Ammonium cycling in the rocky intertidal: remineralization, removal and retention

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Background and motivation

- The rocky intertidal is a cardinal locus for ecological studies – site where fundamental theories were developed

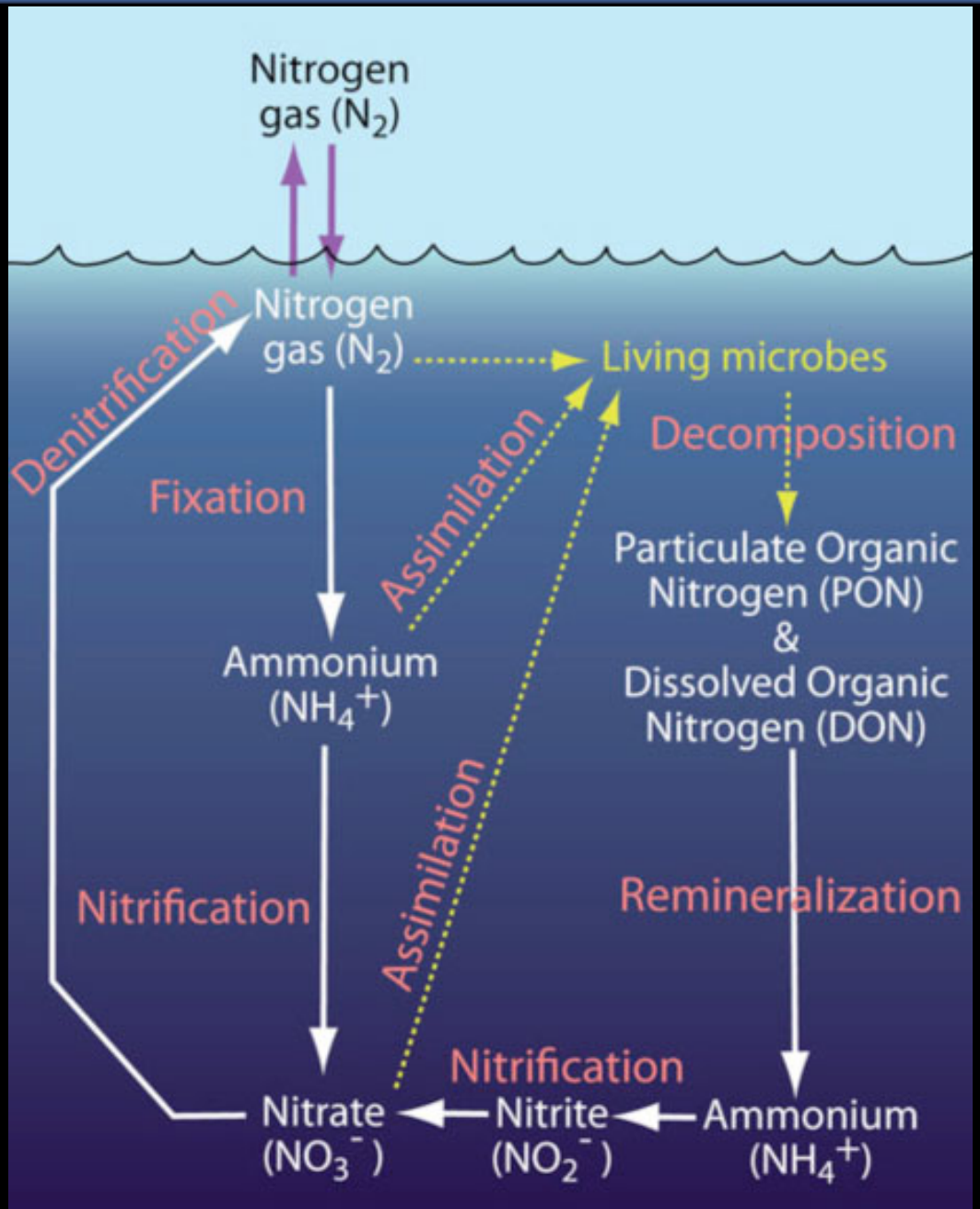
A Note on Trophic Complexity and Community Stability

R. T. Paine

The American Naturalist, Vol. 103, No. 929. (Jan. - Feb., 1969), pp. 91-93.

