6-28-2017

# Intraspecific Variation and Ecosystem Function: Implications for more effective Post-Restoration Monitoring

Donald J. Benkendorf
*Utah State University*, donald.benkendorf@aggiemail.usu.edu

Howard H. Whiteman
*Murray State University*

# Intraspecific Variation and Ecosystem Function: Implications for more Effective Post-Restoration Monitoring

Donald Benkendorf
and Dr. Howard Whiteman

contact info:
dbenkendorf@murraystate.edu

# Why Incorporate Community Ecological Theory in Stream Restoration Monitoring?

- Leads to more accurate predictions regarding restoration effectiveness

  -Which Leads to more robust and meaningful post restoration assessment

*"The science of restoration ecology is so intertwined with basic ecological theory that practical restoration efforts should rely heavily on what is known from theoretical and empirical research on how communities develop and are structured over time." – Palmer et al. 1997*

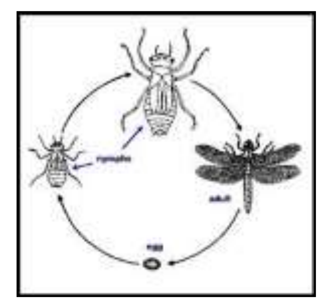
# Questions

- Broadly- “What are appropriate restoration endpoints from a community ecology perspective?” (Palmer et al. 1997)
- More specifically- How important is intraspecific variation to ecosystem functionality and is it something worth monitoring as a restoration endpoint?

# Interspecific vs. Intraspecific Considerations

- Classical approach- a species' functional role is considered discrete and representative of all individuals within that species
- This approach only considers interspecific differences
- However, within species variation (e.g. size and stage) is sometimes greater than between species variation, and this can cause intraspecific functional role to vary greatly.

e.g. life history omnivores and metamorphosing species



# Interspecific vs. Intraspecific Considerations

- Clearly the more classical approach is not the case and can generate misleading predictions

  -E.g. Restoration theory that incorporates biodiversity or functional redundancy, while neglecting the presence and effects of intraspecific variation, may be inaccurate and produce unexpected outcomes.

# Interspecific vs. Intraspecific Considerations

- Currently, research that addresses the varying functional role of individuals below the species level is beginning to be emphasized, and is necessary in light of human impacts that are affecting intraspecific characteristics such as size regimes.

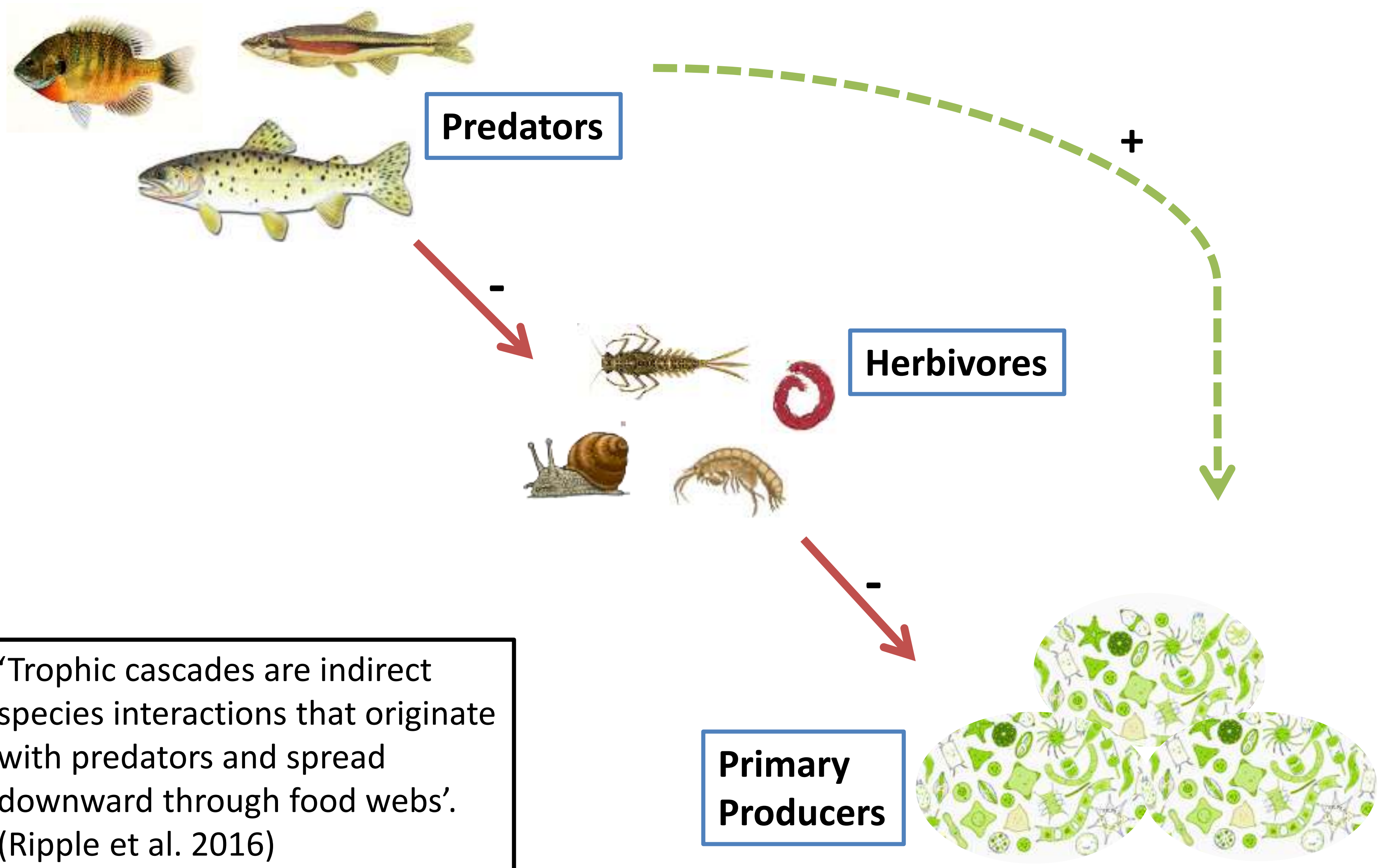
- Therefore monitoring this intraspecific variation may be important.

# Implications

- To contribute to this growing body of research and to shed light on the usefulness of incorporating assessment of intraspecific variation into monitoring programs, we sought to:

1. Address the importance of intraspecific variation (size structure) on the functional role (top-down control) of an omnivore
2. And if this intraspecific variation differentially affected lower community trophic structure and associated ecosystem processes.

# What is Top-Down Control?




‘Trophic cascades are indirect species interactions that originate with predators and spread downward through food webs’. (Ripple et al. 2016)

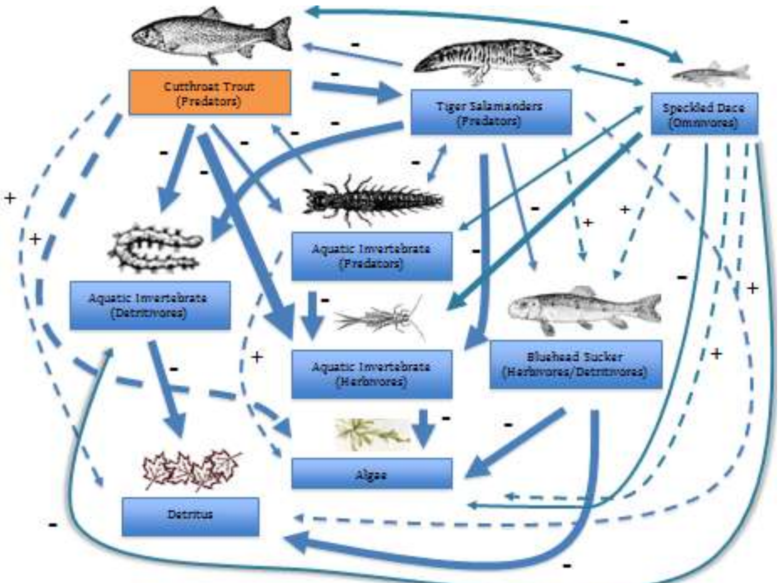
# Omnivory and Top-Down Control

- **Omnivory** generally weakens trophic cascades (Bruno and O'Connor 2005)

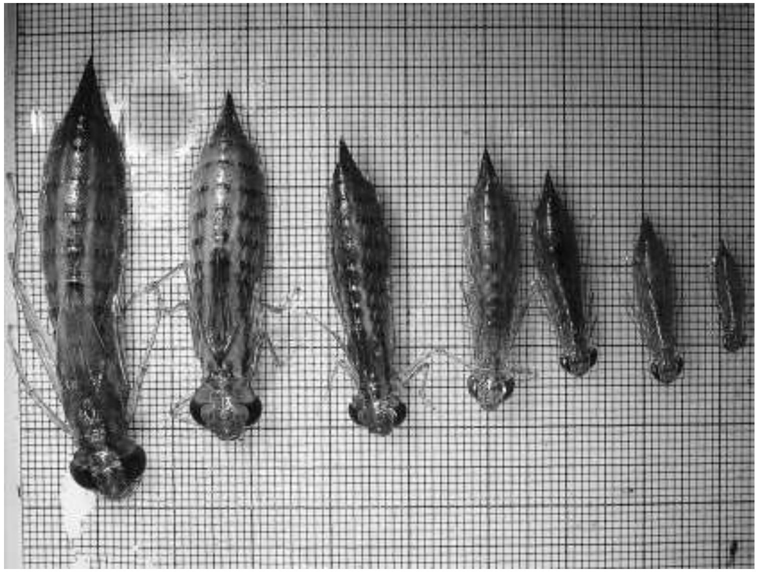
# Omnivory and Top-Down Control

- **Omnivory** generally weakens trophic cascades (Bruno and O'Connor 2005)

- Recent food web level analyses have shown that omnivores often comprise greater than 50% of the total taxa (Dunne et al. 2014).



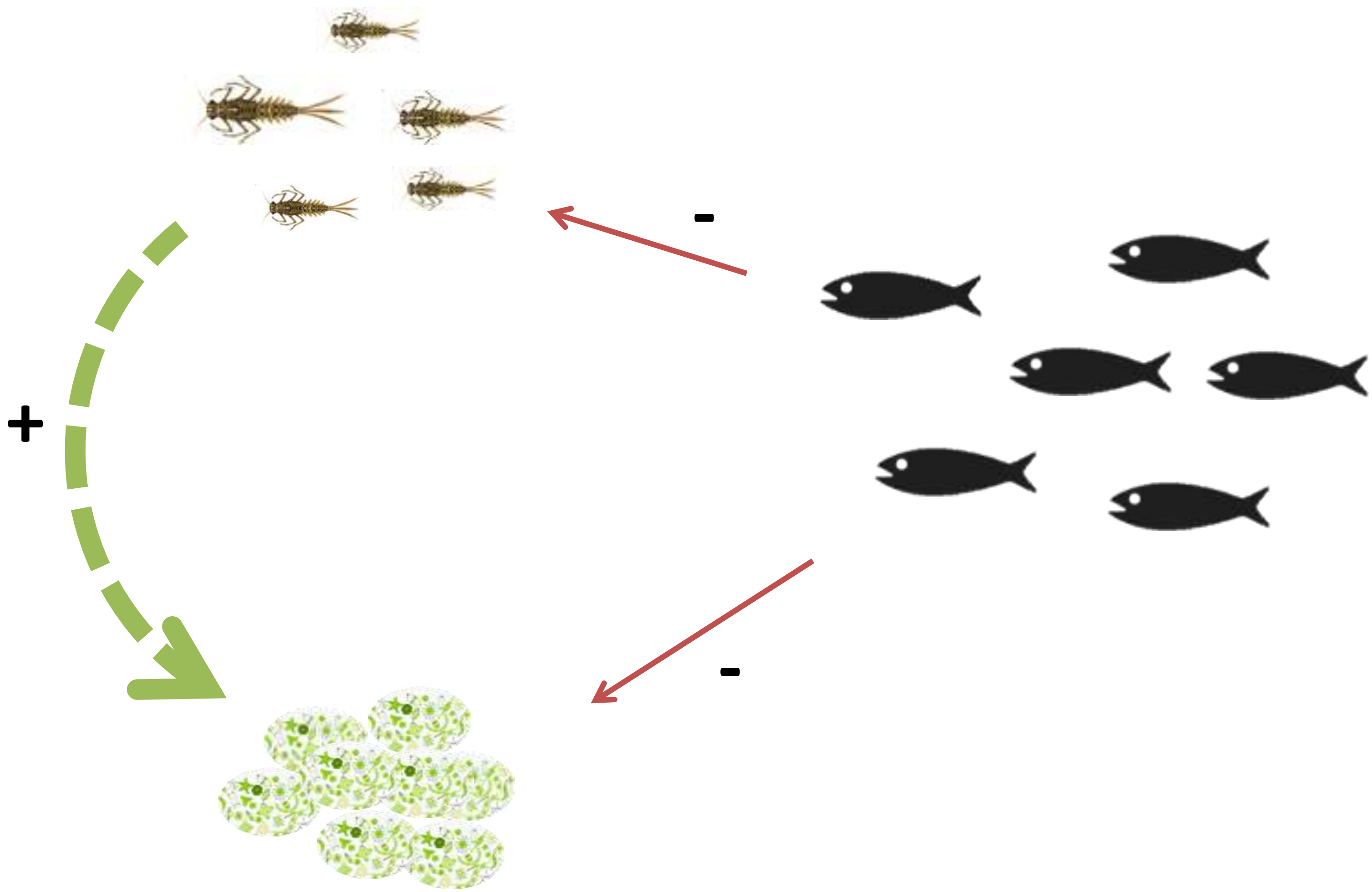
# Factors Affecting Top-Down Control by an Omnivore



