PERI-DICE $^{15}N/^{13}C$ Results

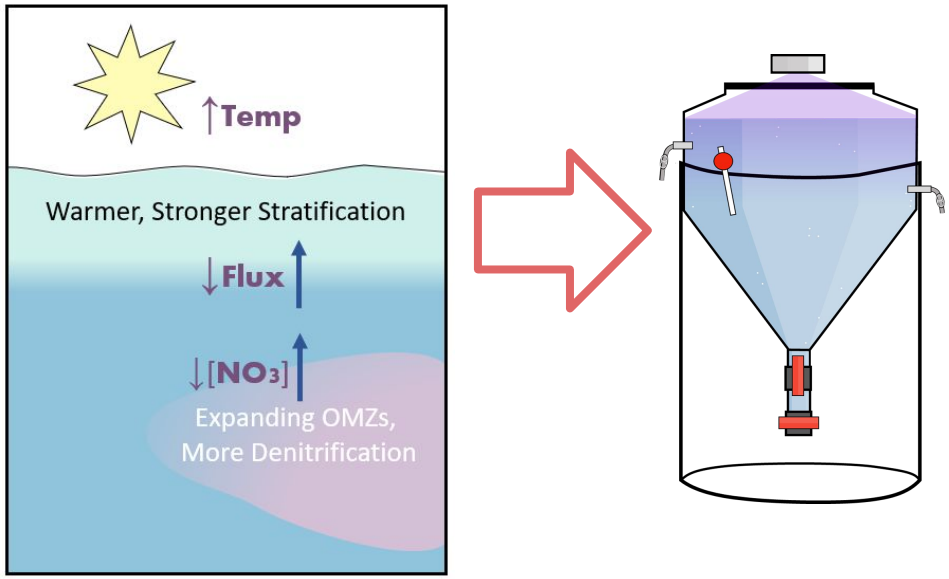
(Trying our best to sort through the mess)

Emily Seelen & Hanna Anderson

PERI-DICE

Destiny In a Changing Environment

Our goal was to create conditions inside the PERIcosms that would mimic conditions caused by **increased stratification** and **accelerated loss of fixed N from deep waters**, both hypothesized effects of climate change



Rate versus Ratio

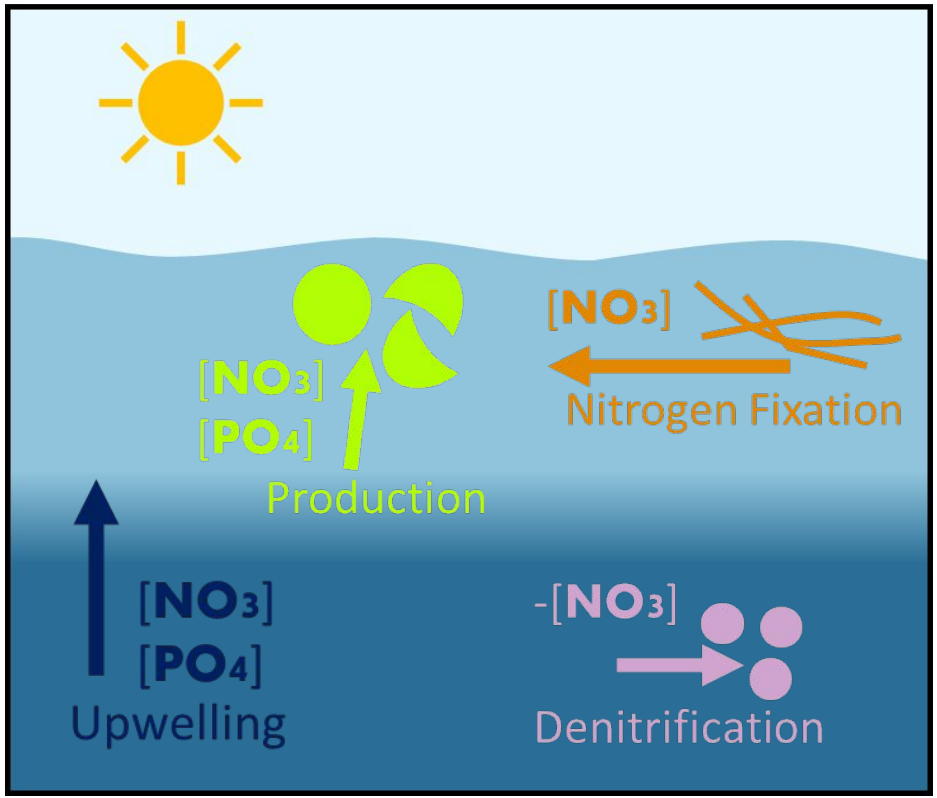
More nutrients =

More biomass

More diatoms

Less N fixation

Non-Redfield Stoich



Lower N:P =

? Biomass

? Diatoms

More N fixation

Redfield Stoich

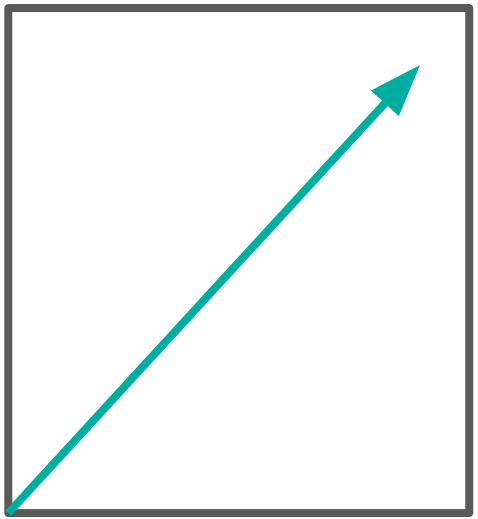
Rate

In a generally N-stressed environment, like the NPSG, adding fixed N should = more primary production

Ratio

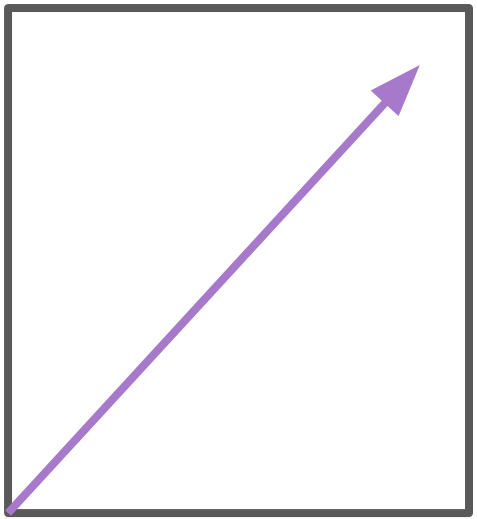
The relative availability of NO_3 and PO_4 can select for specific organisms or impact part. stoichiometry

