Water worlds may be habitable, but not detectable

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Water worlds and pelagic planets with extensive surface liquid water, are intriguing types of planet to consider in the search for life beyond Earth. They fall squarely within the traditional definition of habitable because they have surface oceans. However they may have many times more water than the Earth, which has implications for their biogeochemical cycles. We define a Detectability Index to quantify the likelihood that oxygen (O_2) could be assigned a biological vs. non-biological origin and apply it to the case of O_2 on Earth-like planets with varying amounts of water. On Earth-like exoplanets with just 0.2wt% water, i.e., no exposed continents, a reduced flux of bioessential phosphorus limits O_2 production by photosynthesis to levels indistinguishable from abiotic O_2 production due to photolysis of water vapor plus hydrogen escape. Higher water contents, > 1wt%, lead to high-pressure ice mantles and even lower rates of oxygen production. The counter-intuitive conclusion that planets with more water may be more difficult targets for life detection, highlights the importance of a biogeochemical framework for assessing biological process rates in context with geochemical and geophysical process rates.

