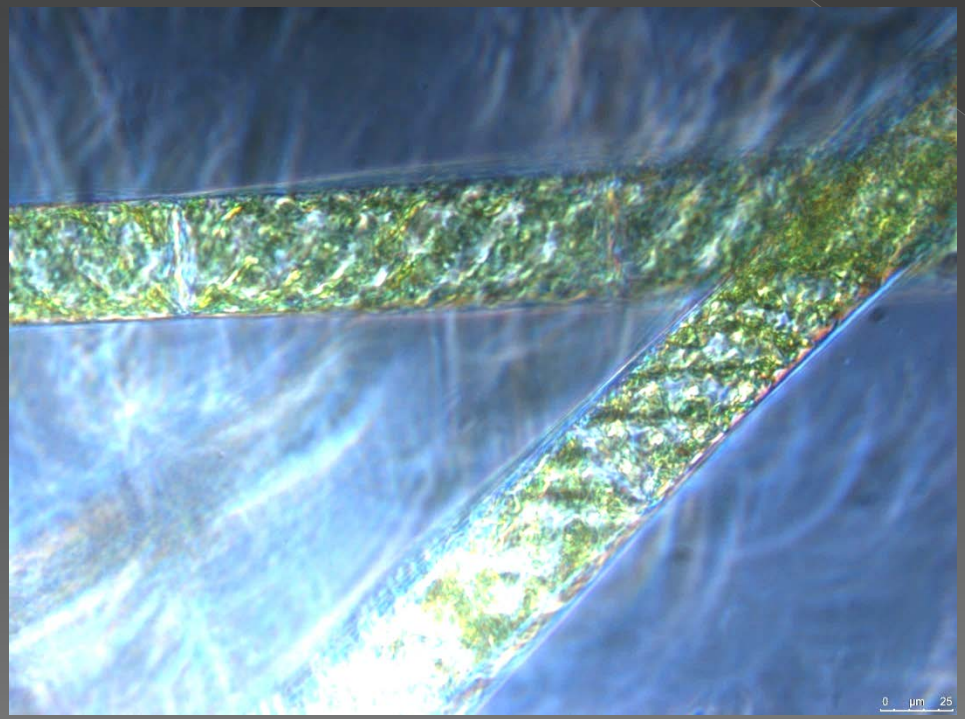
Nickel and Zinc Sorption and Desorption by a Mixed Algae Community Collected From a Mine Drainage Passive Treatment System



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Center for Restoration of Ecosystems and Watersheds
University of Oklahoma

THE UNIVERSITY OF OKLAHOMA
CIVI ET REIPUBLICAE
1890

Overview

1. Introduction
2. Literature Review
3. Hypotheses & Objectives
4. Experimental Setup
5. Results
6. Conclusions

Introduction

- Tri-State Mining District
  - Lead zinc mines
  - Abandoned in 1970
  - Resulted in upwellings
- Mayer Ranch Passive Treatment System (MRPTS)

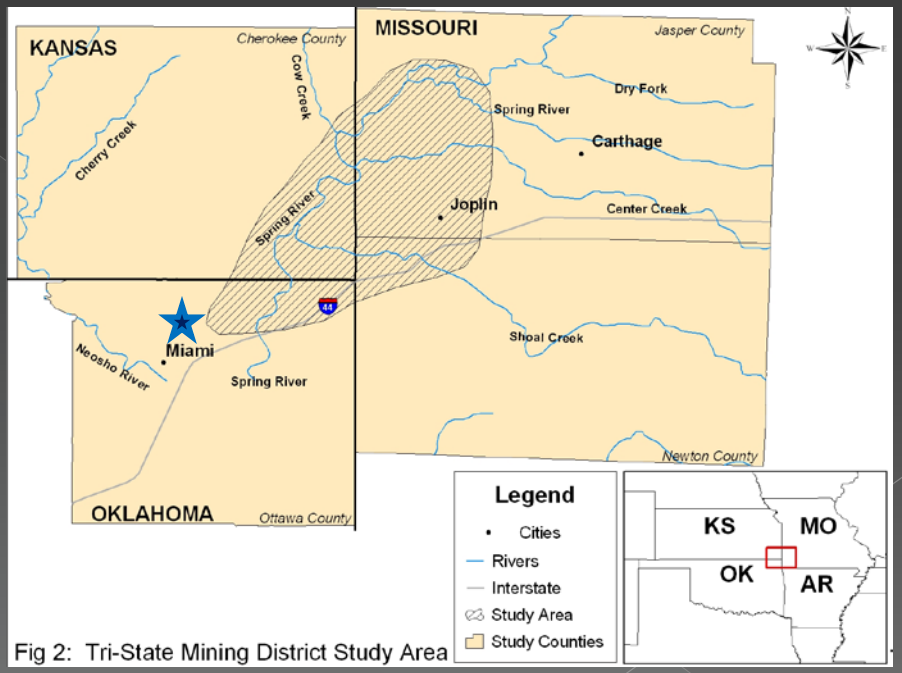
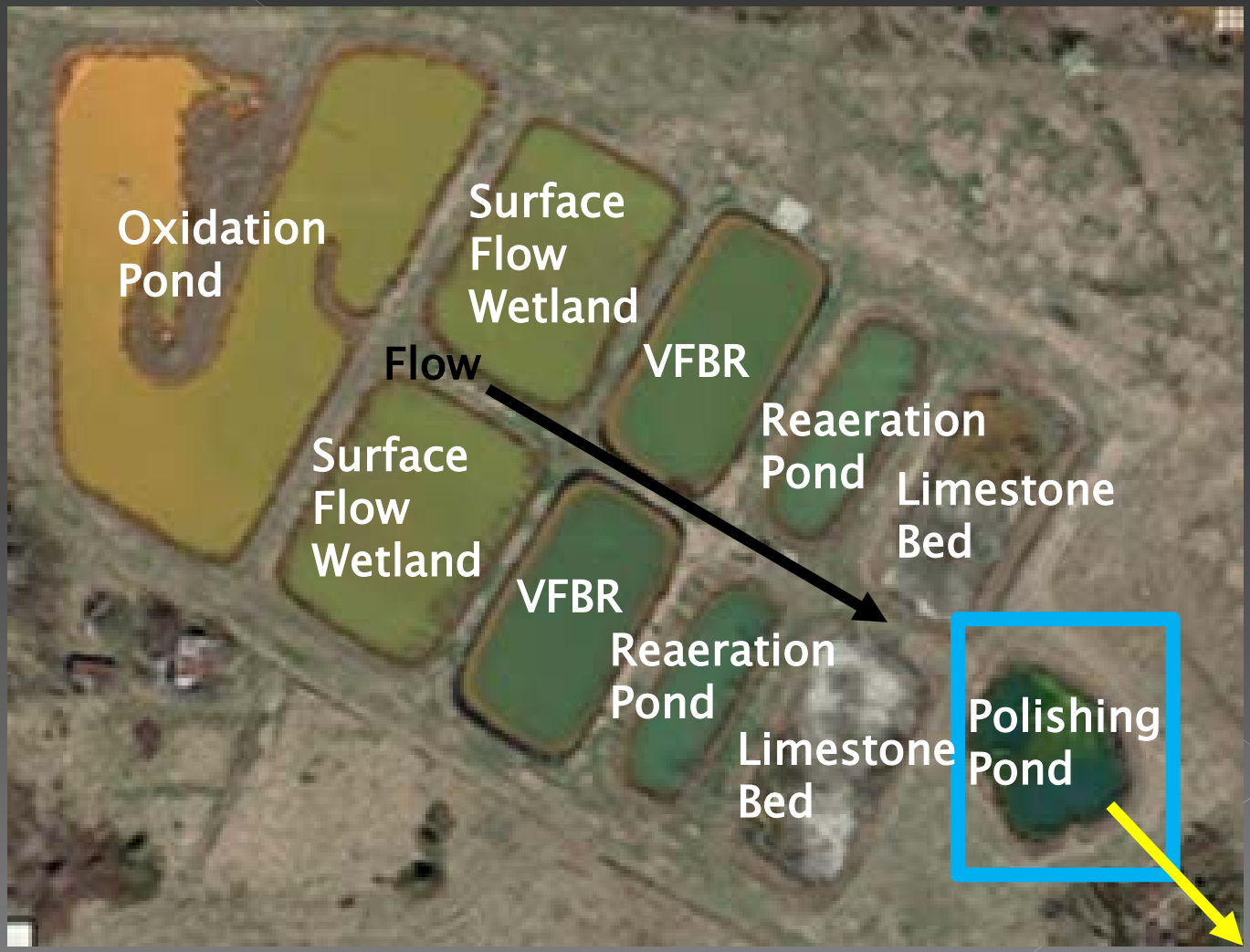


Fig 2: Tri-State Mining District Study Area

U.S. Fish and Wildlife Services

Introduction

Mayer Ranch Passive Treatment System



Introduction

- Trace amounts of Ni and Zn are detectable at the effluent
  - Toxins in high concentrations
- Natural algae consortium may play a role in metal uptake and release

Literature Review

- Metal uptake by algae is possible
  - Adsorption is the main removal mechanism
- Environmental factors and other conditions influence sorption
  - Algae & metal species
  - Age of material
  - pH
  - Growth rate
  - Algae concentration
  - Contact time
  - Presence of charged functional groups
- Metal preferences by algae species

Literature Review

- Algae with previous metals exposure
  - Less inhibited growth
- Release of metals during decomposition theorized
  - Very few studies quantify desorption

Hypotheses

1. Algae from MRPTS will be able to uptake Ni and Zn
2. The concentration of sorbed metals will decrease during decomposition
3. Some Ni and Zn will stay sorbed to algae detritus despite decomposition

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Objectives

1. Determine initial concentrations of Ni and Zn in MRPTS algae and water
2. Measure the uptake of Ni and Zn by algae during the growth phase
3. Determine if conditions promoting algae death affect [Ni] or [Zn]
4. Measure Ni and Zn masses gained or released during decomposition

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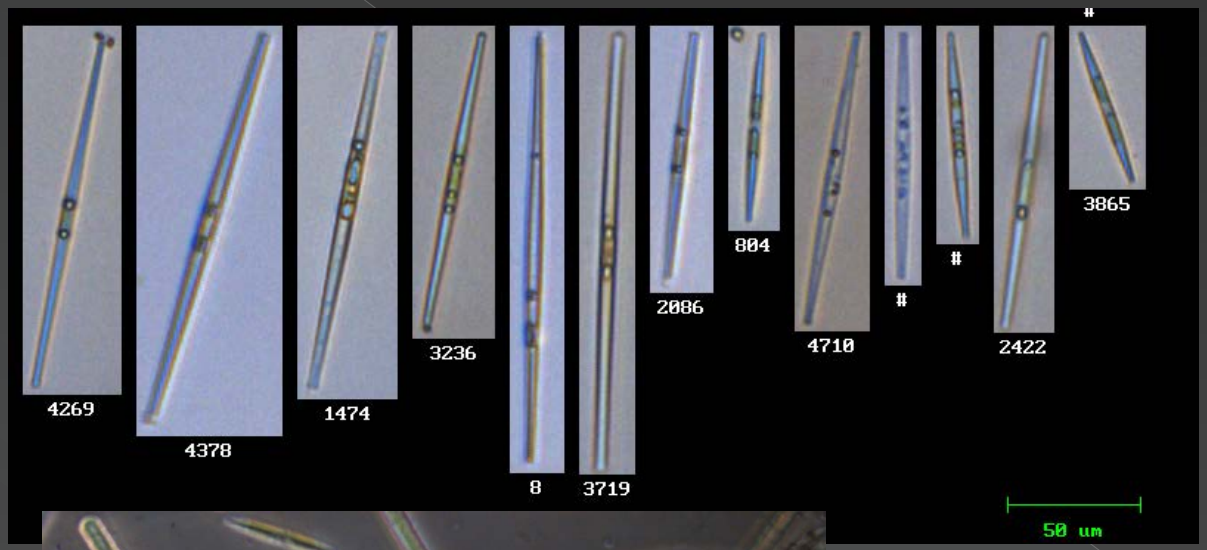
Experimental Setup

