

Theme Session C

Climatic variability in the ICES area – 2000–2005 in relation to previous decades: physical and biological consequences

ICES CM 2006/C:01

Storm climate and related marine hazards in the Northeast Atlantic and the North Sea

Ralf Weisse and Hans von Storch

Storms represent a major environmental threat. At sea, wind pushes water masses towards the coast where water levels may become dangerously high, eventually overwhelming coastal defences and inundating low-lying coastal areas. Also, the sea-surface is affected where wind waves and swell are generated and obviously represent a threat to offshore navigation, shipping, and coastal defence. We review a number of questions related to windstorms in the Northeast Atlantic and the North Sea, in particular:

- 1) How to determine decadal and longer variations in the storm climate? The methodological problem is that many variables suffer from inhomogeneities or are available for too short periods only. Proxies are suggested from which useful information can be derived.
- 2) How has the storm climate developed in the recent past? It is shown that an increase since about the 1960s has been replaced by a downward trend since about 1990. Since about 1990–1995 storm activity has been decreasing.
- 3) How is the storm climate variability linked to hemispheric temperature variations? The hypothesis that a general warming will cause an increase in atmospheric water vapour content and subsequently increased storminess is examined in a millennium simulation with a state-of-the-art climate model. It turns out that the hypothesised link could not be detected during pre-industrial and industrial times even when significant temperature fluctuations were simulated.
- 4) How did storm surges and ocean waves develop in the recent past and what may happen in the expected course of anthropogenic climate change? The issue is examined using detailed regional reconstructions and climate change scenarios.

Keywords: storm climate, storm surges, sea state, ocean waves, climate change.

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ICES CM 2006/C:02

Possible lunar nodal tide effects on climate and ecosystem variability in the Nordic Seas and the Barents Sea

Harald Yndestad

The Arctic Ocean is a substantial energy sink for the Earth's Northern Hemisphere. Fluctuations in its energy budget will have a major influence on the sea temperature and the ecosystems in the Nordic Seas and the Barents Sea. The study investigates dominant cycle periods and phases in a number of long North Atlantic and Arctic time-series. The dominant cycle periods and phases are identified by wavelet and Hilbert transformation on some of the longest time-series in the ICES area. The polar position, the extent of the Arctic ice, the Kola section temperature, North Atlantic Water temperature at Faroe-Shetland Channel, the sea level at Stockholm, the lunar nodal tide, and the NAO winter index. The relations between the dominant cycles in the time-series depend on the causes of fluctuation and the causes of the climatic variability. The wavelet analysis has identified dominant cycles correlated to the astronomical nodal tide periods of $18.6/2=9.2$ and 18.6 years and sub-harmonic cycle periods of about 55 and 74 years. The results indicate we may understand the climate variability as a chain of coupled oscillating systems, from long lunar gravity cycles to oscillating climate cycles and to oscillating ecosystems. An extrapolation of the long cycles indicates that we may expect the mean temperature in the North Atlantic Seas and the Barents Sea temperature will continue to increase to about 2010. In the same period the ecosystem dynamics are expected to be influenced by the 9- and 18-year tidal temperature fluctuations.

Keywords: lunar nodal tide; climate oscillation; eco oscillation; coupled systems; wavelet analysis.

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ICES CM 2006/C:03

Variability and possible convective mixing in the Irminger Sea

M. F. de Jong and H. M. van Aken

Between September 2003 and October 2005, daily CTD profiles were recorded by a mooring located in the cen-

tral Irminger Sea (ICES area XIVb²). The record is explored for variability at time scales up to the length of the record. At short time scales there is large day-to-day, density compensating, thermohaline variability, which points to lateral exchange. The time-series from the record also show significant annual cycles of salinity and potential temperature at intermediate depths. At about 1100 dbar, the maximum amplitudes are 0.008 psu in salinity and 0.04°C in potential temperature. Both salinity and potential temperature reach a minimum in spring.

The annual signal is assumed to originate locally, a result of lateral spreading of newly ventilated water after a deep convection event in the Irminger Sea. This hypothesis is supported by observations of a strong decrease in potential vorticity over the upper 400 dbar towards spring and by individual mooring profiles, which show an increase in mixed layer depth to over 600 m in a few days during the winter of 2004–2005.

The possibility of deep convection is further explored by a model driven by surface fluxes derived from the NCEP re-analyses data set. Model results show it is possible to ventilate the intermediate levels in the Irminger Sea during strong winters.

Keywords: Irminger Sea, annual cycle, profiling mooring, hydrography, intermediate water, deep convection.

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ICES CM 2006/C:04

Bayesian impact analysis of geographical environmental factors: predicting the effects of climatic change and water quality management on fish productivity

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Most of the impact analyses of climatic change or water quality management are based on theoretically driven models due to the fact of missing empirical data. In this paper, we carry out an empirically driven analysis by utilising large data sets of fish productivity (yield) and environmental variables, spanning 21 years and over 1000 km of northern Baltic Sea coastline. Variance over both time and space are utilised to estimate the likely changes in fish productivity in case of climatic change and/or management impacts. High uncertainties both in the data and in the study problem itself, as well as risk-averse attitude needed in safeguarding biodiversity, motivate the use of probabilistic Bayesian methodology. Large-scale 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 the eutrophic status only has a minor impact within the range available in the data. Our analysis shows that

climatic change may potentially have a large effect on the distribution and abundance of northern Baltic coastal fish abundance and distribution through increasing temperature and decreasing salinity.

Keywords: Baltic Sea, fish abundance, environmental factors, Bayesian network, climatic change.

