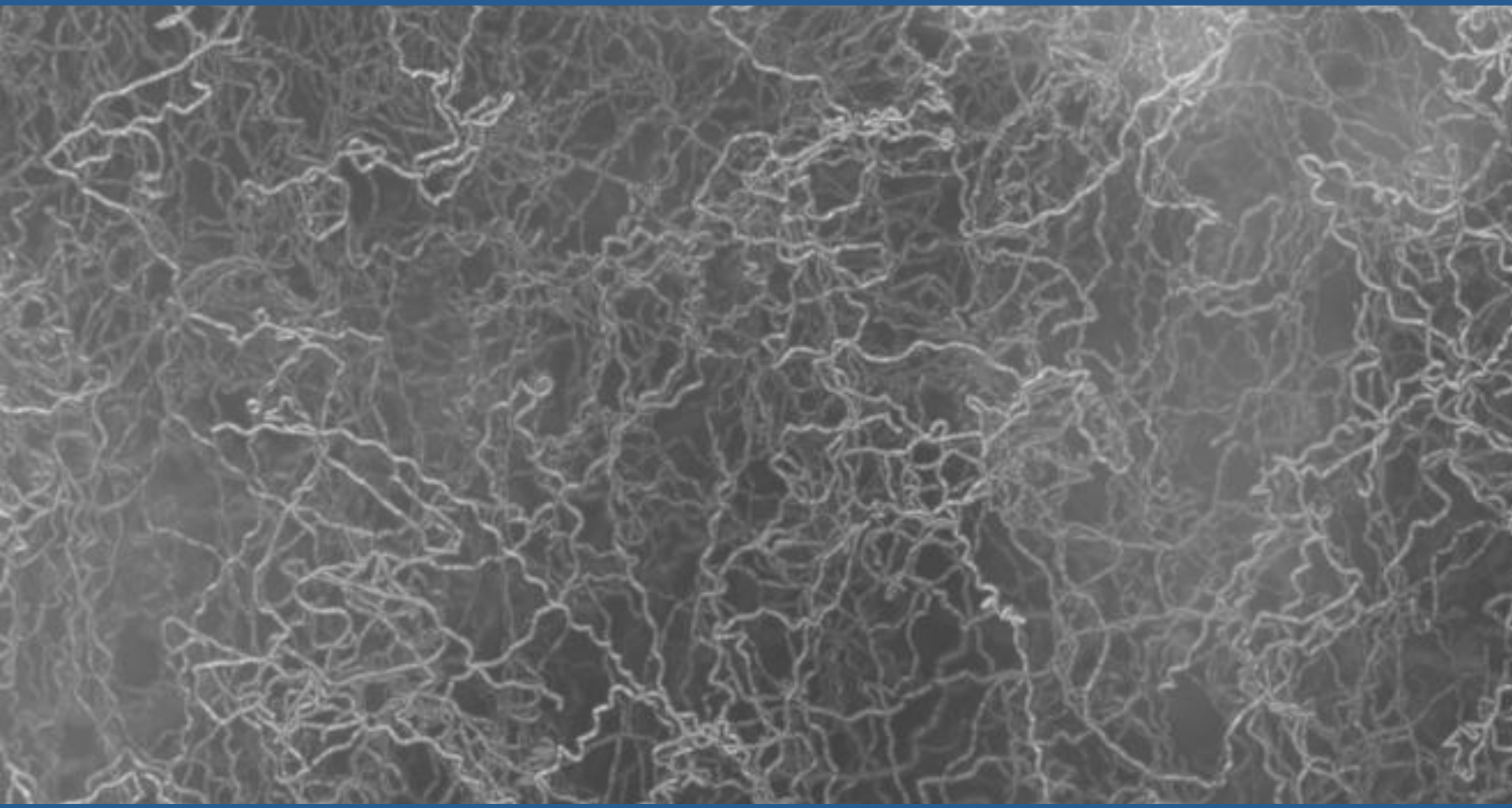
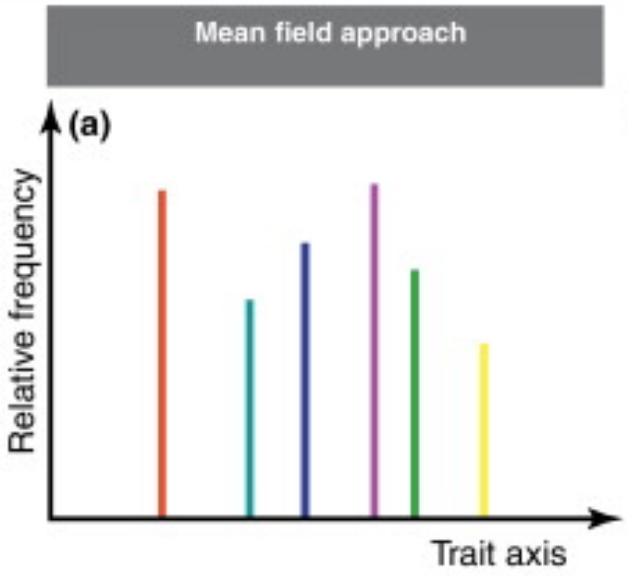
Linking individual movement to population-level dynamics: strain-specific behaviors of *Heterosigma akashiwo*



