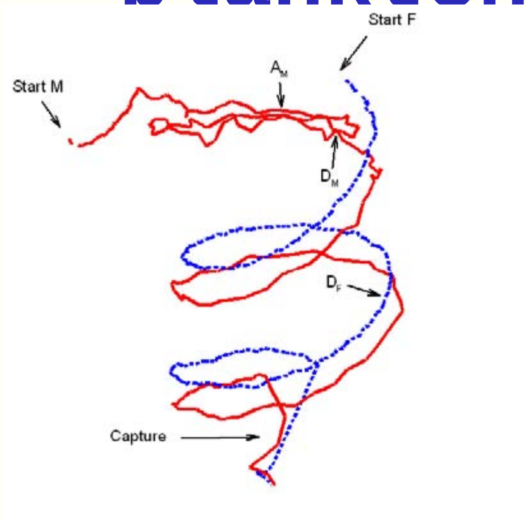
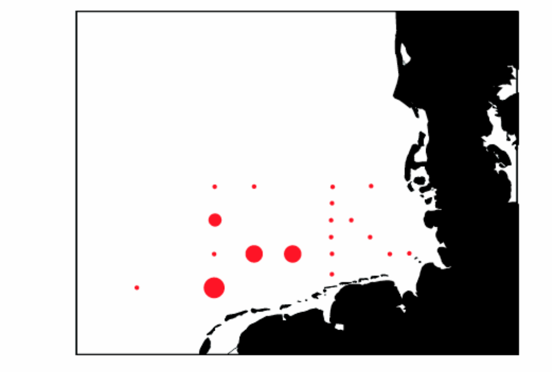
Chasing all kinds: Heterospecific mating and reproductive isolation in planktonic marine copepods





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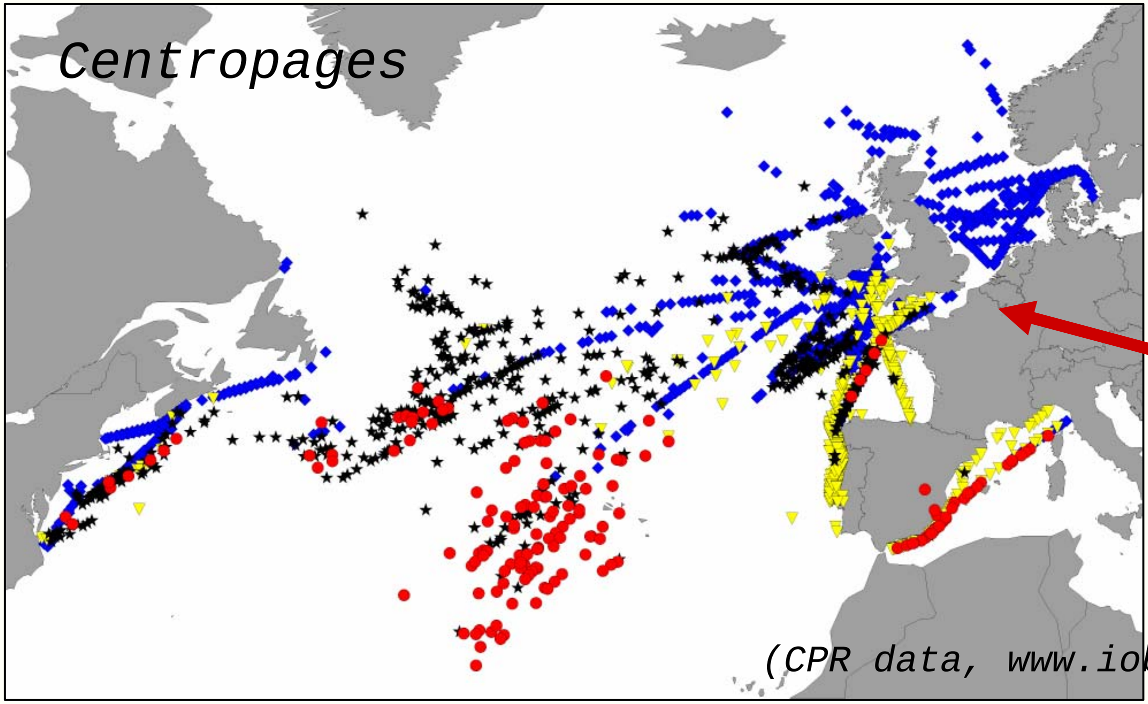
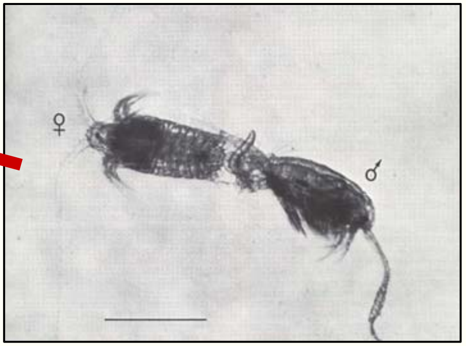
Mating ecology and reproductive isolation in planktonic copepods



