DRAFT Theme Session C – Climatic variability in the ICES area – 2000-2005 in relation to previous decades: physical and biological consequences

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In the 2001 report of the Intergovernmental Panel on Climate Change (IPCC) it was stated that the warmest years on record occurred during the 1990s and early 2000s. These observations were confirmed by Holliday who outlined results from the ICES Report on Ocean Climate (IROC) for 2005. Since 1995 sea surface temperature and salinities have shown a pronounced upward trend over most of the northern North Atlantic with a warm anomaly moving northward. In contrast, in the deep ocean temperatures and salinities have been decreasing since the mid 1970s. Complimentary to these long-term sections are the new data that are becoming available with an unprecedented coverage from ARGO floats for salinity and temperature down to 1000m. Integrated gridded results for the northern North Atlantic between 70° N and 20° S were presented by Gaillard and Autret. While only based on six years data, the ocean near the surface was warmer and saltier over most of the basin with extreme anomalies (more than 1.5°C and 0.2PSU) in the north-west. de Jong and van Aken presented evidence for a thickening and deepening of intermediate water in the winter that possibly indicates that convective mixing is taking place in the northern Irminger Sea ~600m, based on results from two moorings deployed in 2004-2005 and modelling. Skagseth and colleagues showed that dense water produced from brine rejection during ice formation accumulates at the bottom of the Barents Sea and cascades to contribute to intermediate water in the Norwegian Sea via the Bear Island Channel. Post 1990 the water was much fresher and lighter with an Arctic source from East Greenland and the ouflows were shown to be a response to the strength and composition of inflowing Altantic water. Similar compensatory flows were described by Feistel *et al*. as Baltic inflows, which were forced by baroclinic processes (temperature gradient) for the first time on record during the summers of 2002 and 2003, http://www.helcom.fi/environment2/ifs/en_GB/cover/. While not confirmed, these unusual events were probably a consequence of the warm summers of those years. In the past, inflow events that play such a key role in oxygenating the deep basins of the Baltic and have a major impact on ecosystems and eutrophication have all been forced by baratropic processes following intense westerly gales. On the western Irish shelf Nolan and Lyons showed that the circulation pattern is a consequence of interaction between eastern North Atlantic water and freshwater discharge from Irish and more distant rivers (Severn and Loire). Temperature measurements taken at Malin Head since 1960 showed a pronounced upward trend especially after the late 1980s. Cooling by strong winter storms engendered colder years.

Off northern Spain the rate at which sea water is warming over the last 10-15 years has been much higher than the long-term trend of mean global ocean temperature over the 20th century. González-Pola showed that in the upper layer of East North Atlantic Central Water (ENACW) the warming has been due to isopycnal sinking (heave) and in the intermediate Mediterranean Water (MW) to changes in the thermohaline properties of the source waters. Following the anomalously cold winter of 2005 the whole system changed to the coldest and deepest mixed conditions on record and has continued to have different properties than previously. In this same region Victor Valencia and colleagues showed that the seasonal pattern of ocean/metorological conditions has changed during the last five years with many very anomalous months. Off the Iberian Peninsula and in the Bay of Biscay a more detailed account of variability, MEDDY formation and diapycnal mixing of intermediate waters comprising MW and Labrador Sea (LSW) sources was outlined by Sánchez and colleagues. Between the periods 1990-1999 and 2000-2005 a well-defined warming and salinity increase occurred in intermediate waters that appeared to be related to variations in the properties of LSW in the central Labrador Sea. Moving to the north of Jan Mayen, the Greenland and

