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Role of marine ecosystem for increasing CO2 sequestration: effect of a semi-artificial upwelling system

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The ocean plays a major role in shaping the Earth climate by regulating the global cycles of elements as carbon. Most of the carbon in the ocean is stored in deep waters and sediments of the sea floor via the ”the biological pump”.

This pathway begins as phytoplankton that forms the base of the ocean food web and takes up CO_2 and nutrients throughout the process of photosynthesis to form organic matter. The efficiency of the ocean productivity depends mainly on the availability of nutrients (mainly nitrogen, phosphorous and silica) in the euphotic zone, together with the combination of physical parameters as light, temperature and mixing of the water. Several challenges have been done all over the word for nutrient fertilization of shallow waters in the ocean. Mixing between shallow waters with nutrient rich bottom waters is now experienced by means of a man-made sea-mount, which is expected to create a sufficient turbulence for this purpose. If the nutrient-rich bottom water can reach the euphotic zone, the ”biological pump” will be enhanced with a possible atmospheric CO_2 sinking effect. However an effective CO_2 sink, which means in turn an efficient ”biological pump”, depends not only on primary production rates but also on respiration, grazing, degradation and transportation of organic matters to the deep layers.

The main focus of this research is to assess the effect of nutrient fertilization on primary production using an ”artificial sea-mount” as upwelling system and to determine the amount of CO_2 that can be potentially fixed by the marine ecosystem influenced by the artificial upwelling system. The field area is located in the Japan Sea near the Northwest of Kyushu Island, Japan at 33^o 29’N and 129^o 26’E, where an artificial ”sea-mount” of about 12 m height was constructed in order to create the necessary bottom structure for upwelling processes (Fig. 1). Field surveys were carried out on September 5 of 2003, May 11 of 2004 and October 4 of 2005. Two main oceanographic stations were chosen: Stn. C near the ”arine structure”, and Stn. O (10km from station C). Physico-chemical and biological parameters were measured at these stations. Incubations for measurements on primary production using ^{13}C tracer technique and studies on variations of plankton assemblages were carried out for both stations. Incubations were also used for an experiment of organic matter degradation carried out at dark conditions and 20^{o}C during 65 days in the laboratory. Primary production varied widely according to the weather conditions at the three occasions of field studies, especially the light intensity on sunny days or cloudy weather resulted in different primary production values

Net primary production varied between 1365 and 394 mg-C m^{-2} day_{-1} at Stn. C and 1252 and 362 mg-C m^{-2} day_{-1} at Stn. O during the three years of studies. At least 18% to 32% of the particulate organic matter produced at the euphotic zone remained after 65 days of degradation, with high possibility to be transported to deep layers. The difference between the production rate of organic matter between Stn. C and Stn. O can be considered as the ”new production” due to the upwelling of nutrients from deep layer to the euphotic zone carried by the effect of ”sea-mount” These values varied from 32 to 113 mg-C $^{-2}$ day_{-1}.

The above results suggest that new production was enhanced by the effect of a semi-artificial upwelling created around the marine structure. Higher production rates at the Stn. C, indicates an important contribution to capture of atmospheric CO_2 in the studied area. If the produced organic matter is transported to deep layers it might represent a key factor for the CO_2 capture by the planktonic community in this field, because the semi-labile organic matters will become refractory organic matter with an age of hundred or thousands in the deep sea.