BIOGEOCHEMICAL ECOLOGY OF AQUACULTURE PONDS

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By

Richard Scott Jurick Weisburd

Dissertation Committee:

Edward A. Laws, Chairman
Yuan-Hui Li
Fred T. Mackenzie
James M. Price
Stephen V. Smith
Gary D. Pruder

ABSTRACT

The biologically mediated production and consumption of organic matter caused by the photosynthesis and respiration reactions are two of the largest fluxes in the global carbon cycle. Very accurate determinations of the rates of these reactions must be obtained in order to understand their dependance on environmental variations. There remain problems in measuring the rates of photosynthesis and respiration in aquatic systems despite several decades of research in this area.

Two methods to determine rates of organic matter production and consumption were applied in shrimp aquaculture ponds which served as convenient model systems. Several questions were posed: Can net rates of organic matter production and consumption be determined accurately through application of dissolved inorganic carbon (DIC) mass balance in a pond with high advective through-put? Are organically loaded aquaculture ponds autotrophic? How do rates of organic production vary temporally? Are there diurnal changes in respiration rates?

Four marine ponds in Hawaii have been evaluated for a 53 day period through the use of geochemical mass balances. All fluxes of DIC into and out of the ponds were considered. DIC was calculated from hourly pH measurements and weekly alkalinity measurements. The results of the DIC mass balance model are unlikely to seriously affected by the observed

changes in pond water alkalinity. Sensitivity analysis of the model provided estimates of the effects of measurement error and further validated the results. Average uptake of DIC from the pond water, equivalent to net community production, revealed net autotrophy in all cases.

Hourly and longer period variations in organic matter production rates were examined. The daily cycle dominated the variation in rates of net community production. Maximal rates of net community production were maintained for four to six hours starting in mid-morning. Respiration rates decreased rapidly during the night in two of the ponds and remained essentially constant in the others. A similar pattern of decreasing respiration at night was seen in freshwater shrimp ponds which were studied with incubations. A new method involving isotope dilution of ^{14}C-labeled DIC was used to measure respiration rates in light and dark bottles. This method is an inexpensive and convenient procedure which should also be useful in other environments. The incubations demonstrated that plankton respiration rates peak at or soon after solar noon and vary over the course of the day by about a factor of two.

Nutrient budgets suggested that all of the inorganic nutrient supply was required to maintain the measured rates of net community production in three of the four marine ponds. The excess nutrients available in the other pond may have been utilized by the organisms decomposing the lignin-

rich feed. Response times of the ponds to nutrient perturbation simulations ranged from several hours to two days. The simulations also suggest that biological uptake may be the most important factor regulating inorganic nutrient concentrations in the ponds. Organic additions clearly affected net organic production rates.