Lofoten Basins are separated by the Mohn and Knipovich ridges. Isopycnal analysis by Rossby and colleagues shows that a sharp property front exists along the Mid Atlantic Ridge with complex physics in the adjacent basins; T/S-anomalies in the Lofoten Basin probably result from the subduction of surface waters, and varying fluxes from the Arctic and Barents Seas. Based on historical proxy data Weisse and von Storsch reported that there has been no systematic change in the roughening of the storm climate in the Northeast Atlantic and adjacent shelf seas over the past 200 years, although there was an increase from ~1960 to 1990 since when there has been a decline. Against this background scenario model runs suggest that meteorological induced changes in storm surges may increase their reach by up to 30 cm on North Sea coasts towards the end of the century and that extreme wave heights may increase by up to 30 cm (7% of present values) in the south-eastern North Sea by 2085. Neither of these scenarios include any effects from sea level rise. Possible environmental and ecosystem relationships in the Barents Sea with lunar cycles of 9.3, 18.6 and 74.4 with future predictions were outlined by Yndestad. In a contribution by Budgell and colleagues the development of a new coupled ice-ocean model with 35 vertical levels and a grid of 17-20 km covering the North Atlantic and Arctic Oceans was outlined. The model was run for a full year to generated time series from 1958 of hydrodynamic variables such as temperature and volume transport that can be related to fisheries observations. Analysing a comprehensive time series data sets for the same area Lopes and Anadón showed that the warming trend, by enhancing stability, seems to be behind a reduction in density, nutrients and primary production. While upwelling/downwelling intensity has remained constant over the last 30 years the timing of the onset has advanced with consequent effects on the ecosystem. A multivariate analysis by Bode and colleagues of data from the Bay of Biscay showed significant linear trends in climatic, oceanographic and biological timeseries during the period 1950-2005 with superimposed multidecadal oscillations. Described as a combination of several indices, ‘climate’ was related to changes in key oceanographic variables such as SST, upwelling and poleward flow as well as planktonic and fish indices. There was a clear change in the system after the early 1990s with increases in phytoplankton biomass and a reduction in diatoms. A Bayesian analysis by Uusitalo and colleagues of data from the northern Baltic Sea showed that environmental factors not controllable by man (such as length of coastline and area specific thermal conditions) seem to have a dominating role in the determination of fish productivity and species diversity, while eutrophic factors play a minor role. The results indicate that expected future rises in temperature and reductions in salinity are likely to have a large effect on the distribution and abundance of coastal fish in the region.

Addressing more biological issues the next paper by Friedland and colleagues showed that the fishery independent Den Oever recruitment index (DOI) determined from glass eel catches of the European eel *Anguilla anguilla* measured since 1938 in the Netherlands was inversely correlated with the NAO winter index lagged by one year and included a step change in the time series (regime shift) in 1987. With a similar lag the DOI index was also shown to be correlated with ocean-atmospheric changes in the Sargasso Sea associated with upper layer water temperatures, winds and mixed layer depth (MLD) that are likely to have a strong influence during the spawning and early larval development season of leptocephali. Daewell and colleagues used 4 coupled models (3-D hydrodynamic, NPZD, Lagrangian transport and individual species, IBM, of early life stage foraging, growth and survival) to assess the effects of changing environmental factors on the spatial and temporal variability of larval sprat growth in the north Sea over the period 1990-2004. Impressive examples of model output including monthly maps of zooplankton biomass and of potential larval survival were shown, which in the latter case was variable in different regions of the North Sea. In one of two papers presented on the sudden mass occurrence from 2003 of pelagic snake pipefish in the north-east Atlantic Damme and Couperus, using data from trawl surveys, contrasted the oceanic explosion with the occasional records from coastal forms that inhabit sea grass beds and outlined impacts on higher trophic levels and the coincidence with increases in blue whiting and Norwegian spring spawning herring. The second paper by Lindley and

colleagues using mtDNA sequencing established that they were snake pipefish, *Entelurus aequoreus* and showed that they extended from 40° to 57°N. Astthorsson also noted the presence of the first record of pipe fish in Icelandic waters near the shelf edge when describing the appearance of 22 new southerly species since 1995 reflecting warmer temperatures and the stronger influence of North Atlantic water in the area. Many exploited species are also showing extensive changes including the occurrence of mackerel for the first time since 1940. Moving to off the Northwest African coast Meiners and colleagues showed that the recruitment of the European hake is positively and proportionally related to the amplitude of the NAO in the previous year. In this region the NAO is shown to be a proxy for the Canary Current (Trade winds) acting on the ecosystem by modifying the timing and distribution of upwelling.

In addition to the oral papers 11? Posters were presented covering a wide range of themes in all areas of the ICES region. The combined information presented in the theme session showed a wide range of new applications that are being used to address climatic impacts on North Atlantic hydrography and

ecosystems. The results presented from time series observations highlighted major changes, including a pronounced warming of surface waters in the eastern Atlantic that has had pronounced effects on ecosystems and fisheries. A key and often repeated message during the conference was the importance of maintaining, reinforcing and providing appropriate funding mechanisms for long-term measurements.