



Western Washington University  
**Western CEDAR**

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Salish Sea Ecosystem Conference

2014 Salish Sea Ecosystem Conference  
(Seattle, Wash.)

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May 2nd, 10:30 AM - 12:00 PM

## **Drill, baby, drill: Invasive oyster drills are the main driver of native oyster mortality at a restoration site**

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Grason, Emily and Buhle, Eric R., "Drill, baby, drill: Invasive oyster drills are the main driver of native oyster mortality at a restoration site" (2014). *Salish Sea Ecosystem Conference*. 77.

<https://cedar.wwu.edu/ssec/2014ssec/Day3/77>

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# DRILL BABY DRILL!

Invasive oyster drills are the main driver of native oyster mortality at a restoration site

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Northwest Fisheries Science Center  
National Marine Fisheries Service  
NOAA



# A New Landscape for Oyster Recovery



Photos: PSRF & Shelly Solomon

*H. sapiens*



*S. alterniflora*



*C. gigas*

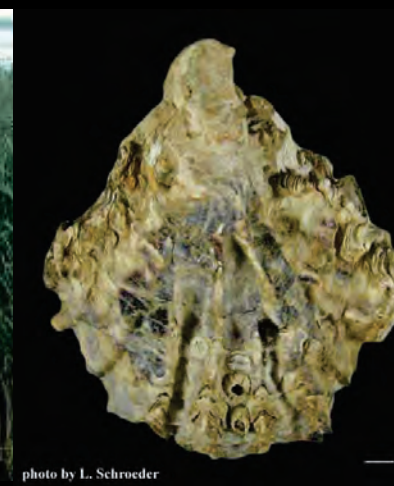


photo by L. Schroeder

*O. inornata*



photo by L. Schroeder

# Japanese Oyster Drills – *Mollusca Non Grata*

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- No planktonic dispersal
- Associated with historic oyster culture sites

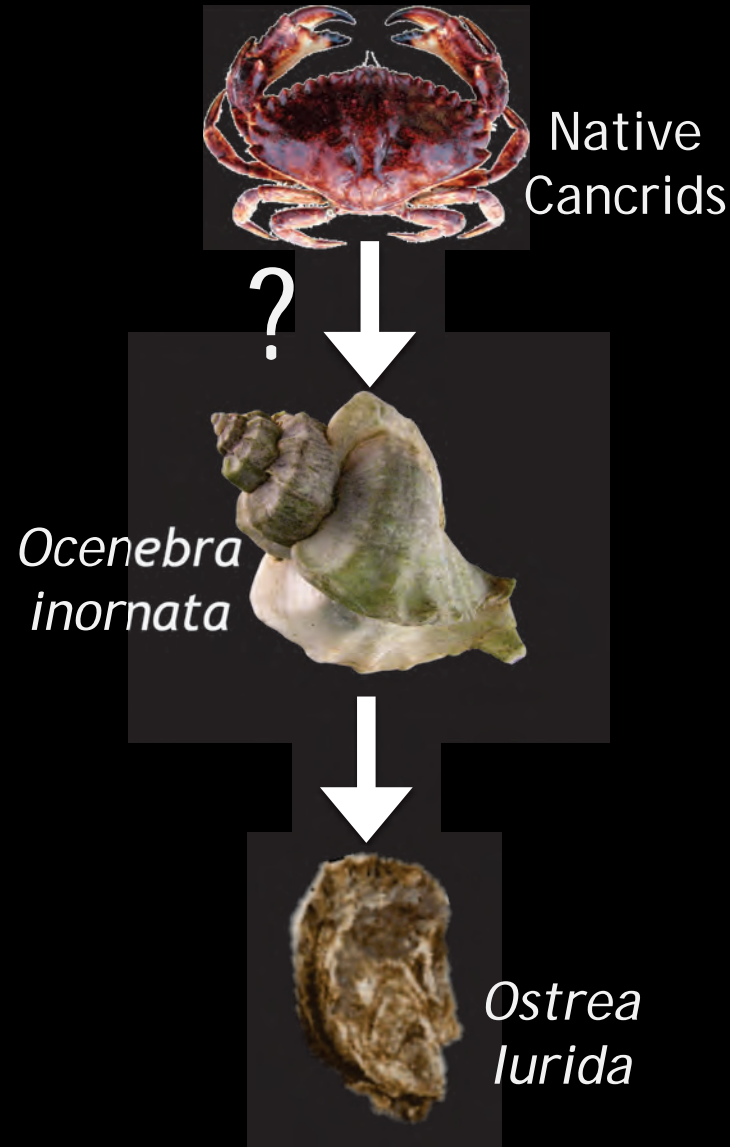


*Ocenebra inornata*

- Taylor Shellfish: \$500k per year on control
- Consume up to 1/3 of outplanted Olys (Buhle et al. 2009)

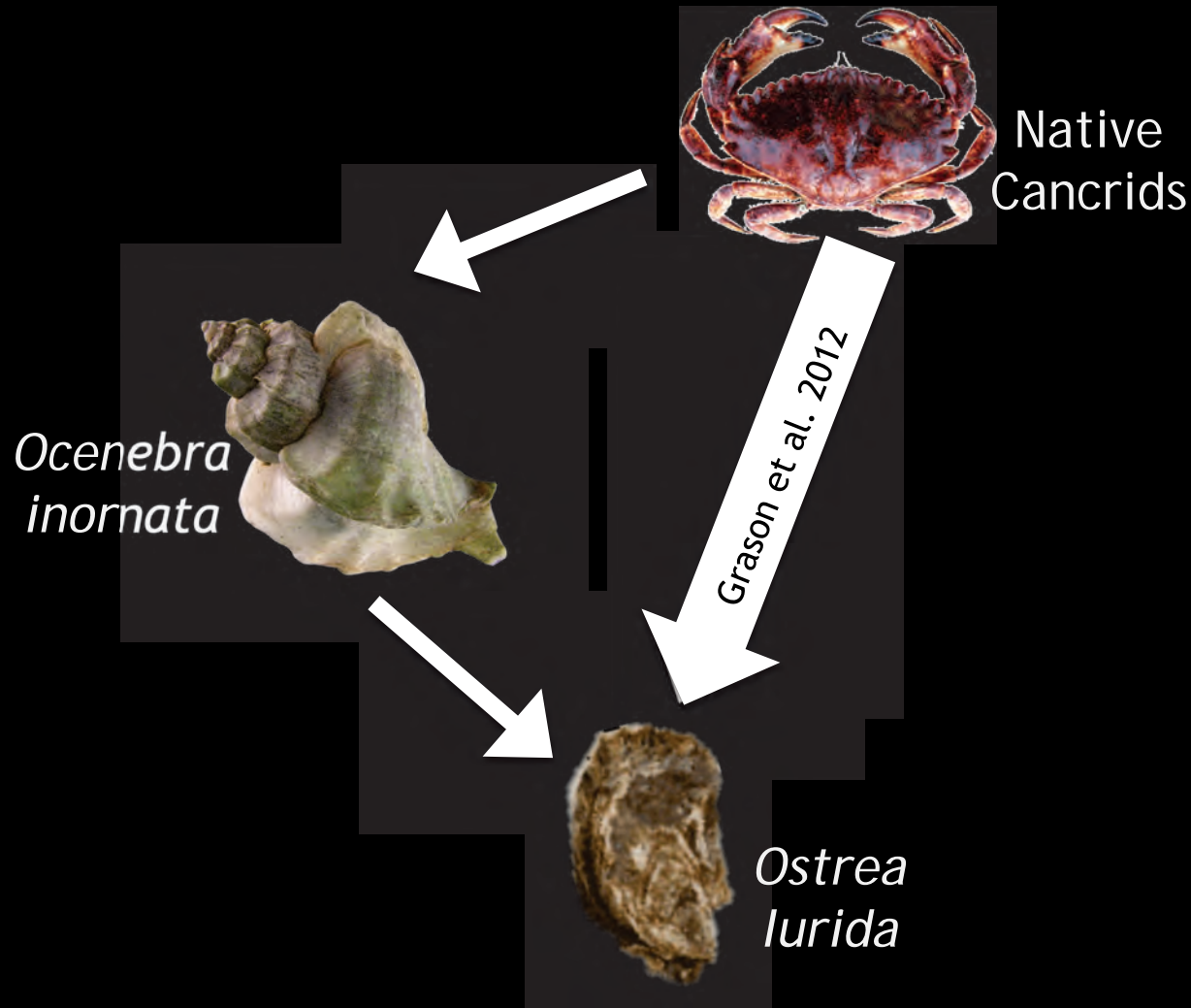
# A predator of my predator is my friend

