Trade-offs between nutrient and predator effects conceal the influence of canals on snails

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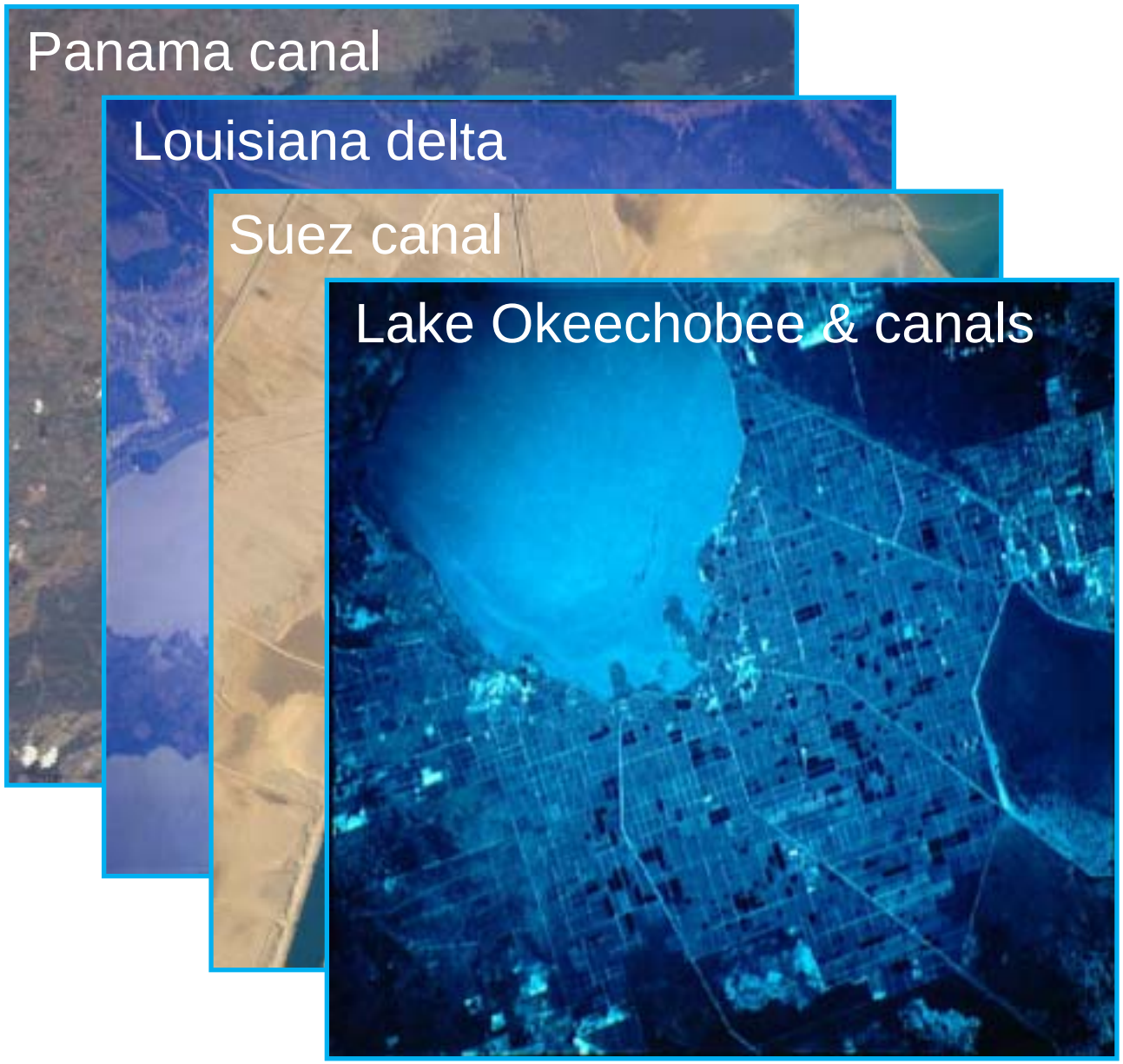
Canals:

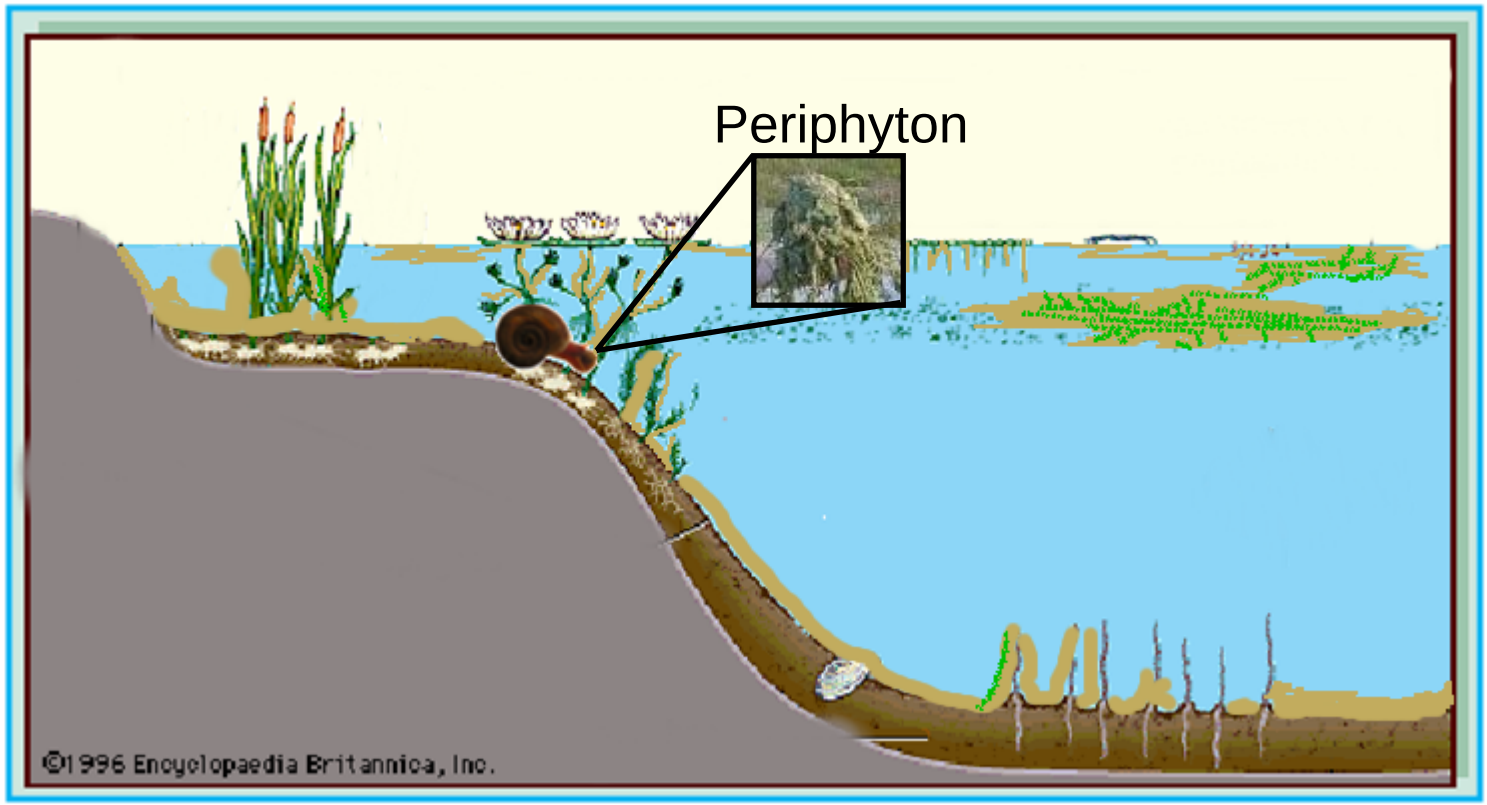

Panama canal
Louisiana delta
Suez canal
Lake Okeechobee & canals

Canal effects

- Predator and nutrient gradients are correlated
  - Near Canal: More nutrients &
    More predators
  - Far from Canal: Fewer nutrients &
    Fewer predators

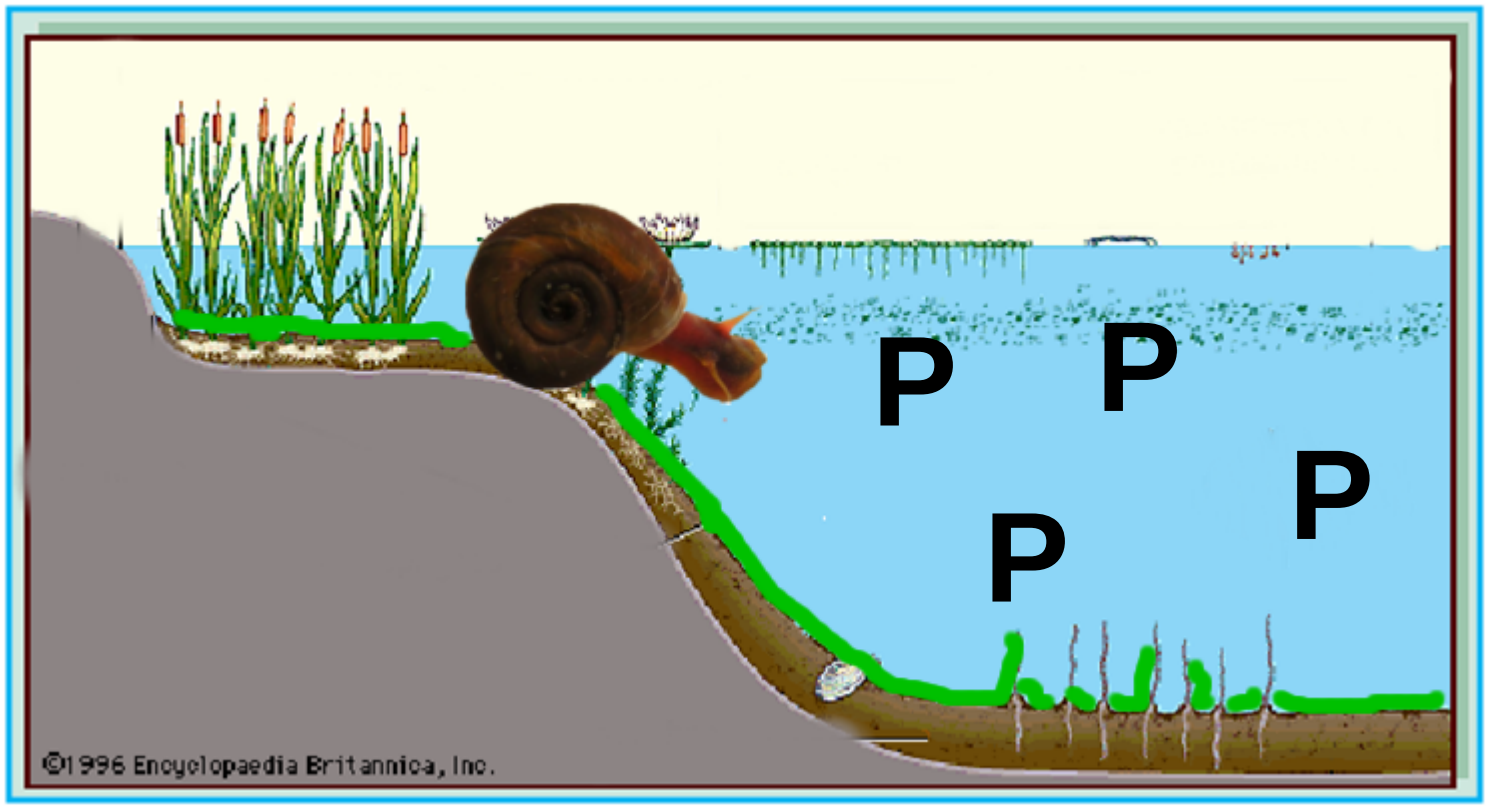
Nutrient effects:

