WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (OF UNESCO)

JOINT WMO / IOC TECHNICAL COMMISSION FOR OCEANOGRAPHY AND MARINE METEOROLOGY (JCOMM)

SHIP OBSERVATIONS TEAM

FIFTH SESSION

GENEVA, SWITZERLAND, 18-22 MAY 2009

SOT-V/Doc. I-3.2
(24.04.2009)

ITEM I-3.2

Original: ENGLISH

REPORT ON ASSOCIATED PROGRAMMES

(Submitted by the Secretariat)

Summary and purpose of the document

This document includes reports from associated programmes or projects, including a report of the International Ocean Carbon Coordination Project (IOCCP) and its relationship with the SOT; a report of the Shipboard Automated Meteorological and Oceanographic System (SAMOS); a report on the Global High Resolution SST Pilot Project (GHRSST); a report on the Ferrybox Project; a report on the SeaKeepers Society; a report on the Alliance for Coastal Technologies (ACT); a report on the Scientific Committee on Oceanic Research (SCOR) Panel on the use of merchant marine vessels for instrumented oceanographic surveys, and its potential relationship with the SOT; and a report on the Oceanoscientific Campaign regarding the making of observations from a sailing race. Feedback will be requested from the SOT on areas of common interest and potential common actions.

ACTION PROPOSED

The Team will review the information contained in this report, and comment and make decisions or recommendations as appropriate. See part A for the details of recommended actions.

Appendices:

A. International Ocean Carbon Coordination Project (IOCCP)
B. Shipboard Automated Meteorological and Oceanographic System (SAMOS)
C. Global High Resolution SST Pilot Project (GHRSST)
D. The Ferrybox Project
E. Alliance for Coastal Technologies (ACT)
F. Proposed SCOR Panel on Merchant Marine Oceanographic Surveys
G. The SeaKeepers Society

- A - DRAFT TEXT FOR INCLUSION IN THE FINAL REPORT

I-3.2.1 International Ocean Carbon Coordination Project (IOCCP)

I-3.2.1.1 Dr Albert Fischer (IOC Secretariat) presented a report on behalf of Maria Hood (IOC Secretariat, and IOCCP Project Coordinator), describing the International Ocean Carbon Coordination Project (IOCCP) and its intersection with the SOT.

I-3.2.1.2 The IOCCP is co-sponsored by the IOC and the Scientific Committee on Oceanic Research (SCOR) and promotes the development of a global network of ocean carbon observations for research through technical coordination and communications services, international agreements on standards and methods, and advocacy and links to the global observing systems.

I-3.2.1.3 Major activities of the IOCCP for 2009 include

(i) the Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP) – revising the1994 WOCE Hydrographic Program Manual and developing a strategy for a global survey, post-CLIVAR. The strategy will be published as a whitepaper for the OceanObs09 conference
(ii) the Surface Ocean CO2 Atlas Project (SOCAT) – A long-term project to develop a global common-format surface ocean CO2 data set with well-documented quality control procedures and no interpolation
(iii) changing Times Inventory – developing a multi-platform inventory of carbon and biogeochemistry time series measurements, including coastal and non-Eulerian observations
(iv) the Guide of Best Practices for Ocean Acidification Research and Data Reporting – to be published in late 2009
(v) a summary for Policymakers / Watching Brief on Ocean Fertilization – commissioned by the IOC Executive Council and the IMO London Convention
(vi) Partners in the EU Carbon Observing System Coordination (COCOS) – to improve interoperability of carbon observations and data streams between the land, air, and ocean domains; and
(vii) Ocean carbon sensor directory – development and maintenance of an on-line directory of the most often used carbon and related sensors and systems.

I-3.2.1.4 The meeting noted with appreciation that Rik Wanninkhof (NOAA AOML) has suggested developing a pilot study for inclusion of SST and SSS on the GTS that could eventually be expanded to cover all interested carbon SOOP participants. He notes, however, that the logistic details of such a pilot experiment are not trivial. For release of salinity data in a timely manner, the IOCCP can request PIs to provide data after the end of each cruise, but personnel costs must be considered. Data are released regularly to CDIAC and a large dataset (SOCAT, see below) will be made public at the end of 2009.

I-3.2.1.5 The meeting also noted that the IOCCP was working on a revision to the Hydrographic Program Manual for the section on “Underway Measurements: Overview, and Near-surface T, S, and bathymetry measurements.” GOSUD has produced a QC manual on the TSG data as part of the GOSUD manual. The chapter on Acoustic Doppler Current Profiling Measurements and Navigation, and the one on meteorological measurements from research ships (“flux” part) will also be updated.

I-3.2.2 Shipboard Automated Meteorological and Oceanographic System Project (SAMOS)

I-2.2.2.1 Dr Shawn Smith (Florida State University, USA) reported on the recent developments of the Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative. SAMOS aims to improve the quality of meteorological and near-surface oceanographic observations collected in-situ on research vessels (R/Vs) and select merchant ships.

I-2.2.2.2 The SAMOS initiative currently focuses on meteorological and near-surface oceanographic data collected by the scientific instrument system (a SAMOS) permanently installed on R/Vs. The

SAMOS data center at the Florida State University (FSU) currently receives data transmissions from 17 U. S. operated R/Vs and one international R/V (Southern Surveyor). Four additional R/Vs are being recruited. The SAMOS initiative provides validation of science instrument systems on R/Vs using a Portable Seagoing Air-sea Flux Standard (PSAFS). The PSAFS combines a set of state-of-the-art instruments to directly measure the air-sea fluxes of heat, momentum, fresh water, and radiation and a suite of instruments making standard meteorological measurements side-by-side with the SAMOS that is permanently installed on a the R/V.

I-2.2.2.3 The Team noted that the second joint SAMOS GOSUD workshop (Seattle, WA, USA 10-12 June 2008) made a number of recommendations for

(i) augmenting data from vessels making automated weather observations with routine visual cloud, weather condition, sea state, and ice conditions;
(ii.) determining critical regions for increased monitoring through underway meteorological and TSG observations
(iii.) encouraging efforts to develop new and make available historical upper-ocean and meteorological observations for use by developing nations
(iv) collecting daily bottle samples of water to monitor TSG performance from vessels making underway thermosalinograph (TSG) measurements; and
(v.) building best practice guides and continuing education materials to support the needs of technical personnel on the front lines of data collection at sea.

I-2.2.2.4 The Team noted with appreciation that SAMOS was collaborating with the Marine Advanced Technology Education Center (Monterey, CA, USA) to develop knowledge and skills guidelines for ocean observing technicians (i.e. for making underway atmospheric and oceanic observations that meet the high-accuracy requirements for climate and oceanographic research). These actions are expected to lead to enhanced curriculum within marine technical training programs. The Team invited its members to participate in the development of related training programs and materials (***action, SOT members, SOT-VI***).

I-2.2.2.5 The meeting noted that the SAMOS initiative was not originally designed to provide meteorological and ocean observations to national oceanographic or meteorological services. The demand to have access to high-quality SAMOS data via traditional services (e.g., GTS) has grown. The Team noted some of the issues that had to be addressed for making SAMOS data available, including

(i) how to distinguish a SAMOS report from a standard VOS report,
(ii) timeliness of delivery (is daily good enough),
(iii) reliability of SAMOS metadata, and
(iv) coordinating with responsible NMS. Mr Smith provided an update addressing these issues, including a new initiative to automate metadata transfer from SAMOS vessels to shore and a new “real-time” U. S. R/V data repository. It requested the Task Team on Instrument Standards to follow up in liaison with Mr Smith (***action, TT IS, SOT-VI***).

I-2.2.2.6 Regarding the provision of SAMOS (and other high-temporal frequency automated weather data) to national meteorological and oceanographic services, the Team made the following recommendations: [*text to be added based on the meeting’s discussion*].

I-3.2.3 Global High-Resolution SST Pilot Project (GHRSST)

I-3.2.3.1 Dr Gary Corlett (Space Research Centre, University of Leicester, United Kingdom) reported on the activities of the Group for High Resolution Sea Surface Temperature (GHRSST) summarizing the approach that GHRSST uses to provide quality indicators for its products. GHRSST is comprised of international experts working together for the provision and application of satellite-derived SST data, and offers a suite of global high-resolution SST products, operationally in near-real-time, on a daily basis.

I-3.2.3.2 The Team noted that GHRSST was now planning to provide long-term SST climate data records covering the satellite era from 1981 onwards. Mr Corlett explained that these products had a limited requirement for ship-borne SST data due to their geographical coverage and usually high measurement uncertainty. GHRSST expressed interest in working with the SOT to address both these issues.

I-3.2.3.3 The Team noted the recommendations from GHRSST for maximising the impact and benefit of existing and future SST measurements from ships. Based on those recommendations, the Team invited its members to collaborate with GHRSST in the view (i) to make additional radiometric skin SST measurements from ships (***action, SOT members, ongoing***). The Team also requested its Task Team on Instrument Standards (i) to better characterize the uncertainties of non-radiometric SST measurements from existing ship data (this can be done using GHRSST data), and (ii) to collaborate with GHRSST to better define requirements for measurements of SST from ships (***action, TT IS, SOT-VI***).

I-3.2.4 Ferrybox Project

I-3.2.4.1 Wilhelm Petersen (GKSS Research Centre Institute for Coastal Research/Operational Systems, Germany) reported on the status of the Ferrybox project and recent achievements. The *FerryBox*[1] concept is to fit robust autonomous measuring systems to ferries and merchant ships, which run regular routes. The concept was tested during the EU FP5 project *"FerryBox"*, which ran from 2002 to 2005. The core work of the *FerryBox* project focused on the use by all the participants of four "core" sensors for- temperature, salinity, chlorophyll-fluorescence and turbidity along with testing of a wider range of sensors by individual groups on the routes. This project was highly successful and demonstrated the value of the measurements made as an integrated part of the marine monitoring cycle. Even after finishing this project, most of the FerryBox systems kept running just financed by the national research institutions. Some European institutions operate the routes. Many of the systems have been developed to support the requirements for both scientific and marine management data.

I-3.2.4.2 The Team noted that systems have also been in operation for sometime in Japan, Korea and in the USA and elsewhere. The FerryBox community is evolving from single institute-driven VOS lines to strategic multi-partner and trans-boundary work. In Europe, such coordination is sought as a pillar for the future deployment of pan-European coastal observing systems and will facilitate the implementation of the EU's Marine Strategy Framework and the Water Framework Directives.

I-3.2.4.3 FerryBox systems have considerable potential for increased use as part of marine management systems around the world, particularly making it possible to monitor the world's major estuaries ands coastal waters such as those of eastern Asia. A particular success has been achieved for the monitoring of air-sea fluxes of carbon dioxide through the IOCCP International Ocean Carbon Coordination Project voluntary observing ship operations. It is important that this work is continued and work particularly in shelf seas is expanded. The coastal carbon system needs to be better monitored in respect to the overall carbon cycle issues and natural carbon sequestration processes. The FerryBox approach is probably the only way that can provide the needed monitoring coverage of carbon import and export in shelf seas and acidification in the coastal zone cost effectively.

I-3.2.4.4 The Team noted that the EU Commission set up the European Marine Observation and Data Network[2] (EMODNET) to open up opportunities for high technology commercial companies in the maritime sector to improve the efficiency of activities such as marine observation, management of marine resources and marine research in European laboratories. The EMODNET vision is for an end-to-end, integrated and inter-operable network of European marine observations, data communications, management and delivery systems, supported by comprehensive user-oriented toolkits. For example,

1: http://www.ferrybox.org
2 : http://www.esf.org/publications/marine-board.html

FerryBoxes play a prominent role in the integrated monitoring of the German Bight of the North Sea through the Coastal Observing System for Northern and Arctic Seas[1] (COSYNA) project.

I-3.2.4.5 The FerryBox concept has considerable potential for expansion particularly for the study of inputs from the world's major riverine inputs such as the Amazon and those following into the China Seas. FerryBoxes can make an important contribution to the development of a global system for observing the coastal ocean. For work in developing countries, the FerryBox approach is particularly important because it is highly cost effective. It can enable the Coastal Module of GOOS to happen in developing countries. Here the JCOMMOPS can play an important role.

I-3.2.4.6 The Team noted that a Community White Paper (Hydes *et al.*) was being prepared for the OceanObs'09 Symposium (Venice, Italy, 21-25 September 2009). This will provide the opportunity to discuss how local FerryBox operations might be coordinated globally through JCOMM to provide input to a Coastal GOOS system.

I-3.2.4.7 Mr Petersen explained that FerryBox systems have to be developed further on in order to increase the possibilities of automated observations on ships of opportunity including for

(i) preparing already new build ships with possibilities to connect a FerryBox system (water inlet, infrastructure for external communication)
(ii) developing robust systems, self cleaning or easily cleaning by the ship crew in order to keep the maintenance to a minimum, and
(iii) further developing robust sensors suitable for autonomous operation in FerryBox systems (e.g. more robust nutrient analysers, high precise pH, algal detection by gene probes, new sensors for zooplankton).

I-3.2.5 SeaKeepers Society

I-3.2.5.1 The meeting noted the letter from John Englander (CEO, SeaKeepers Society) in reply to the invitation letter sent by the WMO Secretariat for attending this SOT Session. In the letter, Mr Englander indicated that SeaKeepers was an independent NGO, which started in 1998 with the idea to advance a new Volunteer Observing System, equipping private yachts, cruise ships, freighters and tankers with highly automated systems for meteorological and oceanographic observing.

I-3.2.5.2 Fifty-seven cost-effective SeaKeeper 1000™ systems (0.01$/observation) have been installed worldwide and experimental efforts have proven the concept. Installations include large private yachts, cruise ships, NOAA vessels, University Research platforms, and a USCG Icebreaker. The modular architecture System is capable of making meteorological (wind, air temperature, humidity, surface pressure) and oceanographic (SST, SSS, dissolved oxygen, Ph, Chlorophyll) measurements. The system is strictly supported by private donations from citizens of 14 nations, except for the contribution of NOAA assisting with satellite transmission fees.

