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SeaWeb has revised its website! Visit www.seaweb.org to find more information about the Conference of Parties meeting in Copenhagen, climate change and the “Colors of Carbon.”

Copenhagen Climate Summit Is Here, Climate Treaty May Not Be

A team of 26 scientists has warned that global emissions of greenhouse gases must decline rapidly for the world to have a reasonable chance of avoiding the very worst impacts of climate change. Their statement came in advance of the much-anticipated United Nations' Conference of Parties meeting in Copenhagen, which began December 7 and runs through December 18.

In a report entitled the *Copenhagen Diagnosis*, the researchers point out that many observable impacts of climate change, including those affecting the ocean, are greater than models had predicted. For example, summer sea ice extent in the Arctic has declined by a rate 40 percent greater than forecasted, and scientists are revising estimates of sea level rise progressively upward—in some cases, as much as 80 percent above previous figures.

“The science is quite decisive,” said Michael Mann, one of the report's authors who is a professor at Penn State University. “There is a very robust consensus about the reality of climate change and the need to confront it quickly.”

Officially known as the 15th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC)—and more frequently referred to as COP 15—the Copenhagen meeting is intended to devise an international

agreement that will come into force on January 1, 2013, superseding the existing agreement on greenhouse gas emission levels, known as the Kyoto Protocol, which was signed in 1997.

Kyoto bound the 37 richest nations to cut their collective emissions by 5.2 percent; the goal for Copenhagen is for industrialized nations to reduce their emissions still further, by up to 80 percent from 1990 levels by 2050, while providing a financial package to developing countries to assist them in weaning their growing economies off fossil fuels and adapting to the impacts of climate change.

The United States signed the Kyoto agreement under President Clinton, but the U.S. Senate has failed to ratify the Kyoto Protocol, a crucial step needed to legally bind the United States to meeting emissions reduction targets. Yet not only has the United States increased its emissions during the past 12 years, so have several of the industrialized countries that ratified the treaty. Between them, the United States and China are responsible for more than 40 percent of greenhouse gas emissions; the next largest emitter, Russia, accounts for 5.5 percent. Many policymakers believe that any agreement from the meeting at Copenhagen must include the United States and China if it is to be effective.

Although observers are optimistic that the first steps toward a financial package will be agreed upon, a growing consensus is emerging that Copenhagen will not produce a legally binding



As the Conference of Parties meets in Copenhagen to discuss how to mitigate and cope with climate change, polar bears are just one species feeling the effects of shrinking Arctic ice. The bears use ice platforms at sea to rest, hunt and raise their cubs. © Nick Cobbing/Greenpeace

successor to Kyoto. It therefore seems likely that Copenhagen will produce a framework agreement that is politically binding but not legally so, with individual nations committing to emissions targets but being under no international requirement to meet those targets. One widely raised possibility is the prospect that Copenhagen would instead kick-start a process that could result in a legally binding treaty being signed at COP 16 in Mexico in December 2010.

For Further Information: The *Copenhagen Diagnosis* may be downloaded at <http://copenhagendiagnosis.org/>. The official website of the Copenhagen Climate Change Conference is at <http://en.cop15.dk>.

Sea Level Rise Will Be Greater Than Predicted, Scientists Tell Legislators

As representatives of approximately 180 countries convene in Copenhagen to discuss ways to reduce greenhouse gas emissions, members of the U.S. Congress are preparing to consider domestic legislation that includes a target of reducing emissions to approximately 80 percent of 2005 levels by 2050.

Two prominent climate researchers addressed legislators and congressional staffers at the U.S. Capitol in late November to underline the urgency of taking action to limit greenhouse warming. Speaking at the invitation of Sen. Bernie Sanders (I-VT), Gordon Hamilton of the Climate Change Institute at the University of Maine and Fiamma Straneo of the Woods Hole Oceanographic Institution presented preliminary findings of recent field work in Greenland. Hamilton said, “the consensus among glaciologists” is that existing predictions of sea-level rise as a result of global warming are considerable underestimates.



Although a natural process for glaciers to calve into icebergs, such as this one off Humboldt glacier, scientists say the rate at which this is occurring off Greenland has increased threefold, contributing to sea level rise.

