ICES/NAFO Decadal Symposium 2011

Keynote Presentations

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The ICES Report on Ocean Climate: variability in the ICES region.

Sarah Hughes, Marine Scotland Science, UK

with N.P. Holliday, F. Gaillard and the ICES Working Group on Oceanic Hydrography.

The ICES Working Group on Oceanic Hydrography (WGOH) maintains, analyses, and develops coastal, shelf and deep ocean repeated stations and sections around the sub-polar North Atlantic, the Nordic Seas and adjacent shelf seas. Each year since 1999, the WGOH has generated a summary of atmospheric and hydrographic conditions in the North Atlantic and published this as an annual report, the ICES Report on Ocean Climate (IROC). The data presented in these reports are reviewed to provide a record of observed inter-annual variability in the North Atlantic over the last decade.

A number of the timeseries are long, some longer than 50 years, and this allows the conditions observed in the decade of (2000-2009) to be compared with earlier decades, putting the recent observations into context with the long term variability. Annual mean values can be useful for examining decadal scale variability, however in order to understand the impact of physical variability on the marine ecosystem changes within seasons may be more important. Seasonal data across the North Atlantic are examined looking for evidence of changes in seasonal patterns.

Over the last decade members of the WGOH have worked together in collaborative research developing new insight into climate variability and the impact on ecosystems. Some of the key findings from this research are reviewed and updated here, including observations of unusually warm and saline Atlantic Water in the Nordic Seas and a comparison of gridded data products (SST and North Atlantic gridded temperature and salinity fields) with selected time series.

Contact details: S. Hughes, Marine Scotland Science, Marine Laboratory, PO Box 101, 375 Victoria Rd., Aberdeen, AB11 9DB, Scotland [e-mail: s.hughes@marlab.ac.uk].

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Climate variability in the North Atlantic, causes and consequences

Peter Rhines, University of Washington, USA

Physical circulation and ocean biology interact in many ways. From the global pattern of nutrient upwelling pathways/meridional overturning circulation (MOC) to microscopic interactions between ocean turbulence and foraging/feeding strategies, ecosystems must deal with basics of stratification of temperature and buoyancy and shearing/straining/vertical&horizontal advection by ocean currents. Here we describe the surges of circulation that have brought (a) unusually warm, saline waters to the subpolar Atlantic Nordic Seas in episodes, particularly in the early 2000s, the late 1980s, the 1960s and the extended pre-Greenhouse warm-period extending from late 1920s to 1950s (Hakkinen & Rhines, *J. Geophys. Res*. 2011; *Science*, 2011 submitted); and, (b), episodes of invasion by buoyant, low-salinity waters overtop of the subpolar Atlantic, from orgins in the Arctic. The warm episodes (a) are linked to atmospheric forcing patterns, the famous NAO but also long periods of repeated atmospheric blocking anticyclones and their effect on wind-stress-curl. These are large, stalled meanders of the jet stream occupying either the Greenland region or the European sector. The cold, low-salinity surface waters (b) are enhanced Arctic outflow which has contributed to recent decline of sea-ace in the Arctic basin.

MOC is usually represented as the maximum streamfunction of the zonally averaged north/up velocity plotted against latitude. This is an incomplete icon-isation. Bergen, Norway and UK oceanographers provide analysis of the MOC in terms of *water-mass transformation* rather than a simple index of velocity. They give this more dynamically informative picture of vertical mixing, lateral transport and air/sea exchange, which has strong connections with ecosystem geography and intensity.

Finally, robotic glider platforms return fine-scale observations of bio-optical profiles coordinated with vertical velocity, shear, temperature and circulation. Relating to water-mass transformation, mode-water production and deep convection, we have shown from Seaglider deployments (Frajka-Williams & Rhines, *Deep-Sea Research,* 2009, 2010, see also Wu *et al.* Mar. Eco. Prog. Ser. 2008) that advection of buoyant low-salinity waters from Greenland boundary currents exerts strong control over primary production: the dominant spring bloom of the western subpolar Atlantic.

Contact details: P. Rhines, University of Washington, Box 357940, Seattle, Washington 98195, USA [e-mail: rhines@ocean.washington.edu].

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Plankton variability in the ICES area

Peter Wiebe, Woods Hole Oceanographic Institution, USA

In the North Atlantic Ocean, zooplankton diversity, biogeography, and phenology are responsive to environmental variation associated with changes in natural climatic factors and anthropogenic forcings. Natural forcings include fluctuations in solar energy, volcanic eruptions, and decadal to millennial scale internal oscillatory variation. In contrast to natural oscillations, human activities (especially greenhouse gas emissions) often appear to drive the ocean system in a unidirectional manner. Environmental time-series and spatial monitoring data are essential to observe and understand these changes in marine zooplankton populations over seasonal, interannual, decadal, and longer time scales. During 2000-2009, substantial changes occurred in zooplankton species' distribution and abundance across the North Atlantic. The extent and direction of responses varied from site to site, and driving forces and climate change effects varied among regions. The length of time-series observations also affected the result: short time-series may give biased results. Since many zooplankton species occur across the North Atlantic Basin, determining the correlation length scales of population fluctuations, discriminating between local and remote forcings, and understanding the underlying mechanisms require a basin-scale approach. Importantly, most sites record only biomass or total abundances by functional groups, yet species data are necessary to recognize biogeographical shifts and pheneological changes.