I-3.2.5.3 The Team noted with concern that while private donors have been very generous over the years, they now take the position that if such a network is valuable to the world community, that there must be support by governments or intergovernmental agencies and institutions to keep it functioning. SeaKeepers projects to run out of operating funds by the end of June. The annual expense to keep the 57 systems operational and calibrated is approximately US$ 500,000 annually. SeaKeepers is willing to assist interested organization regarding the larger question of possible ways to support, fund, or take over their efforts of the last decade while it is still operational.

I-3.2.6 Alliance for Coastal Technologies (ACT)

I-3.2.6.1 Dr Mario Tamburri (Chesapeake Biological Laboratory, University of Maryland, USA)

1 : http://www.cosyna.de

presented a report on performance measures and community outcome regarding the Alliance for Coastal Technologies (ACT). The report included a few examples of the products, services, and impacts of ACT over the past seven years, based on the program's five community-established priorities :

(i) transition emerging technologies to operational use rapidly and effectively
(ii) maintain a dialogue among technology users, developers, and providers

(iii) identify technology needs and novel technologies, and (iv) document technology performance and potential, and
(v) provide the Integrated Ocean Observing System (IOOS) with Information Required for the Deployment of Reliable and Cost-Effective Networks.

I-3.2.6.2 The Team noted that in cooperation with tens of private companies internationally, ACT has conducted a large number of technology evaluations and tested 37 instruments at 8 of the partner field sites. Evaluation reports have been produced and distributed and are available from the ACT web site[1]. ACT workshops have facilitated cooperation with the private industry to address research and development issues, and permitted the provision of information on technology, resulting in better industrial products being used in the marine community.

I-3.2.6.3 The Team further noted that ACT had collaborated with IOOS, NDBC, and the US Army Corps of Engineers on the development of a National Operational Wave Observing Plan and with IOOS on a National Surface Current Plan. It had also collaborated with Marine Metadata Interoperability (MMI) program and Southeastern Universities Research Association (SURA) on the development of a National Data Integration Framework and sensor interoperability.

I-3.2.6.4 More information can be found at the ACT web site.

I-3.2.7 SCOR/IAPSO OceanScope Working Group

I-3.2.7.1 Dr Tom Rossby (Graduate School of Oceanography, University of Rhode Island, USA) reported on the development of the recently approved OceanScope Working Group of the Scientific Committee on Oceanic Research (SCOR) and the International Association for the Physical Sciences of the Oceans (IAPSO). This followed the proposal made at the last SOT Session for SCOR Panel on Merchant Marine Instrumented Oceanographic Surveys.

I-3.2.7.2 The Team noted that the OceanScope would address the compelling need for new technologies with which to monitor currents, and physical, chemical and biological parameters systematically at high horizontal resolution. The first meeting will take place in Montreal July 17-19, 2009. The charge of the working group will be to review and propose possible new and emerging technologies that can be adapted to the merchant marine shipping environment. The working group will produce the OceanScope Implementation Plan for realizing these ideas.

I-3.2.7.3 The OceanScope concept proposes a new paradigm for the systematic and sustained observation of the ocean water column. It seeks to develop a partnership between the ocean observing community and merchant marine shipping industry so that a number of synergies could be realized which to date have not been possible, notwithstanding a very high level of cooperation between individual ship operators and scientists. These include (i.) an enhanced ability identify routes and operators in all oceans, (ii.) new instruments and technologies developed and optimized for automated operation on commercial vessels, and (iii.) real time data streams, automated data processing and distribution to the user community. One option for implementation of this concept would be through the establishment of an international agency, something like space agencies, which are designed to operate on decadal time lines appropriate to the challenges they face.

1 http://www.act-us.info

I-3.2.7.4 The Team noted that the organizers have agreed upon the Terms of References and the working group itself will review sponsoring agencies. A 3-year timeline was proposed culminating in decisions regarding what structures would need to be put in place to carry forward the deliberations and plans of the Working Group into the future.

I-3.2.8 The Oceanoscientific Campaign

I-3.2.8.1 Mr. Martin Kramp (SailingOne[1], Caen, France) reported on the Oceanoscientific Campaign of the SolOceans[2]. The fleet of the new SolOceans round the world sailing race will regularly sail in almost unexplored areas, especially in the Southern Hemisphere round the three capes: Good Hope, Leeuwin and Horn. This is a unique opportunity to collect and transmit scientific data of the ocean-atmosphere-interface. Consequently, scientific partners (such as IFREMER, INSU-CNRS and Météo-France) initialized with SailingOne the OceanoScientific Campaign and each unit of the SolOceans one-design Class will be equipped with scientific probes and a modified BATOS system. The following parameters will be measured (i) wind speed and direction, (ii) air relative humidity, (iii) air temperature, (iv) sea level pressure, (v) SST, (vi) SSS, and (vii) pCO_2.

I-3.2.8.2 After the successful testing of the BATOS system in 2008 on the first unit of the SolOceans one-design Class[3], now the flow-through system[4] is under development. Existing systems do not match because of weight and size, power consumption, water intake or the very rough offshore conditions.

I-3.2.8.3 The Team noted that at the end of 2009, the complete system would be tested under racing conditions: several units of the SolOceans one-design Class will take part in a transatlantic race.

Appendices: 7

1: SailingOne, based in the French Lower Normandy Region, is both organizing the SolOceans race and building the SolOceans one-design Class, which will also take part in other major offshore races.
2: The SolOceans is the first single-handed round-the-world sailing race in which international skippers are guaranteed to compete on equal footing thanks to new sixteen-meter high-tech SolOceans one-design monohulls, all strictly identical to one another: hull, equipment and sails. It is the first race with one leg raced per year: the first leg Europe - New Zealand during the last quarter of the year, followed by the second leg: New Zealand - Europe at the beginning of the following year. Every leg will last approximately fifty days. The number of participants is limited to twelve. The first SolOceans will start on 23 October 2011.
3: One-design Class: all the yachts of the SolOceans race are completely identical to each other in size and equipment. So scientific equipment has no influence on the sailing competition.
4: Flow-through-system: The system which will measure the ocean data at the surface (e.g. salinity, pCO_2). There will be one or several flow-through chambers for used probes. The system contains also a pump, debubbler, filter and valves.

APPENDIX A

REPORT BY THE INTERNATIONAL OCEAN CARBON COORDINATION PROJECT (IOCCP)

(report submitted by Maria Hood, IOC Secretariat)

The International Ocean Carbon Coordination Project (IOCCP) promotes the development of a global network of ocean carbon observations for research through technical coordination and communications services, international agreements on standards and methods, and advocacy and links to the global observing systems. The IOCCP is co-sponsored by the Intergovernmental Oceanographic Commission (IOC) of UNESCO and the Scientific Committee on Oceanic Research (SCOR).

Major activities of the IOCCP for 2009 include:

- The Global Ocean Ship-based Hydrographic Investigations Panel (GO-SHIP) – revising the 1994 WOCE Hydrographic Program Manual and developing a strategy for a global survey, post-CLIVAR. The strategy will be published as a whitepaper for the OceanObs09 conference.

- The Surface Ocean CO_2 Atlas Project (SOCAT) – A long-term project to develop a global common-format surface ocean CO_2 data set with well-documented quality control procedures and no interpolation.
- Changing Times Inventory – developing a multi-platform inventory of carbon and biogeochemistry time series measurements, including coastal and non-Eulerian observations.
- Guide of Best Practices for Ocean Acidification Research and Data Reporting – to be published in late 2009.
- Summary for Policymakers / Watching Brief on Ocean Fertilization – commissioned by the IOC Executive Council and the IMO London Convention.
- Partners in the EU Carbon Observing System Coordination (COCOS) – to improve interoperability of carbon observations and data streams between the land, air, and ocean domains.
- Ocean carbon sensor directory – development and maintenance of an on-line directory of the most often used carbon and related sensors and systems.

At the last JCOMM SOT meeting, the IOCCP and AOML were requested to coordinate procedures for near real-time insertion of salinity data on the GTS and for the carbon community to release data in a time manner: “V-5.2.3 Regarding the value of temperature and salinity data collected by partial CO2 systems and coordinated by IOCCP (agenda item I-3.2.1), the Panel agreed that near-real-time salinity data from TSGs run for pCO_2 observations were valuable for satellite calibration and ocean analyses and forecasts, as was the timely availability of delayed mode data. NOAA/AOML agreed to insert such data on the GTS if communications from the ship were possible. The Panel asked IOCCP and AOML to coordinate procedures for near-real-time insertion of salinity data on GTS (Action IOCCP and AOML), and the SOOPIP Chairperson to urge IOCCP to release salinity data-to-data archives in a timely manner (action: SOOPIP Chairperson).

At present, there are 45 sustained carbon SOOP programs, with 15 lines on commercial ships. However, single investigators drive the majority of these programs, and the majority of these programs are funded by time-limited funds, many of which are nearing the end of their funding period (especially in the North Atlantic).

Several years ago, IOCCP Chair Chris Sabine met informally with JCOMM SOT partners (Charpentier and Ball) to review the possibilities for real-time data release from the carbon lines. After reviewing the geographic distribution of the lines and discussing the extra costs involved in making those data available in near real-time, it was agreed that it might not be worth pursuing at this time, since the majority of the carbon lines are in areas that are already well populated with other VOS / SOOP programmes.

Rik Wanninkhof, NOAA AOML, has suggested developing a pilot study for inclusion of SST and SSS on the GTS that could eventually be expanded to cover all interested carbon SOOP participants. He notes, however, that the logistic details of such a pilot experiment are not trivial. For release of salinity data in a timely manner, the IOCCP can request PIs to provide data after the end of each cruise, but personnel costs must be considered. Data are released regularly to CDIAC and a large dataset (SOCAT, see below) will be made public at the end of 2009.

The Surface Ocean CO_2 Atlas Project

At the "Surface Ocean CO_2 Variability and Vulnerability" (SOCOVV) workshop in April 2007, co-sponsored by IOCCP, SOLAS, IMBER, and the Global Carbon Project, participants agreed to establish a global surface CO_2 data set that would bring together, in a common format, all publicly available surface fCO_2 data for the surface oceans. This data set will serve as a foundation upon which the community will continue to build in the future, based on agreed data and metadata formats and standard 1st-level quality-control procedures, building on earlier agreements established at the 2004 Tsukuba workshop on "Ocean Surface pCO_2 Data Integration and Database Development". The first SOCAT data includes data from over 14 countries, producing an initial database composed of more than 7 million measurements of various carbon parameters from approximately 2100 cruises from 1968 to 2007.

This data set is meant to serve a wide range of user communities. The data set will be published as a 2nd-level quality controlled, global surface ocean fCO_2 (fugacity of CO_2) data set following agreed procedures and regional review. Initially, it was planned to also produce a gridded SOCAT product of monthly surface water fCO_2 means on a 1° x 1° grid with no temporal or spatial interpolation. However, with the use of Live-Access Server, users can now carry out gridding and interpolation based on their own criteria, making the data products more adaptable to a wider range of users.

A small technical meeting was held in Bremen, Germany, on 5 December 2007 (associated with the 3rd CarboOcean Annual Meeting) to agree on 1st-level QC for the data set and to decide on a way forward for the 2nd-level QC issues.

The IOCCP, along with CarboOcean and the SOLAS-IMBER Joint Carbon Group, held a 2nd technical workshop (SOCAT-2 meeting) at UNESCO, Paris, on 16-17 June 2008 to develop internationally agreed 2nd-level quality-control procedures and to discuss the coordination of regional scientific groups to conduct the 2nd-level quality control analyses. Refer to the background document SOCAT-II Report for more information.

http://ioc3.unesco.org/ioccp/Docs/SOCAT2_Final2.pdf

In January 2009, the regional groups were asked to carry out a 2nd-level quality control on the SOCAT data and address key process-related scientific questions requiring large-scale joint synthesis efforts, while aiming for scientific presentations at ICDC-8 (International Carbon Dioxide Conference) in September 2009 and a first public release of the two SOCAT products by late 2009.

The Regional Group leaders are:

- Atlantic and Arctic Ocean– Ute Schuster and Nathalie Lefèvre
- Indian Ocean– VVSS Sarma
- Pacific Ocean – Dick Feely is 30N-30S + South Pacific. PICES has been asked to lead this. Nojiri to help lead.
- Southern Ocean – Bronte Tilbrook with Nicolas Metzl as co-chair.
- Coastal seas – Alberto Borges and Arthur Chen.
- Global group – Dorothee Bakker, Are Olsen, Chris Sabine, Benjamin Pfeil, Nicolas Metzl

The coastal group held a meeting in Kiel in January 2009 with financial support being assembled by the SOLAS International Project Office from various sources including the European COST Action 735. The Pacific Group will have their first meeting in Tsukuba, Japan, from 18-20 March. This will be the first meeting to use the LAS tools and work with the dataset in the LAS. The Pacific regional group will meet with the developers of the Live-Access Server tools to learn how LAS can be used in the QC effort for SOCAT. The participants will install the tools and software on their computers, download the data files for their regions, set up the shared QC environment, and work through several exercises to demonstrate the system. The groups will decide how to make QC decisions that are consistent across regions, and identify any scripts available or needed for reading cruise data into Matlab, ODV, or other software. Time permitting, the groups will begin working through the data set for their region (flagging, determining which 2nd level QC tests may be applied, testing those, etc.). The Atlantic, Southern Ocean, and Indian Ocean groups will meet tentatively in June 2009.

GO-SHIP Revision of the Hydrographic Program Manual

Robert Keeley and Loic de la Villeon have agreed to provide a revision to the Hydrogrpahic Program Manual for the section on “Underway Measurements: Overview, and Near-surface T, S, and bathymetry measurements.” GOSUD has produced a QC manual on the TSG data as part of the GOSUD manual. Eric Firing is revising the chapter on Acoustic Doppler Current Profiling Measurements and Navigation, and Chris Fairall, Frank Bradley, and Bob Weller have submitted their Flux manual for the chapter on meteorological measurements from research ships.

