Interactions between *Z. japonica* and *Z. marina*

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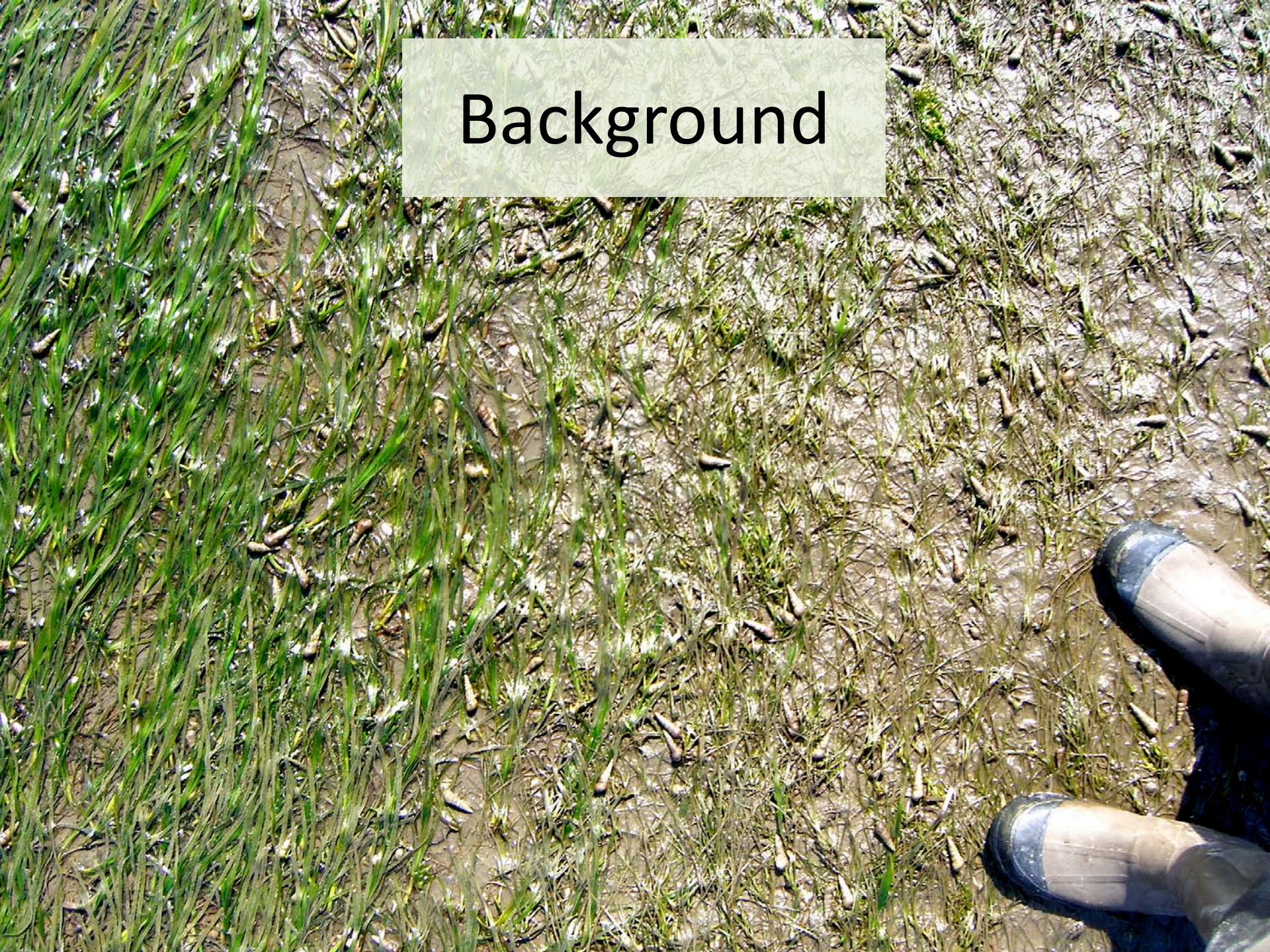
for

The Forum on Science and Management of *Zostera japonica, June 18th-19th, 2013*

Overview

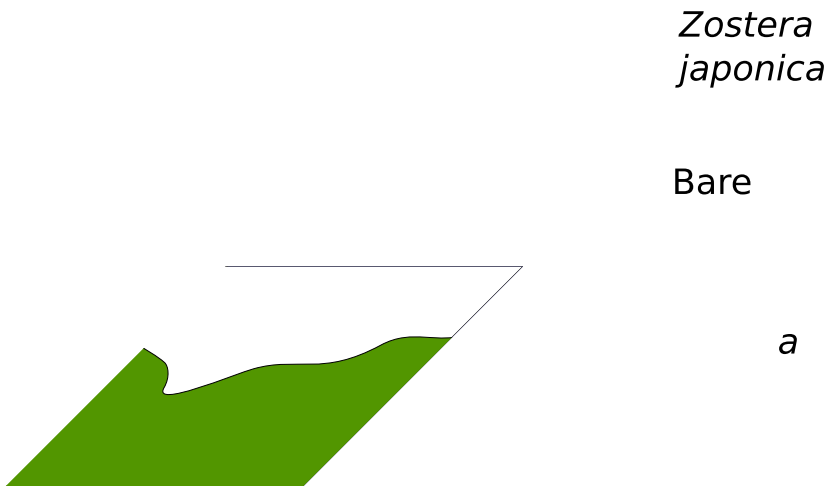
- Background
- Indirect Evidence of Interactions
- Manipulative Competition Experiments
- Synthesis

Background



Eelgrass Zonation in the Pacific Northwest

- Shafer (2007) described three zonation patterns of *Z. marina* and *Z. japonica*



Shafer, D. J. 2007. Physiological factors affecting the distribution of the non-indigenous seagrass Zostera japonica along the Pacific coast of North America. University of South Alabama.

Hannam (2013)

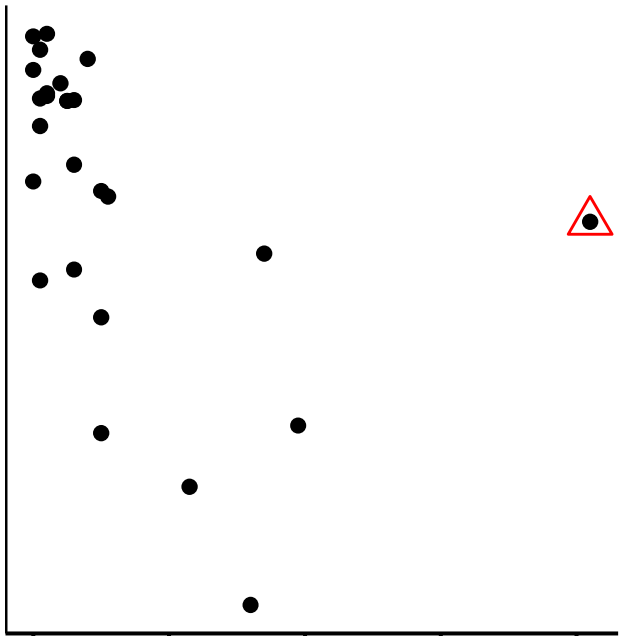
- Examined Puget Sound wide seagrass monitoring data
- Tested predictors of zonation of *Z. marina & Z. japonica*

Hannam, M. 2013. The Influence of Multiple Scales of Environmental Context on the Distribution and Interaction of an Invasive Seagrass and its Native Congener. University of Washington, Seattle.

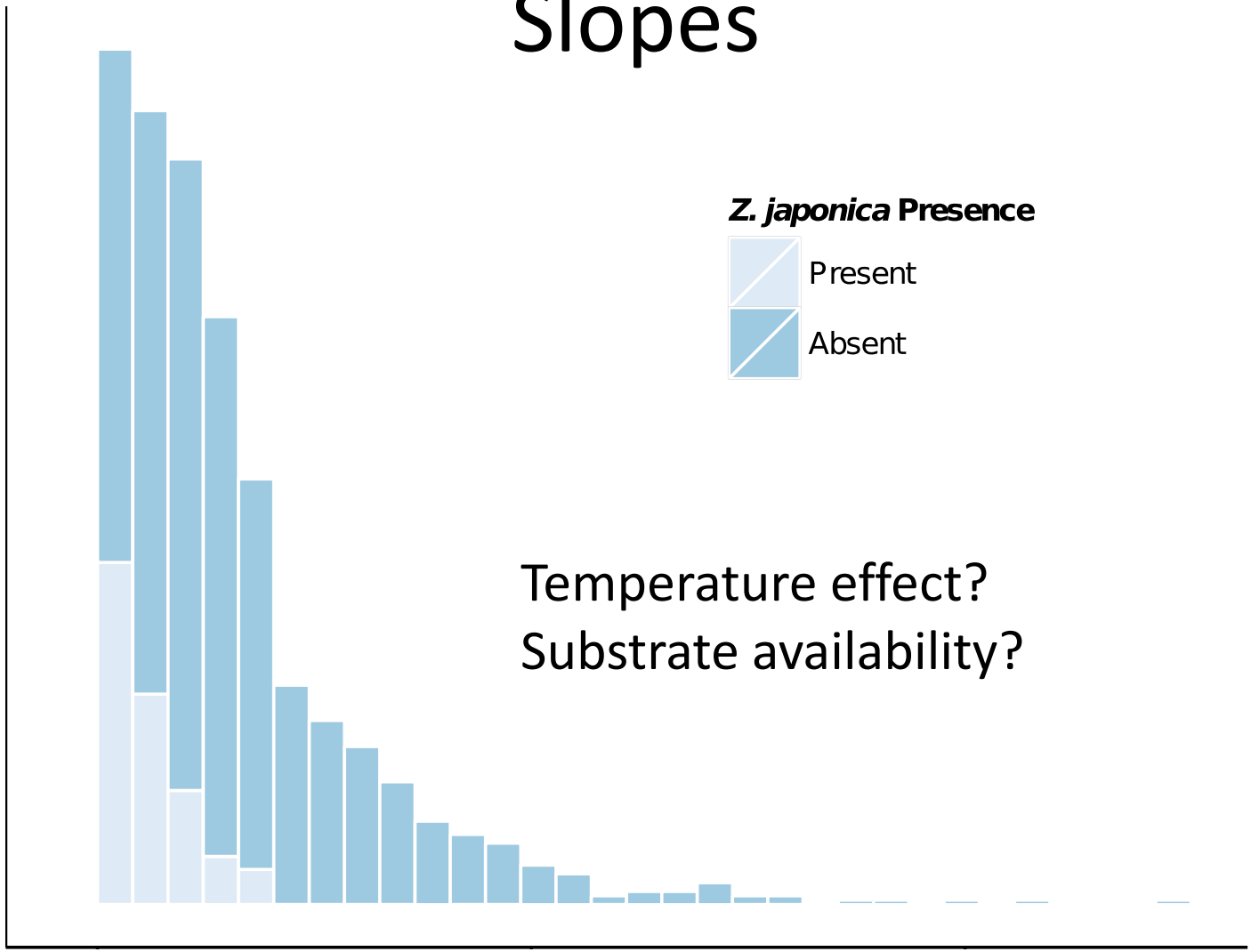
Greater Overlap Where:

Site-averaged (r^2=.55)

- More linear profile



Z. japonica Absent from Steeper Slopes



Temperature effect?
Substrate availability?