- But gaps in our knowledge remain
- One prominent gap is nitrogen cycling processes within the intertidal:
  - what are the sources of fixed N to localized primary production?
  - what are the nutrient links between the intertidal and the nearshore?
  - what pathways does N follow once in the intertidal?

A brief intro to the nitrogen cycle



http://cmore.soest.hawaii.edu/cruises/biolincs/nitrogen.htm

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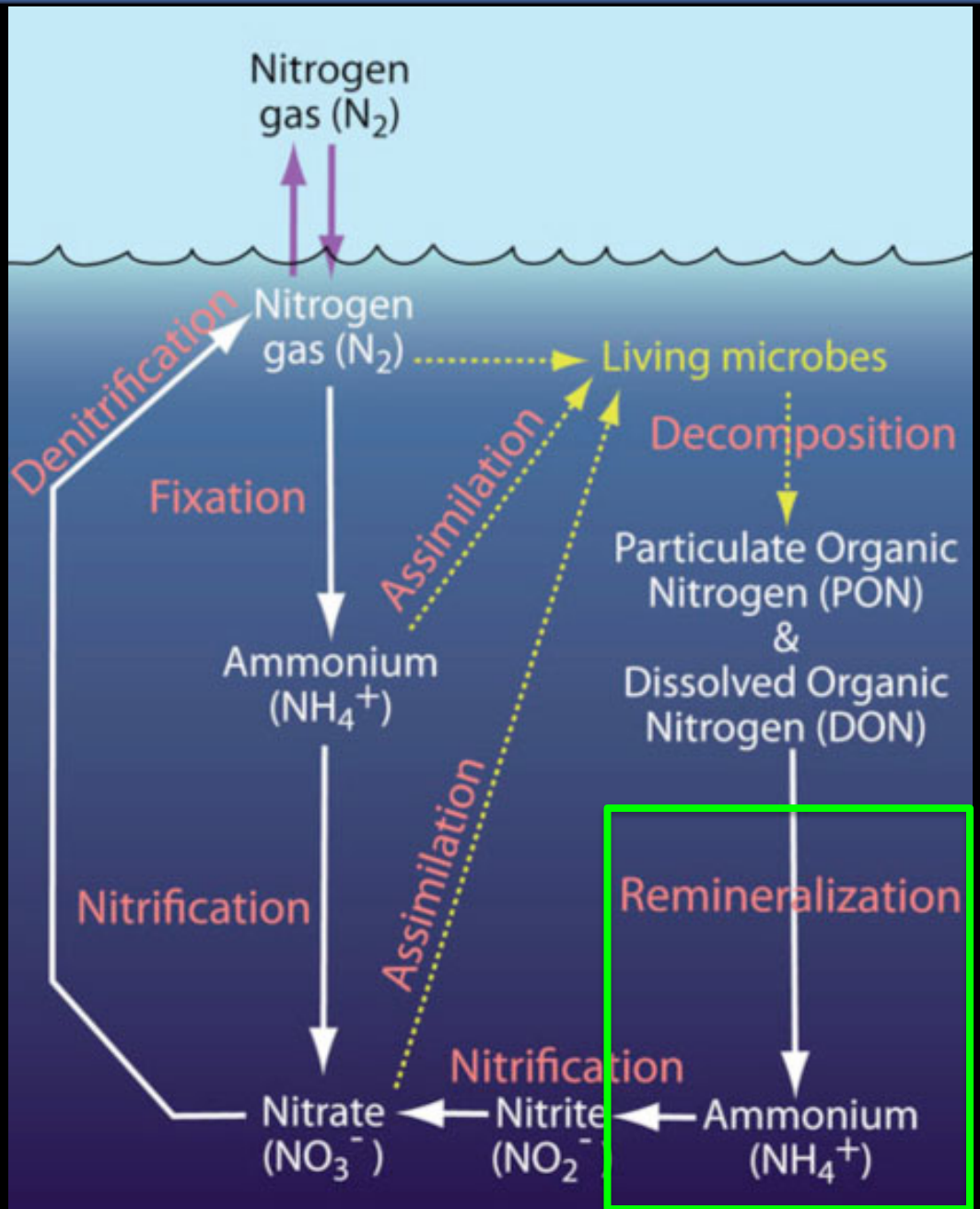

