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Gracilaria cultivation can provide bioremediation in Chinese mariculture

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Seaweed can decrease nitrogen and phosphorus loadings

Gracilaria seaweed is effective at removing inorganic nutrients from water.

Within China's mariculture sector, culture of the red agarophyte *Gracilaria* has rapidly expanded over the past 10 years. Production of *Gracilaria* reached 99,451 metric tons in 2007 and for seaweeds ranked only behind the kelps *Saccharina* and *Undaria*.

The principal *Gracilaria* species cultured throughout China is *G. lemaneiformis*. Growth rates for the seaweed range up to 13.9 percent/day in Jiaozhou Bay in Shandong Province.

G. lemaneiformis is very effective in decreasing nitrogen and phosphorus loadings. The seaweed is also able to inhibit the growth of some microalgae and may increase dissolved oxygen in the water column. Large-scale *Gracilaria* cultivation can be an effective means of improving water quality and promoting a more sustainable mariculture industry in China.

Bioremediation benefits

Nanao is an island county of Guangdong Province with a population of about 70,000. Of these, about 5,000 people are now engaged in the cultivation of *Gracilaria*. The area of cultivation rose from 0.06 hectares (ha) in 1999 to 800 ha in 2006. The seaweed provides several beneficial functions.

Biofiltration

The rapid development of the mariculture industry has aroused concerns about the effects of these activities on the Chinese coastal environment, which can include deterioration of water quality and an increase in contaminants.

Mesocosm experiments demonstrated that *G. lemaneiformis* can effectively remove inorganic nutrients from water. Concentrations of ammonium nitrogen decreased by 85.53 and 69.45 percent, and concentrations of phosphate decreased by 65.97 and 26.74 percent in the mesocosms with *Gracilaria* in comparison to mesocosms without the seaweed. In 24-hour enclosure experiments, *Gracilaria* removed 68.44 percent of ammonium nitrogen, 23.03 percent of nitrate nitrogen and 13.04 percent of nitrite nitrogen.

The maximum uptake rates of nitrate nitrogen, ammonium nitrogen and phosphate by G. lichenoides were 55.88, 35.17 and 3.106 umol/g/h, respectively. The corresponding rates for *G. lemaneiformis* were 53.17, 32.24 and 3.064 umol/g/h, respectively. These studies confirmed that *Gracilaria* species are good candidates for nutrient removal.

Increased D.O. concentrations

Testing during 17 visits to the Shenao culture area in Nanao showed that dissolved-oxygen (D.O.) levels were highest in cages with Gracilaria, second highest in the surrounding sea water outside the cages and lowest in cages with fish.

A 12-day experiment found that concentrations of D.O. were always higher in 1-m^3 mesocosms with *Gracilaria* than those without it (Fig. 1). These results demonstrated that cultivated *Gracilaria* is very effective in improving D.O. levels in mariculture areas.

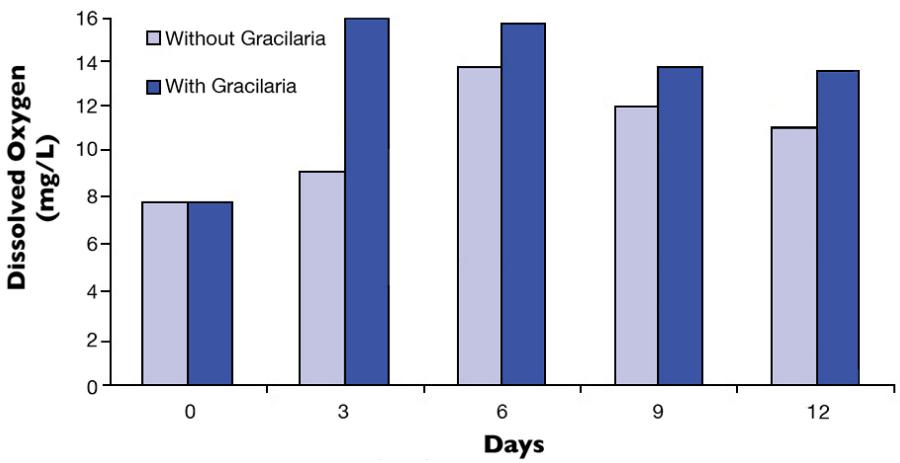

Fig. 1: Dissolved-oxygen concentrations in mesocosms with and without *Gracilaria*.

Decreased microalgae densities

The mesocosm experiments also demonstrated that *G. lemameiformis* limited microalgae growth. The densities of phytoplankton increased from 3.017 x 10^4 to 105.500 x 10^4 cells/L in the mesocosms without *Gracilaria*, whereas the densities increased from 2.387 x 10^4 to 26.500 x 10^4 cell/L in those with *Gracilaria*. The densities of phytoplankton were always lower in the mesocosms with *Gracilaria* (Fig. 2).

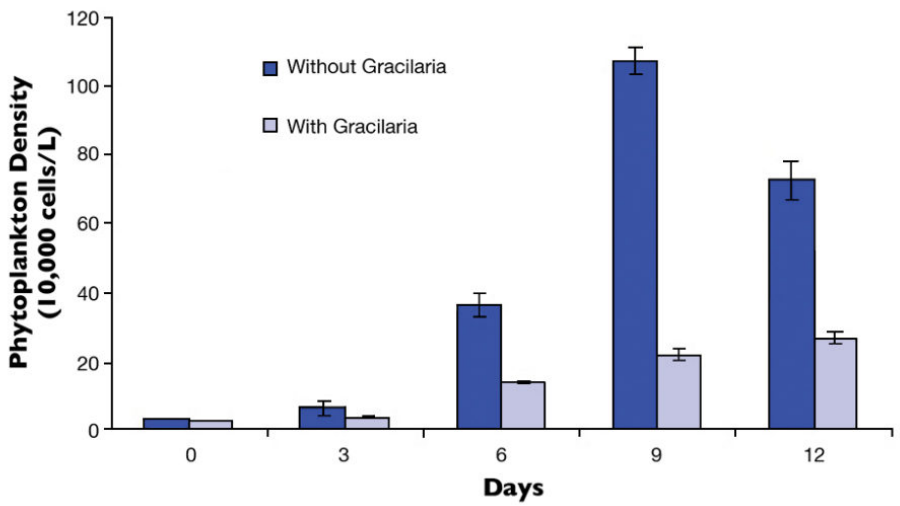

Fig. 2: Phytoplankton densities in mesocosms with and without *Gracilaria*.

Other experiments demonstrated that the fresh thalli of *G. lemaneiformis* significantly inhibited the growth of selected microalgae: *Prorocentrum donghaiense, Alexandrium tamarense, Amphidinium cartera, Scrippsiella trochoide* and *Chaetotoceros curvisetus*.

The results showed that *Gracilaria* can suppress growth and decrease densities of these microalgae. Large-scale cultivation of *Gracilaria* may be an effective ecological strategy to control harmful algal blooms in Chinese coastal waters.

Gracilaria cultivation can help control harmful algae blooms.

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