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ICES CM 2006/C:06

Exceptional abundance of the snake pipefish (*Entelurus aequoreus*) in the northeastern Atlantic Ocean

J. A. Lindley, R. R. Kirby, D. G. Johns, and P. C. Reid

Pipefish (*Syngnathidae*) have occurred with unprecedented frequency in Continuous Plankton Recorder (CPR) samples to the west of the British Isles from 2003 to 2005. Identification by mtDNA sequencing established that they were snake pipefish, *Entelurus aequoreus*. The geographical range of the records were from the outer continental shelf of the Celtic Sea and northwest of Ireland to the mid-Atlantic Ridge between 40° and 57°N, with the greatest abundance near the shelf edge and adjacent oceanic waters south of Ireland and west of Brittany. There were records in every month from February to November, but most were in late spring and summer. A proposed mechanism for the increase in abundance of the species is that recent climate change has had beneficial impacts on the reproduction of adults and the survival of larvae and juveniles.

Keywords: Pipefish, Atlantic Ocean, Continuous Plankton Recorder, climate change, reproduction.

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ICES CM 2006/C:07

Recent changes in the pelagic ecosystem of the Iberian Atlantic in the context of multidecadal variability

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Trends in ecosystem variables of the Eastern North Atlantic shelf near the Iberian Peninsula were analysed in relation to regional climate and oceanographic variability. In addition, detailed changes in oceanographic prop-

erties (surface temperature, upwelling and poleward current activity) and biological components (plankton and pelagic consumers) in the period 1989–2005 were compared with the main trends and multidecadal periods observed in time-series dating back to 1950. In contrast to previous studies, the North Atlantic Oscillation did not appear as the main influence in the climate of the North Iberian region, while East-West and subtropical gradients were the dominant modes. Climatic oscillations at decadal scales were paralleled by similar oscillations in oceanographic and biological variables, but the latter appeared to be only weakly related to climate. Time-lags of up to 5 years in the biological response may partly explain these relationships. The main planktivorous fish species (sardine and anchovy) alternate in periods of 10–15 years of relative dominance, in synchrony with equivalent species around the world. In contrast, plankton cycles appear greatly modified after 1990 in coincidence with shifts in climatic and oceanographic variables. Subregional variability indicated divergent trends in biological variables, particularly the zooplankton increase off A Coruña and the decrease in the Bay of Biscay since 1990. Such divergences are related to direct and indirect effects of global changes in this transitional upwelling region.

Keywords: plankton, fish, interannual variability, climate, NAO, upwelling, continental shelf, NE Atlantic.

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ICES CM 2006/C:08

Linear and non-linear trends driving the hydrography of the southern Bay of Biscay and its effects on phytoplankton

Marcos Llope and Ricardo Anadón

The southern Bay of Biscay shows a very active hydrography due to variation of its Central Waters, the recurrence of mesoscale processes such as slope currents and upwellings, and the year-to-year variations in the strength of the winter mixing. Furthermore, the area is also affected by the general warming reported all over the bay. In this work we make a diagnosis of the state of the Cantabrian pelagic system (North of Spain) by describing its recent past evolution in order to improve our ability to predict its future development. To do so, we analyzed an oceanographic time-series (1993–2003) established by the Instituto Español de Oceanografía off the Asturian coast (www.seriestemporales-ieo.net). Particularly, we looked for the existence of any pattern in the physical, chemical and biological long-term dynamics and any possible relation among them. We found that the upper layers of the ocean show increasing temperature and decreasing salinity and density trends. On the other hand, the intensity of the upwelling, a process which could counteract the warming on the coast, seems to be de-

creasing. These patterns suggest an enhancement of the water column stratification that could be related to the decreasing trends of nitrate, nitrite, silicate, and primary production also observed. In addition to these linear trends, all nutrients showed a superimposed non-linear variation. These cycles worked independently, causing stoichiometric unbalances that may have important implications regarding the structure of the phytoplankton community.

Keywords: long-term trends, warming, nutrient cycles, Bay of Biscay, primary production, phytoplankton structure.

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ICES CM 2006/C:09

Response of Baltic water properties to the unusual inflow sequence since 2002

Rainer Feistel, Günther Nausch, and Eberhard Hagen

An unusual succession of inflow events into the Baltic Sea occurred in 2002 and 2003, including (i) the first ever reported important baroclinic inflow (August 2002), (ii) the Major Baltic Inflow (January 2003), causing the highest oxygen levels in the Gotland Deep since the 1930s, and (iii) the baroclinic inflow (August 2003), which eventually elevated the Gotland Basin deepwater salinity to values last observed in 1977, and turned the surface salinity trend to rise again. Salt residence times of about 20 years in the deep water, and 30 years above the pycnocline, can be estimated from these data. Ventilation of the remote Karlsö Deep took until 2005, two years after the inflow event of January 2003, at a time when the Bornholm and Eastern Gotland Basins were returning to anoxic conditions again. Changes in the redox conditions exert a considerable influence on the nutrient distribution in the deep water. In addition, the inflow events elevated old phosphate-rich water masses which can in turn influence the nutrient content of the surface layer. A possible link of these remarkable processes to the exceptional global and regional climatic conditions in those years is likely, but hypothetical yet.

Keywords: barotropic and baroclinic inflows, deepwater renewal, salinity trend, residence time, Baltic Sea.

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ICES CM 2006/C:11

Interannual variability of the North Atlantic: space and time characterization of the temperature and salinity properties

Fabienne Gaillard and Emmanuelle Autret

Observing systems of the ocean interior coordinated by GOOS are gradually being set up. They now approach global coverage and progressively extend the panel of observed variables. The ARGO project, based on profiling floats, is now close to its nominal extent providing high resolution temperature and salinity profiles over the global ocean. This new project complements previous profile datasets obtained with XBTs and CTD. The data coverage of the North Atlantic allows to closely monitor this basin beginning in 2000. We have thus computed monthly fields of the upper 2000 m, with improved horizontal and vertical resolution. We are then able to follow the interannual variability of the seasonal cycle. The annual mean fields produced extend the series computed by Levitus. We analyze with particular attention the space structure of the anomalies, and the mixed layer depth and properties with the aim of relating them to changes observed in the distribution of biomass.

