



NEWSLETTER

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DATA SHARING POLICY

Now that the field programme is well underway we reproduce a statement by the Data Management Committee, endorsed by the SSG, emphasising our encouragement of data sharing in WOCE.

There is a fundamental tradeoff in WOCE - on the one hand, the protection of the intellectual effort and time of originating investigators (those who plan an experiment, collect, calibrate, and process a data set to answer some questions about the ocean), and on the other hand the need to compare various data sets and data types to check their consistency, to better understand the ocean processes involved, and to see how well the numerical models describe the real ocean. The policy below is a tradeoff between these conflicting needs.

Any data collected as part of WOCE should be made publicly available no later than 2 years (the publication rights period) from collection, unless specifically waived by the SSG and funding agencies.

Collection is interpreted as the completion of the determination of the value of the particular parameter. Thus, for example, tritium/helium collection may not be complete for over a year after return to shore/laboratory.

Individual WOCE programmes (hydrography, surface velocity, etc.) may require all participating investigators to submit (usually within a few months after collection) data collected as part of WOCE to a Data Assembly Centre (DAC) for the purposes of quality control and data synthesis during the public rights period. In that case the recipient DAC may not redistribute such data, or a derivative containing most of the information unless specifically approved by the originating PI, and should use the data for the stated purpose only. Originating investigators are strongly encouraged to share their data before the end of the publication rights period. The receiving investigator should not publish any paper during that period based predominantly on the received data, should co-author results with the originating investigator, and should not redistribute the data.

To assist the WOCE IPO in keeping WOCE participants informed of progress, scientists should submit inventories of data collected to the IPO. This should be done within one month after a cruise or at regular intervals (less than 6 months) in the case of continuing observations such as of sea level and from satellites.

NEWS FROM THE WOCE IPO

With science planning and actual funding levels facing the harsh light of day the Core Project Working Groups, the Planning Committees and the National WOCE Groups have spent this summer adjusting the components of the programmes.

The Core Project 1 Working Group reviewed and discussed in a two-day workshop the WOCE plans for the South Pacific and Indian Oceans. This was followed by the third meeting of the Working Group in Hobart, Australia. The main recommendations focus on gaps in the programme or levels of commitment. The group stressed that WHP sections P9, P10, P11, P18 and the eastern part of P2, which was shifted, should be done to full WHP one-time specifications. In the VOS programme the XBT lines PX12/PX12A in the Pacific and IX14 and IX15 were singled out for special attention, as they are important requirements to derive at heat flux estimates.

Core Project 3, The Gyre Dynamics Experiment, underwent a wide-ranging review at the May meeting in Wormley, UK. The Deep Basin Experiment will start in spring 1991 in the Brazil Basin, the Subduction Experiment will follow shortly after in the Madeira region. But gaps in the float and drifter coverage and in the repeat hydrography were identified and need action. In this context the Working Group discussed the Atlantic

Climate Change Programme (ACCP) of NOAA, a US national programme, in view of its relevance. The first cruise in the Control Volume AR12 is scheduled for August 1991.

Interaction with other global ocean programmes, like TOGA and JGOFS, continued. Sharing resources and coordination of programme elements is beneficial to all. The TOGA conference in Hawaii provided an excellent opportunity to discuss joint elements of TOGA and WOCE, such as the drifter and XBT activities.

Continuing the encouragement to get involved in WOCE on a regional level, the WOCE South Atlantic Workshop in Sao Paulo in August focussed on the direct collaboration between scientists and their groups during the imminent WOCE activities in this region.

In the run-up to the first Intergovernmental WOCE Panel (IWP) meeting in October in Paris, detailed programme reviews have to be produced. The Data Management Committee met in Brest to assess what will be a crucial element of WOCE: the ability to get a wide variety of data sets put together, circulated and made available to other users in WOCE. The IWP will hopefully provide a forum where further support for WOCE will be made available.

K.P. Koltermann, WOCE IPO

NEWS AND VIEWS

Wolfgang Roether (Bremen, FRG) finished the WHP section A21/S1 (Drake Passage) with RV Meteor in the spring of 1990. They also worked along A12/S2 with an increased station spacing. This completes the Large-Volume Sampling in the South Atlantic. The cruise was the first to combine the JGOFS/CO₂-sampling programme and a WHP cruise.

Henrik van Aken (NIOZ, Netherlands) carried out the first occupation of the WHP section AR7E (Scotland-East Greenland) with RV Tyro this summer. They did not finish the western end of the section close to Greenland. Jens Meincke (Hamburg, FRG) will do the next repeat with RV Valdivia in March 1991, and the one-time version of this section A1 with RV Meteor in September 1991.

The western Heat Flux Array ACM1 (Florida Straits at 26.5°N) is in the water. Tom Lee (University of Miami, USA) deployed the array in June 1990 for 18 months.

Eberhard Fahrback (AWI, Bremerhaven, FRG) will turn around the first deployment of the current meter array SCM7 in the Weddell Sea after one year. The next deployment is planned with RV Polarstern later in November and will consist of 20 moorings. He also will work the WHP section SR4 again at that time.

For the Atlantic VOS network 17 of 22 lines have been funded and are expected to be operational by the end of the year.

Russ Davis (Scripps, USA) successfully deployed the first set of ALACE floats from Meteor in Drake Passage.

Jeff Paduan and Peter Niiler (Scripps, USA) started operations at the WOCE Global Drifter Centre in March 1990. It presently focuses on the Pacific deployment.

Bob Dickson (Lowestoft, UK) has the final deployment of array ACM8 in the water south of Denmark Strait off the East Greenland Shelf. It will finally be recovered in spring of 1991. The array was first deployed in September 1986.

ERS-1 is now scheduled for launch in late April 1991, ERS-2 is now an official programme scheduled for launch in 1994. This could give WOCE the desired continuous altimeter coverage for 1991-1997.

Penny Callaghan joined the IPO in June. She provides the input to the WOCE Data Information Unit and will liaise with the DIU in Lewes, DE, USA and the IPO in Wormley, UK.

There will shortly be an announcement inviting applications for scientists to come for a period of secondment to the IPO.

EDDY STATISTICS

Much community modelling effort is being expended during WOCE in the construction of models to simulate the transfers of heat, salt and momentum within and between ocean basins; the fact that these models are built to resolve extremely fine space- and time-scales recognises the fact that these inter-ocean transfers are as likely to be accomplished by the small scale fluctuations of the flow field as by the large scale time-averaged ocean currents themselves.

It is therefore important that the international community is provided with a complete and up-to-date set of flow statistics which describe the horizontal and vertical distributions of eddy kinetic energy over as large an area of the world ocean as practicable and to compare these distributions with the kinetic energy of the mean flow.

A listing of flow statistics from all available long term current meter moorings is being provided early in WOCE to help identify gaps in present coverage and to aid in the design of the global experiment. An updated listing, towards the end of the experiment, will provide modellers with a complete representation of the statistics of the oceans flow field, as measured directly with current meters, for use in testing the simulation of processes in models.

The first compilation, consisting of data from 2369 instrument-years of current measurement has already been assembled and is being used to identify sites where

current meter resources might best be deployed to fill key gaps. This report (Dickson, R.R., 1990: see back page) will shortly appear with a follow-up circulation of the full dataset on floppy disk.

