Global warming will reduce ocean productivity, marine life

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A 10-year, satellite-based analysis has shown for the first time that primary biological productivity in the oceans - the growth of phytoplankton that forms the basis for the rest of the marine food chain - is tightly linked to climate change, and would be reduced by global warming.

The study, published this week in the journal *Nature* by researchers from Oregon State University and five other institutions, found that on a global scale, a warmer climate could cause a rapid, overall reduction in marine life.

“This clearly showed that overall ocean productivity decreases when the

climate warms," said lead author Michael Behrenfeld, an OSU professor of botany and expert on remote sensing of marine biology.

"There is significant regional variability, with some areas showing enhanced production and some area losses," Behrenfeld said. "But on a global basis there is an inverse relationship – increased temperatures cause decreased marine phytoplankton production."

This climate response can be traced to increased stratification in the oceans, the study showed. When the ocean surface warms, it essentially becomes "lighter" than the cold, dense water below, which is loaded with nutrients. This process effectively separates phytoplankton in the surface layer - which need light for photosynthesis - from the nutrients below them, which they also need for growth.

The satellite data used in the study were from NASA's SeaWiFS satellite, or Sea-viewing Wide-Field-of-view Sensor. Since its launch in 1997, SeaWiFS has measured changes in the color of the ocean - as more and more phytoplankton are added, the color shifts from blue toward green. By studying these color changes from space, scientists can calculate how much phytoplankton pigment is in the water, relate this to photosynthetic rate, and correlate these changes to simultaneous changes in climate.

The first climate-driven change in ocean production measured in this study occurred between 1997 and 1999, when the oceans were recovering from one of the strongest El Nino events on record. With the end of the El Nino, global climate began to cool and there was a surge in ocean phytoplankton productivity that peaked in late 1999.

The second climate event was a long-term warming trend that started in 2000 and continues today. Over this period, the ocean sea surface became overall warmer and more stratified, and phytoplankton

productivity went down almost in lockstep at a rate of about 190 million tons of carbon a year. On a regional scale, the decreases in production often exceeded 30 percent.

Despite their microscopic size, ocean phytoplankton are responsible for about half of the photosynthesis on Earth, a process that removes carbon dioxide from the atmosphere and converts it into organic carbon to fuel nearly every ocean ecosystem.

Compared to terrestrial land plants, however, phytoplankton use a very small amount of biomass to convert large amounts of carbon, because they are eaten by predators about as quickly as they grow. The entire global phytoplankton biomass is consumed every two to six days, in contrast to land plants that might have turnover rates of a year to hundreds of years.

“This very fast turnover, along with the fact that phytoplankton are limited to just a thin veneer of the ocean surface where there is enough sunlight to sustain photosynthesis, makes them very responsive to changes in climate,” Behrenfeld said. “This was why we could relate productivity changes to climate variability in only a 10-year record. Such connections would be much harder to detect from space for terrestrial plant biomass.”

Results of the study may provide important insight into how ocean biology might respond to sustained global warming, the researchers said. “A common prediction among global climate models is that warming will cause ocean production to decrease at mid-latitudes and low latitudes, due to intensified stratification,” Behrenfeld said, “This is precisely the response we observed.”

Climate models also predict long term global warming will cause enhanced phytoplankton production near the poles, because of longer

growing seasons, and shifts in the organisms dominating different ecosystems across the globe. These predictions have not yet been confirmed by satellite ocean measurements, and detection of them may require a longer record or advances in satellite technology.

Climate not only influences ocean biology, but ocean biology influences climate.

“Rising levels of carbon dioxide in the atmosphere are a key part of global warming,” Behrenfeld said. “This study shows that as the climate warms, phytoplankton production goes down, but this also means that carbon dioxide uptake by ocean plants will decrease. That would allow carbon dioxide to accumulate more rapidly in the atmosphere, making the problem worse.”

Better understanding this “feedback mechanism” which compounds global warming is a top priority for study, the researchers say.

Source: Oregon State University