Keywords: interannual variability, climatologies.

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ICES CM 2006/C:12 – Poster

Climatic trends in the North Atlantic and their consequences for the Canary Upwelling region

Alexander Sirota, G. Chernega, and S. Kuderskiy

The large-scale atmospheric circulation is one of the main factors determining climatic conditions. In this study we examine the series of atmospheric macro-circulation parameters over the North Atlantic, such as circulation indices and characteristics of the atmosphere's center of action. These time-series demonstrate the presence of alternate succession of long-period trends in the atmosphere circulation during the 20th century. These low-frequency trends are in accordance with variations in the rotation velocity of the Earth. The last remarkable climatic shift in atmospheric circulation over the North Atlantic occurred from the end of the 1980s to the beginning of the 1990s. The development of a new phase in climatic changes is to be expected in the nearest years. This shift may be similar to the one observed in the 1960s–1970s. The Canary Upwelling region, situated near the Northwest African coast has been examined in order to reveal physical and biological consequences of the observed climatic changes. The indicators, which characterize environmental conditions, were the Azores anticyclone position, North East Trade Wind intensity, sea surface temperature, coastal upwelling intensity, and the position of the oceanic front as well. Well-

coordinated variations in large-scale atmospheric circulation over the North Atlantic and indicators characterizing the environmental conditions in the Canary Upwelling region were observed. These variations also coincide with long period fluctuations of the European sardine biomass.

Keywords: North Atlantic, Canary Upwelling region, large-scale atmospheric circulation, climatic trends, sardine biomass fluctuations.

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ICES CM 2006/C:14

Isopycnal analysis of near-surface waters in the Norwegian-Barents Sea region

Tom Rossby, Vladimir Ozhigin, and Sheldon Bacon

The waters of the Nordic and Barents Seas exhibit very large variations in temperature and salinity. In order to distinguish between dynamical and thermodynamical effects we use isopycnal analysis to map the depths of these surfaces on the one hand and property change along these surfaces on the other. Analysis of the 27.7 to 27.9 isopycnal surfaces show that these generally shoal to the north as expected, towards the Greenland Sea in the west and the Barents Sea in the east. However, geostrophically speaking this bowl-like shoaling pattern implies a retroflexion and anticyclonic circulation in the Lofoten Basin. Identifying the processes responsible for this pattern is of fundamental importance to a proper understanding of the dynamics of the region as well as to identify transport pathways of physical, chemical and biological properties. The isopycnal analysis also reveals a conspicuous T/S-anomaly maximum in the Lofoten Basin, which appears to result from convective heat losses and downward mixing of saline waters to deeper isopycnal surfaces where they then appear as warm salty water.

We also show that temporal variations in isopycnal layer depth and water properties can persist and/or propagate around the Nordic Seas for several years. Depth variations likely reflect variations in Ekman pumping while T/S-anomalies probably result from the subduction of surface waters, and varying fluxes from the Arctic and Barents Seas. This isopycnal approach may help us better understand the roles of mechanical and thermodynamic forcing of upper ocean conditions in the Nordic Seas.

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ICES CM 2006/C:15

Climate variability and recruitment success of European hake (*Merluccius merluccius* L.) in NW Africa

César Meiners, L. Fernández, P. Torres, and A. Ramos

Recently European hake abundance was shown to be strongly dependent on climate variability in NW Africa. This relationship was explained by the North Atlantic Oscillation (NAO) driving over upwelling temporality that could be responsible for changes in survival rate during early life stages of European hake. Following this hypothesis, the present study focuses on the relative importance of climate variability on recruitment dynamics of European hake. Interannual variability of recruitment success was analyzed through two types of time-series: (i) from monthly and annual length distribution fishery data (1982–1999) of the Spanish trawling fleet working under Spanish-Moroccan fishery agreements, and (ii) recruitment abundance from scientific Moroccan surveys (annually: 1982–2004). The time-series were compared with the annual smoothed North Atlantic Oscillation (NAO) index to evaluate the type of relationship, persistence and their relative contribution as a variation source of recruitment success. The recruitment to the fishery took place throughout the year with peaks in spring and summer, but the seasonal component was weak. The time-series were in synchrony with the NAO index from the previous year and showed strong positive correlation. The variation of recruitment success explained by the NAO was 40–73%, depending on the size of the time-series. The main NAO effect in recruitment dynamics was the widening-contraction of the Recruitment Window. During the NAO+ phase several success cohorts were recruited each year, while in NAO- the success cohorts were scarce and weak. The climate signal in recruitment dynamics of European hake was robust, recurrent, and persistent independently of the fishing effort.

Keywords: recruitment, European hake, NAO, NW Africa.