- Thick floating and benthic periphyton mats
- Snails eat periphyton



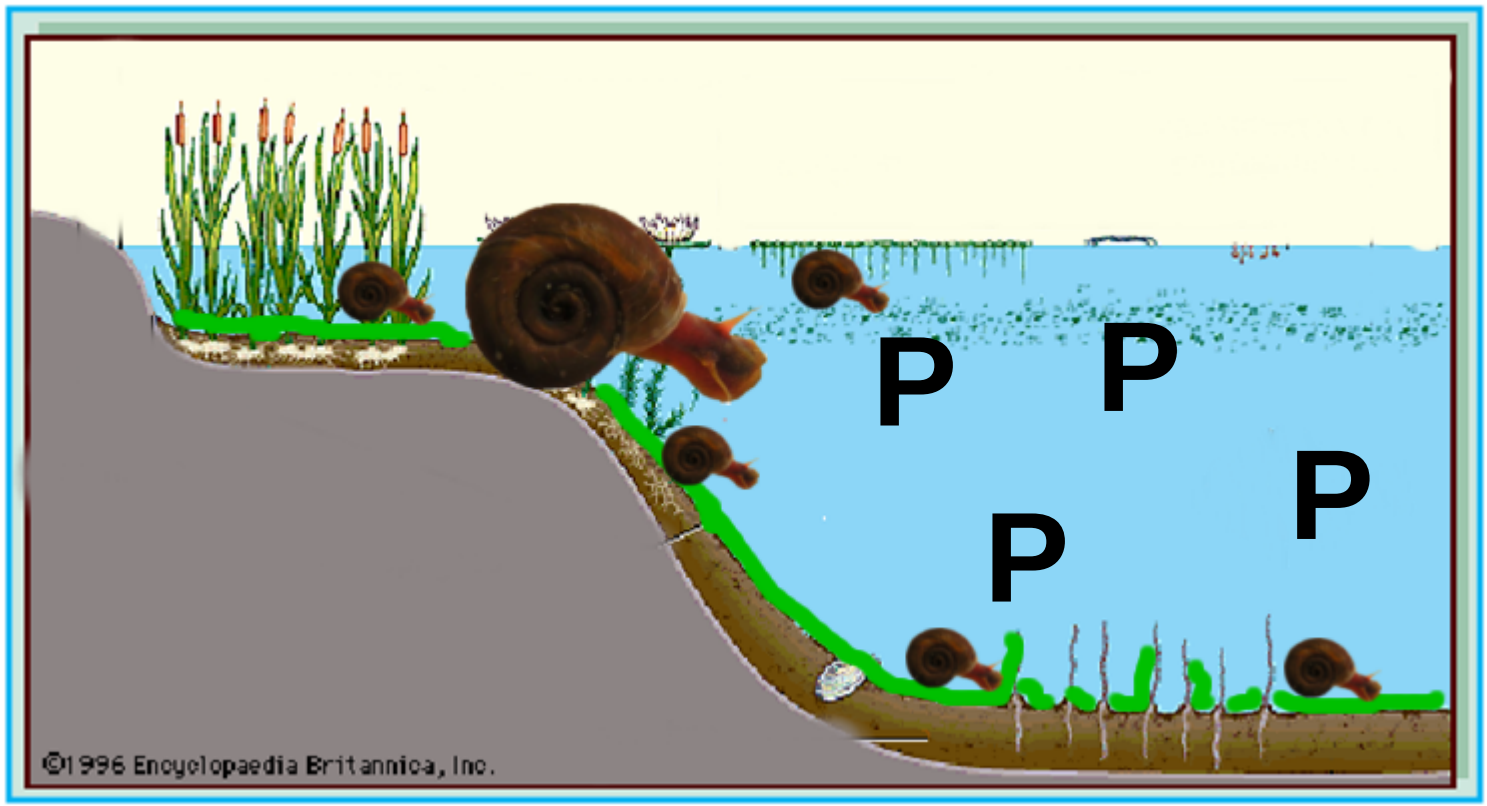
Nutrient effects:

Moderate phosphorous enrichment produces faster growing snails

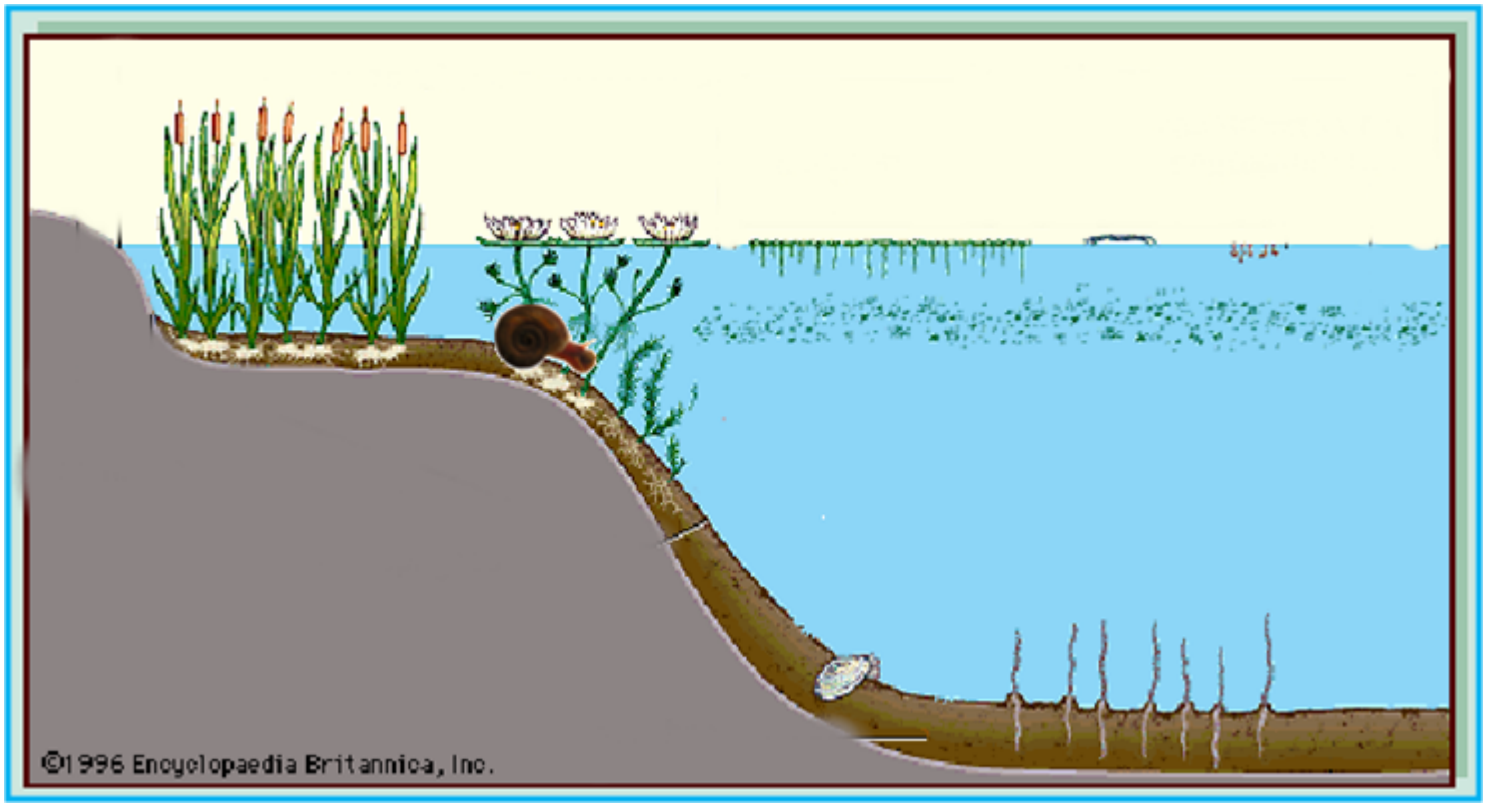


Nutrient effects:

Moderate phosphorous enrichment produces more snails

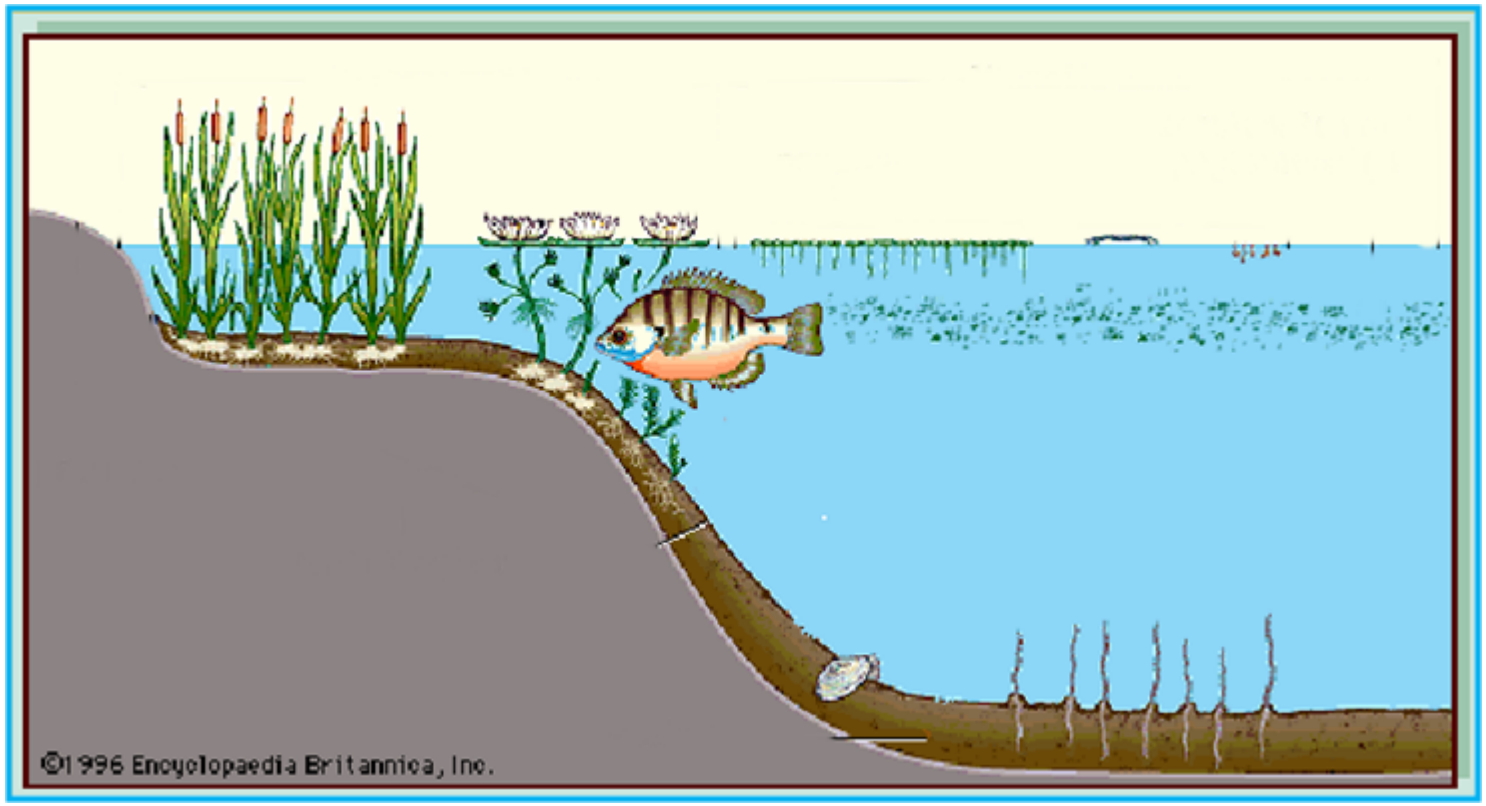


Predator effects:

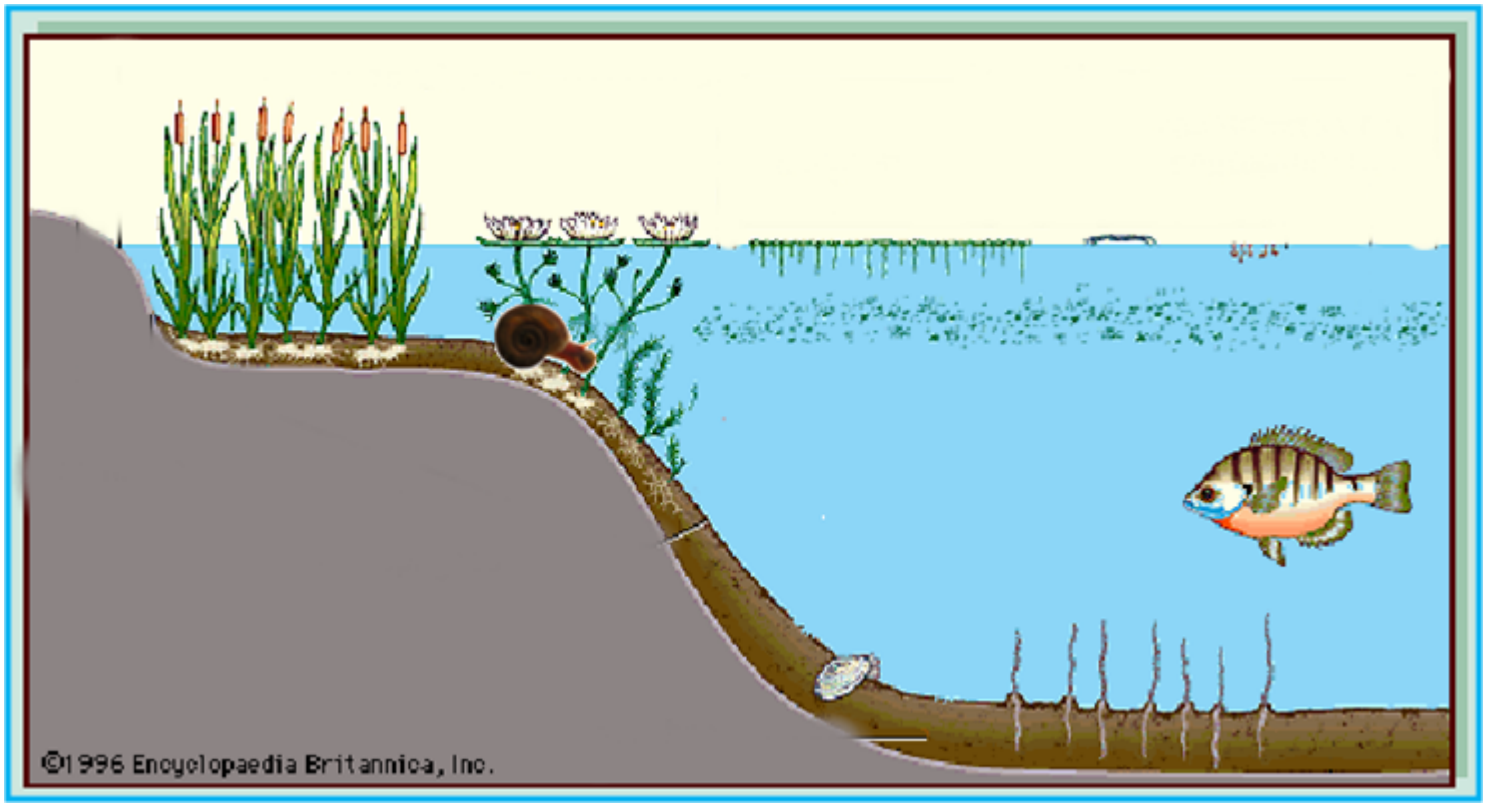


Predator effects:

One individual eats another

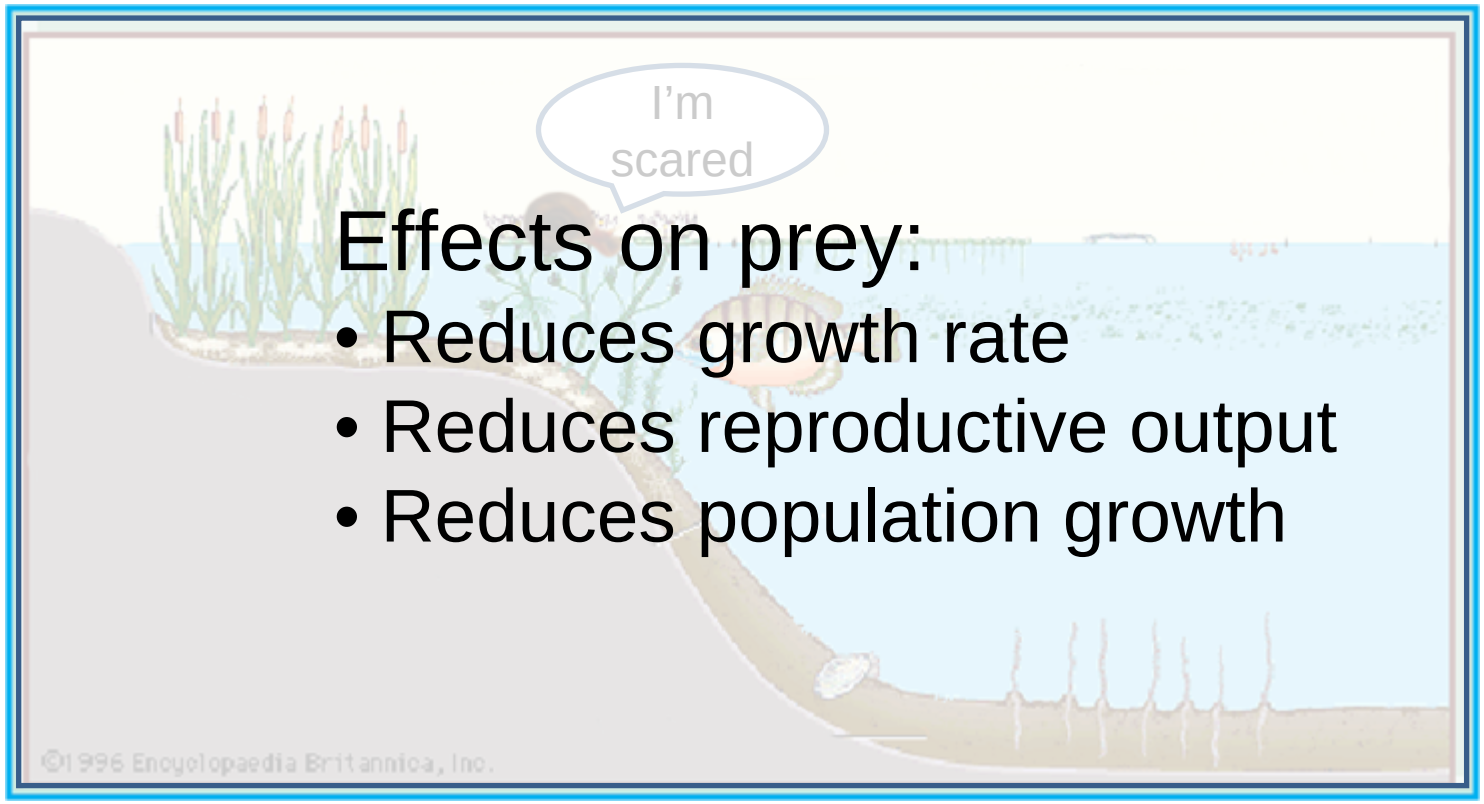


Predator effects:

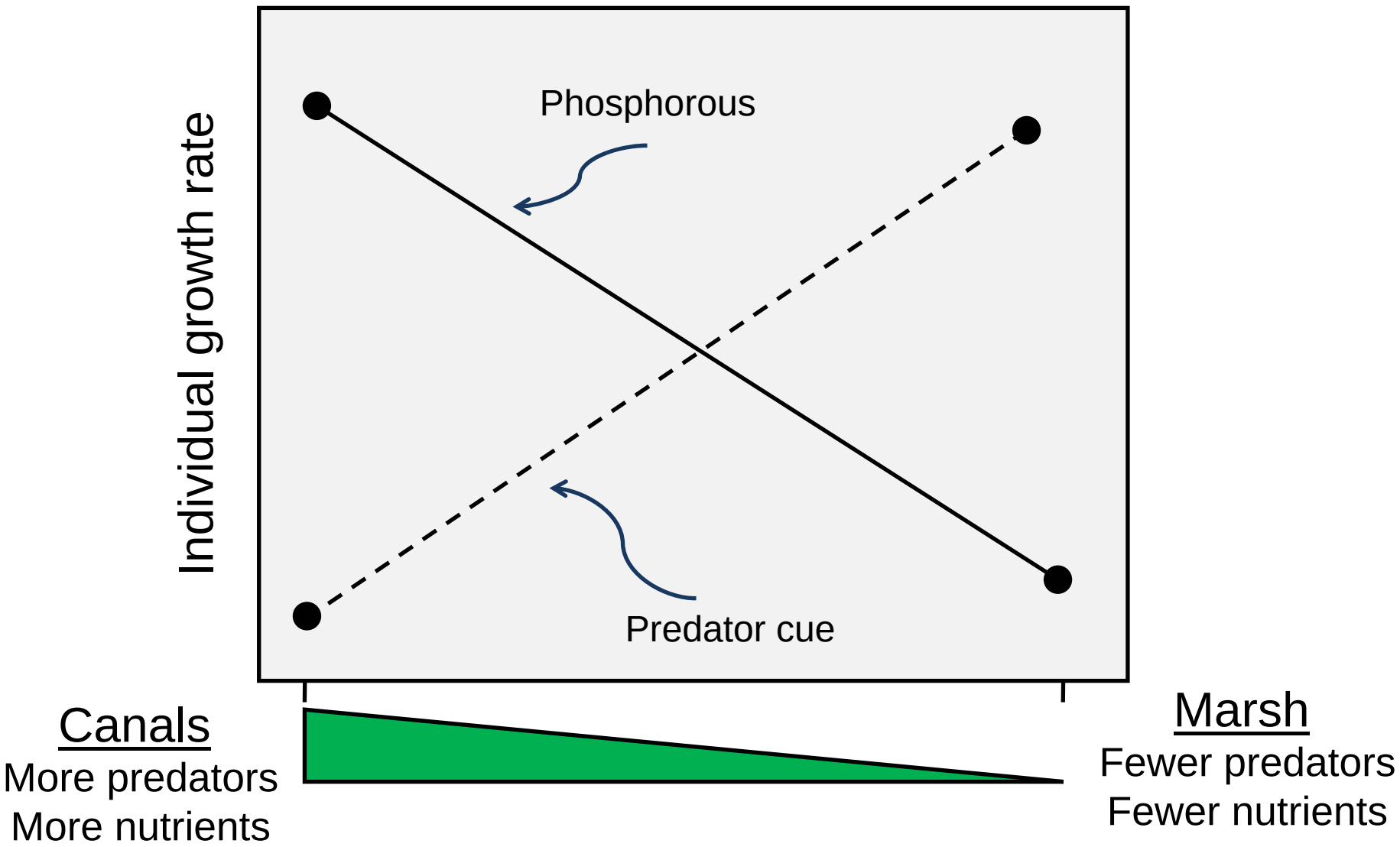


Predator effects:

Predator cues causing a shift in behavior



Trade-offs Confound



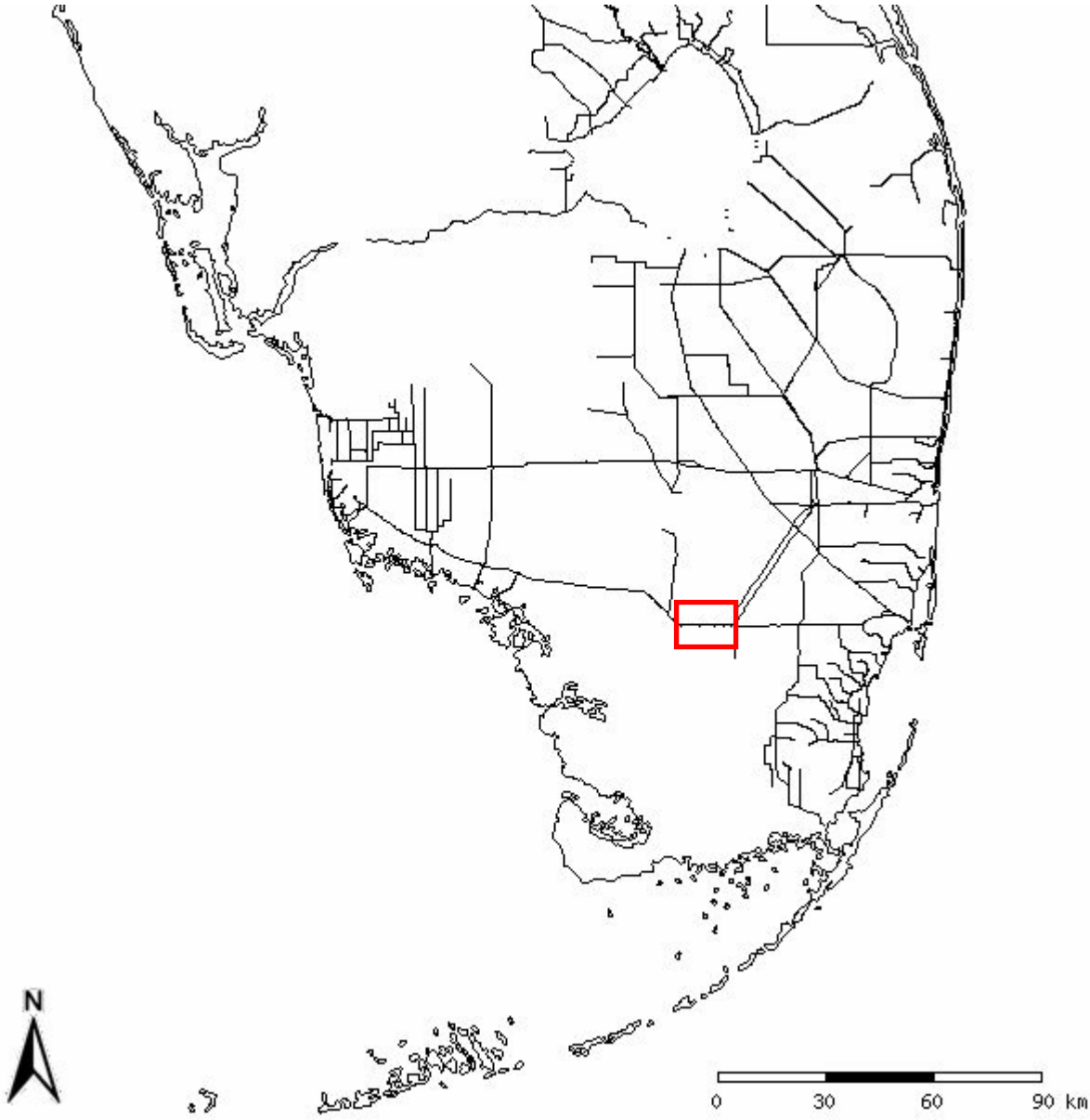
Questions & Goals

o Characterize aquatic communities near and far from the canal during the experiment?

o How do differences alter snail growth and reproduction near and far from the canal?