____

APPENDIX B

REPORT BY THE SHIPBOARD AUTOMATED METEOROLOGICAL AND OCEANOGRAPHIC SYSTEM (SAMOS) INITIATIVE

(report submitted by Mr. Shawn R. Smith[9], Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, Florida, USA)

Summary and purpose of document

This document provides SOT with a summary of the recent activities of the SAMOS initiative

Action proposed

a. SOT is invited to review and comment on the activities of the SAMOS initiative.
b. SOT is asked to provide recommendations for the provision of SAMOS (and other high-temporal frequency automated weather data) to national meteorological and oceanographic services
c. SOT members are asked to participate in the development of training programs and materials for technical personnel responsible for marine atmospheric and oceanic measurements

1. Objectives

1.1 The shipboard automated meteorological and oceanographic system (SAMOS) initiative aims to improve the quality of meteorological and near-surface oceanographic observations collected in-situ on research vessels (R/Vs) and select merchant ships. Scientific objectives of SAMOS include:

(i) creating quality estimates of the heat, moisture, momentum, and radiation fluxes at the air-sea interface,
(ii) improving the understanding of the biases and uncertainties in global air-sea fluxes,
(iii) benchmarking new satellite and model products, and
(iv) providing high quality observations to support modelling activities, (e.g., re-analysis), process studies, and global climate programs.

1.2 To achieve the science objectives, the SAMOS initiative seeks to:

(i) improve access to quality assured SAMOS data for scientific and operational users by providing free and open access to data and metadata,
(ii) expand availability of SAMOS observations collected in remote ocean regions (e.g., Southern Ocean),
(iii) improve the accuracy and calibration of SAMOS measurements,
(iv) provide standards for data and metadata collected on SAMOS equipped vessel,
(v) ensure routine archival of SAMOS data at world data centers,
(vi) develop documentation and training materials for use by data collectors and the user community,
(vii) support comparison studies between in-situ platforms (e.g., R/Vs, VOS, buoys), and
(viii) develop partnerships in the international marine community.

9: smith@coaps.fsu.edu

2. Data collected by SAMOS Initiative

2.1 The SAMOS initiative currently focuses on meteorological and near-surface oceanographic data collected by the scientific instrument system (a SAMOS) permanently installed on R/Vs. A SAMOS is a computerized data logging system that continuously records navigational (ship's position, course, speed, and heading), meteorological (winds, air temperature, pressure, moisture, rainfall, and radiation), and near-surface oceanographic (sea temperature, salinity, conductivity, florescence) parameters while the vessel is at sea. The SAMOS initiative receives measurements recorded at 1-min intervals and derived from higher frequency samples (approximately 1 Hz). These data must be differentiated from the typical voluntary observing ship (VOS) reports that occur at 1-, 3-, or 6-hourly intervals. VOS reports are generated by automated (e.g., French BATOS) or manually read instruments provided by the responsible countries' national meteorological service (NMS). VOS instruments are generally separate from those instruments comprising a SAMOS (typically science quality instruments installed by the vessel operator or third party science investigator). One problem that occurs on R/Vs is that the crew may record their VOS observation using either the ship's NMS instruments or the SAMOS, and the source instrumentation of the observation is not routinely reported. SOT should consider how to address this reporting problem.

2.2 The SAMOS data center at the Florida State University (FSU) currently receives data transmissions from 17 U. S. operated R/Vs and one international R/V (*Southern Surveyor*). Four additional R/Vs are being recruited. SAMOS data are transmitted near 0000 UTC via daily email attachments containing all 1-min data records for the previous day. Once received at FSU, the observations (i) are automatically formatted and combined with vessel metadata (sensor types, locations, units, etc.) stored in a ship profile database, (ii) undergo automated quality evaluation, and (i) are distributed via web (http://samos.coaps.fsu.edu) and ftp servers within 5 minutes of receipt. Vessel operators and at-sea ocean-observing technicians are notified via email when an analyst at FSU notes problems (through automated error logs or subsequent visual data inspection).

3. Improving data accuracy

3.1 The SAMOS initiative provides validation of science instrument systems on R/Vs using a Portable Seagoing Air-sea Flux Standard (PSAFS). The PSAFS combines a set of state-of-the-art instruments to directly measure the air-sea fluxes of heat, momentum, fresh water, and radiation and a suite of instruments making standard meteorological measurements side-by-side with the SAMOS that is permanently installed on a the R/V. The PSAFS was developed by NOAA Earth System Research Laboratory (ESRL) and was deployed on the *Healy* and *Knorr* in 2008. The results from these cruises continued to show the importance of properly exposing sensors to avoid distortion of airflow caused by the vessel. Even a high-quality sensor will return unreliable data when it is poorly positioned on the vessel. Future deployment of the PSAFS will piggyback on previously scheduled science or transit cruises and, when possible, will coincide with cruises to regions of high scientific interest for fluxes.

4. Collaboration with GOSUD

4.1 A second joint workshop was held in Seattle, WA, USA from 10-12 June 2008. The workshop focused on the ongoing collaboration between GOSUD and SAMOS and addressing the needs of the research and operational community for high-quality underway oceanographic and meteorological observations from ships. A full report can be found at

http://www.coaps.fsu.edu/RVSMDC/marine_workshop4/

Recommendations relevant to SOT include:

a. Vessels making automated weather observations should make every effort to augment these data with routine visual cloud (type, height), weather condition, sea state (waves, swell, period), and ice conditions.
b. Expand access to underway meteorological and TSG observations in remote ocean regions and marginal seas. The scientific user community must determine critical regions for increased monitoring.
c. Encourage efforts to develop new and make available historical upper-ocean and meteorological observations for use by developing nations.
d. Vessels making underway thermosalinograph (TSG) measurements should collect daily bottle samples of water to monitor TSG performance.
e. Build best practice guides and continuing education materials to support the needs of technical personnel on the front lines of data collection at sea.

5. Educational Initiatives

5.1 The SAMOS initiative focuses on the need for training and educating in-service and new ocean observing technical personnel. Repeated conversations with sea-going technicians have identified a need for a clear set of guidelines for making underway atmospheric and oceanic observations that meet the high-accuracy requirements for climate and oceanographic research. Furthermore, both government and industry partners have expressed the need for more technicians with strong electronics, internet technology, and instrument training. SAMOS is collaborating with the Marine Advanced Technology Education Center (Monterey, CA, USA) to develop, knowledge and skills guidelines for ocean observing technicians, which will lead to enhanced curriculum within marine technical training programs.

6. Providing Data to Operational Users

6.1 The SAMOS initiative was not originally designed to provide meteorological and ocean observations to national oceanographic or meteorological services. The demand to have access to high-quality SAMOS data via traditional services (e.g., GTS) has grown. Several issues exist to make SAMOS data available including (a) how to distinguish a SAMOS report from a standard VOS report, (b) timeliness of delivery (is daily good enough), (c) reliability of SAMOS metadata, and (d) coordinating with responsible NMS. The author will provide an update at SOT5 addressing these issues, including a new initiative to automate metadata transfer from SAMOS vessels to shore and a new “real-time” U. S. R/V data repository.

7. Acknowledgements

7.1 The SAMOS activities at FSU are supported by the Office of Climate Observation at NOAA via, a NOAA Applied Research Center. The Division of Ocean Science Integrative Program Section of the U. S. National Science Foundation provides additional funding.

____

APPENDIX C

REPORT BY THE GLOBAL HIGH RESOLUTION SST PILOT PROJECT (GHRSST)

(report submitted by Dr Gary K Corlett, Space Research Centre, University of Leicester, United Kingdom)

1. Executive Summary

The Group for High Resolution Sea Surface Temperature (GHRSST) is the international expert group for the provision and application of satellite-derived SST data, and offers a suite of global high-resolution SST products, operationally in near-real-time, on a daily basis. The GHRSST SST products have a limited requirement for ship-borne SST observations due to their non-uniform global geographical coverage and relatively high measurement uncertainty. This report, for the Ship Observations Team (SOT) provides a brief introduction to GHRSST, summarises the approach that GHRSST uses to provide quality indicators for its products, and concludes with a set of three recommendations for the SOT to consider, which address GHRSST requirements for ship-borne SST measurements.

2. Introduction

2.1 The Group for High Resolution Sea Surface Temperature (GHRSST) started in 2002 as one of the pilot projects of the Global Ocean Data Assimilation Experiment (GODAE), and is now the main expert group of users and providers of satellite SST data (Donlon et al., 2007). A new generation of high-resolution (< 10 km) global SST products and services, which have a demonstrated positive impact on ocean and atmospheric forecasting systems, are now provided by GHRSST in near-real-time on a day-to-day basis. Looking forward, GHRSST will continue to improve the quality and provision of high-resolution global SST data, and will expand its portfolio to include historical satellite SST data to support the generation of SST climate data records for the Global Climate Observing System (GCOS). Further details on all aspects of the GHRSST project can be found at http://www.ghrsst-pp.org.

2.2 The group coordinates the harmonisation of a wide variety of SST data streams from satellite and surface based sources that are shared, indexed, processed, quality controlled, analysed and documented within a Regional/Global Task Sharing (R/GTS) framework implemented in an internationally distributed manner. Large volumes of data (currently over 25Gb per day) are harnessed by data services to deliver global high-resolution SST datasets together with meaningful uncertainty estimates for each measurement or analysis grid. Research and development within GHRSST continues to tackle problems such as, instrument calibration, algorithm development, diurnal variability, skin temperature deviation, and validation of GHRSST products. Analysis products together with SST anomaly fields are generated each day as part of an ensemble approach to improving analysis systems and providing confidence in analysis outputs. Diagnostic data sets are provided via a web interface to assist in monitoring the quality of the SST retrievals and analysis products at a large selection of critical places in the global ocean.

2.3 GHRSST provides two major types of global SST products, Level 2 pre-processed (L2P) and Level 4 analysis (L4). The L2P product allows the many different satellite SST data products to be made available to users in a common format, and includes ancillary information to assist a user in assessing whether or not the data are “fit for purpose”. For every input data stream, GHRSST produces an output L2P product that augments the existing SST and geographic information with an estimate of the measurement bias and uncertainty, surface wind speed, aerosol optical depth, surface solar irradiance, sea ice concentration, the time of observation and a set of quality control flags. The L2P data format is NetCDF, following the Climate Forecast (CF) v1.0 convention. The L4 analysis products provide merged, gridded and gap-free SST datasets, which are produced from an optimal analysis of all available satellite and surface-based SST data within the preceding 24-hour period. The

L4 data specification is also CF-compliant NetCDF.

3. Quality Indicators

3.1 A key feature of the GHRSST L2P data product is the provision of Single Sensor Error Statistics (SSES). The SSES provide a bias and standard deviation in comparison to a reference dataset, as well as three quality indicators that together allow the user to make an assessment as to the suitability of a particular satellite SST estimate for their specific application. In an ideal case, the derivation of satellite SST uncertainties would require:

(1) A complete traceable characterisation to agreed national standards of the satellite instrument and SST retrieval algorithm, at all times throughout the lifetime of the mission, and
(2) A suite of global traceable reference data points that preserve the nature of the satellite SST, are of an accuracy and precision that is higher than the satellite sensor, and are provided throughout the mission.

3.2 In addition, if the sensor is part of a series, there should be a sufficient overlap period between successive sensors to allow for a robust characterisation of the inter-sensor period, using the same traceable reference data points for both sensors.

3.3 The bias and standard deviation calculated from the comparison to the reference dataset are derived from a database of match-up coincidences produced within pre-defined spatial and temporal limits; the current GHRSST match-up limits are ±25 km, and ±6 hours. The bias and standard deviation calculated from such a comparison do not provide the uncertainty of each dataset individually, but are simply the mean bias and combined uncertainty of a two-dataset comparison. Consequently, the resulting statistics are often dominated by real changes in the SST that can occur within the predefined spatial and temporal limits. Recently, a new method of multi-sensor match-up processing has been proposed that aims to deduce the uncertainty of an individual dataset, providing it is bias free (O'Carroll et al., 2008).

3.4 When considering possible reference sources, consideration must be given to the nature of the SST being assessed. For satellite SST retrievals produced from infrared radiances, the SST is equivalent to the temperature at a depth of ~10 µm and is referred to as the skin SST; for satellite SSTs produced from microwave radiances, the SST is equivalent to the temperature at a depth of >100 µm and is a weighted average of the temperatures through the skin layer and into the sub-skin region beneath. The deviation between skin and sub-skin reduces to a mean bias of -0.17 K when the surface wind speed is > ~6 ms^{-1}, and so surface wind speed observations also form an essential component of any reference data set for satellite SST uncertainty determination. Ideally, the reference source for assessing the quality of the satellite data should be a measurement at a depth that is as close as possible to that provided by the satellite. Indeed, where possible, it should be the same as that provided by the satellite, which is currently possible for infrared sensors, but not yet for microwave radiometers.

3.5 The current reference data set used in GHRSST is that provided by surface drifting buoys. Although the uncertainty of this dataset is not always traceable to an SI temperature standard, it has been chosen due to its significantly improved global coverage compared to other potential reference datasets. In addition, under certain conditions it is representative of the SST provided by the satellite after the application of a simple adjustment for the thermal skin effect (Donlon et al., 2002). Other potential reference data include ship-based radiometers, which have the advantage of being completely traceable to agreed SI standards through national metrology institutes and also duplicate the nature of the satellite SST measurement (Barton et al., 2004; Rice et al., 2004), moored buoys, and conventional ship measurements from engine room intakes; the TAO/TRITON/PIRATA arrays are considered separately from other moored buoys because they are in the open ocean and far from the coastal regions which often present particular difficulties for the accurate measurements of SST from space, and where most other moored buoys are deployed.