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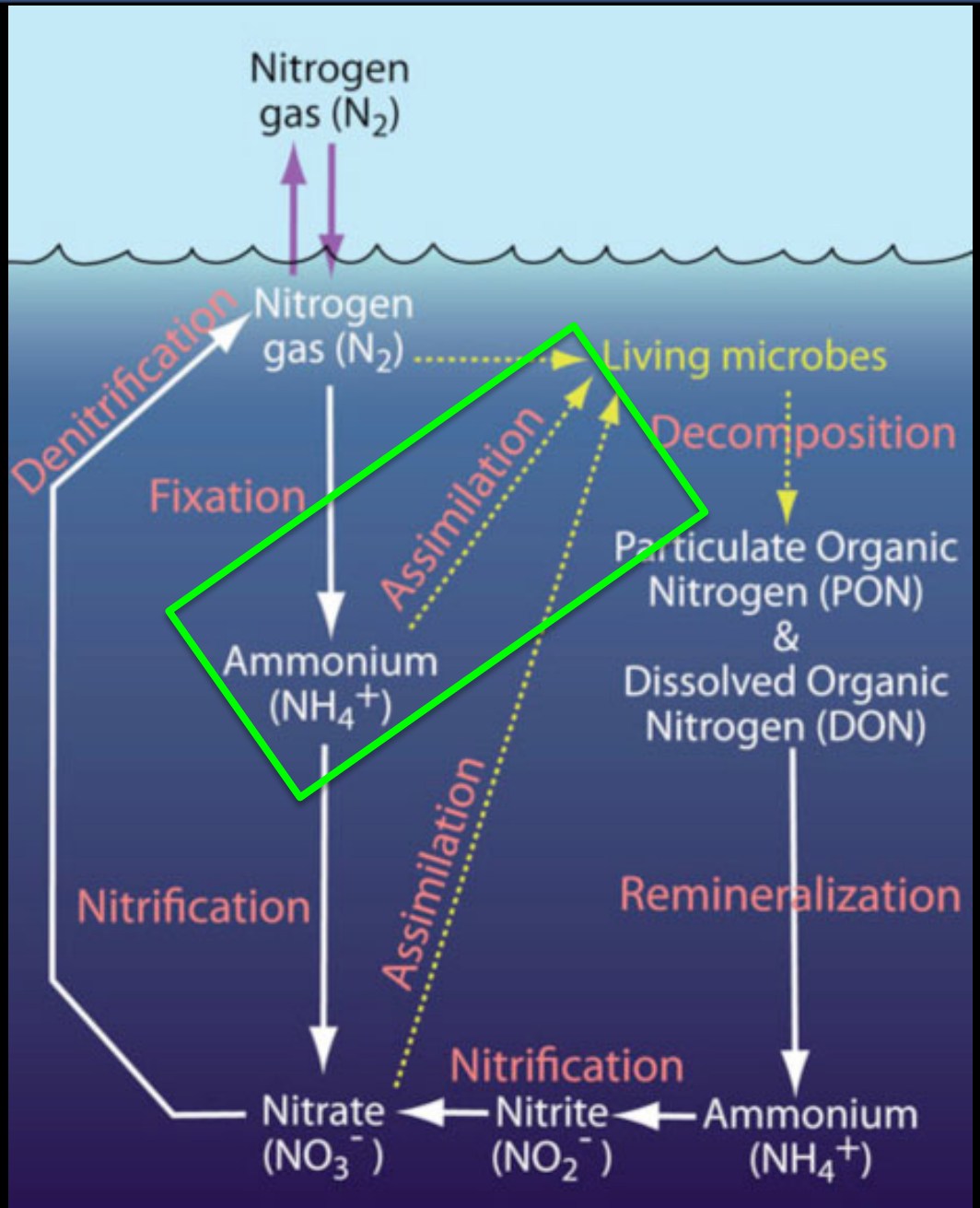