Life History Strategies

- r versus K strategists
- *Z. japonica* devotes more towards sexual reproduction (Harrison, 1979)
- *Z. japonica* faster to recolonize disturbed areas (Hahn, 2003; Bando, 2006)
- *Z. japonica* recruits more from seed (Ruesink, 2010)

Indirect Evidence of Interactions

Harrison (1982)

- Mesocosm study simulation spring and summer:
  - 2 temperatures, 2 day lengths, 2 tidal elevations
- *Z. marina* elongated faster in submerged 'summer' conditions

Harrison, P. G. 1982. Comparative Growth of Zostera-Japonica Aschers and Graebn and Zostera-Marina L Under Simulated Inter-Tidal and Subtidal Conditions. Aquatic Botany 14:373–379.

Nomme & Harrison (1991)

- *Z. japonica* shoot density lower in mixed stands
- *Z. marina* shoot density did not differ between mixed and monospecific stands
- Elevation confounded with composition

Nomme, K. M., and P. G. Harrison. 1991. A Multivariate Comparison of the Seagrasses Zostera-marina and Zostera-japonica in Monospecific Versus Mixed Populations. Canadian Journal Of Botany-Revue Canadienne De Botanique 69:1984–1990.

Nomme & Harrison (1991)

- Lower density of *Z. japonica* transplanted to greater depths

Nomme, K. M., and P. G. Harrison. 1991. Evidence for Interaction Between the Seagrasses Zostera marina and Zostera japonica on the Pacific Coast of Canada. Canadian Journal Of Botany-Revue Canadienne De Botanique 69:2004–2010.

Z. marina Reaches Shallower Where:

Transect-scale

- **More linear profile**
- **More protected sites**
- **Gentler Slopes**
- ***Z. japonica* present**

Site-averaged (r^2=.33)

- **More linear profile**
- **More protected sites**
- Gentler Slopes
- *Z. japonica* present

Z. japonica Reaches Deeper Where:

Transect-scale

- *Z. marina* remains deeper

Site-averaged (r^2 = .44)

- More linear profile
- *Z. marina* grows deeper

Manipulative Competition Experiments

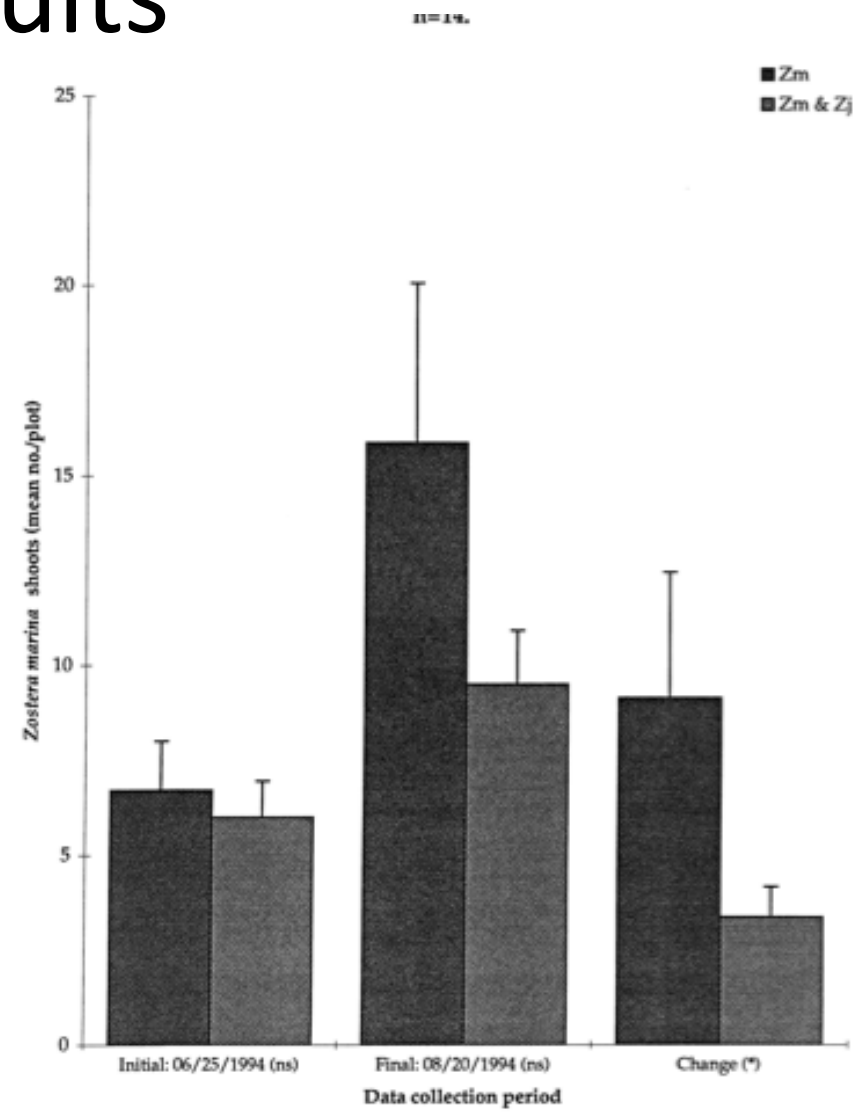
Merrill (1995)

- Treatment: Clipped *Z. japonica* shoots
- Control: No Clipping
- Response: *Z. marina* leaf growth & shoot density

Merrill, G. G. 1995. The effect of Zostera japonica on the growth of Zostera marina in their shared transitional boundary. Page 16. Washington State Department of Ecology, Mount Vernon, WA.

Results

- Higher *Z. marina* density in clipped plots
- Faster leaf growth in clipped plots



Merrill, G. G. 1995. The effect of Zostera japonica on the growth of Zostera marina in their shared transitional boundary. Page 16. Washington State Department of Ecology, Mount Vernon, WA.

Hahn (2003)

- Transplanted sods:
  - From mixed and monocultures (different elevations)
  - To 3 elevations
    - *Z. marina*
    - mixed
    - *Z. japonica*
  - At 3 sites in Padilla Bay

Hahn, D. R. 2003. Changes in community composition and ecosystem processes associated with biological invasions: Impacts of Zostera japonica in the marine intertidal zone. University of Washington.

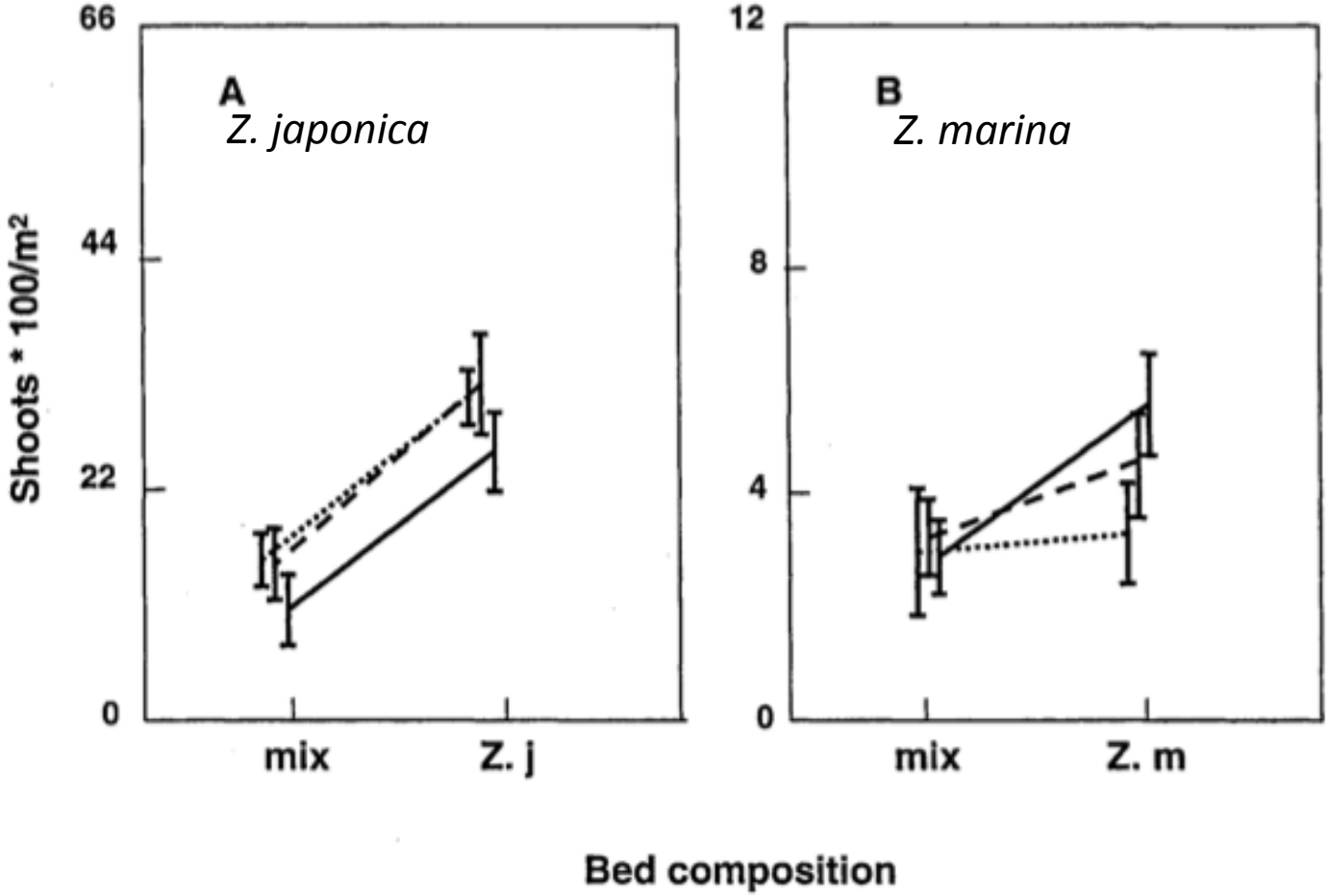


Figure 2.3. Shoot densities for *Z. japonica* (A) and *Z. marina* (B) transplanted to different tidal heights in either monocultures or beds of mixed vegetation. Tidal zones are indicated by line type: solid = *Z. marina* zone, dashed = mixed zone, and dotted = *Z. japonica* zone. Data shown are means +/- SE. (mix = mixed vegetation, Z.j = *Z. japonica*, Z.m = *Z. marina*)

Bando (2006)

- Cleared transplant sites
- Transplanted individual shoots (8 total)
- Either monoculture or mixed
- Responses: leaf elongation, biomass
- Removed and tracked recolonization after 2 years

Bando, K. J. 2006. The roles of competition and disturbance in a marine invasion. Biological Invasions 8:755–763.

