



"Invasion dynamic of skeleton shrimps in European waters: global distribution, ecology and vectors of spread"

2017 Francesca Gherardi Memorial Award



Macarena Ros

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INTRODUCTION

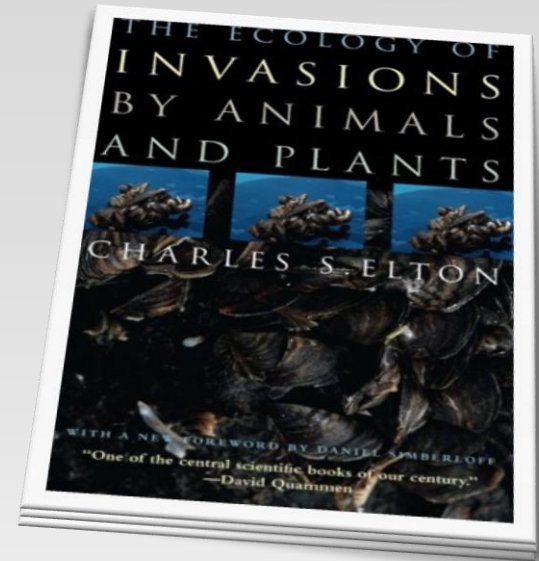


Photo: J.M. Guerra



❑ Biological invasions

➤ Biological invasions can occur when organisms are transported **outside** their **native** range of distribution where they **proliferate, spread, and persist** (*sensu* Elton 1958)



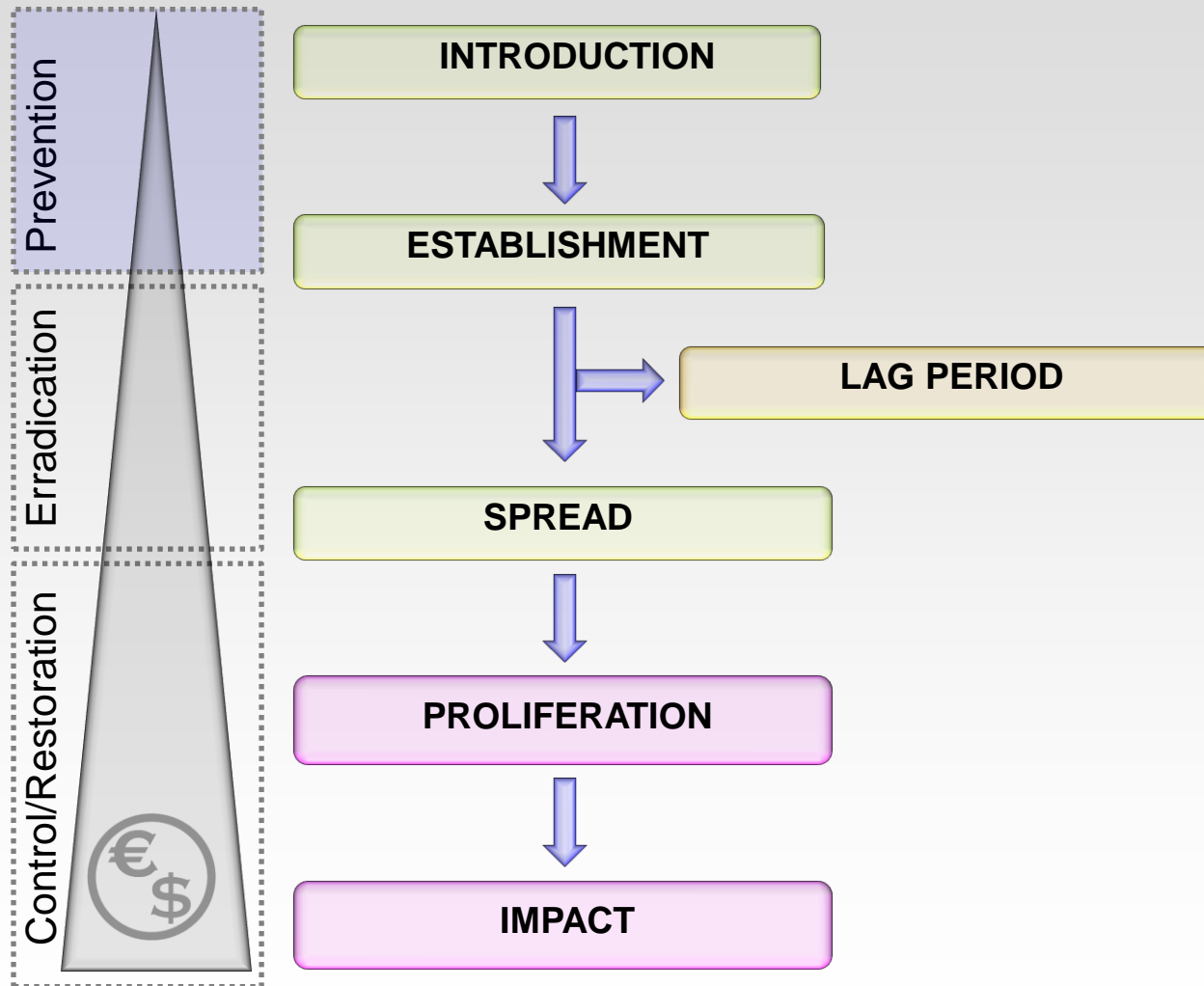
❑ Biological invasions and 'Global Change'



➤ Dramatic **increase** of **species introductions** in the past 200 years (di Castri 1986).



□ Generalized steps in the invasion process and their management



(Modified from Sakai *et al.* 2001)

1. Introduction

2. Model organisms

3. Looking for exotics

4. Introduced species

P. pusilla
C. scaura

5. Impacts

6. Ecology
Habitat use
Trophic strategies

7. Vectors

8. Future perspectives



□ Vectors of introduction and spread of marine introduced species

➤ Shipping traffic



Ballast water
(7000 spp/day; Carlton 2001)



Ship fouling

...and their associated structures

Recreational marinas

Interoceanic canals



➤ **Other vectors:** Aquaculture, intentional releases, etc.

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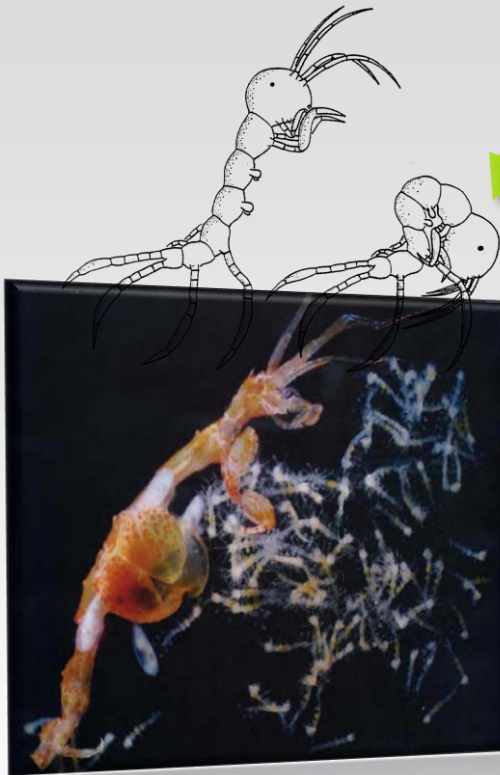
MODEL ORGANISMS:
Caprellid amphipods “skeleton shrimps”



2. MODEL ORGANISMS



Some biological traits...



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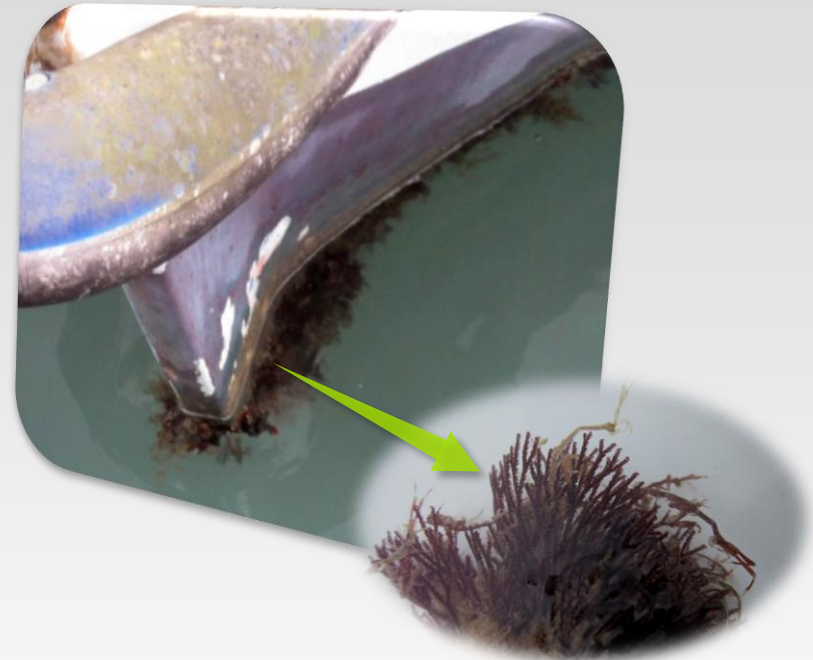
8. Future perspectives



□ Caprellids as a model for understanding marine bioinvasions

➤ Some caprellid species...

1. Reach **high densities** in **artificial submerged structures**
2. Present **high tolerance** to **anthropogenic pollution**



3. Present **high potential** for **introduction, establishment, spread** and **detection** across **many global regions**
4. The **caprellid Mediterranean** fauna has been **well investigated** (we can detect recent introductions)

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A photograph of a marina at dusk. Numerous sailboats with their masts and rigging are docked in the water. In the background, a city skyline is visible, featuring a prominent statue on a tall pedestal. The sky is a mix of orange, pink, and purple, indicating the time is either sunset or sunrise. The water reflects the lights from the boats and the city.

3

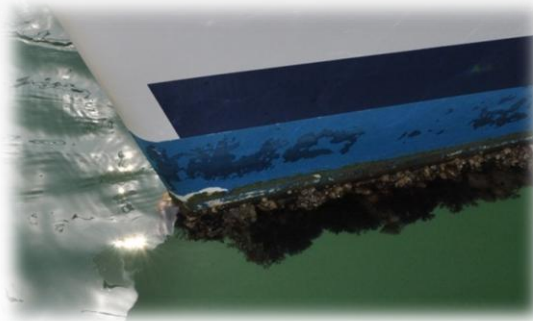
LOOKING FOR EXOTICS:
The role of recreational marinas



❑ The importance of recreational marinas



Under the floating pontoon



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Field surveys: Cádiz, Balearic Islands, Southern Europe

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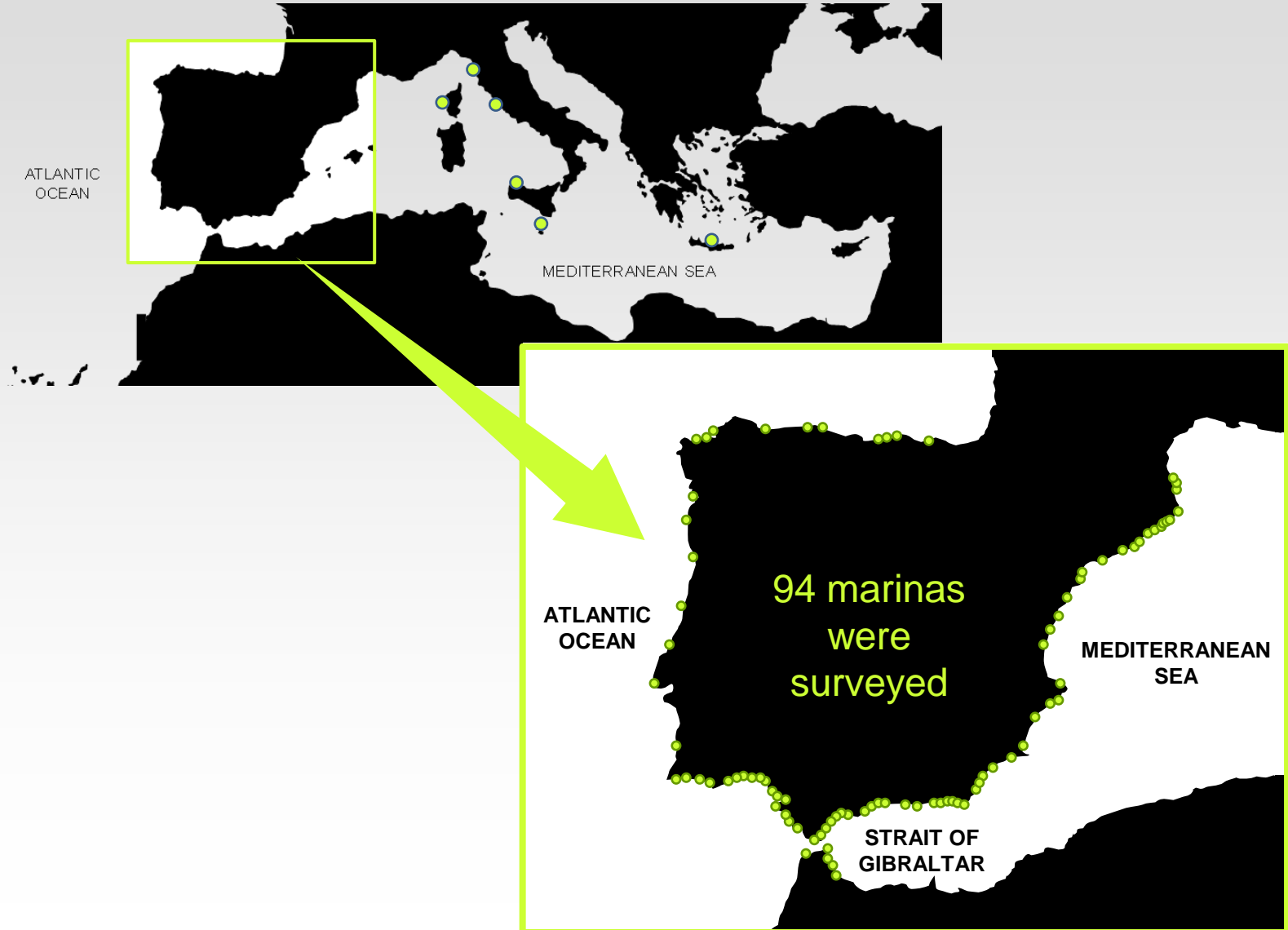
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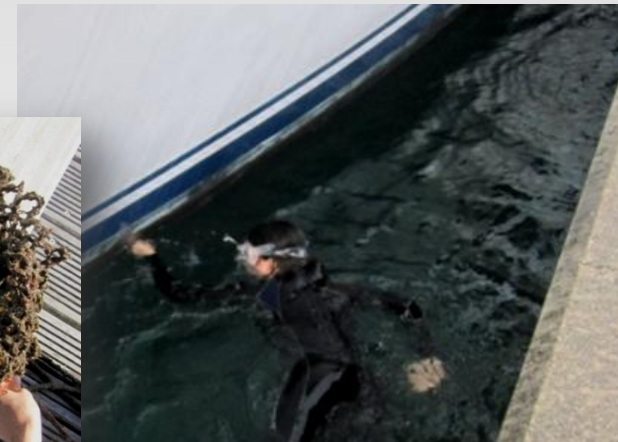
8. Future perspectives





