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Global Temperature-Salinity Profile Programme (GTSPP) - Overview and Future

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Past Chairman IOC/IODE Committee,
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1. INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

The Global Temperature-Salinity Profile Programme (GTSPP) is a joint programme of the IOC Committee on International Oceanographic Data and Information Exchange (IODE) and the Joint IOC-WMO Committee on the Integrated Global Ocean Services System (IGOSS). IODE and IGOSS are technical committees of the Intergovernmental Oceanographic Commission (IOC) and the World Meteorological Organization (WMO).

Development of the GTSPP (then called the Global Temperature-Salinity Pilot Project) began in 1989. The short-term goal of the GTSPP was to respond to the needs of the Tropical Ocean and Global Atmosphere (TOGA) Experiment and the World Ocean Circulation Experiment (WOCE) for temperature and salinity data. The longer term goal was to develop and implement an end-to-end data management system for temperature and salinity data, which could serve as a model for future oceanographic data management systems.

GTSPP went into operation in November 1990. The first version of the GTSPP Project Plan was published the same year. Since that time there have been many developments and some changes in direction, including a decision by IGOSS and IODE to end the pilot phase and implement GTSPP as a permanent programme. Member States of IOC and WMO decided it was time to publish an updated version of the programme plan.

In addition to presenting information on the further development of the GTSPP, this document highlights the more important improvements to international data management practice. This new plan serves both as a guide to future development of the GTSPP and a concise source of information on progress to date.

1.2 RATIONALE FOR THE PROGRAMME

The GTSPP was developed as a response to changing needs in the ocean science and marine operational communities. Scientists conducting research into oceanic and atmospheric processes are addressing global issues and need multi-disciplinary datasets for their experiments. The operational community needs more data in operational time-frames to conduct safe operations at sea. Both the scientific and operational communities are applying the knowledge of ocean processes gained in 4 decades of research. Data are being assimilated into models making predictions addressing sustainable development, climate change, and human and environmental safety.

As a result of these needs, data collection programmes are more complex and produce significantly larger volumes of data. The quality control problem is more difficult because of the increased volume and complexity of the data. Improved means of using high-speed data communications and the World Wide Web in international data management are being developed. Data and improved data and information products need to be available more quickly than in the past.

In short, a new paradigm for international oceanographic data management is required. GTSPP has and will continue to address the development of that paradigm.

1.3 OVERVIEW OF THIS DOCUMENT

This document is directed to the scientific research community and users of operational ocean data. It is also intended to provide an example and be a source of information to programmes such as the Global Ocean Observing System (GOOS) for developing and implementing end-to-end data management systems. The document is also directed towards Member States of IOC. It discusses how Member States can make contributions and how they can benefit from the GTSPP.

Section 1 gives the purpose of this document and describes the rationale for the GTSPP. It also includes this overview of the contents of the document.

Section 2 below presents the objectives of the GTSPP as a permanent programme of IGOSS and IODE. Many of the original objectives of the pilot project have to a great extent been achieved. The objectives given here are revised objectives established for the permanent programme. They are based on the original objectives, what has been accomplished, and the new priorities for GTSPP.

Section 3 describes the benefits that Member States can expect from participation in the GTSPP. The section also contains a number of examples of the benefits that have already been realized by a number of Member States.

Section 4 describes how Member States can participate actively in the further implementation of the GTSPP. Participation in the GTSPP can lead to increased availability of temperature and salinity data for national needs. It can also provide access to improved data management technology for Member States for capacity building.

Section 5 presents information on the present and potential future areas of co-operation of GTSPP with other IOC and WMO programmes. GTSPP has developed an example of a successful end-to-end data management system which can be applied to temperature and salinity data and to other variables that are or will be collected by these other programmes.

Section 6 discusses the very important subject of scientific co-operation and guidance to the data management activities of the GTSPP, why such co-operation is needed, and how it might develop in the future.

Section 7 provides an overview of the Programme Plan and details the more important initiatives that GTSPP is undertaking to improve the existing elements of the programme and to address the elements of the programme that have not yet been implemented. This section is a concise presentation of the plan for the way forward.

Section 8 describes how the programme is managed and identifies the parent bodies.

Annex I contains the Terms of Reference for the Steering Group on IGOSS-IODE End-to-End Data Management Systems.

Annex II contains information on contacting the IOC and GTSPP participants for further information or for data and information products. World Wide Web and e-mail addresses are included.

Annex III contains the List of Acronyms.

Annex IV is a history of the GTSPP. It contains information on the meetings that lead to the development of the GTSPP and its adoption as an IGOSS-IODE Programme. It should be noted that the reports of all these meetings are contained on the first and second editions of the GTSPP

CD-ROM, which is available from the IOC Secretariat and on the IOC HomePage (***http://ioc.unesco.org***).

Annex V describes the more important improvements to international data management and exchange that have been achieved within the GTSPP. Several new concepts were incorporated into the first GTSPP Project Plan. While seemingly straight forward, their routine implementation in an organized and efficient manner in a high volume, time sensitive international data flow had not yet been achieved.

Annex VI lists the objectives of the GTSPP when it was a pilot project. These objectives are reviewed and updated at meetings of the Steering Group.

Annex VII presents details of the elements of the GTSPP. These elements include such items as near real- time data acquisition, communications infrastructure, and delayed mode data acquisition. The annex describes the elements, how they have been implemented, responsibility for operations, etc.

2. OBJECTIVES OF THE GTSPP

When the pilot project for the GTSPP was established there were 6 objectives which appear in Annex F. The following objectives represent the way forward for the permanent programme and reflect the impact of the achievements of the pilot project; the latest activities of IOC and WMO including implementation of the GOOS, GCOS, and WCRP; the completion of WOCE data collection activities; and the development of CLIVAR.

(i) To continue to provide a timely and complete data and information base of ocean temperature and salinity data of known and documented quality in support of global and local research programmes, national and international operational oceanography, and of other national requirements.

(ii) To continue to improve data capture, data analysis, and exchange systems for temperature and salinity data by encouraging more participation by Member States in GTSPP, by locating new sources of data from existing and new instruments and implementing the systems to capture and deliver the data, by taking full advantage of new computer and communications technologies, and by developing new services and products to enhance the usefulness of GTSPP to international clients and Member States.

(iii) To continue to develop and implement data flow monitoring systems to improve the capture and timeliness of GTSPP real-time and delayed mode data, and to distribute information on the timeliness and completeness of GTSPP databases so that bottlenecks in the data flow can be identified and addressed.

(iv) To improve the state of databases of oceanographic temperature and salinity data by developing and applying improved quality control systems, by implementing new data centre tests for QC as appropriate for new instrumentation; by working with the scientific partners of GTSPP to train data centre staff and transfer scientific QC methods to the centre, and by feeding information on recurring

errors to data collectors and submitters so that problems can be corrected at the source.

(v) To facilitate the development and provision of a wide variety of useful data analyses, data and information products, and datasets to the GTSPP community of research, engineering, and operational clients.

The pilot project had another objective to improve the completeness of the historical databases by digitizing historical data existing only in analog or manuscript form and by including digital data not presently at a World Data Centre (WDC). However, this responsibility has since been taken on by the IODE Global Data Archaeology and Rescue Project (GODAR).

3. BENEFITS OF GTSPP FOR MEMBER STATES

GTSPP has an obvious international objective, but it is also intended that Member States benefit at the national and regional level. In particular, Member States benefit from GTSPP because:

$ Member States can receive the most complete and timely dataset available to produce the most reliable and accurate operational products for human safety and environmental protection. GTSPP is always seeking to add data flows from new instruments (e.g., P-ALACE floats) and new data sources to the GTSPP data flows.

$ Member States benefit from global standardization of quality control procedures. The results of the various tests are carried with the data. There is also standardization of data formats and processing methodologies to simplify data exchange nationally and internationally. The GTSPP will continue to develop improved QC and standardization practices in co-operation with its supporting science centres.

$ Member States are able to receive regional and global data flow information and inventories enabling them to obtain the data of interest from the international data exchange organizations. GTSPP will continue to improve and expand these sources of information on the availability of data.

$ New state of the art methods and technologies in communications, artificial intelligence, quality control, and data management are under constant development and are available for transfer to Member States.

The following are some examples of benefits of participation in the GTSPP by some IOC and WMO Member States:

$ GTSPP data management and quality control systems for temperature and salinity data have been written in the national data centre and have been distributed and implemented in oceanographic laboratories in the Member State. This has saved development costs by sharing the workload of the software development and results in fully processed data of a much higher quality arriving at the national data centre much sooner than in the past.

- Data flow monitoring reports that are prepared by comparing the GTS data flows in Europe, Asia and North America have enabled many Member States to improve their understanding of what temperature and salinity data are available from the GTS and to take the necessary steps to ensure they are acquiring the most complete dataset available.

