

# Rising green tides and golden tides: An oceanographic regime shift?

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## Abstract

Blooms of *Ulva* and *Sargassum* macroalgae, often called green and golden tides, respectively, have been reported in many places around the world. These macroalgae provide important ecological functions in the ocean, but can cause many problems when large quantities are washed ashore. Using satellite data, field and laboratory measurements, and novel macroalgae-specific algorithms, we show bloom patterns of *Ulva prolifera* and *Sargassum* between 2000 and 2018 in the western Pacific (Yellow Sea and East China Sea) and tropical Atlantic. While their seasonality indicates algae growth cycles, large quantities detectable in satellite imagery only occurred in recent years. Analysis of environmental conditions suggests that large-scale blooms may become a new norm in these study regions, thus representing potentially a regime shift. How to adapt to such a regime shift and what are its ecological/biogeochemical consequences all remain to be studied, however. Meanwhile, the band-difference algorithm design in these macroalgae studies has led to possibly a paradigm change in ocean color algorithms, as recent studies show that band-difference has superior performance over band-ratio for retrievals of concentrations of chlorophyll-a, particulate inorganic carbon, and particulate organic carbon in most ocean waters.

**Keywords:** *Ulva*, *Sargassum*, regime shift, climate change, algorithm design, chlorophyll-a, particulate inorganic carbon, particulate organic carbon