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# A predator of my predator is my friend...?

...or just another predator.



# Restoration at Liberty Bay

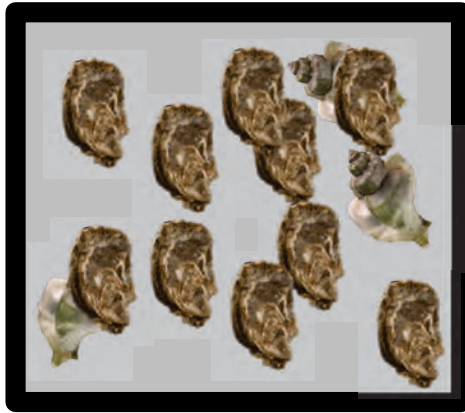


Photo: Brian Allen

# Field Manipulation of Predators

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Drills  
Enclosed



Drills  
Excluded



*Ostrea lurida*



x 10

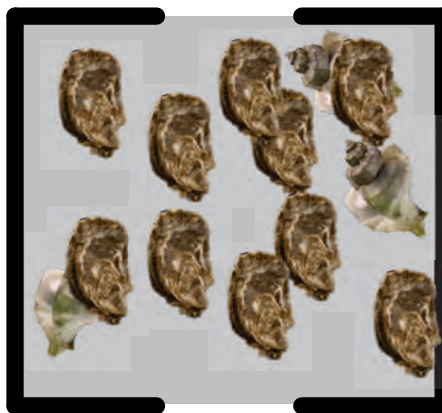


# Field Manipulation of Predators

Crabs  
Excluded



Crabs  
Allowed



Drills  
Enclosed



Drills  
Excluded

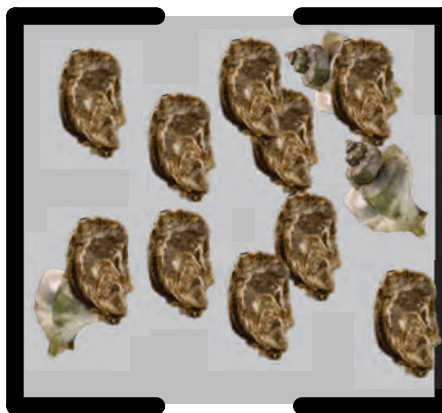
$n = 5$   
April – Aug  
2011

# Field Manipulation of Predators

Crabs  
Excluded



Crabs  
Allowed



Drills  
Enclosed

Drills  
Excluded



No Cage  
Control

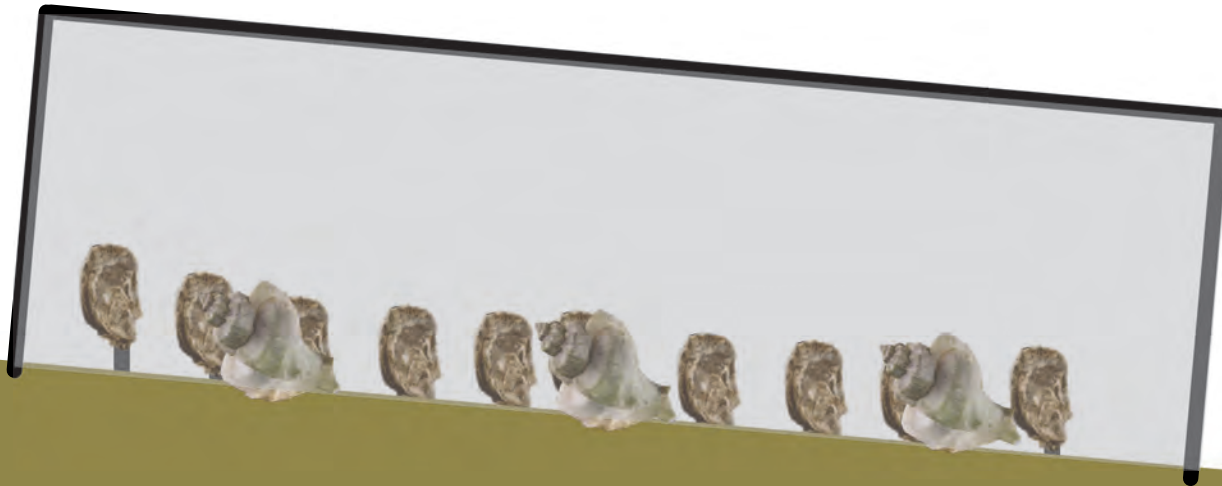


n = 5

April – Aug  
2011

# Field Manipulation of Predators

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# Field Manipulation of Predators

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# GLMMs of Predator Effects

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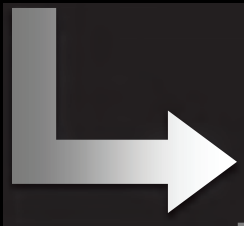
- Crabs Allowed
- Number of Drills
- Month
- Cage (Random)



Generalized  
Linear  
Mixed-effects  
Model



- Oyster Survival
- Drilling Rate:  
How many oysters  
were killed by drills  
per day?



