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Annually recurrent macroalgal blooms (Ulva prolifera) resulting in the world's largest green-tides caused by expansion of coastal aquaculture in the Yellow Sea off China

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The largest macroalgal blooms ever recorded occurred in the Yellow Sea of China in 2008 and 2009 and resulted in extensive green tides along the Shandong Province coastline, including at Qingdao. At their peak these Ulva prolifera blooms covered more than 4,000 km2 and affected 40,000 km2. A smaller bloom was recorded in 2007, but not earlier. Since then massive blooms have occurred annually in summer from 2008 to 2012. Using remote sensing methods, we tracked the source of the 2008 and 2009 blooms to an area along the Jiangsu Province coastline near Yancheng, over 200 km south of Qingdao, where there had been rapid expansion of Porphyra aquaculture to as much as 13 km offshore, prior to the appearance of the first bloom in 2007. Porphyra is grown on rafts which can become heavily fouled with U. prolifera which is disposed of into the sea when the Porphyra is harvested. The timing of the blooms occurred post the April harvest period when daily tidal ranges in this region can be in excess of 7 m. This provides the mechanism for transportation of the floating algae offshore and into the warm nutrient rich waters of the Yellow Sea where it grows rapidly forming large patches. As the patches of algae grow and join, they gradually move north, as a result of wind driven surface currents that prevail in the Yellow Sea in summer, ultimately washing ashore on the Shandong Peninsula. We present a range of oceanographic, biological, ecological and genetic data to support the hypothesis that Porphyra aquaculture provides the source biomass for the Yellow Sea green-tides. Improved aquaculture waste disposal methods in the southern area of Jiangsu Province are likely to reduce or prevent the Yellow Sea green tides and present a feasible solution to a recurrent problem.