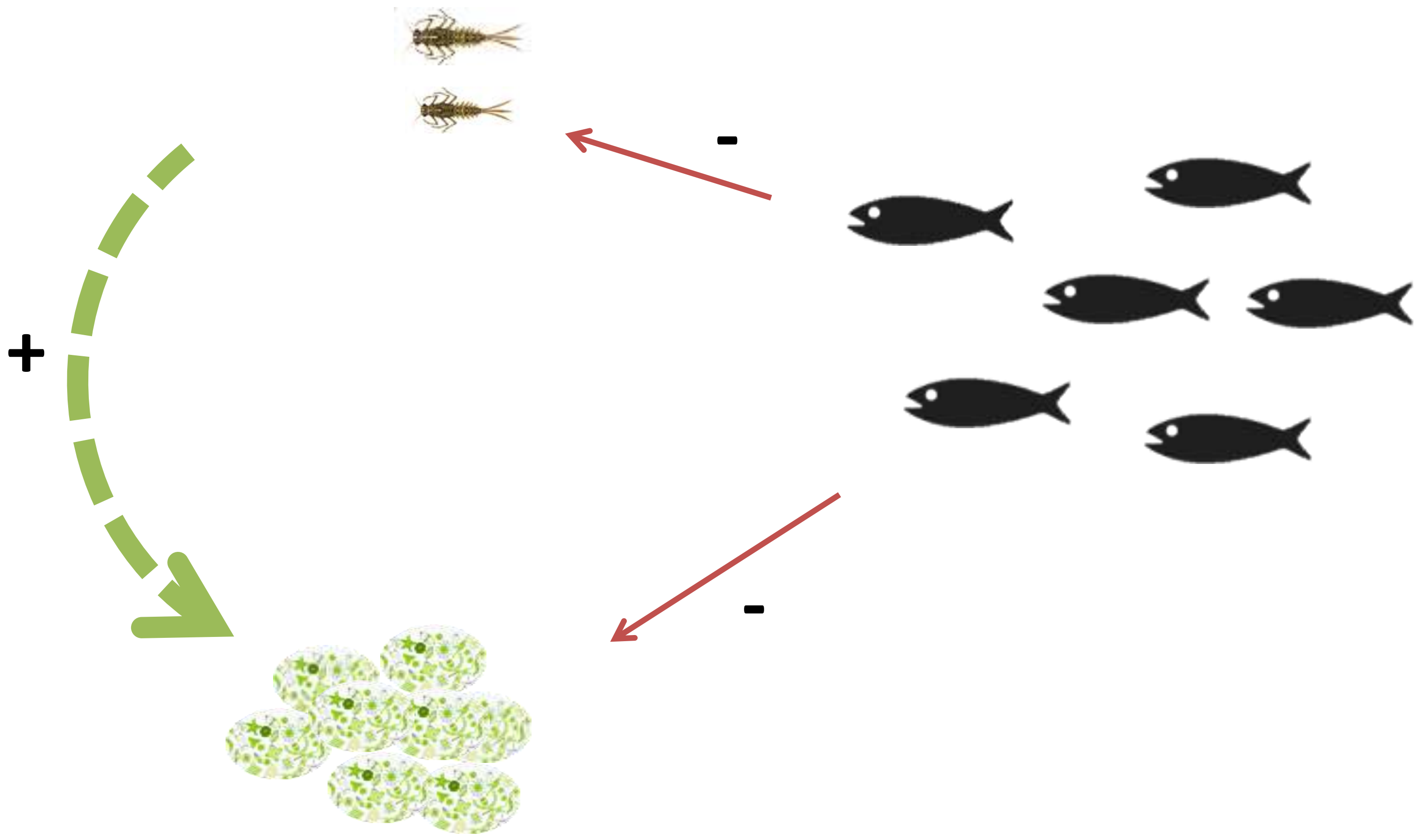
- **Intraspecific size structure**
  (Rudolf and Rasmussen 2013)

- **Density**
  (Katano 2007)

