Annual Report – ACES

Period Covered by the Report: 1/1/02 -12/31/02
Date of Report: 2/27/03
Title: Effects of variation in river discharge and wind-driven resuspension on lower trophic levels of the Mobile Bay ecosystem
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Institution: University of South Alabama and Dauphin Island Sea Lab
Research Category:
Project Period: 3 years + No cost extension

Objective(s) of the Research Project: Proper management of the Mobile Bay estuary and its living resources requires a fundamental understanding of current ecosystem structure and function. We hypothesized that variations in river discharge and wind-driven sediment resuspension in this shallow estuary have dramatic effects not only on the biological community and trophic structure, but also on the way in which anthropogenic materials are processed by the estuarine ecosystem. We are carrying out an integrated study of trophic linkages in the microbial food web (phytoplankton and bacterioplankton) and how they are affected by natural perturbations such as pulsed freshwater flow and wind-driven sediment resuspension. The following major study questions are being addressed: 1) What is the spatial and temporal variation in net carbon production in the Mobile Bay system? 2) How do variations in freshwater delivery and sediment resuspension affect trophic efficiency in the phytoplankton and bacterioplankton communities? 3) How does advective or wind-driven shear affect sediment resuspension, nutrient exchanges and particulate carbon redistribution? Together with a companion project that is focused on higher trophic levels we are examining the relationships between multiple levels of the food web up to juvenile fishes. The data gathered in this study are being used to construct a model of trophic dynamics of the Mobile Bay ecosystem that will be useful for guiding future research and resource managers.

Progress Summary/Accomplishments:

The first phase of this research was a thorough characterization of system state variables and processes rates. We sampled three sites along the main axis of Mobile Bay spanning the oligohaline and polyhaline regions, monthly over an annual cycle. As expected, salinity regimes and sediment resuspension conditions varied considerably during the sampling period. Somewhat unexpectedly, the March 2000-2001 period was characterized by exceptionally low rainfall in the watershed. This resulted in salinities that were at the extreme upper end of the monthly 10-year averages for the different stations. In terms of the annual cycle, salinities in the Bay were low when sampling first commenced, but then increased and remained high throughout the rest of the sampling period. Temperatures ranged from 7.5 ^{o}C in January 2001 to 30.5 ^{o}C in August 2001. Suspended sediments (seston) in surface waters ranged over an order of magnitude from 10 - 150 mg l^{-1} illustrating the high degree of variability in resuspension of bottom sediments that occurs in this shallow system. Despite the large variations in seston,

measurements of primary production, bacterial secondary production and community respiration showed little relationship seston load. In contrast these biological processes were strongly related to temperature, with salinity and nutrient loading having less impact on the overall patterns in these rates.

Primary production was low in spring, despite high freshwater flow and nutrient delivery (Figure 1) . With diminishing freshwater flow, and seasonal advance toward summer, primary production increased and remained high (60-160 mmol C m^{-2} d^{-1}) until fall when rates declined despite continued nutrient availability. Bacterioplankton secondary production averaged 34% of primary production and there was a significant correlation ($P < 0.001$) between these parameters. Estimated bacterial carbon utilization in the water column approximately balanced primary production. Total system respiration (water column + sediments) also closely followed the annual production cycle (Figure 1). This was due to the tight coupling of water column respiration with primary production; sediment respiration was not strongly coupled with water column primary production. Sediment respiration averaged 26% of the total annual carbon processing, but contributed up to 40-60% to total carbon flow during the fall-winter, when freshwater inflow and water column heterotrophic activity were low. Annual primary production ranged from 22-27 mol C m^{-2} but all stations displayed net-heterotrophy on an annual basis with total respiration (water column + sediments) exceeding primary production by 19-25% (4.2 to 6.2 mol C m^{-2} y^{-1}) (Table 1). Station FM-7 was the most heterotrophic over the annual cycle but the differences between stations was small.