3.6 To give an indication of the performance of each dataset, the following table summarises match-up uncertainties for the various reference sources, in comparison to 1-km swath SST estimates from the Advanced Along-Track Scanning Radiometer (AATSR), which flies on the ENVISAT spacecraft. Here, the variance of the comparison has been reduced by limiting the spatial and temporal limits to < 1 km and ± 2 hours.

	Daytime		Nighttime	
Reference Source	Number of match-ups	Standard deviation (K)	Number of match-ups	Standard deviation (K)
Drifting buoys [a]	8301	0.33	10682	0.32
Moored buoys [ab]	884	0.56	1115	0.41
TAO/TRITON/PIRATA [a]	235	0.31	443	0.27
Ships [a]	3367	1.16	3720	1.11
Radiometers [c]	392	0.34	688	0.24

[a] Ground-based observations provided by the Met Office from the ICOADS database (Worley et al., 2005)
[b] Not including the TAO/TRITON/PIRATA arrays
[c] Average of comparisons to the M-AERI (Minnett et al., 2002) and ISAR (Donlon et al., 2008) radiometers

3.7 New developments within GHRSST include, how to use data from extremely stable satellite instruments such as AATSR as a reference data source for other satellite sensors, as AATSR provides data that has a lower uncertainty than the current GHRRST reference dataset (O'Carroll et al., 2008). The AATSR has the unique benefit of a robust traceable onboard two-point calibration system that maintains two blackbodies at temperatures just above and just below the temperature range of the global oceans (Smith et al., 2001).

3.8 The robust derivation and provision of such "Quality Indicators" underpins the new Quality Assurance Framework for Earth Observation (QA4EO) that has recently been developed for GEO (Group on Earth Observations) through a consultation process led by the Committee on Earth Observation Satellites Working Group on Calibration and Validation (CEOS-WGCV). The QA4EO process is based on the adoption of community defined best practises with GHRSST often used as a founding example of good practise and on how it should be implemented within other applications. Further details of the QA4EO framework and its associated key guidelines can be found at:

http://calvalportal.ceos.org/CalValPortal/showQA4EO.do? section=qa4eoIntro

4. Current uses of ship data within GHRSST

4.1 The current use of ship-borne SST data within GHRSST is to some extent limited and falls mainly into two categories. Firstly, radiometric temperature measurements from SI traceable infrared radiometers mounted on ships of opportunity are used as a primary reference data set for infrared sensors that provide a retrieval of the skin SST, such as AATSR or the MODerate-resolution Imaging Spectroradiometer (MODIS). Secondly, more conventional ship-based kinetic temperature measurements from engine room intakes obtained via the Global Telecommunications System (GTS) are used in many of the Level 4 analysis products.

5. Future uses of ship data within GHRSST

5.1 The limited use of ship measurements by GHRSST is mainly due to a combination of their:

- Non-uniform global data coverage, and

- Relatively high uncertainty, in the case of non-radiometric measurements.

5.2 The GHRSST project would like to establish closer links to the Ship Observations Team (SOT), to address both these issues, as improved coverage and uncertainties of SST data from ships would benefit a number of areas within GHRSST, not least in:

- Satellite SST validation
  - Through the provision of additional ship-based radiometric skin SST measurements
  - By identifying existing ships that do provide reliable temperature measurements at cooling water intakes
  - As a ship generally samples the oceans more extensively than a drifter does, in a given month a single ship might take measurements across the Atlantic, Pacific and Indian oceans. Although these data have limited benefit for polar-orbiters, they can be utilised for validation of geostationary satellite data.
- Reanalysis
  - It is well known that the coverage of drifting buoys has increased with time while the coverage of ships has decreased (see for example Reynolds et al., 2002). However, ship data will be extremely useful to the GHRSST reanalysis project to reprocess satellite data records back to 1981, as they provide the largest potential source of reference data in the 1980s.
- Diurnal warming studies
  - In principle, ships could offer coincident measurements at multiple depths to assist in studying the processes involved with diurnal warming. Although there are significant practical problems, with no obvious solution at present, the possibility of obtaining such measurements does merit further study.

6. Recommendations

6.1 To maximise the impact and benefit of existing and future SST measurements from ships, GHRSST recommends that the SOT consider:

(i.) Adding the provision of radiometric skin SST data to its portfolio of measurements.
(ii.) Using GHRSST data to characterise the uncertainties of non-radiometric SST measurements from existing ship data.
(iii.) Establishing a working group to collaborate with GHRSST to better define requirements for measurements of SST from ships.

7. Summary

7.1 In summary, GHRSST now provides a suite of operational global high-resolution SST products in near-real-time on a daily basis. Soon, GHRSST will provide long-term SST climate data records covering the satellite era from 1981 onwards. These products have a limited requirement for ship-borne SST data due to their geographical coverage and usually high measurement uncertainty. GHRSST would like to work with the SOT to address both these issues. The SOT is invited to consider the above recommendations as the first step in this process.

References

Barton, I. J., et al., 2004. The Miami2001 Infrared Radiometer Calibration and Intercomparison.

Part II: Shipboard Results, J. Atmos. Ocean. Tech., 21, 268-283.
Donlon, C. J., et al., 2002. Toward Improved Validation of Satellite Sea Surface Skin temperature Measurements for Climate Research, J. Climate, 15, 353-369.
Donlon, C., et al., 2007. The Global Ocean Data Assimilation Experiment High-resolution Sea Surface Temperature Pilot, Bull. Amer. Meteor. Soc., 88, 1197-1213.
Donlon, C., et al., 2008. An infrared sea surface temperature autonomous radiometer (ISAR) for deployment aboard volunteer observing ships (VOS). J. Atmos. Ocean. Tech., 25, 93–113.
Minnett, P. J., et al., 2001. The marine-atmospheric emitted radiance interferometer: A high-accuracy seagoing infrared Spectroradiometer, J. Atmos. Ocean. Tech., 18, 994–1013.
O'Carroll, A. G., et al., 2008. Three-way error analysis between AATSR, AMSR-E, and in situ sea surface temperature observations, J. Atmos. Ocean. Tech., 25, 1197-1207
Reynolds, R. W., et al., 2002: An improved in situ and satellite SST analysis for climate, J. Climate, 15, 1609-1625.
Rice, J. P., et al., 2004. The Miami2001 infrared radiometer calibration and intercomparison: 1. Laboratory Characterization of Blackbody Targets, J. Atmos. Ocean. Tech., 21, 258– 267.
Smith, D. M., et al., 2001. Calibration of the AATSR Instrument, Adv. Space Res., 28, 31-39.
Worley, S. J., et al., 2005: ICOADS Release 2.1 data and products, Int. J. Climatol., 25, 823- 842.

____

APPENDIX D

REPORT BY THE FERRYBOX PROJECT
FERRYBOX: STATUS AND RECENT ACHIEVEMENTS

(report submitted by Wilhelm Petersen, GKSS Research Centre Institute for Coastal Research/Operational Systems, Germany, and Friedhelm Schroeder, National Oceanographic Centre (NOC), Southampton, United Kingdom)

1. Introduction:

1.1 Until recently a serious hindrance to understanding and forecasting, the state of marine systems has been the lack of monitoring systems that provide on-line data, and observations with sufficient spatial coverage and temporal resolution to give a true view state and change. To overcome this hindrance developments have been pursued in measurement technologies, data logging and ship-shore communications. It is now possible to work with merchant shipping companies to collect this much-needed data autonomously in a cost effective manner.

2. Present status of FerryBox activities:

2.1 The *FerryBox* concept is to fit robust autonomous measuring systems to ferries and merchant ships, which run regular routes. The concept was tested during the EU FP5 project *"FerryBox"*, which ran from 2002 to 2005. The core work of the *FerryBox* project focused on the use by all the participants of four "core" sensors for- temperature, salinity, chlorophyll-fluorescence and turbidity along with testing of a wider range of sensors by individual groups on the routes. This project was highly successful and demonstrated the value of the measurements made as an integrated part of the marine monitoring cycle (Petersen et al. 2007). It is noteworthy that even after finishing this project most of the FerryBox systems kept running just financed by the national research institutions. The map below shows *FerryBox* routes operating in 2008 on the NW European Shelf aimed at providing operational monitoring data.

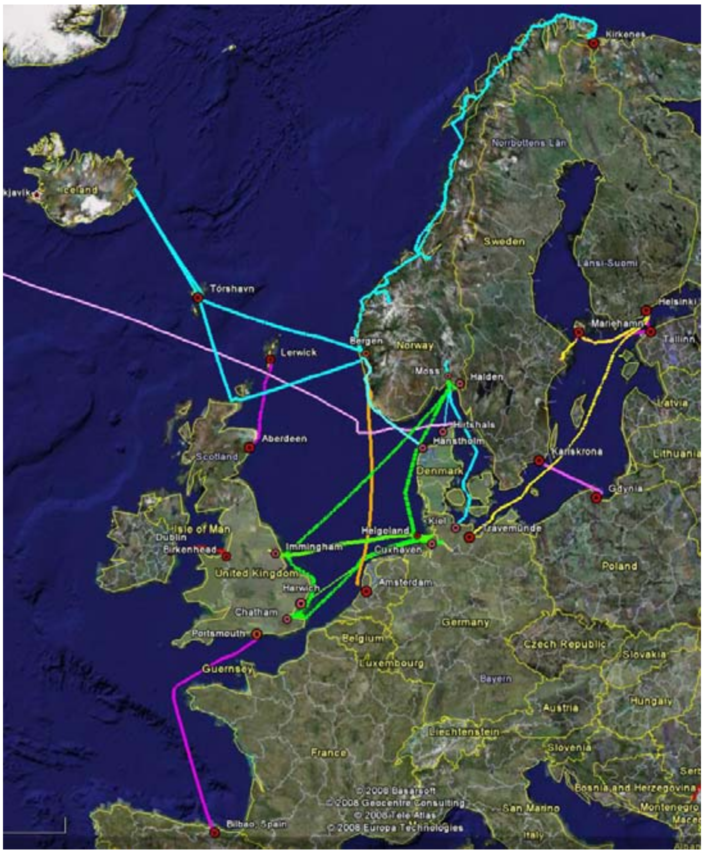


Figure 1: FerryBox routes in the European Seas (status December 2008)

2.2 Routes are operated by institutions in England (NOCS, POL & UEA), Estonia (EMA), Finland (FIMR), France (IFREMER), Germany (GKSS, IFM & IOW), Greece (HMCMR), Norway (NIVA & BCCR), Poland (IMGW), Netherlands (RNIOZ), Scotland (FRS), Sweden (SMHI) and Poland (IMGW). Many of the systems have been developed to support the requirements for both scientific and marine management data. For example, work by the Finnish Marine Institute (now Finnish Environment Institute SYKE) saw the incorporation of the FerryBox in to the Alg@line system (www.algaline.fi) aimed at improved surveillance of the harmful and nuisance blooms of algae that plague the Baltic (Backer et al., 2008).

2.3 Even basic sensors such as salinity proved to provide scientifically interesting data for example on water transport when collected, as part of a consistent time series (Kelly Gerreyn et al., 2006) and it is an important variable for any coastal monitoring programme. Even if most VOS (voluntary observing ship) systems only sample surface waters, the frequency of measurement in time and space and in many instances their real time, capability makes it a unique observation facility, highly complementary to other observations from fixed buoys and research vessels. In addition, profiling instruments such as ADCPs (Acoustic Doppler Current Profiler) can enable VOS ships to, successfully see below the surface (Flagg et al., 2006; Buijsman & Ridderinkhof, 2007) and biological information can be gained from the use of scientific echo sounders (Griffiths & Diaz, 1996). In the Mediterranean Sea VOS are widely used as launcher for XBT (expendable bathy thermographs) profiling the water column for temperature (e.g. Fuda et al., 2000).Also a combination with towed instruments would be possible such as with the CPR (Continuous Plankton Recorder).

2.4 FerryBox (http://www.ferrrybox.org) is about a partnership between scientists and the companies operating ferries and other merchant ships. Systems have also been in operation for sometime in Japan, Korea and in the USA (Ensign & Pearl, 2006) and elsewhere. The FerryBox community is evolving from single institute-driven VOS lines to strategic multi-partner and trans-boundary work. In Europe, such coordination is sought as a pillar for the future deployment of pan-European coastal observing systems and will facilitate the implementation of the EU's Marine Strategy Framework and the Water Framework Directives.

2.5 FerryBox systems have considerable potential for increased use as part of marine management systems around the world, particularly making it possible to monitor the world's major estuaries ands coastal waters such as those of eastern Asia. A particular success has been achieved for the monitoring of air-sea fluxes of carbon dioxide through the IOCCP International Ocean Carbon Coordination Project VOS (Voluntary Observing Ship) operations (e.g. Schuster and Watson, 2007). It is important that this work is continued and work particularly in shelf seas is expanded. Coastal carbon issues are important in the international (UN) agenda because it is felt that management and policy decisions are more easily made at the local and regional level. The coastal carbon system needs to be better monitored in respect to the overall carbon cycle issues and natural carbon sequestration processes. The FerryBox approach outlined here is probably the only way that can provide the needed monitoring coverage of carbon import and export in shelf seas and acidification in the coastal zone cost effectively.

3. Integration of FerryBoxes into observing systems networks

3.1 Eutrophication remains an important environmental issue globally and within Europe. Schemes for monitoring and assessment of eutrophication have been put in place so that individual countries can comply with international conventions (OSPAR and HELCOM) and a range of European Directives (e.g. Nitrates Directive, Water Framework Directive). OSPAR defines eutrophication as the enrichment of waters by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned. To meet OSPAR needs for detection and diagnosis of eutrophication monitoring is carried out for a range of assessment parameters. These include the level of over-winter nutrients, N:P ratios, growing season chlorophyll concentration, abundance of phytoplankton indicator species, shifts in phytoplankton species composition and levels of dissolved oxygen concentration. Multi-year trends in ambient nutrient concentration and riverine nutrient inputs are also taken into account in determining the outcome to an assessment.