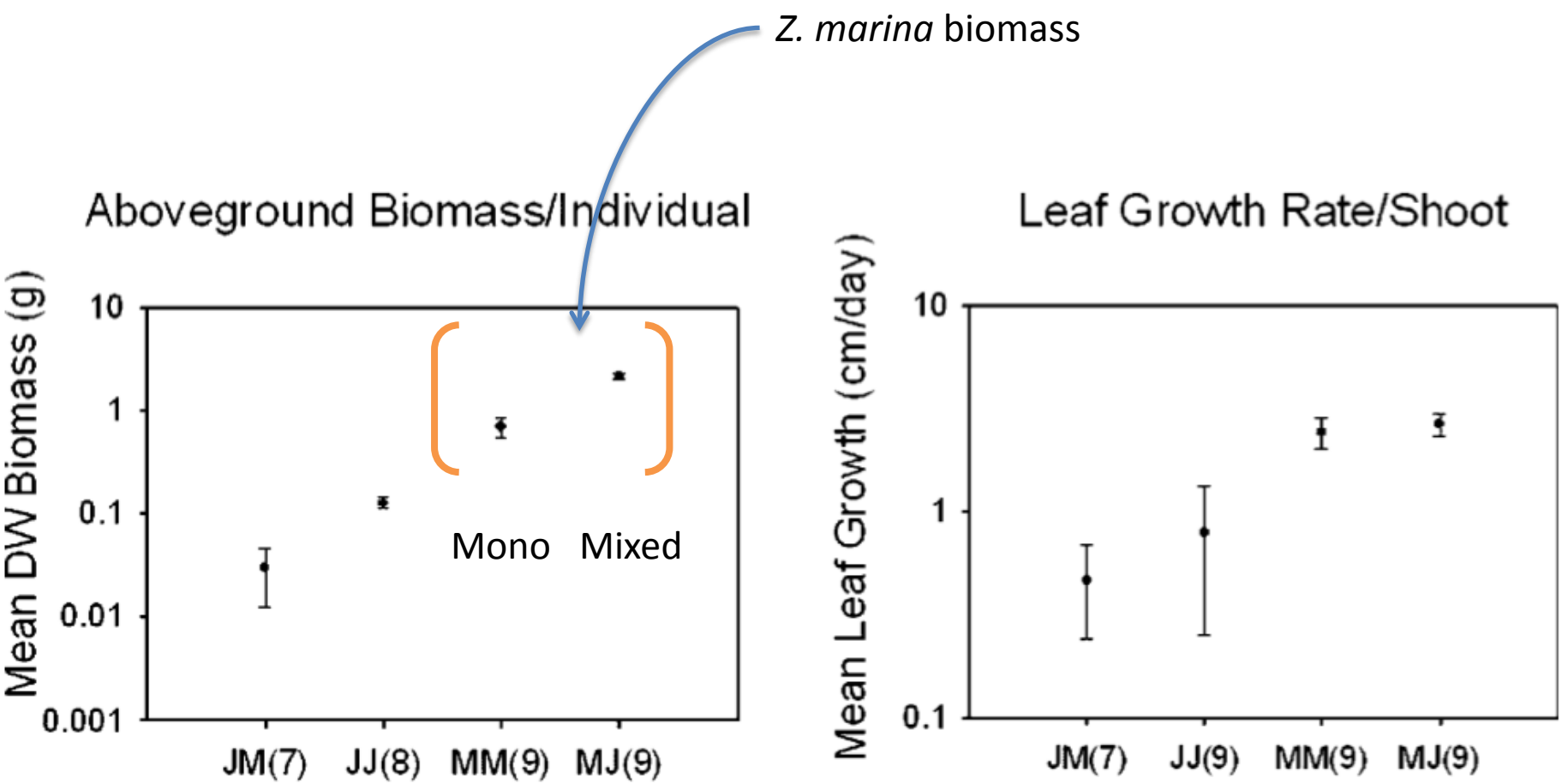
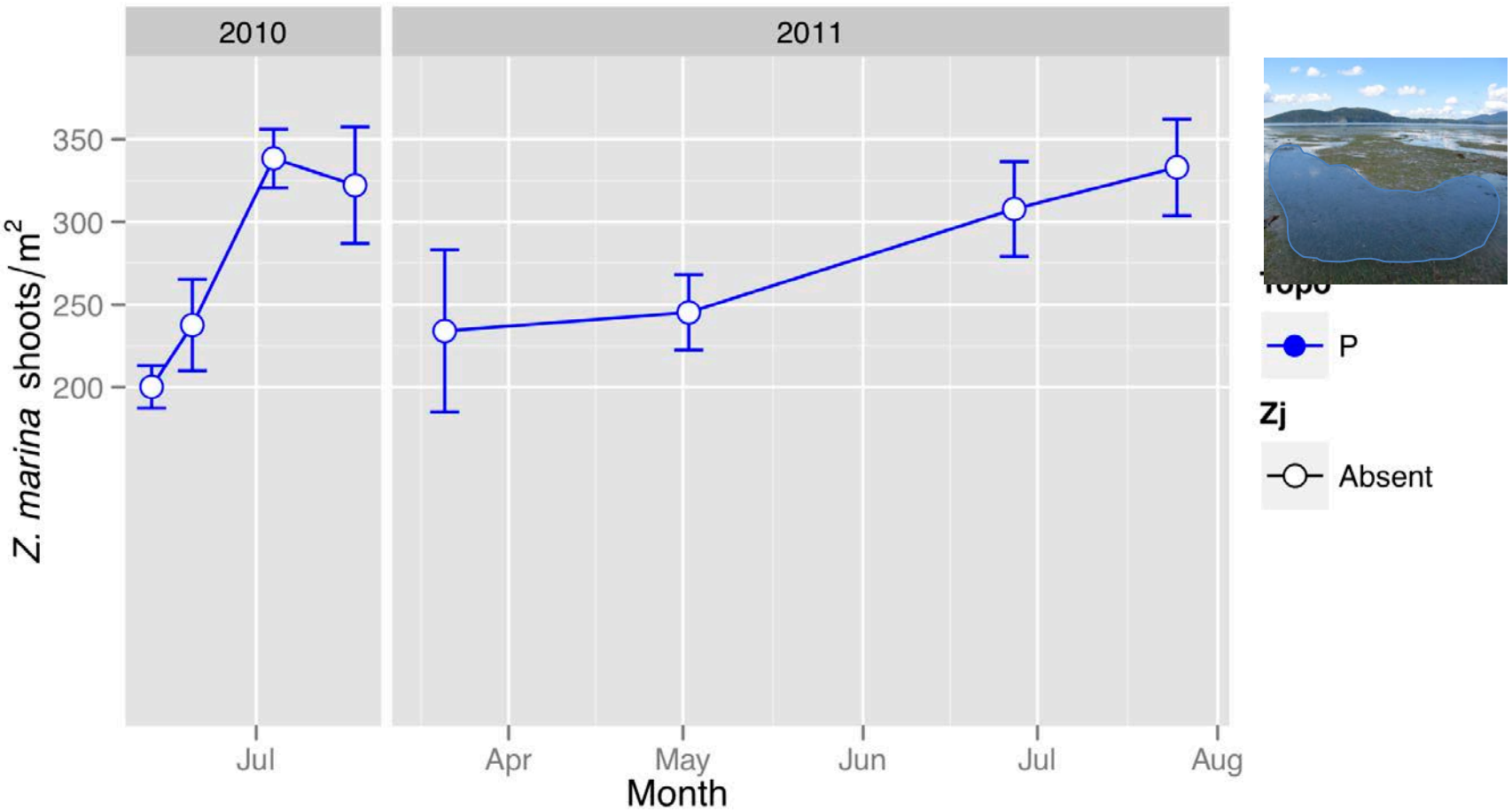


Figure 1. Competition experiment. Mean values ± 1 SD for *Z. marina* and *Z. japonica* response variables in the presence and absence of congeners. Sample sizes (number of plots) are in parentheses. JM = *Z. japonica* in mixed plots, JJ = *Z. japonica* in monospecific plots, MM = *Z. marina* in monospecific plots, and MJ = *Z. marina* in mixed plots.

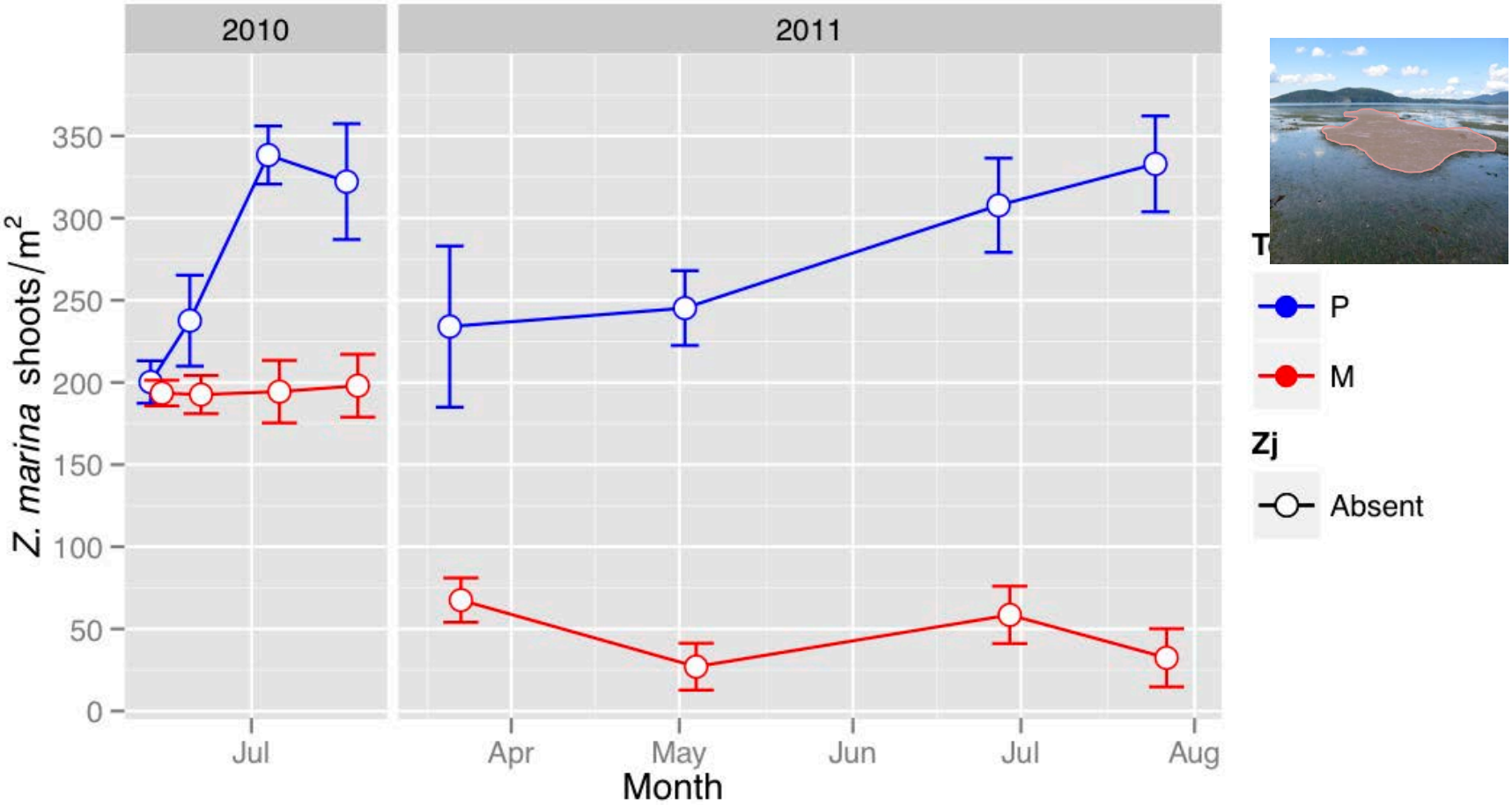
Hannam (2013)

