Testing Relationships Between Propagule Pressure and Establishment Success of a Non-native Species, *Daphnia magna*.

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UMD DULUTH

Great Ships Initiative

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Project Rationale

- Ballast water exchange (BWE) to reduce densities of organisms transferred by ships has been the most common practice.

- In an effort to go beyond the protectiveness afforded by BWE, U.S. EPA and U.S. Coast Guard are developing standards limiting the density discharged to U.S. waters.

Rationale continued

- Setting ballast water discharge standards have relied primarily on expert opinion.

- The process of setting standards have resulted in an assortment of international, national, and state discharge standards.
  1) result from uncertainty about the risk-release relationship
  2) diverse approaches of different decision makers and stakeholders.

Rationale continued

- Ballast discharge standards
  1) Too lenient a discharge standard creates costs for environment and economy
  2) Overly strict standard imposes unnecessary environmental trades
     - Fuel consumption
     - Use of toxic pesticides
     - No empirical justification – target for resistance and delay

Rationale continued

- No effort to collect and integrate the data to provide a robust analysis of the risk-release relationship associated with a discharge standard.

- Models exist which quantify the risk-release relationship, but lack sufficient data.

- Existing experimental and field data are very limited in scope and not U.S. Great Lakes relevant.

Objective

Examine the risk-release relationship associated with rate of release of a surrogate invader, *Daphnia magna*, and the rate of establishment in ambient Duluth-Superior Harbor water.

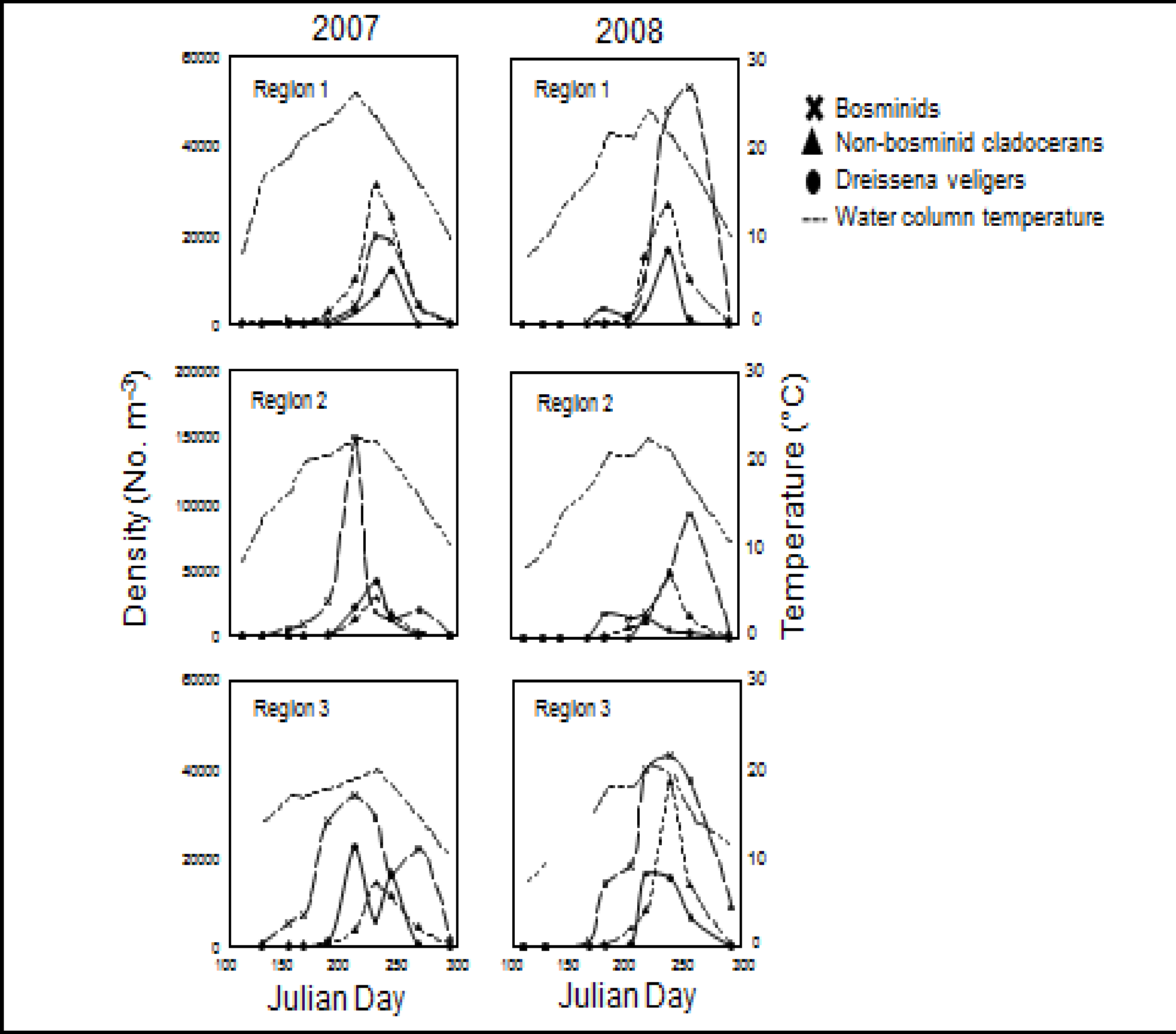
Methods

- *Daphnia magna* served as the surrogate invader
- 200-L mesocosm tanks (total of 6 doses * 3 reps = 18 tanks)
- 16:8 h light:dark cycle
- Range of average physiochemical characteristics
  1) Temp = 14.1-19.6 ºC
  2) pH = 7.83-8.27
  3) Sp Cond =192-310 µS/cm

Methods continued

Experiment length: 8 weeks

1)Nov-Dec 2009
2)May-June 2010
3)Aug-Sep 2010
4)Oct-Nov 2010



Methods continued

- Tanks were stocked with starting densities of *D. magna* that straddled International Maritime Organization (IMO) standard.

- IMO standard = no more than 10 viable organisms per m^3, each greater than 50 µm length in minimum dimension may be discharged.