Elizabeth L. Harvey
Skidaway Institute of Oceanography, University of Georgia
Susanne Menden-Deuer, Tatiana A. Rynearson
Graduate School of Oceanography, University of Rhode Island

Intra-specific level variability



Violle et al. 2012, Trends in Ecology & Evolution

Things move in the ocean!

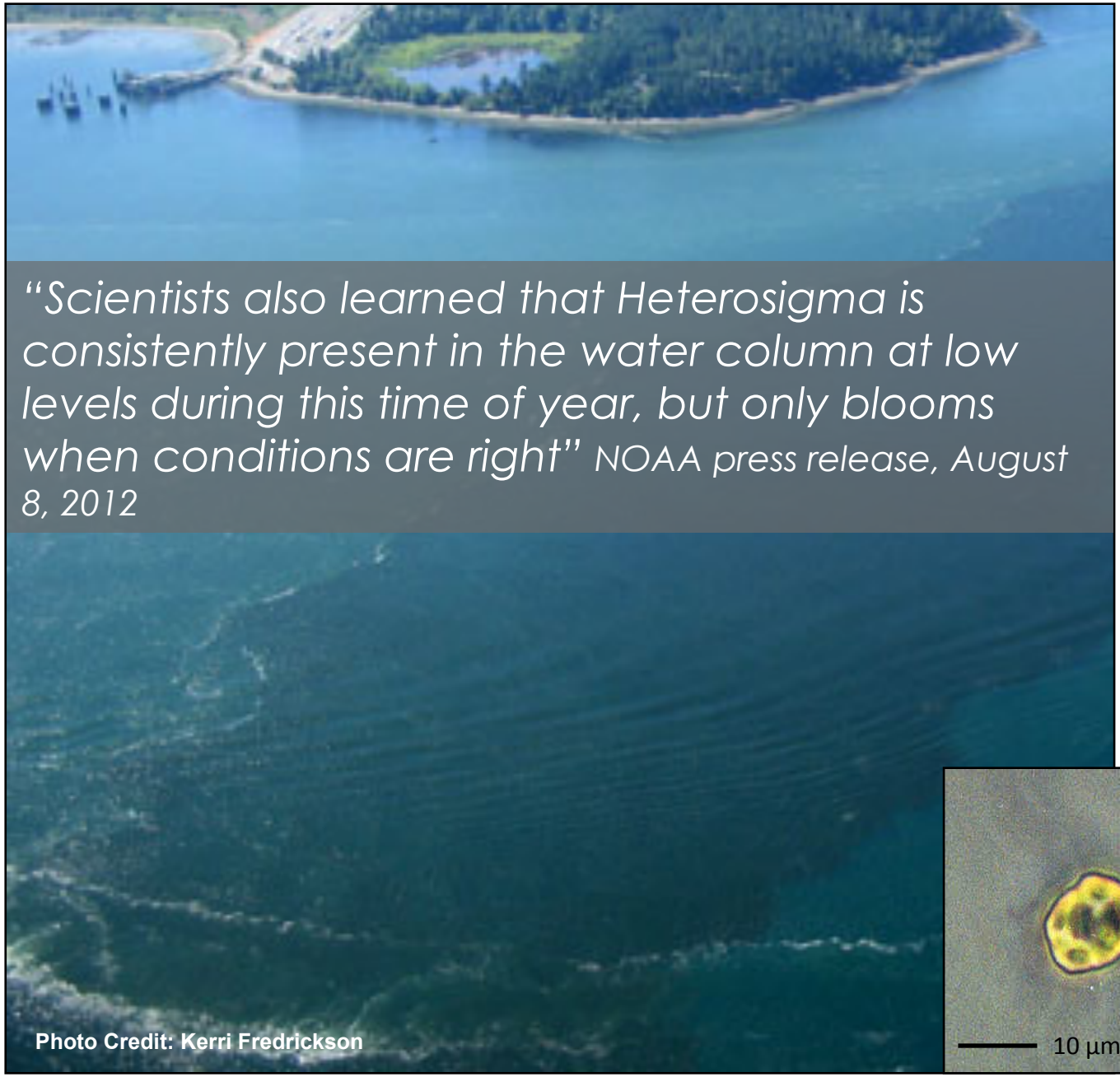
Grow – finding resource patches, light gradients