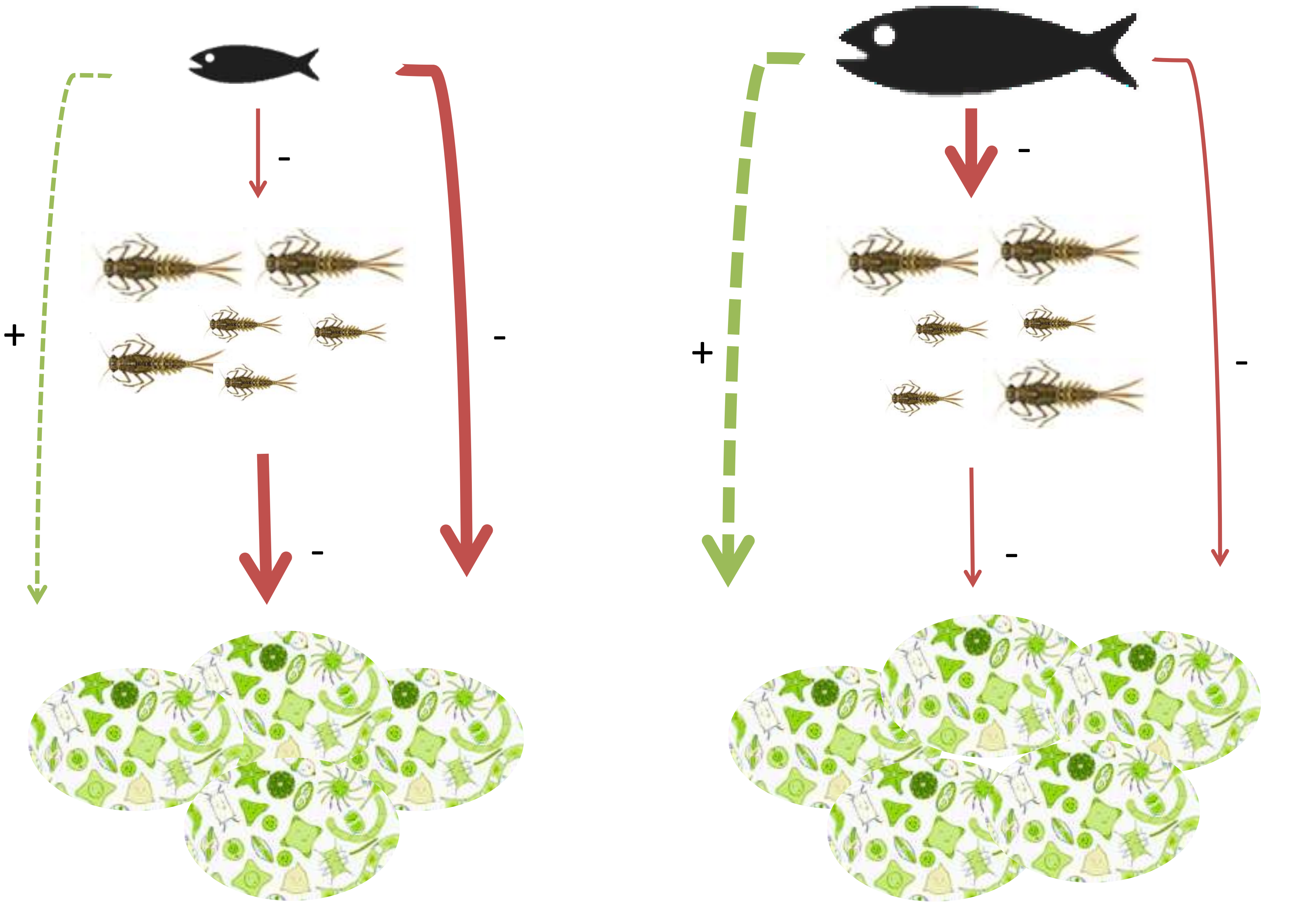
# Density Effects



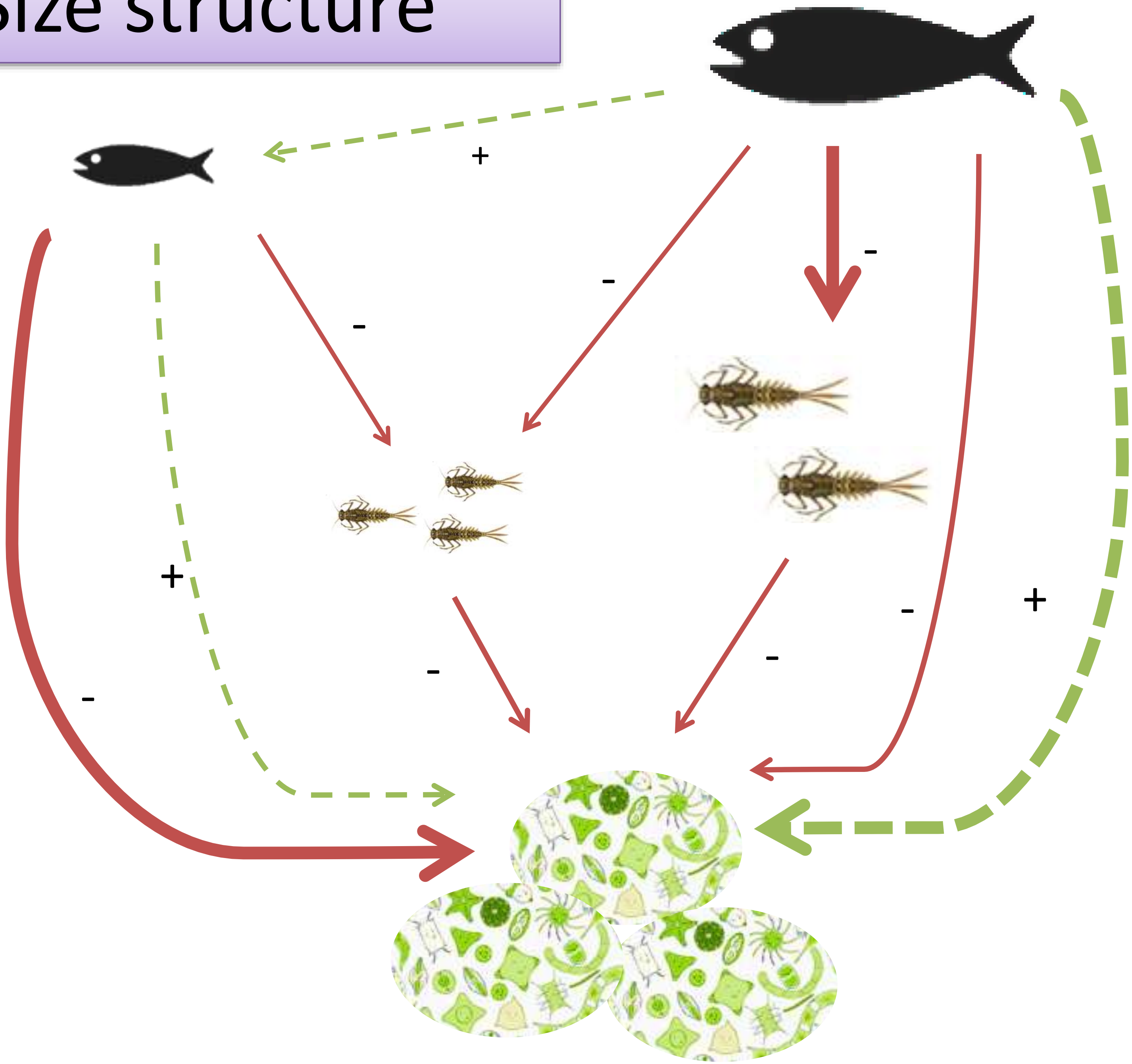
# Density Effects



# Size and Size Structure Effects

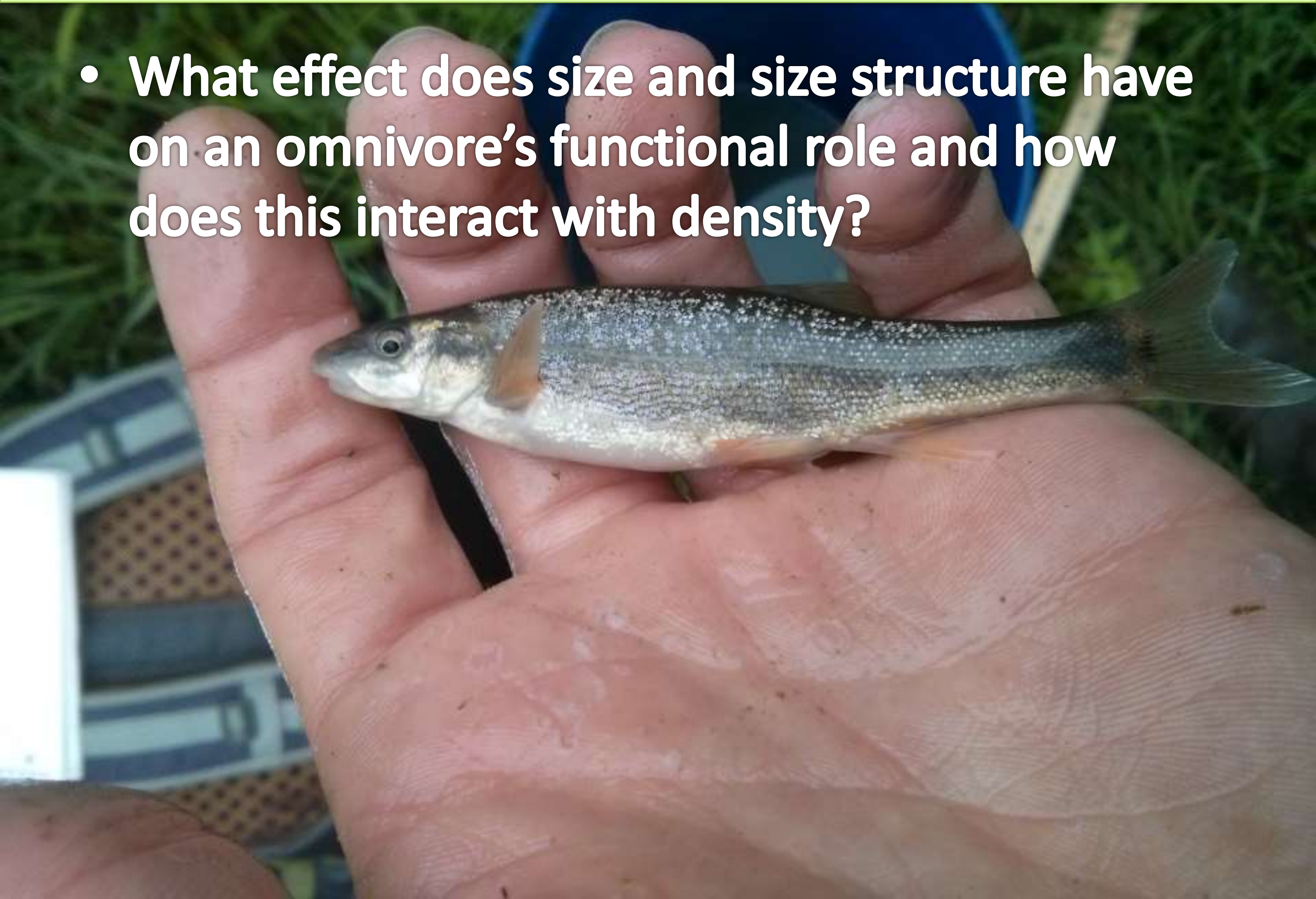


# Size structure



# Broad Research Question

- **What effect does size and size structure have on an omnivore's functional role and how does this interact with density?**

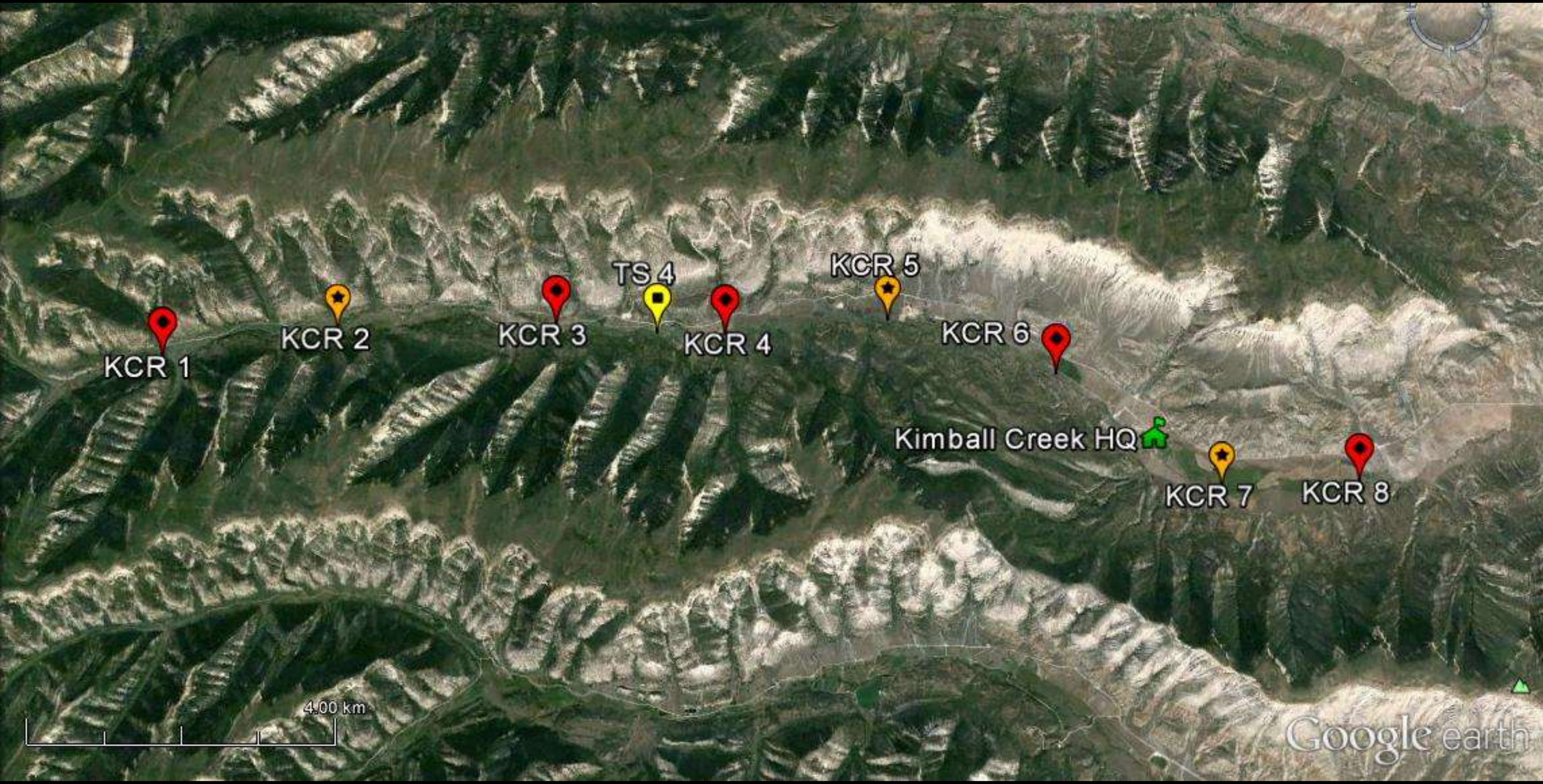


# Study Site: Kimball Creek






# Kimball Creek



# Kimball Creek History

- Kimball Creek historically
- Causes of current degradation

# Proposed Restoration

- Restoration agenda
- Our team has been monitoring Kimball since 2011 for water quality, habitat, biotic communities
- Restoration objectives




# Kimball Creek

- **Study organism**: Omnivorous Speckled Dace which consumes algae and invertebrates

# Specific Research Questions

- Are omnivorous Speckled Dace capable of causing a trophic cascade within beaver pond habitat characteristic of our field site?

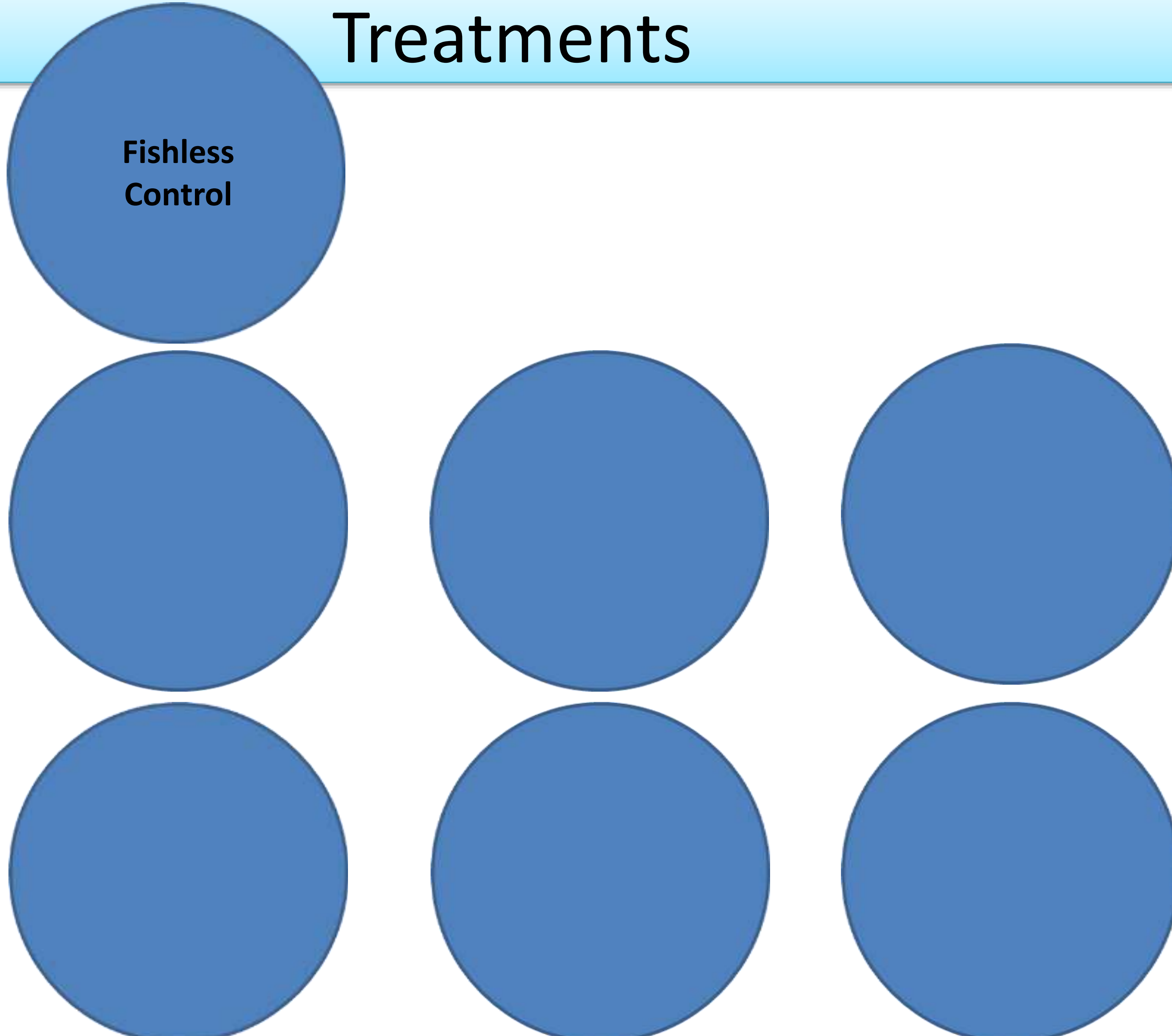
- What effect does size, size structure, and density have on top-down control by Speckled Dace?