❑ Marina sampling survey

- We surveyed in different structures: **floating pontoons, ropes, buoys, wheels, pilings, ship hulls, etc.**



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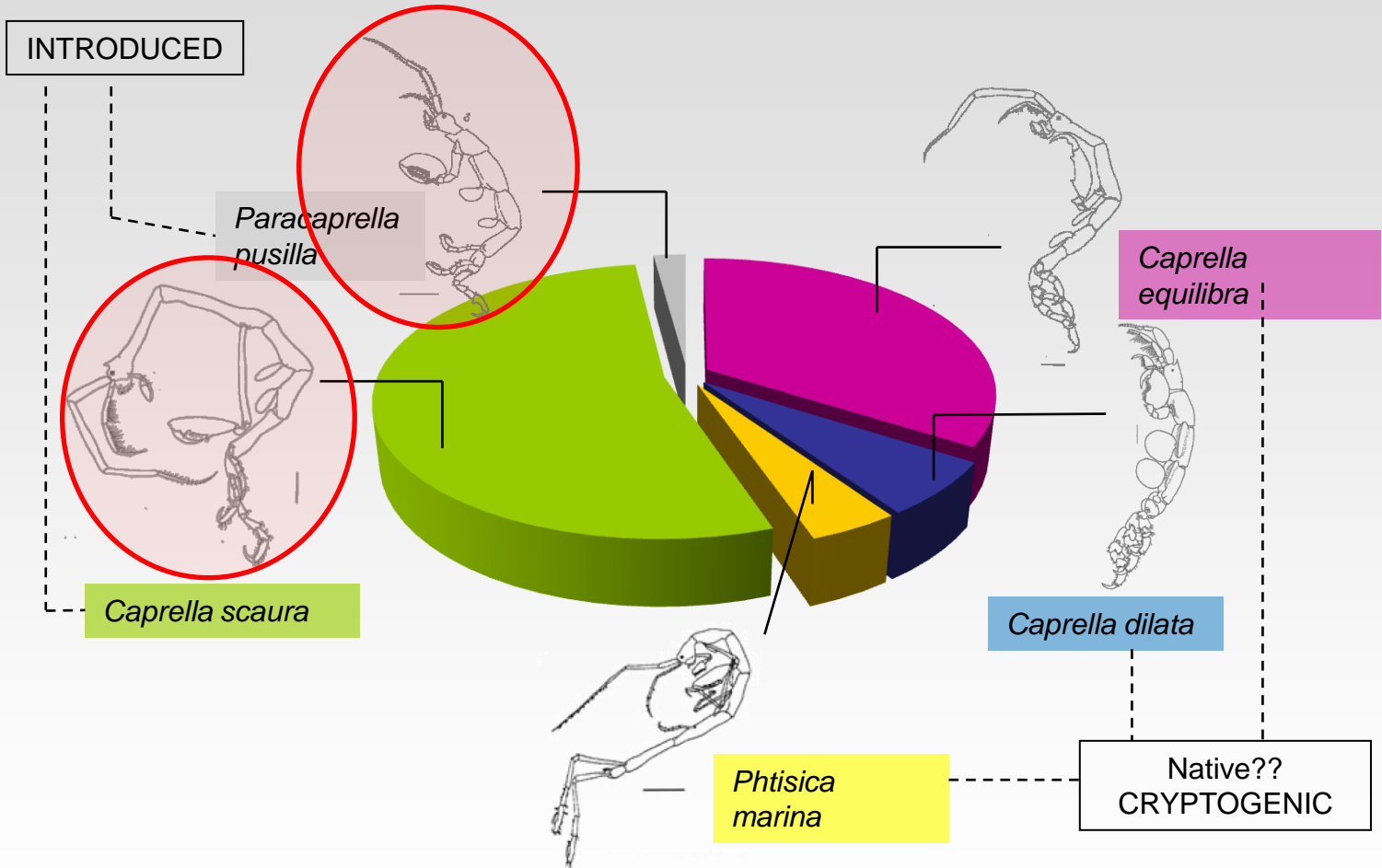
— Habitat use
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Caprellid species found



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A close-up photograph of a translucent, segmented amphipod, identified as Paracaprella pusilla, clinging to a brown, fibrous substrate. The amphipod's body is segmented and appears to have a slightly iridescent sheen. Its legs are visible, and it is positioned in the center-right of the frame. The background is a soft, out-of-focus greyish-brown, highlighting the intricate details of the organism and its environment.

4.1

INTRODUCED SPECIES:

Paracaprella pusilla

4.1 PARACAPRELLA PUSILLA



❑ A “strange” caprellid in Cádiz: *Paracaprella pusilla*



- It appeared in September 2010 and June 2011 (**summer**) associated with the hydroid *Eudendrium racemosum*.

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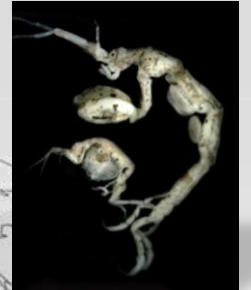
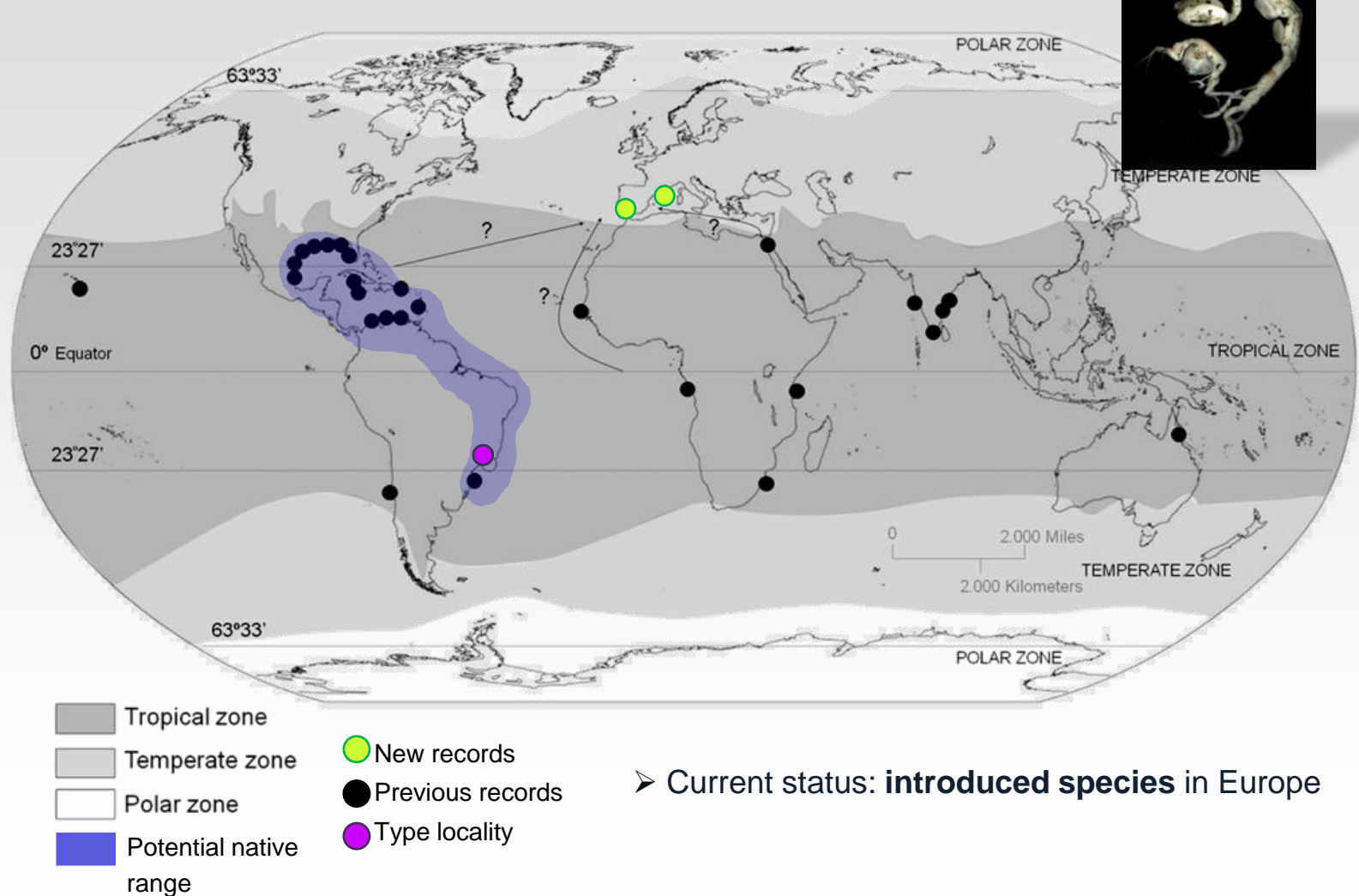
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4.1 PARACAPRELLA PUSILLA



□ Distribution of *Paracaprella pusilla* around the world



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4.1 PARACAPRELLA PUSILLA



Ecology in the introduced range

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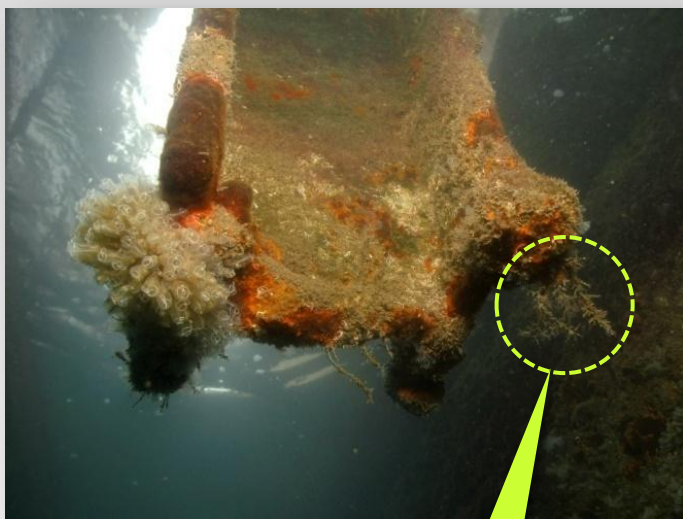
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4.1 PARACAPRELLA PUSILLA