(CPR data, www.iobis.org)



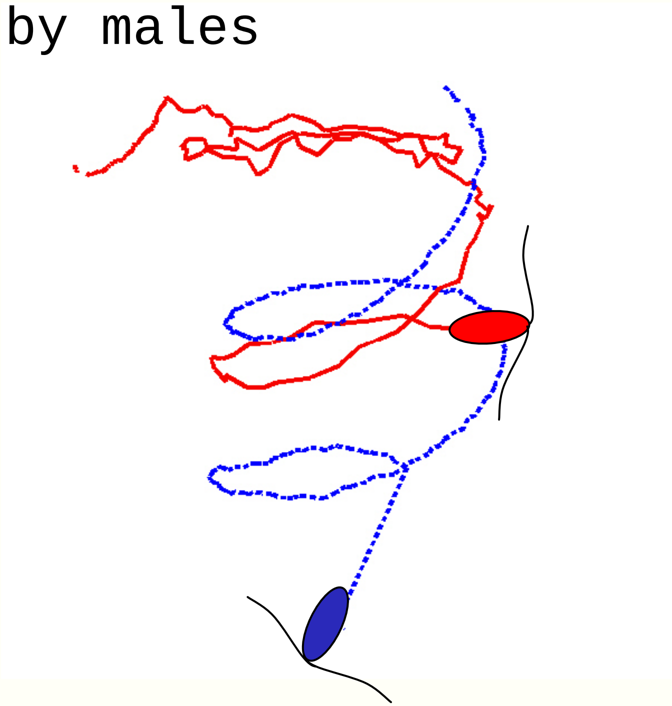
(Blades, 197

What biological traits serve as reproductive isolating barriers between planktonic species?

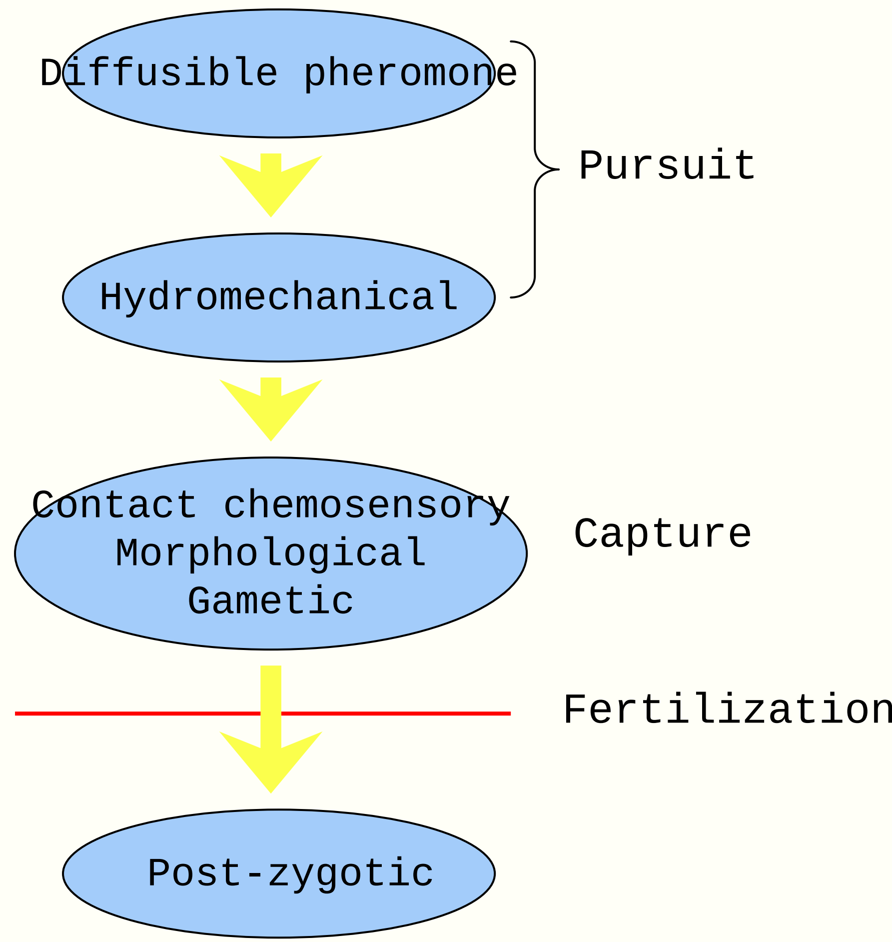
How do these barriers evolve?