© Nick Cobbing/Greenpeace



Geophysicist Richard Bates of the Scottish Oceans Institute at the University of St. Andrews used a probe in front of Humboldt glacier on a recent Greenpeace research expedition to measure water temperature, pressure, current direction, salinity and turbidity in the fjord as the glacier melts and moves on a recent Greenpeace research expedition. © Nick Cobbing/Greenpeace

Hamilton pointed out that the most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC) predicted that global sea levels would rise by anywhere between 7 and 23 inches (18 and 59 centimeters) by the year 2100. The bulk of that rise, he said, would be caused by thermal expansion of the ocean, with some contributed by melting glaciers and a “small component” that IPCC assigns to melting of the Greenland ice sheet.

However, Hamilton said that the sea level rise is more likely to be on the order of 39 to 57 inches (100 to 144 centimeters), not by ice sheet melting but ice sheet dynamics, or an increase in the rate of the natural process by which Greenland adds ice to the ocean. This element is missing from IPCC calculations.

Straneo added whereas one way to deliver water from the ice sheet to the ocean is through melting, Hamilton pointed out that a swifter mechanism is through the calving of large icebergs from outlet glaciers—which lead from the ice sheet to the sea—such as Helheim Glacier in Sermilik Fjord and Kangerdlugssuaq Glacier in southeast Greenland. Although glaciers have always calved large icebergs, Hamilton says that the rate at which they are doing so has increased threefold over the past few years, so that Helheim, for example, is now advancing at a speed in excess of 15,200 yards (14,000 meters) a year, or nearly “half a football field a day.”

Straneo added that researchers noted increases in coastal water temperatures along Greenland at approximately the same time as the outlet glaciers began speeding up and hypothesized that the two may be connected. Straneo, who undertook collaborative research with Hamilton in Sermilik Fjord this past August on board the Greenpeace icebreaker *Arctic Sunrise*, found that water temperatures off Greenland’s east coast are the warmest they have been in 50 years of records and that there is “increasing evidence that ocean warming is playing a role in accelerating Greenland’s glaciers.”

Straneo has detected warm waters at the front of Helheim and other outlet glaciers, which she believes is causing submarine

melting and contributing to the rapid changes in the glaciers. This information is also lacking from IPCC projections, which focus solely on the impacts on glaciers and the ice sheet of atmospheric warming.

The week before Hamilton and Straneo spoke at the Capitol, a study in *Science* confirmed that the Greenland ice sheet as a whole is losing mass at an increasing rate, and that even under best-case scenarios, this lost mass alone will contribute 7 inches (18 centimeters) to sea level rise—the lower level of the IPCC's overall estimate. This mass loss is the result not only of increased iceberg production but also melting of the ice sheet's surface. The study's authors reached their conclusions by comparing two independent satellite observations: One measured the difference between ice loss and total snowfall and the other made detailed observations of slight changes in Earth's gravitational field, caused by the diminution in the ice sheet's size.

Jonathan Bamber of the University of Bristol in England, one of the paper's authors, observed that, "It is clear from these results that mass loss from Greenland has been accelerating since the late 1990s. The underlying causes suggest that this trend is likely to continue in the near future."

Source: van den Broeke, M., et al. 2009. Partitioning recent Greenland mass loss. *Science* **326**: 984.

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Ocean Vulnerable to Multiple Stresses in a Warming World

The global ocean is under assault from multiple causes, all of which interact with and magnify each other and greatly complicate efforts to conserve and manage resources, says a University of Washington researcher in a recent study. Writing in the *Annual Review of Environment and Resources*, Edward L. Miles of the university's School of Marine Affairs and Center for Science in the Earth System notes that, in 1999, he wrote "a moderately optimistic assessment of the health of the oceans." That review identified several threats to marine biodiversity including overfishing, habitat destruction and increasing consumption of natural resources. He characterized the assessment as "moderately optimistic" because, although threats existed, it was not hard to identify them, prescribe solutions or imagine improvement over the course of a few decades at most. Since then, however, the picture has become substantially more complicated.

Two additional stressors in particular have since emerged that "greatly enlarged the suite of multiple stresses that we must face and that give rise to declining optimism." One is a significant change in the thermal structure of the ocean as a consequence of

climate change. Miles notes that such significant increases in surface and subsurface heat in the world ocean prompt massive shifts in the distribution of many species and also result in significantly increased melt rates of polar ice sheets in summer. As these summer melt rates increase, the melting ice adds a large surface layer of freshwater to the ocean, which inhibits the mixing of ocean waters beneath it, resulting in an environment that tends to be less productive biologically.

