

**Reading:** Activities 1.1 and 1.2 provided an understanding of how currents redistribute nutrients with a primary focus on surface currents. Deep-ocean currents also have a profound influence on climate. Deep ocean water is formed at the surface at polar or high latitudes (see map below) where extremely cold/and/or salty water is produced. This water travels in the deep ocean along what is referred to as the ocean “conveyor belt”, which redistributes heat and nutrients globally.

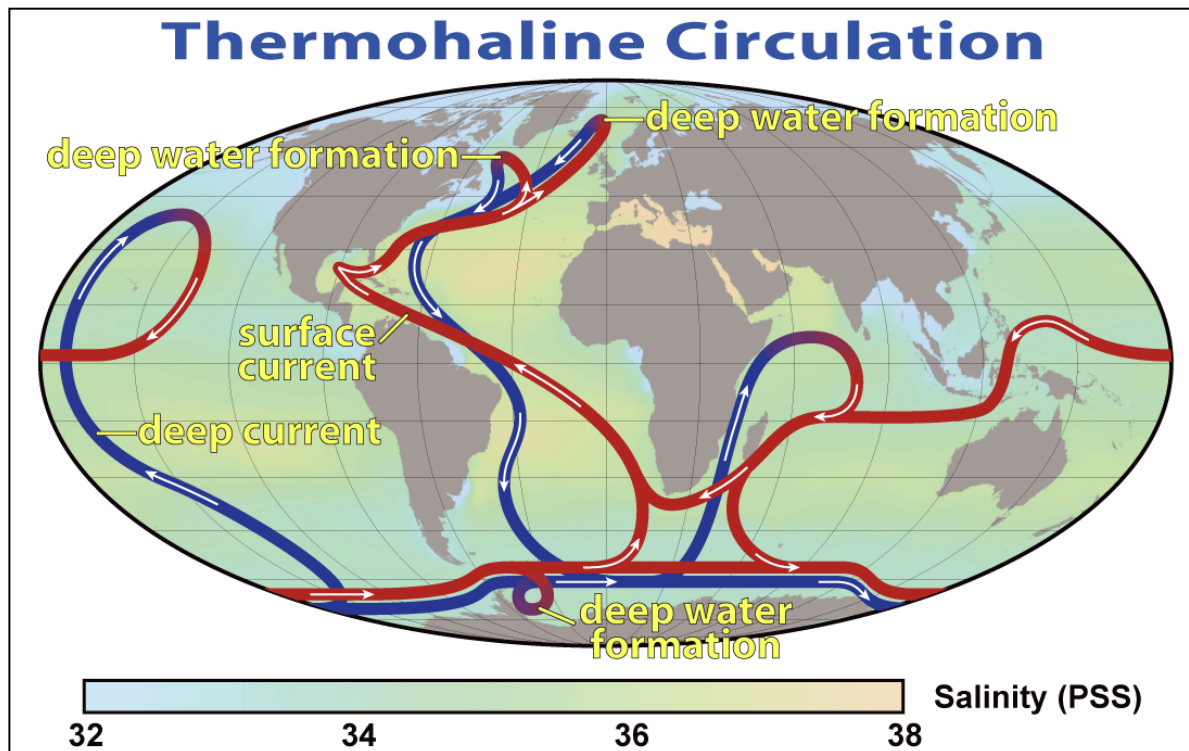


Figure 6. Deep ocean conveyor. Source: NASA Earth Observatory. Salinity = salt concentration in water.

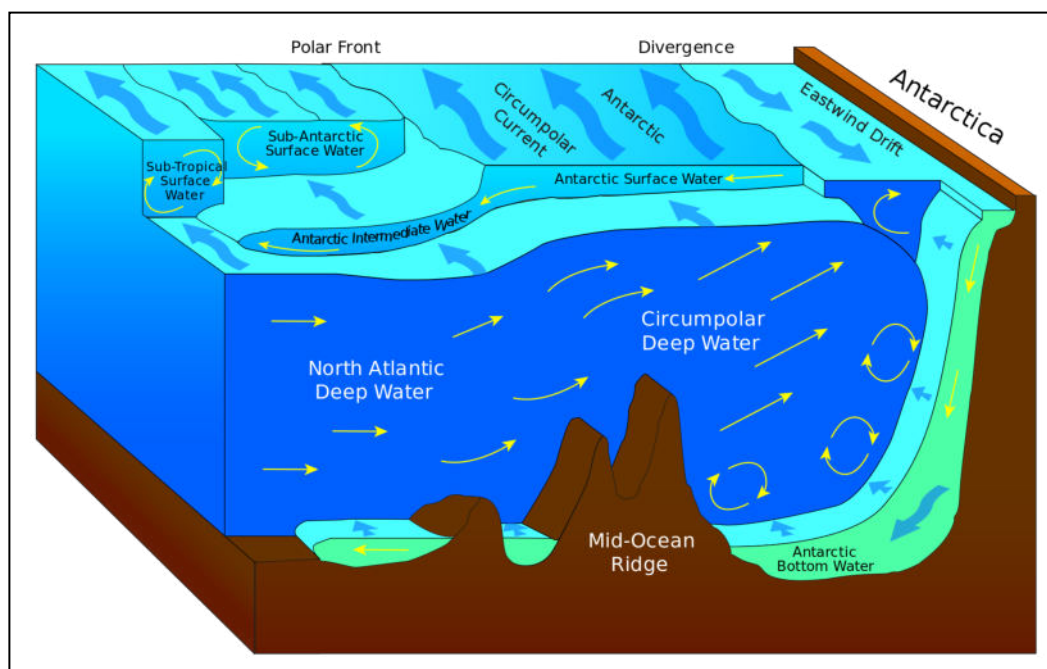


Figure 7. Deep water formation in the Atlantic Ocean (cross-section). Source: Wikimedia Commons “North Atlantic Deep Water”.

