2.3.2 OceanScope Working Group

Summary
This proposal outlines a new paradigm for the systematic and sustained observation of the ocean by working in close collaboration with the merchant marine industry. The overall objective will be to establish a global network of ocean observation platforms on selected commercial ships. The aim will be to encourage the maintenance, expansion and integration of existing volunteer observing ship programs (e.g. CPR, pCO2, ADCP, and XBT) while developing in parallel VOS initiatives that use sophisticated new technology, with real time data streams and data analysis facilities. The proposed SCOR working group will be unique as it will bring together ocean scientists with experience of VOS programs, engineers, instrumentation experts, economists, shipping company representatives and senior merchant marine officers as committee members and associate members of the working group. A developing partnership with the merchant marine will be mutually advantageous as observations reported in real time will be used to enhance ocean forecasting services for the shipping industry on the one hand, and to improve our understanding of the ocean's structure and variability for weather and climate studies on the other.

The oceans cover over 70% of our planet and the merchant marine has a presence on the high seas second to none covering millions of miles each year. In contrast research vessel tracks cover a fraction of this distance and rarely repeat their tracks. Freighters, tankers and cruise ships traverse all major oceans on a regular basis, some on well-defined schedules for 'just in time' delivery. Analogous to satellites probing the earth's atmosphere and ocean surface, merchant marine vessels could serve as 'orbiting' platforms for monitoring the interior of the ocean. We do this already to a limited extent, but rather inefficiently because most of the tools available to us were developed for use on research vessels, not for long-term unattended service. But experience has shown that such programs are possible, and with today's technical know-how the opportunity to make a quantum leap in the observation of the ocean is not only a realistic ambition but an extremely cost effective way to obtain the data sets so critically needed to address the challenges posed to society by global environmental change.

The development of an integrated approach to the monitoring of the global ocean is central to the proposal with as a primary goal the construction of a plan of action to implement the concept. Focusing on four interlocking themes: **ORGANIZATION**, **OBSERVATION**, **COMMUNICATION**, and **INTEGRATION** the working group (with the assistance of other experts) will:

1. address and prioritize the scientific challenges that can be best addressed by an integrated VOS program,
2. outline, and promote appropriate and necessary sensor, instrument and software development,
3. develop an institutional framework that enhances the links between the merchant marine and ocean observation communities including ongoing VOS and SOOP programs, and
4. identify and develop an integrated framework for data management and distribution.

To ensure sustained interest and follow-through, a SCOR working group with its international participation, well-defined terms of reference and ability to maintain focus for several years will form an ideal framework to achieve these objectives. Initial responses to the ideas presented above from contacts at IOC and other international links have been positive.

The Marine Environment

The extensive regions of the ocean interior continue – despite their enormous climate and biochemical importance - to be extremely difficult to probe and monitor on a regular basis due to the high cost of research vessels and fixed moorings, and hence the very low density of marine measurements, especially in horizontal dimensions. This stands in complete contrast to the extraordinary ability of satellites to provide frequent and detailed views of the space-time evolution of the surface of the ocean, including temperature, color, roughness and elevation. However, these systems sample only the surface. It has been said many times before that we know less about the ocean interior than we do of the moon! Oceanographers have sampled and studied the oceans from research vessels for well over a century, but our knowledge of how the ocean behaves over a very wide range of space and time scales remains very poor. How do currents vary in time, shift in position, how much mass and heat do they transport, how do basic biogeochemical processes and biological space/time distributions differ between ocean basins and regional seas - all questions of enormous importance to our understanding of the atmosphere-ocean system that regulates our climate.