Reproduce – sexual reproduction, excystment

Survive – escape from predators

- Motility is highly variable on an individual level
- Even small differences can have significant consequences – difference of 20 $\mu m\ s^{-1}$ is equivalent to differences of two body lengths a second or 1.7 m per day.

Examples from *Heterosigma akashiwo*



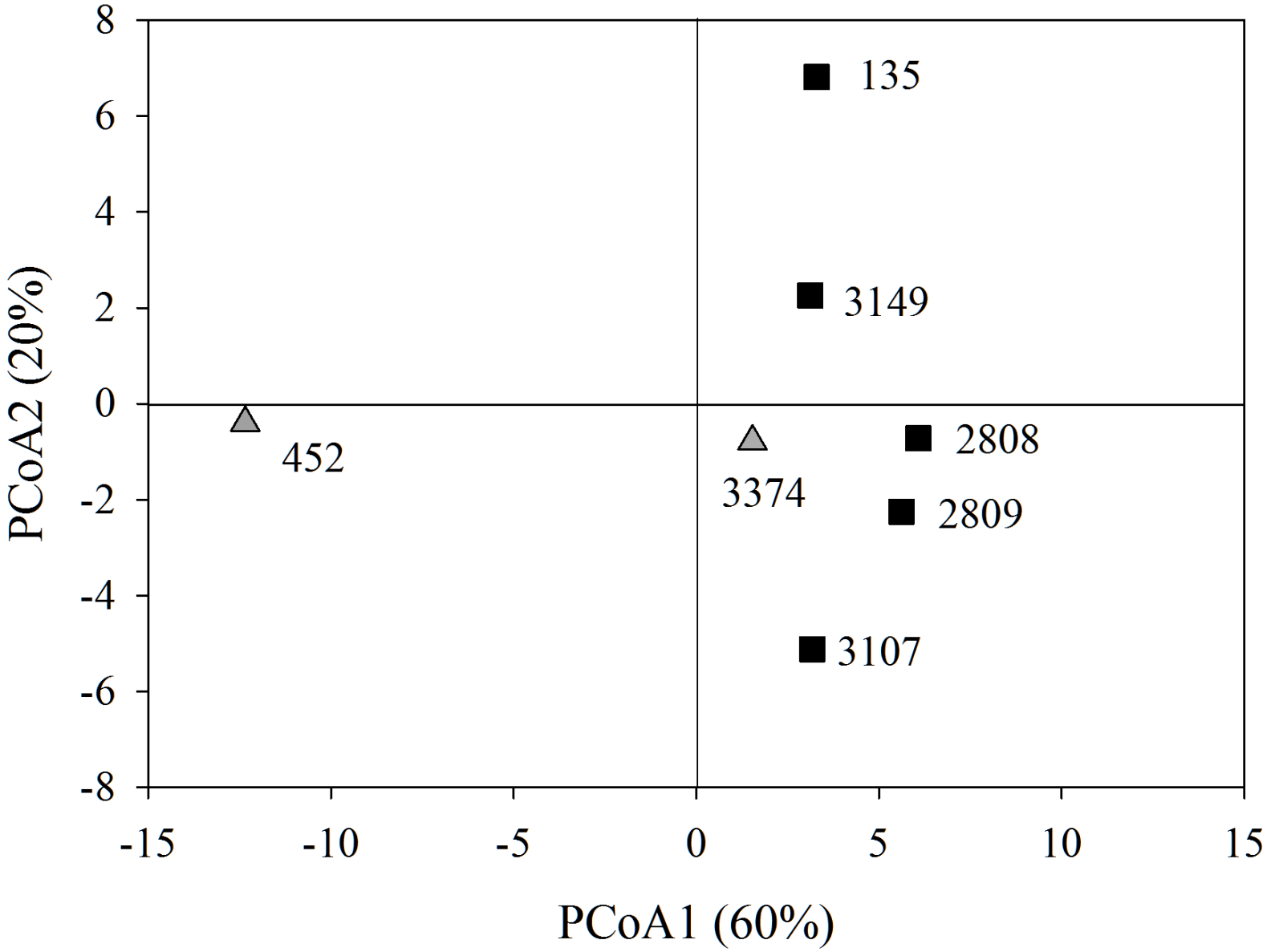
"Scientists also learned that Heterosigma is consistently present in the water column at low levels during this time of year, but only blooms when conditions are right" *NOAA press release, August 8, 2012*

