TAO, Vol. 16, No. 2, 513-528, June 2005

A Case Study of System and Planktonic Responses in a Subtropical Warm Plume Receiving Thermal Effluents from a Power Plant

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(Manuscript received 1 October 2004, in final form 3 May 2005)

ABSTRACT

To explore planktonic and ecosystem responses to thermal effluents of a power plant, three transect surveys were conducted in Nov-01', May-02' and Jun-02' at the bay adjacent to the outlet of Taiwan Nuclear Power Plant II. At the given station, seasonal trends were evident with most maximal measurements observed in Jun-02'. Physical mixing between background seawater and thermal effluents played an important role in determining planktonic biomass since chlorophyll (Chl, < 0.15 - 1.27 mgChl m^{-3}) and bacterial biomass (BB, 11 - 48 mgC m^{-3}) increased almost linearly seaward. Temperature (20 - 45°C) manipulation experiments suggested that phytoplankton were more vulnerable than heterotrophs to thermal stress. Differential temperature responses of auto- and heterotrophs result in primary production (PP, < 1 - 100 mgC m^{-3} d^{-1}) increasing seaward, while community respiration (CR, 15 - 68 mgC m^{-3} d^{-1}) and bacterial growth rate (BGR, 0.03 - 0.9 d^{-1}) showed opposite trends. The plume system was heterotrophic (PP/CR ratio < 1) in areas with bottom depths ca. < 10 m, and then switched to autotrophic status (PP/CR ratio > 1 - 3.7) in deeper regions. High observed dissolved organic carbon (DOC) anomaly (23 - 34 gC m^{-3}) implied that heterotrophic metabolism was seldom limited by bottom-up control processes. Short-term manipulation experiments showing that BGR and CR increased with rising temperature up to ca. 37°C, which was ~12°C higher than frequently reported values from most coastal and estuarine ecosystems. We ascribed this to the effects of temperature-substrate interaction. The results of organic carbon (zooplankton extract) ad-

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dition experiments suggested a certain fraction of the in *situ* DOC was as labile as animal tissue since the increasing trends of BGR in the enriched and control treatments behaved similarly. From a carbon cycling perspective, the positive temperature responses of heterotrophic activities imply that in coastal systems with a high loading of anthropogenic DOC, the biogenic emission rate of CO_2 might increase exponentially as global temperatures rise.

(Key words: Phytoplankton, Primary production, Bacteria, Community respiration, Temperature, Q_{10})

1. INTRODUCTION

Studies on planktonic tropho-dynamics based on ecosystem perspectives have become very popular since the eighties. Research results derived from natural ecosystems have greatly increased our understanding of biogeochemical processes occurring within and between systems. As a result of increasing anthropogenic activities, many coastal systems are becoming subject to human disturbance. A study of behaviors such as one on biomass and rate parameters of various plankters in a highly disturbed system might serve as a good reference point for our current understanding of carbon cycling and planktonic tropho-dynamics.

One of the environmental issues caused by the operation of nuclear power plants is their potential thermal stress on aquatic organisms living nearby. In Taiwan, several cases such as that of the "malformed fish" (Hung et al. 1998) and coral bleaching (Dai 1999) have been reported as resulting from the thermal effluents of power plants. Related studies of thermal stress on planktonic activities have been conducted elsewhere, but with limited measurements focusing only on one or two individual processes. For example, Servais and Billen (1989) studied thermal effects on primary and bacterial production. Choi et al. (2002) studied thermal stress and its effects on the activity of heterotrophic bacterioplankton and nanoflagellates. System characteristics such as the ratio of primary production to community respiration i.e. the P/R (or PP/CR) ratio were not analyzed in both studies. Moreover, these two (and most relevant) studies were conducted in temperate regions with maximal temperature < 30°C. Temperature responses of planktonic activity in the thermal plume at temperature > 30°C remain unexplored. This study was designed to understand the controlling mechanisms over the seasonal and temporal variations of autotrophic and heterotrophic processes as well as system characteristics in a subtropical warm plume system adjacent to the Tai-Power power plant.

2. MATERIALS AND METHODS

2.1 Study Site and Sampling

Three transect surveys were conducted in Nov-01', May-02'and Jun-02' at the bay adja-