Our inability to sample and resolve fields in the horizontal continues to be a major challenge in oceanography. All the more so given that the very energetic mesoscale eddy field not only serves to maintain mean distributions in the ocean, but also to expel gradients to the perimeters of homogenized regions where strong physical and biochemical contrasts develop. Thus mixing can create uniform regions on the one hand (the standard view of eddy processes) yet create strong contrasts on the other. But we know very little about the latter due to the lack of high-resolution subsurface sampling techniques. To take but one example, we still know surprisingly little about zooplankton and myctophid distributions except in a very few areas of the open ocean. We also see growing (and surprising) evidence that the shape of the ocean bottom can play a significant role in constraining ocean currents, not merely at depth but also in the upper ocean. Measuring ocean currents, temperature, and a wide suite of biochemical properties concurrently at high resolution in the horizontal remains a fundamental challenge.

Background

For more than a century officers of the merchant marine have - as part of their watch at sea - sent in weather reports on a regular basis. These observations of air and sea surface temperature, barometric pressure, winds and sea surface conditions have been of enormous importance to the forecasting services of neighboring countries. Further, the archives of these marine observations have formed the basis for much of what we know about the climate of the seas including the enormously important early charts of prevailing winds and ocean currents (e.g. Maury, 1855). But these early observations were largely limited to the ocean surface. Some 80 years later, starting in 1931, Alistair Hardy began a remarkable program to monitor plankton variability by arranging for freighters and ferries to tow Continuous Plankton Recorders on regular routes on a monthly basis (www.SAHFOS.ac.uk). These repeat tows along selected routes have allowed researchers to construct an accurate measure of biomass and various species in the surface waters and how they vary spatially, seasonally and over longer periods of time. A little later in the century mechanical bathythermographs were developed allowing observers to obtain upper ocean profiles of temperature from ships underway. This was followed by the development of the Expendable Bathythermograph (XBT) in the 1960s (e.g. Baker, 1981) that made it possible to develop an understanding of low-frequency variability in the ocean down to the depth of the main thermocline (e.g. Molinari, 2004). And more recently yet, a few commercial vessels have been equipped with Acoustic Doppler Current Profilers (ADCP) to measure and monitor upper ocean currents and their variability, e.g. across the Kuroshio (Hanawa et al., 1996) and the Gulf Stream (Rossby et al., 2005 and Beal et al., 2008). Similar repeat sections have been operated since the mid-1960s (but mostly later) and are now coordinated as part of the International Ocean Carbon Coordination Project (IOCCP) (See CAVASSOO website below.)

Repeat sampling along designated lines confers a tremendous advantage because patterns of change and their magnitudes can be identified and quantified with unparalleled accuracy. These above examples from volunteer observing ships (VOS) indicate the enormous potential of merchant marine vessels for probing the ocean water column on a regular schedule. Discussions that took place at a well-attended session on VOS-based observations held at the 2008 AGU 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. Research vessels cannot in any way provide a comparable service.

The above encouraging examples notwithstanding, the use of merchant marine vessels to observe the oceans synoptically is far from achieving its considerable potential. One can summarize the reasons for this in a few words: lack of suitable instruments and access to ship platforms, each checkmating the other in a catch-22 loop. In terms of physical measurements temperature profilers are not optimized for merchant ships, so XBTs are used. In most cases their deployment requires a technician to be in attendance, greatly increasing the cost of measurement. Widespread use of VOS has been discouraged by these high costs plus the challenge of accessing merchant ships on regular routes in selected regions of the world. In consequence there has been little effort to develop an automated technique for profiling temperature. ADCPs, although they work reasonably well on their own, are not designed for the 'industrial' environment of freighters. More precisely, the ADCPs at present need considerable protection with industrial-strength uninterruptible power supplies (UPS). It is possible to build ruggedized instrumentation, but this won't happen until a broader demand for such equipment develops. A number of vessels were equipped with 'Ferry-boxes' as part of an EU project (http://www.ferrybox.org/) that included e.g. thermosalinographs, flurometers for chlorophyll and other instruments to measure, turbidity, oxygen, nutrients and pCO2 with real-time transmission of raw data via satellite. Some of these ships are still operating with research funds, but the program has not moved into operational mode now that the funding for the original project has stopped. The Ferry Box project provided useful information about surface water properties, but the equipment was expensive to install and maintain and generally required regular technical support. Finally, a substantial planning effort and installation cost in dry dock had to be covered for each vessel with little economy of scale or sharing.

