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

Final Project Report
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A University of Wisconsin - Superior and University of Minnesota Duluth Consortium

UMD DULUTH

UNIVERSITY of WISCONSIN Superior

Great Ships Initiative

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, the 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 has 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 economic and environmental costs.
     a) Fuel consumption
     b) Use of toxic pesticides
     c) No empirical justification – target for resistance and delay

Rationale continued

- International Maritime Organization (IMO) standards
  1) Less than 10 viable organisms per cubic meter greater than 50 microns in min. dimension
  2) Less than 10 viable organisms per mL between 10-50 microns in min. dimension

- Federal Standard–Coast Guard Authorization Act of 2008
  1) 100 times more strict than IMO

- California's standard
  1) No detectable living organisms that are greater than 50 microns in min. dimension
  2) Less than 0.01 living organisms per mL between 10-50 microns in min. dimension

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.

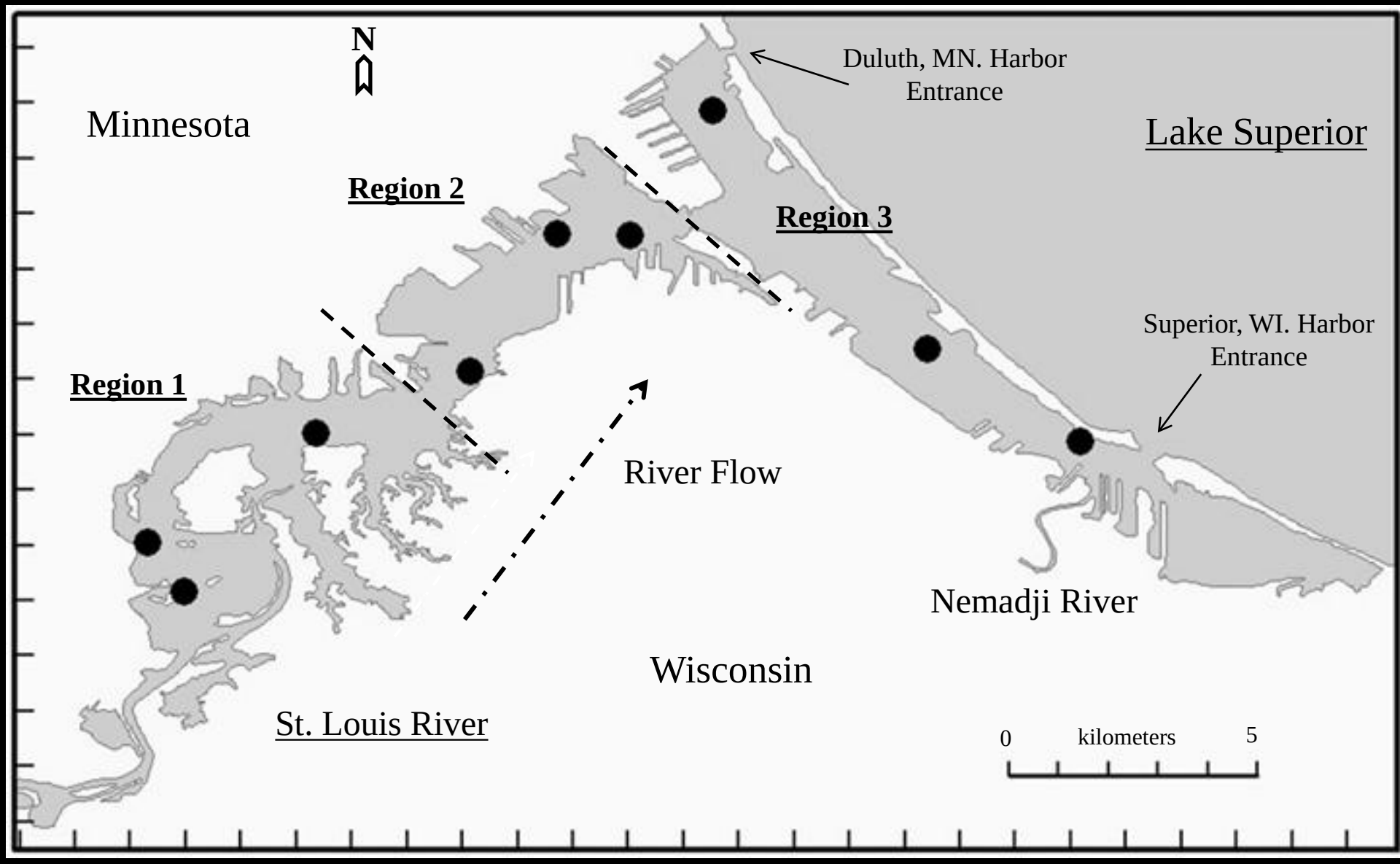
- Existing experimental and field data are very limited in scope and not U.S. Great Lakes relevant.