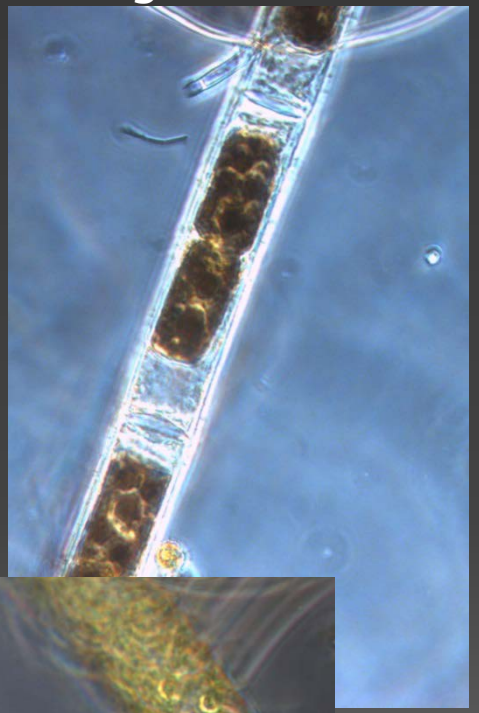
Sample Collection

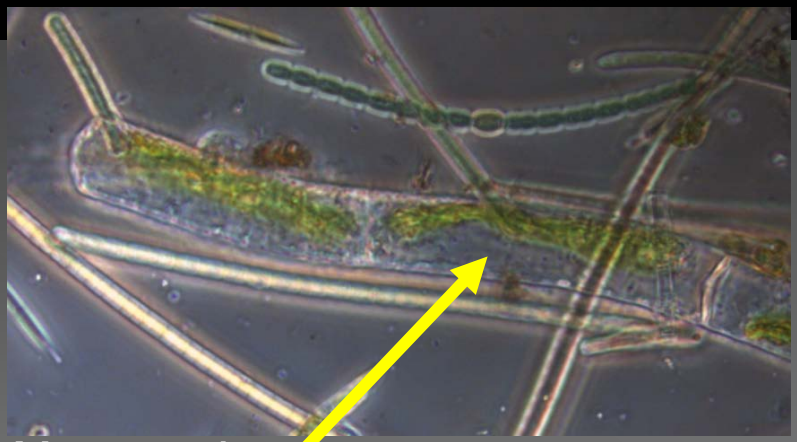
Algae Present

Pennate Diatoms



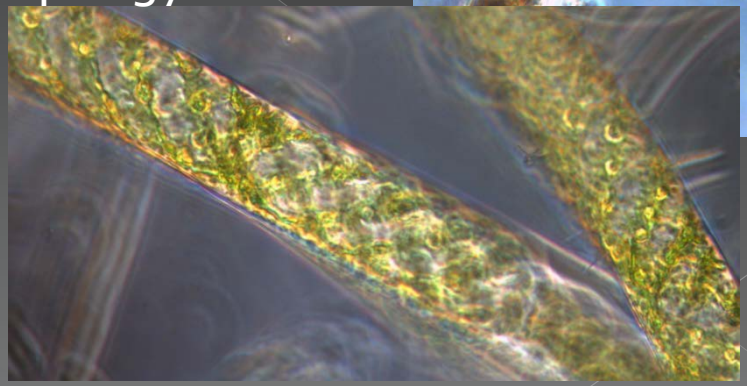
Oedegonium





Mougeotia

Spirogyra



Experimental Setup

- Measure Ni and Zn in initial algae and water samples
- Five [Ni and Zn] in triplicate
  - 0.5, 2.0, 5.0, 10.0, and 20, mg/L
- Cell 6 water as blank samples
- No algae control sample (10 mg/L Ni and Zn solution)
- Destructive sampling (i.e., deplete samples for analysis)

Experimental Setup

- **Growth Phase (5 days):**
  - Provide photosynthetically active radiation (PAR) lights
  - 20°C

Experimental Setup

- **Chilled Phase (2 days):**
  - Promote death of algae
    - Eliminate light
    - 0°C

Experimental Setup

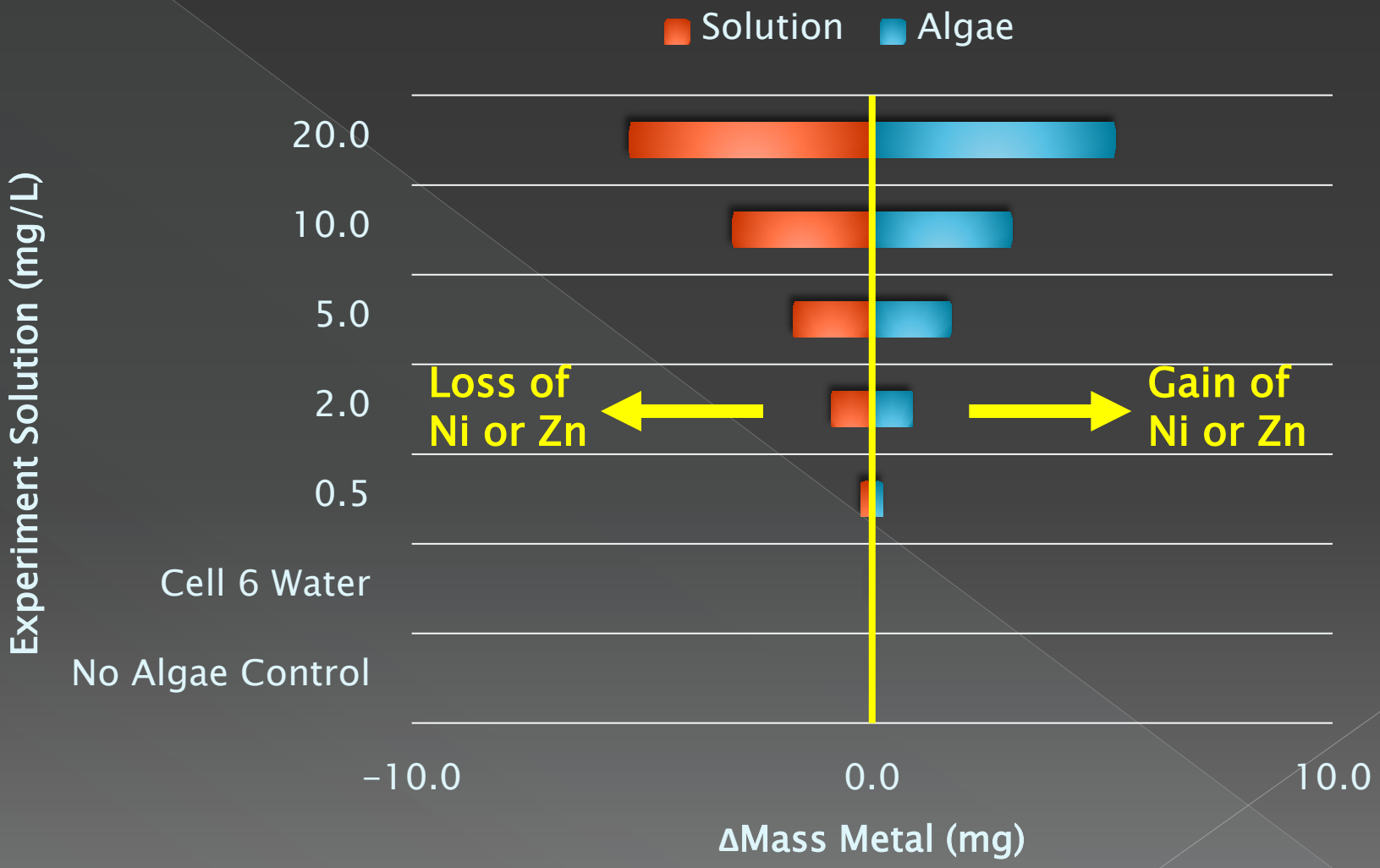
- **Decomposition Phase (21 days):**
  - Remain covered to prevent light
  - 20°C

Initial Samples

Initial Samples

	Nickel	Ni Std. Dev.	Zinc	Zn Std. Dev.
MRPTS Cell 6 Water (mg/L)	0.05	+/- 0.0006	0.01	+/- 0.0001
MRPTS Cell 6 Algae (mg/Kg)	210	+/- 11	1213	+/- 161

