'Top-Down' Effects in the James

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Overview of 2013 Data Collection:

1. Monitoring: weekly collections (CHLa, MC, etc.) at 12 stations in tidal fresh plus continuous monitoring at one station (Rice).
2. Toxicity Assays: Microcystin effects on larval fish, zooplankton, wedge clams & sturgeon.
3. Analysis of top-down effects by consumers

SAP Workplan

Subtask 1.2— Environmental factors favoring algal blooms

"A second issue to be addressed is the role of consumers in regulating algal abundance in the tidal freshwater James. The Work Group recommends that some effort should be devoted to estimating grazing losses."

Key questions:

1. Who are the important consumers of phytoplankton in the James?
2. What is the importance of grazing in the context of other loss processes (e.g., advection)?
3. How do we use this information (implications for attainability, etc.)?

Mechanisms for Top-Down Effects

1. 'grazing' - removal of CHLa via ingestion
2. consumer-mediated nutrient recycling – regeneration of nutrients in bioavailable form through excretion by consumers
3. 'selectivity effects' – alteration in community assemblages and trophic interactions through selective feeding by consumers

Today's Presentation:

- How much CHLa is being removed by grazers?
- How much N is being recycled by consumers?

Assessing Top-Down Effects

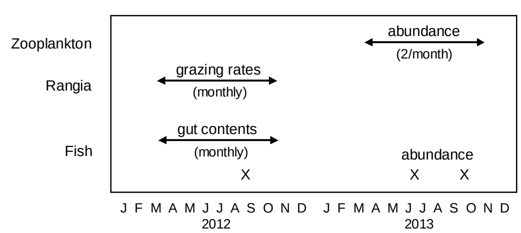
Primary consumers in tidal-fresh James:

- Zooplankton (rotifers, copepods, cladocerans)
- Benthic filter-feeders (Wedge Clams)
- Fish (Atlantic Menhaden, Threadfin Shad, Gizzard Shad, juvenile Blue Catfish)

Data Needed:

- Consumer abundance
- Per capita consumption rate for CHLa and PON

Data Used for this Analysis



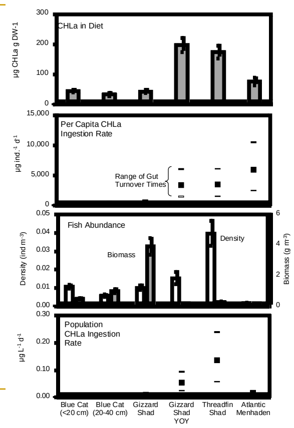
Other data:

a. species-specific zooplankton grazing rates (prev. published)
b. Rangia biomass in the James (CBP benthic surveys)
c. fish gut clearance rates (prev. published = 4-18 d^{-1})

Fish Grazing

Planktivorous fish consume a greater proportion of algae in their diet.

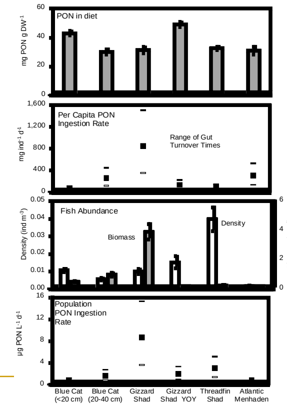
Per capita ingestion rates are high (1,000's μg/d) but population-scale estimates of CHLa removal are small due to low fish abundance.



Fish N Cycling

Benthic and pelagic fishes have similar N content in diet.

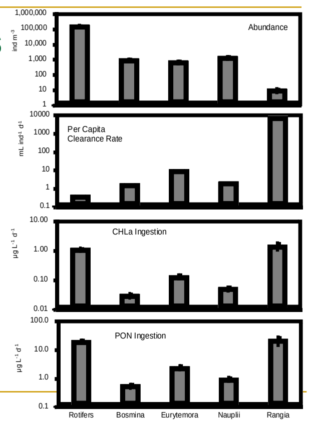
Benthic fishes (Gizzard Shad) dominate N cycling due to high ingestion and high abundance.



Other Consumers

Rotifers (high abundance) and Wedge Clams (high per capita feeding rates) dominate CHLa consumption and N recycling.

Wedge clam = *Rangia cuneata*



Grazing compared to CHLa production and other losses:

Production = NPP (mg C/L/d) x CHLa:C. NPP from diel O_2 monitoring at Rice Pier. CHLa:C from monitoring*.

Advective Loss = ($CHLa_{out}$ – $CHLa_{in}$) x discharge

Respiration (del Giorgio & Peters 1994)

$R_{total} = R_{autochthonous} + R_{allochthonous}$

$R_{allochthonous}$ (at NPP=0) = 2.0 ± 0.2 mg C/m^2/d

R_{total} (mean) = 5.6 mg C/m^2/d

$R_{autochthonous}$ = 3.6 mg C/m^2/d x CHLa:C

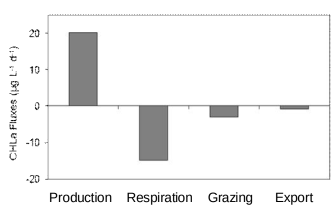
All data expressed as mean daily volumetric rates for March-Nov 2012-13.

*CHLa:C = 12.2 ± 0.8 μg:mg; N = 108, R^2 = 0.70, p<0.0001

Grazing compared to CHLa production and other losses:

The main fate of algal production is bacterial decomposition (R = 74%).

Grazing accounts for 15% of production and 4% is export (to lower James).



Data are mean daily values for March-November 2012-13.

Consumer N cycling vs. algal N demand and other inputs:

Algal N demand = NPP (mg C/L/d) x N:C. NPP from diel O_2 monitoring at Rice Pier. C:N = Redfield.

External Inputs = 0.125 mg DIN L^{-1} d^{-1}*

Respiration (microbial-mediated N regeneration)

$R_{total} = R_{autochthonous} + R_{allochthonous}$

$R_{autochthonous}$ * Redfield C:N (6.6)

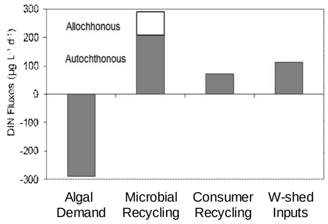
$R_{allochthonous}$ * C:N (15) from monitoring

*Bukaveckas & Isenberg (2013) *Estuaries & Coasts*

Consumer N cycling vs. algal N demand and other inputs:

Microbial recycling sufficient to meet algal N demand.

Grazing = 25% of algal N demand and external inputs are equivalent to 39% of demand.



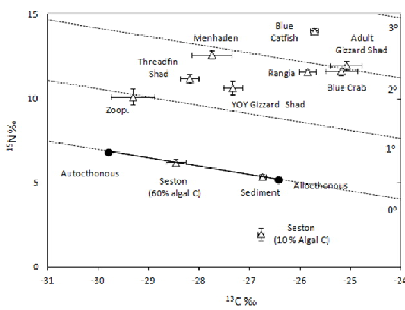
Data are mean daily values for March-November 2012-13.

Role of Consumers in James River

1. Internal cycling is an important source of N supporting primary production in the James. Consumer-mediated recycling is equivalent to 25% of algal demand (point sources = 30%).
2. Consumers remove only a small proportion of daily CHLa production (15%)* though this is large relative to export losses (4%).

How important is autochthonous production in supporting food web? Stable isotopes can be used to answer this question.

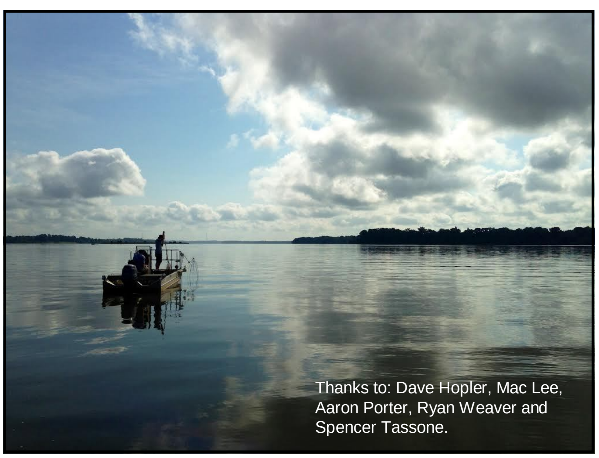
James River Food Web
from stable isotope analysis



Autochthony in James River

Sample	N	^{13}C ‰	^{15}N ‰	Trophic Level	Biomass (g DW m^{-3})	% Autocthonous
Seston (10% algal)	28	-26.8 ± .06	2.0 ± .36	-		-
Seston (60% algal)	28	-28.5 ± .20	6.2 ± .22	-		-
Sediment	18	-26.7 ± .07	5.4 ± .13	-		-
Zooplankton	6	-29.3 ± .43	10.1 ± .49	0.97	0.2 -0.8	96.0%
Rangia	30	-25.8 ± .16	11.6 ± .09	1.86	2.33	23.6%
Blue Crab	20	-25.2 ± .31	11.7 ± .28	1.96	-	4.1%
Threadfin Shad	29	-28.2 ± .19	11.2 ± .26	1.42	0.06	68.3%
Menhaden	15	-27.8 ± .39	12.6 ± .25	1.88	0.02	69.1%
YOY Gizzard Shad	28	-27.3 ± .19	10.6 ± .40	1.39	0.03	43.7%
Adult Gizzard Shad	28	-25.1 ± .32	11.9 ± .27	2.06	0.98	2.3%
Blue Catfish	61	-25.7 ± .08	14.0 ± .14	2.55	0.37	8.7%

Autochthonous organic matter accounts for 29% of metazoan production in the James. This biomass-weighted average reflects the large contributions of *Rangia* and adult Gizzard Shad to total biomass (72%) and their low dependence on autochthonous production (24% and 2%, respectively).



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