Project Objectives

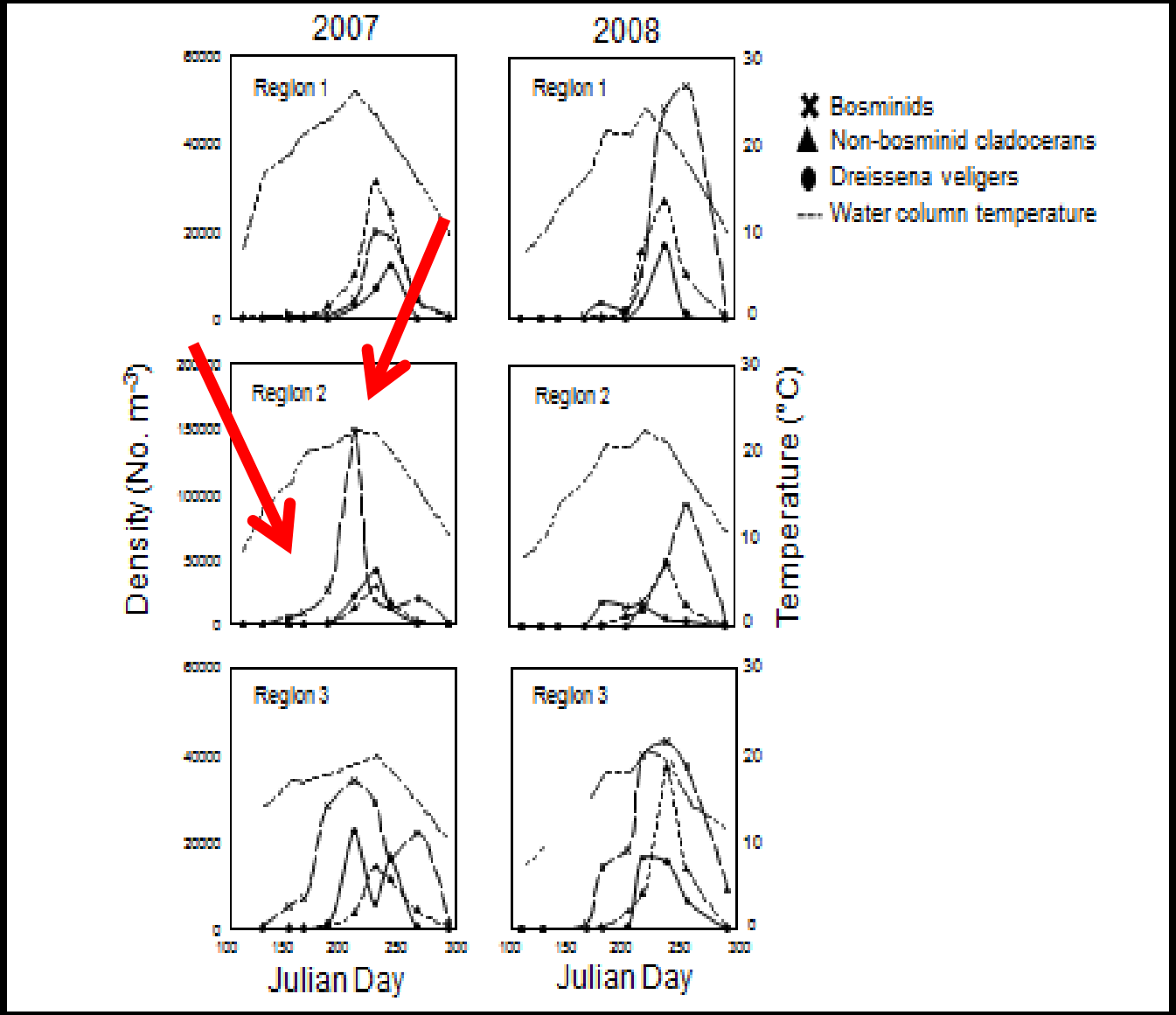
1) Objective of first and second years: characterize the density and diversity of crustacean zooplankton in the Duluth-Superior Harbor and St. Louis Estuary.

2) Objective of third and forth years: quantify relationships between colonization success (risk) and propagule pressure (release) of zooplankton in the Duluth-Superior Harbor that bracket IMO standards.