- Because of the improved availability of ocean temperature and salinity data in operational time-frames, oceanographic labs in some Member States have decided to begin regular preparation and distribution of temperature and salinity distribution maps for use by fishermen and by aquaculture interests. Because of the interest in the products, these labs have in some cases actively sought out other sources of temperature and salinity data. They then convinced these other sources to submit their data to GTSPP in operational time-frames so it would be available for their products. In the process they have increased the coverage of the GTSPP dataset for all users.

- Feedback of information on problems with the data to the operators of some ships of opportunity have enabled these operators to correct the problems. The number of problems in the monthly reports has decreased noticeably since this reporting was initiated. This results in an improved dataset for all users.

- There has been a significant improvement in the quality control carried out on their data by data centres participating in GTSPP. Before GTSPP procedures were implemented datasets had many errors in position, date-time, and variable fields. The datasets also had a large number of duplicate observations as datasets from various sources were combined. This required users to develop and maintain their own systems for quality control and duplicates removal. Many users now use the datasets directly, saving the workload of maintaining QC and duplicates removal systems and the workload of operating them.

It is expected that as GTSPP moves forward and Member State participation increases, more and varied benefits of this nature will be realized.

4. MEMBER STATE PARTICIPATION IN THE GTSPP

As of 1998, there are 14 organizations in 8 Member States of IOC and WMO participating actively in the GTSPP. Active participation means that the Member State or organization is doing something for GTSPP on a regular basis.

It is the goal of GTSPP to increase this participation. The types of contributions that are being made now are described below. Ideas on new contributions are also included. Member States that do not yet do so are encouraged to examine their data related activities and where appropriate to actively support the GTSPP.

The existing contributions are varied. Some organizations are supplying data. Others are assembling the data and applying quality control. Others are providing information for monitoring the data flow on the GTS. Some are acquiring data from national sources that do not normally contribute to the international systems and providing the data to GTSPP centres. Scientific

organizations are providing scientifically based quality control to datasets for their region of expertise. Other organizations are providing computer software for use in GTSPP data centres. There is a wide range of activities involved in establishing and operating this programme. There are many ways to participate in the GTSPP.

The best progress will be realized in the future if contributions come from more Member States so that a heavy workload is not imposed on a small number of active participants. If the workload is spread:

- the work tasks can be completed in a timely manner,
- a large number of agencies gain a sense of involvement by actively contributing to GTSPP, and
- the workload of individual agencies is reduced to a level where it can be undertaken without compromising national activities.

As indicated above, there are many areas where Member States can make valuable contributions. Within their own marine science communities Member States can:

- encourage an increase in the number of temperature and salinity observations transmitted in near real-time,
- undertake quality control checks according to the GTSPP Quality Control Manual on data collected by national programmes and attach GTSPP meta data and flags,
- improve mechanisms allowing the more timely submission of both near real-time and delayed mode data,
- encourage national research agencies to develop data and information products as part of the scientific quality assurance process and as a service to national and international users,
- actively acquire historical temperature and salinity data that has not previously been exchanged,
- provide advice and assistance to the programme in the areas of data management, quality control, communications, and product development, and
- provide software that can be used by centres managing the GTSPP data and can be distributed to centres in Member States.

For example, one area that needs improvement is the submission of near real-time salinity observations, surface and sub-surface. Globally there are very little salinity data transmitted over the GTS. Member States should make every effort to encourage their research vessels to submit TESAC messages from CTD casts or TRACKOB messages from thermosalinographs.

All Member States automatically play a part in GTSPP through their normal IGOSS/IODE activities. To participate more actively in the GTSPP, Member States can write to the IOC

Secretariat, the WMO Secretariat, or to the Chairman of the GTSPP Steering Group outlining the areas in which they wish to contribute.

5. GTSPP INTERFACE WITH EXISTING PROGRAMMES

When the Global Temperature-Salinity Pilot Project began, the first elements of the World Climate Research Programme (WCRP) and the Tropical Ocean and Global Atmosphere (TOGA) Experiment were being implemented. The World Ocean Circulation Experiment (WOCE) was being developed.

In fact, GTSPP was developed to respond to the needs of TOGA and WOCE and had a very successful working relationship with those programmes. Since that time, TOGA has been completed and WOCE has moved from the data collection phase of the programme to synthesis and analysis activities. Two new programmes have been established and GTSPP is turning its attention to serving those programmes, as well as continuing to work with WOCE. The new programmes are the Global Ocean Observing System (GOOS) and CLIVAR (the Climate Variability Programme).The GTSPP principle continues to be to work in co-operation with existing programmes that either require or collect and manage temperature and salinity data. Both GOOS and CLIVAR will require the use of T&S data and be involved in specifying requirements for its collection. GTSPP will work with its parent committees of IGOSS and IODE to implement mutually beneficial programmes with GOOS and CLIVAR.

The following sections outline the areas of potential additional services to WOCE and potential services to GOOS and CLIVAR.

5.1 WORLD OCEAN CIRCULATION EXPERIMENT (WOCE)

The WOCE programme consists of a number of experiments. One of the experiments is the Upper Ocean Thermal Programme (UOT). The main data requirements of the UOT are for heat and salt distributions of the upper ocean. The development of accurate distributions of these variables requires the most complete and accurate temperature and salinity databases. GTSPP has helped with the management of these data during the data collection phase of the WOCE programme through participation in the WOCE UOT Data Assembly Centre (DAC).

The new requirement for GTSPP support to WOCE is to address the compilation of the databases in a form that will be useful in the synthesis and analysis phase of the Experiment. GTSPP will also seek additional temperature and salinity profile data collected during the WOCE period by other national and international programmes. GTSPP will provide copies of the databases as they exist at any given time to those conducting the synthesis and analysis phase of the Experiment.

Another important focus of the new GTSPP programme is in working with the WOCE Data Products Committee (DPC) to build the UOT part of the WOCE Data Resource. The WOCE Data Resource is an active distributed archive of the WOCE data which will continue to make the data available to users after the completion of WOCE. In many cases the Data Resource will continue to grow where observation systems are put in place to continue important WOCE measurements.

Another area of WOCE-GTSPP co-operation is related to the WOCE Subsurface Data Centre that has been established in Brest, France. This centre operates a database with sub-surface temperature and salinity data for a specific area of ocean and time frame of interest to WOCE. There is a regular exchange of data between the Brest Centre and the GTSPP Centre in the US NODC in Washington DC. This exchange ensures that each centre has copies of all available data relevant to its mandate. GTSPP will continue to work with the Brest Centre to ensure that both Centres are working with the complete database.

5.2 CLIVAR

CLIVAR is a 15-year Climate Variability (CLIVAR) programme to study climate variability and predictability. It is the primary WCRP programme for the study of the role of the ocean in the coupled climate system. It can be regarded as a programme that builds on the knowledge gained through TOGA, WOCE, and the 1995 study of anthropogenic effects on climate change that was carried out by the Intergovernmental Panel on Climate Change.

CLIVAR anticipates that the IOC and WMO and their subsidiary bodies will work together to codify and monitor the standards for making, processing and archiving meteorological observations for operational needs in the terrestrial, marine, and cryospheric environments. This will lead to the maintenance and continued growth of a reliable global climate record. CLIVAR also anticipates that IOC and WMO will institute and maintain an international infrastructure for encouraging, assisting and co-ordinating individual nations contributing to the deployment and maintenance of operational observing systems.

To serve CLIVAR's needs, these data must be provided in a timely fashion. It is also important to ensure that as much data as possible that are collected by observing systems deployed for research purposes are inserted expeditiously into the operational data processing and archiving streams.

GTSPP was designed with requirements for programmes such as CLIVAR in mind. GTSPP has been organized to provide data in the most timely manner possible and with early as possible examination and documentation of the data quality. GTSPP also has made significant progress in acquiring data collected by the oceanographic research organizations to make it available to national and international clients. GTSPP therefore expects to provide continuing support to climate research and prediction by supporting CLIVAR as it has supported TOGA and WOCE.

5.3 GOOS

The Global Ocean Observing System is responsible for the development of future ocean observing systems that will address issues including climate change and prediction, health of the oceans, marine living resources, the coastal zone and ocean services. The intention is that the data collection and management aspects of GOOS be built on the existing systems of IGOSS, IODE, GLOSS, DPCP, and others. Thus, GOOS is a future client for GTSPP services.

As with CLIVAR, GTSPP was developed to meet the perceived needs of GOOS. The GTSPP model is regarded as a prototype for the data management systems that will be needed for many aspects of GOOS. In particular, GTSPP has and will continue to put significant effort into the development of real-time quality control systems, data flow monitoring and the development of the continuously managed database concept. These developments have placed GTSPP in an

excellent position to contribute significantly to the implementation of the data management aspects of GOOS.

