

Clam recruitment across substrates in Willapa Bay

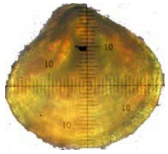
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Funding sources: Washington Sea Grant, Oyster Reserve Fund

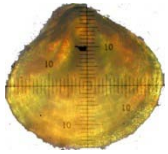
Focus on two life-history stages -



Settlement

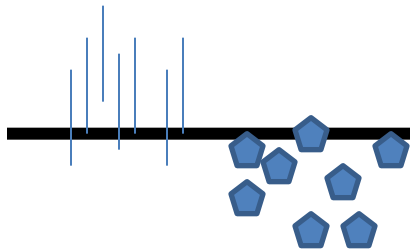
Recruitment

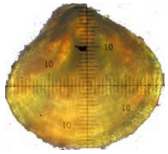




Settlement

Recruitment

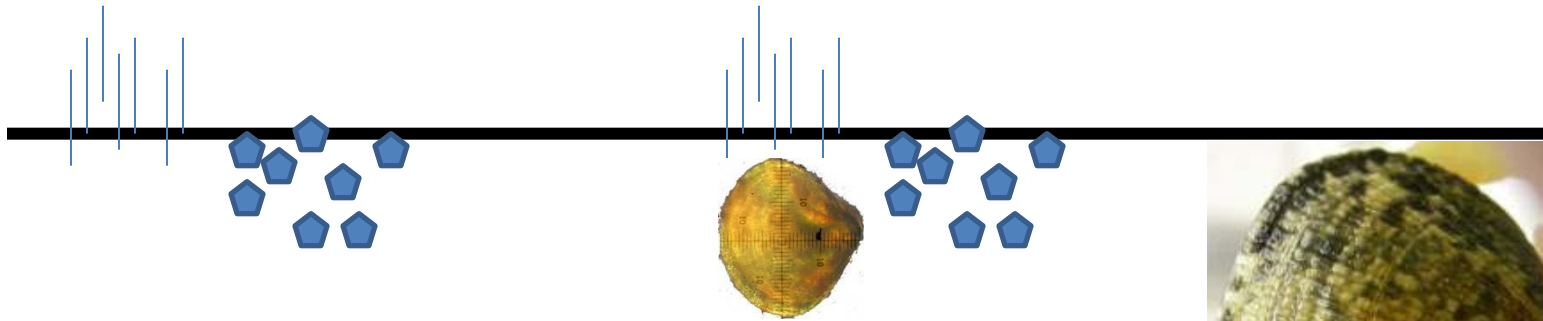


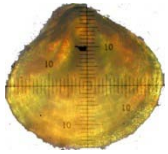


Settlement

Post-Settlement
Survival

Recruitment



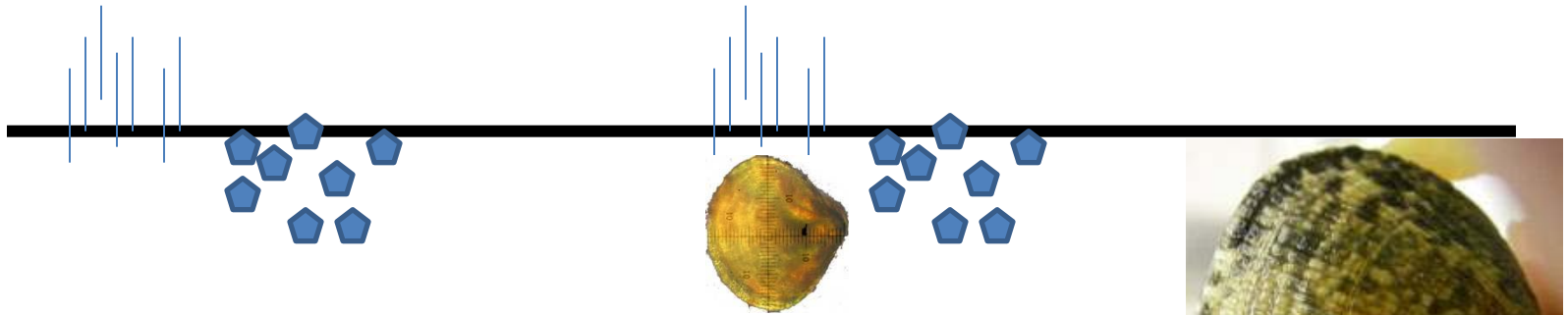


Settlement

Biology – predators

Post-Settlement
Survival

Recruitment



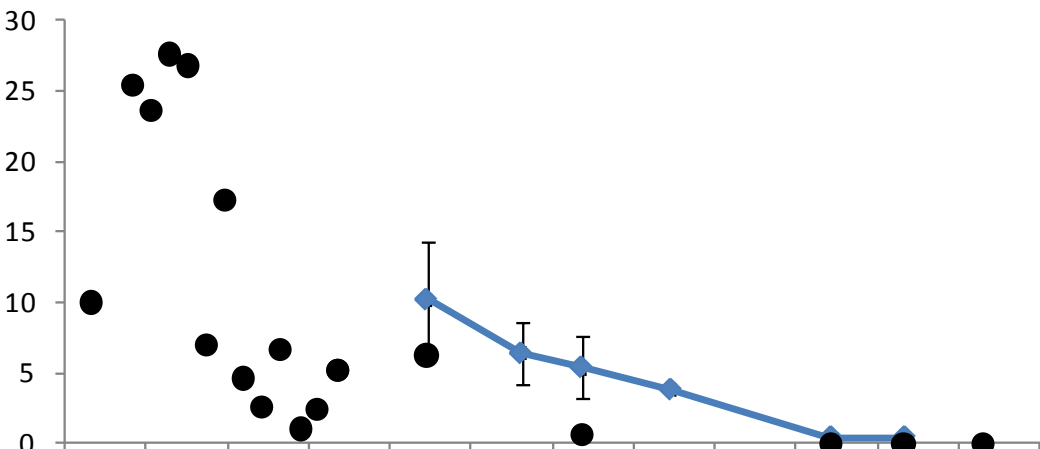
Chemistry- DO, DIC



Questions

- How is clam settlement or recruitment influenced by *Z. japonica*?
 - Ecological theory suggests complex structure increases diversity and abundance of associated organisms, but particular species may not respond positively
- How is clam settlement or recruitment influenced by amendment by rock or shell substrates?
 - Beach frosting reduced settlement but increased survival in Puget Sound (Thompson 1995)
 - Shell may improve interstitial water chemistry (Green et al. 2009)

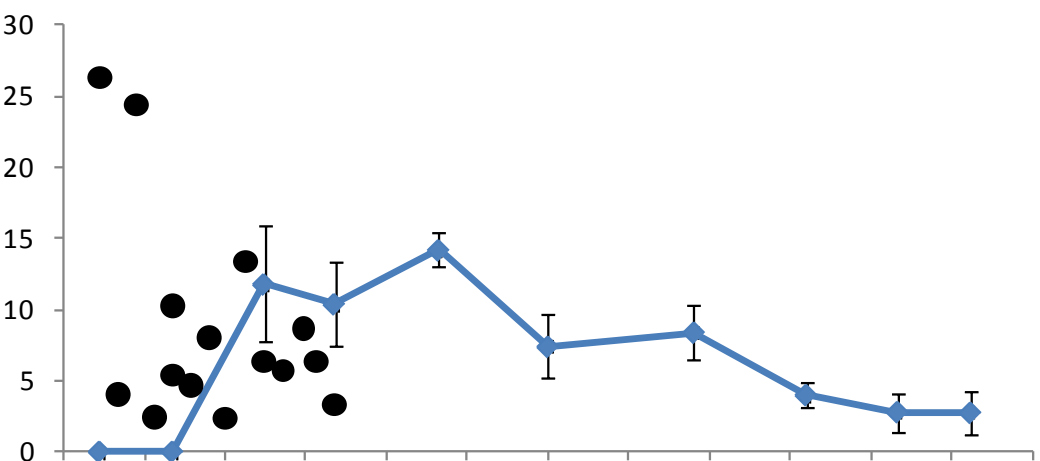
2010



Settlement
June – Dec

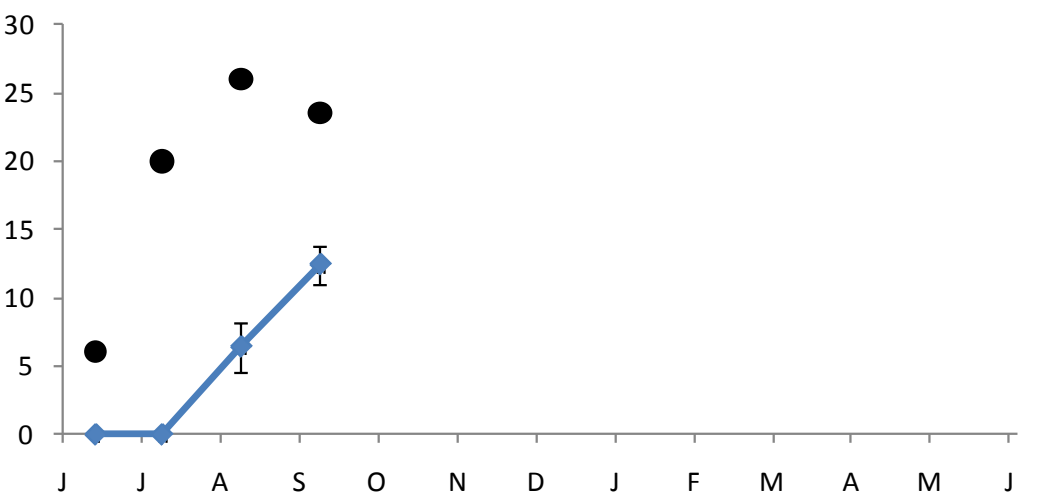
Clams per bag

2011



Blue lines = 0.5
mm clams in
monthly samples
Points = 0.2-0.5
mm very recent

2012

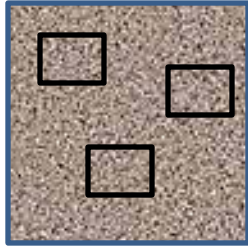


Methods: 3 experiments

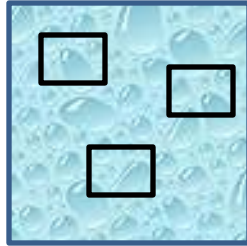
Test	Measure
4 substrates added in mesh bags (round rock, crushed gravel, clam shell, oyster shell)	3 wks, 6 wks, 9 months
Tidal elevation Clam bed vs. <i>Z. japonica</i> habitat Mechanical removal or addition of <i>Z. japonica</i> in small plots	2 months, 9 months
Chemical removal of <i>Z. japonica</i> in large plots 3 substrates added in small plots (round rock, crushed gravel, shell with gravel)	11 months

