The influence of viral reproduction strategies on marine microbial community dynamics

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High abundance of viruses found in aquatic environments

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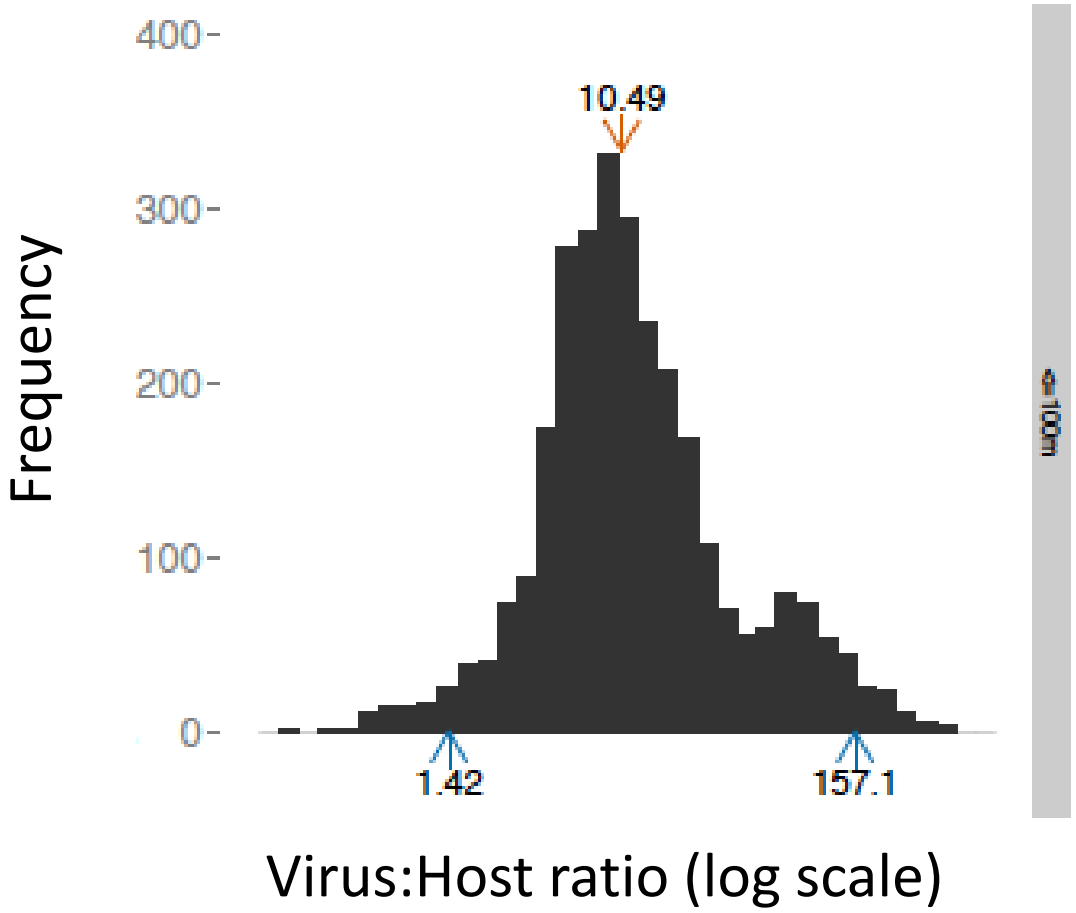
THE concentration of bacteriophages in natural unpolluted waters is in general believed to be low[1,2], and they have therefore been considered ecologically unimportant[3]. Using a new method for quantitative enumeration, we have found up to 2.5×10^8 virus particles per millilitre in natural waters. These concentrations indicate that virus infection may be an important factor in the ecological control of planktonic micro-organisms, and that viruses might mediate genetic exchange among bacteria in natural aquatic environments.

- Nature, **1989**

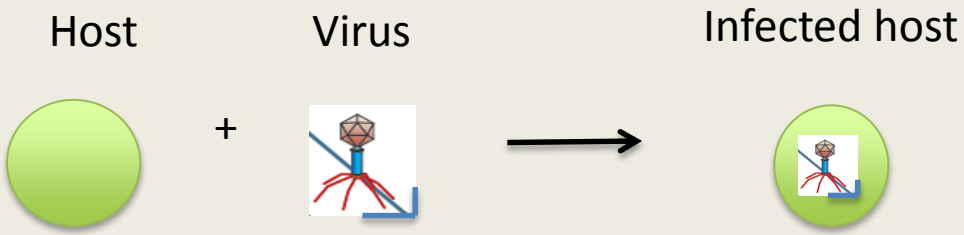
Viruses usually outnumber their hosts!



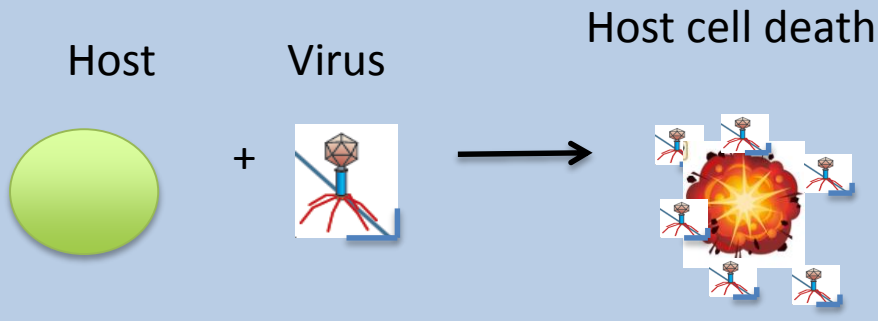
Wigington et al., 2015

Which *traits* explain high viral abundance?

Lysogenic infection – *non-fatal*

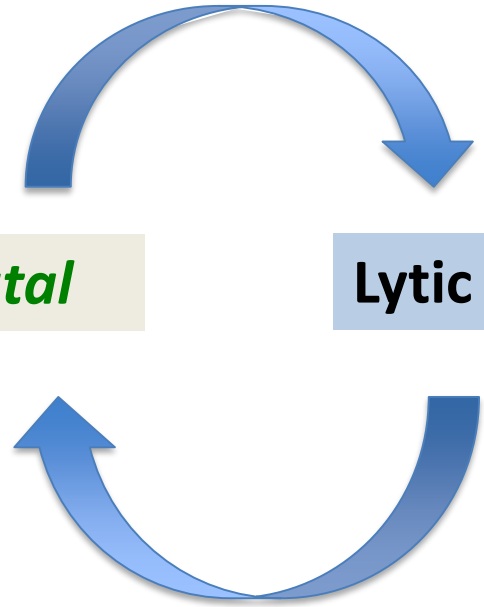


Lytic infection – *cell death*



…third possibility: switching!