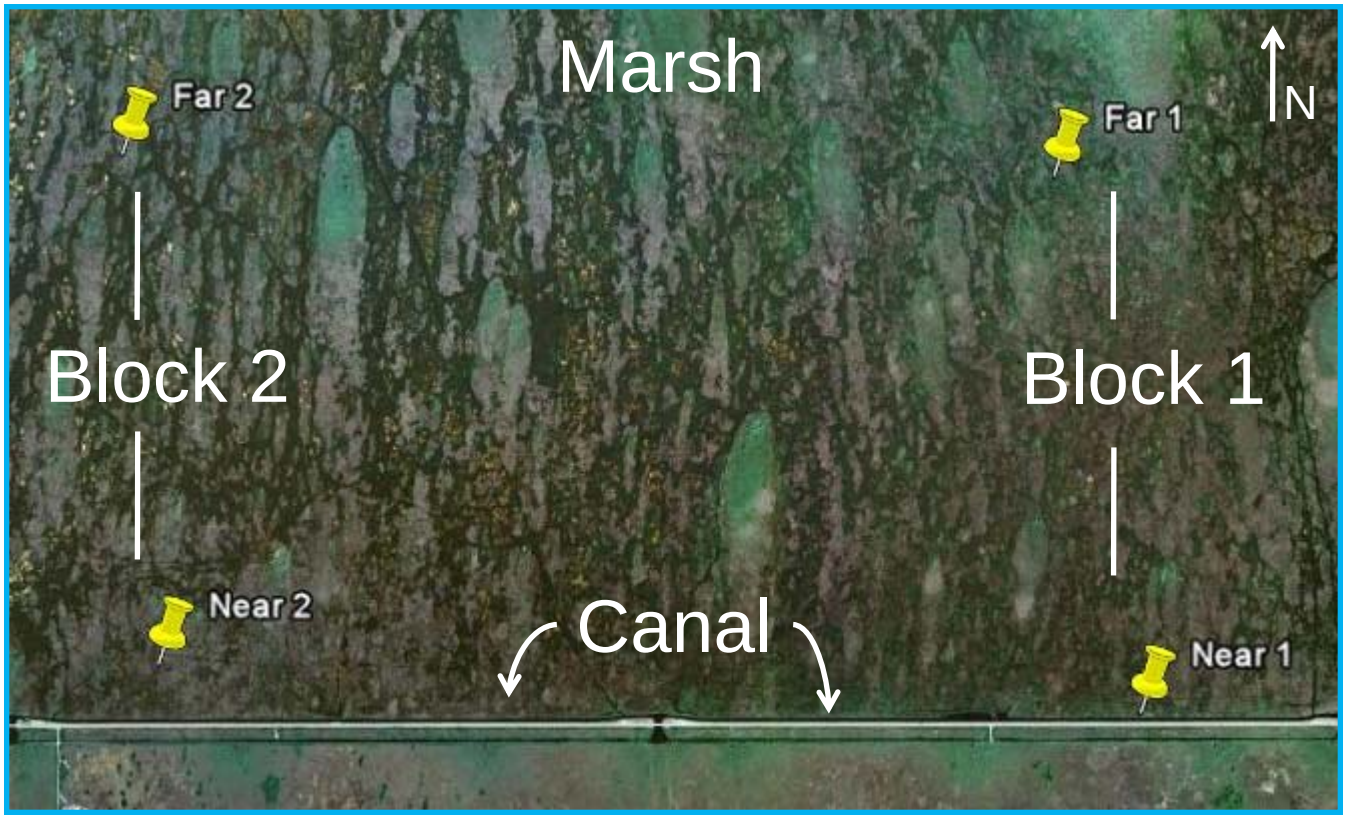
o Why are these findings important?

The Everglades



Experimental Sites

- 2 sites near & 2 sites far from a canal in 2 blocks



Aquatic Community Characterization

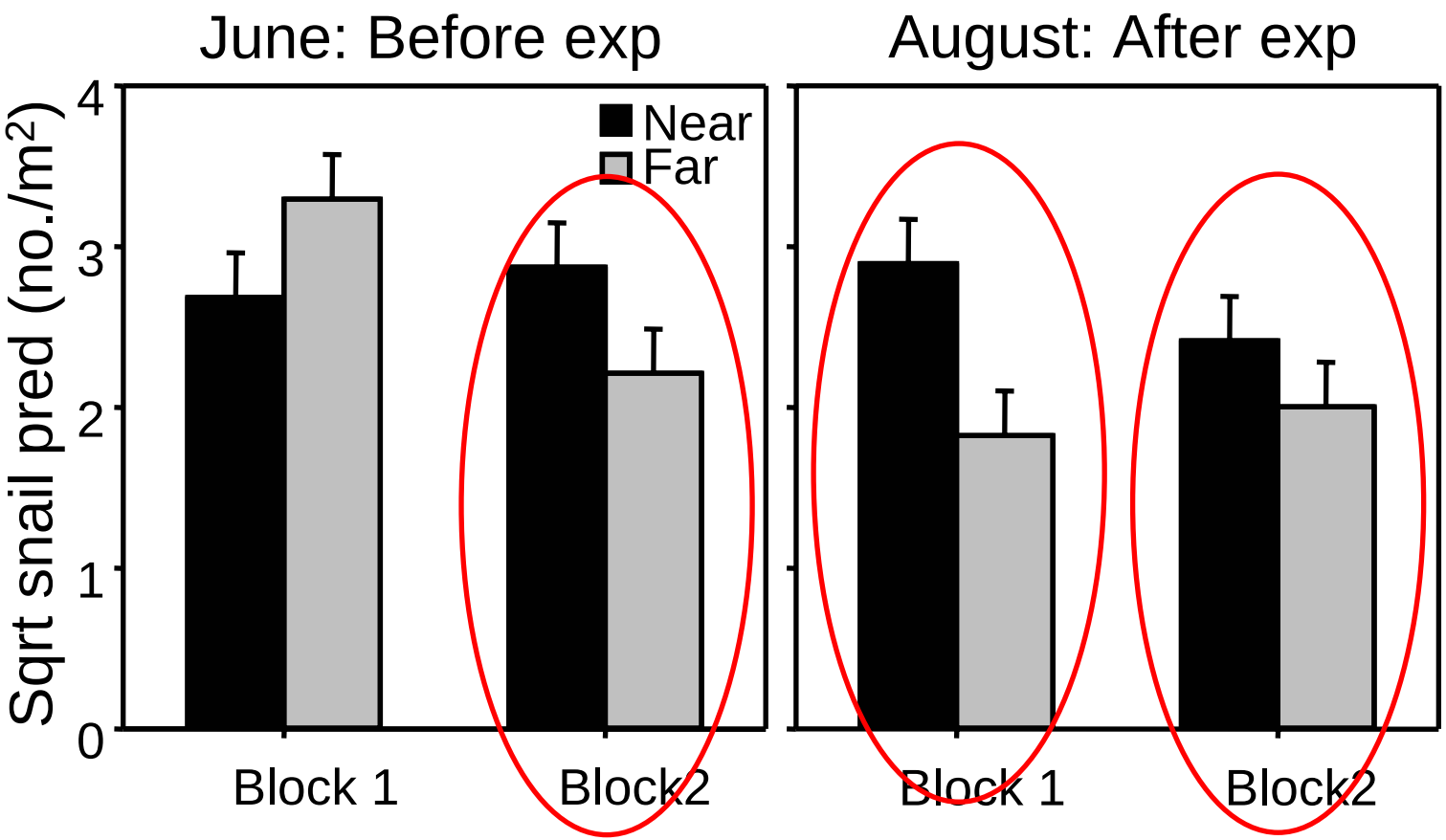
o 2 sites near & 2 sites far from a canal in 2 blocks

o Before and after the experiment at each site:

- Seven $1m^2$ throw traps
  - Small fish & invertebrate abundance
  - Periphyton volume
  - Summed all snail predators

Aquatic Community Characterization

o Generally more snail predators near canal



Aquatic Community Characterization

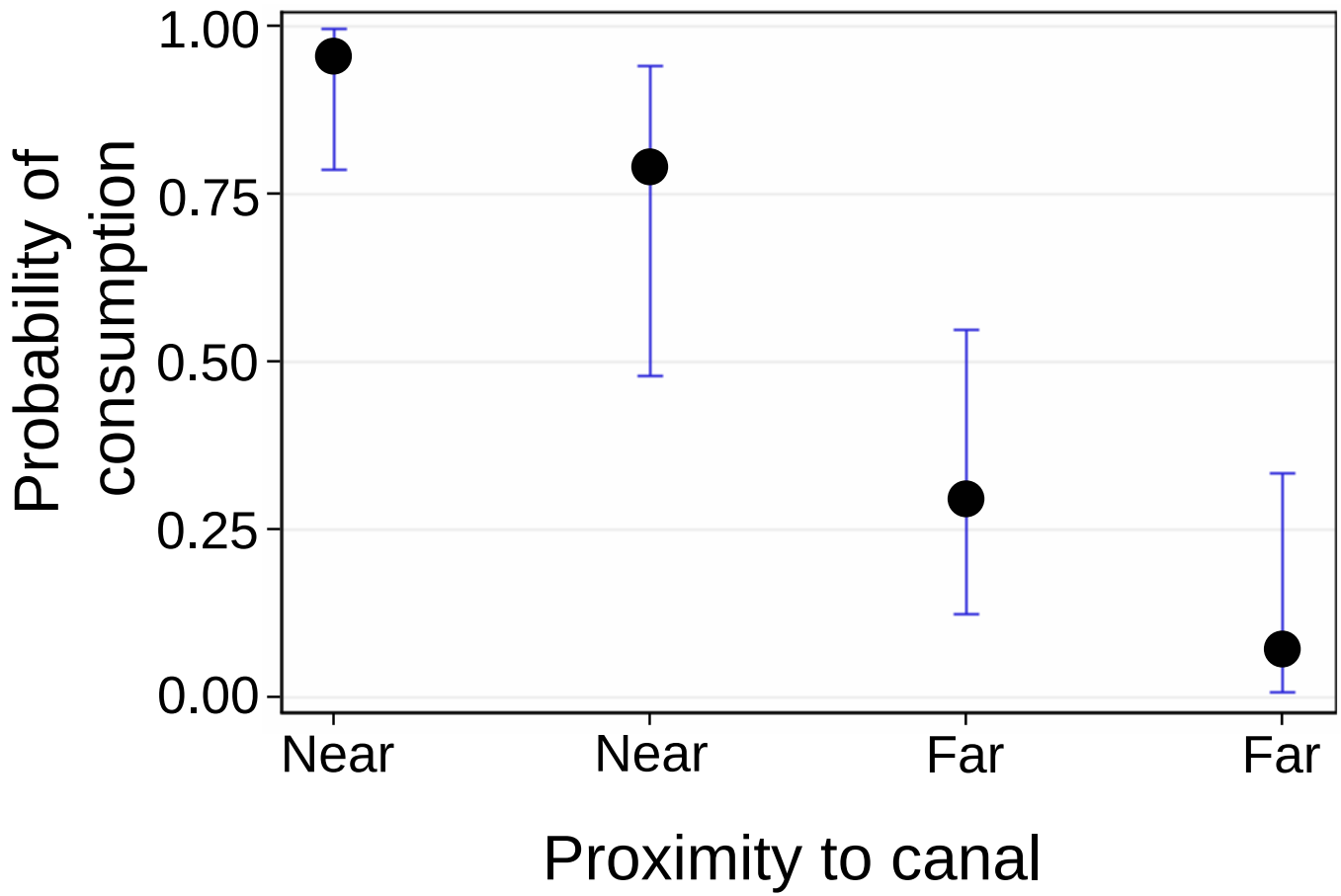
o 2 sites near & 2 sites far from a canal in 2 blocks

o Before and after the experiment at each site:

- Seven $1m^2$ throw traps
  - Small fish & invertebrate abundance
  - Periphyton volume
- Twenty tethered snails & controls
  - PVC tethers spaced 3-m apart
  - 20 snails/site attached to 1 m of 6 # line with super glue
  - 4 snails tethered inside control cage

Tethering Near and Far

- More predation near the canal
- Equals more predator cues



Aquatic Community Characterization

- o 2 sites near & 2 sites far from a canal in 2 blocks
- o Before and after the experiment at each site:
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  - • Twenty tethered snails & controls
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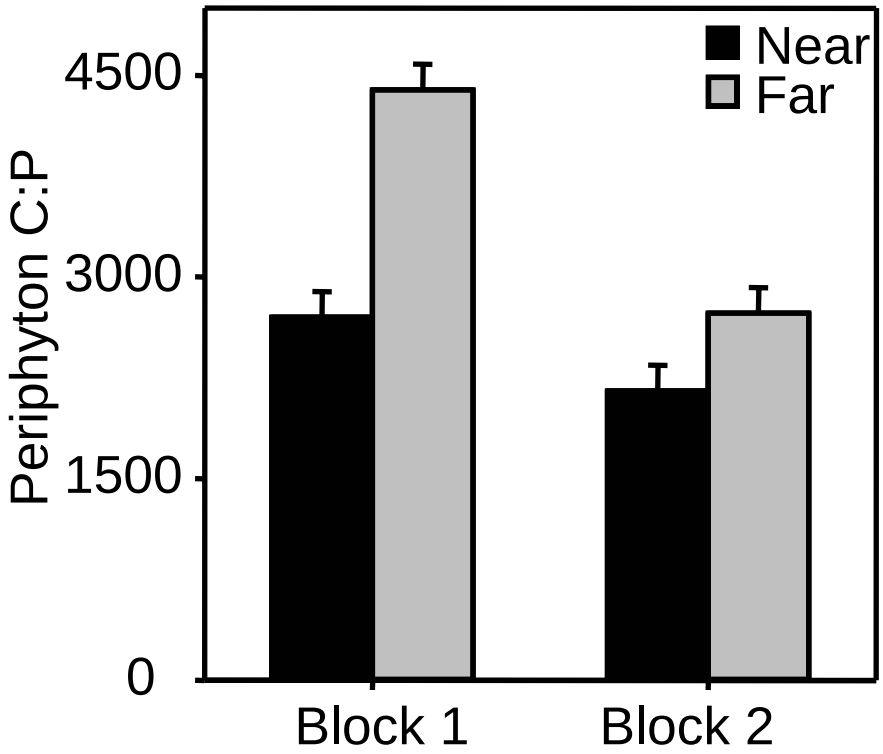
    - - 20 snails/site attached to 1 m of 6 # line with super glue
    - - 4 snails tethered inside control cage
- o Before, during, and after the experiment at each site:
  - • Collected periphyton