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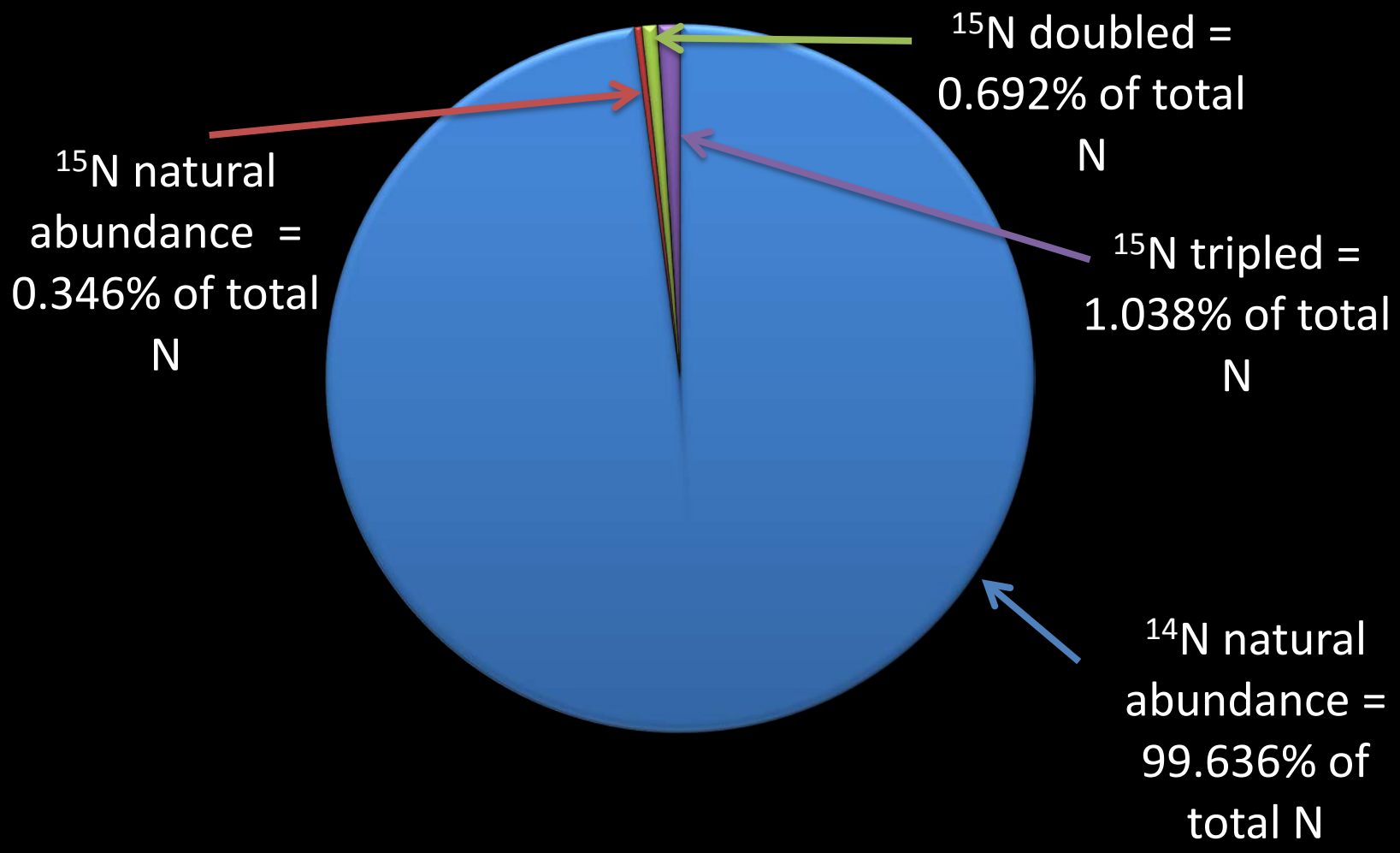
Limitations of prior work

- Previous studies have used changes in NH_4^+ concentration to estimate rates of processes
- Only provides estimate of the NET sum of all processes, no way to determine actual rates of individual processes
- Used artificial mesocosms – exclusion of many components of the ecosystem = inaccurate rates