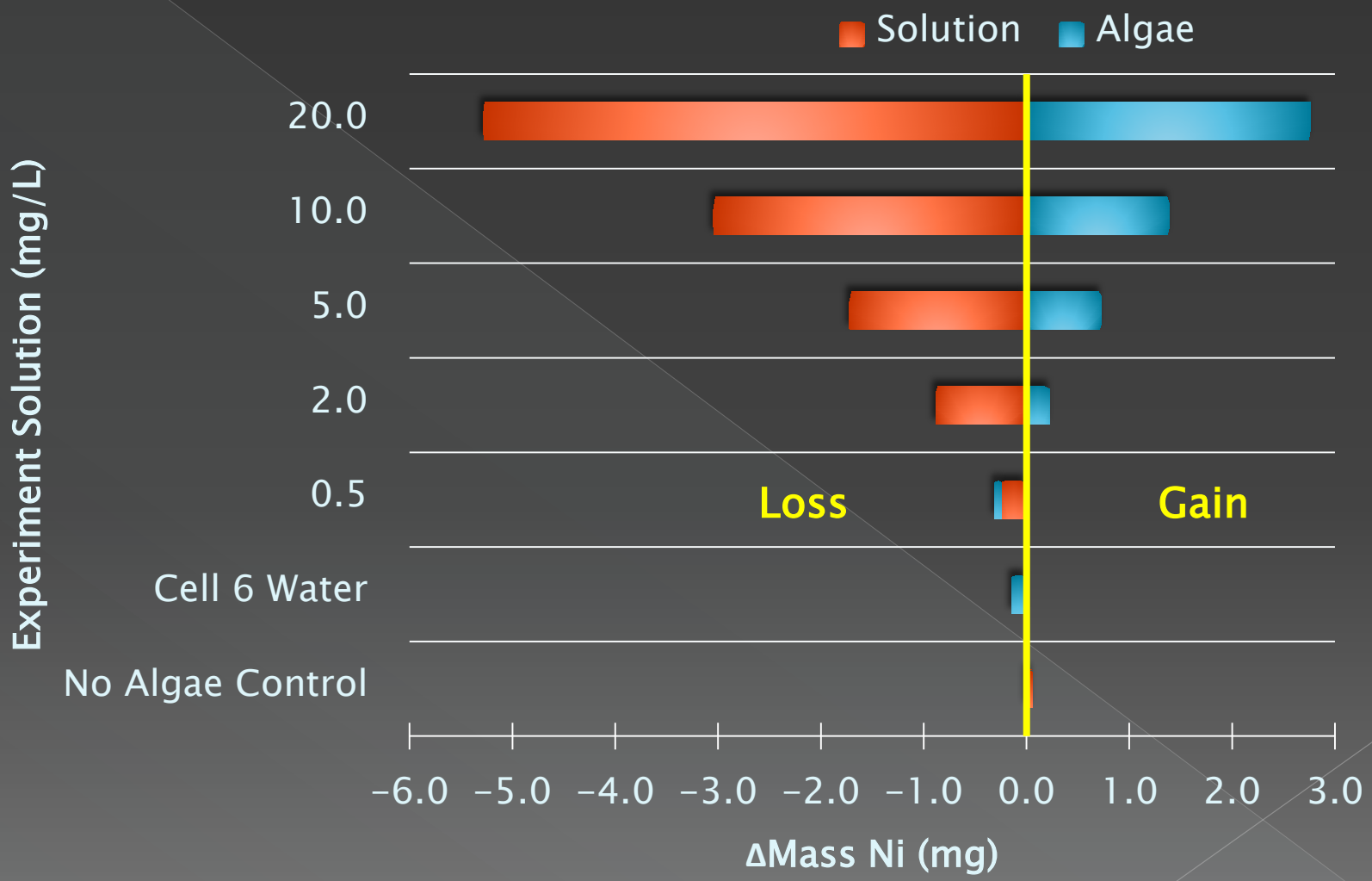
Results – Data



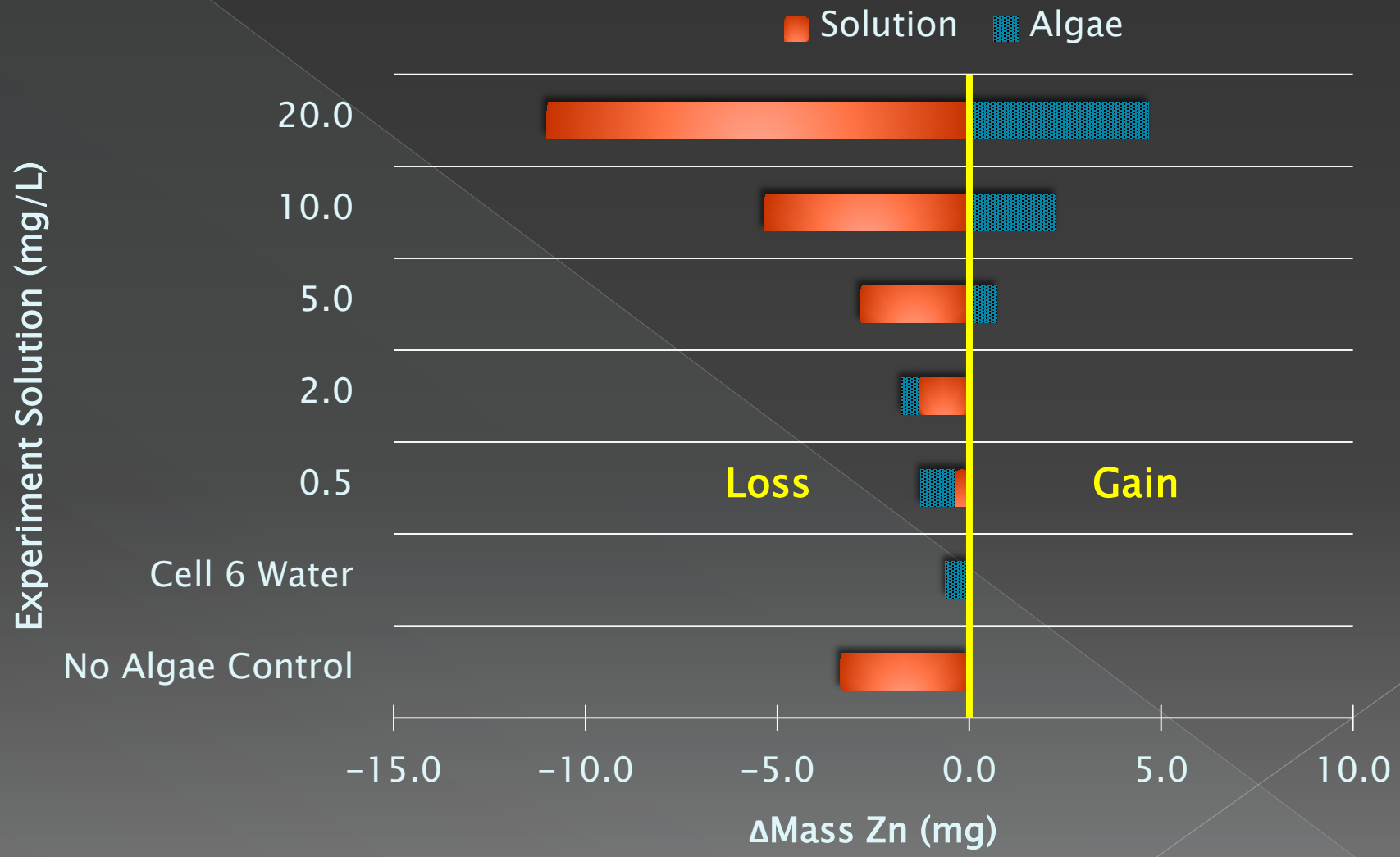
Growth Phase

20°C
w/ light cycles

Growth Phase – Nickel



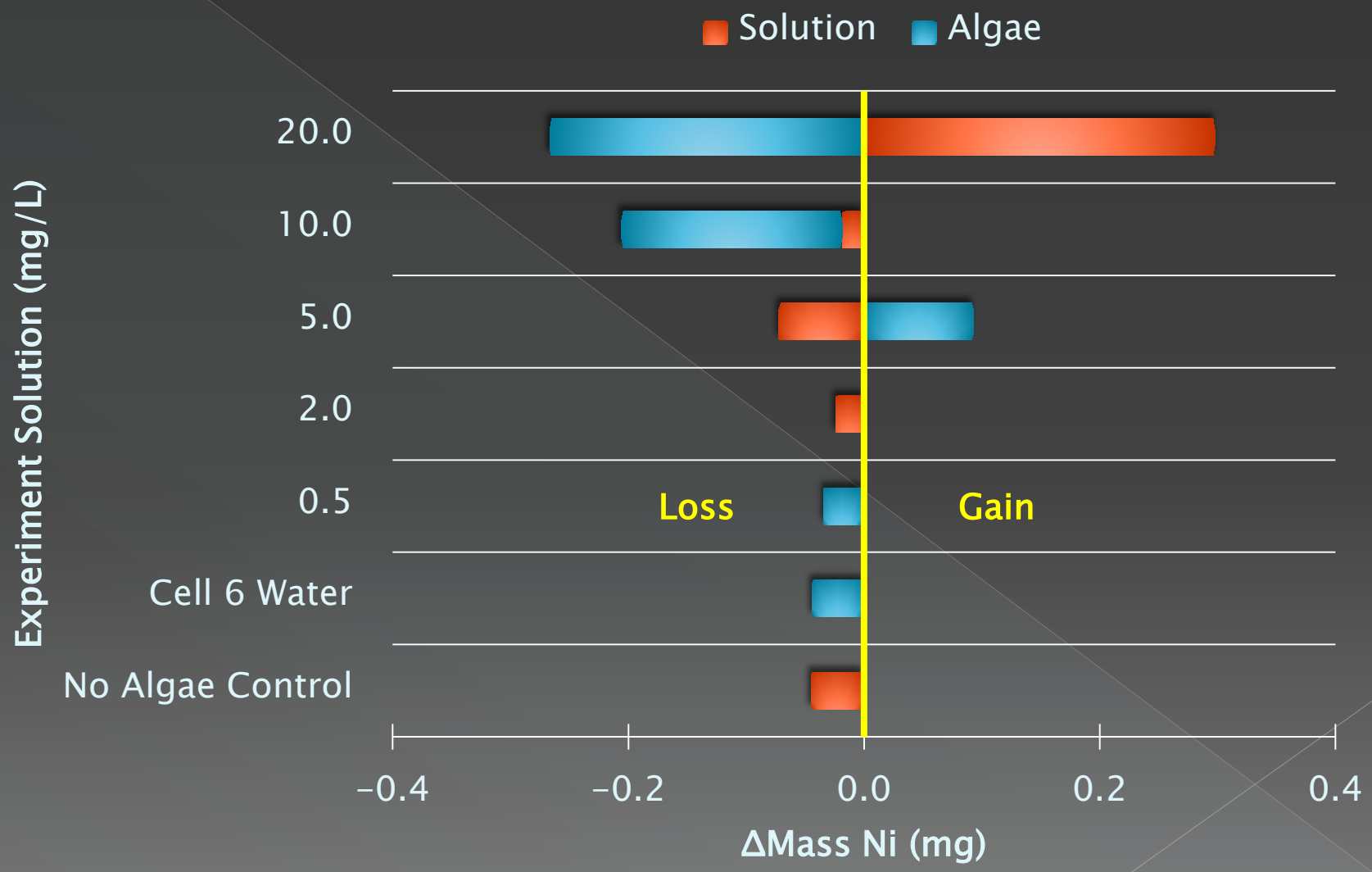
Growth Phase – Zinc



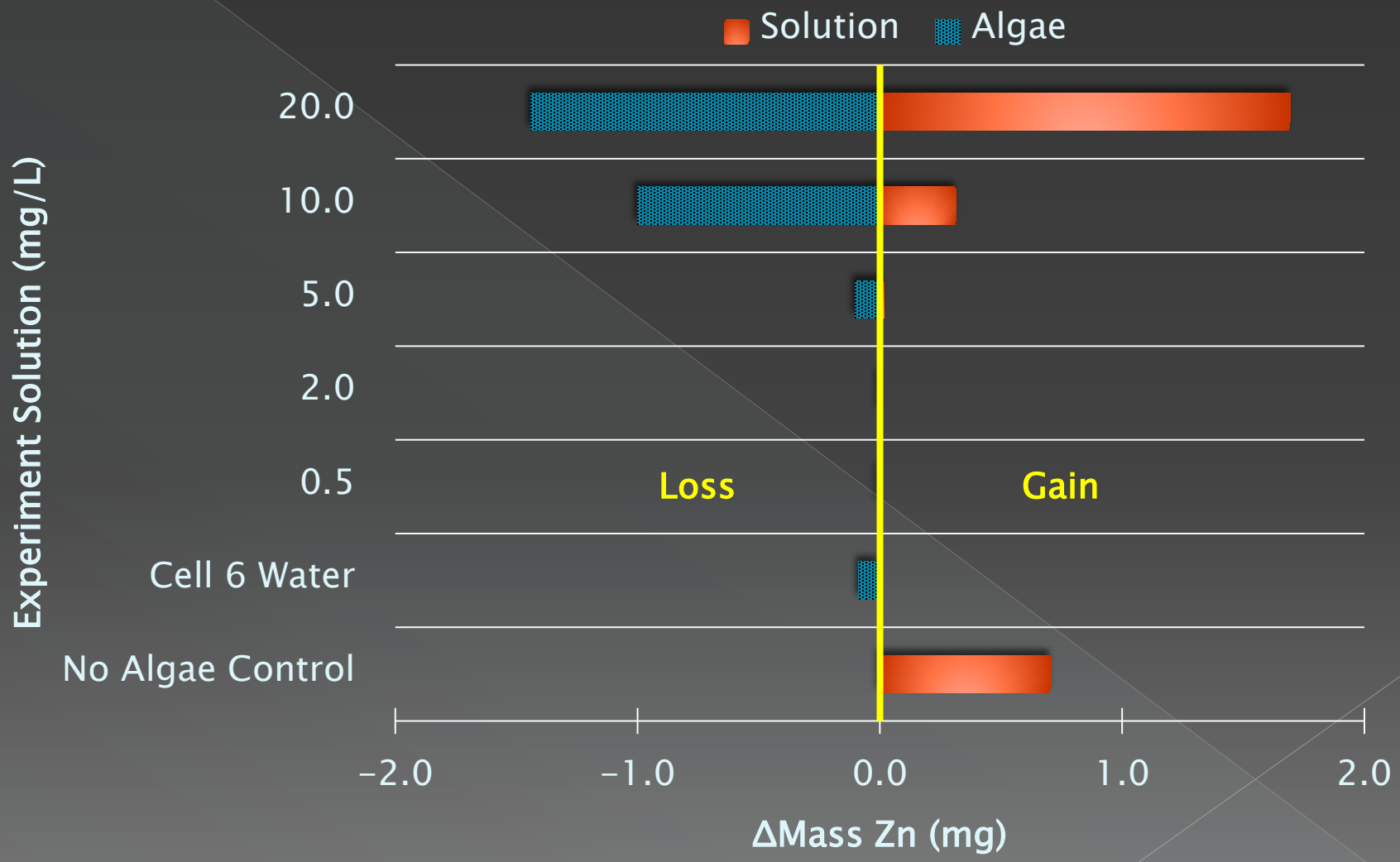
Chilled Phase

0°C
w/o light