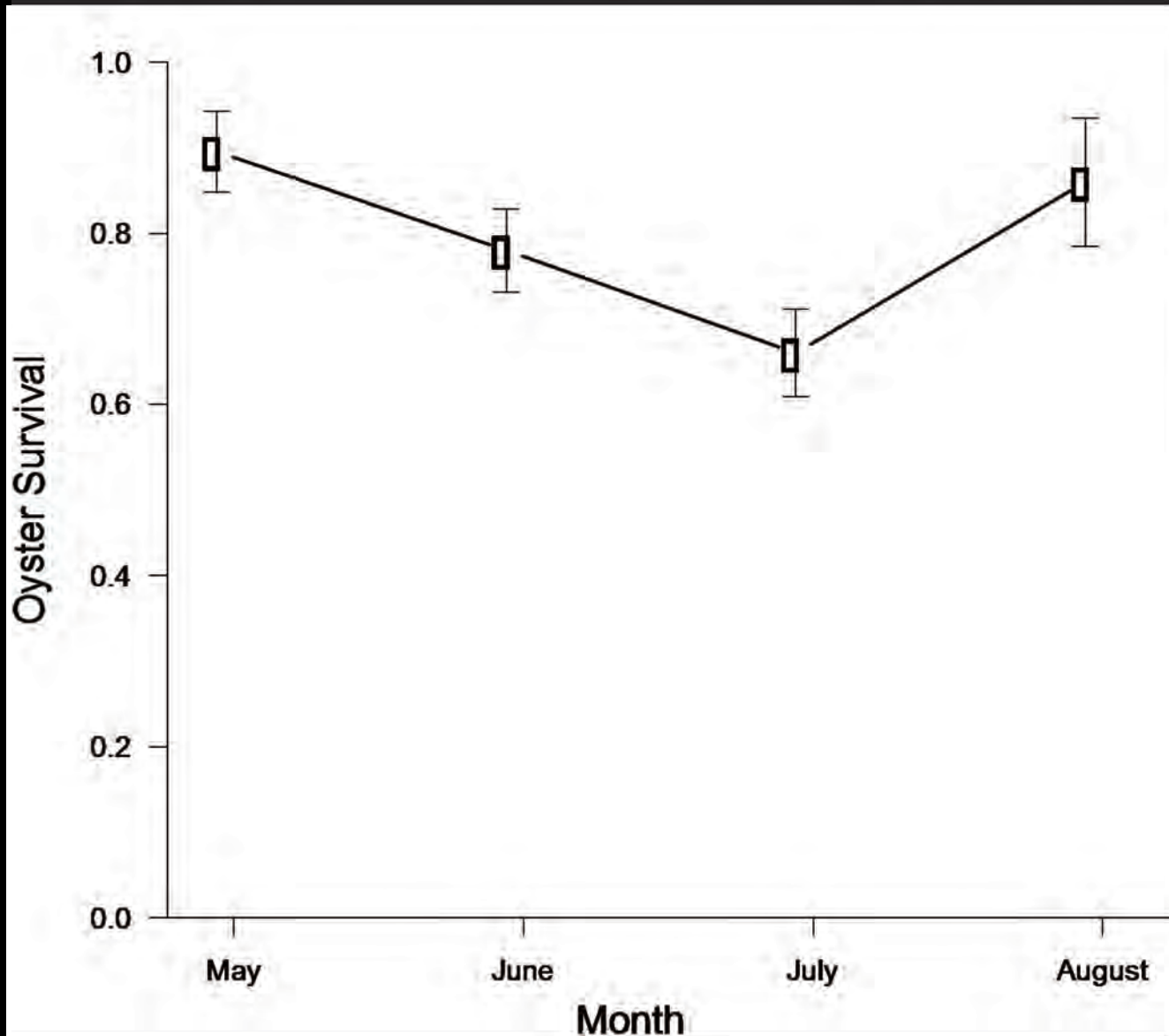
Model Averaging & Variable Weighting

Information Theory (AICc)

Which parameters appear in the best models?