Primary Production



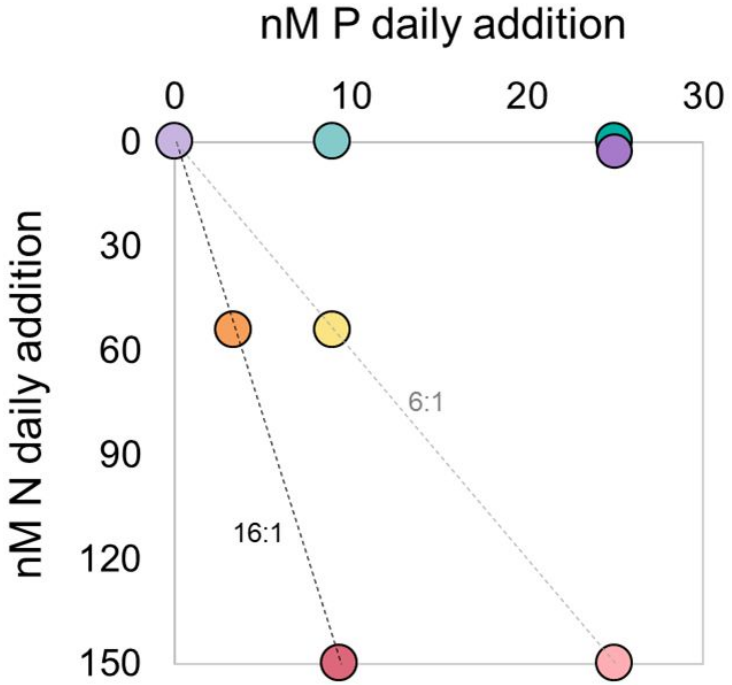
NO_3 supply

N_2 Fixation



PO_4 supply

Treatment design



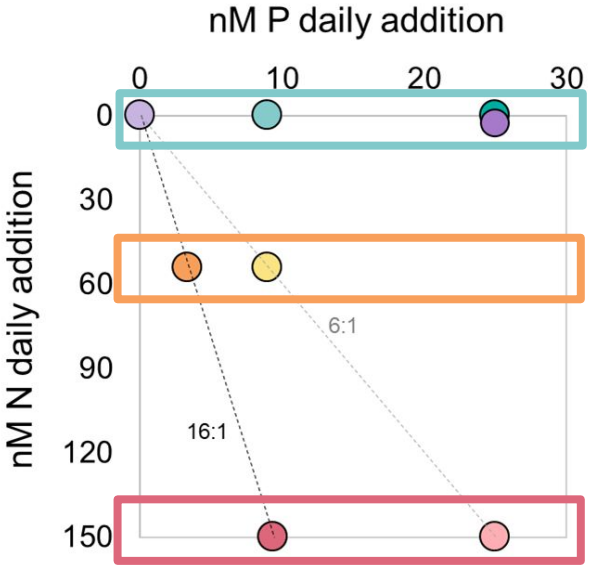
Original Treatment Names

C -N -P +Fe	**ZF** -N +++P -Fe
ZL -N +P +Fe	**ZH** -N +++P +Fe
RL +N +P +Fe	**LL** +N ++P +Fe
RH ++N ++P +Fe	**LH** ++N +++P +Fe

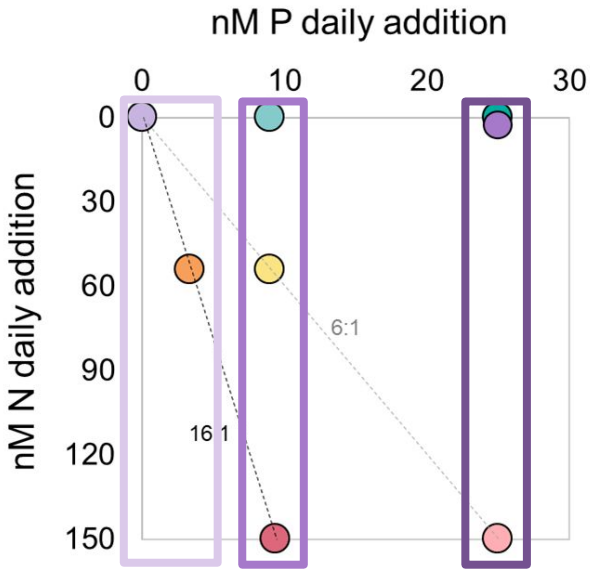
Increasing N

Increasing P

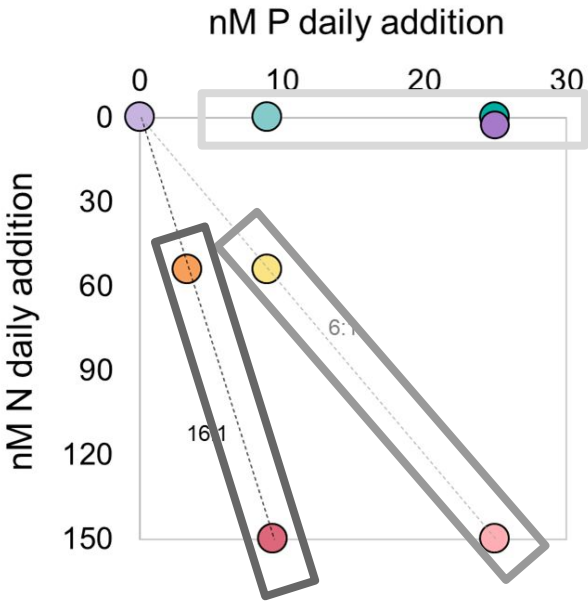
3 Nitrogen “Supply Rates”



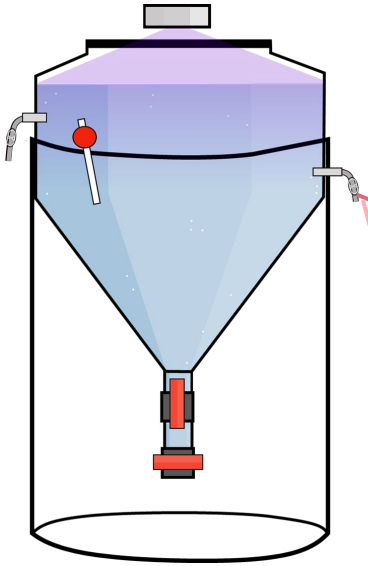
3 Phosphate “Supply Rates”



3 Supply Ratios

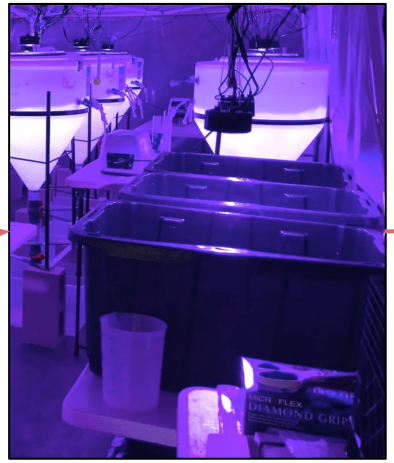


What is the impact of nutrient supply rate and ratio on primary productivity and nitrogen fixation?



$^{15}N_2$ enriched seawater

$^{13}HCO_3^-$

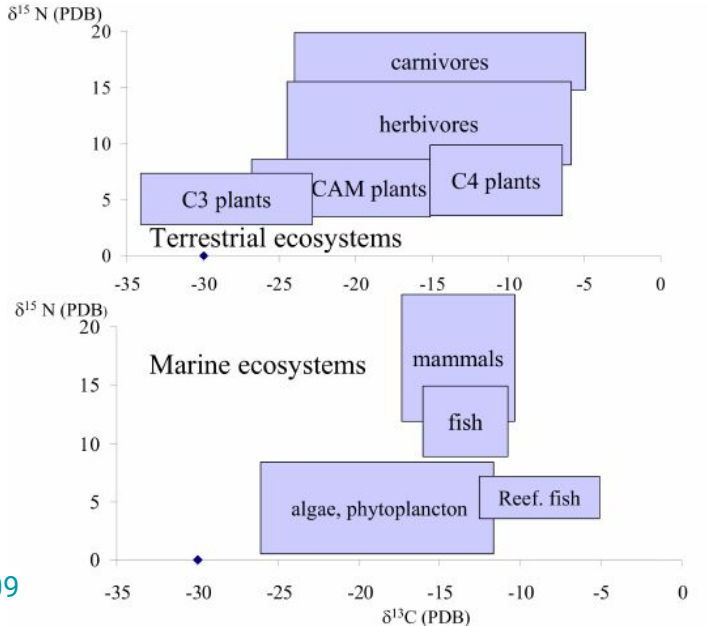


Popp Lab (UH Manoa) for analysis

Natural Abundance Stable Isotopes

Particulate C and N isotopes

Natural abundance $\delta^{13}C$ and $\delta^{15}N$ are often used to decipher PC source and trophic position