The Concept

We propose a fresh start that addresses the need to develop sensors and systems that are optimized for the rigorous environment of routine operation on merchant ships, suitably packaged and easily maintained. To employ an obvious analogy, the atmosphere and ocean surface is probed on a routine and systematic basis with highly reliable instruments developed for satellite application; the same approach should be possible for the sub-surface ocean using ships as 'satellite' platforms. With fresh thinking, and taking full advantage of the possibilities offered by modern technology, a much-improved coverage of the ocean interior can be achieved for a comparatively small additional expense. Just to give a hint at what might be possible, with instruments mounted in the hull one could measure a wide range of physical, biological and chemical properties. Some techniques exist today; others would require considerable development. Much as is done today for remote sensing satellites we need to let loose our creative instincts and engineering skills to develop the instrumentation that could take full advantage of these ocean platforms. Instruments topside would measure a wide range of atmospheric properties providing ground-truth to satellite-based remote sensing systems. As experience grows expectations and requirements will evolve (precipitation being an obvious example). All measurements would be forwarded to a central unit, which would handle shipboard data archiving as well as all communications between ship and shore. Communications will work both ways: ship-to-shore (near-) real time transmission of data for post-processing and distribution, and shore-to-ship for system performance analyses and corrective action as required. But, as with satellites, a very high level of hardware reliability and software robustness must be built into these systems so that they can provide unattended operation over periods of months to years. We offer the following vision statement:

"In partnership with the merchant marine shipping industry develop an integrated approach to the observation of the global ocean on regular and sustained basis. This effort, which might be called 'OceanScope' - to give it a name - will equip commercial ships with instrumentation to automatically measure and report on currents and the physical, chemical and biological state of the water column throughout the water-covered planet. These data will in time become a fundamental resource for studies of the climate and health of our planet."

Proposal

The above concepts are all feasible, but cannot be implemented on a one-by-one basis, they beg for concerted action. Furthermore, all partner countries in SCOR share a common interest in the ocean, for reasons of commerce, optimal ship routing, fisheries, defense, and on the longer time scale the ocean's role in climate. The SCOR approach to resolving issues of common interest seems eminently well suited to the issues posed above. We propose to establish a SCOR working group to develop the concept of a merchant marine-based global observing system of the ocean interior. The working group would bring together experts from science, technology, and the marine industry to develop an entirely new paradigm for working with the merchant marine that incorporates and builds on the past and ongoing experience of current practitioners. Rather than thinking in terms of volunteer observing ships, a very modest concept, we propose a pro-active or purposeful approach, namely the development of new technologies and new modes of cooperation with the merchant marine. A fundamental point should be emphasized here. Experience has shown that the operators of merchant ships are receptive to the presence of ocean and atmosphere observing instrumentation onboard their vessels. They see this as providing a service that will provide feedback to their own benefit as well as, in many cases, giving green credentials. Ship operators invariably only require that the equipment makes no demands on their costs, insurance, time, people or operations. This is where the analogy with orbiting satellites comes in: satellite-borne instrumentation has been designed, optimized and tested for these platforms before they fly so that they can and will perform without any need for hands-on human intervention. The working group will identify suitable scientific objectives and translate these into what might be called 'mission' requirements. The group will be tasked with identifying mechanisms for stimulating the development of 'mission-proof' instrumentation as well as exploring and documenting necessary communications requirements and developing parameters for selecting vessels to be equipped (vessel type, route, hull shape, etc). And, perhaps most important of all, to develop a flexible, easy-to-implement international infrastructure for cooperation between existing and new VOS programs with the merchant marine and the institutions responsible for the instrumentation. The first goal of the working group will be to produce a Development Plan and a procedure for its implementation. This work will take some time, and in order to provide the plan with both support and supervision it is recommended that the working group be active for at least three years or until such time that an operational structure has been implemented that can assume these oversight and management responsibilities.