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ICES CM 2006/C:16

Oceano-meteorological conditions in the SE Bay of Biscay for the period 2001–2005. A comparison with the period 1986–2005 and other reference periods

V. Valencia, A. Fontán, A. Borja, and N. Goikoetxea

In spite of the local character of the meteorological and oceanographic data collected in the Basque Coast, they are representative of mesoscale situations in the Bay of Biscay and indicate also teleconnections with global scale factors such as the NAO. On the other hand, some seasons of the first five-year period of the 21st century in

the SE Bay of Biscay and other areas have been defined as “extreme” (warm summer in 2003; cold and long winter in 2005; very dry spring and summer seasons in 2005; etc.). Consequently, frequent seasonal anomalies are apparent and, in general, it means that winter-summer duality prevails against the establishment (in terms of values and mean duration) of spring and autumn as typical transitional seasons at mid-latitudes and the intergyre region of the NE Atlantic Ocean. The purpose of this paper is to analyse the coupling between meteorological and oceanographic data in the SE Bay of Biscay for the period 2001–2005 in comparison with the period 1986–2005 and other reference periods. Main points of view will be: i) relationships between atmospheric temperature, SST and heat content; ii) salinity in relation to the precipitation-evaporation balance and river outflow; and iii) dynamic aspects related to the wind velocity and direction, e.g. the upwelling-downwelling duality, as a factor combining *in situ* modifications and variations related to the advective-convective transport. Another purpose of this paper is to revisit trends and anomaly patterns of some periods and compare the assessment (in terms of slope, absolute or accumulated anomalies) depending on the period of reference as well as upon the start and end points of the period of observation itself. Finally, practical reference periods are proposed for the assessment of some oceano-meteorological variables in the SE Bay of Biscay.

Keywords: oceano-meteorological coupling, climate, time-series, Bay of Biscay.

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ICES CM 2006/C:17

Mass occurrence of snake pipefish: result of a change in climate?

Cindy J. G. van Damme and A. S. (Bram) Couperus

In 2004 a sudden mass occurrence of snake pipefish *Entelurus aequoreus* appeared in the Northeastern Atlantic and has been increasing since.

Before 2004 snake pipefish was mainly found in coastal areas and occasionally in oceanic waters. Here we put forward the hypothesis that the sudden appearance in the deeper waters is a result of the change in the average lengths of calanoids which in turn is caused by changes in the hydroclimatic environment.

The calanoid population is nowadays dominated by the smaller *Calanus helgolandicus* which can be preyed upon by snake pipefish. Although food is available in high quantities, the oceanic specimens of snake pipefish are much leaner than the coastal specimens. Competition for food may be lower in the coastal areas. Apart from appearance the habitat is different for the two types of

snake pipefish. The oceanic form lives in the water column while the coastal form is found in sea grass beds.

The mass occurrence of the snake pipefish is affecting the whole ecosystem. Seabirds are feeding their chicks with them and they are also found in stomachs of fish and sea mammals.

Keywords: snake pipefish, *Entelurus aequoreus*, climatic change, distribution, Atlantic.

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ICES CM 2006/C:18

Ocean-climate change, regime shifts and possible impacts on the recruitment of the European eel, *Anguilla anguilla*

Brian Knights, Kevin D. Friedland, and Michael J. Miller

Recruitment of glass eels of the European, American, and Japanese eel has fallen almost synchronously since the late 1970s. This implies common causes, probably ocean-climate changes affecting survival of leptocephali. Relationships between recruitment and the North Atlantic Oscillation and the El Niño/Southern Ocean Oscillation have previously been demonstrated for the N Atlantic and N Pacific species respectively. Warming in the Sargasso Sea and the N. Atlantic and changes in current systems has been implicated in starvation-advection explanations for effects on recruitment of *Anguilla anguilla*. Regime shifts have recently been documented in the NW Atlantic/North Sea (and in the NE Pacific) that also possibly correlate with recruitment declines. This paper will discuss on-going studies into ocean-climate factors in the N Atlantic and recruitment to Europe to further clarify these issues, using novel modelling approaches and utilizing more detailed and extensive ocean-climate data. Predictions for the future are made and multi-disciplinary and integrated monitoring and research considered for managing eel stocks and fisheries.

Keywords: *Anguilla* spp., larval recruitment, NAO, oceanography, climate change, Sargasso Sea, Gulf Stream; N Atlantic Drift.

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ICES CM 2006/C:19

Investigating the effect of changing environmental factors on spatial and temporal variability in larval sprat growth and survival in the North Sea

Ute Daewel, Myron A. Peck, Michael A. St. John, and Corinna Schrum

While intra-annual variations in larval fish vital rates are usually affected by spawning time and seasonality in the prey field and temperature, inter-annual variability depends upon a more complex combination of different factors (e.g. currents, turbulence, stratification, prey field, temperature) that are often correlated to larger-scale dynamic processes (e.g. NAO). However, recent studies indicate that the strength of such large-scale climate-recruitment correlations vary temporally. A clearer understanding of the influence of climate variability on trophic dynamics may emerge by resolving the complex interactions of different factors on larvae growth and survival.

Coupled 3-D hydrodynamic and ecosystem models are expedient tools that can be used to quantify coherences between environmental factors and fish vital rates. For this purpose, we have been employing four inter-linked models: 1) a hydrodynamic model (HAMSOM) provides 3-D fields of hydrographical properties, 2) a NPZD model prescribes local prey fields (ECOSMO), 3) a Lagrangian transport model simulates temporal changes in cohort distribution, and 4) an individual-based model (IBM) depicts foraging, growth, and survival of fish in early life stages. The IBM is currently parameterised for eggs and larvae of sprat in the North Sea. Previous results for certain climatically opposed years indicated that larval survival was heavily influenced by the interplay between prey availability and temperature with less survival in warmer years due to higher metabolic costs. Here we present the results of model simulations covering a 14-year period (1990 to 2004) and discuss the impact of longer-term environmental changes on potential growth and survival of sprat early life stages.

Keywords: spatially-explicit IBM, sprat, North Sea, inter-annual variability.