Copepods: How to find the right mate?

Pre-mating isolation: multiple potential sources of information for species recognition by males



Chronological cue hierarch

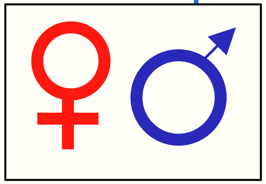


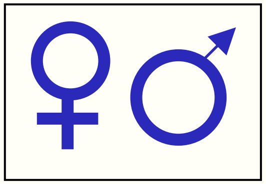
Objectives and Approach

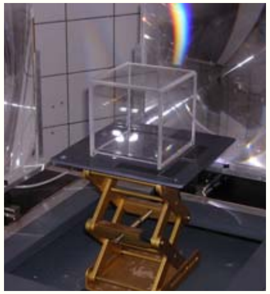
Objectives

1. Identify the mating signals that play a role in species recognition.
2. Determine the frequency and fate of heterospecific mating.
3. Examine the importance of heterospecific mating behavior to the reproductive ecology of natural populations.

Paired Mating Experiments

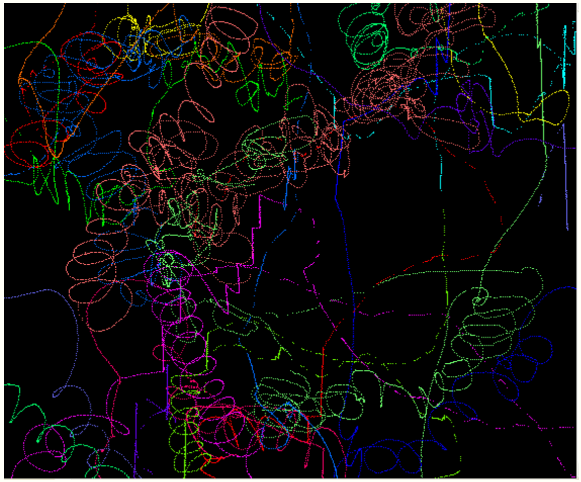






Centropages, Temora

Motility Experiments



Calculations

- Male mate-search volume rates
- Hetero- and conspecific encounter rates in North Sea populations