# Mesocosm Setup

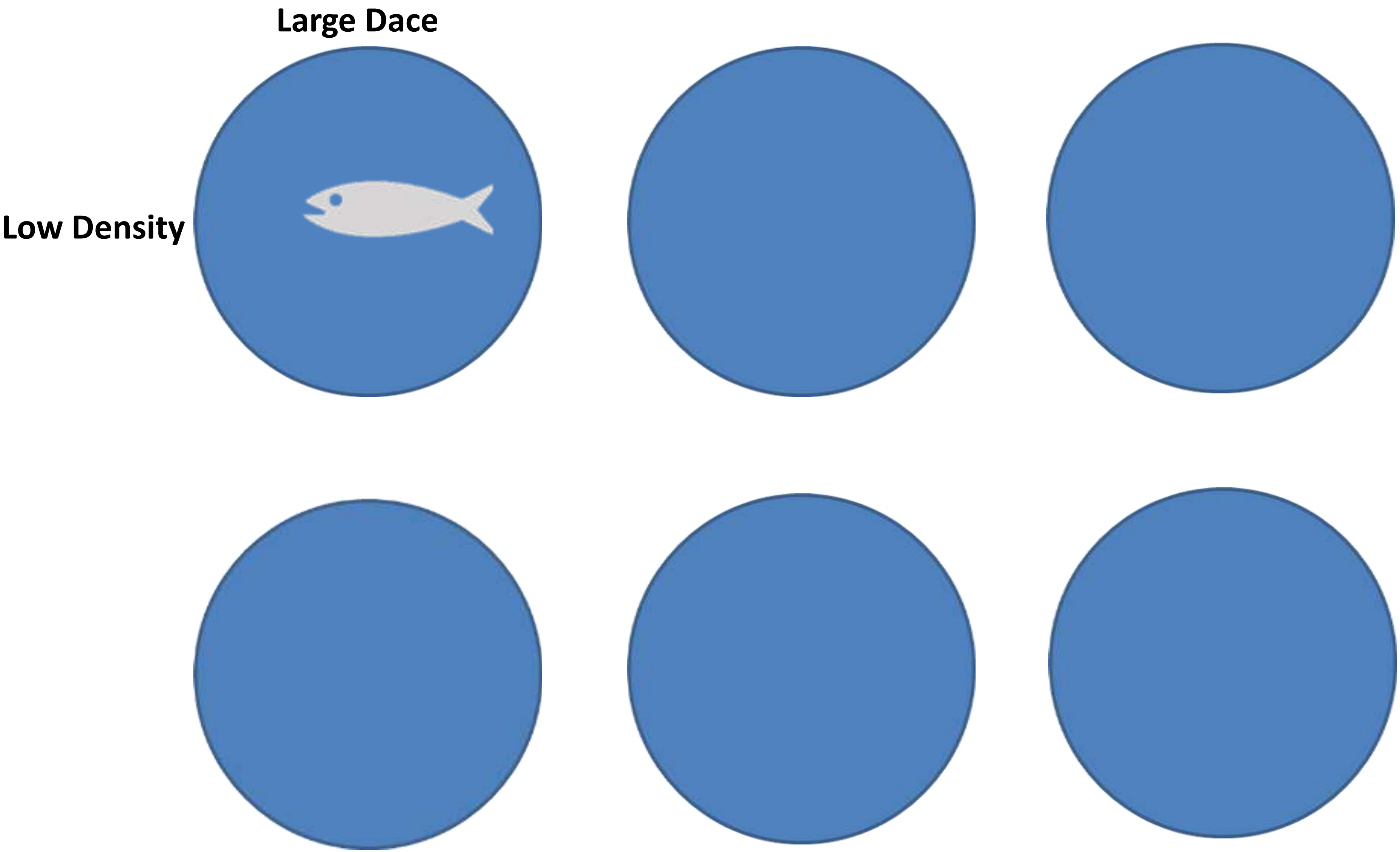
# Experimental Design

- 5 replicates/treatment
- Biweekly sampling of algae, invertebrates, water chemistry
- 8 week experiment