Current Meter years for which statistics are available		
	1981	1988
North Atlantic	365	1297
North Pacific	16	350
Equatorial	21	360
Arctic	12	112
Antarctic and South Atlantic	40	250
TOTAL	454	2369

Compared with earlier years (see table) when the global inventory of current meter data was small and dominated by recoveries from the North Atlantic, the report shows that the dataset has expanded greatly during the 1980s with a much more uniform distribution. The continued expansion and broadening of global coverage is essential to the global aims of WOCE; only if we can achieve a further global expansion of the moored instrument coverage will we be able to test and verify the community models currently under development.

R.R. Dickson, MAFF Fisheries Laboratory, Lowestoft.

THIRD CORE PROJECT 1 MEETING

The Core Project 1 Working Group met 9-11 April 1990 at the CSIRO Division of Oceanography in Hobart, Tasmania, Australia (CP1-3). Preceding the Working Group meeting a South Pacific and Indian Ocean Workshop was held on 5-6 April 1990. The results of the workshop were incorporated into the CP1-3 discussions.

The CP1 WG made a detailed assessment of the status of the programme and concluded that the overall level of commitment was encouraging but there were a number of aspects that were of concern - in particular the lack of detailed planning for work in the Indian Ocean. Such planning must be carried out in the next two years to prepare for the implementation of the plan in 1994. In order to accelerate the planning of the Indian Ocean work, the CP1 WG recommended that a meeting be held of possible PIs no later than 1992.

The WHP one-time survey was well subscribed although it was noted that in the N. Pacific there is no plan for a basin-wide section across the subtropical gyre for estimation of the meridional heat flux. Because there was no representative of the tracer community at the meeting, a detailed review of the large and small volume tracer aspects of the WHP Programme was not done. The report of the Geochemical Tracers Scientific Panel was discussed and it was concluded that probably there

are sufficient interest and resources to carry out the programme. Repeat hydrography was reviewed and modifications to the coverage were made. The lack of repeats of the meridional heat flux lines was noted and it was decided that the VOS XBT programme was probably the most likely avenue for obtaining the needed measurements of the annual cycle.

The float programme must concentrate on the provision of a global mapping at a level near 1,000 m where the eddy noise is minimal. The WG stated that this must take precedence over any special releases in the plans. Of the special releases the measurement of cross equatorial flow should receive the highest priority. The WG decided to consider further the status of the WOCE equatorial programme at the next CP1 WG meeting. The development of the surface drifter plan was judged to be proceeding well in the Atlantic and Pacific. The WG placed a high priority on the design of an atmospheric pressure sensor for inclusion on the drifters because of the improvement in flux estimation that would result. Moored arrays in many areas are planned for late WOCE. A concern was expressed that better coordination in time between the heat flux arrays and the associated hydrographic lines was needed.

B.A. Taft, WOCE IPO

THIRD CORE PROJECT 3 MEETING

Between 21 and 23 May 1990 the third meeting of the WOCE Core Project 3 WG was held at Wormley.

The meeting reviewed progress on the major CP3 components. Further information can be obtained from the scientists named at the end of each section.

Deep Basin Experiment

This is in good shape and will primarily involve US, French and FRG investigators. The observational programme is made up of one-time and repeat hydrography and moored arrays in the deep in- and out-flow channels of the Brazil basin. These will be supplemented by deep SOFAR floats, the US work for which is now funded.

Nelson Hogg (WHOI), or WOCE IPO

Eastern Boundary Arrays

There will be work on the dynamics of the eastern boundary west of the UK and west of the Iberian peninsula by Spain, Portugal and the USSR.

John Huthnance (POL), Isabel Ambar, Portugal

Subduction/Ventilation Experiment

This primarily US experiment will take place in 1991-93 in the Azores/Madeira area. It is fully funded and will involve measurements of surface forcing, moorings, bobber, floats (to cycle between density surfaces), ALACEs and repeat hydrography as well as a number of microstructure components. The objective will be to observe the southward spread of subducted water and the mechanisms by which this occurs.

WOCE IPO, Jim Luyten (WHOI)

Enhanced Basin Scale Measurements

These provide a framework within which the process studies can be carried out. Foremost among these is a requirement for neutrally buoyant floats and surface drifters. While ACCP and other initiatives may provide the drifter coverage, floats are more problematical. Tom Rossby described the development of a loud sound source (LSS) via which the N. Atlantic could be insonified using a relatively small number of LSS. Since the CP3 meeting plans are being made for a European initiative to fund both LSS and floats from European Community funds.

John Gould (IOSDL, Wormley)

Modelling

Modelling of the N. Atlantic was reviewed by Bill Holland. There is a real need for a greater involvement by experimentalists in the analysis and interpretation of output from the US community model. The planned UK isopycnal model will eventually provide a useful comparison with the CME results.

Bill Holland (NCAR)

Tracer Release Experiment

The UK has a strong involvement in this through Andy Watson (PML). Sulphur hexafluoride, a "benign" deliberate tracer, will be released into the thermocline near 30°N 20°W in summer 1992. Subsequent sampling cruises will determine the iso- and dia-pycnal spreading of the plume which will be tagged with SOFAR floats.

Andy Watson (PML, UK)

Control Volumes

There will be repeated intensive surveys, after the fashion of the Armi-Stommel Beta Triangle, in CP3 to observe the circulation of areas of the subpolar gyre. Two will be occupied, in the NE Atlantic by UK and in the NW Atlantic by Canada/USSR. Each will provide comprehensive full depth cover of the subpolar gyre with CTDs and tracers.

John Gould (IOSDL, Wormley)

Vivaldi

This is a UK proposal to map twice yearly with ADCP and SeaSoar the upper 400 m of the NE Atlantic, and was discussed in the context of the report of the WOCE Surface Layer Panel. The WG has concerns about the balance between the wide geographical coverage of the proposal as it was presented, and the intent to only provide coverage to subthermocline depths by means of daily CTDs. The WG, while realising that plans for Vivaldi were still being developed, recommended that there should be careful integration with other CP3 basin scale measurements.

Raymond Pollard (IOSDL, Wormley)

The meeting report is available from the WOCE IPO.

W.J. Gould
Institute of Oceanographic Sciences Deacon Laboratory
Wormley, Surrey, UK

ALACE EXPLORES ANTARCTIC CIRCUMPOLAR CURRENT

The Autonomous Lagrangian Circulation Explorer (ALACE, pronounced as the Alice of Wonderland) is a small (23 kg, 1.3 m long) subsurface float which is designed to permit exploration of the low-frequency, or mean, general circulation. ALACE periodically cycles to the surface for about a day where it is located by, and transmits data to, System Argos satellites. Because ALACE is autonomous of acoustic tracking networks it is cost effective, particularly when deployed in relatively low density arrays over wide areas. Autonomy from acoustic tracking eliminates the cost of the tracking array and permits deployment of a complete array from ships-of-opportunity on a not-to-interfere basis. The disadvantage of this system is that continuous tracking is lost; in typical use displacements over 15 to 30 day periods are reported.