Copepod mating: *C. typicus* female + *C. hamatus* male

Incomplete pre-mating isolation for 3 species pairs

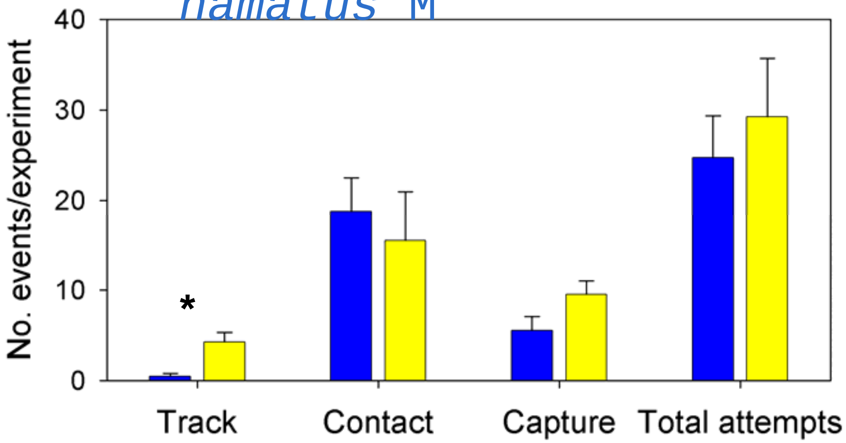
Centropages	Track	Contact	Capture	Sperm
typicus F / *hamatus* M	Y	Y	Y	Y
hamatus F / *typicus* M	Y	Y	Y	Y
Temora				
stylifera F / *longicornis* M	Y	Y	Y	Y
longicornis F / *stylifera* M	Y	Y	Y	N
Centropages - Temora				
typicus F / *longicornis* M	Y	Y	N	N
longicornis F / *typicus* M	?	?	?	?

Other forms of isolation:

- Reduced frequency of heterospecific mating attempts?
- Gametic (post-mating, prezygotic) or post-zygotic isolation?

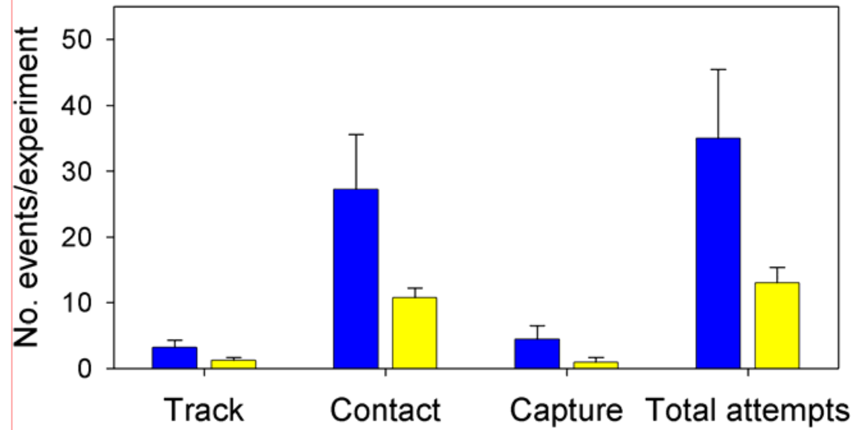
Males frequently pursue the wrong female