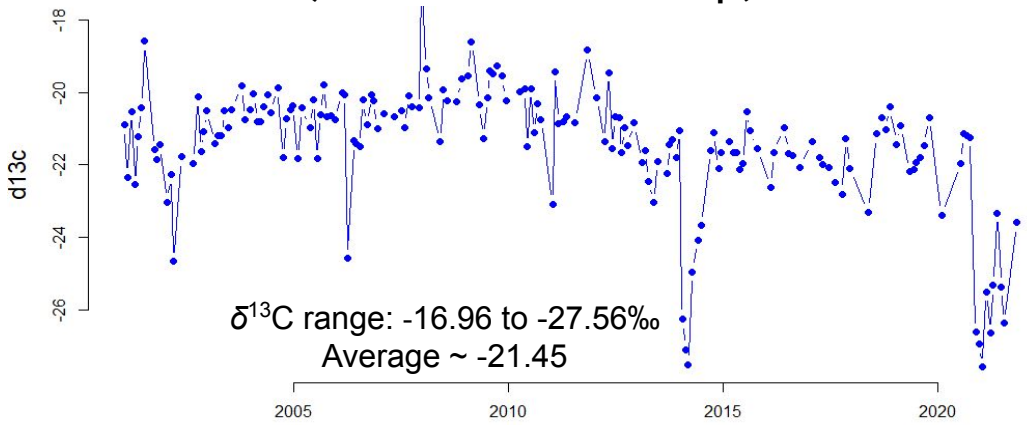


Szostek 2009

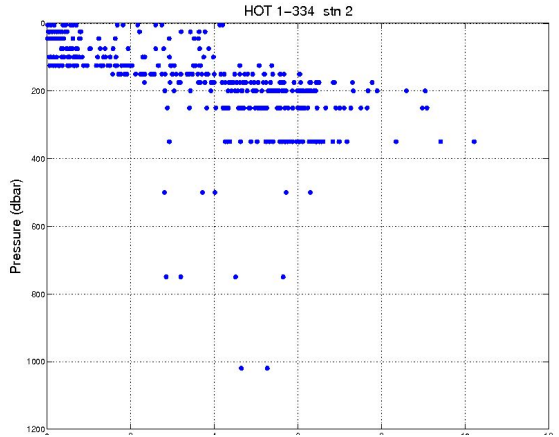
$\delta^{13}C$ and $\delta^{15}N$ enriched incubations indicate the net C and N fixation rates by quantifying the amount of tracer that was incorporated into the biomass

$$N_2\ fixation\ rate = \frac{(A^{PN}_{sample} - A^{PN}_{control})}{(A_{N2} - A^{PN}_{control})} x \frac{[PN]}{\Delta t}$$

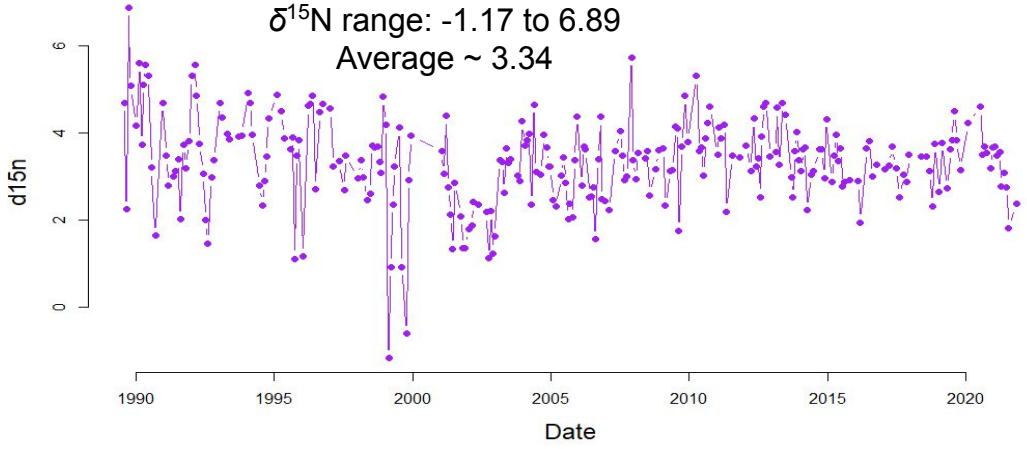
Typical particulate $\delta^{13}C$ and $\delta^{15}N$ values at station ALOHA
(150 m sediment trap, station ALOHA HOT-DOGS database)

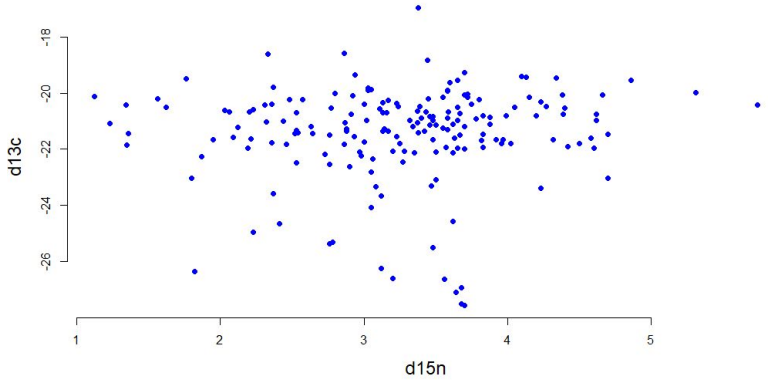


$\delta^{13}C$ range: -16.96 to -27.56‰
Average ~ -21.45

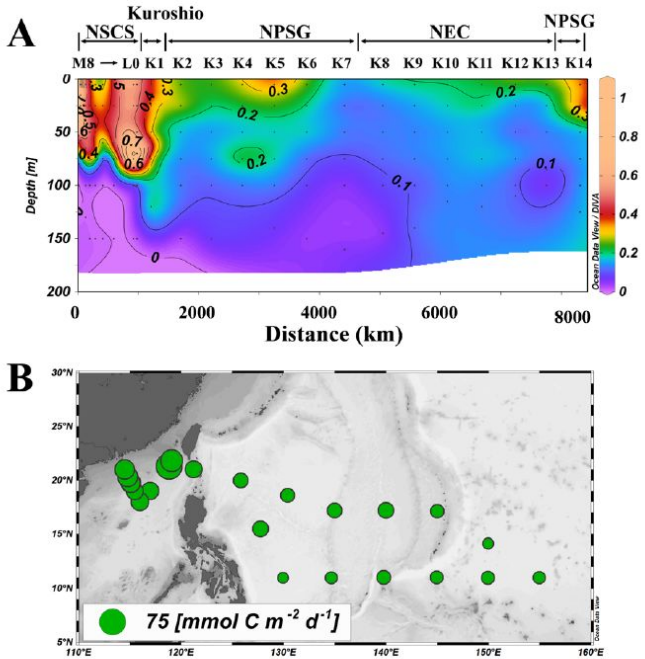


$\delta^{15}N$ range: -1.17 to 6.89
Average ~ 3.34



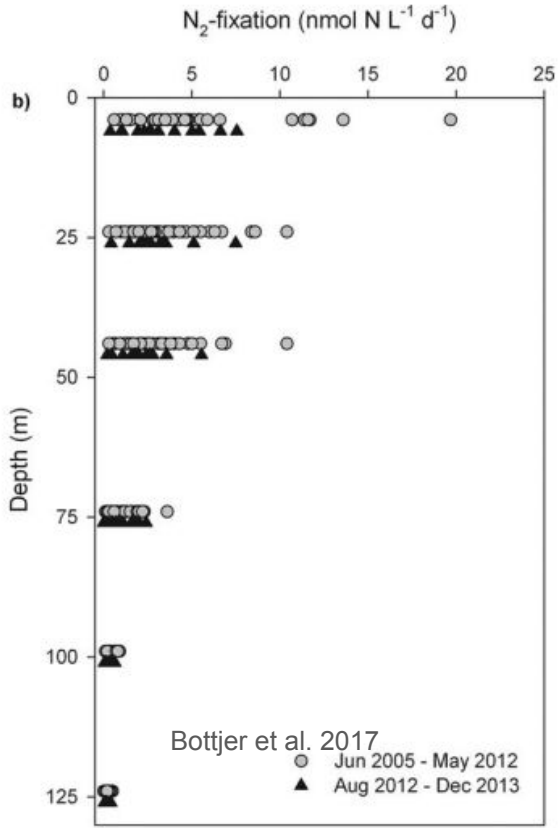


An example of expected rates



A: Vertical primary production (μmol C L^{-1} d^{-1}) profile in tropical western N Pacific.