EXPERIMENT 1

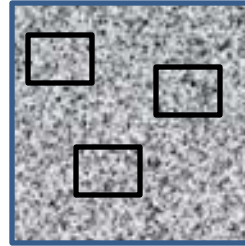
Crushed gravel



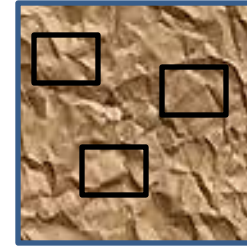
Round rock



Crushed oyster shell



Crushed clam shell



50 cm



X 5 replicates

X 3 sites



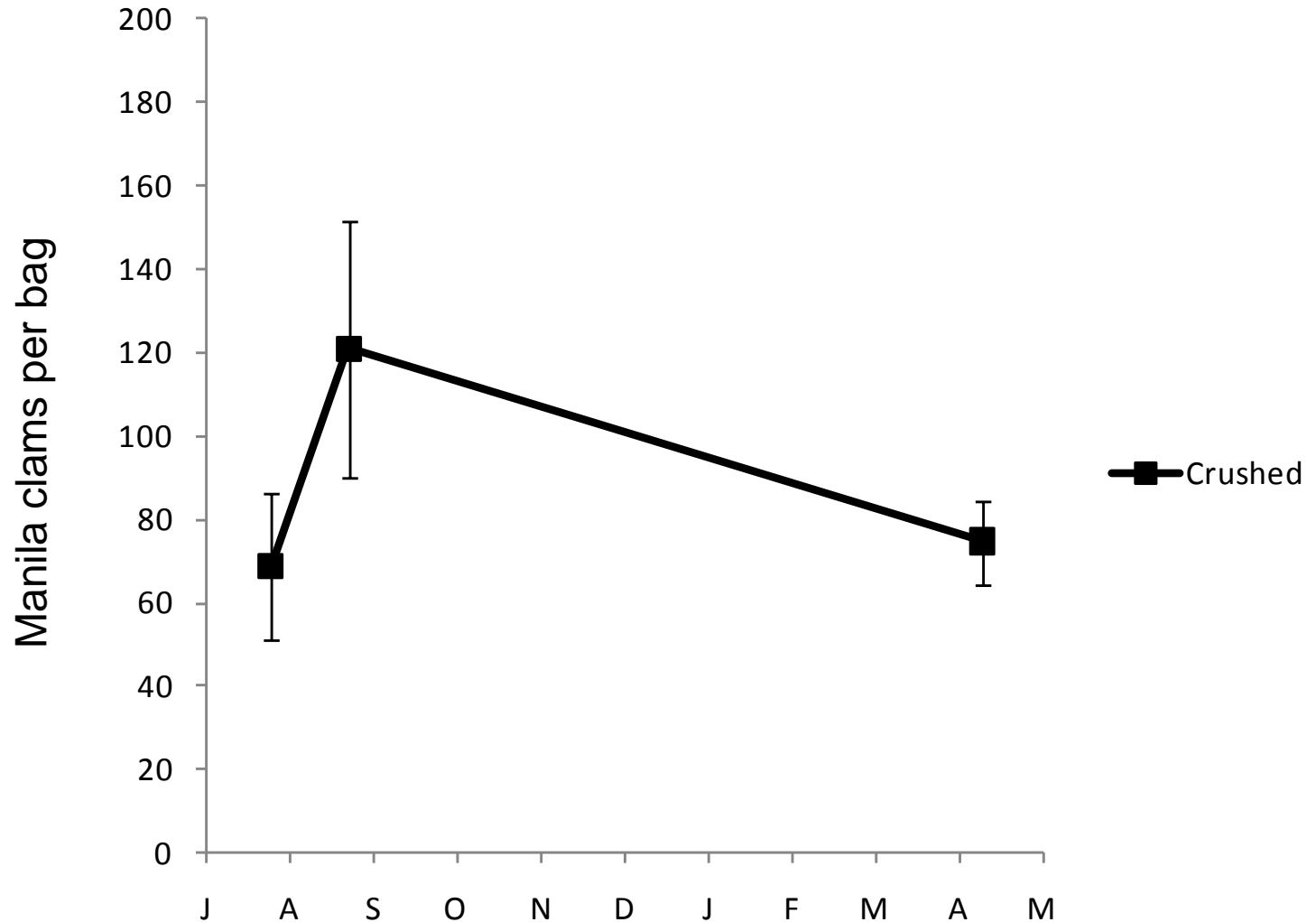
EXPERIMENT 1

Recruitment of fingernail-sized clams

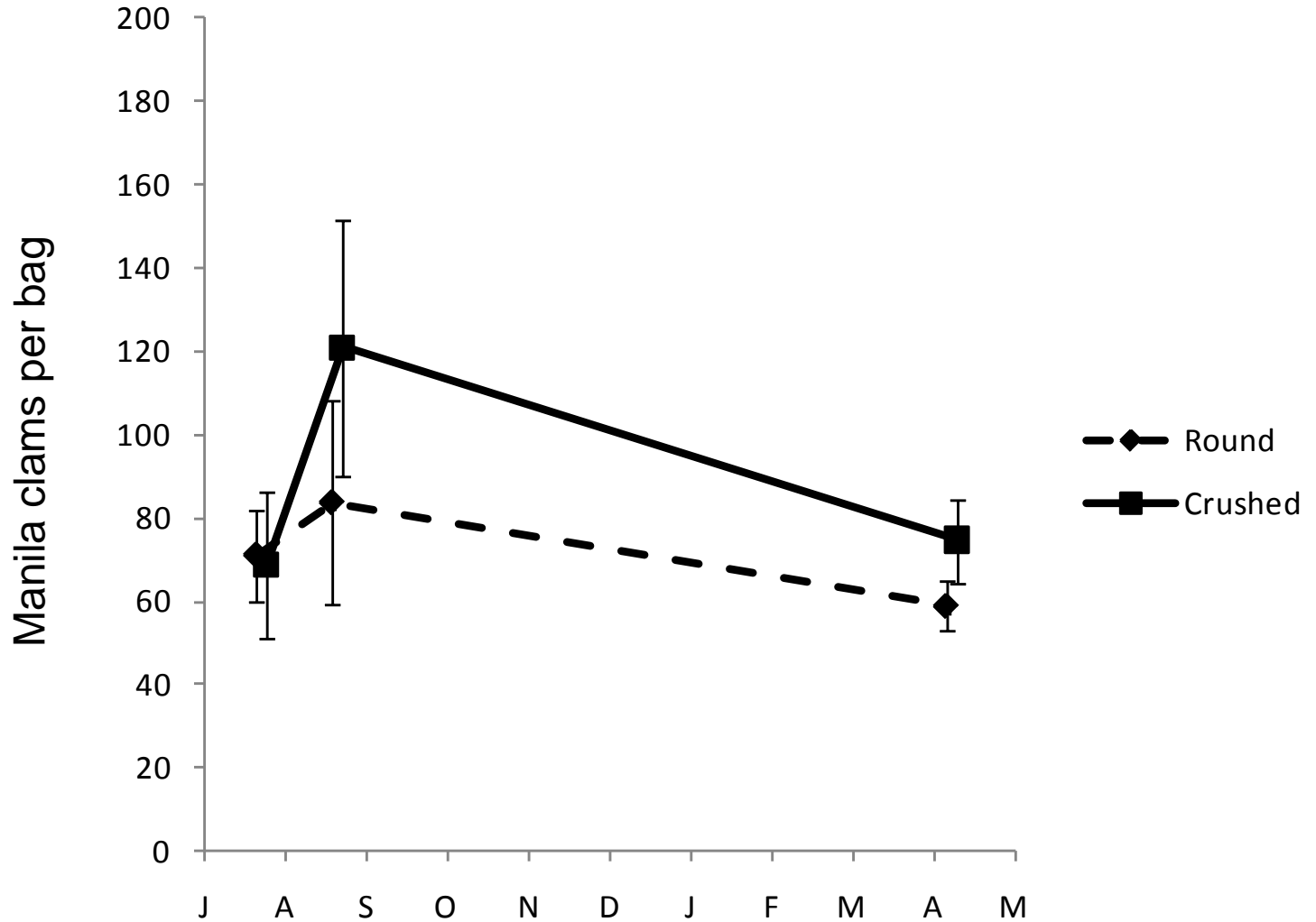
~70 per bag

~400 per square foot

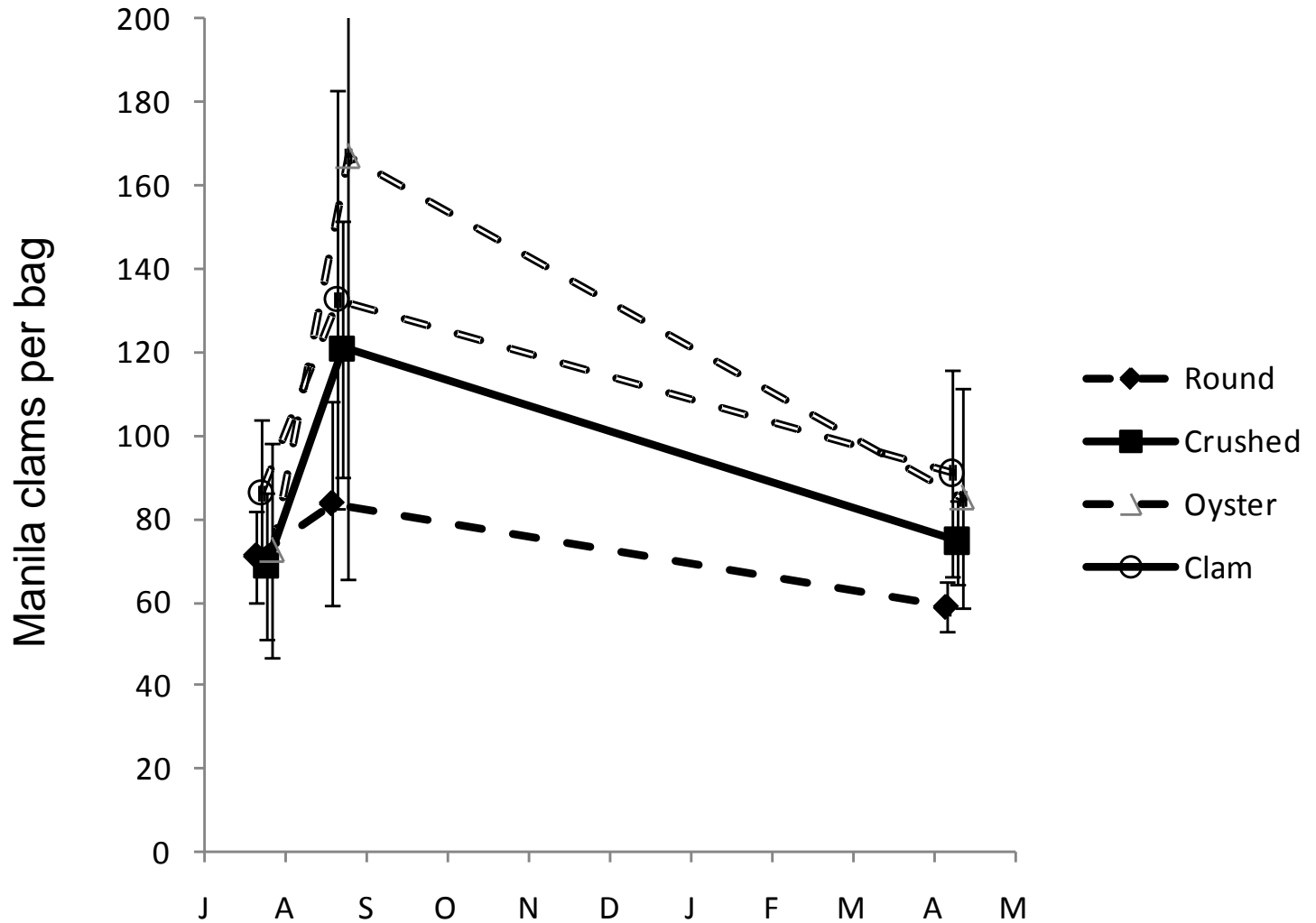