Environmental / physiological trigger



Lysogenic infection – ***non-fatal***

Lytic infection – ***cell death***

Environmental / physiological trigger

Main questions

Which type of **environment** (e.g. oligotrophic, eutrophic, etc.) **select** different strategies?

Can switching between lysogenic and lytic production partly explain high **viral production**?

Talk outline

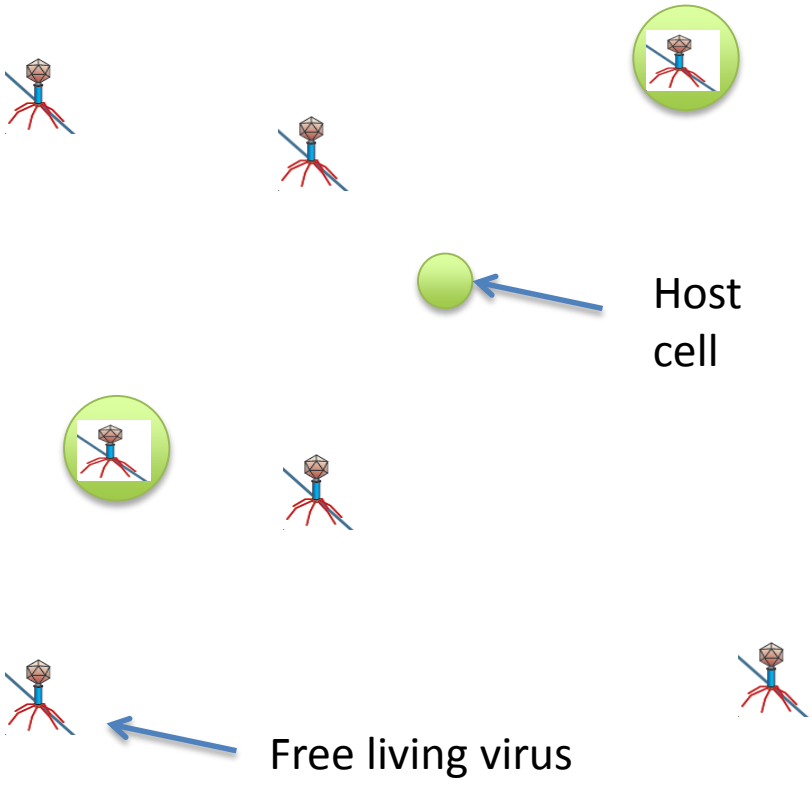
Part 1: What is the **cost-benefit** of lysogenic vs. lytic reproductive traits?

Part 2: Use of a **competition model** to explore environmental selection of traits

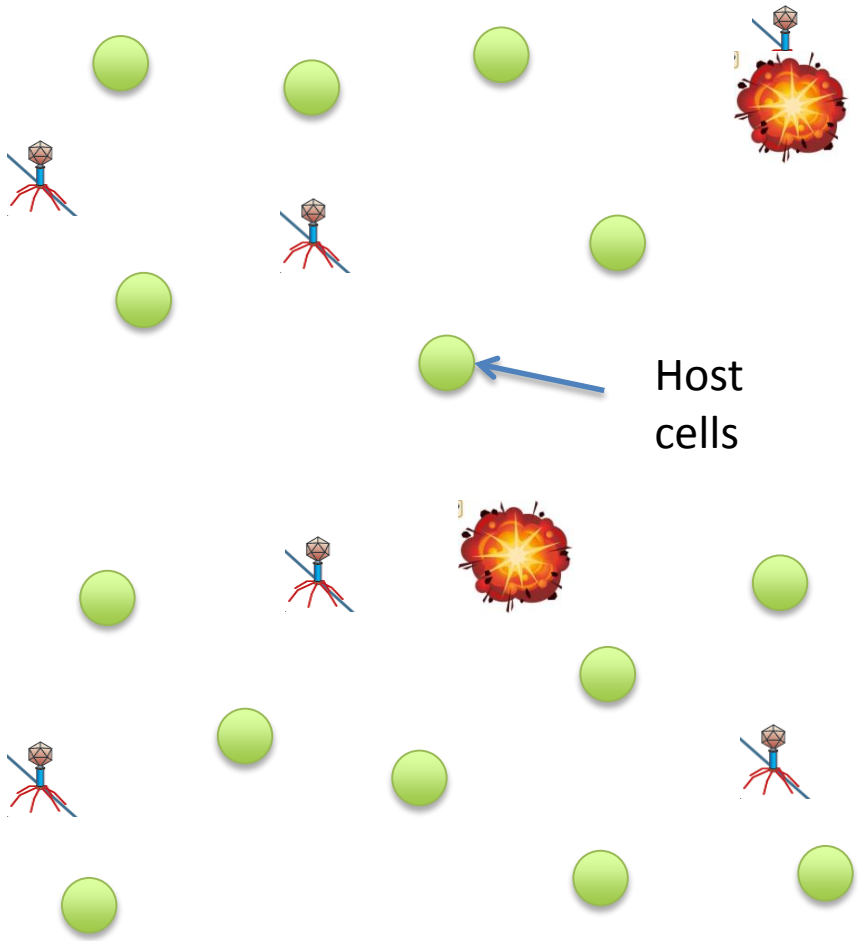
Part 3: Is **switching observed** in the environment, and does it enhance viral production?