C:P Ratio Near and Far

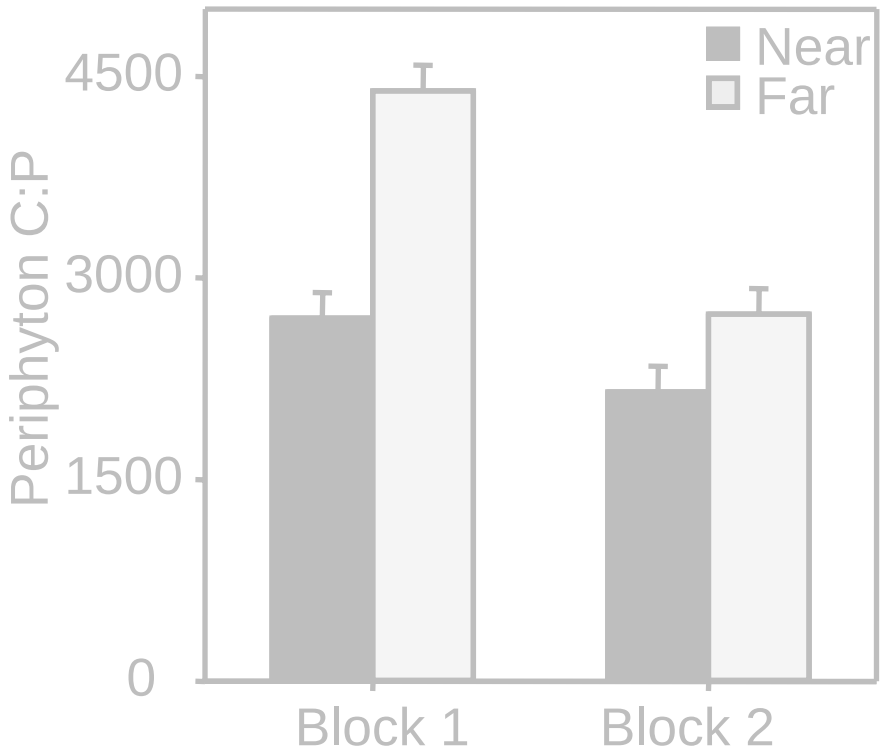
o C:P ratio for periphyton was lower near the canal



$F_{3, 13} = 26.1$; $P = < 0.001$

C:P Ratio Near and Far

- C:P ratio for periphyton was lower near the canal
- Chlorophyll-*a* in periphyton was higher near the canal



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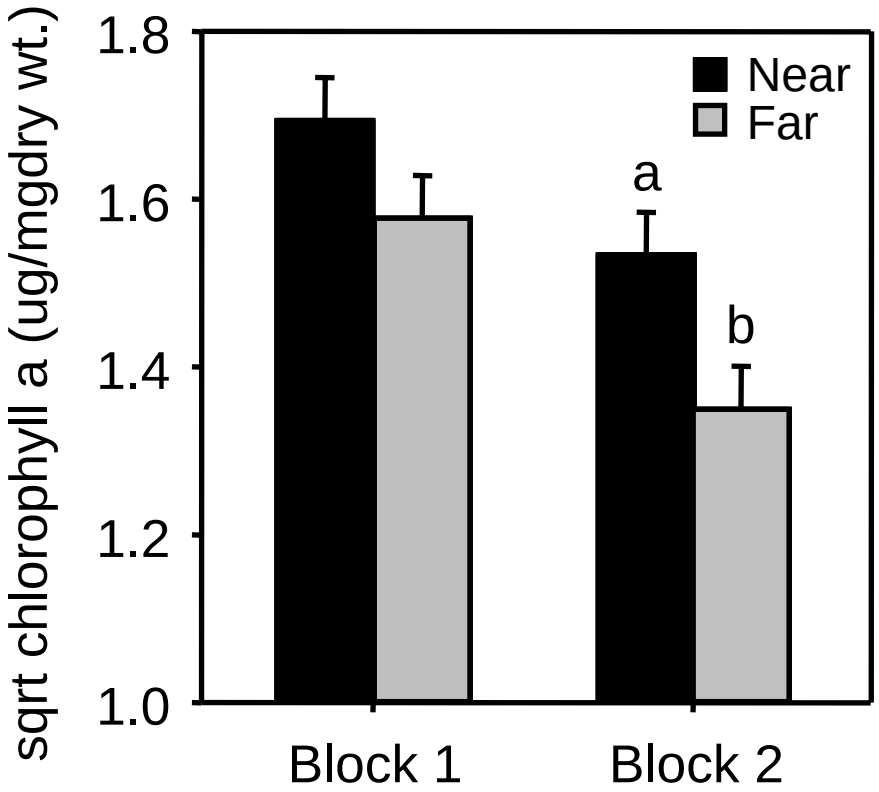
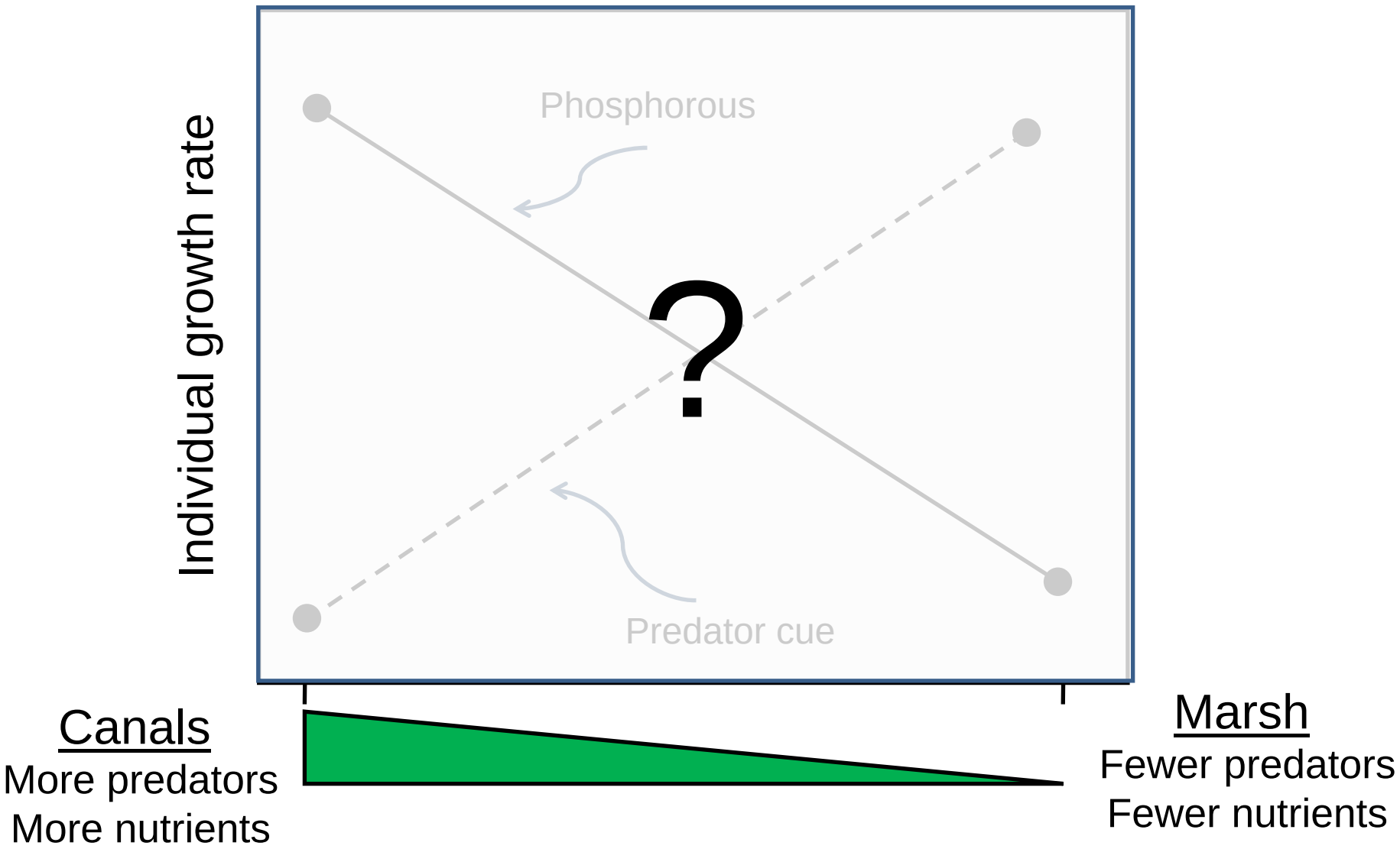


$F_{2, 24} = 8.60$; $P = 0.0005$

Trade-offs Confound



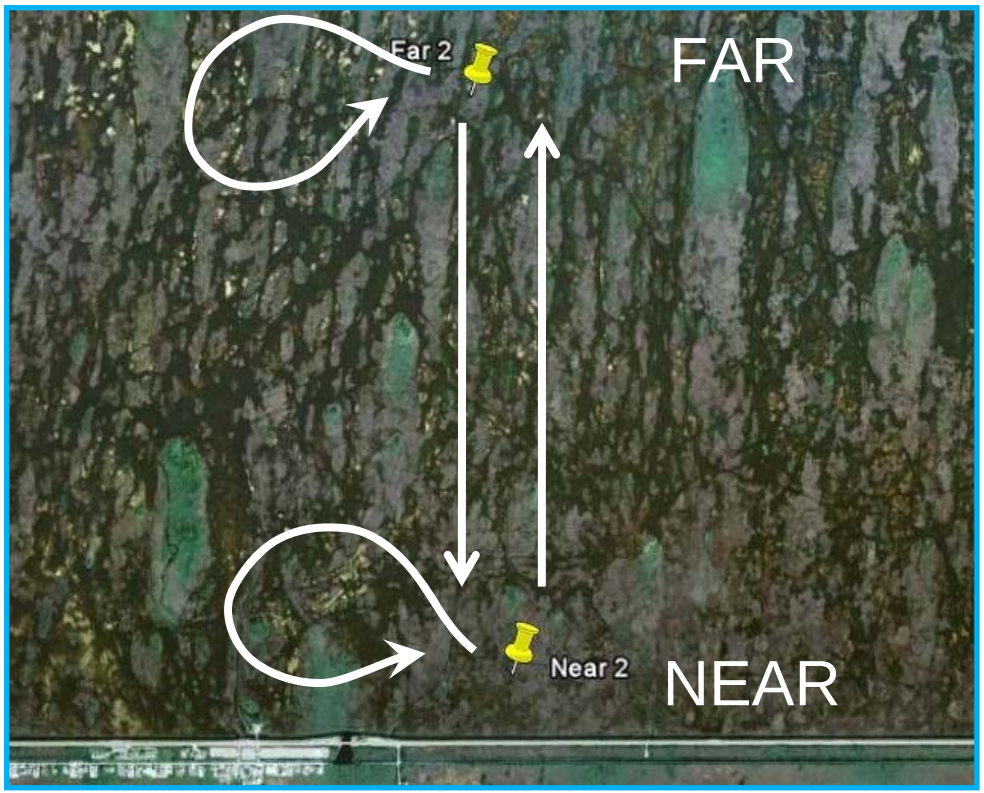
Reciprocal Transplant Experiment

Reciprocal Transplant Experiment

- Snails: Present or Absent

Reciprocal Transplant Experiment

- Added local periphyton to bags
- Transported periphyton between sites



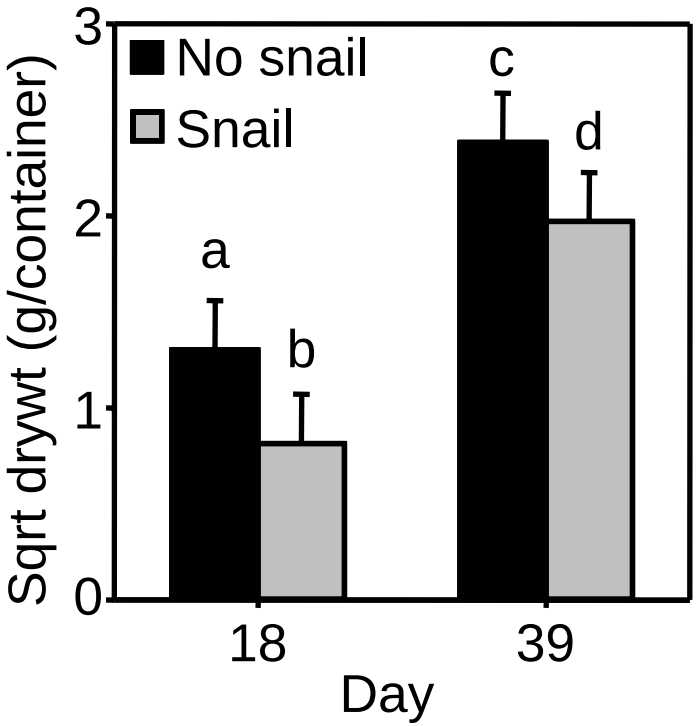
Reciprocal Transplant Experiment

- Experiment ran for 39 days
- Measured snail growth on day 18 and day 39
- Sampled periphyton from bags on 18 & 39 d

