Study concludes climate change will wreak havoc on oceans by 2100

October 17 2013

A scarred coral reef. While coral reefs are not among those habitats that will experience the most overlapping stressors, it only takes one to cause large impacts on coral ecosystems including massive bleaching events, as shown here. Credit: Andrew Thurber, Oregon State University

(Phys.org) —A new study looking at the impacts of climate change on the world's ocean systems concludes that by the year 2100, about 98

percent of the oceans will be affected by acidification, warming temperatures, low oxygen, or lack of biological productivity – and most areas will be stricken by a multitude of these stressors.

These biogeochemical changes triggered by human-generated greenhouse gas emissions will not only affect marine habitats and organisms, the researchers say, but will often co-occur in areas that are heavily used by humans.

Results of the study are being published this week in the journal *PLoS Biology*. It was funding by the Norwegian Research Council and Foundation through its support of the International Network for Scientific investigation of deep-sea ecosystems (INDEEP).

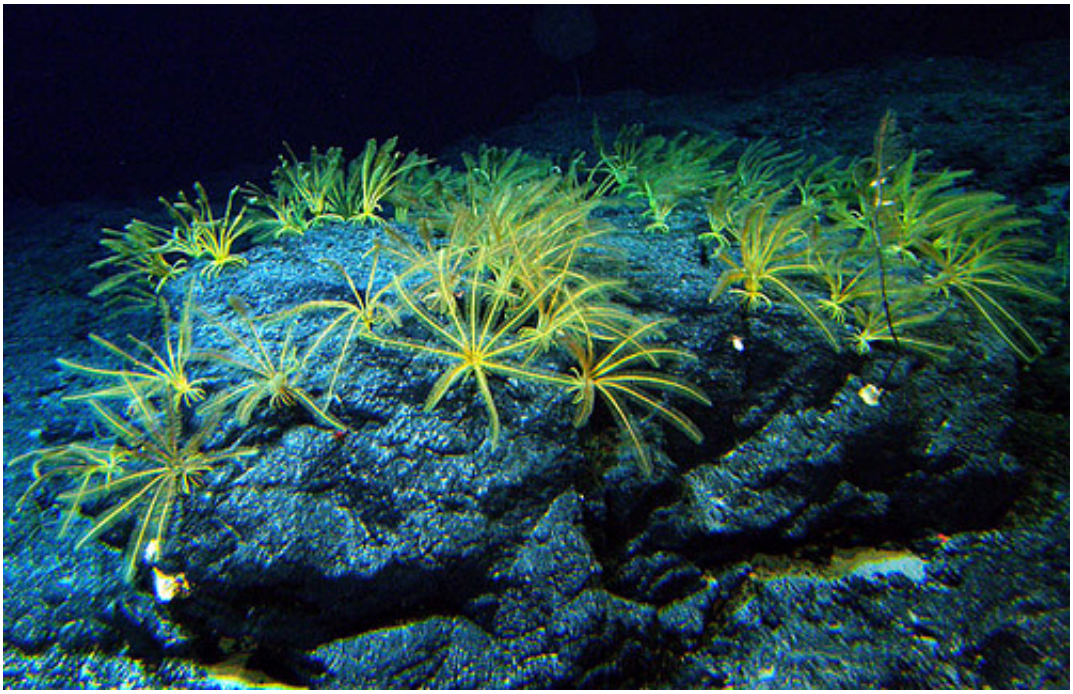
"While we estimated that 2 billion people would be impacted by these changes, the most troubling aspect of our results was that we found that many of the environmental stressors will co-occur in areas inhabited by people who can least afford it," said Andrew Thurber, an Oregon State University oceanographer and co-author on the study.

"If we look on a global scale, between 400 million and 800 million people are both dependent on the ocean for their livelihood and also make less than $4,000 annually," Thurber pointed out. "Adapting to climate change is a costly endeavor, whether it is retooling a fishing fleet to target a changing fish stock, or moving to a new area or occupation."

The researchers say the effect on oceans will also create a burden in higher income areas, though "it is a much larger problem for people who simply do not have the financial resources to adapt."

"What is really sobering about these findings is that they don't even include other impacts to the world's oceans such as sea level rise, pollution, over-fishing, and increasing storm intensity and frequency,"

added Thurber, a post-doctoral fellow in OSU's College of Earth, Ocean, and Atmospheric Sciences. "All of these could compound the problem significantly."



Deep-sea substrate. Deep sea hard substrate are among the areas that will be heavily impacted by climate change, even though they host some beautiful and bizarre creatures such as these Sea Lily's (Crinoids). Credit: NOAA HURL Archives

In their study, the researchers used global distribution maps of 32 marine habitats and biodiversity hotspots and overlaid that with climate models developed for the Intergovernmental Panel on Climate Change Fifth Assessment Report, presented in Stockholm, Sweden, this fall. They then compared the results with the latest available data on human use of marine goods and services to estimate the vulnerability of coastal populations worldwide.

The models had a range of outcomes, but all agreed that most of the world's oceans would suffer negative impacts of varying intensities from the four major stressors. Only a small fraction of the oceans – mostly in Antarctica and to a lesser extent, small areas of the Atlantic – will see potential increases in oxygen or biological productivity, the study noted.

By 2100, nowhere in the world are ocean waters expected to be cooler or less acidic than they are today.

"When you look at overlapping stressors, the Northern Hemisphere appears to be in real trouble," Thurber said. "The same grim outlook is apparent for the strong upwelling zones off Chile and southern Africa. Another 'red spot' is the Pacific Northwest of the United States, which already is seeing the impact of low oxygen and rising acidification."

It is the combination of stressors that makes upwelling areas – where deep, nutrient-rich water is brought to the surface to fertilize the upper water column – of greatest concern, the researchers noted. The models also suggest that marine food webs based on the production of euphausiids and other krill, or tiny marine crustaceans, are highly at-risk.

"A lot of marine animals, including many whale populations, are dependent upon krill or the other organisms that consume krill, for survival – and krill habitat has some of the greatest overlap in all the stressors we looked at," Thurber said. "On the other hand, coral reefs – even though they didn't rank as high as other areas for stressor overlap – are in trouble due to just two of the stressors, acidification and temperature. So a low score doesn't necessarily mean these areas are unlikely to be affected."

Thurber and three colleagues originally conceived of the idea of the meta-analysis of data to forecast the impact of climate change on the world's deep sea, an idea that was re-cast when they organized an

international workshop that drew many principal investigators of recent climate change studies. Notable among the researchers was Camila Mora of the University of Hawai'i at Mañoa, who spearheaded an effort to include shallow water and the human elements into the data analysis.

Antarctica surface. Only 2 percent of the world's oceans won't face multiple stressors from climate change during the rest of the decade - and most of them are in Antarctica. Credit: Andrew Thurber, Oregon State University

"The consequences of these co-occurring changes are massive," Mora said. "Everything from species survival to abundance, to range size, to body size, to species richness, to ecosystem functioning are affected by changes in ocean biogeochemistry."

The study is unusual because of its scope, and the analysis of multiple factors. Most previous studies have looked at one variable – such as

ocean warming or increasing acidification – but not multiple stressors, or they focused on one geographic area. It also brought the human dimension into play, which few climate change studies have attempted.

"One of the real highlights of the study is its inclusion of the deep sea into our understanding of human impacts on climate," Thurber said. "We often think of this vast habitat as immune to human activity, but we found that this largest and most stable area of our planet is likely to see multiple impacts from our activities."

Among the possible biological responses to the four stressors:

- Although warming off the surface waters in polar regions may lead to enhanced growth and productivity of some species, in a vast majority of the world it likely will lead to species loss, reduced animal density, and enhanced risk of disease;
- Acidification will increase mortality of calcifying marine invertebrates and likely lead to species loss;
- Hypoxia, or low oxygen, will cause mortality in many species and could enhance dominance by other species that are hypoxia-tolerant;
- As productivity declines, many food web structures will be altered and reduced abundance may lead to dominance shifts from large to small species.

Provided by Oregon State University