Part 1: Cost-benefit of reproductive strategies

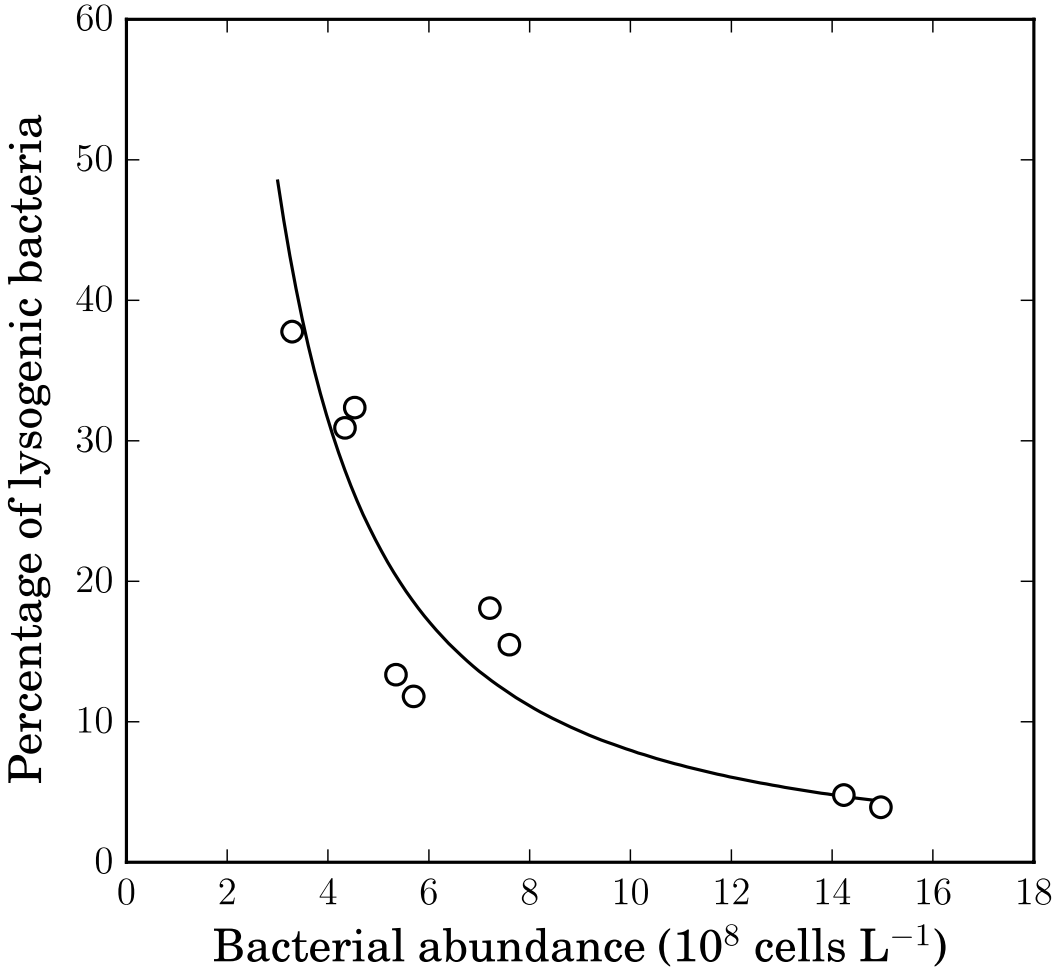
Lysogeny benefit: safety when host abundance is low



Lysis benefit: high reproduction when host abundance is high

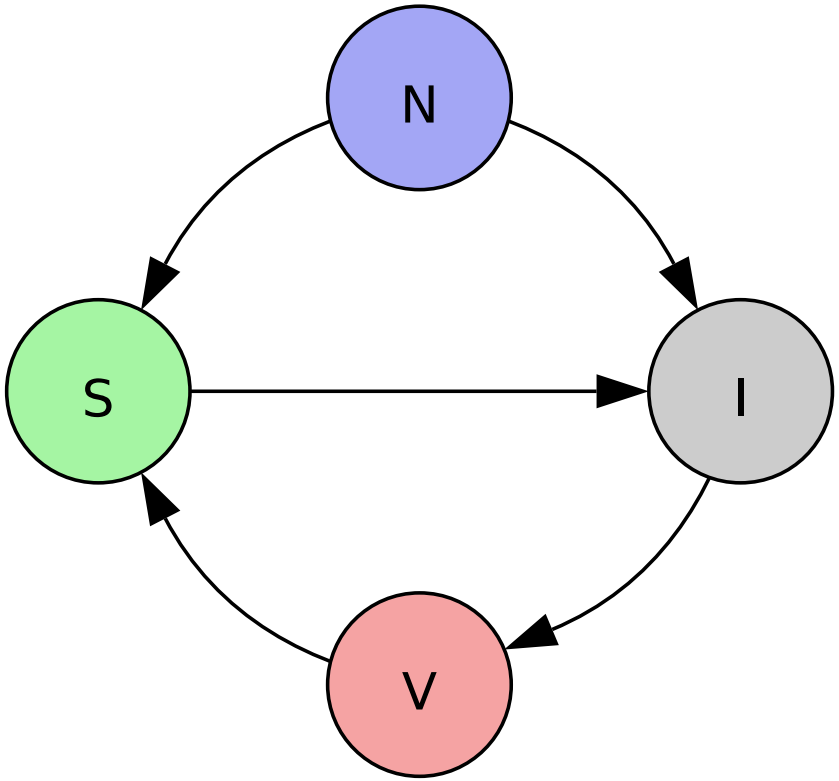


Lysogeny dwindles as host abundance declines, Payet and Suttle, 2013



Can enhanced nutrient input cause this change?