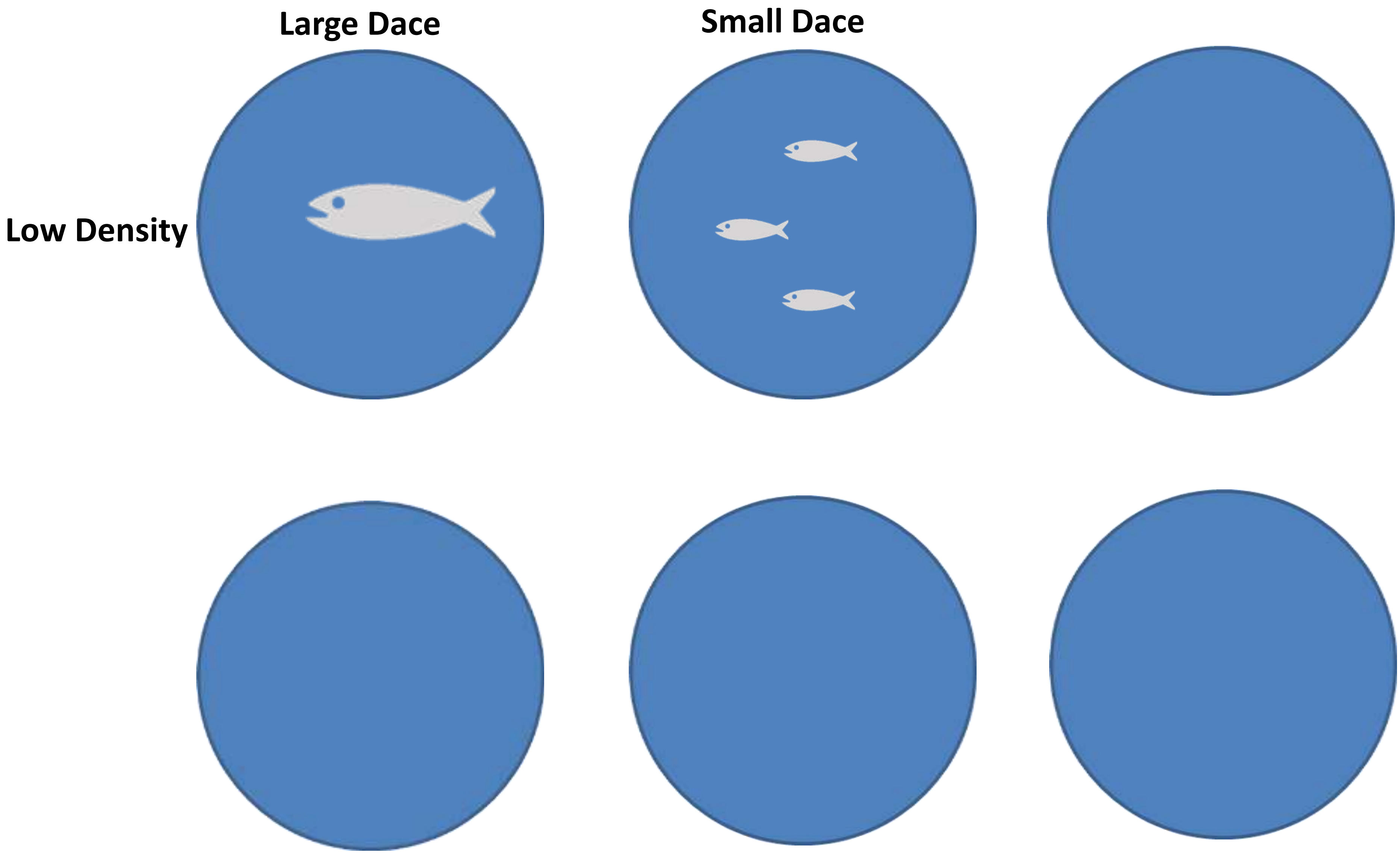
# Treatments



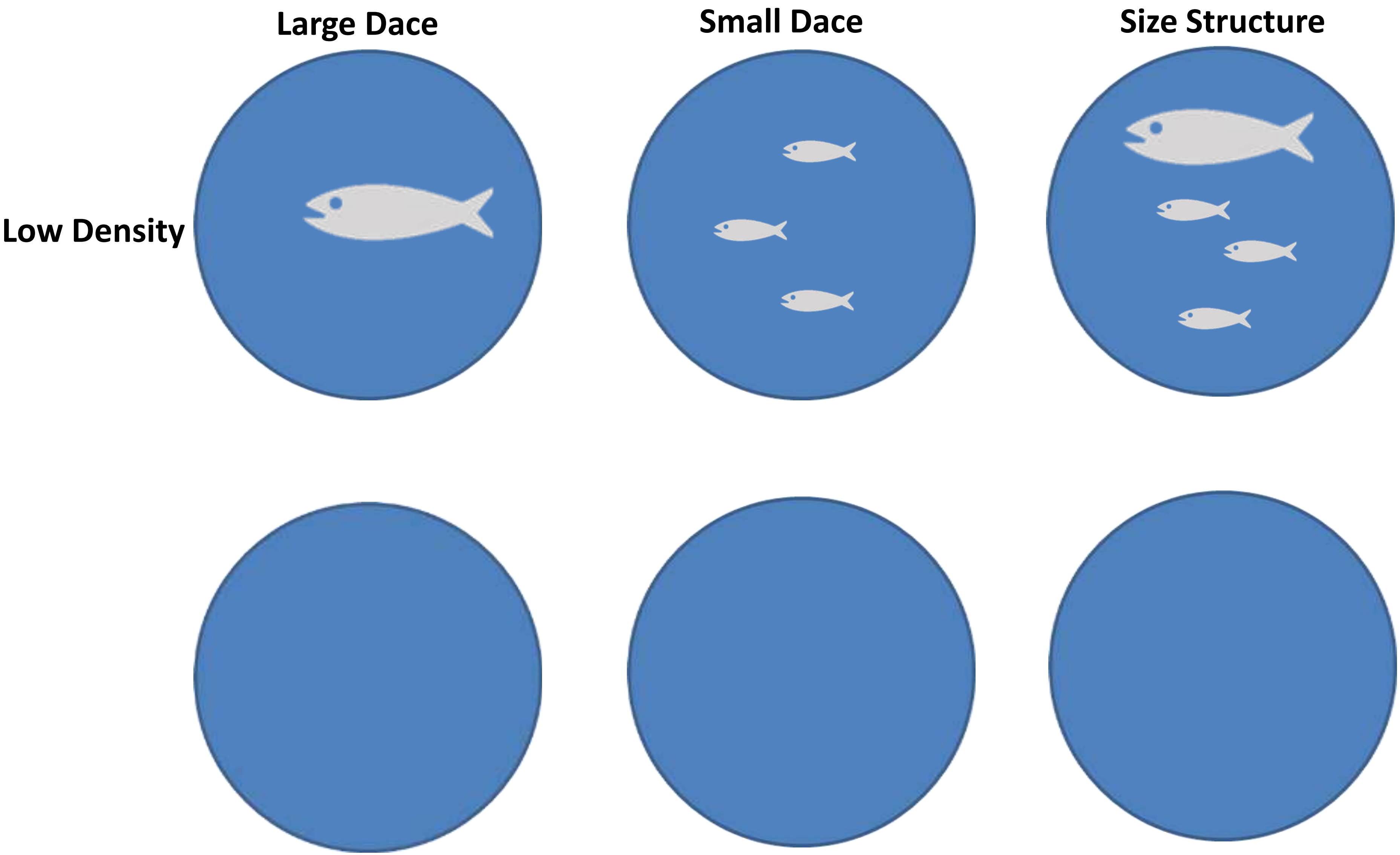
# Treatments



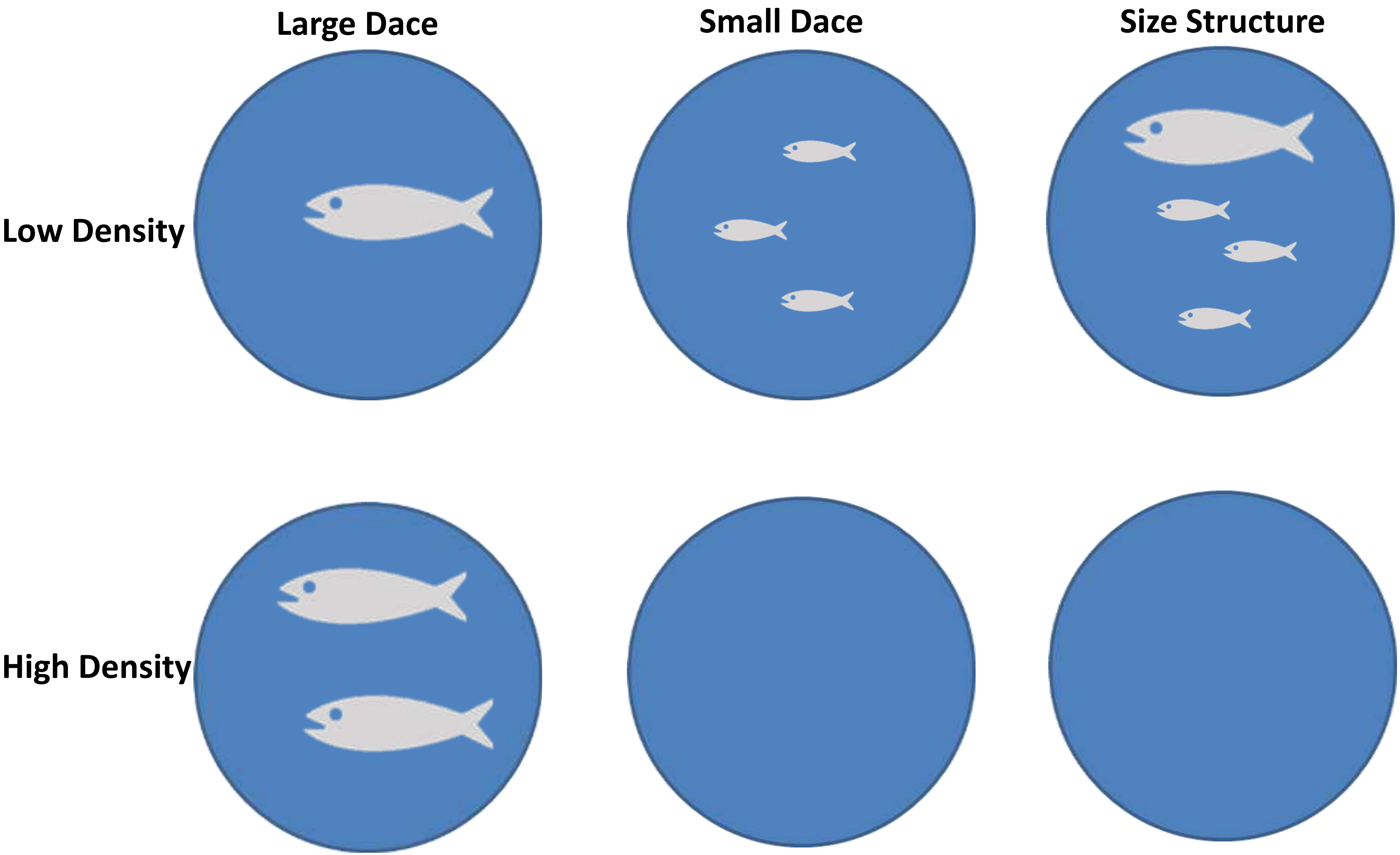
# Treatments



# Treatments

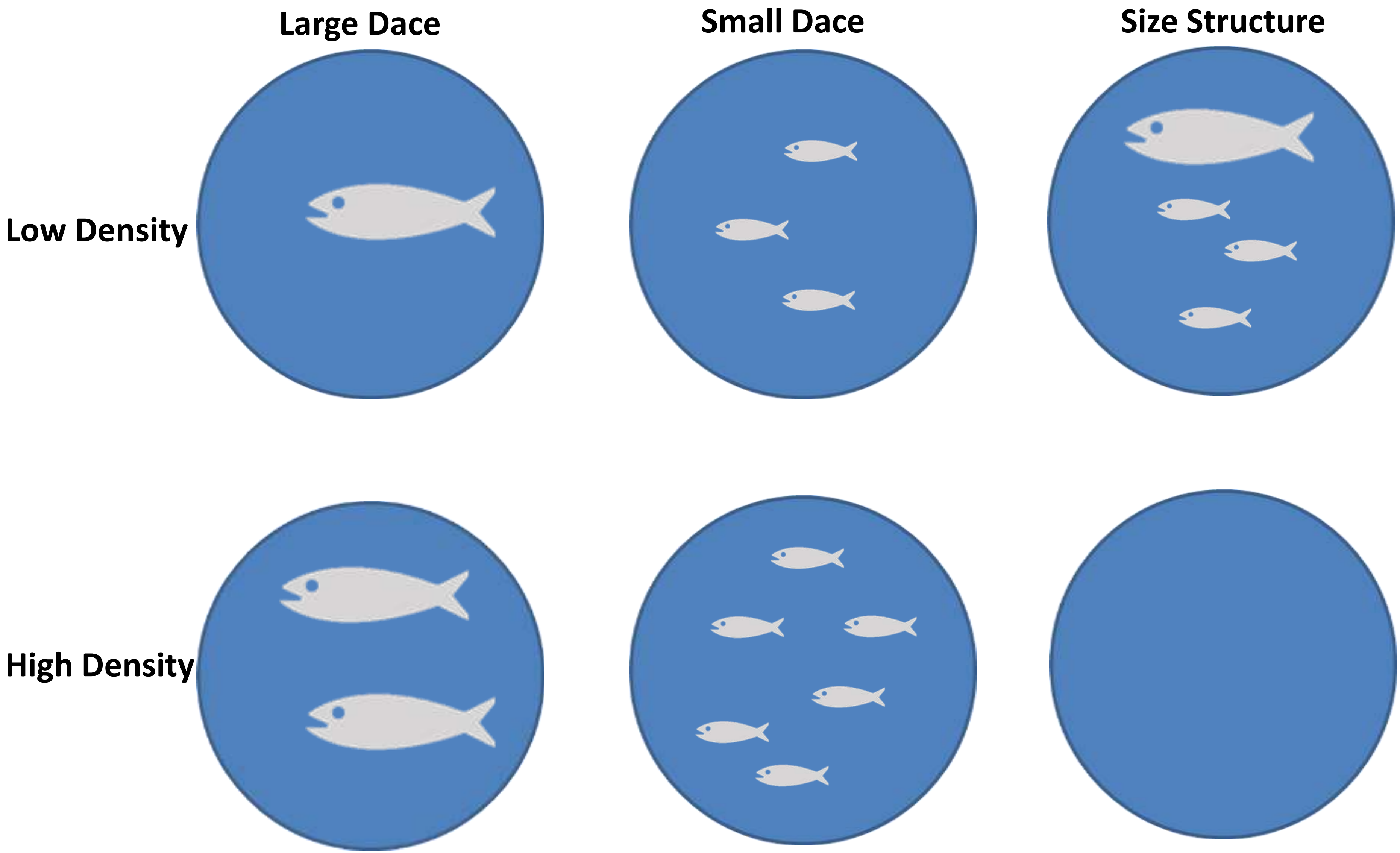


# Treatments



Large Dace
Small Dace
Size Structure
Low Density
High Density

# Treatments


Large Dace
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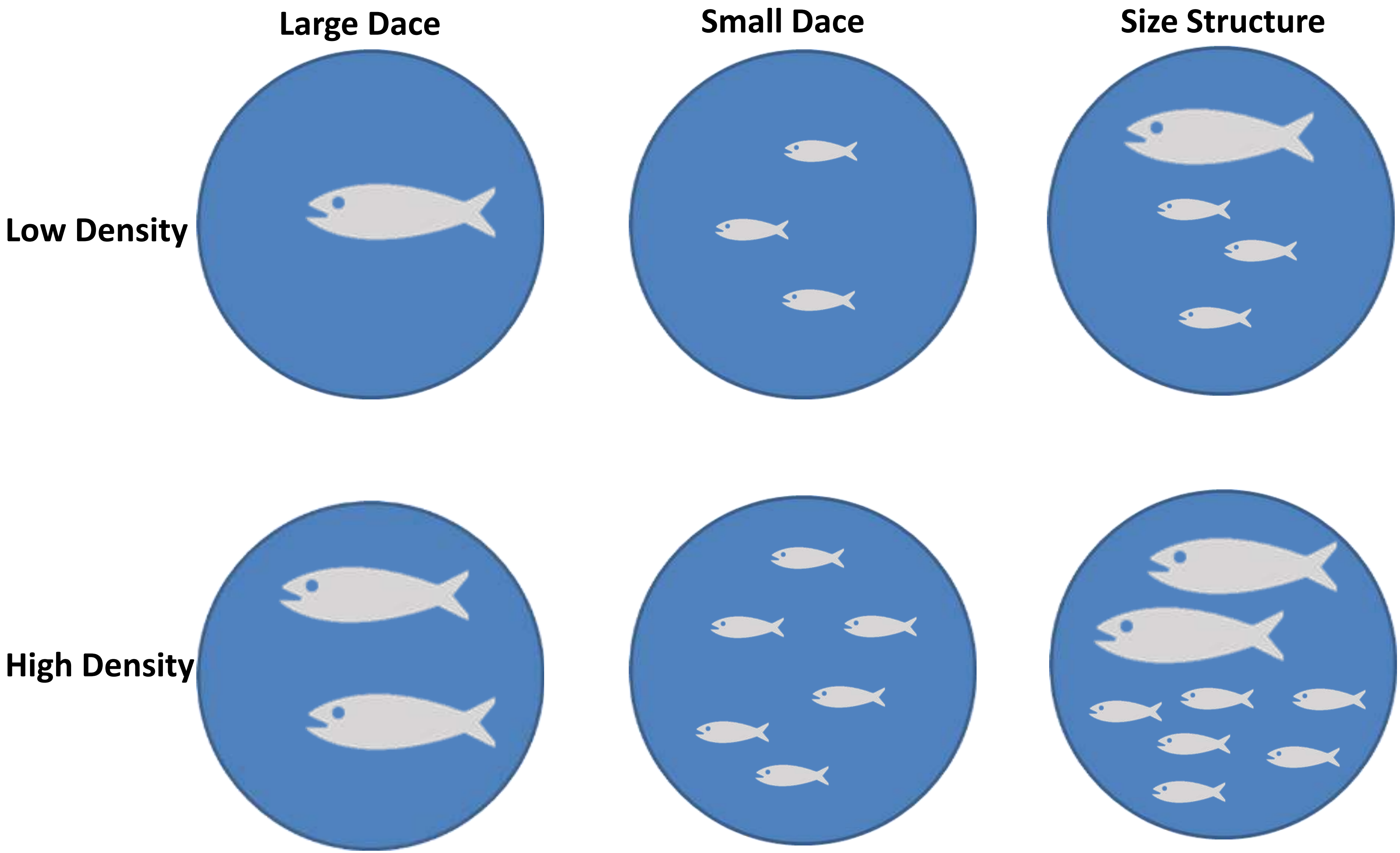
# Treatments


Large Dace
Small Dace
Size Structure
Low Density
High Density

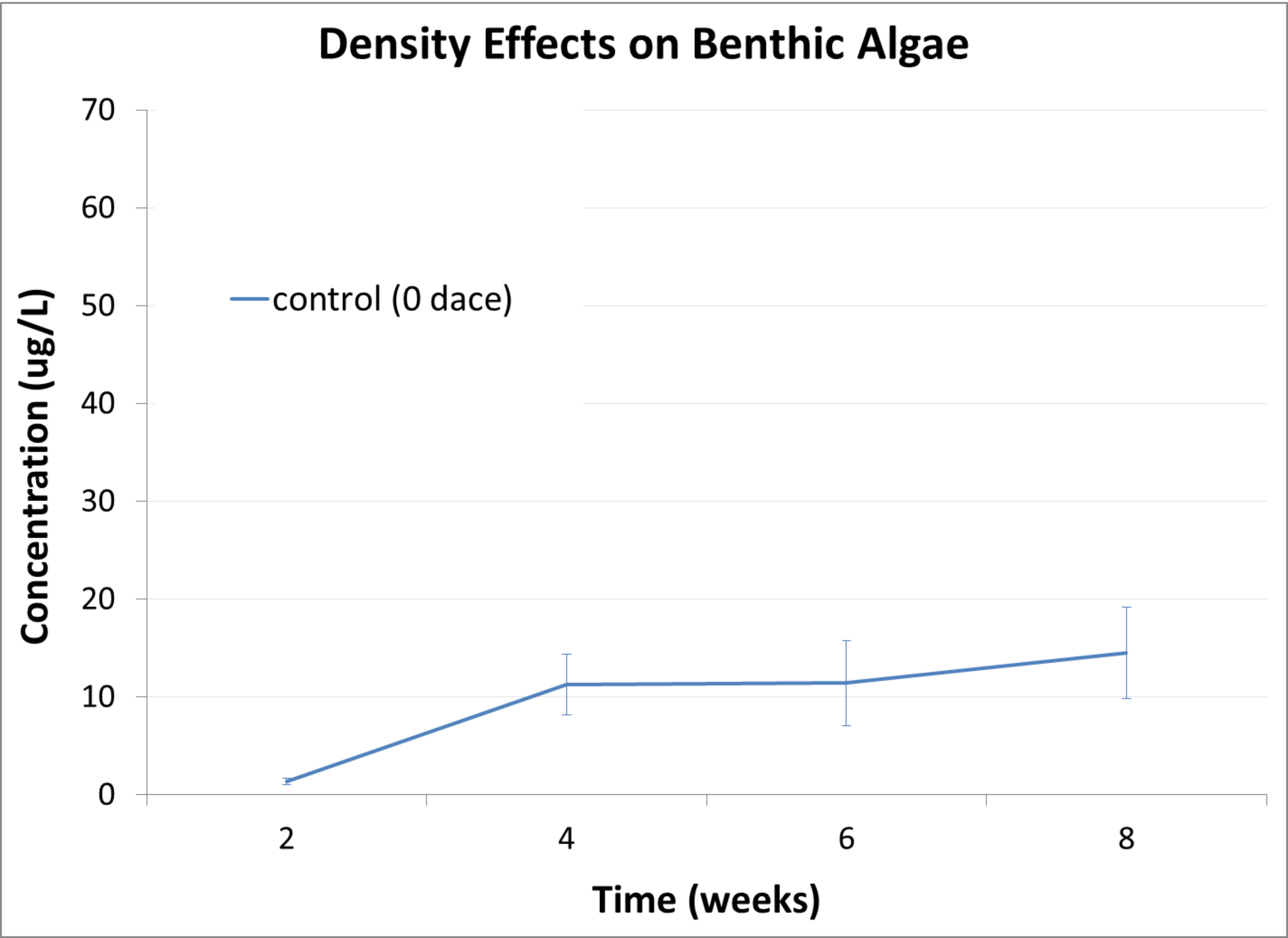
# Data Collection

- Zooplankton
- Macroinvertebrates
- Leafpacks
- Algae
- Emergence
- Water samples
- Pelagic invertebrates
- Stable isotope samples
- YSI water quality
- Dace length/weight