C typicus F - *C. hamatus* M

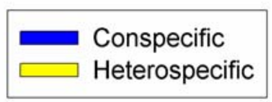


Control: *C. hamatus*

C hamatus F - *C. typicus* M



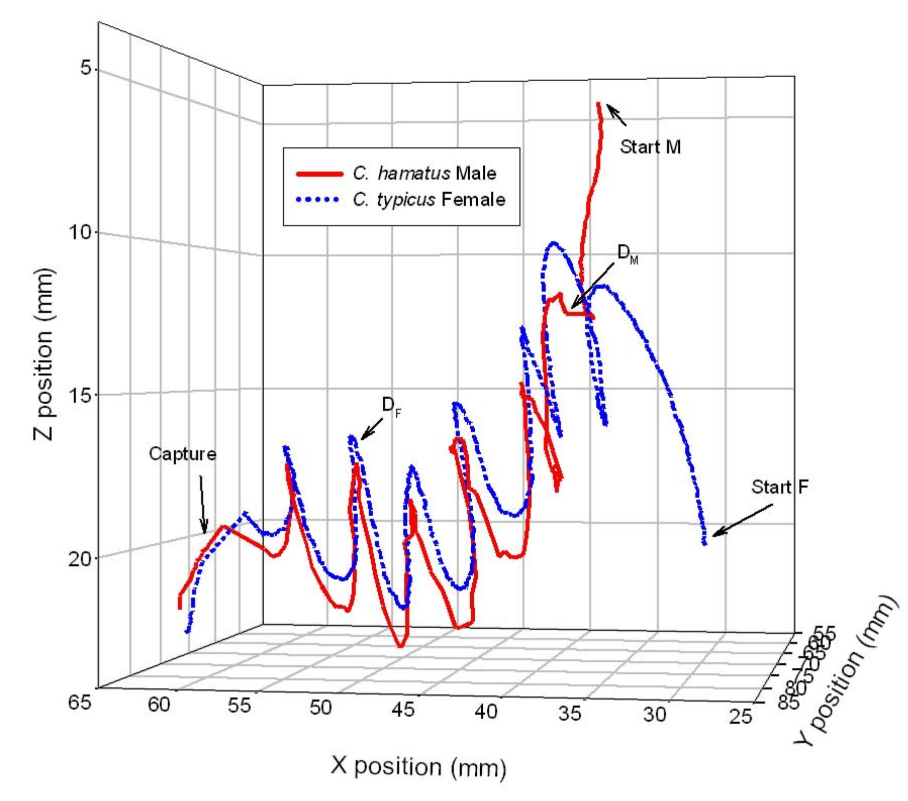
Control: *C. typicus*



1. Males attempt heterospecific mating at comparable frequencies to conspecific controls.
2. Spermatophore transfers rare.

Mating signals used in species recognition?

Is any species information contained in chemical or hydromechanical cues detectable prior to capture?



Observations:

- Male velocity during pursuit
- Duration of chase
- Trail age at encounter
- Length of pursued trail
- Along track distance at encounter
- Proportion of time trail is lost
- Proportion of time male initiates tracking in incorrect direction

Heterospecific: 24 events (14 captures)

Conspecific: 27 events (10 captures)

No species information in the pheromone signal

No difference in male tracking behavior between hetero- and conspecific mating events

Conspecific	Heterospecific	Sig?	
10%	23%		Lost trail
35%	32%		Incorrect initial tracking direction
22.4 (13.4 - 33.8)	25.3 (13.5 - 57.2)	NS	Male velocity during pursuit (mm/sec)
0.8 (0.3-9.6)	1.2 (0.2 - 8.6)	NS	Duration of chase (sec)
4.1 (0.2 - 7.6)	3.1 (0.36 - 26.5)	NS	Trail age at detection (sec)
26.3 (11.7 - 57.9)	26.1 (8.7 - 138.8)	NS	Length of pursued trail (mm)
17.1 (4.8 - 41.4)	16.3 (5.6 - 97.8)	NS	Along track distance at detection (mm)

Heterospecific mating: Important in natural populations?

Is the ocean filled with sexually attractive pheromone trails?

Heterospecific mating: Important in natural populations?