Methods


N
Minnesota
Duluth, MN. Harbor Entrance
Lake Superior
Region 2
Region 3
Superior, WI. Harbor Entrance
Region 1
River Flow
Nemadji River
Wisconsin
St. Louis River
0
kilometers
5

Methods continued



Methods continued

- 200-L mesocosm tanks
  1) Total of 5 doses of surrogate invader * 3 reps + 1 filtered harbor water control * 3 reps = 18 tanks per trial
  2) Experimental length = 8 weeks
  3) May, July, October/November * 2 years (2010, 2011) = 6 trials

Methods continued

- *Daphnia magna* served as the surrogate invader
- Weekly estimates of *D. magna* were made.
- Day 56
  1) Entire 200 L was searched for *D. magna*
  2) Background community was collected and preserved for identification

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

IMO Standard

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)

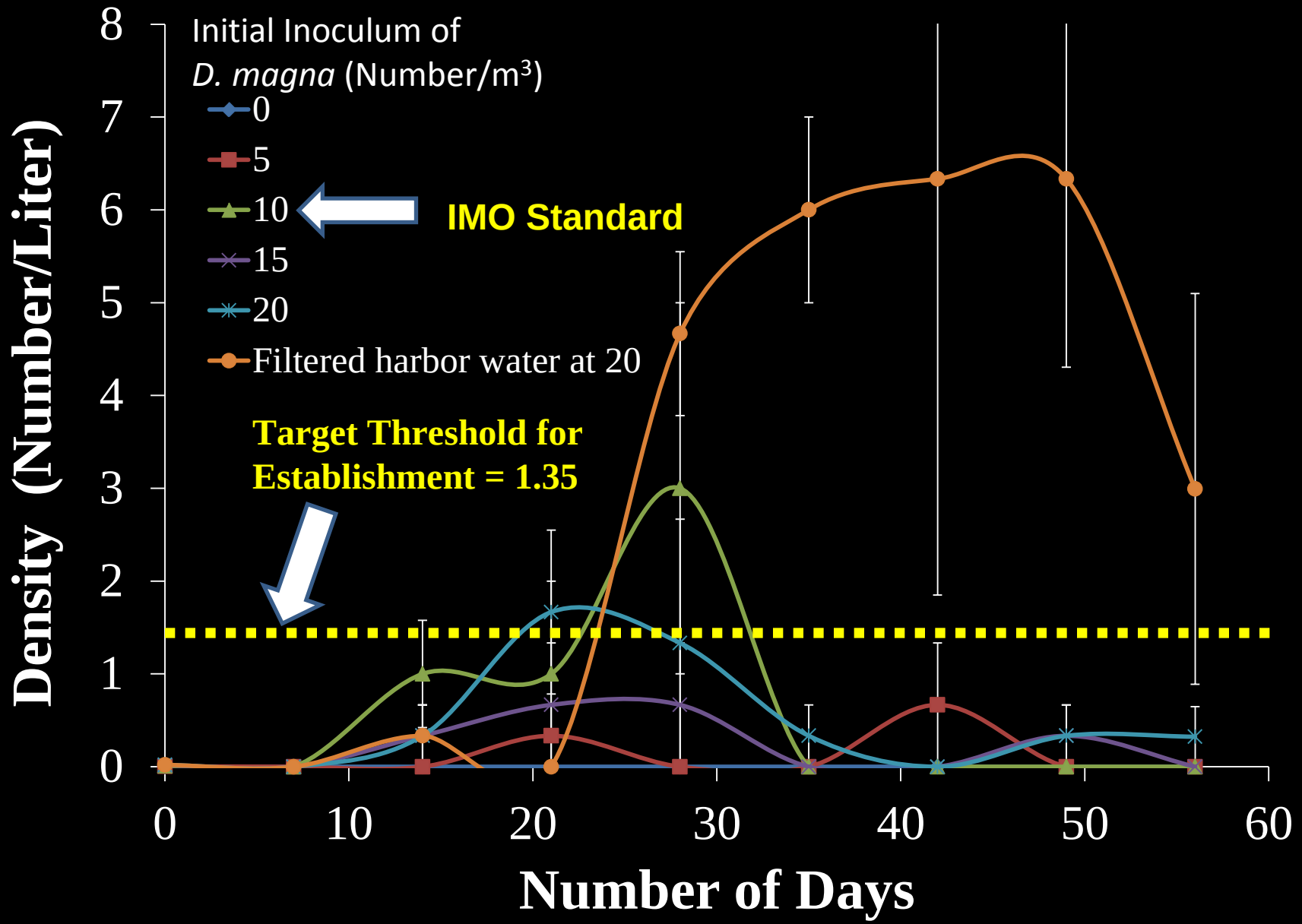
D. mendotae (1.0 mm)