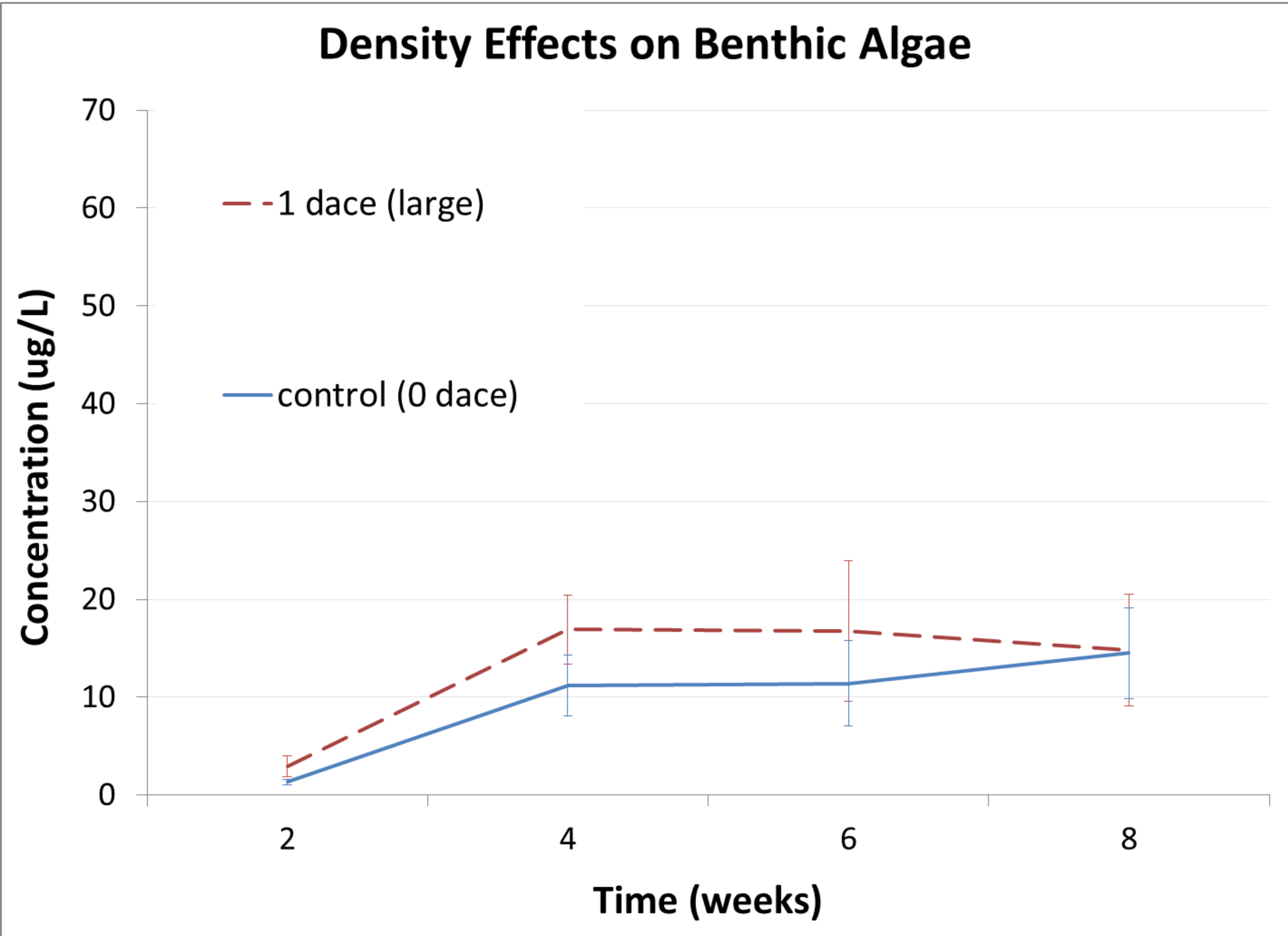
# Data Collection

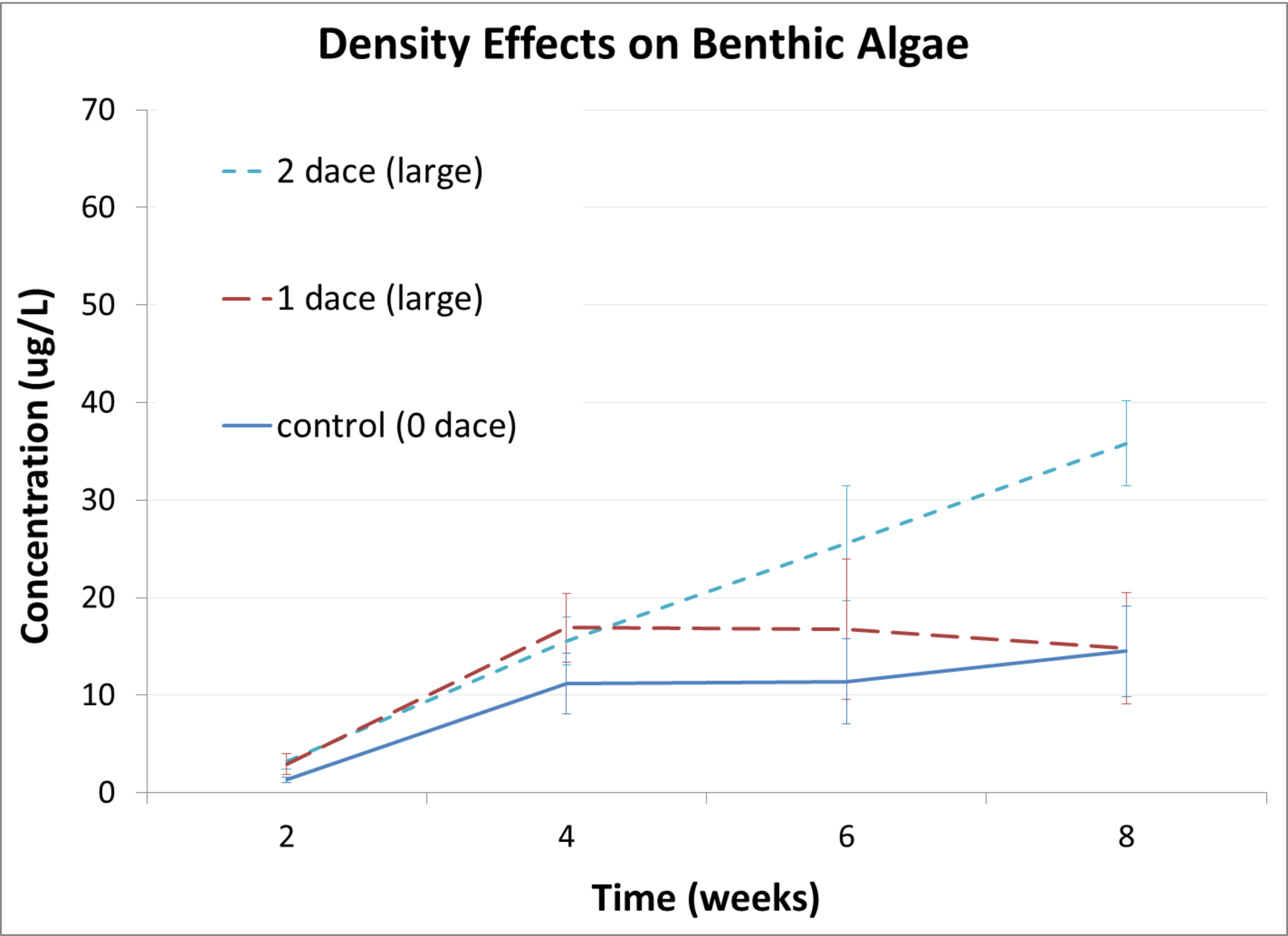
- Algae

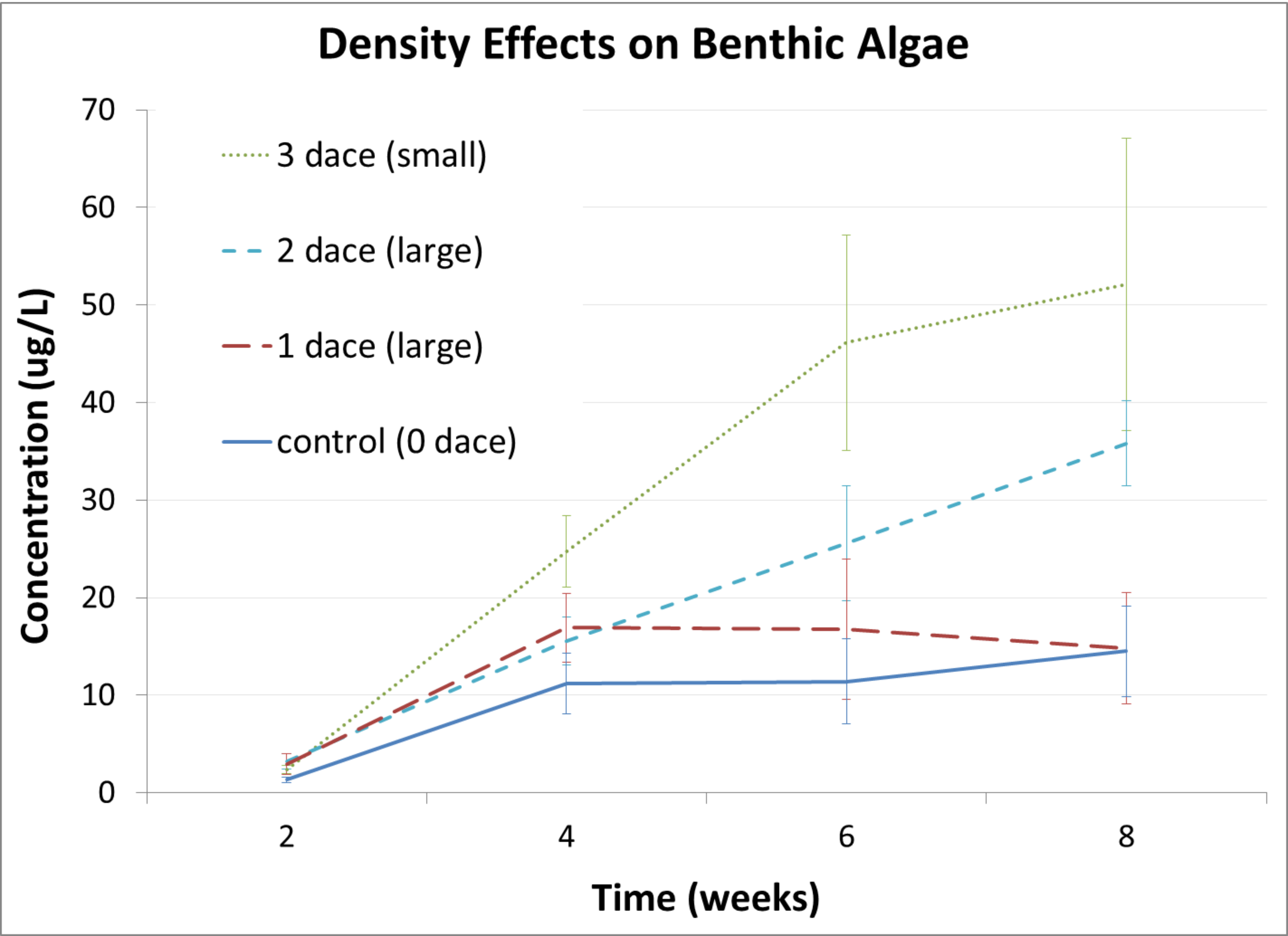
| | Pr(>F) |
|---|---|
| treat | 0.000225 *** |
| time | < 2.2e-16 *** |
| treat:time | 1.359e-07 *** |