B: Spatial distribution of integrated PP (nmol m^{-2} d^{-1})

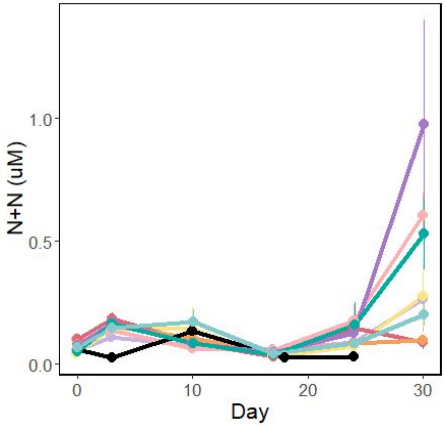


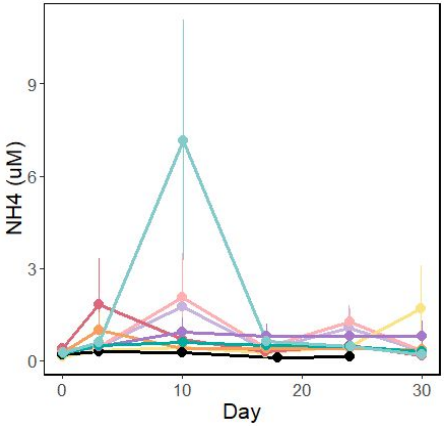
~0-20 nmol N/L/d
Typically ~4 in surface water

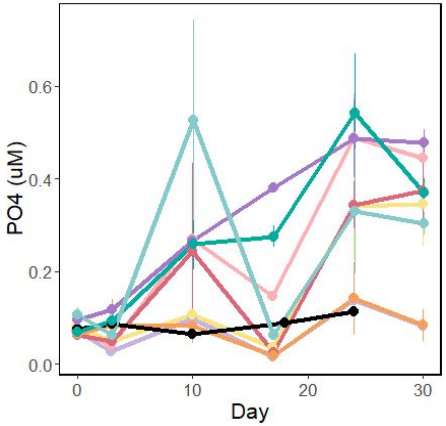
Wen et al., 2022: Fig. S5

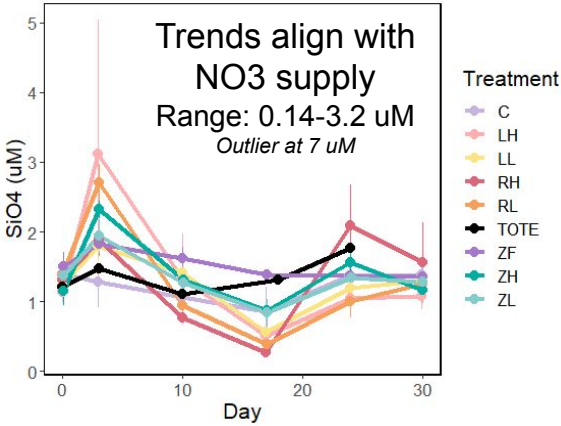
PERI-DICE RESULTS- Nutrients

Measured by SLAB









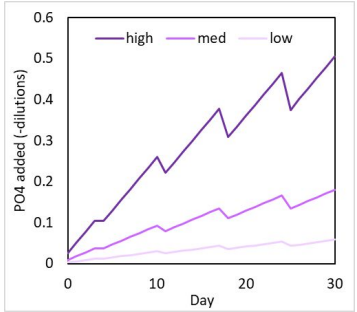
Average from day 0 to 24 is 0.09 uM

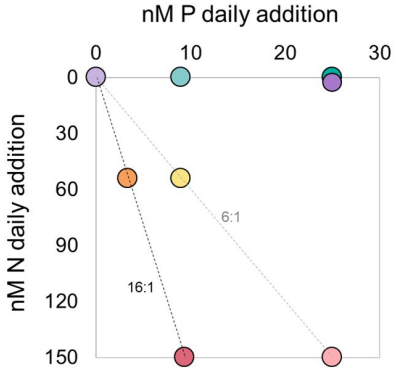
Increases at the end group with PO4 supply

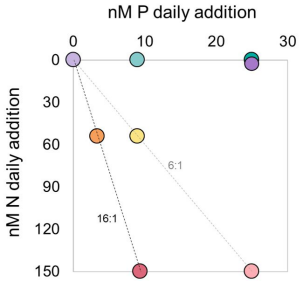
Average is 0.46 uM after values >4 uM were removed (n=6)

Trend with supply is unclear

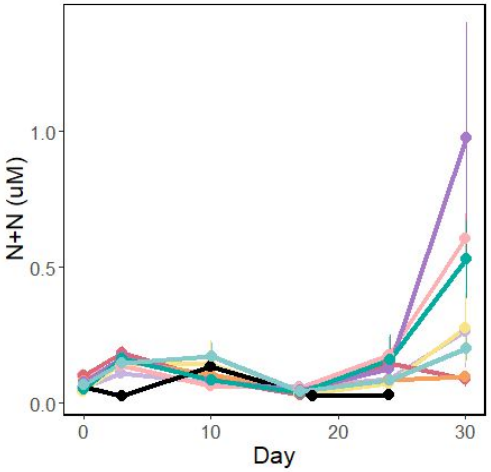
Trends align with PO4 supply

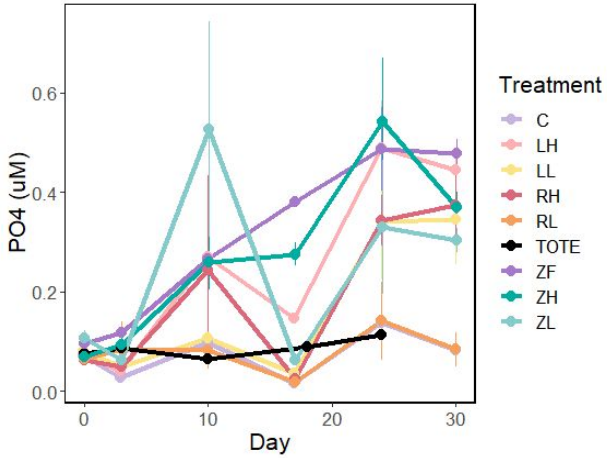


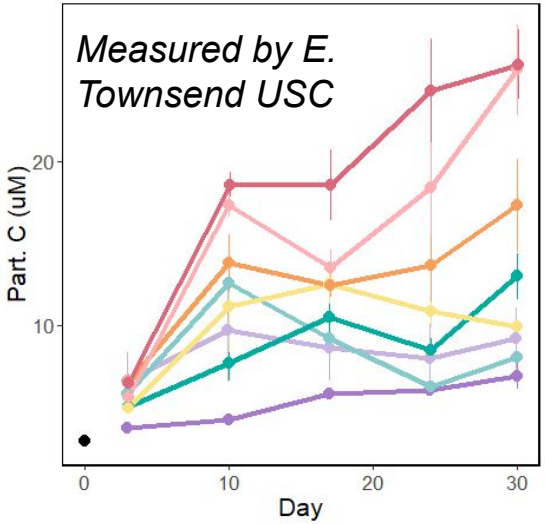


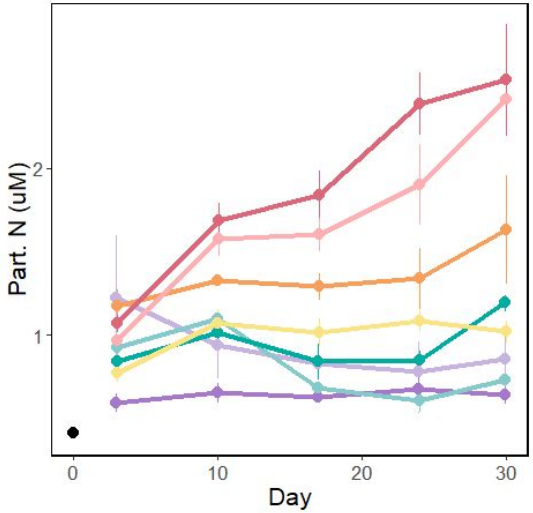


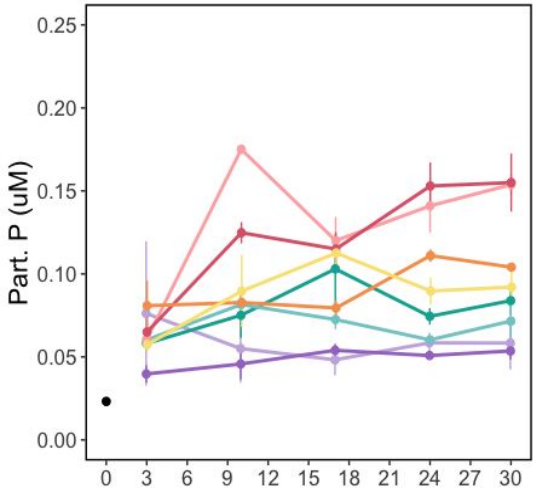
Nutrients more influenced by P supply, particles by N supply?



