Bioremediation and micro-bubble techniques for environmental management of the fish farm and the enclosed coastal bay

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In the enclosed seas in Japan, fish farming has been developed since the 1970s, and the total year production of the fish culture reached approximately 250 thousand tones in the 1990s. The fish farming, however, tends to suffer from deterioration of the environmental conditions caused by the activities of the fish farming itself. The fish farm is apt to be established in the enclosed cove or bay with restricted water exchange to protect it from strong wind and wave. There, fish is cultured in net pens with extremely high densities. DO levels of the water in the net pens tend to significantly decrease due to respiration of the fish. The fish excretion discharges a large amount of nutrients outside the fish farm, and causes eutrophication of the water, following a blooming of toxic phytoplankton. The fish farm also discharges a large amount of organic particulates such as feces and food residues on the sea floor just below the fish, and results in organic enrichment of the sediment and dissolved oxygen depletion of the bottom water during the summer. The hypoxic (or anoxic) bottom water often causes a catastrophic disturbance on the benthic ecosystem, and affects the fish farm by vertical mixing of the water. For sustainable development of fish farming and management of healthy environment in the enclosed coastal areas with the fish farm, we need to develop effective measures to solve the negative influence of the fish farming to the environment.

Our research project aims at improving DO conditions of the water in the net pens for fish farming by addition of micro-bubbles, enhancing the growth of the fish in the improved DO conditions, and treating the organically enriched sediment on the sea floor just below the fish farm with mass-cultured colonies of a deposit-feeding small polychaete, *Capitella* sp. I. We developed a micro-bubble generator usable in seawater. It generates tiny air bubbles with several to several tens micrometer in diameter. Since the surface area to the volume of the micro-bubble is much larger than that of the ordinary air-bubble, it receives markedly smaller buoyancy, and dissolves into the water efficiently. We repeated the tests of the micro-bubble generator in a fish farm, and confirmed that the micro-bubble generator (only 400W electricity consumption) could increase 0.5 - 0.9 mg/l of DO in the whole water column (up to 18 m in depth) within a 10 m radius from the generator. For the treatment of organically enriched sediment in the fish farm, we developed a mass-culture technique of *Capitella* sp. I. This species and its closely related sibling species are common members of the benthic communities in the organically enriched sediment in the coastal areas throughout the world. It often exhibits the explosive population growth in favorable benthic conditions, exploiting the organic matter in the sediment. Therefore, we expect that the organically enriched sediment is quickly treated by artificially inducing the rapid population growth of *Capitella* by spreading the seed colonies. In the autumn of 2003 and 2004, we prepared a mass-culture of *Capitella* colonies, and put it on the organically enriched sediment just below the net pens in a fish farm of red sea bream in Amakusa, Kyushu, the western Japan. We succeeded to establish extremely high density colonies of over 500 thousand indi./m^2 and markedly decreased the organic matter content of the sediment just below the net pens during the winter.

In this paper, we introduce the outline of this research project, referring to the recent results of the experiments in the laboratory and the fish farm. This study is supported by the Research and Development Program for New Bio-industry Initiatives.