❑ Clepto-commensalist behavior



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4.1 PARACAPRELLA PUSILLA



❑ Deterrent behavior



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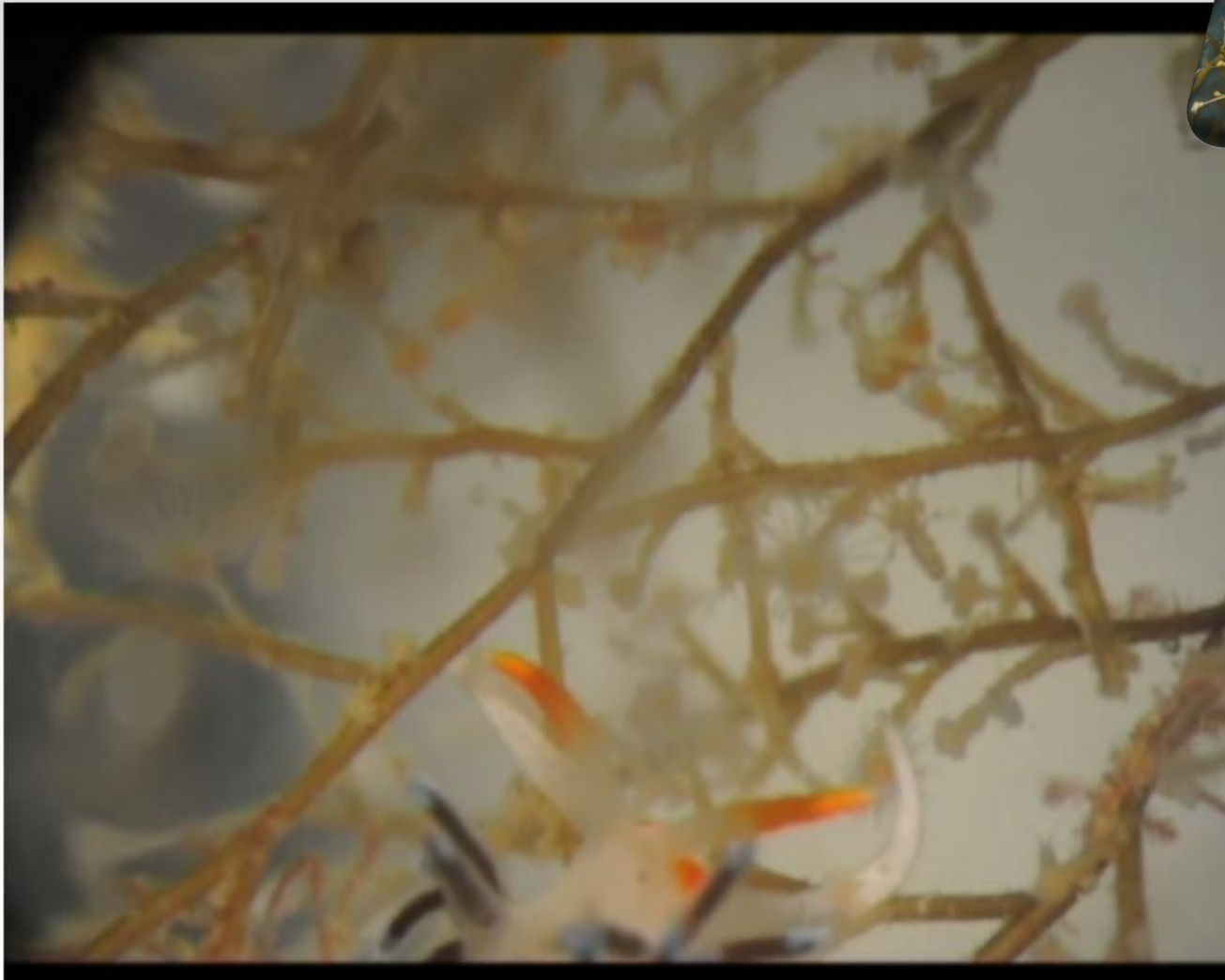
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4.2

INTRODUCED SPECIES:

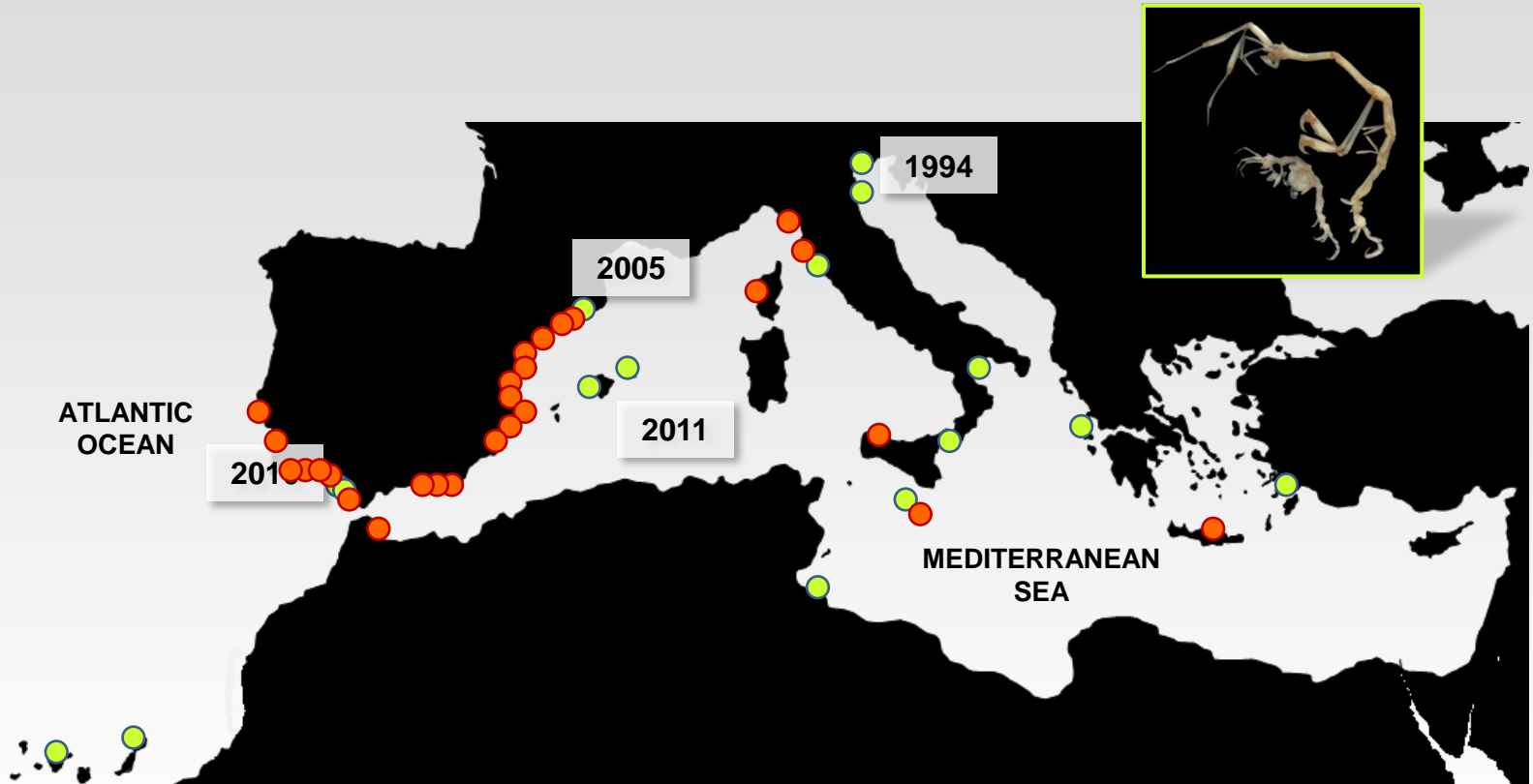
Caprella scaura



4.2 CAPRELLA SCAURA



□ Sampling survey along the Iberian Peninsula and north Africa



- Previous records of *C. scaura*
- New records of *C. scaura*

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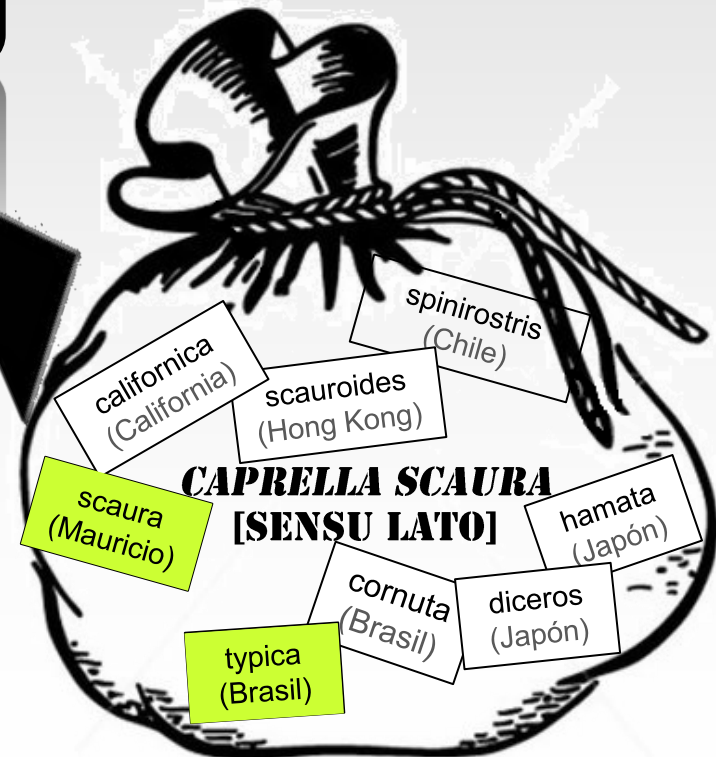
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4.2 CAPRELLA SCAURA



- ❑ What 'subspecies' of *C. scaura* complex is invading Europe?



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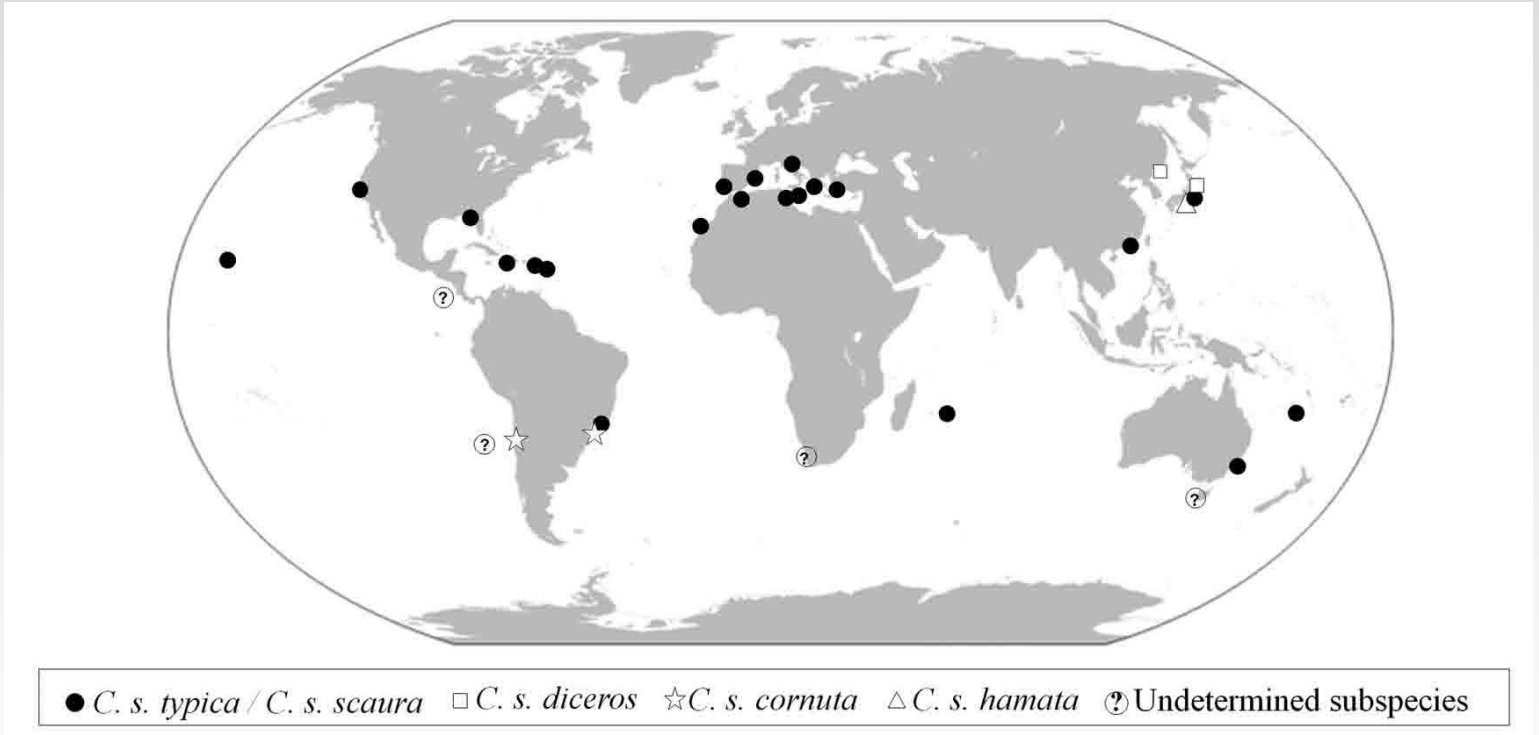
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- ❑ What 'subspecies' of *C. scaura* complex is invading Europe?