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ICES CM 2006/C:20

New fish records and records of rare southern species in Icelandic waters in the warm period 1996–2005

O. S. Astthorsson and J. Pálsson

In the past 10 years more than 20 southern fish species not previously recorded within the Icelandic 200-mile EEZ have been caught in the area by Icelandic research and fishing vessels. Some of these species have been

found on common fishing grounds and close to land and are therefore considered to reflect actual changes that are taking place in the fish fauna around Iceland. Five of the first-time records (e.g. flounder (*Platichthys flesus*), *Chaunax suttkusi*, *Brotulotaenia crassa*, *Lycodes ter-ranova*, *Melanocetus johnsoni*) are from more than one location or from different years. Many rare species that used to be recorded only occasionally (or that had not been recorded for a long time) have in recent years been recorded almost annually (e.g. twaite shad (*Allosa fal-lax*), mackerel (*Scomber scombrus*), and sea lamprey (*Petromyzon marinus*)). Also several rare southern species have in recent years been extending their distribution to more northern locations (e.g. garpike (*Belone belone*), snake pipe fish (*Entelurus aequoreus*), greater fork-beard (*Phycis blennoides*)). The records of new and rare fish species are discussed in the context of a positive hydro-graphic anomaly (temperature and salinity), both in the Atlantic water to the south and in the Sub-Arctic waters to the north of Iceland since the middle of the 1990s.

Keywords: Icelandic waters, new fish records, rare fish records, climate warming.

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ICES CM 2006/C:22

Variations in the cascading of Barents Sea bottom water to the Norwegian Sea

Øystein Skagseth, Harald Loeng, Kjell Arne Mork, and Paul Budgell *et al.*

Variations in the dense bottom water outflow in the Fugløya-Bear Island Channel to the Norwegian Sea are investigated in relation to the inflow of Atlantic Water and the water mass transformation within the Barents Sea. Various data sets are combined to resolve both the processes and the variations in the properties back in time. The data sets that are analysed include current meter records from 1997 to date, hydrographic measurements back to the 1960s, and atmospheric re-analyses data.

Keywords: Barents Sea, Atlantic Inflow, bottom water formation, cascading.

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ICES CM 2006/C:23

Development of a global hindcast archive of ocean and ice conditions 1958–2004 with a focus on the North Atlantic and Arctic

W. Paul Budgell, Lars Asplin, Vidar S. Lien, and Einar Svendsen

A coupled ice-ocean model is being run in hindcast mode to simulate global ocean and ice conditions for the period 1958–2004. The archived model fields are being used to generate time-series of various parameters that can be related to fish stock recruitment and fish migration. The model fields are also being used for initialisation and boundary forcing of nested high-resolution regional models of larval drift.

The ocean component of the model is the Regional Ocean Modelling System (ROMS), while the ice component is a dynamic-thermodynamic sea ice model. The model is run on a stretched spherical grid which has a horizontal resolution of 17–20 km in the North Atlantic and Arctic Oceans. There are 35 vertical levels in a generalized terrain-following coordinate system.

Sample results from the model archive are presented and model-generated time-series of temperatures and volume transports at key sections are related to fish stock recruitment.

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ICES CM 2006/C:25

Recent warming and salinification of the North Atlantic Ocean as observed by ICES standard sections

N. Penny Holliday, Sheldon Bacon, and members of the ICES Working Group on Oceanic Hydrography

The ICES Working Group on Oceanic Hydrography covers a huge geographical area that stretches across the North Atlantic from the east coast of North America to the Iberian Peninsula, around the subpolar gyre and its surrounding shelf seas, through the Nordic Seas, and as far north as the Fram Strait, and including all the adjacent marginal and shelf seas (Labrador, North, Baltic, Barents). Standard sections and stations form the framework around which sustained observations, modelling, and analysis are based, and some of the sections have been measured for over a century. Each year the WGOH publishes a summary of the climate of the ocean in this region (the ICES Report on Ocean Climate or IROC, formerly known as the ICES Annual Ocean Climate Status Summary or IAOCSS). The IROC summarizes temperature and salinity variations from monthly to decadal

timescales and highlights the important environmental features of the year.

The IROC 2005 shows that the whole of the North Atlantic and Nordic Seas were warmer and more saline than the long term mean. Since 2000, the eastern subpolar gyre has been progressively warming and becoming more saline, ending the freshening period that began in the 1960s. In 2005 the anomalously warm and saline North Atlantic water was seen in the Norwegian Sea and had reached the Fram Strait and begun to enter the Arctic Ocean. Meanwhile the warm anomaly north of Iceland first observed in 2004 had entered the Irminger and Labrador Seas.

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ICES CM 2006/C:26

Water masses variability in the upper layers of the Northeast Atlantic and possible relationships with the air-sea fluxes. The severe winter 2005 case

César González-Pola, A. Lavín, R. Somavilla, and M. Vargas-Yañez

A monthly time-series carried out by the Spanish Institute of Oceanography in the Bay of Biscay, eastern North Atlantic, sampling the upper 1000 m, has shown local warming rates for the last 10–15 years that are much higher than the long-term ocean trend in the 20th century. Warming trends have also been presented in the Balearic Sea covering the whole water column Western Mediterranean (WM). The overall picture is consistent with the fact that climatic warming has accelerated over the last few decades. Some climatic signals were noticed in both locations: After the extremely cold winter of 2005 in southwestern Europe, an unusually deep mixed layer of around 300-m depth was formed in the southern Bay of Biscay and strong changes were detected in the hydrographic conditions of the upper layers of the East North Atlantic Central Water, producing the coldest year of the time-series 1993–2005 for the depth interval of 0–300 m. Below the mixed layer, the general warming trends are maintained. Disruption in the warming trends of the deep waters in the Mediterranean Sea were also detected in winter 2005. Some recent works relate the correlation of the deep WM and the NA to the coherence in the large-scale atmospheric patterns affecting water masses formation areas in both basins. The relatively high frequencies of sampling allowed a precise description of the interannual variability of the water masses, and made it possible to infer relationships with the air-sea fluxes at their respective formation areas.

