



Climate and Oceans Planetary Boundaries: for Climate Literacy

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This paper argues that to inform climate-ocean literacy the 2015 Planetary Boundaries (PBs) paper (Will Steffen, 2015) as a guide for “human development on a changing planet” by “a safe operating space for humanity”, requires urgent updating with extension of boundary indicators. This particularly applies to oceans and to climate change, which are linked. Ocean health is the ultimate determinant of climate and biosphere. The 2009 PBs abstract said their exceedance “could see human activities push the Earth system outside the stable environmental state of the Holocene, with consequences that are detrimental or even catastrophic for large parts of the world. The 2015 paper said “planetary boundary (PB) framework provides a science-based analysis of the risk that human perturbations will destabilize the ES (Earth System) at the planetary scale.” Risk is the product of likelihood and magnitude. By magnitude, ES destabilization is an unprecedented greatest of risks ever, even at low likelihood. The 2015 paper states, “Three of the PBs (climate change, stratospheric ozone depletion, and ocean acidification) remain essentially unchanged from the earlier analysis” of 2009. However, climate and ocean change indicators have increased to an extreme degree, at an extreme rate, since 2009. PBs (2015) does not include rates of change, though crucial to risk. Future climate change is calculated from climate sensitivity, still put at 3°C by the IPCC, but (properly) up to 6°C with slow feedbacks by PBs (2009), a large risk not addressed in PBs (2015). PBs (2015) makes atmospheric CO₂ and radiative forcing the only metrics and puts the CO₂ safety limit at “350 ppm CO₂ (350-450 ppm)” while 2009 put the limit at 350 ppm. 450 ppm is far above today’s level of 417ppm. These two metrics are not enough to determine climate safety. Today’s CO₂ equivalent of 504 ppm is a commitment above 2°C and the danger limit is 1.5°C. Increasing radiative forcing determines ocean heating. The radiative forcing (RF) limit is given as 1W m² (2009 and 2015). NOAA (2021) puts RF at 3.183. PBs (2015) determines ocean safety only by ocean acidification, though the rapid ocean heating, ocean de-oxygenation, sea surface temperature increase and ocean carbon sink are crucial. The planetary boundary would be Ocean Change. The sole metric limit given for ocean acidification is aragonite saturation, while the actual metric for ocean acidification is pH. While the global climate emergency is widely recognized since the 2018 IPCC 1.5°C Report, PBs (2015) puts climate change within the safety (green) zone, with a range of uncertainty (yellow zone). Ocean acidification is put inside the green safety zone. Ocean acidification has increased 30% and is accelerating. Since 1980, ocean heat has increased 235 zettajoules, which is about 3900 times all the energy used by the human world per year. Open ocean oxygen has been declining since 1975. Ocean warming, acidification and deoxygenation are projected to increase at least for decades. The 2015 PB limits are far from safe for oceans and climate.