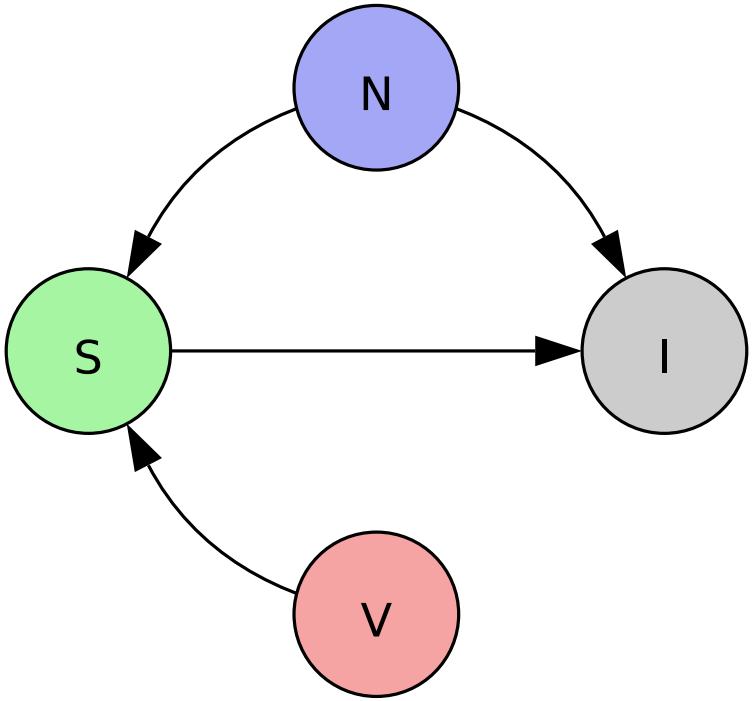
Simple model of infection



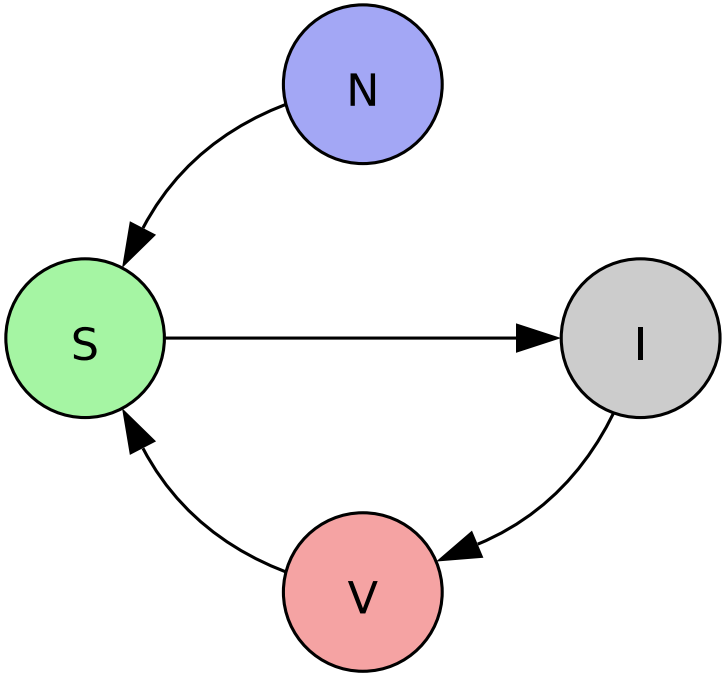
N – nutrients **S – Susceptible hosts** **I – infected hosts** **V - viruses**

γ - key trait for reproduction strategy

Lysogeny *($\gamma = 1$)*

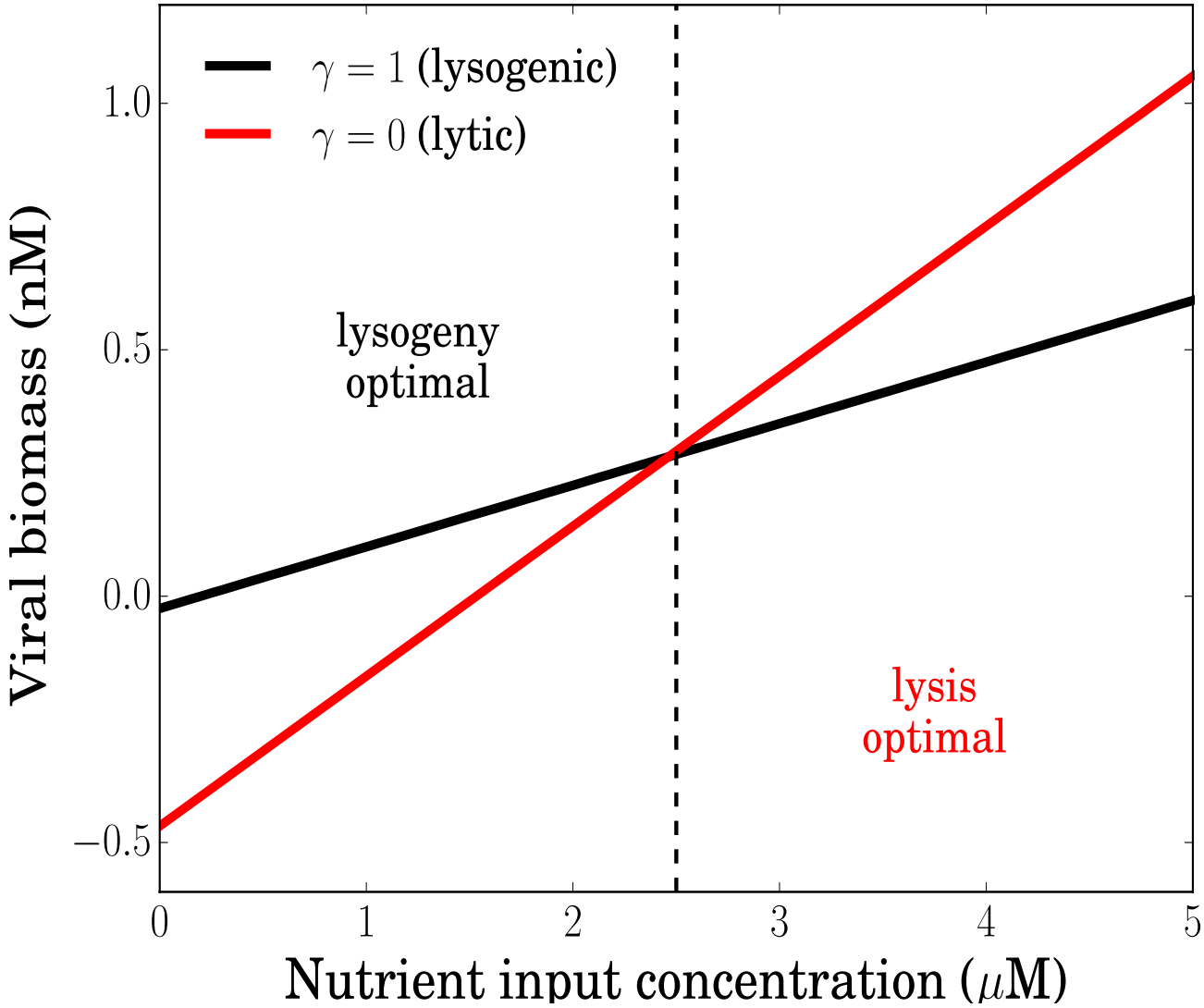


Lysis *($\gamma = 0$)*



N – nutrients **S – Susceptible hosts** **I – infected hosts** **V- viruses**

The model says that switching from lysogeny to lysis may lead to enhanced viral production when nutrient input is high