Chilled Phase – Nickel



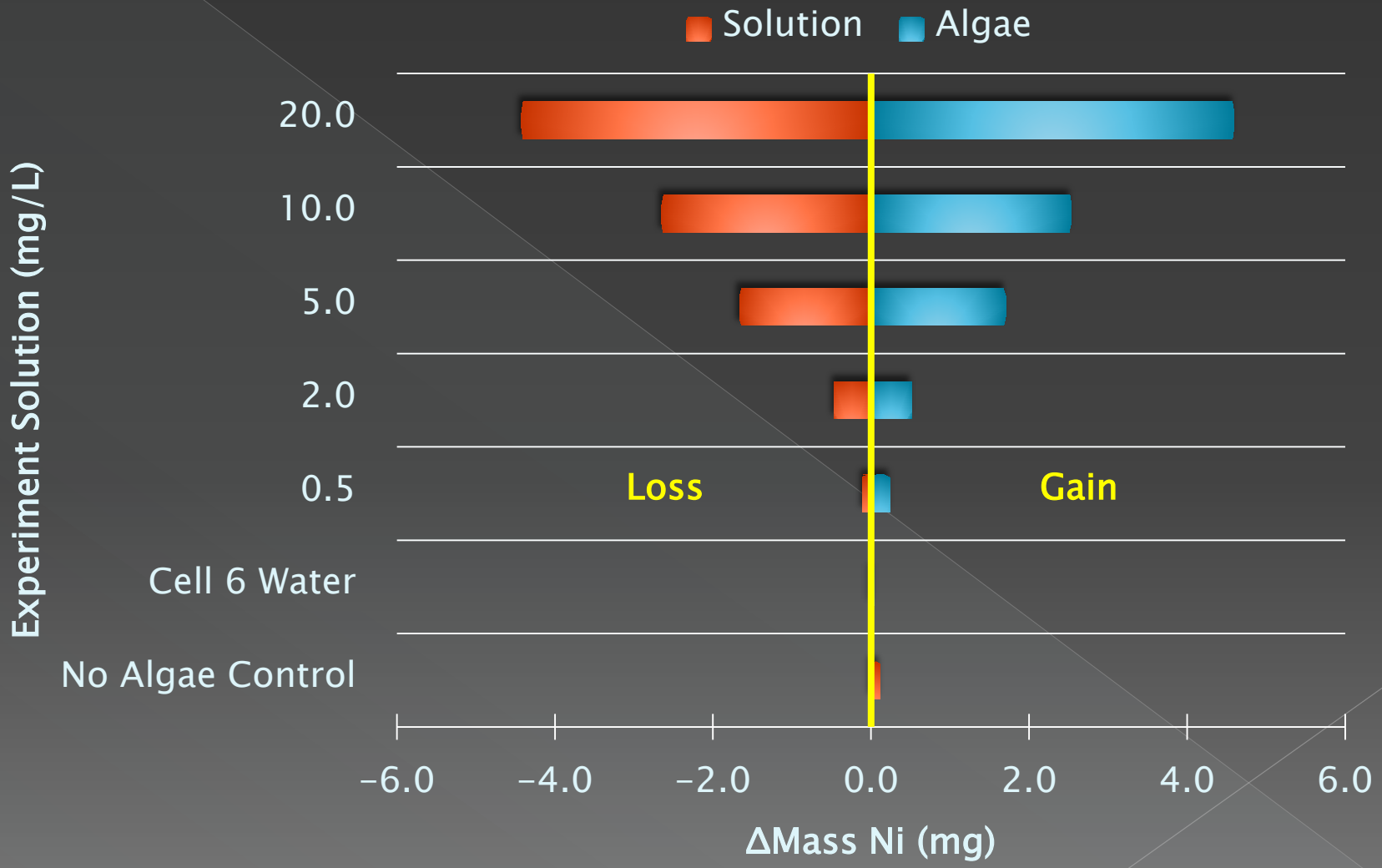
Chilled Phase – Zinc



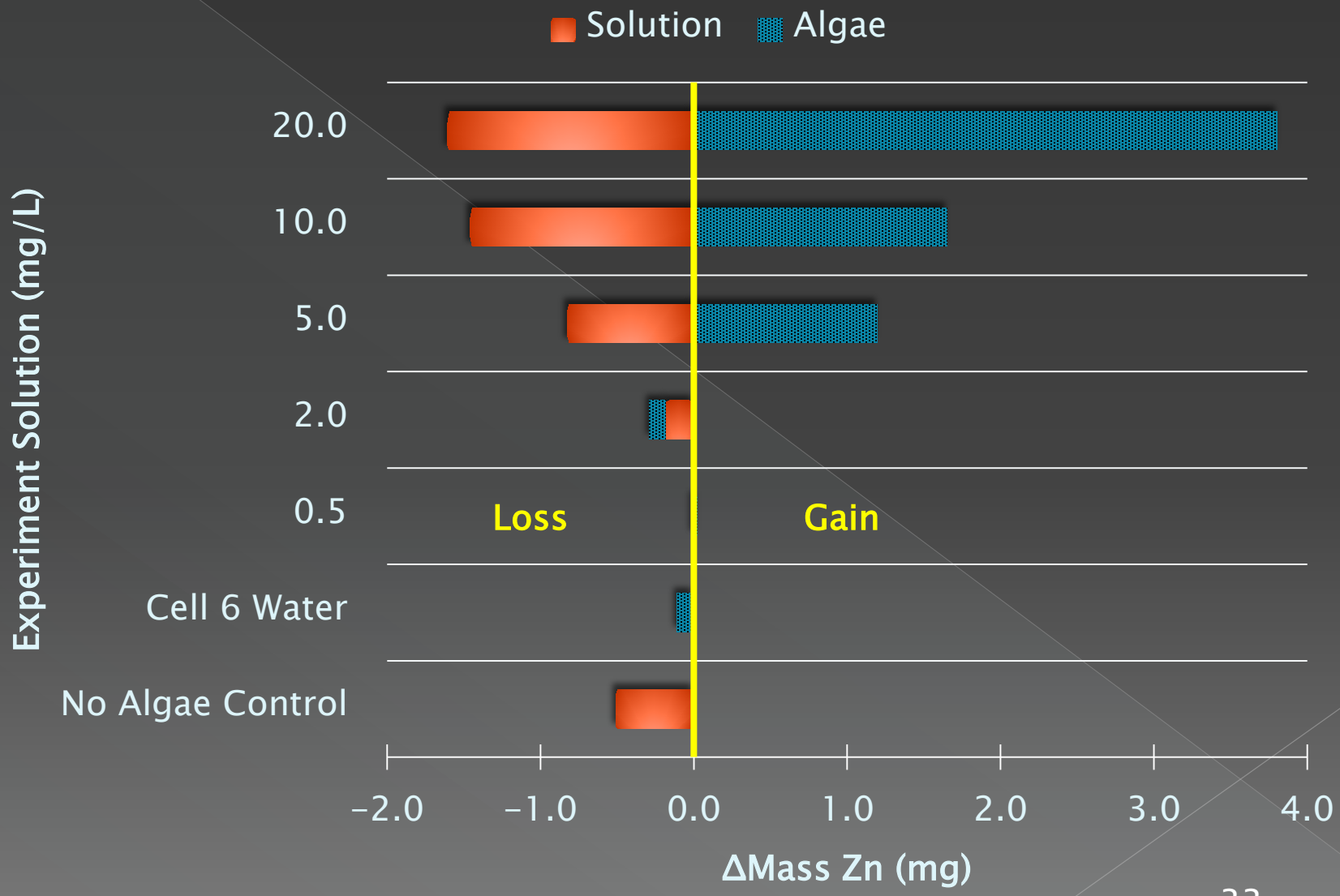
Decomposition Phase

20°C
w/o light

Decomposition Phase – Nickel



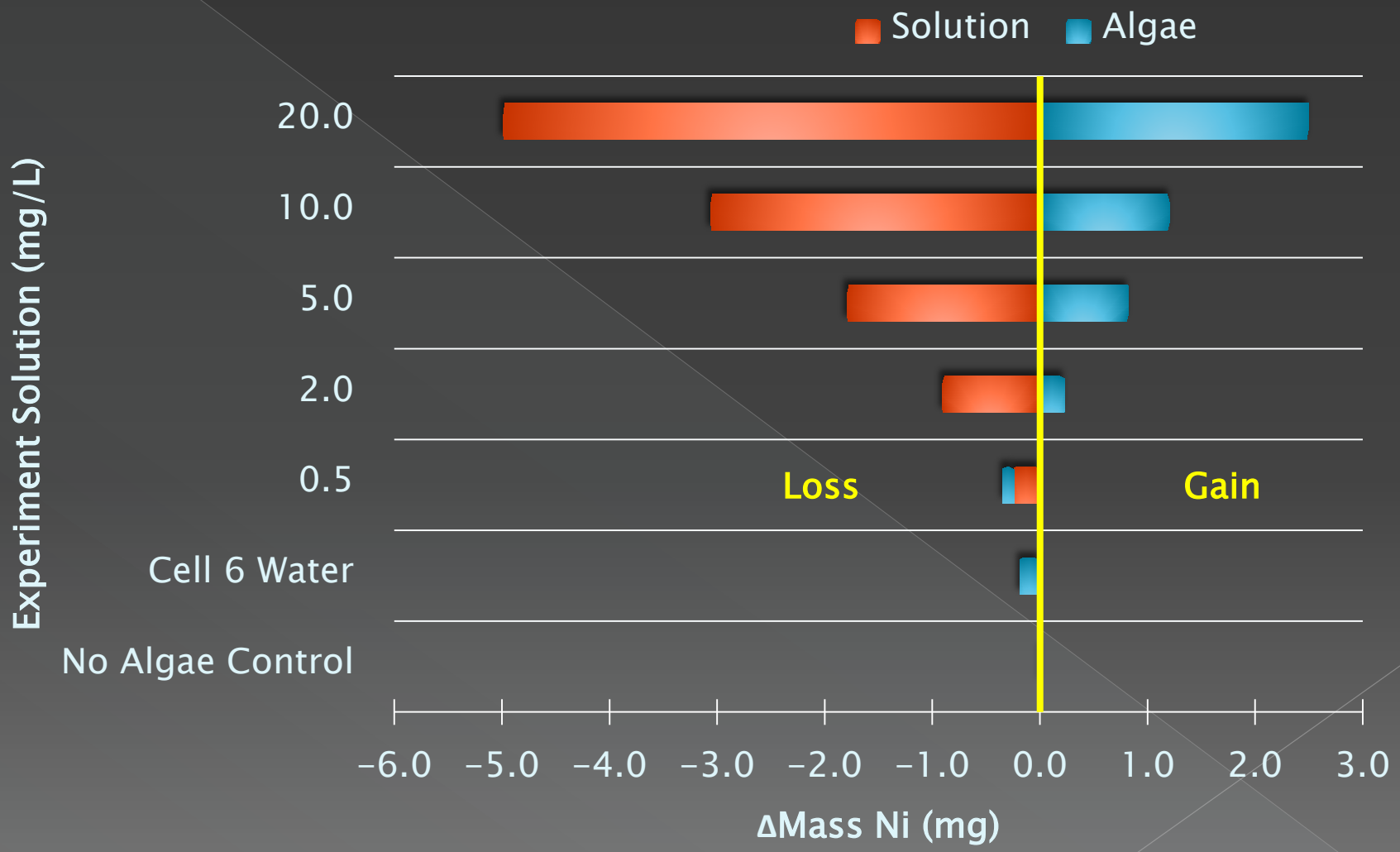
Decomposition Phase – Zinc



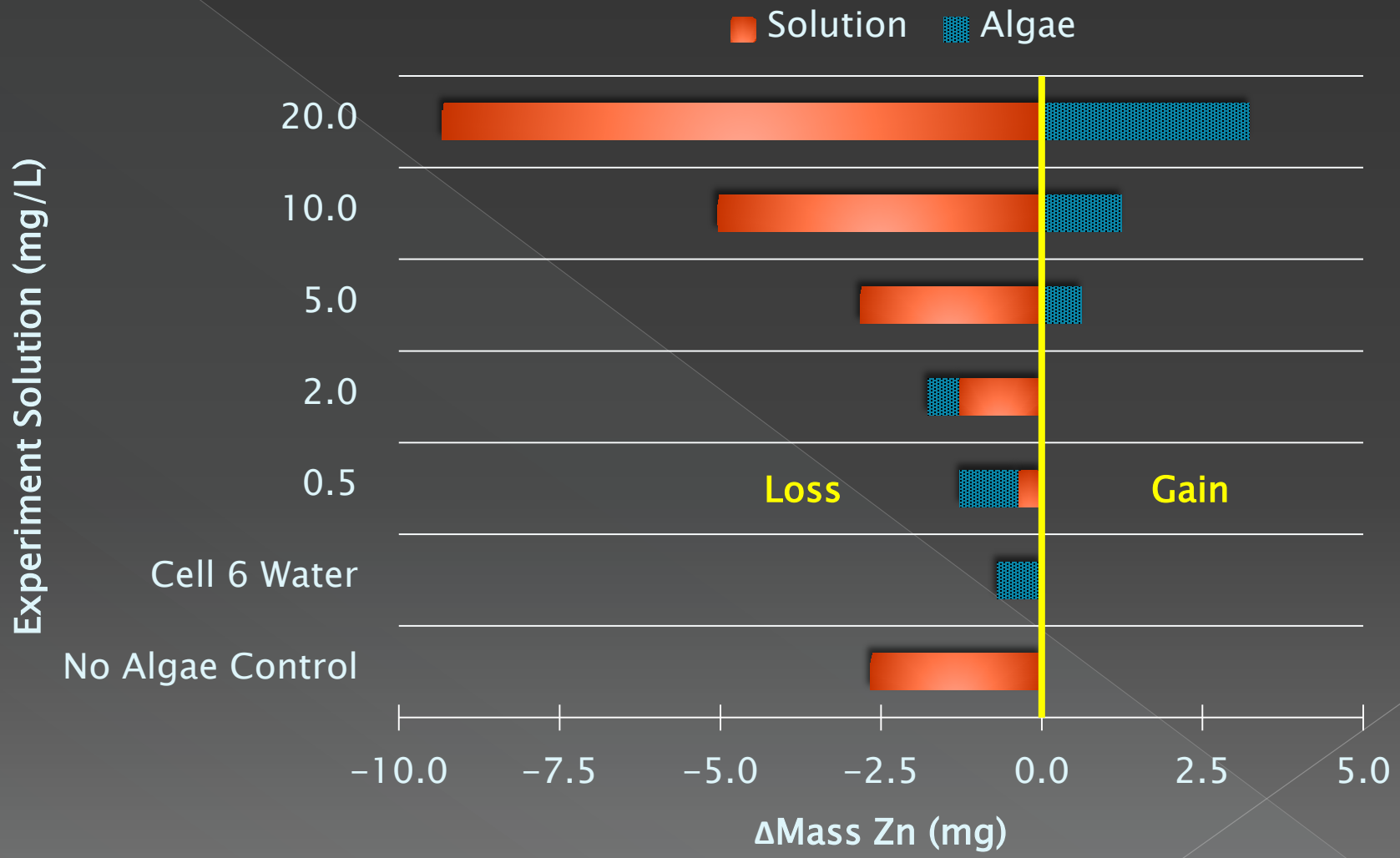