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An underwater photograph showing a large, purple sea urchin in the center. The urchin has many long, thin spines. It is resting on a rocky seabed covered with various marine organisms, including small white and orange polyps. The background is a blurred view of the ocean floor with more rocks and marine life.

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POTENTIAL IMPACTS
of *Caprella scaura*

5. POTENTIAL IMPACTS



Study area and host substratum

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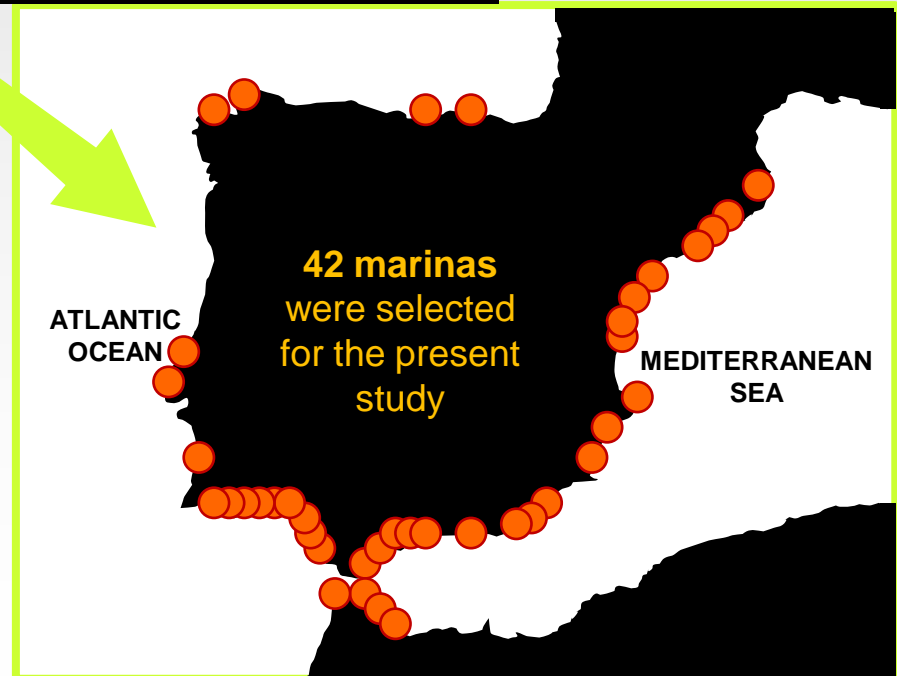
Habitat use
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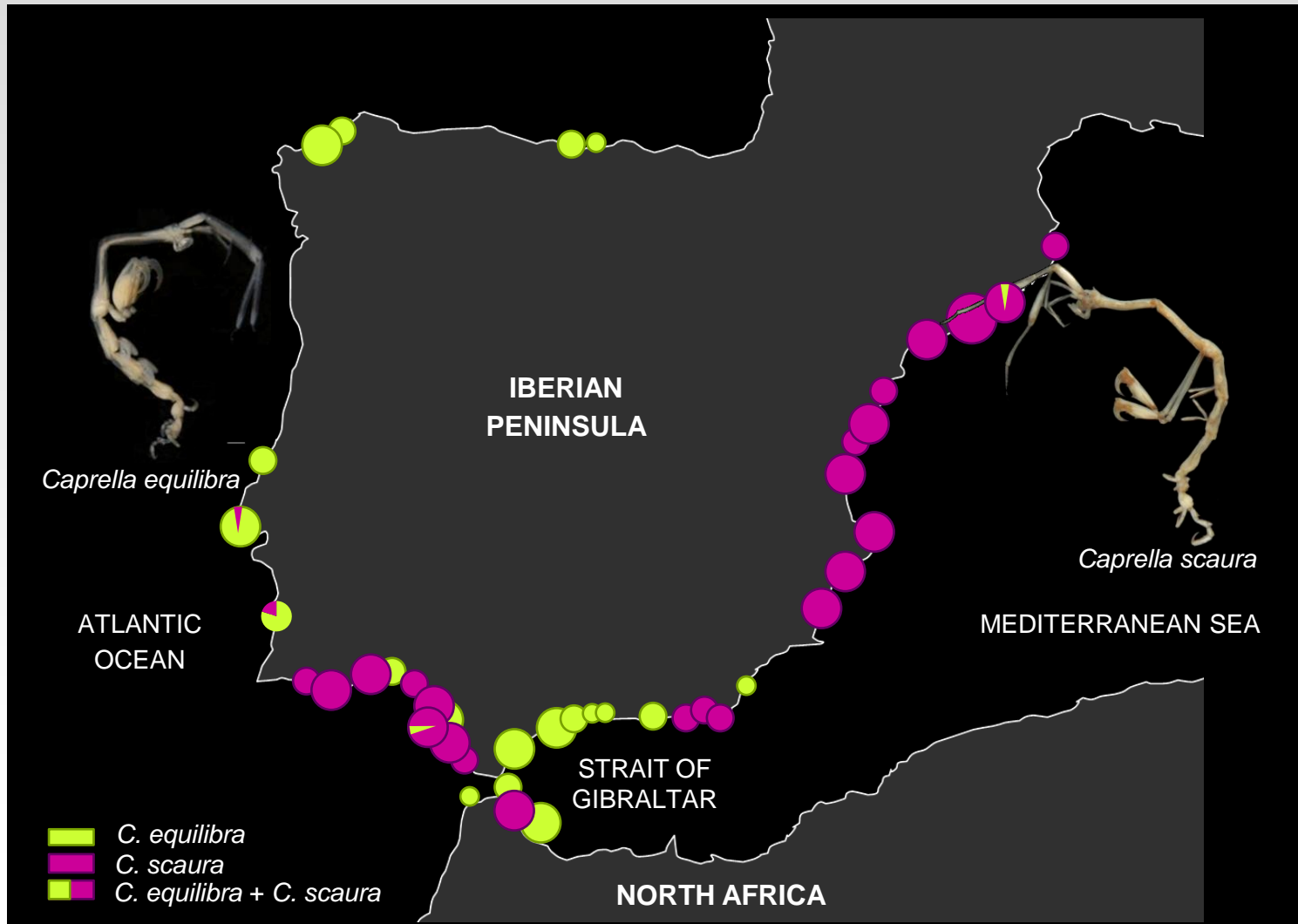
➤ Marinas in which *B. neritina* was absent were discarded from the present study.



5. POTENTIAL IMPACTS



Caprellid species distribution pattern



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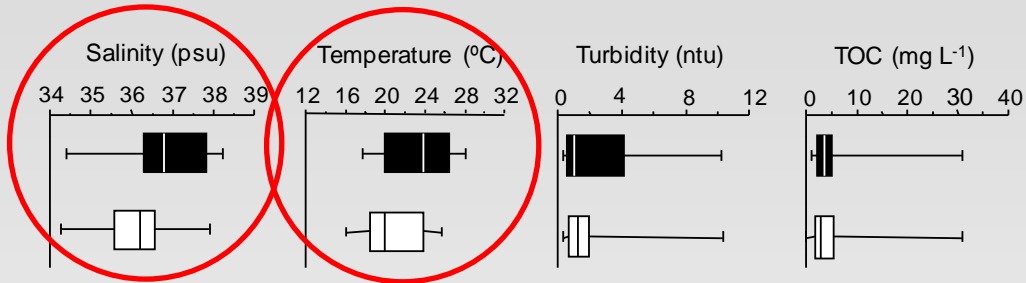
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5. POTENTIAL IMPACTS

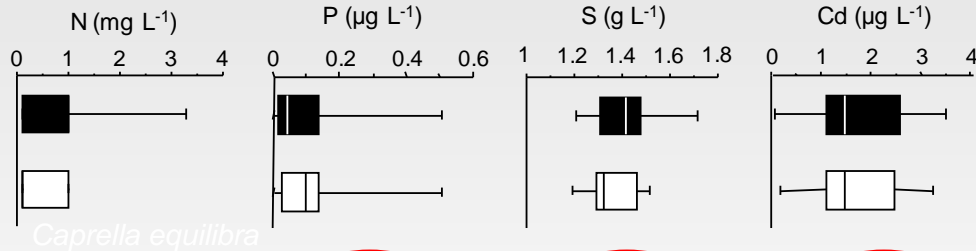


Tolerance ranges

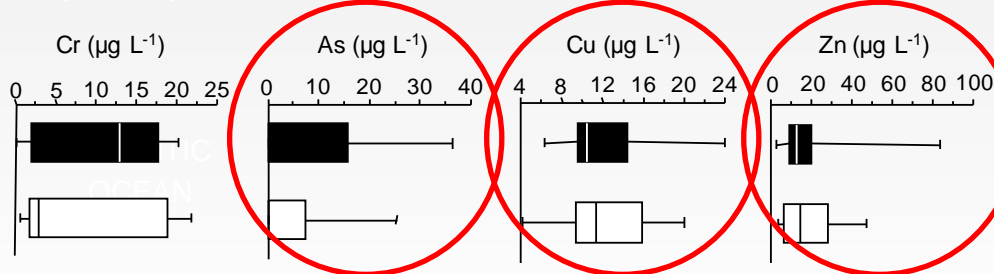


Caprella scaura
 Caprella equilibra

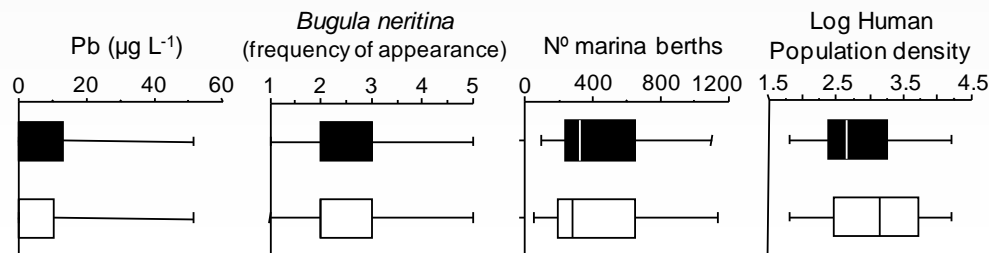
Explanatory variables (16)



Caprella equilibra



Caprella scaura



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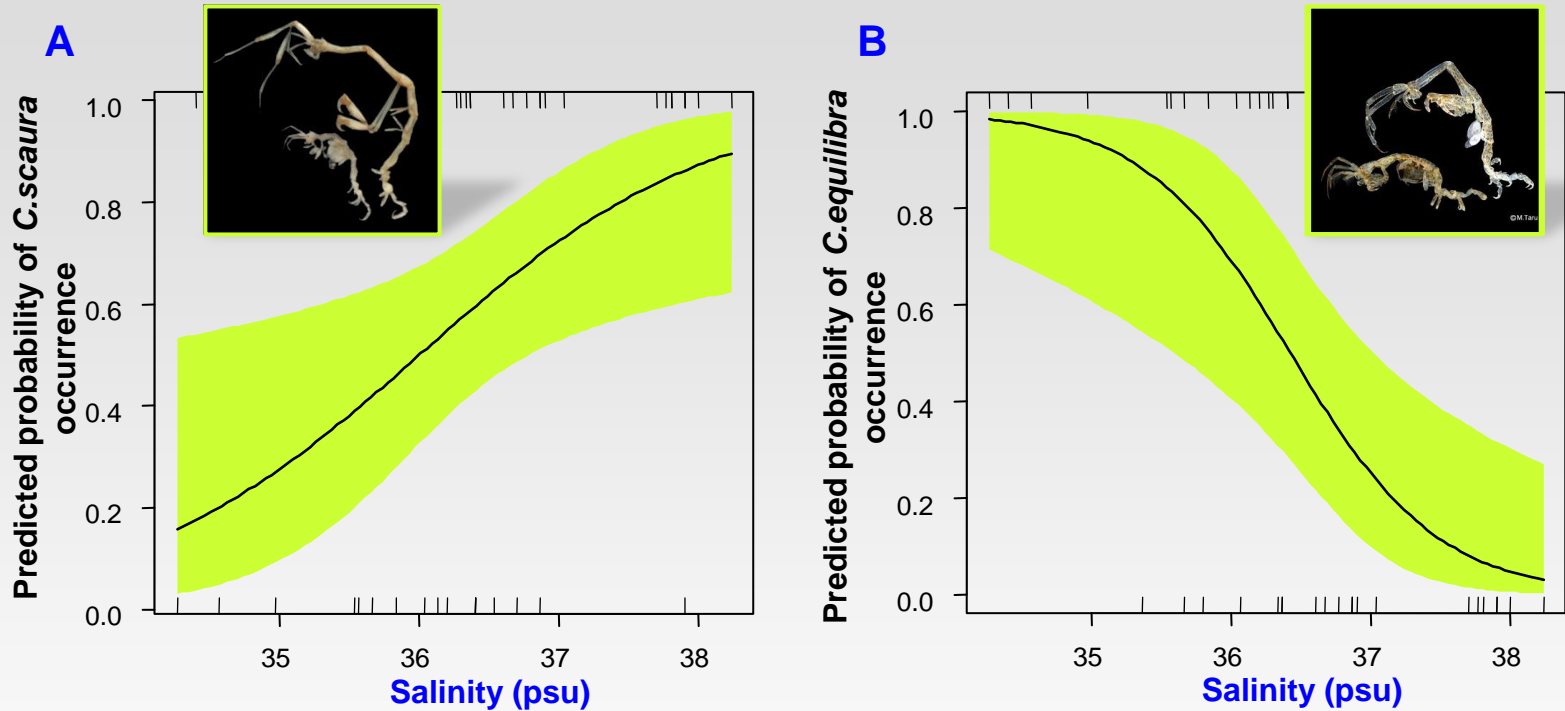
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5. POTENTIAL IMPACTS