D. retrocurva (0.5 mm)

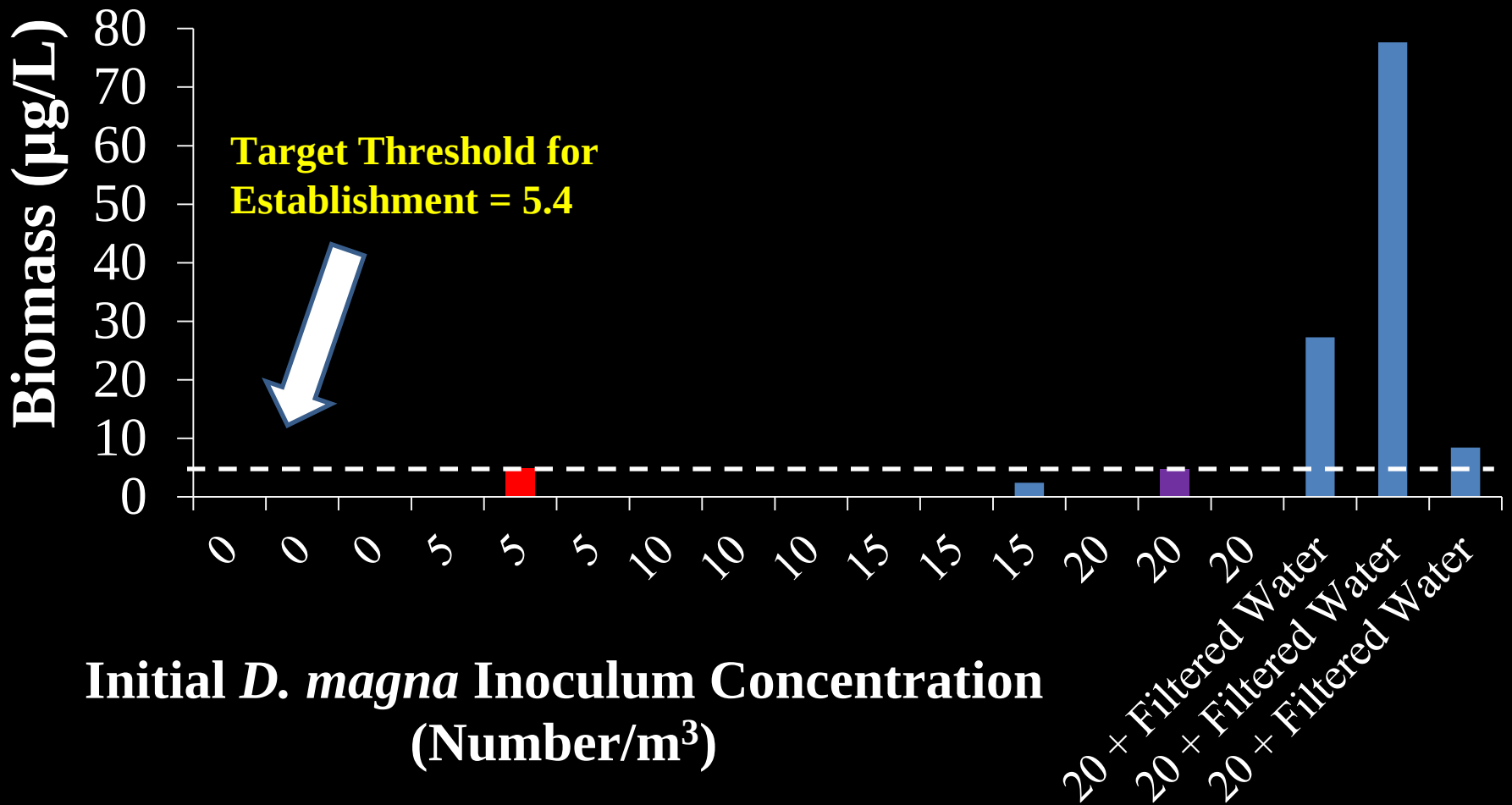
	Establishment Criteria	
Trial Periods	Density (No./L)	Biomass (µg/L)
May	0.05	0.2
Jul	1.35	5.4
Oct/Nov	0.59	2.3