3.2 Traditional monitoring of coastal and offshore waters has relied upon intermittent sampling using survey vessels. Such an approach is costly and given the significant temporal and spatial variability of the eutrophication assessment parameters (e.g. phytoplankton blooms, storm induced increased freshwater input) these can lead to large uncertainties in the accuracy of data used for assessments. In Europe, this uncertainty, in the evidence base for environmental assessments is a serious concern when the outcome to an assessment may be subject to legal scrutiny with the threat of punitive fines and costly remediation. More recently novel monitoring methods based on the use of FerryBoxes using ships of opportunity or fixed point monitoring from buoys have begun to be used. As a result there has been, for some countries, a step-wise increase in the size of the database used to assess eutrophication leading to greater accuracy and robustness in assessments, thus improving reliability. After data processing, analysis, the information is returned to the managing environmental agencies for assessment and thence to policy makers.

3.3 The value of this integrated approach required by OSPAR and other authorities is beginning to be recognised. Concerted efforts are underway to expand the approach to ensure that the benefits that can be achieved are fully realised. An objective of the EU's new maritime policy is to integrate existing, but fragmented initiatives in order to facilitate access to primary data for public authorities, maritime services, related industries and researchers. Marine related data are available from many sources but assembling them for particular applications takes considerable effort and there is no overall policy to keep them for posterity. The EU Commission therefore set up EMODNET (European Marine Observation and Data Network) to open up opportunities for high technology commercial companies in the maritime sector to improve the efficiency of activities such as marine observation, management of marine resources and marine research in European laboratories. The EMODNET vision is for an end-to-end, integrated and inter-operable network of European marine observations, data communications, management and delivery systems, supported by comprehensive user-oriented toolkits (http://www.esf.org/publications/marine-board.html).

3.4 In practice these ideas are being realised by practical and more local initiatives such as the EMECO (European Marine Ecosystem Observatory, http://www.emecogroup.org) which are actually setting about providing a framework and the tools to integrate data sources from different agencies, using different platforms (ships, buoys, satellites) from different countries. The building blocks of EMECO include national marine monitoring programmes, regional marine and coastal observatories, FerryBox routes, buoy networks and satellite remote sensing. This will provide integrated information products via web interfaces that will form part of the evidence base to underpin regional scale assessments of eutrophication and in the future of ecosystem health. EMECO will also help to meet the new challenges posed by the new European Marine Strategy Framework Directive (MSFD) and the implicit need to deliver an ecosystem approach. The MSFD requires a wide range of marine scientific evidence to support the ecosystem approach. The evidence required will be cross-boundary and will be based on observations from physics to fish over wide time and space scales. Delivery of an ecosystem approach at basin scale can only be done through collaboration and coordination of effort between agencies and countries.

3.5 One example of integrated monitoring in which FerryBoxes play a prominent role is the coastal observing system COSYNA (http://www.cosyna.de) in the German Bight of the North Sea. The system that is under construction and, consists of the following observational components (see Figure 2): Three FerryBoxes routes are included along with two measuring poles in the Wadden Sea, two coastal X-band radar stations, a HF Radar network that covers the German Bight, wave-rider buoys for calibration of the radar measurements and two stationary FerryBox type instrument modules on shore. These modules operated by the GKSS research centre and are complemented by several stations operated by other institutions (BSH, AWI, and University of Oldenburg). In the near future additional sensors will be installed on existing research platforms and wind energy platforms.

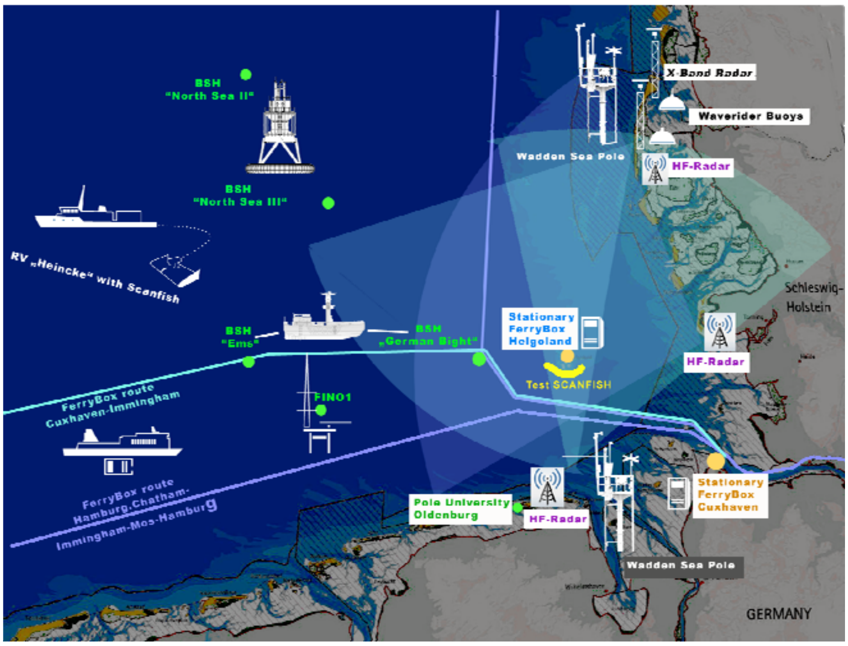


Figure 2: Coastal Observatory COSYNA in the German Bight (North Sea)

3.6 These automated and remote-controlled measurements are complemented by regular ship cruises (four times per year), which include continuous surface measurements (using FerryBox type systems on the research ships) and continuous measurements with an undulating tow-fish in the depth. Under suitable weather conditions, data from satellites (e.g., ENVISAT) are used to get a better spatial coverage of SST, chlorophyll, suspended sediments and yellow substance. Data from all these systems are quality-controlled by the project partners and stored in a database with web access (http://www.coastlab.org). Quality-assured, near-real- time COSYNA data from observations are assimilated into models in order to provide reliable now-casts and short-term forecasts. The systematic coupling of observations and forecasts will be the basis for scientific applications that support different end users from science and political bodies to make environmental management decisions.

3.7 For example, FerryBoxes will a measure a wide range of parameters (S, T, O2, CO_2, pH, turbidity, chlorophyll (fluorescence), nutrients, species composition (based on discrete water samples), algal groups (fluorescence spectra). This suite of data together with remote sensing, and other observational data and model outputs, will form the basis for a synoptic description of the system. Data collected by FerryBoxes are being used directly as continuous ground truth data for remote sensing: Using appropriate transport models the data of the FerryBox and the satellite over flight are matched temporally and spatially (e.g. Petersen et al., 2008).

4. JCOMM and FerryBox:

4.1 The FerryBox concept is already in use globally in Australia, Japan and the USA for example. It has considerable potential for expansion particularly for the study of inputs from the world's major riverine inputs such as the Amazon and those following into the China Seas. This aspect of the work should be strongly encouraged. Similarly, it has the potential to provide key information on changing levels of productivity helping fisheries science in many areas of the world. As such, FerryBoxes can make an important contribution to the development of a global system for observing the coastal ocean. For work in developing countries, the FerryBox approach is particularly important because it is highly cost effective. It can enable the Coastal Module of GOOS to happen in the third world. Here, the JCOMMOPS (Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology

(JCOMM) Observing Platform Support Centre) can play an important role.

4.2 A community white paper (Hydes et al.) is being prepared for the OceanObs'09 Symposium to be held in Venice 21-25 September 2009. This paper will outline the state-of-the-art in the use of commercial ships to, routinely collect biogeochemical and hydrographical data with FerryBox systems and will describe recent developments in technology and the application of such systems around the world. Further, on it will consider emerging technologies and those required to improve the effectiveness of such systems. The OceanObs'09 conference will provide the opportunity to discuss how local FerryBox operations might be coordinated globally through JCOMM to provide input to a Coastal GOOS system.

4.3 On longer time scale a SCOR working group 'OceanScope' will start work in 2009 to look at the long term future and enhancing the partnership between the ocean observing community and merchant marine shipping industry. The targets of OceanScope are 1) an enhanced ability to identify routes and operators in all oceans, 2) new instruments and technologies to be developed and optimized for automated operation on commercial vessels, and 3) real time data streams, automated data processing and distribution to the user community. One option for implementation of this concept would be through the establishment of an international agency, something like space agencies, which are designed to operate on decadal time lines appropriate to the challenges faced.

5. Future Improvements and Developments of FerryBox Systems

In the future FerryBox systems have to be developed further on in order to increase the possibilities of automated observations on ships of opportunity. This will be in particular:

- preparing already new build ships with possibilities to connect a FerryBox system (water inlet, infrastructure for external communication...)
- developing robust systems, self cleaning or easily cleaning by the ship crew in order to keep the maintenance to a minimum
- further development of robust sensors suitable for autonomous operation in FerryBox systems:
    - more robust nutrient analysers
    - high precise pH including alkalinity (under development) for budgeting the complete carbonate system (ocean acidification)
    - better quantitative as well as more specific algal detection by gene probes, PSICAM (under development) for better estimation of primary production and HAB detection
    - new sensors for zooplankton (e.g. video plankton recorder)

References

Backer, H.; Leppänen, J-M., (2008) The HELCOM system of a vision, strategic goals and ecological objectives : implementing an ecosystem approach to the management of human activities in the Baltic Sea – Aquatic conservation: marine and freshwater ecosystems 18:321-334.

Buijsman, M.C. and H. Ridderinkhof, 2007. Long-term ferry-ADCP observations of tidal currents in the Marsdiep inlet. J. Sea Res. 57, 237-256

Ensign, S.H. and HW. Paerl. 2006. Developing an unattended estuarine nutrient monitoring program using ferries as data-collecting platforms. Limnology and Oceanography Methods 4:70-76

Flagg, C. N., M. Dunn, D.-P. Wang, H. T. Rossby, and R. L. Benway (2006), A study of the currents of the outer shelf and upper slope from a decade of shipboard ADCP observations in the Middle Atlantic Bight, *J. Geophys. Res.*, 111, C06003, doi:10.1029/2005JC003116.

Fuda, J.; Millot, C.; Taupierletage, I.; Send, U.; Bocognano, J. (2000). XBT monitoring of a meridian section across the western Mediterranean Sea Deep Sea Research (1) 47, 2191-2218.

Griffiths G.1; Diaz J.I. (1996) Comparison of acoustic backscatter measurements from a ship-mounted Acoustic Doppler Current Profiler and an EK500 scientific echo-sounder. ICES Journal of Marine Science, 53, 487-491

Kelly-Gerreyn, B.A., Hydes, D.J., Jegou, A.M., Lazure, P., Fernand, L.J., Puillat, I.. Garcia-Soto, C., 2006. Low salinity intrusions in the western English Channel. Continental Shelf Research, 26, 1241-1257

Petersen, W., Colijn, F., Hydes, D., Schroeder, F., 2007. FerryBox: From On-line Oceanographic Observations to Environmental Information.EuroGOOS Publication No. 25. EuroGOOS Office, SHMI, 601 76 Norkoepping, Sweden ISBN 978-91097828-4-4

Petersen, W., Wehde, H., Krasemann, H., Colijn, F., Schroeder, F., 2008. FerryBox and MERIS Assessment of coastal and shelf sea ecosystems by combining in situ and remotely sensed data. Estuarine, Coastal and Shelf Science 77, 296-307

Schuster, U., A. J. Watson. A.J., (2007). A variable and decreasing sink for atmospheric CO2 in the North Atlantic, J. Geophys. Res., 112, C11006, doi:10.1029/2006JC003941

APPENDIX E

ALLIANCE FOR COASTAL TECHNOLOGIES PERFORMANCE MEASURES AND COMMUNITY OUTCOMES

(report submitted by Mario Tamburri, Alliance for Coastal Technologies, Chesapeake Biological Laboratory, University of Maryland, USA)

Below are a few examples of the products, services, and impacts of ACT over the past seven years, based on the program's five community-established priorities. Additional detailed information is available upon request and at www.act-us.info.

1. TRANSITION EMERGING TECHNOLOGIES TO OPERATIONAL USE RAPIDLY AND EFFECTIVELY

- *"The user community is most likely to adopt new approaches and technologies when there is broad cross-agency consensus that they are applicable and mature. Agencies should be active participants in developing cross-agency state-of-the science assessments to create consensus." "The evaluation studies conducted by the Alliance for Coastal Technologies (ACT) are a good example of the positive impact of this model."*
  - Ocean Research and Resources Advisory Panel (ORRAP)
  Best Practices for Increasing the Impact of Research Investments (2007)

- *"As a global supplier and leader in water quality sensing technologies, field portable and ruggedized instrumentation systems, and automated and autonomous data collection platforms, the Alliance for Coastal Technologies has made a measurable and positive impact on our business. Specifically, ACT Workshops have helped focus and steer our marketing, and research & development initiatives, ACT Technology Evaluations have provided us with valuable information and feedback on the state of our own technology, allowing us to make changes, modifications, and adjustments to our products, designs, and future research & development activities, and ACT has helped accelerate the transition of our newer technologies toward a more effective and wide scale operational use."*
  - Kevin McClurg, Sales and Business Development Manager
  YSI Inc.

