INTERACTIONS BETWEEN *ZOSTERA JAPONICA* AND ESTUARINE FAUNA IN THE PACIFIC NORTHWEST

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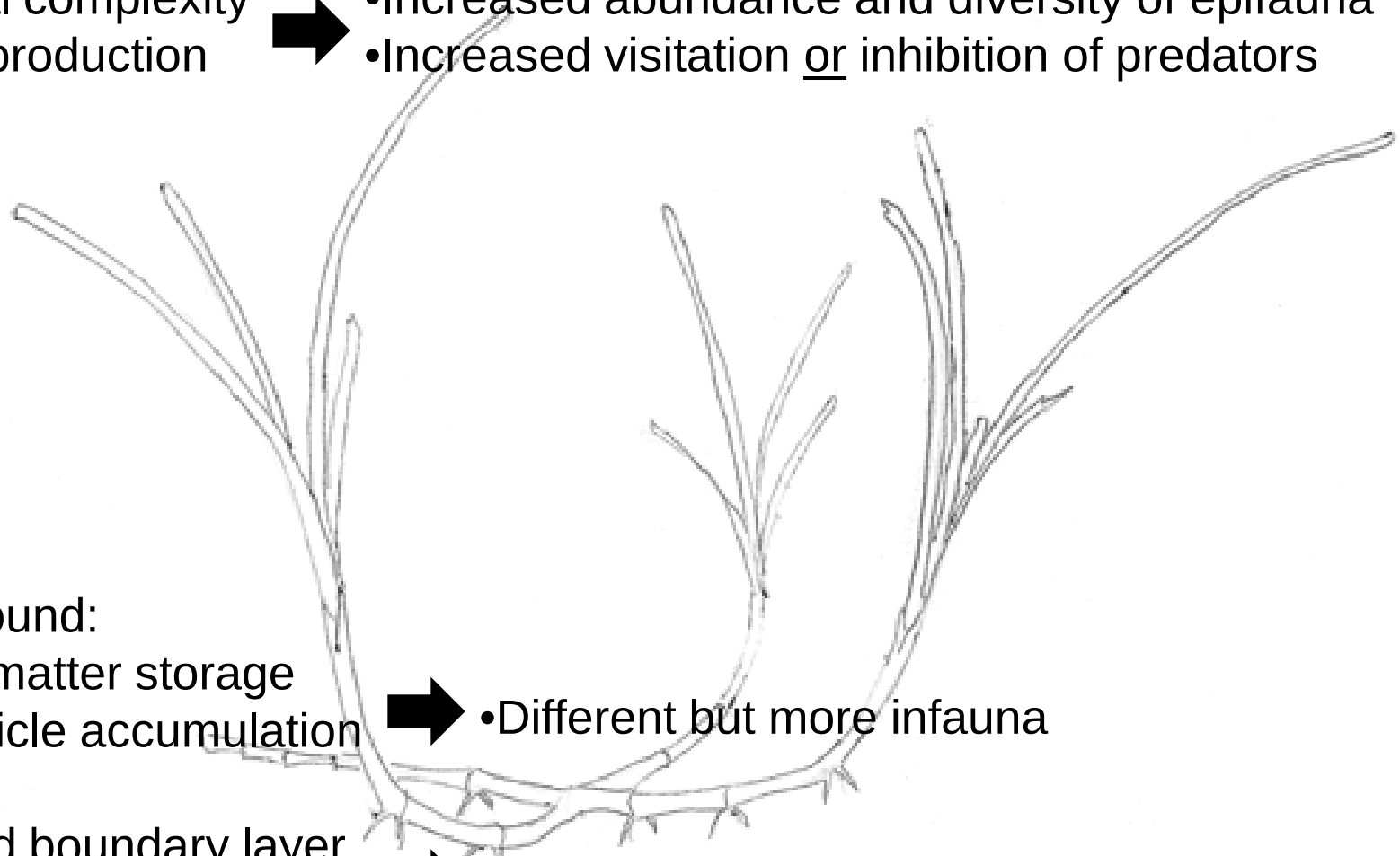
Above-ground:

- Structural complexity
- Primary production

→

- Increased abundance and diversity of epifauna
- Increased visitation <u>or</u> inhibition of predators



Below-ground:

- Organic matter storage
- Fine particle accumulation

→ • Different but more infauna

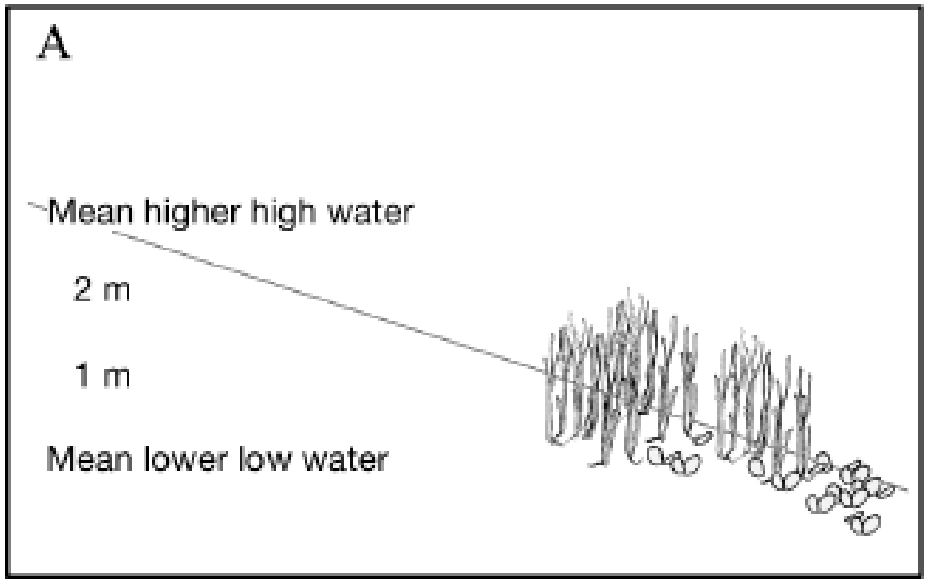
- Increased boundary layer
- Space occupancy

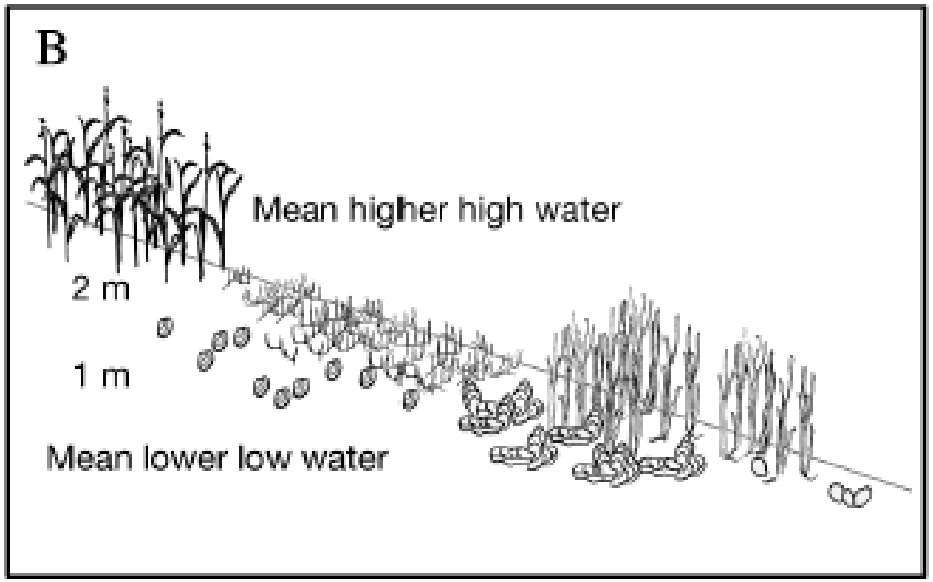
→ • Decreased infaunal abundance or production

Image: M. Hannam

Non-native *Zostera japonica* provides higher shoot density but smaller blade size relative to native *Z. marina*

Comparisons of faunal assemblages between non-native and native seagrass could be confounded by tidal elevation