Issues and Organization

At this stage we propose that the SCOR working group be organized around four central themes, organization, observation, communication and integration. The first refers to developing appropriate frameworks for collaboration between the maritime industry and the marine research communities, the second to the development and implementation of observational programs, the third to shore-based supervision of shipboard systems, and data transfer, distribution and archiving and the fourth to the integration of the proposed development with existing ocean observing programs into a global collaborative system that contributes to the Global Ocean Observing System (GOOS). Each of these areas spans a wide-range and overlapping set of issues. The following subheadings: scientific requirements, instrumentation, networking, platforms and institutional links show how intimately they are linked.

1. *Scientific requirements:* Under this heading the working group will review emerging scientific questions in relation to our present observational skill. For example, what aspects of the ocean interior do scientists think are the most important issues for which more information is required? The intention will be to focus upon the desirability of particular

measurements, sensors and technologies rather than their current availability. Historically, scalar or state variables have occupied center stage as researchers have endeavored to characterize the present state of the ocean. However, vector information has much to offer as changes in currents and property fluxes can help presage future changes in state – variations in currents and state tend to be out of phase with the former leading the latter. And recent advances in modeling have shown that assimilating deep velocity profiles using Kalman filtering or 4D methods can be just as fruitful as assimilating temperature or salinity. To meet future scientific and operational forecasting needs, it may be essential to reach below the main thermocline to resolve the weakly-sheared deep velocity field. Measuring currents at great depth is technically possible today but will require some development to become operational. Experience has taught us that long-term averages of Eulerian time series of currents do not settle down due to the red nature of the velocity spectrum. Eulerian current measurements also suffer from topographic biases. Averaging currents across space gets around both sources of uncertainty so that degrees of freedom accumulate far more rapidly.

Repeat sampling at suitably high-resolution of such biological parameters as upper ocean phytoplankton and mid and upper ocean zooplankton is essential to characterize their temporal and spatial variability. High resolution species data for these taxa are virtually restricted to the near surface northern North Atlantic sampled by the CPR. Given the stress that is being put on marine living resources by commercial fisheries in concert with climate change, there is a need to routinely measure biomass distribution in a wide range of size classes along selected routes. This information is needed to predict shifts in community composition that may profoundly affect the availability of the living marine resources constituting a major fraction of the protein diets in many nations as well as providing information on the changing composition of the plankton that is so crucial for understanding the carbon cycle. Just as the towed plankton recorder opened the window to surface plankton distributions and documented population shifts related to environmental changes, acoustic techniques might be able to do the same for the entire water column. This is just a brief hint of what could be done.

A supplementary need for improved information on the changing role of biota in the biological pump by use of new and existing technologies is noted. The processes involved in the biological pump and its variability are poorly understood on a regional, never mind global scale, and quantifying its role is crucial to an improved understanding of oceanic uptake of CO2. The information provided will be invaluable to modelers and for validation of satellite remote sensing products.

2. *Instrumentation:* Here we address the state of the technology from the perspective of merchant marine-based applications (i.e. robustness and reliability) and explore avenues for future development. Focusing again on currents, what technologies might be available for their measurement at depth - even if at low vertical resolution? What techniques might be developed to monitor thermocline biomass variability? Can we develop low cost (recall that unit cost is a very steep inverse function of numbers) probes of temperature, conductivity, oxygen, ..., that telemeter their data back acoustically to a dedicated hydrophone in the hull of the ship? With the entire circuitry for a probe on a single silicone wafer production costs could be reduced enormously. In addition to this one-way data transfer from expendable probes, ships can also serve as acoustic modems to receive and retransmit underwater

instrumentation in their vicinity.