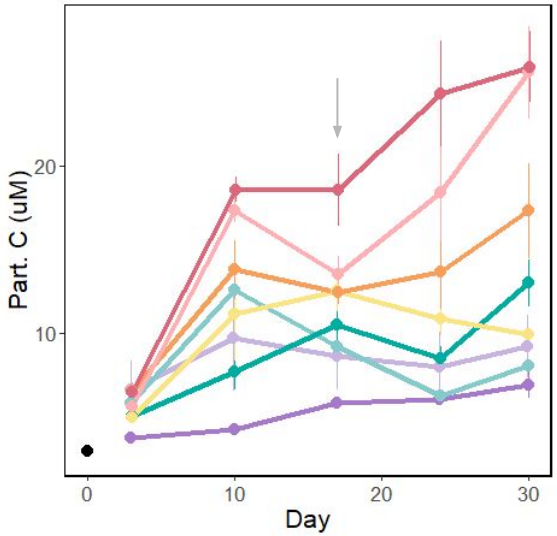


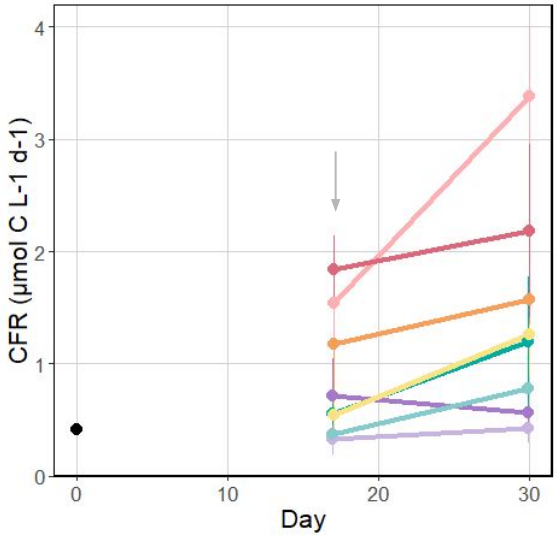


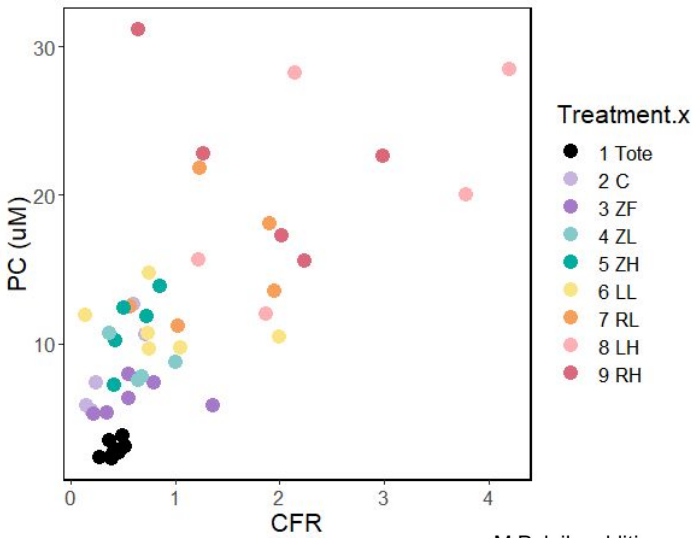




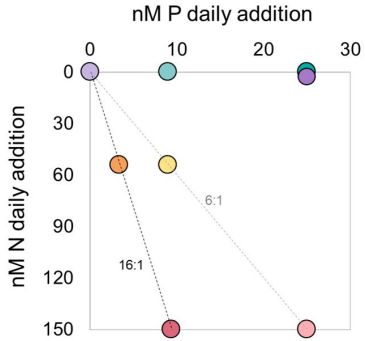
PERI-DICE RESULTS- Carbon



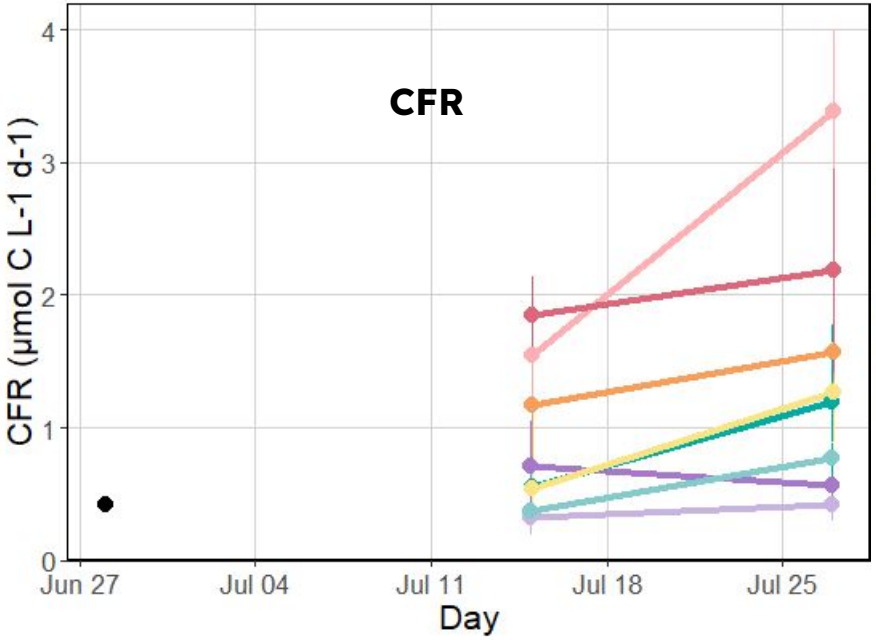


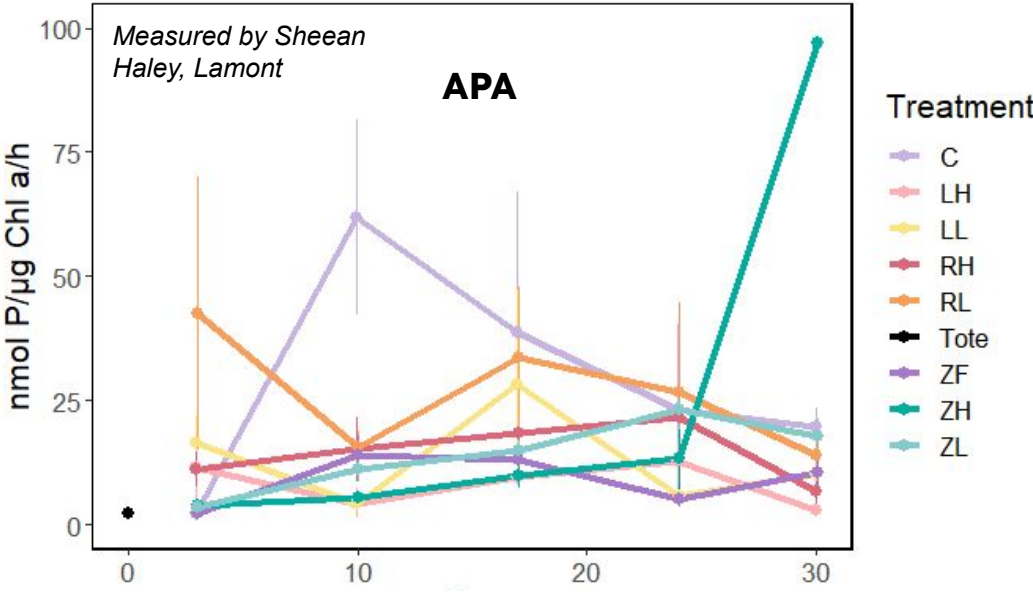


- Highest rates at high N+N (LH, RH) regardless of Redfield ratio
- Lowest rates at low N+N (C, ZF, ZL, ZH)
- RL has higher C fixation than LL. RL is at Redfield and has less nutrients LL is lower than Redfield.

