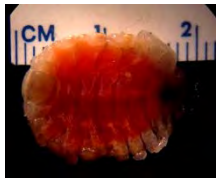
Backstory:

Upogebia **is a high biomass ecosystem engineer that reworks and remineralizes estuary sediments (DeWitt et al. 2004, D'Andrea and DeWitt 2009)**

Bopryid Isopod parasites infest decapod crustaceans and effectively castrate their female hosts

Markham (2004) described *Orthione griffenis*, collected from the intertidal estuary mud shrimp, *Upogebia pugettensis* of Yaquina Bay OR in 2002



Orthione **was introduced to North America from Asia in the 1980s (Chapman et al. 2012)**

Orthione **is associated with severe declines of *Upogebia* over its entire range (Chapman 2012, Dumbauld et al. 2011).**

Interactions and mechanisms:

Variable host condition and possible vulnerability -

Orthione **restricted to reproductive sized *Upogebia***

Highest prevalence among *Upogebia* females

No relation between parasite load and host weight loss

(Smith et al. 2008, Dumbauld et al. 2011, Griffen 2009, Repetto and Griffen 2012)

Could *Orthione* prevalence among *Upogebia* females result from sex change or greater male mortality? (Griffen 2009, Repetto and Griffen 2011) Asson

A relation between energetics and parasite load? (Repetto and Griffen 2011) Burton

Could trophic conditions for hosts control host vulnerability? ~Young

Can an ecosystem engineer of Oregon estuaries, the blue mud shrimp, be spared from extinction?

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Dept. Fisheries & Wildlife, HMSC

Oregon State University

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Acknowledgements:

Amy Chapman, Ralph & Donelle Breitenstein, Brett Dumbauld, Nancy Edwards, MCWS, Lincoln County Community Consortium,

and many, many others

2 Mar. 2017

MidCoast Watershed Council

Photo by Donna McCoy July 06

Geography of modern diversity

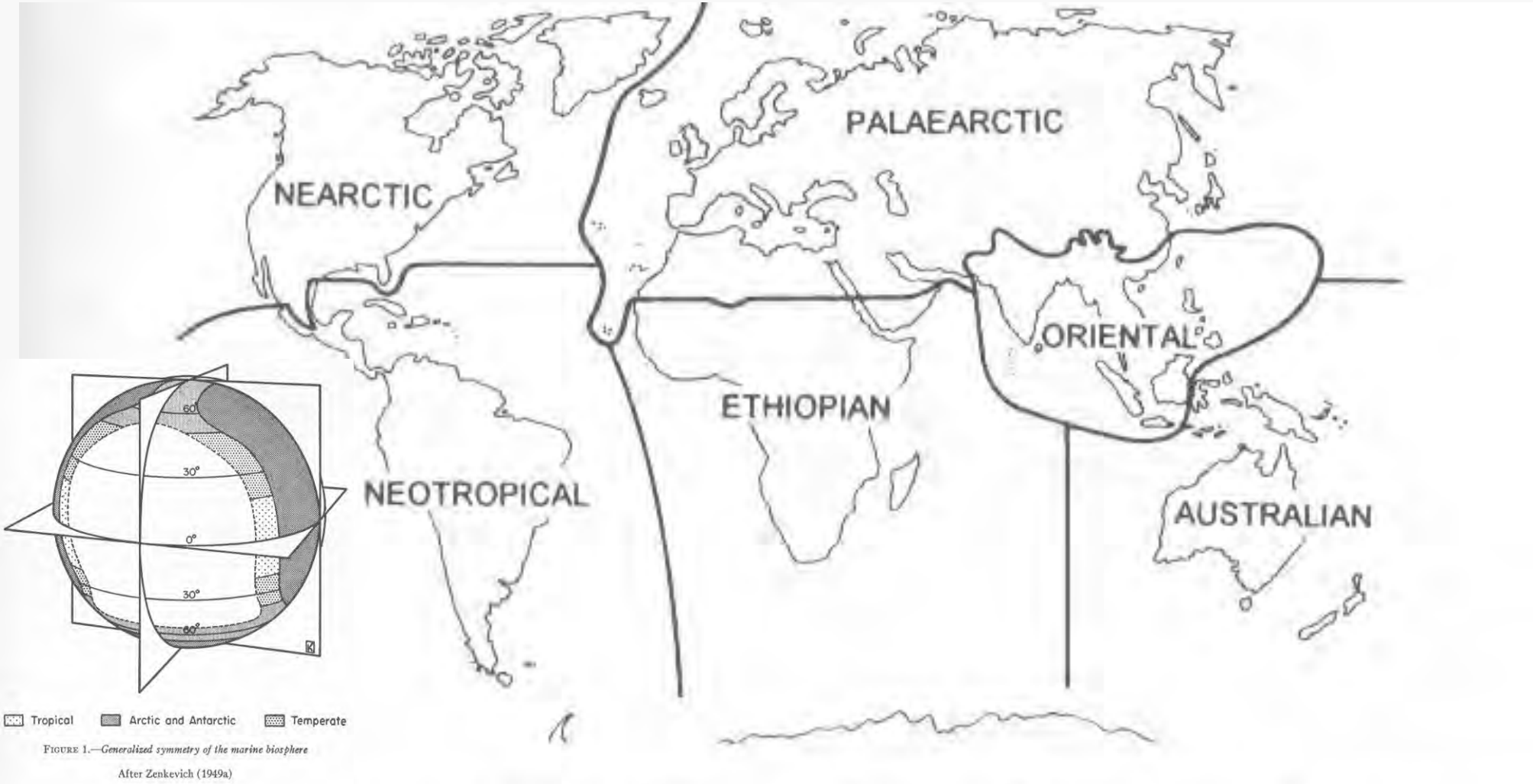
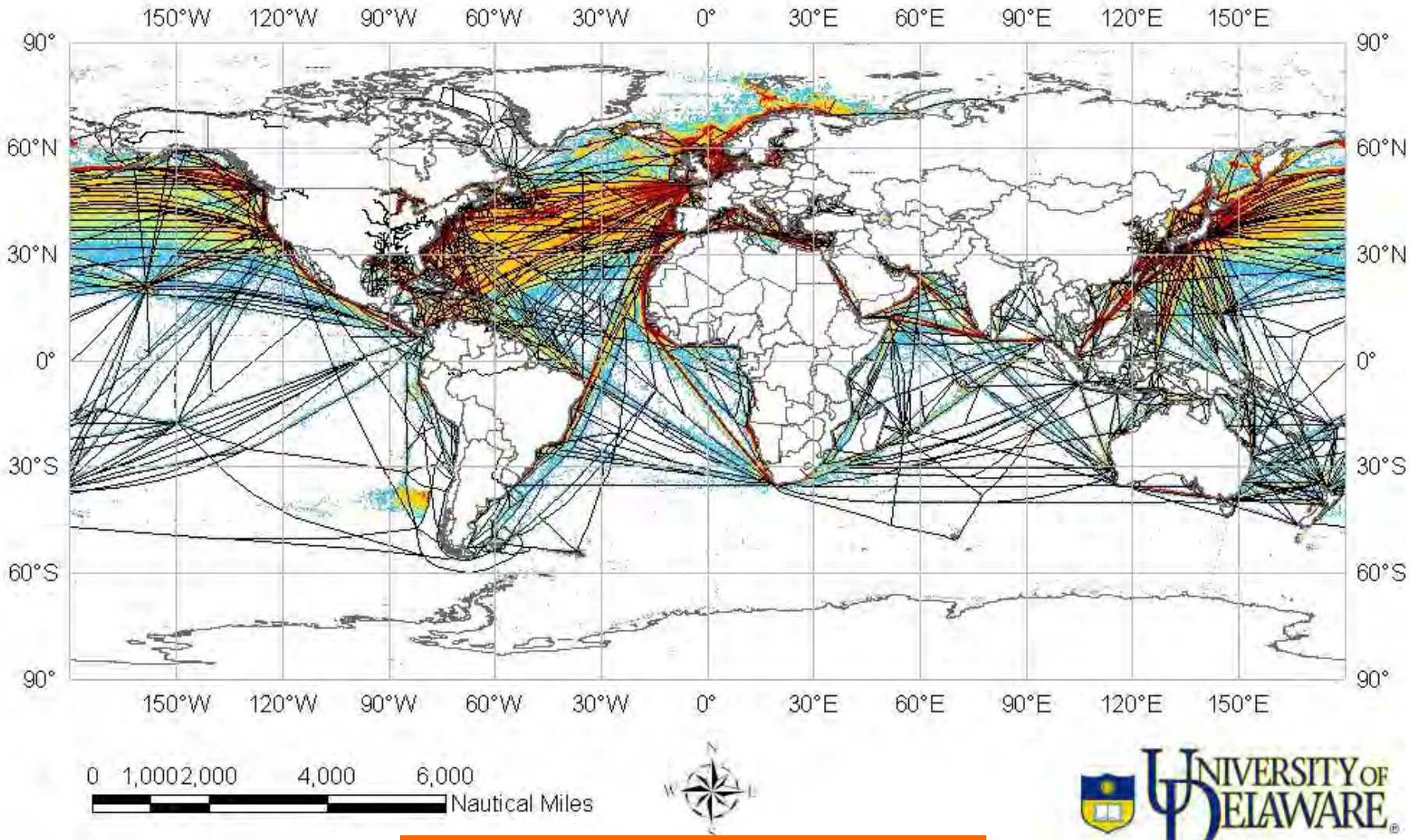


FIGURE 1.—*Generalized symmetry of the marine biosphere*

After Zenkevich (1949a)

Figure 2.1 Wallace's six realms. Different authors use slightly different boundaries in some places. (From Wallace, 1876; illustration by Mike Hill.)

http://sappingattention.blogspot.com.es/2012/11/reading-digital-sources-case-study-in.html

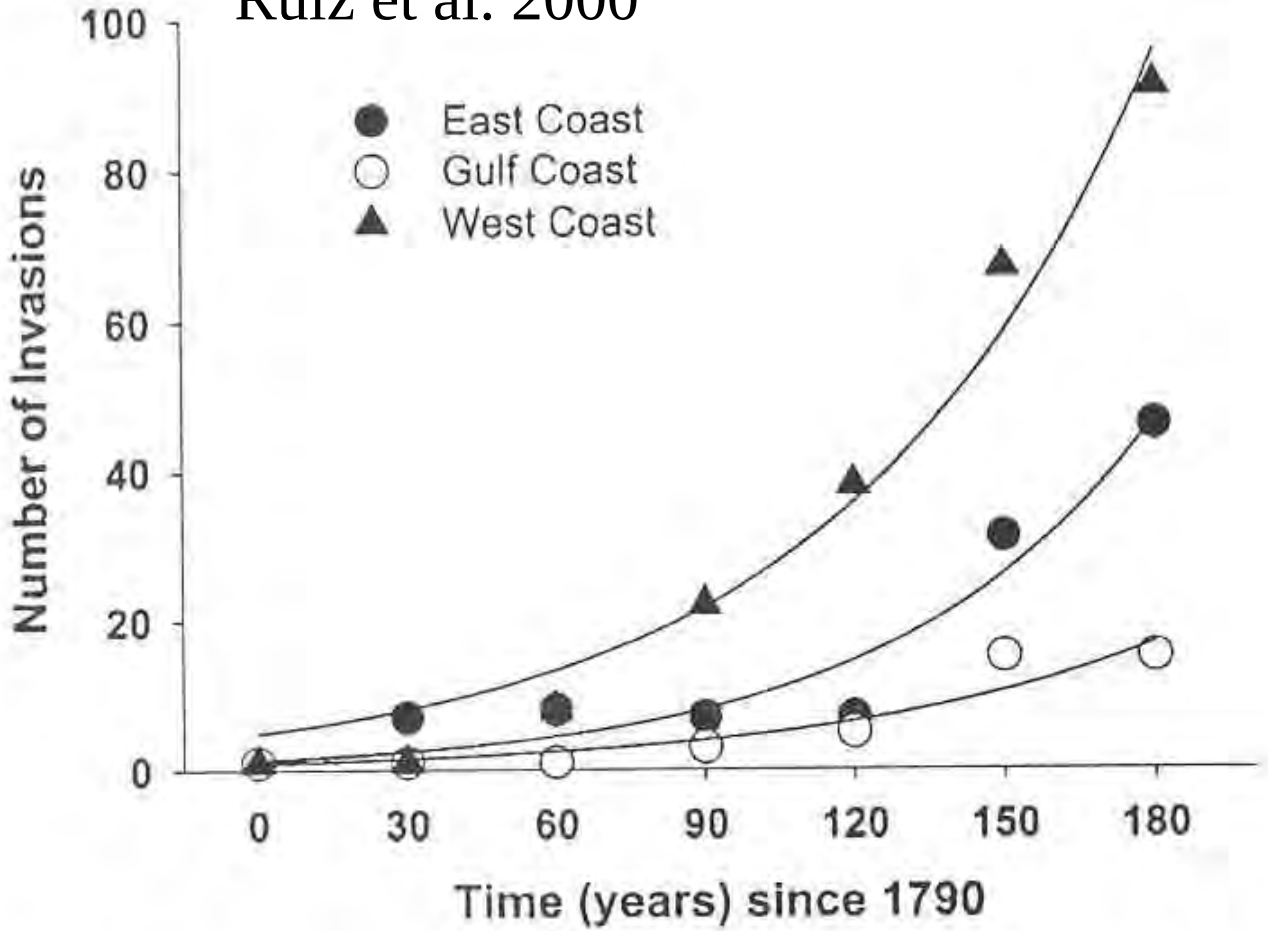


World Waterways Network: 2008

UNIVERSITY OF DELAWARE

Exponentially increasing dominance of non-coevolved introduced species in all marine ecosystems

Ruiz et al. 2000



Invasions are Conservation's Dark Side

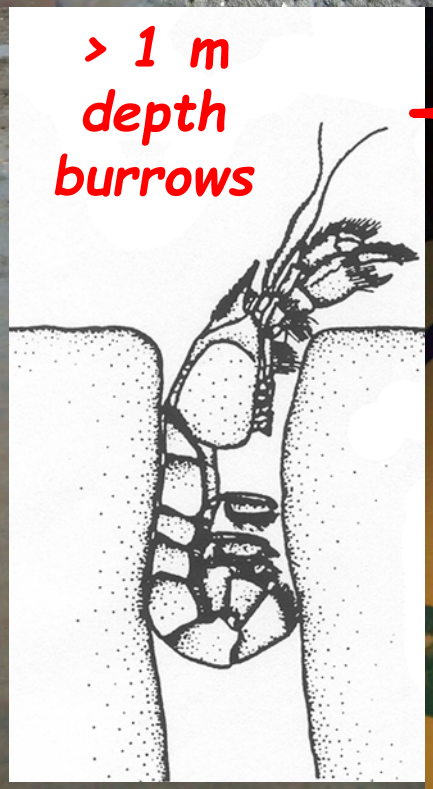
Introduced species are often not constrained by evolution