Results – Overall

*Includes previous phase/s

Chilled Phase – Nickel



Chilled Phase – Zinc



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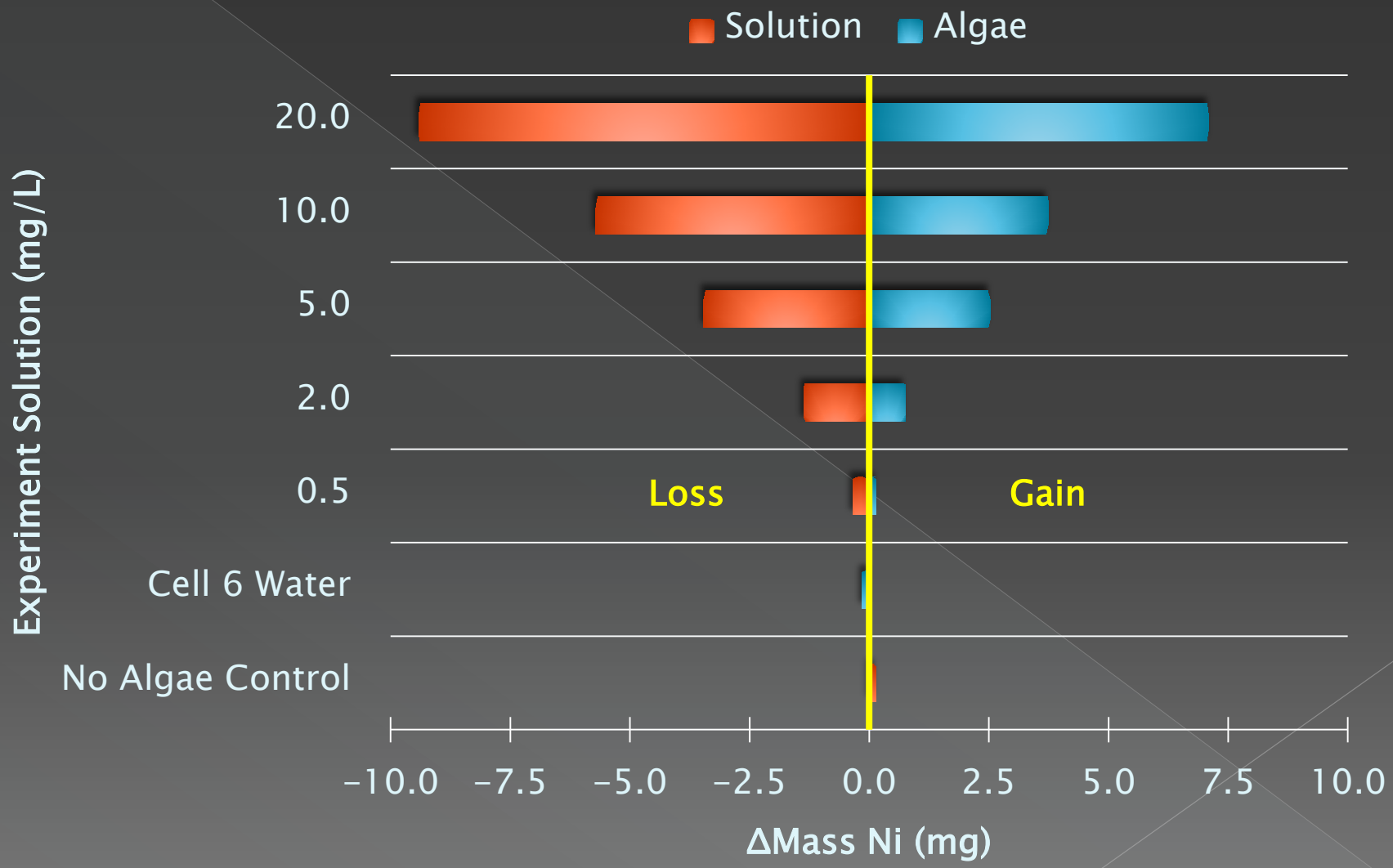
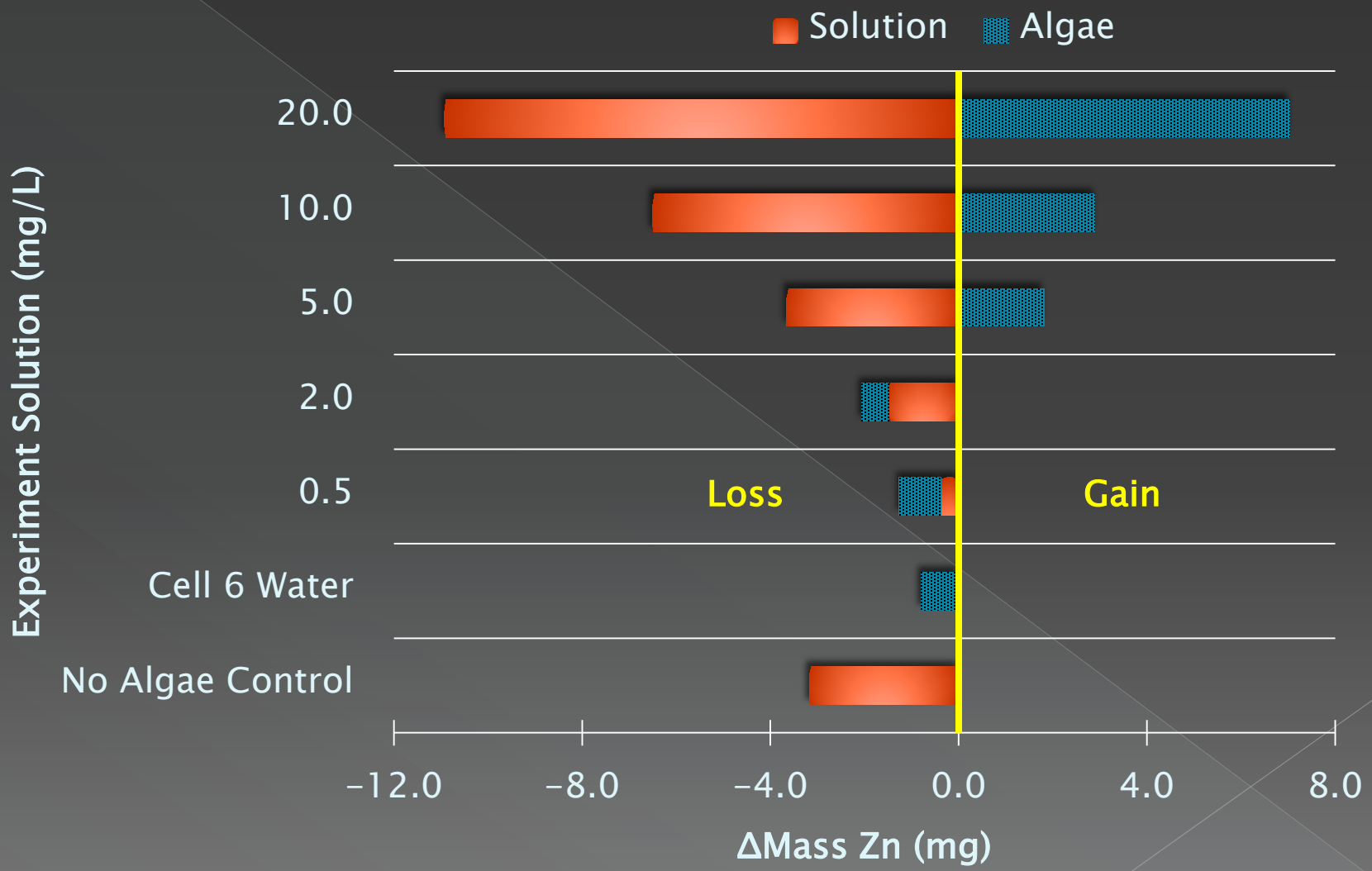
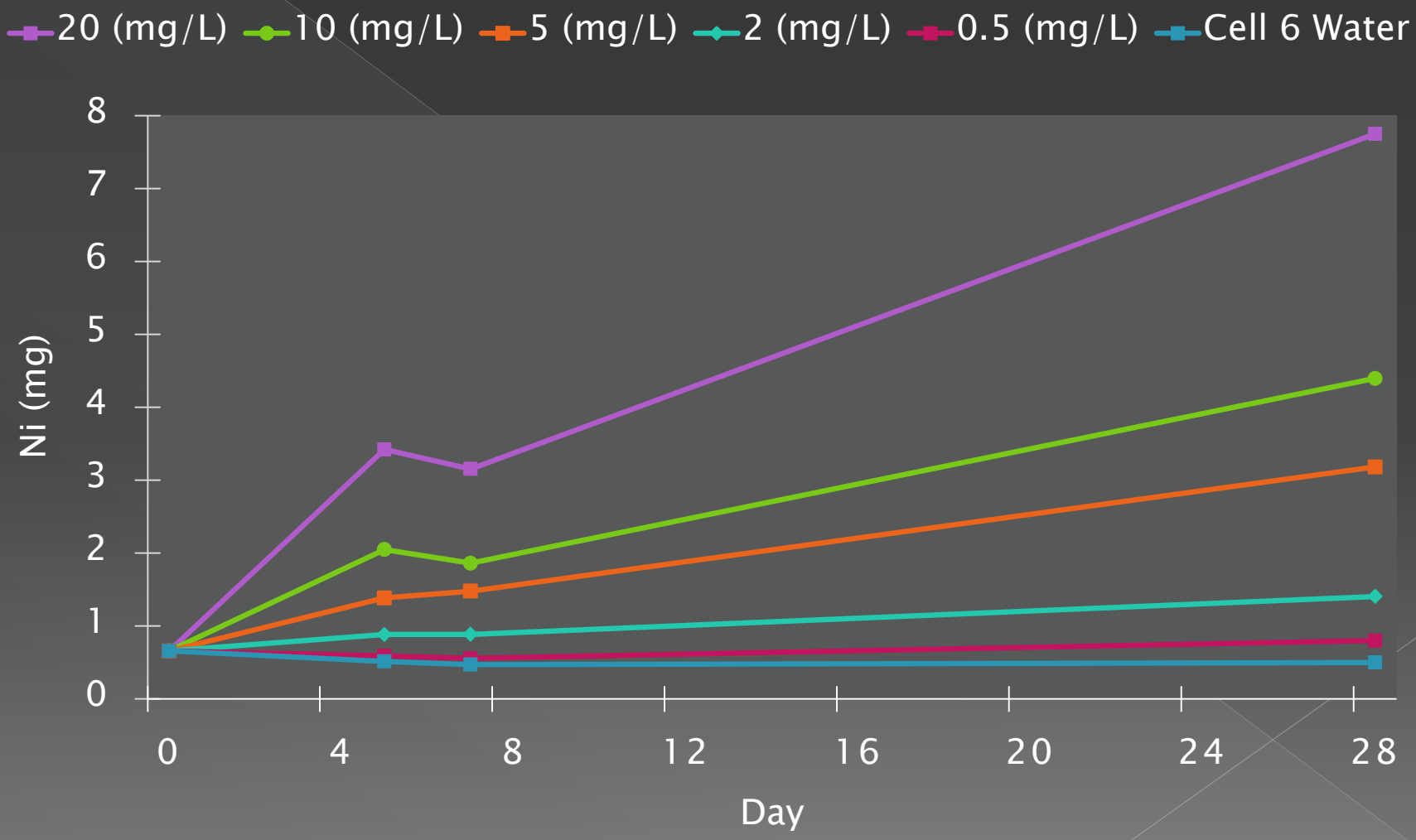