□ Modelling species distribution: the importance of salinity



➤ **Best GLM model** (smallest **Akaike's Information Criterion** corrected for small sample size (**AICc**)):

-*Caprella scaura* occurrence ~ salinity

-*Caprella equilibra* occurrence ~ salinity + Human population density + Turbidity

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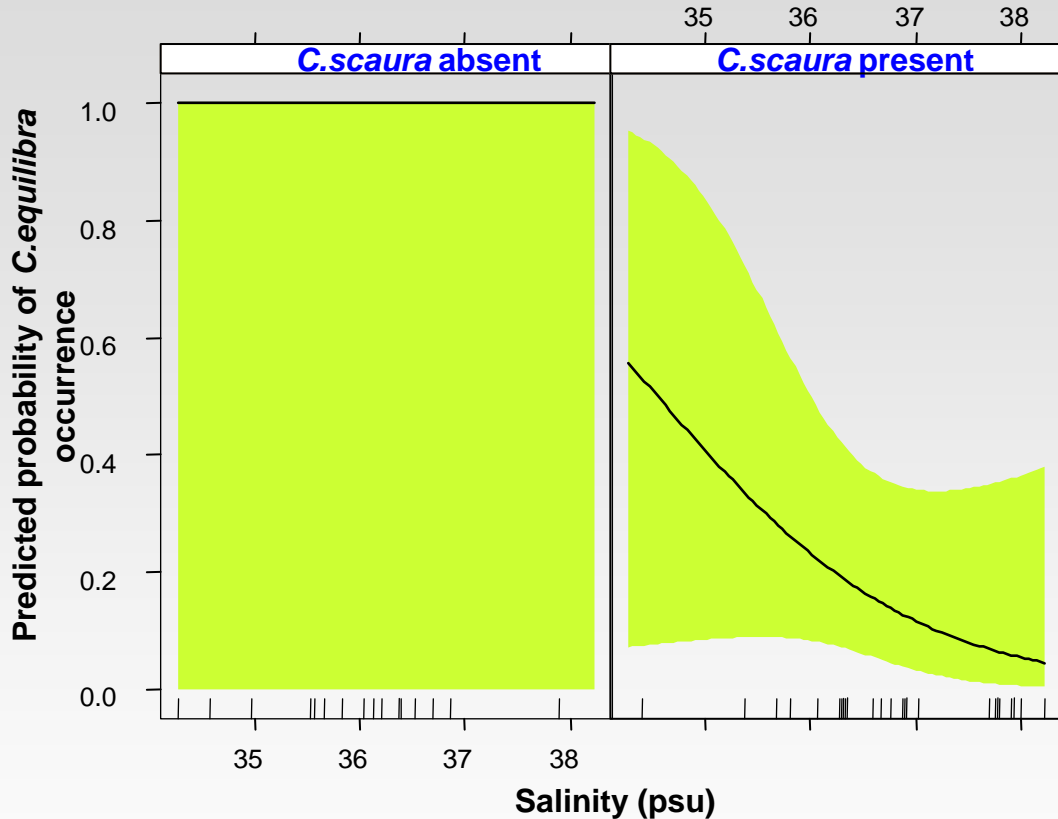
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5. POTENTIAL IMPACTS



□ Evidence for the existence of competitive interactions



➤ *C. equilibra* occurrence pattern is explained significantly better when a term describing *C. scaura* occurrence is included in the model.

Regression model	Residual df	Residual deviance	Change in deviance	P
Best environmental model	38	37.724		
Best environmental model + <i>C. scaura</i> occurrence	37	6.323	31.401	0.0001

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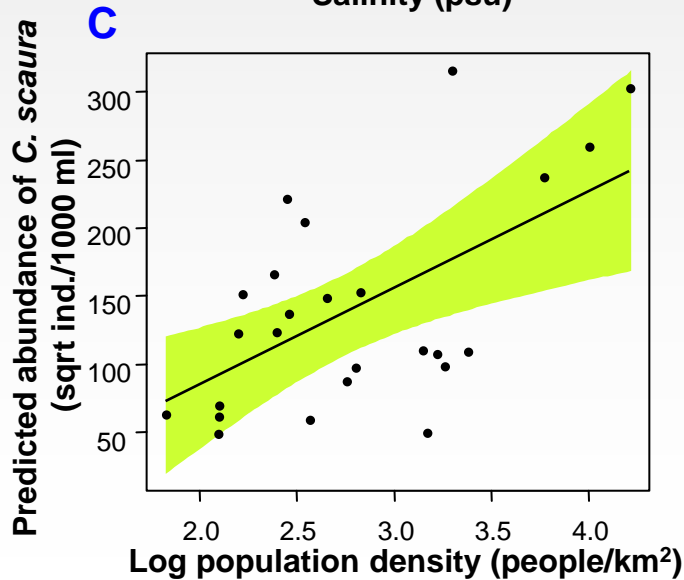
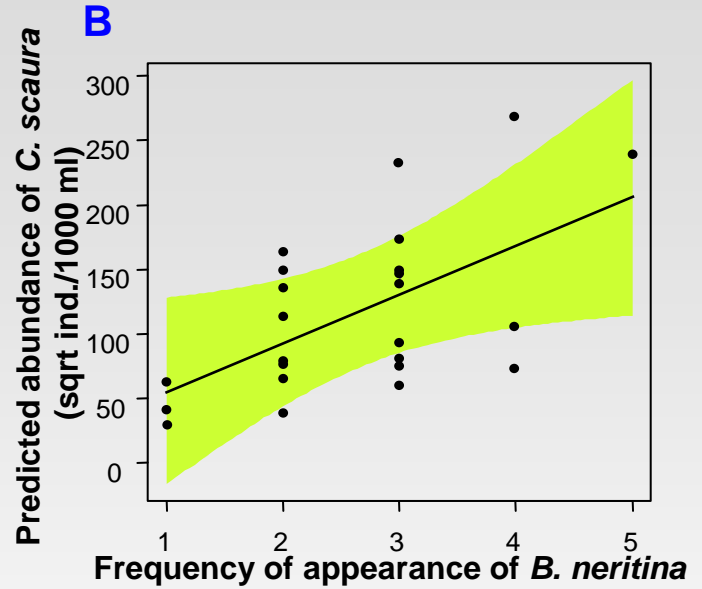
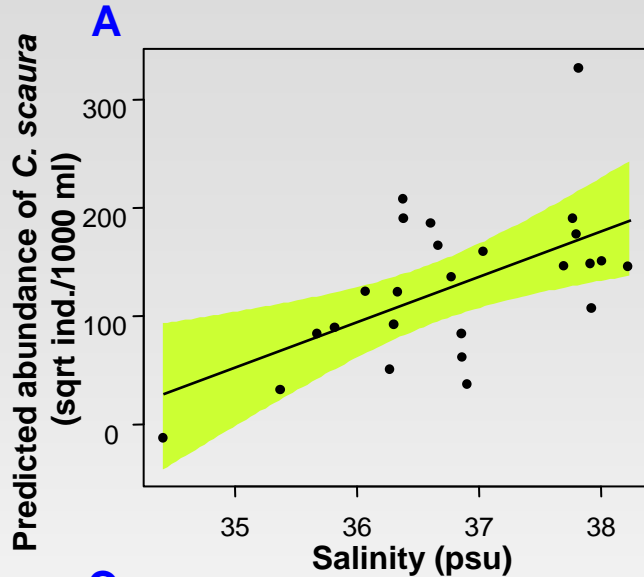
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5. POTENTIAL IMPACTS



Relevant factors in the abundance pattern of *C. scaura*



$(\sum w_i)$

IMPORTANCE

Salinity (+)*

Freq. appearance *B. neritina* (+)*

Human population density (+)*

Pb (-)

Turbidity (+)

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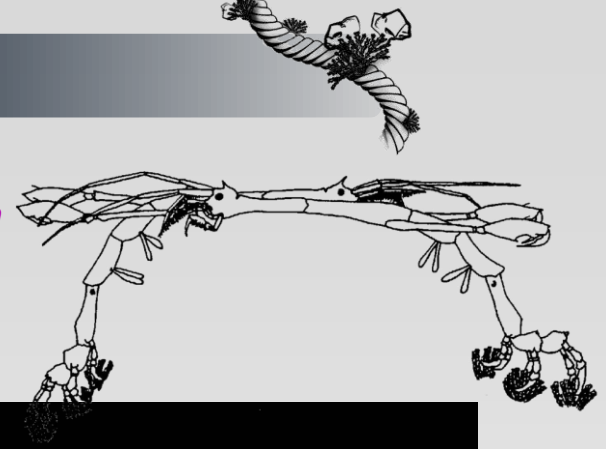
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□ Aggressive behavior in *Caprella scaura*



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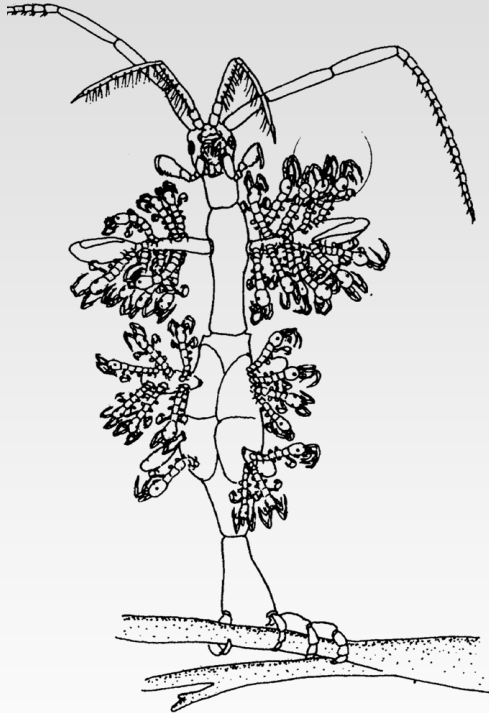
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□ Parental care



Refigured from Lim & Alexander (1986)



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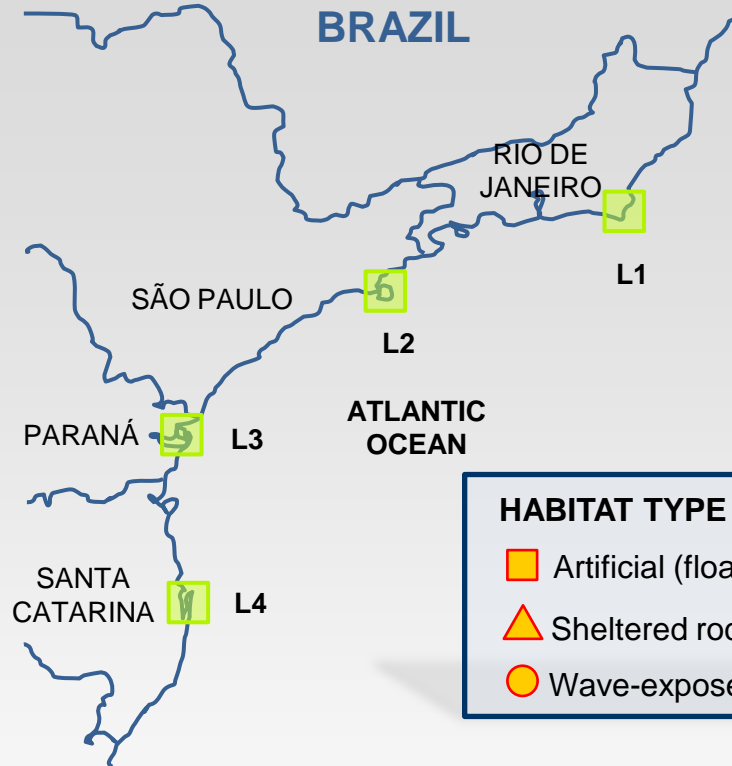
6.1

