Proposal for a Joint IAPSO/SCOR Working Group on Deep Ocean Exchanges with the Shelf

Background

As part of its strategy for the 21st century, the International Association for the Physical Sciences of the Oceans (IAPSO) has proposed a new scientific focus area on Deep Ocean Exchanges with the Shelf (DOES). The primary goal of DOES is to understand the physical and chemical interactions taking place at the shelf break between the deep ocean circulation and the shelf currents, and their impact on marine life and biogeochemical cycles. SCOR has identified interdisciplinary work focussed on the shelf break as a priority area for new working groups. IAPSO is thus proposing this joint working group.

The joint WG will consist of a mixture of physical, chemical and biological oceanographers, including both theoretical and observational experts. Although much of the work of the group will be concerned with planning better physical models of the shelf break region, an important aim is to include the requirements of chemical and biological oceanographers for output from such models. The involvement of scientists from developing countries will help to meet the capacity-building goals of both organisations.

The support of IAPSO and SCOR will enable the members of the working group to hold a first meeting to push forward the research required on this topic, to arrange a DOES workshop for all interested scientists, and to hold a final meeting to complete the final publication of the working group. Although much preliminary work can be conducted by email, it is vital to have face-to-face meetings to make significant progress.

Rationale - Deep Ocean Exchanges with the Shelf

The shelf break is a region of steep slopes, strong narrow currents, internal tides, shelf waves and significant vertical motion. With the advent of much finer resolution in ocean models, it is a good time to address the links between the shelf circulation and the deep ocean circulation at the shelf break. Improved understanding of the exchanges between the shelf and the deep ocean will be useful for more realistic models for studying climate, the carbon cycle, sedimentation and marine ecosystems. The increased detail in the improved models often leads to prediction of features that have not yet been observed. This can lead observational oceanographers to include fieldwork in their cruise plans that will either establish the existence of these new features or test the validity of the models.

Even as ocean models become more realistic by having much finer resolution in space and time, there are still significant problems in resolving the high variability that occurs around the shelf break between the deep ocean and continental shelves. Modellers have often regarded the shelf break as the nominal seaward boundary of shelf models or the coastal boundary of deep ocean models. Even with the finest resolutions in ocean general circulation models, the shelf region is poorly resolved with only a few grid points. Ocean observers have had difficulty in securing measurements at the edge of the shelf due to the narrowness of the currents and steep slopes. However, new technologies are now enabling measurements in such challenging environments. For example, swath bathymetry gives accurate bottom topography, the ship's dynamic positioning allows precise placing of moorings and

acoustic Doppler current profilers allow measurements throughout the water column even in strong currents. At the same time, fine-scale (1km or less) coastal models such as the Regional Ocean Model System (ROMS) with multiple depth layers are now being used to model the movement of water, chemical species and sediments on the shelf, and are being connected to biogeochemical models of the local ecosystem. Meshing these models into larger-scale deep ocean models offers the chance to resolve some of the unknowns.

The exchanges and fluxes that occur near the shelf break are important parts of the global ocean circulation. These fluxes include sediments and biomass as well as seawater. Coupled ocean-atmosphere general circulation models require, for example, the input of freshwater outflow from rivers. These inputs are generally added at the location of the river. But, in reality the fresher water flows along the shelf, sometimes for considerable distances, before it crosses the shelf break and enters the deep ocean (for example, along the Oregon coast, as has been modelled by Baptista et al. (2005)). Similarly the formation of Antarctic Bottom Water and other dense water masses often occur over continental shelves before they flow offshore. An example of a biological flux is the movement of patches of krill on and off the Antarctic shelf, as described by Murphy et al. (2004).

Strong tidal mixing at the shelf break and over variable topography is an important feature in the energy balance of the Earth's oceans (see, for example, Jayne and St.Laurent (2001), Wunsch and Ferrari (2004)). Internal and surface tides are built into shelf models but are usually absent from deep ocean general circulation models. Strong mixing associated with significant topography is an important component in the theories of the global thermohaline circulation. Coastal models often use terrain-following coordinate systems (sometimes called sigma coordinates). Although this method deals better with the changes in shelf slopes compared with models using standard grid boxes, they introduce significant problems due to pressure gradient force error as described in Berntsen and Furnes (2005).

A new generation of high-resolution models is under development including for example (i) the Nucleus for European Modelling of the Ocean (NEMO) begun in France but now forming the basis of a wider European project and using interactive nesting (see www.lodyc.jussieu.fr/NEMO/); (ii) the next generation of the Hamburg Shelf Ocean Model (HAMSOM), called the Vector Ocean-Model (VOM), including biological and physical coupling on an unstructured adaptive grid (see Harms et al. (2003)); (iii) the Imperial College Ocean Model (ICOM) using an unstructured mesh (see Gorman et al. (2006)); and (iv) the Hybrid Coordinate Ocean Model (HYCOM) a data-assimilative hybrid isopycnal-sigma-pressure coordinate ocean model (see Chassignet et al. (2006)). The WG will monitor the progress of these new models, and encourage the use of such models for looking at the details of processes near the shelf edge and for the inclusion of biogeochemical fields. The WG will also encourage further observations in regions that can validate and enhance the understanding of the model output.

With the advent of the new observational technologies and the new generation of ocean models, this is an appropriate time to set up this working group. Improved models and observations leading to a better understanding of the processes that occur between the shelf and the deep ocean will be of benefit in maintaining fish stocks and dealing with threats of pollution from oil and gas wells, and for studying river runoff and sedimentation. Coastal areas are often regions of enhanced primary production due to coastal upwelling. Understanding the carbon cycle in such ecosystems is relevant to climate studies.