3. *Networking:* Several issues need to be addressed here. First, communication within a vessel. This could be done through ethernet communications between instrument sites and the bridge or wireless through a series of transmitters distributed throughout the ship. These solutions are much easier to accomplish during the original construction. Second, communication with the outside world. Here, Iridium and Inmarsat will go a long way towards system monitoring and low-bandwidth data transfer with high data rates reserved for when a vessel arrives in port. A choice or balance between the two band-width options might be possible depending upon priorities. Large shipping companies most probably have standard communications methodologies already in place for vessel tracking, routing and data transfer, but if not, the option to promote this capability in conjunction with data messaging may be attractive to them. Communication issues also may involve shipboard data processing at various levels of detail, inclusion of data description and identification (metadata) and shipboard data archival and retrieval. Much has been done in this area in the satellite community, and further relevant technology will be available as a result of the nascent U.S. NSF-sponsored Ocean Research Interactive Observatories Network (ORION) program.
4. *Platforms:* This topic would include a review of vessel designs and an evaluation of the advantages and disadvantages of different hull forms. In so far as acoustic observations of the water column from the vessel is concerned, a major requirement will be to identify vessel hull types that are relatively free of bubble sweep-down, including measures that might be employed to ameliorate this limitation. What comparatively inexpensive preparations might be built into a vessel during construction in anticipation of use? Here we have in mind features such as reserved hull plate areas for very low-profile external sensors, standard sea-chests with cofferdams to accommodate expected hull-mounted instrumentation, seawater plumbing connections in anticipation of flow through surface water analysis equipment and cable channels and pass thru's for interior wiring (electrical and fiber-optic). At construction time these costs are very modest but as retrofits they can become prohibitive. Vessels with particular silhouettes may be advantageous for some kinds of meteorological measurements requiring "clean" air and air flow. Consideration may also need to be given to superstructure arrangements and access for sensors requiring a clear view of the skies and options for fitting gyro-stabilized platforms for stable horizon requirements. The overarching consideration is that standardized procedures, technologies and approaches need to be developed to facilitate easy installation, removal and (when necessary) servicing, and to take advantages of economies of scale to enable the establishment of a large-scale integrated network of instrumented commercial vessels.
5. *Institutional:* This is a large and important topic with many subtopics. Institutional links are needed between research, government and international agencies charged with ocean and climate monitoring and the maritime industry. Almost certainly this will require a program office that searches for, develops and provides a liaison between appropriate ship operators and the scientific community. Second, development of formal arrangements or letters of understanding between the parties to avoid misunderstandings and/or subsequent confusion. It is understood that vessel operators may at any time shift vessels from one route to another for commercial reasons, but with proper lines of communications it may be possible to anticipate or minimize the impact of such changes in operation. For example, given adequate warning (and stand-by response capability) even underwater hardware can be removed by scuba divers without a dry-dock. Conversely the same capability would permit equipment installation to take advantage of newly available commercial routes and opportunities.

Third, given justifiably heightened security concerns it will be important for the scientists and technicians to prepare in advance. Obtaining prior clearance (and documentation) to enter port facilities has become the rule rather than the exception. Fourth, it will be important to educate both communities (scientific and industrial) of the operational, personnel and logistical needs of the other. A key to success will be recognizing and honoring each other's needs and concerns.

Summary of Activities **<u>Mode of Operation of the Working Group</u>**

	Organization	**Observation**	**Communication**
Scientific requirements	User community; real-time forecasting/ climate studies	Type of parameter; scalar/ vector; air/water; accuracy; sampling frequency	Real-time/ delayed/ distribution networks
Satellite validation	Remote sensing developers/ users/ tech. designers/developers	Atmosph/oceanic spectral parameters, chlorophyll fluorescence, currents	Real-time/ delayed/ processed products
Instrumentation	Developers/ users/ partnerships	Type of sensors/ atmosph/ oceanic/ acoustic/ optic/ towed systems	Development/ evaluation/ testing
Networking	Shipboard/ ship-to-shore/ user communities/ GTS?	Data collection/ software/ prewire ships at construction time	Transmission/ software
Platforms	Designers/ users/ vessel owners	Type of observable topside/ hull-based/ towed	Design and approval process
Institutional links	Merchant marine/ science/ gov't/ regulatory	Shipboard activities	Establish formal lines of communication