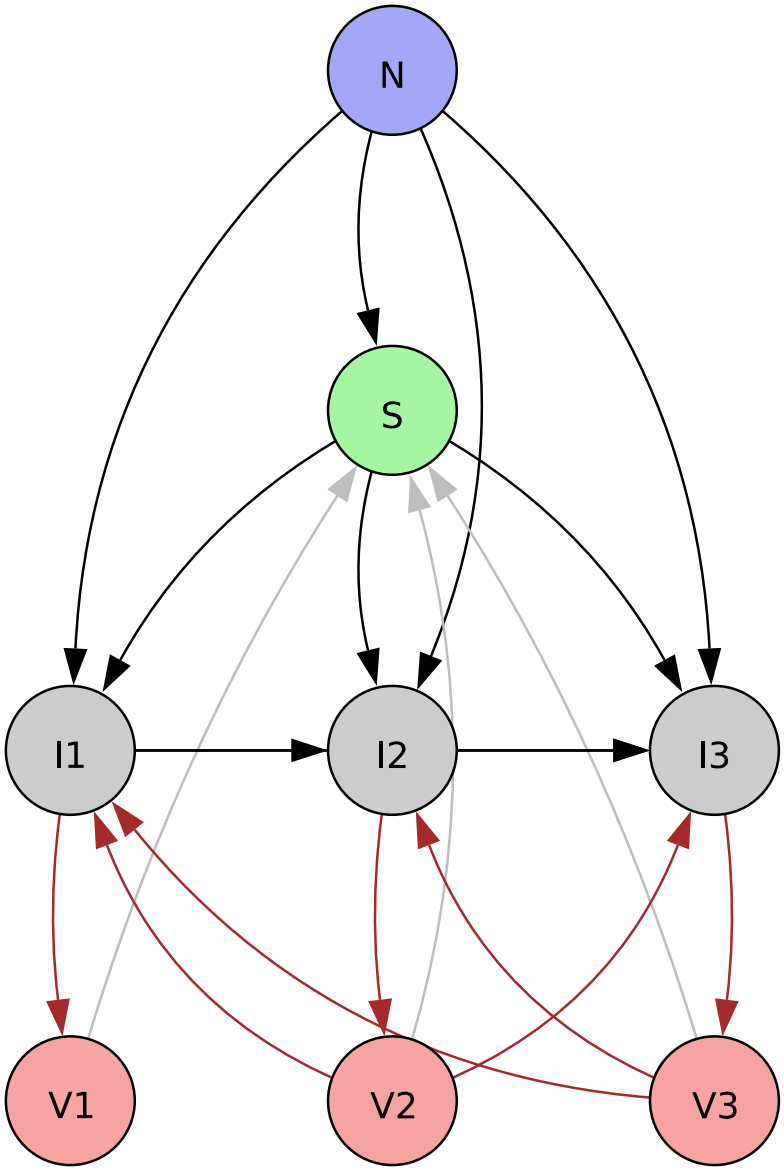
Part 2: In which environments are lysogeny vs. lysis selected?