Decomposition Phase – Zinc



Algae – Nickel



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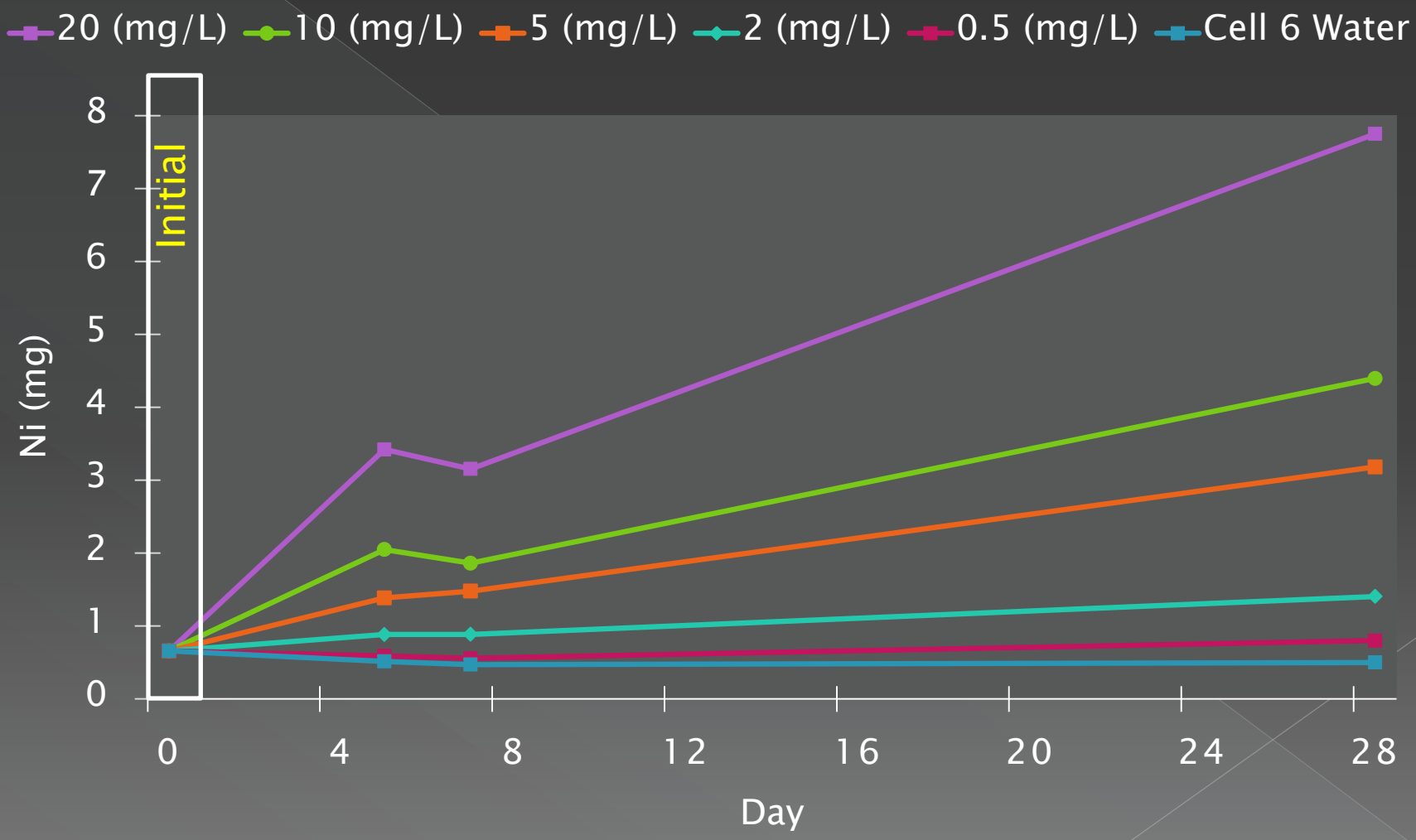

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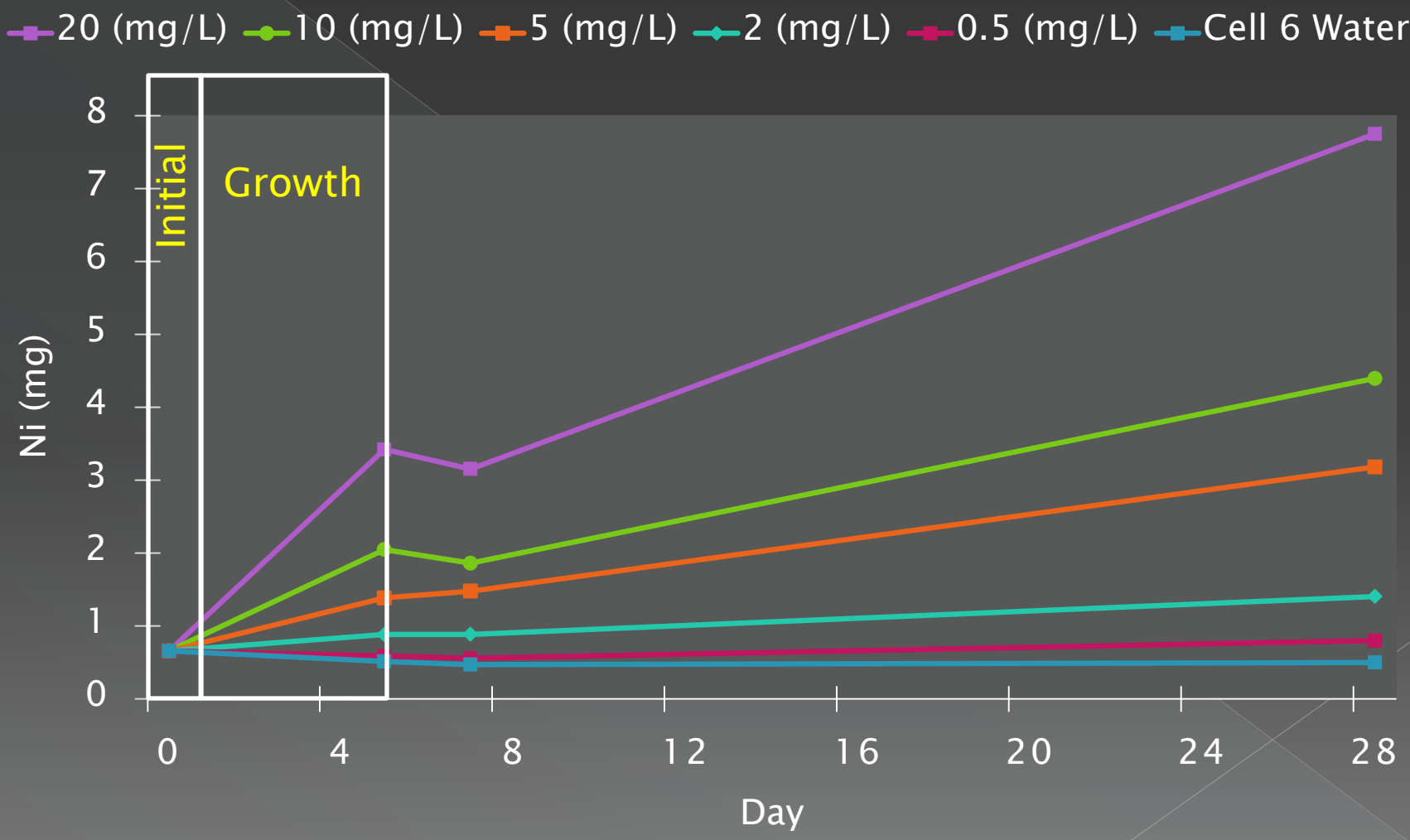

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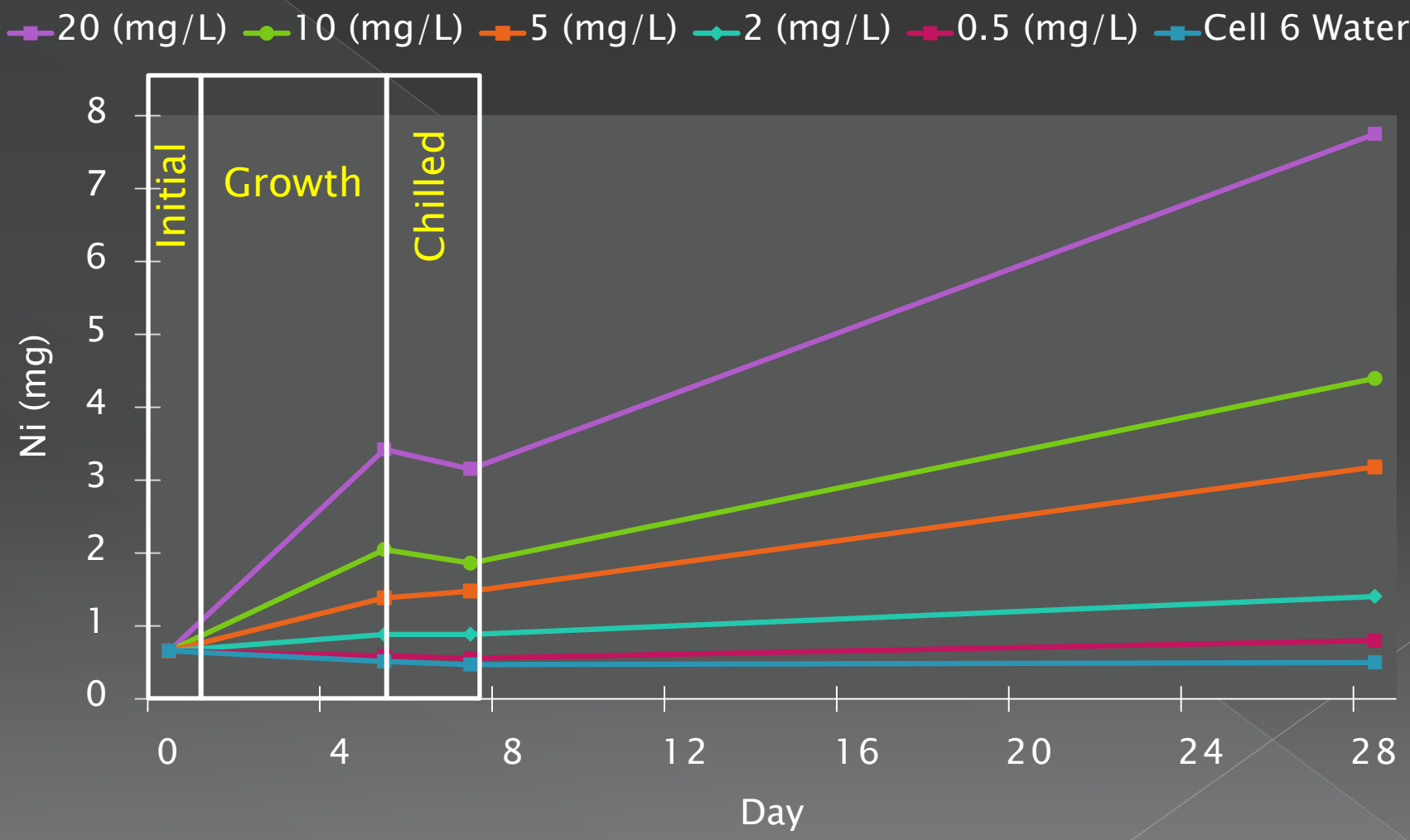

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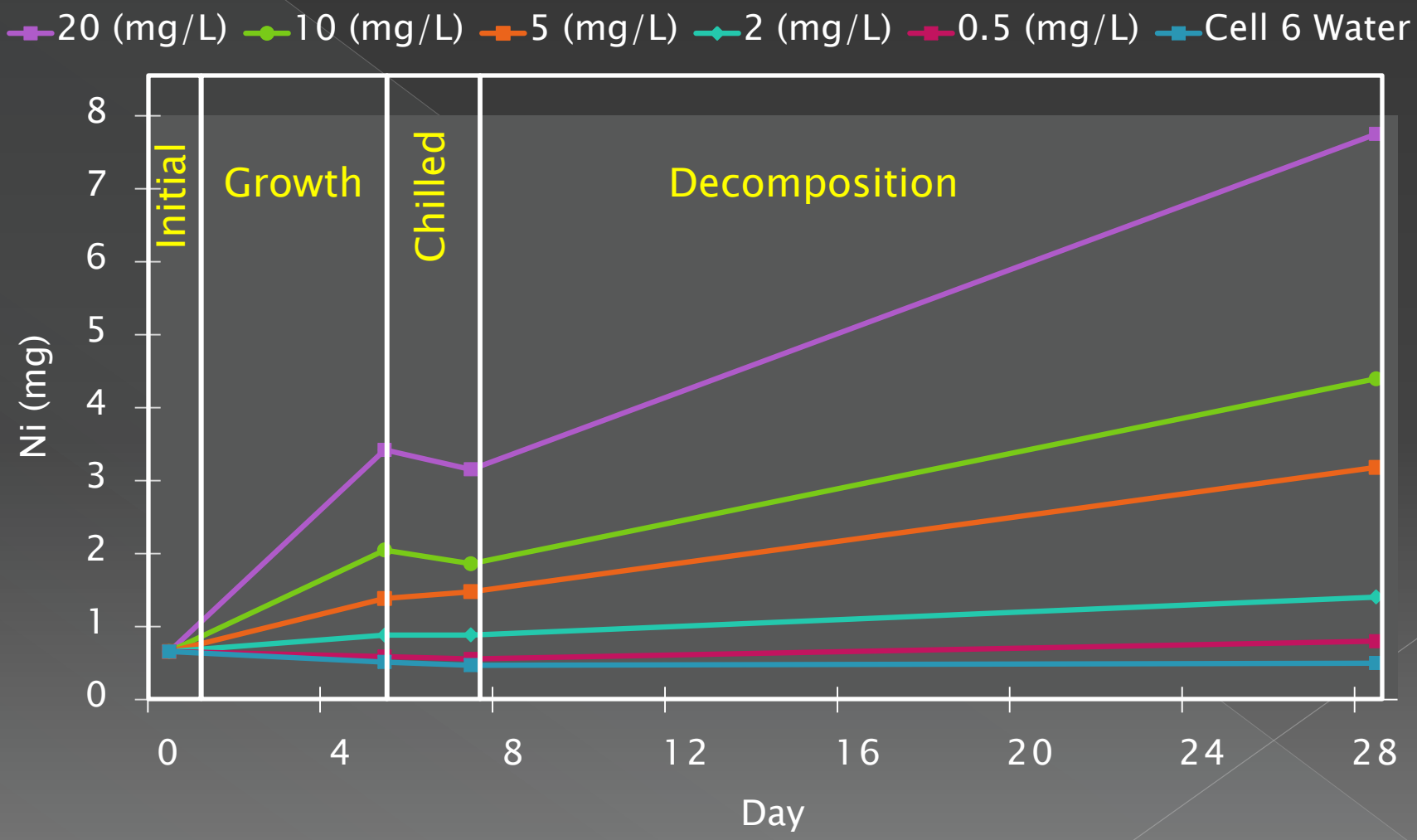

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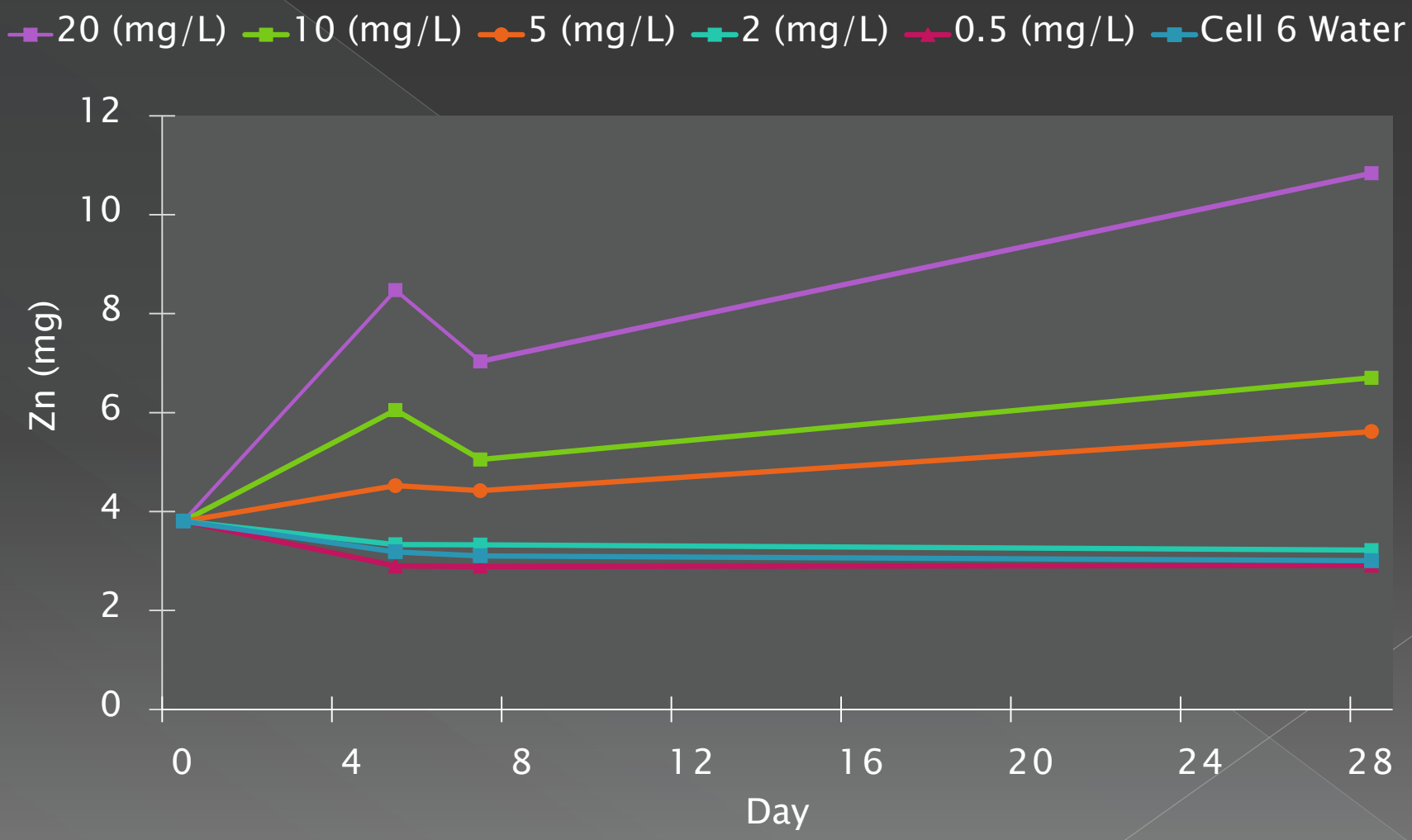
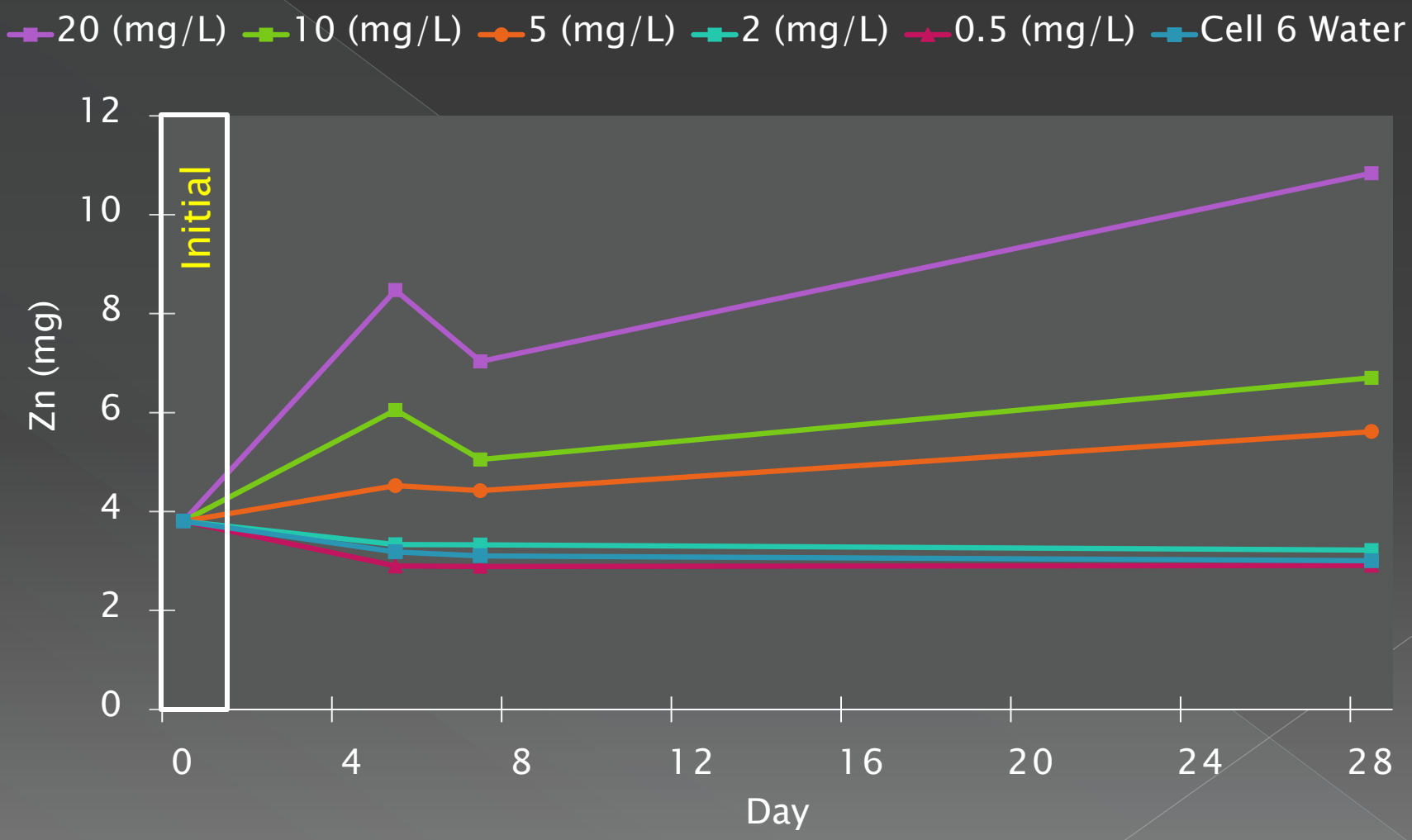

20 (mg/L)
10 (mg/L)
5 (mg/L)
2 (mg/L)
0.5 (mg/L)
Cell 6 Water
Zn (mg)
12
10
8
6
4
2
0
0
4
8
12
16
20
24
28
Day

Algae – Zinc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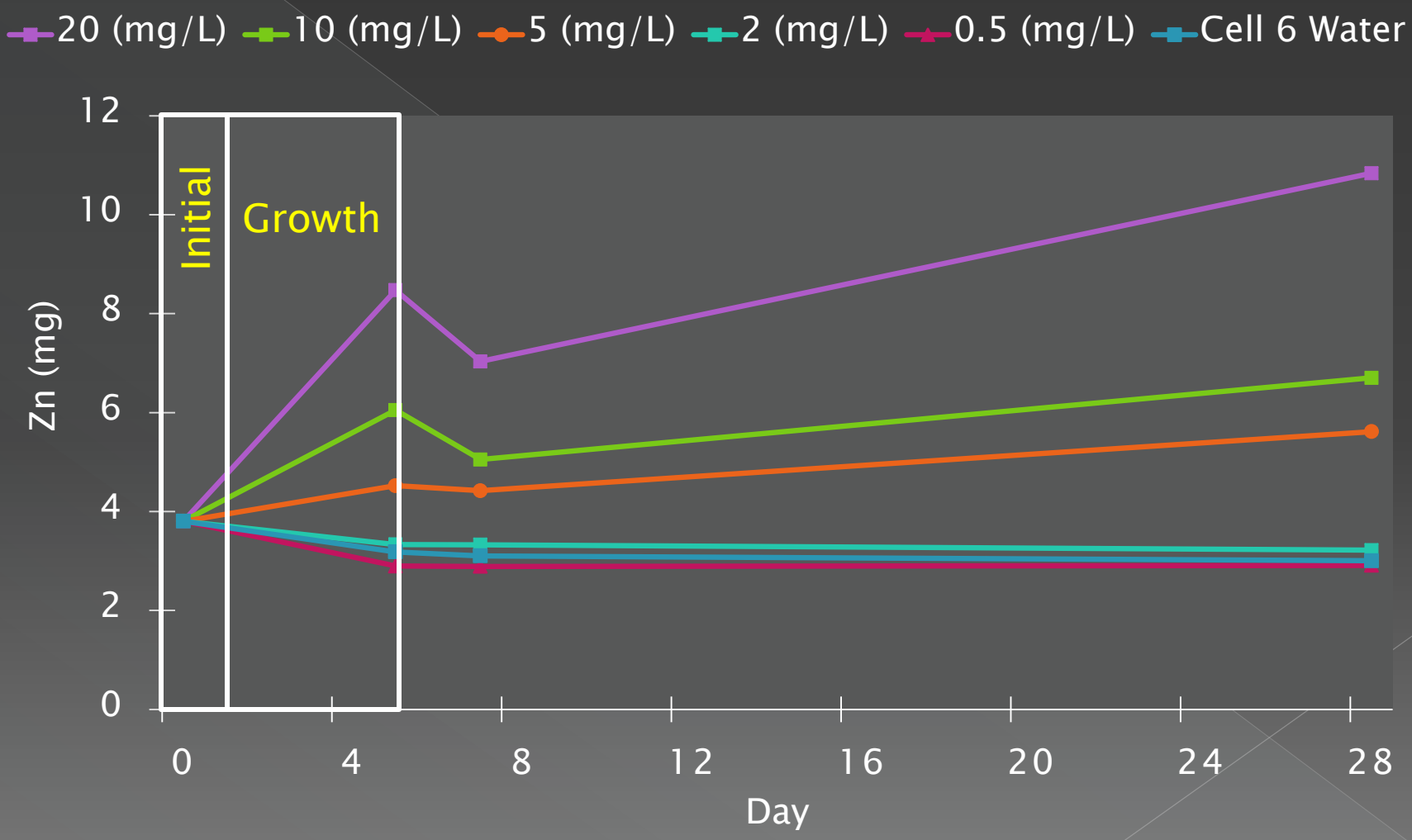
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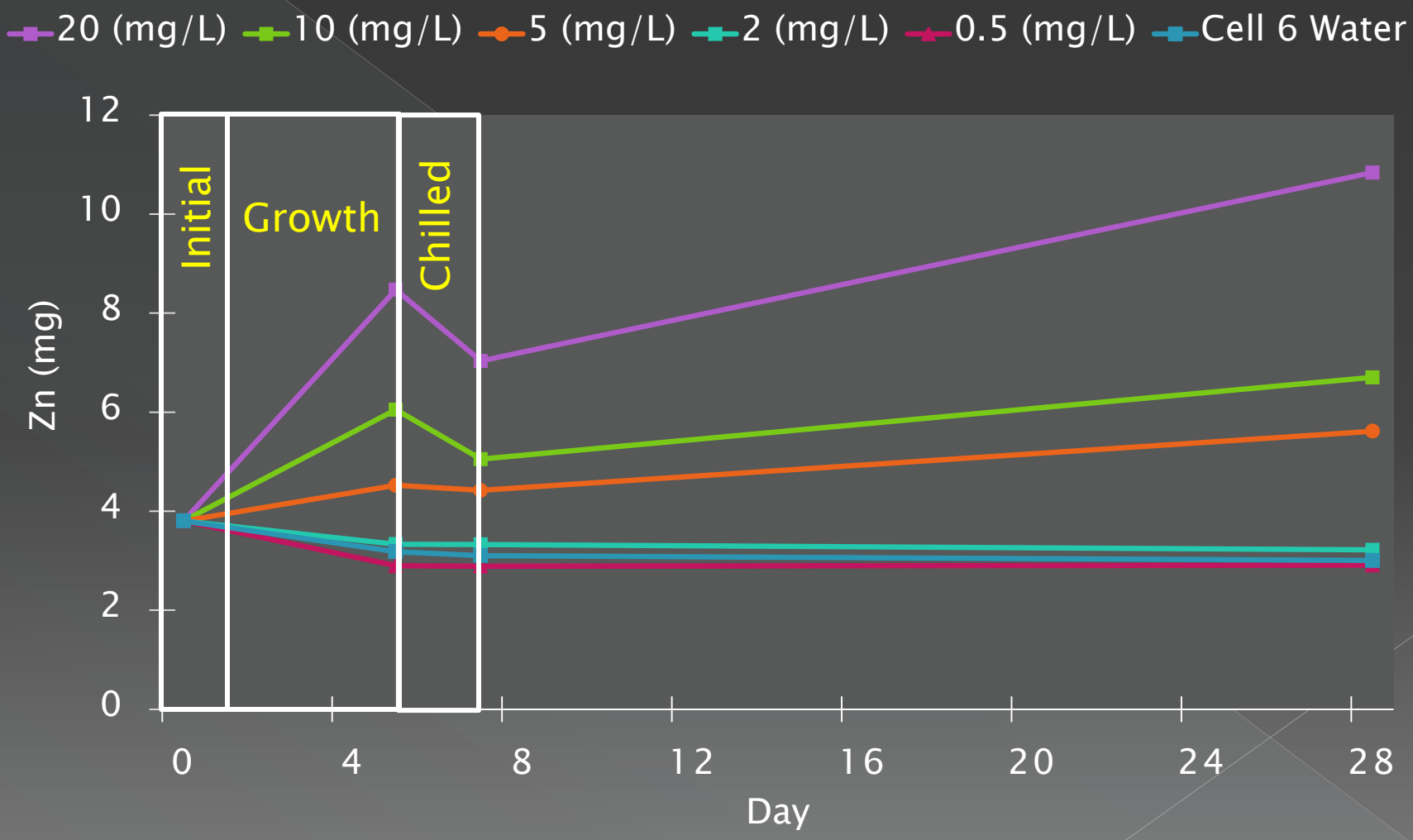
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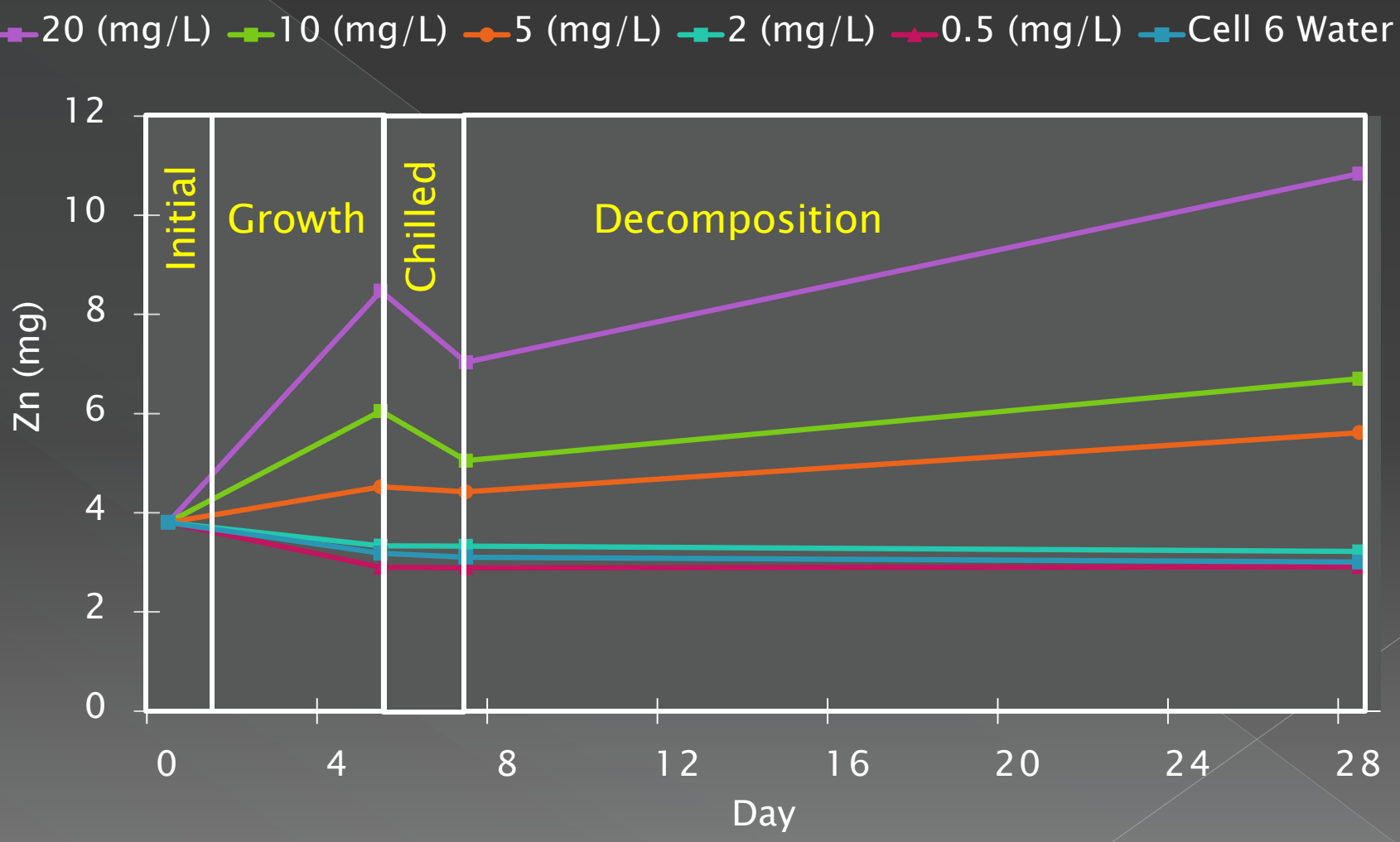
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Decomposition
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4
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10
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4
8
12
16
20
24
28
Day

Conclusions

- Sorption occurred during growth and decomposition
- Desorption back into solution occurred during chilled phase
- Overall
  - Sorption and retention of Ni & Zn by algae
- Greater sorption with greater [Ni] and [Zn]

Conclusions – Hypotheses

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   - Confirmed

Conclusions

- Naturally growing algae at MRPTS is capable of sorbing Ni and Zn
  - Likely providing additional treatment
- Sorption was exhibited by living and decomposed algae
  - Algae will continue to provide treatment
  - More algae present means more treatment

Future Research

- Peak Sorption
- Effects of seasonality
- Quantifying yearly uptake
  - Treatment $ saved
  - Cost benefit of supporting algae for treatment in a passive treatment system

Acknowledgements

- Grand River Dam Authority (GRDA)
  - Rich Zamor
  - Steve Nikolai

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- Center for Restoration of Ecosystems and Watersheds (CREW)
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Thank You!

Any Questions?