Implementation of Multi-Disciplinary Sustained Ocean Observations (IMSOO)

Demonstration Theme 3: Open Ocean, Shelf and Coastal Ocean Interactions

Background/Motivation:

Circulation in the coastal ocean and near shore zone influences a diverse range of human activities including maritime industry, recreation, and defense, and it plays a vital role in environmental health and productivity that deliver important ecosystem services. The coastal circulation is driven by local terrestrial influences at the land-shore boundary, coastal zone meteorology, tides, and equally importantly by remote forcing at the shelf/open-ocean boundary.

In many coastal circulation regimes, the proximity of energetic boundary currents in deep water at the shelf edge is a key dynamic in mediating shelf/open-ocean exchange. On coasts for which estimates exist, fluxes of nutrients and carbon across this boundary are leading order terms in the nitrogen and carbon budgets of shelf ecosystems. In addition, mass, heat and salt exchange across the open ocean-shelf are also of significant importance in the coastal and basin-scale ocean budgets. The exchange at the ocean boundary, and shelf edge dynamics have immediate impacts on ecosystem function and productivity on weekly to seasonal time scales, but can also drive multi-decadal changes in ecosystem structure through effects on habitat ranges and biodiversity.

Direct observations of biogeochemical and physical exchanges across the shelf-open ocean boundary have not been sustained to the extent required to fully complement observations within the ocean interior. In large part, this is due to the particular challenges of maintaining observing networks within energetic regimes, and capturing the significantly shorter time and space scales of variability there. While there is an appreciation of the importance and impact of these exchanges between the shelf and open ocean, the effect on the coastal ocean biodiversity and ecosystem is poorly understood.

The long-term monitoring of physics, biogeochemistry and biology across the open ocean-shelf boundary, at key locations (i.e. western and eastern boundaries, and upwelling region), will provide a comprehensive reference data set that will measure exchanges across the open ocean-shelf boundary, improve our understanding of the relationship of boundary currents and the basin-scale gyre forcing, and determine the impact of boundary current variability on coastal marine ecosystems. The observations will also be used to generate initialized boundary conditions for high-resolution coupled reanalysis and forecast model of the coastal seas, and asses the simulation of various regional and coastal models. The continued monitoring of the open ocean-shelf boundary and coastal oceans, combined with a suite of dynamical models, is central to our understanding of how climate signals are communicated through the ocean.

Addressing these issues by downscaling coarse resolution climate model predictions through the application of higher resolution regional and coastal models has shown promise, but still
faces research challenges. Furthermore, a significant amount of physical, biogeochemical and biological response on the continental shelf is due to episodic oceanic and atmospheric events at timescales of variability that are absent from coarse models and cannot be recovered locally. To be valid globally, the veracity of downscaled models needs to be appraised by supporting observations of shelf edge fluxes in a diversity of circulation regimes.

Coastal observing systems have now become sufficiently comprehensive that it is feasible to broadly measure these shelf-sea/deep-ocean exchange processes in conjunction with deep-ocean observing networks that capture variability within boundary current regimes, and the ocean interior, at increasingly fine scales.

Aims:

Specific issues that a comprehensive (observations, and dynamical models) Open Ocean/Shelf and coastal ocean Interaction study should address are:

- understand the impacts and influences of large-scale remotely driven variability on boundary currents and how this affects the shelf and coastal ocean;
- understand how variability of the strength and dynamics of the dominant boundary processes that drive shelf-sea/deep-ocean exchange, including nutrient forcing, carbon export, and other aspects of productivity of shelf and coastal waters;
- understand the response of boundary and shelf dynamics and exchange to local and regional wind and buoyancy forcing fields, and the impact of these on biogeochemical fluxes and ecosystem properties at the shelf and in the coastal ocean.

The provision of robust three-dimensional and time-varying ocean circulation estimates in boundary current regimes, resolving scales of a few kilometres, is seemingly within reach through advances in data-assimilative ocean models. However, development of integrated systems that could deliver the scope of observations required, and the models capable of fully utilizing them, is challenging. To succeed, this will require a coordinated international effort that brings together the expertise of the ocean modelling and observational communities.

Outcomes:

- Articulate requirements for open ocean/ shelf and coastal ocean monitoring i.e.
  - Scientific applications,
  - Questions to be addressed,
  - phenomena/processes to capture,
  - variables to be measured, at what spatial and temporal scales
  - modelling approaches (reanalysis, data assimilation, observations-model comparisons for observation planning and improved model parameterisations).
- Articulate the role and synergies of the range of networks and technologies in boundary current observations, including (but not limited to), Satellite Observations, Deep and Shelf Moorings, XBT Lines, Gliders, HF Radar, net tows, CPR, line-transect sampling, animal telemetry, active and passive acoustic monitoring.