Competition model

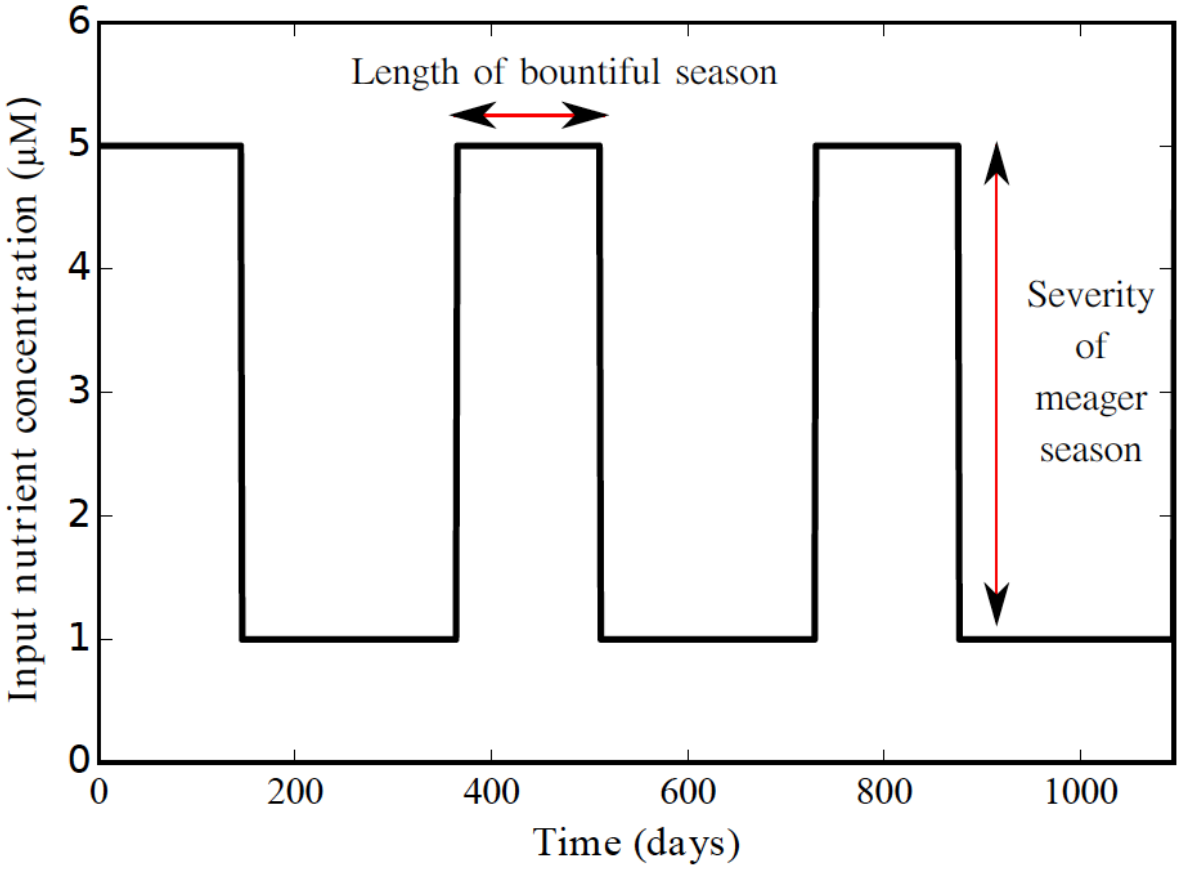
V1 – purely ***lysogenic***

V2 – purely ***lytic***

V3 – ***switching*** between lytic and lysogenic

