CLAMER CLIMATE CHANGE & EUROPEAN MARINE ECOSYSTEM RESEARCH

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Advance interviews are available.

Icy Meltwater Pooling in Arctic Ocean: a Wild Card in Climate Change Scenarios

Freshwater is twice the volume of Lake Victoria and growing;

Scientists inventory, synthesize 13 years of research on climate change and Europe's marine environment

A massive, growing pool of icy meltwater in the Arctic Ocean is a wild card in future climate scenarios, European researchers said today.

Estimated in 2009 at 7,500 cubic km – twice the volume of Africa's Lake Victoria – and growing, the water could flush quickly into the Atlantic with unpredictable effect when prevailing atmospheric patterns shift, as occurred most recently in the 1960s and 1990s.

The situation is one of many disquieting findings captured by project CLAMER, a collaboration of 17 institutes in 10 European countries to inventory and synthesize the research of almost 300 EU-funded projects over 13 years related to climate change and Europe's oceans and near-shore waters, and the Baltic and Black Seas.

The full inventory and synthesis will be presented at an international conference at the Royal Flemish Academy of Belgium, Brussels, Sept. 14-15. This news release, highlighting research on climate-related physical ocean changes, will be followed in months to come by descriptions of impacts on marine life, and impacts on the economies and people of Europe.

Oceanographer Laura de Steur of the Royal Netherlands Institute for Sea Research says a mostly clockwise wind pattern for the past 12 years in the Arctic has contained – largely in an area known as the Beaufort Gyre (also called the Canada Basin) – a pool of relatively fresh water from unusually high river discharge and melting sea ice.

When the general atmospheric circulation pattern does shift, the fresh, cold water is expected to enter the North Atlantic, with unpredictable impact on an ocean current system important to both European weather and marine food chain. Signs of such an atmospheric shift appeared in 2009 but the episode was too short to cause a major flush.

Says Dr. de Steur: "The volume of water discharged into the Arctic Ocean, largely from Canadian and Siberian rivers, is higher than usual due to warmer temperatures in the north causing ice to melt. Sea ice is also melting quickly – another new record low for ocean area covered was documented this past January by the National Snow and Ice Data Center (http://nsidc.org/arcticseaicenews) – adding even more freshwater to the relatively calm Arctic Ocean."

"In addition, sea ice that is thinner is more mobile and could exit the Arctic faster. In the worst case, these Arctic outflow surges can significantly change the densities of marine surface waters in the extreme North Atlantic. What happens then is hard to predict."

The scenario echoes the premise of a controversial 2004 disaster film, "The Day After Tomorrow," which depicted catastrophic cooling in Europe, dismissed by Dr. de Steur as Hollywood absurdity.

"Ice ages occur on geological time scales of tens of thousands of years," she says. "However, large regional changes could be in store if the ocean circulation changes."

Many scientists are concerned about the future of the ocean circulation system that carries heat north to moderate the European climate.

Essentially, as warm water flows from the tropics to the North Atlantic, it cools and increases in salinity, making it heavier. At the north end of the current, near southern Greenland, these currents are cooled strongly by the atmosphere. This cold, dense oxygenated water sinks and cascades like poured cream south along the sea floor. Further south, it warms and rises, lifting nutrients essential to the marine food chain in the process, then flows north again.

It amounts to a giant "conveyor" known as the Atlantic Thermohaline Circulation, or THC.

The hypothesis is that additional ice melting throughout the Arctic region would dilute northern saltwater and alter its density, causing the conveyor to slow.

According to Detlef Quadfasel of the Hamburg University's climate centre, changes in the THC could be abrupt, occurring over a decade or two, but more gradual change is expected.

Direct observations of ocean currents over the past two decades and numerical model simulations have revealed a remarkable stability of the North Atlantic overturning strength.

However, most climate models predict a 20 per cent weakening of the current by the end of this century.

Scientists note that rising atmospheric temperature related to the build-up of greenhouse gases might at least temporarily counteract the cooling effect on Europe if North Atlantic underwater currents slow. However, the western edge of Europe, particularly the United Kingdom and Scandinavia, could cool substantially nonetheless.