One of the important initiatives of the new GTSPP programme is focussed on the provision and distribution of useful data products and information to the client community. The initial approach to this aspect of the programme is to develop a distributed set of World Wide Web sites among the UOT DAC sites with data products and information for clients.

6. SCIENCE SUPPORT

Continued scientific acceptance and involvement continues to be crucial to the continued success of GTSPP. It has been demonstrated again and again within national and international programmes that close co-operation between the scientists and data managers is required for success and increases efficiency significantly to the benefit of the scientific and data management programmes. GTSPP must continue to actively seek co-operative arrangements with the scientific community. This will occur through a number of mechanisms including:

$ giving demonstrations and presentations at relevant meetings, developing World Wide Web pages,

$ inviting representatives of major field and scientific programmes to participate in GTSPP meetings,

$ seeking participation in formal and informal meetings that discuss any aspects of the programmes,

$ sending GTSPP representatives to meetings of major scientific programmes to give advice on data management planning and actively promote GTSPP, and

$ requesting members of IOC Missions to promote GTSPP during visits to Member States.

The recommendation of the Fourth Session of the Steering Group on the GTSPP was to transfer scientific QC techniques to the data centres where possible. This decision was based on the practical realities of funding of such work in scientific laboratories. It does not lessen the need for scientific support to the QC process and to GTSPP in general. This support will still be needed to ensure a high quality database through continued scientific analysis and evaluation of the GTSPP datasets. It is essential that GTSPP continue to function as a combination of data management and scientific endeavour. This is the only way the programme will result in a timely and complete database of temperature and salinity data of known and agreed standards of quality.

7. PROGRAMME PRIORITIES AND PLANS

The priorities for the pilot project were as follows.

- establishing real-time data flow monitoring procedures,
- implementing procedures to improve the capture of data,
- completing the development of a "scientifically" accepted quality control manual,

- design and implementation of the Continuously Managed Database system,
- implementing necessary high speed communications links between centres, and
- "recruiting" and co-ordinating the appropriate agencies to undertake the scientific quality assessment (including data analysis and product development) to provide global coverage temperature and salinity data.

Priority was initially placed on the implementation of the real-time data flow elements of the pilot project because of the needs of TOGA and the WOCE UOT Programme. As decided at the Fourth Session of the GTSPP Steering Group, priorities for further development of GTSPP will now shift to delayed mode data acquisition, data from new sources and data and information products. Another important new initiative is the development of activities supporting the synthesis and analysis phases of WOCE, the development and implementation of GOOS, and the development and implementation of CLIVAR.

GTSPP priorities and plans can be described in terms of improvements to the existing elements and major new initiatives focussing on the lesser developed aspects of the programme.

7.1 IMPROVEMENTS TO EXISTING ELEMENTS

$ Transfer of scientific QC to the data centres

As discussed earlier in this plan an active programme for transferring the scientific quality control procedures developed in the WOCE UOT science centres is being implemented. The transfer includes the training of data centre staff through exchange visits and in some cases transfer of quality control software.

$ Continued comparison of the contents of the BREST and US NODC databases.

Comparisons of these two databases will continue on a regular basis to ensure the client communities of each centre will have the most complete database available for their use.

$ Resolution of differences in interpretation of data and meta data standards.

Over past few years various meta data codes have been assigned by the GTSPP and WOCE UOT centres. Because the system is operational, there is not always time to debate the assignments with other GTSPP centres. Some differences in usage have resulted. Present usage will be agreed and documented, changed where necessary, and a process for assignment of codes and usage of fields will be implemented.

$ Continued support of GTSPP (NODC and MEDS) to the SOOPIP.

MEDS will continue to operate the GTSPP Real-Time Assembly and QC Centre and the US NODC the Continuously Managed Database as a contribution to the permanent programme. This includes providing support as necessary to the Ship-of-Opportunity Implementation Panel (SOOPIP) in their efforts to maintain the real-time sampling networks of the WOCE UOT Programme.

$ Co-operation with WMO GTS monitoring.

GTSPP will continue to work with the World Weather Watch in the annual monitoring of the GTS data flows to ensure a high level of performance in circulating ocean data in real-time.

7.2 NEW INITIATIVES

$ Capture of new data sources including new instrumentation for both the real-time and delayed mode data streams.

The profiling ALACE float is an instrument that has come into broader use in the 1990s. This instrument descends to a preprogrammed depth, drifts with the currents for a given time, and surfaces to transmit position and sensor data via satellite. While descending and ascending, temperature and salinity profile data are observed. GTSPP is seeking access to these data in both real-time and delayed mode. GTSPP is also actively pursuing the acquisition of other types of data such as that from towed undulating instruments for inclusion in the databases.

$ Delayed mode data acquisition and monitoring of the data flows.

There are two initiatives in the GTSPP plan in relation to delayed mode data. The first is to further develop the delayed mode aspects of the system including data flow monitoring in order to improve the completeness and timeliness of the database. The second is to complete processing of the delayed mode WOCE data according to the schedule proposed by the GTSPP-IV meeting. This second initiative is to ensure that all available temperature and salinity data are acquired for use in the synthesis, analysis, and modelling phase of WOCE.

$ Development of data product and information aspects of the GTSPP.

GTSPP at present produces a number of data and information products. Included are maps and inventories of temperature and salinity data acquired in real-time and in the CMD. Data flow analyses from GTS centres in North America, Europe and Asia are produced on a monthly basis. Analyses of errors occurring in data are produced monthly and fed back to operators for use in dealing with recurring problems. Maps of surface and sub-surface temperatures from the databases are produced by the Science Centres. Several datasets for various areas of ocean are produced on a regular basis and forwarded to clients with operational needs on a several times per week or monthly basis.

Enhancements to these services are constantly under development. The Science Centres are developing additional products that prove useful in serving their national and international clients and making them available through their WWW sites. This method of development is considered the most effective as it ensures that the development efforts are directed to products that are needed.

GTSPP can provide where needed other custom datasets on a regular basis for clients with operational needs. The Programme is also developing improved services through its network of national and international WWW sites.

$ Development of services for WOCE, GOOS and CLIVAR.

Section 5 of this document describes in detail the relationship of GTSPP to WOCE, GOOS and CLIVAR. To summarize, GTSPP will continue to provide services to WOCE through the final phases of the experiment. Specifically,

GTSPP will support the analysis phase of the experiment by making available at any time the most complete and timely datasets available; and will assist as possible in the development of the WOCE Data Resource by providing assistance to the WOCE DPC in the development of the Resource, and by operating the appropriate distributed databases in the resulting operational system.

For the development of GOOS and CLIVAR, GTSPP will provide assistance as appropriate in the development and implementation of new data flows from existing and new sources of temperature and salinity data; and the preparation of new data manipulation tools, data products and analyses for processing and analysis centres established by these programmes.

8. PROGRAMME MANAGEMENT

8.1 PARENT BODIES

The parent bodies for GTSPP are the Intergovernmental Oceanographic Commission and the World Meteorological Organization (Figure 1). At the Seventh Session of the Joint IOC-WMO Committee on IGOSS, it was recommended that GTSPP become a permanent programme of IGOSS and IODE. The Fifteenth Session of the Committee on IODE and the IOC and WMO Governing Bodies approved this recommendation. The GTSPP is now a permanent programme rather than a pilot project.

The permanent programme has been renamed the Global Temperature-Salinity Profile Programme which retains the acronym GTSPP.

8.2 STEERING GROUP

The Terms of Reference of the Steering Group on the GTSPP were established at the Thirteenth Session of the Committee on International Oceanographic Data and Information Exchange (New York USA, 17-24 January 1990).

That Steering Group was responsible for the continuing development and implementation of the Programme. The Group directed the development of the Programme and promoted participation. The Group included members from the scientific community for scientific guidance to participants.

At the Fourth Session the future of the Steering Group was discussed. The conclusion was that GTSPP was sufficiently developed that it no longer needed the full attention of a steering group. The meeting noted that IGOSS and IODE had approved the development of end-to-end data management systems for the various data types common to the two bodies. It was noted that the GTSPP was in fact the first example of an IGOSS-IODE end-to-end data management system. The meeting therefore proposed that the Steering Group for the GTSPP be modified to become a Steering Group for IGOSS and IODE end-to-end data management systems with new Terms of Reference.

This new role for the Steering Committee has been agreed by the IOC and WMO Secretariats, the Chairman of IGOSS, and Officers of the IOC Committee on IODE at the Meeting

in Goa, India, 10-13 February 1998. The new Terms of Reference for the Steering Group are included here as Annex I.