Keywords: air-sea fluxes, climatic variability, North Atlantic, water masses, warming trend, Western Mediterranean.

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Hydrological variability of intermediate water masses in the eastern North Atlantic and in the Bay of Biscay during 2003–2005 and comparisons with historical data

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Intermediate waters in the northeastern Atlantic around the Iberian Peninsula and in the Bay of Biscay form a transitional area subjected to the confluence of waters with the Mediterranean (MW, 800–1200 m depth) and Labrador Sea Water (LSW, 1600–2000 m depth) components, capped with upper eastern north Atlantic central (ENACW) and deeper north Atlantic deep (NADW) waters. MW flows out through the Strait of Gibraltar as a topographically-steered vein along the Iberian slope that intermittently detaches MW eddies (Meddies) that transport large volumes of MW into the open ocean. Meddies originate at specific locations along the Iberian margin, namely steep promontories and abrupt canyons, such as the St. Vincent Canyon and the Estremadura Promontory. Existence of northern Meddies has been recently reported. MW interacts with water with high LSW content, mixed in its the pathway from the Labrador Sea and advected onto the study area along the Armorican slope from a south-eastward branch of the main flow. This interaction gives rise to the formation of Deep Mediterranean Water (DMW) due to turbulent mixing and double diffusive processes. The fraction LSW in the eastern North Atlantic is at most 20%. Variations at this level have an important effect on meridional heat transport and are subjected to variations at the place of LSW generation as well as variations of the other components of North Atlantic Deep Water.

In this work we present recent hydrographic observations acquired within the frame of the VACLAN project. These suggest the Galician Bank and Ortegal promontory as generation areas for northern Meddies due to the intensification and instabilization of the MW flow. In addition, places for diapycnal mixing between the MW and LSW are illustrated for 2003–2005 and compared with historical data from the previous decade. These comparisons made it possible to estimate the arrival time of the LSW to the western Iberian margin, as well as the mixing and spreading patterns of these two water components. Based on these data a new pathway is suggested for the southward transport of LSW west of the Charcott Seamounts towards the Galician Bank.

Keywords: Eastern North Atlantic, Mediterranean Water, Labrador Sea Water, Bay of Biscay, Iberian Peninsula, climate variability.

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ICES CM 2006/C:28

Ocean climate variability on the western Irish Shelf, an emerging time-series

G. D. Nolan and K. Lyons

In an attempt to fill the gap in long-term hydrographic measurements between the well-established sections off Iberia and in the Northern Rockall Trough, Ireland has initiated several standard oceanographic sections in southern Rockall Trough and on the western Irish shelf.

The continental shelf west of Ireland is exposed to the open Atlantic Ocean. Fresh water discharges from Irish rivers and those further afield (e.g. Loire, Severn) interact with Eastern North Atlantic Water on the Irish shelf to produce the observed circulation pattern. Summer CTD measurements have been made along a section at 53° North on the western Irish shelf since 1999. A long-term gridded climatology is used to discern the mean conditions along this section and anomalies are calculated for the period.

Warmer conditions were observed along this section in 2003 and 2004, broadly consistent with other regions of the NW European shelf while cooler conditions were observed in 2001 and 2002. Salinity also exhibits strong inter-annual variability along this section depending on the timing and magnitude of discharges from Irish rivers and rivers in the UK and France. Fresh conditions observed in 2001, 2002, and 2005 are linked to strong discharges from the Loire and Shannon rivers.

Keywords: Western Irish Shelf, Rockall Trough, ocean climate.

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ICES CM 2006/C:29 – Poster

Oceanographic factors influencing the formation of zooplankton biomass in the central latitudinal zone of the Barents Sea

Vladimir Boitsov, E. Orlova, and V. Nesterova

Major trends in the formation of zooplankton biomass were studied for years with different water temperature (1983, 1987, 1989, and 2004). The investigations revealed an important role of water masses of different origin and temperature in the formation of specific and age structure in plankton (copepods). Factors influencing the formation of plankton biomass were the most appar-

ent in warm years (1983, 1989, and 2004), when large amounts of *Calanus finmarchicus* were brought parallel to an increased inflow of coldwater fauna with Arctic waters. These years were characterised by a wide distribution of *Calanus glacialis*, the biomass of which was similar to or higher than that of *C. finmarchicus*. Data from oceanographic sections obtained in May–July were used to study some mechanisms underlying the drift of *C. finmarchicus* from the Norwegian to the Barents Sea. It is shown that in summer, zooplankton of the western and southwestern Barents Sea is transported by the Atlantic waters due to continuous advection. The conditions related to the formation of mixed aggregations consisting of local and brought copepods occur in the areas of quasi-permanent anticyclonic eddies where zooplankton is accumulated.

Keywords: *Calanus finmarchicus*, *Calanus glacialis*, copepods, frontal zone, water temperature, zooplankton.

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ICES CM 2006/C:30 – Poster

New species in the North Sea

Henk J. L. Heessen and Jim R. Ellis

In recent years a number of new fish species have been reported from the North Sea, e.g. the violet stingray (*Pteroplatytrygon violacea*) and butterfish (*Stromateus fiatola*). At the same time the abundance of the striped red mullet (*Mullus surmuletus*), a southerly species, has increased so dramatically that a fishery for this species has since developed. Other species are recently found in significantly higher numbers than some decades ago.

Our poster presents an overview of these species based on catches by research vessels and commercial fishermen from the Netherlands and the United Kingdom.

Keywords: North Sea, fish, crustaceans, distribution.