- Cleared transplant sites on mounds and pools
- Transplanted shoots onto each type of site
  - monocultures
  - mixed
- Responses: Shoot density, biomass
- Transplanted shoots of *Z. marina* into variable densities of *Z. japonica*
- *Responses: Rhizome elongation & branching, leaf length & width*

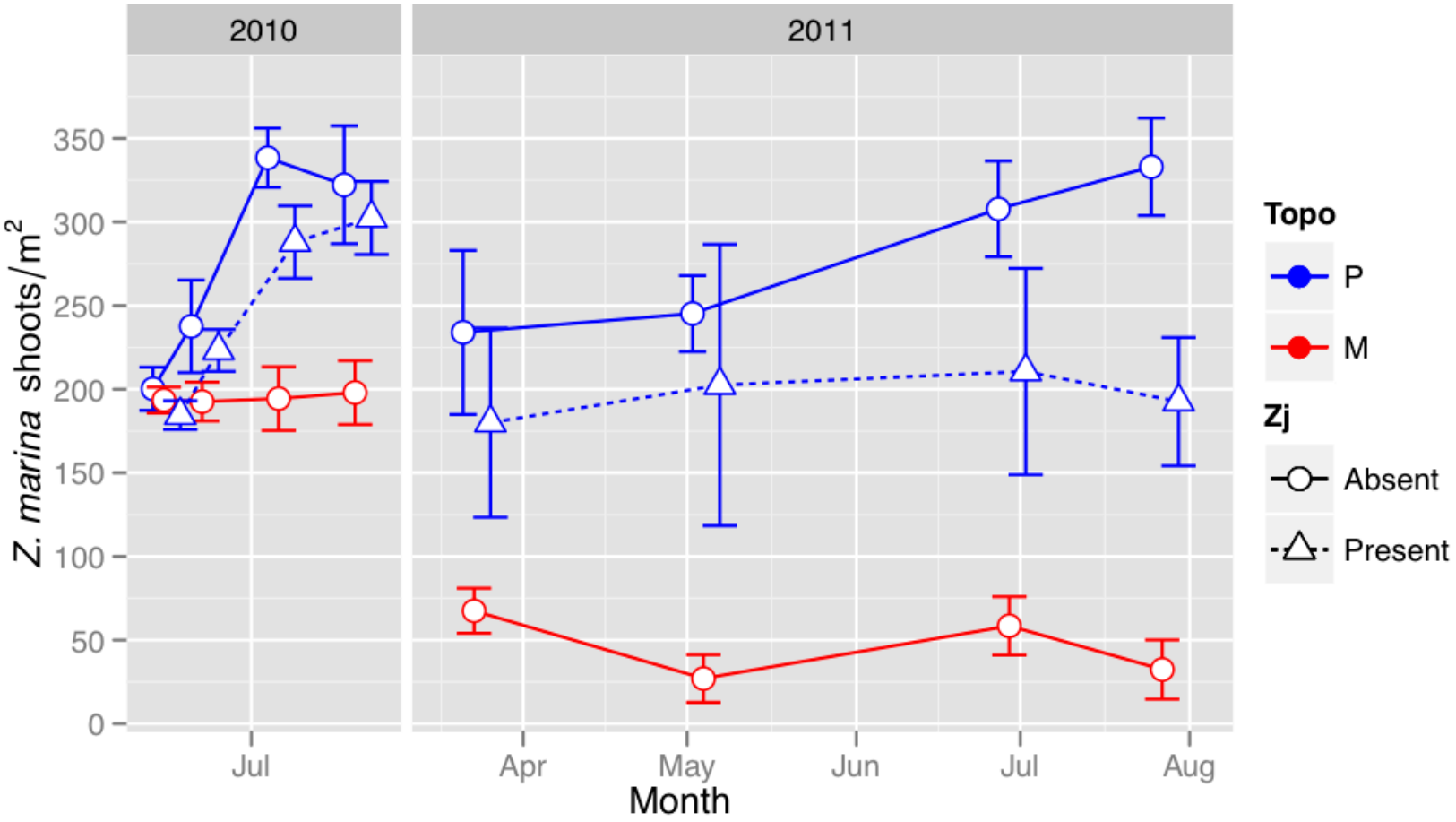
Z. marina Transplant Control: Monoculture in Pools



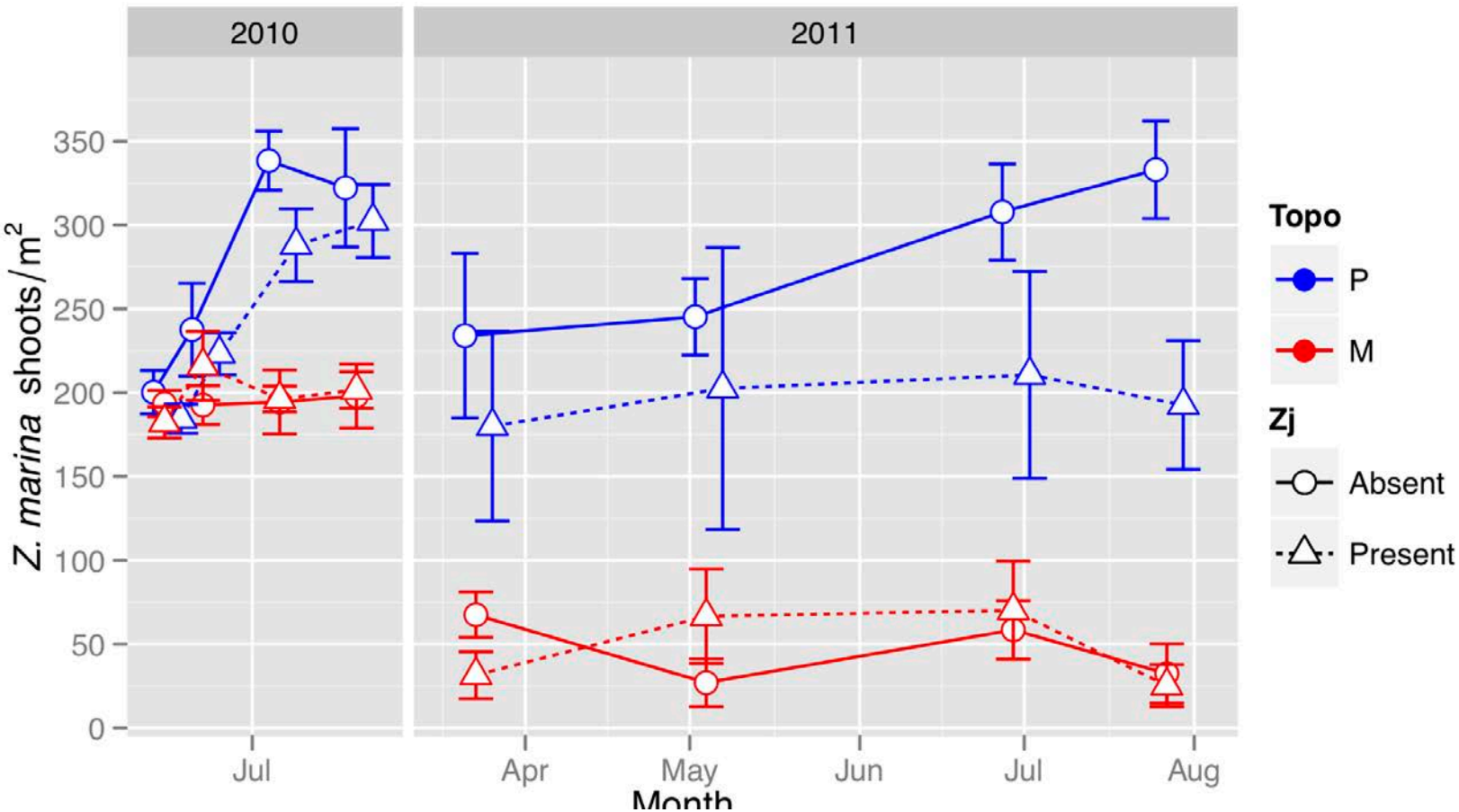
Mounds reduce *Z. marina* shoot density



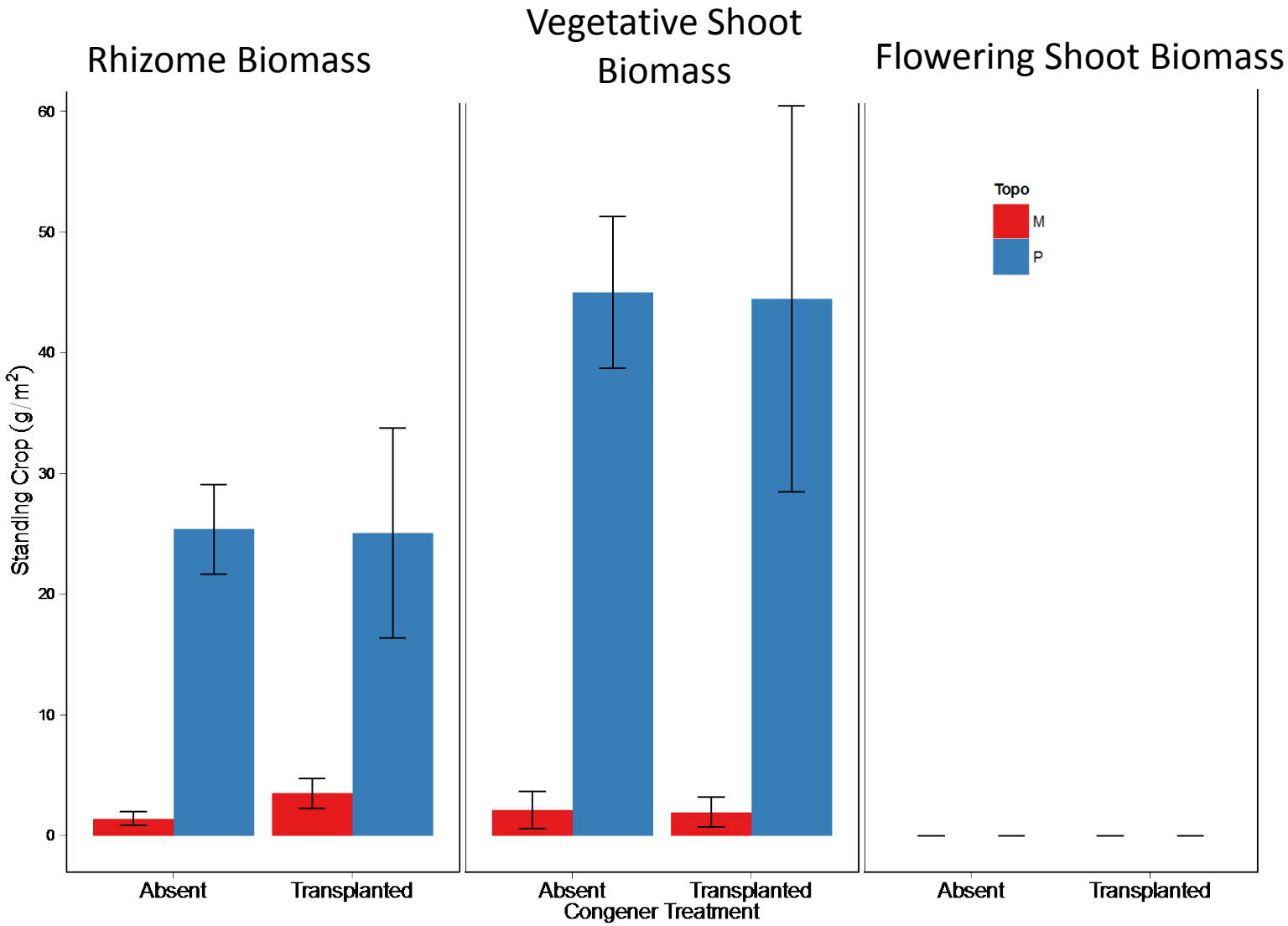
Does *Z. japonica* reduce *Z. marina's* shoot density?