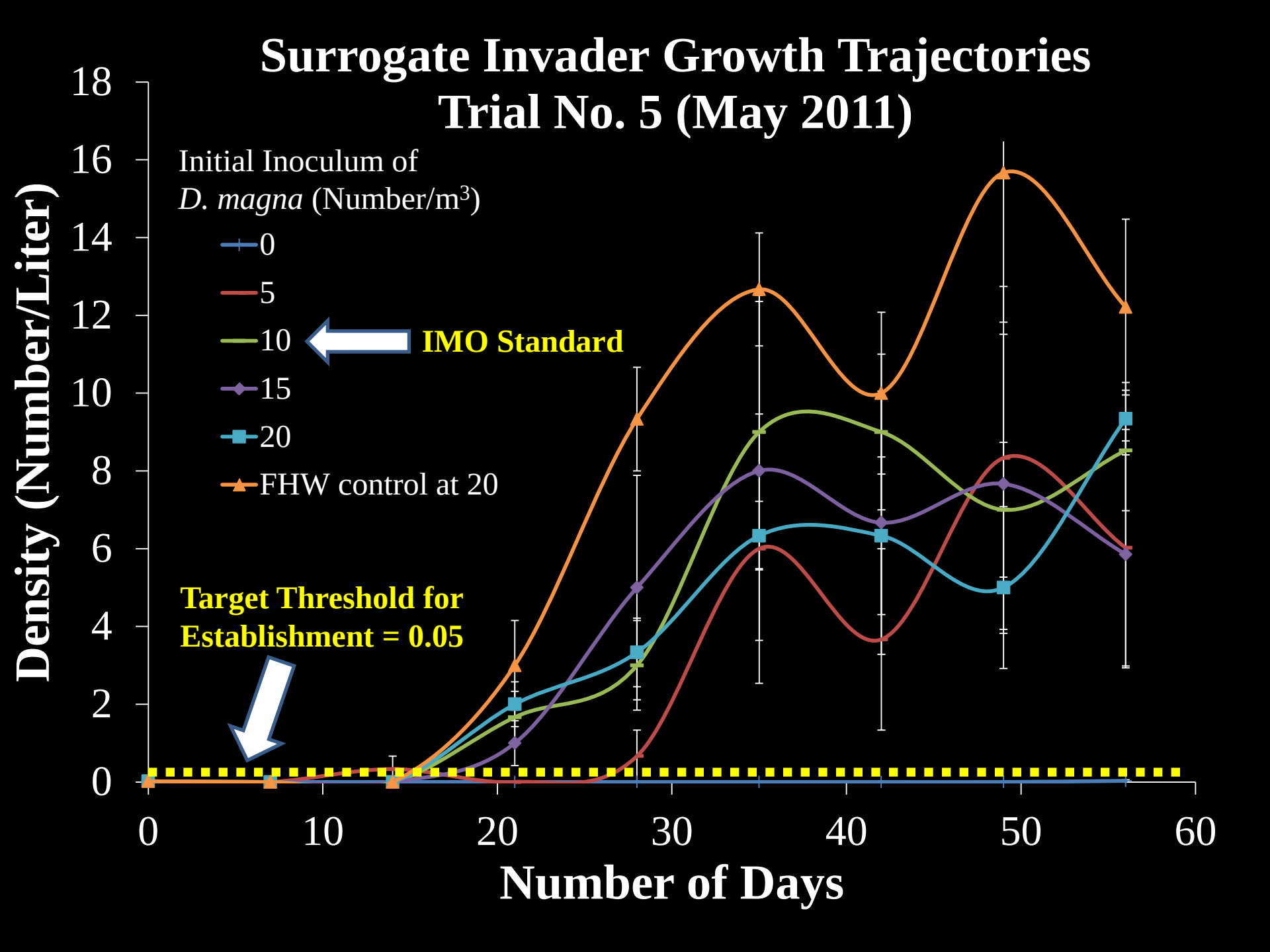
Results

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

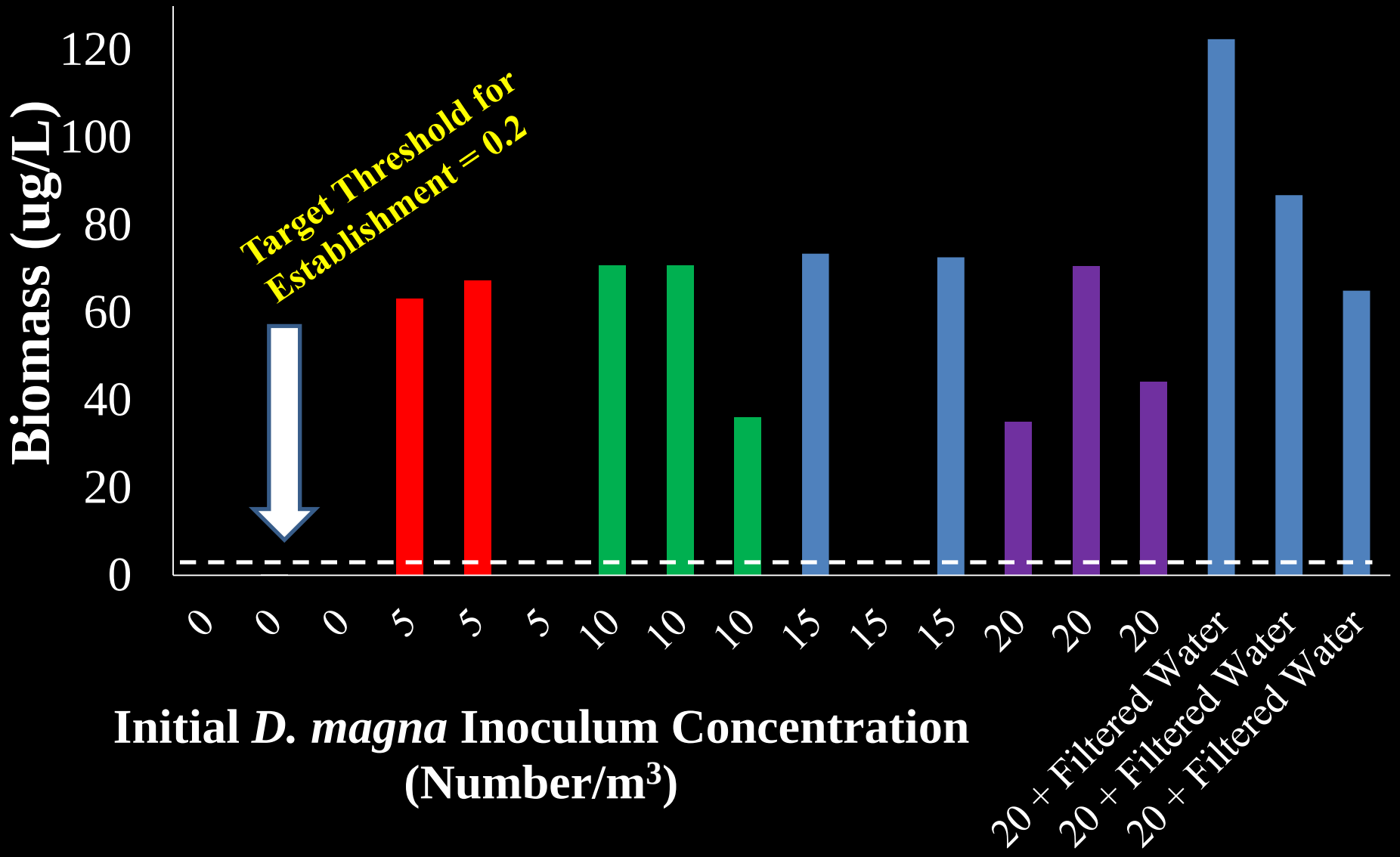


Average For Weeks 6-8 of *D.magna* Biomass
Trial No. 3 (Jul 2010)