2. MAINTAIN A DIALOGUE AMONG TECHNOLOGY USERS, DEVELOPERS, AND PROVIDERS

- Visitors to ACT website: ~ 1,500/day and ~ 45,000/month with 46% new and 54% return
- Companies / Instruments listed in the ACT Technologies Database: 432 / 4,021
- Visitors to ACT Technologies Database: ~ 400/day and > 10 minutes/visit
- ACT Technology Training Events conducted: 3 with ~ 150 participants
- *"A direct result of the ACT Workshop on Underwater Passive Acoustic Monitoring of Remote Regions was the formation of partnerships between academics, managers, and military personnel to use an emergent technology to solve a priority marine conservation issue; enforcement of fisheries regulations in remote areas within the newly formed Papahanamokuakea Northwestern Hawaiian Islands Marine National Monument… ACT is also partnering with Conservation International on the new Main Hawaiian Islands Seascape Strategy, a $10 million dollar privately funded program to improve the social, cultural, economic, and environmental health of the nearshore marine environment. Through identification of science goals and technology needs, and through the use of the ACT workshop format to define partnerships between diverse stakeholder*

groups, ACT is directly involved in the formation of a pioneering marine conservation program that is poised to be a model for worldwide replication"
- Melissa Bos, Main Hawaiian Islands Seascape Strategy Facilitator
Consultant to Conservation International

3. IDENTIFY TECHNOLOGY NEEDS AND NOVEL TECHNOLOGIES

- ACT Technology Workshops conducted: 39 with > 1,500 participants
- Technology Workshop reports printed and distributed to date: ~ 25,000
- Technology Workshop reports downloaded from website: >30,000/year

- *"As a result of information derived from ACT's Towed Vehicle Workshop, Chelsea Instruments undertook an internal design and production review with the aim of reducing costs. After working with several companies in China and Taiwan, Chelsea was able to reduce the cost of our towed vehicle fairing system, saving up to $30k per technology package for the end user."*
  - Richard Burt, Marketing Director
  Chelsea Instruments, Ltd., UK

4. DOCUMENT TECHNOLOGY PERFORMANCE AND POTENTIAL

- ACT Technology Evaluations conducted / underway: 37 Instruments tested at the 8 Partner field sites
- Companies participating in ACT Technology Evaluations: 24 companies from 7 countries
- ACT Technology Evaluation reports printed and distributed to date: ~ 2,500
- ACT Technology Evaluation reports downloaded from website: > 25,000/year
- *"As the lead agency for monitoring and assessing the health of the Chesapeake Bay, Maryland DNR is continually evaluating new monitoring and assessment technologies. ACT has played a key role in this process, as DNR does not have the resources to evaluate the myriad of new monitoring technologies and instrument manufacturers to select the most accurate and reliable sensors. Participation in ACT activities has saved DNR countless dollars and hundreds of hours of staff time, provided the justification for purchasing and deploying specific instruments, and ultimately, provided us with the means to better understand the status of Bay."*
  - Bruce Michael, Director of Resource Assessment Service
  Maryland Department of Natural Resources

- **"***Within the grand scheme of national research to applications transitions, I believe the ACT has played a unique and invaluable role in providing an unbiased platform for fostering emerging technologies within the ocean science and monitoring community. This has proven very useful to both the public and private sectors. As an example, WET Labs entered its products into two recent ACT evaluations in 2005 and 2006. Within the past year, I can recall at least three separate NOAA groups remark on the resultant ACT reports when considering purchase of our company's products. Moreover, sales of our related product lines have grown by well over 50% during the past year – in part, attesting to the adoption of these tools by the water monitoring community."*
  - Casey Moore, President
  WET Labs, Inc

5. Provide the Integrated Ocean Observing System (IOOS) with Information Required for the Deployment of Reliable and Cost-Effective Networks

- Collaborated with IOOS, NDBC, and the US Army Corps of Engineers on the development of a National Operational Wave Observing Plan and with IOOS on a National Surface Current Plan.
- Collaborating with Marine Metadata Interoperability (MMI) program and Southeastern Universities Research Association (SURA) on the development of a National Data Integration Framework and sensor interoperability
- *"ACT has contributed to the ease with which NANOOS has evaluated technologies for incorporation into our Regional Coastal Ocean Observing System. Individual leaders within NANOOS have attended ACT workshops that have provided a venue in which to reach both users and industry representatives to discuss technology strengths and limitations. These discussions, particularly those on HF wave technology and nutrient sensors, have influenced decisions NANOOS has made on investing in technologies as well as to clarify the needs of the coastal observing community for manufacturers. The capability to talk directly with industry is particularly powerful when considering the future build-out of IOOS. As we build our observing system, the testing that ACT does is a great money and time-saving resource."*
  - Jan Newton, University of Washington
  Executive Director, Northwest Association of Networked Ocean Observing Systems

____

APPENDIX F

REPORT BY THE OCEANSCOPE WORKING GROUP OF THE SCIENTIFIC COMMITTEE ON OCEANIC RESEARCH (SCOR) AND THE INTERNATIONAL ASSOCIATION FOR THE PHYSICAL SCIENCES OF THE OCEANS (IAPSO)

(report submitted by Dr Tom Rossby, Graduate School of Oceanography, University of Rhode Island, USA)

1. Introduction

Thanks to the positive reception of our presentation to JCOMM/SOT-IV two years ago, regarding a proposal to SCOR '*To develop a new paradigm for working with the shipping industry for the systematic and sustained observation of the upper ocean water column…'* the proposed working group has been approved and will be co-sponsored by both SCOR and IAPSO. The working group, called 'OceanScope', will address the compelling need for new technologies with which to monitor currents, physical, chemical and biological parameters systematically at high horizontal resolution. The first meeting will take place in Montreal July 17-19, 2009. The charge of the working group will be to review and propose possible new and emerging technologies that can be adapted to the merchant marine shipping environment. The product of the working group will be the 'OceanScope' Implementation Plan for realizing these ideas.

2. Background

2.1 Repeat sampling along designated lines confers a tremendous advantage because patterns of change and their magnitudes can be identified and quantified with unparalleled accuracy. The success of VOS and SOOP programs bear witness to the possibilities provided by the merchant marine fleets of the world. These programs focus on the marine atmosphere and surface waters. There is a compelling need to reach down into the water column as well. The most energetic scales of variability and thus the ones that control much of mixing in the ocean, are set by the radius of deformation, O(10-40) km. This is a very small scale and one that is missed by all in-situ observation systems! Discussions that took place at a well-attended session on VOS-based observations held at the 2008 Ocean Sciences Meeting highlighted an increased interest in working with the merchant marine, while at the same time noting the difficulties and challenges in doing so.

2.2 The use of merchant marine vessels to observe the ocean synoptically is far from achieving its enormous potential. The reasons can be briefly summarized in a few words: lack of suitable instrumentation and lack of systematic access to ship platforms - each checkmating the other in a catch-22 loop. In terms of subsurface physical measurements, XBTs is the only instrument available. In some cases, their deployment requires technical support aboard ship such that the cost per profile is comparatively high. Their widespread use of VOS has been discouraged by these high costs, in conjunction with the challenge of gaining the requisite very regular access to the merchant marine fleet. Because the "market" has, remained small there has been little concerted effort to develop an automated inexpensive technique for profiling temperature, much less salinity or other water properties. ADCPs, although they work reasonably well on their own, are not really designed for the automated deployment aboard commercial vessels. For example, the computer controls and data storage of available ADCPs need to be ruggedized with industrial-strength uninterruptible power supplies (UPS). It is possible to build ruggedized instrumentation, but this will not happen until a broader demand for such equipment develops. Fully automated ways of accessing and distributing the large data sets generated need also to be developed. Some recent developments have taken place that help show what may be possible. These include the 'Ferry-box' and the 'SeaKeeper 1000 System', both of which measure sea surface temperature and conductivity. They may include pH for acidity, fluorometers, and other sensors to measure turbidity, oxygen, nutrients and pCO_2 with real-time transmission of raw data via satellite, but even these systems require regular attention and calibration several times a year.

3. The Concept

The 'OceanScope' concept proposes a new paradigm for the systematic and sustained observation of the ocean water column. It seeks to develop a partnership between the ocean observing community and merchant marine shipping industry so that a number of synergies could be realized, which to date have not been possible, notwithstanding a very high level of cooperation between individual ship operators and scientists. (In fact, successes have stimulated this initiative.) These include 1) an enhanced ability identify routes and operators in all oceans, 2) new instruments and technologies developed and optimized for automated operation on commercial vessels, and 3) real time data streams, automated data processing and distribution to the user community. One option for implementation of this concept would be through the establishment of an international agency, something like space agencies, which are designed to operate on decadal time lines appropriate to the challenges they face.

SCOR (Scientific Committee on Oceanic Research) and IAPSO (International Association for the Physical Sciences of the Oceans) have reached a preliminary agreement to support a working group assisted by a number of associate members, representing a unique assembly of ocean scientists with experience of working with the merchant marine, engineers, sensor and instrument experts, shipping company representatives and senior merchant marine officers, to design and write an Implementation Plan for 'OceanScope'.

4. Working Group Terms of Reference (ToR)

4.1 Our overall objective will be to develop an integrated implementation plan for systematic observation from merchant marine vessels. To give the working group focus and direction, the following Terms of References have been agreed upon by the organizers and sponsoring agencies. That said, as soon as the working group convenes, its first order of business would be a review of the ToR and approval as stated or after appropriate refinement.

1. Identify ocean observation and scientific needs with respect to parameters and geographic location
2. Given these needs identify and prioritize marine routes for sustained ocean observation
3. Classify and identify commercial vessel types suitable for sustained observation
4. Identify available technologies that can enhance vessel capability for ocean observation
5. Identify and prioritize instrument needs to meet *future* mission requirements
6. Identify and develop procedures (hardware and software) to meet communication needs
7. Develop procedures and algorithms for managing data flow, handling, and archival. The address related issues of data ownership (e.g. when routes occur within national within Exclusive Economic Zones), data availability and data dissemination. In general, the expectation is that the data would be made freely and widely available to all interested users.
8. Address what kind(s) of organizational structure(s) will best serve to initiate, implement and sustain an integrated international merchant-marine based ocean observation program, linked closely to existing ocean observing systems and programs with access to appropriate and sufficient long term funding sources – e.g., an "Ocean (or Interior) Space Center"- hereafter termed an OSC.

4.2 The details behind these are quite interesting and will be discussed at the JCOMM/SOT-V meeting in May 2009.

5. Timeline (assuming a yearly meeting schedule)

Year 1:

- Review and adjust as necessary the TOR
- Produce three-year work/action plan for the Working Group
- Complete tasks as defined at first meeting
- Begin discussion and conceptual design of an appropriate organizational structure
- Review organizational paradigms in relation to existing ocean observing systems
- Explore funding sources/structures

Year 2:

- Complete and distribute first interim report
- Review and develop as necessary the Work Plan for years 2 and 3.
- Complete a proposal for the implementing body (e.g. an OSC).
- Develop funding (prepare and submit proposals to various national and international agencies and private sources based upon the interim report)

Year 3 (with or without WG meeting at this time; TBD):

- Issue final report
- Complete and submit a series of papers for a special edition of a journal or book.
- Revise – as appropriate – the implementation proposal
- Explore further funding sources. It is hoped, by this stage that some funding will be in place to initiate the program including a start-up of the final implementing body, and preliminary funding for commercial instrument and software development.
- Review and decide what structures will need to be put in place to carry forward the deliberations and plans of the Working Group into the future.

6. Summary

The focus of the working group will be on developing skills and technologies to observe the water column on a systematic basis. This is where marine science is hurting particularly badly. As noted, we do not today have any means of observing, let alone resolving the most energetic scales in the ocean today. We cannot even measure currents and transports accurately. Vessels in regular traffic can change that completely for with remote sensing acoustic and optical techniques we have to ability to resolve currents, biomass, mixed layer depth, perhaps even profile temperature continuously. There is much horizontal fine structure in the ocean (fronts being the obvious example) that remains transparent to observation. Until we can quantify and track these, we will have a very incomplete picture of the dynamical structure of the oceans, and hence of the processes that in the end control the large-scale distributions of important dynamical, physical, chemical and biological patterns in the ocean.

APPENDIX G

REPORT BY THE SEAKEEPERS SCOCIETY

(Letter from John Englander, CEO, SeaKeepers Society)

THE INTERNATIONAL SEAKEEPERS SOCIETY

March 31, 2009

Mr. Etienne Charpentier
World Meteorological Organization
7 bis, Avenue de la Paix
Case Postale No. 2300
CH-1211 Geneve 2
Switzerland

Sent via e-mail attachment

Dear Mr. Charpentier,

This is in response to the WMO letter dated March 12, 2009. We sincerely appreciate the invitation sent by Mr. Zhang on behalf of the WMO and the IOC inviting SeaKeepers to attend the JCOMM SOT-V meeting May 18. Unfortunately, this becomes our opportunity to inform you and the other parties of our current status and unlikely ability to accept your invitation.

As you are aware SeaKeepers started in 1998 with the idea to advance a new Volunteer Observing System, equipping private yachts, cruise ships, freighters and tankers with highly automated systems for meteorological and oceanographic observing.

We are pleased to state that today we have some 57 installed systems worldwide and that our experimental efforts have proven the concept. Installations include large private yachts, cruise ships, NOAA vessels, University Research platforms, and a USCG Icebreaker. The system, now called the SeaKeeper 1000™, is described in the attached PDF.

For the last decade we have supported this system strictly by private donations from citizens of 14 nations. The only exception to this is that NOAA assists with our satellite transmission fees in order to get the weather data in a timely manner. We should also point out that we are an independent NGO, having separated from the University of Miami more than 5 years ago.

Our private donors have been very generous over the years, inspired to advance the technology, generating good economical data for marine meteorology, oceanography, and climate studies. However they now take the position that if such a network is valuable to the world community, that there must be support by governments or intergovernmental agencies and institutions to keep it functioning. The current economic crisis has had a terrible impact on our donations. We project to run out of operating funds by the end of June.

While we are engaged in some discussions that might extend this financial projection, we feel the need to advise both the WMO and the IOC of our status, given your leadership roles. Thus it does not seem practical or appropriate for us to attend the Geneva meeting to discuss technical aspects and the ongoing operation of our system.

4101 Ravenswood Road, #128 • Ft. Lauderdale, FL 33312 USA • Tel. 1 954-766-7100 • www.seakeepers.org

The annual expense to keep the 57 systems operational and calibrated is approximately US$ 500,000 annually. While we have appealed to NOAA to explore ways to take over this infrastructure, to date we do not have any positive solution. Given the great need for weather, ocean, and climate data, we would hope that someone has an idea as to how this program might be funded or taken over by a suitable agency or institution.