RESULTS

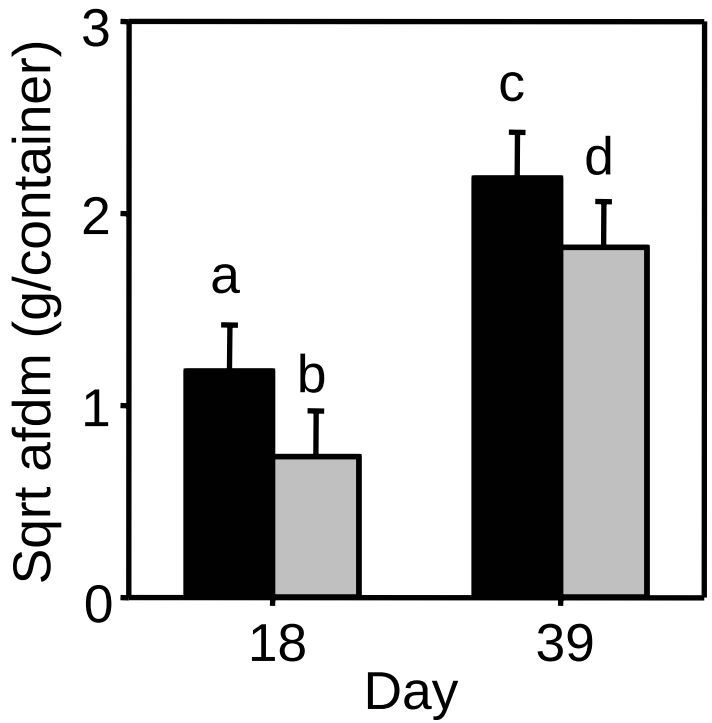
Periphyton Consumption

o Snails reduced periphyton during the experiment



Snail grazing:

$F_{1, 30.2} = 23.1$; $P < 0.0001$



Snail grazing:

$F_{1, 30.1} = 21.8$; $P < 0.0001$

Snail biomass through time

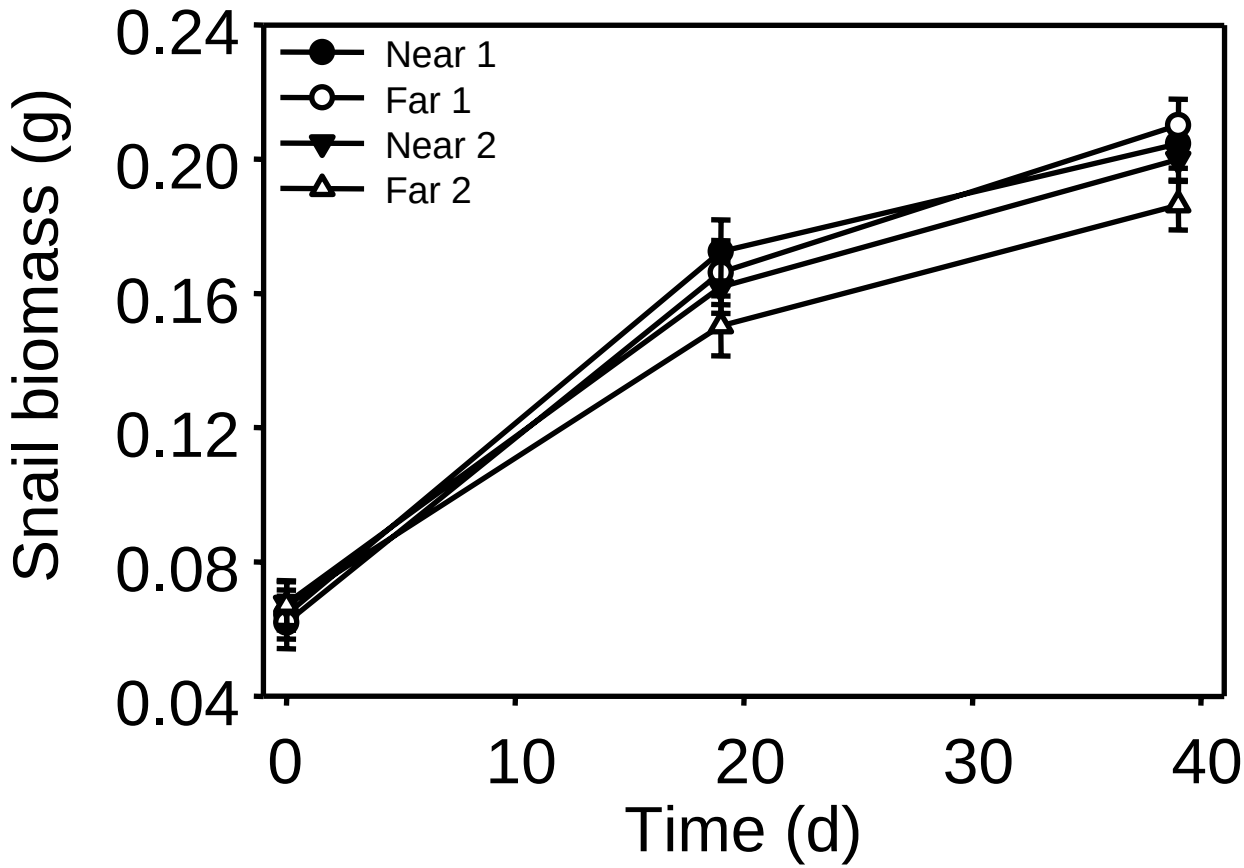
o Repeated measures analysis of variance

Snail biomass

Within subjects	Effect	F	P
	Day	154.8	< 0.0001
	Day × site	0.4	0.9
	Day × Peri origin	1.2	0.3
	Day × Site × Peri origin	0.8	0.6
Between subjects	Site	1.1	0.4
	Peri Origin	1	0.3
	Site × Peri origin	3.5	0.03

Snail biomass through time

o Snails had similar growth at sites near and far from the canal.



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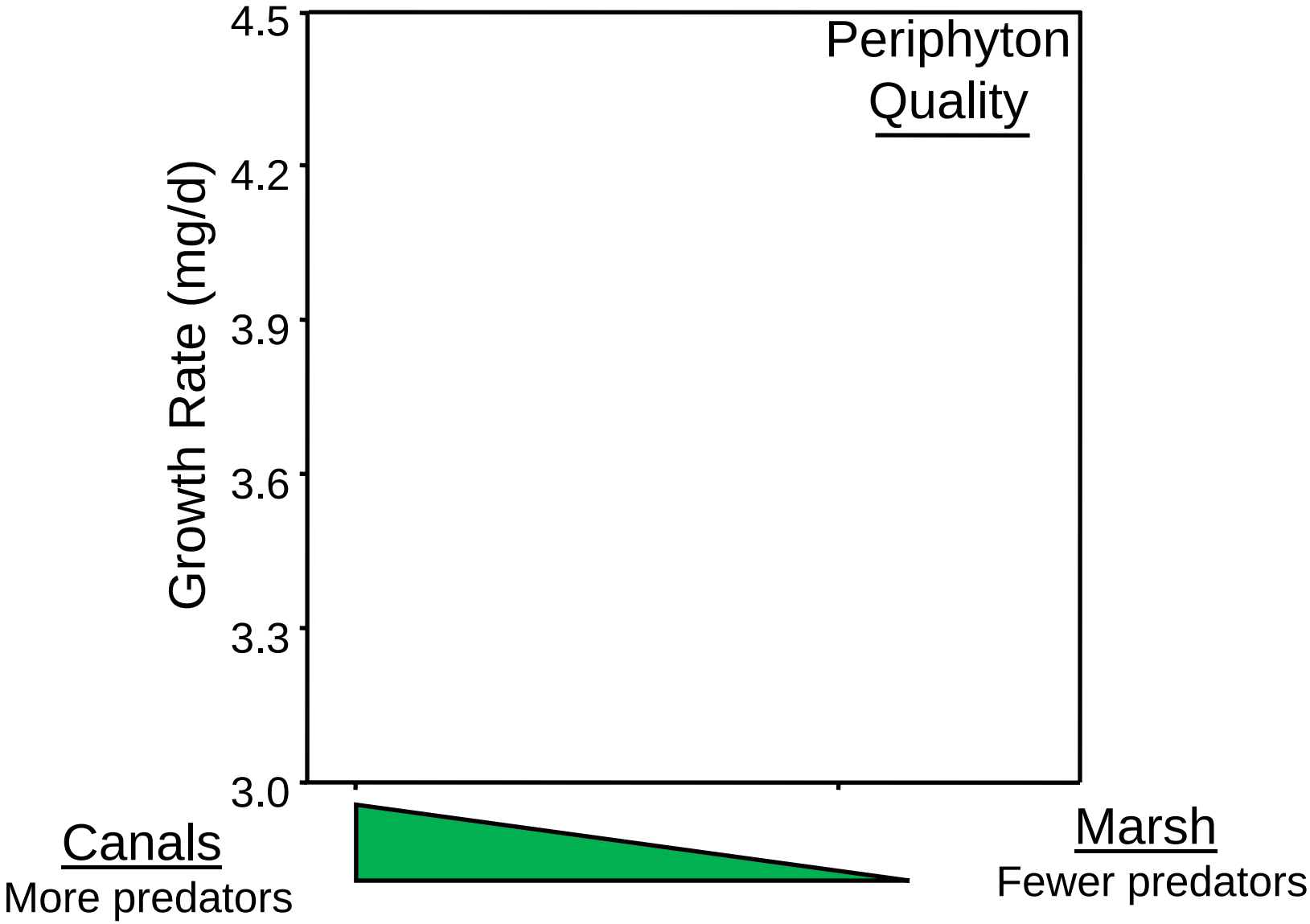
Snail biomass near and far

o Far sites + Near periphyton = Fastest Growth



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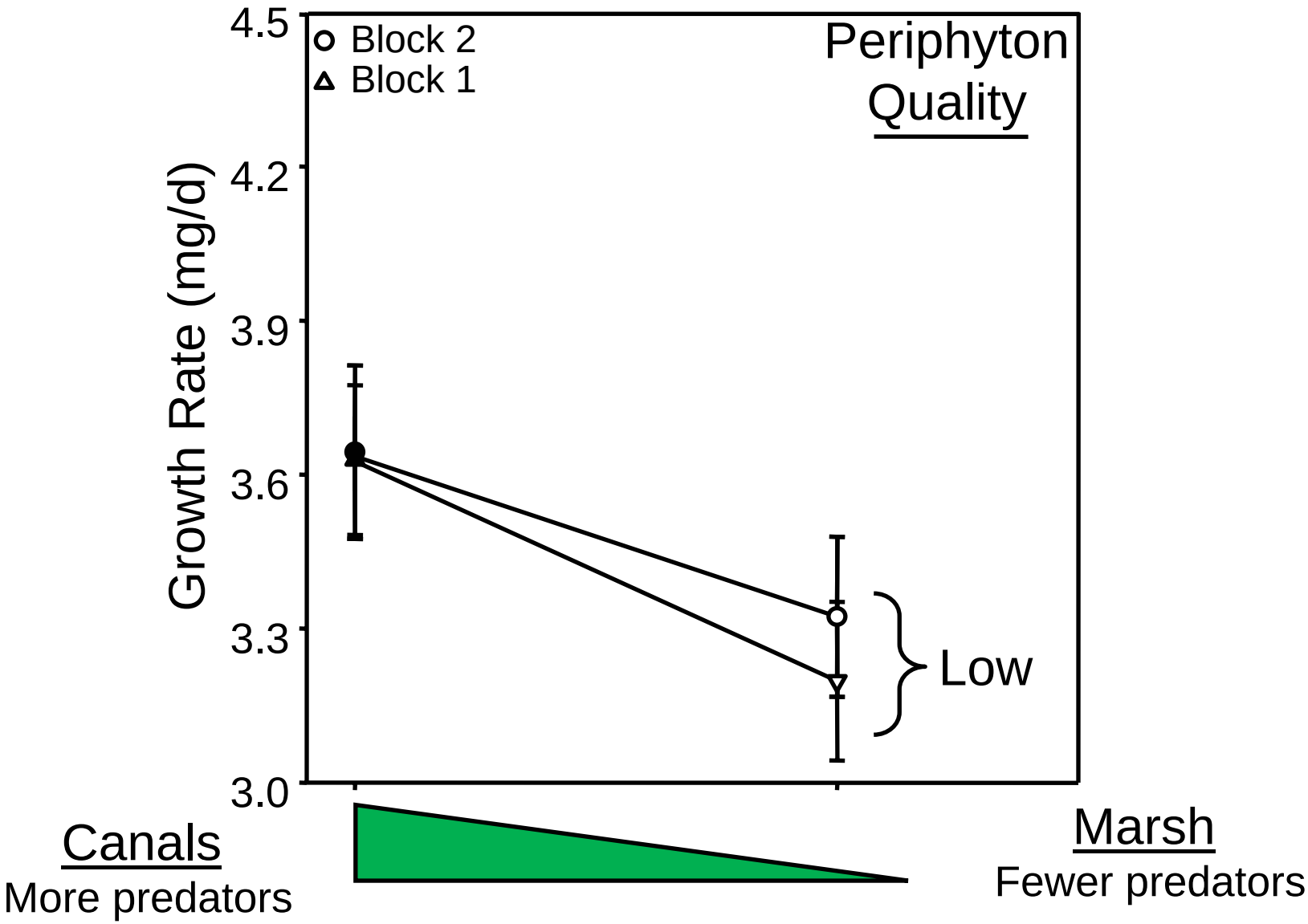

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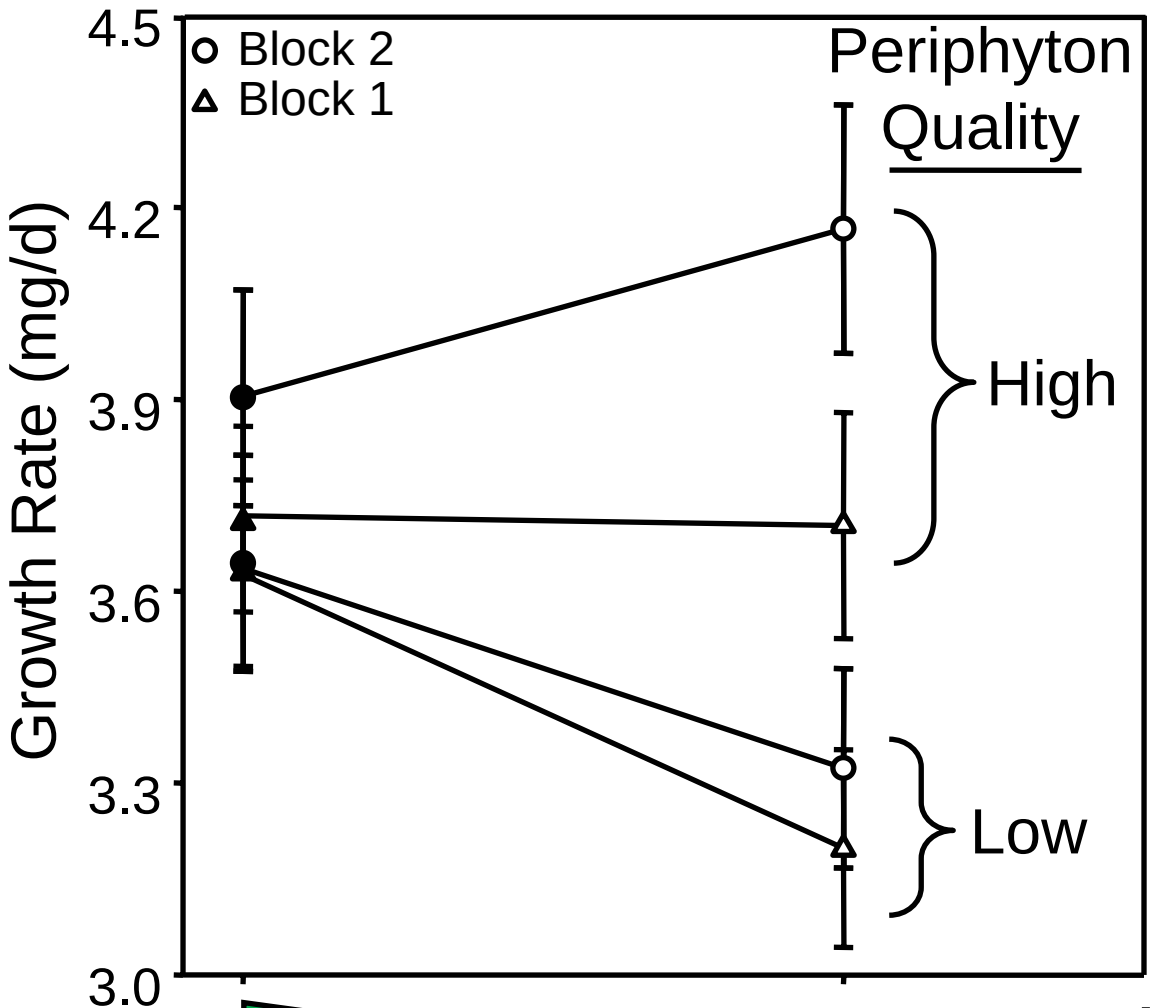
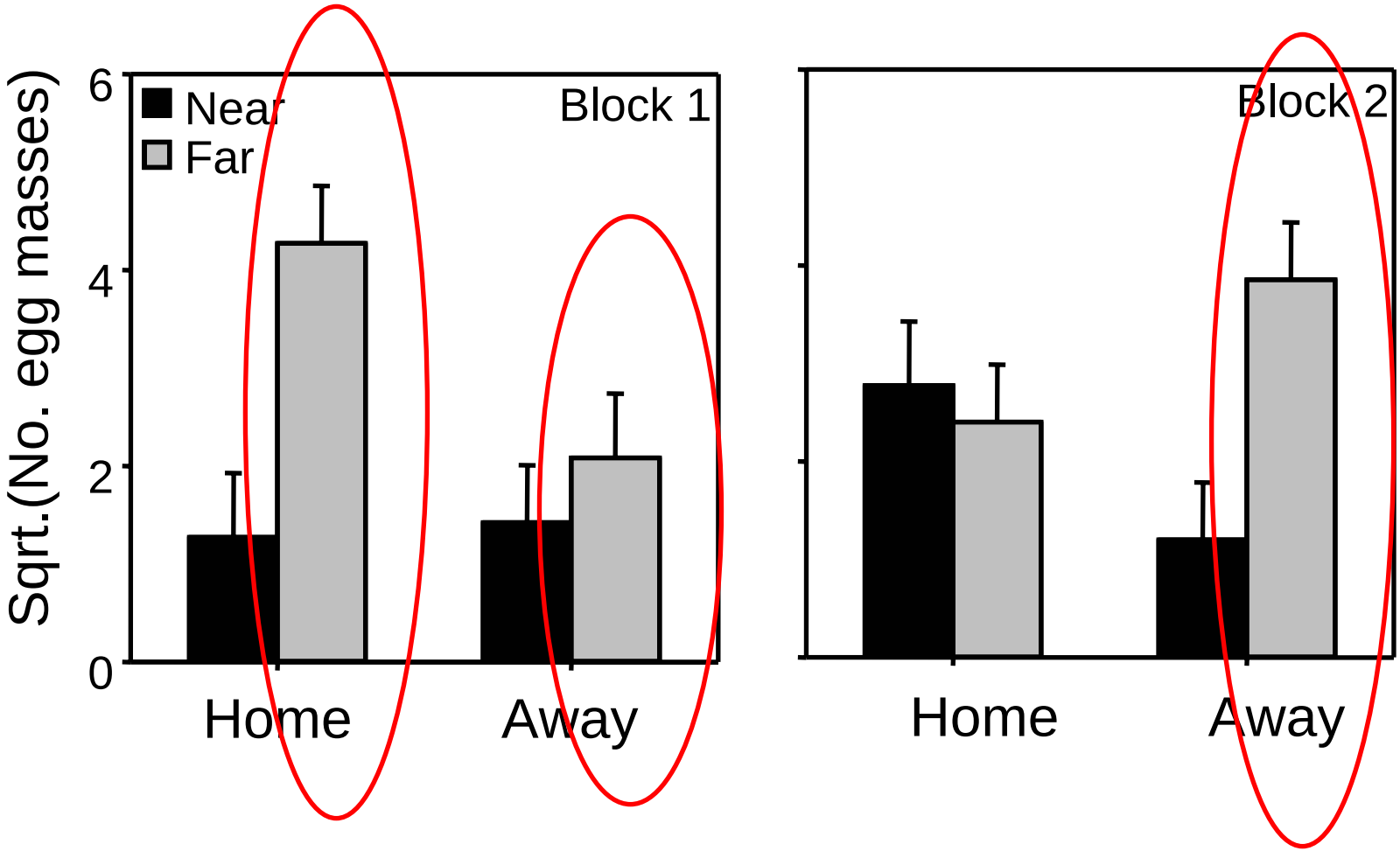


Canals
More predators

Marsh
Fewer predators

Snail reproduction near and far

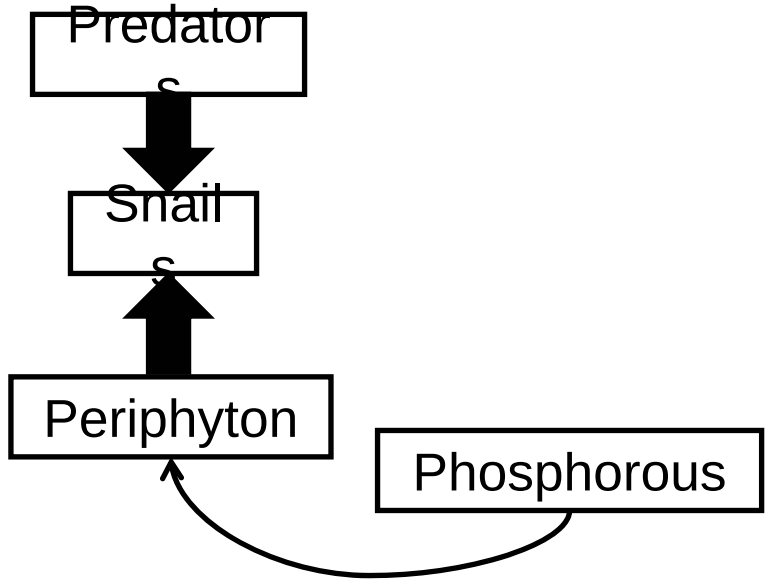
- More reproduction at far sites



Summary

Near =

High resource quality
+
More Predators



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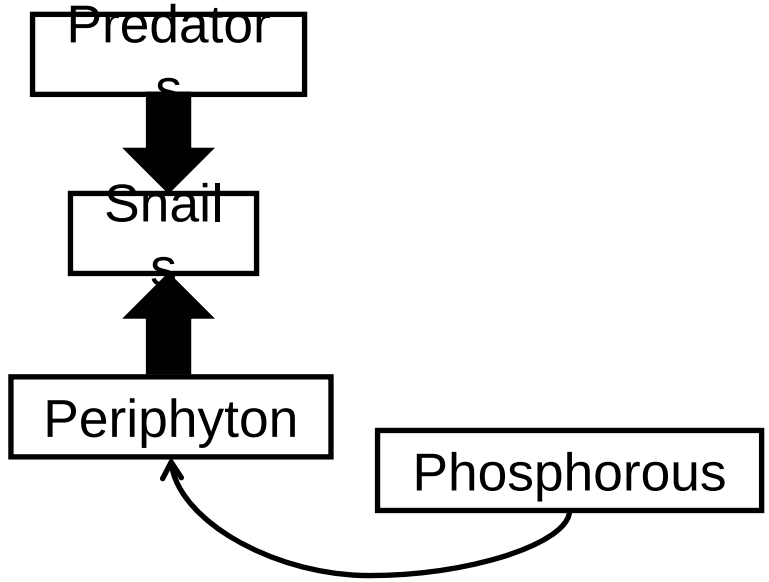
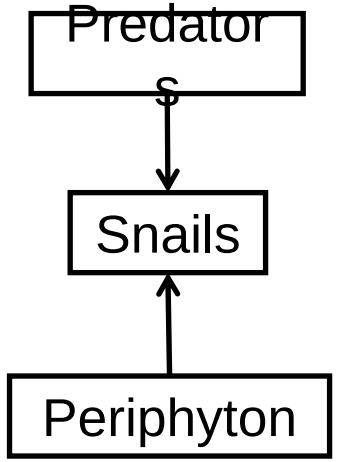


Far =

Low resource quality
+
Fewer Predators



Questions & Goals

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o Why are these findings important?

Separating the effects

- Separating these effects leads to better understanding of biotic and abiotic drivers

- Understanding components of the net effect leads to better forecasting of future environmental change

- Separating effects with experiments can aide interpretation of monitoring data

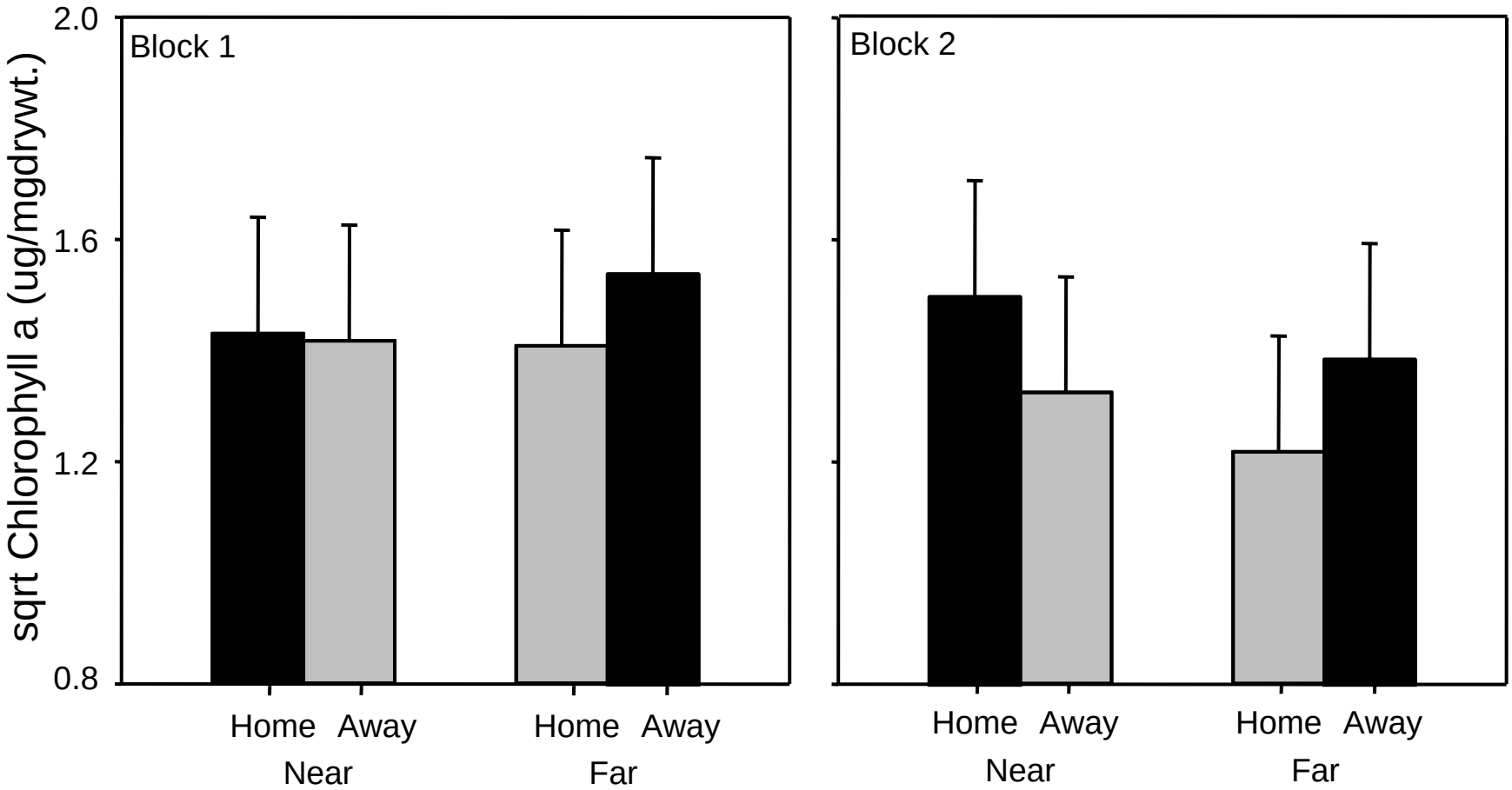
Acknowledgements & Questions

- Trexler lab
- Evelyn Gaiser
- Gaiser lab
- Lisa Jiang
- Adam Obaza
- Liz Huselid
- Liz Harrison

Resource quality across Space & Time

Within subjects	Effects	DF	F	P
	Day	1, 60	54.5	<.0001
	Day × Site	3, 60	0.4	0.73
	Day × Snail	1, 60	2.8	0.10
	Day × RT	1, 60	0.7	0.40
	Day × Site × Snail	3, 60	0.8	0.50
	Day × Site × RT	3, 60	2.0	0.12
	Day × Snail × RT	1, 60	0.5	0.50
	Day × Site × Snail × RT	3, 60	0.4	0.74
Between subjects				
	Site	3, 60	2.0	0.12
	Snail	1, 60	39.4	<.0001
	Recip. Trans (RT)	1, 60	0.5	0.49
	Site × Snail	3, 60	0.4	0.78
	Site × RT	3, 60	4.4	0.01
	Snail × RT	1, 60	0.0	0.93
	Site × Snail × RT	3, 60	1.4	0.25

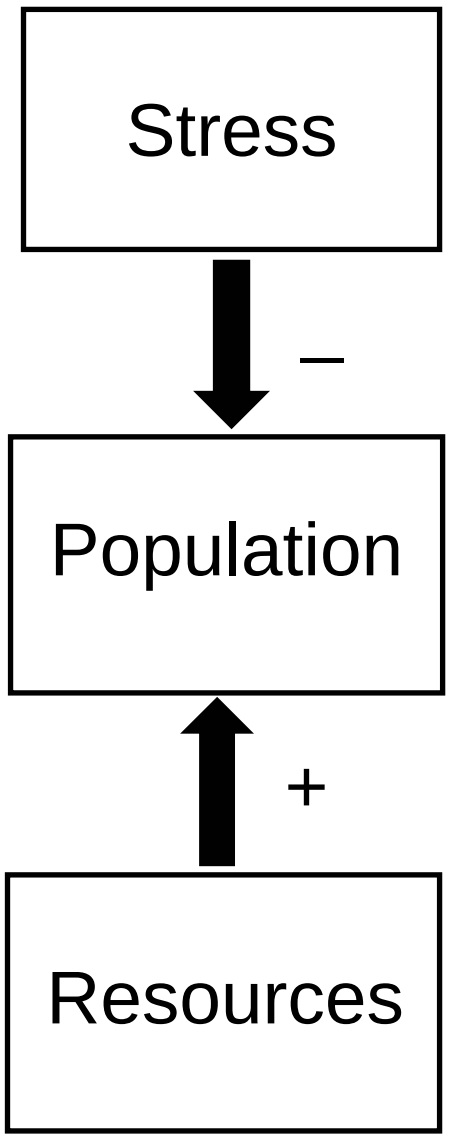
Resource quality across sites



Separating the effects

Human modifications

- Simplified food web
- Survey multiple ecosystems
- Manipulation experiments
  - Add/Remove stress
  - Add resources
- Reciprocal transplant experiments



Summary

o Community composition was different near compared to far from the canal

o Periphyton was more nutritious near compared to far from the canal

o Snails grew fastest on periphyton that originated near but placed far from the canal.

o Snail produced more egg masses far from the canal

The Everglades

o Characterizing anthropogenic effects

Marshes

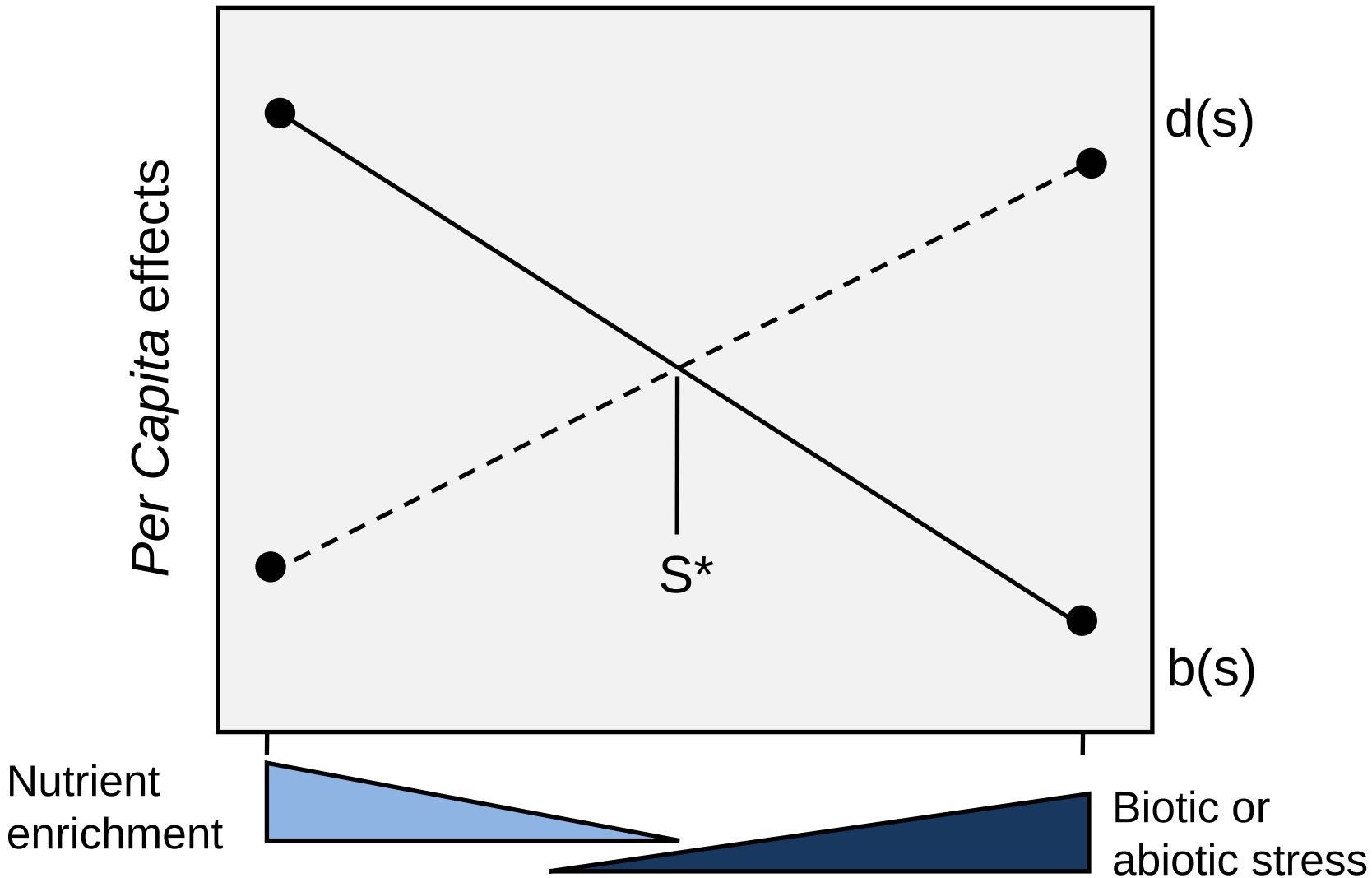
- Lower Phosphorus (P) & contaminants
- Fewer small consumers & macroinvertebrates

Canals

- Higher P & contaminants
- More small consumers & macroinvertebrates
- Refuge for large predators

Rehage & Trexler 2008; Gaiser et al. 2005; Perry 2004; Turner et al. 1999

Anthropogenic Effects

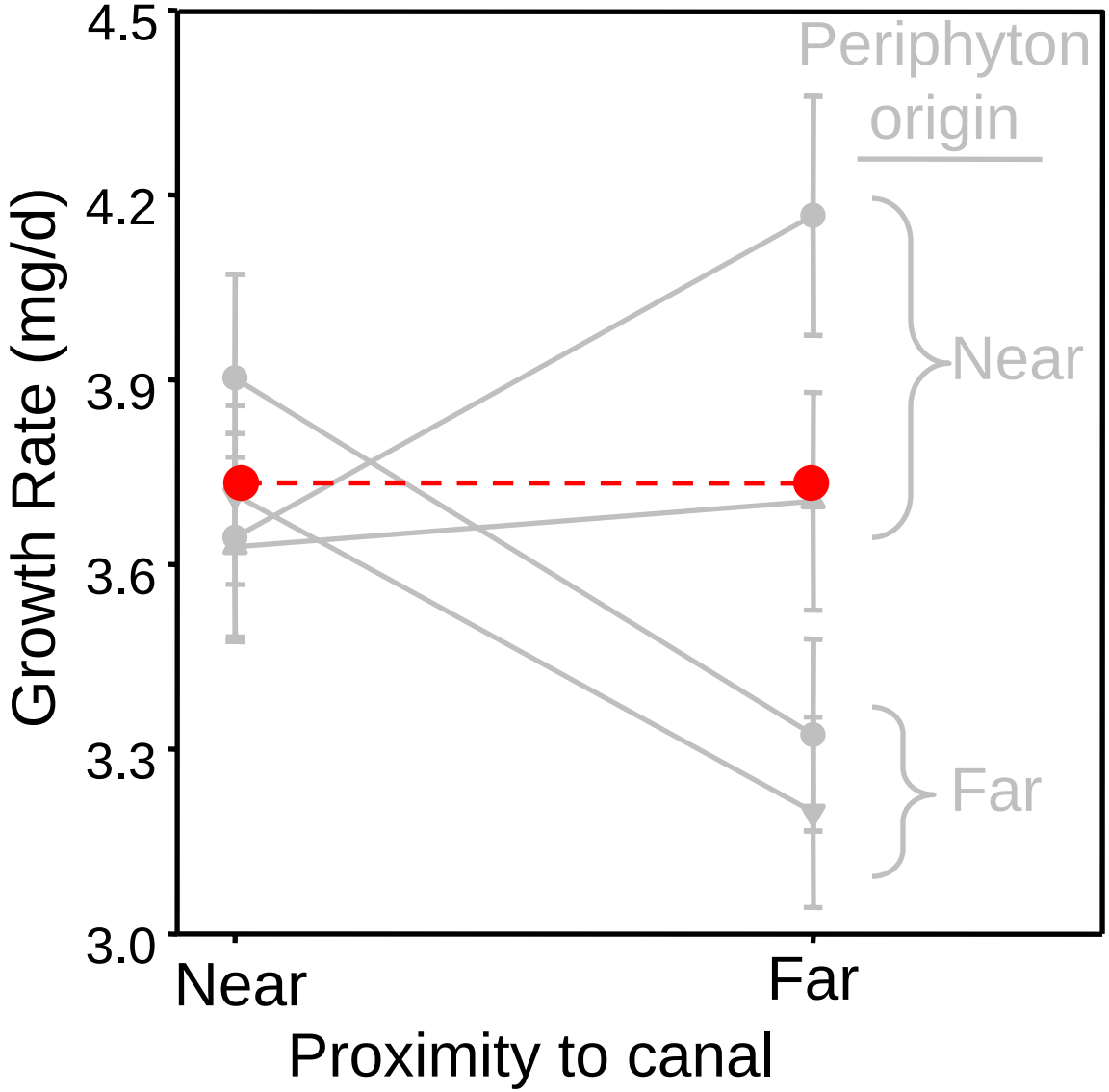


Adapted from Chase and Leibold 2003

Summary

Near = High nutrients + High biotic

Far = Low nutrients + Low biotic



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