NATIVE-RANGE ECOLOGY: Habitat use





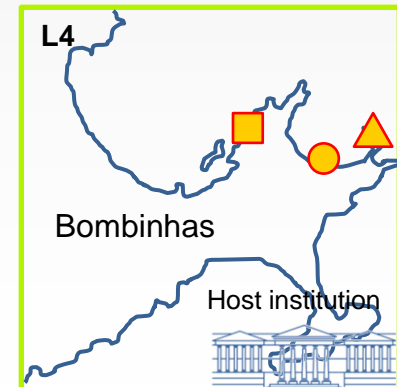
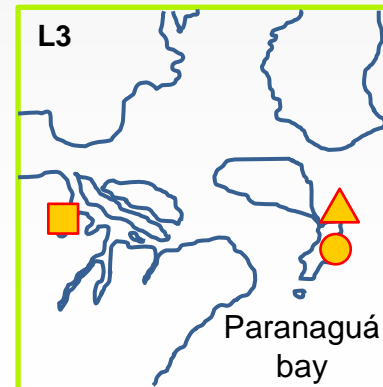
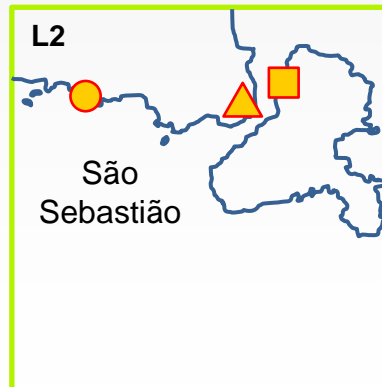
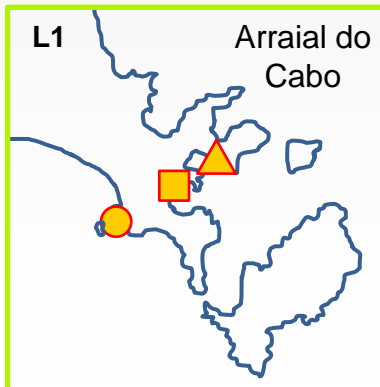
Experimental design



HABITAT TYPE

- Artificial (floating docks)
- ▲ Sheltered rocky shores
- Wave-exposed rocky shores

- 3 habitat types
- 3 sites per habitat type
- 3 replicates per site



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□ Habitat use patterns: distribution of target species

➤ In general, abundance and composition of target caprellids were different among habitats (Three way ANOVA_SNK)

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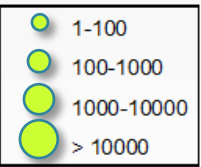
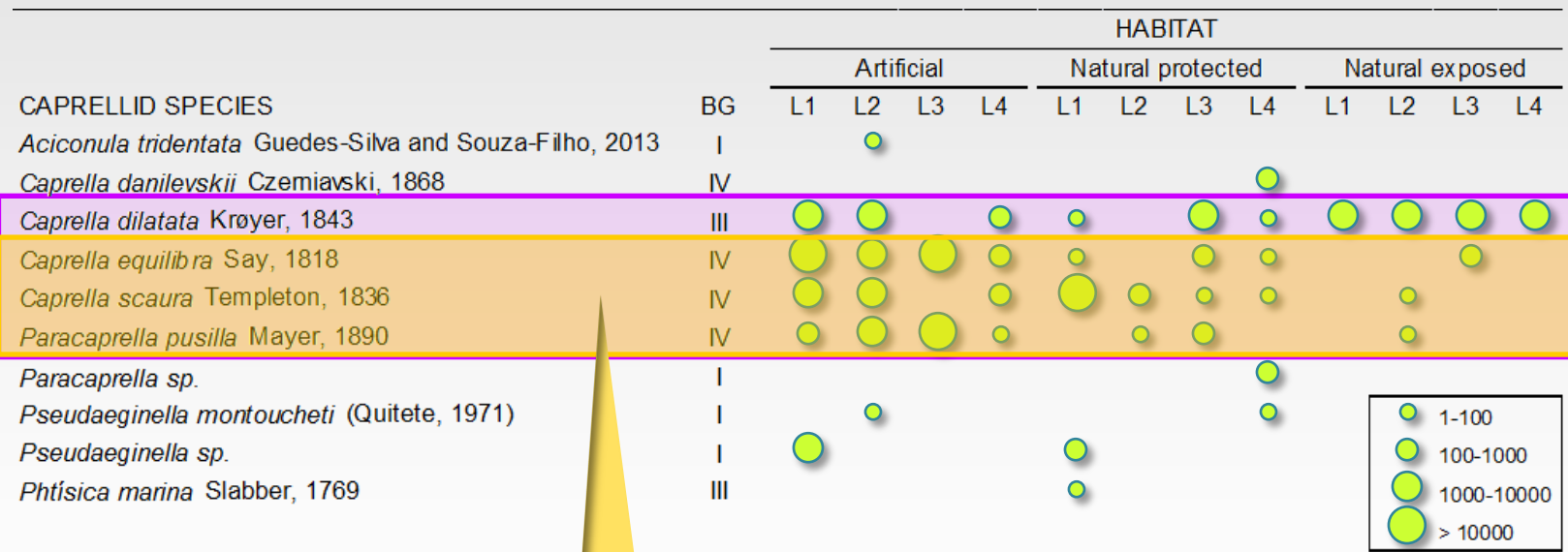
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Species abundance: **ARTIFICIAL > NATURAL (SHELTERED > WAVE-EXPOSED)**



Wide-ranging species and wave exposure (wave fetch)

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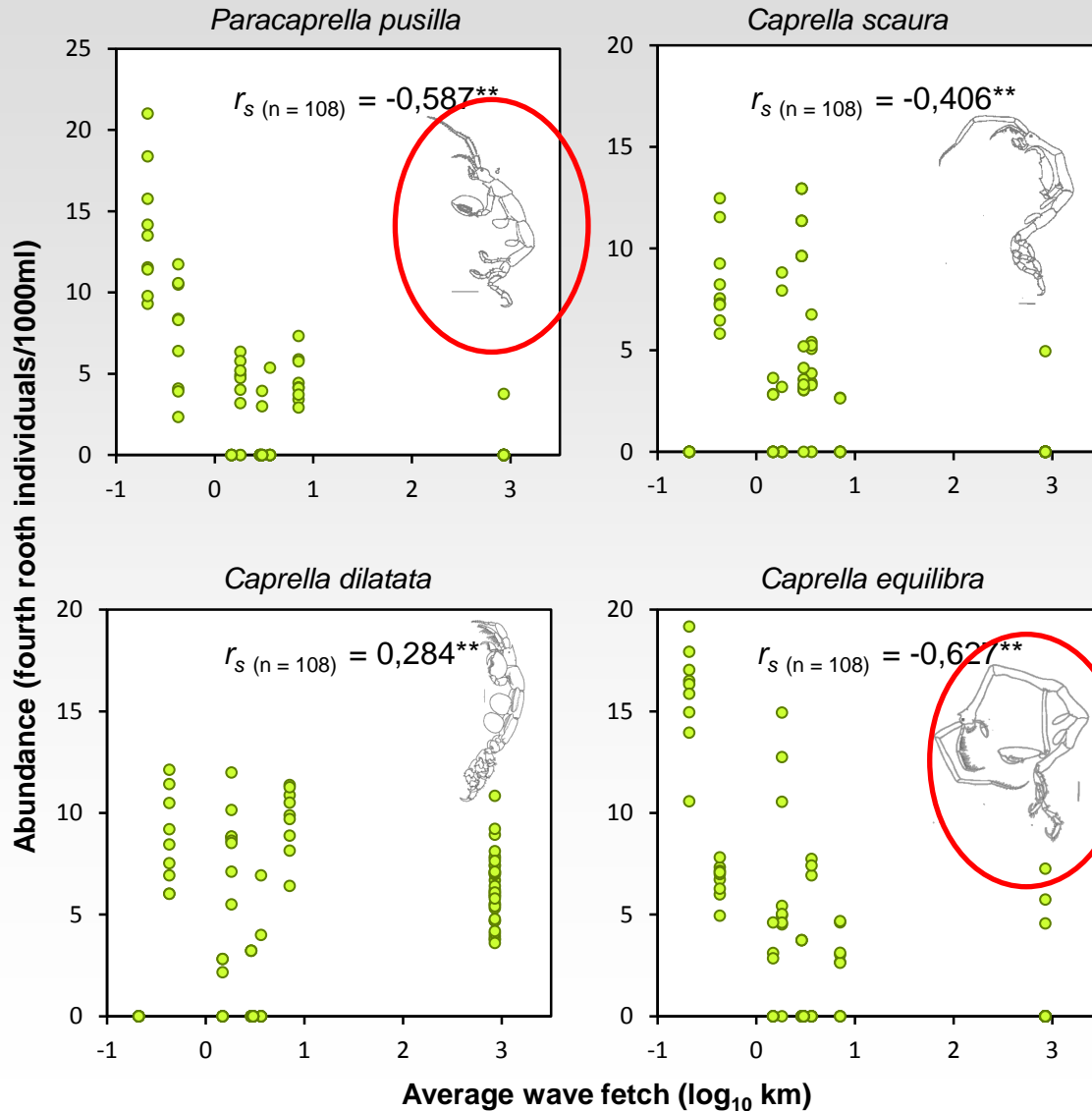
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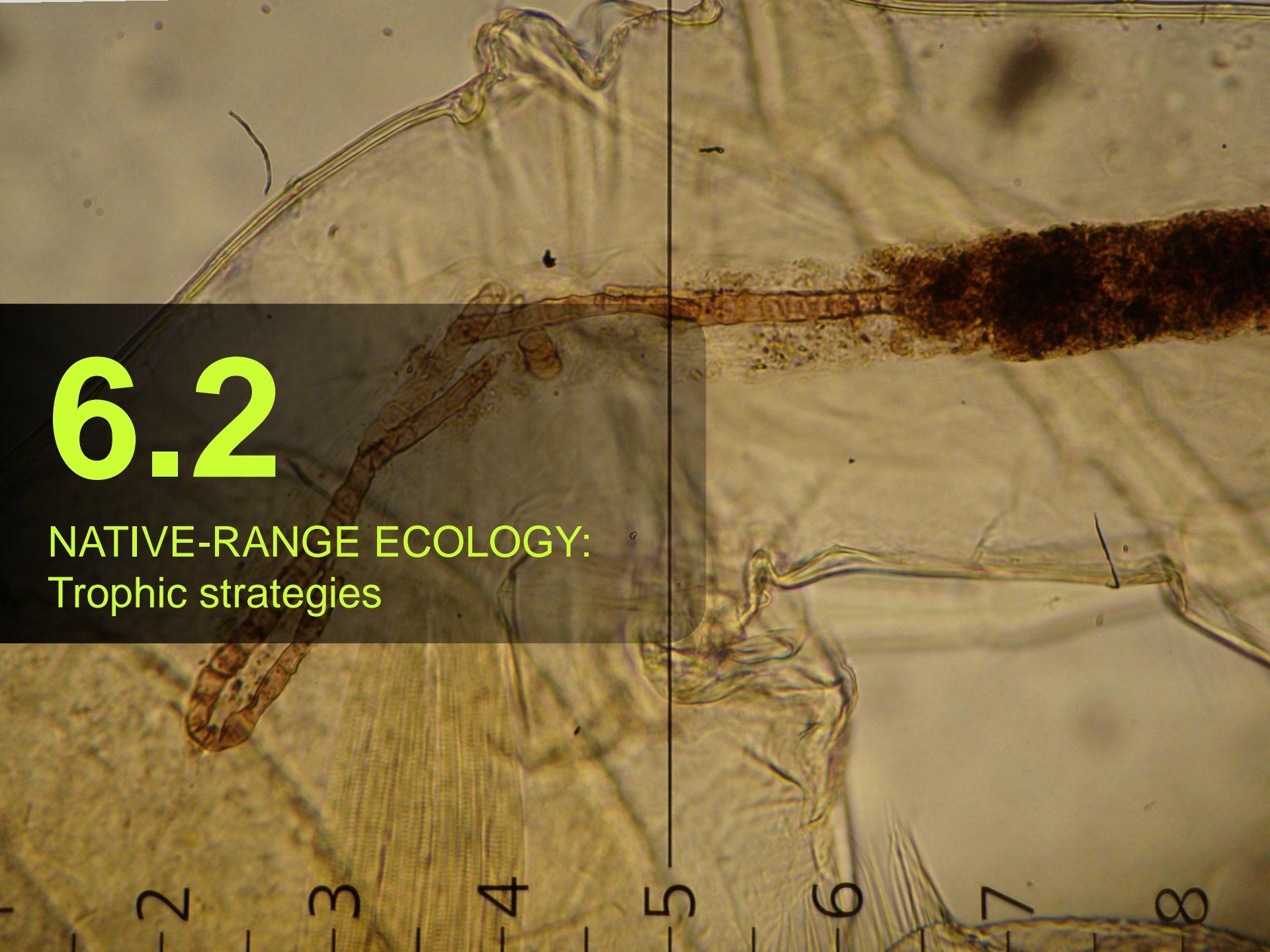
- Habitat use
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**p<0.01

A microscopic image of a biological specimen, possibly a nematode, showing its internal structure and a dark, textured region. A vertical ruler is visible at the bottom, with markings from 2 to 8. A semi-transparent black box is overlaid on the left side of the image, containing the text.