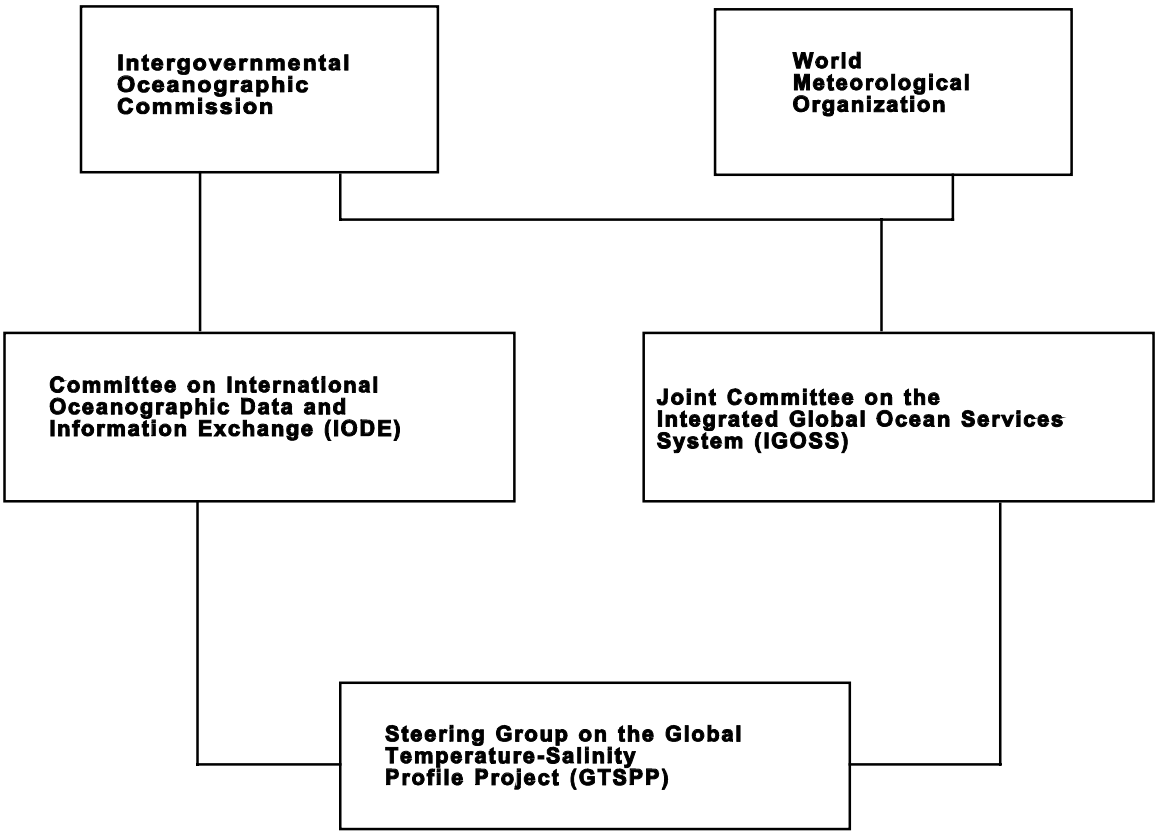

Figure 1. Management of the GTSPP

ANNEX I

TERMS OF REFERENCE FOR THE STEERING GROUP ON IGOSS/IODE END-TO-END DATA MANAGEMENT SYSTEMS

Operate a programme for the development of end-to-end data management systems for the collection and management of data sets to support IGOSS/IODE requirements including the Global Ocean Observing System.

1. In conjunction with user groups and data collectors, develop and specify QC, meta data standards, analysis procedures and data flows to provide the data required by the various international and regional users at the time-scales appropriate to their needs.

2. Design and implement data flow monitoring systems to ensure that the data are collected, processed and distributed according to agreed schedules and responsibilities.

3. Develop and ensure the production of data analysis and presentation products to provide the necessary datasets and graphic presentations to meet the needs of the variety of users including GOOS.

4. Design and implement electronic distribution standards and procedures to distribute the datasets and data products to users at time-scales consistent with their needs.

5. Recruit volunteer centres to undertake the work keeping in mind opportunities for sharing the workload and acquiring the required expertise to accomplish the tasks at hand.

6. Support where possible the relevant international project offices of the global science experiments including GOOS and CLIVAR in their data management endeavours.

7. Report to the IGOSS and IODE Committees.

ANNEX II

CONTACTING THE GTSPP

For more information on the GTSPP contact the following sources:

1. IOC Secretariat

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IOC HomePage: http://www.unesco.org/ioc/

II. WMO Secretariat

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**Note: The GTSPP has published a first CD-ROM, which contains extensive information about the GTSPP and the data available to the end of 1995. This CD-ROM is available from the IOC Secretariat. Information on the GTSPP is also available on the IOC HomePage.

The GTSPP CD-ROM was updated in a joint project with the WOCE Data Products Committee. It was issued in May 1998. It contains all the GTSPP and UOT meeting reports, quality control manuals prepared by both projects and documentation of the volume and formats of the data on the CD. The contents of the continuously managed database are included. Delayed mode data that have been received have replaced the real-time data for January 1990 to the end of 1997. There are more than 680,000 profiles of temperature or salinity data.

This CD-ROM should be referenced as WOCE Data Products Committee, 1998: WOCE Global Data: Upper Ocean Thermal Programme, Version 1.0, WOCE IPO Report N$^{o.}$ 158/98, Southampton, U.K.

ANNEX III

LIST OF ACRONYMS

CD-ROM	Compact Disk - Read Only Memory
CMD	Continuously Managed Database
CLIVAR	Climate Variability Programme
GODAR	Global Oceanographic Data Archaeology & Rescue Project
GTS	Global Telecommunications System
GTSPP	Global Temperature-Salinity Profile Programme
DAC	(WOCE) Data Assembly Centre
DMC	(WOCE) Data Management Committee
DPC	(WOCE) Data Products Committee
ICSU	International Council of Scientific Unions
IGOSS	Integrated Global Ocean Services System
IOC	Intergovernmental Oceanographic Commission
IODE	International Oceanographic Data & Information Exchange
JEDA	Joint Environmental Data Analysis (Centre)
MEDS	Marine Environmental Data Service
NODC	National Oceanographic Data Centre
QC	Quality Control
RNODC	Responsible National Oceanographic Data Centre
SOOPIP	Ship-of-Opportunity Implementation Panel
TOGA	Tropical Ocean & Global Atmosphere (Experiment)
UOT	(WOCE) Upper Ocean Thermal (Programme)
WCRP	World Climate Research Programme
WDC	World Data Centre
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment

ANNEX IV

HISTORY OF THE GTSPP

The original concept for the Global Temperature/Salinity Pilot Project (GTSPP) was raised at the **Second Joint IOC-WMO Meeting of Experts on IGOSS-IODE Data Flow** (Ottawa, Canada, 18-22 January 1988). The meeting developed a draft proposal for a project to develop a high quality, scientifically acceptable global ocean thermal dataset.

The meeting of **The Group of Experts on Responsible National Oceanographic Data Centres (RNODCs) and Climate Data Services** (Wormley, UK, February 1988), with participants from IODE, WOCE and TOGA, discussed the WCRP ocean data needs and the role of the IODE system in meeting those needs. A recommendation "*...that a pilot project (global thermal database) be implemented to prove the value of the concept...*" was supported by the meeting.

At the **Fifth Session of the Joint IOC-WMO Working Committee for IGOSS** (Paris, 14-23 November 1988), a plan proposing a pilot project on global temperature and salinity data management was presented to the Committee by Canada and the USA. Inclusion of salinity data was a result of consultations with potential users prior to the IGOSS meeting.

The First *Ad Hoc* Consultative Meeting on the GTSPP was held at the US National Oceanographic Data Centre in Washington, DC (23-25 January 1989). The Meeting developed goals and defined the Project's major elements. The Summary Report of this meeting, titled "Report of an *Ad Hoc* Consultative Meeting on the Global Temperature/Salinity Pilot Project (An IGOSS-IODE Programme)" is available on the GTSPP CD-ROMs, published in 1996 and 1998 and available from the IOC Secretariat as indicated in Annex II.

The Second *Ad Hoc* Consultative Meeting on the GTSPP was held at the Marine Environmental Data Service in Ottawa, Canada (25-28 July 1989) and further advanced the Project. This meeting worked out the data flows and co-ordinated the activities of WOCE and TOGA, and the GTSPP in managing temperature and salinity data. The Summary Report of this meeting, titled "Second *ad hoc* Consultative Meeting on the Global Temperature/Salinity Pilot Project (A Proposed IGOSS-IODE Project)" is also available on the GTSPP CD-ROMs.

A Workshop on the GTSPP was held prior to the Thirteenth Session of the Committee on IODE in New York (15-16 January 1990). Many aspects of the project were discussed and clarified. The formation, terms of reference, and composition of the Steering Group on the GTSPP was also defined. The recommendations of the Workshop were discussed at IODE-XIII and the results of the discussions can be found in the report of that meeting. With the approval of the IODE session, GTSPP became an official IODE/IGOSS pilot project.