The other stressor is the relatively recent discovery that the ocean is becoming more acidic. The global ocean has taken up approximately 30 percent of all anthropogenic carbon dioxide emissions since 1750, which has resulted in a roughly 10 percent decline in its pH. This has severe ramifications for marine life that requires calcium carbonate to build shells and skeletal frames, because that compound dissolves in more acid waters. As Miles notes, this has already had particularly serious impacts on near-surface tropical corals.

Additional stressors do not just mean additive impacts, Miles writes. They interact synergistically to produce outcomes that are different, qualitatively as well as quantitatively, from single factors acting alone. Nor do these outcomes necessarily progress in a linear fashion; instead, a multiplicity of stressors can suddenly create a critical threshold, or "tipping point," at which change can begin to happen much more rapidly or the entire system can shift into a different state.

Such synergies inevitably exacerbate adverse effects on marine ecosystems and the marine environment generally, Miles concludes. As a result, "the outlook for the future is far more uncertain than it was in 1999."

Source: Miles, E.L. 2009. On the increasing vulnerability of the world ocean to multiple stresses. *Annual Review of Environment and Resources* **34**: 18.1–18.25

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Climate change and ocean acidification have compounded the multiple stresses on marine biodiversity, from habitat destruction to overfishing. Elliott Norse, Marine Conservation Institute/Marine Photobank

Ocean May Be Reaching Limits of Carbon Dioxide Absorption

The global ocean plays a key role in regulating climate, among other mechanisms, by acting as a “carbon sink” that absorbs anthropogenic carbon dioxide emissions. The ocean is reckoned to have taken up approximately 30 percent of such emissions since the mid-18th century. According to a new study in the journal *Nature*, the ocean absorbed 2.3 billion tons of carbon dioxide in 2008; but while the overall amount was a record, the percentage of anthropogenic emissions that the ocean has been taking up has started to diminish and since 2000 may have declined by as much as 10 percent.

Samar Khatiwala of Columbia University and colleagues developed a mathematical technique to infer the concentration of industrial carbon in surface waters and its transport to deep water through ocean circulation. This allowed them to reconstruct the uptake and distribution of industrial carbon in the oceans over time and to produce the first ever year-by-year timeline of the growth of industrial carbon in the ocean.

Khatiwala and colleagues estimate that today the ocean holds about 150 billion tons of carbon, roughly one-third more than in 1990. About 40 percent of the carbon entered the ocean through the frigid waters of the Southern Ocean around Antarctica because carbon dioxide dissolves more readily in cold, dense seawater than in warmer waters. From there, currents transport the carbon north. The extra carbon dioxide in seawater is causing the ocean to become slightly more acidic, which is threatening the ability of some marine biota to create the calcium carbonate shells and skeletal frames they need. But that same acidification is



Scientists estimate the percent of human-produced emissions that the ocean has been taking up has started to diminish, perhaps as much as 10 percent since 2000.
Charlotte Stevenson/Marine Photobank

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setting in motion a chemical process in which the ocean, as it acidifies, becomes progressively less able to continue absorbing carbon dioxide.

“Because of this chemical effect, over time, the ocean is expected to become a less efficient sink of manmade carbon,” said Khatiwala in a press release announcing his study’s findings. “The surprise is that we may already be seeing evidence for this, perhaps compounded by the ocean’s slow circulation in the face of accelerating emissions.”

Khatiwala said the reduction in carbon absorption was a small change in absolute terms, but that what was more important was the long-term trend, which he said implies that more emissions will remain in the atmosphere.

“We cannot count on these sinks operating in the future as they have in the past, and keep on subsidizing our ever-growing appetite for fossil fuels,” he said.

Source: Khatiwala, S., F. Primeau and T. Hall. 2009. Reconstruction of the history of anthropogenic CO₂ concentrations in the ocean. *Nature* **462**: 346–349.

For Further Information and Accompanying Video:
www.ideo.columbia.edu/~spk/Research/AnthropogenicCarbon/anthroco2.html

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