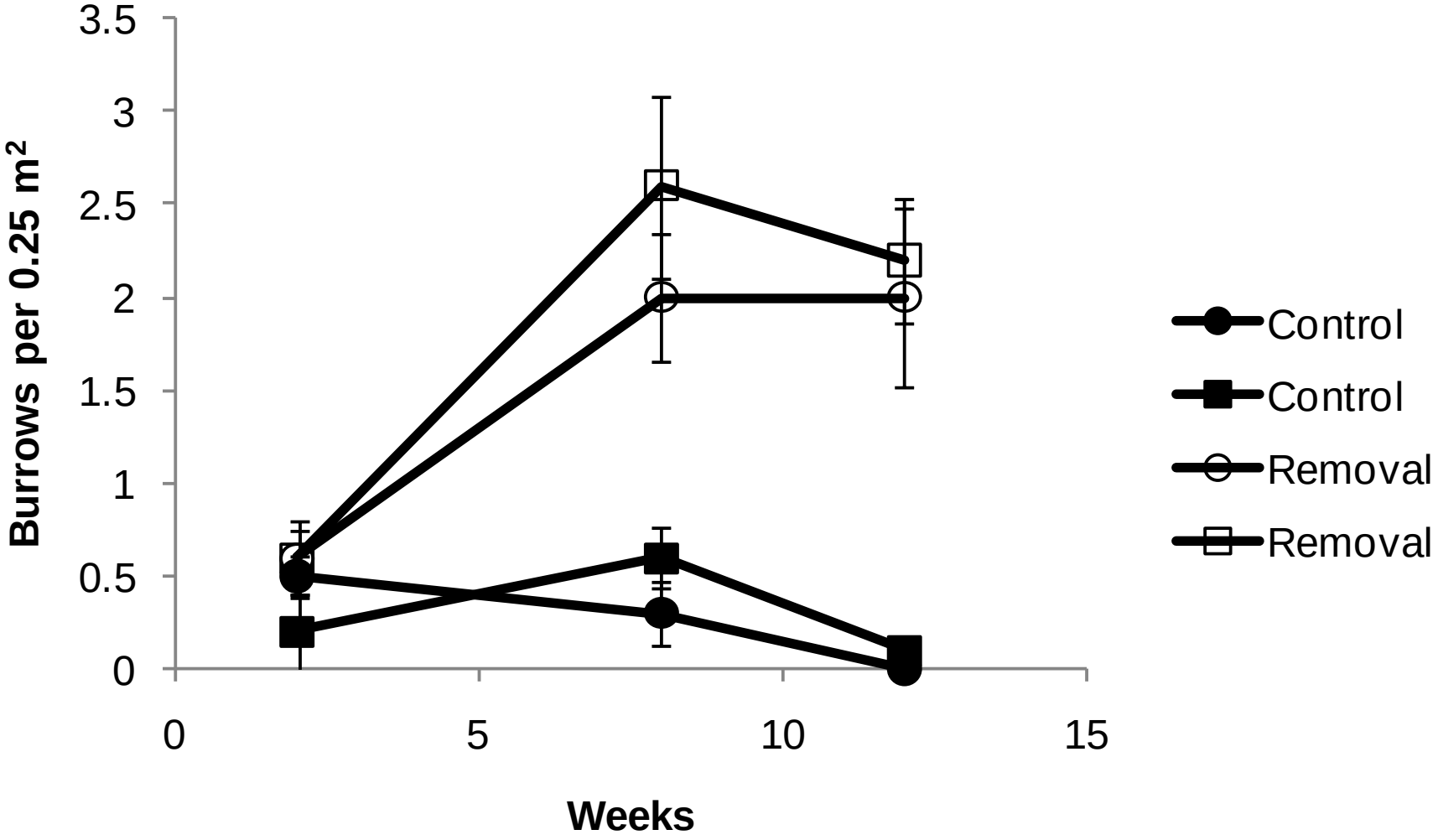
Location	Method	Replication	Result with Zj	Reference
Roberts Bank, BC	Natural expansion of Zj	1977-1984	Burrowing shrimp decline	Harrison 1987
Roberts Bank, BC	Addition of Zj, Removal of Zj in 0.25 m^2	N=5, N=20, N=20 x 2	Fewer burrowing shrimp and tubeworms	Harrison 1987
Coos Bay	Cores inside and outside Zj patches	N=5 at 3 sites and 9 times	Infauna SR higher due to lower-elevation taxa; Higher abundances of 10/11 dominant taxa	Posey 1988
Coos Bay	Addition of Zj to 1m^2, compared to disturbance control and control	N=7, initiated at different times	3 species more abundant, 1 species less so, 3 unchanged	Posey 1988
Boundary Bay	Cores in existing habitat types across elevations	3 cores every 100 m along 2 transects	Molluscs eaten by birds asserted to be more abundant in eelgrass, but no obvious analysis	Baldwin and Lovvorn 1994 MB
Netarts Bay	Reciprocal shrimp and Zj transplants, bottomless buckets	N=5 in each of 4 treatments	Fewer shrimp burrows, at least in mid-summer	Berkenbusch et al. 2007
Willapa Bay	Removal of Zj in 100 m^2	N=5	Lower condition of Manila clams	Tsai et al. 2010
Willapa Bay	Removal of Zj in 20x20 m	One plot, 12 cores in and outside	No difference: Abundance, richness, diversity higher in Zj both before and after treatment	Booth et al. 2011

TABLE 1. Densities of *Callianassa californiensis* (shrimp) burrow openings and of *Praxillella gracilis* (tube worms) in 0·25 m^2 quadrats on two parallel transects (Figure 1B, A and B) covering three vegetation zones, showing the effect of removal of all seagrass shoots initially and after 2, 8, and 12 weeks. Data are means (with one standard error in brackets) of 20 quadrats per treatment except for the 23-week data when only 10 quadrats were sampled

Vegetation zone	Time (wk)	Transect A		Transect B	
		Control	Denuded	Control	Denuded
Shrimp					
Z. marina	2	0·1 (0·10)	0·4 (0·13)	0·1 (0·07)	1·0 (0·28)
	8	0	0·8 (0·28)	0	0·8 (0·20)
	12	0	1·6 (0·30)	0	2·3 (0·37)
	23	0·3 (0·20)	1·3 (0·45)	ND	ND
Mixed	2	0·6 (0·25)	0·7 (0·22)	0·4 (0·18)	0·8 (0·25)
	8	0·1 (0·07)	1·0 (0·22)	0·2 (0·16)	1·4 (0·32)
	12	0·1 (0·07)	1·4 (0·28)	0	1·5 (0·34)
	23	0·4 (0·40)	1·4 (0·67)	ND	ND
Z. japonica	2	0·5 (0·20)	0·6 (0·20)	0·2 (0·12)	0·6 (0·15)
	8	0·3 (0·16)	2·0 (0·35)	0·6 (0·17)	2·6 (0·49)
	12	0	2·0 (0·48)	0·1 (0·05)	2·2 (0·34)
	23	0·2 (0·20)	1·3 (0·50)	ND	ND
Tube worms					
Z. marina	2	12·9 (2·45)	15·8 (1·77)	10·9 (1·26)	25·4 (5·17)
	8	8·4 (0·58)	11·7 (1·46)	7·9 (0·70)	21·7 (5·26)
	12	7·0 (1·09)	13·2 (0·91)	5·6 (0·56)	19·0 (2·80)
Mixed	2	13·4 (1·49)	21·4 (2·39)	6·3 (0·78)	18·4 (1·78)
	8	5·3 (0·80)	12·6 (1·57)	5·6 (0·44)	15·0 (1·37)
	12	6·6 (0·28)	13·8 (1·16)	7·6 (0·73)	12·8 (1·05)
Z. japonica	2	17·5 (2·39)	28·8 (2·80)	12·7 (2·35)	24·2 (1·55)
	8	6·3 (0·87)	19·2 (1·88)	5·6 (0·48)	13·4 (1·34)
	12	4·7 (0·43)	15·4 (1·19)	6·8 (0·54)	16·4 (1·25)

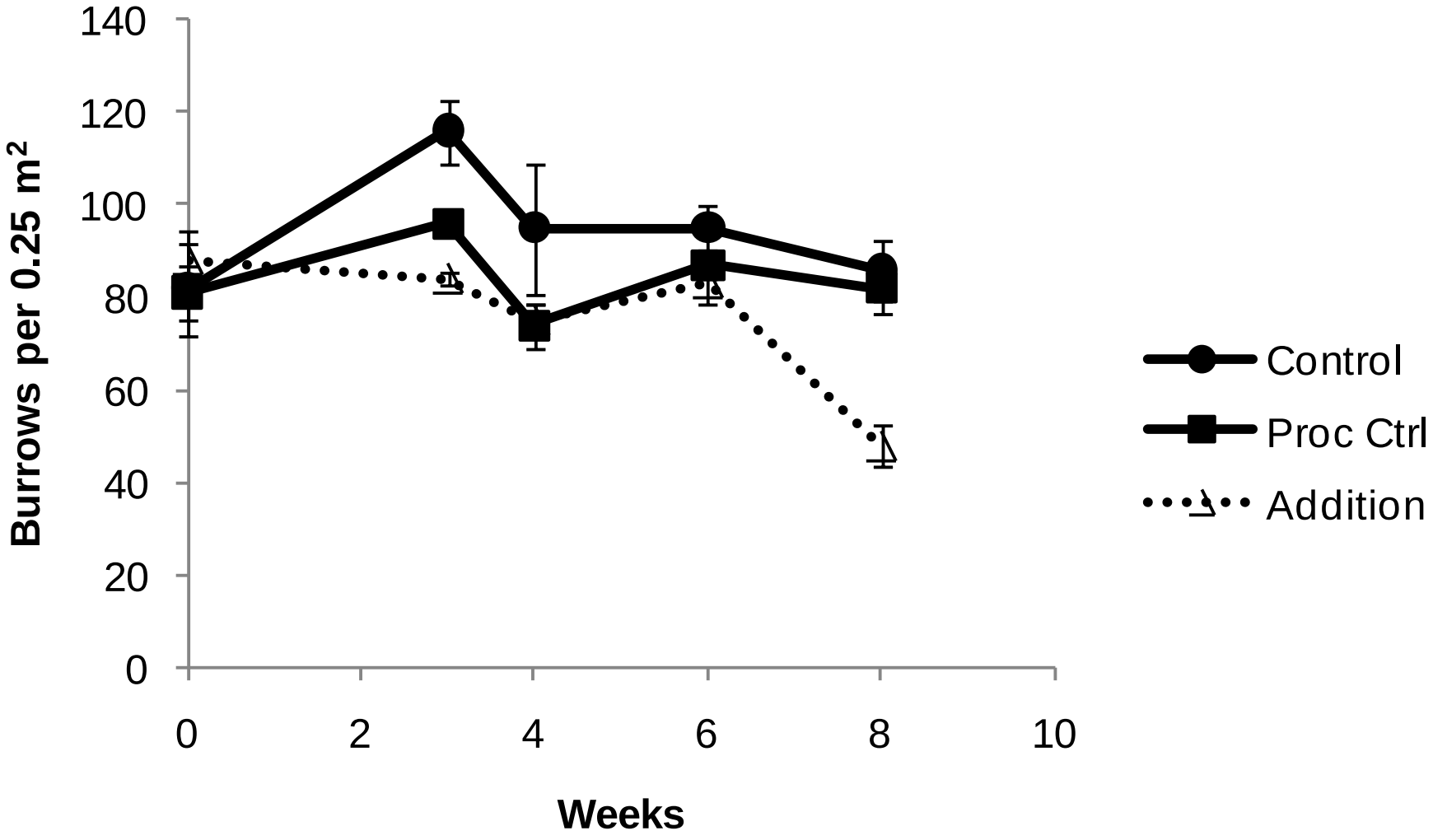
Harrison 1987

Burrow counts rise after removal of *Zostera japonica* (each point = 20 quadrats)



