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Pelagic Metabolism in the Parker River/Plum Island Sound Estuarine System

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In this experiment we quantified pelagic metabolism in the Plum Island Sound estuary, Massachusetts. Pelagic metabolism is an important process in estuarine ecosystems, with *in situ* primary production usually being the primary source of organic carbon supporting the trophic web.

Production and respiration were determined by incubating water in bottles for 14 and 24 h every other day for three consecutive weeks in June and July 1995. Water was collected at three stations along the estuary at sunrise and incubated *in situ* at light levels corresponding to 0%, 54%, 90%, and 100% light extinction. Net daytime production (NDP), dark respiration (NR), gross production (GP), and net community production (NCP) were calculated from changes in dissolved oxygen (l) measured by automated Winkler titration. Chlorophyll-*a* concentrations were measured concurrently.

Spatial patterns were evident throughout the estuary. NDP and NCP are highest in the upper water column and decrease with depth. Surface productivity decreases from greater than 100 mmol O₂ m⁻³ d⁻¹ in the upper estuary to less than 20 mmol O₂ m⁻³ d⁻¹ in the lower Sound (Fig. 1A). Turbidity, as measured by light extinction (Fig. 1B), and chlorophyll levels are highest in the upper estuary (Fig. 1C). Respiration remains relatively constant (averaging -55 mmol O₂ m⁻² d⁻¹) through much of the estuary, but rises to an average -83 mmol O₂ m⁻² d⁻¹ in the Sound portion of the estuary (conductivities greater than 45 mS cm⁻¹). NCP levels indicate that the water column is net autotrophic until conductivities exceed 46.5 mS cm⁻¹ in the Sound, at which point it becomes net heterotrophic (Fig. 1D). This spatial pattern of autotrophy and heterotrophy may reflect the utilization of watershed inputs of inorganic nutrients in the upper estuary and the remineralization of autochthonous organic matter transported downstream to the lower estuary.

Patterns of turbidity and production per unit chlorophyll provide some insight into the controls of primary production in the estuary. The pattern of increasing production per unit chlorophyll down the estuary suggests that production is light-limited. Although the upper estuary contains a larger amount of phytoplankton, as indicated by chlorophyll concentrations, turbidity of the water reduces light availability and hence production per unit chlorophyll. In the Sound, clarity of the water column allows light penetration to all levels, increasing the specific production rate.

Bottle methods for studying metabolism often underestimate total system metabolism because they fail to measure the substantial metabolic contributions by benthic and nektonic communities (1). Estimated benthic respiration in the estuary is -46 mmol m⁻² d⁻¹ (Hopkinson, unpub.). In comparison, pelagic metabolism (-55 and -83 mmol O₂ m⁻² d⁻¹) contributes 54% to 64% of total system respiration (*i.e.*, sum of benthic and pelagic metabolism). This proportion is similar to what has been observed in comparable estuaries (2). However, in contrast to measurements of whole system respiration (3), respiration estimated from the sum of the benthic and pelagic components is much lower. This difference may be due to the resuspension and mixing of labile organic matter between benthos and water column; this mixing does not occur in bottles or in core tube measures of benthic respiration.