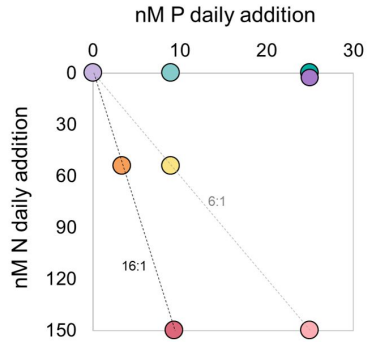


Linking productivity with nutrient stress



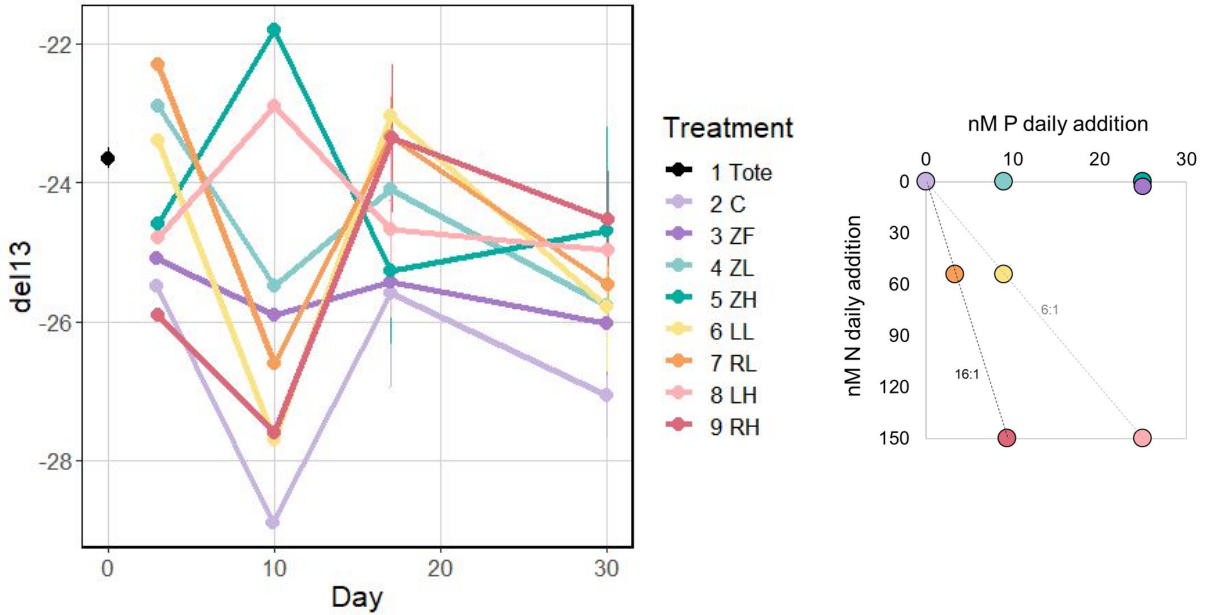


- ZH had APA peak despite high P addition
- LH and RH had high CFR and low APA
- RL lags behind in CFR and has more APA
- Magnitude of nutrient addition is more influential than being at Redfield ratio



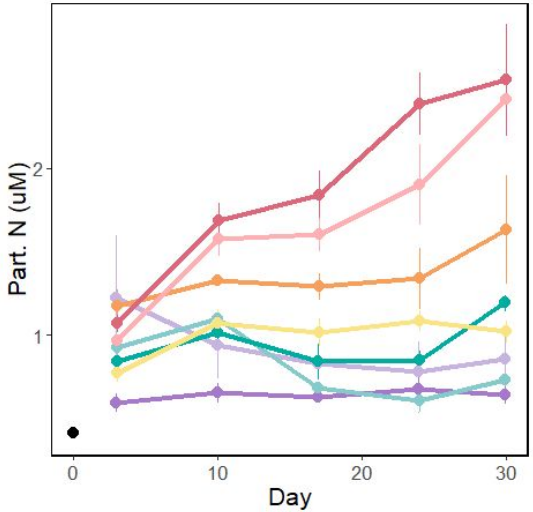
$\delta^{13}C$ natural abundance trends

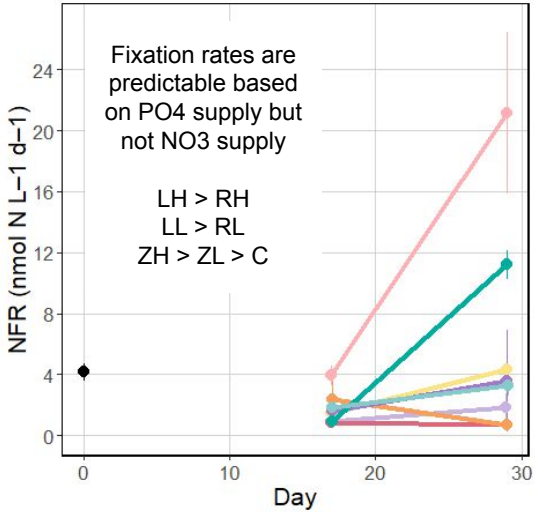
- Station ALOHA $\delta^{13}C$ PC at 150m ranges from -16.96 to -27.56‰
- This data is within expected values for marine plankton

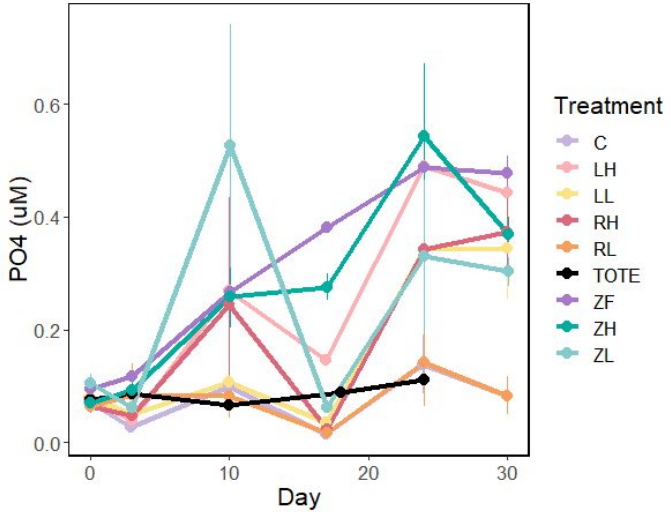


Trend with N supply?

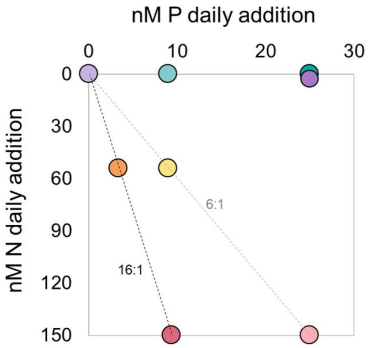
PERI-DICE RESULTS- Nitrogen

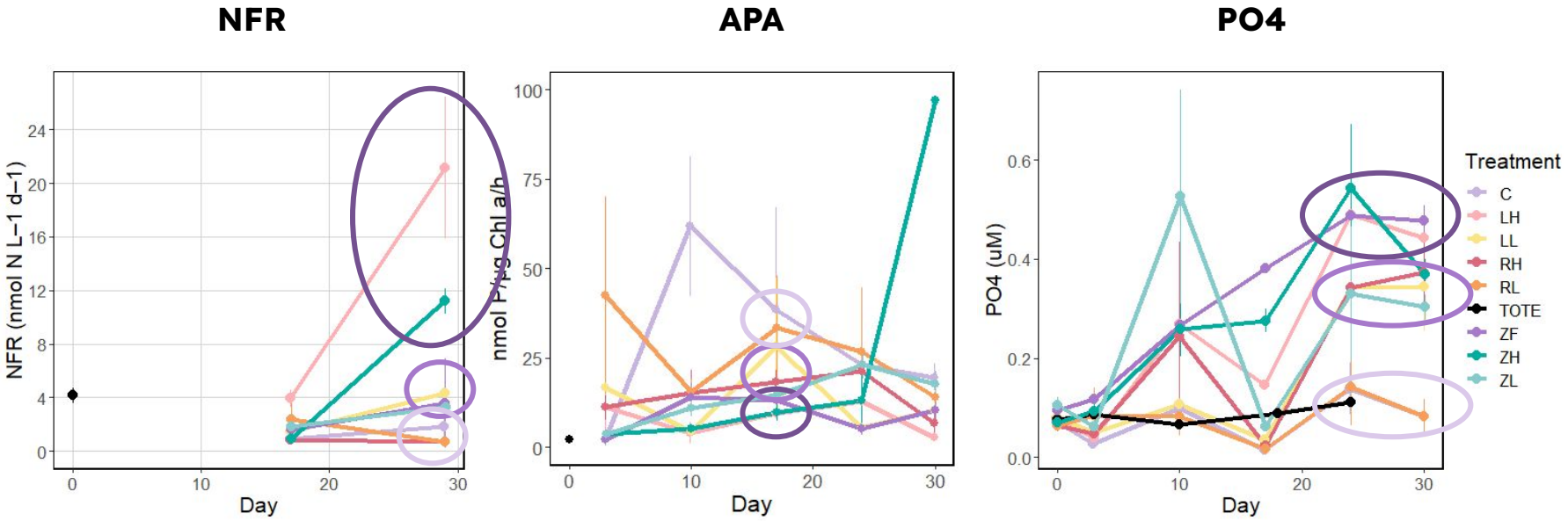




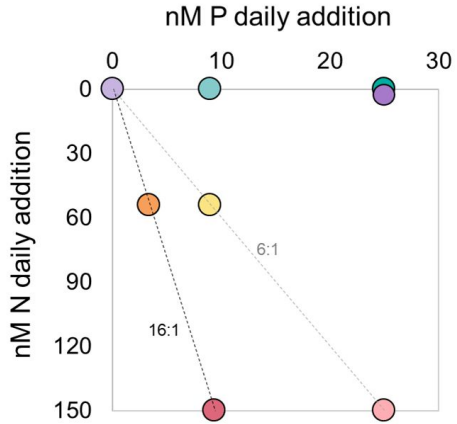


- Highest rates at highest PO4 +Fe additions (LH, ZH)
- Lowest rates when supplied at Redfield (RL and RH)
- All rates are ~within what has been measured at ALOHA
- Phosphate concentrations align with PO4 additions