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ICES CM 2006/C:31 – Poster

The peculiarities of the interannual variability in temporal alterations of the cold and warm seasons and their duration in the Norwegian, Greenland and Barents Seas

Marat A. Bogdanov and Y. N. Tananaeva

The interannual variability of the warm and cold seasons in the Norwegian, Greenland, and Barents Seas is con-

sidered on a basis of the weekly SST maps constructed by the satellite data. The beginning and duration of the seasons are assessed by the date of the stable crossing of the specified locations or meridians and parallels by the various isotherms on their aquatories.

It was shown that the interannual variability in the date of the beginning of the season is opposite to its duration, i.e. an earlier season beginning in the current year corresponds to a longer duration of the season, compared to the previous year. The interannual variability of the season duration determines the interannual variability in the duration of the following season but with the opposite sign. The rates of warming and cooling in the Norwegian Sea aquatory depend on the initial "warming" conditions. Over the last 10 years a trend has been noted in the seas towards an earlier beginning of the warm season and its longer duration. Since 1995 there have been essential interannual differences in the longevity of warm and cold seasons of up to several months.

During the mentioned years the longevity of the 10°C-isotherm staying north of 60°N increased from 170 to 245 days. A stable relationship was observed between the interannual variability of thermal conditions in the East Icelandic Current in the cold season, and the interannual variability of thermal conditions in the northern Irminger Sea in the following warm season.

Keywords: North Atlantic, sea surface temperature, duration of the warm and cold seasons, Irminger Sea, Norwegian Sea, Greenland Sea, Barents Sea.

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ICES CM 2006/C:32 – Poster

Shift of development peak for pelagic cladocerans as an indicator of climatic variability in the Gulf of Riga, NE Baltic Sea

Anda Ikauniece

Zooplankton in the Gulf of Riga consists of three main groups – calanoid copepods, cladocerans, and rotifers. Copepods are present during the whole year whereas cladocerans and rotifers appear seasonally. The pelagic cladocerans in the Gulf of Riga have an annual abundance maximum in summer when the water temperature reaches the highest level of the year. Since the mid-1960s the cladocerans have peaked in August and their share of the total biomass has been up to 90%. Since the mid-1990s the peak has been observed at an earlier time and since 1998 it has not occurred in August. Moreover, the total abundance of cladocerans has decreased since the mid-1990s and their amount does not exceed 30% of the total zooplankton biomass. The stated phenomena are discussed in relation with the larger-scale climatic variability and its local modifications in the period 2000–

2005. The biological consequences of peak's temporal shift can include a change of feeding conditions for certain size classes of herring and sprat and will be discussed in detail.

Keywords: cladocerans, abundance, climate, Baltic Sea.

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ICES CM 2006/C:33 – Poster

The autumn and winter fishery and distribution of the Icelandic summer-spawning herring during 1978–2006

Asta Gudmundsdottir and Thorsteinn Sigurdsson

Available information on the fishery of the Icelandic summer-spawning herring and results from research cruises are used to describe how the distribution of the main component of the fishable stock and the overwintering grounds have changed during the period 1978–2003. An attempt is also made to relate the observed changes in the distribution of herring to hydrographic conditions in February, i.e. at the time when the herring forms dense overwintering schools. The summer-spawning herring stock collapsed due to overfishing and environmental changes during the late 1960s, but since 1973 the stock has gradually increased and been recorded in extensive areas over the shelf. Thus, the spawning stock has increased from about 10 thousand tonnes around 1972 to a historical maximum of about 500 thousand tonnes in recent years. When the fishery resumed during the late 1970s it mainly took place off the southeast coast and the overwintering grounds were near Hrollaugseyjar off the southeast coast. Since then the fishing grounds have been changing and may be classified into five periods. During the most recent period, or from 1998 until present, the fishery has taken place from Langanes off the northeast coast and south to Ingólfshöfði off the southeast coast and from Eldey off the southwest coast and north to Kögurgrunn off the northwest coast. Most likely, the overwintering grounds have during that time been at three locations, Héraðsdjúp, Eldey, and Kolluáll, with the largest part being in the area last mentioned. It appears that with higher sea temperatures in recent years the herring has been distributed in a wider area over the shelf and at present it is to be found more or less all around the country.

Keywords: environment, fishery, herring, stock distribution.

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ICES CM 2006/C:34 – Poster

Current changes of key environment factors contributing to the Baltic sprat reproductive success as compared to the previous decades

E. M. Karasiova

As is well known, the reproductive success of the Baltic sprat depends on the multiple factors the major of which are: 1) thermal regime of the sea in winter and spring seasons, and 2) nutrient inflow into the pelagic layer, ultimately affecting the feeding conditions of offspring in summer (STORE, 2002). In 2000–2005 the trend towards a surface temperature increase (observed in the 1990s in May as compared to the period from 1976 to 1990) was generally continued in the Gdansk Deep of the Baltic Sea. Besides, during 2000–2005 a noticeable average increase of the near-bottom temperature occurred, resulting in the earlier reproduction of sprat in the Gdansk Deep in 2004. Compared to 1973–1990 a considerable reduction in the frequency of northeasterlies was recorded which positively affected the air temperature increase in winter. These climatic variations resulted in a decrease in the negative effect of cold winter on sprat recruitment abundance formation. At the same time a reliable positive relationship between the frequency of northeasterlies causing upwelling in June and July and sprat year-class strength were seen both in 1973–1990 and in 1991–2003. It is demonstrated that starting from 1998, the correlation between the above parameters increased when the southeastern wind was excluded from the northerlies and easterlies combination. It is assumed that summer upwelling near the eastern coast during the latest years probably affected the reproductive success of the Baltic sprat stronger than upwelling near the southern coast of the sea.

Keywords: reproductive success of sprat, frequency of northeastern winds, summer upwelling, thermal regime.