Encounter rate: $E = \beta C_f C_m$

β = *search volume rate*

$$\beta_{trail,cruiser} = 2Lu_{2D}\left(\sqrt{\frac{D_P L}{v}} + S\right)$$

Kiørboe and Bagoien, 2005

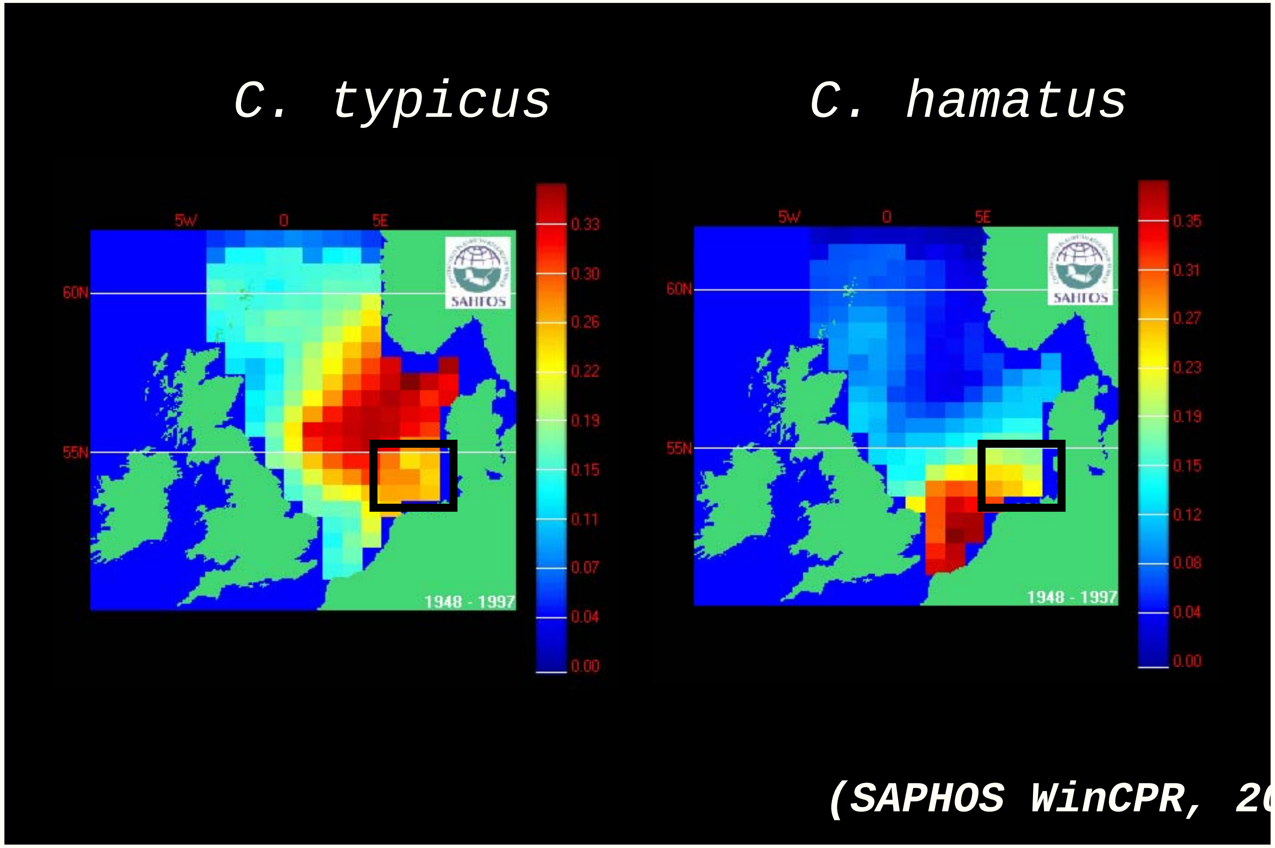
$\beta_{typicus}$ = *168*
$\beta_{hamatus}$ = *24*
$\beta_{hamatus\ M,\ typicus\ F}$ = *96*

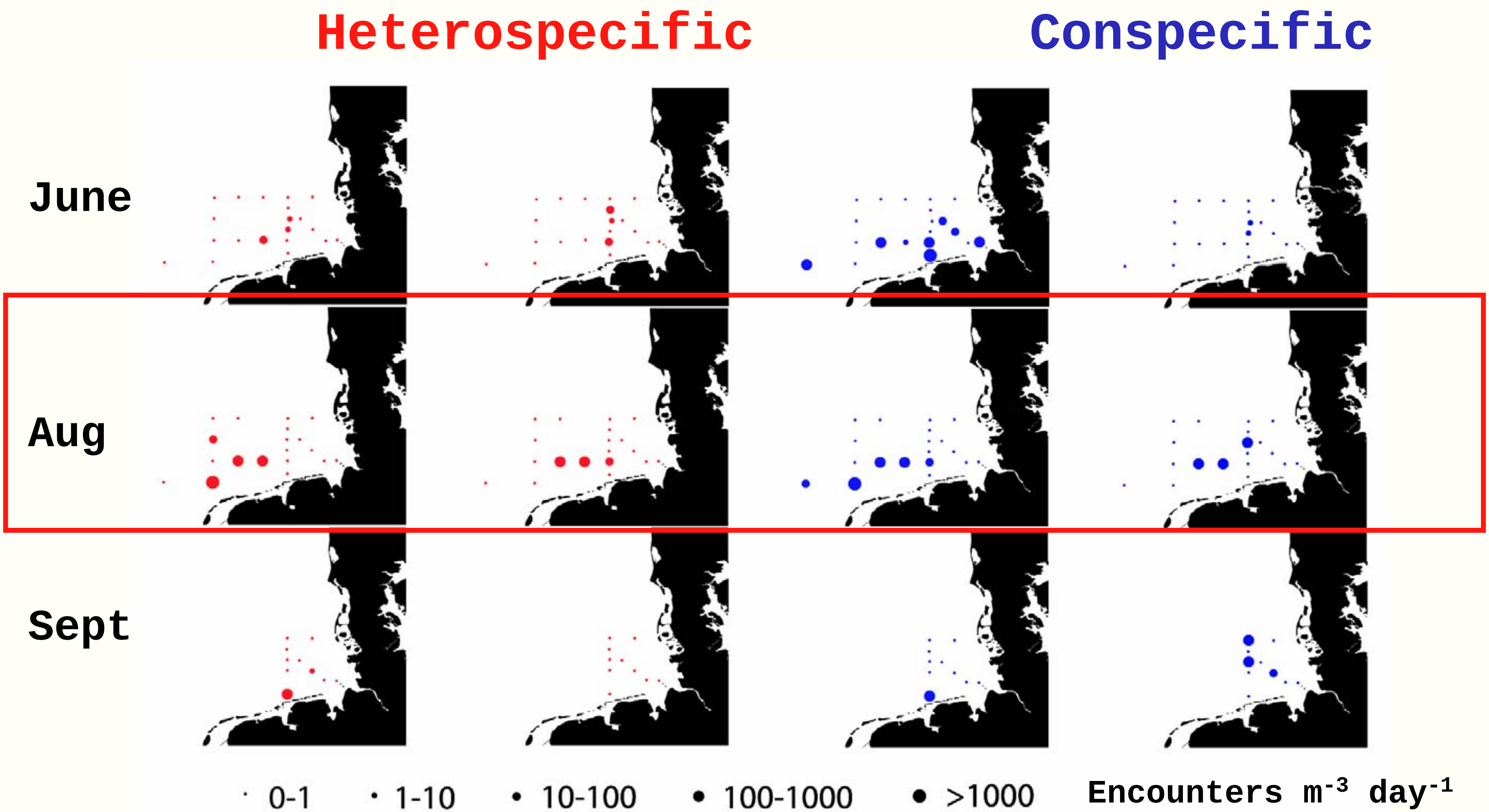
$\beta_{typicus\ M,\ hamatus\ F}$ = *43*