Novel approach: natural tidepool mesocosms + isotope tracer

Photo credit: M Altabet

Stable isotope tracers – logic and utility

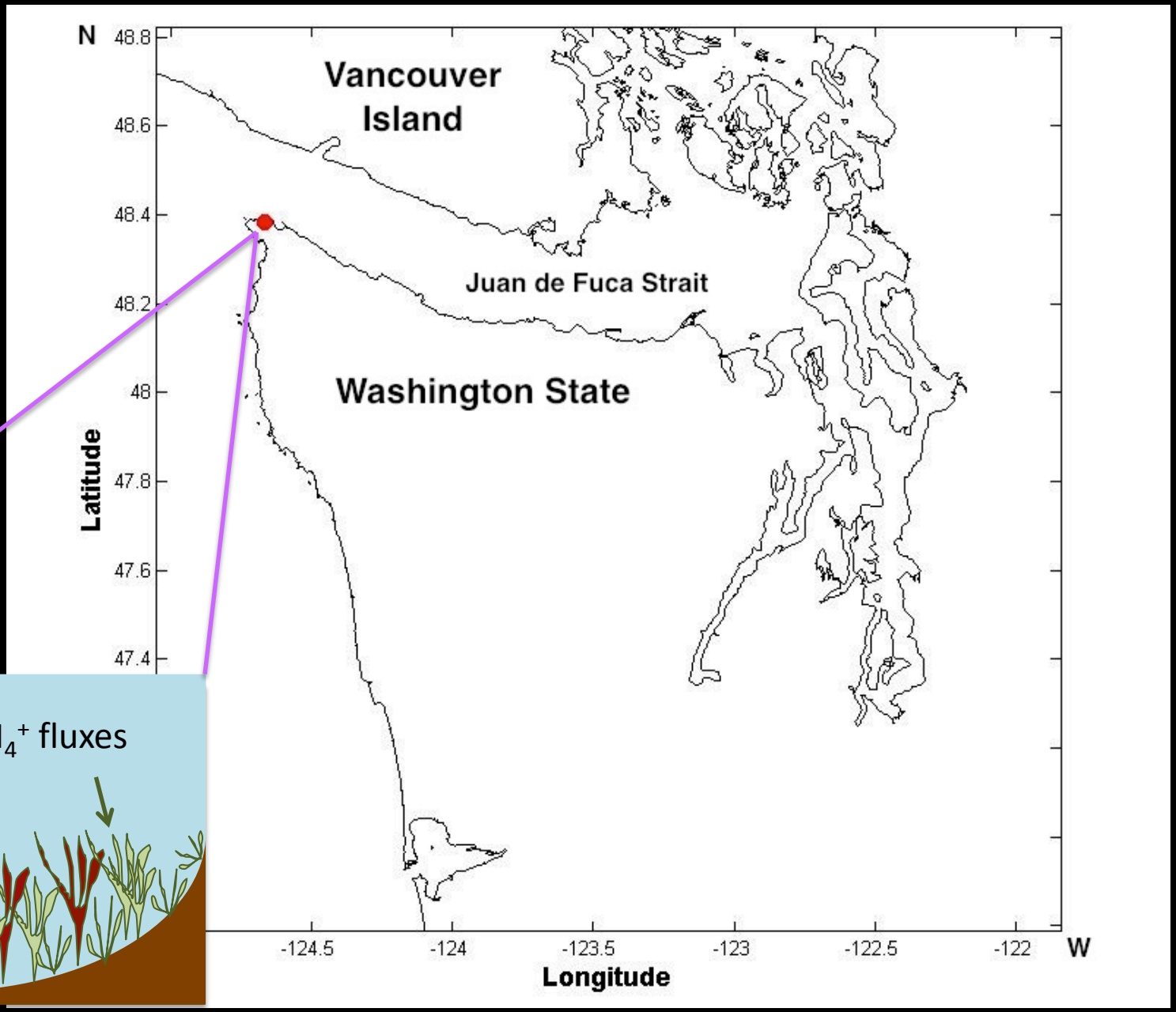


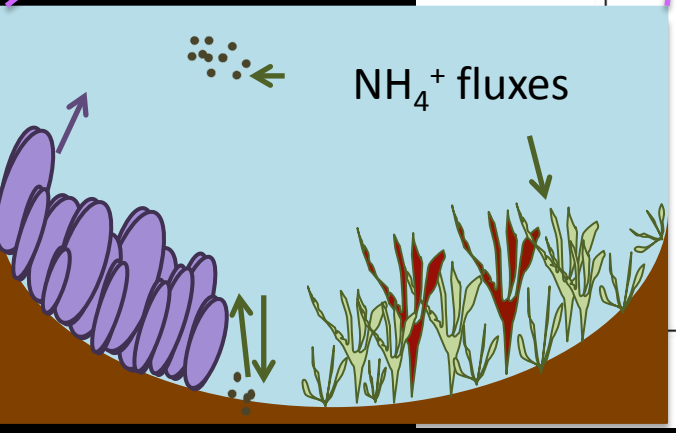
Hypotheses and aims

- **Hypothesis**: NH_4^+ remineralized within the rocky intertidal is a significant source of fixed N to localized ecosystem production
- **Aim**: To determine the role of the dominant invertebrate, the California mussel (*Mytilus californianus*) to NH_4^+ remineralization and removal
- **Objective**: To investigate diurnal differences in these processes
- **Objective**: To investigate the relative contributions of benthic versus suspended processes to tidepool N cycling

