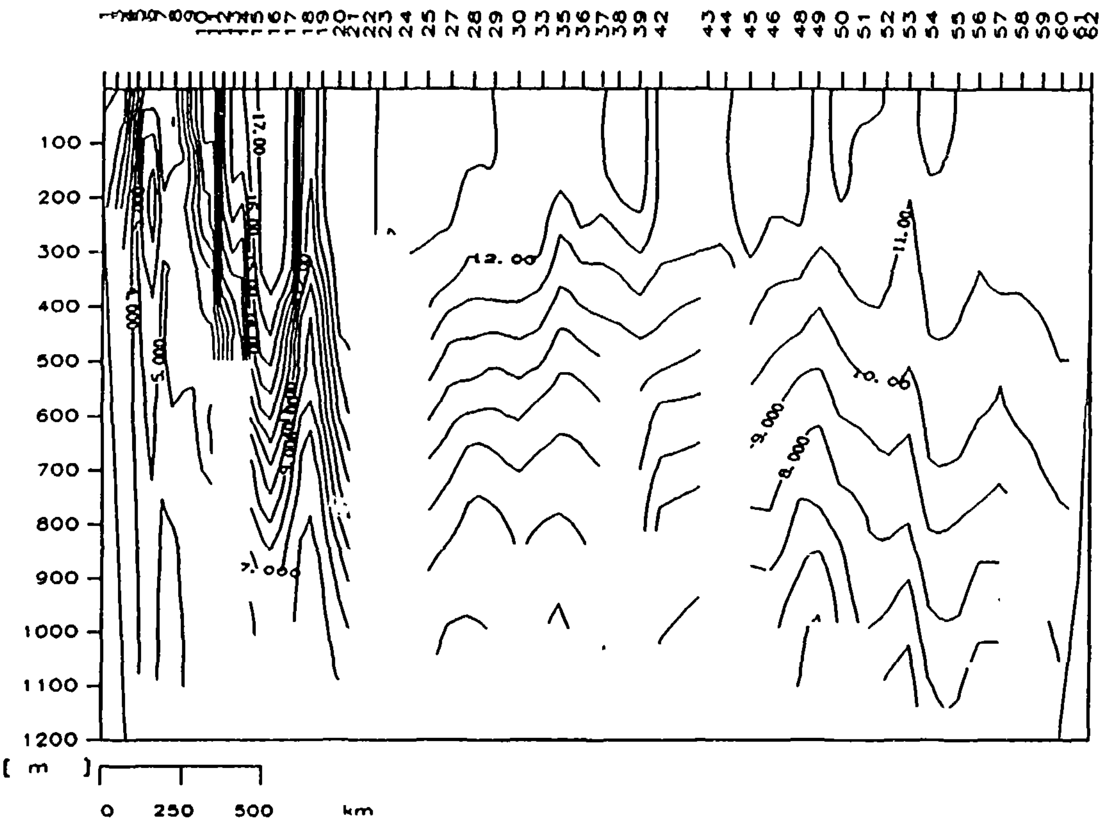
SOOP 172 TEMPERATUR/ degC

Gridding Parameter:
No of GRD-Points in X= 50
No of GRD-Points in Y= 50

Area in X, by no. of profiles= 2
Area in Y, by physical units = 100
Order of Orthogonal Surface = 1

BSH
Hamburg

b)



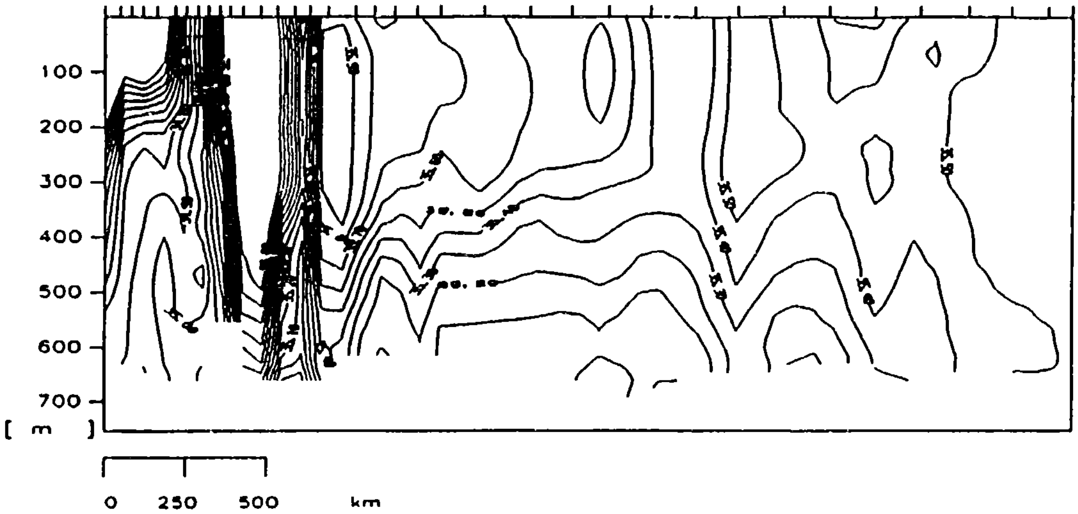
Orthogonal Surface Analysis: DAKE 172 N-ATL.east

Gridding Parameter:
No of GRD-Points in X=100
No of GRD-Points in Y=100

Area in X, by no. of profiles= 2
Area in Y, by physical units = 100
Order of Orthogonal Surface = 1

BSH
Hamburg

c)



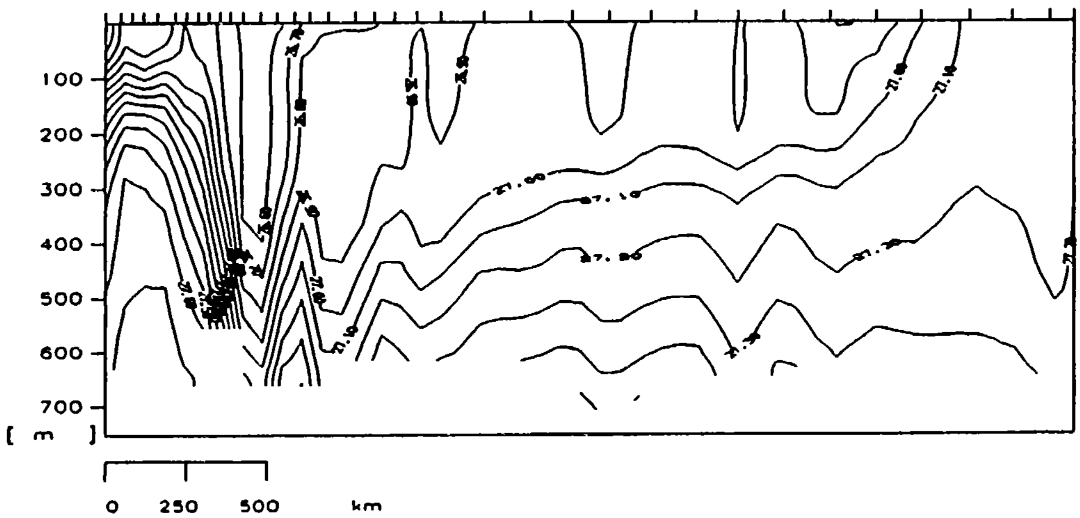
SOOP 172 SALINITY/ pSal

Gridding Parameter:
No of GRD-Points in X= 50
No of GRD-Points in Y= 50

Area in X, by no. of profiles= 2
Area in Y, by physical units = 100
Order of Orthogonal Surface = 1

BSH
Hamburg

d)



SOOP 172 SIG-TS/ kg/m3

Gridding Parameter:
No of GRD-Points in X= 50
No of GRD-Points in Y= 50

Area in X, by no. of profiles= 2
Area in Y, by physical units = 100
Order of Orthogonal Surface = 1

BSH
Hamburg

e)

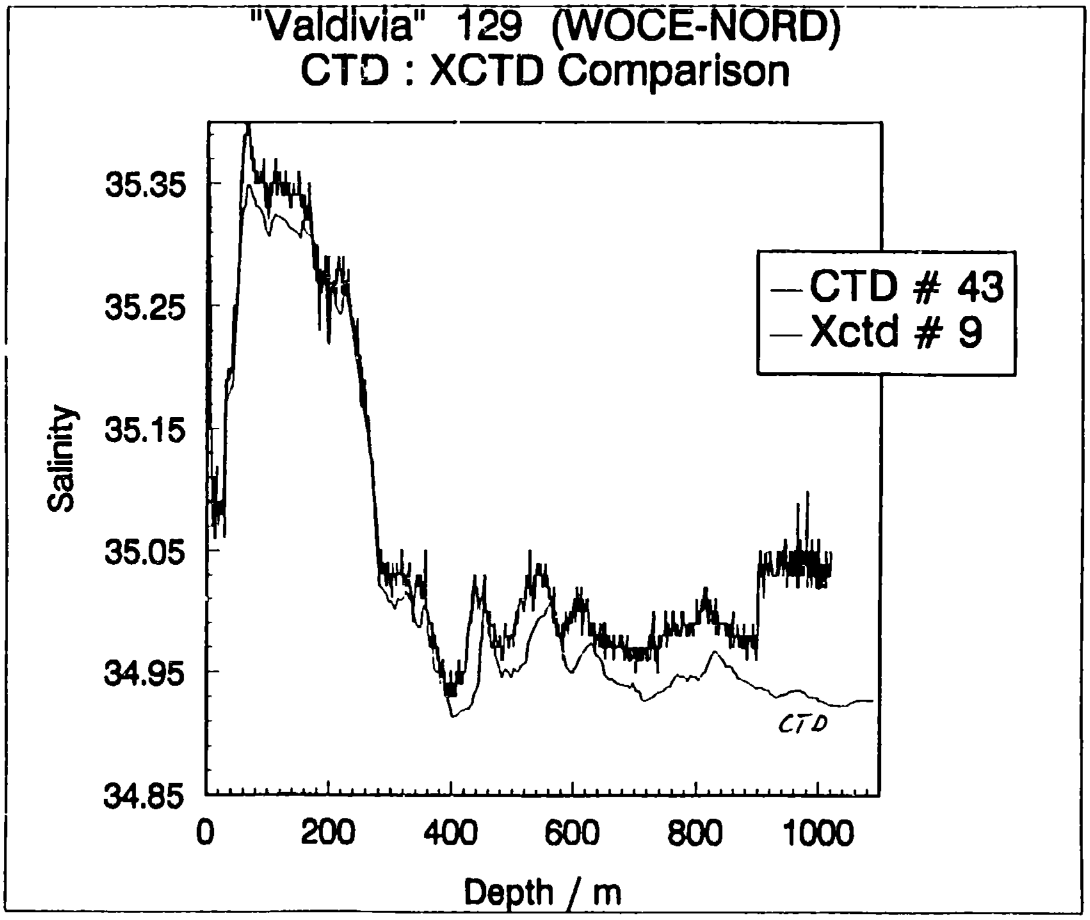
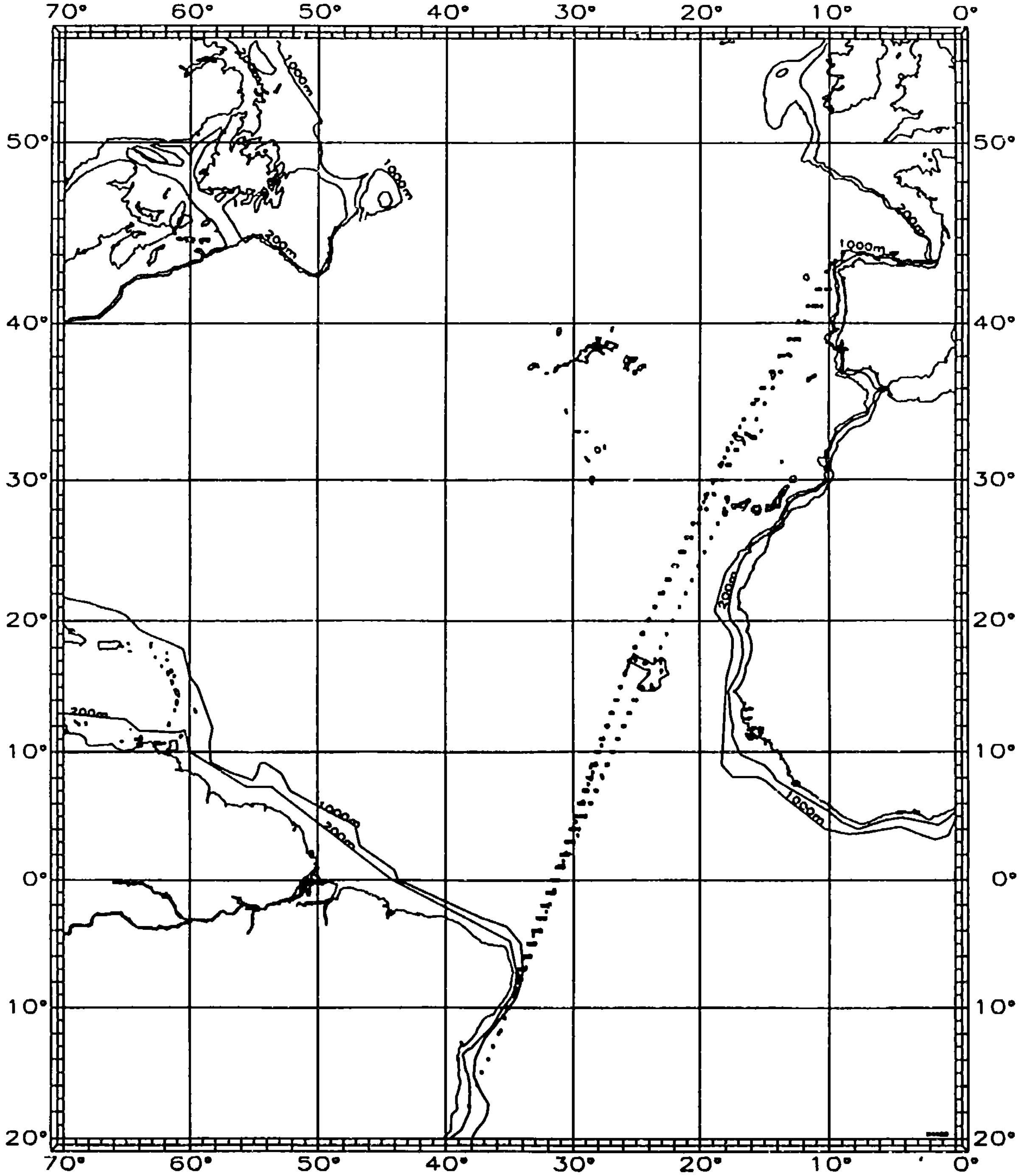
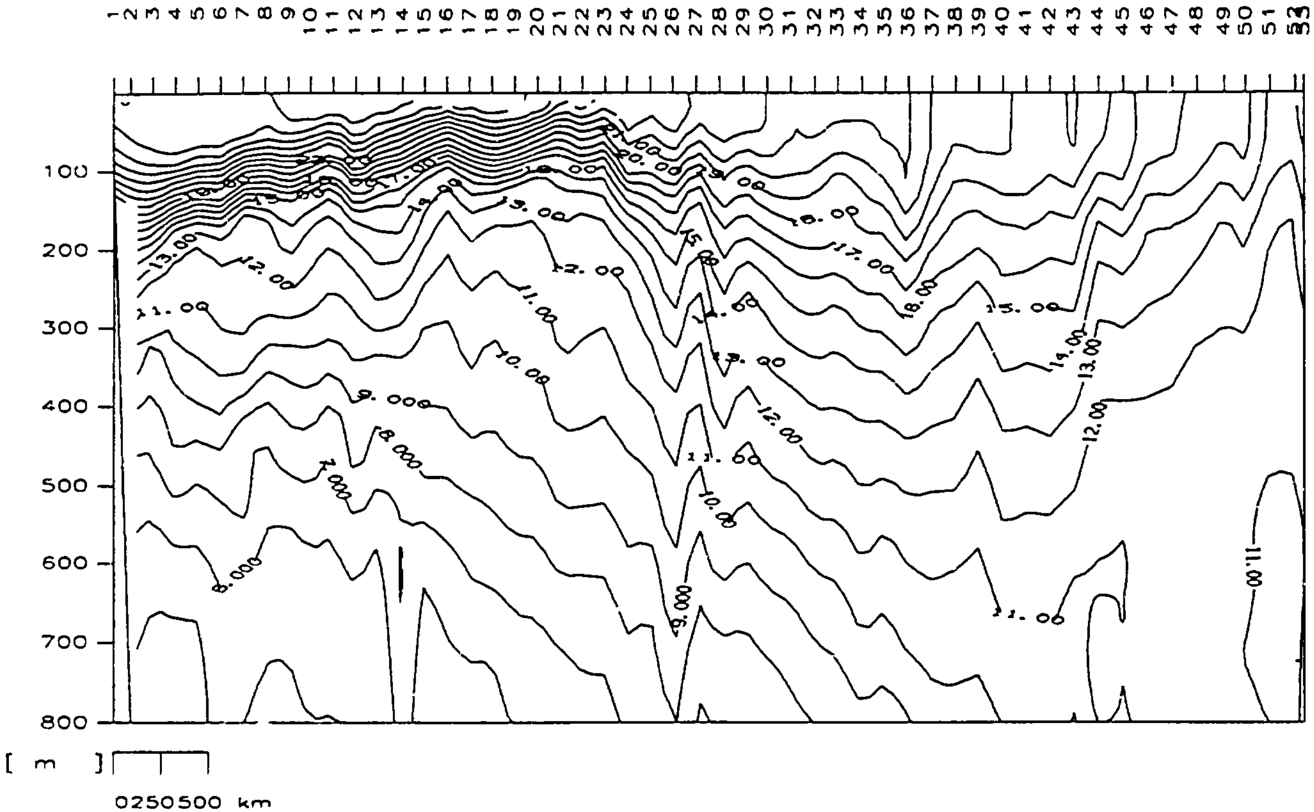