	C. hamatus	***C. typicus***
L	4	15*
u_{2D}	2.48	3.92
v	5.7	6.5*
S	0.13	0.15*

* *from Kiørboe and Bagoien, 2005*

Encounter rates in the North Sea

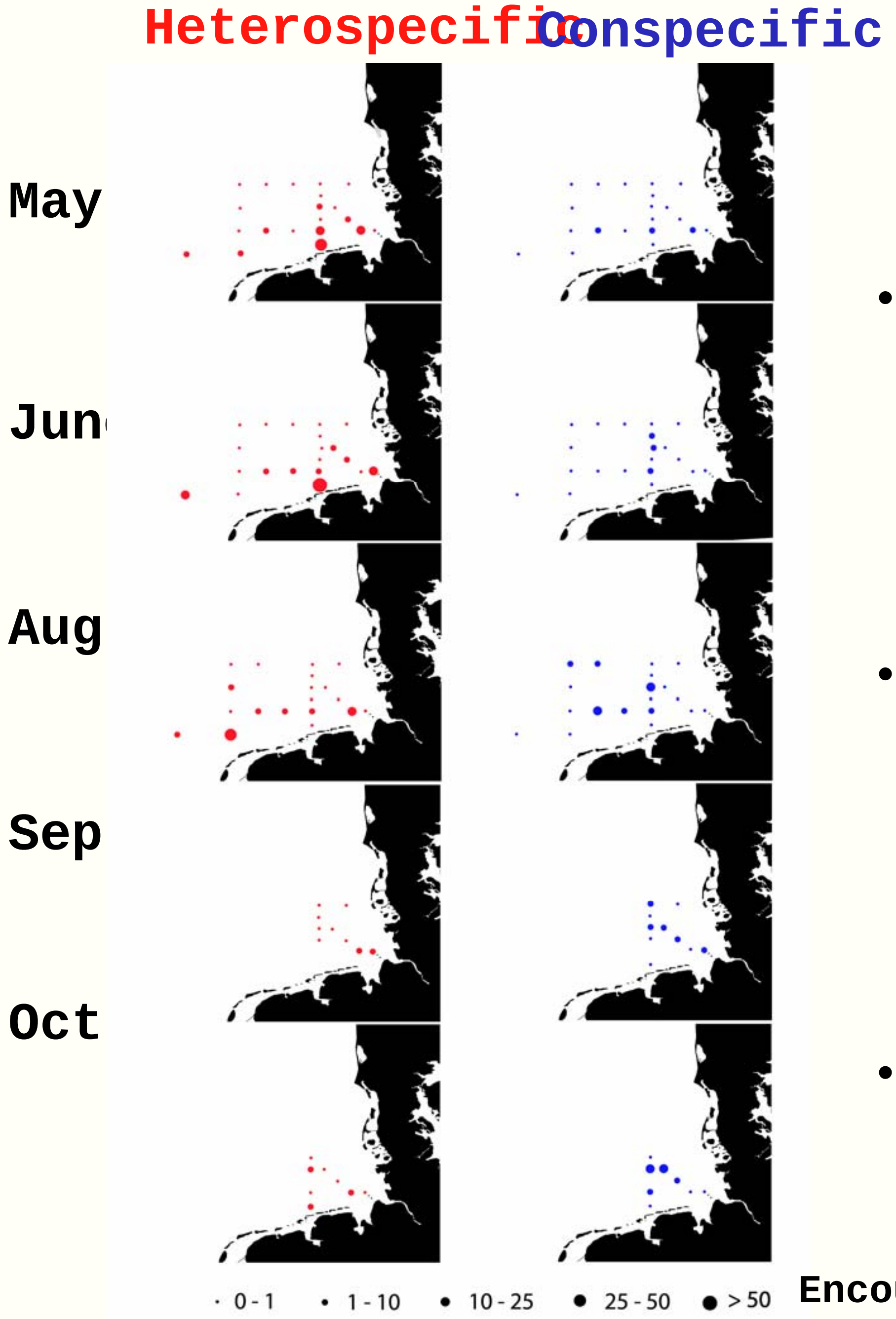




- Highest heterospecifc encounter rate in August (~2000 enc m^{-3} day^{-1})
- Same order of magnitude for hetero- and conspecific encounter rates

2004 Abundance data courtesy of GLOBEC Germany, and

Specific encounter rates, *C. typicus* females:



Encounters female $^{-1}$ day^{-1}

- *C. typicus* is chemically 'conspicuous' to males of both species, and bears the higher fitness cost of heterospecific mating attempts.
- Often encounters heterospecific males at higher rates than conspecific males (up to 100+ encounters day $^{-1}$).
- Selection for temporal + spatial isolation of species?

2004 Abundance data courtesy of GLOBEC-Germany, and Jürgen Alheit

Broader implications……… so far

1. Diffusible pheromone signal highly non-species specific
   - Males may detect and respond to pheromone trails created by a variety of species

2. No or nearly no species information contained in pheromone or hydromechanical cues
   - Cues detectable at contact - surface proteins, morphological shape - are primary in species recognition

3. Heterospecific mating attempts can be a significant fraction of total mating events during part of the reproductive season
   - Higher pheromone producing, faster, rarer species will suffer the greatest burden of heterospecific mating
   - Selection against heterospecific mating attempts: mechanism to create habitat isolation between congeners?

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