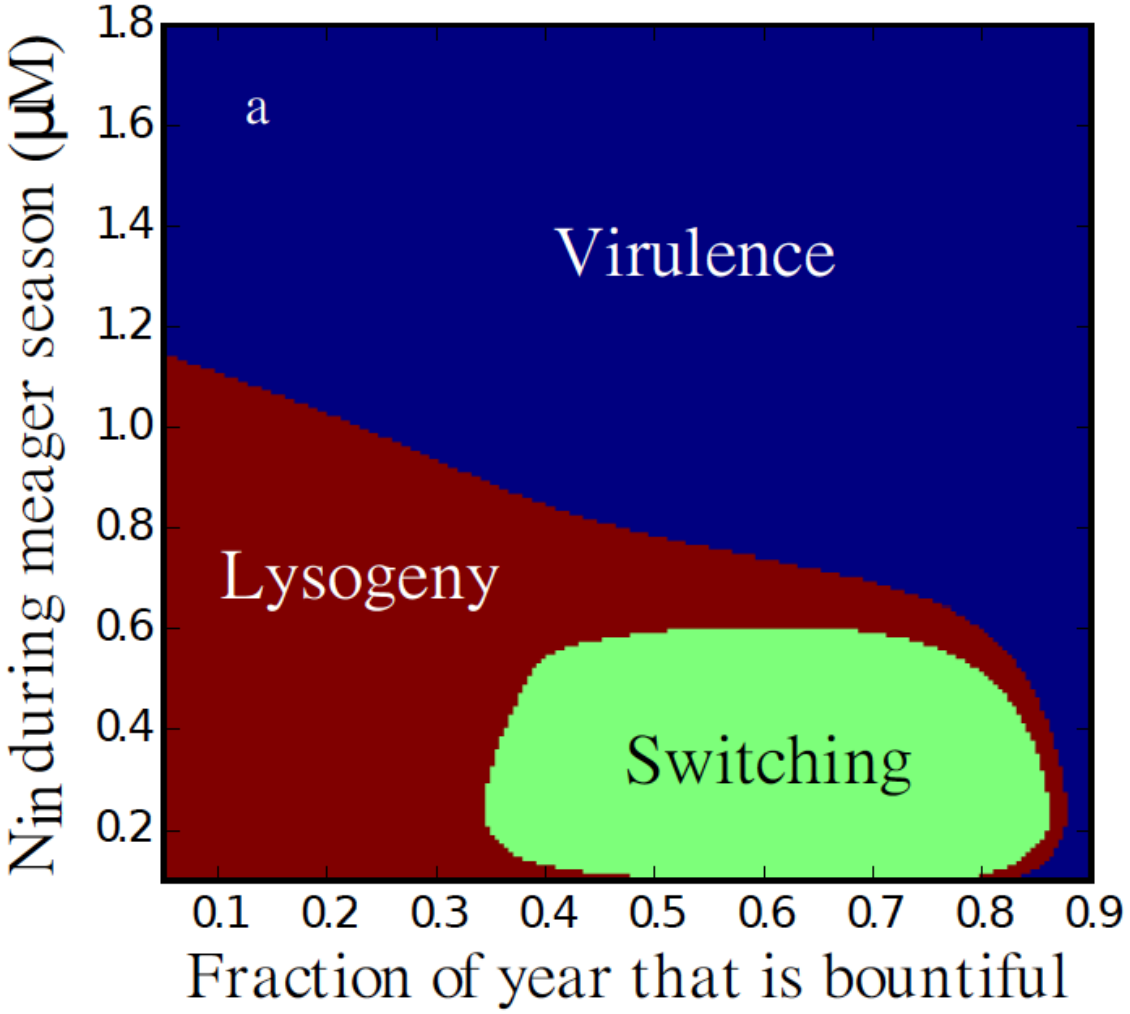


Environmental variation



Mimic nutrient input seasonality

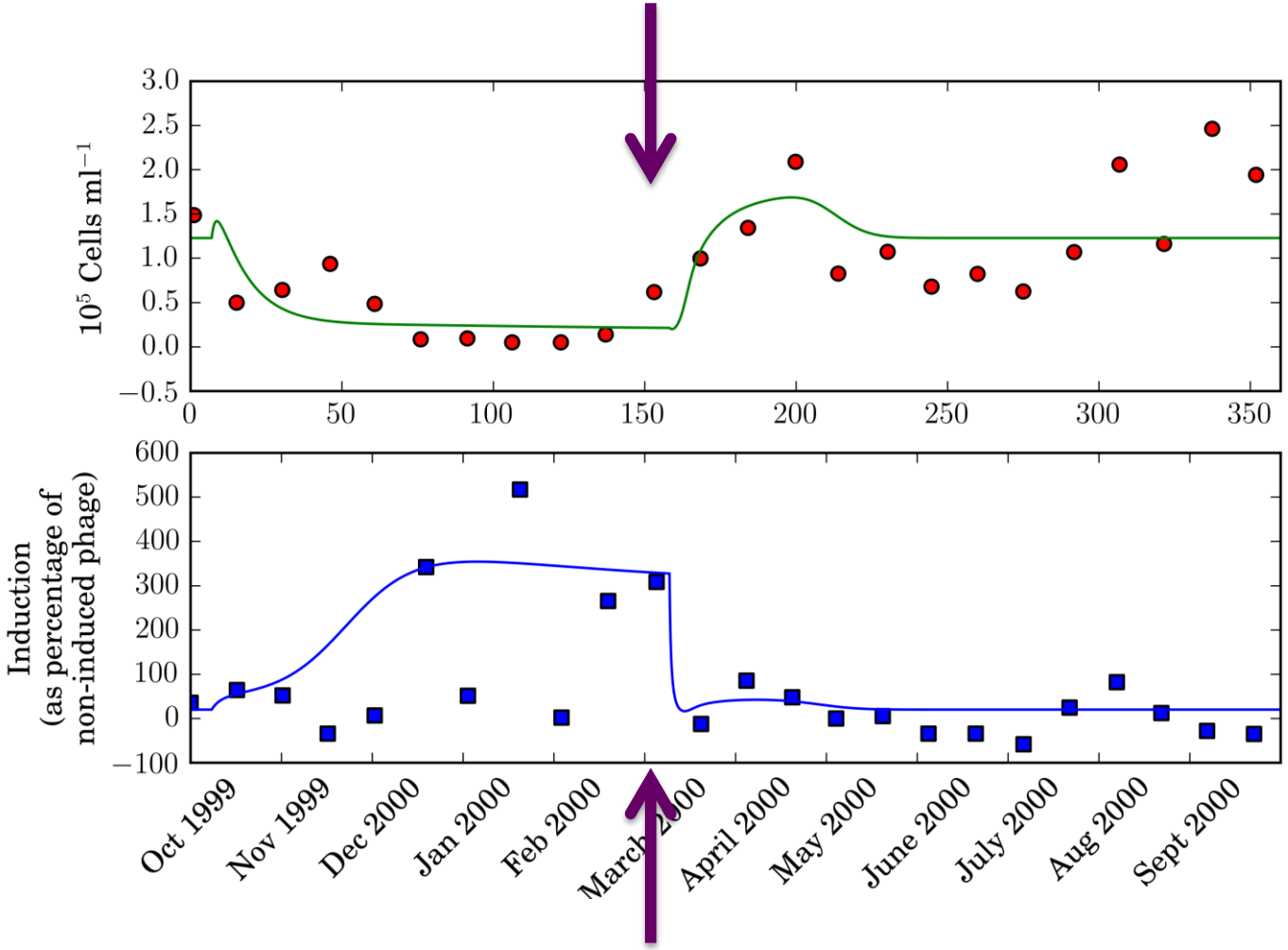
Dominant strategy in competition experiments?