Fig. 4: XCTD vs. CTD comparison profile for salinity



"MONTE ROSA" (DGLM 25.07.1990 – 01.03.1993, 18 Sections, AX-11)

Fig. 5: XBT data distribution of BSH line AX-11 from July 1990 to March 1993



Orthogonal Surface Analysis: DGLM 079 T-ATL. northbound

Gridding Parameter:	Area in X, by no. of profiles= 2
No of GRD-Points in X=100	Area in Y, by physical units = 100
No of GRD-Points in Y=100	Order of Orthogonal Surface = 1

BSH
Hamburg

Fig. 6: XBT section carried out by CMS "Monte Rosa" in Dec/Jan 1992/93

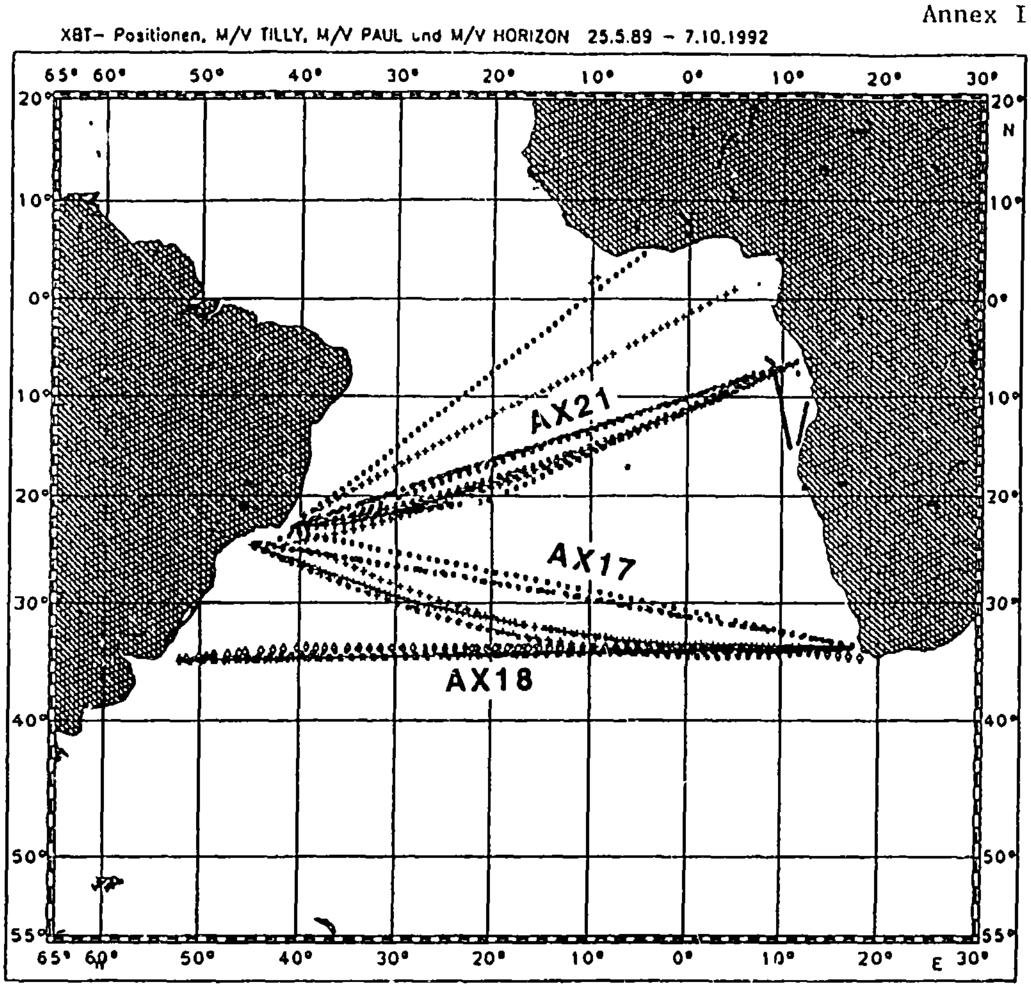


Fig. 7: XBT data distribution of IfM Kiel XBT programme from May 1989 to October 1992

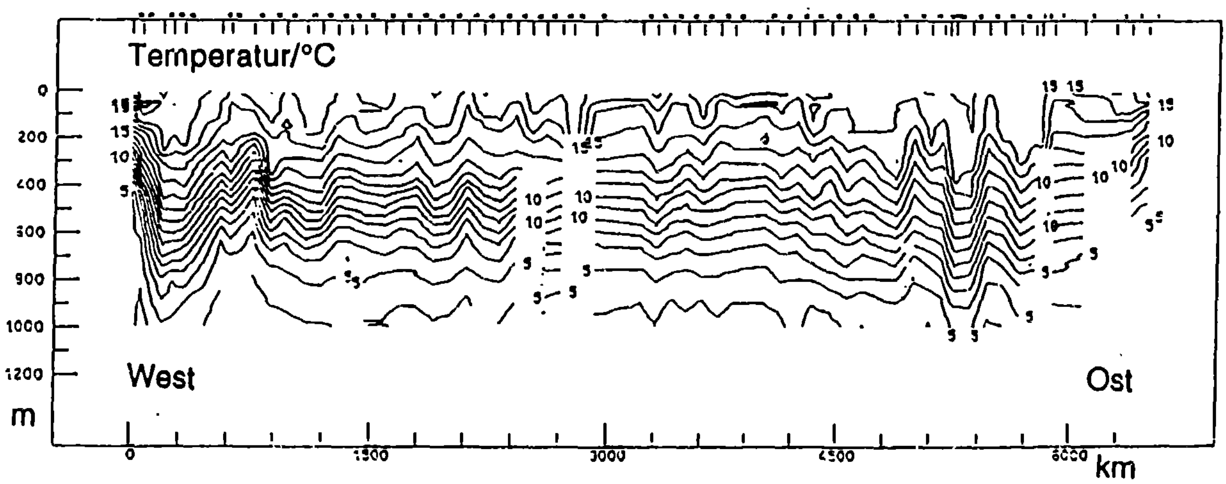


Fig. 8: XBT section of line AX-18 from Buenos Aires to Cape Town carried out by MV "Horizon" in October 1992

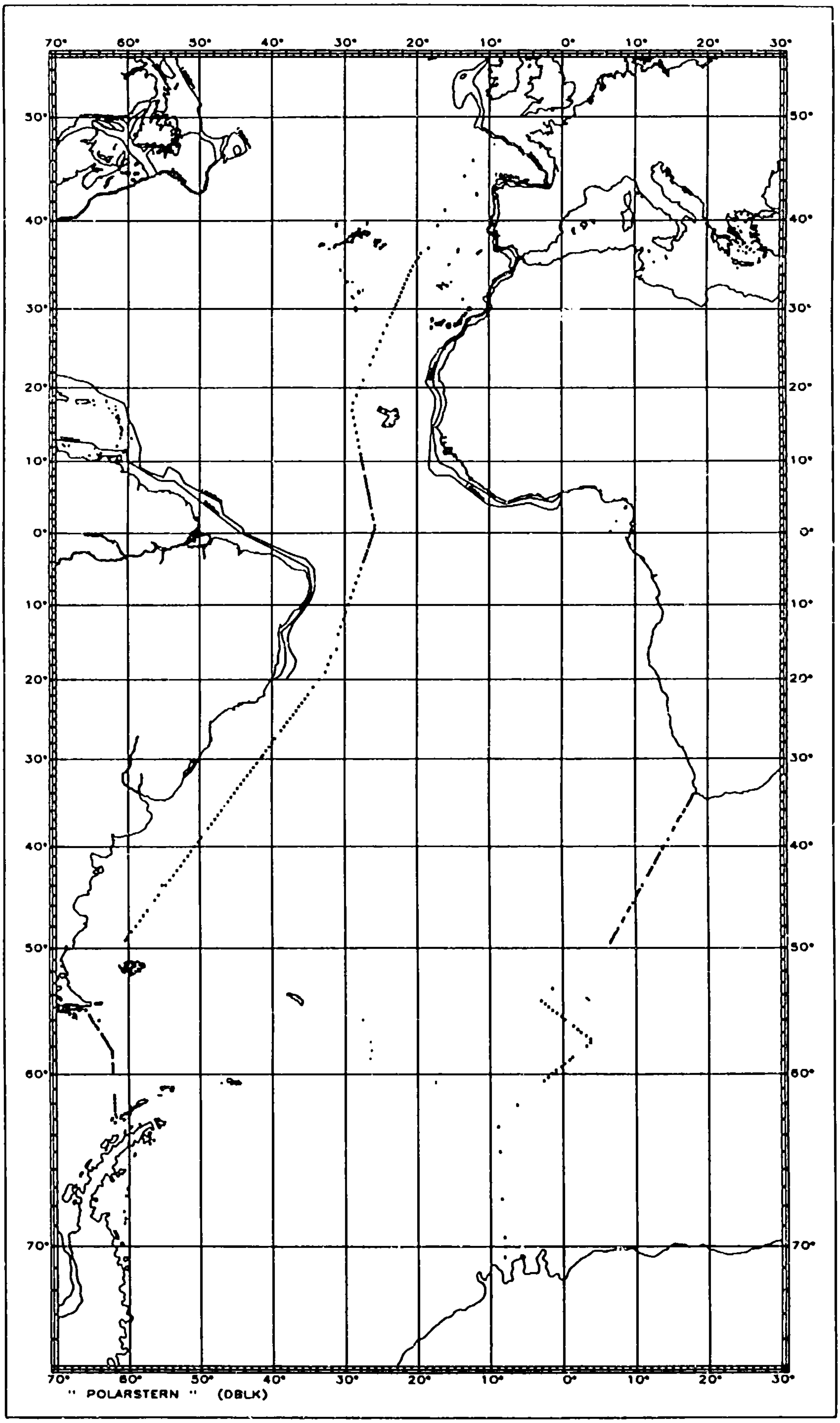


Fig. 9: Trackplot of BATHY messages received at BSH from RV "Polarstern" during her Antarctic season 1992/93

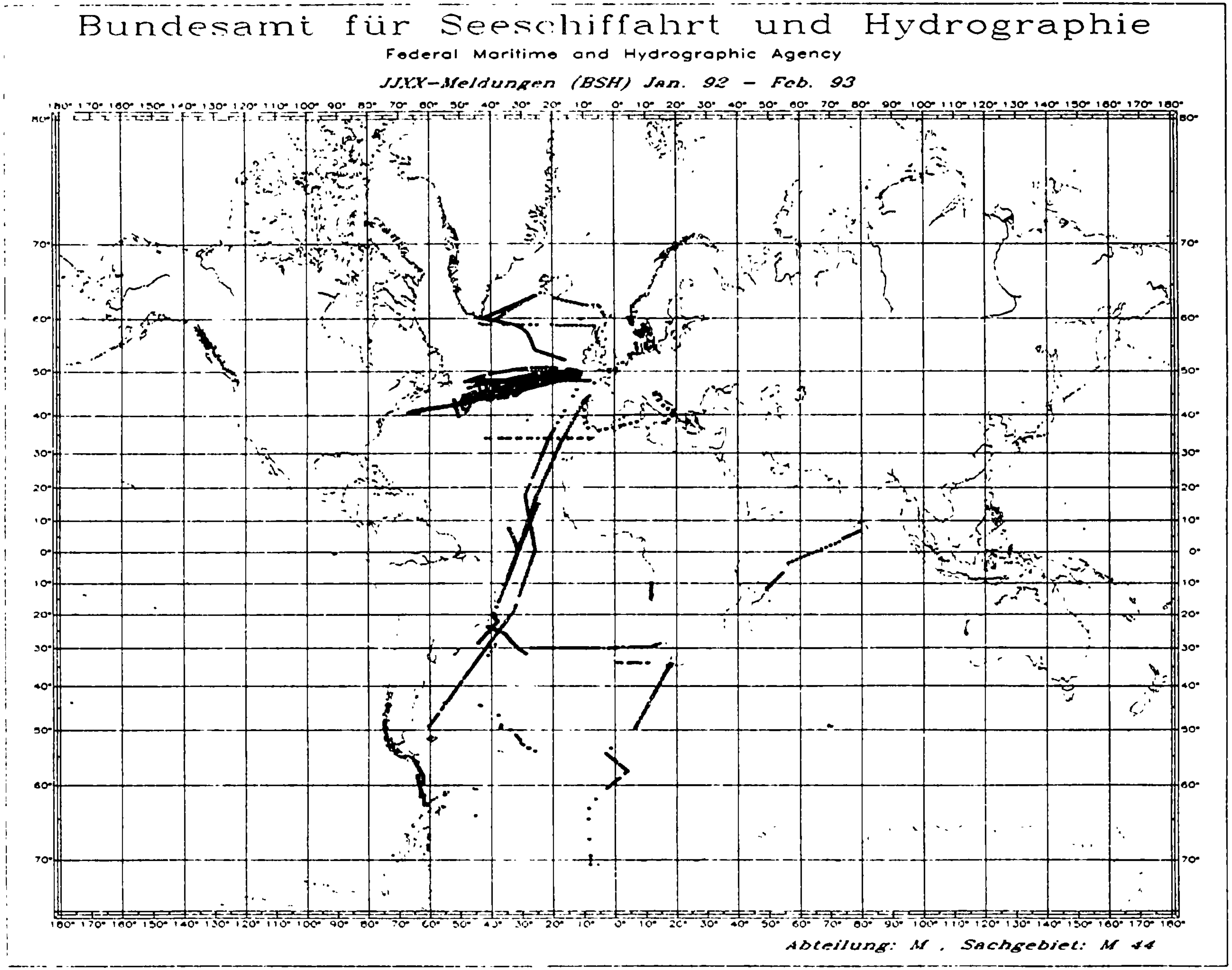
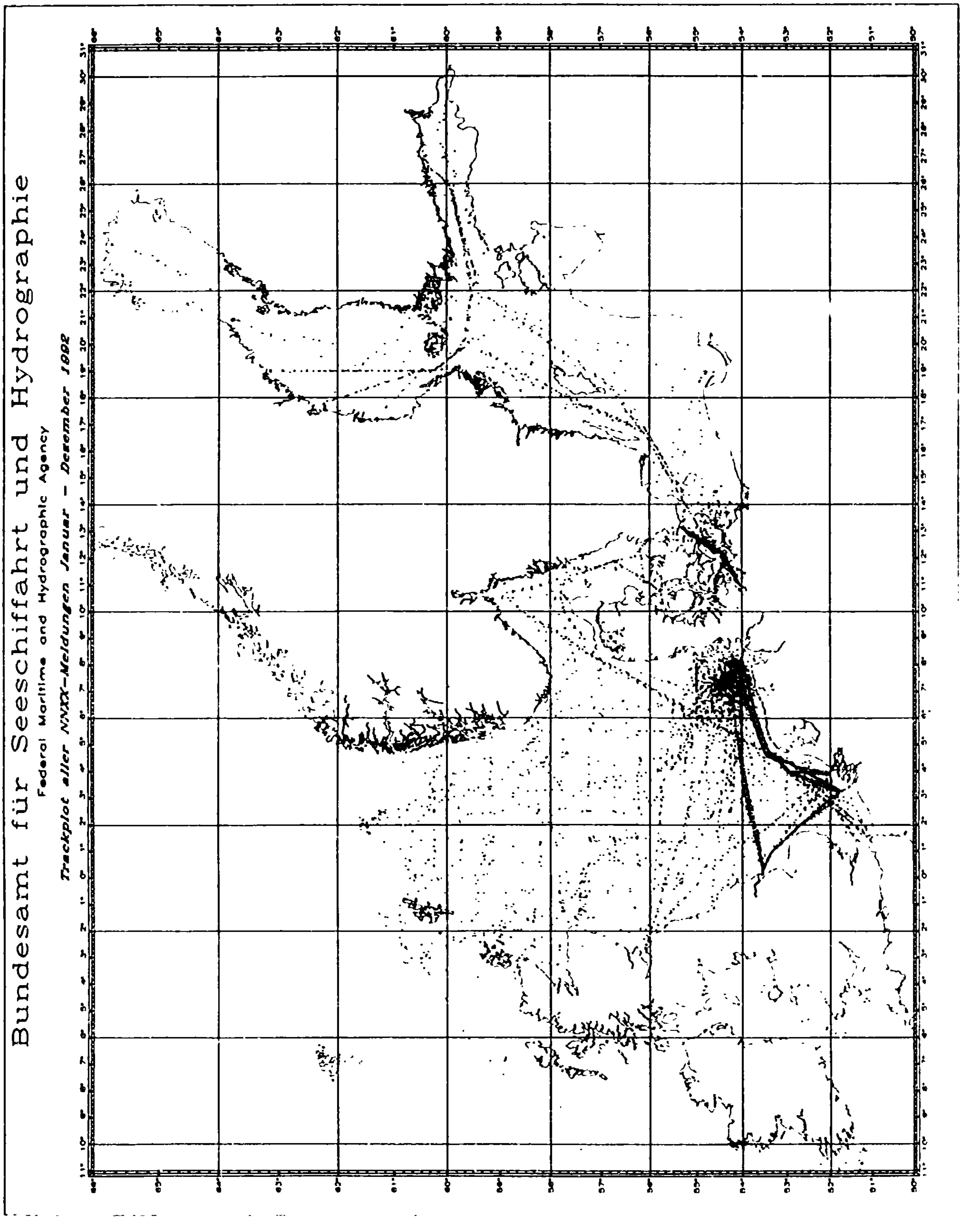


Fig. 10: Trackplot of BATHY messages submitted to GTS by BSH

Fig. 11: Trackplot of TRACKOB messages of the BSH SST programme



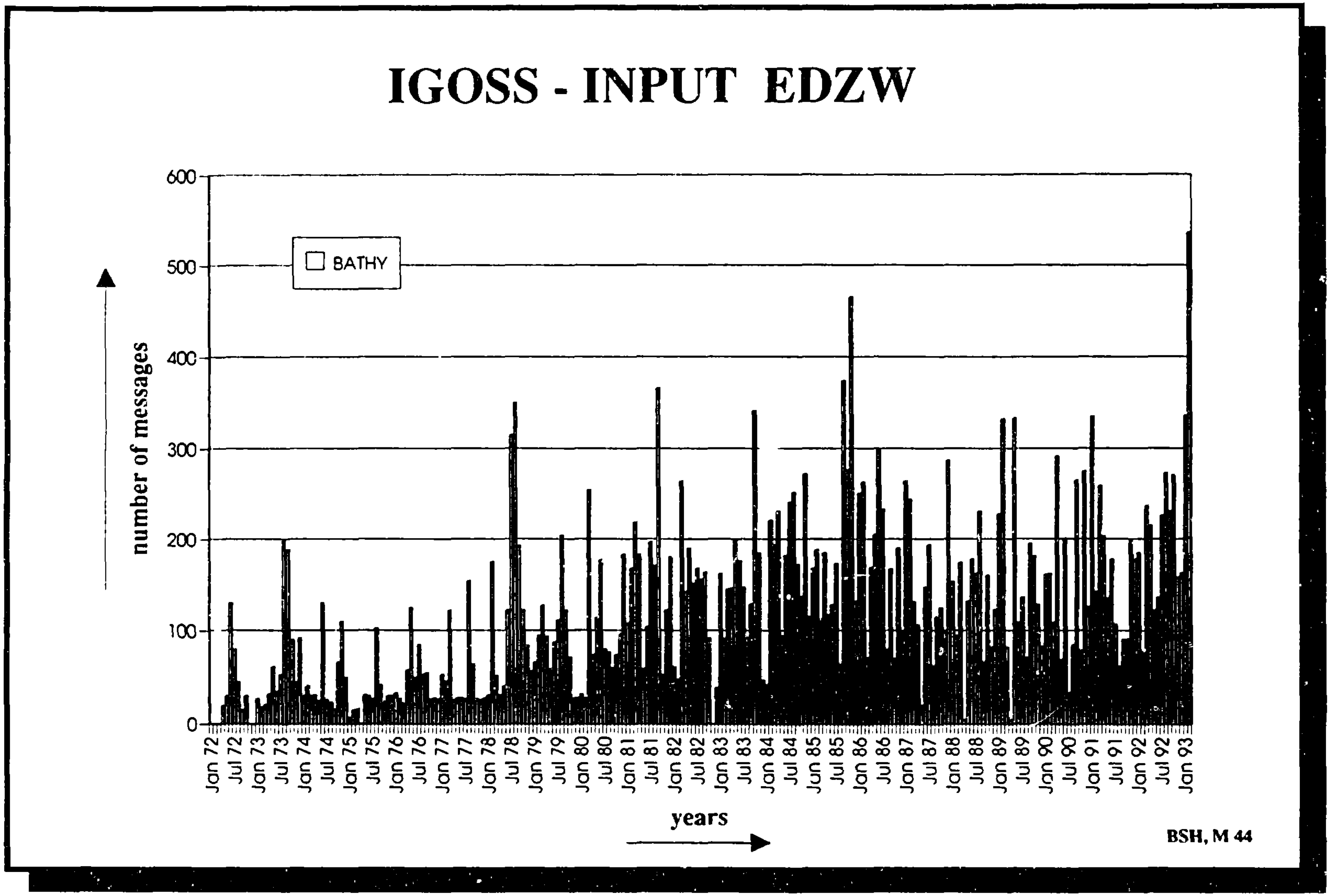


Fig. 12 a): Time series of monthly BATHY input by BSH

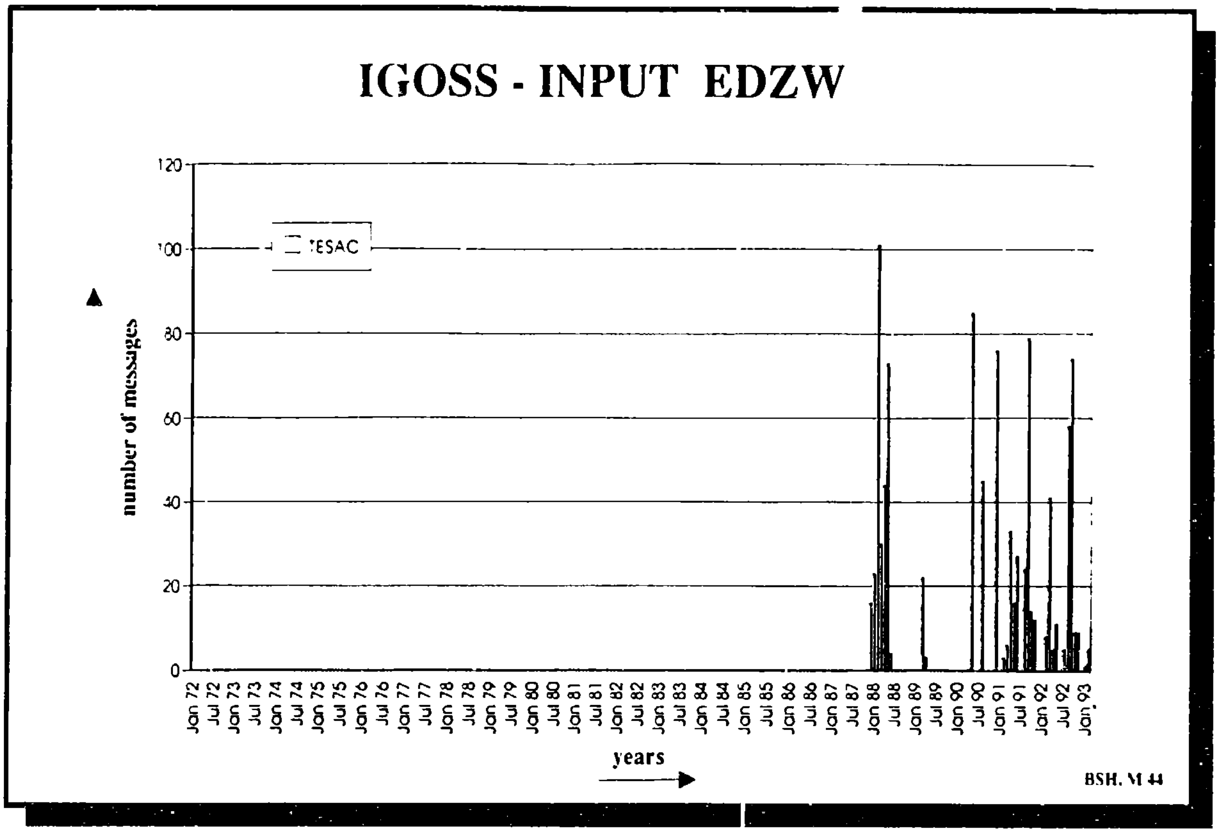


Fig. 12 b): Time series of monthly TESAC input by BSH

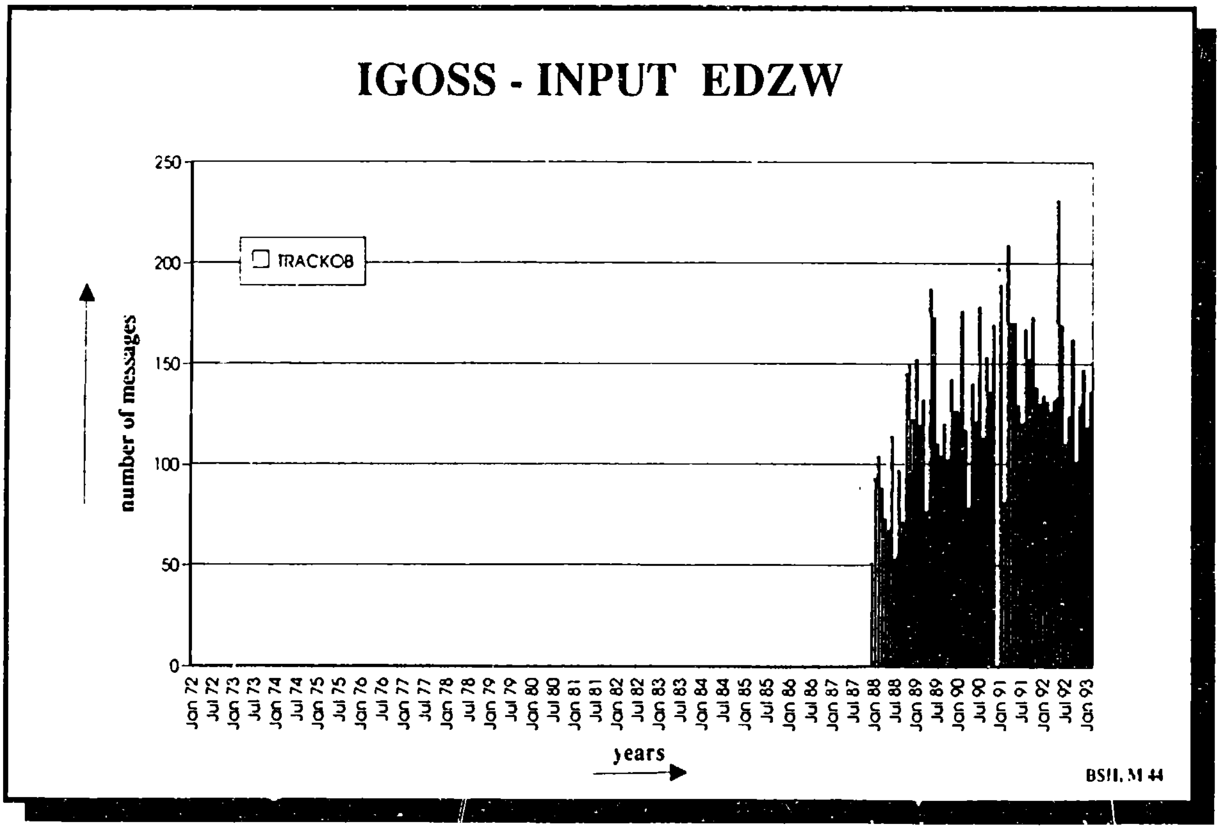


Fig. 12 c): Time series of monthly TRACKOB input by BSH

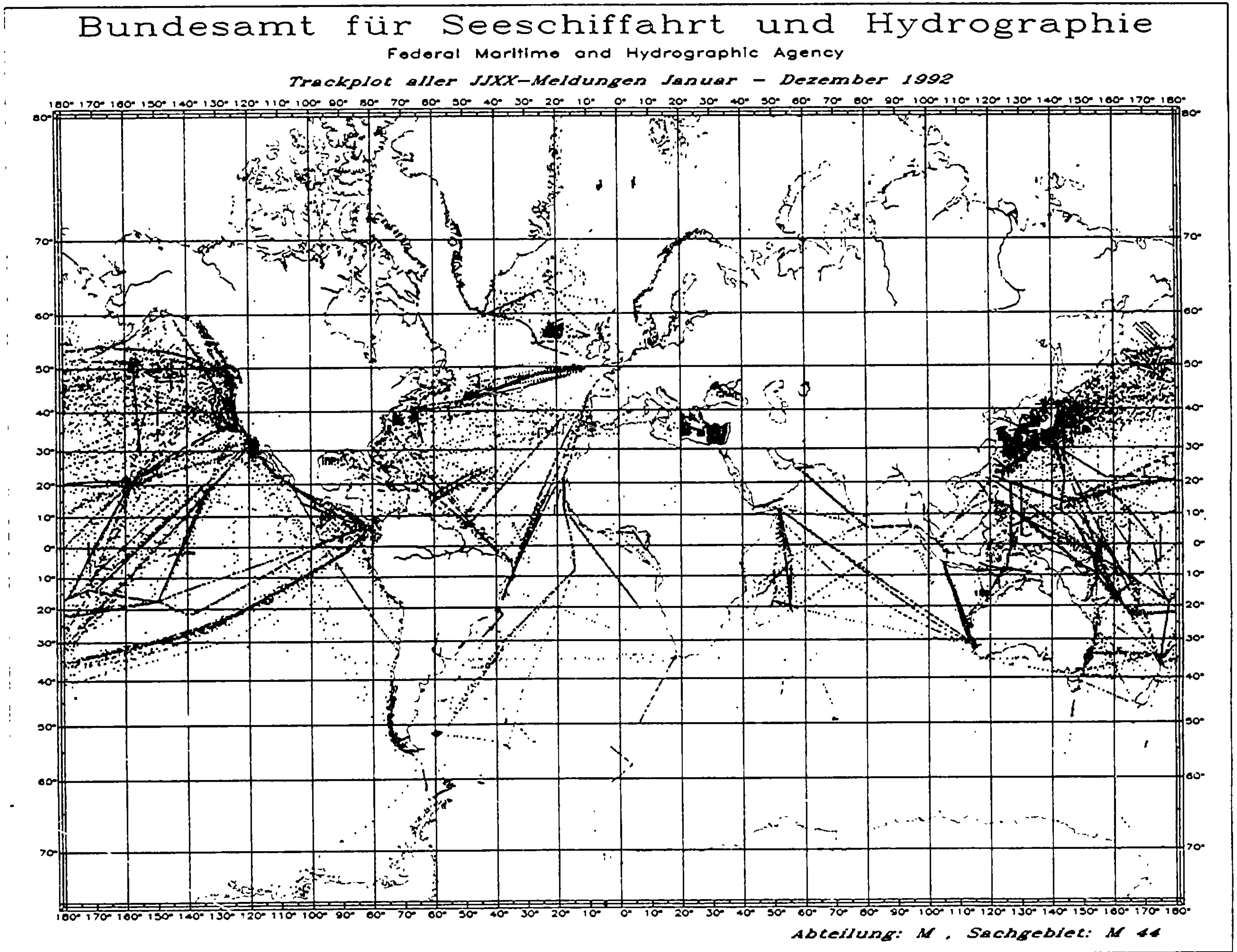


Fig. 13: Trackplot of BATHY messages received at BSH (output + input)

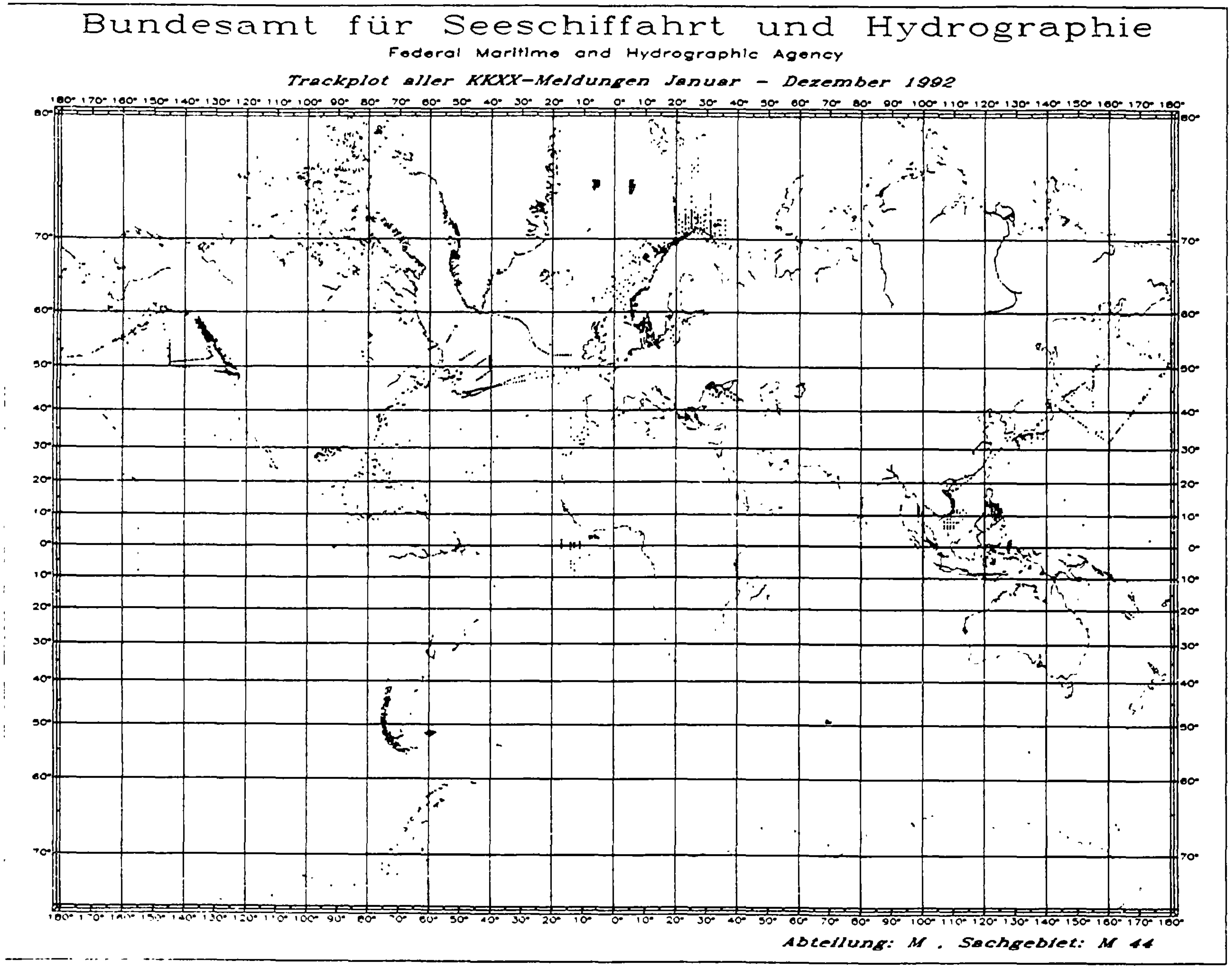


Fig. 14: Trackplot of TESAC messages received at BSH (output + input)

UNITED KINGDOM

UK Hydrographic Department

General

As in previous years, the UK Ship-Of-Opportunity (SOO) activities during 1992 have been focused on the Atlantic Ocean. However, I am happy to report that closer cooperation between the Ministry of Defence and the UK scientific community has resulted in an expansion of the UK area of interest to include the whole of the Atlantic and the adjoining Southern Ocean.

For a variety of reasons, it was decided during 1991 to gradually phase out the Bathy Systems SA 810 recorders and replace them with the Sippican Mk 12 equipment. The first of the new systems, comprising the Mk 12 board in an industrial PC with NOAA-produced software, entered service in the MV BRUARFOSS on 6 December 1992 and a second system was installed in OWS CUMULUS on 17 February 1993.

Withdrawal of the MV SELFOSS(c/s TFAB) from WOCE line AX-0 (Iceland to Gibraltar) during 1991 coupled with difficulties in supporting the Iceland-based MV SKAFTAFELL(c/s LALW) resulted in the XBT/DCP equipment being removed from both vessels during 1992.

Status of Voluntary Observing Ships

The ships currently being used fall into 3 categories:-

A. Research ships operated by the Marine Research Institute (MRI), Reykjavik, Iceland with routine maintenance/repairs/ liaison carried out by MRI personnel.
B. Royal Research Ships operated by the Research Vessel Services(RVS), Barry, UK with routine maintenance/repairs/ liaison carried out by RVS personnel.
C. Weather ships and Merchant Vessels making regular visits to UK ports with routine maintenance/repairs/liaison carried out by Hydrographic Office/Department personnel.

Category A.

1. RV BJARNI SAEMUNDSSON (c/s TFEA) - fitted with the Bathy Sysyems SA 810 recorder and Synergetics 3400 Platform Transmitting Terminal (PTT). Operates, primarily, within a 200 mile radius of Iceland and has been making DCP tranmissions via METEOSAT since August 1991.
2. RV ARNI FRIDRIKSSON (c/s TFJA) - fitted with same XBT/DCP equipment as RV BJARNI SAEMUNDSSON (ex MV SELFOSS). Operates within the Icelandic EEZ and commenced DCP transmissions in January 1993.

Category B

1. RRS DISCOVERY (c/s GLNE) - fitted with same XBT/DCP equipment as the RV BJARNI SAEMUNDSSON (ex RRS CHARLES DARWIN). Presently operating in the South Atlantic and Southern ocean and commenced DCP transmissions in November 1992
2. RRS CHARLES DARWIN (c/s GDLS) - at present only fitted with a Bathy Systems SA 810 recorder which is being used to make routine XBT observations whilst on passage between research cruises in the North Atlantic. Data being forwarded to Hydographic Office for release to the IGOSS community after analysis.

Category C

1. OWS CUMULUS (c/s GACA) - occupies Weather Station Lima and until very recently was fitted with the Bathy Systems SA 810 recorder and Synergetics 3400 PTT. Since August 1992, DCP transmissions have been severely corrupted and to date, despite numerous visits to the ship and a complete change of equipment, the cause remains a mystery.
2. MV BRUARFOSS (c/s TFUD) - fitted with the Sippican Mk 12/ Synergetics 3400 XBT/PTT system since December 1992 and gathering data along the eastern half of WOCE line AX-1 (Iceland to UK)

In addition, the Hydrographic Department:-

a. looks after the NOAA-sponsored VOS, MV WESTMOOR (c/s ZCAQ) i.e meets the ship on arrival at the Port of London, supplies XBT probes and trouble-shoots any technical problems.
b. supplies XBT probes to the MV SKOGAFOSS (c/s B2QT) - sponsored by the Bedford Institute, Nova Scotia - to cover the central section of WOCE line AX-1 (Cape Farewell to Reykjavik)
c. supplies XBT probes to the Natural Environmental Research Council(NERC) scientists for use during research cruises in the Atlantic and Southern oceans.

UK Returns for the period 1/1/92 - 31/12/92

Ship Name	WOCE Line	Probes Deployed (Note 1)	Messages Transmitted (Note 2)	Profiles Accepted (Note 3)
OWS CUMULUS c/s GACA	N/A	895	487	604(Note 4)
RV B-SAEMUNDSSON c/s TFEA	N/A	349	207	247
RRS CHARLES DARWIN c/s GDLS	N/A	45	45	45
RRS DISCOVERY c/s GLNE	N/A	74	8(Note 5)	0(Note 4)
MV BRUARFOSS c/s TFUD)	AX-1	15	7	0(Note 4)

Notes

1. XBTs dropped based on data tapes received at Hydrographic Office.
2. JJXX messages received at the UK Meteorological Office (Bracknell) via METEOSAT/Radio and entered on GTS.
3. Profiles accepted after analysis at the Hydrographic Office.
4. Not all data received has been analysed.
5. Ship was outside the METEOSAT footprint for much of the time.

Present Monitoring Procedure

Real-time monitoring of all DCP transmissions is achieved using a METEOSAT receiver at the Hydrographic Office. In addition, the Meteorological Office maintain a record of all JJXX messages received at Bracknell via Darmstadt (European Space Operations Centre) and entered on the Global Telecommunication System(GTS).

Planned Expansion/Changes to the existing VOS Network

a. Replace the NOAA-owned XBT/PTT equipment in MV WESTMOOR with a Sippican Mk 12/Synergetics 3400 XBT/PTT system procured by the UK Hydrographic Department in order to simplify the repair and maintenance of the equipment.
b. Procure an additional Synergetics 3400 PTT for use in RRS CHARLES DARWIN
c. Liaise with the UK Institute of Oceanographic Sciences in the development of software to produce TESAC messages from SEASOAR (Undulating Oceanographic Recorder) - for use in RRS DISCOVERY.

UNITED STATES OF AMERICA

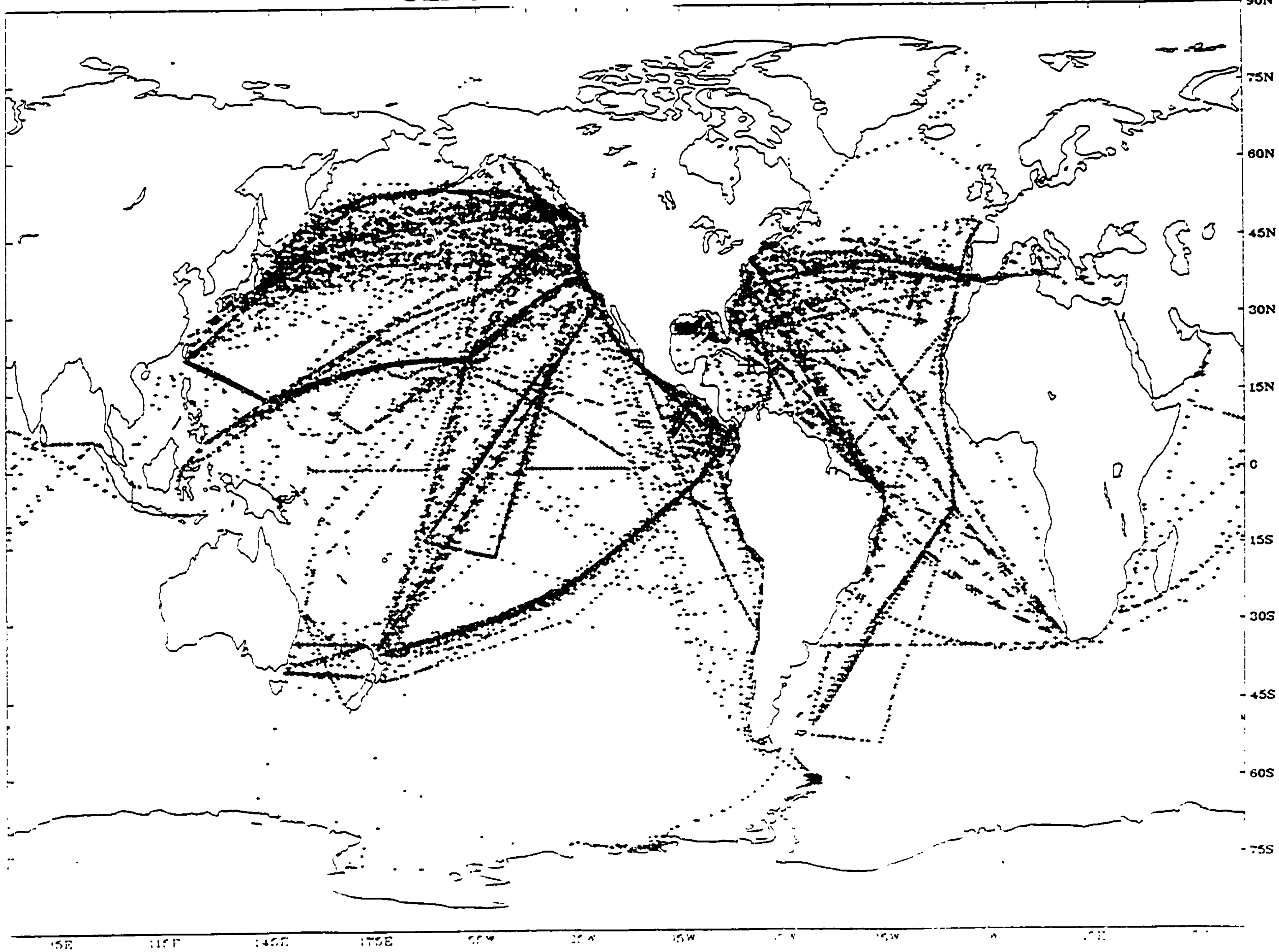
In 1992, 76 ships participated in the U.S. VOS XBT program, transmitting 13,034 XBT observation in real time. Another 2,627 XBT observations not received in real-time were forward to the National Oceanographic Data Center (NODC) for dissemination. The location of XBT observations collected in 1992 are provided in Figure 1. All observations received in real time are available to the international community via the Global Telecommunications System.

The program collects XBT data along certain routes in support of scientific programs such as the Tropical Ocean Global Atmosphere (TOGA) Program and the World Ocean Circulation Experiment (WOCE). The number of XBT observations by route and ship for 1992 are provided in Table 1. The location of the TOGA/WOCE XBT routes are provided in Figure 2.

In 1993, the supply of XBT probes is expected to increase as a result of implementing several expansion lines. The planned expansion will be on AX-2, AX-14, AX-16, PX-50, IX-15, and IX-25.

Figure 1.

SEAS 1992 XBT Observations



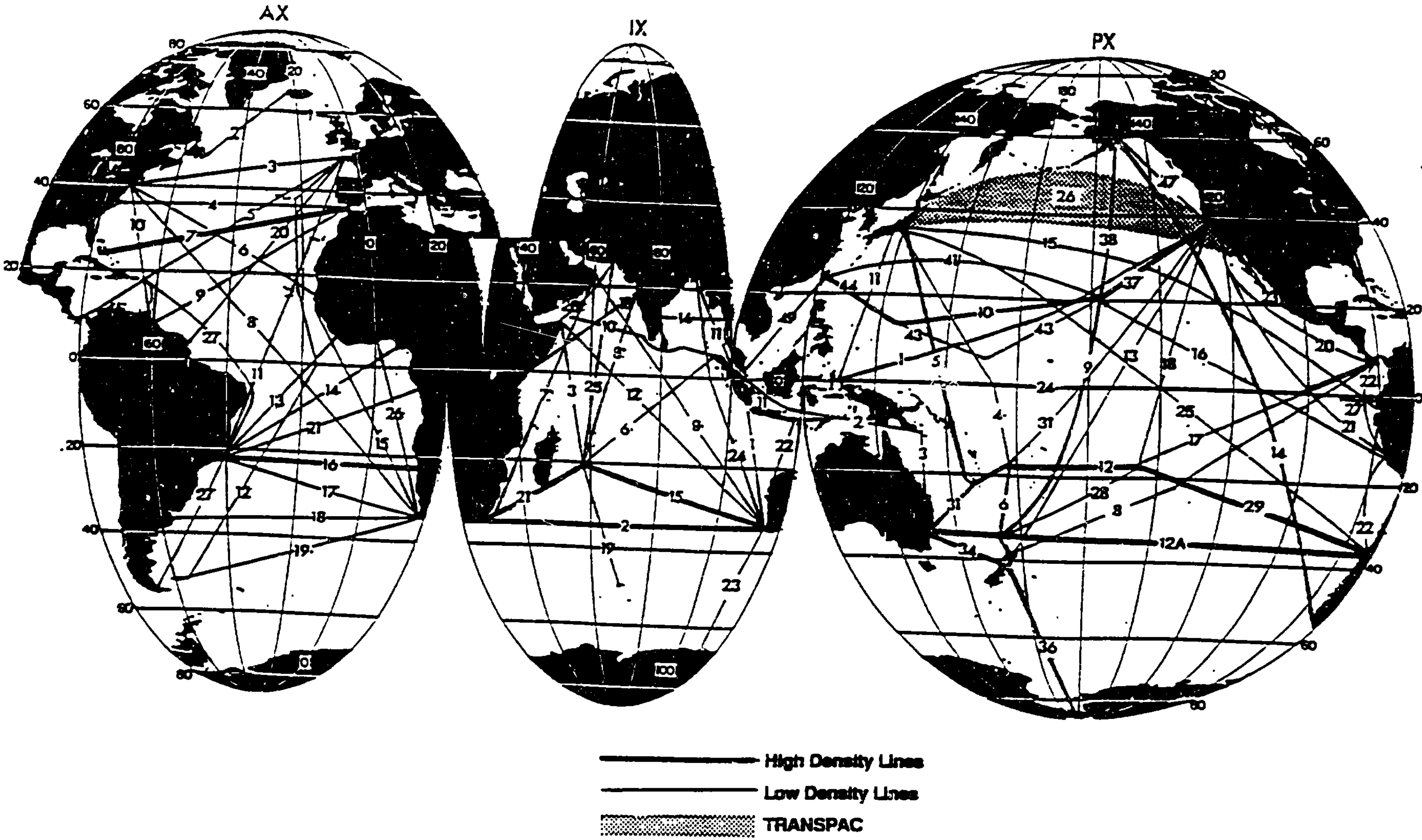


Figure 2. TOGA/WOCW XBT Network

Table 1. 1992 XBT's by Route and Ship

AS OF 93/03/04

ROUTE	FROM	TO
A04	NEW YORK	GIBRALTER

SHIP	# DROPS
TEXAS CLIPPER	11
MT MITCHELL	7
POLAR SEA	41
SEA-LAND ACHIEVER	541
ROUTE TOTAL	600

ROUTE	FROM	TO
A05	PANAMA	EUROPE

SHIP	# DROPS
STAR DRIVANGER	6
BIBI	22
PACPRINCE	79
PACPRINCESS	100
ROUTE TOTAL	207

ROUTE	FROM	TO
A07	GULF OF MEXICO	GIBRALTER

SHIP	# DROPS
TEXAS CLIPPER	3
MALCOLM BALDRIGE	75
STAR DROTTANGER	13
BIBI	50
PACPRINCE	34
PACPRINCESS	14
ROUTE TOTAL	189

ROUTE	FROM	TO
A08	NEW YORK	CAPE OF GOOD HOPE

SHIP	# DROPS
MT CABRITE	36
SEAL ISLAND	25
VIDAL	493
SAINT BLAIZE	262
ROUTE TOTAL	816

ROUTE	FROM	TO
A10	NEW YORK	TRINIDAD/CARACAS

SHIP	# DROPS
POLAR SEA	28
ROUTE TOTAL	28

ROUTE	FROM	TO
A11	BRAZIL	EUROPE

SHIP	# DROPS
STAR DROTTANGER	13
ROUTE TOTAL	13

ROUTE	FROM	TO
A17	RIO DE JANEIRO	CAPE OF GOOD HOPE

SHIP	# DROPS
NEDLLOYD VAN NOORT	36
ROUTE TOTAL	36

ROUTE	FROM	TO
A18	BUENOS AIRES	CAPE OF GOOD HOPE

SHIP	# DROPS
NEDLLOYD VAN NOORT	63
ROUTE TOTAL	63

ROUTE	FROM	TO
A23	GULF OF MEXICO	GULF OF MEXICO

SHIP	# DROPS
TEXAS CLIPPER	2
WHITING	84
OREGON II	125
AMERICA STAR	15
MELBOURNE STAR	2
SEALIFT ATLANTIC	24
STAR DROTTANGER	1
VIDAL	8
BIBI	2
CHAPMAN	14
PURITAN	12
PACPRINCE	4
ROUTE TOTAL	293

ROUTE	FROM	TO
A27	GULF OF MEXICO	CAPE HORN

SHIP	# DROPS
MT CABRITE	54
SEAL ISLAND	8
ROUTE TOTAL	62

ROUTE	FROM	TO
A29	NEW YORK	BRAZIL

SHIP	# DROPS
STAR DROTTANGER	13
SEA WOLF	233
COLUMBUS OHIO	424
ROUTE TOTAL	670

ROUTE	FROM	TO
A32	NEW YORK	BERMUDA

SHIP	# DROPS
OLEANDER	440
ROUTE TOTAL	440

ROUTE	FROM	TO
A33	BOSTON	HALIFAX

SHIP	# DROPS
YANKEE CLIPPER	156
ROUTE TOTAL	156

ROUTE	FROM	TO
I06	MAURITIUS/LA REUNION	MALACCA STRAIT

SHIP	# DROPS
MT CABRITE	24
NEDLLOYD VAN NOORT	108
NEDLLOYD VAN DIEMEN	10
ROUTE TOTAL	142

ROUTE	FROM	TO
I07	CAPE OF GOOD HOPE	PERSIAN GULF

SHIP	# DROPS
SEAL ISLAND	21
SAINT BLAIZE	12
ROUTE TOTAL	33

ROUTE	FROM	TO
I10	MALACCA STRAIT/SING	RED SEA

SHIP	# DROPS
BOGASARI LIMA	30
GOLDENSARI INDAH	8
ROUTE TOTAL	38

ROUTE	FROM	TO
IND		

SHIP	# DROPS
MT MITCHELL	14
POLAR STAR	2
ROUTE TOTAL	16

ROUTE	FROM	TO
MED		

SHIP	# DROPS
TEXAS CLIPPER	46
STAR DROTTANGER	3
BIBI	6
SEA-LAND ACHIEVER	1
ROUTE TOTAL	56

ROUTE	FROM	TO
NA		

SHIP	# DROPS
TEXAS CLIPPER	1
WHITING	10
MT MITCHELL	99
OREGON II	74
MALCOLM BALDRIGE	326
ALBATROSS IV	2
SEALIFT ATLANTIC	27
POLAR SEA	82
DELAWARE II	13
TABASCO	1
MAURICE EWING	12
ROUTE TOTAL	647

ROUTE	FROM	TO
NP		

SHIP	# DROPS
SURVEYOR	24
DISCOVERER	21
MCARTHUR	49
MILLER FREEMAN	96
FARNELLA	3
TOWNSEND CROMWELL	21
MOANA WAVE	62
DAVID STARR JORDAN	30
JOHN V VICKERS	9
POLAR STAR	18
SEDCO BP/471	127
THOMAS WASHINGTON	6
MAURICE EWING	2
ROUTE TOTAL	468

ROUTE	FROM	TO
P01	CALIFORNIA	INDONESIA

SHIP	# DROPS
BOGASARI LIMA	285
GOLDENSARI INDAH	348
ROUTE TOTAL	633

ROUTE	FROM	TO
P03	CORAL SEA	CORAL SEA

SHIP	# DROPS
PACKING	28
ROUTE TOTAL	28

ROUTE	FROM	TO
P07	AUCKLAND	SEATTLE/VANCOUVER

SHIP	# DROPS
COLUMBUS VIRGINIA	50
ROUTE TOTAL	50

ROUTE	FROM	TO
P08	AUCKLAND	PANAMA

SHIP	# DROPS
AMERICA STAR	446
MELBOURNE STAR	532
QUEENSLAND STAR	92
ROUTE TOTAL	1,070

ROUTE	FROM	TO
P09	HAWAII	NOUMEA/AUCKLAND

SHIP	# DROPS
COLUMBUS VICTORIA	119
COLUMBUS WELLINGTON	96
COLUMBUS VIRGINIA	50
ROUTE TOTAL	265

ROUTE	FROM	TO
P10	HAWAII	GUAM/SAIPAN

SHIP	# DROPS
SEA-LAND NAVIGATOR	114
SEA-LAND TRADER	122
SEA-LAND PACIFIC	95
SEA-LAND ENTERPRISE	246
ROUTE TOTAL	577

ROUTE	FROM	TO
P12	TAHITI	CORAL SEA

SHIP	# DROPS
MOANA PACIFIC	28
POLYNESIA	13
ROUTE TOTAL	41

ROUTE	FROM	TO
P13	NEW ZEALAND	CALIFORNIA

SHIP	# DROPS
COLUMBUS VICTORIA	152
COLUMBUS WELLINGTON	146
COLUMBUS VIRGINIA	190
PACKING	51
ROUTE TOTAL	539

ROUTE	FROM	TO
P14	ALASKA	CAPE HORN

SHIP	# DROPS
SURVEYOR	20
MT CABRITE	133
SAINT LUCIA	1
SEAL ISLAND	65
POLAR SEA	151
SEDCO BP/471	20
VIDAL GORMAZ	12
ROUTE TOTAL	402

ROUTE	FROM	TO
P17	TAHITI/MURURAO	PANAMA

SHIP	# DROPS
MAURICE EWING	11
ROUTE TOTAL	11

ROUTE	FROM	TO
P18	TAHITI	CALIFORNIA

SHIP	# DROPS
POLAR STAR	21
MOANA PACIFIC	198
POLYNESIA	231
ROUTE TOTAL	450

ROUTE	FROM	TO
P20	CALIFORNIA	PANAMA

SHIP	# DROPS
DAVID STARR JORDAN	89
POLAR SEA	86
NEDLLOYD MADRAS	97
NEDLLOYD MANILA	32
STAR DRIVANGER	8
STAR DROTTANGER	15
NEDLLOYD VAN NOORT	8
NEDLLOYD VAN DIEMEN	8
ROUTE TOTAL	343

ROUTE	FROM	TO
P21	CALIFORNIA	PERU

SHIP	# DROPS
SURVEYOR	49
MCARTHUR	43
DAVID STARR JORDAN	31
NEDLLOYD MADRAS	113
NEDLLOYD MANILA	152
NEDLLOYD VAN DIEMEN	19
ROUTE TOTAL	407

ROUTE	FROM	TO
P25	VALPARAISO	JAPAN/KOREA

SHIP	# DROPS
ANDINO	244
ROUTE TOTAL	244

ROUTE	FROM	TO
P26	TRANSPAC	TRANSPAC

SHIP	# DROPS
SEA-LAND NAVIGATOR	168
MT CABRITE	15
SEA-LAND TRADER	155
POLAR STAR	12
PACDUCHESS	145
SEDCO BP/471	81
SEA-LAND PACIFIC	125
SEA-LAND ENTERPRISE	184
STAR DRIVANGER	11
STAR DROTTANGER	40
SKAUGRAN	288
SEA-LAND DEFENDER	190
CALIFORNIA CERES	276
SKAUBRYN	333
NEDLLOYD VAN NOORT	91
NEDLLOYD VAN DIEMEN	103
GOLDENSARI INDAH	29
TAI HE	331
ROUTE TOTAL	2,577

ROUTE	FROM	TO
P28	TAHITI	SYDNEY/AUCKLAND

SHIP	# DROPS
POLAR STAR	18
ROUTE TOTAL	18

ROUTE	FROM	TO
P29	TAHITI	VALPARAISO

SHIP	# DROPS
COPIAPO	33
ROUTE TOTAL	33

ROUTE	FROM	TO
P31	CALIFORNIA	SYDNEY/NOUMEA

SHIP	# DROPS
MOANA PACIFIC	31
POLYNESIA	309
ROUTE TOTAL	340

ROUTE	FROM	TO
P34	SYDNEY	WELLINGTON

SHIP	# DROPS
AMERICA STAR	38
MELBOURNE STAR	79
QUEENSLAND STAR	12
COLUMBUS VICTORIA	31
COLUMBUS WELLINGTON	41
COLUMBUS VIRGINIA	27
PACKING	7
ROUTE TOTAL	235

ROUTE	FROM	TO
P37	HAWAII	CALIFORNIA

SHIP	# DROPS
SEA-LAND NAVIGATOR	75
CHEVRON CALIFORNIA	13
CHEVRON MISSISSIPPI	9
SEA-LAND TRADER	47
COLUMBUS VICTORIA	8
COLUMBUS WELLINGTON	7
SEA-LAND PACIFIC	57
SEA-LAND ENTERPRISE	154
MICRONESIAN PRIDE	2
PACKING	12
MICRONESIAN COMMERCE	38
MICRONESIAN INDEPENDENCE	29
ROUTE TOTAL	451

ROUTE	FROM	TO
P38	HAWAII	ALASKA

SHIP	# DROPS
CHEVRON CALIFORNIA	50
CHEVRON MISSISSIPPI	43
ROUTE TOTAL	93

ROUTE	FROM	TO
P39	HAWAII	SEATTLE/VANCOUVER

SHIP	# DROPS
COLUMBUS VICTORIA	49
COLUMBUS WELLINGTON	25
COLUMBUS VIRGINIA	32
PACKING	54
MICRONESIAN COMMERCE	13
MICRONESIAN INDEPENDENCE	16
ROUTE TOTAL	189

ROUTE	FROM	TO
P42	HAWAII	NEW GUINEA/SOLOM IS

SHIP	# DROPS
PACKING	90
ROUTE TOTAL	90

ROUTE	FROM	TO
P43	HAWAII	MARSHALL IS/GUAM

SHIP	# DROPS
MICRONESIAN PRIDE	3
MICRONESIAN COMMERCE	53
MICRONESIAN INDEPENDENCE	53
ROUTE TOTAL	109

ROUTE	FROM	TO
P44	TAIWAN	GUAM

SHIP	# DROPS
SEA-LAND NAVIGATOR	40
SEA-LAND TRADER	44
SEA-LAND PACIFIC	38
SEA-LAND ENTERPRISE	164
MICRONESIAN COMMERCE	36
MICRONESIAN INDEPENDENCE	36
ROUTE TOTAL	358

ROUTE	FROM	TO
P47	ALASKA	CALIFORNIA

SHIP	# DROPS
CHEVRON CALIFORNIA	136
CHEVRON MISSISSIPPI	90
ROUTE TOTAL	226

ROUTE	FROM	TO
P49	JAPAN/TAIWAN	SINGAPORE

SHIP	# DROPS
NEDLLOYD VAN NOORT	3
NEDLLOYD VAN DIEMEN	3
GOLDENSARI INDAH	7
ROUTE TOTAL	13

ROUTE	FROM	TO
SA		

SHIP	# DROPS
SURVEYOR	181
VINA DEL MAR	3
ROUTE TOTAL	184

ROUTE	FROM	TO
SP		

SHIP	# DROPS
SURVEYOR	12
DISCOVERER	8
MOANA WAVE	57
JOHN V VICKERS	30
POLAR STAR	7
POLAR SEA	118
SEDCO BP/471	14
MAURICE EWING	5
ROUTE TOTAL	251

ROUTE	FROM	TO
TES		

SHIP	# DROPS
J W POWELL	2
DISCOVERER	15
WHITING	12
MILLER FREEMAN	15
OREGON II	44
ROUTE TOTAL	88

GRAND TOTAL 15,288

ANNEX IV

PLANNED XBT USAGE

AUSTRALIA (CSIRO projection)

TWI Line	1993	1994	1995
PX-02	18	18	?
PX-03/PX-05	8	8	?
PX-30/PX-31	HD 4	HD 4	HD 4
PX-32 (Part)	12	12	?
PX-34	HD 4	HD 4	HD 4
IX-01	18	2 HD+18	HD 2
IX-09 (Part)	12	12	?
IX-12	16	16	?
IX-22/PX-11	8	8	?
HD=High Density ≈12-18/day Other: 4-6/day			?: Subject to funding beyond TOGA

FRANCE (ORSTOM Noumea)
PLANS FOR 1993-1994

NOTE: At the end of TOGA 31 Dec 1994, there are no plans for 1995.

TWI Line #	Program and number of ships on line	20°N-20°S Number of Sections	Number of XBT launches/day
PX-05	TOGA - 5 ships	20 sections/yr	4/day
PX-51	TOGA - 5 ships	12 sections/yr	4/day
PX-52	TOGA - 5 ships	6 sections/yr	4/day
PX-53 H.Kong-Fiji	TOGA - 5 ships	9 sections/yr	4/day
PX-04	TOGA - 5 ships	6 sections/yr	4/day
PX-03	TOGA - 6 ships	18 sections/yr	4/day
PX-12	TOGA - 6 ships	18 sections/yr	4/day
PX-17	TOGA - 6 ships	12 sections/yr	4/day
PX-31	TOGA - 1 ship	6-10 sections	4/day

GERMANY

	Europe-N.America	Europe-Brazil	Rio-Cape Town	Buenos Aires-Cape Town
TWI #	AX-03	AX-11	AX-17	AX-18
Ship	Koeln Atlantic	Monte Rosa	Horizon Frontier	Horizon Frontier
Call Sign	DAKE	DGLM	J8GG4 J8GC9	J8GG4 J8GC9
Programme	WOCE	IGOSS/WOCE	WOCE	WOCE
Start	May 1988	1981	May 1989	Sept 1989
Finish	1995?	open	1995?	1995?
Frequency	8/year	8/year	6/year	6/year
Density	12/day	6/day	6/day	6/day
Probes	T7/T5 XCTD (2/yr)	T7	T7/T5	T7/T5
Agency	BSH	BSH	IfM Kiel	IfM Kiel
Real-Time	METEOSAT	METEOSAT	METEOSAT	METEOSAT

In addition, several research vessels will carry out XBT measurements irregularly while en route (broadcast mode):

R.V. METEOR DBBH
R.V. POLARSTERN DBLK
R.V. WALTHER HERWIG DBFP
R.V. GAUSS DBBX
R.V. VALDIVIA DESI

UNITED STATES OF AMERICA (NOS)

PACIFIC OCEAN

LINE	NUMBER OF TRANSECTS 1993	NUMBER OF TRANSECTS 1994	4/DAY UNLESS NOTED
PX-01	12	12	2/DAY
PX-08	12	12	
PX-09	12	12	2/DAY
PX-10	12	12	
PX-12	12	12	2/DAY
PX-14	12	18	
PX-18	18	18	
PX-20	12	12	2/DAY
PX-21	12	12	2/DAY
PX-25	9	9	
PX-26	140	140	2/DAY
PX-29			
PX-31	10	10	2-4/DAY
PX-33/34	30	30	2/DAY
PX-37	30	30	2/DAY
PX-38	8	8	2/DAY
PX-39	20	20	2/DAY
PX-43	12	12	
PX-44	12	12	
PX-47	30	30	2/DAY

ATLANTIC OCEAN

LINE	NUMBER OF TRANSECTS 1993	NUMBER OF TRANSECTS 1994	4/DAY UNLESS NOTED
AX-02	5	12	
AX-04	12	12	
AX-07	12	12	
AX-08	8	12	
AX-10	12	12	
AX-12	7	7	
AX-14	4	12	
AX-16	4	12	
AX-17	6	12	
AX-18	6	12	
AX-29	12	12	
AX-32	12	12	4-24/DAY
AX-33	12	12	2/DAY

INDIAN OCEAN

LINE	NUMBER OF TRANSECTS 1993	NUMBER OF TRANSECTS 1994	4/DAY UNLESS NOTED
IX-02	?	12	
IX-06	8	8?	2/DAY
IX-15	?	12	
IX-21	?	12	

ANNEX V

PROPOSED FORMAT FOR BI-ANNUAL SHIP VISIT REPORT

TWI Line	Month	Call Sign	Ship Name	# good XBT's	# Xmttd BATHY	# transects P-Partial
AX1	Jan	PJJU	Oleander	45	40	3 (1p)
		SKJU	Skogafoss	32	27	2
AY1	Feb					

etc.

Statistics for report to be submitted by: Australia, France, and USA.

ANNEX VI

SOC REAL-TIME MONTHLY REPORT

By the 10th of each month, the following information should be sent via OMNET to **C.NOE:**

Ship Name; Call Sign; Good; Duplicate

Example: OCEANDER; PVVU; 32; 7

The information will be put in a database, the data will be for the month i.e. 1-30 April.

ANNEX VII

RECOMMENDED CODE CHANGE TO BATHY MESSAGE FORMAT

I. INSTRUMENT TYPE

A. EXPENDABLE BATHY PROBES

Sippican
T-4, T-5, FAST DEEP, T-6, T-7, DEEP BLUE, T-10, T-11

Sparton
XBT-4, XBT-5, XBT-5DB, XBT-6, XBT-7, XBT-7DB, XBT-10, XBT-20, XBT-20DB

Depth Calculation used by manufacturers Sippican and Sparton: a subscript indicating the fall rate equation used.

Example:
- a. 6.702a+8.2012b*b
- b. new equation
- c. etc.
- d. unknown

B. MECHANICAL BATHY PROBES

C. HYDROCAST

D. OTHER

Thermistor Chain
Mooring
Platforms
Anchored vessel

II. RECORDERS-CONTROLLERS
(Expendable Probes, Thermistor Chain)

Sippican
MK2A/SSQ-61, MK9, AN/BHQ-7/MK8, MK12

Sparton
SOC BT/SV PROCESSOR MODEL 100

Bathy Systems
SA-810

Argos
XBT-ST

Scripps Metrobyte controller

TSK
Automatic launcher

Mooring

When these changes are approved by the CBS of WMO, we may consider disseminating a change to Manuals and Guides 3 "Guide to Operational Procedures for the Collection and Exchange of IGOSS Data" - Second Revised Edition.

ANNEX VIII

REPORT BY TASK TEAM ON QUALITY CONTROL OF AUTOMATED SYSTEMS (TT/QCAS)

R.Bailey[1], K.Hanawa[2], D.Roemmich[3], P.Rual[4], A.Sy[5], M.Szabados[6], J.Withrow[7]

[1] CSIRO Div. of Oceanography, Hobart, Australia
[2] Tohoku University, Sendai, Japan
[3] Scripps Institution of Oceanography, San Diego, USA
[4] ORSTOM, Noumea, New Caledonia
[5] Bundesamt fuer Seeschiffahrt und Hydrographie, Hamburg, Germany
[6] NOS/NOAA, Washington DC, USA
[7] Intergovernmental Oceanographic Commission, Paris, France

Expendable oceanographic probes have formed the backbone of large scale oceanographic research programmes in recent times. These types of probes can be launched whilst underway from ships-of-opportunity, such as merchant vessels, enabling large scale repeated coverage of the major ocean basins. As the importance of the ocean's role in the climate system has become increasingly acknowledged, so has the need to observe and monitor the variability of the major components of the ocean that are related to the climate system. This is being successfully achieved through the use of expendable oceanographic probes. These probes will no doubt be heavily relied upon in future operational climate and oceanographic programmes.

Although the stated accuracies of the expendable probes were sufficient for early studies, the very small changes in the ocean due to climate change and interannual variability have resulted in a growing need to utilise these instruments to the limits of their accuracies. This has inevitably lead to a number of studies on the actual accuracies of the instruments. Some of these studies have been focused and revised under the auspices of a Task Team on Quality Control of Automated Systems (TT/QCAS) set up by the Integrated Global Ocean Services System (IGOSS).

TEMPERATURE ACCURACY - (XBT)

The specified temperature accuracy of the commonly used expendable bathythermograph (XBT) is +/- 0.15^{0}C. Earlier studies (eg. Heinmiller et al., 1983; Roemmich and Cornuelle, 1987) have generally found the XBT to achieve this accuracy. These results have usually been achieved by either a comparison of temperatures measured by XBTs and Conductivity Temperature and Depth (CTD) sensors in the isothermal layer, or through controlled tank measurements.

Start-up Transients

The XBT is known, however, to suffer from a minor start-up transient problem (see Fig.1) which leads to inaccurate temperature measurements in the top few metres (Roemmich and Cornuelle, 1987; Bailey et al., 1989). As a rule, the first 3.9m of the XBT profile should be ignored.

Bowing Problem

An apparent inconsistent error in temperature measurement has also been observed with an early version of the Bathy Systems SA-810 XBT recorder. This problem has commonly become known as the "bowing problem" (Bailey et al., 1989), and manifests itself as an erroneous gradual increase (bowing) in the temperature profile with depth which is most observable in areas where commonly one would expect an isothermal temperature profile such as the mixed layer (see Fig.2).

When temperature profiles in the mixed layer are compared between simultaneous XBT and CTD measurements, temperature errors at the base of the mixed layer were sometimes observed to be as high as 0.75-1.0^{0}C. Bailey et al., 1989 found the mean difference in temperature in the mixed layer to be 0.22^{0}C. The apparent cause is insufficient current being driven down the XBT wire by the SA-810 recorder. The wire is only quality controlled to carry around 150-200 microamps, and the early version of the SA-810 only drives approximately 20 microamps down the wire. Any slight imperfections in the wire at these current levels will cause problems in the signal transmission, and indeed amplify problems such as leakage through insulation imperfections, etc.

The magnitude of the resulting error is highly variable and often difficult to detect. Fortunately the amount of data collected by such units in the data archives is comparatively small. Owners of this type of recorder are strongly advised to increase the current source in the unit.

DEPTH ACCURACY - (XBT)

The specified depth accuracy of the XBT is +/- 2% of the depth or 5m (whichever is the greater). However, several studies (eg. Flierl and Robinson,1977; Seaver and Kuleshov, 1982; Heinmiller et al.,1983) have observed depth errors in the XBT that exceed the specified depth accuracy. These depth errors also translate into temperature errors.

Several investigators (Seaver and Kuleshov, 1982; Heinmiller et al., 1983; Green, 1984; Hanawa and Yoritaka, 1987; Singer, 1990: Hanawa and Yoshiwaka, 1991) have since estimated revised fall rate equations (depth is inferred from an assumed fall rate of the probe and is not measured directly) using a number of different techniques. Unfortunately, some of the techniques do not accurately account for potential temperature errors which may cause apparent depth errors, and often temporal variability in the ocean was not allowed for in comparing XBTs to CTDs. Consequently the revised equations vary, and in some cases when depth correction algorithms are applied to new data the errors are actually increased (Bailey et al., 1989). It was therefore decided to re-investigate the problem and to determine an accurate correction algorithm.

Depth Error Detection Method

The accuracies of the depth calculations for the XBT were determined for this study from a number of coordinated experiments where XBTs were compared to standard precision CTDs (see Fig.3). As far as possible, the XBTs and CTDs were dropped simultaneously to reduce errors in the comparisons that may result from the natural temporal variability in the temperature fields due to internal waves, etc. A new temperature-error-free method for determining the depth errors in the XBT was developed for the study which compares the temperature gradient profiles for the XBT and CTD to each other in order to calculate the depth differences in observed features. This information is then used to calculate a general correction for the depths given by the manufacturers' fall rate equation (for a full description of the method see Hanawa et al. 1993).

Depth Error Correction

Depth accuracies were determined for Sippican and TSK T-7, T-6, and T-4 types of XBT, all of which use the same manufacturers' fall rate equation

$$d = 6.472\,t - 0.00216\,t^2 \qquad \text{Eq. 1}$$

where d is the depth of the probe at time t secs after the probe contacted the water. These types of probes are the most commonly used expendable probes in oceanographic programmes.

The accuracies in depth were found in general to be outside of the manufacturers' specifications (see Figs 4 and 5), but appeared to be independent of the probe manufacturer, production batch and geographical location. Before correction, the mean depth error for the Sippican and TSK T-7 XBT was 26m at the terminal depth of 760m, compared to 15m as given in the specifications

As the revised fall rate equations from the analysis for each individual data set and type of probe were found to be statistically the same (see Fig.6), the XBT depths for the types of probes considered can be corrected by the one linear correction formula

$$Z = 1.035\,d \qquad \text{Eq. 2}$$

where Z is the corrected depth, and d is the XBT depth given by the manufacturer's fall rate equation. When applied, this correction brings the depth accuracy of the these types of XBTs to within the manufacturers' specifications (see Figs 4 and 5).

Other types of probes with different fall rate equations are presently under evaluation, and they include the new Sparton T-7 XBT. Preliminary results for the Sparton T-7 indicate they have a worse depth error than the equivalent Sippican T-7 (even though they are supposed to have the same fall rate equation and be dynamically similar). Sparton are presently modifying their T-7 probe.

Start of Descent Timing Delay

A depth error resulting from an error in the recognition of the start of descent time of an XBT (ie probe contact with the water) has also been observed during testing of some versions of the

Sippican Mk-9/MS-DOS XBT system (see Fig.7). The problem was found to be due to a software error in the recognition and handling of different versions of the GPIB driver routines. In some cases the delay in recognition was as much as 3-4 seconds which translates to a depth offset in the readings of around 18-20 metres. In most cases the delay was approximately 0.3-0.6 seconds, ie equivalent errors in depth of approximately 2-3 metres. The resultant data errors are highly erratic and random in nature, and in most cases the degree of depth error is indeterminable in data collected in the field under normal conditions. Accordingly, data recorded with the offending software/hardware combinations should be considered as highly suspect and handled accordingly. The very latest version of the software does not have this problem.

SALINITY ACCURACY - (XCTD)

The specified temperature and conductivity accuracies for the Sippican expendable conductivity-temperature-depth probe (XCTD) are +/- 0.03^{0}C and 0.03 microsiemens/cm respectively. Although the XCTD is now officially in production, a number of problems have become apparent from studies undertaken in the coordinated evaluation trials of the TT/QCAS.

XCTD Evaluation

Firstly, it has been discovered that the method of wet calibrating the XCTD causes serious drifts in the conductivity calibrations due to soaking of the wire. Drifts are particularly apparent at high temperatures and can lead to large offsets in the conductivity/salinity measurements (up to 0.7 ppt in some cases). The calibration procedures have now been altered but there is as yet limited data available to prove that the changes have been successful. Secondly, there appears to be a fall rate (depth accuracy) problem with the XCTD as well as the XBT. This now needs evaluating and requires further data to come up with a statistically sound revision. Thirdly, tests showed a slight time response mismatch between the temperature and conductivity sensors resulting in severe spiking in the salinity profiles. Fourthly, there is an apparent problem with the Sippican data filtering techniques in the software which creates a large discontinuity in the conductivity/salinity measurement at 900m. Finally, experiences of different users to-date also show that the instrument is very sensitive to grounding problems and possibly to external electromagnetic interference.

Fig. 8 shows the results of one evaluation trial, which demonstrates several of the problems mentioned above. From the comparisons with the CTD, mean errors in temperature and conductivity for the XCTDs were 0.06 +/- 0.15^{0}C and 0.24 +/- 0.21 microsiemens/cm respectively, ie outside of the specified accuracies.

TRANSFER OF CORRECTED DATA

It is essential that such information as the probe type, probe manufacturer, recorder type, and the depth formulation used be stored and submitted with data to allow identification in the data bases of erroneous data and to allow possible corrections to be applied as prob'ems arise. A problem facing the correction of the data bases for the problems discovered so far is that in most cases the required information for identifying the problem recordings has not been stored. Further, from the results on depth errors associated with XBTs, it is highly recommended that the manufacturers' fall rate equation (Eq. 1) be maintained in all data exchanges until revised fall rate equation procedures are in place. This includes data submissions to national and international data centres,as well as data transmissions over the Global Telecommunications System (GTS). The major hurdle facing the international community now is to maintain a recognisable homogeneity in the data sets during the period while the necessary changes are made to the data bases and data transmission systems.

CONCLUSIONS

Careful studies have shown that the commonly used XBT probe can operate to specifications in temperature and depth accuracy. The XBT can therefore continue to be considered an extremely valuable tool for climate research by providing wide scale coverage in time and space of the thermal properties of the upper ocean.

Although the XCTD is not yet performing to specifications, it appears most of the problems encountered at this stage are correctable and are being worked upon. The instrument will be retested when these developments are completed.

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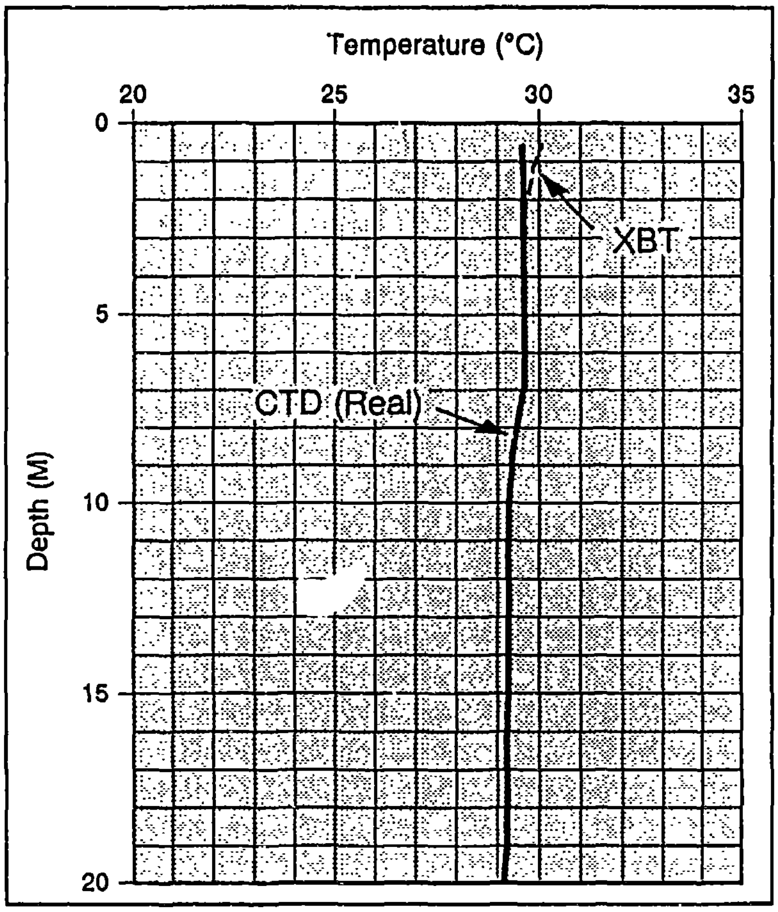

Figure 1. A comparison of XBT and CTD profiles showing a typical XBT start-up transient.

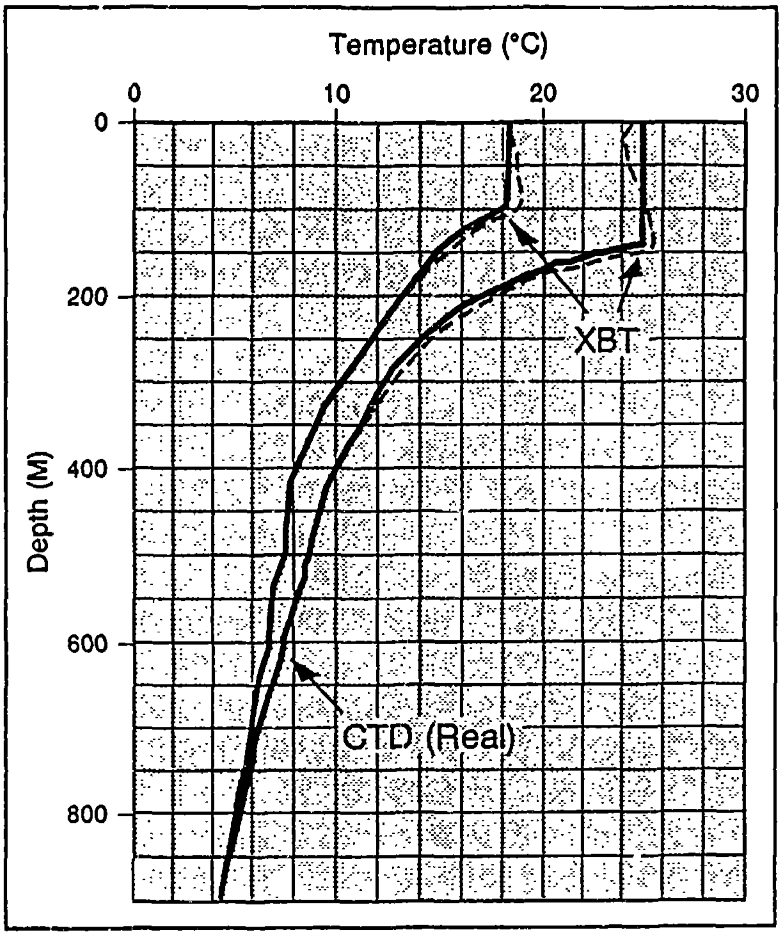

Figure 2. Schematic of the "bowing problem".

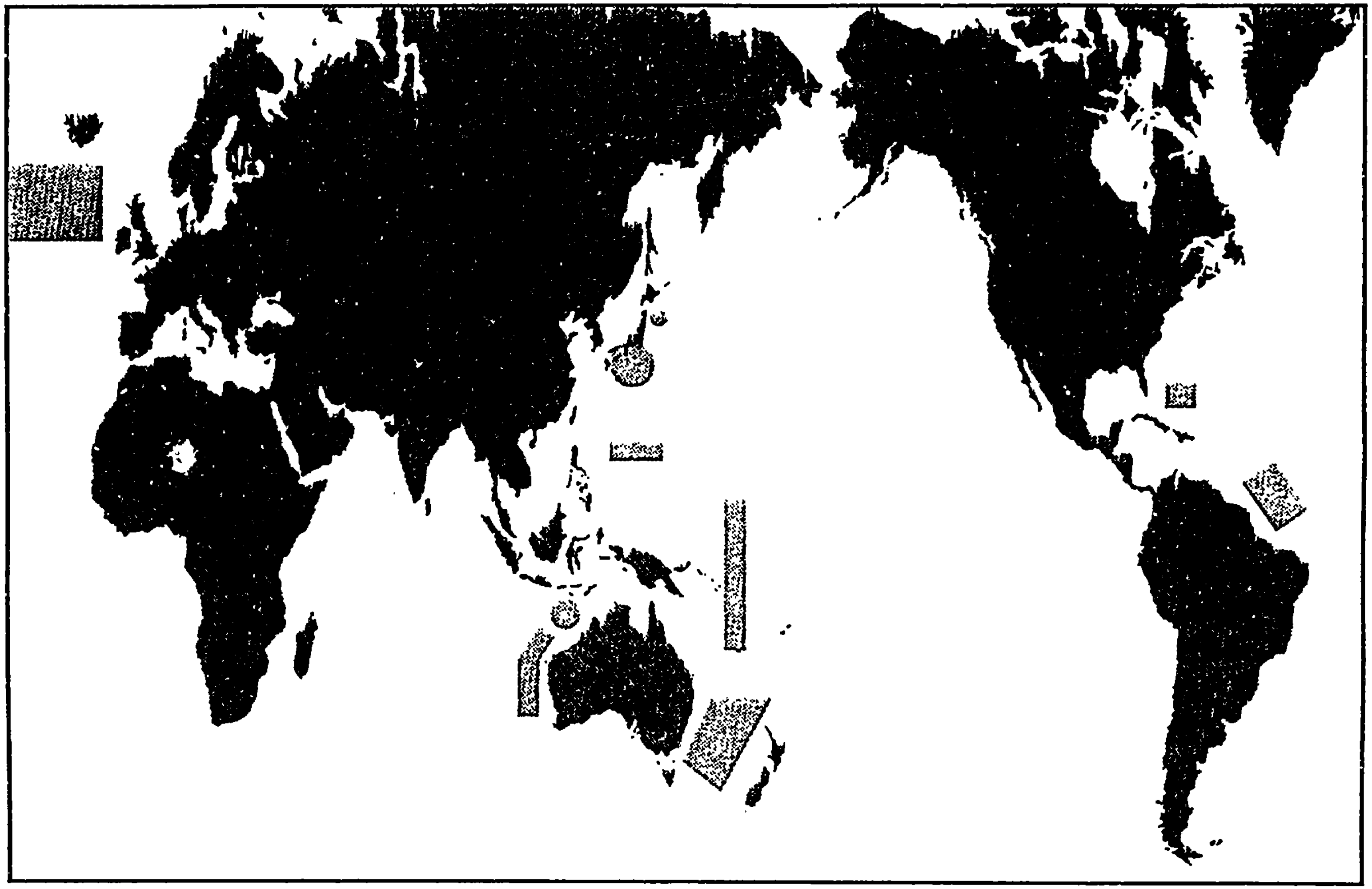

Figure 3. Locations of the various XBT/CTD comparison experiments for determining depth accuracies of XBTs. The experiments were carried out in as many different water masses as possible to determine the influence of different densities on the fall rate characteristics of the probes.

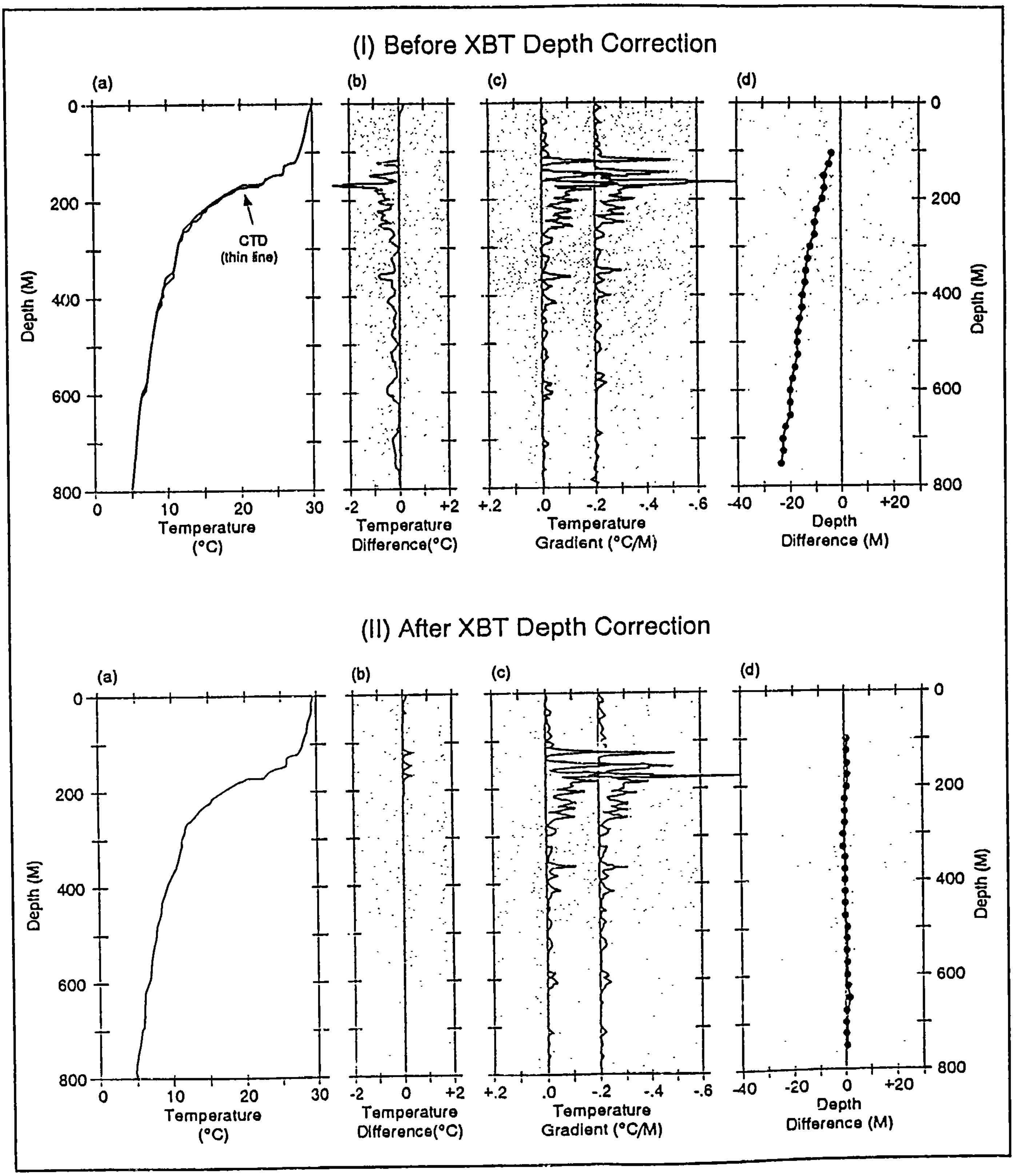

Figure 4. Typical example of XBT/CTD comparison before (I) and after (II) XBT depth correction: (a) CTD and XBT temperature profiles; (b) profile of temperature difference; (c) CTD and XBT temperature gradient profiles; (d) detected depth differences