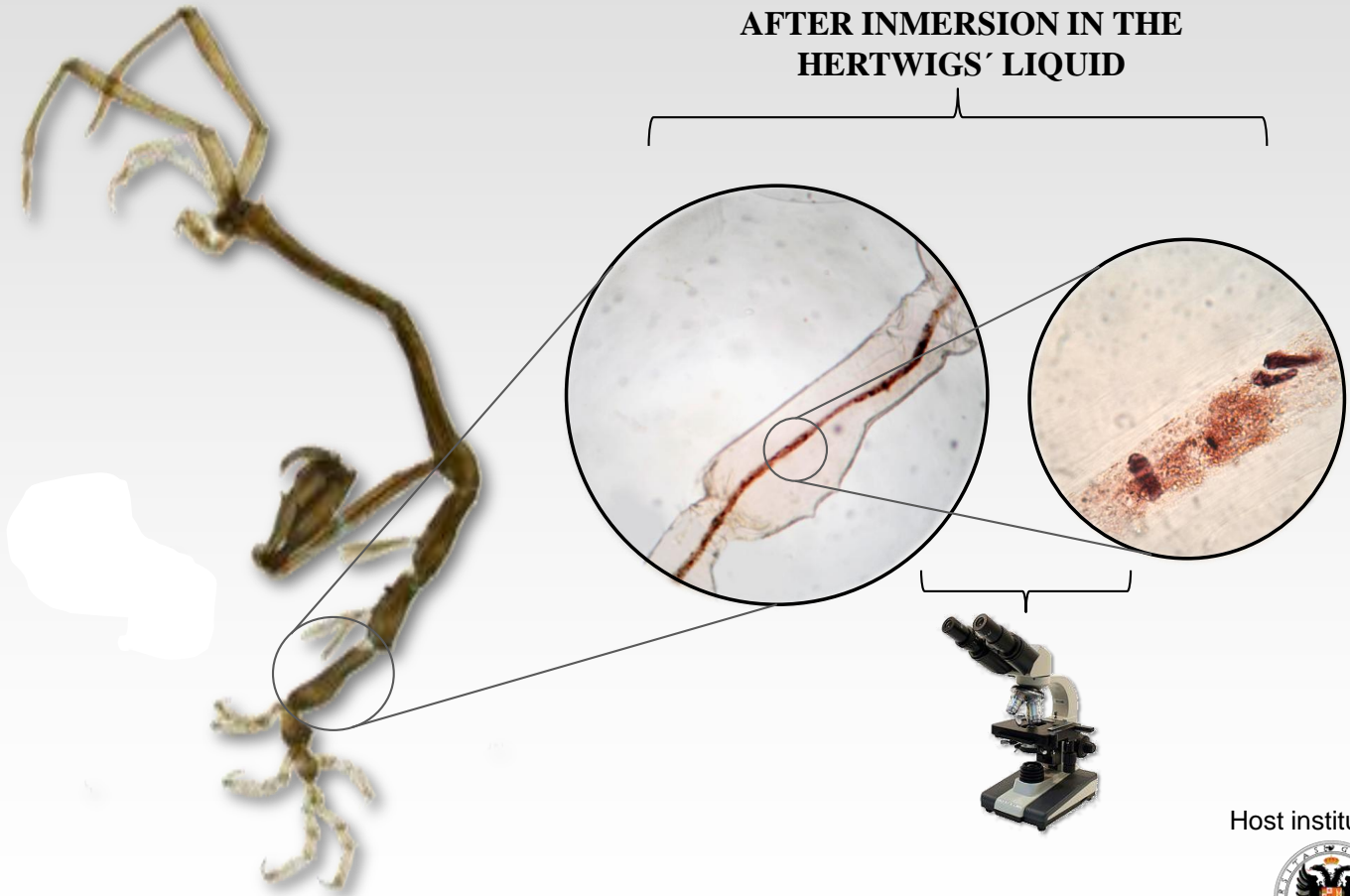
6.2

NATIVE-RANGE ECOLOGY:
Trophic strategies



Methodology

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Host institution





□ Trophic strategies: influence of habitat type (ANOVA)

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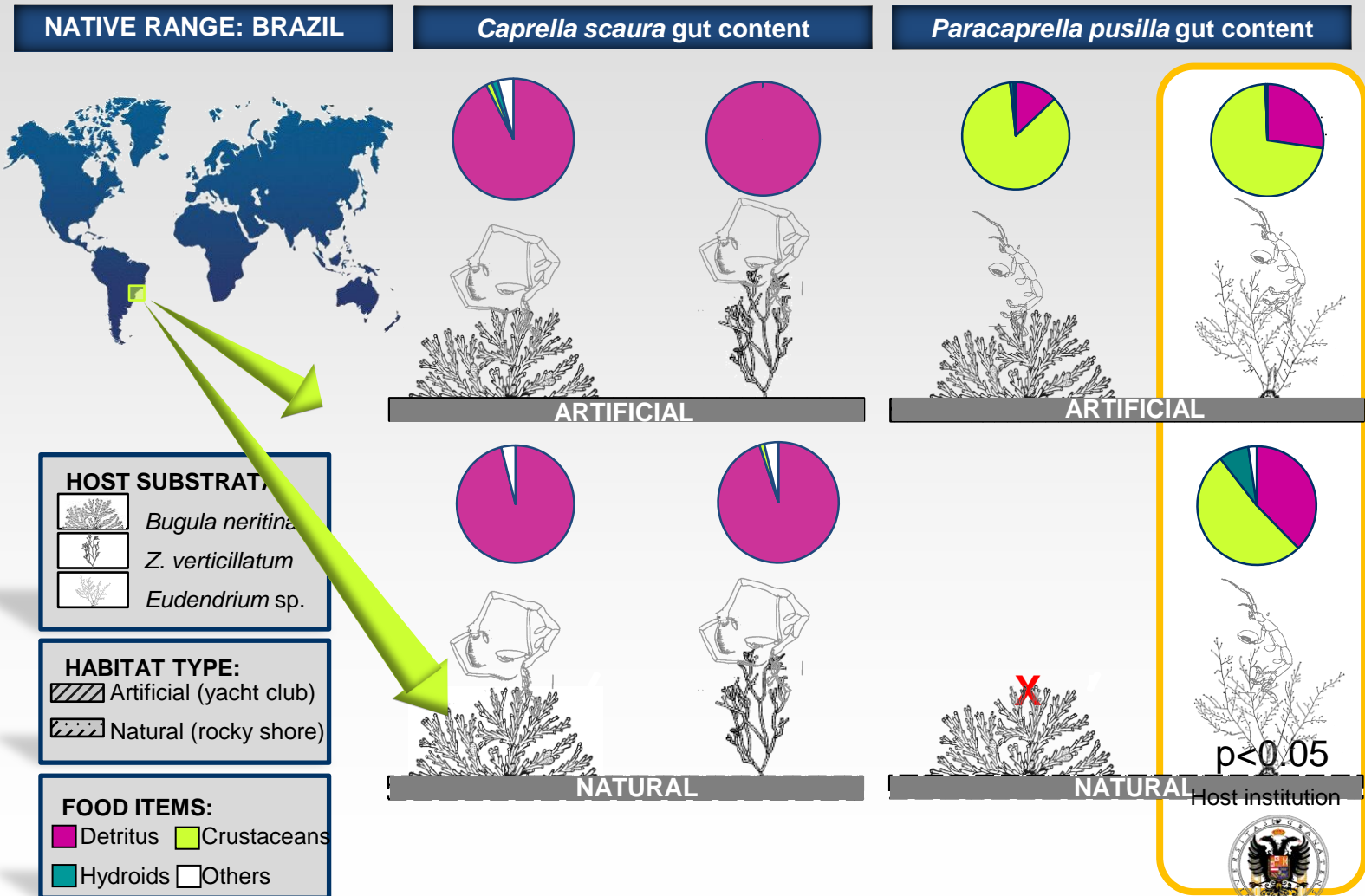
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□ Trophic strategies: influence of host substratum (two-way ANOVA)

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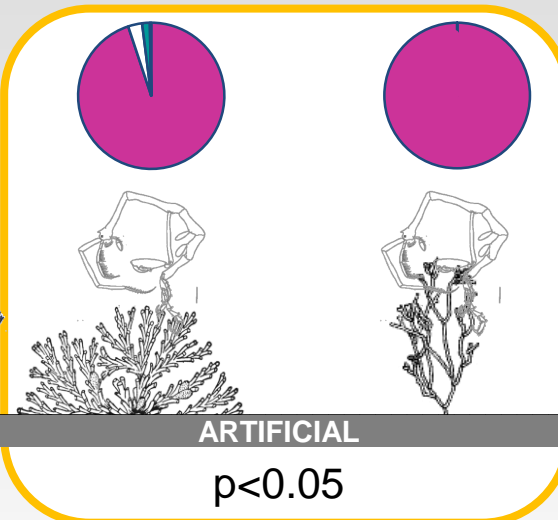
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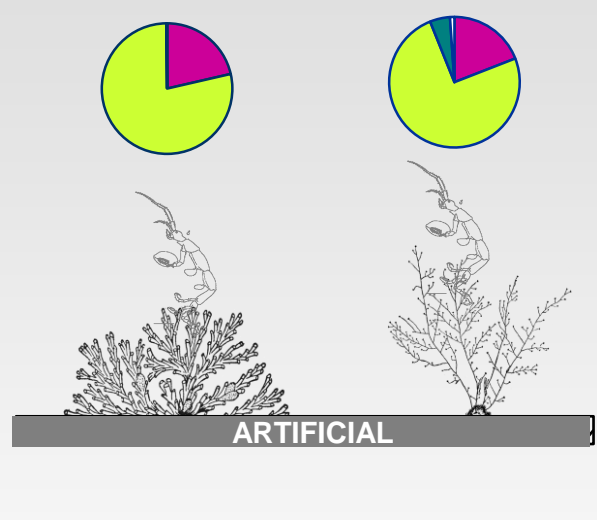
INTRODUCED RANGE: SPAIN






***Caprella scaura* gut content**





***Paracaprella pusilla* gut content**







HOST SUBSTRATA:

-  *Bugula neritina*
-  *Z. verticillatum*
-  *Eudendrium* sp.

HABITAT TYPE:

-  Artificial (yacht club)
-  ~~Natural (rocky shore)~~

FOOD ITEMS:

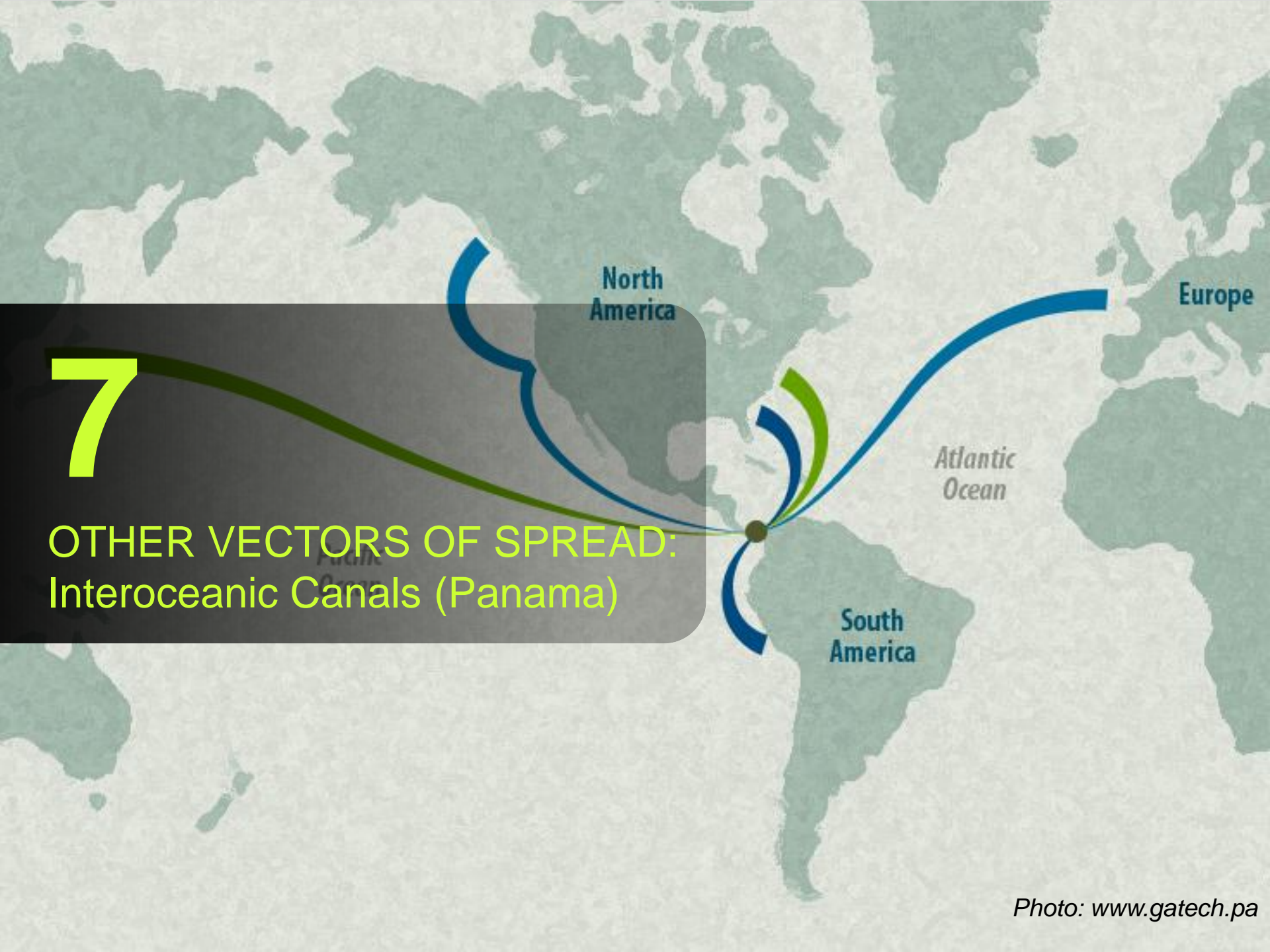
-  Detritus
-  Crustaceans
-  Hydroids
-  Others