Variable Weight: 0 - 1

# Oyster survival varies by season

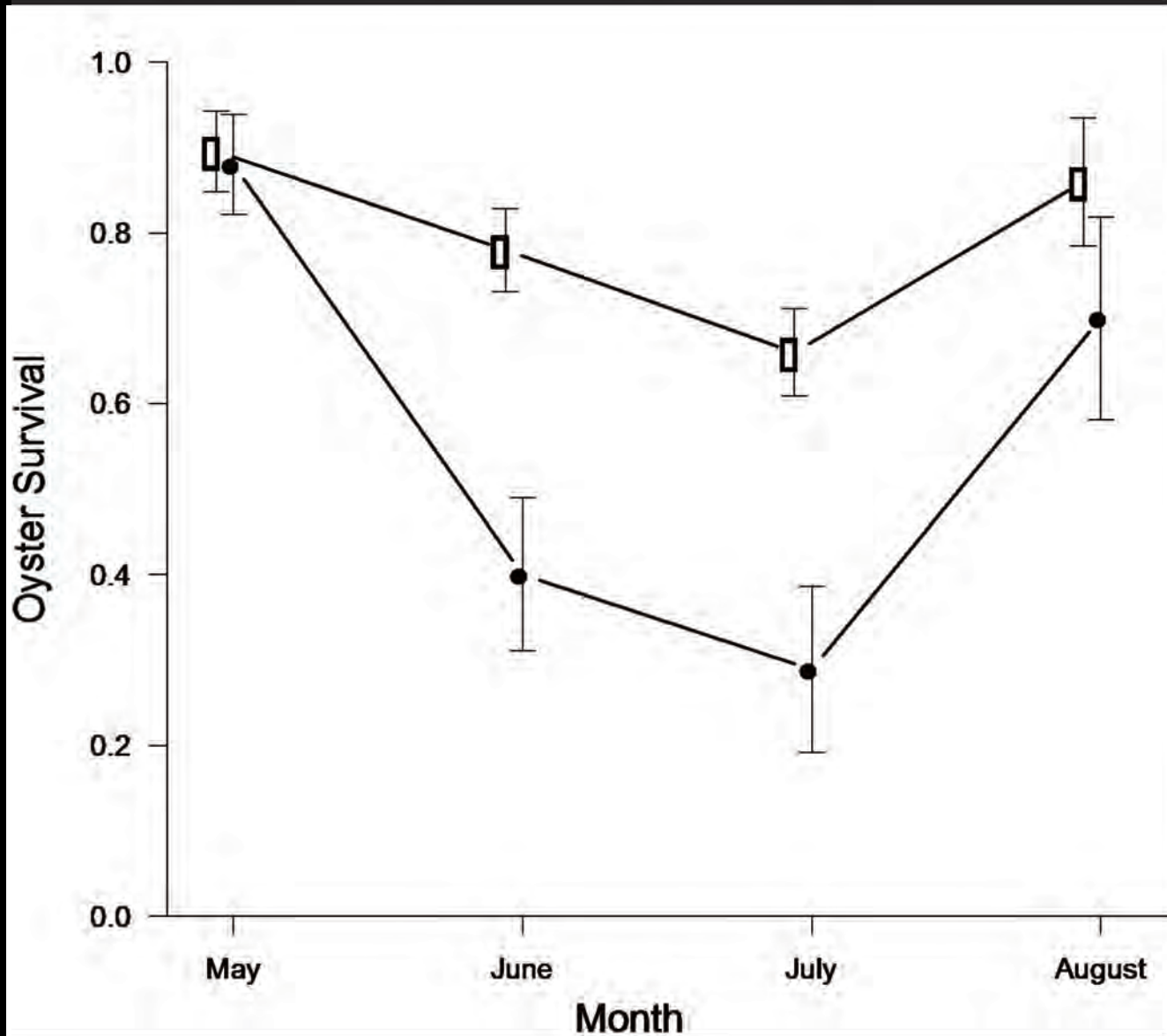


—■— No crabs, no drills

Variable Weight

Month: 1.0

# Drills Reduce Oyster Survival



—□— No crabs, no drills  
—●— No crabs, + drills

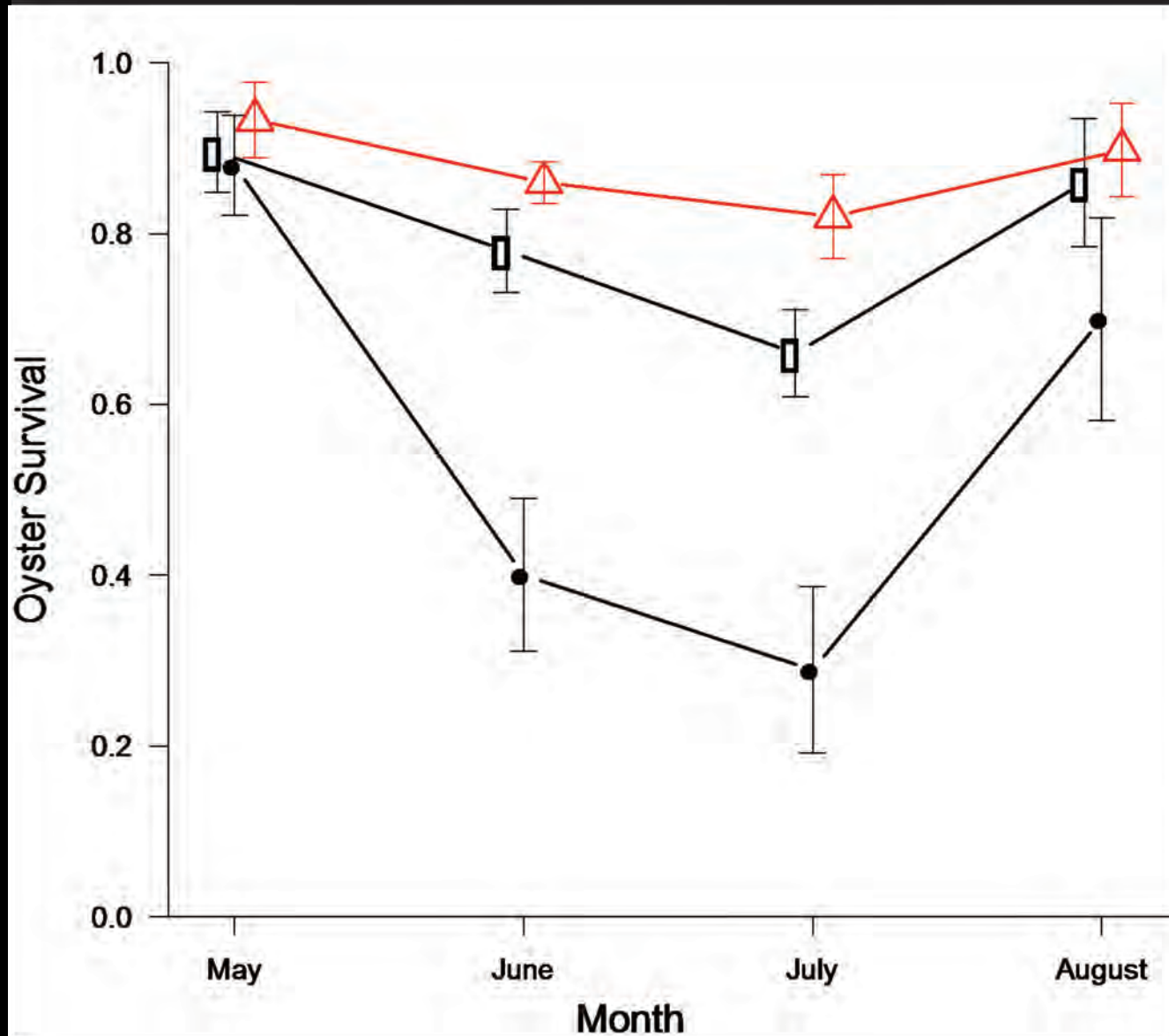
Variable Weight

Month: 1.0

Drills: 1.0

Month X Drills: 0.05

