Theme Session Q

Physical and biological consequences of North Atlantic circulation patterns

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Circulation plays a crucial role in determining the physical and biological characteristics of marine ecosystems with important consequences for transport of heat, freshwater and nutrients, as well as affecting species distributions, recruitment (abundance), phenology, production and metabolic rates. This theme session, co-sponsored by ESSAS (Ecosystem Studies of Subarctic Seas), the ICES Working Group on Oceanic Hydrography, SICCME and PICES, was held to explore some of these advective processes and highlight their impacts. The session consisted of 8 oral presentations and 4 posters.

Several aspects of the effects of advection were presented focusing upon different spatial and temporal scales. The importance of atmospheric forcing on interannual variability in advection was examined in the Bering and Chukchi seas region. A shift in the storm paths in the North Pacific between 2006-2011 and 2000-2005 resulted in an increase in the sea surface elevation in the North Pacific, while in contrast there was a decrease along the Arctic coast in the Pacific sector. This increase in the pressure head from the Pacific towards the Arctic drove increased northward flow through Bering Strait resulting in 25% higher volume transport compared to the earlier period. In a separate study, this northward transport was shown to strongly influence the hydrography and hence the associated food webs structure in the northwestern Chukchi Sea. The region nearest the Bering Strait contains mostly Bering Sea water and a pelagic-dominated ecosystem characterized by oceanic zooplankton, zooplankton-feeding birds, higher species richness of demersal fish, and pelagic feeding seals. In contrast, the region farther to the east and north is determined by ice melt water that generates a benthic-dominated ecosystem with more neritic zooplankton, benthic mega- and macro-fauna, and benthic feeding marine mammals.

In the Atlantic, phosphate concentrations in the Barents Sea decreased 20% from the mid to late 1980s and then stabilized. Corresponding phosphate variability at this multidecadal scale was observed in the Norwegian Sea south to the North Sea, and together with the mean circulation, supports the hypothesis that the phosphate signal is advected into the Barents Sea. Seasonal hydrographic variability on the West Greenland shelf was shown to be controlled by advection from off East Greenland. Upper layer temperatures on the shelf at the southern tip of Greenland are determined by the arrival of Arctic water off East Greenland, which are then advected northward along West Greenland and during the late spring and summer are warmed through solar heating as they progress. This results in a northward increase in the peak monthly mean temperature to at least Davis Strait. The monthly mean salinity minimum caused by the ice melt off East Greenland was also observed to be advected northward. Two presentations discussed the Mediterranean Overflow Water (MOW) as it is advected into the Gulf of Cadiz, immediately seaward of the Strait of Gibraltar. The MOW plunges over the sill at the Strait and being denser then the surrounding waters it generates mainly near bottom flow. As it enters the Gulf, it turns right under the influence of the Coriolis force and forms several branches as it follows bathymetric features, such as channels, gullies and mounts (Fig. 1). Although the major mixing process between the MOW and the surrounding waters is associated with entrainment as the MOW flows down from the sill to the bottom of the Gulf of Cadiz, secondary circulation features such as the flow around bends in curved channels result in significant additional mixing.



Fig. 1. The salinity and currents in the various branches of the MOW in the Gulf of Cadiz. ENACW-Eastern North Atlantic Central Water; MOW(SC)-Shallow Core (250-350 m); MOW(UC)-Upper Core (350-500 m); MOW(LC)-Lower Core (>800 m).

A number of presentations examined climate forcing on various species and trophic levels. Although not focused on advection per se, they often dealt with climate variables influenced by advection. One such study produced statistical distribution models for several zooplankton species in the North Atlantic based on present distributions in relation to sea surface temperatures, salinities, phytoplankton and pH, as well as bathymetry. These were then used to project climate change scenarios of the zooplankton distributions. Results suggest an average displacement northwards of around 9 km/decade, earlier peak abundances and a turnover of species that is greatest south of the Gulf Stream. Exploration of recruitment of King scallops in the eastern English Channel showed that late spring-early summer SST was the main environmental factor controlling recruitment. This period corresponds to both the breeding season and the pelagic larval stage. Several investigations examined conditions around the Iberian Peninsula. A statistical analysis of weight-length relationships of Iberian sardines showed evidence of density dependent effects, with higher weights per length under warmer temperatures and greater zooplankton prey. Coherence between climate indices and fisheries helped to identify 2 and possibly 3 regime shifts in the NW Iberian waters. An upwelling index was described and their characteristics in terms of hydrographic and atmospheric structure throughout the North Atlantic were presented. This was recommended as a local climate index for the NW Iberian Peninsula. Seasonal and interannual cetacean strandings along the Galician coast were shown to be significantly correlated with oceanographic conditions, especially upwelling.

Advection was shown to play a major factor in explaining observed interdecadal to seasonal variability in several regions of the Northern Hemisphere. Increasing attention will need to be paid to changes in advection and its consequences if we are to adequately anticipate and prepare for the future effects of climate change.