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Literature Cited

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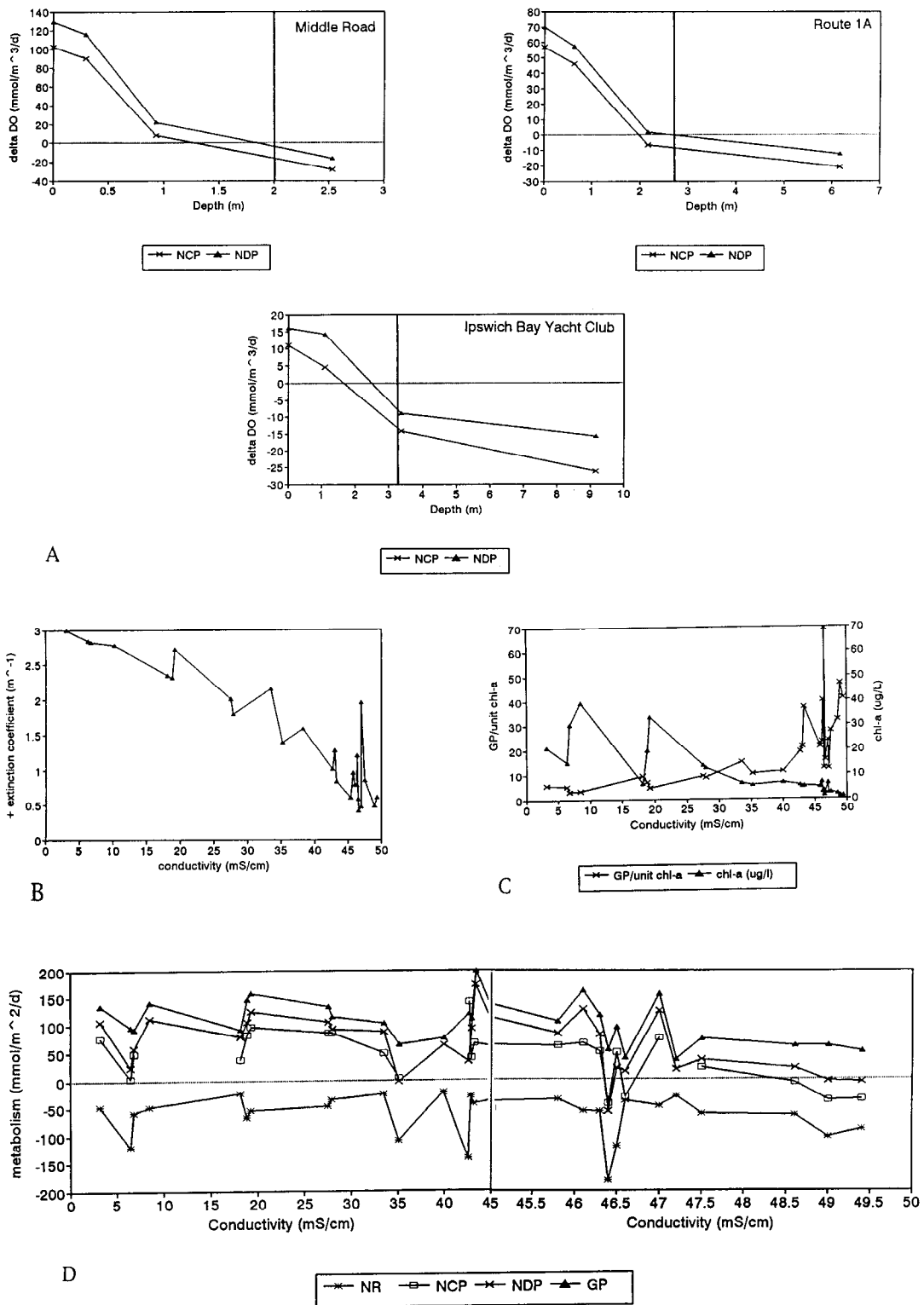


Figure 1. (A) Depth profiles for sampling sites, averaged over the three-week study period. Points represent depths in water column for 0%, 54%, 90%, and 99.8% (dark) light extinction; the vertical lines are the average depths at each site. For daily profiles, the integrated area under the NCP curve represents net community production (mmol m⁻² d⁻¹); the area under the NDP curve represents net daytime production (mmol m⁻² d⁻¹). (B) Extinction coefficients (given as positive values) along the length of the estuary. (C) Spatial pattern of chl-a (μg l⁻¹) and production per unit chl-a (mmol O₂ m⁻² d⁻¹ per unit chl-a). (D) Metabolism calculated through changes in BOD bottle oxygen, across a range of conductivities in the estuary (note change in scale on x-axis).