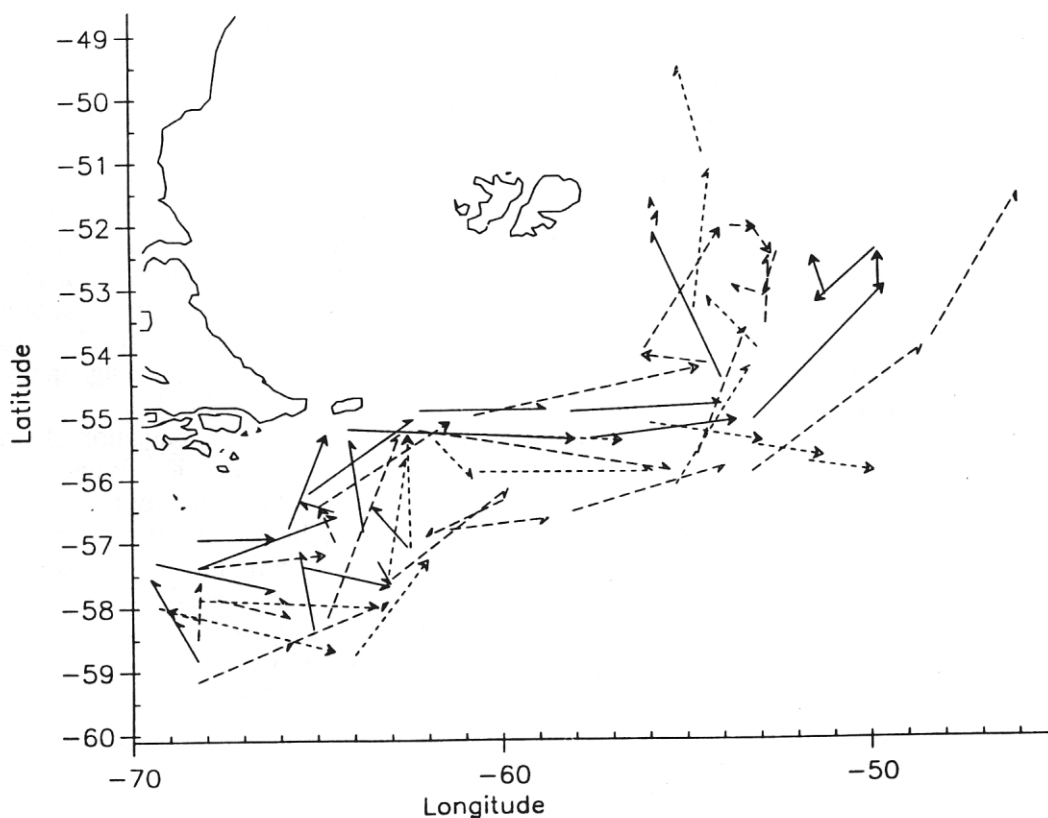
In their first full-scale field test, ten ALACEs were deployed from the Meteor as it crossed Drake Passage carrying out WHP section A21. The floats were set to drift at 700 meters for 14 days between surfacing cycles. Two of the floats malfunctioned and the only Argos reports from them were received on the second surfacing and were too weak for positioning. The other eight were all still operating as intended at the end of August. The 14-day subsurface displacements completed by the end of May are shown in the accompanying figure. The displacement arrows from each float are uniquely coded using three styles of arrow-shaft and three different

arrow heads. The gaps between successive arrows show the displacement during the 24-hour surface interval.

The Circumpolar Current sampling density is, in terms of float-years per unit area, very much less than needed for the WOCE global float survey. Nevertheless, the character of the general flow is reasonably well described and some measure of eddy motion is obtained. Even in the face of substantial eddy variability, interpretation is not unduly prejudiced by discontinuous tracking or the periods of on-surface drift.

The ALACE float was designed specifically for the WOCE global float programme which seeks to map absolute velocity on one level to provide a level of known motion to complement the hydrographic programme. Developed under NSF support at Webb Research Corporation and Scripps Institution of Oceanography, ALACE's design life is 50 cycles to 1000 meters over five years. Additional deployments will begin in 1991 in the Pacific during US occupation of WHP sections P19 and P16. As reliability improves it is hoped that additional investigators will take advantage of the ALACE technology to observe low-frequency flow and to repetitively profile ocean properties.

R. Davis
Scripps Institution of Oceanography
La Jolla, CA. 92093
USA



ARE MERCURY DEEP-SEA REVERSING THERMOMETERS OUT OF DATE?

Since the turn of the century protected and unprotected mercury reversing thermometers have been an invaluable tool for oceanographers to determine *in situ* temperature and pressure values on hydrographic casts. With the advent of electronic measuring devices such as conductivity-temperature-depth sondes (CTDs), which record the hydrographic properties of the ocean with much higher vertical resolution, they have somewhat lost their importance for direct oceanographic data acquisition. However, due to their stability in time and their accuracy they still serve as *in situ* calibration tools for CTDs, *e.g.* when mounted on rosette samplers. A few years ago, new, electronic digital reversing thermometers and pressure meters have been developed and are now commercially available. At first glance they offer several advantages compared to traditional mercury thermometers: an easy to read digital display and a short equilibrium time (0 (10 s)) of the platinum resistance sensor. The latter may result in reduced station-time and thus save money.

In WOCE Newsletter No. 8 (1989) Fahrbach reported results from an intercomparison of one set of protected and unprotected mercury thermometers (56/51 samples) and several sets of digital thermometers and pressure meters (257/216 samples), obtained during a cruise of RV Polarstern in the Greenland Sea. The digital meters were manufactured by SIS (Sensoren-Instrumente-System), Kiel and the mercury thermometers by Kahl, San Diego. Both data sets were compared with temperature and pressure readings from a CTD (make not specified). About one third of the digital meters failed during the cruise. Of the rest, 80% of the digital thermometers showed a mean deviation of less than 2 ± 2 mK. The intercomparison of the one mercury thermometer with the CTD-temperatures resulted in a mean difference of -1 mK with a standard deviation of 6 mK. The corresponding values for the pressure intercomparison were less than 6 ± 3 dbar for the digital instruments and 9 ± 6 dbar for the one set of mercury thermometers. Three messages can be extracted from Fahrbach's note: (1) the digital devices are easy to read, *i.e.* they are comfortable and misreadings are reduced, (2) they are more precise than mercury thermometers and (3) due to their short equilibrium time, their use saves time and thus money.

Electronic measuring devices in oceanography are known to sometimes exhibit drifts on short time scales (during a cruise) as well as sudden jumps in the calibration caused by clashes of the instrumentation against the hull of the ship during bad weather. In contrast, mercury thermometers are very stable in time and a clash usually results either in total destruction or no change in the calibration at all. To us it always seemed appropriate to check electronically derived data (CTD)

with data sampled with instruments based on a different physical principle. Comparing instruments with the same inherent errors leave out this possibility. Nevertheless the above three statements are intriguing.

To check these we have re-analyzed some of our recently collected *in situ* data and carried out several laboratory experiments in the calibration tanks of the Institut für Meereskunde, Kiel and of Gohla-Precision, Kiel. The field data stem from several cruises in the Greenland Sea. For the laboratory tests six SIS-instruments from IFM Kiel and two Gohla mercury thermometers from IFM Hamburg were used.

The “easy-to-read” argument

It is of course clear that large digital displays are more easy to read than a mercury column, which position has to be estimated between graduation marks. Using a magnifying glass this is, however, possible to within one fifth between marks even for inexperienced users. As part of our student education we usually get all students (4-12) to read the thermometers from the first stations of a cruise. For the low range thermometers (-2 to 3 or 6°C) standard deviations between the individual readings of the same thermometer were in all cases less than 0.004 K and for wide range thermometers (-2 to 20°C) less than 0.012 K. With more experience (by the end of the cruises) these values were reduced to 0.002 K and 0.008 K. Thus, the errors introduced by different people reading the thermometers do not reduce the accuracy of the measurements.