Photo Credit: Kerri Fredrickson

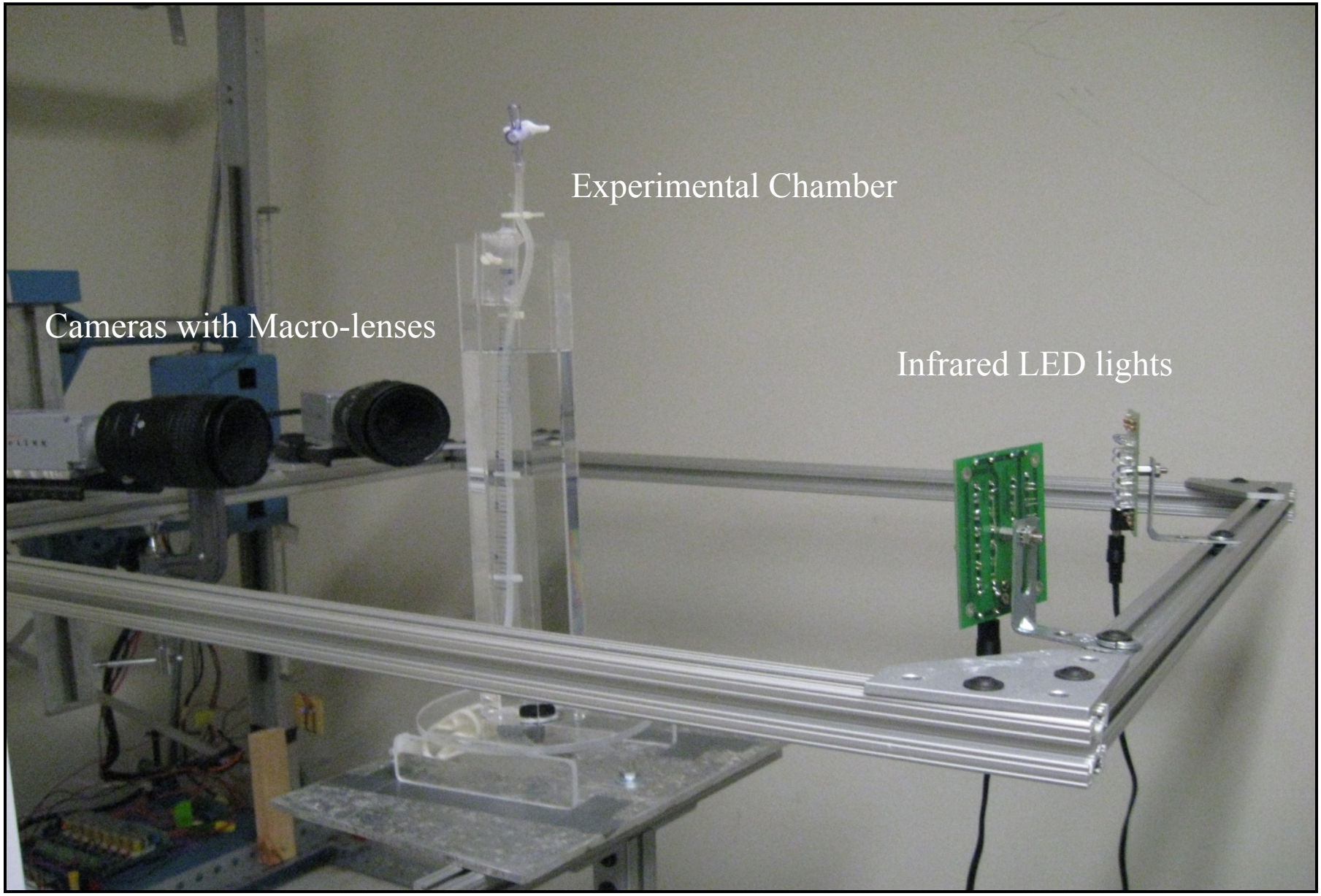
Strains used for investigating intra-specific variability

