Final Report Summary

Kremer and Goebel 2002 project: Water Column Production and Consumption in Long Island Sound: Measurements and coupled bio-physical modeling

Daily and annual integrated rates of primary productivity and community respiration were calculated using physiological parameters measured in oxygen-based photosynthesis-irradiance (P-I) incubations at 8 stations throughout central and western Long Island Sound (cwLIS) during the summer and autumn of 2002 and 2003 and the late spring of 2003. Each calculation takes into account actual variations in incident irradiance over the day and underwater irradiance and standing stock with depth. Annual peak rates, + 95% confidence interval of propagated uncertainty in each measurement, of gross primary production (GPP, 1,730 + 610 mmol O2 m-2 d-1) community respiration
(Rc, 1,660 + 270 mmol O2 m-2 d-1), and net community production (NCP, 1,160 + 1,100 mmol O2 m-2 d-1) occurred during summer at the western end of the Sound. Lowest rates of GPP (4 + 11 mmol O2 m-2 d-1), Rc,(-50 + 300 mmol O2 m-2 d-1), and NCP (-1,250 + 270 mmol O2 m-2 d-1) occurred during lat autumn-early winter at the outer sampled stations. These large ranges in rates of GPP, Rc, and NCP throughout the photic zone of cwLIS are attributed to seasonal and spatial variability. Algal respiration (Ra) was estimated to consume an average of 5% to 52% of GPP, using a literature-based ratio of Ra : Rc. From this range, we established that the estimated Ra accounts for approximately half of GPP, and was used to estimate daily net primary production (NPP), which ranged from 2 to 870 mmol O2 m-2 d-1 throughout cwLIS during the study. Annual NPP averaged 40 + 8 mol O2 m-2 yr-1 for all sampled stations, which more than doubled along the main axis of the Sound, from 32 + 14 mol O2 m-2 yr-1 at an eastern station to 82 + 25 mol O2 m-2 yr-1 at the western-most station. These spatial gradients in productivity parallel nitrogen loads along the main axis of the Sound. Daily integrals of productivity were used to test and formulate a simple, robust biomass-light model for the prediction of phytoplankton production in Long Island Sound, and the slope of the relationship was consistent with reports for other systems.

Conclusions

Present calculations demonstrate high levels of production and phytoplankton biomass in LIS. This productivity is consistent with the nitrogen loads into cwLIS, and the level of eutrophication follows a trend shown with other systems. Autochthonous production is a plausible source of organic matter for hypoxia and anoxia in the bottom waters of the Sound. Ranges and temporal variability in daily and annual rates compare favorably to those found throughout nearby, eutrophic estuarine systems, such as Narragansett and Chesapeake Bays, despite variations in spatial distributions of production.

The composite parameter BZI was a good predictor of NP, although there is uncertainty in the assumed rate of Ra. The corroboration of the BZI model with local, direct measurements of rates of pelagic primary production in cwLIS provide a robust model formulation for predicting productivity in eutrophic estuaries. This successful application of the simple BZI model to LIS provides an additional case demonstrating its generality across many diverse systems each yielding a nearly constant slope. We stress again that the consistency of the BZI approach should be checked, and if necessary, modified, in order to accurately represent primary production within a system, particularly if conditions of the modeled estuary change, such as the presence of nutrient limitation due to the alleviation of eutrophication. The BZI approach seems to be a viable alternative to numerical schemes that base their primary production rate on a chain of mechanistic assumptions involving temperature, light, and nutrients and a set of uncertain physiological parameters. The results presented here strengthen the case for the validity of this semi-empirical formulation for primary productivity as a modeling approach especially suitable for management purposes. We plan to merge this formulation with ecological and physical models of oxygen metabolism for LIS.

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