Crushed gravel – results show expected seasonal pattern of accumulation from summer recruitment, followed by overwinter mortality



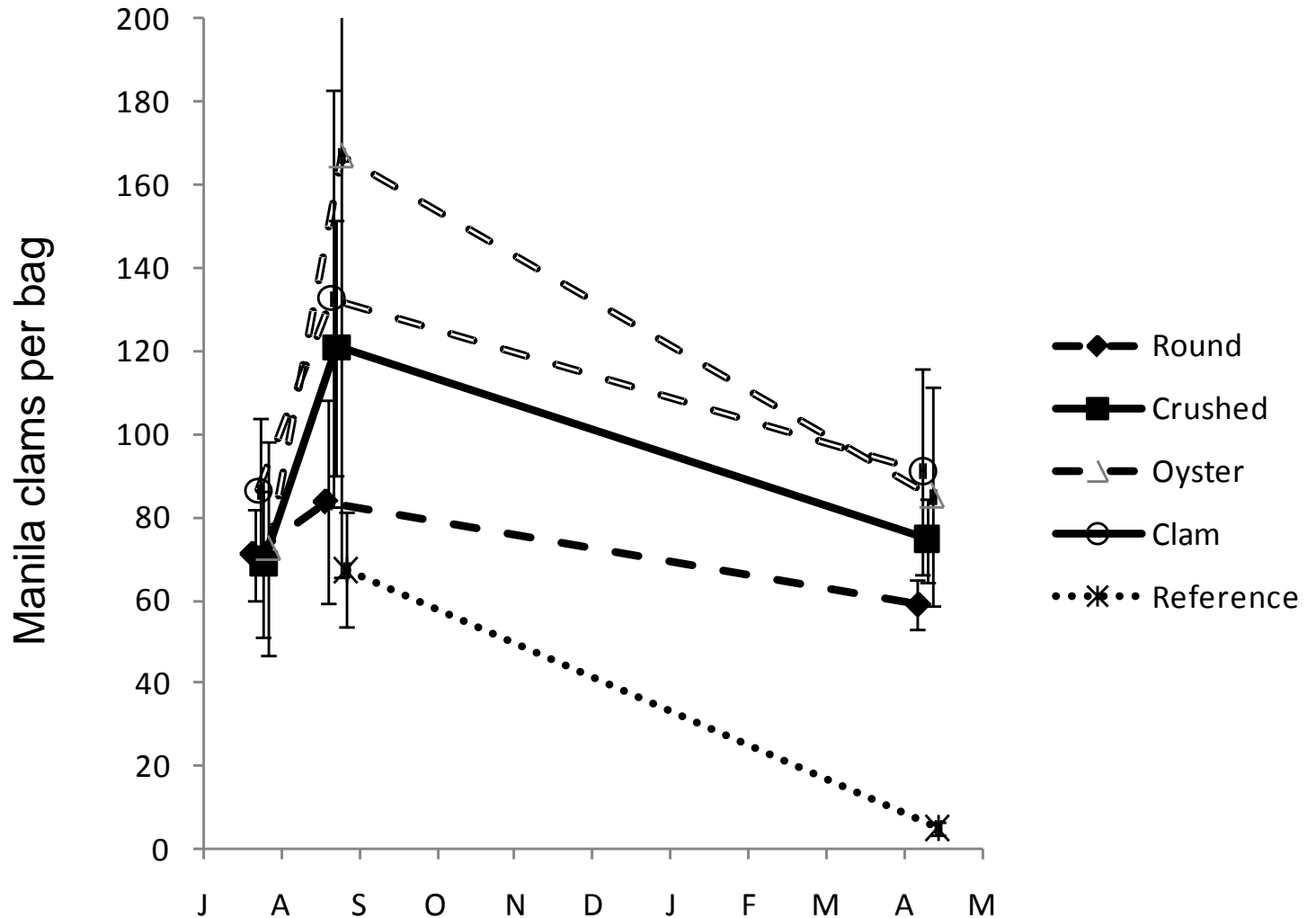
Round rock – no advantage for settlement or survival



Shell treatments – weak settlement advantage, no survival benefit



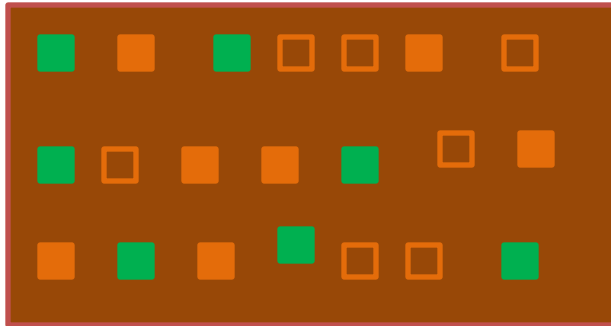
Reference area of fine-grained sediment – lower clam abundance than in bags with rock/shell due to overwinter mortality