Most of the work outlined above can be achieved by the working group over a two-year period with two face-to-face meetings, one in the early months of the group's formation and a second one after roughly a year. It is envisaged that at the first of these meetings the specific issues listed above will be developed through pre-prepared presentations and discussions. Lead writers will be nominated to draft section contributions for a Development Plan in collaboration with others as appropriate. This work will be reported and discussed at the second meeting of the working group. At this second meeting the members will be in a better position to determine the time scale for completing any remaining tasks, including a possible role in the supervision of the development and implementation of the recommendations in the Development Plan.

The Working Group

The proposed SCOR working group would include experts in all the areas addressed above. A key to success will be to find people who have the time and interest to contribute in a practical way to the objectives of the working group. We note that the response to discussions outlining the basic plans of the proposal, held with a wide cross section of ocean science researchers, representatives of the instrumentation, communication and maritime industries and more recently attendees at the JCOMM/SOT-IV meeting in Geneva (April, 2007), have been strikingly positive. Additional voluntary or independently aided contributors to the meetings of the Working Group, or by correspondence will be sought with, where appropriate, nominations from international organizations such as IAPSO, IOC, ICES, PICES, POGO, GEO and of course SCOR. If possible, funding will also be obtained to enable an environmental economist to participate in the working group meetings. In advance of each meeting, the basic agenda for the discussions, time and venue will be advertised to enable participation of additional experts with relevant experience from countries adjacent to the meeting venue. Funds will also be sought, independently of SCOR, to enable participation of representatives from developing countries and some young scientists/engineers.

Full Members

- Prof H. Thomas Rossby (GSO/URI, USA) - Chair Physical Oceanography and technology
- Prof Philip C. Reid (U. Plymouth, SAHFOS, UK) – Co-Chair Marine Biology and Fisheries
- Int'l Chamber of Shipping Industry expert
- Dr David Hydes (NOC, SOTON, UK) VOS technologies
- Mr. Markku Kanerva (DeltaMarin, Finland) Naval architect
- Prof. Fred Soons (Utrecht Univ) Marine Law
- Prof. Doug Wallace (GEOMAR, U. Kiel, Germany) Ocean carbon
- Prof. Rod Zika (U. Miami) Chemistry, instrumentation
- TBD Passive optics
- TBD Active optics/bioacoustics/communication?

We have approached several groups in China, Japan and Korea for participation in the working group.

Associate Members

- TBD IAPSO representative
- Prof. Peter Ortner (Univ. Miami) Biological Oceanography and Technology
- Dr. C. Flagg (SUNY, Stony Brook Univ.) Physcial Oceanography
- Dr. J. Churnside (NOAA, Boulder) Active optics
- TBD (JCOMMOPS, Paris, France) Marine operations, communications
- Dr. Gwyn Griffiths (NOC, SOTON, UK) marine technology, bioacoustics
- Dr. Rik Wanninkhof (NOAA) Global Ocean Carbon Budget
- Dr Joaquim Goes (Bigelow Laboratory) Remote sensing expert
- Marine technology experts

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Other members and areas of expertise will be sought as plans continue to develop.

We should mention here a few companies that have been actively supporting sustained ocean observation:

- Maersk Line (Copenhagen, Denmark)
- The Brittany Ferries (Roscoff, France)
- The DFDS Tor Line (Copenhagen, Denmark)
- P&O Ferries (Dover, U.K.)
- The Royal Arctic Line (Nuuk, Greenland)
- The Bermuda Container Line (Hamilton, Bermuda)
- Royal Caribbean Cruise Line (Miami, Fl, USA)
- The China Navigation Company (Hong Kong, China)
- The Smyril Line (Torshavn, Faroes)

We also have contact with several shipping companies and marine activities, including:

- Wallenius Marine AB (Stockholm, Sweden)
- Neste Shipping Oy (Keilaranta, Finland)
- Skaugen Marine Construction (Skaugen, Shanghai, China)
- V.Ships Leisure S.A.M. (Monaco)
- Color Line Marine (Sandefjord, Norway)
- Teekay Shipping (Vancouver, BC, Canada)
- Höegh Autoliners (Oslo, Norway)

Suggested Terms of Reference

The overall objective will be to develop an integrated plan for systematic observation from merchant marine vessels. To achieve this means addressing and resolving issues of which the list below includes some of the major ones mentioned in the text. Of course, once the working group convenes, it should begin with a review of the ToR and approve/modify them as appropriate.

- Identify ocean observation and scientific needs in terms of parameters and locations
- Identify and prioritize marine routes for sustained ocean observation
- Classify and identify merchant vessel types suitable for sustained observation
- Identify technologies that can enhance vessel capability for ocean observation
- Identify and prioritize instrument needs to meet *future* mission requirements
- Identify and develop procedures (hardware and software) to meet communication needs
- Develop procedures and algorithms for managing data flow, handling, and archival
- Develop information and advisory links with the scientific and government communities for input and feedback
- Identify and resolve EEZ questions, including data ownership, release and sharing
- Design a structure – an Ocean Space Center – to coordinate and implement a merchant-marine based ocean observation program. This would ab initio be conceived as a stand-alone ‘center’ to avoid the complications of embedding (and/or losing) its needs in a larg-

er existing structure. But, once the exercise has been completed, it might either be merged into or designed with strong ties to existing ocean observing systems.

- Identify and develop procedures for creating the funding structure to start up and sustain the proposed merchant-marine ocean observation program.

Timeline (assuming a once/year 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 Ocean Space Center (OSC)
- Review OSC paradigm in relation to existing ocean observing systems
- Explore funding sources/structures
- Develop a website for the Working Group

Year 2:

- Issue first interim report
- Develop and review as necessary the Work Plan for years 2 and 3.
- Complete a proposal for the Ocean Space Center.
- Develop funding (Prepare and submit proposals to government agencies using interim report)

Year 3:

- Issue final report
- Complete and submit a series of papers a special edition of a journal or book.
- Revise – as appropriate – proposal for Ocean Space Center.
- Explore further funding sources. It is hoped by this stage that some initial funding will be in place to start program. If this is the case, start-up of Ocean Space Center, initial funding to industry for 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.

In Summary

There is little doubt that a partnership between the International Oceanographic Community and the merchant marine fleet to equip an appropriate set of vessels to systematically and repeatedly probe the ocean interior at high resolution both horizontally and vertically will have a fundamental impact on our knowledge and understanding of the marine environment and ocean interior. The time is right. First, activities by various groups have clearly shown that partnerships between vessel operators and the scientific community can work well, in many cases over decades. Second, experience from both marine and satellite-based technologies show that systems can be developed for long-term reliable operation, an essential requirement for autonomous operation on merchant marine vessels, and third, (if we ever doubted it), the oceans play a fundamental role in regulating and modulating our climate. The richness of circulation patterns in the ocean and their time scales of overturning imply a continuous spectrum of variability. The best way to understand how the ocean responds to and impacts our climate is through accurate measurement.

The ocean scientific community and merchant marine, working together in partnership, with the help of the SCOR Working Group proposed here will provide the means of helping to make the ideas presented in this proposal a reality.

Web Sites
Sir Alistair Hardy Foundation for Ocean Science
www.SAHFOS.ac.uk
CO2 program: http://tracer.env.uea.ac.uk/e072/publications/first_annual_rep.pdf
Worldwide Merchant Marine Fleet http://www.cia.gov/cia/publications/factbook/fields/2108.html

Information on present volunteer observing ship programs
www.bom.gov.au/jcomm/vos/vos.html
Two academic programs:
http://www.rsmas.miami.edu/rccl/ http://www.po.gso.uri.edu/rafos/research/ole/index.html

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