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Nutrient management for sustainable Nori (*Pyropia yezoensis*) aquaculture in the Seto Inland Sea, Japan

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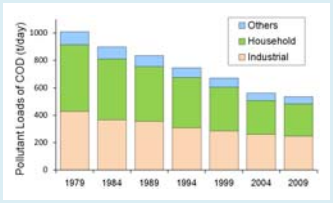
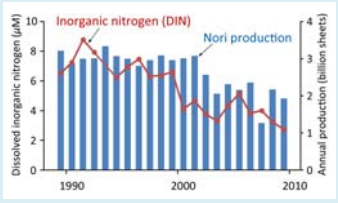
Nutrient deficiency causes the poor crop of Nori

The production of Nori (*Pyropia yezoensis*) is getting lower because of the bleaching of Nori which is caused by nutrient deficiency in the sea water. In the Seto Inland Sea of Japan, eutrophication occurred rapidly during the period of rapid economic growth of Japan around 1970. After that, however, effective anti-eutrophication measures reduced the eutrophication in the sea water and nutrient level became lower in this decade. Additionally, occurrences of diatom blooms cause depletion of inorganic nitrogen and decreased the production.



Time series of pollutant load into the Seto Inland Sea, Japan (According to the ministry of the environment, Japan)



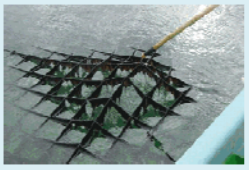
Time series of annual production of Nori in the Seto Inland Sea, and dissolved inorganic nitrogen (DIN) concentration in Harima-nada, eastern part of the Seto Inland Sea.

Measures to maintain suitable nutrient level

For sustaining the production of Nori, measures has been taken to maintain appropriate inorganic nitrogen level;

1) Application of nitrogenous fertilizer
2) Additional discharge of dam water
3) Moderate operation of sewage treatment plant (STP)

Nori aquaculture



Nori aquaculture with floating net.
Left: Normal condition, Right: Bleached Nori thalli.

Dried Nori is an important part of the Japanese food.

Red alga Nori (*Pyropia yezoensis*) is one of the important aquaculture productions in Japan. The production in 2010 was 329,000 tons (85 billion yen) accounting for 30% (20%) of marine aquaculture production volume (value) in Japan.

Various techniques including open water systems with floating net or fixed net, artificial seeding of conchospores, low temperature storage of nursery nets has been sustaining the large production.

Study area

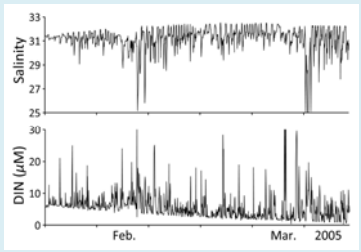
Nori aquaculture with floating net is conducted in the estuary of Kako River which run into Harima-nada, eastern part of Seto Inland Sea, Japan.

Nutrient is discharged from the River, industrial plant and sewage treatment plant.

Model simulation

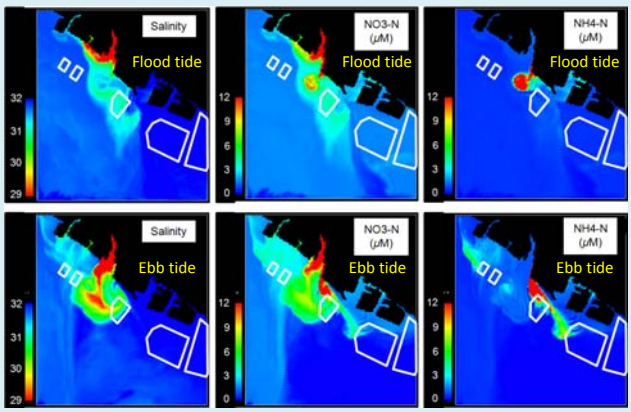
We assessed the nutrient condition during the Nori aquaculture season (winter) by using a numerical model. *The model is based on Princeton Ocean Model and include low trophic ecosystem processes.* The model simulation showed behaviors of nutrient rich water masses in the aquaculture area.

The Nori production is sustained by nutrient discharge from Kako River, the water way.



Time series of calculated salinity and dissolved inorganic nitrogen in the aquaculture area

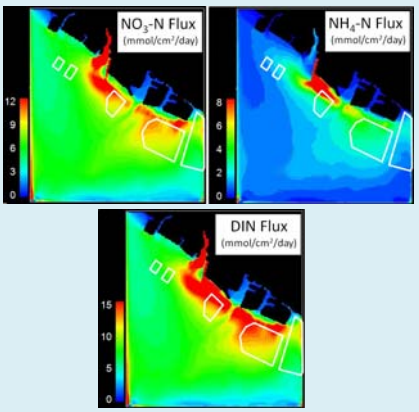
Nutrient is discharged intermittently from the river and the water way.



Distributions of nutrient in the surface layer calculated by the model

The riverine water flows near shore at flood tide while it flows off shore into the aquaculture area at ebb tide. Nitrate nitrogen (NO3-N) discharged from the river affects much on the eastern part of the aquaculture area.

Ammonium nitrogen (NH4-N), which is discharged predominantly from the industrial plant into a water way, is supplied to the eastern part of the aquaculture area near the mouth of the water way.



Average values of Nutrient flux in winter

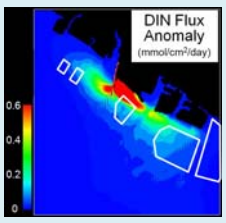
Nutrient flux is necessary for Nori to uptake nutrient and sustains its growth. The model simulation indicated that the Nori production is sustained by nutrient discharge from Kako River and the water way.

Effect of moderate operation of STP

The moderate operation of sewage treatment plant (STP) is conducted experimentally during the winter to increase nutrient level in the aquaculture area. In the moderate operation, inhibitions of nitrification and denitrification in the treatment process increase inorganic nitrogen discharge.

A numerical simulation demonstrated the increase of inorganic nitrogen flux in the aquaculture area by the moderate operation of STP and figured out the effective area.

The moderate operation of STP is one of the practical measures to increase inorganic nitrogen in Nori aquaculture areas.



Increase of DIN flux by moderate operation of the sewage treatment plant

The moderate operation increase nutrient flux in the aquaculture area. The operation is effective to supply nutrient and prevent bleaching of cultured Nori.

Acknowledgement

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