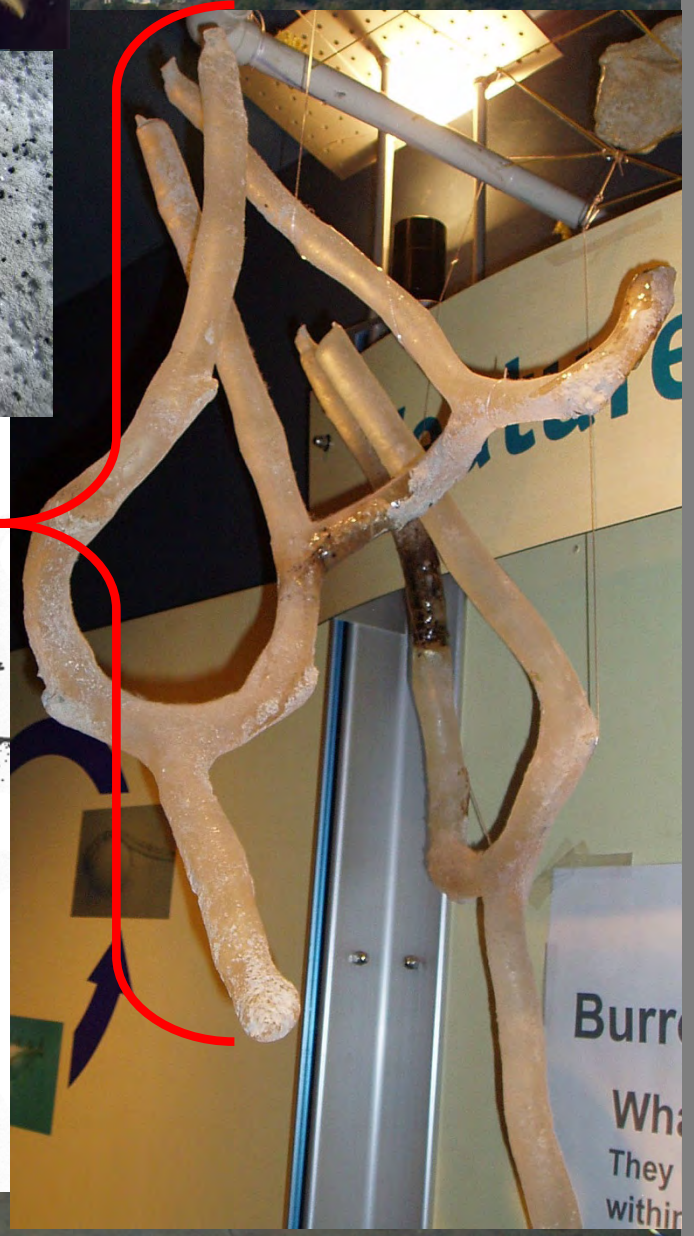
Introductions can become extinct

Introductions can cause extinction

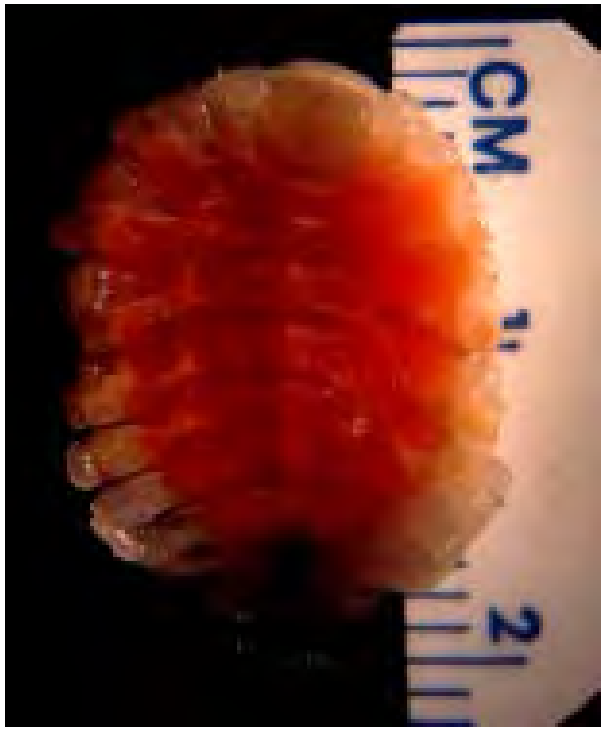
Upogebia pugettensis is an ecosystem engineer in estuaries due to its high biomass, and its reworking and remineralization of sediments (*e.g.* D'Andrea and DeWitt 2009)

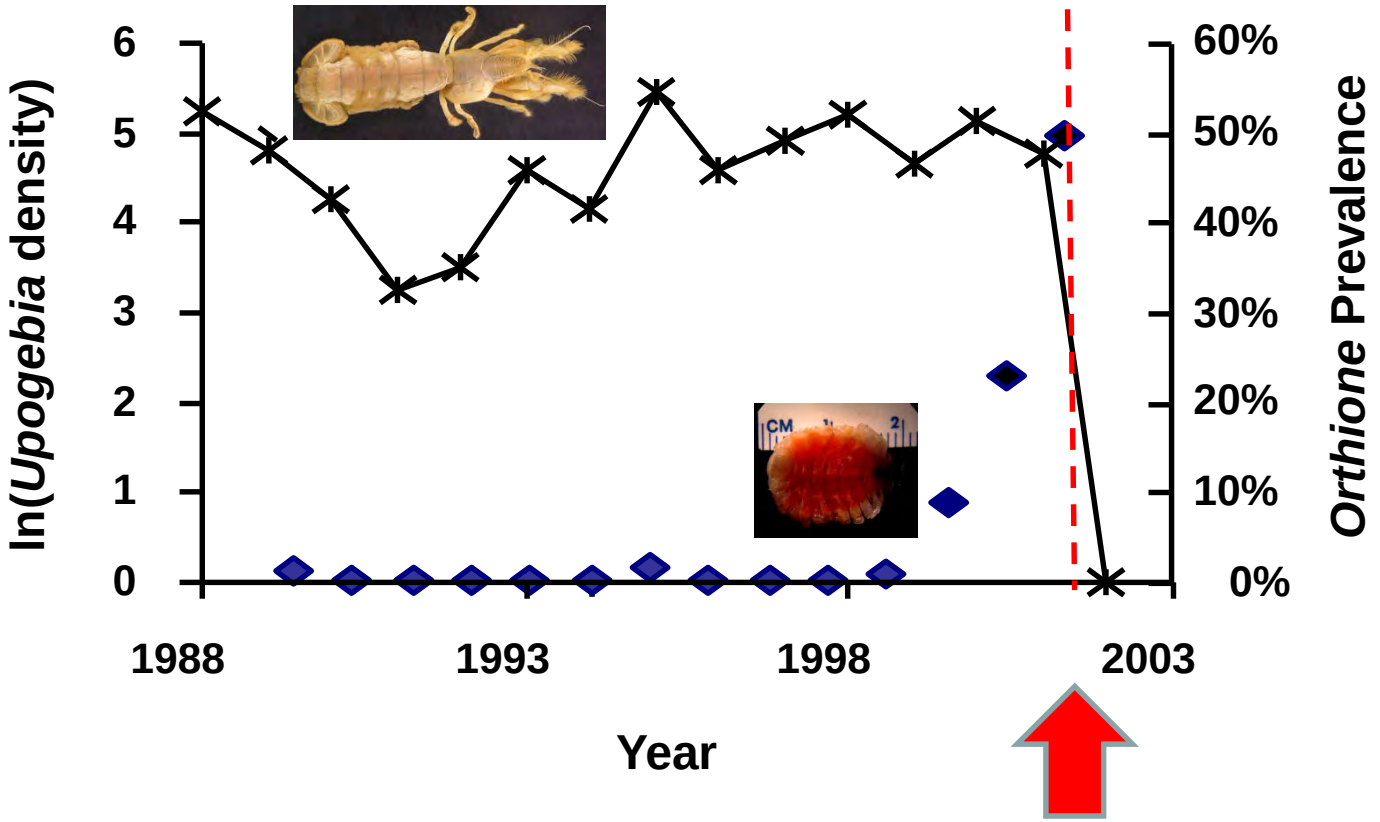
The trophic links of Upogebia to estuary sediment chemistry are intimate and significant.





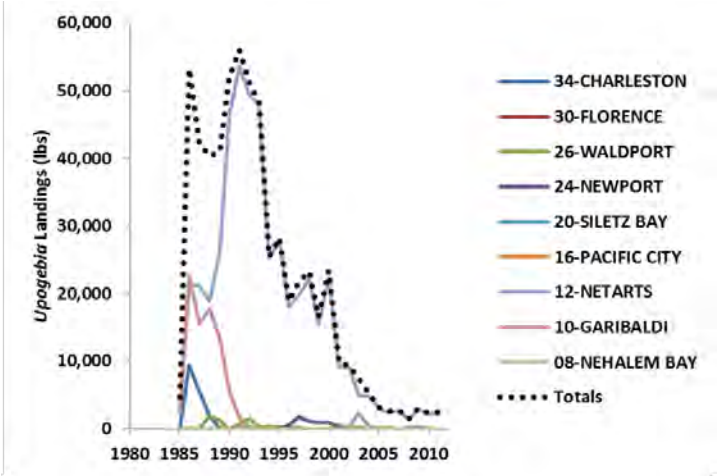
Journey Begins

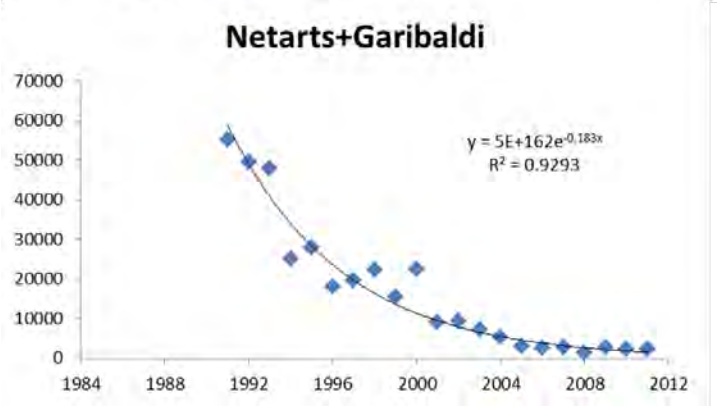




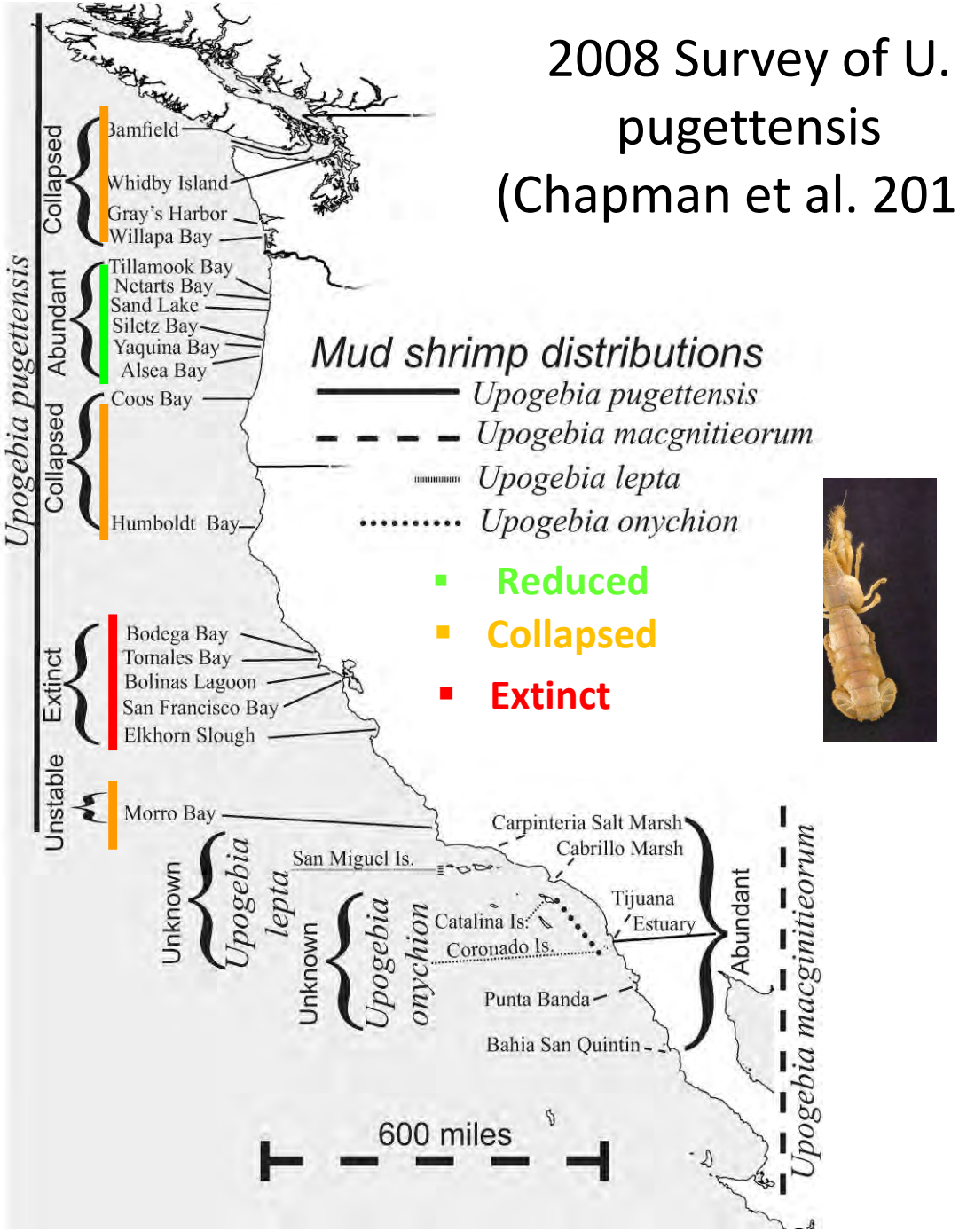
Orthione griffenis Markham, 2004 (Published winter 2004

Orthione timing coincides with _Upogebia_ declines _Upogebia_ are possibly recruitment limited (Dumbauld et al. 2011, Chapman et al. 2012)





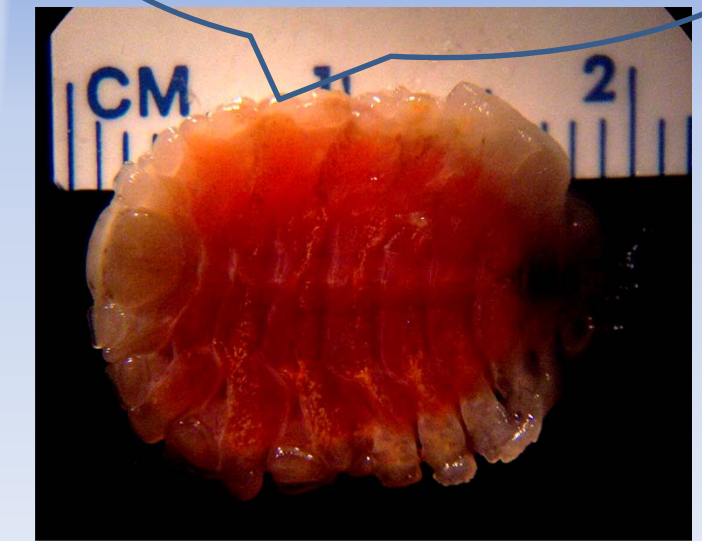
2008 Survey of U. pugettensis (Chapman et al. 2012)



Only known (first?) introduced bopyridan parasite

Bopyridan ecology, natural history and population biology unknown

Who?
Me????

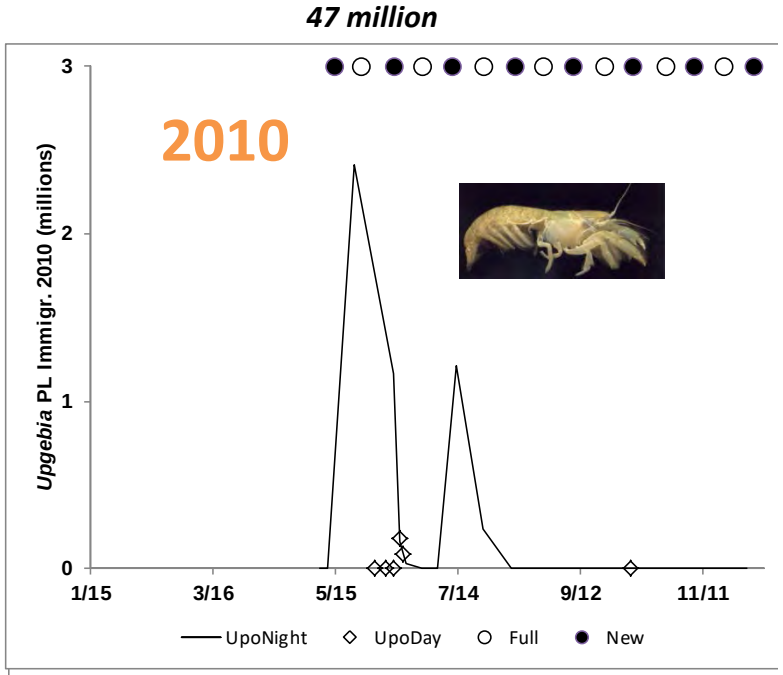


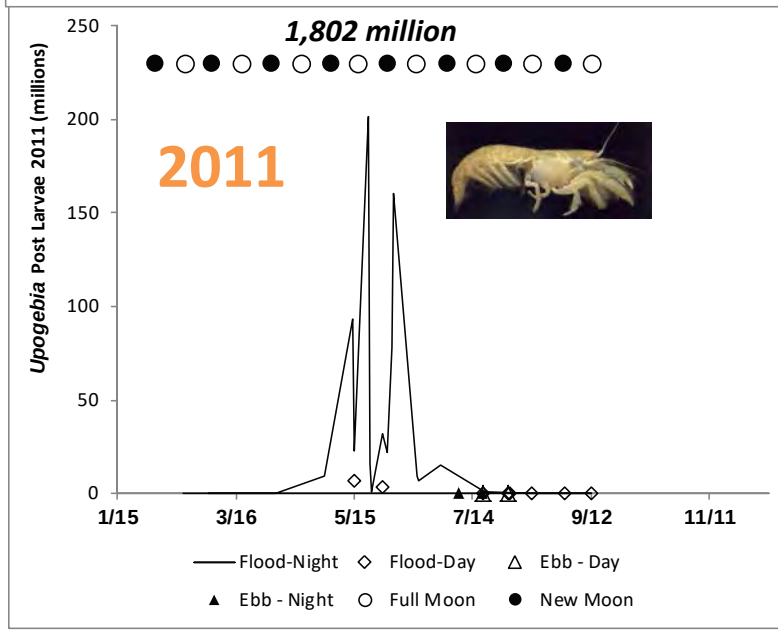
Previous records of bopryidans controlling host populations unknown

Could effective castration limit *Upogebia* populations?