The “accuracy” argument

Mercury thermometer-intercomparison: On most cruises, preferably at the beginning, all bottles of the rosette sampler are triggered at one depth level in a region of homogeneous water. This is done to check the internal consistency of the temperature measurements and to sort out bad thermometers. Results from seven such intercomparisons, using low range thermometer (-2 to 3° or 6°C) are given in Table 1.

The mean standard deviation of these simultaneous measurements is 0.005 K. When the most deviating thermometers (usually not more than one out of the set) are taken out, this variability reduces to 0.004 K or less.

Mercury thermometer-CTD comparison: A comparison of mercury reversing thermometer readings with *in situ* CTD values, which form a basis for the calibration of the platinum resistance sensor gave a mean standard deviation of 0.006 K for the low range and of 0.014 K for the large range thermometers. The individual results are listed in Table 2.

Table 1: Intercomparison of deep sea reversing mercury thermometers. All thermometers had been calibrated within two years prior to the cruise.

cruise	Station No	mean °C	Std. dev. K	No. of thermom.	make
Valdivia 21	12	-0.952	0.003	7	Gohla
Valdivia 48	26	-0.946	0.002	8	Gohla
Valdivia 48	118	-1.069	0.006	9	Gohla
Valdivia 48	120	-1.012	0.006	9	Gohla
Valdivia 54	28	-1.023	0.003	9	Gohla
Valdivia 67	11	-0.911	0.006	8	Gohla
Valdivia 67	33	-0.762	0.006	8	Gohla
Valdivia 78	5	-0.842	0.005	6	Gohla
Valdivia 78	123	-1.074	0.004	6	Kahl

Table 2: Intercomparison between mercury deep sea reversing thermometer readings with CTD temperatures.

cruise	therm. range	No. of readings	Std. dev. K	make thermom.	make CTD
Valdivia 21	LR	572	0.008	Gohla	ME
Valdivia 26	HR	68	0.016	Gohla	ME
Valdivia 35	HR	57	0.012	Gohla	ME
Valdivia 48	LR	216	0.009	Gohla	ME
Valdivia 54	LR	207	0.005	Gohla	ME
Valdivia 67	LR	89	0.005	Gohla	ME
Valdivia 67	LR	50	0.008	Gohla	SZE
Valdivia 71	LR	93	0.006	Kahl	NB
Valdivia 72	HR	62	0.017	Gohla	ME
Meteor 8	LR	36	0.003	Gohla	SZE*
Meteor 8	LR	95	0.005	Kahl	NB
Valdivia 78	LR	62	0.005	Gohla	SZE*
Valdivia 78	LR	100	0.008	Kahl	NB
Valdivia 87	HR	28	0.009	Gohla	SZE*

LR - Low range thermometers -2° to 4° or 6°C
 HR - High range thermometers -2° to 20°C
 ME - Meerestechnik Elektronik CTD
 NB - Neil Brown CTD Mk III
 SZE - Salzgitter Elektronik CTD LS 2000

These values can be directly compared with Fahrbach's (1989) results who found a standard deviation of 0.006 K for the one Hg-thermometer and 0.002 K for the digital instruments.

Such a comparison between CTD and reversing thermometer values does of course not only reflect the quality of the reversing thermometers but also that of the CTD. During the first cruises listed in Table 2, CTD values were read off the display directly, leaving it to the operator to find a suitable average. During later cruises (marked by an asterisk) averages over 20 cycles were calculated in the computer during the triggering of the bottle. While this should not have an influence on the mean value of the calibration, provided enough samples have been taken, the standard deviation during these

cruises was reduced from 0.007 K to 0.004 K (LR) and from 0.015 K to 0.009 K (HR).

Laboratory tests: To study accuracy and reproducibility of temperature measurements with mercury and digital thermometers two pairs of each were triggered simultaneously at different temperatures in a calibration bath. There were two runs, on 12 and 17 January 1990. Before reversing, the thermometers were allowed to equilibrate for at least 8 minutes, the bath temperature was constant to within 0.001 K.

The mercury thermometers (Gohla, No. 11359 and 11360) have a range -2°C to 10°C with graduation marks every 0.02 K while the digital thermometers (SIS, No T211 and T212) have a range -2°C to 40°C with a resolution of 0.001 K and 0.01 K for temperatures

below and above 20°C, respectively. The result of this test is summarized in Figure 1.

At the four temperatures tested the mercury thermometers stayed within 0.004 K of the manufacturers calibration. Mean differences were 0.002 K or less with a standard deviation of 0.002 K. The two digital thermometers in contrast showed mean differences of up to 0.008 K with a variability of up to 0.004 K. The digital thermometers also showed several misrecordings, altogether 5 out of 54 measurements.

Digital thermometer recalibration: In preparing for a cruise, four other digital thermometers (T339-342) were calibrated at the Institut für Meereskunde, Kiel on 21 December 1989. These results and the values of the manufacturer SIS (calibration of 3 December 1989) are summarized in Figure 2. In all cases the two calibrations show significant differences between 0.006 K and 0.012 K. Because these differences were rather large we at first suspected an error in our (IFM) calibration. However, a re-recalibration at Gohla-Precision on 23 December confirmed our results within a few mK (Figure 2).

It is of course not clear whether these differences reflect a bad calibration by the manufacturer or a drift of the instrument. Fahrbach (1989) reported a time drift of an SIS instrument of 0.002 K per 17 days while the values found here would correspond to a drift of up to 0.012 K in 18 days.

Stability of mercury thermometers: Out of a set of five mercury thermometers (-2° to 6°C) bought by IFM Hamburg in 1984 two (No. 8820, 8821) survived until now. They were calibrated at 1 K intervals in 2/84, 11/86, 10/88 and 11/89. The maximum change obtained between successive calibrations was 0.007 K corresponding to a drift of 3 mK/a. However, mean time drifts were 1.43 ± 1.37 mK/a and 1.41 ± 0.76 K/a for the two instruments respectively. As these values are at the limit of the calibration accuracy one may state that mercury reversing thermometers are indeed very stable.

The “time-saving” argument

There are widely different opinions in the oceanographic community as how long a mercury reversing thermometer has to equilibrate before an accurate measurement can be taken. Current practice ranges from 3 to 10 minutes. The platinum resistance probes of the digital thermometers have a response time of $T_{0.9} = 2.3$ s which is significantly less.

To check the individual equilibrium times, one mercury and one digital thermometer were heated in a water bath to 23°C, moved to the calibration tank (5°C) and then triggered after different time intervals between 0.5 and 7 minutes. The results are shown in Figure 3. The small error bars of at most 2 mK on the time axis at 5°C indicate the changes in the bath temperature due to the heating by the warm thermometers.

The digital thermometer reached 99% of its final value in less than 30 s while the mercury thermometer

needed about 150 s. The 99.9% levels were reached after 150 s and 330 s, respectively. This corresponds to time constants ($1/e$) of 6.5 s and 33 s, respectively. These values have to be viewed with respect to what conditions are met in the real ocean.

In the deep water step-like vertical temperature changes seldom exceed 0.2 K and the required accuracy of the measurement is 0.003 K, corresponding to a 98.5% level. In the upper tropical ocean almost instantaneous temperature variations may be as large as 5 K, the attainable accuracy here can be at most 0.01 K, corresponding to a 99.8% level. Thus, with a soaking time of 3-4 min for mercury thermometers one is certainly on the safe side for making accurate measurements. With a typical set of three bottles on the rosette sampler equipped with reversing thermometers and 50 deep stations during a cruise this time adds up to about 8 hours.