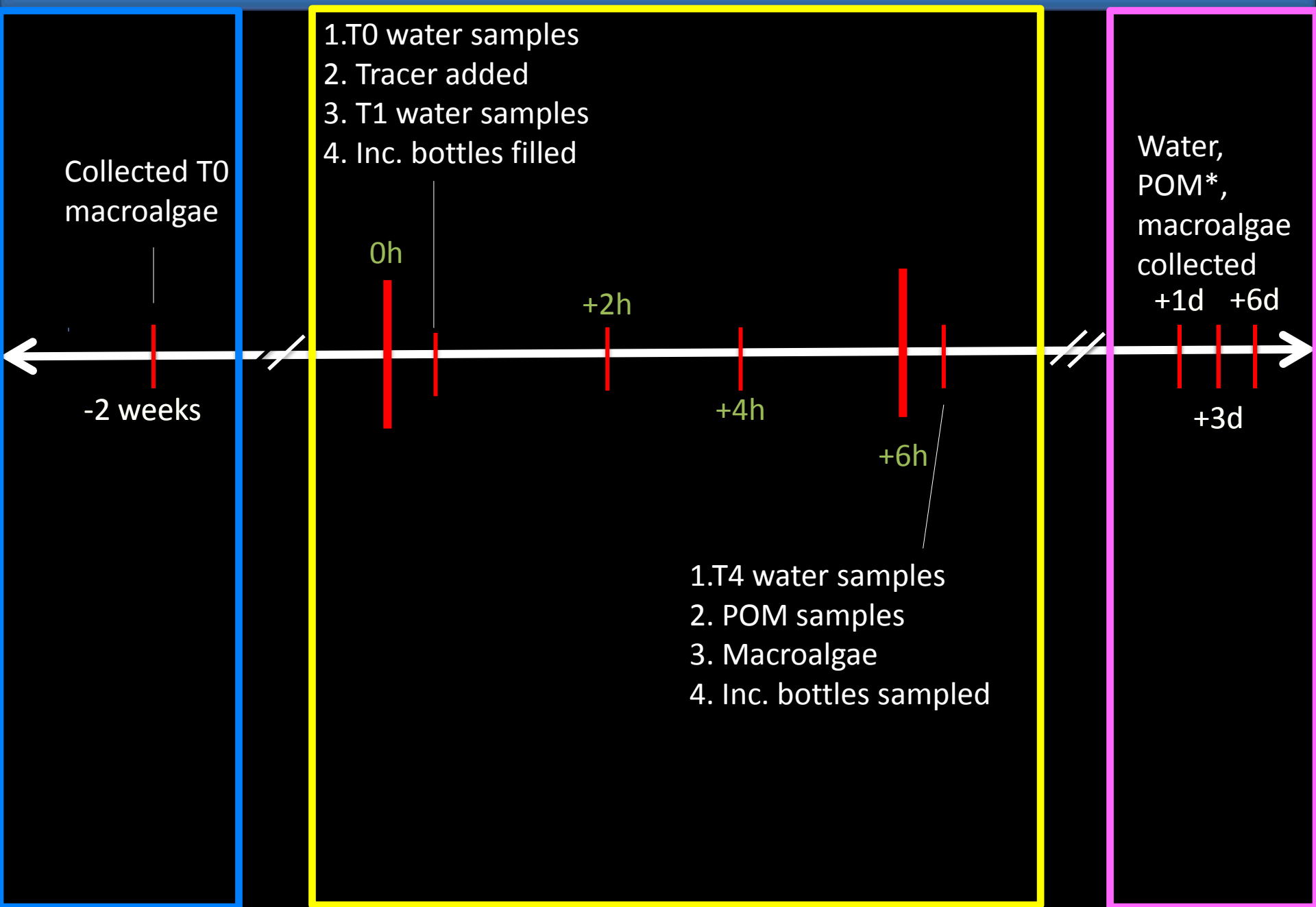
Study site

Credit:
J Carlson;
C Pfister





Experimental timeline



Laboratory sample analysis

- NH_4^+ isotopes
  - Altabet lab
  - Ammonium oxidation method (Zhang et al 2007)
- NH_4^+ concentration
  - UWashington
  - UNESCO (1994) methods
- Macroalgal and filter samples
  - UChicago
  - EA-IRMS

Rate calculations