Our system is extremely versatile and cost effective. It samples all parameters every few seconds, then logs and transmits at set intervals. Salinity and temperature are typically measured to a precision of 0.05 or better. The modular architecture for ocean and atmospheric sensors seems timely given the demand for measurements of such parameters as CO_2, CH_4, O_3, etcetera. Over the last 10 years, we have achieved accurate measurements for US$ one cent each, all costs included. The opportunity to use thousands of yachts and merchant vessels seems very timely given the need for better met and climate information, at higher temporal and spatial resolution. (Last week we attended a very encouraging workshop on this subject in London hosted by IMarEST that reinforced the opportunity for this vessel-of-opportunity effort to be expanded.)

We are interested and available to travel to make any presentation regarding the larger question of possible ways to support, fund, or take over our efforts of the last decade while it is still operational. For your interest, our technical support continues under the direction of Technical Director, Mr. Geoffrey Morrison here in Fort Lauderdale, should you have any inquiries for him.

We believe that this innovative program must be continued. Our center can be relocated anywhere; indeed the ships are deployed globally. Any ideas or response from you, your committee, or others at the WMO or IOC are very welcome. Please distribute this message to all those copied on your letter of invitation so that they might understand our regrettable situation.

Respectfully,

John Englander

John Englander, CEO
International SeaKeepers Society

Appendix: SeaKeeper 1000™ Booklet (12 page)

THE SEAKEEPER 1000™

Automated, Data Logging, Modular, Transmitting
Ocean, Weather & Climate Monitoring System

The International SeaKeepers Society's current fleet of 55 deployed systems is a major contributor to daily weather forecasts, to understanding and predicting climate change, and to tracking such critical issues as ocean acidification. This patented technology is endorsed and used by leading institutions around the world.

Inside:

- **FLEET DATA REPORT**
  90 Million Scientific Measurements Taken In 2008
- **REAL-TIME DATA DISPLAY**
  Compelling New Graphic Interfaces
- **ENDORSEMENTS**
  Global Ocean Leaders Praise Seakeeper 1000™
- **FINANCIAL SUMMARY**
  Calibrated, High-Resolution Data at Less Than 2 Cents Per Measurement

THE INTERNATIONAL SEAKEEPERS SOCIETY

The International SeaKeepers Society | U.S. Office & Laboratory
4101 Ravenswood Road | Suites 111 & 128 | Fort Lauderdale, FL 33312
+1.954.766.7100 | www.seakeepers.org

The SeaKeeper 1000™ System

OCEAN, WEATHER AND CLIMATE MONITORING UNIT

The SeaKeeper 1000™ is a fully automated *flow-thru* unit that samples, measures, records and then transmits oceanographic and atmospheric data (*i.e.* climate data) via satellite to scientists and resource managers around the globe.

More than 55* systems are installed worldwide on a variety of platforms (with 17* more in the process of installation), all of which are capable of carrying additional FSIS™ compliant sensors.

SEAKEEPER 1000™

CURRENT DEPLOYMENTS

- PRIVATE YACHTS
- COMMERCIAL SHIPS
- CRUISE SHIPS
- NOAA BUOYS
- CAR FERRIES
- LIGHTHOUSES
- SCRIPPS PIER
- USCG ICE BREAKER
- NOAA RESEARCH VESSELS

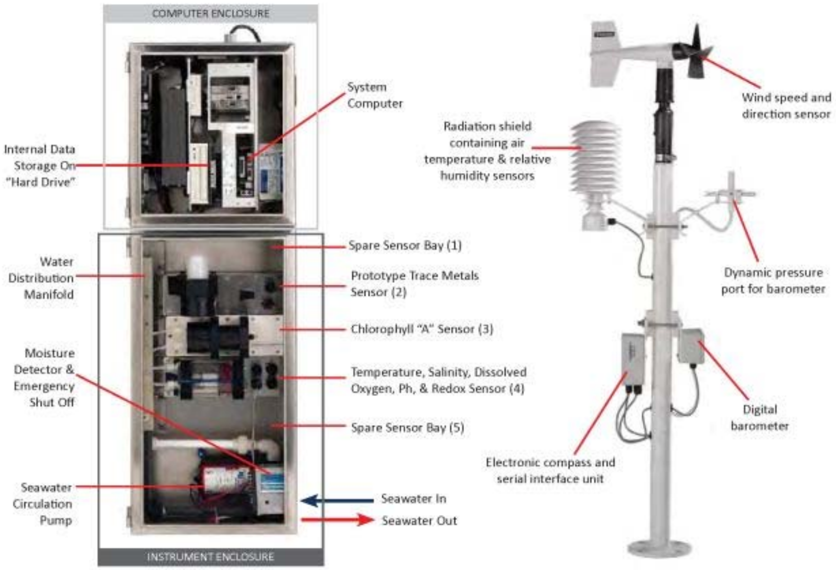
The SeaKeepers fleet took approximately 90 million scientific measurements in 2008 alone, at an astonishingly low cost of less than 2 cents a measurement.

The SeaKeeper 1000™ system has been recognized throughout the scientific community, including the United Nations' Intergovernmental Oceanographic Commission and the World Meteorological Organization, who issue joint certificates of participation in the Global Ocean Observing System to all SeaKeeper-equipped vessels.

The SeaKeeper 1000™ is being used by leading institutions including the U.S. National Oceanic and Atmospheric Administration's divisions of the National Data Buoy Center (NDBC), part of the National Weather Service, and the National Marine Sanctuaries Program, for deployment aboard their new monitoring vessels.

***As of January 2009**

OCEANOGRAPHIC SYSTEM **METEOROLOGICAL STATION**



- Highly innovative - can operate unattended for months.
- Installs on vessels, piers, or buoys.
- Patented modular system - allows suite of up to five sensor modules.
- Low maintenance and operating costs.
- Satellite communication, dial-up, or CD/DVD data output options.
- Endorsed by the United Nations' World Meteorological Organization and used by the US NOAA National Weather Service and National Marine Sanctuaries Programs.
- Research, Environmental Monitoring, and Educational Applications.
- Ideal for monitoring remote and sensitive locations.
- Proven - presently operating at more than 50 globally dispersed installations, with 17 additional systems in various stages of development.

Available Measurement Parameters

wind speed & direction • barometric pressure • air temperature • relative humidity
sea surface temperature • salinity • pH • dissolved oxygen • redox potential (pollution)
ocean color (CDOM) • water clarity (turbidity) • phytoplankton (chlorophyll)

Sensors in Development

blue green algae • heavy metals • carbon dioxide • nutrients

Fleet Data Report

SeaKeepers Ocean and Atmosphere Monitoring Report

This Fleet Data Report is a summary outlining explaining the SeaKeepers mobile fleet of monitoring and data-collection activities. In addition to a Fleet Data Report, the owner of a vessel hosting a SeaKeeper 1000™ system (or the captain, and/or anyone else designated by the owner), receives a strictly confidential summary of their vessel's data contributions, a Vessel Data Report, including the ship's track along which the data was collected. Those Founders and other SeaKeepers supporters who are not underwriting a SeaKeeper 1000™ monitoring system will receive the summary document.

The intention of the Vessel Data Reports and Fleet Data Reports is to:

1. Provide feedback to the owner and ship operators about the status of the scientific instruments installed on their vessel.
2. Provide a basis of comparison with the rest of the SeaKeepers' fleet.
3. Provide a summary of the collective contributions being made to ocean science and meteorological/climatological forecasting by the SeaKeepers Society and its supporters.

The following document is a sample of the information that will be provided and includes the general fleet summary that will be publicly available.

STANDARD MEASUREMENTS

MET Parameters	OCEAN Parameters
Air Temperature	Sea Surface Salinity
Relative Humidity	Oxygen Concentration
Barometric Pressure	pH
True Wind Speed	Eh
True Wind Direction	Sea Surface Temperature

THE SEAKEEPERS INNOVATION

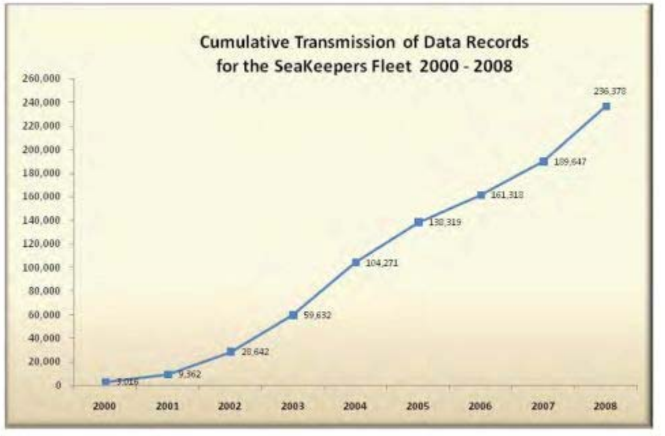
The SeaKeeper 1000™ data system's innovation is based on a couple distinct features: it uses state-of-the art, modular sensor technology and the system's automated 24/7 sampling means consistency and extremely low operating costs. Additionally, using private yachts and other "vessels of opportunity" dramatically reduces costs of data sampling. Since the first deployments in 2000, SeaKeepers has demonstrated a new level of efficiency in producing the kind of highly accurate data needed by scientists to monitor and model what is happening with our oceans, atmosphere and climate. The SeaKeeper 1000™ monitoring system automatically measures and records data every minute, and then transmits a representative sample record via satellite every three hours. All data collected, however, is stored on each system's hard drive and periodically downloaded for finer levels of analysis.

Tens of thousands of scientists worldwide are working to understand and project oceanographic and climatologic trends. Their work relies on large, easily accessible, and highly accurate databases to conduct their studies and analyses. SeaKeepers is proud to be on the cutting edge of this movement and a leading contributor to this global effort to better understand the future of our oceans and its impact on humankind.

Fleet Data Report

Transmitted Data Records History, 2000 - 2008

ABOUT TRANSMITTED DATA RECORDS AND SAMPLE DATA COUNTS



With existing technology, most SeaKeepers data is transmitted via satellite every three hours. These 3-hour summaries, or Transmitted Data Records (TDR's), are sent via satellite as an email to SeaKeepers server computer. EACH TDR typically represents 180 actual one-minute-data-samples. These detailed "high resolution" data sets must be manually recovered from the ships during service calls. The figures indicated below and on the next pages are estimates of the number of one-minute-data-samples, extrapolated from the actual number of satellite transmissions. SeaKeepers hopes to evolve to a system of broadband data transmission in 2009-10 which will enable sending all data off the ships daily. NOTE: The *total* data counts could vary slightly in this Report, as the final data is collected at different times of the day.

TRANSMITTED DATA RECORDS FOR SEAKEEPERS FLEET, 2000-2008

	Counts	Extrapolated High Resolution Data Counts
Total TDR's transmitted to date (2000-2008)	**236,346**	**38,408,040 samples**
METEOROLOGICAL parameter count transmitted in the above TDR's	1,092,422	
OCEAN parameter count transmitted in the above TDR's	890,462	
Total MET & OCEAN parameters transmitted from the fleet to date	1,982,884	316,612,980 individual measurements in samples

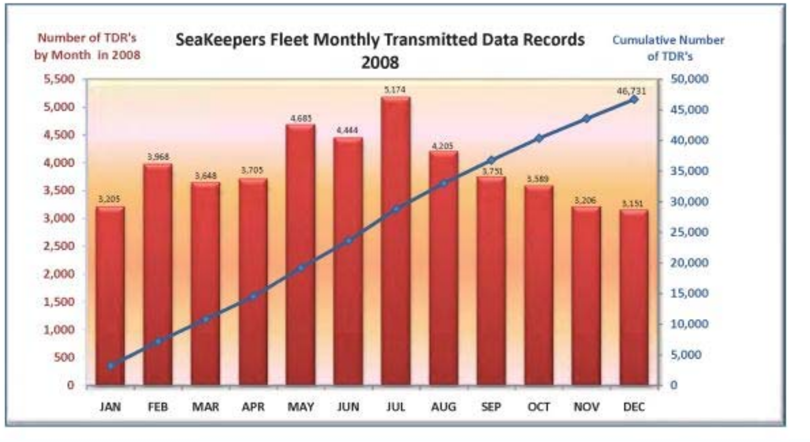
WHERE DOES THE DATA GO?

Upon receipt, the data messages undergo preliminary quality control, then are encoded and distributed over the Global Telecommunication System (GTS), a network managed by the World Meteorological Organization, which channels data to 156 member nations' National Weather Services and to several international organizations that track surface oceanographic data. These latter organizations include, but are not limited to, the National Centers for Environmental Prediction in the US; the Marine Environmental Data Service in Canada; the Global Oceans Surface Underway Data pilot project in France. These centers archive and make data available to the worlds scientists and climatologists.

Fleet Data Report

Transmitted Data Track map and Records For Fleet In 2008

In many cases, overlapping tracks hide multiple transmission points. In 2008 SeaKeepers took approximately nine million data samples; each data sample typically represents at least 10 individual measurements (to total 90 million specific measurements), which are available to thousands of scientists worldwide analyzing and modeling our changing oceans.



Fleet Data Report

SeaKeeper 1000™ Data Records and Associated Metadata

All scientific data today must be accompanied by metadata - defined as "data about the data." Metadata, in fact, encompasses many factors. Where is the sensor located? How many feet above or below sea level (depending on meteorological or oceanographic sensor)? What is the specific model and the technology of the sensor? How accurate is it? When was it calibrated? Answers to all of these allow scientists to qualify the numbers. Thus each particular measurement needs to be put in the content of its metadata. While this might seem a minor issue, it multiplies and complicates the databases and formats, in addition to substantially increasing the volume of data to be recorded, transmitted, stored, and analyzed. Without the metadata, knowing that the sea surface temperature (SST) is 18.6010C, or that the salinity is 37.864 PSU, is of little value scientifically.

There are two ranges that are used to determine the first level quality of the acquired data. One range is the reasonable range for each variable. This says whether the data is reasonable from a scientific point of view. It does not take into account spatial, temporal, or statistical considerations. The other range is the physically possible range for each variable. This is a reflection of the physical constraints due to geometry or sensor design.