Host institution



7

OTHER VECTORS OF SPREAD:
Interoceanic Canals (Panama)



6. OTHER VECTORS: INTEROCEANIC CANALS



□ *P. pusilla* at the entrances of the Panama Canal: ADR model

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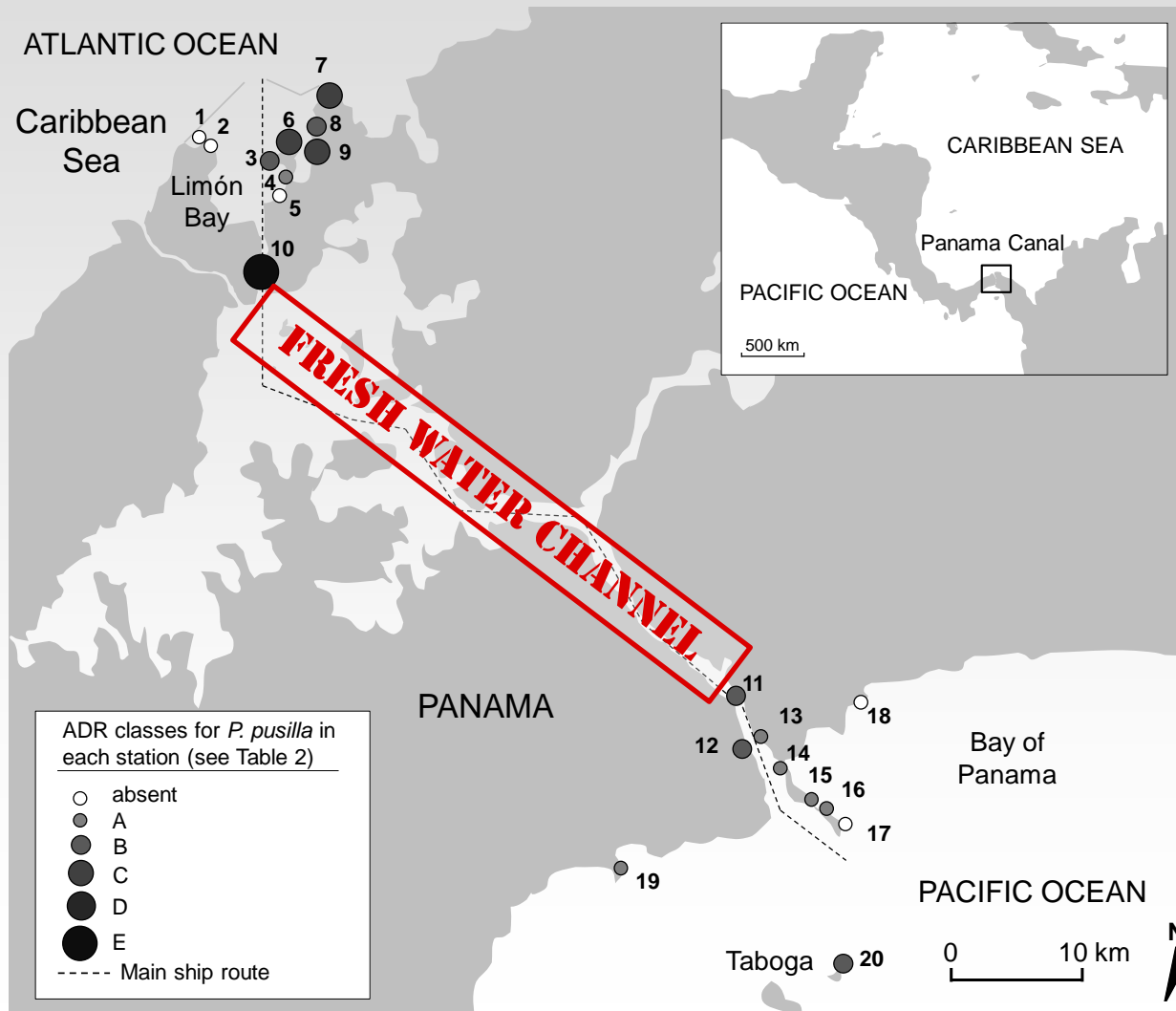
P. pusilla
C. scaura

5. Impacts

6. Ecology
— Habitat use
— Trophic strategies

7. Vectors

8. Future perspectives





□ Salinity tolerance experiment



➤ Range-finding experiment:

- Males and females separately
- Seven salinity treatments: 0, 5, 15, 25, 30, 45, 55
- Control: 35

➤ Second experiment:

- Males and females separately
- Eleven salinity treatments: 13, 15, 19, 21; 41, 43, 45, 47, 49, 51
- Control: 35

Total individuals used: 570 (285 males and 285 females)

1. Introduction

2. Model organisms

3. Looking for exotics

4. Introduced species

P. pusilla
C. scaura

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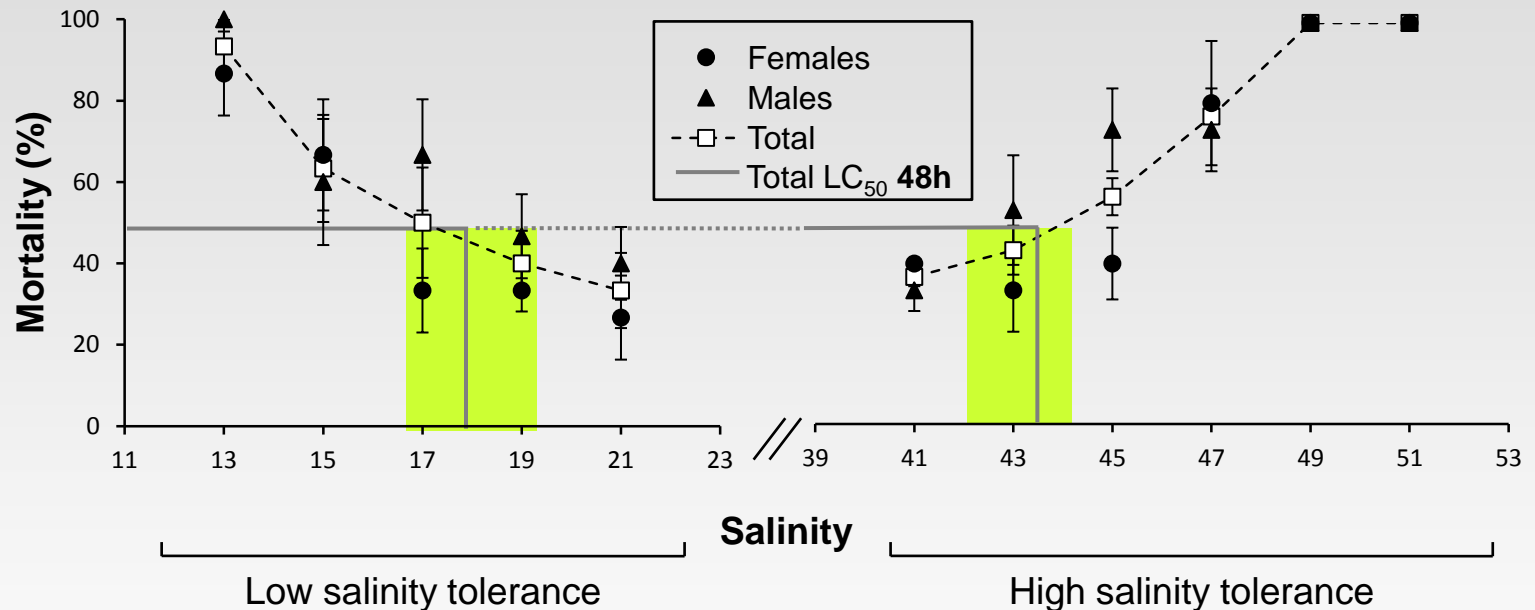
8. Future perspectives

Host institution





Salinity tolerance experiment



➤ **Median lethal concentration (LC₅₀)** were calculated by use of **Probit model**

➤ The **lower LC₅₀ for females**, which was 16.7 (15.1 - 18.4), was **significantly below** (Pairwise Students't-test, $p < 0.05$) **that for males**, estimated as 18.7 (17.2 - 22.2).

1. Introduction

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3. Looking for exotics

4. Introduced species

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C. scaura

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6. OTHER VECTORS: INTEROCEANIC CANALS



□ On the introduction of *P. pusilla* in the Pacific Ocean

1. Introduction

2. Model organisms

3. Looking for exotics

4. Introduced species

— *P. pusilla*
— *C. scaura*

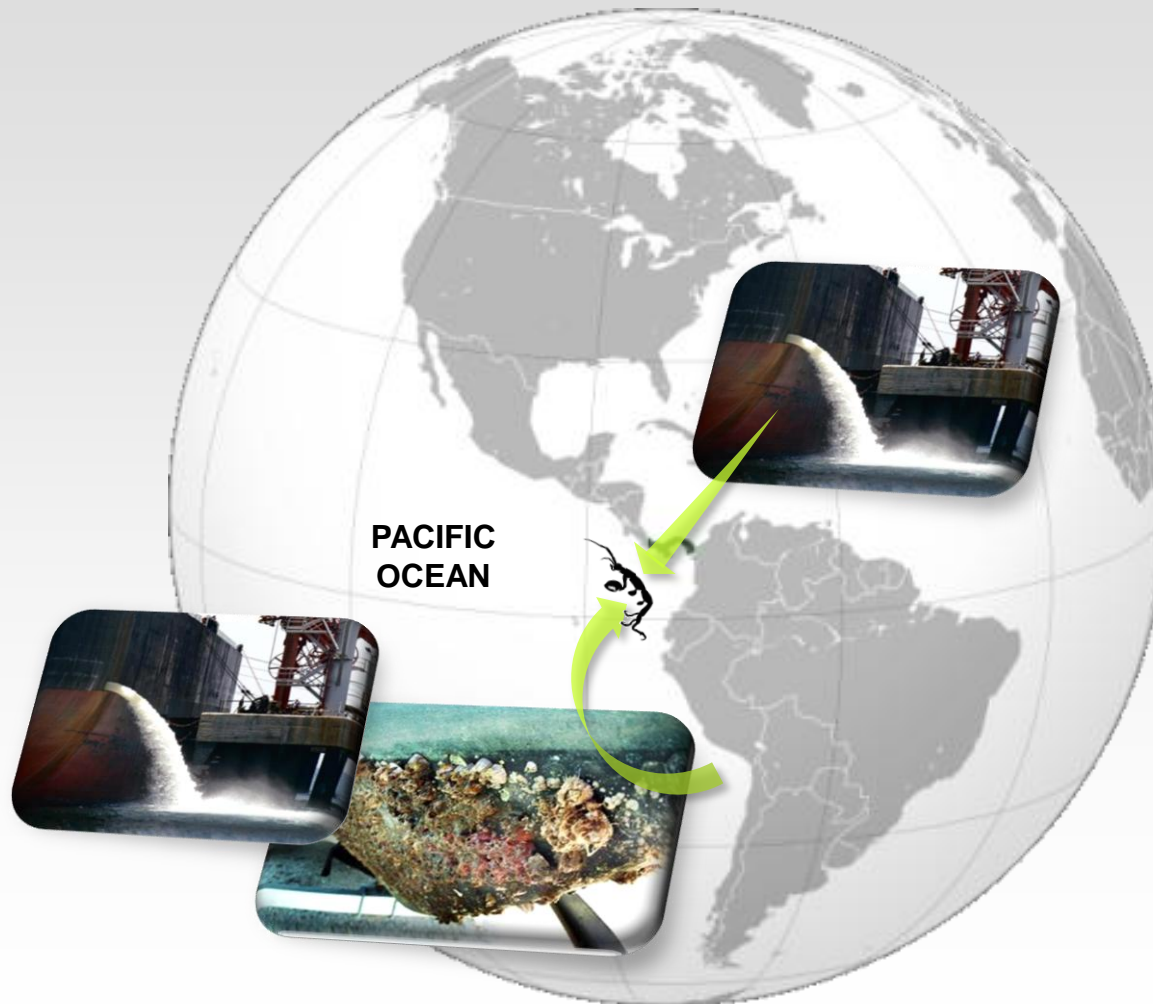
5. Impacts

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Host institutions



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