Some 20 institutes from nine European countries, coordinated by the Institution of Oceanography at the University of Hamburg, are now cooperating in extensive studies of the THC through project THOR, for "ThermoHaline Overturning – at Risk?"

Another pair of projects, RAPID and RAPID-WATCH, involves researchers from the UK, Norway, the Netherlands and the United States in the collection of annual readings from 19 monitoring devices across the Atlantic at 26.5 degrees North. Statistically relevant data will be available after a decade of readings in 2014.

Large-scale salinity changes might also be in store for the Baltic Sea, one of the largest brackish-water ecosystems in the world, says Thomas Neumann, at Germany's Leibnitz-Institute for Baltic Sea Research. Its salinity is controlled by the amount of freshwater flowing off the surrounding land, as well as how much water is exchanged with the North Sea.

The circulation pattern where the two seas meet prevents mixing of the Baltic's surface and deep water, creating conditions of low or even no oxygen in the lower layer. Life in this zone has become highly adapted to the resulting extremes in salinity and oxygen conditions.

Within the next century, warming and other shifts caused by climate change could lead to lower salinity. "Given the extreme conditions for marine life in the Baltic Sea," such changes could "dramatically impact species distributions" at all depths, Dr. Neumann says.

"The changes in these physical parameters may totally alter the habitat conditions and distribution patterns of many species," agrees researcher Muyin Wang, of the University of

Washington in Seattle.

Other physical ocean changes in store

The prospect of an altered ocean circulation pattern ranks among the most worrisome physical ocean changes among many predicted by the community of several hundred scientists connected by the European Union-sponsored project CLAMER.

Among other physical ocean changes either underway or foreseen by European researchers:

* Rising seas around Europe will become warmer and more acidic;

* The seasonal mixing of deep and shallow waters, essential to the marine food chain will be disrupted; and

* More powerful and more frequent storms brewed offshore will batter coasts.

Public survey to complement research inventory

“There is a gap between what is known through research and what policy makers and the public know and understand about the impacts of climate change on the oceans,” says Carlo Heip, General Director of the Royal Netherlands Institute for Sea Research, which coordinates project CLAMER.

“This gap must be filled to spur public acceptance of measures essential to reducing and adapting to the impacts in store.”

Project CLAMER will also release in September a pan-European survey revealing public awareness of marine issues, top concerns, most trusted information sources and measures Europeans support to avoid or adapt to serious ocean changes.

While the precise consequences of climate change aren’t fully understood, the research results – a combination of observations and sophisticated computer modeling, point to significant alteration of the oceans, consequent upheavals within and among species that live in them and, as a result, the potential for major economic and social impacts on Europe.

The researchers note that climate change impacts are inter-related and some might amplify each other or cancel each other out.

"We know there is potential for substantial change, with wide-ranging impacts," says Jan Mees, Director of the Flanders Marine Institute (Vlaams Instituut voor de Zee, VLIZ)

"We must both learn more and disseminate the knowledge in hand. Greater awareness is our best hope for motivating attempts to slow climate change and prepare for what it will bring."
There is already evidence that physical changes in the oceans will have devastating ecological, biological and economic impacts.

Among other recent research results:

New patterns of seawater mixing on which marine animals depend

The mixing of deeper and shallower ocean waters determines whether and when nutrients, oxygen and heat are distributed. It usually occurs in a seasonal pattern, depending on sea depths, winds, changes in temperature and salinity, and flows of freshwater from rivers and melting. Most often, waters remain in stable layers throughout the summer and this stratification breaks down from fall to spring. Marine species are adapted to these cycles, so changes could impact their reproduction and survival.

Modeling by Britain's Hadley Centre for Climate Prediction and Research shows the strength of seasonal stratification will increase by 20 per cent on Europe's sea shelf areas, mainly because of temperature changes, and by 20 to 50 per cent in the open-ocean, largely because of the forecast declines in salinity. In shelf seas not affected by river discharges, stratification is projected to start five days earlier and break down five to 10 days later each year, extending the period when the waters don't mix by 10 to 15 days.