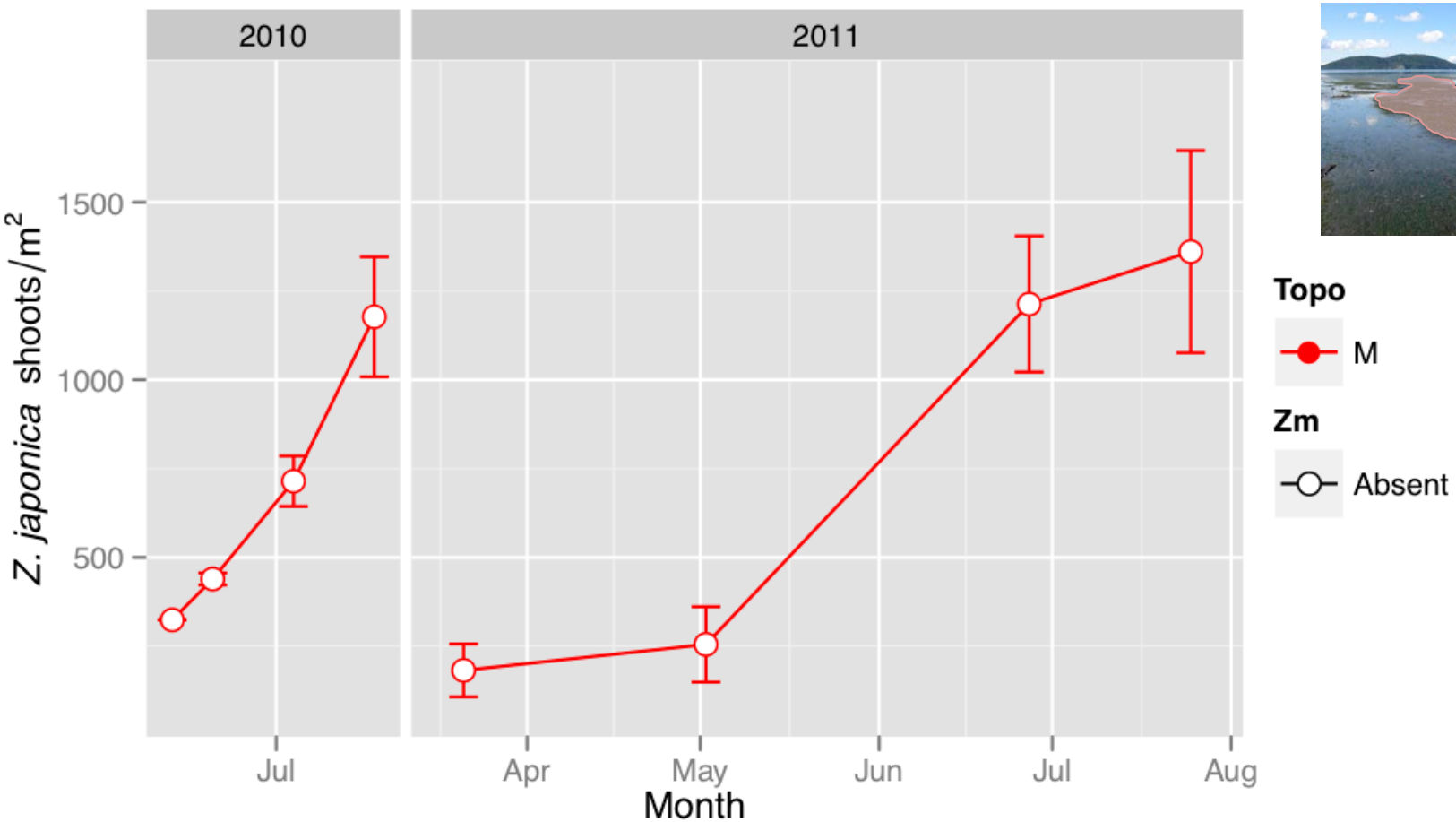
Best-fit Model: Topo X Time



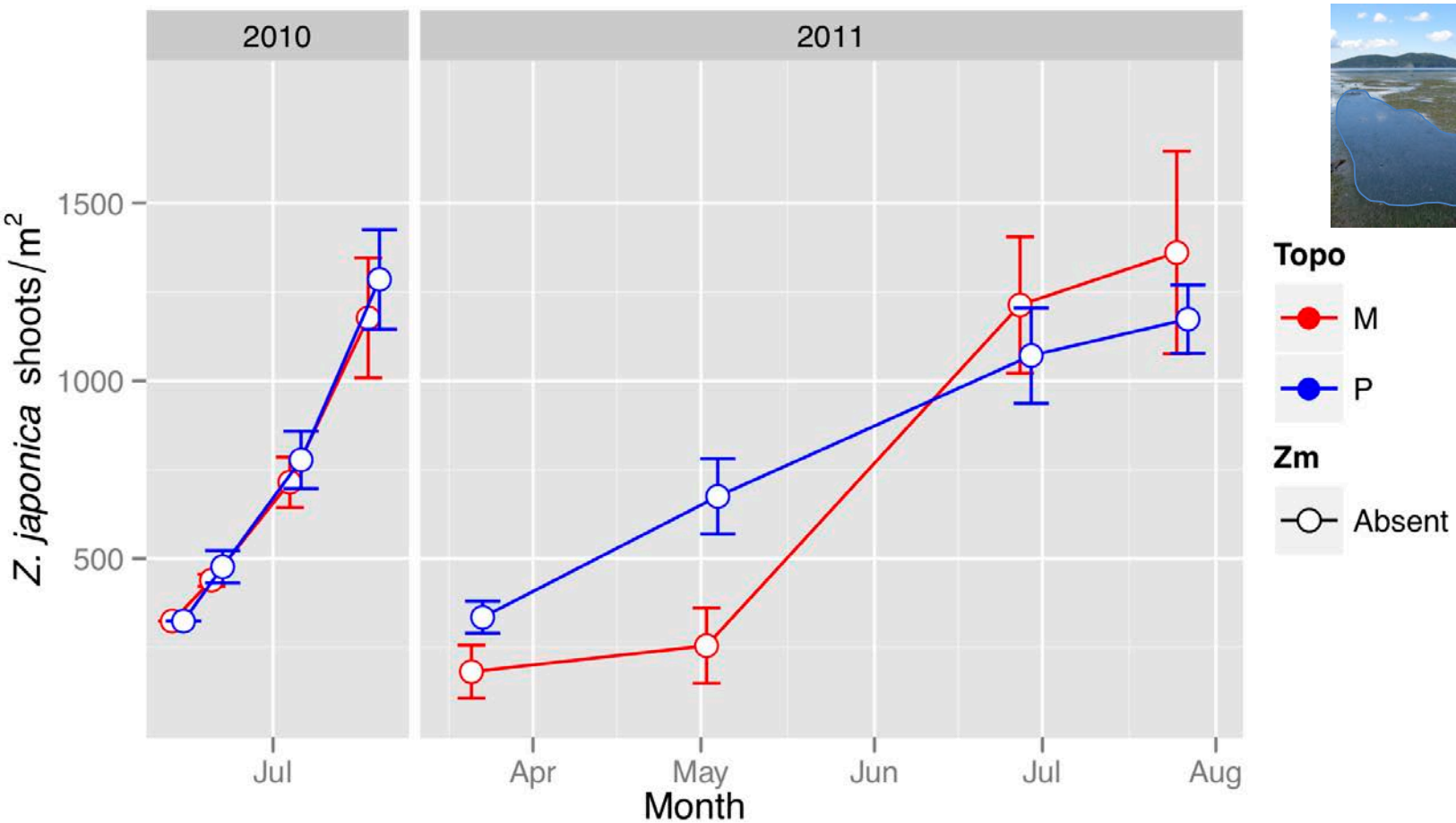
Mounds Reduce *Z. marina* Biomass



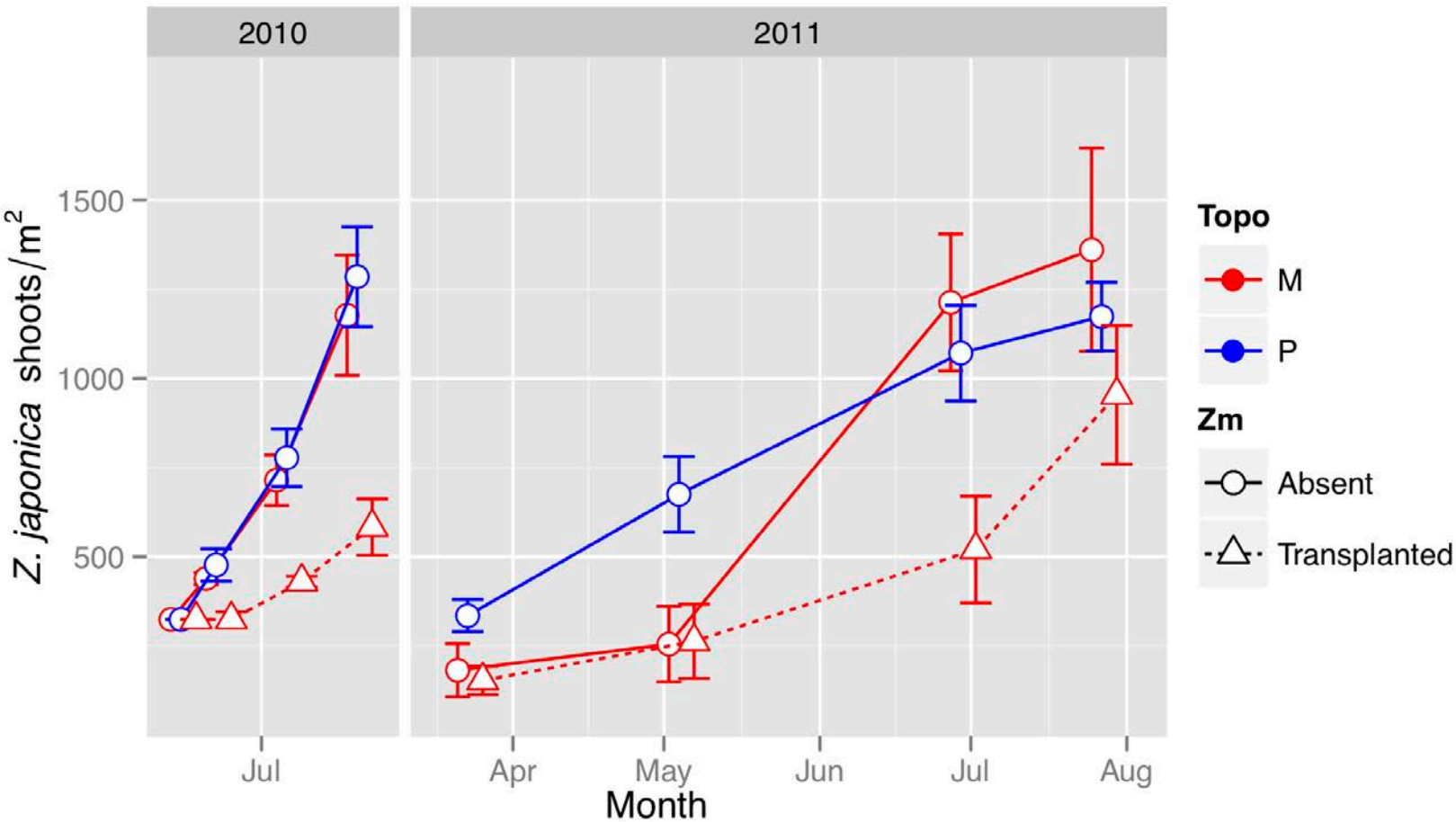
Z. japonica Transplant Control: Monoculture on Mounds