Conclusions

The accuracies of the reversing thermometers as specified by the manufacturers are 0.005 K in the range -2° to 20°C for the digital instruments and 0.005 K for the low range mercury thermometers (-2 to 4, 6 or 10°C).

In contrast to Fahrbach's (1989) findings our study shows that these specifications are not met by the digital reversing thermometers. The overall accuracy as determined by several recalibrations in a laboratory tank is more like 0.01 K. In addition, these instruments are characterized by a relatively high failure rate of up to 30%.

Provided that mercury reversing thermometers are read carefully, the obtainable accuracy in the field is 0.005 K, as is specified by the manufacturer. The failure rate is low (<10%) and the calibration appears to be constant over several years.

The digital instruments have a very small time constant, while under normal oceanic conditions mercury thermometers require an equilibrium time of at the most 3-4 minutes, depending on the ambient temperature gradient.

The longer time required for taking a temperature measurement with a mercury reversing thermometer is, in our opinion, more than balanced by the fact, that these instruments provide an independent (mechanical) measurement, that they are more accurate, have a better stability in time and are more reliable. Mercury reversing thermometers are not out of date!

Fahrbach, E. (1989): The use of electronic digital thermometers and pressure meters. WOCE Newsletter No. 8, 12-13.

Detlef Quadfasel
Norbert Verch
Institut für Meereskunde
der Universität Hamburg
Troplowitzstr. 7
2000 Hamburg 54, F.R.G.

Jürgen Langhof
Institut für Meereskunde
an der Universität Kiel
Düsternbrooker Weg 20
2300 Kiel
F.R. Germany

THE INTERNATIONAL TEMPERATURE SCALE OF 1990, ITS-90

The International Committee for Weights and Measures at its meeting in September 1989 approved the above temperature scale. It replaces the International Practical Temperature Scale of 1968 (IPTS-68) and will take effect from 1st January 1990. [Note that the term practical is dropped from the title.] ITS-90 takes advantage of technological advances and more closely approximates the thermodynamic temperature scale than previous scales (IPTS-68, IPTS-48 etc).

Of particular interest to oceanographers are the properties of ITS-90 in the range -2°C to +35°C. The single most important property is that the triple point of water remains unchanged at 273.16 K or 0.010°C; however at standard atmospheric pressure the boiling point of water falls to 99.974°C. Consequently in the interval 0-100°C temperatures measured on the ITS-90 scale are lower than values measured on the IPTS-68 scale. But below 0°C they are higher. The differences are expressed in the following table.

$t_{90}/^{\circ}\text{C}$	-10	0	10	20	30	40
$t_{90}-t_{68}/^{\circ}\text{C}$.002	.000	-.002	-.005	-.007	-.010

Over this range (although slightly nonlinear) the relation between the temperature scales can be adequately represented by the expression

$$t_{90} = 0.99976 t_{68}$$

Initially it is expected that oceanographers will employ the above expression to correct temperatures measured on the IPTS-68 scale but new calibration procedures will be introduced in National Standards Laboratories commencing 1990 and it is hoped these practices will rapidly spread to oceanographic calibration

facilities. The value for the fixed points on the ITS-90 scale and the instruments and interpolation equations to be employed for the measurement of temperature are described in a text to be published in the journal *Metrologia*, early in 1990.

Although the impact of the new temperature scale on ocean temperature measurements and their climatology is likely to be small (or even negligible), unfortunately this is not true for its knock-on effects. Corrections will be required for the computation of salinity and other state properties of sea water.

It is imperative that in the determination of derived oceanographic quantities, where t_{90} is used as an entry to standard algorithms (UNESCO Technical papers in *Marine Science*, 1988 volume 44) that the first executable statement be

$$t_{68} = 1.00024 t_{90}$$

The algorithms will then utilise the temperature scale employed in their formulation.

Recognising that there will be a period within which the IPTS-68 scale will remain in use, it is recommended that

1. for the near future all temperatures reported in the literature be labelled t_{90} or t_{68} as appropriate, and
2. oceanographers adopt the ITS-90 scale as soon as possible.

P M Saunders
Chairman WHP sub-group on standards and calibration
Institute of Oceanographic Sciences Deacon Laboratory
Wormley, Surrey, UK

ERRORS IN XBT PROBES

The following notes suggest the need for a close look at the present performance of XBT systems in contributing to WOCE objectives. There is a lot of experience around in the use of XBTs so we should be able to adopt procedures in WOCE for in situ checking of the system that will improve on the basic performance of the instrument.

In WOCE there is a Surface Layer Scientific Panel (Chair: Raymond Pollard, IOSDL, UK) charged with advising the SSG on the scientific requirements for a WOCE surface layer observational programme, a Voluntary Observing Ship (VOS) Planning Committee (Chair: Robert Molinari, NOAA/AOML, Miami) providing scientific advice on the design of the observational programme, and a Data Assembly Center

(J-P. Rebert, Orstom, Brest) concerned with the assembly and quality control of XBT data.

If you have constructive suggestions on the improvement/assessment of XBT data in terms of field procedures, we suggest that you communicate with the VOS Panel.

Depth Error in T-7s

On the recent cruise of RRS Charles Darwin a number of Plessey T-7 probes were dropped in water depths less than the maximum depth of the probe. This allows for a direct check between the water depth indicated by the vessel's precision echo sounder and that shown by the probe hitting the bottom.

The data were recorded using a Bathysystems SA-810 recorder coupled to a Zenith Personal Computer. Echo sounder depths were corrected using UK Hydrographic Department Echo Sounding Correction Tables (NP139) for areas 1 and 9. All probes were dropped at ship speeds between 8 and 12 kts and in water with surface temperatures close to 11°C.

A significant number (19) were dropped along the 700m depth contour and so give a good idea of the scatter of values. These show that at 700 m the T-7 XBT reads shallow by 37.4 ± 6.6 m, a 5% error. A plot of error against depth suggests an approximately linear relationship between error and water depth.

Hanawa and Yoshikawa in their presentation at the recent TOGA conference in Honolulu compared Japanese produced T-7 probes, dropped with the vessel hove to, with simultaneous CTD profiles. Their depth errors were approximately half those measured here. The fact that the checks made on Charles Darwin were made under conditions in which the probes would normally be used suggests that the error values have some validity. However the difference between our checks and those of Hanawa and Yoshikawa may still be due to the fact that the probes come from different manufacturers.

While there are obvious dangers in introducing a multiplicity of time to depth conversion algorithms it now seems evident that there are systematic errors which could be corrected in existing data sets. We should, I believe, take whatever opportunities present themselves of making independent checks on XBT performance.

W.J. Gould
Institute of Oceanographic Sciences Deacon Laboratory
Wormley, Surrey, UK

The 'Bowing' Problem

During the expansion of the CSIRO's Voluntary Observing Ship (VOS) network, CSIRO began equipping merchant ships with Bathy System SA-810 XBT controllers under the SEAS II configuration. Ships already in the network remained equipped with Sippican Mk-9 XBT systems. Quality control of the data recorded by one ship equipped with a Bathy Systems Controller, and another ship equipped with a Mk-9 System, (both ships operating on the same route in the seas north of Australia) revealed consistently different representations of the surface isothermal layer. The Bathy Systems Controller displayed a gradual increase (or 'bowing') in temperature over the surface 'isothermal layer'. The Mk-9 system displayed typical surface isothermal layers (*i.e.* no increase in temperature). As more data was collected by ships operating in the network, the differences in the representation of this layer between the two types of systems became more apparent. In some cases, the Bathy Systems controllers displayed increases of 0.7°C and above from the top to the bottom of the 'isothermal' layer.

It was at this stage that we decided to compare both types of XBT systems against a CTD on the RV Franklin in the waters to the north-west of Australia. The study found (see Bailey *et al.*, 1989) that the output of Bathy Systems controller was misrepresenting the temperature of this important layer, and confirmed the 'bowing' problem. The temperature errors are assumed to extend beyond the isothermal layer though we can only distinguish the problem in the mixed layers where the real temperature gradient is zero.

Analysis of the data recorded by the Bathy Systems controllers in the CSIRO VOS data network showed 35% of the data to have errors in the isothermal layer temperature to be greater than the assumed error of the XBT (0.15°C) [ed. but see the following note].

R. Bailey
CSIRO Division of Oceanography
PO Box 1538
Hobart, Tasmania 7001
Australia.

Bailey, R.J., H.E. Phillips and G. Meyers, 1989.
Relevance to TOGA of Systematic XBT Errors,
Proceedings of the Western Pacific International
Meeting and Workshop on TOGA COARE,
Noumea, New Calendoncia, May 24-30, 1989.
Edited by J. Picaut, R. Lukas and T. Delcroix.

Laboratory Study of 'Bowing'

Initial results of laboratory experiments have shown that a probable cause of the 'bowing' phenomenon is electrical current leakage from minute imperfections in the insulation of the two-wire system of the XBT probes, which uses sea water as the third wire in a differential voltage/constant current measuring system.

The size of the insulation imperfection has a strong effect on the size of the error signal introduced into the temperature record and it is most likely that all measuring systems are subject to this error. Results indicate with increasing electrical current levels the digitizer masks the effect of wire leakage so as to make the 'bowing' effect less pronounced. The Bathy Systems controller with a lower current level of 12 microamps is not as effective in swamping out the electrical potential generated by the copper-saltwater electrochemical cell as the Sippican Mk-9 with 200 microamps. It is possible to increase the Bathy Systems current level to match the Sippican digitizer. The causes of wire insulation failure are uncertain at this time, although probe storage and ageing may be a factor.

M. Szabados
Ocean Observations Division
NOAA/NOS
1825 Connecticut Avenue NW
Washington, DC 20235
USA

NEW XBT LINE NUMBERING SYSTEM

TOGA, WOCE and IGOSS have agreed to use one numbering system for XBT lines to make coordination and identification amongst these common programmes easier. This, of course, means that some of the WOCE numbers used since the Implementation Plan was issued in 1988 have been changed. The new system is called TWI. Many of the WOCE numbers have been retained, making adjustment to the new system rather easy. The TWI numbers and corresponding former WOCE numbers are given below. A full TWI list, with maps, may be obtained from IPO. If lines are established in the future, TWI numbers will be assigned by IGOSS. Notification of new lines will be through the Newsletter and the WOCE Data Information Unit (WOCE.DIU). TWI should be used immediately by all, particularly XBT programme managers and those seeking WOCE XBT data or information. Note that former WOCE PX2, 3 and 12A will be assigned TWI numbers in the near future.

One caution when using the TWI system: the Pacific lines given here refer mainly to the WOCE High Density (30-50 km observation spacing) sampling scheme. Others, TOGA for example, use the same numbers for their broadcast mode (150 km spacing) lines where routes are common.

INDIAN OCEAN

TWI	Former WOCE Number	Route
IX-1	IX-1	Fremantle - Sunda Strait
IX-2	IX-2	Cape of Good Hope - Fremantle
IX-3	IX-3	Red Sea - Mauritius/La Reunion
IX-6	IX-13	Mauritius/La Reunion - Malacca Strait
IX-7	IX-5	Cape of Good Hope - Persian Gulf
IX-9	IX-12	Fremantle - Persian Gulf
IX-8	IX-6	Mauritius - Bombay
IX-10	IX-10	Red Sea - Malacca Strait/Singapore
IX-11	IX-7	Calcutta - Java Sea
IX-12	IX-9	Fremantle - Red Sea
IX-14	IX-14	Bay of Bengal
IX-15	-	Mauritius - Fremantle
IX-18	IX-4	Mombasa - Bombay
IX-19	IX-19	La Reunion - Amsterdam/Kerguelen
IX-21	IX-21	Cape of Good Hope - Mauritius
IX-22	IX-22	Fremantle - Timor Strait/Banda Sea
IX-23	IX-23	Fremantle - Antarctica
IX-24	IX-11	Fremantle - Calcutta

ATLANTIC OCEAN

TWI	Former WOCE Number	Route
AX-1	AX-1	Greenland - Scotland/Denmark
AX-2	AX-2	Newfoundland - Iceland
AX-3	AX-3	English Channel - NY
AX-4	AX-4	NY - Gibraltar/Lisbon
AX-5	AX-5	English C. - Panama Canal
AX-6	AX-6	NY - Dakar
AX-7	AX-7	G. Mex - Gibraltar
AX-8	AX-8	NY - Cape of Good Hope
AX-9	AX-9	Trinidad - Gibraltar
AX-10	AX-10	NY - Trinidad/Caracas
AX-11	AX-11	Europe - Brazil
AX-12	AX-12	Europe - Antarctica Islands and/or Antarctica
AX-13	AX-13	Rio - Monrovia
AX-14	AX-14	Rio - Lagos
AX-15	AX-15	English C. - Cape of Good Hope
AX-16	AX-16	Rio - Walvis Bay
AX-17	AX-17	Rio - Cape of Good Hope
AX-18	AX-18	Buenos Aires - Cape of Good Hope
AX-19	AX-19	Cape Horn - Cape of Good Hope
AX-20	AX-20	English C. - French Guyana
AX-21	-	Rio - Pointe Noire/Luanda
AX-26	-	Lagos - Cape of Good Hope

PACIFIC OCEAN

TWI	Former WOCE Number	Route
PX-5	PX-4	Japan - Coral Sea (Sydney/Noumea)
PX-6	PX-10	Suva (Fiji) - Auckland
PX-9	PX-9	Hawaii - Noumea/Auckland
PX-10	PX-5	Hawaii - Guam/Saipan
PX-44	PX-5	Taiwan - Guam
PX-12	PX-12	Tahiti - Coral Sea
PX-29	PX-12	Tahiti - Valparaiso
-	PX-12A	Sydney - Valparaiso
PX-14	PX-8	Alaska - Cape Horn
PX-26	PX-1	TRANSPAC
PX-31	PX-11	Sydney - Noumea - California
PX-34	PX-13	Sydney - Wellington
PX-36	PX-14	Christchurch - McMurdo
PX-37	PX-6	Hawaii - California
PX-38	PX-7	Hawaii - Alaska
-	PX-2	30°S-30°N across Pacific - TOGA
-	PX-3	Tokyo - San Francisco

FRAM - THE FINE RESOLUTION ANTARCTIC MODEL

Model Description

FRAM is a primitive equation numerical model of the Southern Ocean between latitudes 24°S and 79°S. The code is based on that of Cox. The horizontal grid is $1/4^\circ$ latitude by $1/2^\circ$ longitude. There are 32 vertical levels, ranging in depth from 20.7 m at the surface to 233 m at the bottom. (There are 6 levels in the top 200 m.) The topography used is a smoothed version of the DBDB5 topography. The model variables are potential temperature, salinity and velocity, in all about 20 million. When the snow and ice model is included, extra variables for snow and ice thickness and temperature will be added.

The model starts from rest with initial temperature of -2°C and salinity 36.69 everywhere, and relaxes to the Levitus annual mean temperature and salinity over 6 years. For the first 2 years 160 days, the relaxation timescale is 180 days for depths above 160 m and 540 days for the deeper levels. From then until 6 years the timescale is 360 days throughout. This is equivalent to the normal robust diagnostic scheme, except that the relaxation is so weak that the eddy field can develop.

Surface forcing, in the form of Hellerman annual mean winds, is introduced after 2 years 6 months - increasing linearly from zero to the mean values over 6 months. After 6 years seasonal winds are introduced and surface forcing of temperature and salinity is operated by relaxing the surface layer only to the annual mean Levitus values with a time scale of one year.

Towards the end of 9 years (day 3256), the viscosity and diffusion change from harmonic to biharmonic and the bottom friction changes from linear to quadratic (see FRAM Newsletter No. 2, 1990). The model runs on to the end of 10 years. We are now repeating this period with a combination of harmonic and biharmonic viscosity and diffusion for comparison before making a choice for the remainder of the model run.

The next stage is to include heat and freshwater fluxes, leading on to the snow and ice model. There have been delays associated with the lack of surface flux data over much of the Southern Hemisphere. The radiation data of Esbensen and Kushnir are to be used, interpolated where necessary.

Model Behaviour

After one model day the stream function shows large amounts of energy generated around topography. By day 10 the model has settled down and produced a recognisable Circumpolar Current with steering south of New Zealand, round Kerguelen and through the fracture zone of the mid-ocean ridge of the South Pacific. The amplitude of the Circumpolar Current, measured by the

transport through Drake Passage, grows roughly linearly with time. When the winds are added, the model responds in about 10 days with a 23 Sv increase in transport.

The transport, total kinetic energy of the model and other diagnostic fields settle down between years 5 and 6, indicating that the momentum budget of the model is near its asymptotic state. The transport through Drake Passage is about 200 Sv. The main regions of eddy formation are in the Agulhas Current and along the path of the Circumpolar Current. Following the introduction of seasonal forcing after 6 years, the transport through Drake Passage has been oscillating between 195 and 200 Sv. There has been an increase in eddy energy near the ACC and eddies produced by the Agulhas Current are continuing to radiate into the South Atlantic.

Model datasets

The output of the model is stored on archive tape at the end of each model month. Each archive dataset consists of a single file, containing a header section made up of ASCII characters followed by the data written as binary images in the 32-bit (4 bytes) IEEE floating point format. SUN computer and many other mini-computers (*e.g.* Silicon Graphics) use this format internally.

The archive datasets are available to the community together with the Fortran 77 software needed to read the file and extract horizontal and vertical (N-S and E-W) sections of the model variables. Users will need to write their own programs to extract sections at other angles or which cover only part of the model domain. Plotting programs in the 'C' language are also available for use on SUN 4 computers. The preferred medium for the supply of data is on 2 Gbyte Exabyte tapes. Each full dataset is 90 Mbytes. We recommend that those planning to use the model output use the dataset from the end of 6 years first.

For further details contact: Mrs Beverly de Cuevas, IOS Deacon Laboratory, Wormley, Godalming, Surrey, GU8 5UB, UK.

WOCE started in Labrador Sea

John Lazier of the Bedford Institute in Canada worked the WHP section AR7W across the Labrador Sea with RV Dawson from 29 June to 11 July 1990. First results show that temperatures for some layers changed dramatically since last year. They decreased by 0.32°C between 1962 and 1981, then increased by 0.15°C between 1985 and 1986, remained constant for the following four years, and dropped back down to the 1981 level over this last year. The next Newsletter will cover more.

THE WOCE SURFACE LAYER PROGRAMME

Measurements of the fluxes of momentum, heat and fresh water across the surface of the ocean have been a basic element of WOCE plans. The improved determination of these fluxes has been the goal of the JSC/CCCO Working Group on Air-Sea Fluxes which has concentrated its efforts on the assimilation of data, especially that on surface stress data as measured by satellite scatterometers, into atmospheric general circulation models. Similar techniques for the determination of heat and fresh water fluxes have also been considered. A subgroup of this working group has addressed the question as to which *in situ* WOCE measurements could best be used to support this effort. Their recommendations include surface pressure measurements in the southern hemisphere, experiments in a variety of regions to measure the parameters used in bulk formulas so that they may be compared to those obtained from AGCMs and the improvement of atmospheric VOS measurements (see WCRP-23).

More recently a meeting was held at Florida State University, Tallahassee, 19-21 February 1990, to address the more general aspects of the WOCE Surface Layer Programme and to re-examine the question as to whether the measurements required by the Implementation Plan would meet the objectives of Goal 1 of WOCE. These measurements include XBTs taken from both research vessels and the VOS, surface drifters measuring surface current and temperature, and satellite measurements of the sea-surface stress and temperature.

The meeting recognized the developing role of models of the upper ocean in assimilating a variety of data in a manner consistent with the local and large-scale dynamical balances. These are now being run in an operational mode in conjunction with atmospheric models. Such operational ocean models, as well as those used for predictions of climate change resulting from increasing greenhouse gases, show the large differences between the surface heat fluxes predicted by atmospheric models, which over the ocean essentially respond to the SST, and those fluxes which are consistent with the observations of the changing heat content of the ocean. In the case of climate prediction using coupled ocean-atmosphere models, this has led to the use of empirical surface flux corrections that allow the model ocean and atmosphere to remain in statistical steady state in the absence of changes in the atmospheric concentration of greenhouse gases or variations in the incoming solar radiation.

The Tallahassee meeting made a number of recommendations concerning the WOCE Surface Layer Programme. In particular, it recognized the need for *in situ* upper ocean measurements to be available as soon as possible, at least within a few weeks, and where possible on the GTS so that they can be used in operational ocean models. Assimilation of data into ocean models either on an operational basis or at a later time when more complete data sets become available was seen as a fundamental need. In the latter context the use of adjoint techniques was seen as important.

The meeting also emphasized the need for upper ocean salinity data, especially at high latitudes, and recommended that the possibility of obtaining surface salinity on VOS ships should be investigated.

The relative effectiveness for WOCE purposes of data from satellites, the VOS programme, moored buoys and surface drifters in constraining the changing heat content of the surface layer and the implied surface heat fluxes was discussed. While some estimates can be made for single data sets, such as XBTs from the VOS programme, the more general question concerning the most effective mix of measurements awaits further results of the sensitivity of models to the different data types.

The considerations of the Tallahassee meeting are relevant to the emerging efforts to develop systematic oceanic measurements as part of a Global Ocean Observing System, the scientific aspects of which are being addressed by the JSC/CCCO Ocean Observing System Development Panel which met for the first time recently in Washington. The work of this panel encompasses both the objective of monitoring changes in the climate of the ocean (that is, Goal 2 of WOCE) and the need for data to initialize ocean models for the prediction of climate changes such as the ENSO events being addressed by TOGA. Systematic observations of the upper ocean obtained on a cooperative operational basis are seen as timely by a number of nations and may do much to establish the climatology of the upper ocean as well as provide data needed to meet WOCE and TOGA objectives. Initially, of course, it will be the measurements obtained as part of WOCE and TOGA which will form the basis of such an observing system.