- Remineralization rates: exponential curves fit to data ($y=ae^{-bx}$)
- Removal rates: mass balance
- POM uptake rates: tracer incorporation
- Macroalgal specific uptake rates: tracer incorporation

Isotopic signals exponentially decrease while concentration values increase over time

water isotope values

water concentration values

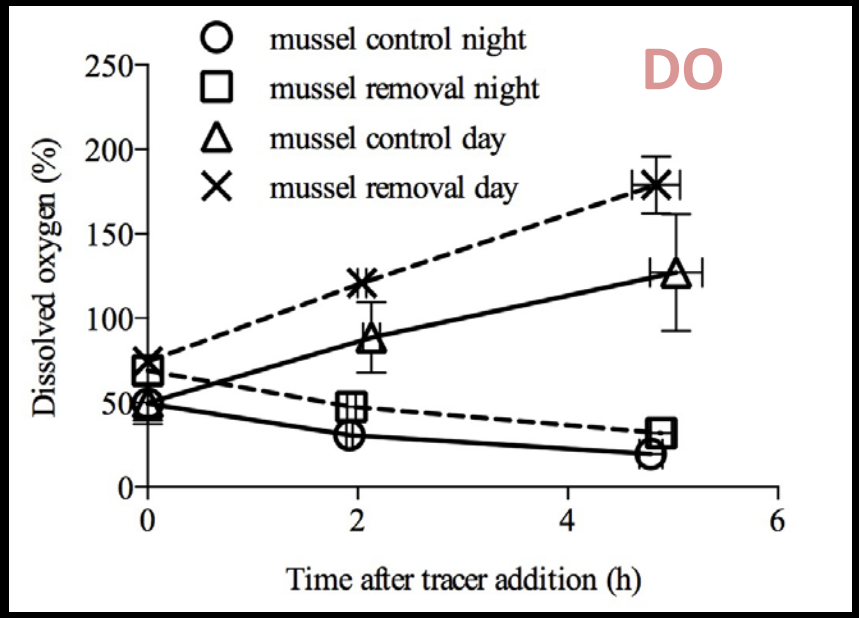
Pather et al. Accepted. Limnology and Oceanography