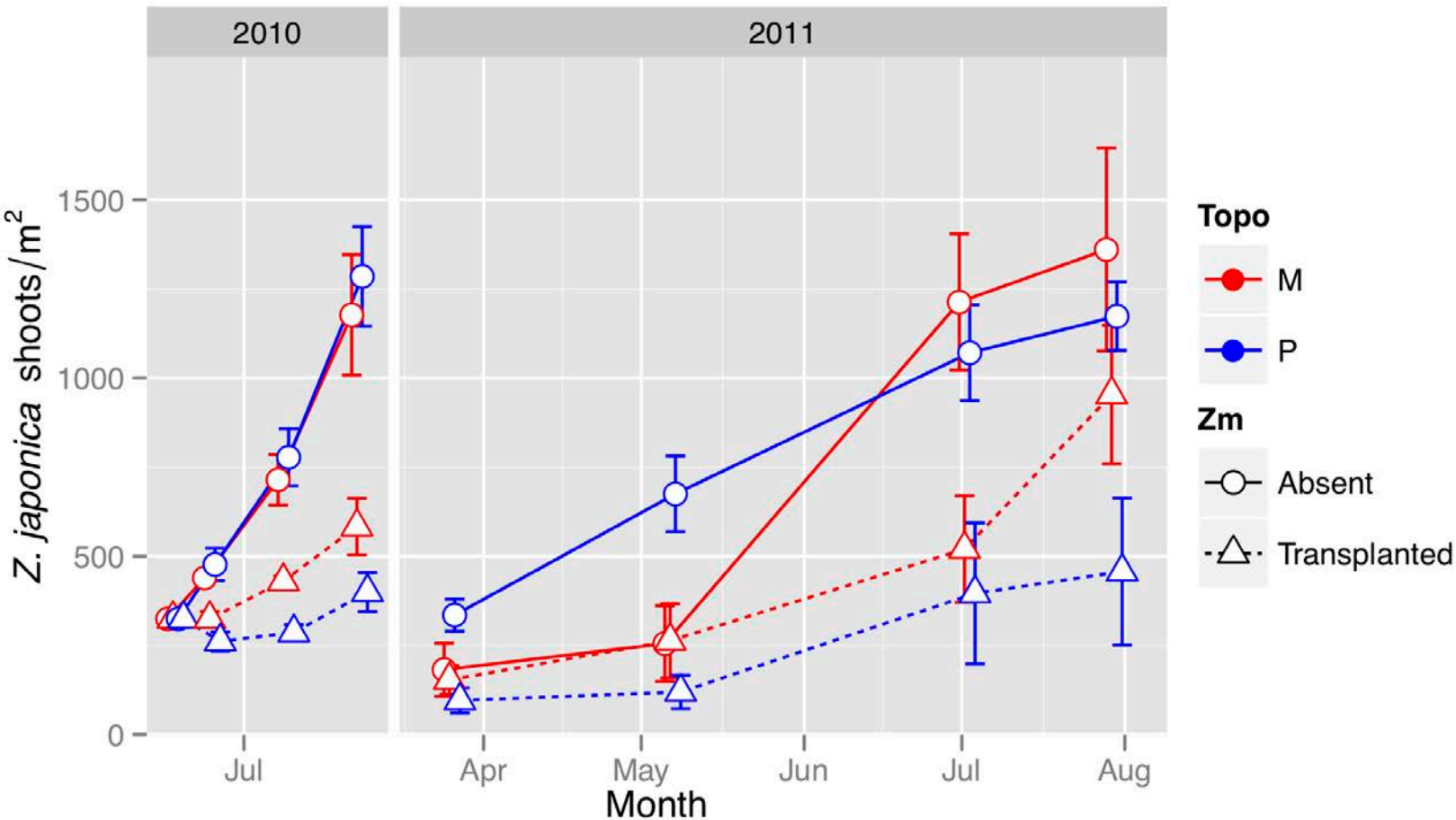
Pools have little direct effect on *Z. japonica*



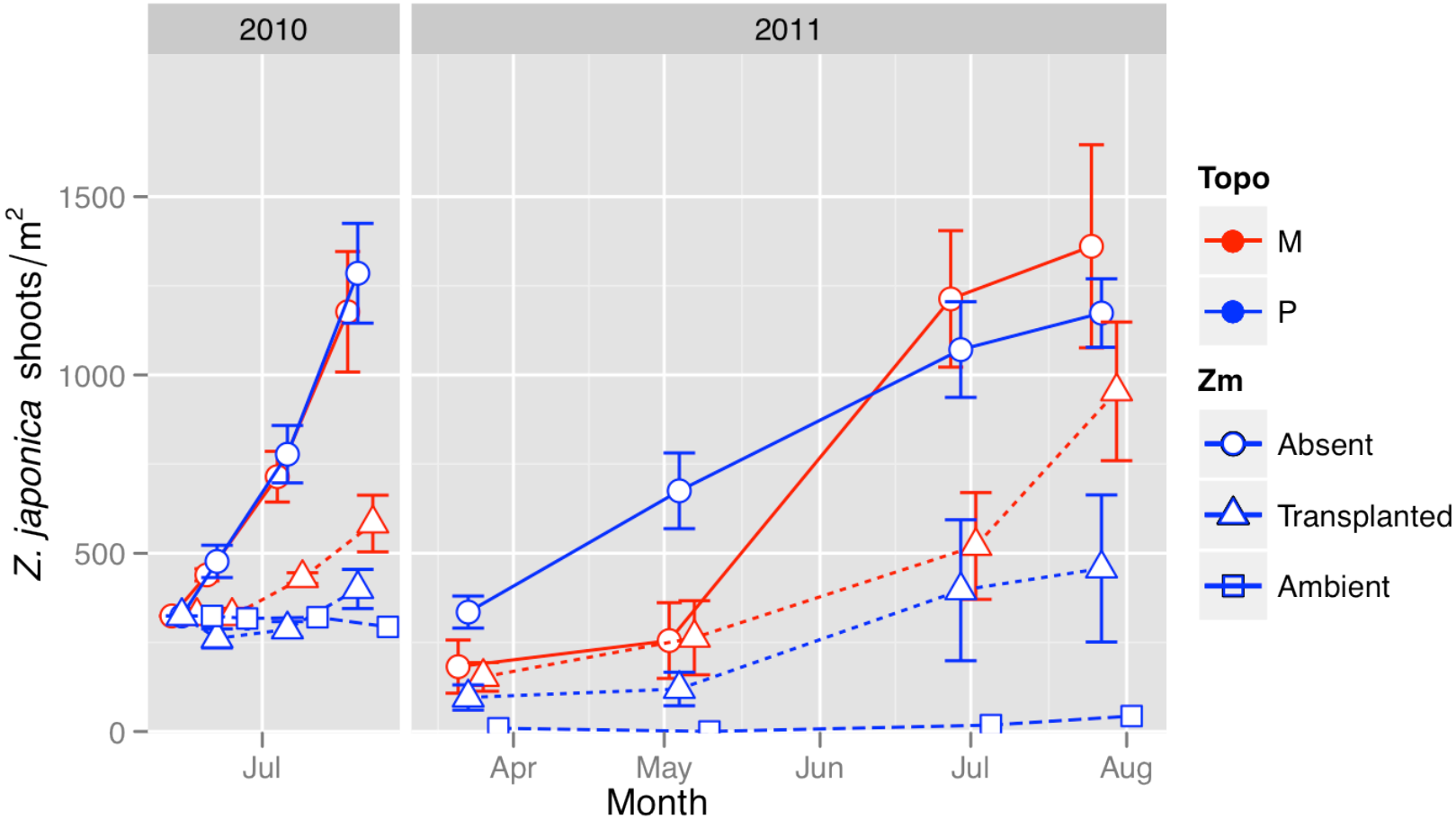
Z. marina reduces *Z. japonica's* shoot density