Could lost reproduction control *Upogebia* populations?

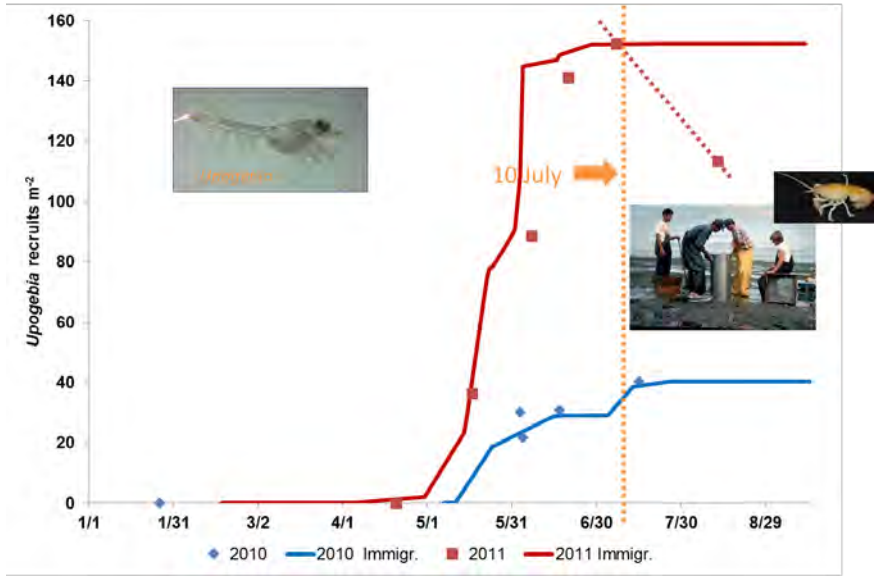
Yes. Upogebia are recruitment limited





***2010 Upogebia* 3% of 2011**

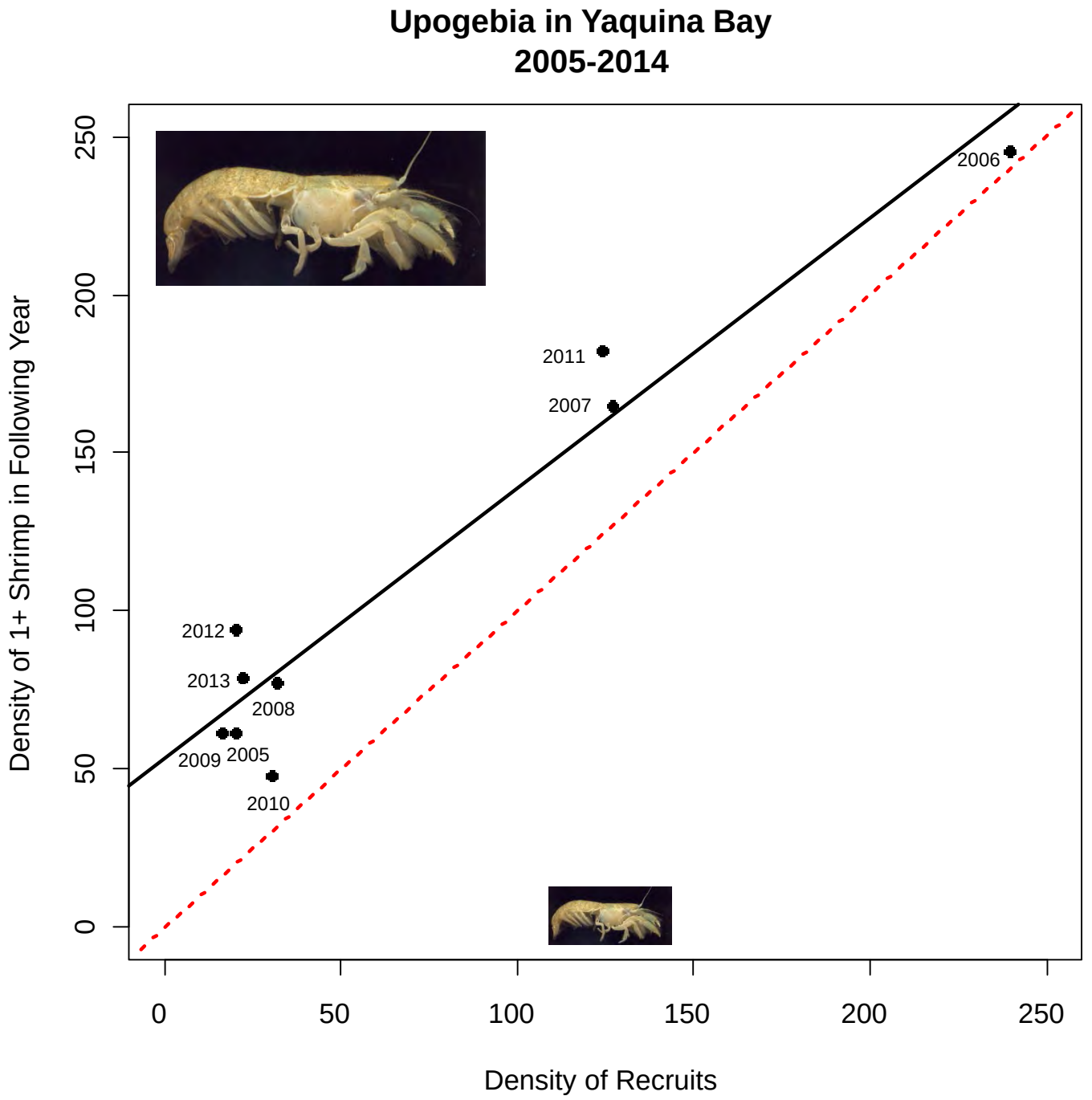
Benthic abundances increase with immigration



2010 and 2011 *Upogebia* 0-year benthic density accumulation with immigration

Yes.

Mature *Upogebia* populations are recruitment limited



Can *Orthione* reach all hosts?

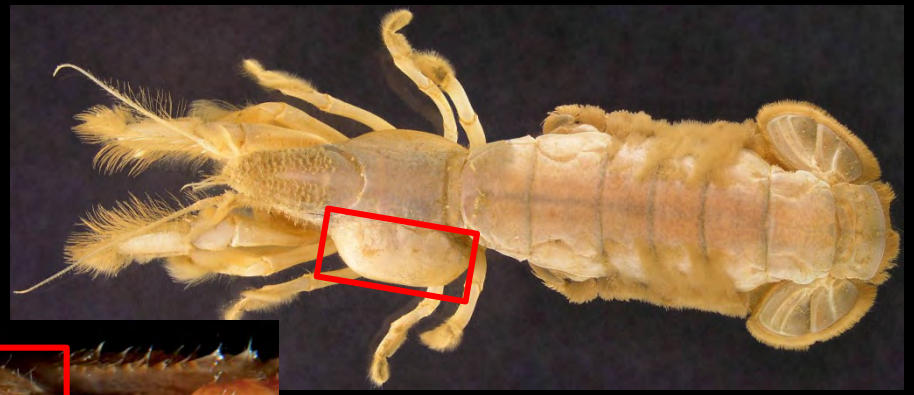
Are *Orthione* host limited?

Are there likely host refuges?

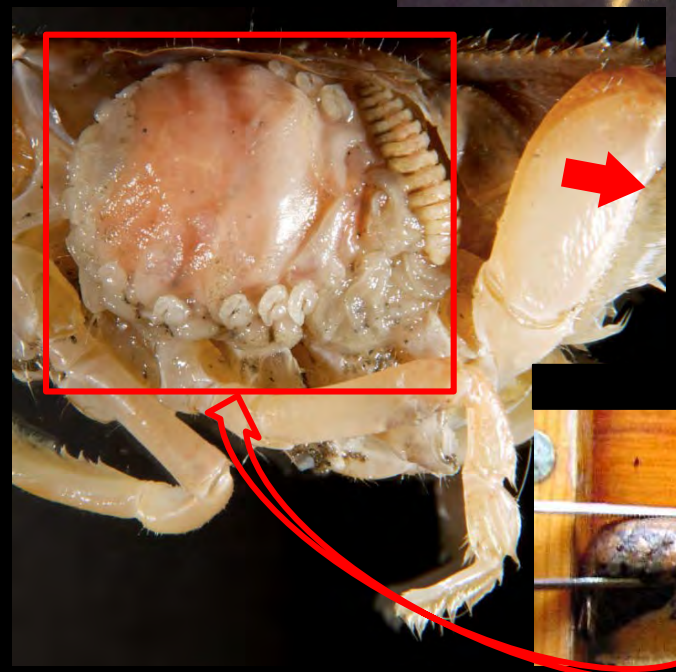
Are the *Orthione* propagules limited?

Who?
Me????

Abundant, persistent *Orthione* populations?

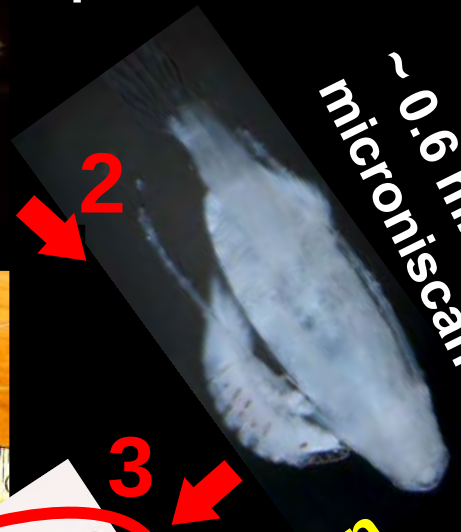


~ 0.3 mm pelagic epicaridan



1

2



~ 0.6 mm pelagic
microniscan

3

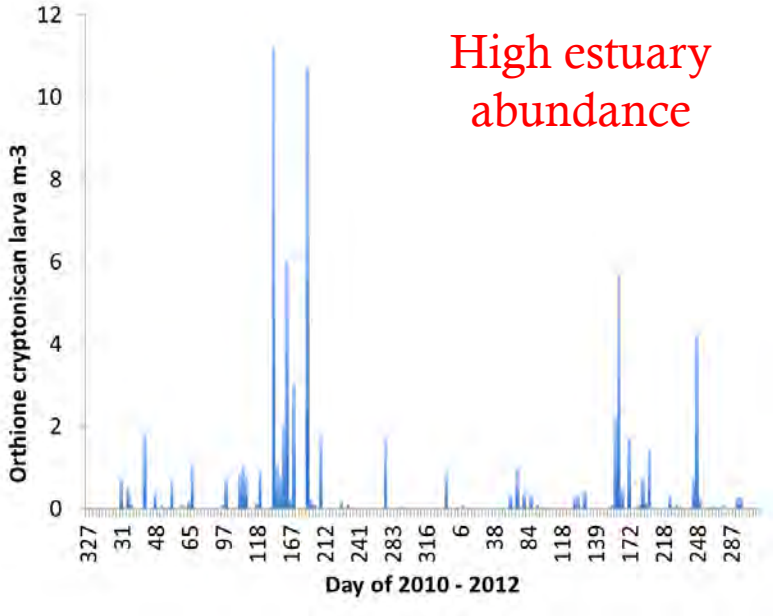
~ 0.8 mm cryptoniscan
settles into host

***Brooding Orthione* and its 3 larval dispersal stages**

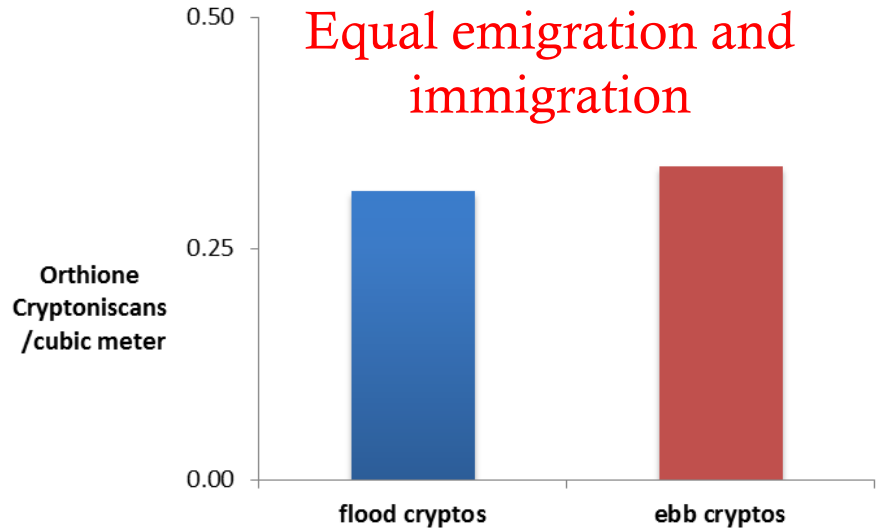
Breitenstein et al. (unpublished MS)

Cryptoniscan movements in flood and ebb tide plankton samples: **They wait.**

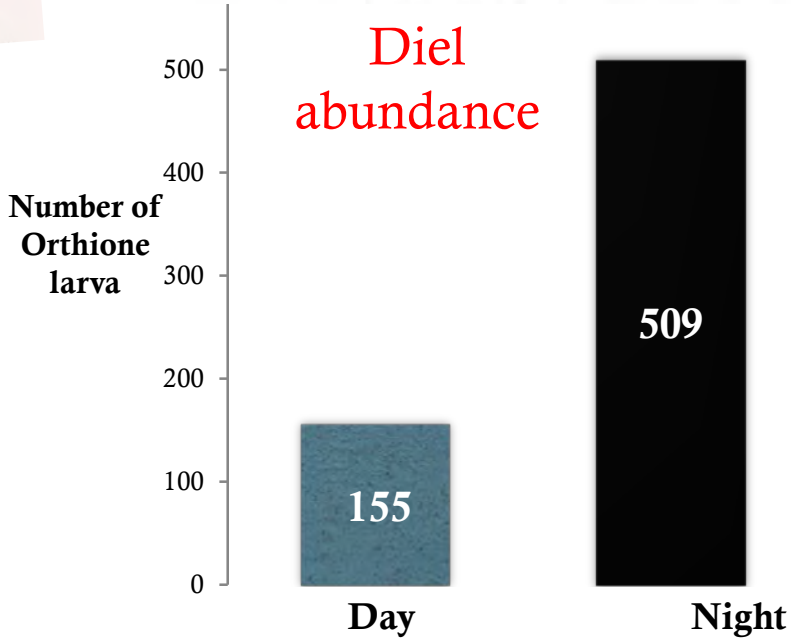
High estuary abundance



Equal emigration and immigration

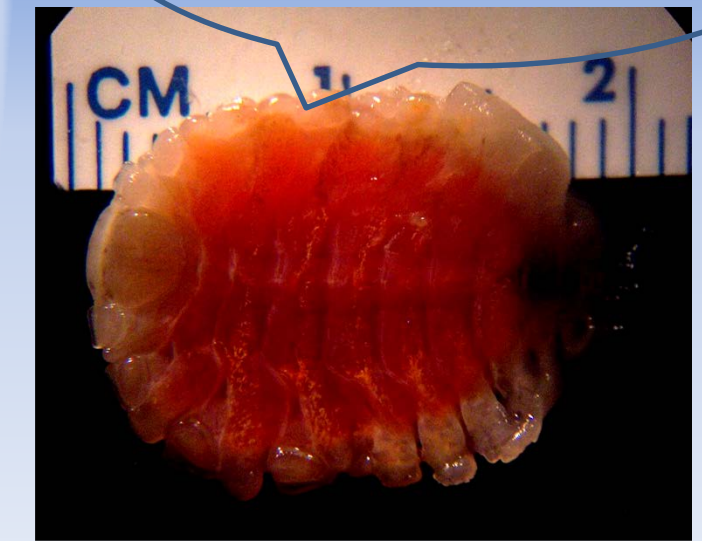


Diel abundance



Only known (first?) introduced bopyridan parasite
Bopyridan ecology, natural history and population biology

Who?
Me????



No previous records of bopryidans controlling host populations

First hypothesis – could effective castration limit reproduction?

Could lost reproduction control host populations?

Unexpected infestation patterns

Infest > 12 mm shrimp and ~2 females for each male

Dumbauld et al. 2011

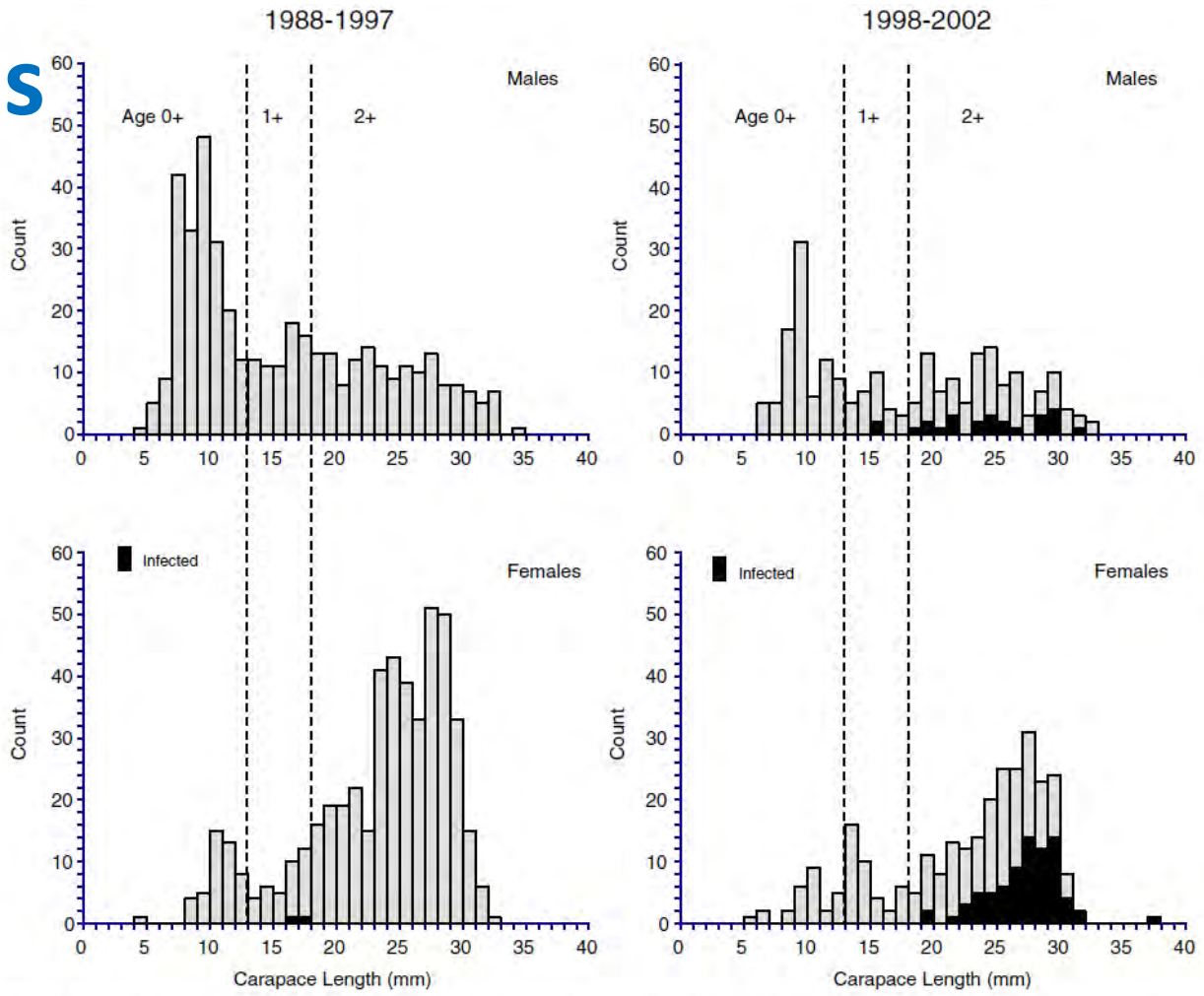


Fig. 2 Size (CL in millimeters) of male (*top*) and female (*bottom*) *U. pugettensis* collected at Cedar River, Willapa Bay before (1988–1997, *left*) and after *O. griffenis* became abundant (1998–2002, *right*). The higher overall prevalence of isopod parasites on female hosts can be explained by their presence on >18 mm CL shrimp which are presumably 2+ animals (presumed age classes divided by *dashed lines*) and a skewed sex ratio with more large females present regardless of whether the parasite is present

Smith et al. 2011

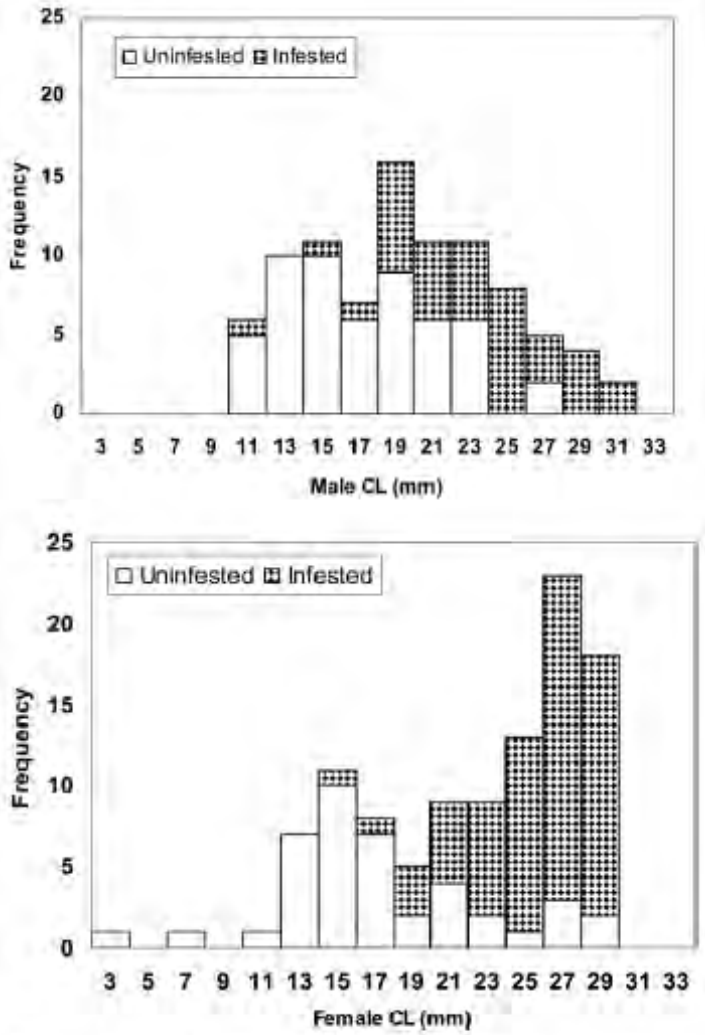
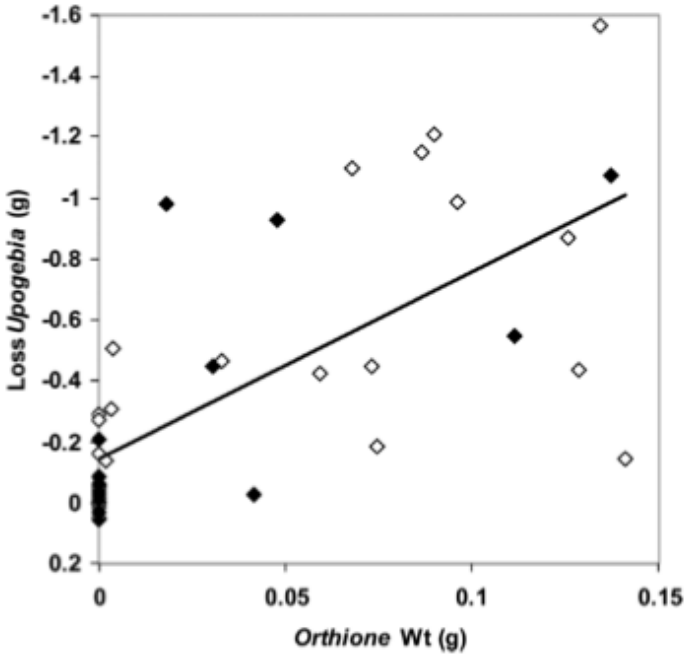


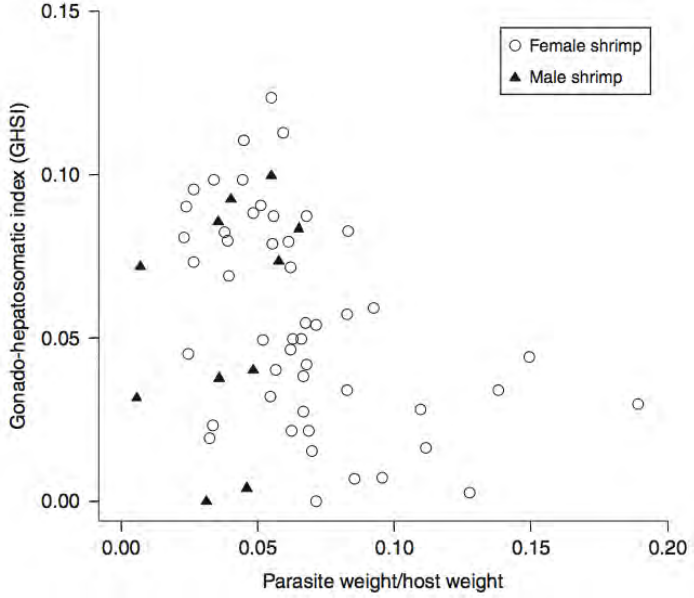
Fig. 2. Carapace length (CL) frequencies of infested and uninfested (diamonds and open) males and females of *Upogebia* from all samples at 2 mm midpoint intervals.

No Evidence of Energetic Cost

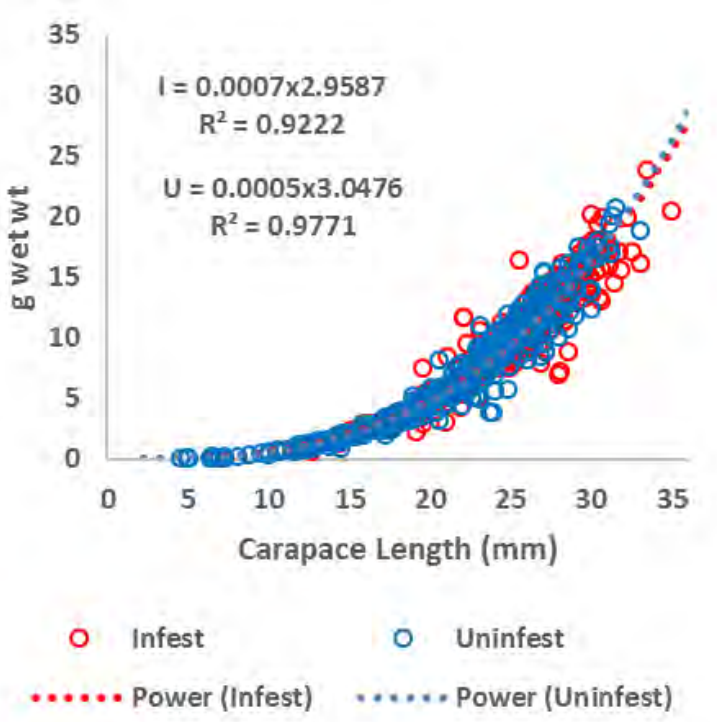
No apparent association of weight loss and parasite size (Smith et al. 2008)



No apparent relation between lipid concentrations and relative size of parasite (Repetto and Griffen 2012)

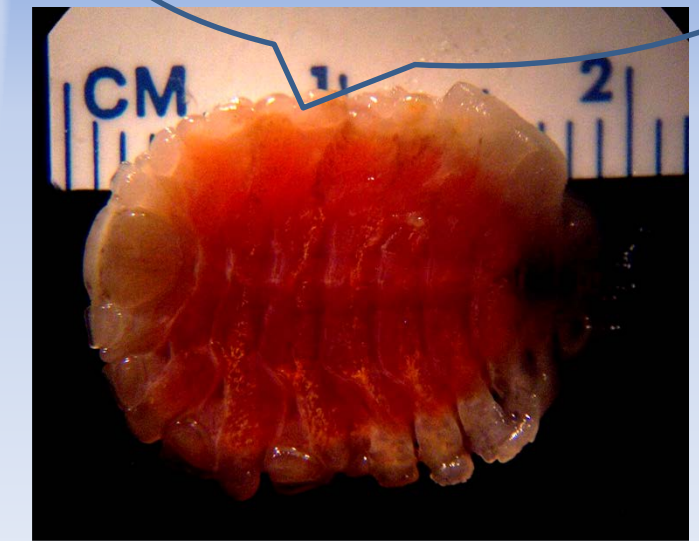


No apparent loss of host weight associated with *Orthione* (Burton et al. In Prep.)



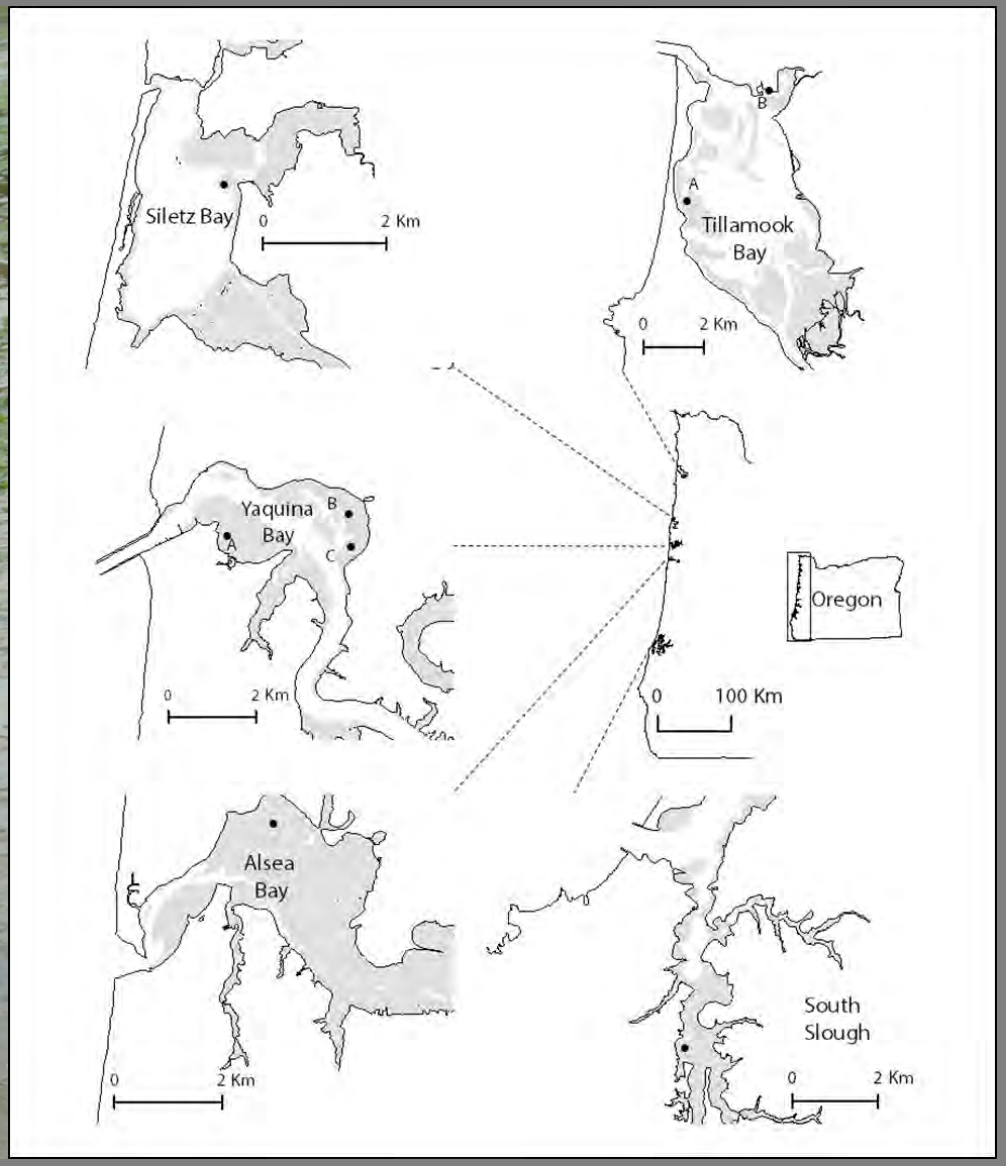
Do Orthione limit host reproduction or otherwise stress their hosts?

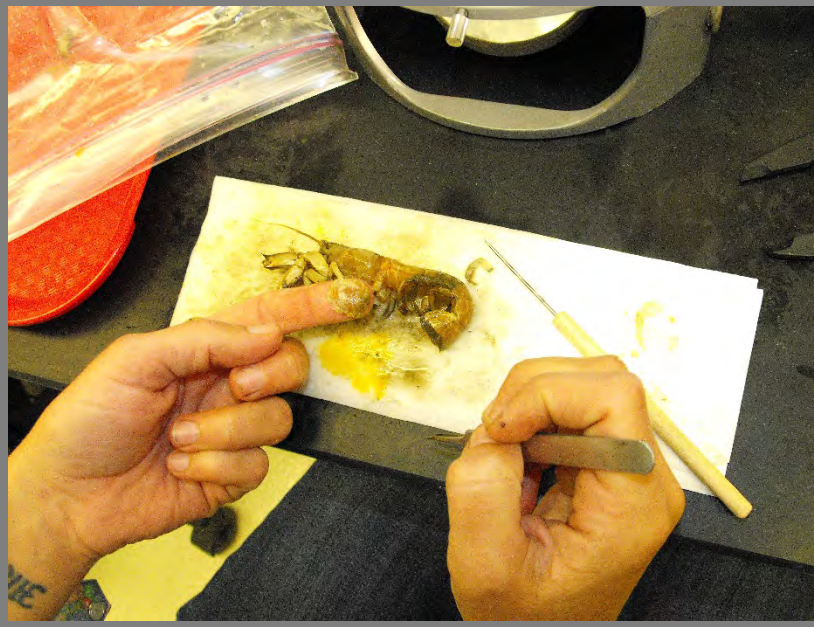
Who?
Me????

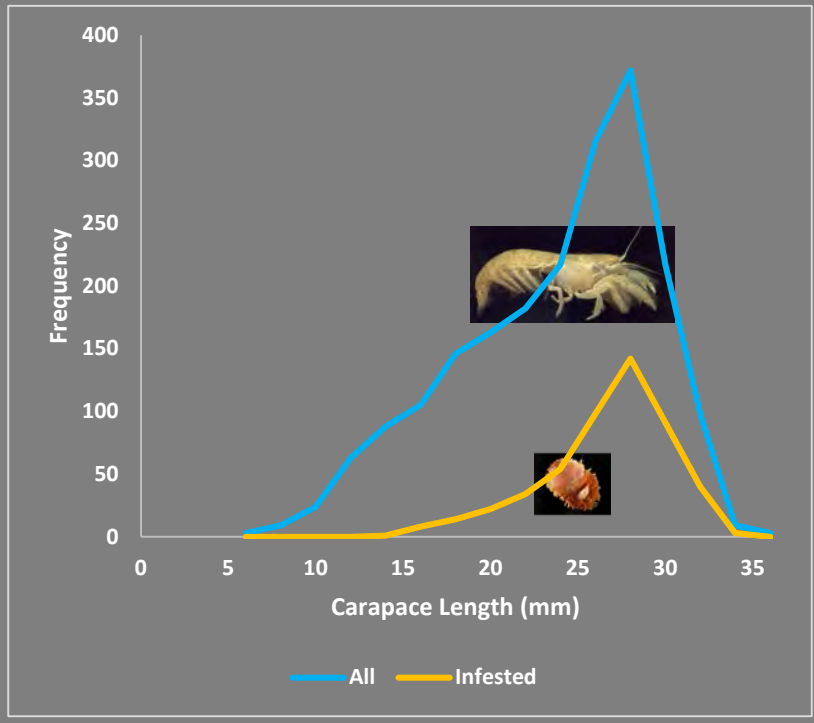


1) Do they change host sex?
2) Do they kill host males?

3) Do they take enough host resources for effective castration?

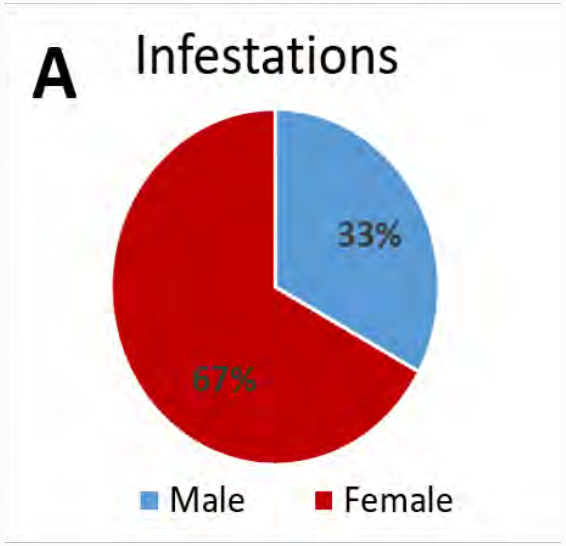

Siletz Bay
0
2 Km
Tillamook Bay
A
B
0
2 Km
Yaquina Bay
A
B
C
0
2 Km
Oregon
0
100 Km
Alsea Bay
0
2 Km
South Slough
0
2 Km

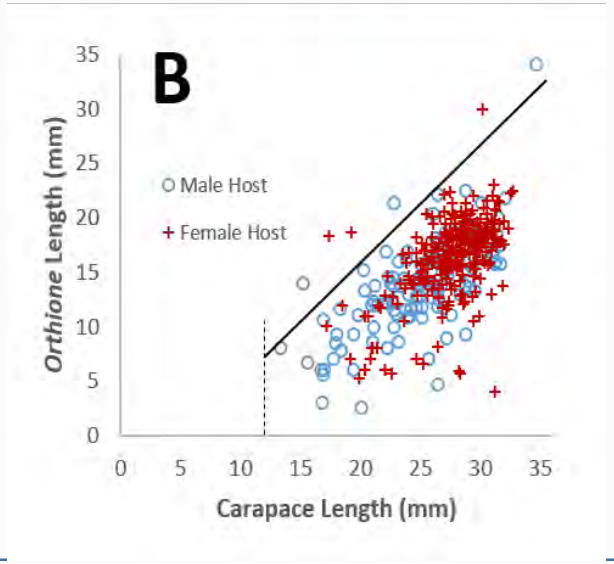


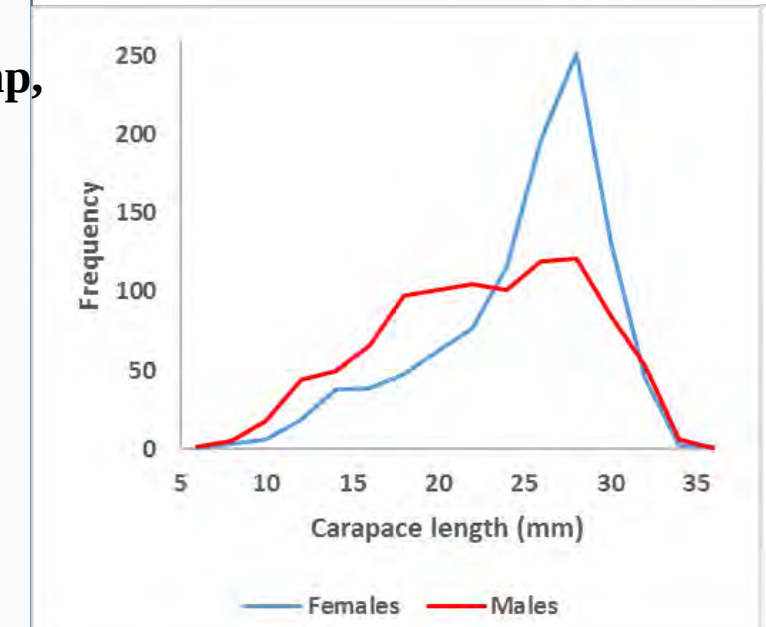

400
350
300
250
200
150
100
50
0
Frequency
0
5
10
15
20
25
30
35
Carapace Length (mm)
All
Infested

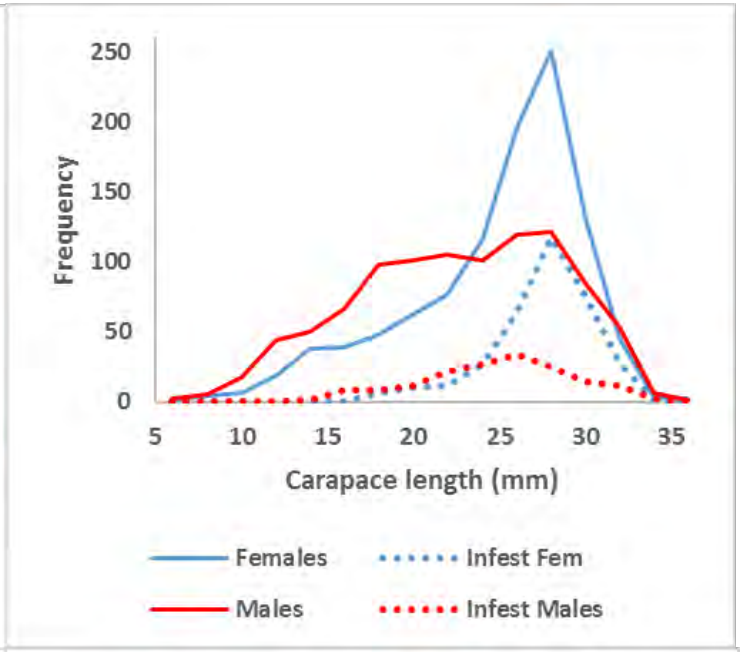
No evidence that the introduced parasite, *Orthione griffenis*, causes sex change or differential mortality in the native mud shrimp, *Upogebia pugettensis*

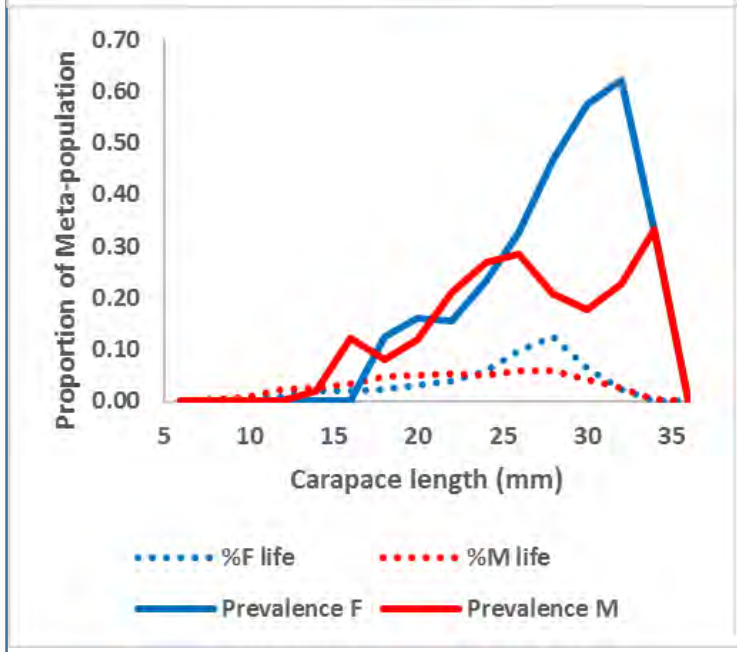
Danielle Asson, John W. Chapman, Brett R. Dumbauld

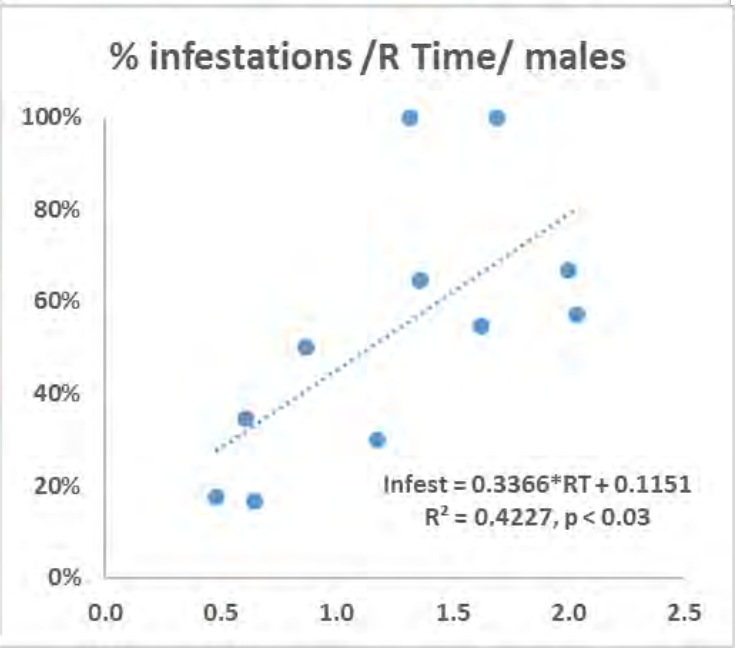










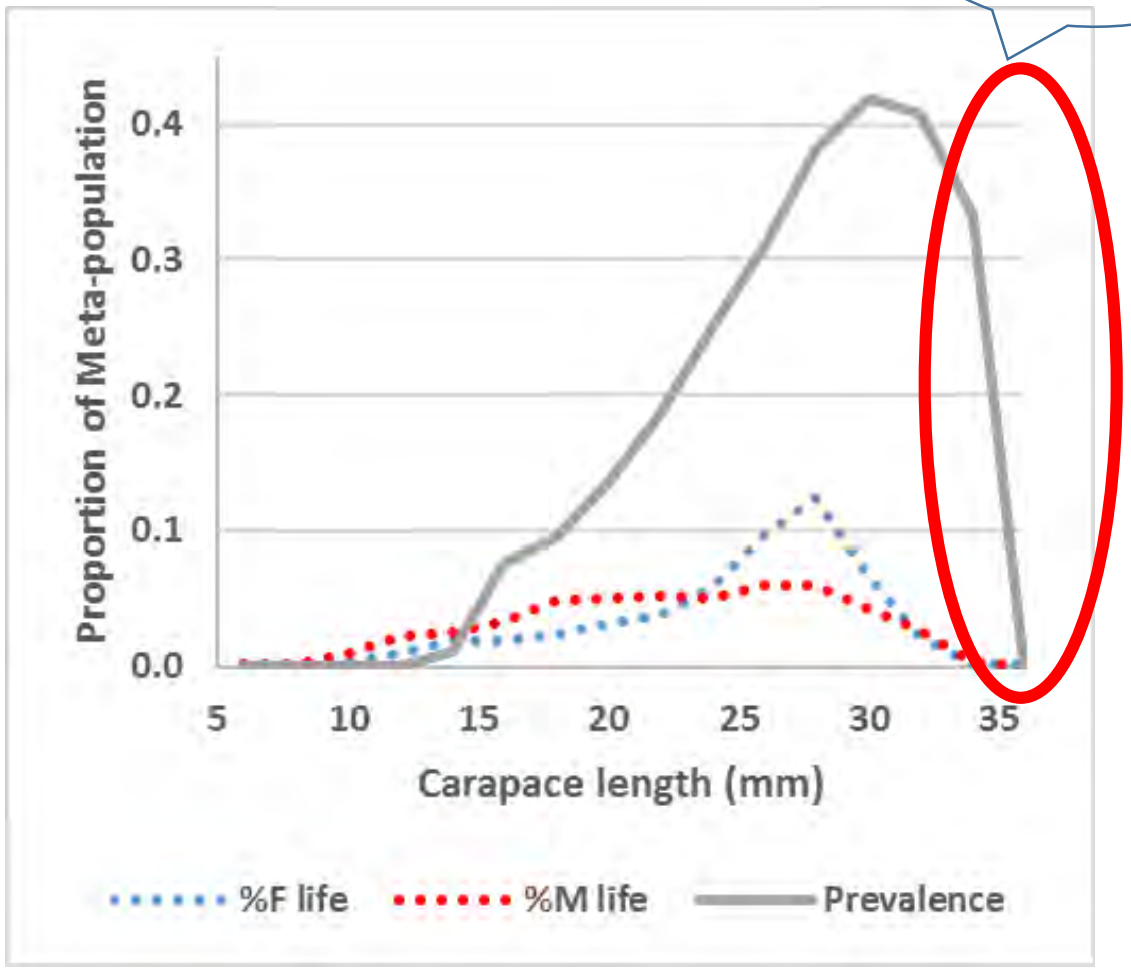


Do Orthione limit host reproduction or otherwise stress their hosts?

1) Do they change host sex? **NO**
2) Do they kill host males? NO

<u>And</u> there seems to be an energetic cutoff at around 12 mm

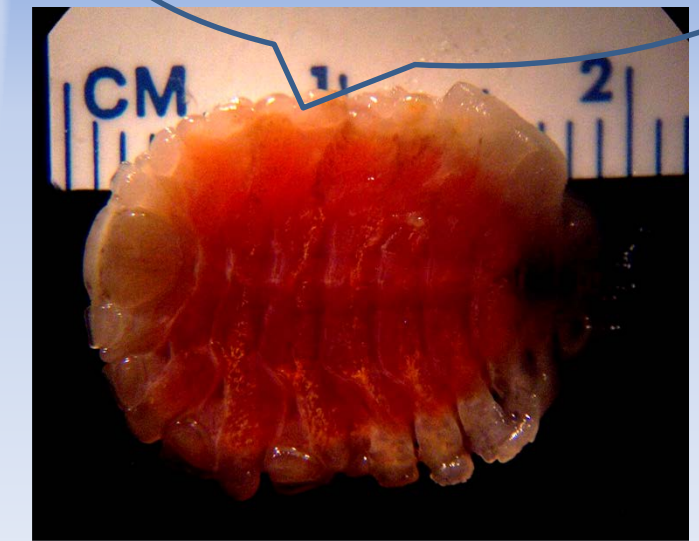
But more questions remain



Remember this decline

Do Orthione limit host reproduction or otherwise stress their hosts?

Who?
Me????

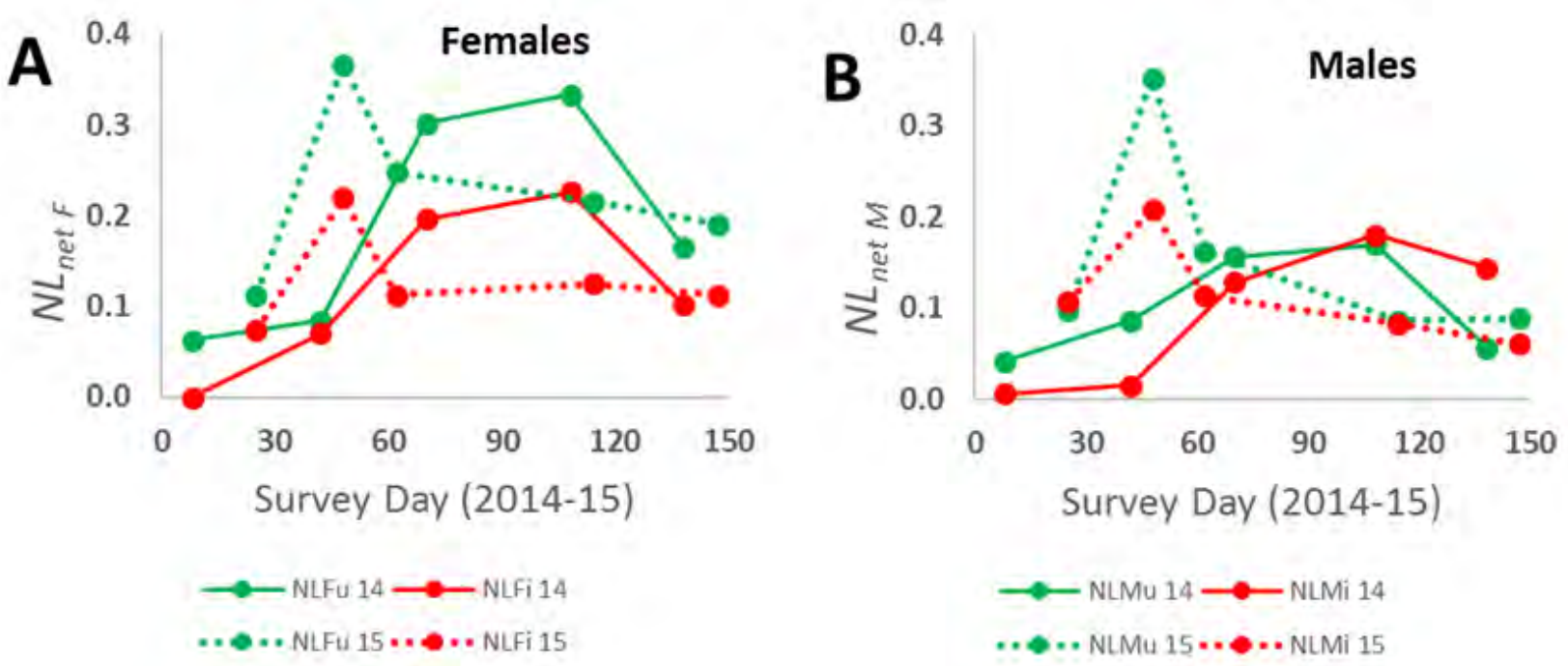


1) Do they change host sex? **NO**
2) Do they kill host males? NO

3) Do they take enough host resources for effective castration?

Energetic losses to the introduced bopyrid isopod parasite, *Orthione griffenis*

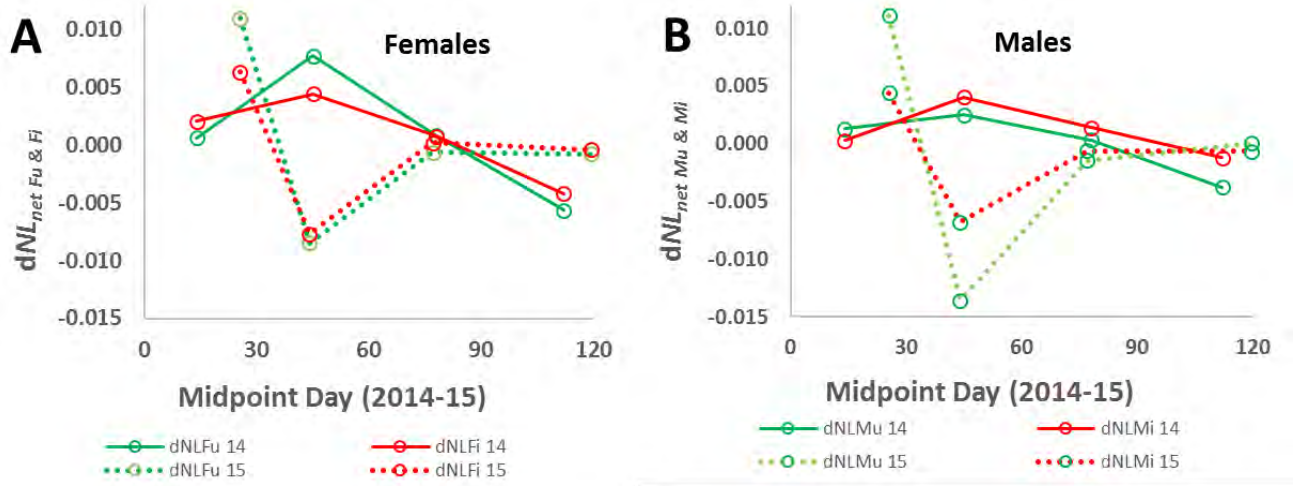
Andrea R. Burton, John W. Chapman, Brett R. Dumbauld, Richard Caldwell, and Louise A. Copeman

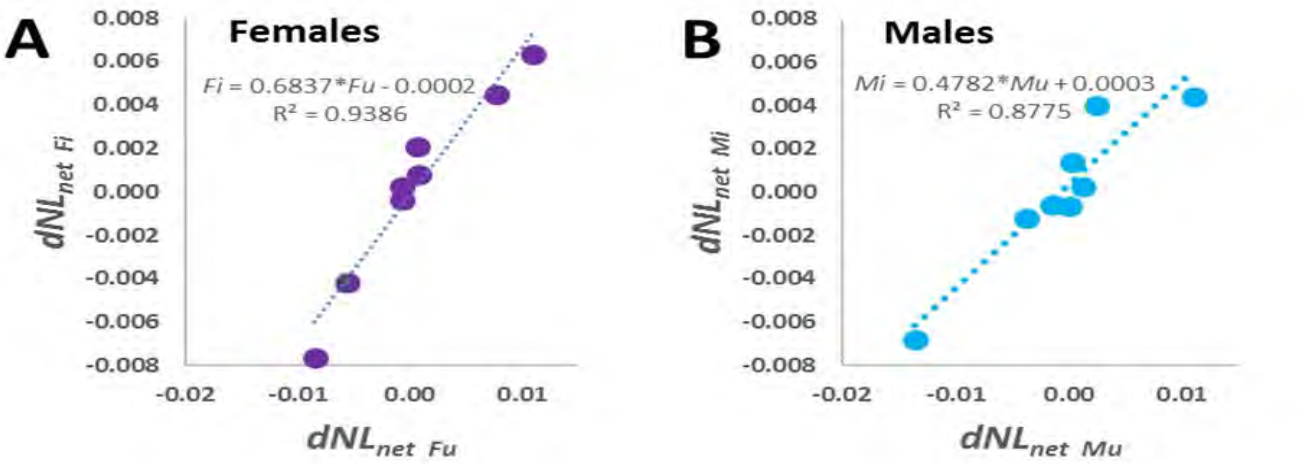


Infested shrimp lose lipids!

Energetic losses to the introduced bopyrid isopod parasite, *Orthione griffenis*

Andrea R. Burton, John W. Chapman, Brett R. Dumbauld, Richard Caldwell, and Louise A. Copeman

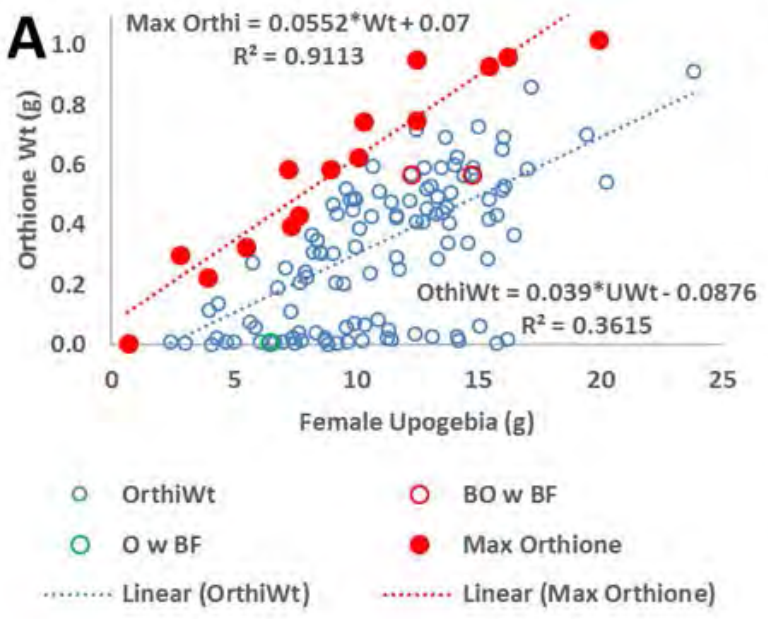


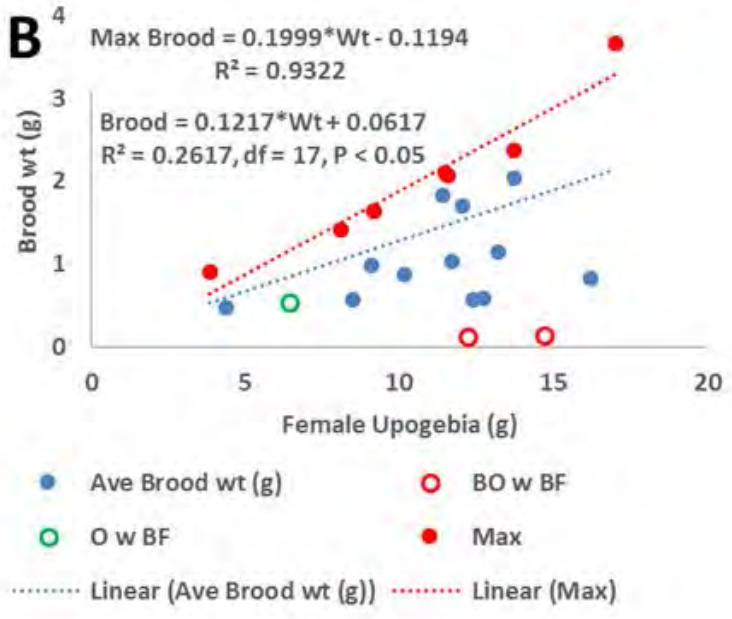


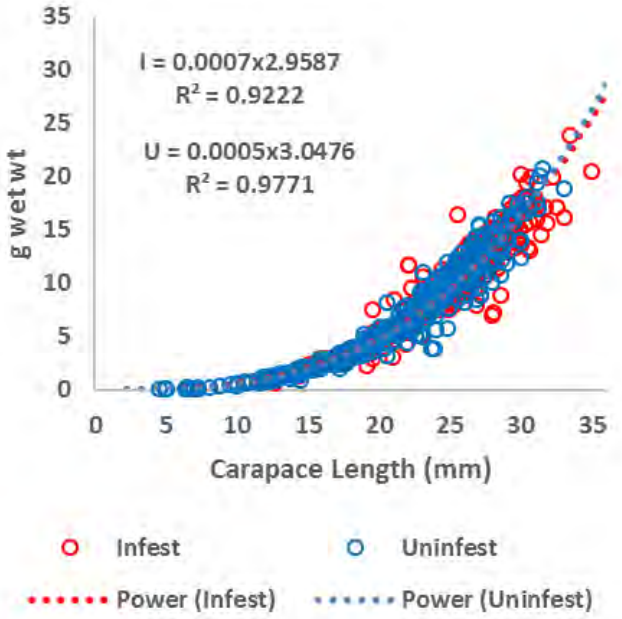
They lose lipids **a lot** of lipids!3

Growth adjustments by *Upogebia pugettensis* hide energetic losses to the introduced bopyrid isopod parasite, *Orthione griffenis*

Andrea R. Burton*[1], John W. Chapman[2], Brett R. Dumbauld[1], Richard Caldwell[3], and Louise A. Copeman[4]







Crustacea adjust their sizes to energy/biomass

Do Orthione limit host reproduction or otherwise stress their hosts?

1) Do they change host sex? **NO**
2) Do they kill host males? **NO**
3) Do they take enough host resources for effective castration? **Yes**

Do Orthione limit host reproduction or otherwise stress their hosts?

Yes. YOU!

Who?
Me????

End of story?

No. Not end of story

Invasion of San Francisco Bay by *Upogebia major*

A newly recognized non-native species with potentially large ecosystem consequences

Michael McGowan — Maristics
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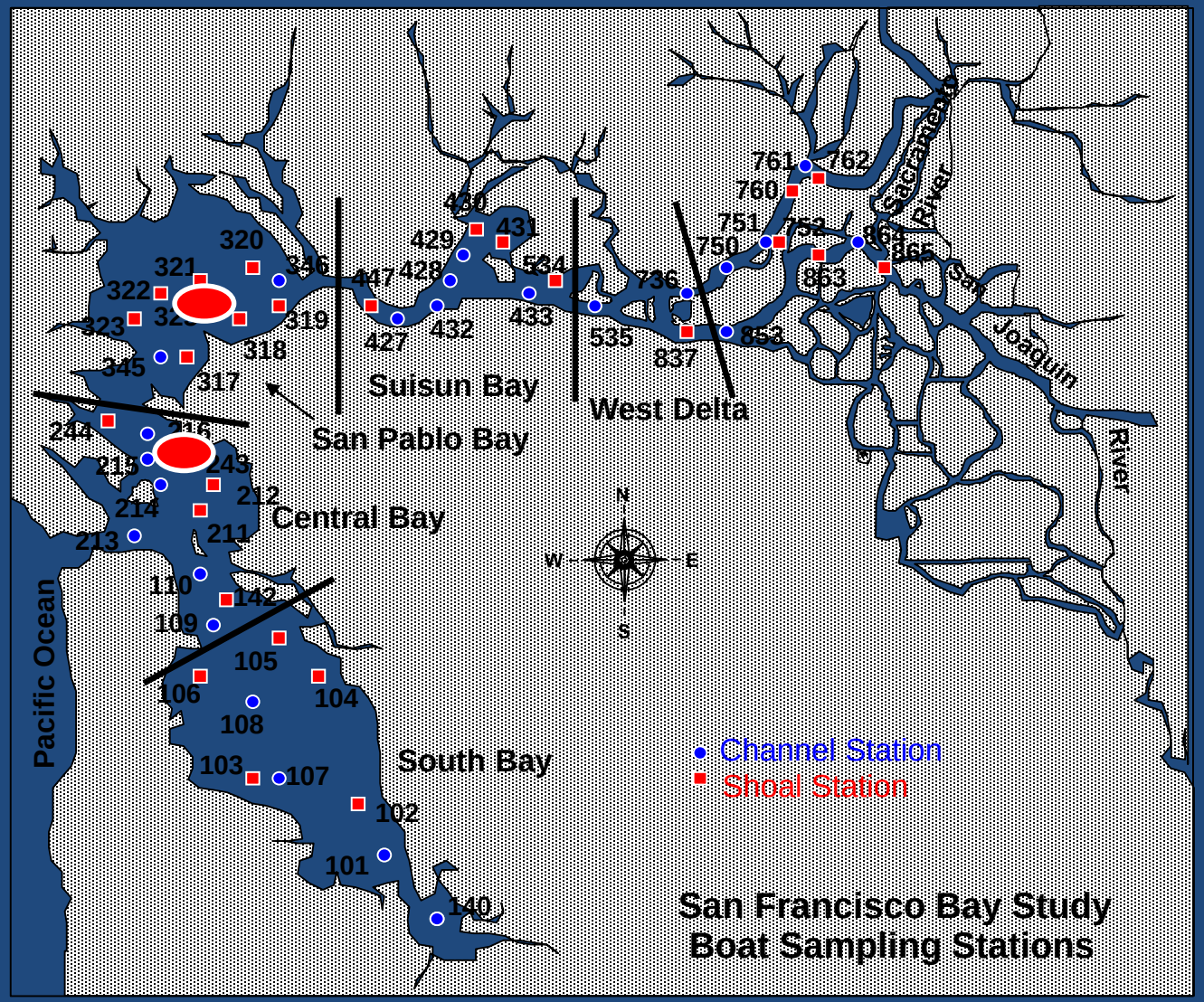
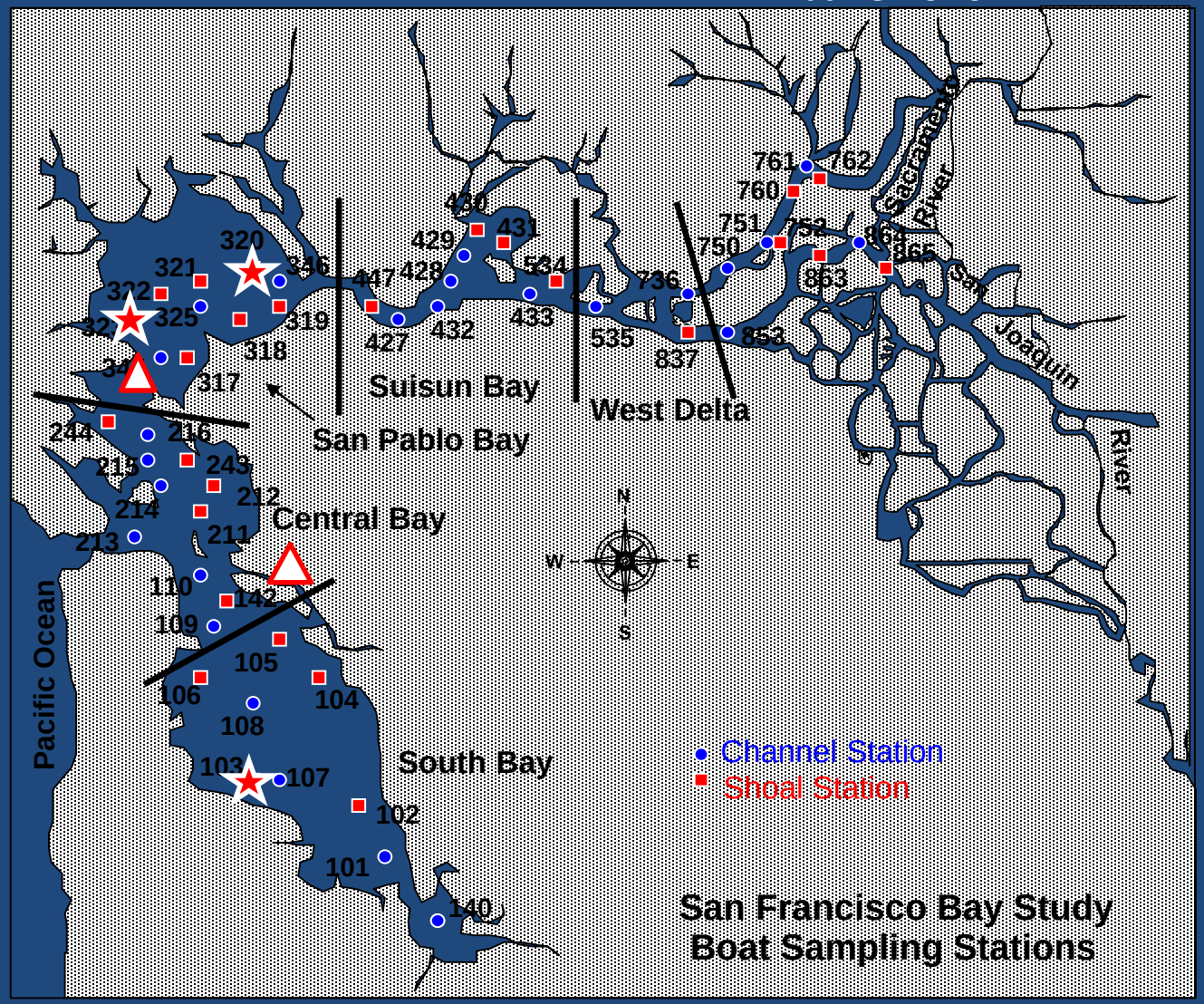
Andrew Cohen — C.R.A.B.
Kathy Hieb — California Dept. Fish and Game

USACE July 2011 *Upogebia* sp. benthic in mud



DFG larval *Upogebia*

MLML benthic in mud June 2010

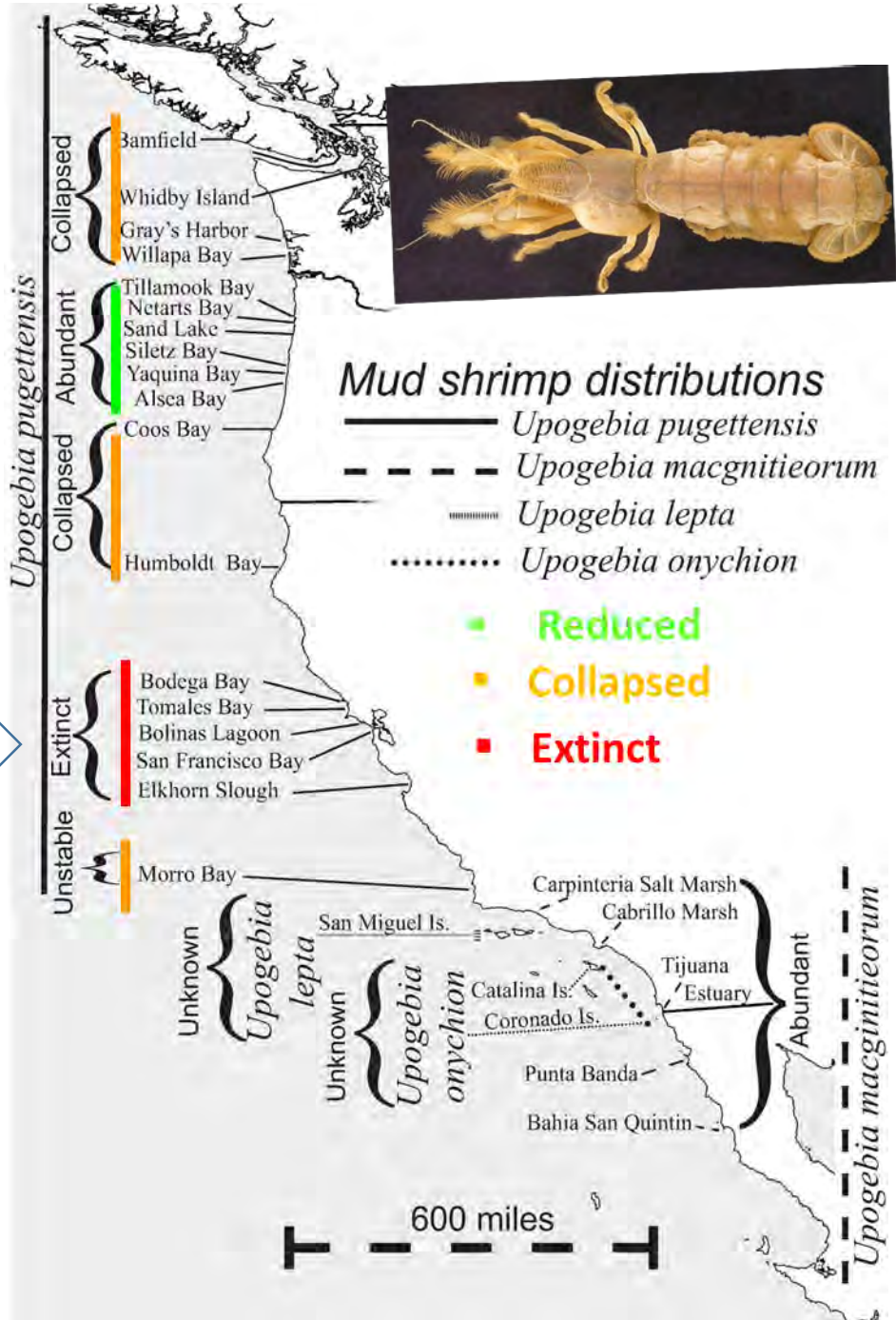


The Asian mud shrimp, *Upogebia major* invasion of the northeast Pacific: a coevolved host of the introduced Asian bopyrid isopod, *Orthione griffenis*

John W. Chapman[1], Michael F. McGowan[2], Ralph A. Breitenstein[3], Andy Cohen[4] Kathy Hieb[5] and Ralph Appy[5]

How come so late a discovery?

San Francisco Bay **2010**
Drakes Estero 2015
Bodega Harbor 2016



The Asian mud shrimp, *Upogebia major* invasion of the northeast Pacific: a coevolved host of the introduced Asian bopyrid isopod, *Orthione griffenis*

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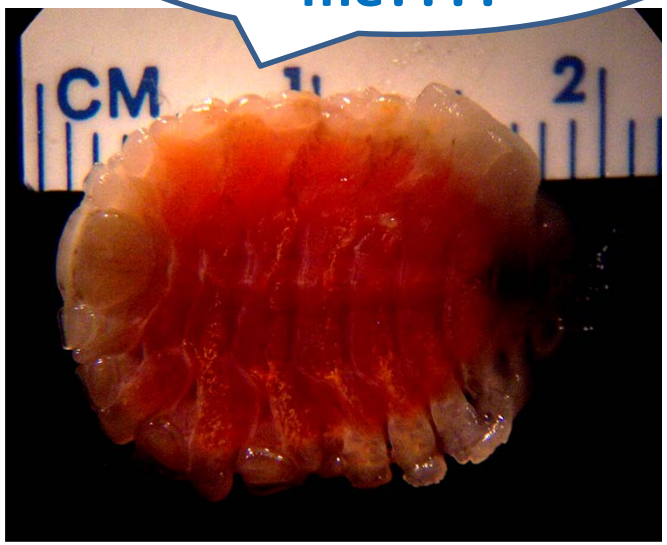
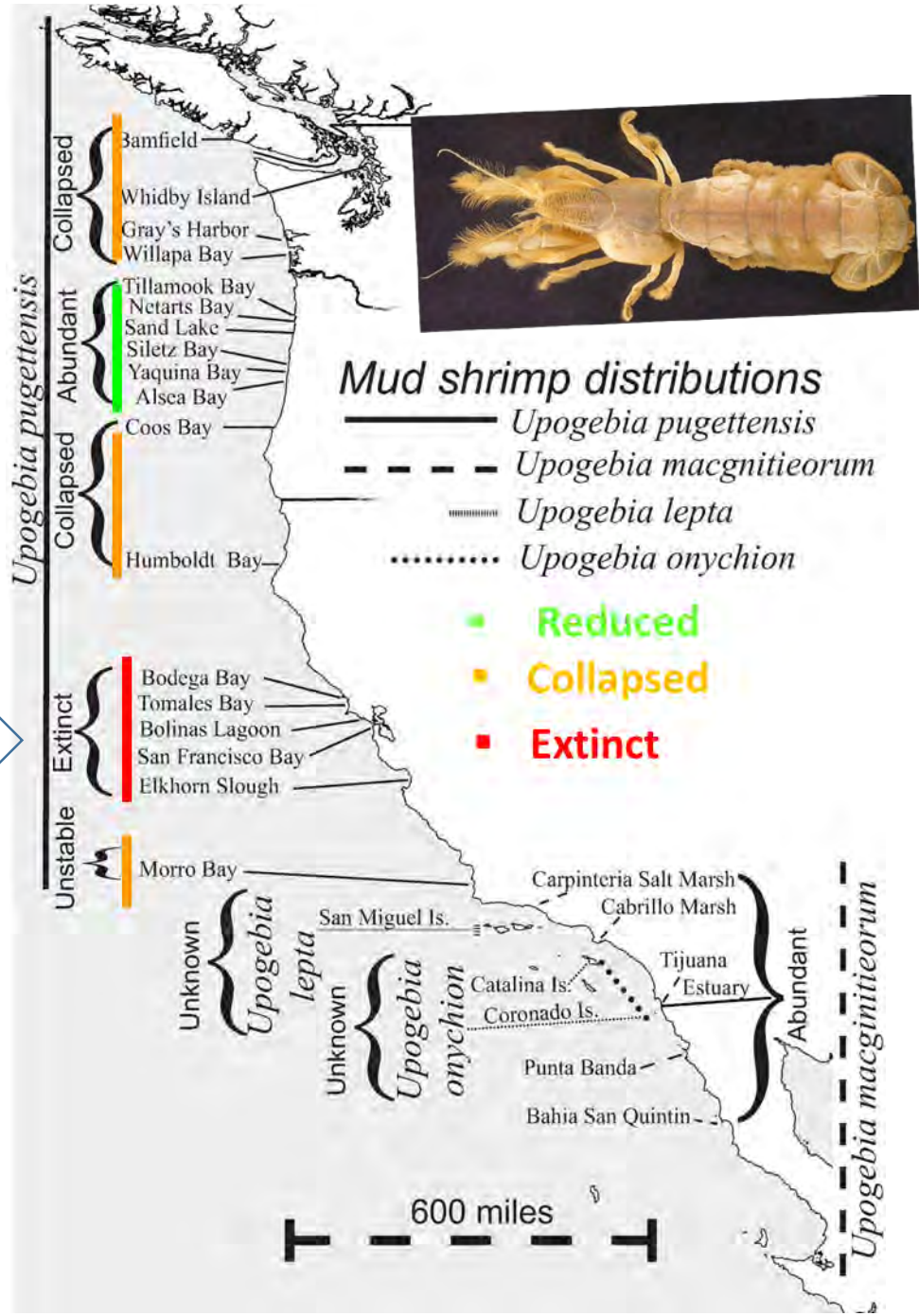
Drakes Estero 2015
Bodega Harbor 2016