# Crabs Increase Oyster Survival



- No crabs, no drills
- No crabs, + drills
- △— + Crabs, no drills

Variable Weight

Month: 1.0

Drills: 1.0

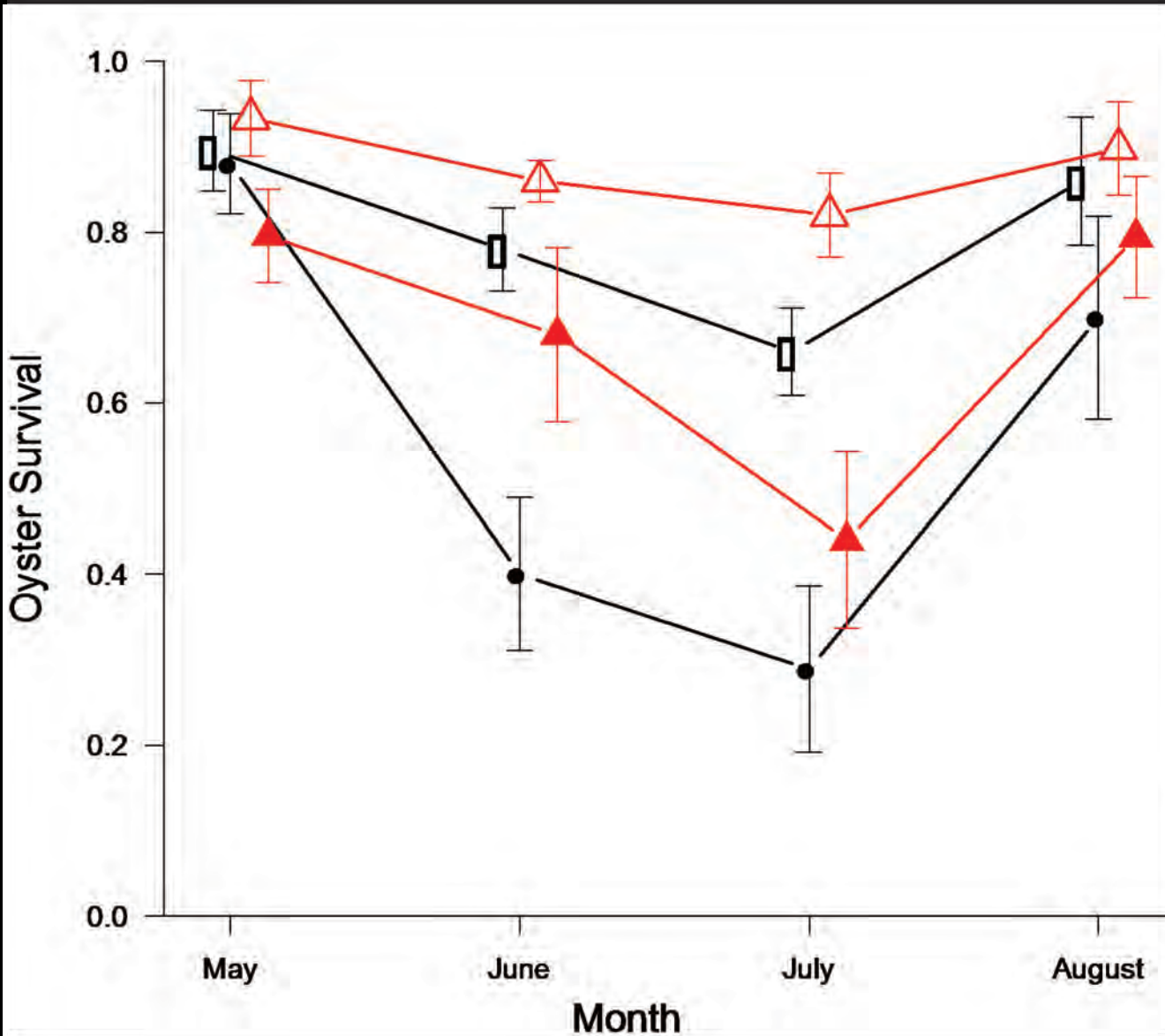
Crabs: 0.89

Crab X Month: 0.11

Month X Drills: 0.05



# Predators interact additively



- No crabs, no drills
- No crabs, + drills
- △— + Crabs, no drills
- ▲— + Crabs, + drills

