Application of artificial upwelling for possible increase of fishery resources

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World demand of fisheries products tends to increase steadily with a shift to piscivorous due to an increased consumption supported by increased income in developing countries. On the contrary, the supply of natural fisheries products is reaching a ceiling around 70 millions tons due to excessive fishing and the deterioration of fishery environment, and then the supply of fisheries products is now getting stringent.

It has been hanging low that more than half the number of natural fisheries resources evaluated for a long period of time in Japan, and the total catch of fisheries products is getting low in the past years. Then immediate actions in order to recover fisheries resources are highly requested.

The Fishery Agency of Japan has challenged for restricting excessive fishing, restoring seaweed and seagrass beds to protect juveniles and eggs, and released artificially raised juveniles. Artificial improvement of primary productivity in the ocean has also been challenged as one of effective approaches.

Most living beings depend entirely on organic matter produced by plants through photosynthesis. Then, the Fishery Agency has challenged to increase fisheries resources by creating suitable environment for phytoplankton which increase the base of food chain.

In general, fluxes of inorganic nutrients low in the surface water of ocean, which strongly limit the productivity of phytoplankton. However, it is known that concentrations of inorganic nutrients become higher below 50m in depth. Therefore phytoplankton productivity could be enhanced if inorganic nutrients sitting below depths are brought up to shallow depths by human actions. Ryther (1969) pointed out that 50% of fishes is produced in the upwelling area that covers only 0.1% of world ocean surface.

The Fishery Agency has supported various researches and technology developments for generating effective artificial upwelling as well as nutrient concentrations around the structure and its stimulation on primary productivity. Then a pioneer experiment of man-made sea mountain was conducted at a depth of 82m off the coast of Ikitsuki in Nagasaki Prefecture in 1995. This experiment proved how to construct the structure that generate efficient upwelling in deeper sea than 50m in depth. About 5,000 blocks were produced using coal ash of 20,000 tons as recycled, and then natural resource was never used.

To evaluate the effect of the sea-mount, the ocean color data of satellite were analyzed. It was then confirmed that the chlorophyl-a concentrations in the surrounding sea area increased by 1.5 times after the construction of the sea-mount, and primary production increased. It also turned out that the hauls increased from 250 tons to 1500 tons per year in the sea area of 20km$*$18km before and after the experiment, respectively. The reef ecosystem was also created around the sea-mount. Various attached organisms found habitat on block surface and space between blocks became hiding place for some organisms. Many fishes approached to the sea-mount for eating organisms living there.

Phytoplankton increased by the sea-mount supported an increase in living aquatic resources. Additionally, it is thought that CO2 fixed by phytoplankton might be transported to a deeper depths. A further research is required in order to evaluate possible CO2 sequestration associated with the seat-mount.

In these results, the Fishery Agency started to construct the sea-mount as public works in the fiscal year of 2003, and has already completed construction at 3 locations. The investigation has been continued in order to improve forecasting accuracy of the actual increase of primary productivity and CO2 sequestration.

Further efforts on investigation will be given for evaluating protection effects of man-made sea-mount on the living being for fishery products. Construction technologies in deeper sea will also be examined and developed as well as looking for wider applications in more sea areas.