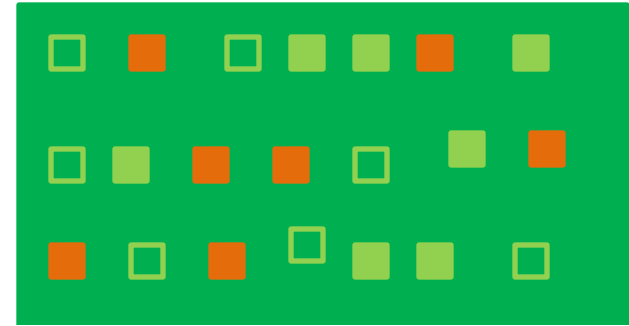
EXPERIMENT 2

2 habitats

Commercial clam bed



Zostera japonica



3 treatments
Eelgrass addition
Disturbance control
Control

Eelgrass removal
Disturbance control (transplant)
Control

X 7 replicates

X 2 tidal elevations

X 2 sites

Plots sampled by coring

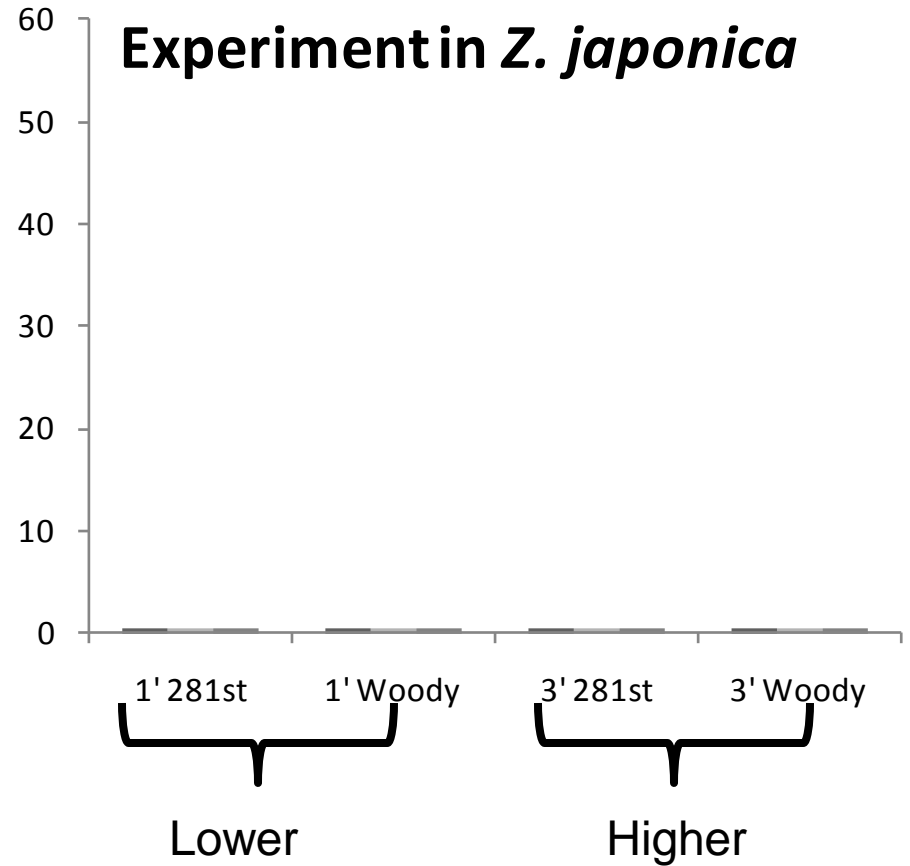
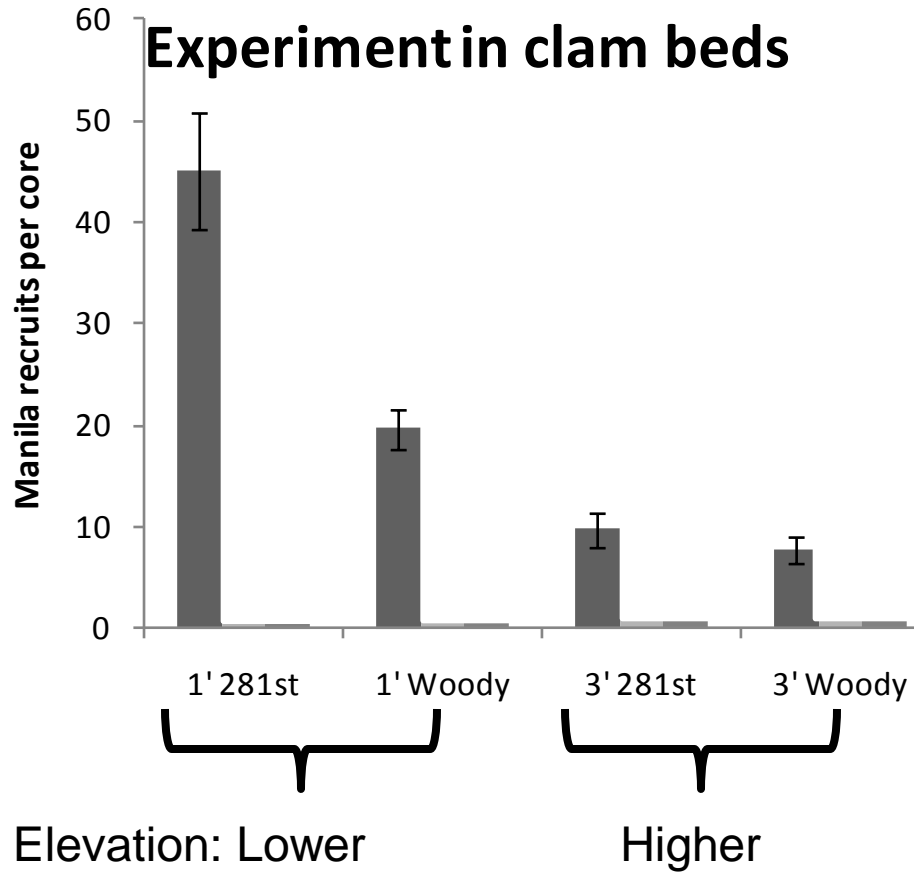


Non-native dwarf eelgrass
Zostera japonica

EXPERIMENT 2

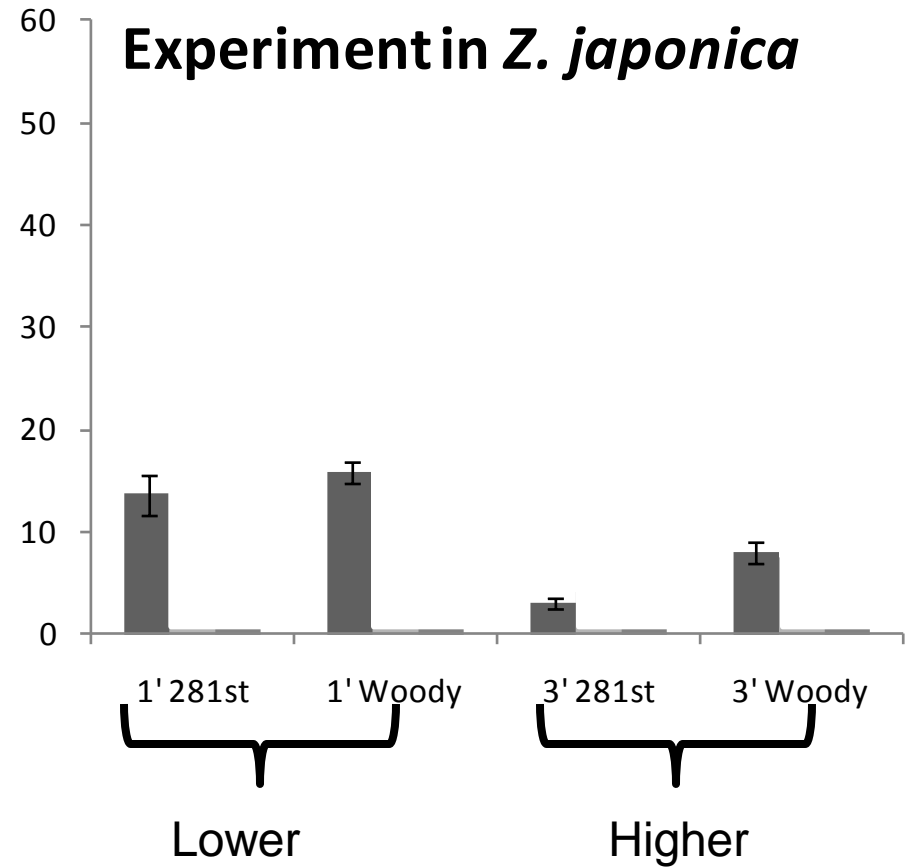
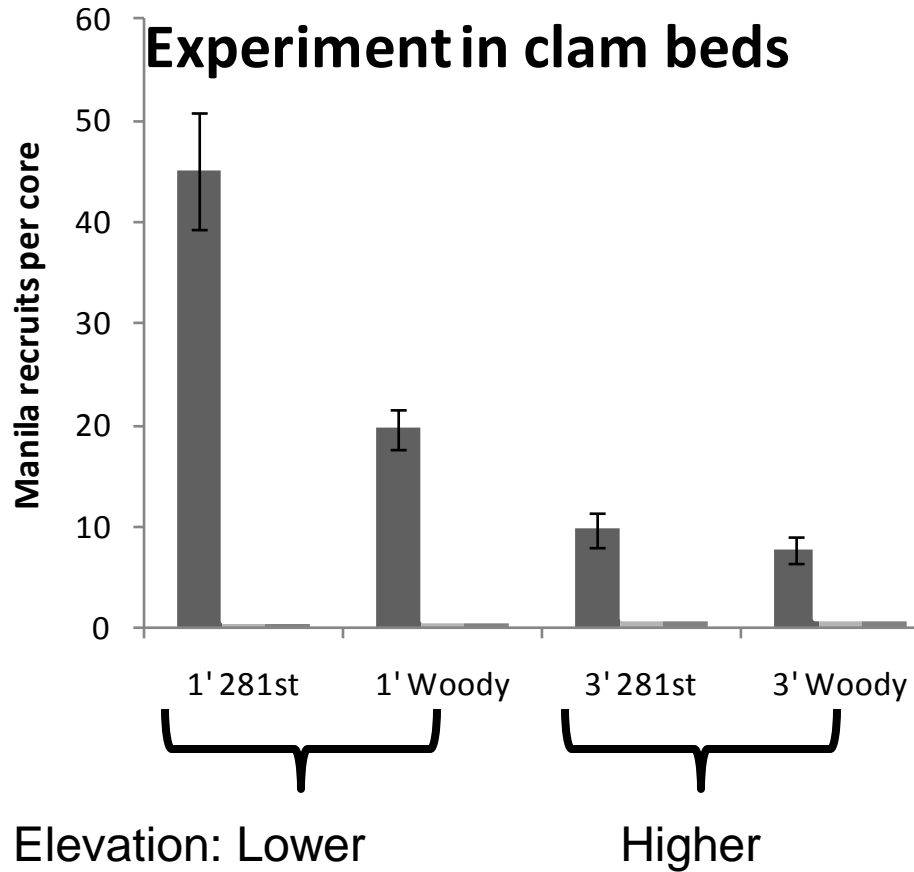
2 months:

Higher settlement at lower elevations



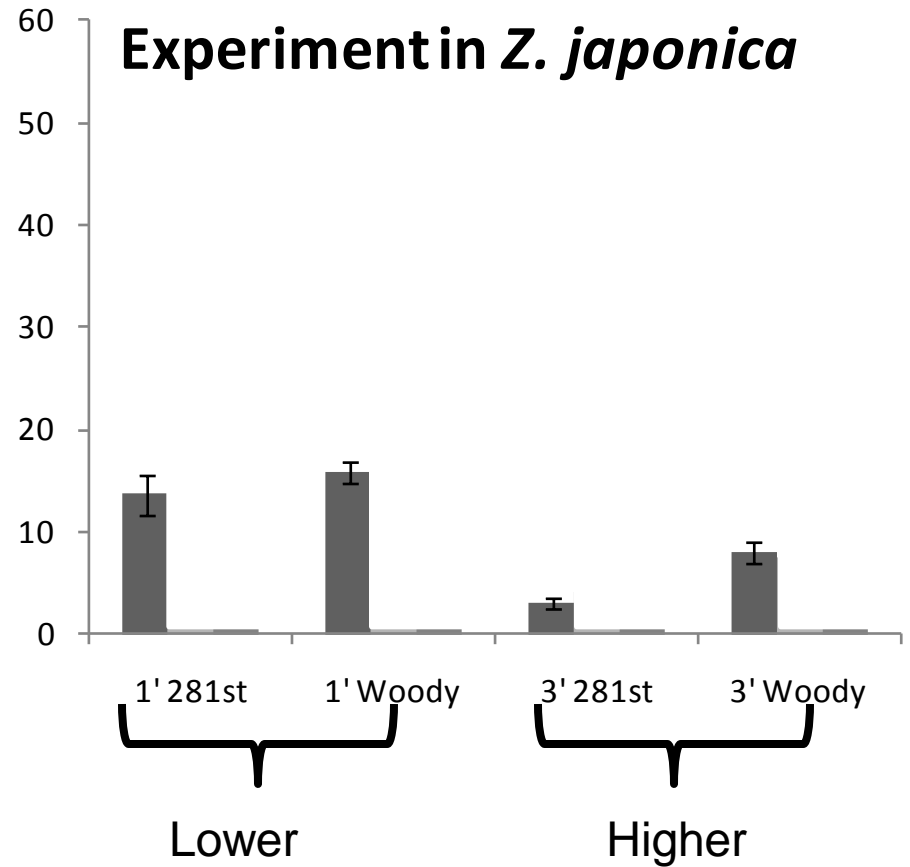
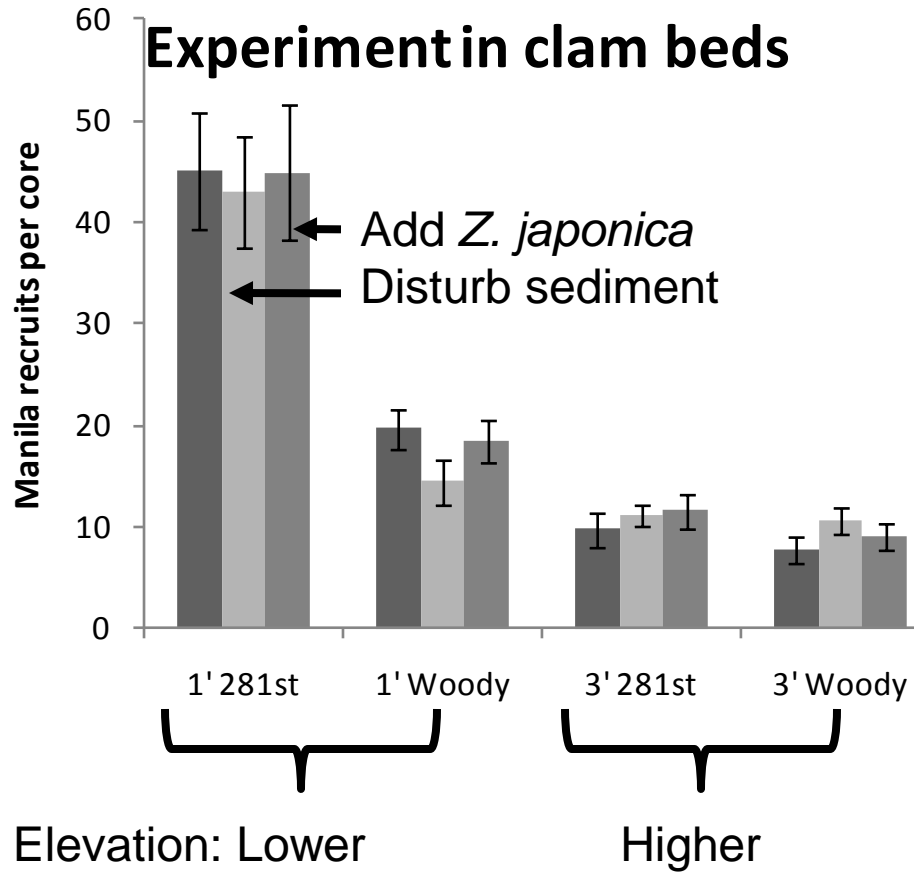
2 months:

Higher settlement at lower elevations in both habitats



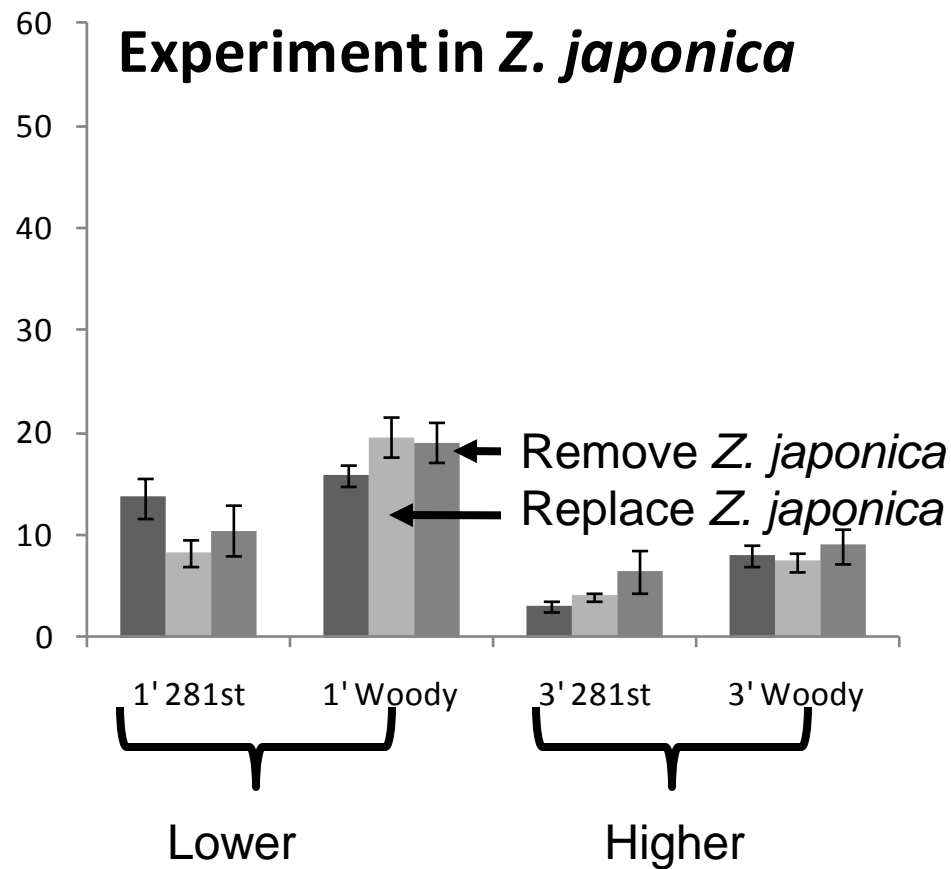
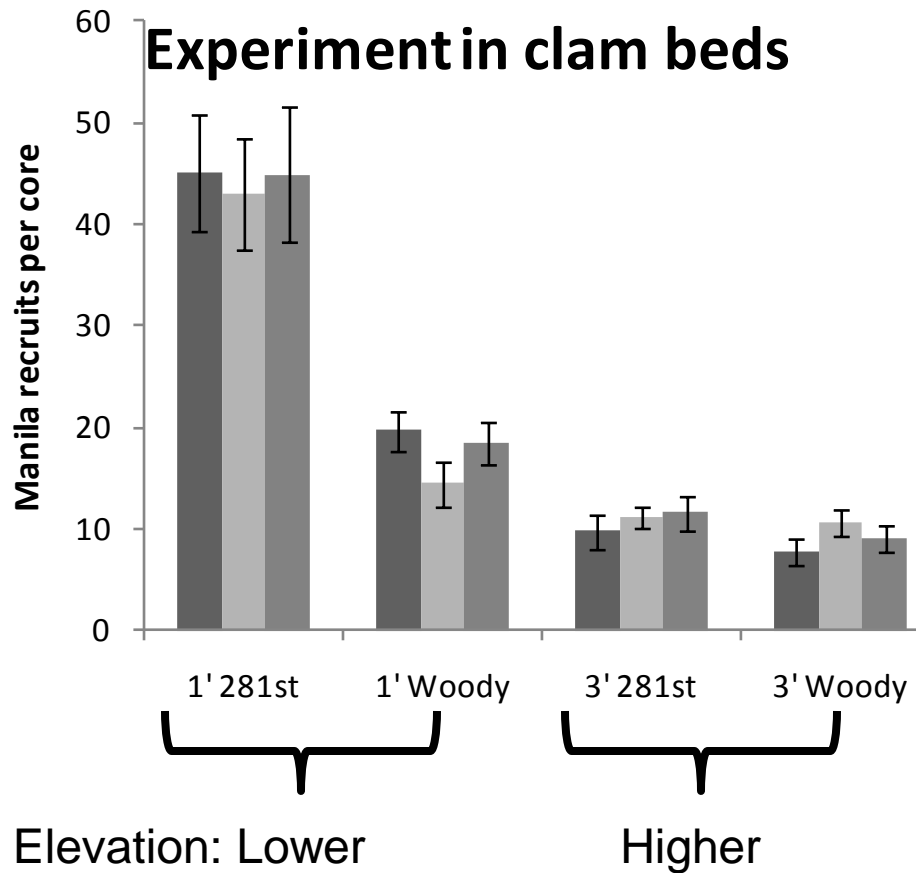
2 months:

Plot-level treatments had no effect on settlement

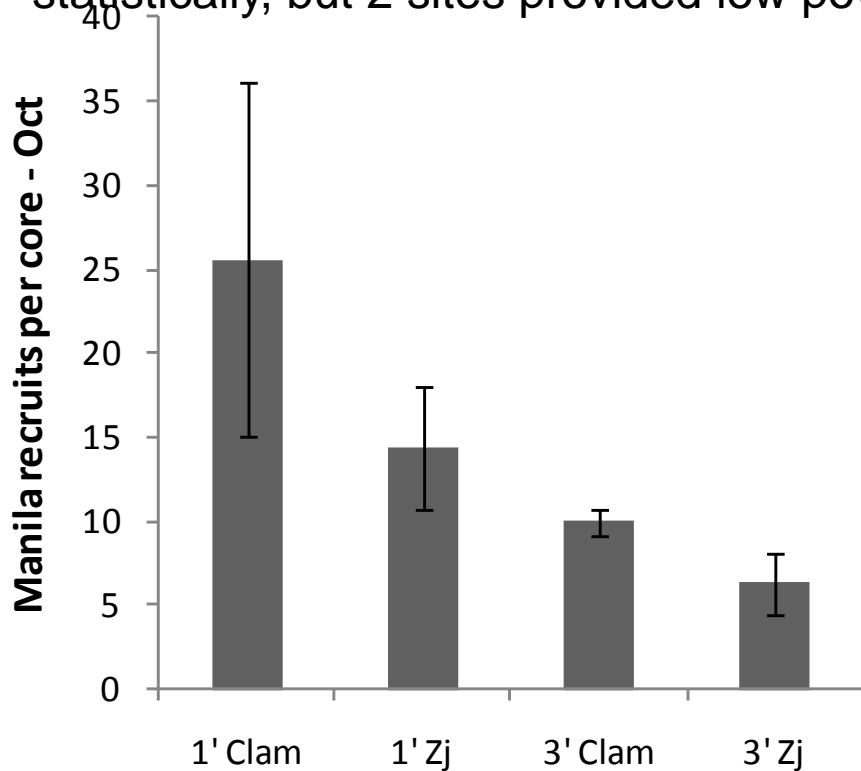


2 months:

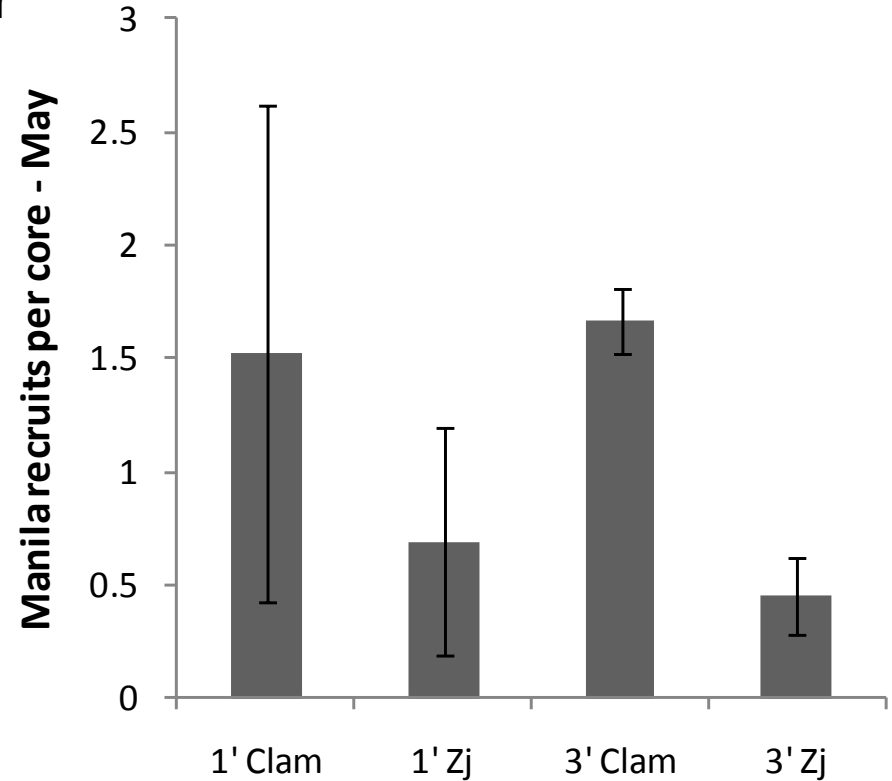
Plot-level treatments had no effect on settlement



After 2 months, Manila clams were less abundant at high than low elevations
No effect of habitat was detectable statistically, but 2 sites provided low power



After 9 months, Manila clams were less abundant in *Z. japonica* than on clam beds