## Variable Weight

Month: 1.0

Drills: 1.0

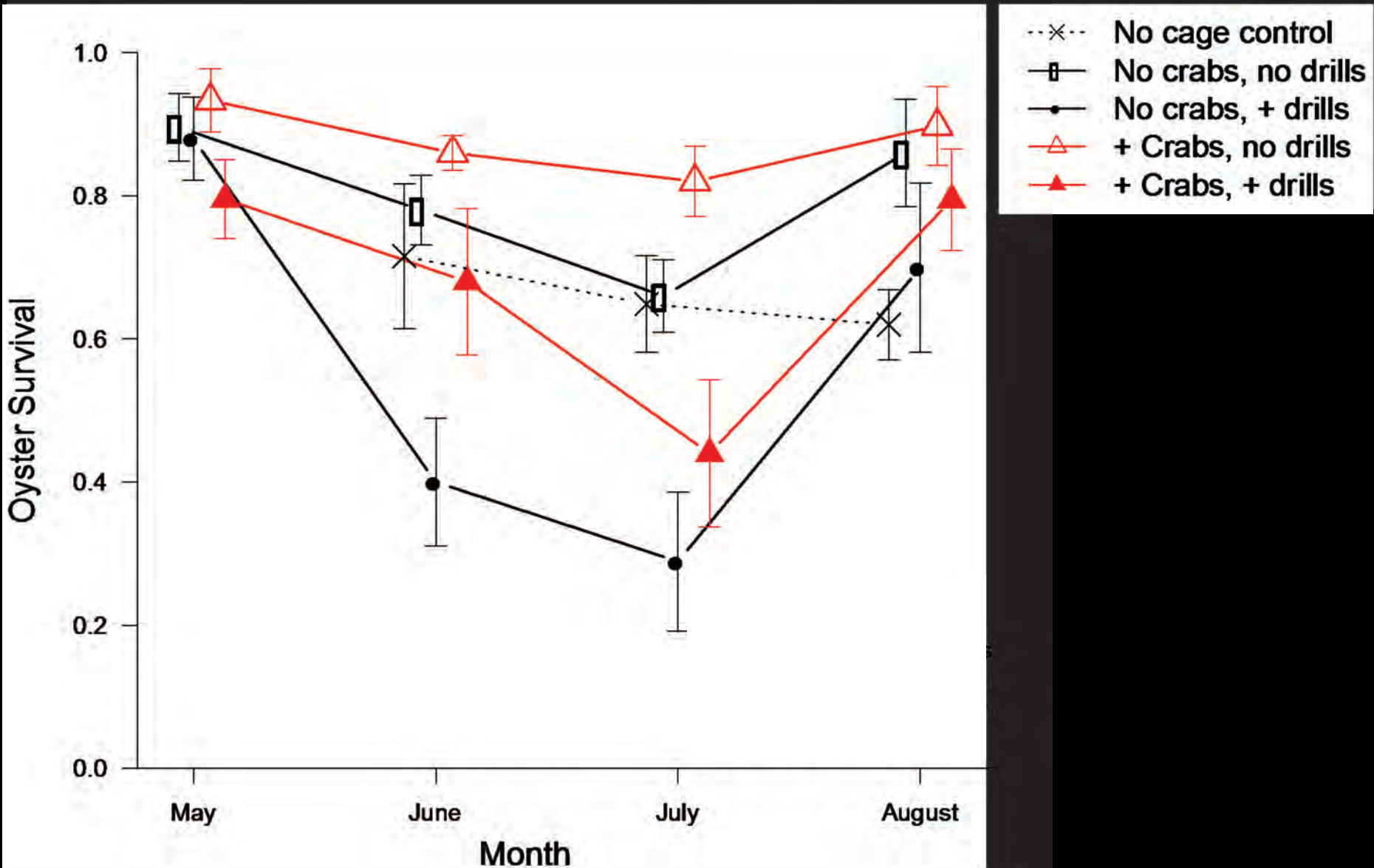
Crabs: 0.89

Crab X Drills: 0.19

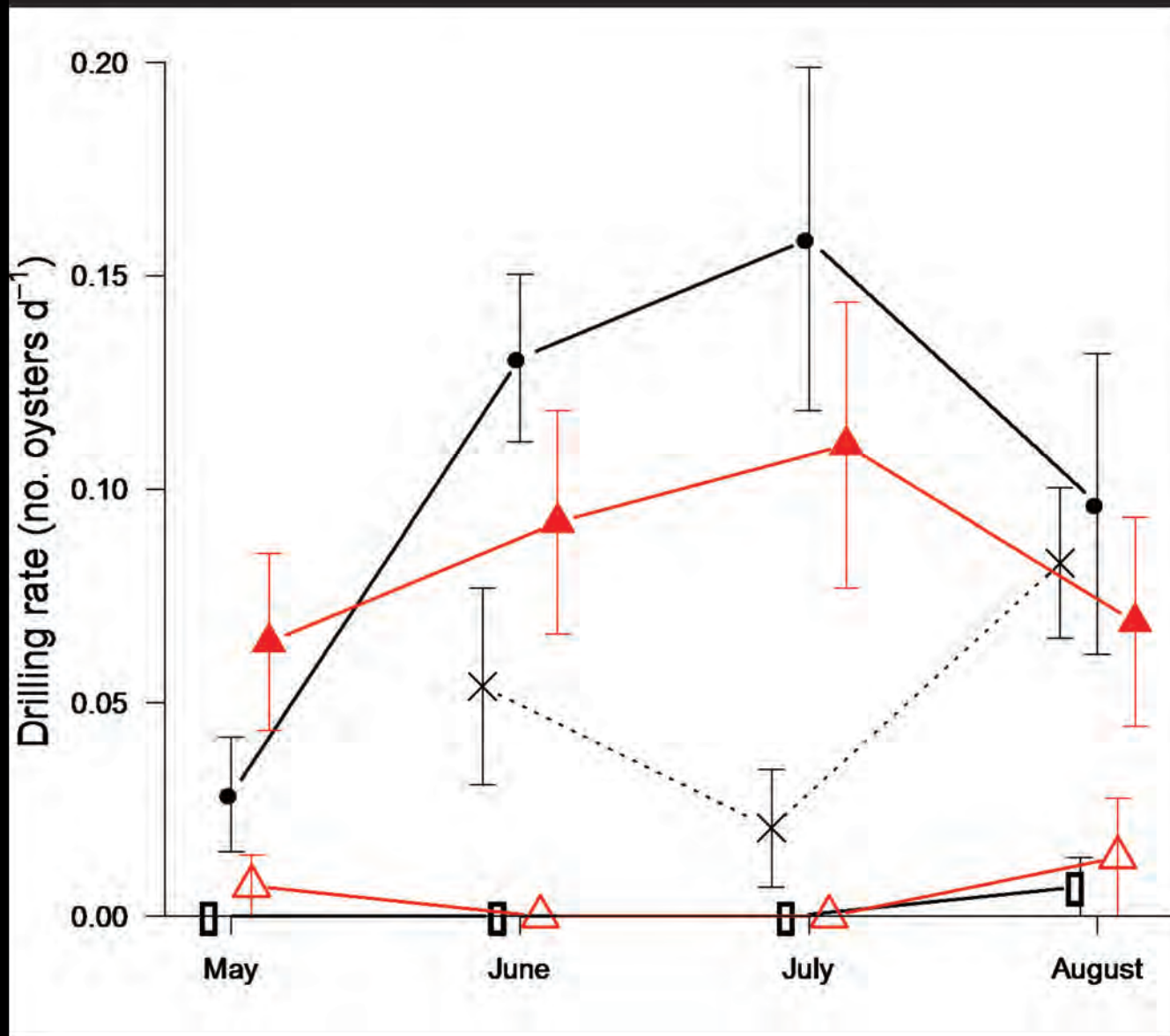
Crab X Month: 0.11

Month X Drills: 0.05

# Ambient predator effects vary



# Drilling rates vary seasonally



- x--- No cage control
- No crabs, no drills
- No crabs, + drills
- △— + Crabs, no drills
- ▲— + Crabs, + drills