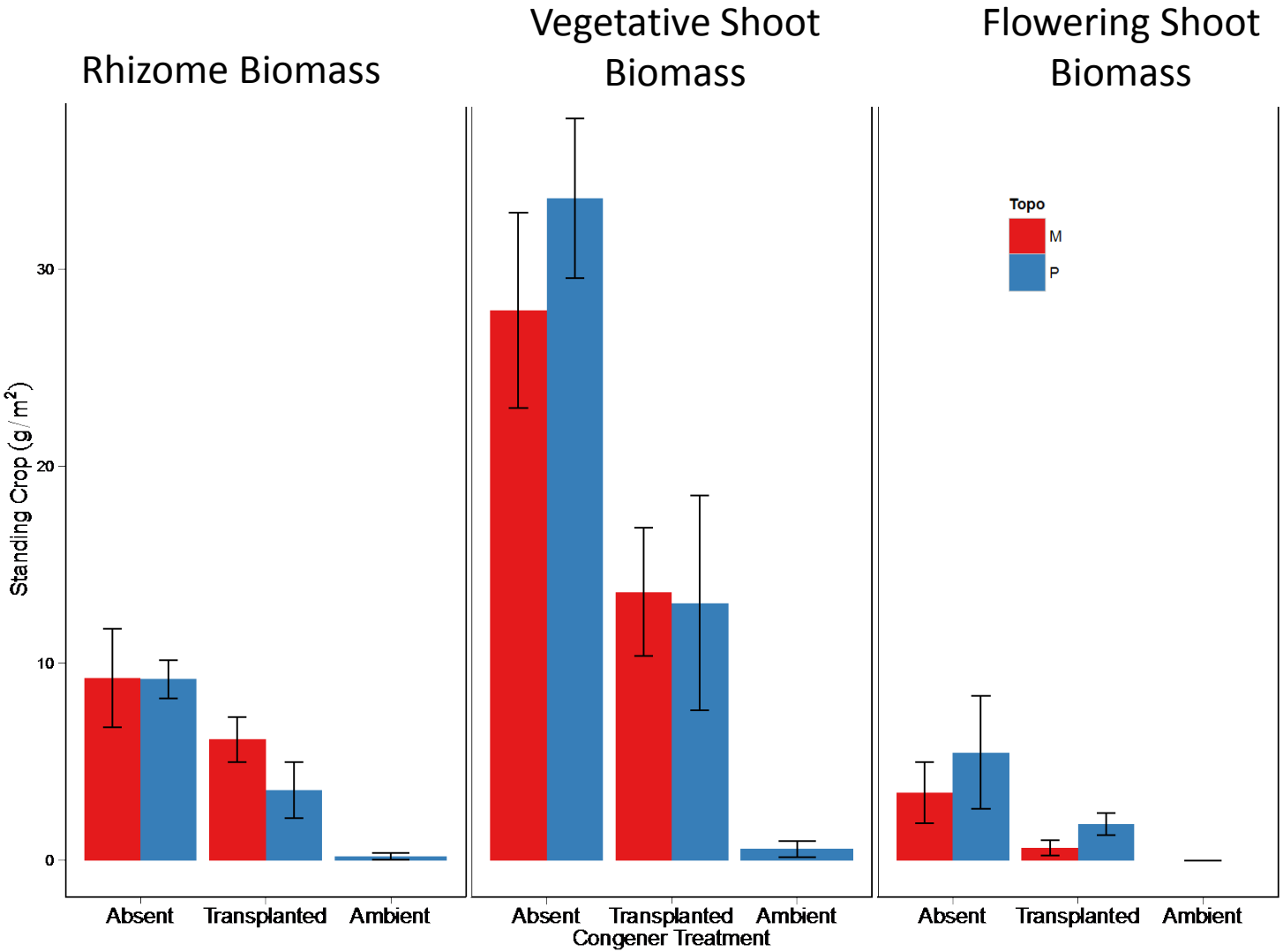
Best-fit Model: Topo X *Z. marina* X Time



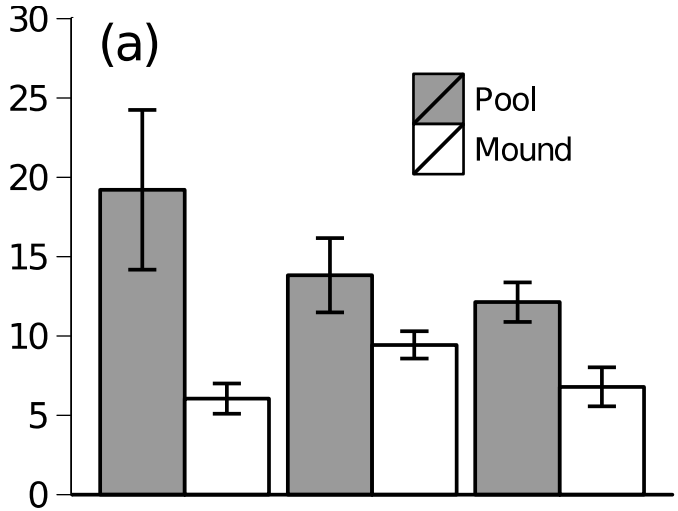
Ambient *Z. marina* excludes *Z. japonica*

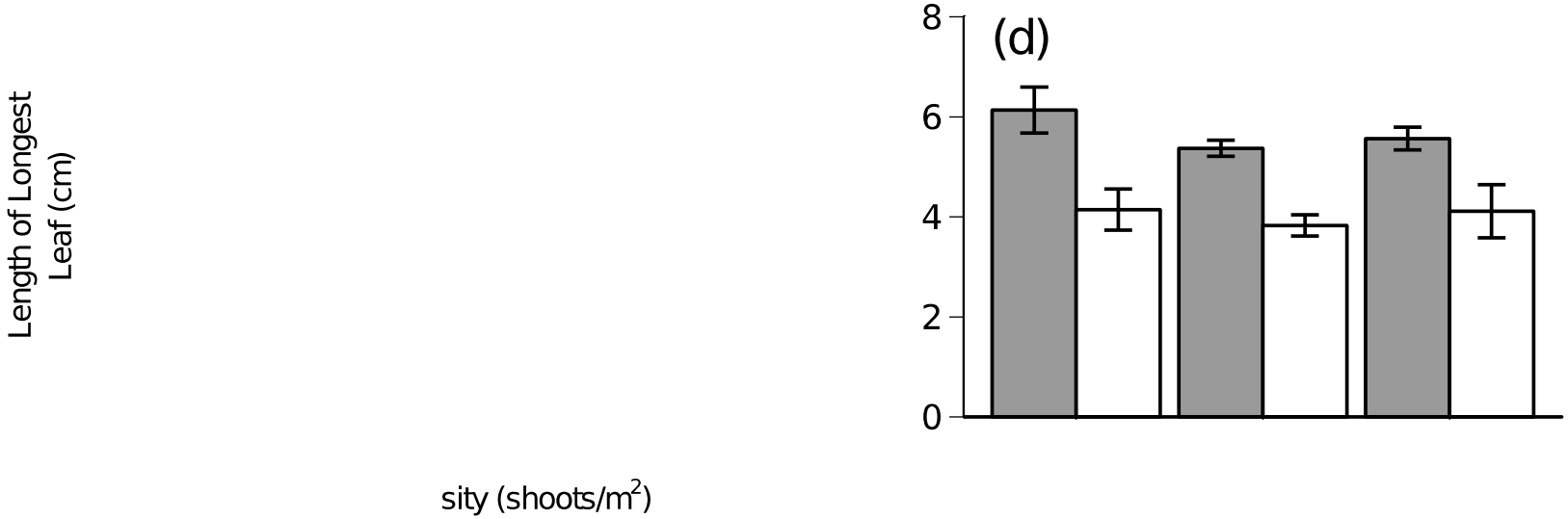


Z. marina Reduces *Z. japonica* Biomass



Z. japonica Shoot Density Effects





Common findings

- Where they co-occur, *Z. marina* & *Z. japonica* compete
- Precise outcomes are context dependent, but:
- *Z. marina* dominates
- *Z. japonica* suppresses *Z. marina* where *Z. marina* is <u>not</u> stressed

Outstanding Questions

- How do different life stages interact?
- Are priority effects important?
- How do densities affect interactions?
- What are mechanisms of competition?
- Does facilitation occur at some scales?