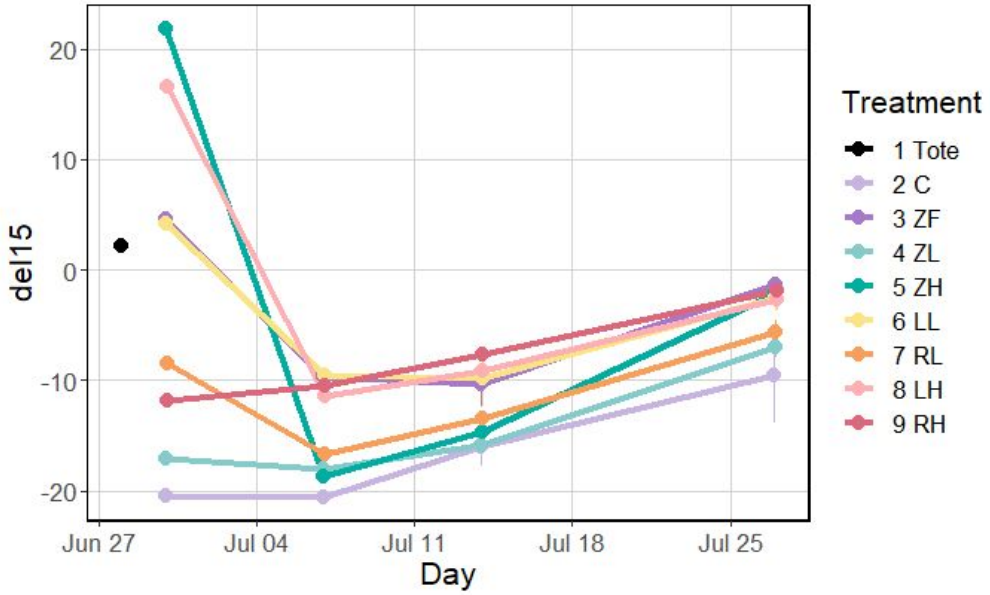




- High PO4 supply = low APA = high NFR
  - RH and ZF are the exception for NFR
  - APA trends with PO4 are less obvious at the end

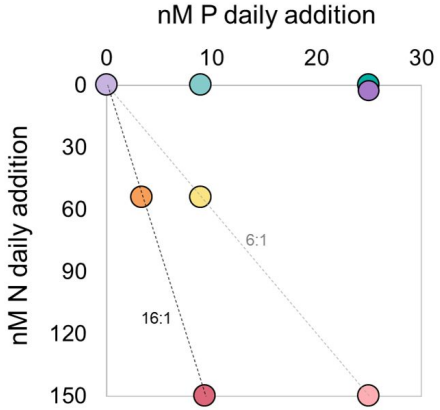


$\delta^{15}N$ natural abundance trends



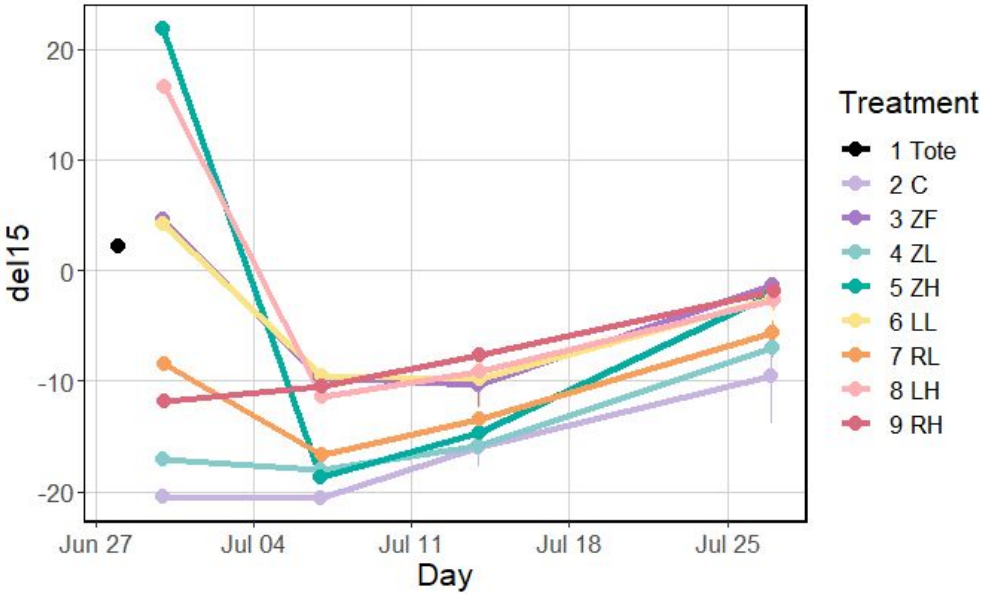
- Samples were isotopically light! Converged on 0 as the experiment progressed.
- NH_4 consumption in a diatom incubation led to higher $\delta^{15}N$.

Wacky, but can it be real or is this contamination?



A WILD IDEA…

Can growth on NH4 explain the trend?



Waser et al., 1998

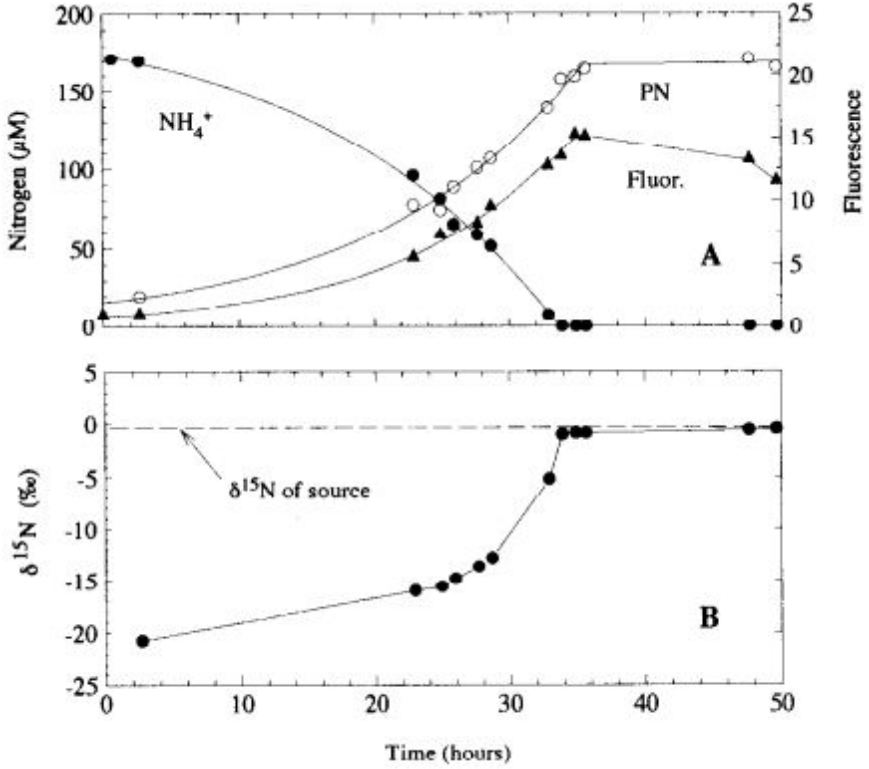
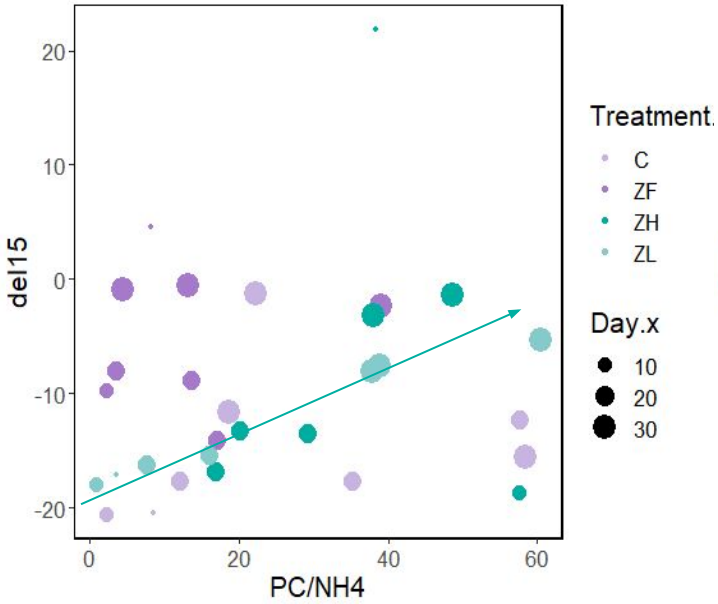
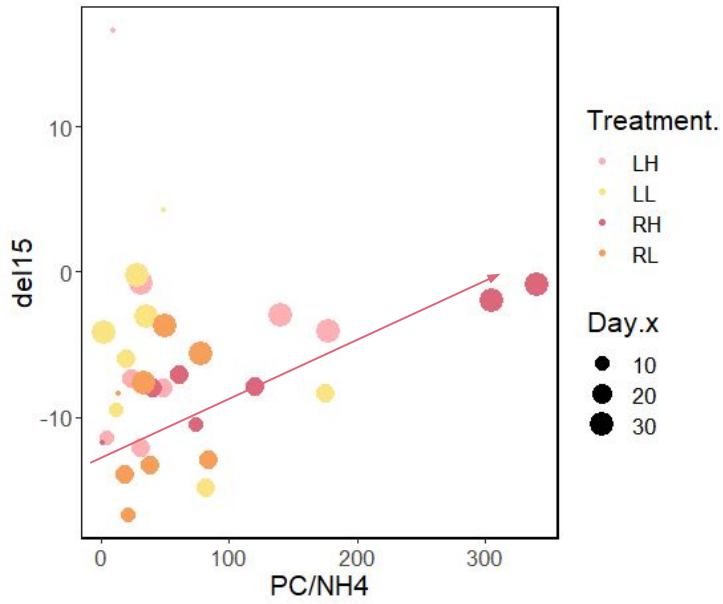
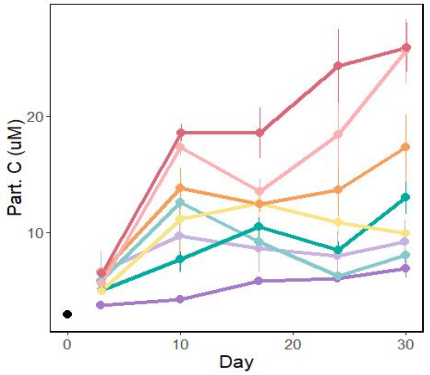


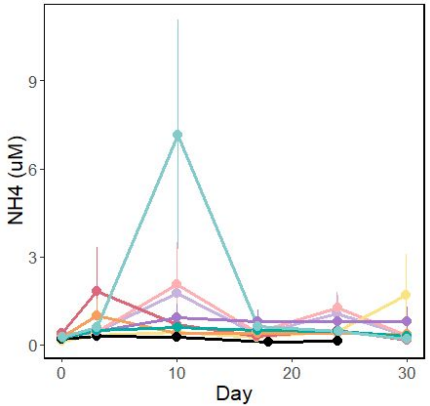
Fig. 2. Growth of *T. pseudonana* on ammonium during log and stationary phase at initial NH_4^+ concentration of 189 μM. A. Time series of NH_4^+ (●), PN (○), and fluorescence (▲). B. Time series of the $\delta^{15}N_{PN}$ (the dashed line represents the $\delta^{15}N$ of the NH_4Cl source of −0.3‰). NH_4^+, PN, and fluorescence curves were fit to exponential functions during the log phase (*see* text for details of the best fits), whereas the remaining data points were connected with straight lines.

If Part. C / NH_4 is at all a good proxy for NH_4 availability , then we would expect low ratios to be more negative. BUT, this is a severe over simplification. Ideas welcome!









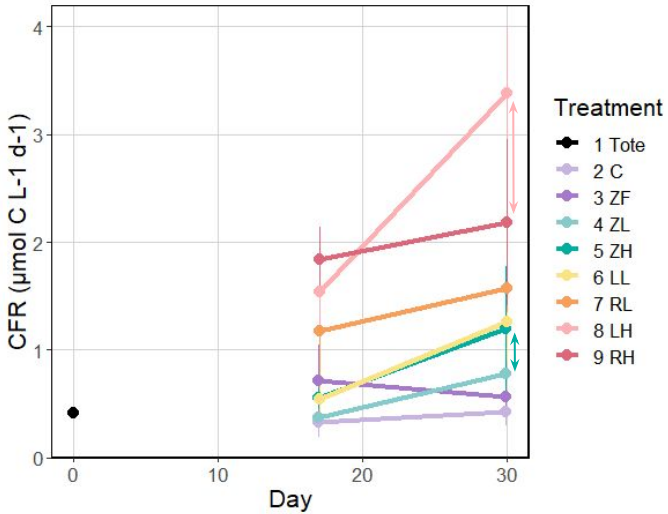
This could also just be a bad idea

What is the impact of nutrient supply rate and ratio on primary productivity and nitrogen fixation?

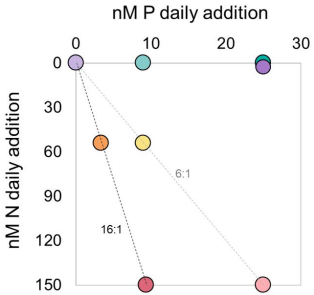
Influenced by RATE

Primary Production

Particulate CNP



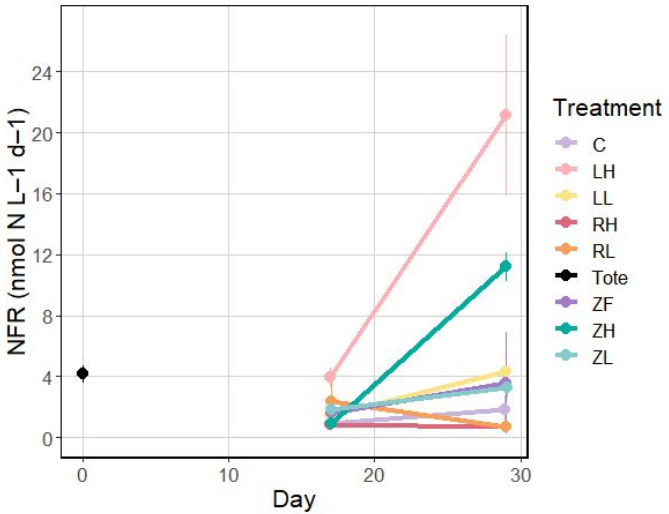
Nitrogen fixation enhances CFR regardless of N supply (except what is going on with LL and RL??)



Influenced by RATIO

Nitrogen Fixation

Measured Nutrients



Summary & future questions

Natural abundance

- ^{13}C natural abundance is similar to typical marine algae
- ^{15}N natural abundance… results are wacky! Can they tell us anything important, or is it contamination?
  - Is there any evidence that the system would have high NH_4 production?
    - Zooplankton (IFCB data)

Incubation data

- ^{13}C: C fixation rate
  - PERI-DICE: highest rates were at high N+N treatments, some variable effects of RR
  - Future Q's: Do the changing rates observed in PERI-DICE reflect anything measured at ALOHA? Are there correlations with export flux? (productivity / sed trap data)
- ^{15}N: N_2 fixation rates
  - Can N_2 fixation can explain some of the differences in CFR seen at station ALOHA?
  - Can we detect the role of N_2 fixation when pericosm productivity seems driven by NO_3 addition?
- Should we run more incubation results??