The passage is a excerpt of an article published by Penn News on March 20, 2014. Anthropogenic = human-caused.

### **“Deep Ocean Current May Slow Due to Climate Change, Penn Research Finds**

Far beneath the surface of the ocean, deep currents act as conveyer belts, channeling heat, carbon, oxygen and nutrients around the globe.

A new study by the University of Pennsylvania’s [Irina Marinov](#) and [Raffaele Bernardello](#) and colleagues from [McGill University](#) has found that recent climate change may be acting to slow down one of these conveyer belts, with potentially serious consequences for the future of the planet’s climate.

“Our observations are showing us that there is less formation of these deep waters near Antarctica,” Marinov said. “This is worrisome because, if this is the case, we’re likely going to see less uptake of human produced, or anthropogenic, heat and carbon dioxide by the ocean, making this a positive feedback loop for climate change.”

Marinov is an assistant professor in Penn’s [School of Arts and Sciences’ Department of Earth and Environmental Science](#), while Bernardello was a postdoctoral investigator in the same department and has just moved to the National Oceanography Centre in the United Kingdom. They collaborated with Casimir de Lavergne, Jaime B. Palter and Eric D. Galbraith of McGill University on the study, which was published in [Nature Climate Change](#).

Oceanographers have noticed that Antarctic Bottom Waters, a massive current of cold, salty and dense water that flows 2,000 meters under the ocean’s surface from near the Antarctic coast toward the equator has been shrinking in recent decades. This is cause for concern, as the current is believed to “hide” heat and carbon from the atmosphere. The Southern Ocean takes up approximately 60 percent of the anthropogenic heat produced on Earth and 40 to 50 percent of the anthropogenic carbon dioxide.”

#### **Here’s what the article says about how atmospheric CO<sub>2</sub> is taken up:**

“In conducting photosynthesis, the phytoplankton take up carbon, which is then passed down through the deep ocean layers as these organisms and the organisms that eat them die and decompose. If it were not for this process, atmospheric carbon dioxide levels would be about 200 parts per million higher than the currently observed 400 ppm.”

“The Southern Ocean is emerging as being very, very important for regulating climate,” Marinov said.

Along with colleagues, Marinov used models to discern whether the shrinking of the Antarctic Bottom Waters could be attributed to anthropogenic climate change.”

**Questions:**

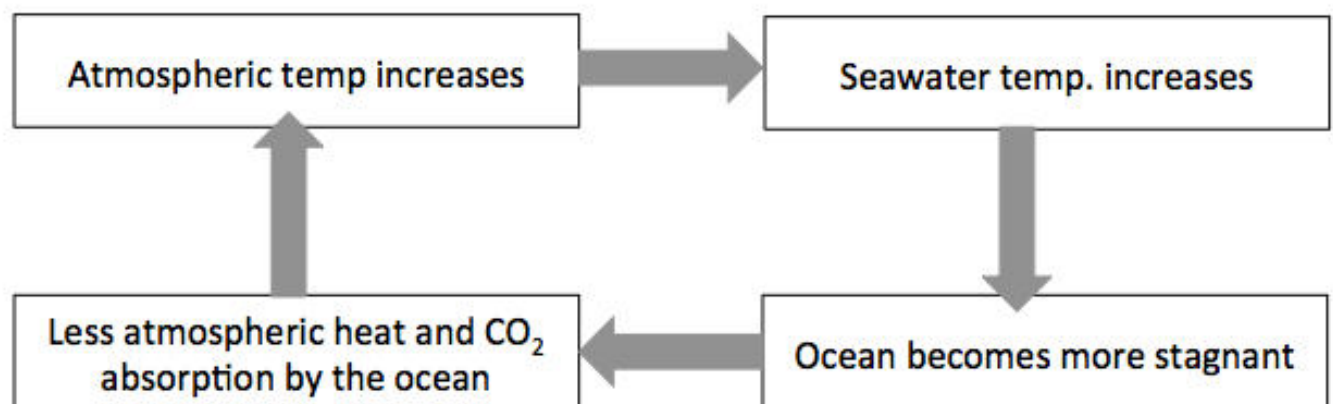
1. What is the primary mechanism for downwelling of water close to the poles? (possible answers: converging currents, decrease in temperature or increase in salinity)

Decrease in temperature = 2 pts

2. In the article, researchers have noted that deep-water formation at the poles is in decline. Describe two mechanisms that can decrease the rate of downwelling at high (polar) latitudes.

Increased temperature and decreased salinity (from melting glaciers) of surface water. 3 pts for one, 5 pts for two.

3. The article implies that deep ocean circulation may slow down. In the space below, summarize (step-by-step) the “positive feedback loop” the authors are referring to. Start with “increase in atmospheric temperature” and explain how this can cause even more atmospheric heating via changes in deep ocean circulation.



Two points for each box = 8 pts

4. Some scientists have predicted that slowing of ocean circulation will diminish upwelling zones in our world’s oceans. Predict how this might change fishing industries worldwide by outlining steps between **change in upwelling zones** and **fish populations**.

Decreased upwelling will decrease delivery of deep, nutrient-rich water to phytoplankton communities in surface waters. This will decrease bioproductivity, which will decrease fish populations = 5 pts.