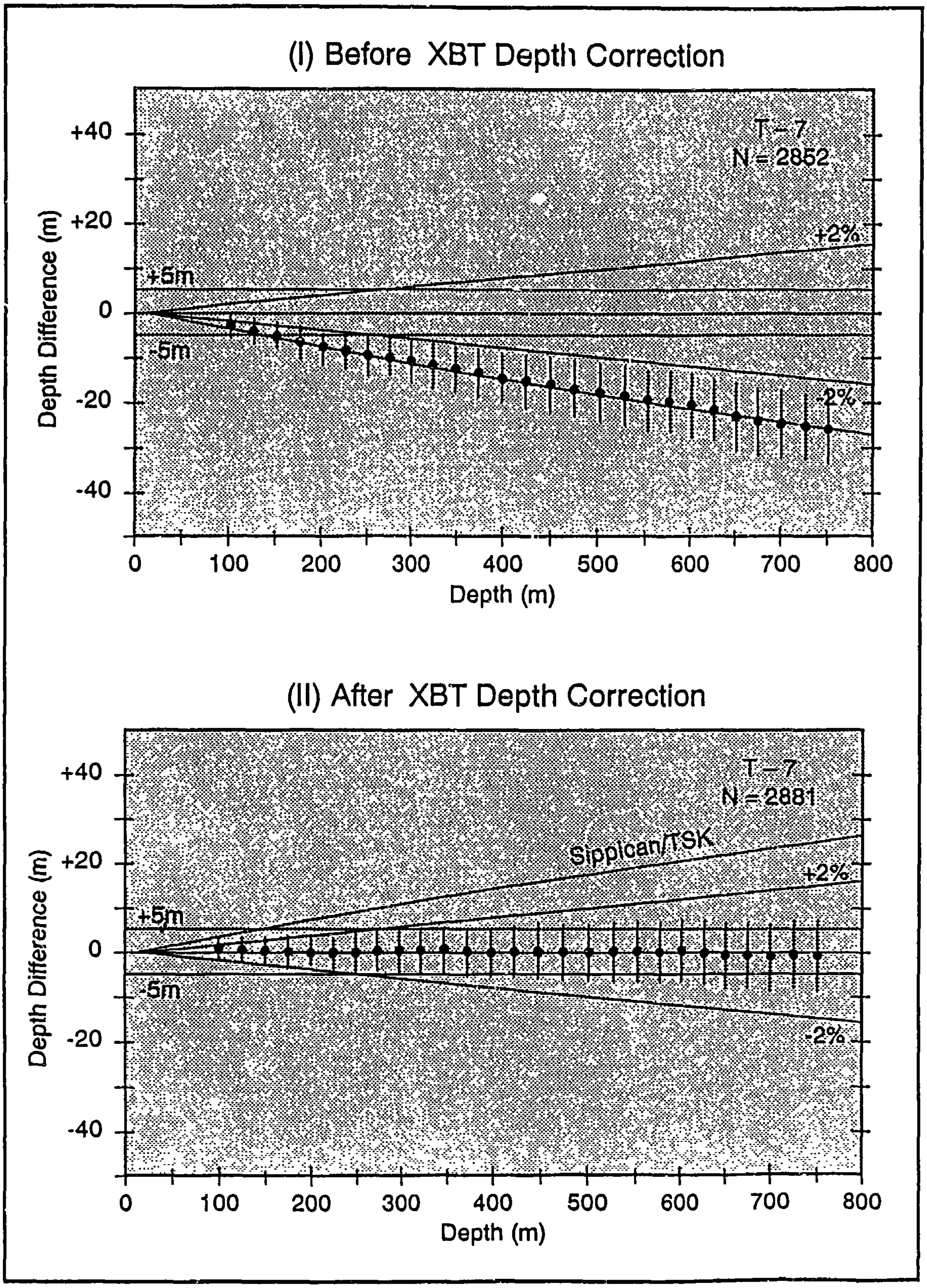

Figure 5. Mean depth differences detected for the total T-7 data set before (i) and after (II) XBT depth correction. Vertical bars are twice the standard deviation.

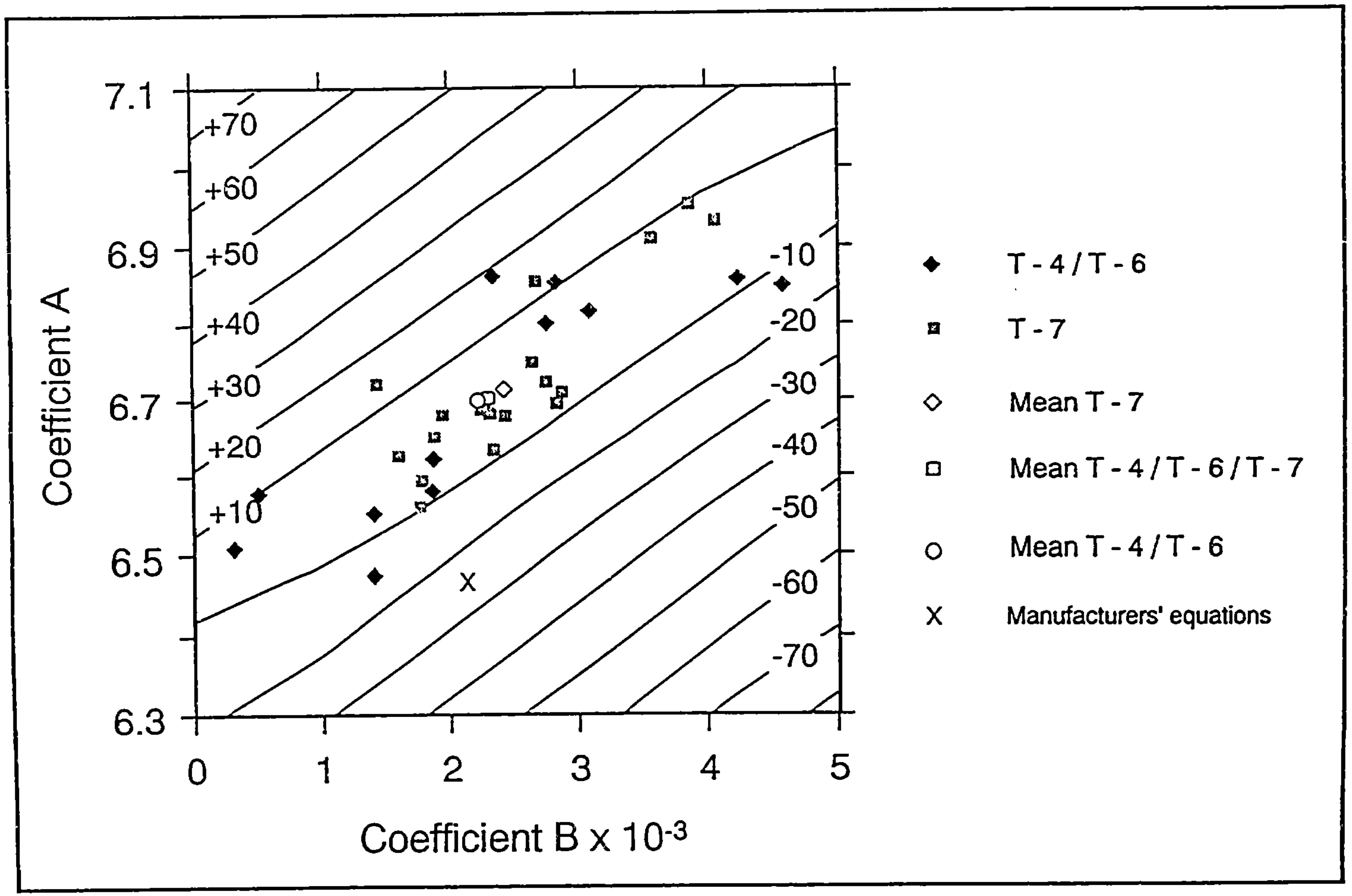

Figure 6. Scatter plot of coefficients a (t term) and b (t^2 term) of the fall rate equations determined for individual comparison experiment data sets, combined data sets for each probe type, and the combined data set for all probe types considered in the study. Contours are the maximum depth differences (in metres) from the the new equation determined for the T-7 probe data set for other combinations of a and b. Note that different combinations of a and b can give the same accuracy.

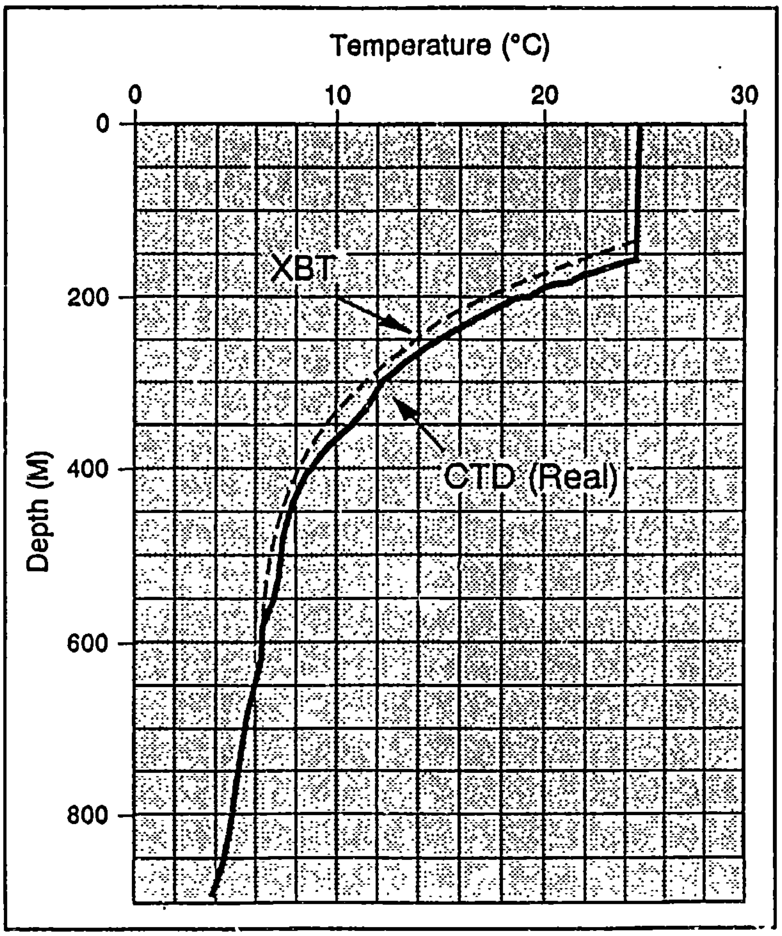

Figure 7. Schematic of depth errors associatedwith an error in the recognition of the start of descent of a probe.

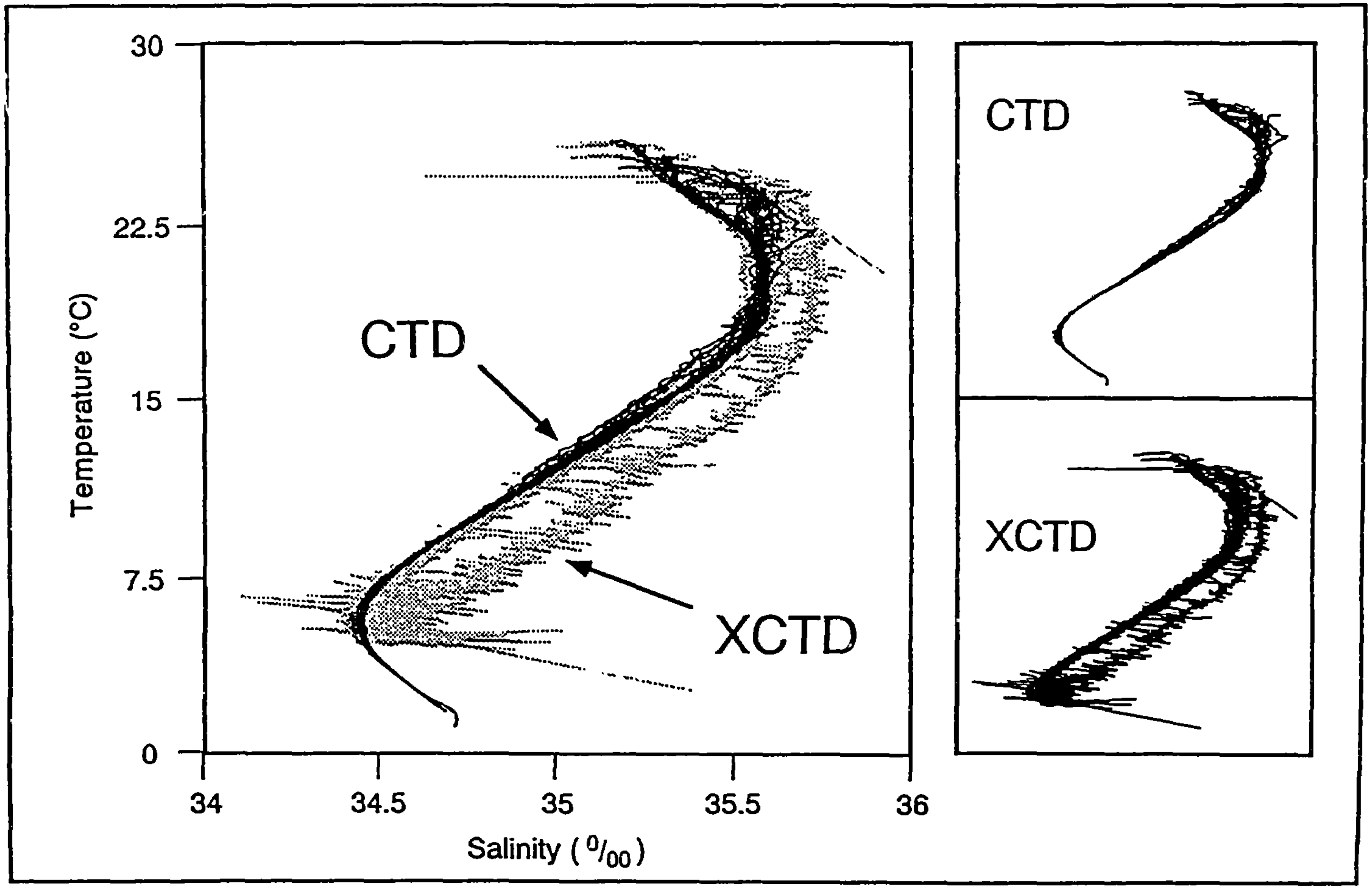

Figure 8. Comparison of Temperature-Salinity relationships measured by CTD and XCTDs in the Coral Sea by the CSIRO. Although there is general good agreement between the two, note the scatter in the XCTD profiles compared to the CTD profiles (particularly where the CTD shows a tight T-S relationship) and the XCTD whose conductivity measurements were seriously offset resulting in an erroneous T-S profile.