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ICES CM 2006/C:35 – Poster

Temporal series observations of water masses off Cape Finisterre North West of Spain

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Observation of temporal series of oceanographic variables in the Northwest of the Iberian Margin may contribute to the understanding of long-term variability and circulation in the NE Atlantic in relation to seasonal and interannual variability to external forcing. The distribution and variability of the water masses in a section off

Cape Finisterre was studied by analysis of the distribution of potential temperature, salinity, dissolved oxygen, phosphate, nitrate, and silicate. An Objective Multi-parameter Analyses (OMP) was used to allow a quantitative description of the water masses. The intermediate water masses consist of four local source water types: Iceland-Scotland Overflow Water (ISOW), Labrador Sea Water (LSW), Mediterranean Sea Water (MW), and Sub-Arctic Intermediate Water (SAIW). The latter is formed as winter mode water north of the sub-arctic which west of the Iberian Peninsula represents a water mass formed by winter convection in the Porcupine Sea Bight and the northern Bay of Biscay. The deep water is a mixture of Antarctic Bottom Water (AABW), Denmark Strait Overflow Water (DSOW), and Iceland-Scotland Overflow Water (ISOW). All the intermediate water masses present a clear stratification: MSW, as a core of high salinity between 500 and 2000 m is separated from the Central Water (ENACW) by the subsurface salinity minimum due to the SAIW and from the deep water by the LSW. The core of LSW, at depths between 1000 m and 3000 m, only mixes with the overlaying MW and the underlying ISOW. An increase of the MW has been detected from 2003 to 2005 along with seasonal variability. In contrast LSW presents a proportional decrease.

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ICES CM 2006/C:36 – Poster

Climate variability in the Barents Sea 2000–2005

Randi Invaldsen, Harald Loeng, and Vidar Lien

The Institute of Marine Research observed the climate variability in the Atlantic inflow to the Barents Sea by measuring the volume transport and hydrographic conditions between Norway and Bear Island. The conditions for the period 2000–2005 are compared with observations back to the mid-1960s. The last five years are obviously the warmest five-year period within this time frame. We will also evaluate how representative the measurements at the inflow area are for the entire Barents Sea.

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ICES CM 2006/C:37 – Poster

Climatic variability in Icelandic waters and potential effects on biota

Héðinn Valdimarsson, Steingrímur Jónsson, and Höskuldur Björnsson

Icelandic waters are an area of substantial climatic variability and at the same time areas of extensive biological

productivity. During the last decade temperature and salinity in the Atlantic water south and west of Iceland have been higher than earlier in the period of seasonal observations which started after 1970. These changes have been reflected in the waters north of Iceland during this time, although less regularly. Some potential effects of these environmental changes on biota and distribution of fish species are described and discussed.

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ICES CM 2006/C:38 – Poster

The ICES Annual Ocean Climate Status Summary 2005: Prepared by the ICES Working Group on Oceanic Hydrography

Sarah L. Hughes, Penny Holliday, and Sheldon Bacon

The ICES Annual Ocean Climate Status Summary is prepared each year by the ICES Working Group on Oceanic Hydrography (WGOH). The IAOCSS is an ICES contribution to GOOS, summarizing a large and complex dataset in a timely manner and in an accessible format. Ocean climate data from 15 regions around the North Atlantic are brought together by WGOH members and summarized in the report. This paper presents a summary of the results from the 2006 IAOCSS report.

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ICES CM 2006/C:39 – Poster

Climatic changes in the deep Norwegian Coastal waters and Skagerrak 2000–2005 in relation to previous decades

Jan Aure and Didrik S. Danielssen

Climatic conditions in the deep Norwegian coastal water, from Skagerrak to the Barents Sea, are to a large degree influenced by the Atlantic water. The seasonal variations

are also much less than in the upper layer. Temperature and salinity are observed on a regular basis at a set of nine stations from Torungen (Skagerrak) to Ingøy (Finnmark). This takes place two or four times a month from the surface to the bottom. The Torungen-Hirthals hydrographic section in the Skagerrak is observed regularly once a month. The decadal mean temperatures in the deep water (150 m) along the Norwegian coast and in the Skagerrak were quite stable in the period from 1950 to 1990. The mean decadal temperature in this period was about 7.2 °C in the Skagerrak and along the Norwegian West coast. In the coastal areas off Northern Norway the mean temperature was reduced to 6.1 °C outside Lofoten (station Eggum) and to 4.7 °C close to the North Cape (station Ingøy). In the 1990s the decadal mean temperature in the deep coastal water increased considerably and temperatures in the first part of the 1990s were the highest observed since observations along the Norwegian coast started in 1936. The temperature anomaly in the 1990s was closely connected to an increase in the Atlantic inflow to the Norwegian Sea and warm winters (high level of North Atlantic Oscillations – NAO).

After a certain temperature decrease in the late 1990s the temperatures again increased to the same high levels as in the early 1990s in the deeper layer of the coastal waters. In 2000–2005 the mean temperature in the deep water along the coast from Skagerrak to the North Cape was 0.7–1.0 °C higher compared to the period 1960–1989. The mean temperature increase 2000–2005 related to the standard deviation 1960–1989 (diffT/stdev) was considerable and varied between 1.2 and 2.1, with the highest value at station Ingøy.

In contrast to the situation in the 1990s, the NAO index and the inflow of Atlantic water has been approximately normal between 2000 and 2005. The relatively high temperatures along the Norwegian Coast from the Skagerrak to the Barents Sea must then have another explanation and are probably connected to increased inflow from the warmer easterly branch of the North Atlantic current.

Keywords: climate variability, deep Norwegian coastal water, long time-series, monitoring.

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