Clam beds – recruitment 16/ft²
Z. japonica – recruitment 6/ft²

EXPERIMENT 3



No addition



Crushed gravel



Round rock



Gravel + shell



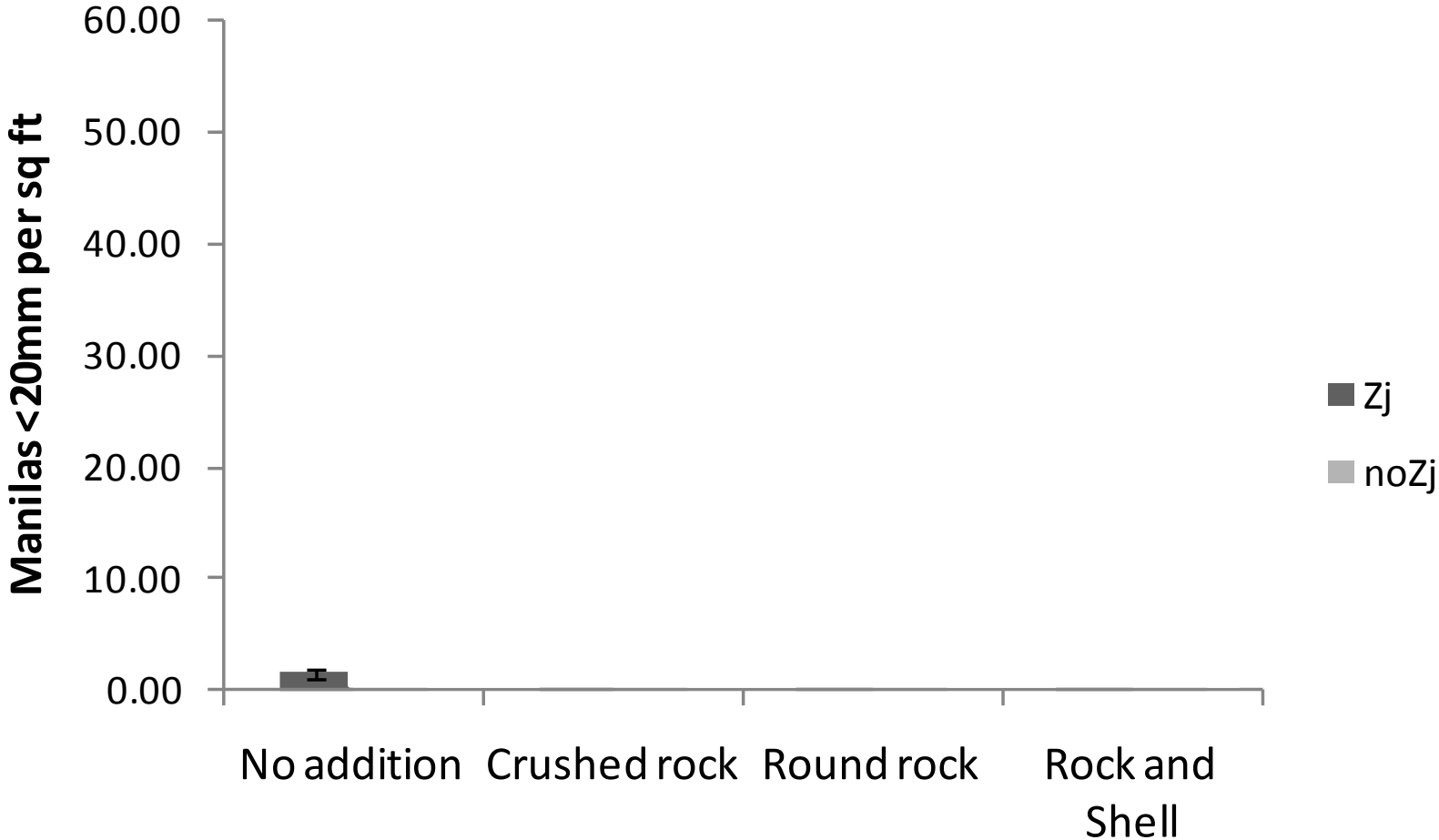
Z. japonica sprayed with imazimox

X 2 plot replicates

X 6 subplot replicates

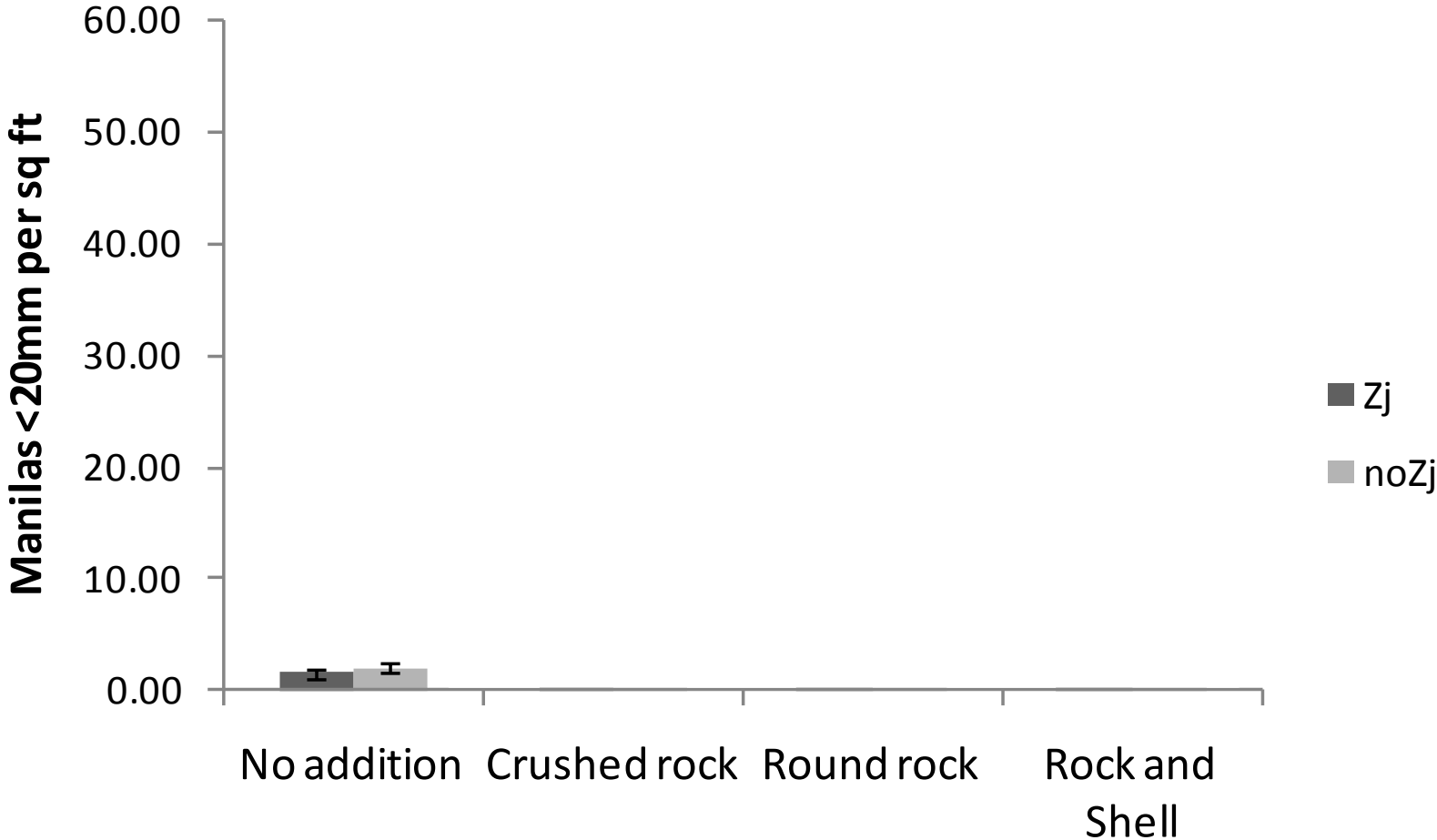
EXPERIMENT 3

Compare *Z. japonica* and removal, then substrate addition



EXPERIMENT 3

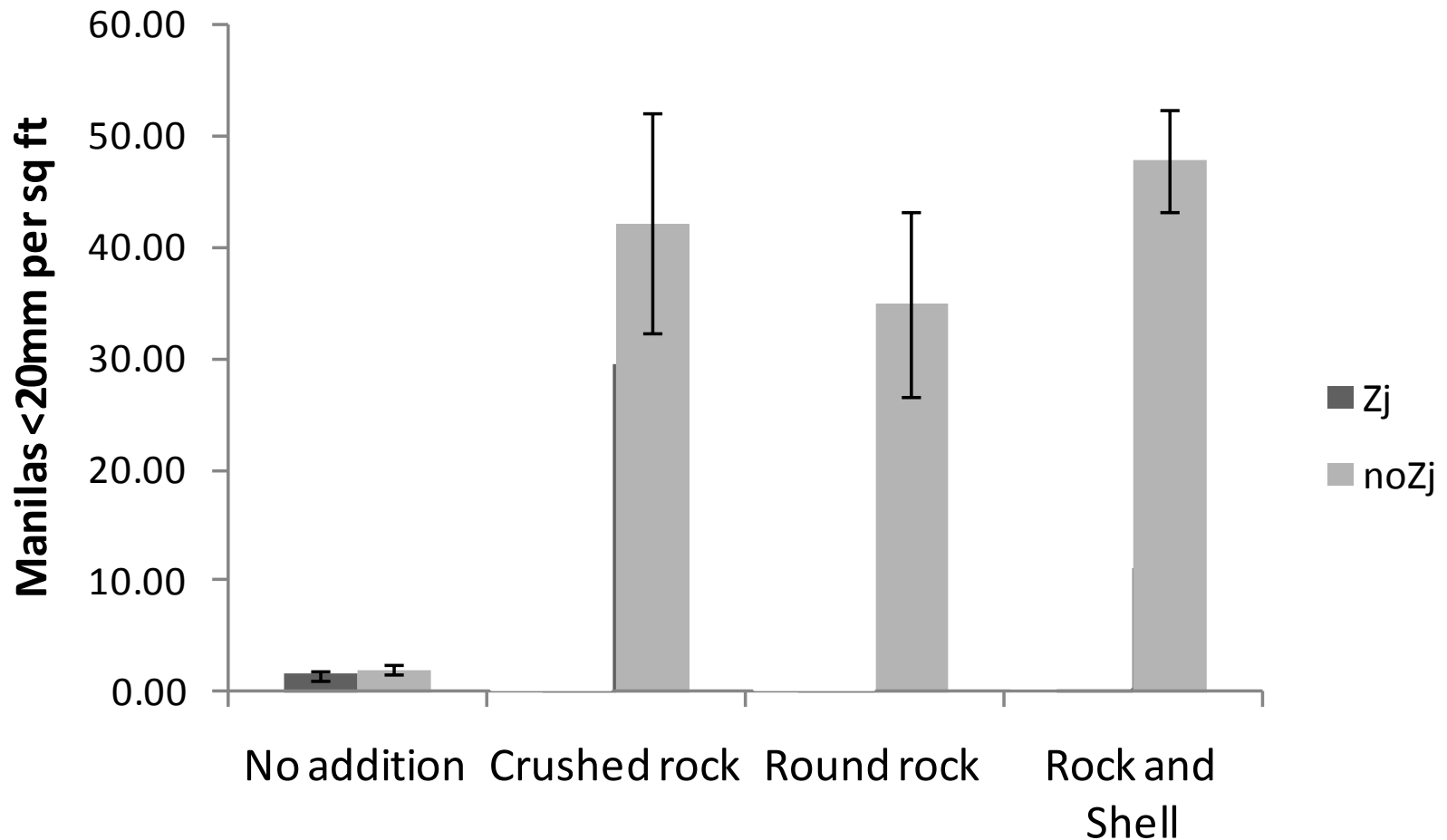
Removing *Z. japonica* did not markedly improve clam recruitment