G.T. Needler
WOCE Chief Scientist
IOS Deacon Laboratory
Wormley, UK

WOCE SOUTH ATLANTIC WORKSHOP SAO PAULO, BRAZIL, 6-10 AUGUST 1990

The workshop was convened to coordinate all relevant WOCE activities in the South Atlantic Ocean, to establish close working relations between participating scientists and laboratories and to identify areas where future research is required in the WOCE South Atlantic Programme.

29 scientists from Argentina, Brazil, France, Germany, the United Kingdom, the United States and Uruguay participated in open and detailed discussions.

We agreed that in view of the critical role of the Atlantic Ocean in general, and the particular role of the South Atlantic in the context of global heat and freshwater transports and its impact on the climate system, every effort should be made to implement and maintain the established WOCE programme.

WOCE has started. At the end of 1989 the first WOCE cruises were worked in the Drake Passage and across the Atlantic sector of the Southern Ocean and the Weddell Sea. This will be followed by a Meteor cruise in the beginning of 1991 to deploy the mooring array ACM3 and work the section A9 at 20°S. This will also be the start of the Deep Basin Experiment, which will be maintained for at least two years in the Brazil Basin. Other cruises and mooring deployments will follow in quick succession.

WOCE work has also started in the equatorial region and will pick up in 1991 and continue throughout the Intensive Observation Period to at least 1995.

The workshop acknowledged the impressive set of activities scheduled for the whole of the Equatorial and South Atlantic Ocean. It suggested further areas of close interaction between laboratories and scientists to achieve the WOCE goals:

- (1) Argentinian, Brazilian and Uruguayan scientists will develop a programme to work AR8. This will include hydrographic sections across the shelf into the deep ocean at preferably quarterly intervals for at least two years.
- (2) A number of other sections across the shelf between 45°S and 10°N are being pursued. Cross-equatorial sections are also encouraged.
- (3) The heat flux array ACM3 at section A10 will be augmented on the shelf by Brazilian moorings.
- (4) The work done in the confluence region was highly appreciated. The continuation of the interpretation of relevant fieldwork is strongly recommended where they contribute to the WOCE goals.
- (5) Several sites for good- to high-quality tide-gauge measurements were identified. It was agreed to maintain these sites and to upgrade their quality and the data links so that they could provide

important input to the WOCE Sea Level Programme.

- (6) Modelling activities were reviewed. The developing global models and existing South Atlantic models give the WOCE community the opportunity to establish close working relations with modelling groups in South America and to support the development of relevant South Atlantic models.
- (7) The workshop agreed that satellite-derived data for model input or other analysis as planned for the WOCE programme, will be made available to those scientists working on South Atlantic problems. This is regarded as a major contribution to enable the development of model and satellite data applications in South America.
- (8) The VOS network in the South Atlantic is getting well underway. Further support is needed to maintain these lines; ship greeting, instrumentation and scientific analysis have been identified as areas for improvement.
- (9) The WOCE Drifter Programme in the South Atlantic needs further support. It is seen as an area where South American laboratories can get strongly involved as it addresses on the regional level problems of national interest.
- (10) The workshop agreed that every support is needed to maintain and preferably increase support for WOCE-related oceanography in South America. The availability of ships, instrumentation and manpower is crucial to a programme with a global impact such as WOCE. Direct involvement in WOCE through collaboration will help to identify critical areas and define how best to support regional scientific interest.
- (11) We will work out ways to assist the development of collaborative efforts between scientists through enhanced bilateral and joint programmes.

The workshop owed much to Professor Ikeda, IOUSP, Sao Paulo, for his support and for the meeting arrangements. My impression is that the South Atlantic Programme for WOCE will be well supported, that the involvement of South American scientists needs continued international encouragement and that WOCE will be an important platform to maintain a lively oceanographic community.

K.P. Koltermann
WOCE IPO
IOS Deacon Laboratory
Wormley, UK

1990-91 Calendar

Subject:	Intergovernmental WOCE Panel, IWP-1
Date/Place:	22-25 October, Paris, France
Contact:	IOC.SECRETARIAT or WOCE.IPO

Subject:	World Climate Conference
Date/Place:	29 October - 7 November, Geneva, Switzerland
Contact:	INTL.TOGA (H.L. Ferguson)

Subject:	Core Project 2: Choke Point Workshop
Date/Place:	6-7 November, Galveston, TX, USA
Contact:	WOCE.IPO

Subject:	Core Project 2 Working Group, CP2-4
Date/Place:	February 1991, TBD
Contact:	WOCE.IPO or A.GORDON

Subject:	Core Project 3 Working Group, CP3-4
Date/Place:	February 1991, Bermuda
Contact:	IOS.WORMLEY (W.J. Gould)

Subject:	WOCE Hydrographic Programme, WHP-8
Date/Place:	17-19 April 1991, Hamburg, FRG
Contact:	WOCE.IPO or IFM.HAMBURG

Subject:	Core Project 1 Working Group, CP1-4
Date/Place:	April 1991, La Jolla, CA, USA
Contact:	WOCE.IPO

Subject:	16th WOCE SSG Meeting, WOCE-16
Date/Place:	7-9 May 1991, Halifax, Canada
Contact:	WOCE.IPO

Subject:	Data Management Committee Meeting, DMC-4
Date/Place:	Autumn 1991, Japan
Contact:	WOCE.IPO

Recent WOCE Publications

WOCE Workshop, Moscow, 15-17 January 1990.
WOCE Report No. 44/90, 41pp. WOCE IPO, April 1990.

US WOCE Implementation Plan 1990, US WOCE Implementation Report No. 2, 100pp., US WOCE Office, Texas A&M University, College Station, TX 77843, USA, July 1990

Dickson, R.R., 1990: Flow Statistics from Long-term Current-Meter Moorings in January 1989, WCRP-30, WMO/TD-337, WOCE Report No. 46/90

WOCE VOS/DMC Upper Ocean Thermal Data Assembly Centre Meeting, Florida State University, 15-16 February 1990. WOCE Report No. 45/90, 28pp. WOCE IPO, May 1990.

Towards a Deep Basin Experiment (Core Project 3), Woods Hole, MA, 27-28 September 1989. WOCE Report No. 55/90, 36pp. WOCE IPO, May 1990.

Report of the Third Meeting of the WOCE Core Project 1 Working Group, CP1-3, Hobart, Tasmania, 9-11 April 1990. WOCE Report No. 53/90, 18pp. WOCE IPO, June 1990.

Report of the Third Meeting of the WOCE Core Project 2 Working Group, CP2-3, Wormley, UK, 13-16 March 1990. WOCE Report No. 54/90, 18pp. WOCE IPO, June 1990

Surface Velocity Programme, Report of the Second Meeting (SVP-2) with focus on the Atlantic Sector, Toulouse, France, 9-11 October 1989. WOCE Report No. 50/90, 50pp. WOCE IPO, July 1990.

The WOCE Handbook. WOCE Report No. 51/90, 34pp, WOCE IPO, August 1990.

WOCE Hydrographic Programme, Report of the Sixth Meeting, WHP-6, Scripps Institution of Oceanography, 31 January - 2 February 1990. WOCE Report No. 49/90, 12pp, WOCE IPO, August 1990.