Strain Name	Ocean Basin	Location	Date	Carbon content pgC cell^{-1} (SD)
CCMP2808	NE Pacific	Guemes Channel, WA, USA	2006	160 (3.7)[a]
CCMP2809	NE Pacific	Guemes Channel, WA, USA	2006	143 (3.4)[b]
CCMP3149	NE Pacific	Lummi Bay, WA, USA	2007	115 (3.1)
SPMC135	NE Pacific	Burrow's Bay, WA, USA	2008	131 (3.1)[b]
CCMP3107[1]	NE Pacific	Nowish Inlet, British Columbia, Canada	2008	162 (2.9)[a]
CCMP452	NW Atlantic	Long Island Sound, CT, USA	1952	155 (3.3)[ab]
CCMP3374[1]	NW Atlantic	Greenwich Cove, RI, USA	2010	97 (2.6)

All strains are genetically different



Laboratory observations of plankton motility and distributions



Automated image analysis

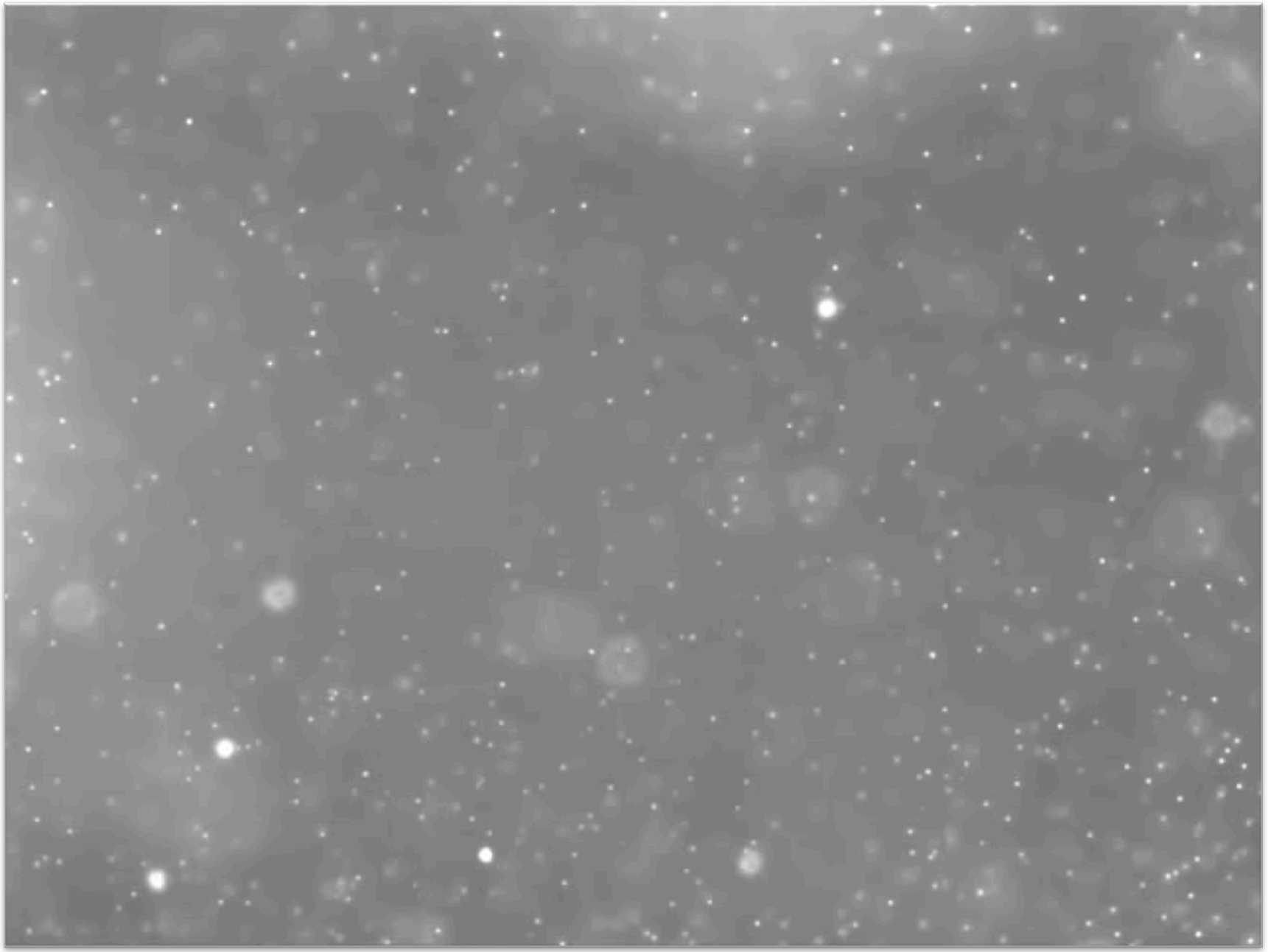
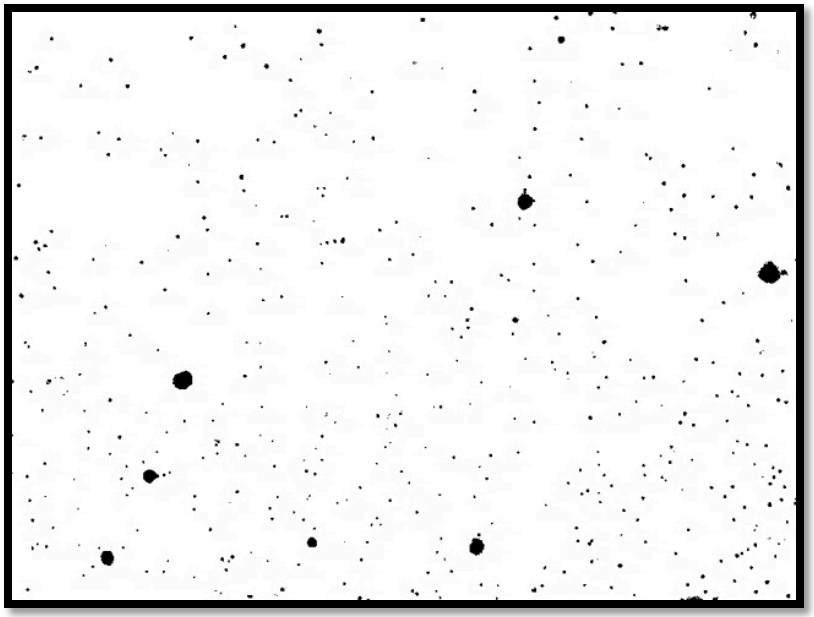
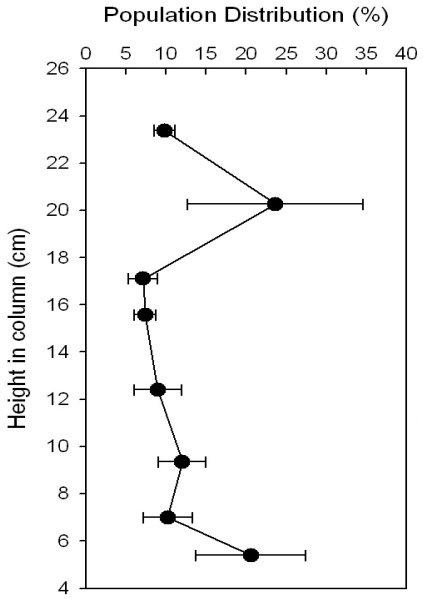