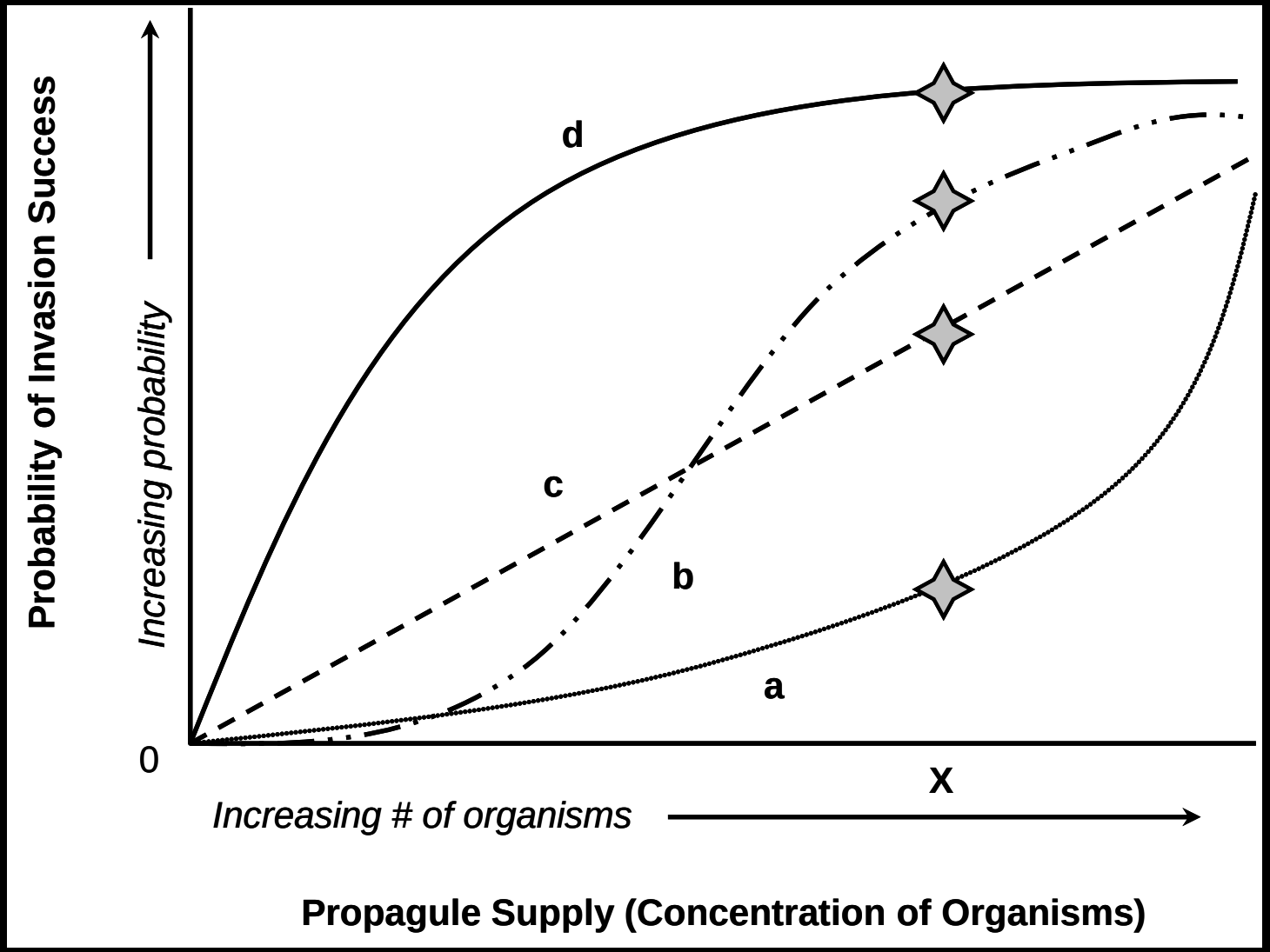



Surrogate Invader Growth Trajectories
Trial No. 5 (May 2011)
Initial Inoculum of
D. magna (Number/m3)
0
5
10
15
20
FHW control at 20
IMO Standard
Target Threshold for