Interaction with other programmes

Two existing SCOR WGs have links with this proposed WG. The published output from WG 111 on Coupling Waves, Currents, and Winds in Coastal Models will form part of the current knowledge of shelf oceanography. The ongoing IAPSO/SCOR WG 121 on Ocean Mixing will provide useful input about deep ocean mixing to the proposed WG.

The ongoing international Antarctic Zone (iAnZone) project (an affiliated programme of SCOR) is concerned with modelling and observations in the Southern Ocean, including strategies to understand climate variability in the Antarctic Zone. It includes the Synoptic Antarctic Shelf-Slope Interactions Study (SASSI); a programme of observations over the Antarctic shelf and slope as part of the International Polar Year (see http//roughy.tamu.edu/sassi/sassi.html).

The carbon cycle in the shelf and upwelling zones is an important ingredient for the modelling by the Climate Variability and Predictability (CLIVAR) programme. The discussion of applications on chemical and biological fluxes needs to be in collaboration with projects such as the International Geosphere-Biosphere Programme (IGBP) Land-Ocean Interactions in the Coastal Zone (LOICZ) project and the SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) project. IMBER is particularly concerned with how long term global change (including changes to the deep ocean/shelf fluxes) will affect biochemical cycles and ecosystems. Members of the WG would interact with scientists involved in these programmes to determine the mutual benefit that can be derived from collaboration and to avoid unnecessary duplication.

Other important collaborators are to (i) the Surface-Ocean-Lower Atmosphere Study (SOLAS) for their interest in biogeochemical interactions and feedbacks between ocean and atmosphere, and (ii) GEOTRACES, the international study of global marine biogeochemical cycles of trace elements and their isotopes, where the proposed WG can help with the understanding of the processes in the ocean that affect the concentrations of these tracers. Links between the proposed working group and SOLAS and GEOTRACES will be straightforward as members of their steering and planning committees work in the same building as the proposed chairman of the proposed WG.

Statement of Work / Terms of reference

IAPSO proposes the formation of an international joint working group with SCOR to advance modelling and observations of deep ocean exchanges with continental shelves. IAPSO wishes to foster research work on the links between shelf and deep-sea oceanography by using the working group to generate ideas and encouragement for future research by the wider oceanographic community with funding from national and international bodies.

The working group will complete the following tasks, over a period of four years:

(1) Establish the current state of knowledge and make recommendations for future research related to the following topics:

- processes due to shelf waves, internal tides, shelf break upwelling;
- river and estuary input of sediment and fresh water into shelf seas;

- dissipation of tidal motion along the continental margins;
- chemical and biological flux exchanges between the deep ocean and coastal ecosystems;
- the influence of ocean physics and chemistry around the shelf break on fisheries and climate; and
- coupled physical-chemical-biological numerical models that have a more realistic description of the exchanges at the shelf edge;

(2) Determine where further observational programmes (using improved technology) are needed to improve understanding of shelf break processes and to provide help with the formulation of more realistic models of the fluxes between the shelf and the deep ocean;

(3) Serve as an international forum for oceanographers to discuss current research on the interaction between the coastal zone and the deep ocean, by using the services and membership database provided by IAPSO.

(4) Foster collaboration between developed and developing countries that have interest in the shelf zone; limited-area models are required to help scientists in countries that do not have access to large computers, and

(5) Produce a comprehensive, published final report incorporating the latest results on the above topics. This report will be in a form of a special issue of a peer-reviewed journal or a book by a major publisher.

Timetable: If approved by SCOR, the following three working group meetings will be held:

1. The proposed first formal meeting of the WG will take place in July 2007 in association with the International Union of Geodesy and Geophysics meeting in Perugia, Italy. Preliminary work prior to this meeting (conducted by email) will lead to identification of additional Associate WG members, and the creation of an agenda for the meeting.
2. The second meeting will occur at the time of the proposed Workshop on Deep Ocean Exchange with the Shelf to involve a wider group of experts from many countries. To support delegates from developing countries, other sources of funding will be sought (including ONR, the EU and SCOR). A venue in 2008 in a developing country would be ideal, for example Cape Town, South Africa.
3. The third and final meeting will be held in July 2009 in association with the IAPSO/IAMAS Joint Assembly to be held in Montreal, Canada. This meeting will be for final discussions to input into the final report of the working group.

Membership

Working group membership is proposed to consist of scientists from various countries with expertise in both modelling and observations of the oceans and in biological, chemical and physical oceanography. If approved, there are 10 proposed Full Members and 2 Additional Members whose travel will be funded by IAPSO. Further Associate Members may be identified to widen the WG expertise.

Full Members:

John Johnson (UK), Chair	Ocean models, particularly shelf. Limited area models.
Piers Chapman (USA), Vice-Chair	Marine chemistry. Nutrients and tracers in the ocean circulation.
Isabel Ambar (Portugal)	Ocean observations, particularly off Iberia. Meddies.
Jan Backhaus (Germany)	Shelf / ocean exchange. Slope convection. Biological models.
Hu Dunxin (China)	West Pacific Physical oceanography and marine sedimentation.
Wajih Naqvi (India)	Marine chemistry. IMBER steering committee. Marginal seas.
Alex Orsi (USA)	Cross-shelf exchanges. iAnZone co-chair. Convection and fronts.
Gordon Swaters (Canada)	Ocean models. Process studies.
Olga Trusenkova (Russia)	Bathymetric effects in the Japan Sea.
Takeshi Matsuno (Japan)	Water exchanges to/from Kuroshio. Biological production.

Additional Members (funded by IAPSO):

If this working group is approved, IAPSO will fund the travel costs for

Pedro Monteiro (South Africa)	Marine Chemistry. Benguela coast (ocean-shelf-river).
John Middleton (Australia)	Ocean circulation over continental shelves. Coastal trapped waves.

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