High seasonality favors switching

Part 3: Is switching observed in the environment, and does it enhance viral production?

Increase in host cell abundance



Synechococcus

Model result

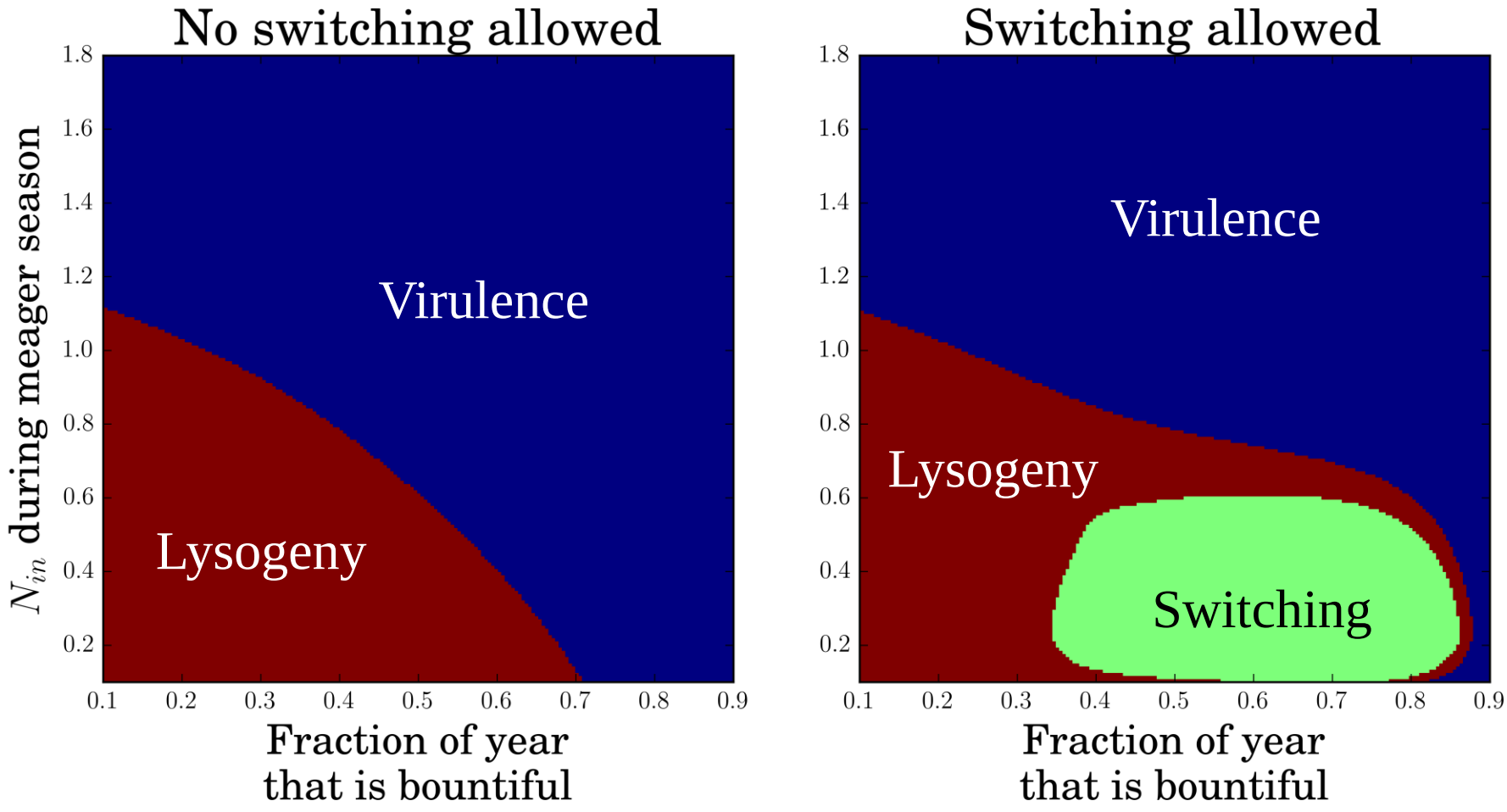
Observations

Model result

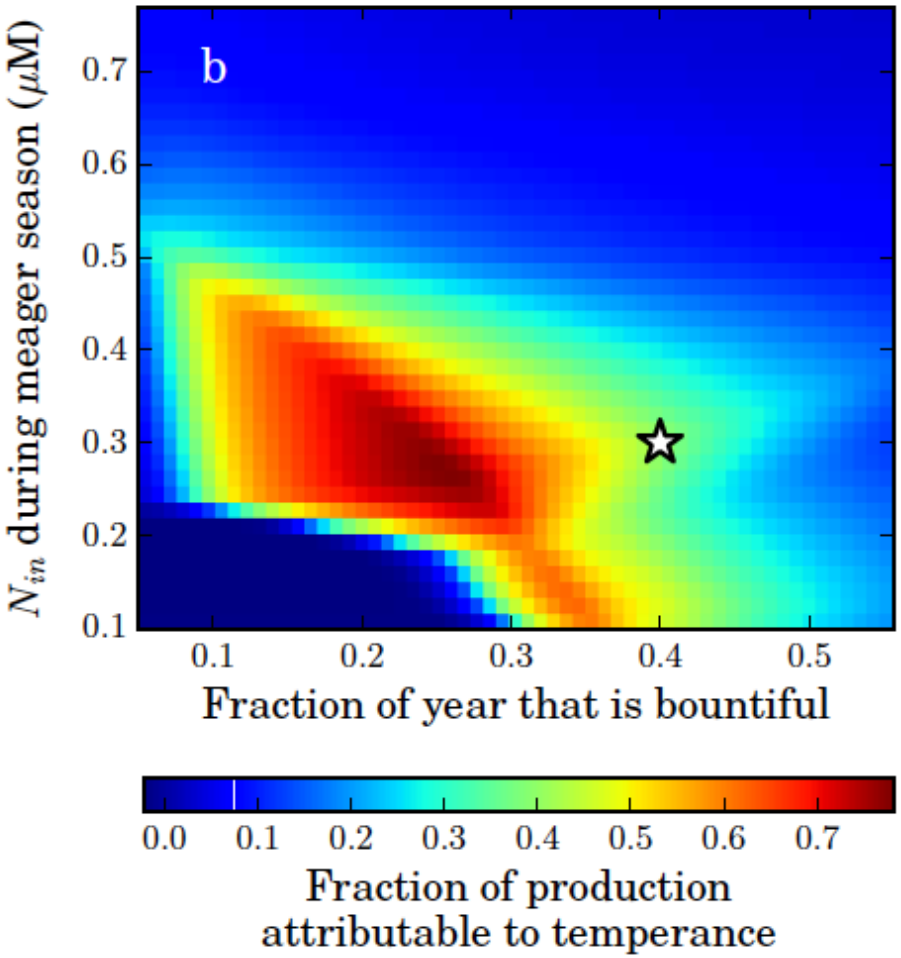
Switch from lysogeny to lysis

Data from Tampa Bay, Florida, McDaniel et al., 2002

How does switching back and forth influence viral production?



Fraction of phage production attributable to switching

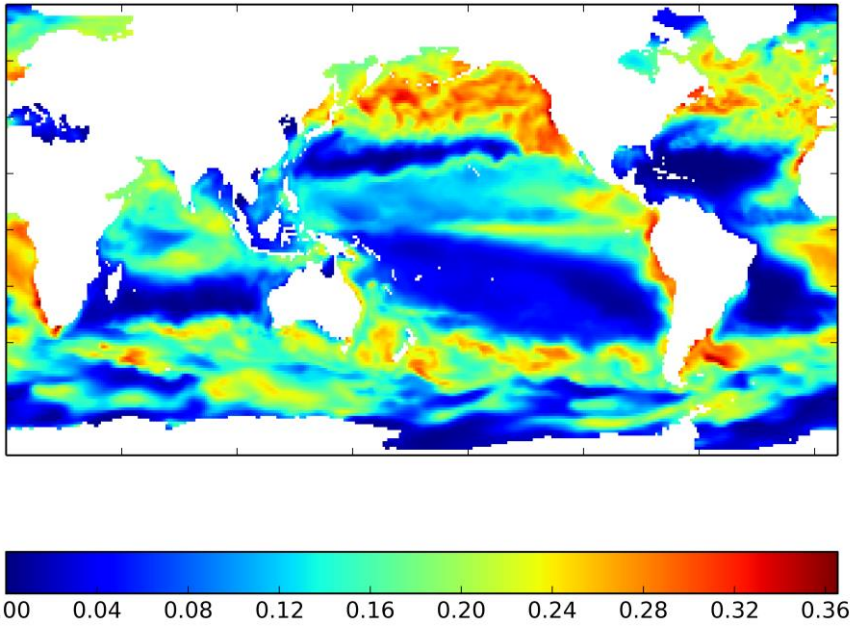


Switching can account for more than 70% of total phage production

Conclusions

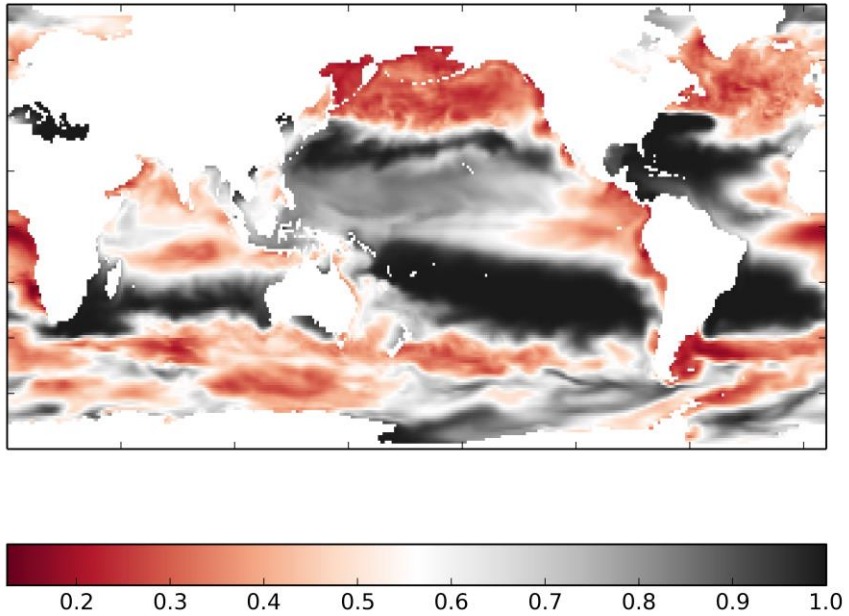
- **Switching** from lysogeny to lysis is **selected** in 'boom and bust' **environments**
- The ability to switch can account for **>70%** of **phage production** in boom and bust environments
- Biogeography of reproductive strategy may be fundamental if we are to understand viral production and ecology in the ocean

Total bacterial viruses



Viral biomass (nM)

Fraction of viruses that are lysogenic



Fraction of viruses

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Thank you for listening!
..Questions?

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