EXPERIMENT 3

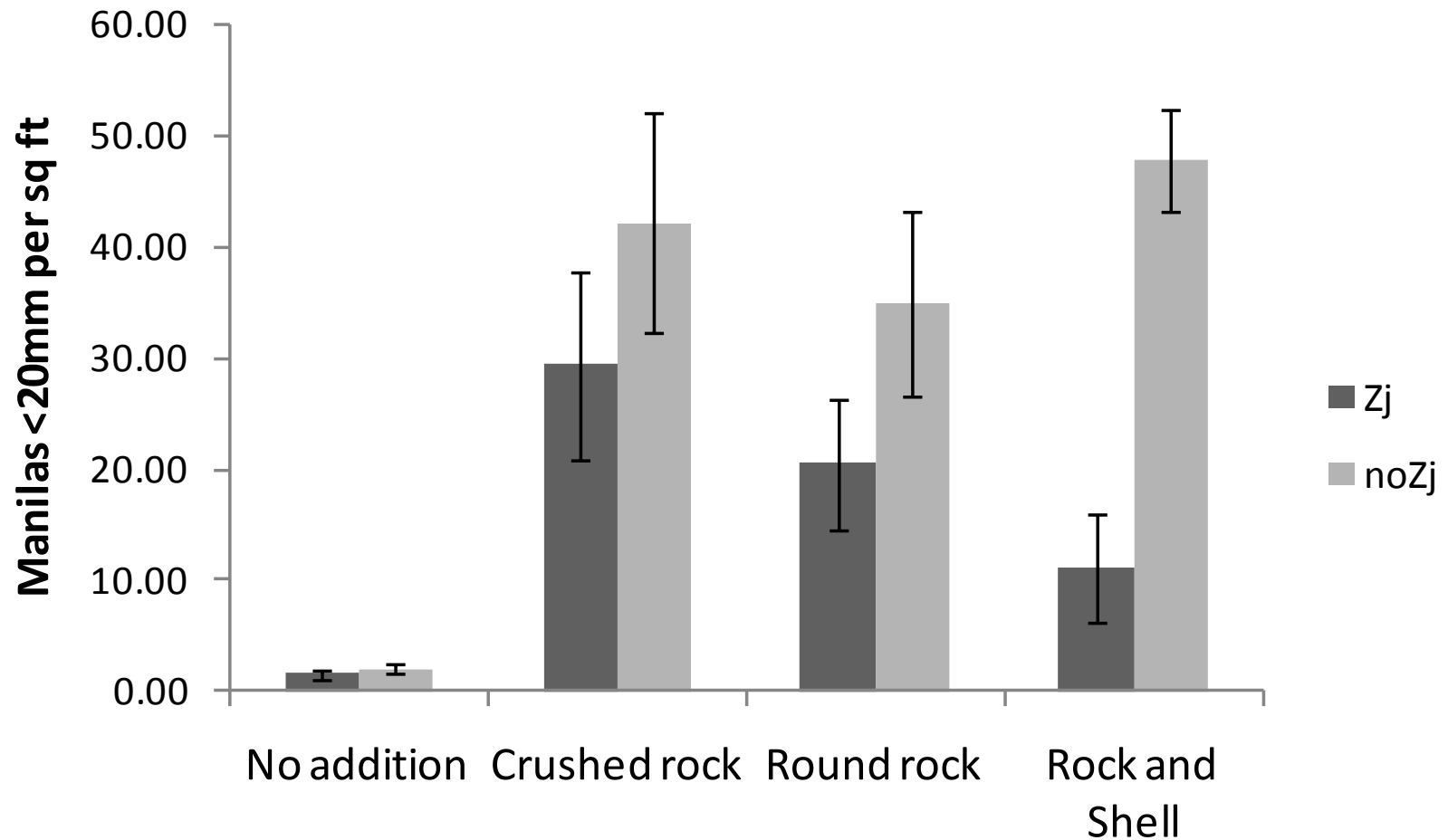
Removing *Z. japonica* and adding rock or shell substrate dramatically improved clam recruitment

Substrates were equally effective with or without shell



EXPERIMENT 3

Z. japonica reduced the effectiveness of substrate addition

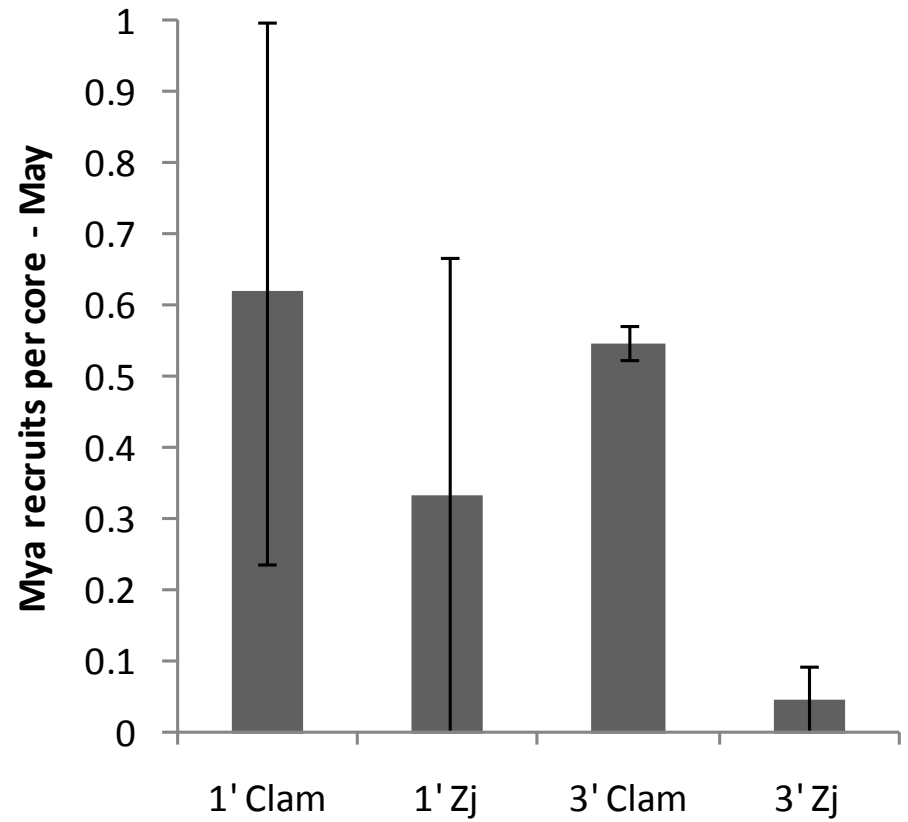
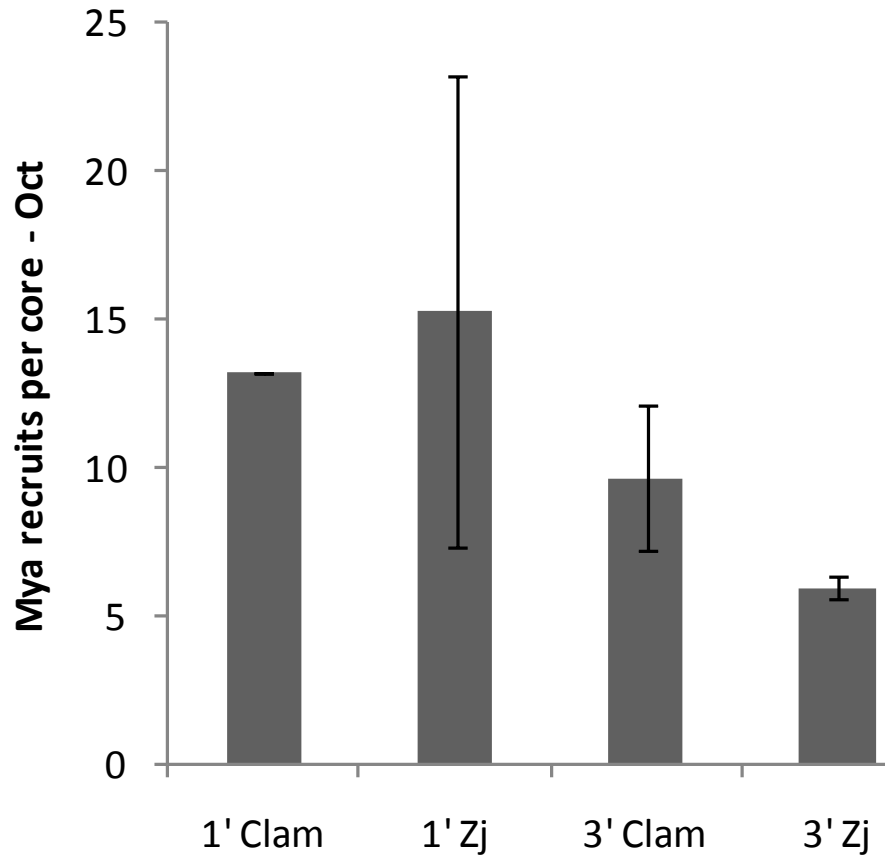


All the results

- <10% overwinter survival of newly-settled clams, much improved by mesh and substrate
- High settlement across multiple habitats and substrates, accumulating over many months
- Recruitment response relative to generic graveling:
 - No effect of adding crushed shell
 - No effect of adding round rock
- Little effect of *Z. japonica* on recruitment to fine-grained tideflats, but negative effect of *Z. japonica* on recruitment to graveled tideflats (large scale)

Results for *Mya arenaria*- extra slides

EXPERIMENT 2 – Eastern soft-shell clams



EXPERIMENT 3 – Eastern soft-shell clams