Warming seawater

Warming is the feature most commonly associated with climate change and, in fact, sea surface temperatures are rising around Europe and throughout the world. The average global increase is 0.004 degrees Celsius per year. The annual rate is 0.002 for the North Atlantic Ocean; for the Black Sea it's 0.003 degrees; for the North and Mediterranean Seas, 0.004 degrees; and for the Baltic, 0.006.

While there has been significant variability over the past century, major warming has occurred since the 1980s, says Jun She of the Danish Meteorological Institute, with computer models forecasting a rise of 2C or more by 2100.

Britain's Hadley Centre modeling indicates that Europe's northwest coastal shelf regions off …Greenland? will warm substantially more than the open-ocean – by between 1.5C and 4C, depending on location.

Smaller-scale modeling suggests an annual warming of 2C to 4C on the Baltic Sea surface, 1.7C in the North Sea and up to 5C for the Bay of Biscay.

Souring seas

Some of the most dramatic findings to date involve acidification of the oceans as they absorb more of the atmosphere's growing load of carbon dioxide.

"Ocean acidification is detectable and underway," says Marion Gehlen, of the Laboratoire des Sciences du Climat et de l'Environnment, near Paris.

Acidification undermines the ability of certain plankton species to grow shells. These tiny creatures support the entire ocean food web and help consume and sink much of the oceans' carbon dioxide content. Harmful plankton species will replace beneficial varieties in some areas.

A lower pH means higher acidity. The measuring scale is logarithmic, which means even a small numerical difference represents a major change in pH.

The average pH of ocean surface waters is already 0.1 units (30%) lower than in pre-industrial times and a decrease by 0.4 (120%) units is projected by 2100 if greenhouse gas emissions from human activity continue to rise in a 'business-as-usual' fashion.

The likely result: "profound changes" in the structure and functioning of marine ecosystems, say Gehlen and Paul Tréguer, of l'Institut Universitaire Européen de la Mers, in Brest, France.

Some of the most important drops in pH have been reported in the Iceland Sea, an important source of North Atlantic deep water. Here, the winter surface water reading decreased by 0.0024 units per year between 1985 and 2008 – a rate 50 per cent faster than at two subtropical monitoring stations.

The depth at which the water contains too little aragonite to support life is now at 1,710 metres, and is increasing by about 4 metres per year. This rate of change, combined with the topography of the ocean floor in the region means that each year another 800 square kilometres of sea floor becomes exposed to this “dead” water.

Plankton surveys invariably reveal harmful impacts of these changes, especially at shallower depths, which are home to more of the organisms that rely on aragonite and calcium carbonate, the report states. Still, “there is an urgent need to clarify the effects.”

Shoreline erosion on the rise

If, as expected, climate change leads to higher sea levels and more frequent and fierce storms, erosion along Europe’s coast will accelerate. Precise predictions are difficult, because the impacts will depend on detailed local conditions, says Andrew Cooper, professor of coastal studies at the University of Ulster, in Ireland.

One general pattern, however, is that in Northern Europe, the land is still rebounding from the weight of Ice Age glaciers and as it rises, sea level, in effect, falls. In Southern Europe, however, with the land static or, in come cases subsiding, the sea is rising relative to the height of the shoreline.

As climate change raises sea level it will likely increase the rate and extent that shorelines migrate inland, while Northern Europe, “may find that sea-level rise now exceeds the rate of land uplift, leading to relative sea level rise for the first time in millennia,” Cooper says. “This would increase the extent of coastline subject to erosion.”

Project CLAMER partners

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Royal Netherlands Institute for Sea Research
Royal Netherlands Academy of Arts and Sciences

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Flanders Marine Institute

United Kingdom
Sir Alister Hardy Foundation for Ocean Science
Centre for Environment, Fisheries and Aquaculture Science
Natural Environment Research Council
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