Establishment = 0.05
Density (Number/Liter)
Number of Days
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50
60

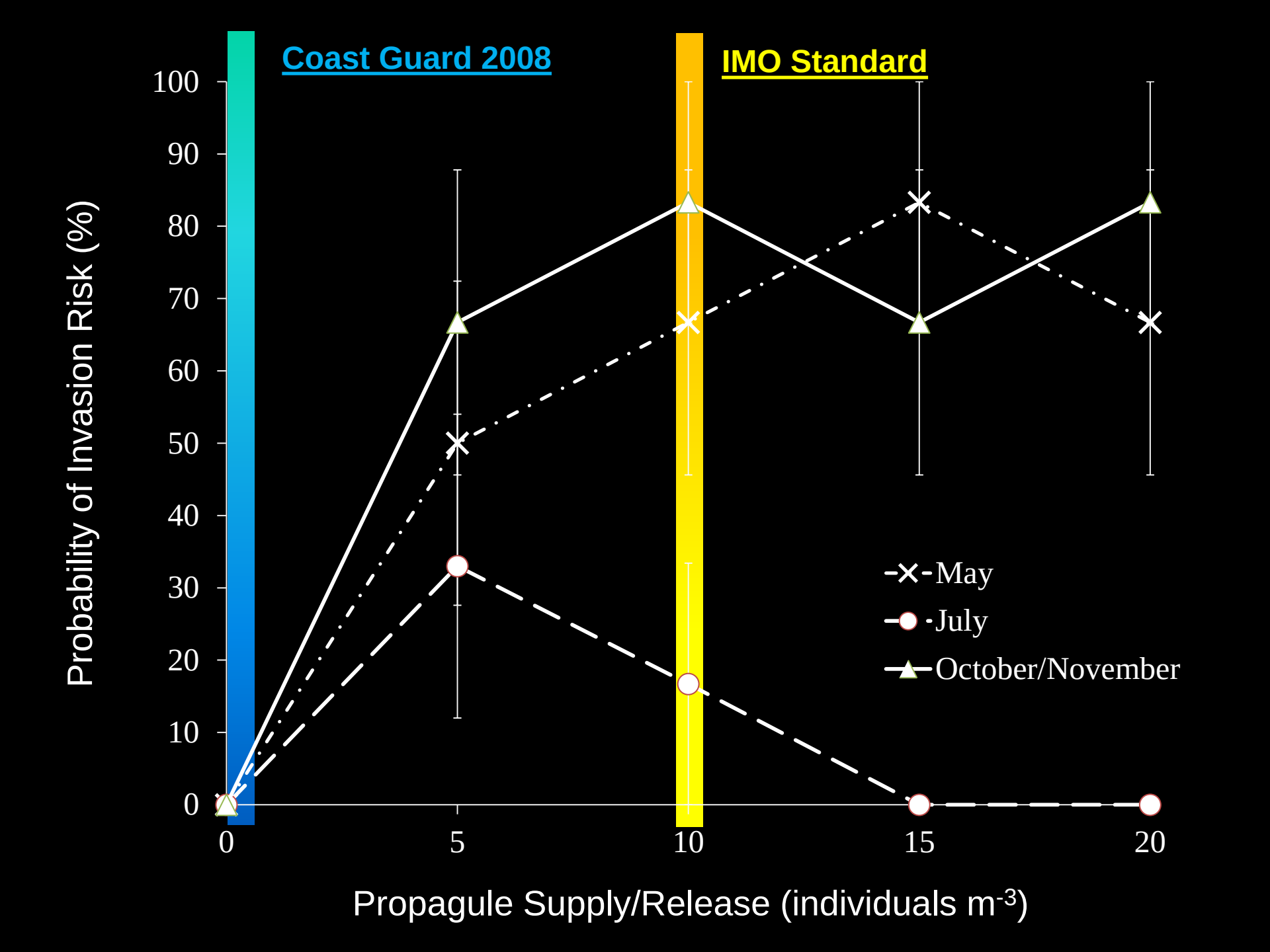
Surrogate Invader Growth Trajectories
Trial No. 5 (May 2011)