The First Session of the Steering Group (Brest, France, 17-19 September 1990) reviewed and finalized for publication the GTSPP Project Plan, the QC Manual, and the Brochure. The format for the exchange of data between GTSPP Centres was established, and the Implementation Plan was updated. The operational algorithms for the Continuously Managed Database and for duplicates identification and management were reviewed and documented.

Procedures for the development of data flow monitoring for the GTS were established. A new potential product list was established.

Two centres volunteered and were accepted to become the main processing and data management centres for GTSPP data. The Marine Environmental Data Service (MEDS) in Canada manages the Real- Time QC and Assembly Centre. This centre gathers and merges all available global temperature and salinity data, effects GTSPP QC on the data, resolves duplicates, and provides datasets to users on a 3 times per week schedule. The centre also monitors data quality and alerts data collectors to recurring problems.

The US National Oceanographic Data Centre (NODC) operates the Continuously Managed Database (CMD) for the real-time and delayed mode data, carries out delayed mode QC and duplicates resolution, co-ordinates the scientific quality control activities, and handles distribution of the data to users, both national and international.

The Second Session of the Steering Group (Obninsk, Russia, 15-20 July 1991) reviewed progress on implementation of the pilot project. In particular the meeting reviewed the real-time data flows and formats, the results of quality control of the real-time data, and the development of the continuously managed database. Some small adjustments and changes of procedures were indicated but on the whole, progress was considered very favourable. Continuation of the monitoring of the real-time data flow on the GTS was judged as highly useful and was to be continued. Support to the WOCE Upper Ocean Thermal Data Assembly Centre (WOCE UOT DAC) was found to be adequate for the moment pending further discussion at WOCE meetings to be held in the fall in Washington. Plans for development of a GTSPP CD-ROM were initiated.

The Third Session of the Steering Group (Ottawa, Canada, 15-19 November 1993) discussed the potential for additional temperature and salinity profile data. Data from undulating instruments are sometimes treated as profiles and could be handled within GTSPP systems provided appropriate supporting meta data were included. Declassified data from the navies of various IOC countries were also noted as a source of data that is also coming available. As a further service to WOCE the meeting recommended that computerized monitoring of the sampling of the WOCE/TOGA lines be implemented. The US NODC volunteered to provide that service. MEDS agreed to continue feedback of information to operators on commonly occurring errors in data reports from ships and buoys.

The meeting also discussed the standardization of the scientific QC procedures and of the languages and libraries to make sharing of software between GTSPP participants easier. The meeting reviewed and updated the GTSPP action plan for the next intersessional period.

The Fifteenth Session of the Committee on IODE (Athens, Greece, 23-31 January 1996) concurred with the view of the Seventh Session of the Joint IOC-WMO Committee for IGOSS that the GTSPP should become a permanent IOC-WMO programme with the name Global Temperature-Salinity Profile Programme.

The Fourth Session of the Steering Group (Washington, DC, USA, 16-19 April 1996) dealt with co-operation with the GODAR Project, redefined the limits of the GTSPP responsibilities, and reviewed the roles of the science centres and the data centres in regard to quality control of the data. Decisions were made that GTSPP would deal only with profile data and that aspects of the GTSPP related to historical salinity data collected before 1990 would be left to the GODAR Project. In each case GTSPP had not yet developed the ability and systems to manage these other data. In each case another competent organization had offered to undertake the work as a contribution to international data management.

GTSPP IV also reviewed the manner in which the quality control tasks were distributed between the science centres and the data centres. Concerns were expressed that the science centres did not have sufficiently stable funding to guarantee that they could continue to apply their QC to the data into the indefinite future. It was therefore recommended that there should be a continuous process of transfer of scientific QC techniques and training to the data centres through exchange visits, training, etc. The science centres would still be involved at a lower level of effort providing guidance and advice.

The meeting also discussed sources of additional data from both new instrumentation and other data collectors. The delayed mode data flow was found to be behind schedule and goals were set to bring that element of the Programme back on schedule.

ANNEX V

IMPROVED METHODOLOGIES IMPLEMENTED BY THE GTSPP

1) Enhanced Scientific Input to the Data Management Activity

The United States National Oceanographic Data Centre (NODC), in an effort to promote and improve data management activities in the USA, established a co-operative venture with the Scripps Institute of Oceanography. This project was called the Joint Environmental Data Analysis (JEDA) Centre. It demonstrated the utility and feasibility of having a scientific node in data quality control. The benefits of JEDA were two fold. JEDA improved the quality and the usefulness of the data held nationally by NODC and distributed to other NODCs and RNODCs. Also, the activities of JEDA resulted in the production of a number of very useful products. GTSPP was designed to include these kinds of interactions and co-operation between the scientific community and the data centres.

In developing its strategies for data management, the World Ocean Circulation Experiment Data Management Committee (DMC) adopted a similar model in defining the Data Assembly Centre or DAC. A DAC consisted of one or more scientific organizations working co-operatively with one or more data centres to handle the data from a WOCE experiment. The scientific organizations contributed knowledge of oceanography and data collection procedures. The data centres contributed data processing, archiving, and distribution expertise. The result of applying these models to the development of the GTSPP is higher quality reliable data that is properly documented for present and future users.

This closer co-operation between the scientific community and the data centres has showed real benefits both for GTSPP and WOCE data management. As the techniques for scientific quality control of the data are proven and standardized, they are being incorporated into data centre operations. This enhances the capabilities of the data centre and allows the scientific centres to concentrate on the science, the development of further QC techniques, or the development of more useful products.

ii) The Continuously Managed Database

The concept of the continuously managed database has been a significant advance in making data available to the user community sooner and in a form that is more convenient for them. Prior to the CMD concept, users had to contact 3 or more sources to obtain the most complete dataset at any given time. The real-time data would have to be obtained from one or more IGOSS SOCs. The historical data would be from a WDC or from one or more NODCs and RNODCs. The delayed mode data, if available at all, would probably have to be obtained from one or more oceanographic laboratories. The data would be in several formats, and there would be duplicates of observations in several of the files obtained. Meta data would be scarce and varied and the use of flags and indicators would be different between the files from different sources.

The CMD was designed to avoid these problems. Data would be available in one format. Duplicates would be removed. The QC flags and the meta data indicators would all be the same. The database would include the latest data available; as delayed mode data would have replaced the lower resolution data collected from the GTS.

Thus the user could be a user immediately he received the data rather than first being a data manager. It would not be necessary to convert formats to a common one or carry out individual QC evaluations and duplicates removal. Significant efficiencies are achieved by having data organized once in a data centre, as to having a system whereby each user has to repeat a series of data management tasks before the data can be used.

The continuously managed database has been a very successful advance in data management within the GTSPP.

iii) Enhanced and Standardized Quality Control

In the development of the GTSPP there were several problems with the manner in which QC systems were implemented in data centres. The first problem was that most data centres had their own version and series of QC tests that could be applied. Checks against climatology were not applied routinely. Duplicates checking was rare. There were no meta data attached to data that had been through QC to detail what QC tests were applied and which ones failed. GTSPP attempted to address these and other problems.

The first step was to agree on the quality control tests that would be done. Draft lists of the tests were prepared and discussed at the Steering Group Meetings. Agreement was achieved and the GTSPP QC manual was published as a result. Variables were defined to hold the information on which tests were applied and which failed. The GTSPP format was developed to carry these variables with the data. Meta data and QC flags were standardized for real-time, delayed mode, and historical versions of the data. The meta data were designed to allow the user to differentiate between the various versions of the observation (e.g., between real-time and delayed mode versions). A table of information called the history group was developed to be carried with each observation (station of data). The history group identified where the data had been and what each organization had done to it.

The duplicate management algorithms were developed and tested using the real-time data flow. Similar versions of the algorithm for detection of duplicates and selection of the copy of the observation that would be retained were implemented in the real-time data centre in the MEDS and in the CMD input preparation in the US NODC.

These improvements to documenting the management of the temperature-salinity data have not only allowed the users of the data to understand what has been done to the data, but also have proven very useful to the data centres in finding and solving problems with the processing of the data.

iv) Improved Data Flow Monitoring

The Global Telecommunications System is used to circulate meteorological weather and ocean reports around the world to meteorological and oceanographic centres. Various types of bulletins have different requirements for distribution. Some are for local or national distribution. Others are for international or global distribution. There is a mix of technologies in the various countries. Consequently the GTS is complex and routing problems can occur.

Two of the goals of the GTSPP are to improve the performance of IOC and WMO data exchange systems and to circulate monitoring reports on data flow and data availability. To accomplish this goal for the GTS, a monitoring system has been put in place for the flow of oceanographic reports on the GTS, in particular BATHY and TESAC reports.

To accomplish this monitoring, Germany and Japan supply copies of the ocean data they receive from the GTS to the Real-Time QC and Assembly Centre (MEDS) in Canada. The reports from these European and Asian centres are then compared to those received in the USA and Canada. The complete dataset is assumed to be the combination of the data received in the 4 centres with the duplicates removed. Thus, a comparison of the reports received versus the reports not received in each of the 4 centres can be prepared. This report is published on the World Wide Web in about the middle of each month for the previous month. For the first time, users of real-time ocean data can be aware of which data are available and what they missed. This allows any IGOSS or IODE centre to contact the appropriate GTS centre to correct routing tables to ensure they get the most complete dataset possible in real-time.

The result of this monitoring indicated that various centres were receiving of the order of 65% to 95% of the data from month to month. Not only has this monitoring allowed the centres to improve their capture of real-time data, but it has ensured that the data centres capture 95% or more of the available data instead of losing up to 30% per month.

22) Feedback of Information on Data Problems to the Data Collectors

International ship-of-opportunity programmes have been operated on behalf of IGOSS and various international science programmes for many years. Until GTSPP, there was no complete and comprehensive examination of the quality of the data in a single centre. This made it difficult to identify common types of errors and compare various sources of the data to identify specific ships or buoys that were repeatedly making the same types of errors.

The Real-Time QC and Assembly Centre in MEDS has undertaken this task. Each month a statistical analysis is done for the ships and buoys reporting for that month. When the number of reports with errors for a ship or buoy exceeds 10% of its data for a month a message is sent to the operator with an explanation of the types of errors that are occurring. This provides the operator with the information necessary to address the problem.

After two of years of providing this feedback, it has been noticed that there has been a statistically significant decrease in the number of such errors.

ANNEX VI

OBJECTIVES OF THE PILOT PROJECT

The objectives at the beginning of the Pilot Project were as follows.

(i) To create a timely and complete data and information base of ocean temperature and salinity data of known quality in support of global research programmes and of national requirements.

(ii) To improve the performance of the Intergovernmental Oceanographic Commission (IOC)/ IODE and World Meteorological Organization (WMO)/IOC IGOSS data exchange systems by actively pursuing data sources; exercising the data inventory, data management, and data exchange mechanisms as they are intended to work; and recommending changes where necessary to meet national and international requirements.

(iii) To disseminate, through a widely distributed monitoring report produced on a regular basis, information on the performance of the IODE and IGOSS systems.

(iv) To improve the state of databases of oceanographic temperature and salinity data by developing and applying improved quality control systems to these databases.

(v) To improve the completeness of these historical databases by the digitization of historical data presently in analog or manuscript form and by including digital data not presently at a World Data Centre (WDC). **Note that this objective has been undertaken by the GODAR project of IODE. GTSPP is concerning itself with data collected in 1990 and later.

(vi) To distribute copies of portions of the database and selected analyses to interested users and researchers.

ANNEX VII

ELEMENTS OF THE GTSPP

Figure 2 is an attempt to present the rather complex data flows of national and international programmes within which GTSPP must find its place. The boxes in the Figure represent generic centres. A given international IGOSS or IODE centre may fit within several boxes in carrying out its national and international responsibilities. The following sections discuss this Figure in terms of 7 essential elements of the GTSPP.

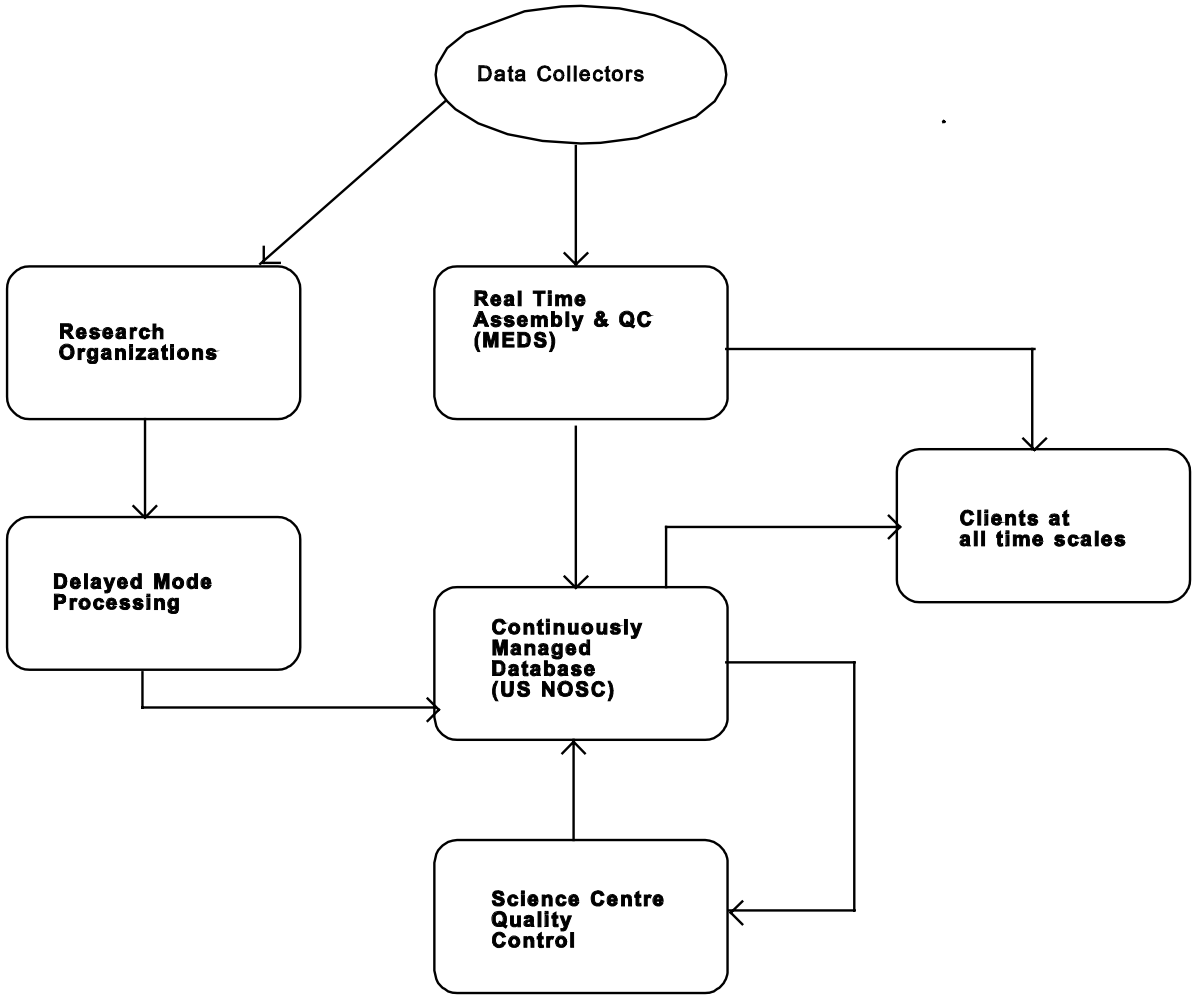

Figure 2 The GTSPP Data Flow

These 7 essential elements of the GTSPP are given below. All of these elements must function for the Programme to be fully operational.

The elements of GTSPP are:

(i) Near real-time and operational time frame data acquisition;
(ii) Delayed mode data acquisition;
(iii) Communications infrastructure;
(iv) Quality control procedures;
(v) Continuously managed database;
(vi) GTSPP data and information products;
(vii) Data flow monitoring.

(i) Near Real-Time and Operational Time Frame Data Acquisition

Near real-time data acquisition within GTSPP depends on the GTS of the World Weather Watch of WMO and the telecommunications arrangements for BATHY and TESAC data established by IGOSS. Copies of other real-time or operational time frame datasets are acquired from any other available sources via the Internet of other high-speed networks. The goal is to ensure that the most complete operational time frame dataset is captured.

Figure 3 is a graphic representation of the GTSPP operational time frame data flow. The "data collectors" in the top boxes follow one of two procedures. In the first case, the data are provided to GTS centres that place it on the GTS with minutes to a few hours of its collection. In the second case, the data are supplied to a national organization that forwards it to the real-time centre in MEDS within a few days to a month of its collection.

The real-time data that are circulated on the GTS are copied by both MEDS and the IGOSS SOCs, and by users of real-time data who have access to the GTS. These users would include meteorological and oceanographic centres that issue forecasts and warnings, centres that provide ship routing services, and centres that prepare real-time guidance products for the fishing industry. Some of the IGOSS SOCs provide copies of the data they received to MEDS for a monthly analysis of GTS data flows.

MEDS compiles the global dataset from the various sources, applies the documented GTSPP QC and duplicates removal procedures, and forwards the data to the US NODC 3 times per week. At NODC, the data are added to the continuously managed database, also 3 times per week. There are also several clients that receive copies of the data sent from MEDS 3 times per week. These are clients who do not need the data within hours but rather within a few days. By getting the data from the GTSPP Centre in MEDS they save having to operate computer systems to do quality control and duplicate removal.

At the beginning of the pilot project, the US NODC would accumulate a monthly set of near real-time data and merge it with any delayed mode data received for the relevant period. The monthly datasets were forwarded to the agency responsible for the scientific evaluation and quality control. After the first year, this process was discontinued for the real-time data. It was found that the QC procedures in the data centres had improved so that the scientific QC did not add much value to the dataset. It was decided that scientific QC would be reserved for a more final version of the dataset after the delayed mode data had replaced much of the real-time data.

Note that the regular route for real-time data to the box marked "Operational Clients" in Figures 2 and 3 is not affected by GTSPP. This route provides for uninterrupted flow of data for weather and operational forecasting through the national weather services of Member States. These centres need the data in hours rather than days.

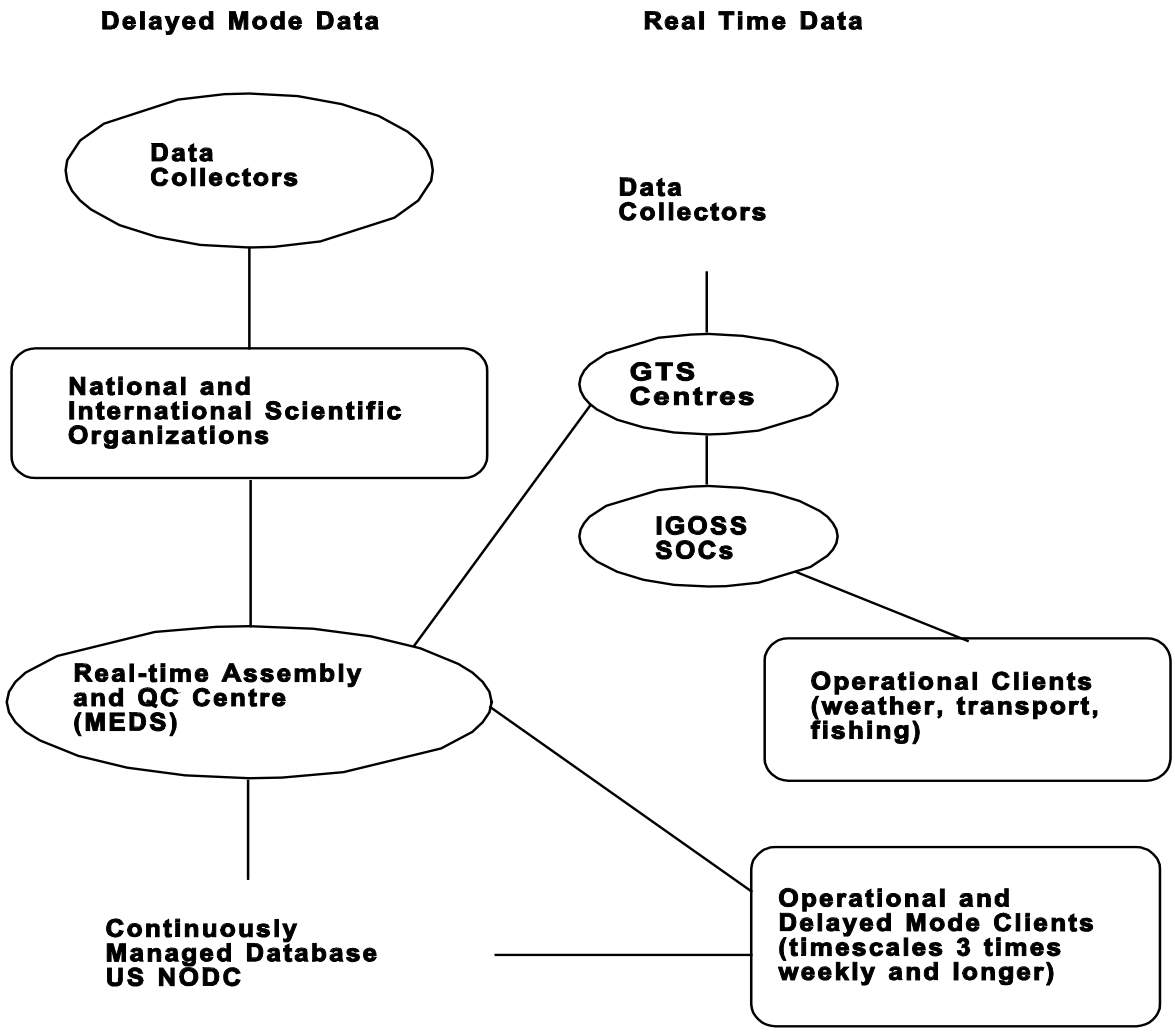

Figure 3 Real Time Data Flow

(ii) Delayed Mode Data Acquisition

GTSPP utilizes, to the extent possible, the existing IODE data network and processing system to acquire and process delayed mode data. Figure 4 shows the delayed mode data flow in graphic form. The data flow into the continuously managed database in the US NODC is through a "Delayed Mode QC" process. This process is analogous to the QC carried out on the real-time data and is to conform to the specifications of the GTSPP QC Manual. In some cases, where appropriate arrangements can be made, this box and the QC it implies could actually exist and be performed in another national oceanographic data centre on behalf of NODC.

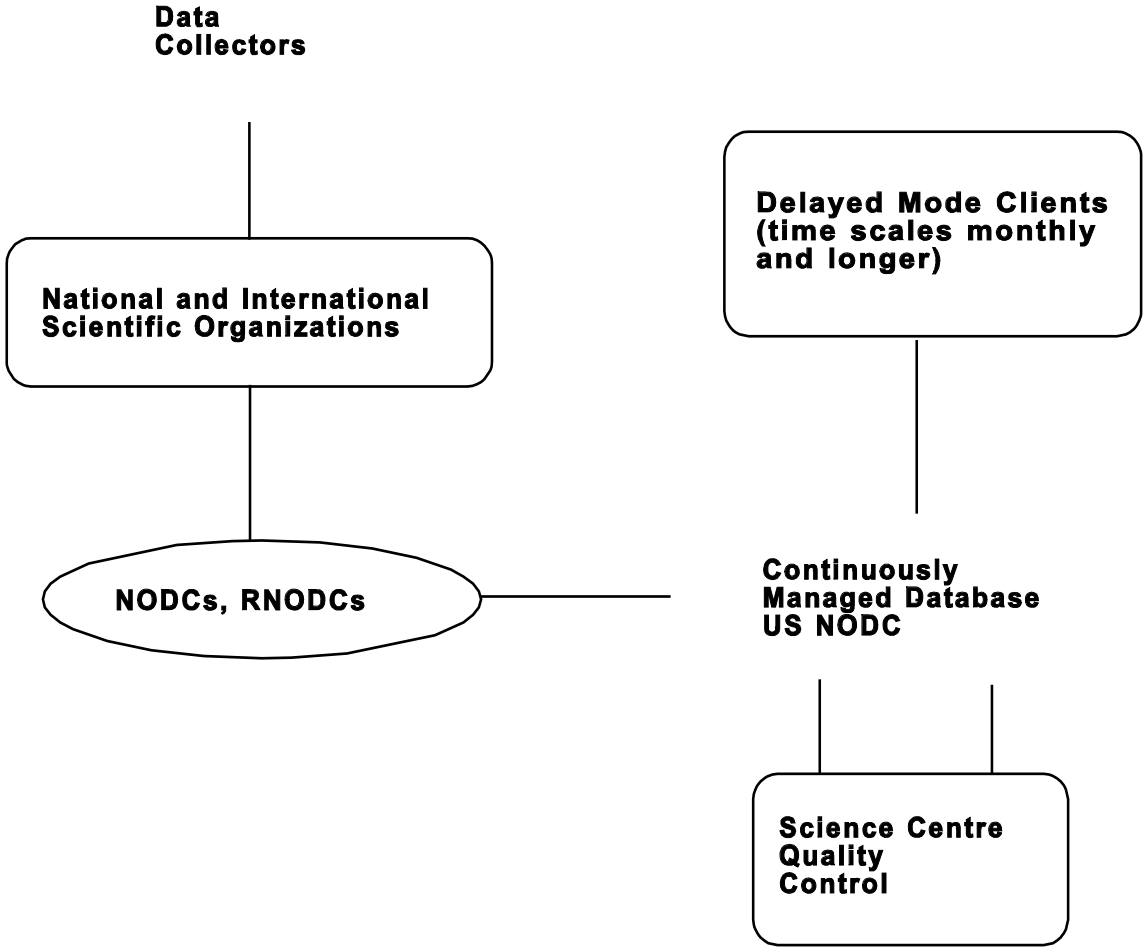

Figure 4 The Delayed Mode Data Flow

Having proceeded through the delayed mode QC process, the data then follow the same route as the real-time data through the rest of the CMD process; however, on a different time schedule because of the more irregular times of arrival. During the merging of the data into the CMD, any duplicates occurring between near real-time and delayed mode data sources will be identified with the highest resolution duplicate being retained as the active CMD copy.

Acquisition of delayed mode data from the Principal Investigators is a priority for the GTSPP. It is necessary for GTSPP participants to work diligently in a pro-active manner with

both the Principle Investigators and the data managers of the global programmes that collect the temperature and salinity data. The goal is to get the delayed mode data into the CMD within one year or less of its collection. An excellent way for any national oceanographic data centre to support GTSPP actively is to obtain national datasets of temperature and salinity data, apply GTSPP QC procedures, and submit them to the US NODC for inclusion in the CMD.

Delayed mode data are usually exchanged on magnetic media or CD-ROMs. However, in many instances where high-speed networks are available, data are now being telecommunicated.

Member States without the ability to exchange data in GF3 are encouraged to submit data in any form they can. GTSPP will attempt to provide assistance to overcome any data exchange difficulties.

(iii) Communications Infrastructure

The ability to acquire data and to ensure that it is provided to the GTSPP Continuously Managed Database in a timely manner is dependent on the communications infrastructure. Operation of GTSPP involves a range of communication mechanisms, which include:

(i) satellite re-transmission from buoys and ships-to-shore (international),
(ii) HF radio ship-to-shore,
(iii) high speed networks (primarily Internet),
(iv) magnetic or optical media,
(v) the GTS.

Over a period of time, the objective is to move to faster and more automated means of communications for data acquisition and dissemination, and for the dissemination of data products and information.

Internet and the World Wide Web have become very important in the dissemination of data, information products, and information concerning the programme. Some of the products have near real- time uses, the applicability of which can be greatly enhanced by their timely distribution. Publication of such products on the World Wide Web has become the option of choice to provide the data quickly to clients that have access to the Internet. For users in Member States that do not have access to the Internet, other options for telecommunicated products have to be implemented. For example, GTS data flow products have been circulated to some Member States by fax. Member States that can not receive products and data available from GTSPP on the Internet should contact the IOC Secretariat with a request that some other arrangements be made.

Figure 2 does not contain any specific information on communications infrastructure. However, the characteristics of the communications infrastructure are implied to a certain extent by the connections between the boxes.

(iv) Quality Control Procedures

The quality control element continues to be crucial to the successful operation of GTSPP. It is essential that all data maintained in the GTSPP Continuously Managed Database (CMD) is of a known quality and that the scientific community, including the major global research programmes, accept the validity of the quality control flags attached to the GTSPP data.

The philosophy of GTSPP is to create a complete database. This is achieved partly by retaining all data that meet the minimum level of quality. Once an observation has successfully passed the first level of checks (which consist of relatively simple data structure, format and range related tests), it will not be removed or deleted from the CMD except in the case of exact duplicates.

The GTSPP Quality Control Manual covers the checks that are undertaken by participating data centres. It describes the approach of using a small number of quality control flags by using a series of data quality levels to identify data validity.

The quality control levels range from a minimum series of checks up to the more sophisticated numerical assessments. All the data that have been checked and have passed the lowest quality level criteria are included in the CMD with the appropriate flag and it will then be available to the user.

A significant feature of the GTSPP quality control procedures is that they form the basis for a global quality control standard. The scientific community can accept this standard because that community has been heavily involved in its development. Gaining this acceptance has been a major achievement for GTSPP. It is very important that the scientific community continue to be involved in suggesting, reviewing and agreeing to GTSPP quality control procedures.

It was decided at the Fourth Session of the Steering Group on the GTSPP that it is desirable and necessary to transfer the scientific QC procedures being done by the WOCE UOT Science Centres to the data centres. Economic considerations in the 1990s have made it clear that continued support of GTSPP data management by the science centres can not be guaranteed at the level of the past few years. Although apparently initiated for negative reasons, this "transfer of technology" to the data centres is a positive step in its own right. Upgrading data centre skills has been a goal of IODE for the past several years and can only lead to better data centre performance and services.

On the other hand, involvement of the scientific community in the development and maintenance of GTSPP QC procedures and the skills of the data centre persons performing the QC must be maintained at a significant level to ensure continued success. GTSPP through its participating centres must work to maintain effective working arrangements with the science programmes to ensure the adequacy of its QC activities. Only in this way can the continued validity and acceptability of the GTSPP dataset be guaranteed.

(v) Continuously Managed Database

All the activities of GTSPP, including data acquisition, communications, data flow analysis, data quality control, and scientific analysis, result in the creation of the global temperature and salinity dataset. To manage this dataset, a Continuously Managed Database (CMD) was implemented.

As data are acquired in both near real-time and delayed mode, they are added to the database. Delayed mode data have a higher resolution and are calibrated and quality controlled by the originator. Thus, the delayed mode data represent a "better" version of the data for all purposes. This "better" version replaces the data obtained in near real-time. This "better" version of the data arrives later than the real-time version. The Continuously Managed Database therefore holds the most current and highest quality dataset available at any given time. It will be

continuously refined as additional quality checks are undertaken. The term Areplace@ here means replace as the active copy of the observation in the database. As stated earlier, observations that have passed quality control and entered the database are not removed. They are flagged to indicate that a higher quality version of the observation exists in the database.

The system supporting the CMD provides a number of functions including:

(i) Overall management and archiving of GTSPP data;
(ii) Monitoring of data acquisition and data flow;
(iii) Development and production of data management statistics and information products;
(iv) Production of subsets of data in response to requests;
(v) Management of updates to the databases on a regular and frequent basis;

(vi) Detection of duplicate data, including exact and inexact duplicates and duplicates between operational and delayed mode observations;

(vii) Management of meta data, which describe the actual dataset.

Subsets of GTSPP data covering areas of national interest or global datasets are provided to Member States on request.

(vi) GTSPP Data and Information Products

GTSPP has a role in the production of two types of data and information products. The first role is a direct one whereby GTSPP actually produces the product as part of the operation of the programme. The second role is in providing a higher quality and more complete dataset to others who are producing products and information about ocean temperatures and salinities. Examples of the first type of product are:

- Maps and inventories of temperature and salinity data that have been collected.
- Data flow analyses for the North American, European and Asian sections of the GTS.
- Statistical analyses of errors in data to be fed back to data collectors to allow them to improve their data collection programmes.
- Maps of the distribution of surface and sub-surface temperatures from ships of opportunity and moored and drifting buoys. The maps are produced by the science centres for quality control purposes and are made available on the World Wide Web.

At the present time, various other research and operational agencies produce data analysis products in response to national and international needs. If these analyses are produced using a more complete and higher quality *in situ* dataset from GTSPP, then the product will be of higher quality. This is the second type of role for GTSPP in products and information.

It is important that GTSPP compliments rather than competes with other national and international organizations in producing products. The GTSPP role is to provide a high quality dataset that will assist these organizations in producing higher quality products. An example

would be GTSPP providing the most complete and best quality in situ dataset available for a numerical modelling study.

By supporting the work of the scientific experts in other organizations, GTSPP can expand its expertise in uses of the temperature and salinity data, as well as assisting the work of the experts. These experts are in many cases in a better position to produce scientific analyses and products because of special expertise and local knowledge.

The development and distribution of data and information products helps to promote and advertise the GTSPP. The products demonstrate additional uses for the data and show the effectiveness of GTSPP as a data management model and as an important contributor to the global research programmes.

GTSPP data and information products are disseminated as widely as possible via a number of means including mail, electronic mail, publishing on the World Wide Web, and on CD-ROM.

(vii) Data Flow Monitoring

The implementation and operation of GTSPP involves the use of considerable resources, including manpower, computer systems, and communications networks. In order to maximize the effectiveness and the data returns for the investment, it is essential that the data flow of the system be carefully monitored.

The monitoring programme is intended to assist all participants, including data contributors and user groups, to have knowledge of the effectiveness of the programme and to modify aspects that are not performing efficiently. It will also provide an indication of improvements in the system as the programme develops.

In particular, GTSPP exercises the monitoring procedures developed in IGOSS and IODE and assists with the further development and improvement of these procedures.

GTSPP data flow monitoring will aim to meet the following objectives:

(i) provide information on the data flow in GTSPP for both real-time and delayed mode data,
(ii) identify problem areas and bottlenecks in data flow and information distribution,
(iii) provide statistics that can be used to promote GTSPP, and
(iv) provide feedback to the data contributors, data centres, and data analysis centres.