Actual *D. magna* Added (Number)	Calculated Dose (Number/m^3)
0	0
1	5
2	10
3	15
4	20

Methods continued

- Weekly estimates of *D. magna* were made by subsampling 1.0 L of water
  1) All *D. magna* were returned to respective tank
  2) Background community was concentrated and preserved for identification
  3) On day 56 the entire 200 L was searched for *D. magna*

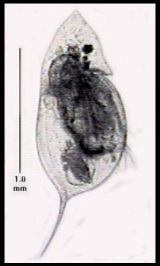
Target Establishment Thresholds

5 species of daphnia present in Duluth-Superior Harbor (2007-2008)

- *D. ambigua*
- *D. parvula*
- *D. pulex*
- *D. mendotae*
- *D. retrocurva*

D. magna (3-5 mm)

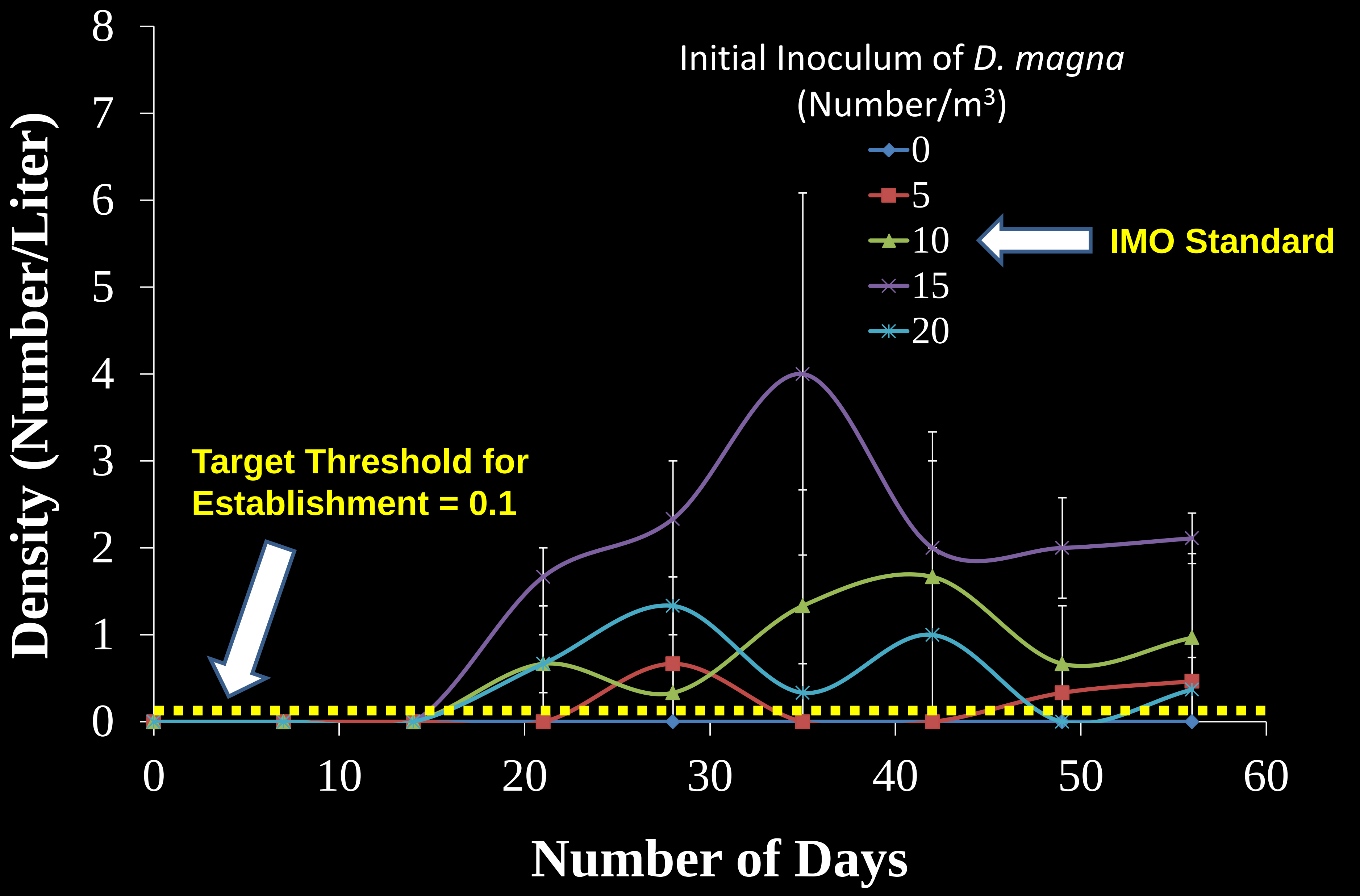
D. mendotae (1.0 mm)



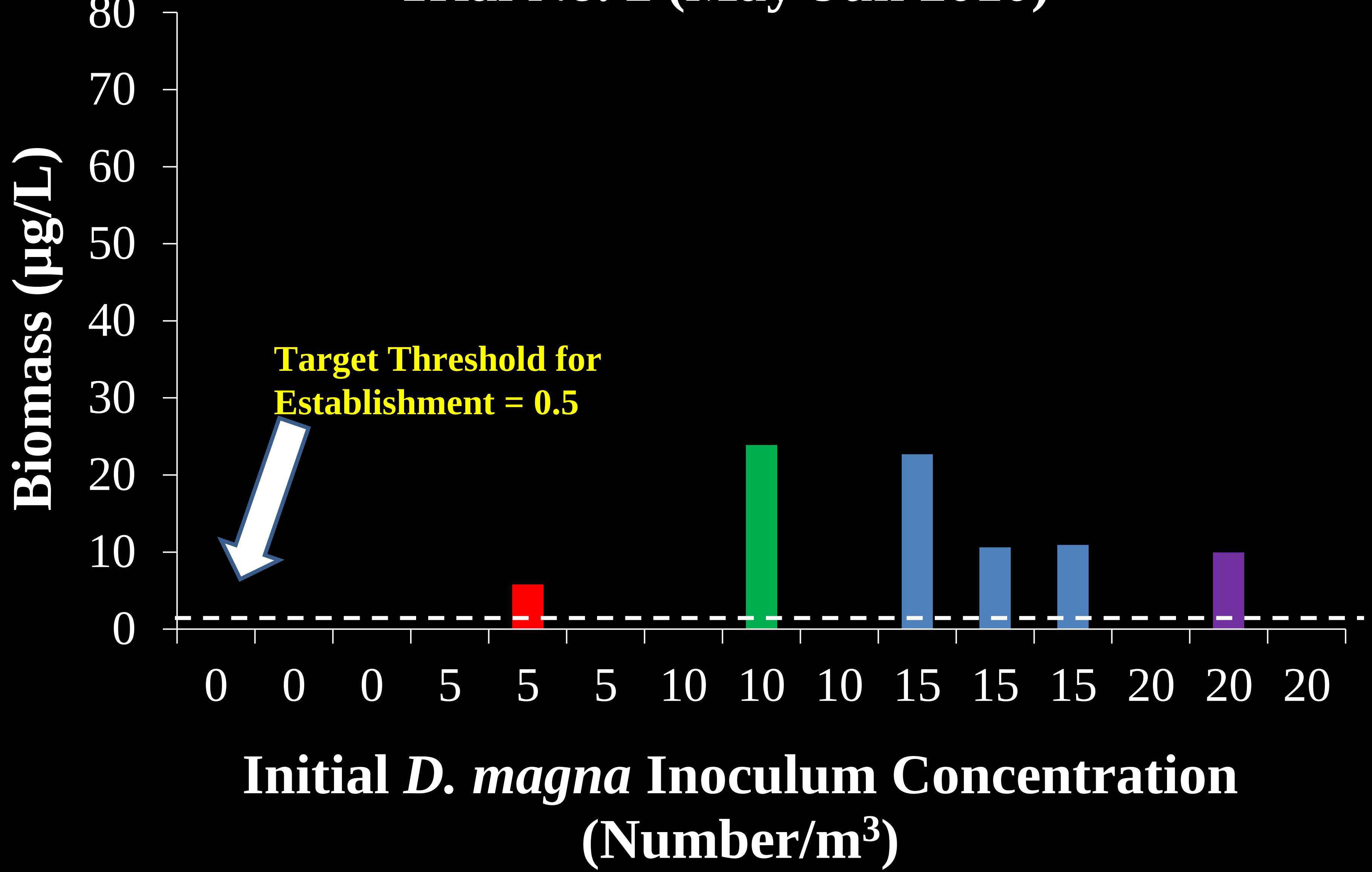
D. retrocurva (0.5 mm)

	Establishment Criteria	
Trial Periods	Density (No./L)	Biomass (µg/L)
May-Jun	0.1	0.5
Jul-Aug	1.6	6.5
Oct-Nov	0.8	3.1
Nov-Dec	*0.1*	*0.5*

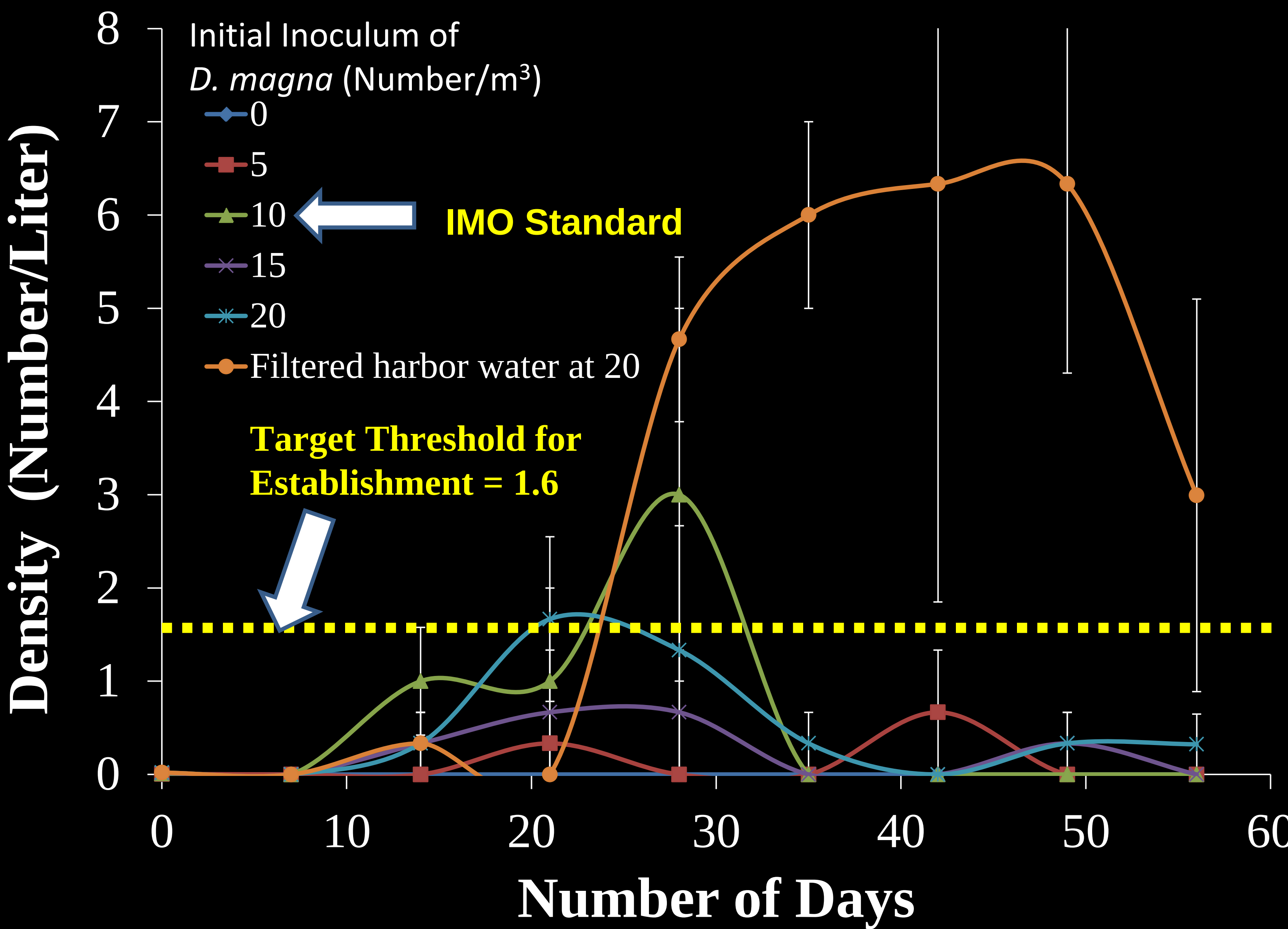
Surrogate Invader Growth Trajectories
Trial No. 2 (May-Jun 2010)



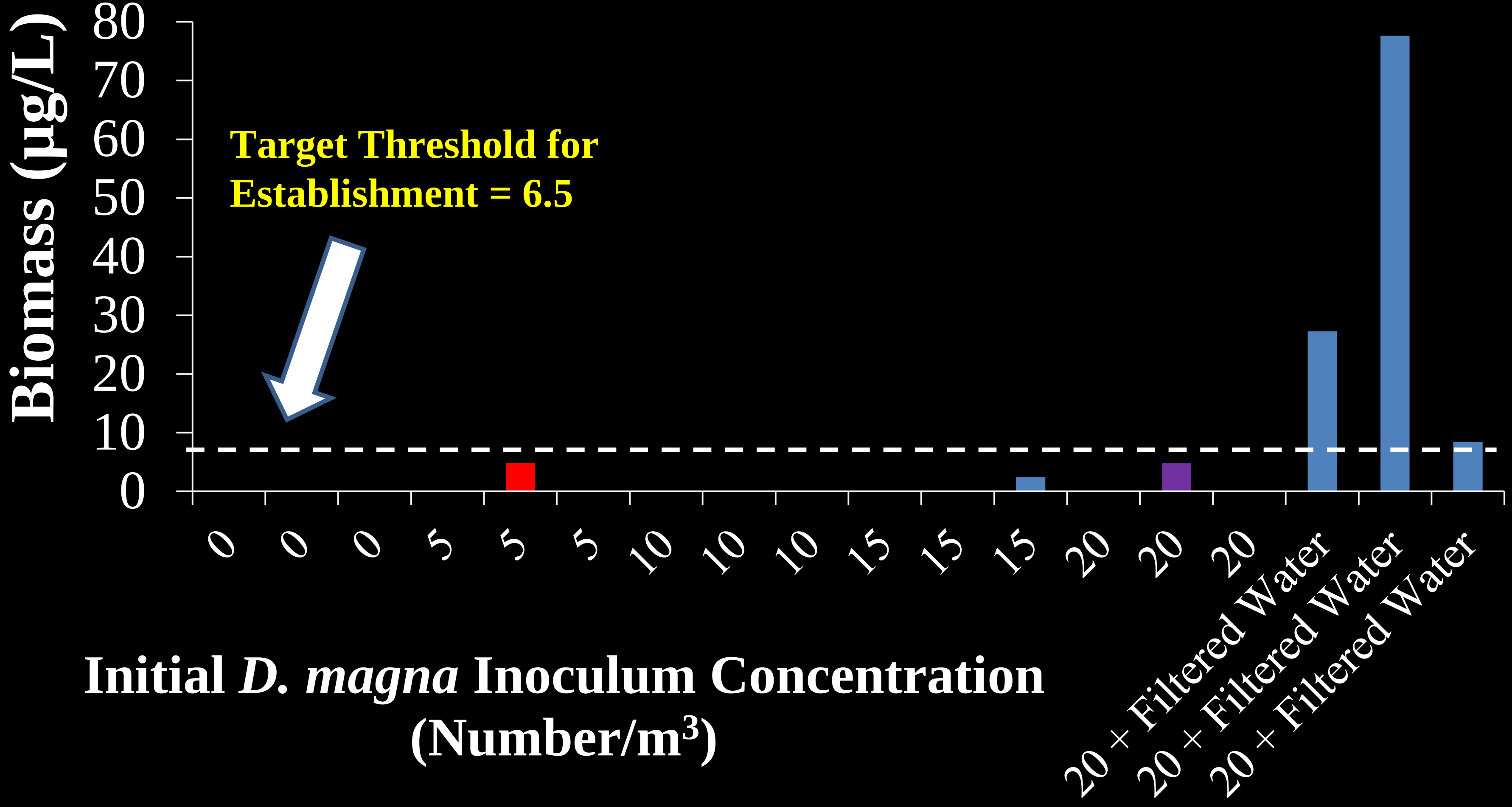
Average For Weeks 6-8 of *D.magna* Biomass Trial No. 2 (May-Jun 2010)



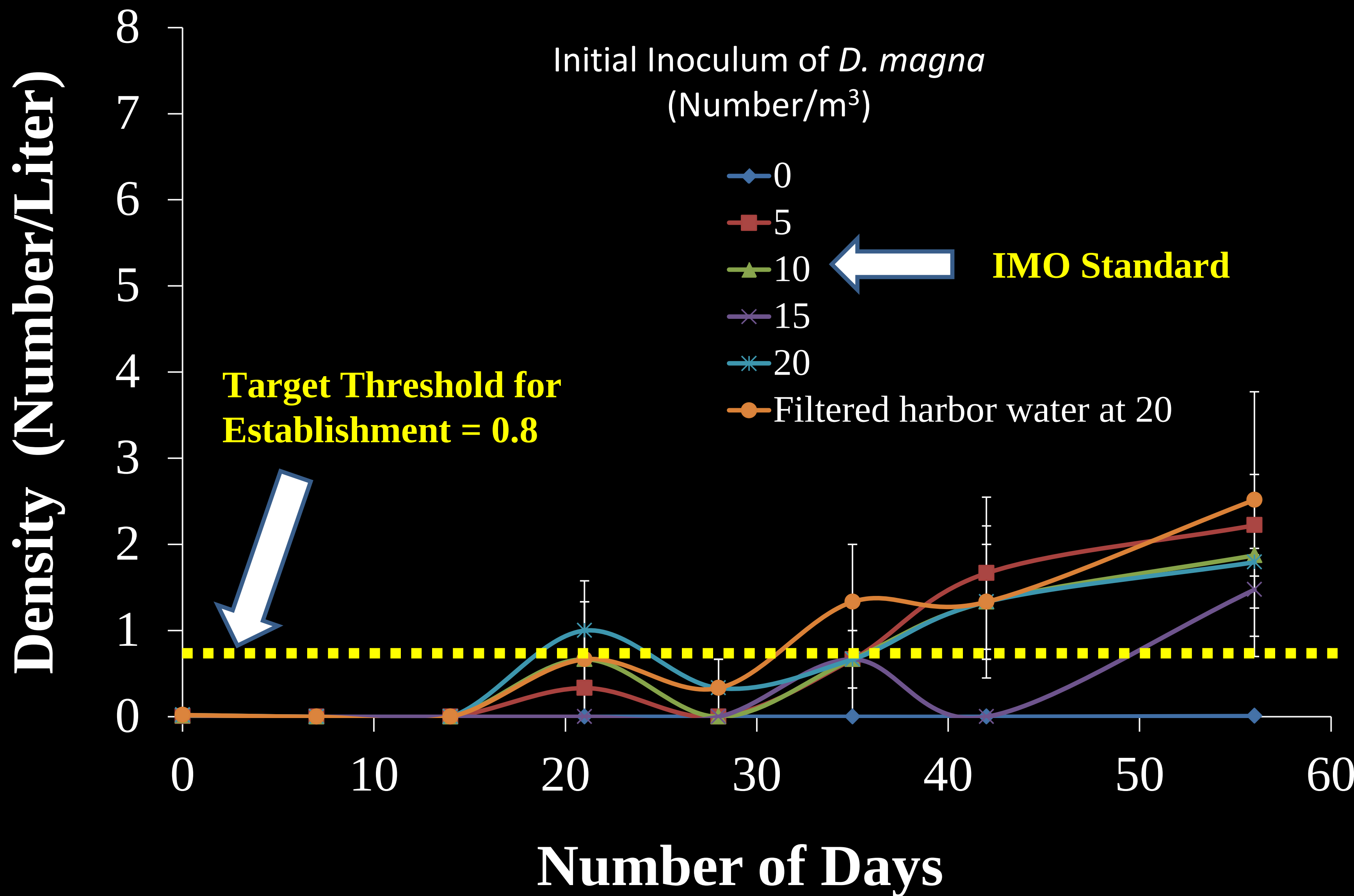
Surrogate Invader Growth Trajectories
Trial No. 3 (Jul – Aug 2010)



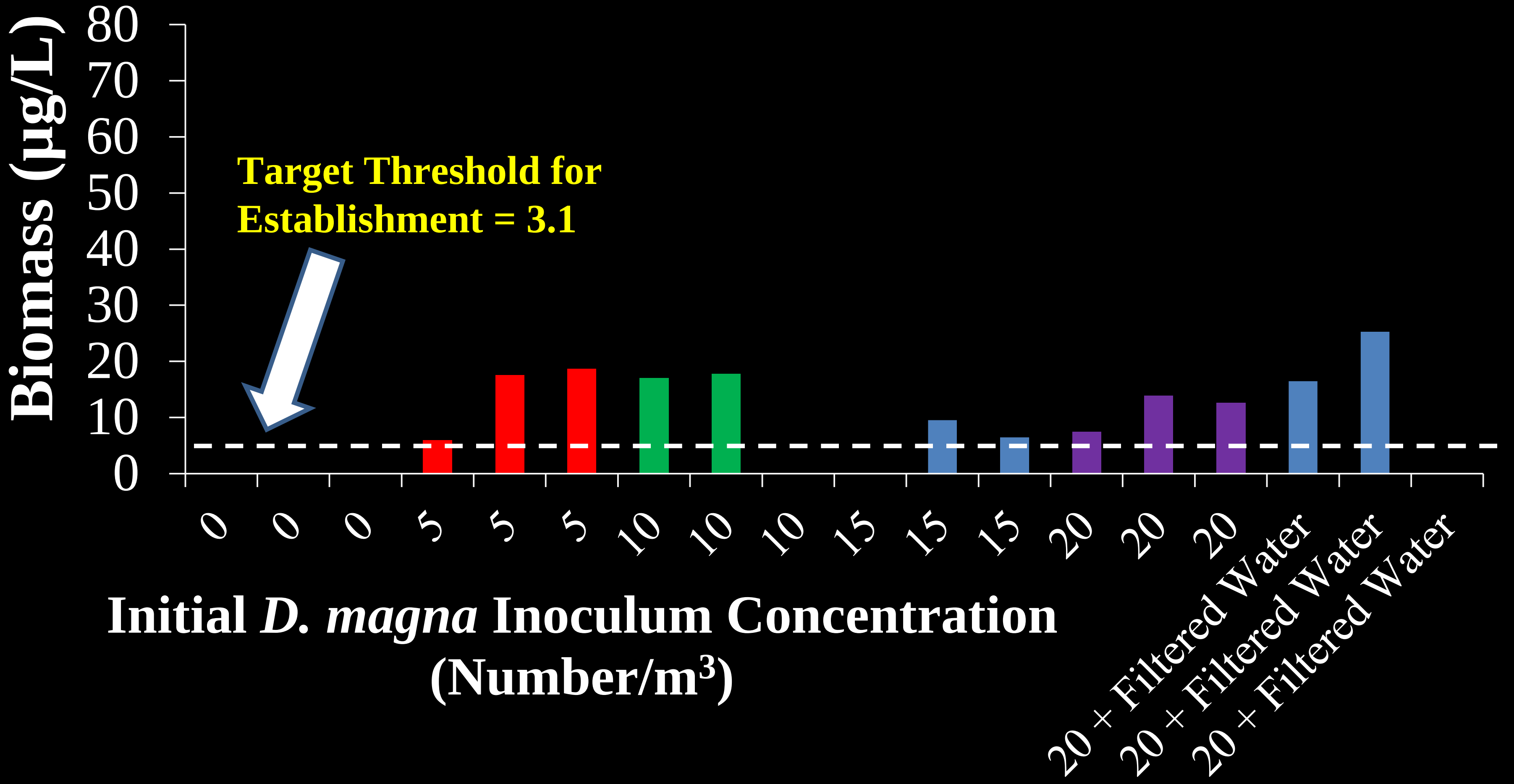
Average For Weeks 6-8 of *D.magna* Biomass
Trial No. 3 (Jul – Aug 2010)



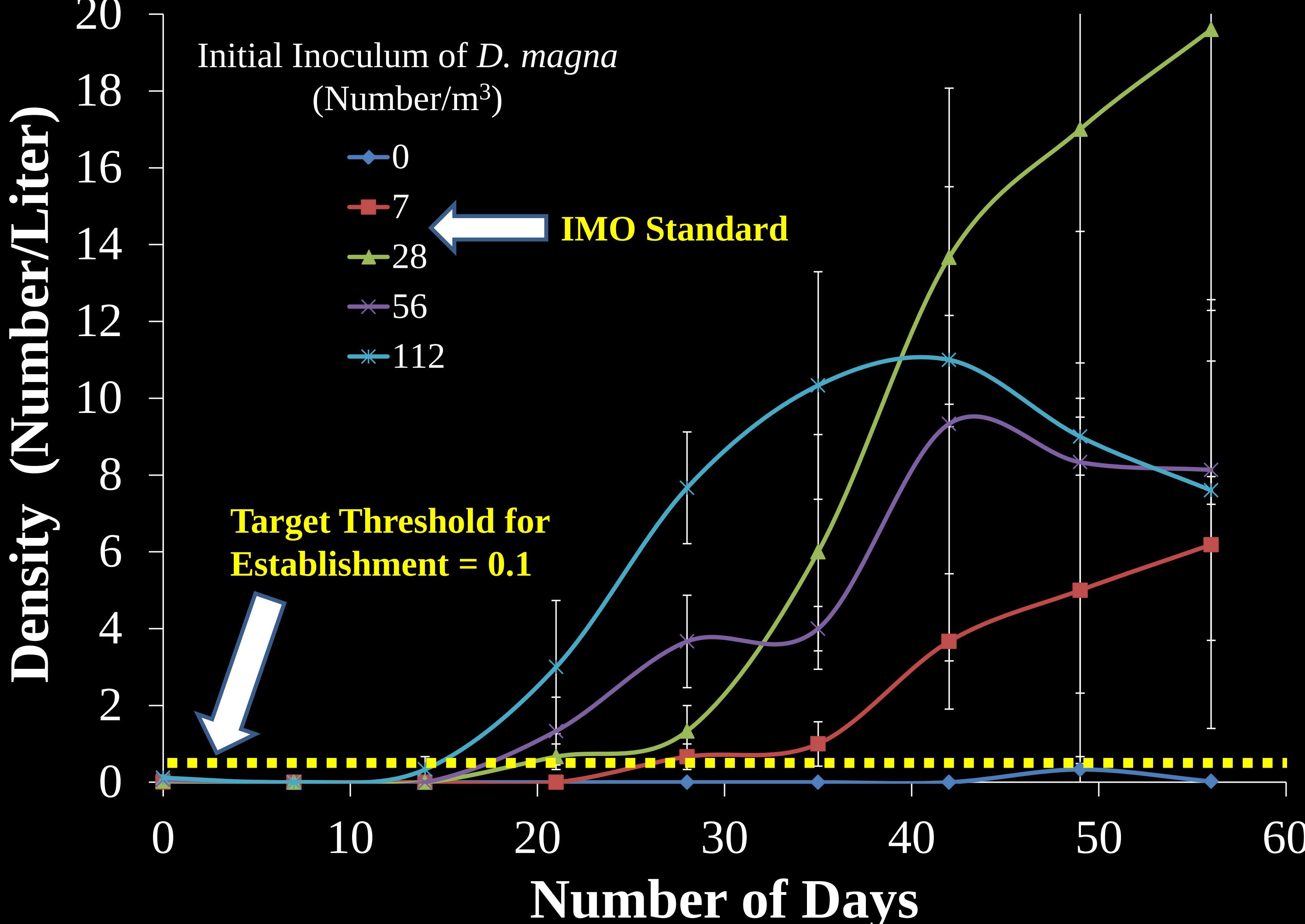
Surrogate Invader Growth Trajectories
Trial No.4 (Oct-Nov 2010)



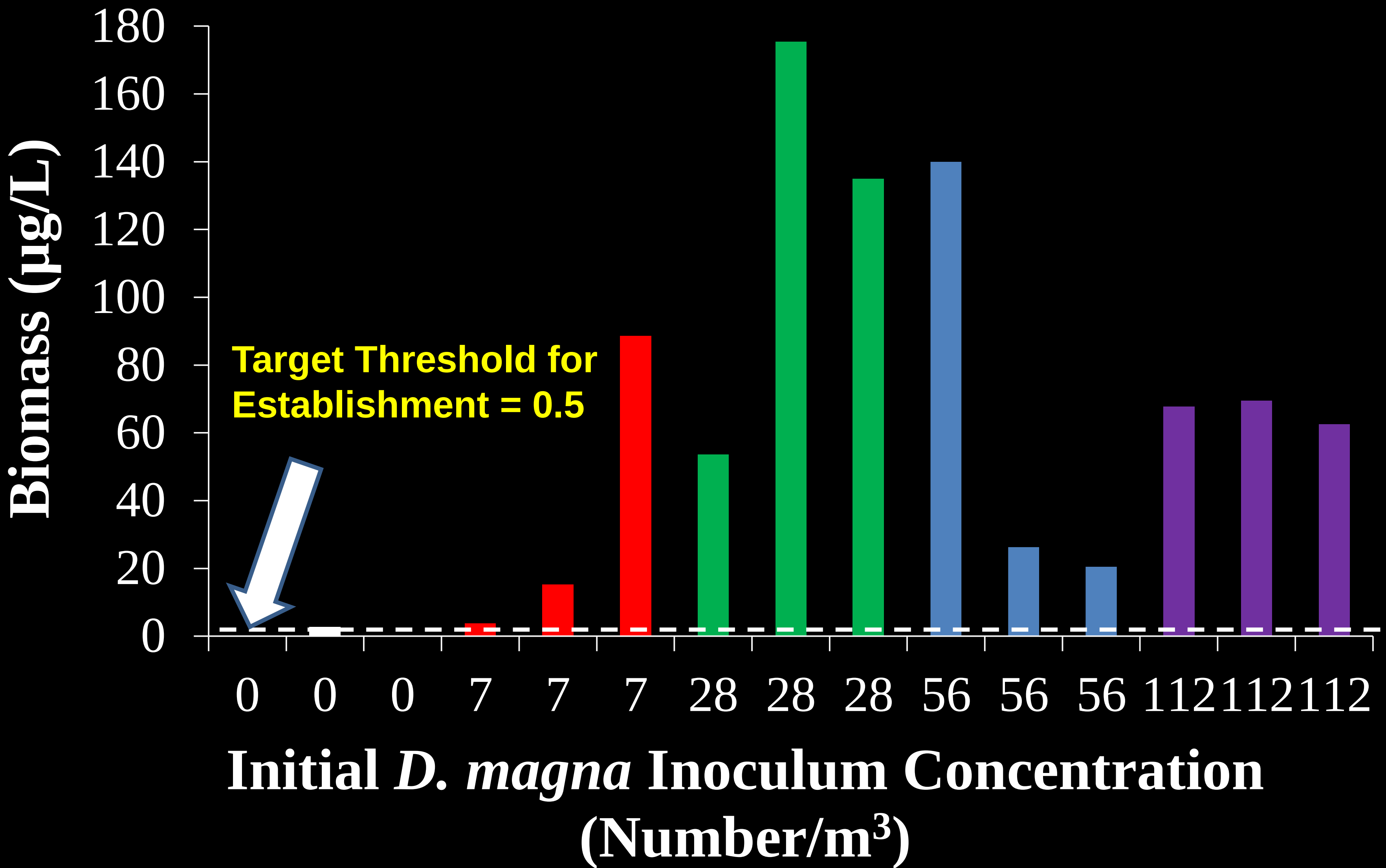
Average For Weeks 6-8 of *D.magna* Biomass Trial No.4 (Oct-Nov 2010)



Surrogate Invader Growth Trajectories
Trial No. 1 (Nov-Dec 2009)



Average For Weeks 6-8 of *D.magna* Biomass Trial No. 1 (Nov-Dec 2009)

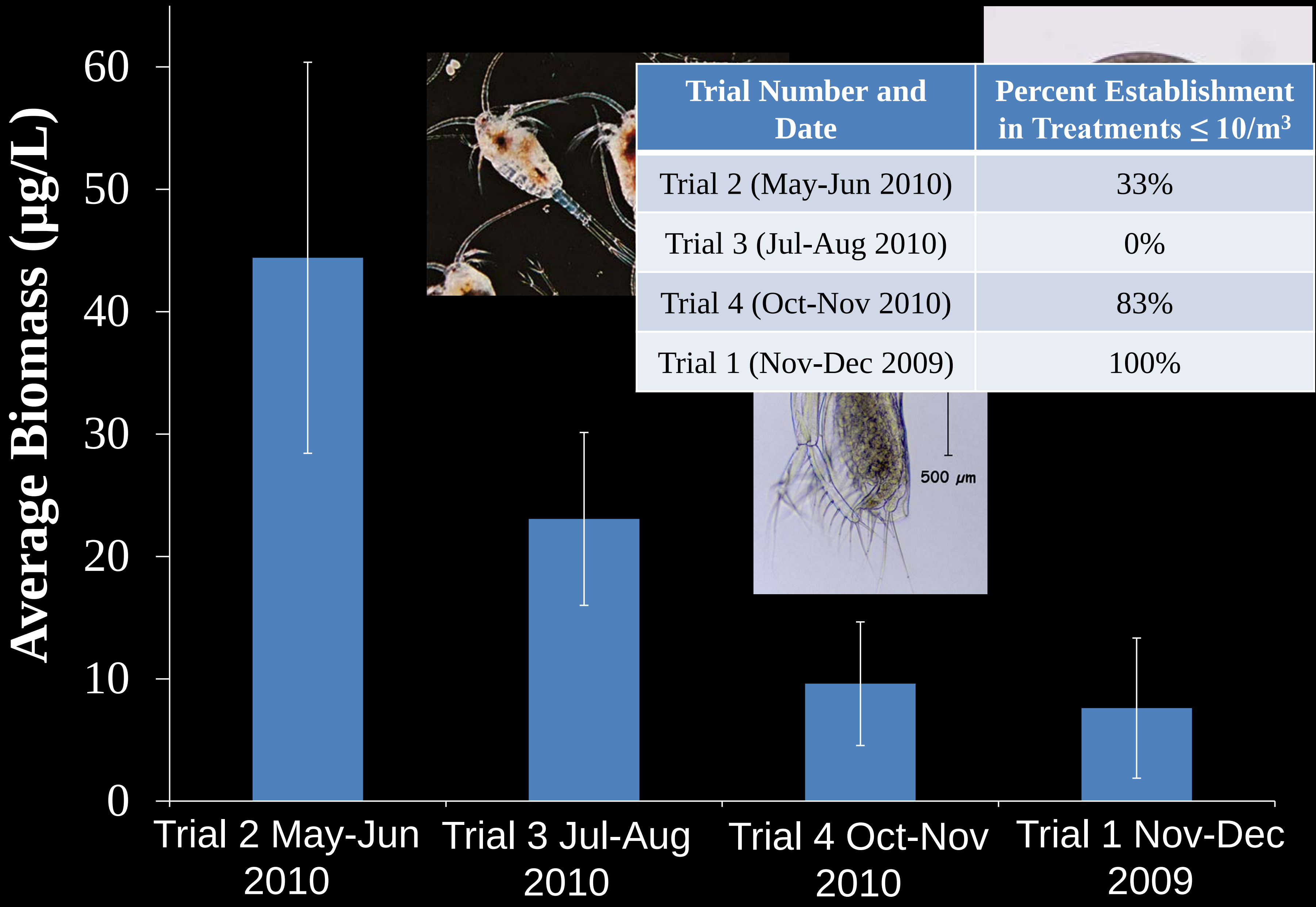


Results Summary

- In 3 of the 4 trials *D. magna* were able to overcome small densities in the seed populations.

Trial Number and Date	Percent Establishment in Treatments $\leq 10/m^3$
Trial 2 (May-Jun 2010)	33%
Trial 3 (Jul-Aug 2010)	0%
Trial 4 (Oct-Nov 2010)	83%
Trial 1 (Nov-Dec 2009)	100%

Average Day 0 Crustacean Biomass



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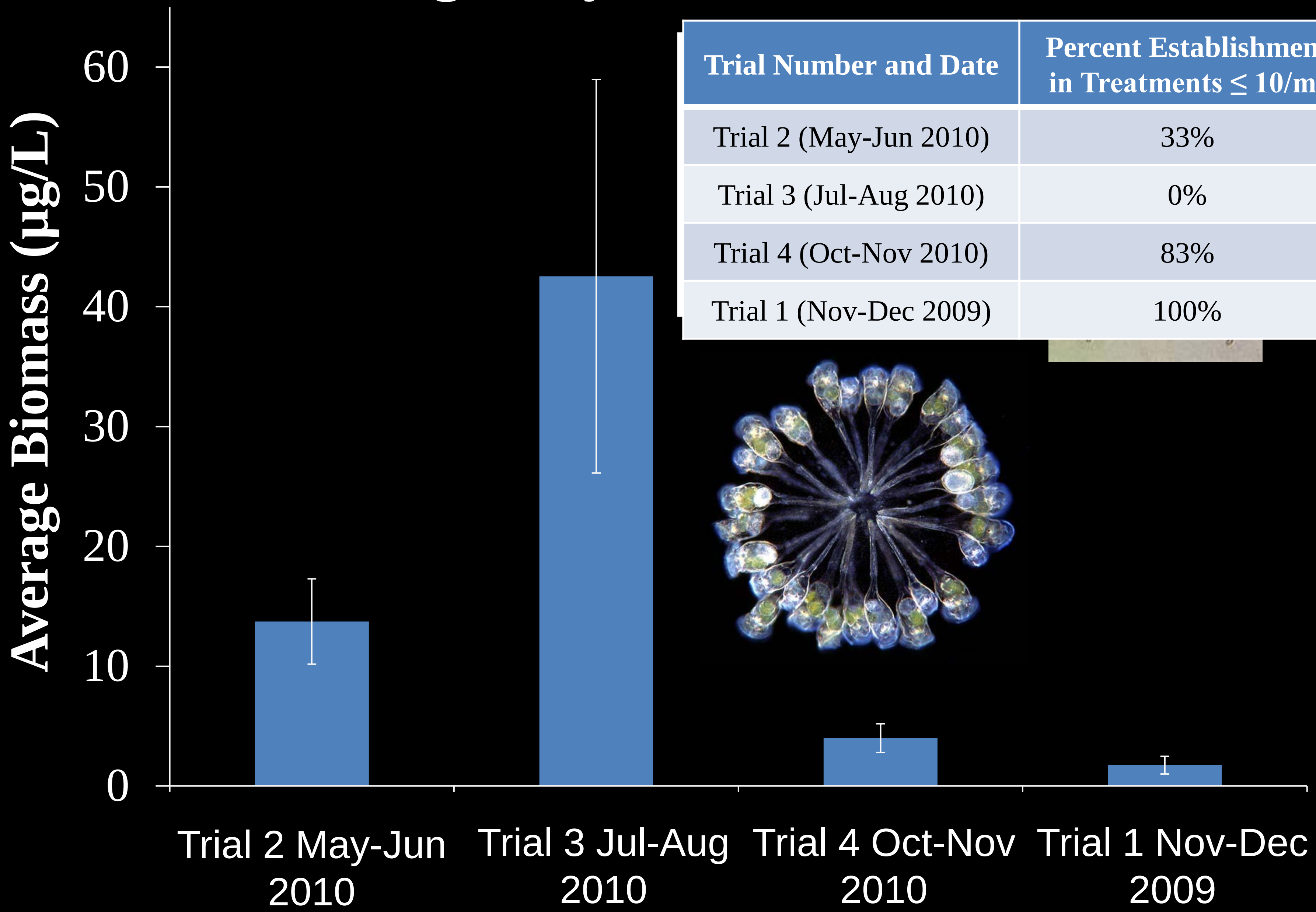
Average Day 0 Rotifer Biomass



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Conclusions

- Establishing criteria to interpret whether a trial population of *D. magna* has colonized in a tank is not straightforward and relies in part on the understanding of natural densities attained by similar taxa in the ecosystem.

- In 3 of the 4 trials *D. magna* were able to overcome small densities in the seed populations which were below the IMO standard.

- These mesocosm studies do not take into account:
  - Vertebrate predators
  - No Allee effects since surrogate invader is an asexual reproducer
  - Assumes somewhat limited diffusion

Conclusion

- Assessing the Relationship Between Propagule Pressure and Invasion Risk in Ballast Water - Committee on Assessing Numeric Limits for Living Organisms in Ballast Water; National Research Council (June 2011).

1) empirically characterize the risk of establishment of aquatic invasive species through experiments – Short term

2) ground the experimental information in reality through directly surveying the rate of release of live propagules – Long term

3) directly surveying the receiving system to determine the actual rate of establishment – Long term

Acknowledgements

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