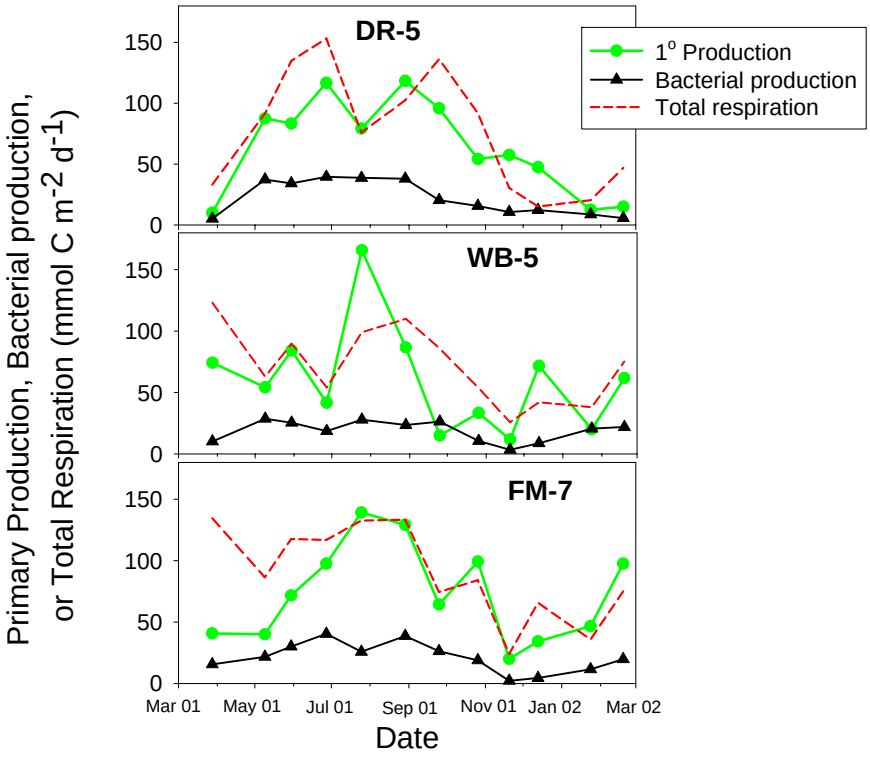

Figure 1. Annual cycle of depth-integrated primary production, bacterial secondary production, and total respiration for three stations in Mobile Bay, Alabama. All stations are along the central axis of the Bay. Station DR-5 was the furthest upstream, WB-5 in mid Bay and FM-7 near the mouth of the Bay. Total respiration includes water column community respiration and sediment respiration.

Table 1. Annual integrated primary production or respiration at three stations in Mobile Bay, Alabama. Values are in mol C m^{-2} y^{-1}.

Station	1° Prod	Water Column Respiration	Sediment Respiration	Net	Net as % of 1° Prod
DR-5	22.7	-21.6	-6.8	-5.7	-25%
WB-5	22.3	-21.0	-5.5	-4.2	-19%
FM-7	26.8	-26.4	-6.6	-6.2	-23%

Size fractionation experiments showed that 30-60% of bacterial secondary production and community respiration was associated with particles > 20 μm in size. This suggests that attached bacteria were very important in this turbid system. This finding has implications for the trophic transfer of bacterial secondary production because this production may be directly available to detritivores and macrozooplankton. The high rates of particle associated bacterial activity were somewhat surprising in light of the fact that bacterial production was not correlated with seston load. This may be because high seston loads diminish primary production (by limiting light penetration) on which bacterial production seems to depend strongly.

A closer examination of how resuspension affects trophic dynamics was conducted by sampling intensively over a one month period during which several resuspension events occurred. Here again, no relationship between bacterial secondary production, nor community respiration was observed with suspended sediment load. More detailed analysis of the event sampling data is ongoing.

Publications/Presentations:

Publications:

Osland, M. and R. P. Kiene. Influence of natural sediment resuspension events on size fractionated plankton respiration in lower Mobile Bay, Alabama. *In preparation* for Estuaries.

Kiene, R. P, J. Pennock, J. L. Cowan, E.F. Blythe and M Axell. Spatial and temporal variability in autotrophic production and heterotrophic carbon utilization in a large Gulf-Coast estuary, Mobile Bay, USA. *In preparation* for Estuarine Coastal Shelf Science

Kiene, R. P., M. Aikens, L. Linn, and M. Axell. Factors affecting bacterial production and growth efficiency in a large estuary subject to frequent sediment resuspension. *In preparation* for Aquatic Microbial Ecology.

Kiene, R.P. M. Axell, L. Gallagher, and J. Pennock. Short-term variability in bacterial production and primary production in relation to sediment resuspension events in Mobile Bay, USA. *In preparation.*

Presentations:

Russel, C and J. Pennock. Effects of sediment resuspension on sediment water exchange of nutrients and primary production: a mesocosm study. Estuarine Research Federation Meeting. St. Petersburg, Florida, November, 2001.

Kiene, R. P, J. Pennock, J. L. Cowan, E.F. Blythe and M Axell. 2002. Spatial and temporal variability in autotrophic production and heterotrophic carbon utilization in a large Gulf-Coast estuary, Mobile Bay, USA. Abstract. American Society of Limnology and Oceanography, Victoria, British Columbia, June 2002.

Future Activities: Most of the major field work of this project is now completed, with the exception of mesocosm experiments that are currently in progress. The first of these mesocosm

experiements has been carried out and the rest will be conducted in spring and summer 2003. The mesocosm experiments are being carried out by Ms. Carolanne Russel, a M.S. student. Data analysis and synthesis is ongoing. One of the remaining tasks is to integrate data from the ACES Lower Trophic Level study with that of the ACES Higher Trophic Level into an EcoPath-EcoSim model describing the trophic linkages in Mobile Bay. This activity will take place in summer and fall 2003.

Supplemental Keywords:

Relevant Web Sites: General information about the PI's research programs and this ACES project can be found at http://mas.usouthal.edu/ and www.disl.org.

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