Variable Weight

Month: 1.0

Drill Num.: 1.0

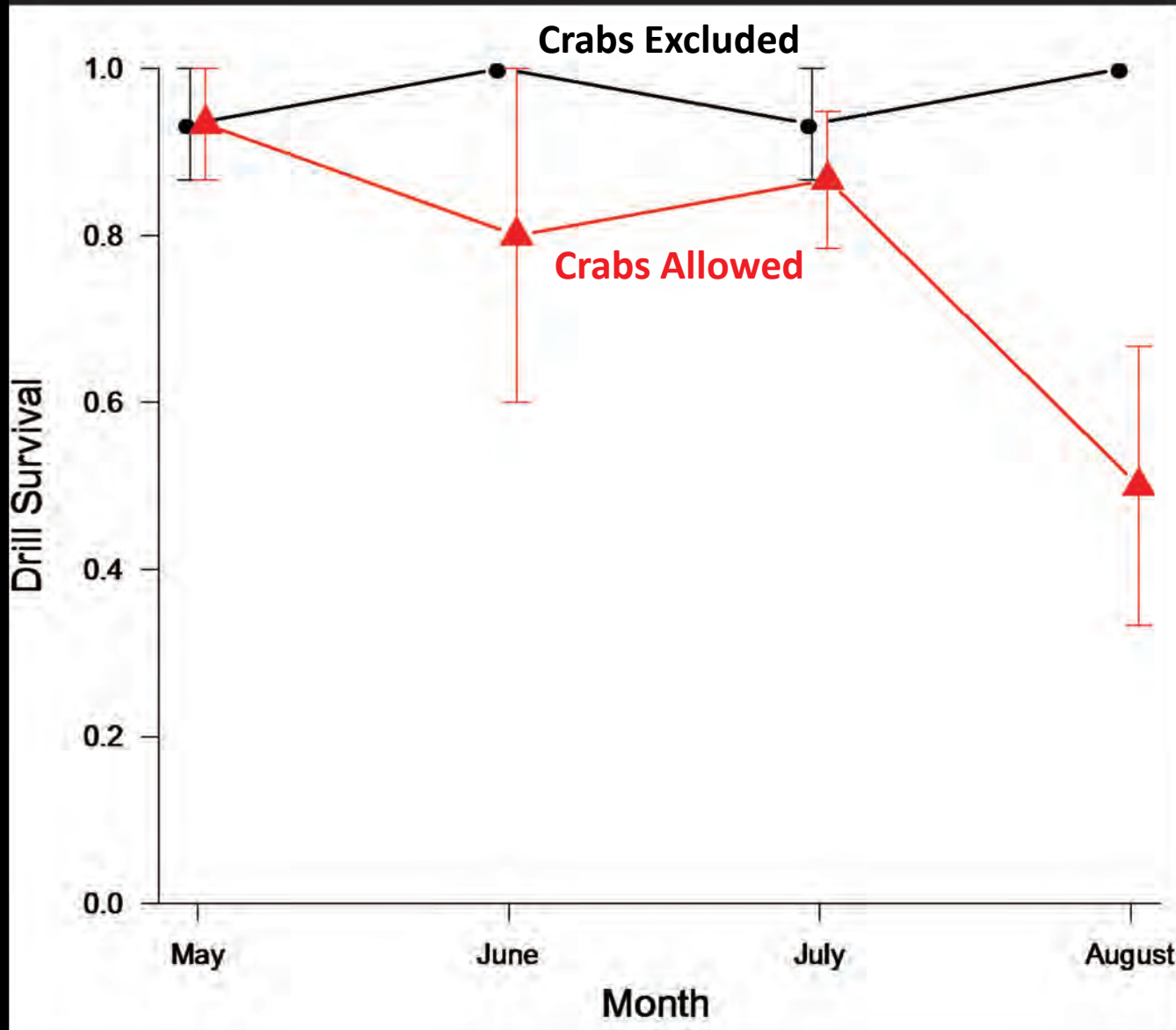
Crabs: 0.33

Crab X Drills: 0.09

Crab X Month: 0.04

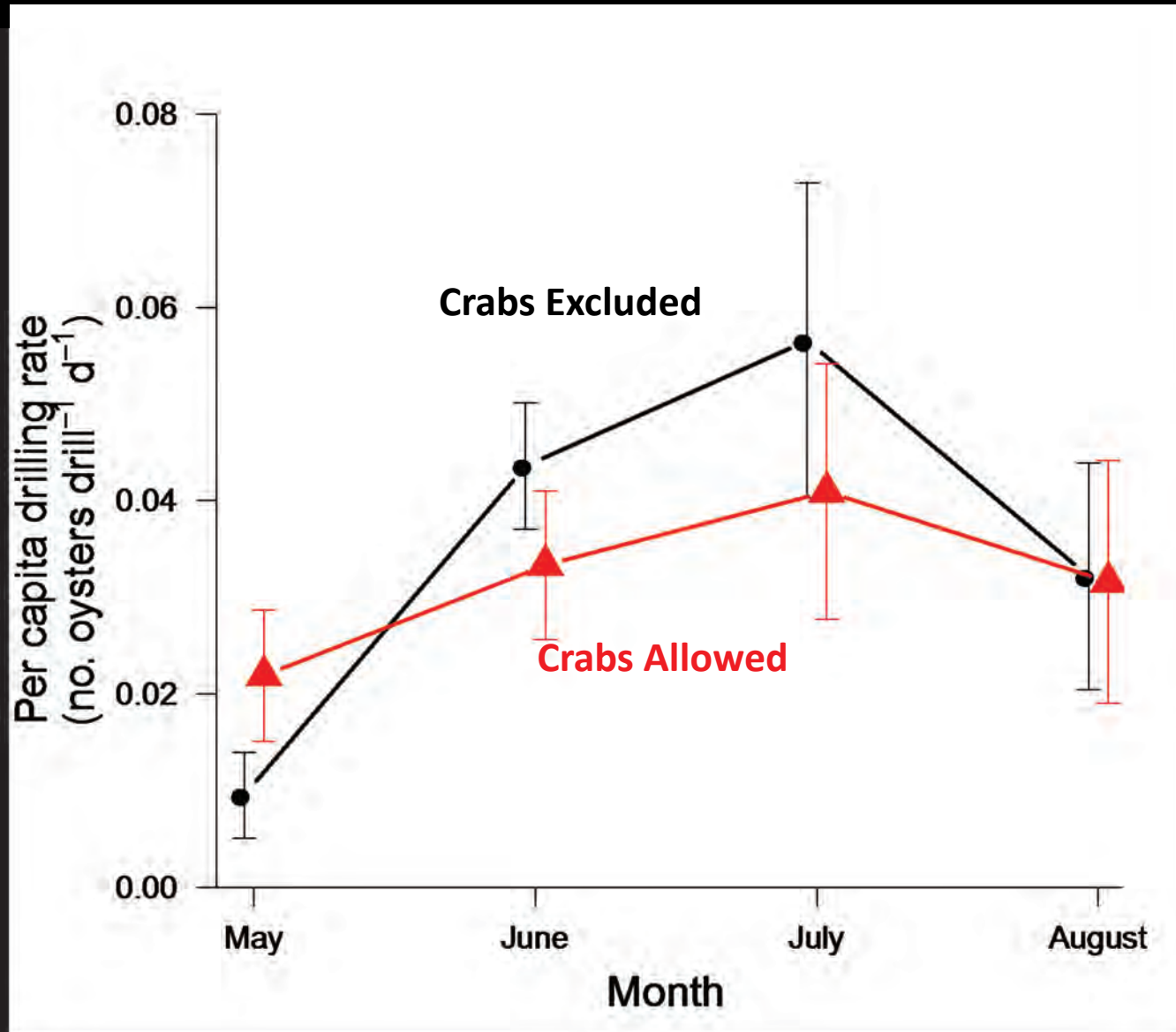
Month X Drills: 0.09

# Crabs only reduced drills in August



\*only treatments where drills were included in cages

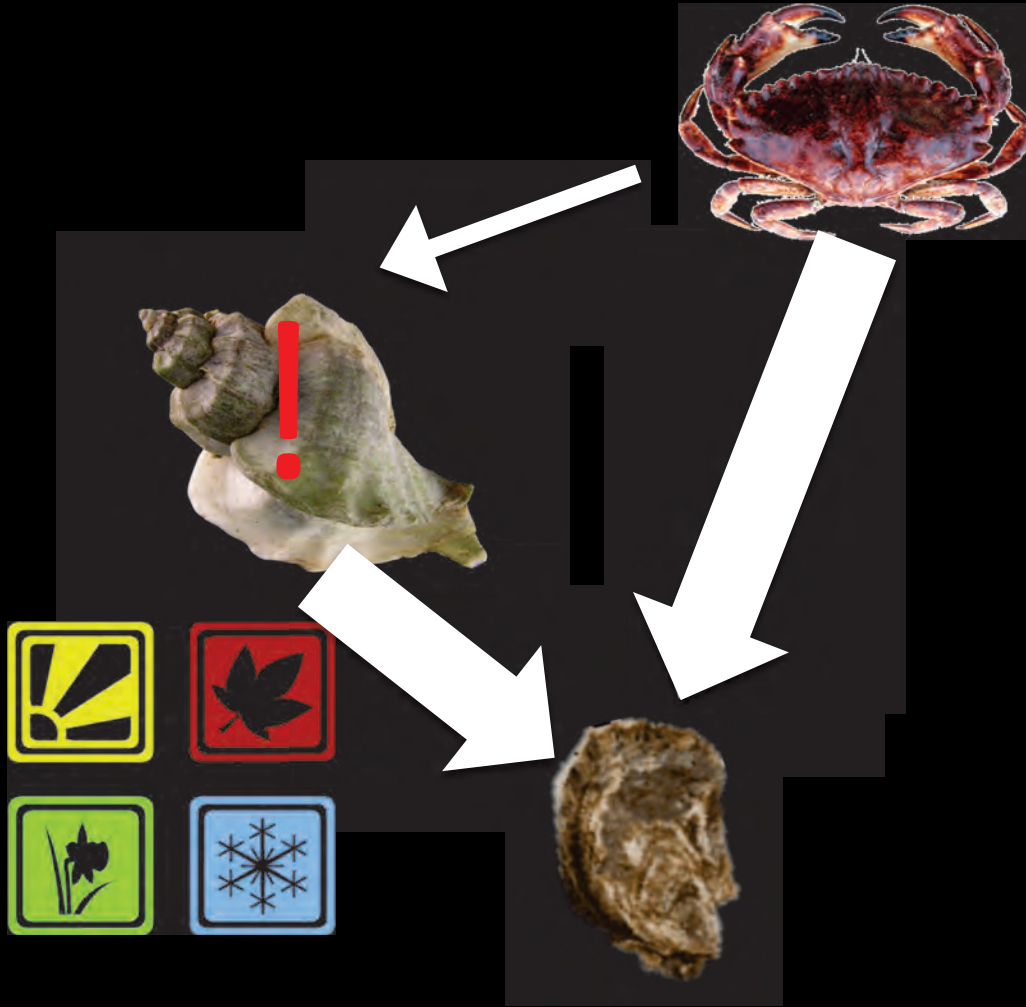
# Drill feeding rates mirror mortality



# drills = Average of Initial and final number

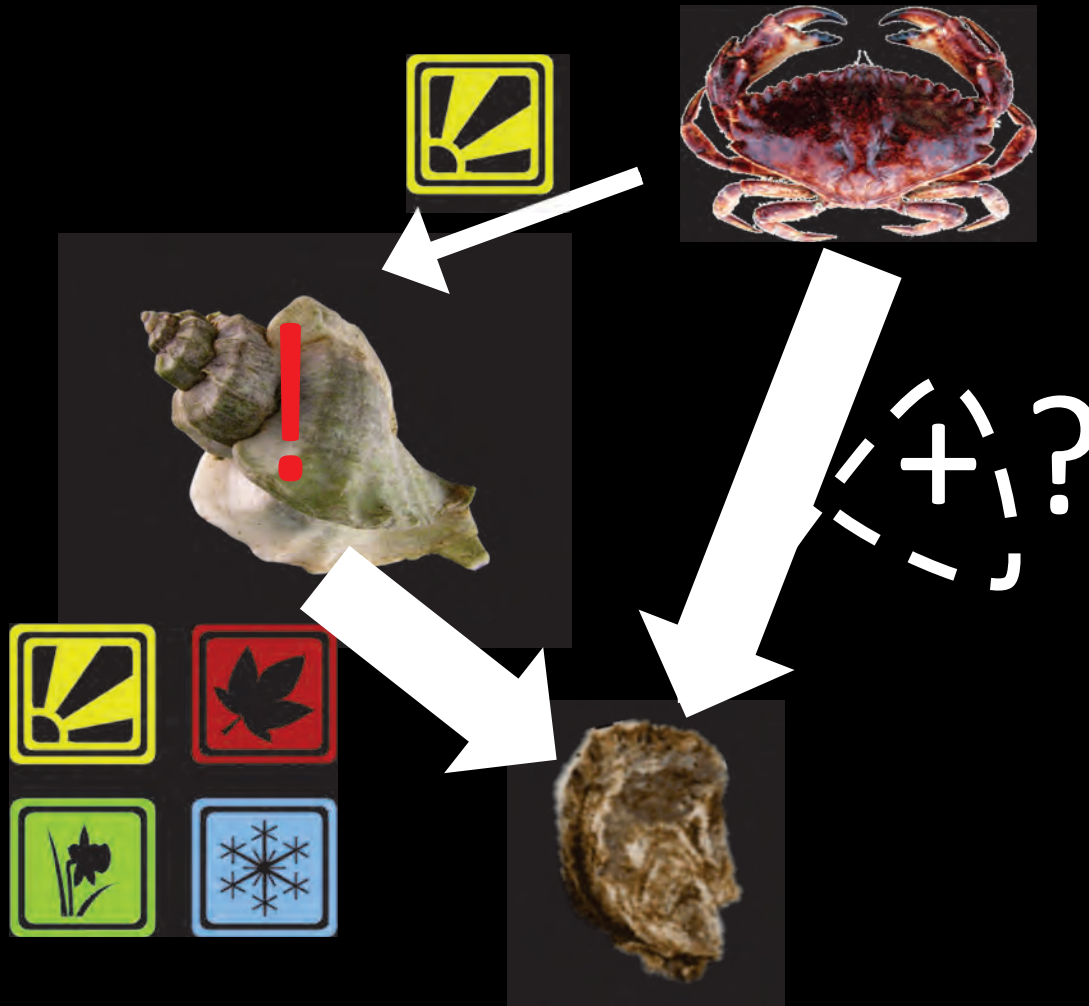
# Drills are major drivers of oyster success

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# Crabs are not bad news for oysters

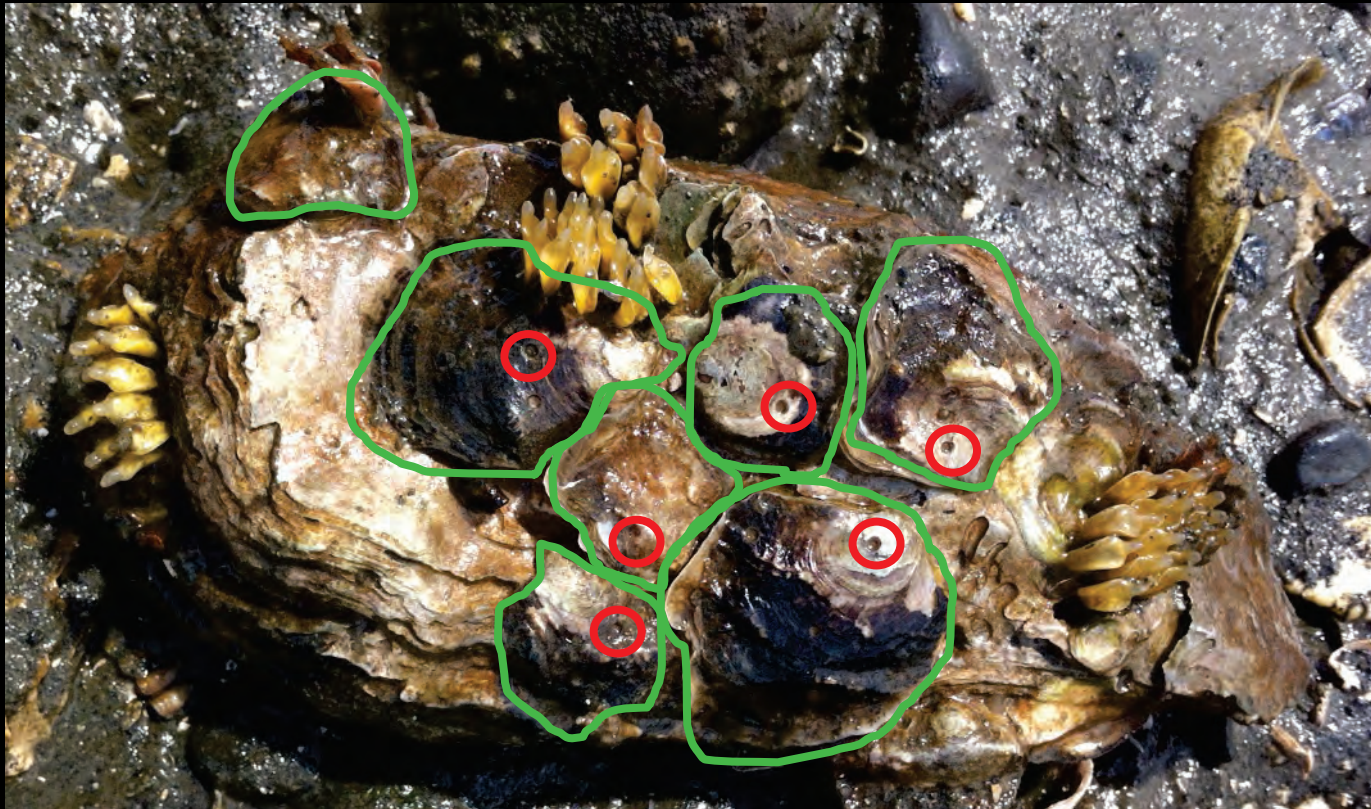
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# Recommendations

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- **Avoid** drills at restoration sites
- Research density/size refuge for oysters





# Many, many thanks are due to...

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**Puget Sound  
RESTORATION FUND**

Brian Allen &  
Besty Peabody

## <3 Shore Access and Hospitality <3

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Gitch and Yungkeit Families

Oyster Master  
Joth Davis



## Field and Lab Support

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- Jennifer Ruesink
- Greg and Molly Jackson
- Avanthi Jayasuria
- Nima Yazdani
- Marie Clifford
- Matt Flora-Tostado

**Thirsty for more?**

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