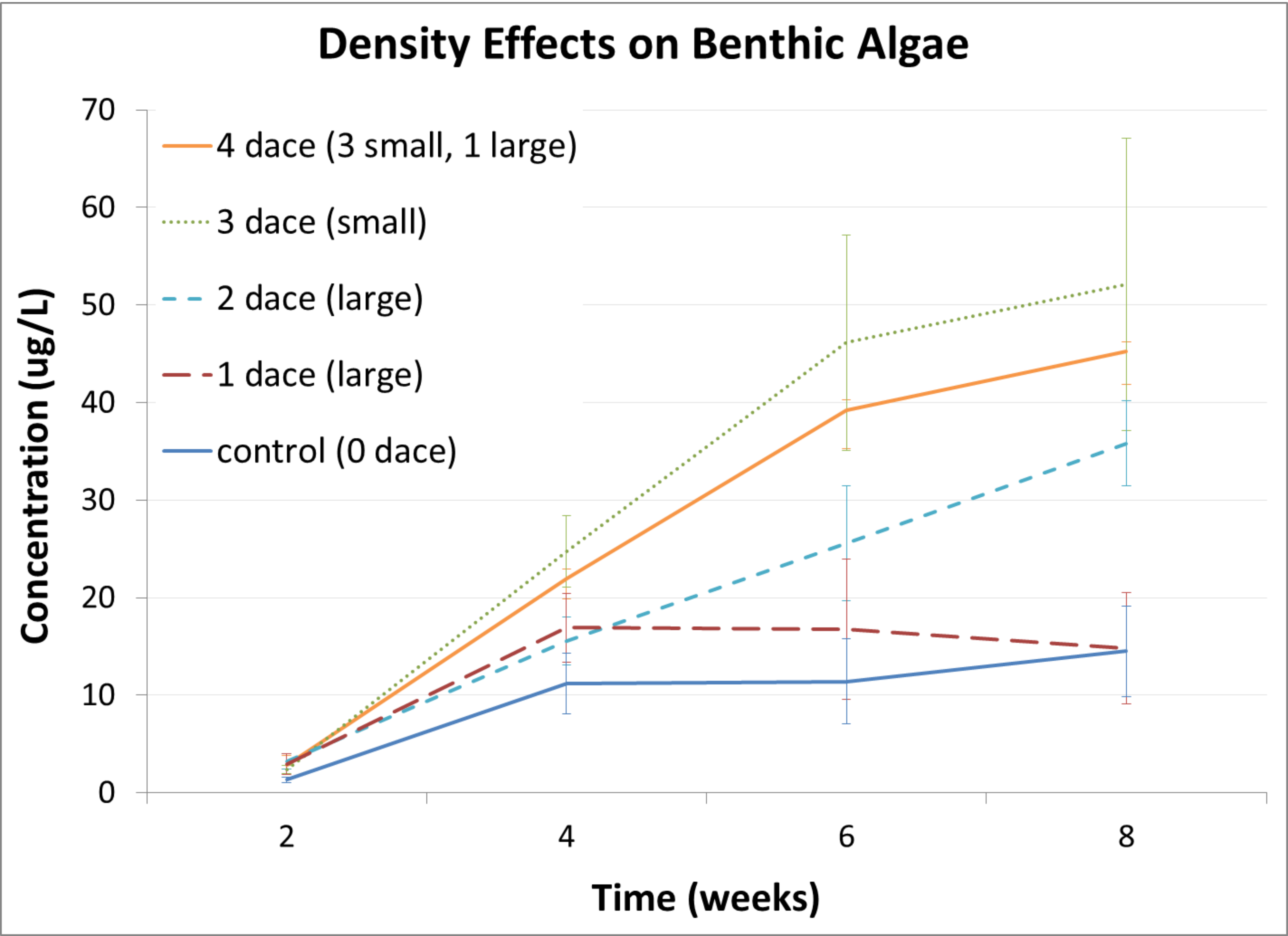
Density Effects on Benthic Algae
Concentration (ug/L)
70
60
50
40
30
20
10
0
control (0 dace)
2
4
6
8
Time (weeks)


Density Effects on Benthic Algae
70
60
50
40
30
20
10
0
1 dace (large)
control (0 dace)
Concentration (ug/L)
2
4
6
8
Time (weeks)

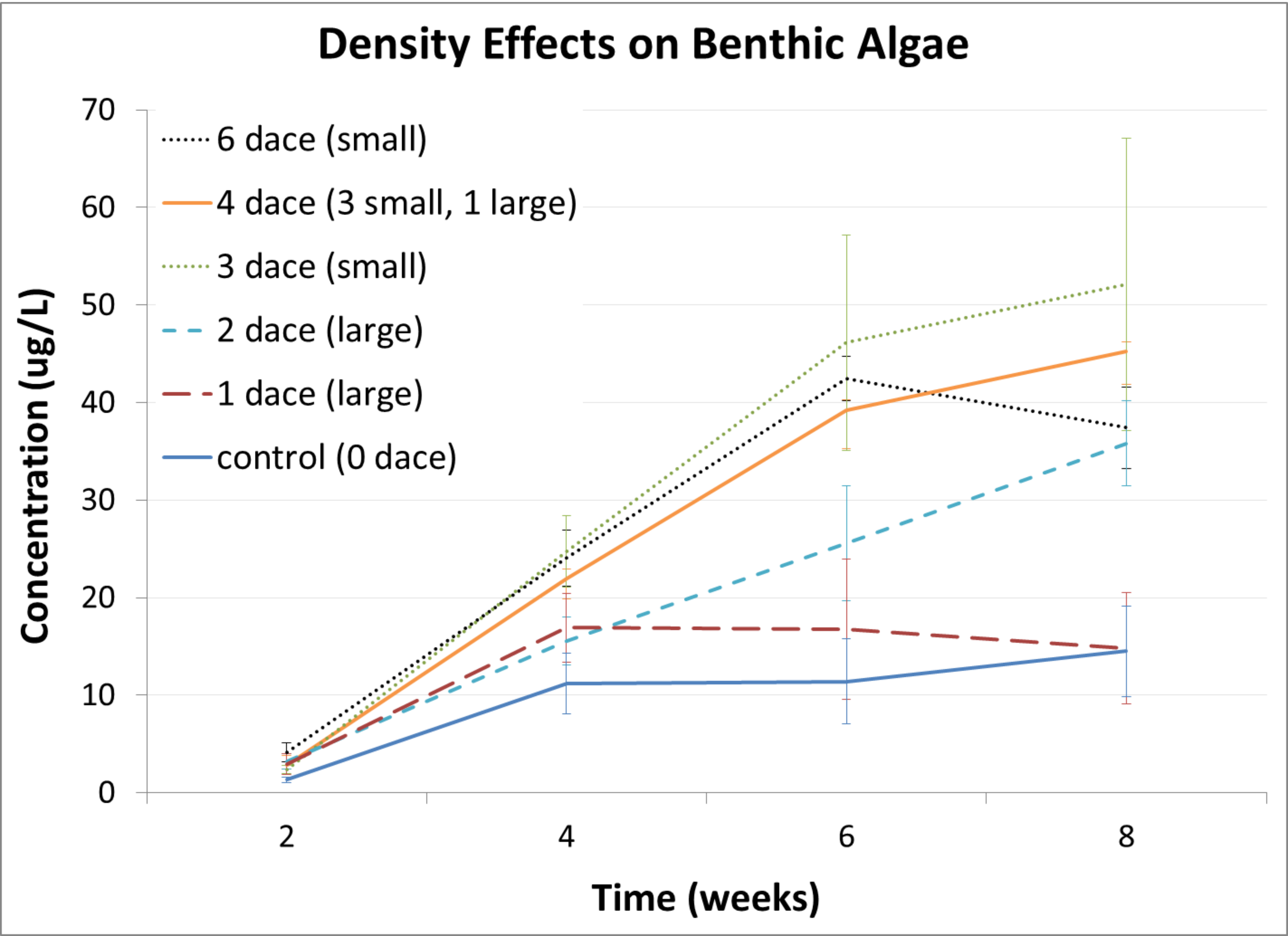

Density Effects on Benthic Algae
70
60
50
40
30
20
10
0
Concentration (ug/L)
2 dace (large)
1 dace (large)
control (0 dace)
2
4
6
8
Time (weeks)



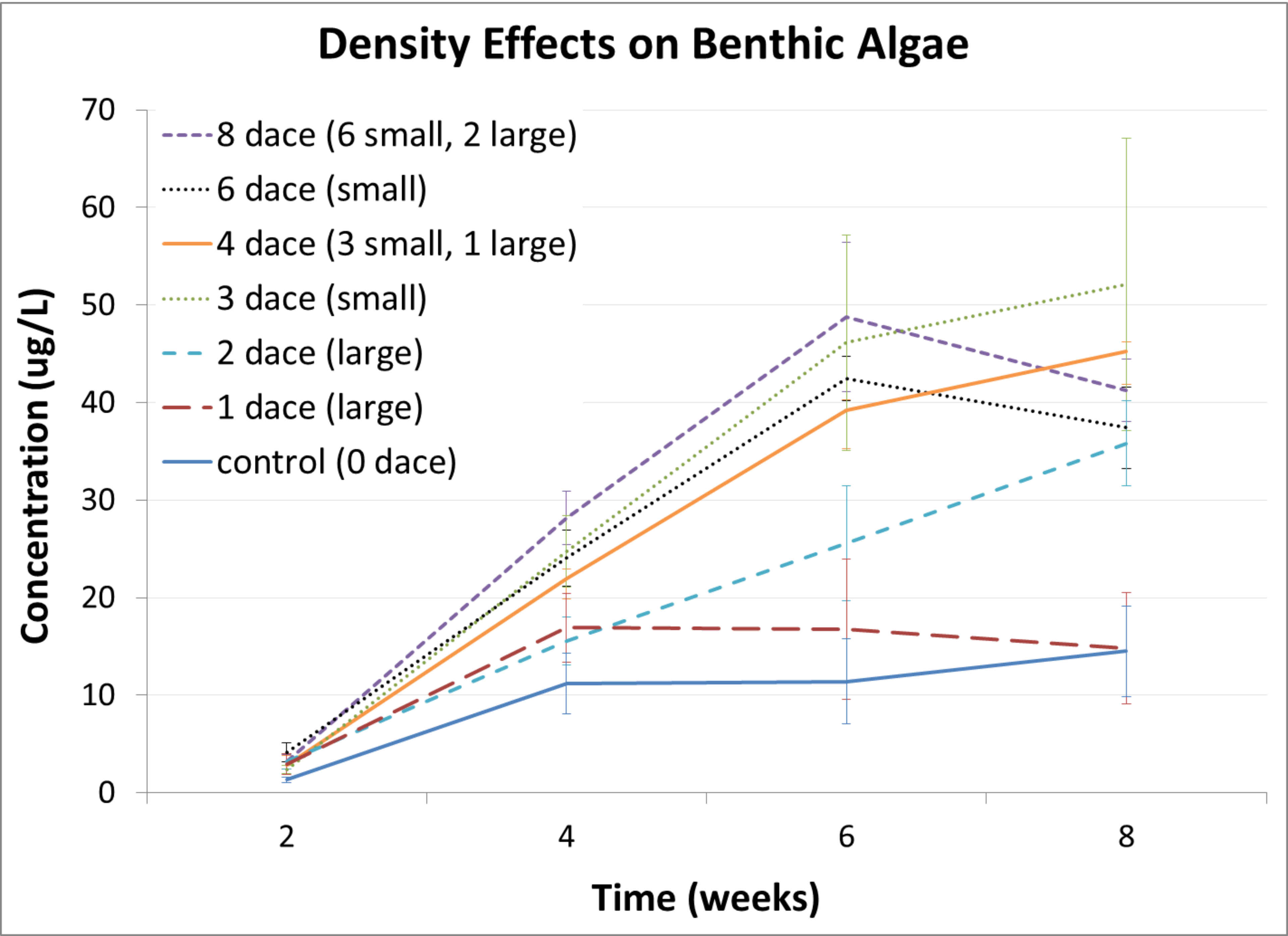
Density Effects on Benthic Algae
3 dace (small)
2 dace (large)
1 dace (large)
control (0 dace)
Concentration (ug/L)
0
10
20
30
40
50
60
70
2
4
6
8
Time (weeks)



Density Effects on Benthic Algae
4 dace (3 small, 1 large)
3 dace (small)
2 dace (large)
1 dace (large)
control (0 dace)
Concentration (ug/L)
Time (weeks)
0
10
20
30
40
50
60
70
2
4
6
8



Density Effects on Benthic Algae
6 dace (small)
4 dace (3 small, 1 large)
3 dace (small)
2 dace (large)
1 dace (large)
control (0 dace)
Concentration (ug/L)
70
60
50
40
30
20
10
0
2
4
6
8
Time (weeks)



Density Effects on Benthic Algae
8 dace (6 small, 2 large)
6 dace (small)
4 dace (3 small, 1 large)
3 dace (small)
2 dace (large)
1 dace (large)
control (0 dace)
Concentration (ug/L)
0
10
20
30
40
50
60
70
2
4
6
8
Time (weeks)

# Conclusions

- Density appears to be the most important factor controlling this potential trophic cascade.
- Analysis of invertebrate data will elucidate specific pathways of this potential trophic cascade
- No obvious size effect on algae

# Implications for More Effective Predictions and Monitoring

- Shackell et al. 2010
- Stevenson et al. 2016
- Renneville et al. 2016- more size than presence dependent

- These studies support the potential importance of monitoring size variation.

# Acknowledgements


- Huge thanks to The High Lonesome Ranch for funding and a place to conduct this research
- Gerry Harris, Angie Hayden, and Hancock Biological Station for logistical support
- Watershed Studies Institute and Jones College of Science Engineering and Technology for funding

Many thanks to…

- Dr. Howard Whiteman
- Dr. Michael Flinn
- Dr. Timothy Spier
- Dr. Chris Mecklin

- Carla Rothenbuecher
- Scot Peterson
- Kaylin Boeckman
- Robin Baker
- Abigail Glass
- Alyssa Allen


Questions?

- This result is in line with the results of Shackell et al. (2010), who found in the northwest Atlantic that fishing-induced body downsizing of predatory fish drove a trophic cascade reflecting a relaxed strength of predation despite that their total number actually increased.
- despite that predator numbers actually increased. Given that metabolism, including feeding rate, scales with body mass to a power exponent lower than one (often with a 3/4 exponent, Peters 1983, Woodward et al. 2005, Barneche et al. 2014), increased numbers of smaller-sized predatory fish should result in an overall increased prey consumption
- In contrast, the observed trophic cascade in the northwest Atlantic shows a relaxed predation pressure from predatory fish.