Mussels enhance NH_4^+ cycling processes

remineralization

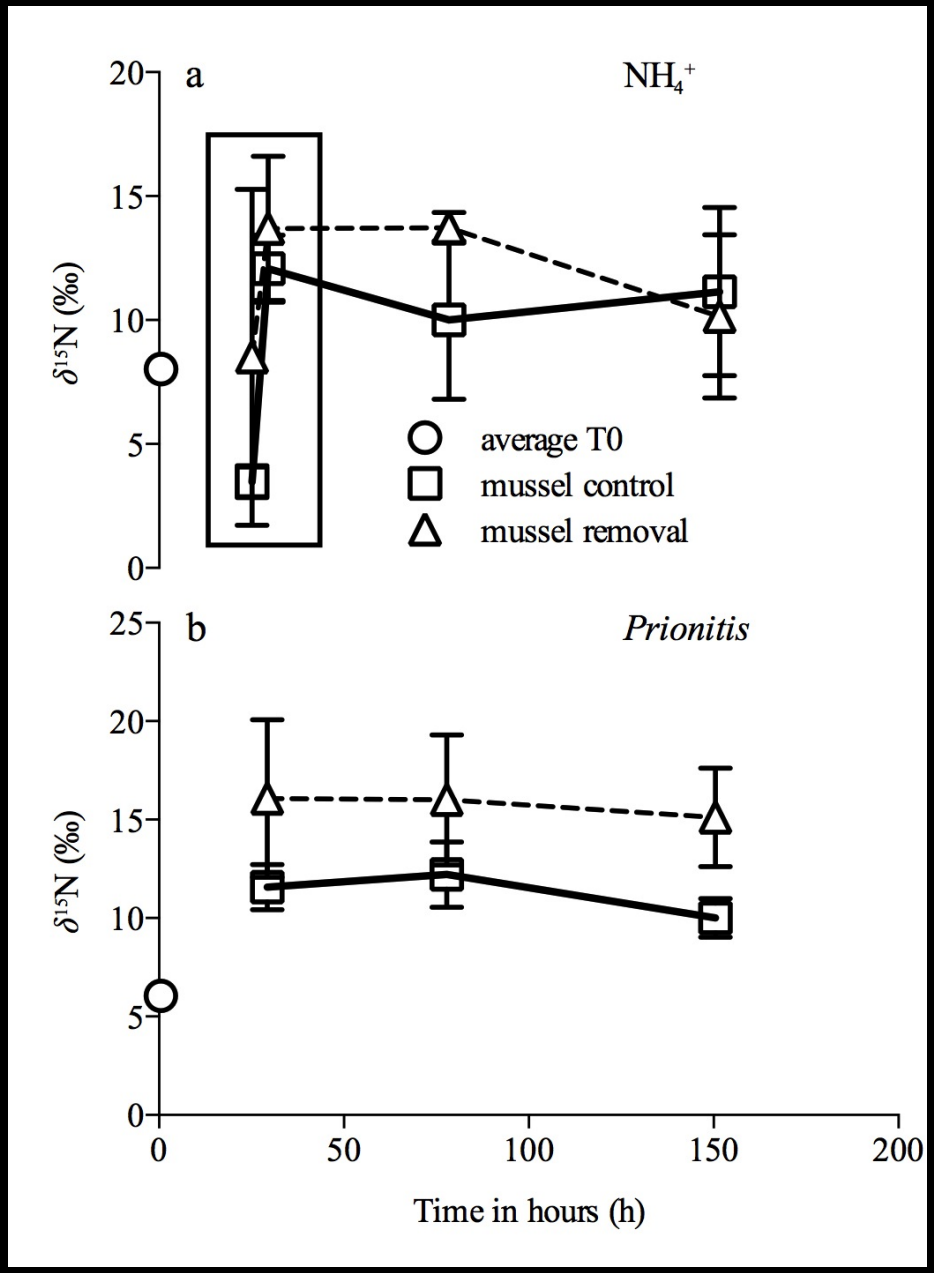
removal

- mussel control rates > mussel removal rates ($p<0.05$ for both a and b in 2010)
- day time rates > night time rates ($p<0.05$ for both a and b in 2010)
- whole tidepool rates > suspended rates ($p<<0.05$ for both a and b)



Remineralization and removal rates are tightly coupled

NH_4^+ remineralized within the intertidal is retained there



Implications for sustainability

- The California mussel is essential to the supply of fixed N to rocky intertidal production
- Thus, the rocky intertidal is not continually dependent on upwelled new N
- This is consistent with other studies on coral reef systems, marine mammals, and on freshwater fish showing broader, non-trophic roles for macrofauna in mediating nutrient cycles

Mussels under threat!