Harrison 1987

Burrow counts fall after addition of *Zostera japonica* (each point = 5 quadrats)



Harrison 1987

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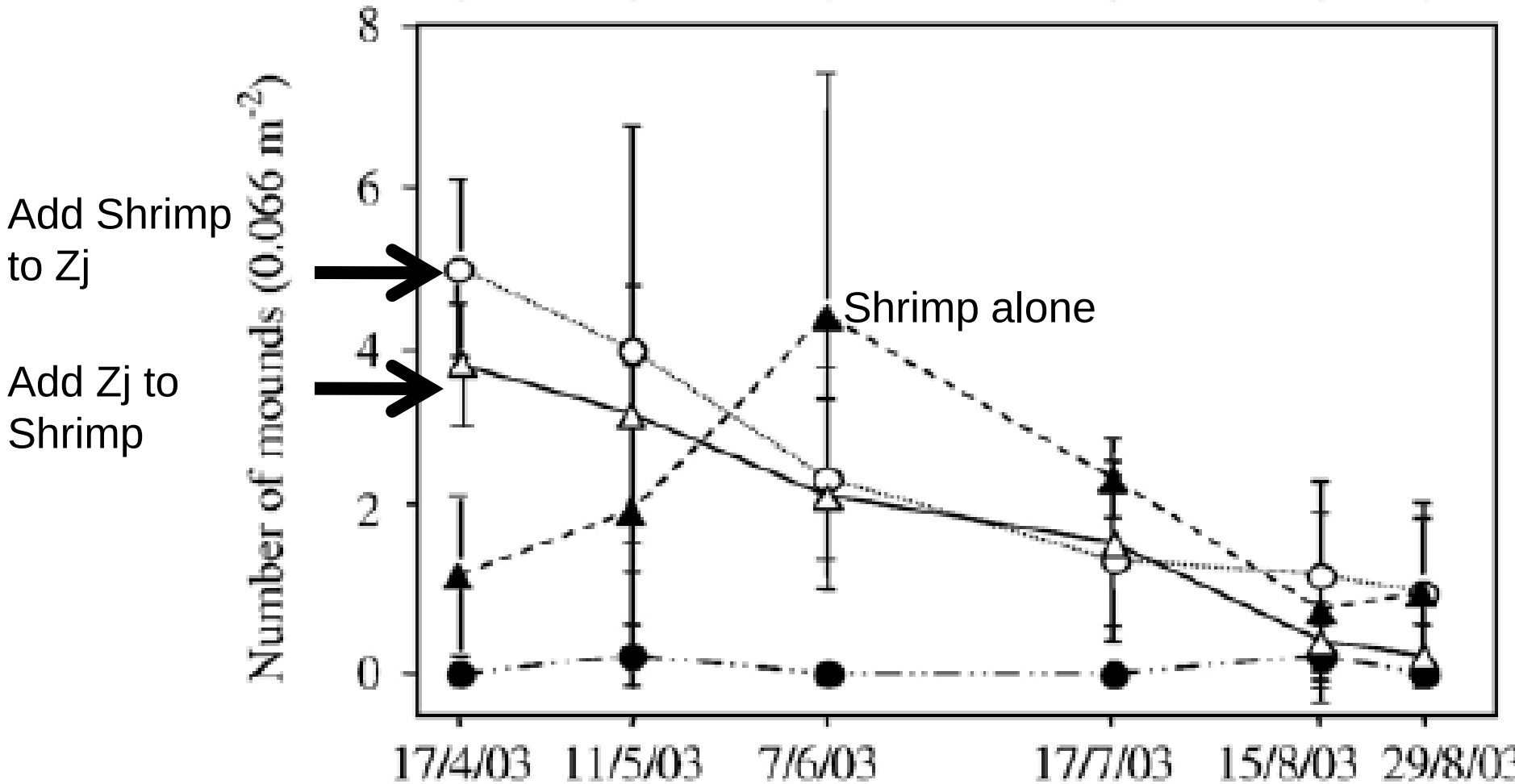
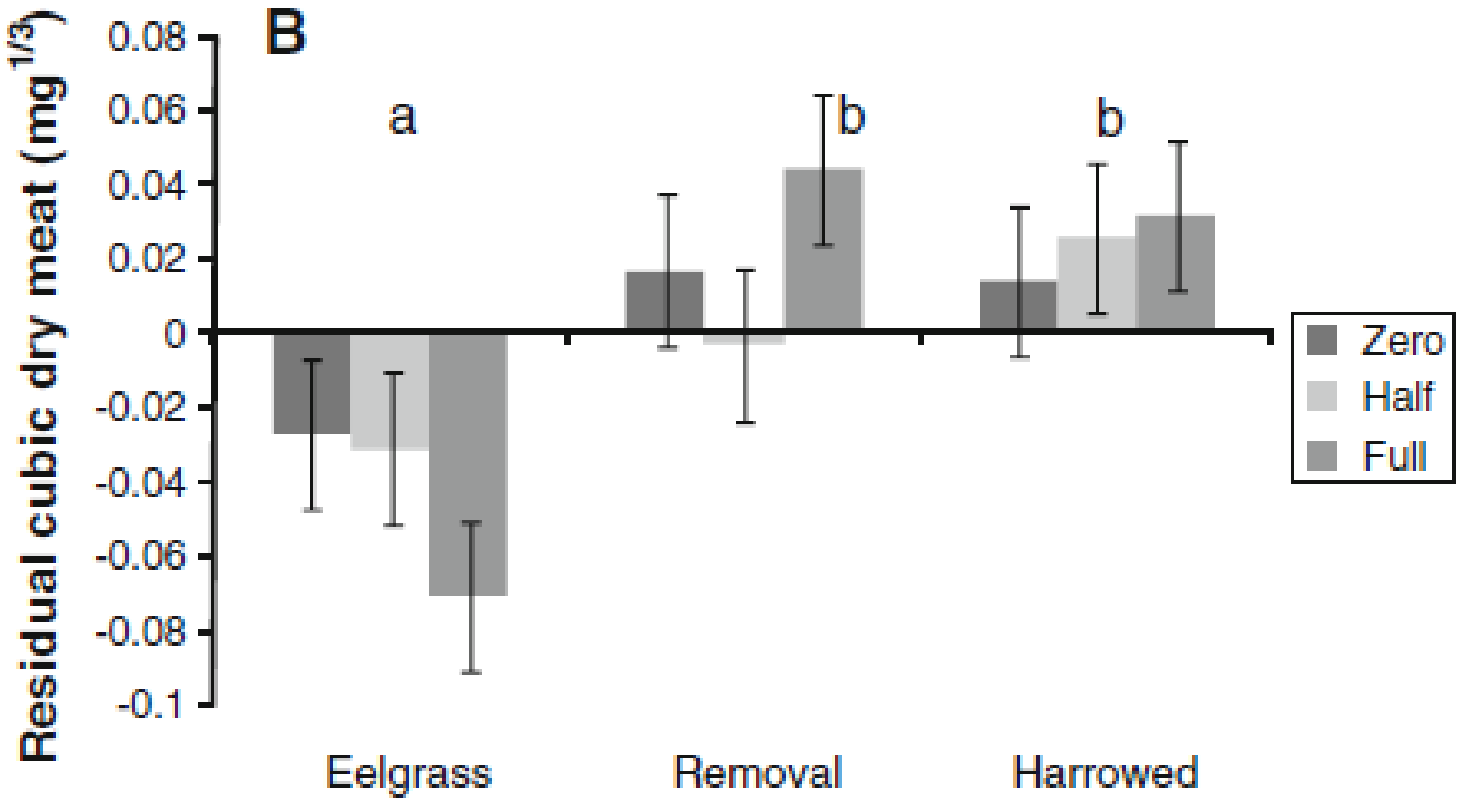
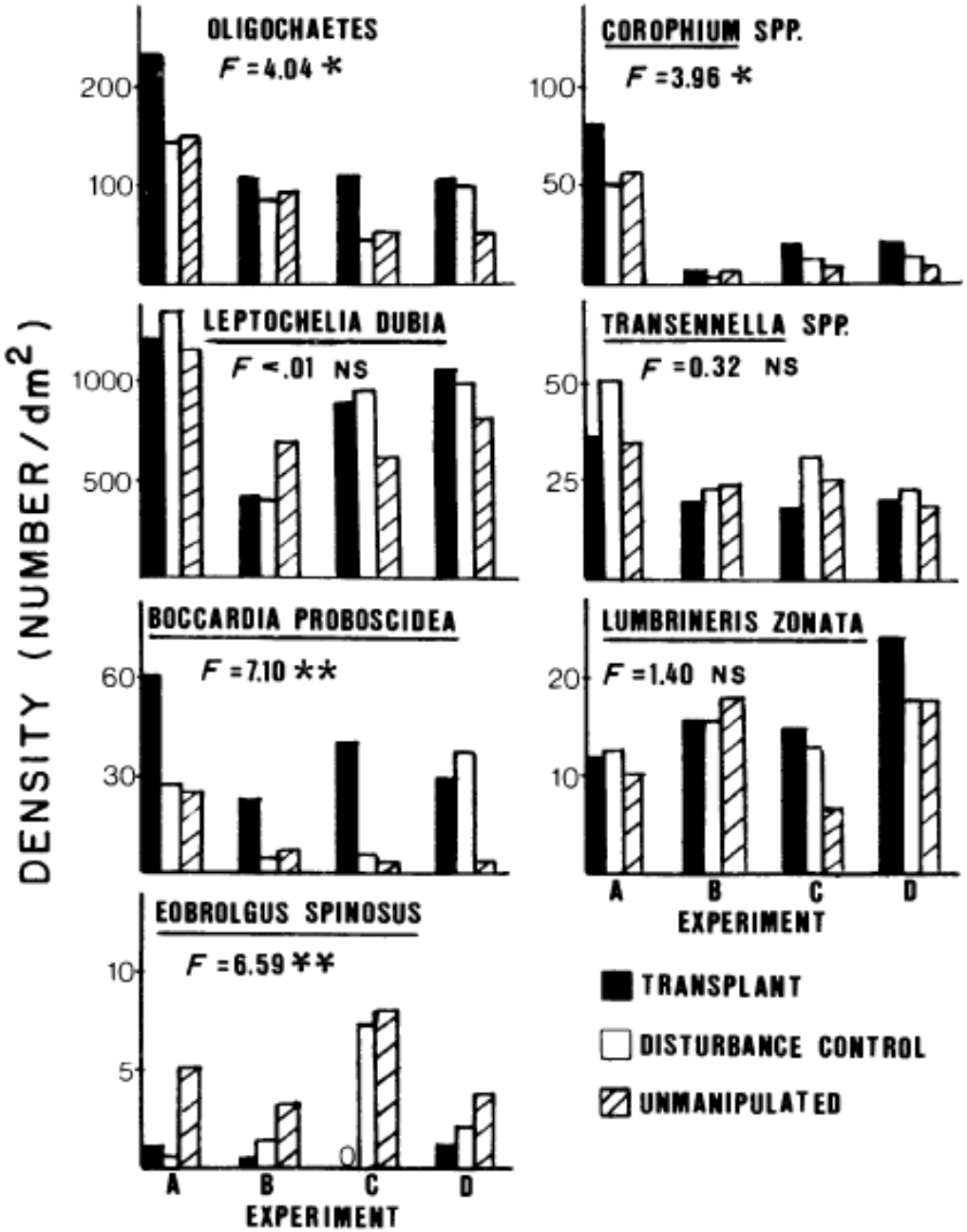


Berkenbusch et al. 2007

Clam condition but not growth increases after removal of *Zostera japonica* (each bar= 5 quadrats)



Tsai et al. 2010



Some species increase in abundance after addition of *Zostera japonica* (7 sets of plots initiated across 4 times)

Posey 1988

Comparisons across habitats

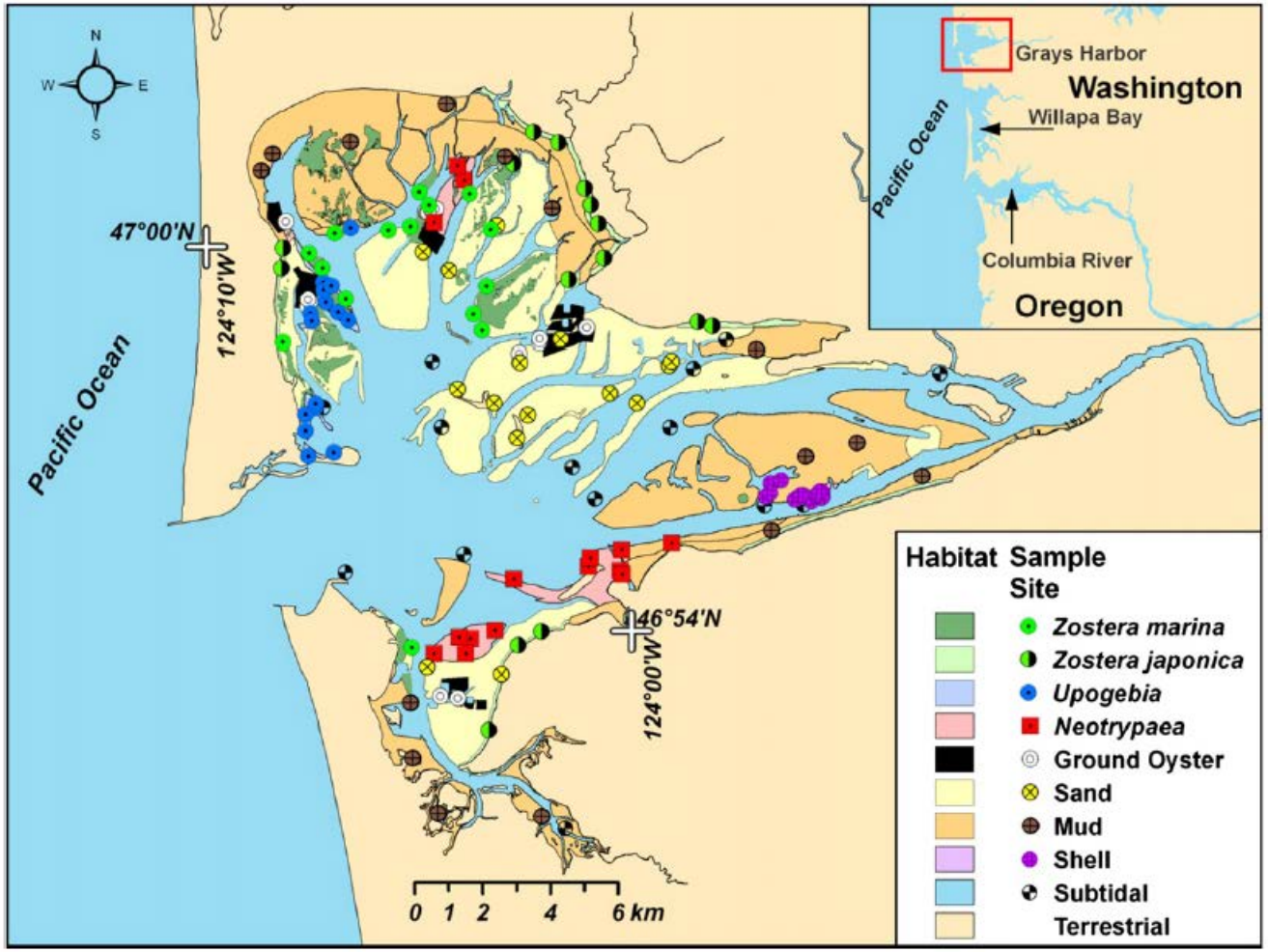
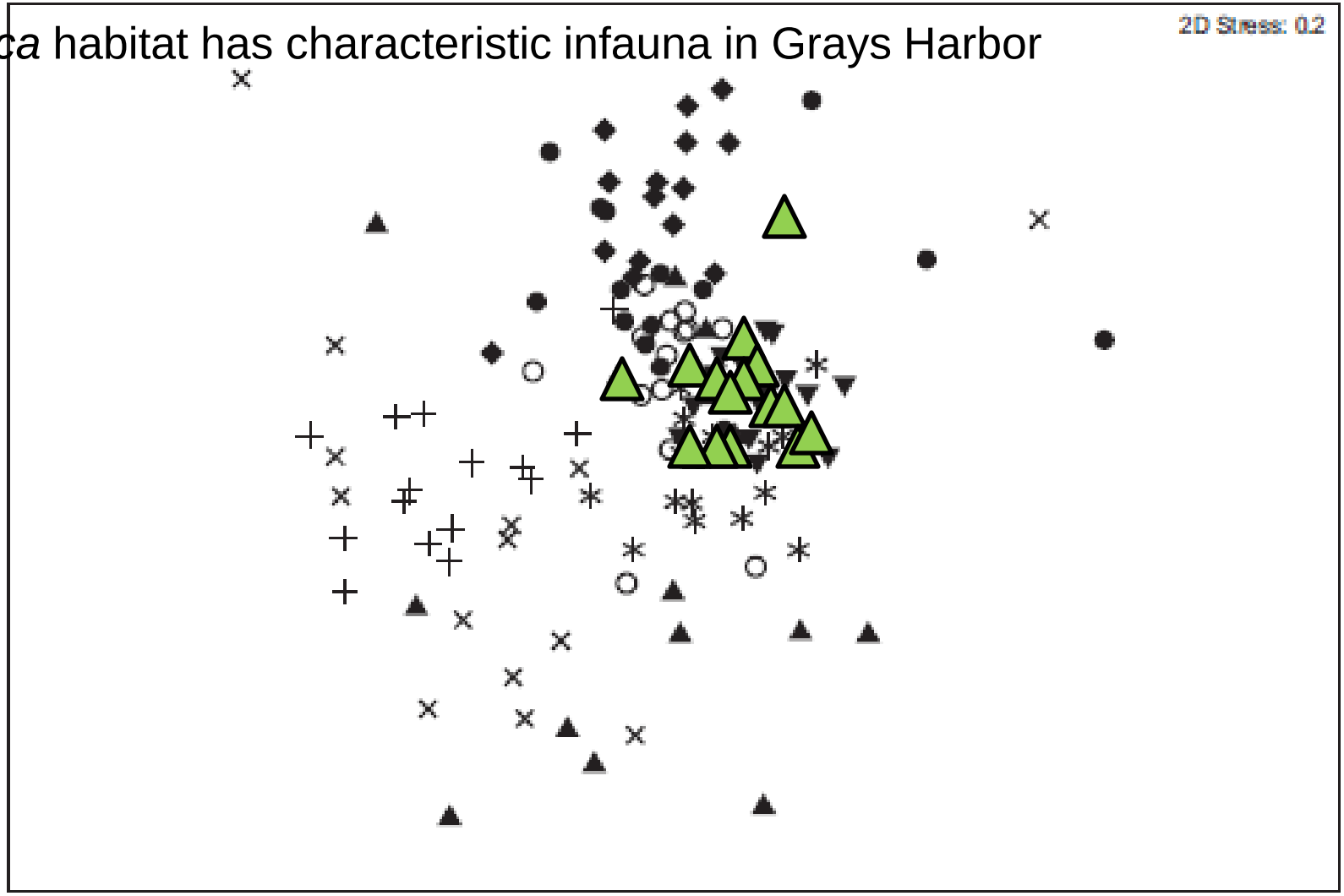


Fig. 1. Map of Grays Harbor showing the areas of nine habitats and the random station locations sampled in each habitat.

Ferraro and Cole 2011

Framework Infauna Epifauna Fish Birds

Z. japonica habitat has characteristic infauna in Grays Harbor



◆ *Zostera japonica* △ *Zostera marina* ▼ Oyster ✱ *Upogebia*

+ *Neotrypaea* ● Mud ○ Shell × Sand ▲ Subtidal

Ferraro and Cole 2011

Z. japonica habitat has relatively high infaunal richness, abundance, and biomass

Grays Harbor

3.2 *Zj* 20 12	3.0 *Zm* 8.4 14	2.8 Oyster 8.8 10
2.0 *Up* 6.5 2.8	2.0 Mud 3.8 5.6	2.0 Shell 3.7 1.6
1.5 *Nc* 2.1 2.8	1.3 Subtidal 1.8 2.0	1 Sand 1 1

Key

S Habitat *A* *B*	
Indistinguishable Bray-Curtis similarity	

Tillamook Bay

3.4 Oyster 26 6.7	3.2 *Zj* 45 11	
2.8 *Up* 36 3.9	2.2 *Zm* 5.1 3.9	
1.2 Sand 1.5 1.6	1 *Nc* 1.4 1.1	1 Sub 1

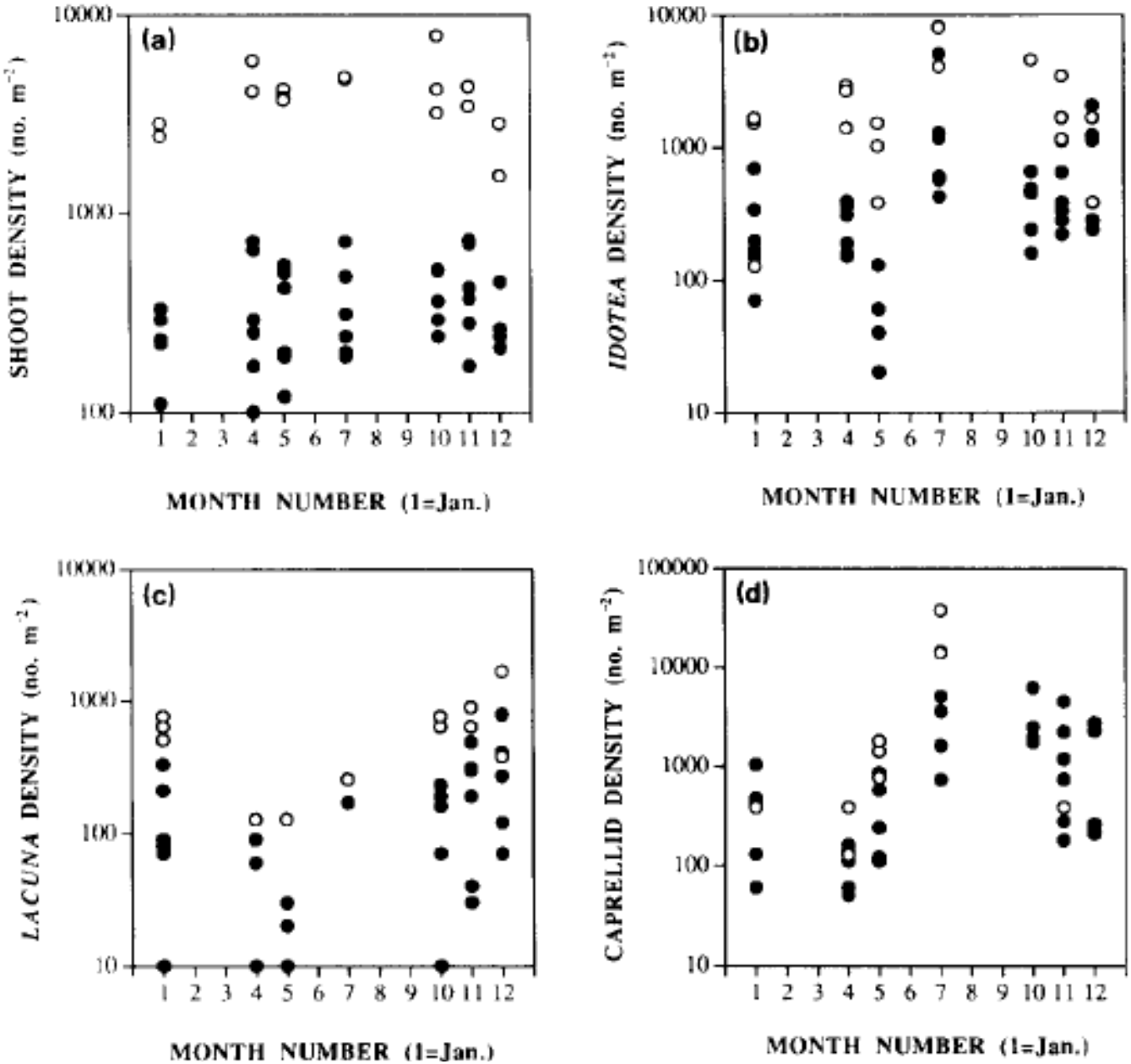
Ferraro and Cole 2011, 2012

Location	Method	Replication	Result	Reference
Padilla Bay	$0.25m^2$ plots in existing habitat types across elevations	See below	YOY Dungeness crab – see below	Dinnell et al. 1986
Padilla Bay	Epibenthic pump and “pitfall” traps of incoming tide’	N=3 at 0.5’(Zm), 1.2’ (Zj), 4.5’ (mud)	No statistical analysis: Epibenthic abundance similar but richness higher in vegetation; Benthic boundary layer abundance and richness higher in Zm than Zj and mud	Simenstad et al. 1988
Boundary Bay	Sweep nets in existing habitat types across elevations	$0.3\ m^3$ at intervals	Several amphipods increase in abundance – vegetation (Zj, Zm) is usually better predictor than tidal elevation	Baldwin and Lovvorn 1994 MB
Padilla Bay	Collect shoots from existing habitat types across elevations	3 samples in each of 3 zones at 7 times	Caprellid amphipods, isopods, snails increase with shoot density from Zm to Zj	Thom et al. 1995

YOY Dungeness crab

Habitat	No. quadrats, 25 Aug 1986	Mean m^{-2} YOY Dungeness crab	No. quadrats, 10 Sept 1986	Mean m^{-2} YOY Dungeness crab
Z. japonica	4	1	3	55
Z. marina	33	8	3	0
Z. marina + algae	4	1	7	11
Ulva	14	10	6	37
No plant cover	2	0	3	4

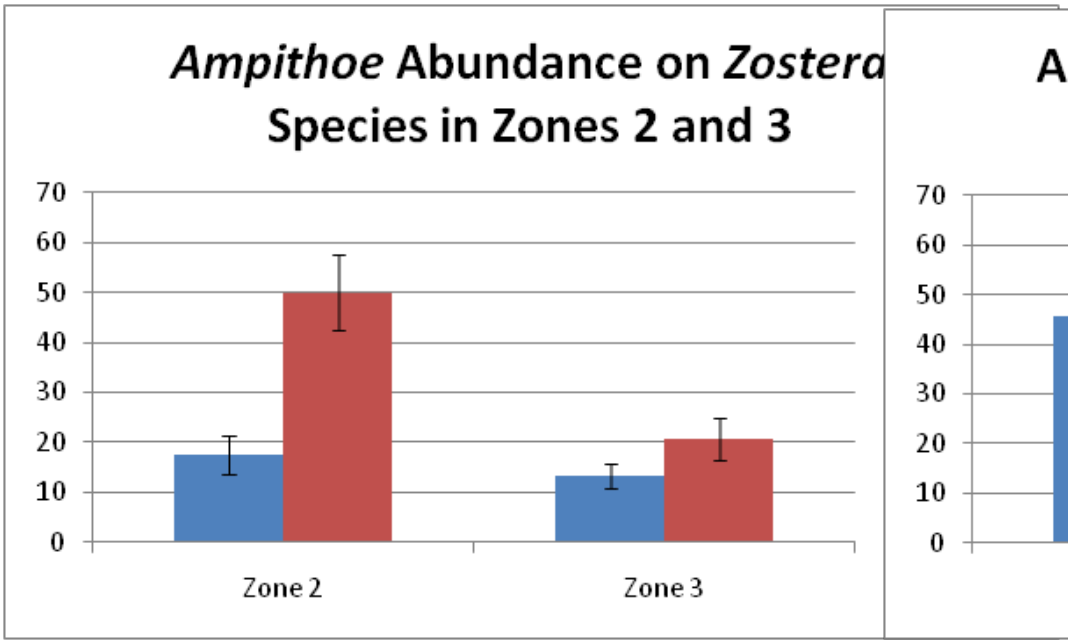
Dinnell et al. 1986

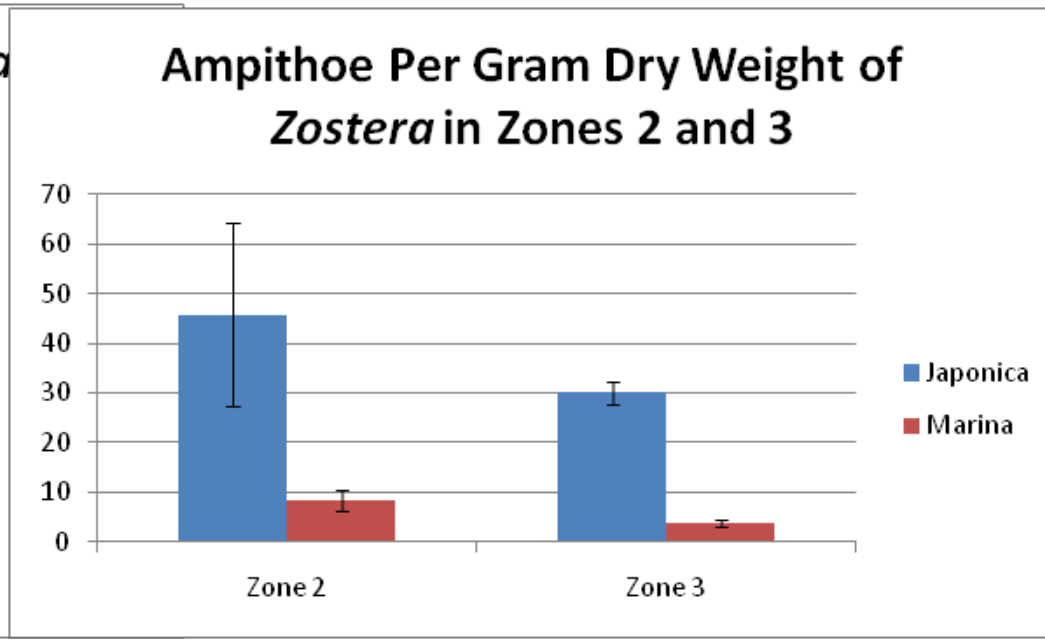


Z. japonica zone had higher abundance of mesograzers per area relative to *Z. marina* zone in Padilla Bay

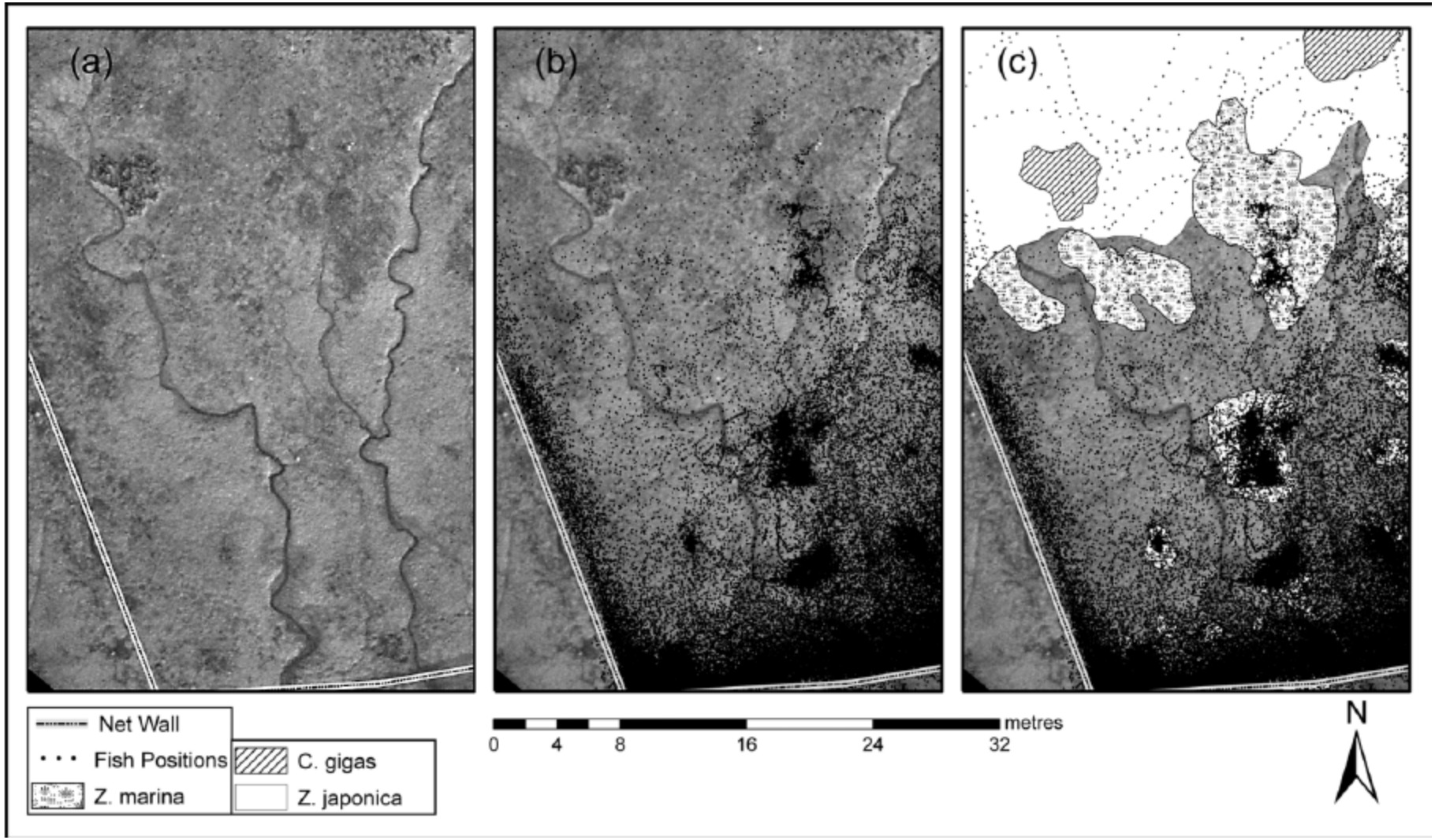
Thom et al. 1995

Z. japonica had lower amphipod abundance per area but higher amphipod abundance per biomass relative to *Z. marina* at the same tidal elevation in Willapa Bay



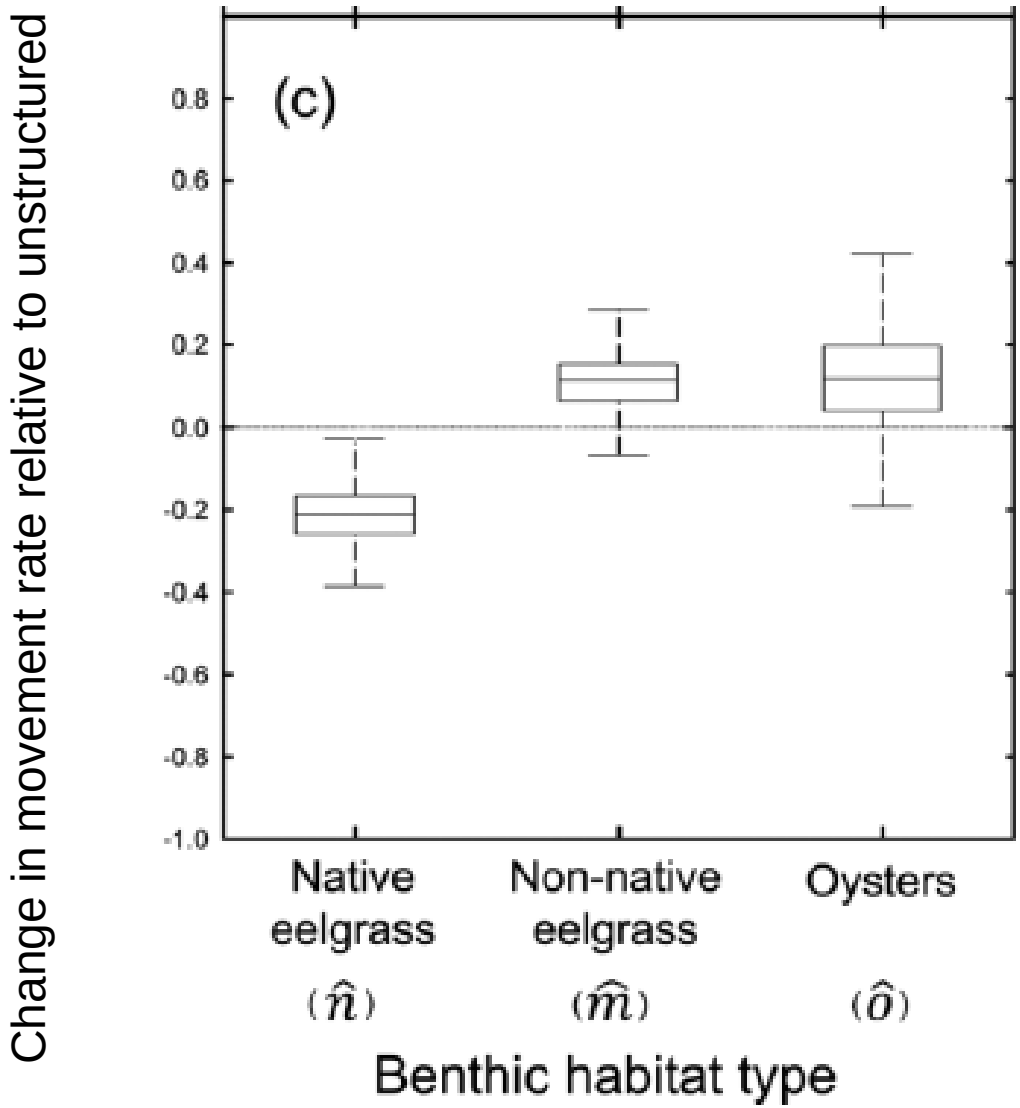


K. Krupin, undergraduate project, Biology 433 Spring 2013



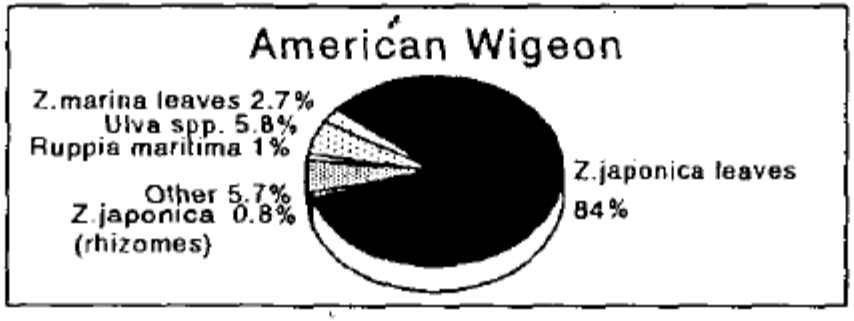
Semmens 2008

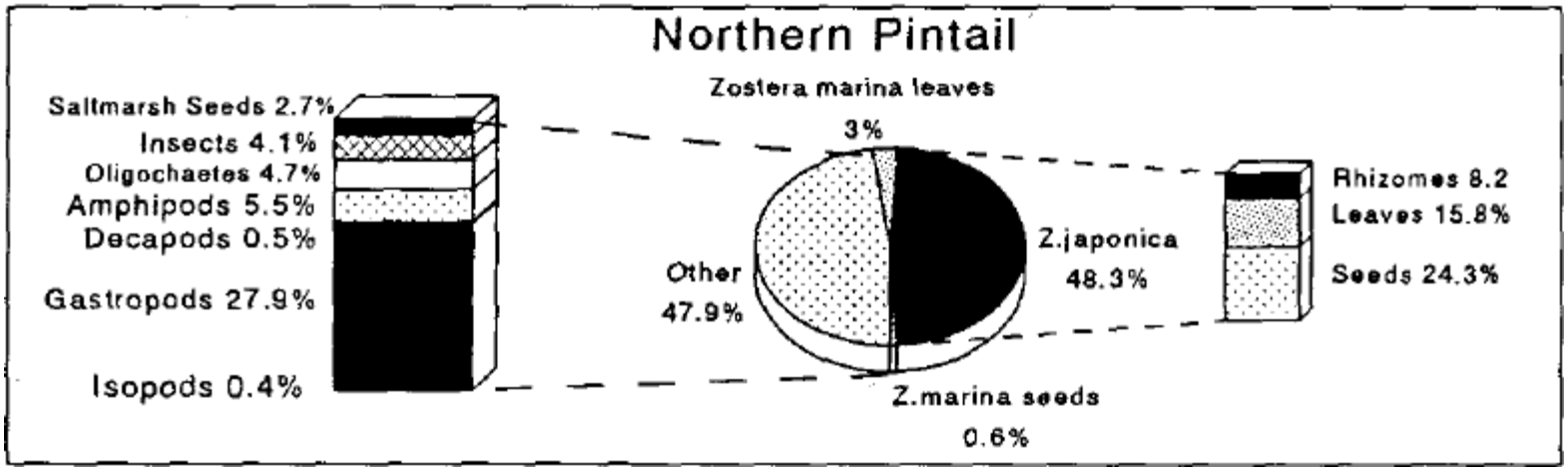
Chinook salmon hatchery smolts reduced swimming speed in *Z. marina*, but swimming speed in *Z. japonica* was similar to over unstructured habitat



Semmens 2008

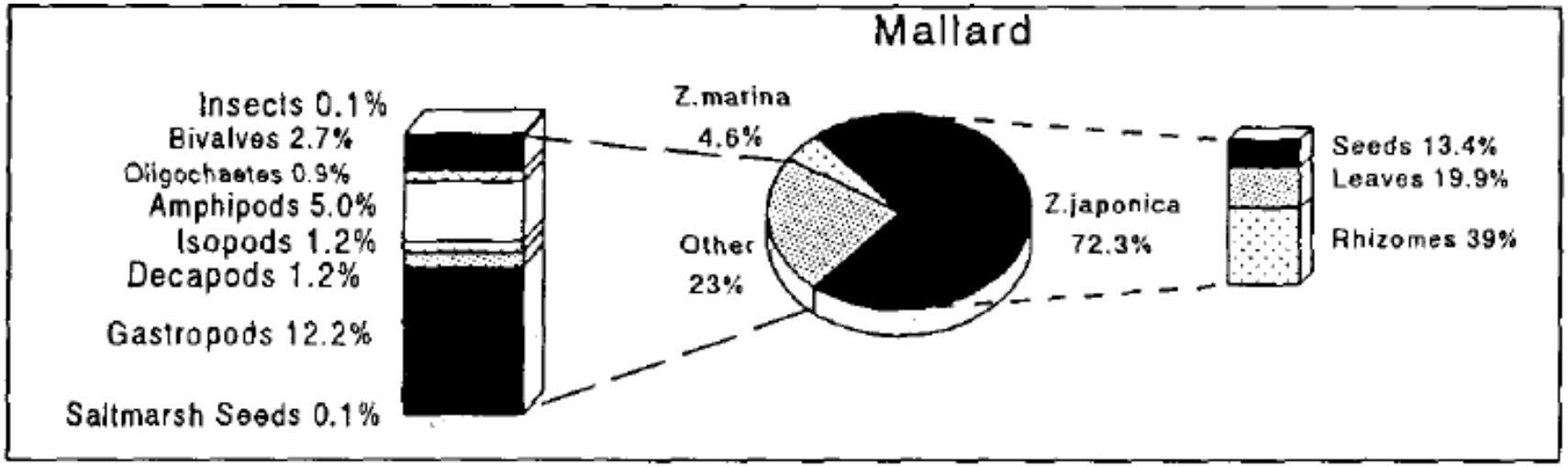
Overwintering birds in Boundary Bay, BC, consume *Z. japonica*

