

Seaweed Cultivation in the Oligotrophic Open Ocean: Measuring Growth, Sinking, and Carbon Sequestration Potential

HAOJIA ABBY REN^{1,2}, CAREL TAN^{1,2}, YI CHI CHEN², RUEI-HSUAN KANG², BRANDON STEPHENS³, YI-CHIA HSIN^{2,4}, JUI-SHENG CHANG⁵, TUNG-YUAN HO⁴ AND DANIEL M. SIGMAN⁶

¹Department of Geosciences, National Taiwan University

²Research Center for Critical Issues, Academia Sinica

³Institute of Oceanography, National Taiwan University

⁴Research Center for Environmental Changes, Academia Sinica

⁵Center of Excellence for the Oceans, National Taiwan Ocean University

⁶Princeton University

Large-scale seaweed cultivation has been proposed as an ocean-based strategy for reducing atmospheric CO₂. However, most seaweed farming occurs in nutrient-rich coastal waters or shallow shelves, where carbon sequestration would require burial in sediments and/or the production of highly recalcitrant, long-lived organic matter. In contrast, if seaweeds can be grown at large scale in the open ocean or proximal to it, seaweed carbon may sink into the deep ocean, where it would contribute to the ocean's biological carbon pump, storing carbon for hundreds of years or longer even if it is regenerated to CO₂ in deep waters. The feasibility of large-scale seaweed cultivation in oligotrophic open waters is untested and will depend on the characteristics of seaweed growth, degradation, and sinking. In this study, we constructed a 300 m² typhoon-resistant seaweed platform off eastern Taiwan, adjacent to the deep North Pacific basin and along the Kuroshio Current, where surface nutrients remain near zero year-round. Direct measurements and incubation experiments indicate that *Eucheuma perplexum* has a specific growth rate of 1–1.5% per day, with net primary production (NPP) of 1.6–2.4 gC/m²/day—comparable to kelp growth in temperate regions. Degradation experiments show that seaweed biomass decomposes at ~5% per day under both oxic and anoxic conditions. Additionally, DOC released during *E. perplexum* growth degrades rapidly, with only ~20% remaining after three weeks. These results suggest minimal long-term carbon storage as biomass in sediments or refractory DOC. However, modified net traps beneath the platform captured substantial sinking biomass, mostly in large fragments (>2 mm), accounting for 13–23% of seaweed NPP. The sinking flux varied with current conditions, with one extreme typhoon removing nearly half the biomass. To track carbon fate, we will use a particle transport model embedded in a high-resolution (750 m) regional ocean circulation model. This will estimate the fraction of seaweed-derived particulate and dissolved organic carbon reaching depths below 1000 m before full decomposition. Our preliminary findings suggest that large-scale seaweed cultivation in oligotrophic open oceans is feasible, especially with regard to the