# Hypotheses Summary Slide

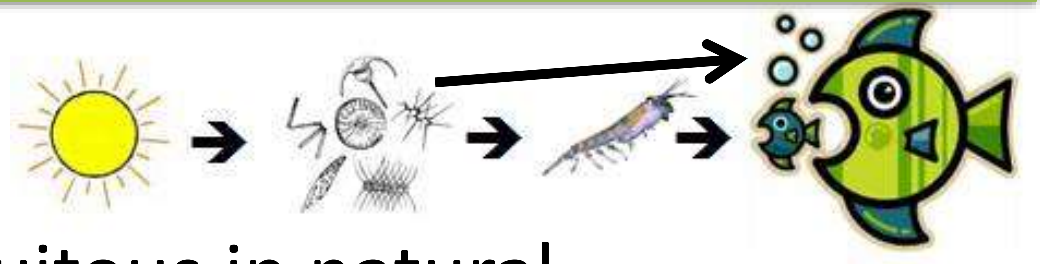
- Higher omnivore densities may dampen a trophic cascade by causing the omnivore to feed on a higher proportion of algae.

| Factor | Invert. impact | Algal impact |
|---|---|---|
| Low density | Weaker ↓ | Weaker ↑ |
| High density | Stronger ↓ | Stronger ↑ |
| Small size | Weaker ↓ | Weaker ↑ |
| Large size | Stronger ↓ | Stronger ↑ |
| Size structure | Intermediate ↓ | Intermediate ↑ |

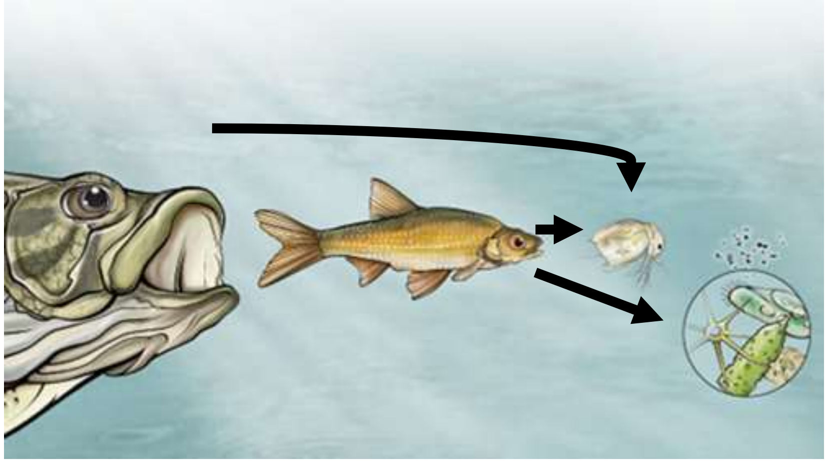
# Significance

- Climate change, habitat degradation, and other forms of human disturbance alter species densities and size structures and understanding the  induced effects are important for conservation and restoration agendas.

# Significance

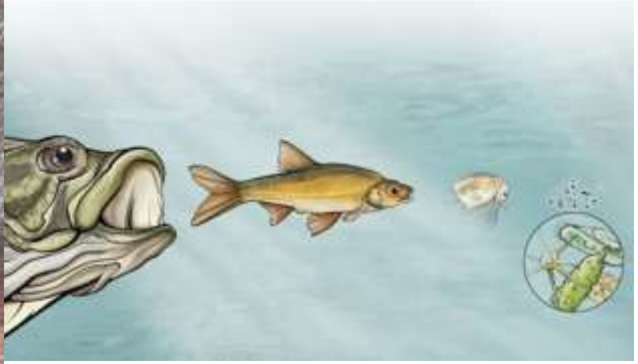


- Omnivores are ubiquitous in natural ecosystems and understanding how certain factors affect omnivory will provide better informed decision making.



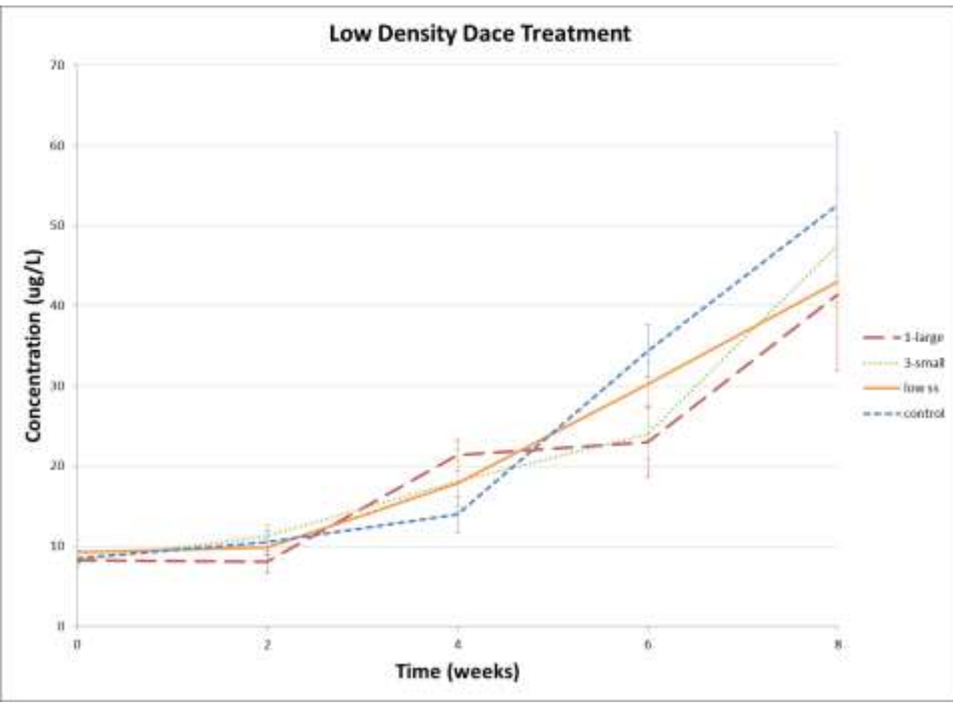
# What's an Omnivore again?

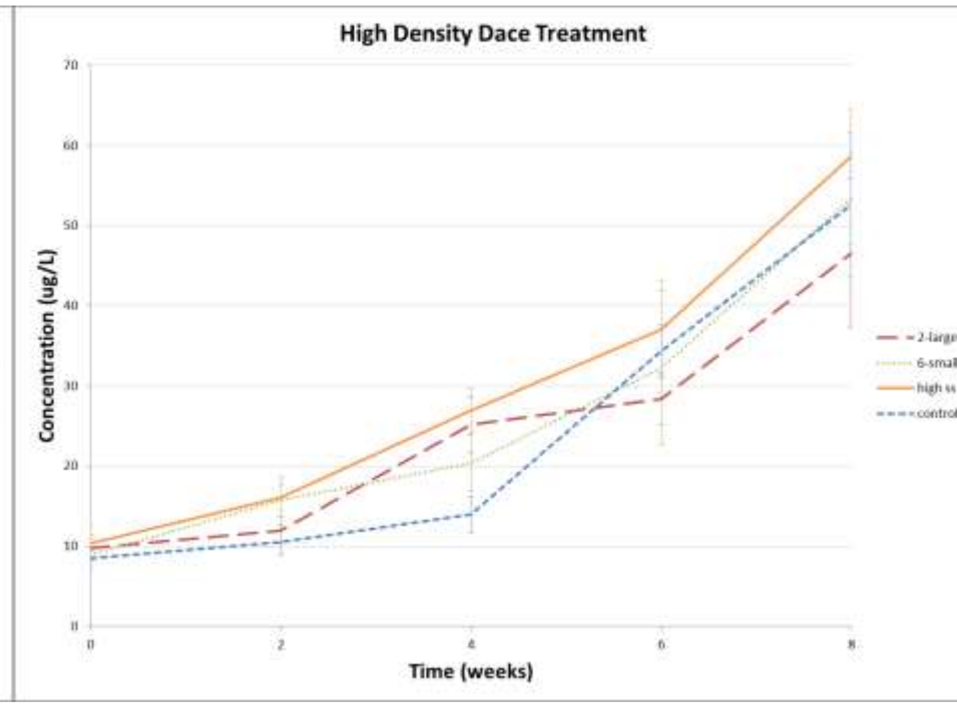
- Feeds on plants and animals? (not necessarily)
- Feeds on multiple trophic levels.
- Turns out omnivory is ubiquitous. Recent food web level analyses have shown that omnivores often comprise greater than 50% of the total taxa (Dunn



# Phytoplankton Results

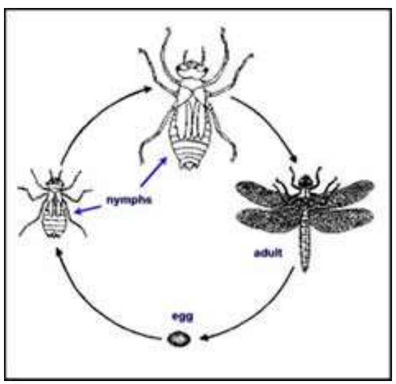
| | Sum Sq | Mean Sq | NumDF | DenDF | F.value | Pr(>F) |
|---|---|---|---|---|---|---|
| treat | 1084 | 180.6 | 6 | 26 | 2.226 | 0.07254 |
| time | 34192 | 8547.9 | 4 | 104 | 105.370 | < 2e-16 *** |
| treat:time | 1489 | 62.0 | 24 | 104 | 0.765 | 0.77149 |



# Interspecific vs. Intraspecific- take out

- Classical approach- a species functional role is considered discrete and representative of all individuals
- Within species variation often greater than between species variation



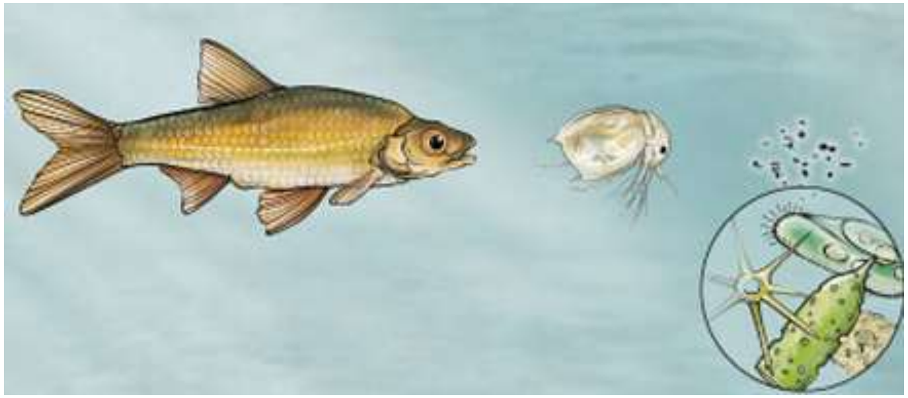

-e.g. metamorphosing species (Kratina et al. 2012)


- Currently, research that addresses the varying functional role of individuals below the species level is being emphasized

# Omnivory- take out

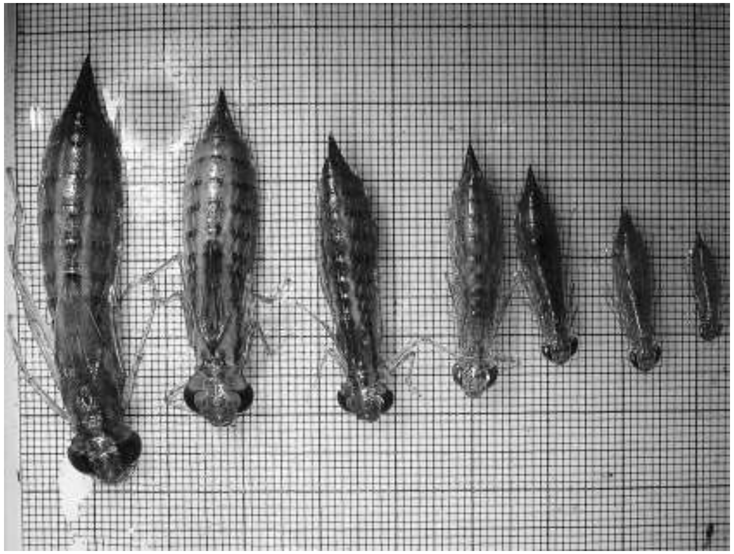
- However, the effects of omnivory within a species are not always straightforward and can vary with intraspecific trait variation






# Factors Affecting Top-Down Control

- **Intraspecific size structure**
  (Rudolf and Rasmussen 2013)



- **Omnivory** generally weakens trophic cascades
  (Bruno and O'Connor 2005)

# Omnivory and Trophic Cascades

- **Omnivory** generally weakens trophic cascades (Bruno and O'Connor 2005)