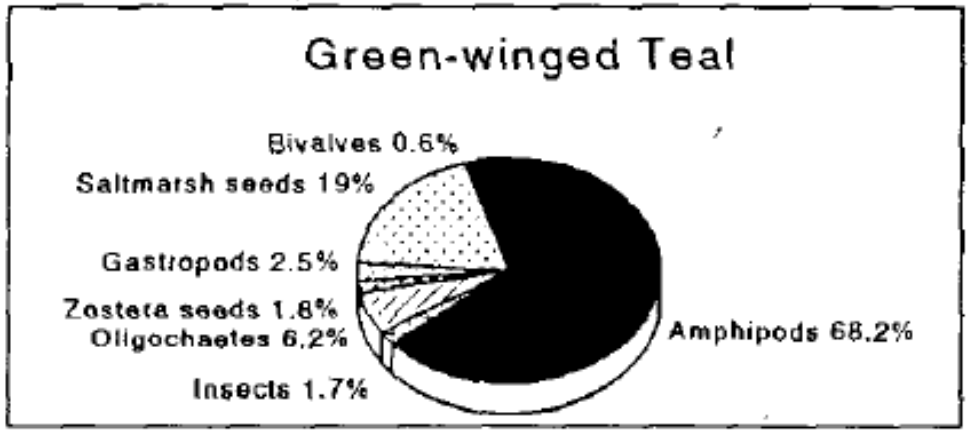


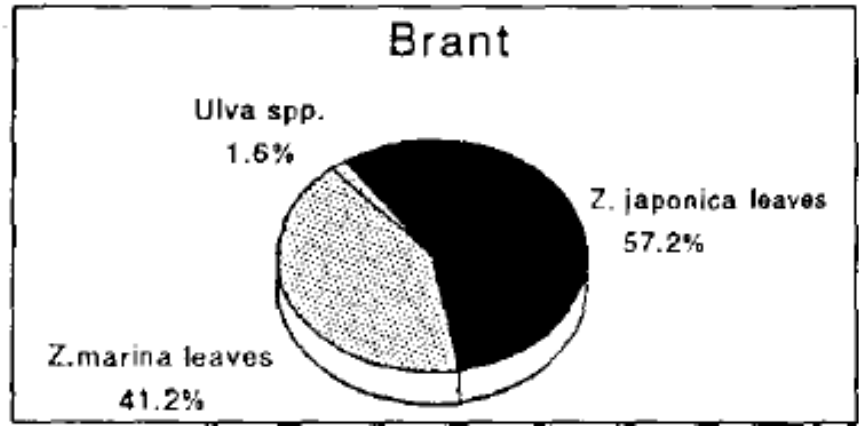


Baldwin and Lovvorn 1994

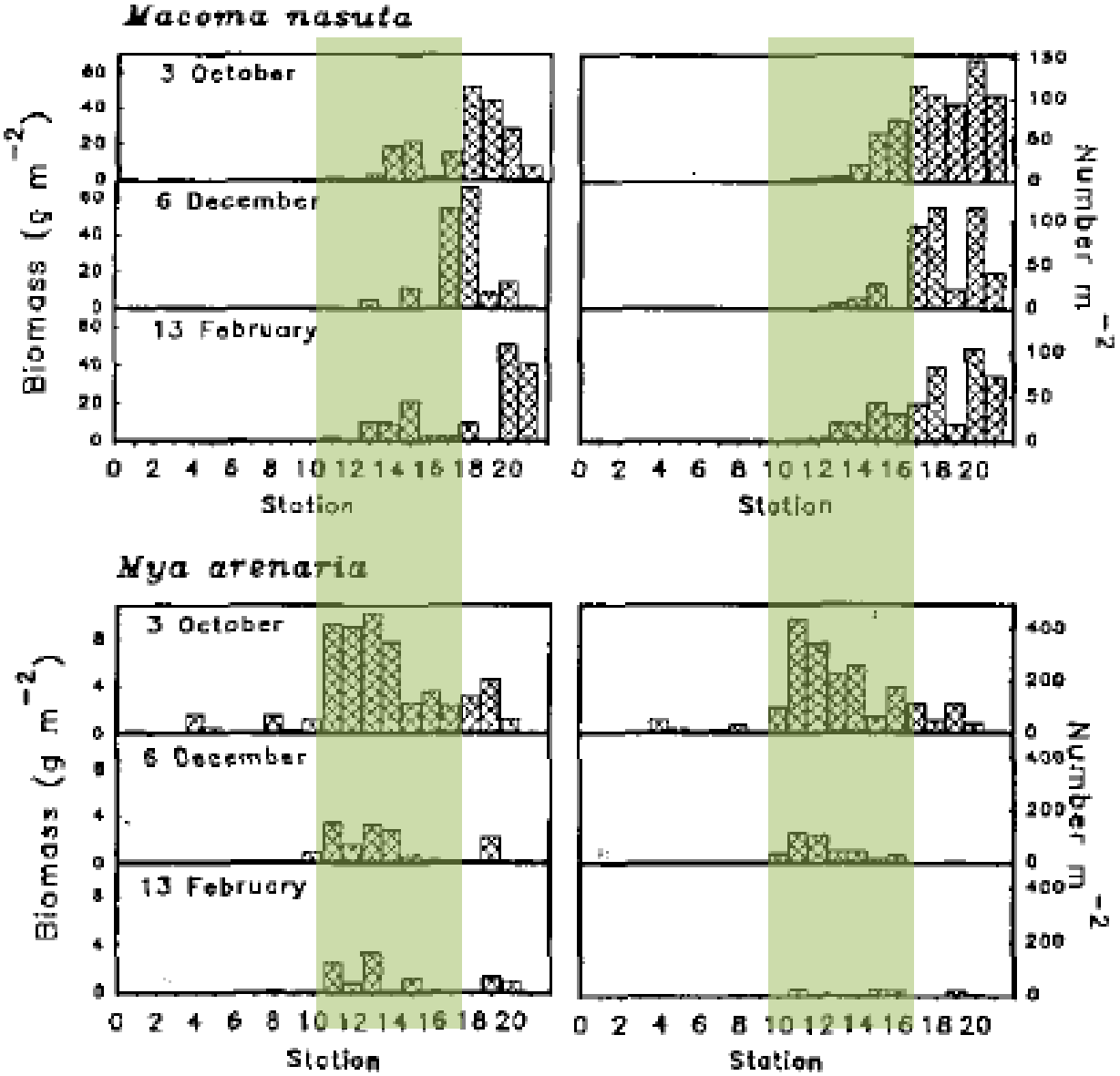
Overwintering birds in Boundary Bay, BC, consume *Z. japonica*







Baldwin and Lovvorn 1994



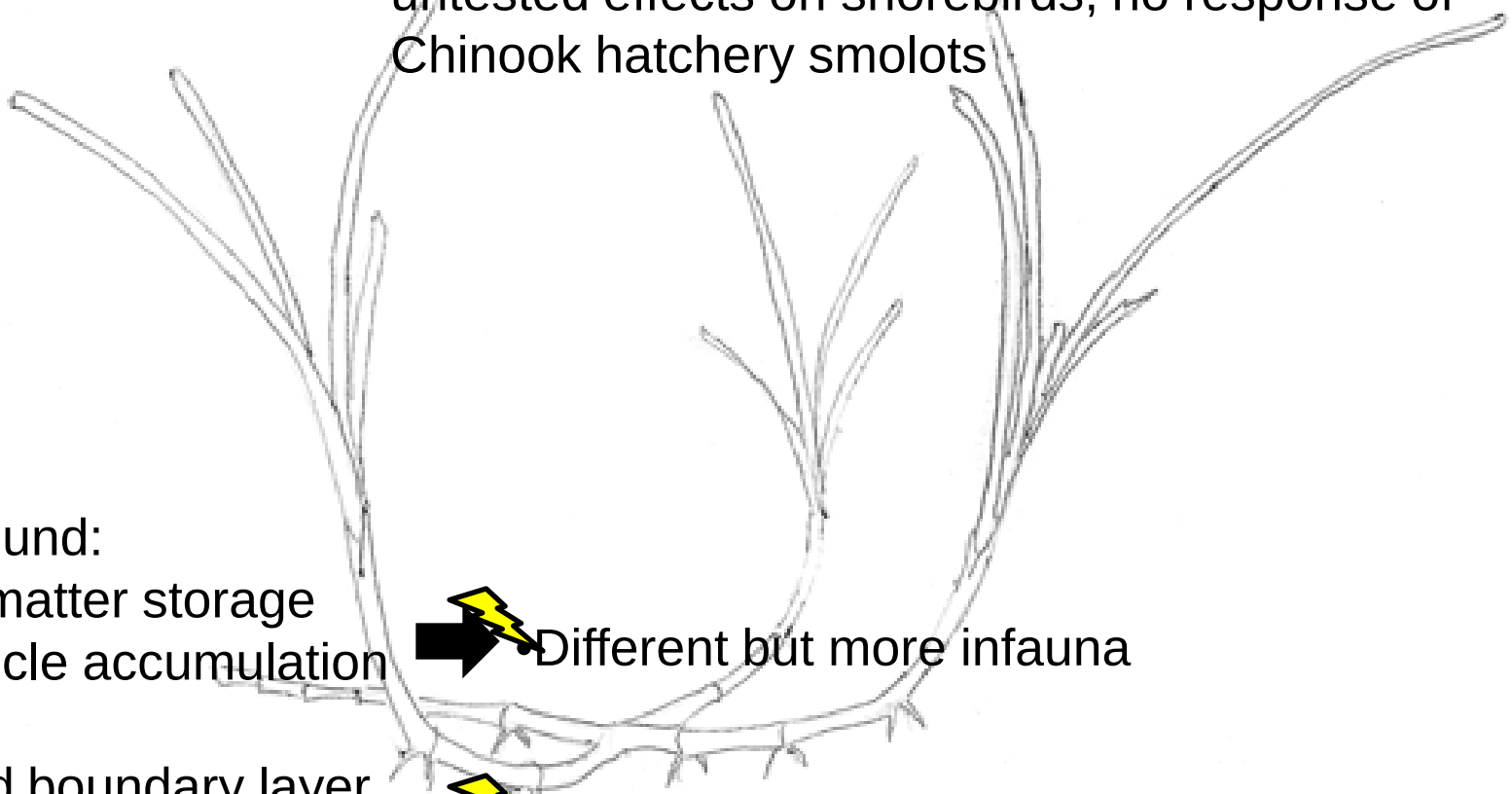
Overwintering birds in Boundary Bay, BC, may be responsible for declines of some faunal species in *Z. japonica*

Baldwin and Lovvorn 1994

Framework Infauna Epifauna Fish Birds

Above-ground:
- Structural complexity
- Primary production

- Increased abundance and diversity of epifauna
- Habitat used by brant and dabbling ducks, untested effects on shorebirds, no response of Chinook hatchery smolts



Below-ground:
- Organic matter storage
- Fine particle accumulation

- Different but more infauna

- Increased boundary layer
- Space occupancy

- Decreased burrowing shrimp abundance and clam production

Image: M. Hannam