NOTE: Any NULL output occurs because the data does not exist. The quality flag for each field will be encoded into the data field itself with color. A good datum will display as **black**, a datum which has failed the reasonable-range test will display as orange, and a datum which has failed the physical-range test will display as red.

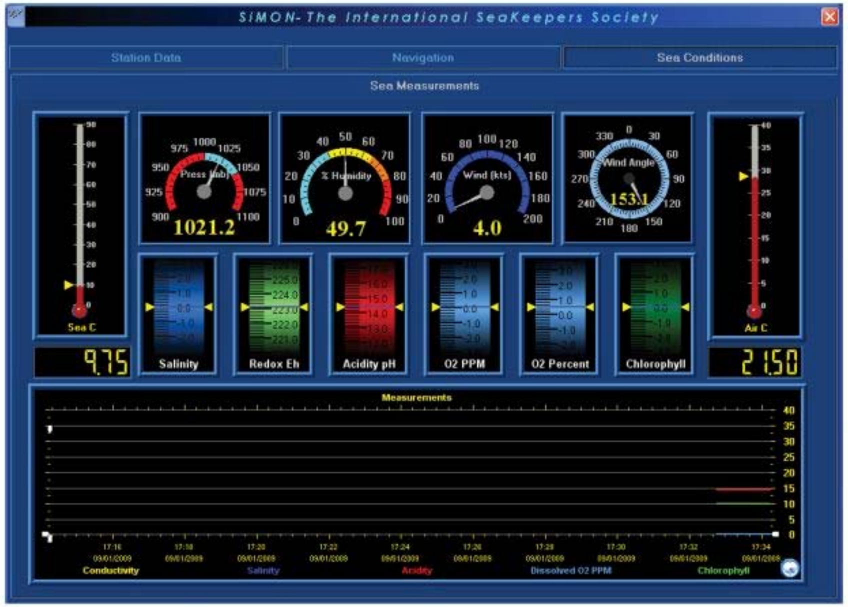
Variable	Code	Type	Unit of Measure	Accuracy +/-	Resolution	Reasonable Range	Physical Range
DATE/TIME/LOCATION STAMP							
Date			MM/DD/YYYY	± .013 sec	.001 sec	MM [1-12]/DD [1-31]/ YYYY [2000-2009]	
UTC time			HH:MM:SS	± .013 sec	.001 sec	0 to 23 hours	0 to 23 hours
Latitude			Degrees	± .02 minutes	.001 minutes	[-80 , 80]	[-90 , 90]
Longitude			Degrees	± .02 minutes	.001 minutes	[-180 , 180]	[-180 , 180]
OCEAN DATA							
Cell Pressure	CP	IV	Decibars	± 0.1	0.01	[0 , 20]	[0 , 30]
Cell Temperature (Internal)	CT	IV	°C	± 0.003	0.001	[-1.8 , 45]	[-1.8, 45]
Conductivity	CND	IV	mmho/cm	± 0.003	0.001	[0 , 75]	[0 , 75]
Sea Surface Salinity (Calc)	SLN	P	psa (practical salinity units)	± 0.006	0.001	[0 , 45]	[0 , 45]
Oxygen Saturation	O2S	IV	% Saturation	± 0.1	0.01	[2 , 110]	[0 , 150]
Oxygen Concentration	O2C	P	ppm (mg/liter)	± 0.1	0.1	[0 , 12]	[0 , 12]
pH	Ph	P	pH units	0.14	0.01	[6 , 8.5]	[1 , 14]
Eh	Eh	P	mV (milliVolts)	± 1	0.1	[-1000, +1000]	[-1000 , 1000]
Sea Surface Temperature	SST	P	°C	± 0.003	0.001	[-1.8, 45]	[-1.8 , 45]
ATMOSPHERIC DATA							
Wind Speed (apparent)	WS	IV	knots	± 0.5	0.1	[0 , 120]	[0 , 200]
Magnetic Wind Direction	MWD	IV	Degrees	± 6	0.1	[0 , 359.9]	[0 , 359.9]
Air Temperature	AT	P	°C	± 0.3	0.1	[-30 , 45]	[-50 , 50]
Relative Humidity	RH	P	%	± 2	0.1	[40 , 120]	[0 , 160]
Barometric Pressure	P	P	hPa (hecto Pascals)	± 1	0.06	[940 , 1040]	[800 , 1080]
Compass Heading	CH	IV	Degrees	± 5	0.1	[0 , 359.9]	[0 , 359.9]
Relative Wind Direction	RWD	IV	Degrees	± 5	0.1	[0 , 359.9]	[0 , 359.9]
True Wind Speed (Calc)	TWS	P	Knots	± 0.6	0.1	[0 , 120]	[0 , 200]
True Wind Direction (Calc)	TWD	P	Degrees	± 6	0.1	[0 , 359.9]	[0 , 359.9]
Course Over Ground (Calc)	COG	IV	Degrees	± 3	1	[0 , 359.9]	[0 , 359.9]
Speed Over Ground (Calc)	SOG	IV	Knots	± 0.5	0.1	[0 ,50]	[0 , 50]

IV - Intermediate Variable

P = Parameter

Real-Time Data Display

Onboard Graphic Interface of Collected Data



Thanks to Corporate Partner Palladium Technologies Inc., SeaKeepers now has the capability to display all SeaKeeper 1000™ data measurements, in real-time, onboard a host vessel. These pages represent some of the compelling data screens that display oceanographic and/or meteorological data with accompanying graphic support.

Palladium produces the SiMON bridge and navigation monitoring system for the yachting industry. While the data display was designed for the SiMON system, a simple, free program will enable the displays to function on any yacht or vessel now transmitting SeaKeeper 1000™ data. This free software will be provided to every vessel equipped with a SeaKeeper 1000™ monitoring system in early 2009. In addition, these displays will soon be available remotely, in real time, through any computer or communication device that can be connected via the Internet.

The new SeaKeepers display technology will also provide the opportunity to learn more about the sea and the challenges we face in our rapidly changing world. Drop-down screens will describe in laymen's terms the importance of the parameters being measured by SeaKeeper 1000™ monitors, what questions scientists are looking to answer, and the impact this information could have on the sea and mankind.

Expert Testimonials

***Dr. Sylvia Earle**, Marine Biologist, Author, former NOAA Chief Scientist; National Geographic Society Explorer in Residence:* "I think the SeaKeeper 1000 has been an extraordinary innovation in allowing scientists to enlist the thousands of vessels that previously were not able to gather data. Today the ocean is changing quickly —almost in front of our eyes. With the budget challenges the world faces, enabling yachts, cruise ships, tankers, and freighters to essentially become scientific platforms, at essentially no cost to the scientific community, is a huge contribution."

***Jean-Michel Cousteau**, Film Maker, Author, Marine Conservation Expert, President of Ocean Futures Society:* "We need more information about our oceans. We already know there are huge problems with the ocean ecosystem, and need data to see how it is changing. The SeaKeeper 1000 is a innovative system that enables cost-effective gathering of data related to ocean acidification, red tide, and the other phenomena that are quickly changing the sea. Our solutions must be science based, and high quality data is essential."

***Conrad C. Lautenbacher, Jr.**, Vice Admiral, U.S. Navy (Ret.), former Under Secretary of Commerce for Oceans and Atmosphere, United States Department Commerce:* "The SeaKeeper 1000 system is well known and used throughout NOAA. The data collected by these instruments are integrated into NOAA's atmospheric and ocean data centers and used for a wide variety of products and services. The International SeaKeepers Society is an exemplary public-private partnership and I applaud their commitment to raising public awareness and stewardship for our oceans."

***Richard E. Dodge**, Dean Nova Southeastern University Oceanographic Center and Executive Director National Coral Reef Institute:* "We are currently using the SeaKeeper 1000 for an important and joint management-driven water quality investigation together with NOAA, EPA, and Florida DEP. This instrument is ideal for providing real-time continuous measurements. The goal is to determine flux of nutrients and other water components impinging on coral reefs from the outflow of a major Florida port."

Expert Testimonials

***Dr. Richard W. Spinrad**, Assistant Administrator Ocean and Atmospheric Research, National Oceanic and Atmospheric Administration:* "SeaKeepers marine observations enhance our capacity for marine forecasts and are a valuable contribution to our mission requirements. Having demonstrated success at delivering marine observations to our Ocean Prediction Center through the National Data Buoy Center, we are compelled to assess the value of broadening the application. It is evident to us that the SeaKeeper 1000's integrated modular sensor suite is adaptable to a broad set of platforms of opportunity and we would like to explore other applications to further support additional mission needs."

***Dr. Paul Moersdorf**, former Director National Oceanic and Atmospheric Administration US National Data Buoy Center/ National Weather Service:* "Anytime you have more than a couple dozen observing platforms, you are making a significant contribution to ocean observing. With well over 50 instrument equipped ships, SeaKeepers has become one of the nation's larger providers of maritime data."

***Dr. James T. Morris**, University of South Carolina, Director Marine and Coastal Sciences:* "We have been working with SeaKeepers on a project that will take advantage of the unique capabilities of the SeaKeeper 1000 to map the water chemistry of North Inlet estuary. While this area has a long continuous record of water chemistry data from fixed locations, we have virtually no data about the spatial variability. This can only be understood by using a mobile instrument that can sample a variety of variables at a high frequency and then records the coordinates of these samples... like the SeaKeeper 1000. This is going to give us images of the estuary over time and space that will be truly unique."

***Robert Keeley**, Chief Oceanographic Systems Development, Canada's Department of Fisheries and Oceans:* "Lately we have seen a strong increase in the number of oceanographic measurements coming from SeaKeepers vessels. Reporting from more than 1500 locations, the data have come from every ocean, some from coastal waters and a significant number from open ocean. The data are made available to the weather and oceanographic centres of the world, and are being used in weather and ocean forecasting. These measurements are a valuable contribution to forecasting because of the scarcity of ocean observations."

Financial Summary

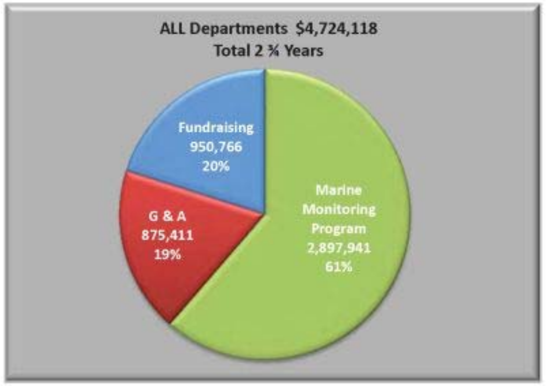
DATA AT LESS THAN 2¢ PER MEASUREMENT

With an annual budget of $1.7 million and a staff of seven, the following is a sampling of what the International SeaKeepers Society accomplished in 2008:

- We purchased, assembled, installed, maintained, and calibrated highly sophisticated scientific monitoring systems on a global network of 55* vessels (with another 17* in the process of installation).
- We collected, transmitted, distributed and/or stored an excess of 90,000,000 scientific measurements.
- We engaged in an active program of education and networking, meeting with and speaking to yachting industry groups, yacht clubs, corporations, universities, scientific institutions, and government agencies.
- We produced a variety of educational materials, including a quarterly newsletter, an active website, and our new HD DVD, "Be a SeaKeeper."
- With Scripps Institution of Oceanography we are developing the next generation of SeaKeepers monitoring equipment for use in coastal waters to protect human health, property and marine life.
- We attended boat shows, trade fairs, conventions and other venues to seek new platforms for our ocean-monitoring technology.
- Although always a registered 501(c)(3) nonprofit in the United States, we were granted formal not-for-profit association status in Monaco in 2008.
- We were honored with the Marine Technology Society's Special Commendation and Award for "outstanding accomplishments leading to significant advances in marine affairs."
- The International SeaKeepers Society celebrates 10 years dedicated to education and conservation through research.
- The first SeaKiosk™ prototype, an educational, interactive communications station, was delivered.
- The SeaKeeper 1000™ system was installed on a wind powered Autonomous Unmanned Surface Vessel prototype developed for the National Oceanic and Atmospheric Administration (NOAA) and the United States Navy.
- We founded a new tier of support - the Captains Advisory Council - to assist with various functions of SeaKeepers Professionals and provide insight on the needs and nuances of the yachting industry.
- We launched a new program that creates Reports summarizing our data contributions for our fleet and each vessel.

3-Year Recap of SeaKeepers' Expenditures

Cumulative 2006, 2007, and Q1-Q3 of 2008



*As of January 2009

THE INTERNATIONAL SEAKEEPERS SOCIETY

SeaKeepers: In Brief

The International SeaKeepers Society is a charity supported by the luxury yachting industry that seeks to find "free rides" for sophisticated, high-volume, scientific monitoring equipment we developed to help oceanographers, climatologists and meteorologists understand the challenges we face from major changes taking place in our seas and atmosphere and to help mitigate the impact on people and marine life.

90 million	Approximate number of individual measurements taken by the entire SeaKeepers fleet in 2008. Data collected includes weather data, sea temperature, salinity, dissolved oxygen, pH (acidity—vital for understanding critical acidification phenomenon) and more.
$1.7 million	Total operating budget for the Society. A model of efficiency, this funds not only staff, but building, installing, maintaining and calibrating all the SeaKeeper 1000™ systems.
55*	Total number of SeaKeeper 1000™ systems deployed. Our cost effective network of ocean and climate monitoring systems is currently deployed on 35 yachts, six cruise ships, piers, a ferryboat, and a US Coast Guard Icebreaker.
17*	Number of systems currently in the process of deployment.
<2¢	Cost per individual measurement. As a result of the "free ride" on these "vessels of opportunity," our technology costs less than two pennies per measurement.
100%	Amount of funding from private donations. In order to continue providing data that insures improved marine and general weather models and supplements climate and ocean studies by thousands of scientists worldwide we rely entirely on private donations.

*As of January 2009