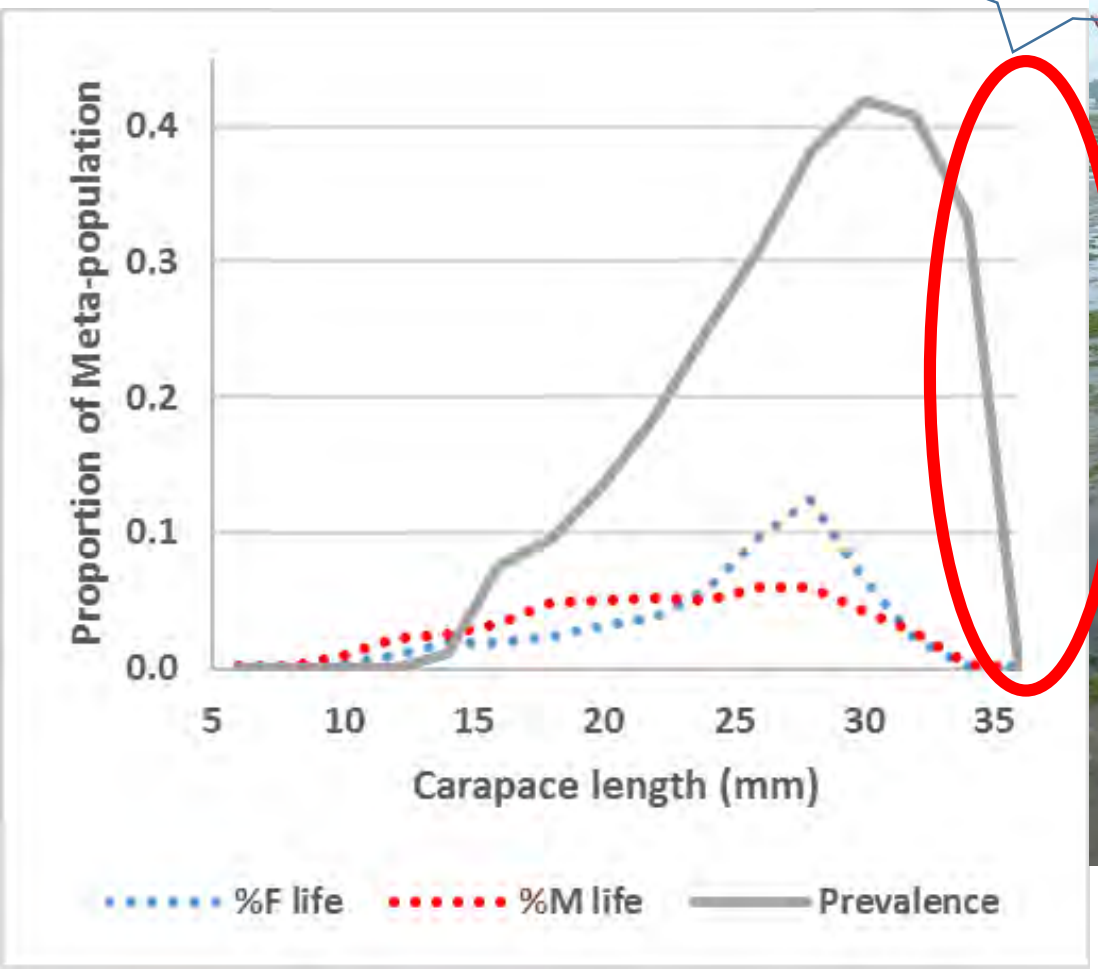
What's that got to do with me????



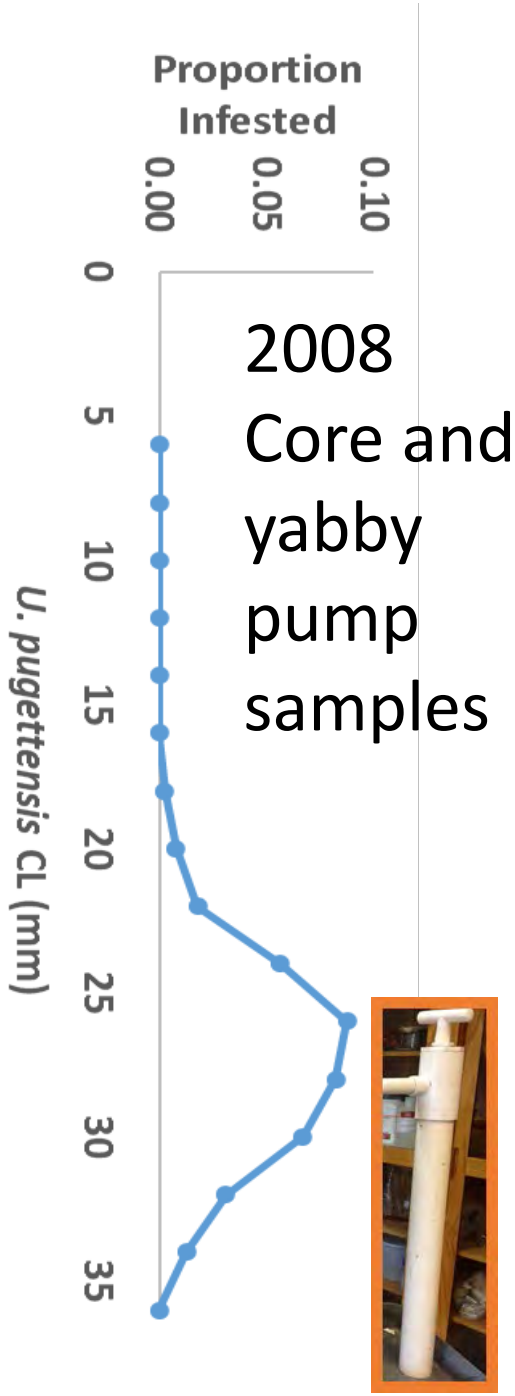
Upogebia major is a native host of *Orthione griffenis*



More questions



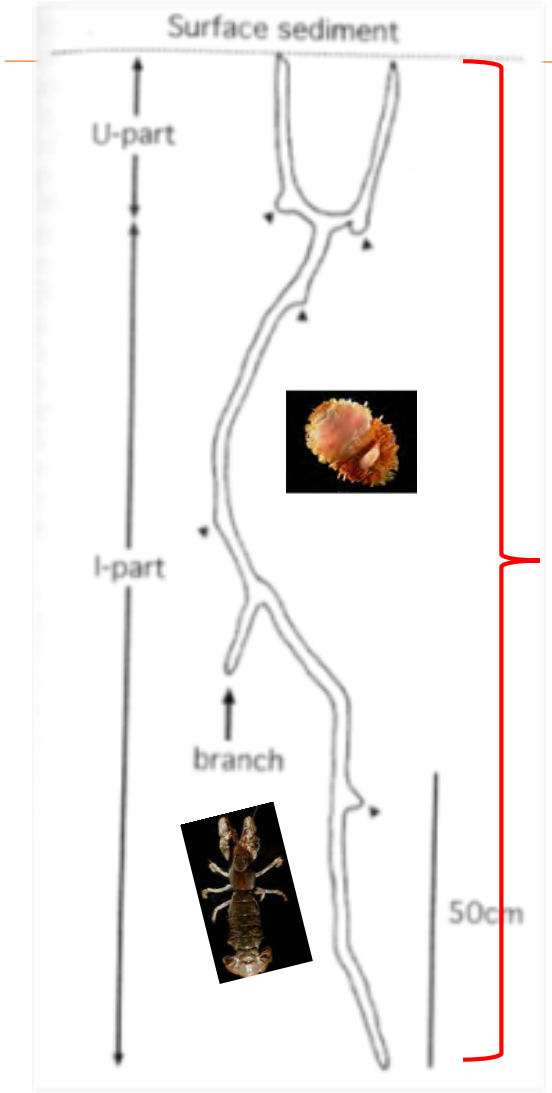
Did you remember?



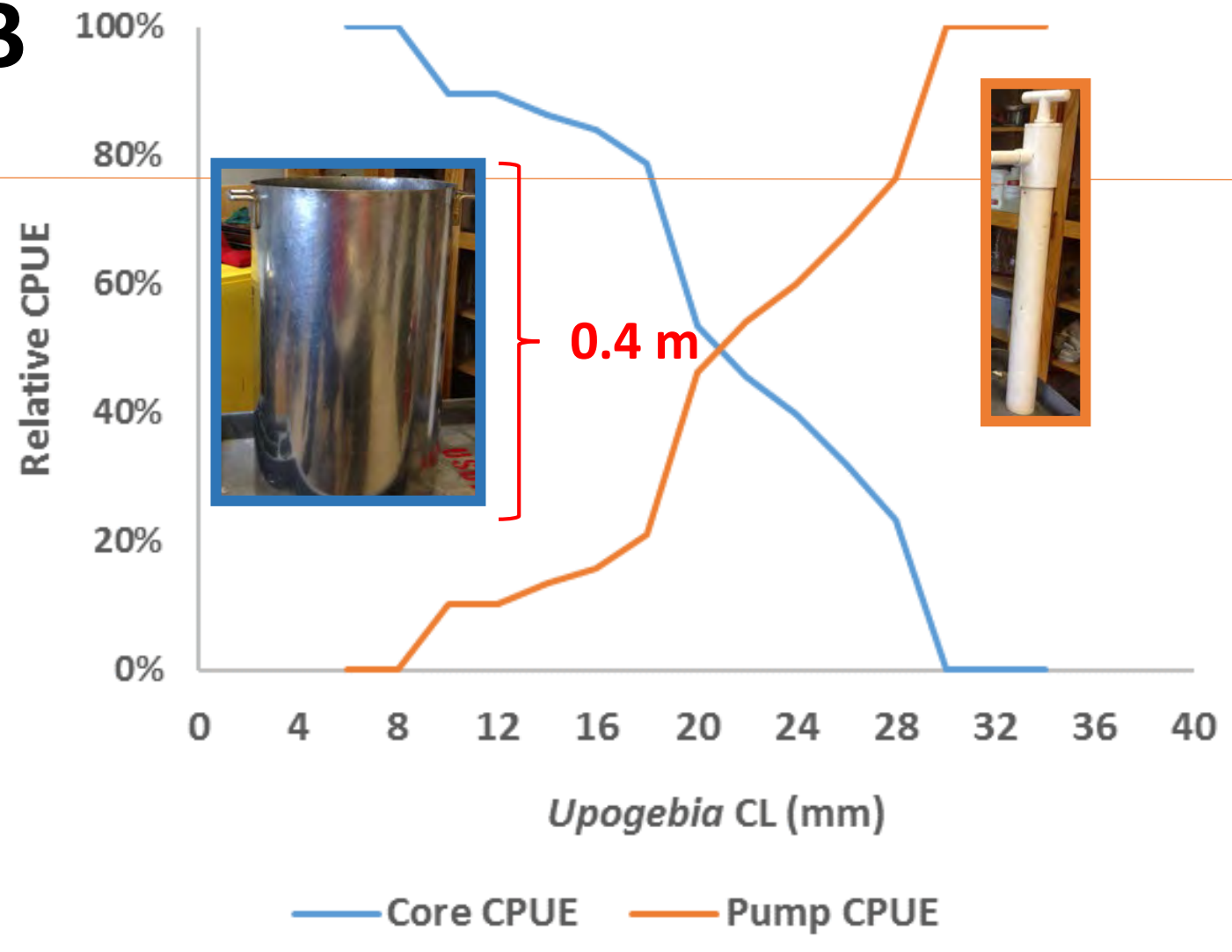
2008 Core and yabby pump samples

Possibly more to this than “time at size”

A



B



C

Cores miss the biggest and deepest shrimp

Deep Core Project 2017

Team 1: Omar M. Alkhaldi, Eric M. Beebe, Cade T. Burch. Team 2: Connor Churchill, Patrick L. Finn, Jacob A. Garrison. Team 3: Zachary M. Gerard, Evan J. Leal, Derrick E. Purcell, Derrick E

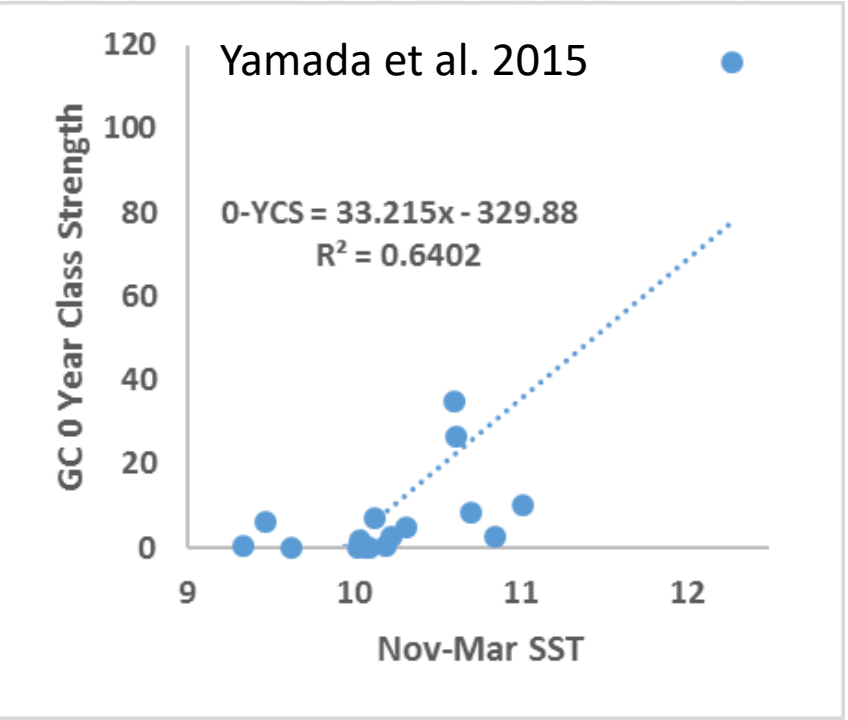
Vol. 537: 173–189, 2015
doi: 10.3354/meps11431
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published October 14

Biological and physical ocean indicators predict the success of an invasive crab, *Carcinus maenas*, in the northern California Current

Sylvia Behrens Yamada[1,*], William T. Peterson[2], P. Michael Kosro[3]

Table 1. Relative abundance of age-0 *Carcinus maenas* in Oregon and Washington estuaries. Catches are given as the number of age-0 crabs per 100 trap-days (min of 50–100 trap-days per estuary) at the end of their first growing season (late August to early November). When no catch data for age-0 crabs were available, we deduced the presence (p) or absence (–) of a cohort from age class analysis of adult crabs in subsequent years. The 5 years with highest year-class strength are shaded

Site	Catch (no. per 100 trap-days)																
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	100	2	1	1	0	–	–	3	2	0		0					
	76	2	4	4	0	10	–	77	8	0	0	0	12	0	0	0	0
	125	p	p	2	0	17	10	17	32	0	0	0	0	0	0	0	1.5
	139	–	–	6	0	15	0	92	65	0	0	2	30	0	0	0	25.7
	192	20	31	p	1	7	7	14	20	3	2	0	5	0	0	0	2.1
	65	–	–	–	0	1	0	5	32	7	1	0	4	1	0	–	1.5
	6	5	5	5	6	6	6	6	6	6	5	6	5	5	5	4	5
strength	116	4.8	7.2	2.6	0.17	8.33	2.83	34.7	26.5	1.67	0.6	0.33	10.2	0.2	0	0	6.16
-class	2.068	0.763	0.914	0.556	0.068	0.970	0.583	1.553	1.439	0.426	0.204	0.124	1.049	0.079	0	0	0.855



Thanks a bunch!

No problem!

Thank you!