Model Development



Modified from Ruiz G.M. and J.T. Carlton 2003. Invasion vectors: a conceptual framework for management. In: Invasive Species, Vectors and Management Strategies. Ruiz G.M. and J.T. Carlton (Eds). Washington D.C.: Island Press. 459-504.


Coast Guard 2008
IMO Standard
Probability of Invasion Risk (%)
100
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
Propagule Supply/Release (individuals m-3)
May
July
October/November

Conclusions

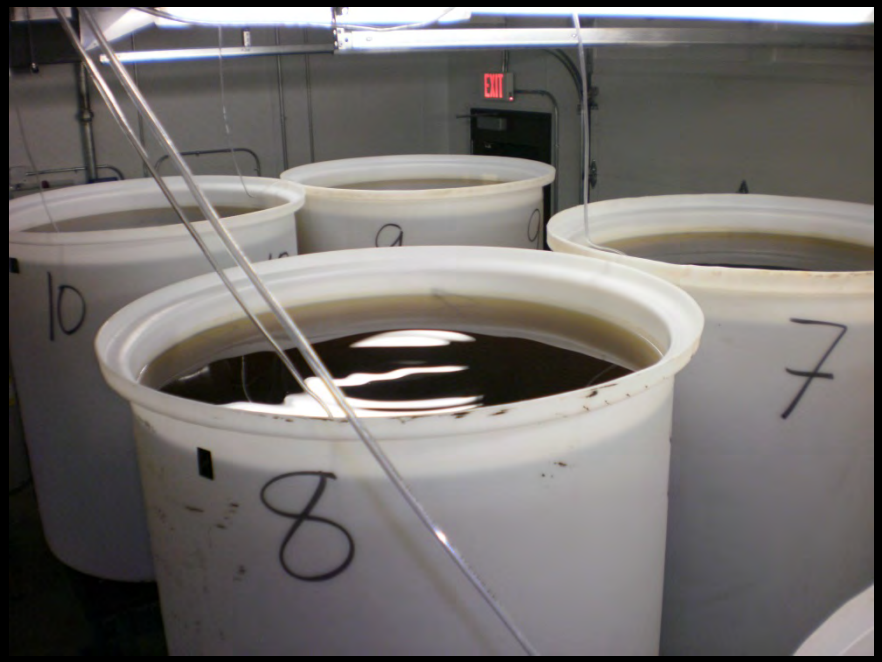
- IMO discharge standard would not be protective for *D. magna* in the Duluth-Superior Harbor, establishment success is seasonally dependent.

- The transition point for increasing risk of establishment *D. magna* in Duluth-Superior Harbor is less than the IMO standard.

- First experimental demonstration of risk-release for a non-native species.

Future Work

- "Characterizing the Risk-Release Relationship for Aquatic Invasive Species in the Great Lakes."
  1) Funded by Great Lakes Protection Fund
  2) GLMRI project instrumental in securing funds



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- The many graduate and undergraduate student research assistants

QUESTIONS

Sampling sediment from ballast tank of American Century.
Photo credit: Carol Wolosz