Application of an ecological model for evaluation of CO2 fixation capacity of marine ecosystem: effect of artificial upwelling

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The level of CO_2 on the earth is the result of equilibrium between production and consumption. Consumption is by terrestrial and aquatic photosynthesis and organic production by the respiration of plants, animals and of course by the human activity. There are now evidences that terrestrial ecosystems produce as many CO_2 as they consume by photosynthesis. What happen in the oceans? Numerous international programs have studied carbon fluxes in the ocean. They conclude that, phytoplankton biomass is low due to a strong limitation by the lack of nutrients (mainly nitrogen) in the euphotic layer. However primary production in the ocean can be enhanced if nutrient availability is improved. In shallow continental shelves improving of mixing between shallow waters with nutrient rich bottom waters was experienced by means of a man-made seamount, which is expected to create a sufficient turbulence for mixing between shallow and deep waters in some extent. If primary production is enhanced, atmospheric CO_2 will be captured as organic matter and can sink to deep layers. The purpose of this research is to determine the amount of CO_2 that can be potentially fixed by the marine ecosystem using an ecological model applied to the study area. Two main oceanographic stations were chosen: Stc. C near the artificial upwelling area, and Stc. O (10km from station C). Physico-chemical parameters as water temperature, salinity, Chl-a and nutrients concentrations were measured at these stations. Incubations for measurements on primary production using ^{13}C tracer technique and studies on variations of plankton assemblages were also carried out. A one dimension-biogeochemical model composed of five compartments: phytoplankton, zooplankton, nonliving POC, heterotrophic bacteria and DOC, was employed as the carbon sink model. Fig. 1 shows the concept of the model in this study.

Photosynthesis rates at Stns. C and O varied between 1369 to 185 mg-C $m^{-2}day^{-1}$ at Stn C and 1146 to 174 mg-C m^{-2} day^{-1} at Stn O, meanwhile respiration rates by phytoplankton were 260 to 90 mg-C m^{-2} day^{-1} and 296 to 100 mg-C m^{-2} day^{-1} at Stns C and O respectively. These values were used for the calculation of P/R ratios as 7.0 to 2.1 for Stn C and 5.1 to 1.7 at Stn. O. Net primary production rates (photosynthesis - $respiration_{pp}$) were 1101 to 97 mg-C m^{-2} day^{-1and} 850 to 74 mg-C m^{-2} day^{-1} at Stn O. These data indicate that Stn. C was more productive environment for phytoplankton than Stn. O. Table 1 shows carbon fluxes calculated using the present ecological model. Magnitude of photosynthesis and respiration on May of 2004 were lower compared with other observation periods and these results were due to the bad weather conditions in which the incubation experiments were carried out on May 2004 with a considerable lower light illumination, and lower water temperature.Net production rates of POC at Stns. C and O on May 2004 were -123 and -236 mg C m^{-2} day^{-1} indicating that POC concentration decrease on May of 2004 in the biogeochemical model. However, the range of production rate of organic matter varied between 68 ˜1094 mg-C m^{-2} day^{-1}, indicating that atmospheric CO_2 could be up taken by the marine biota. Higher P/R ratios found at Stn C suggest that enhancing in nutrient supply by the ”mount” produced new organic matters with the consequent CO_2 sink. Moreover the contribution to new production by semi-artificial upwelling can be clearly observed from the difference in primary production rates between the two selected stations, with an important contribution of capture of atmospheric CO_2 in the studied area.