Beginning in 2001, the ICES Working Group on Zooplankton Ecology (WGZE) has produced a summary report on zooplankton in the ICES area based on time-series data from national monitoring programs. The most recent report includes data updated to 2009 from 40 stations (9 in Northwest Atlantic, 16 in Northeast Atlantic, 9 in Baltic Sea, 6 in Mediterranean Sea), as well as the CPR time-series for North Atlantic standard areas. Complementing this effort is a global collection of zooplankton biomass and total copepod abundance time-series data compiled by the SCOR Working Group 125. These data and analyses are invaluable for documenting changes in zooplankton diversity, biogeography, and phenology; interpreting changes in relation to hydrographic parameters, and differentiating natural and anthropogenic drivers of the observed variation.

Contact details: Peter Wiebe, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA [e-mail: pwiebe@whoi.edu].

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Seal-Cod Interactions on the Eastern Scotian Shelf: Decadal Scale Processes and 'The Balance of Nature'

Michael Sinclair, Bedford Institute of Oceanography, Canada

with R. O'Boyle.

For most fish stocks, a major reduction in fishing mortality has resulted in increases in abundance. The cod stock on the eastern Scotian Shelf is a notable exception. It collapsed in the early 1990s, and a moratorium on fishing has been in place since 1993. The stock has continued to decline, and has experienced high natural mortality. In parallel, the abundance of Grey seals foraging in the area has doubled about every seven years since the 1960s. The causes of the high cod natural mortality are not well understood, but seals are not considered to have played a significant role. This lecture takes a fresh look at the impact of seals on cod abundance. Abundance trends of the "Sable" and "Gulf" seal herds which forage on the Scotian Shelf are estimated to 2050. Total annual food consumption of the two herds is estimated, and the implications of changes in energy density of the diet evaluated. At present, in excess of 250,000 tons of fish are consumed annually by the 'Sable" herd, with the 'Gulf" herd consuming about 50,000 tons. The literature on Grey seal diets indicates that cod is a major item, even at low cod abundance. An exploratory approach is taken towards defining parameters of a Type 2 "functional response" of seal foraging on cod. A range of cod size/age selectivity options is considered, with best fit to the data being "flat top" partial recruitment. In a cohort analysis of 1970 – 2005 cod abundance, seals are treated as an additional fishing gear sector. Model results infer that seals account for most of the increases in natural mortality since the late 1980s. It is concluded that Grey seals are responsible for the lack of recovery of cod since 1993, and also have contributed to its collapse. Projections to 2050 predict a continuing decline, with cod becoming extirpated. However, recent increases in cod abundance are not predicted by the model. This case history on decadal fluctuations in seal and cod abundance is discussed in relation to concepts of "the balance of nature".

Contact details: Michael Sinclair, Bedford Institute of Oceanography, Dartmouth, Nova. Scotia, Canada, B2Y 4A2 [e-mail: Michael.Sinclair@dfo-mpo.gc.ca].

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Ecosystem variability: preparing an integrated assessment of the North Sea.

Andrew Kenny, Centre for Environment, Fisheries and Aquaculture Science, UK

An understanding of the causes of variability (or state change) in marine ecosystems is fundamental for developing effective management approaches. It is central to the implementation of the ecosystem approach and in meeting numerous policy objectives (e.g. the European Commisson's Marine Strategy Framework Directive, MSFD, to deliver Good Environmental Status) What is less well defined is how much understanding is enough to ensure the development of effective environmental policies and management practices? This is largely a question related to knowledge transfer, maximising the value of what we know and what we hold in the form of empirical data, and presenting the results in a manner that is helpful for those making management decisions.

In the late 1990's ICES recognised these challenges and initiated a process which is still active today in developing regional integrated ecosystem assessment approaches as part of its Regional Seas Programme. The activities are presently divided between two different approaches, namely: i. data driven, and ii. management driven. The difference essentially being, data driven approaches focus on assessing patterns of ecosystem variability which are then used to identify the key causes of change at a range of spatial and temporal scales; whereas management driven approaches, through existing knowledge of human activities and their impacts on the marine ecosystem, focus on identifying the key causes of change from the outset. In an ideal world, where there is effective transfer of knowledge from the empirical data to the identification of the key causes of ecosystem change, the outcome of the two approaches should be the same.

What we have learnt from a data driven approach is that change in the North Sea (as it is for all ecosystems) is the norm. The North Sea exhibits cyclical trends in state across all trophic levels, but at any given time not all components vary with the same rate, magnitude or direction of change. Describing and understanding such differences, in particular their dependencies, has resulted in a much greater appreciation of the importance in understanding and in defining a hierarchy of ecosystem variability at a range of space- and time-scales. In essence, what is emerging is an ordered picture of component trends within trends making up the whole ecosystem, some of which we are able to control directly (e.g. fishing effort), but others we are not (e.g. primary and secondary production). This ordered picture of variation should help to prioritise the identification of the causes of change as part of the management driven approach and to ensure the most appropriate management actions are therefore taken.

Contact details: Andrew Kenny, Cefas, Pakefield Road, Lowestoft, Suffolk, UK [e-mail: andrew.kenny@cefas.co.uk].