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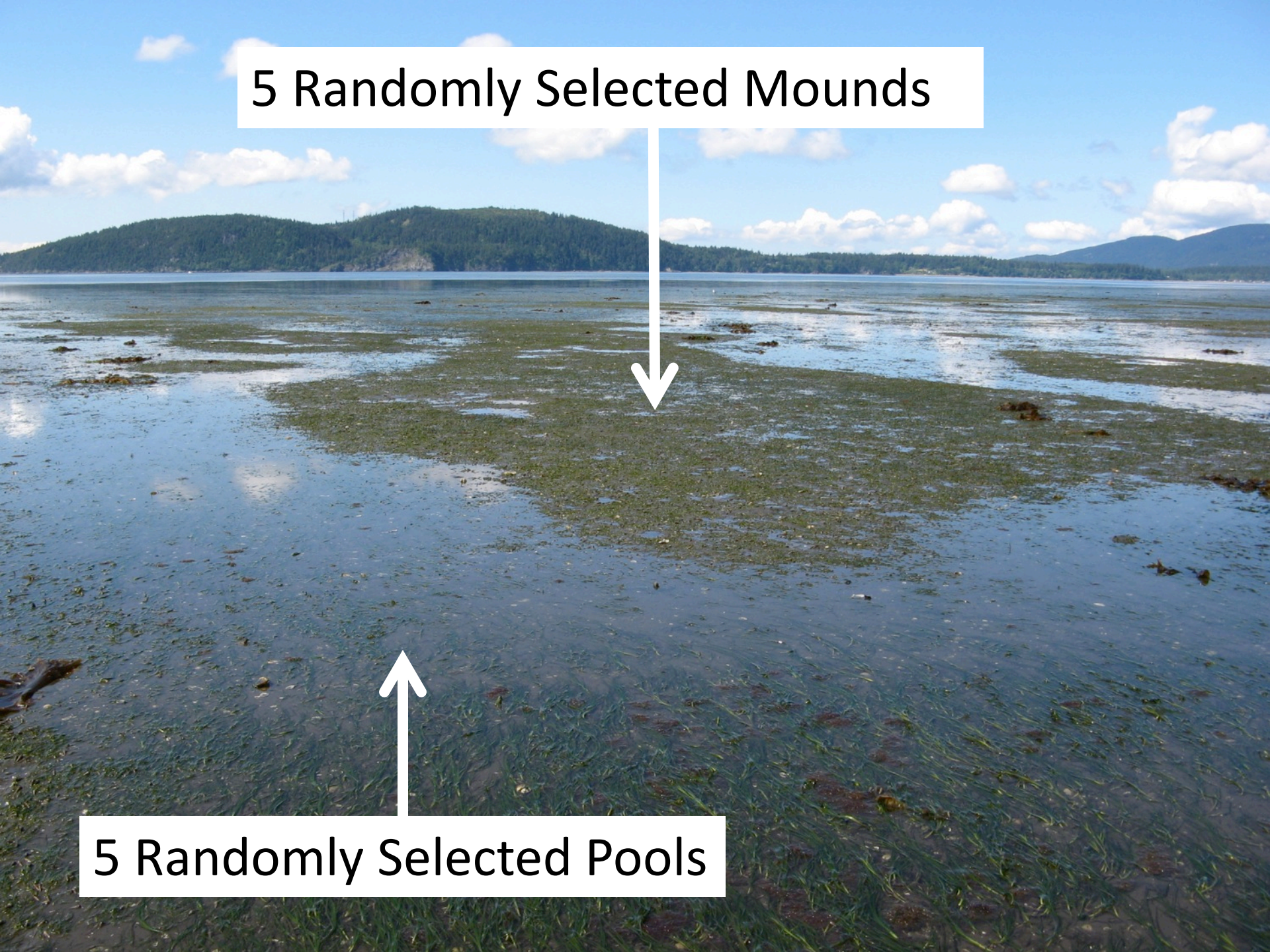
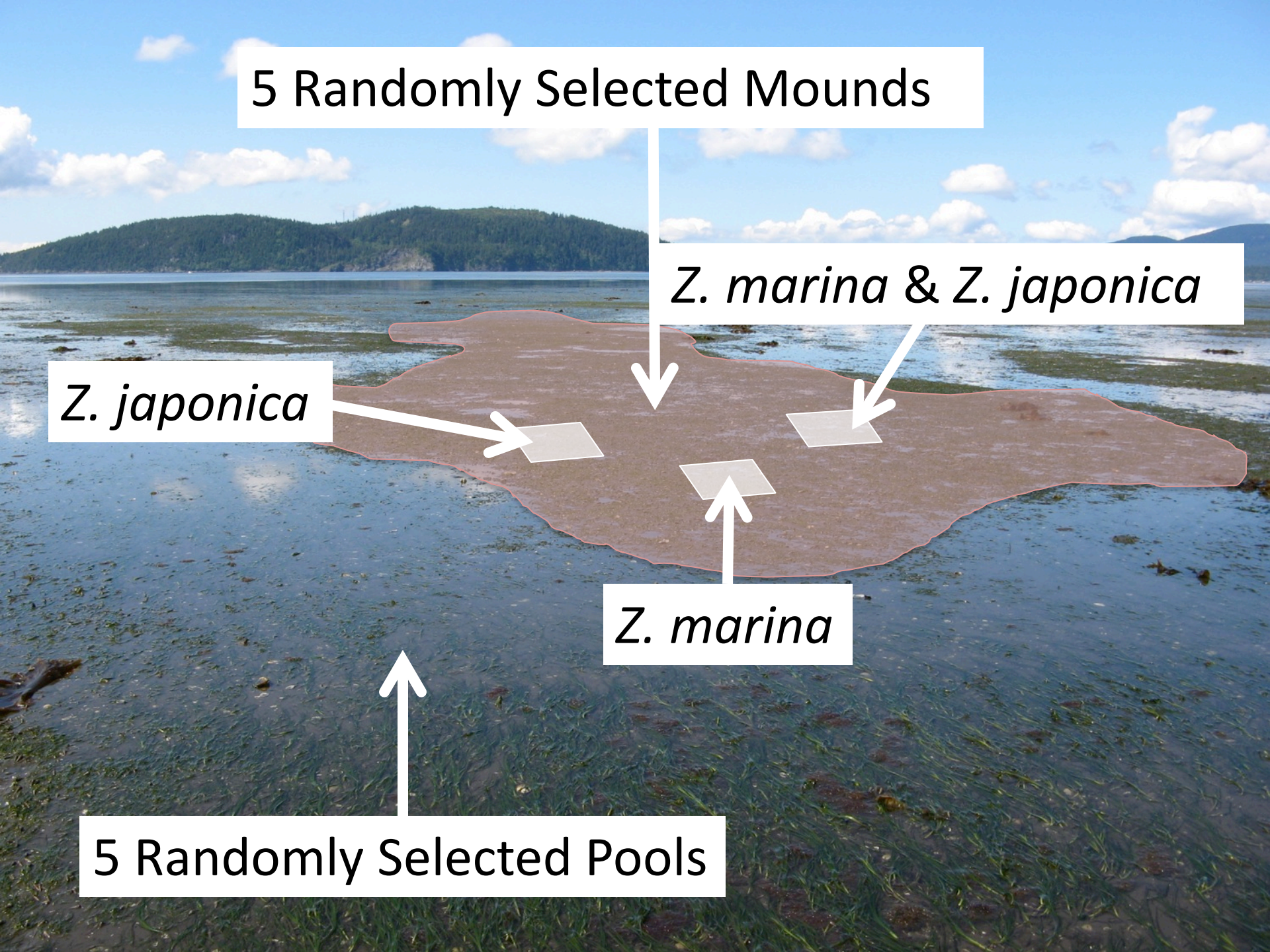
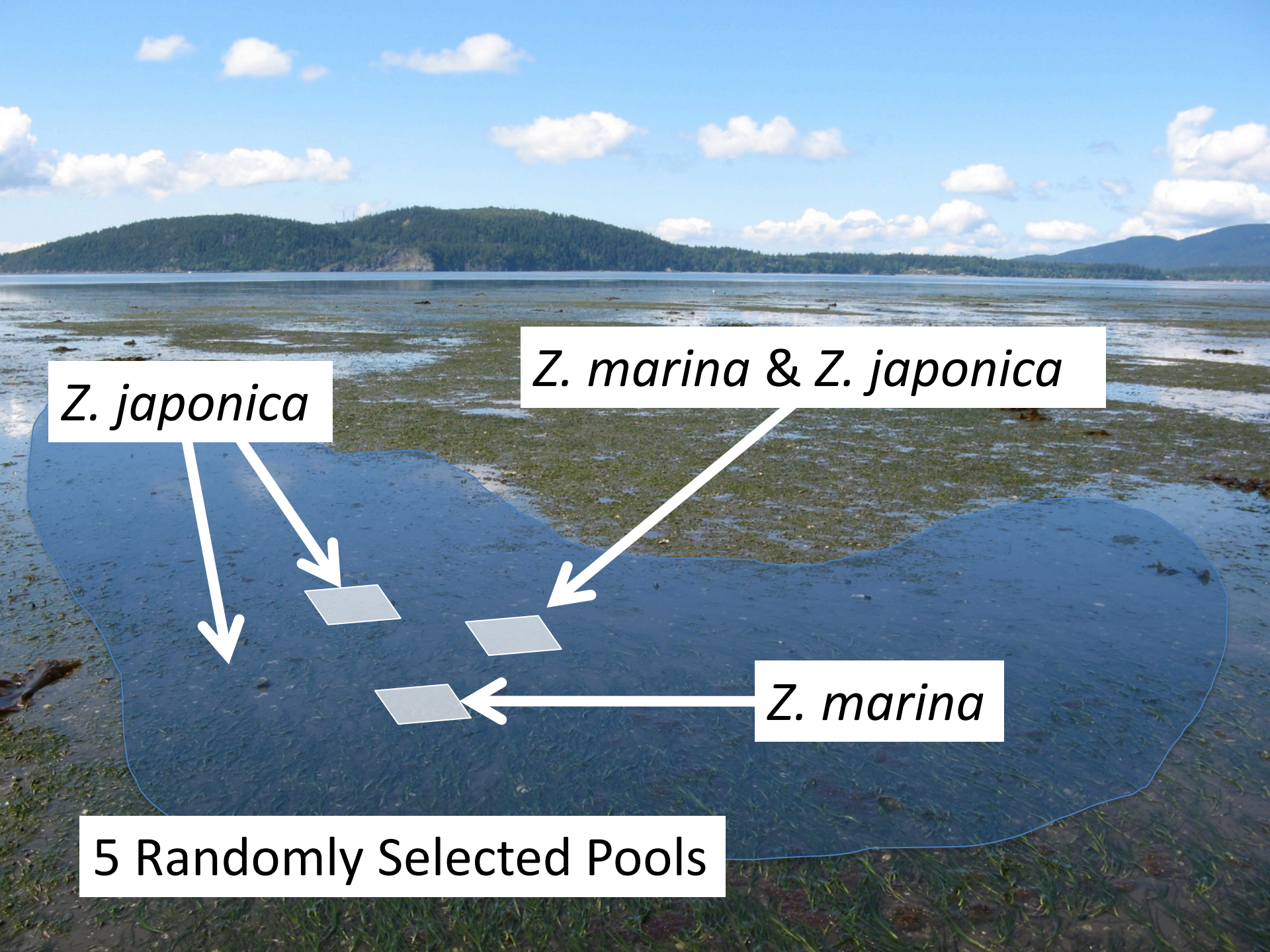
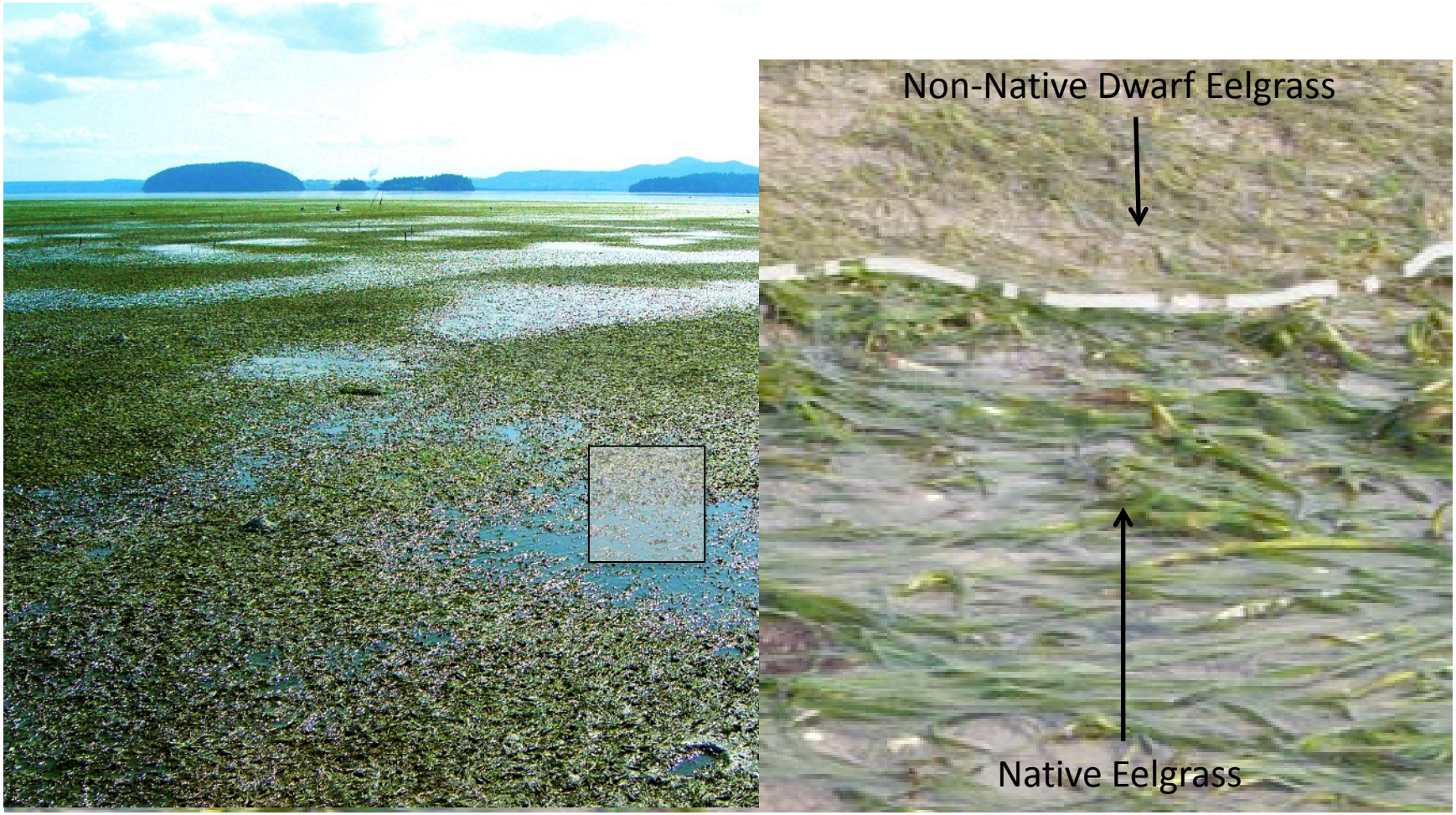
Questions & Discussion


5 Randomly Selected Mounds
5 Randomly Selected Pools


5 Randomly Selected Mounds
Z. marina & Z. japonica
Z. japonica
Z. marina
5 Randomly Selected Pools


Z. japonica
Z. marina & Z. japonica
Z. marina
5 Randomly Selected Pools

Intertidal Microtopography: