Do phytoplankton use more NH_4^+ or NO_3^-?

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1. Do phytoplankton use more NH_4^+ or NO_3^-?

Eutrophication is increasing worldwide and usually begins with increased availability of N to primary producers, primarily as NO_3^-.

- Leads to algal & phytoplankton growth
- Causes eelgrass die-off which leads to loss of fin- and shellfish habitat.
- Decomposition of algae leads to hypoxia/ anoxia which may kill organisms that cannot escape.
- Phytoplankton require N as:
  - nitrate (NO_3^-)
  - nitrite (NO_2^-)
  - **ammonium (NH_4^+) PREFERRED**
  - dissolved organic nitrogen (DON)

2. Site

Childs River is a sub-estuary of the Waquoit Bay system, on Cape Cod, MA. Land-use on the watershed of Childs River includes a large proportion of residential area, as well as other land-cover types, resulting in a land- derived N-load to the estuary more than 20 times the load to a comparable pristine system.

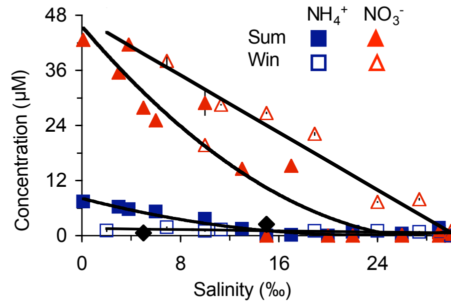
3. Methods

We measured concentrations and $\delta^{15}N$ of NH_4^+, NO_3^-, and chlorophyll *a*. We compared the $\delta^{15}N$ of chlorophyll *a*, $NH_4^+$and NO_3^- to determine which form of N was used.

Stable Isotopes:

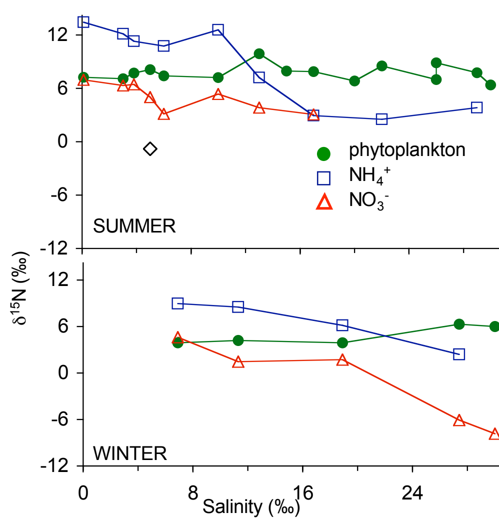
- Ratio of ^{14}N and ^{15}N varies in different materials
- $\delta^{15}N=[(R_{sample}/R_{standard})-1]X1000$, $R={}^{15}N/{}^{14}N$ (‰)
- Fractionation (ε) is a change in $\delta^{15}N$ during biological reactions because ^{14}N reacts faster than ^{15}N.
- Phytoplankton take up $^{14}NO_3^-$ or $^{14}NH_4^+$ slightly faster than $^{15}NO_3^-$ or $^{15}NH_4^+$; ε ranges from 4 to 7 ‰ for NO_3^-, 0 to 14‰ for NH_4^+

4. More NO_3^- than NH_4^+ was available for phytoplankton



- $NH_4^+ \leq NO_3^-$.
- NH_4^+ higher in summer than in winter.
- NO_3^- and NH_4^+ behaved conservatively in winter.
- NO_3^- and NH_4^+ decreased beyond passive mixing in summer, likely due to uptake by primary producers or microbial processes.

5. Phytoplankton acquired their $\delta^{15}N$ from NH_4^+ upstream, then maintain $\delta^{15}N$ downstream.

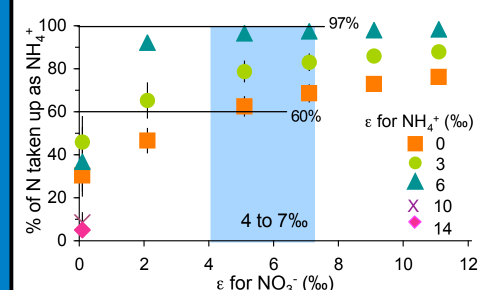


- $\delta^{15}N$ of NO_3^- and NH_4^+ decreased down estuary
- $\delta^{15}NH_4^+$ was higher than $\delta^{15}NO_3^-$.
- Phytoplankton $\delta^{15}N$ did not change with salinity.
- Phytoplankton $\delta^{15}N$ increased from winter to summer.

6. Phytoplankton in Childs River took up most of their N as NH_4^+.

To determine % contribution of NH_4^+ and NO_3^- to phytoplankton, we used the following equation:

$$\%NH_4^+ = \frac{(\delta^{15}NO_3^- - \varepsilon_{NO3-}) - \delta^{15}N_{phytoplankton}}{(\delta^{15}NO_3^- - \varepsilon_{NO3-}) - (\delta^{15}NH_4^+ - \varepsilon_{NH4+})}$$



We varied ε_{NO3-} along the x-axis (0 to 12‰), and ε_{NH4+} by different symbols (0 to 14‰), and solved the equation using our data for $\delta^{15}N$ of chlorophyll *a*, NO_3^- and NH_4^+. The blue shaded area shows solutions for values of ε for NO_3^- (4 to 7 ‰) and ε_{NH4+} (0 to 14‰), that are typical of estuarine phytoplankton.

Childs River phytoplankton derived 60 to 97% of their N from NH_4^+.

7. Conclusions

It appears that phytoplankton acquired a significant pool of NH_4^+ upstream which provided an N source for growth and division downstream.

Phytoplankton get most of their N from NH_4^+, in spite of high NO_3^- in the estuary, so reducing NO_3^- may not solve eutrophication.

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