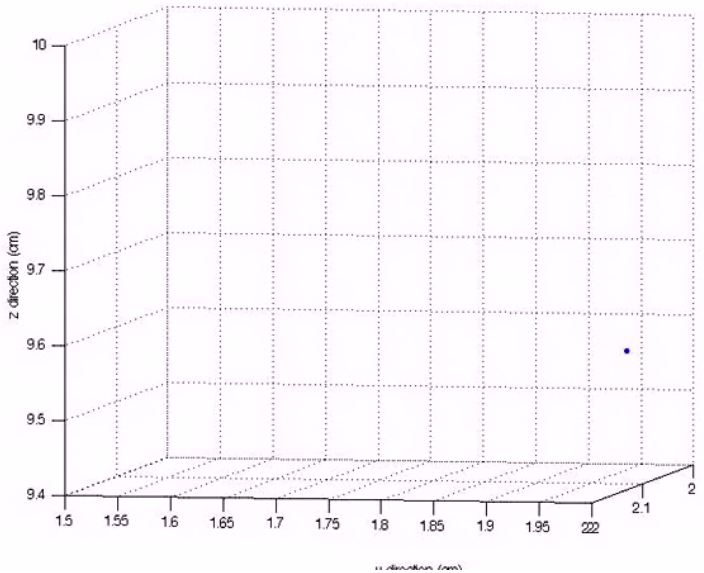
Image analysis yields population distributions and movement behaviors



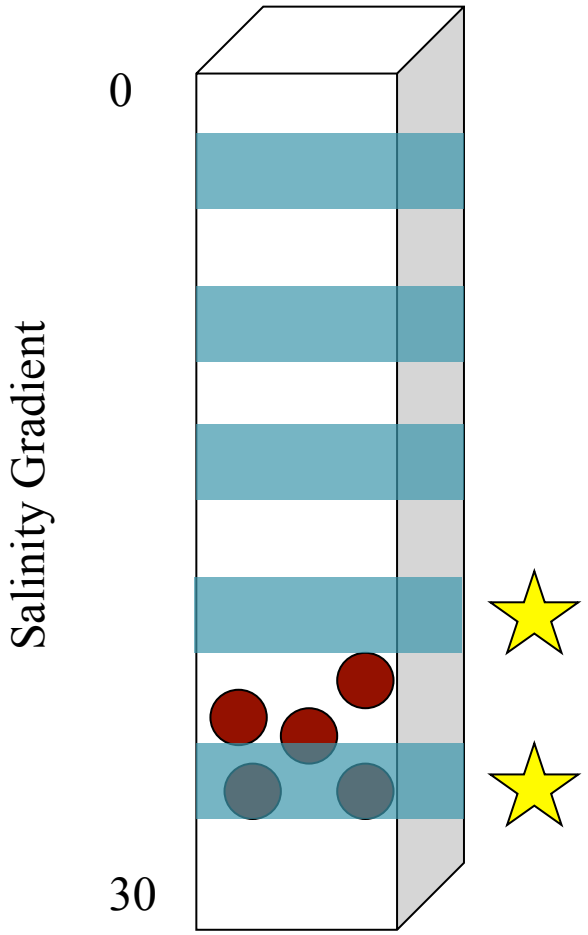
1. Population Distribution



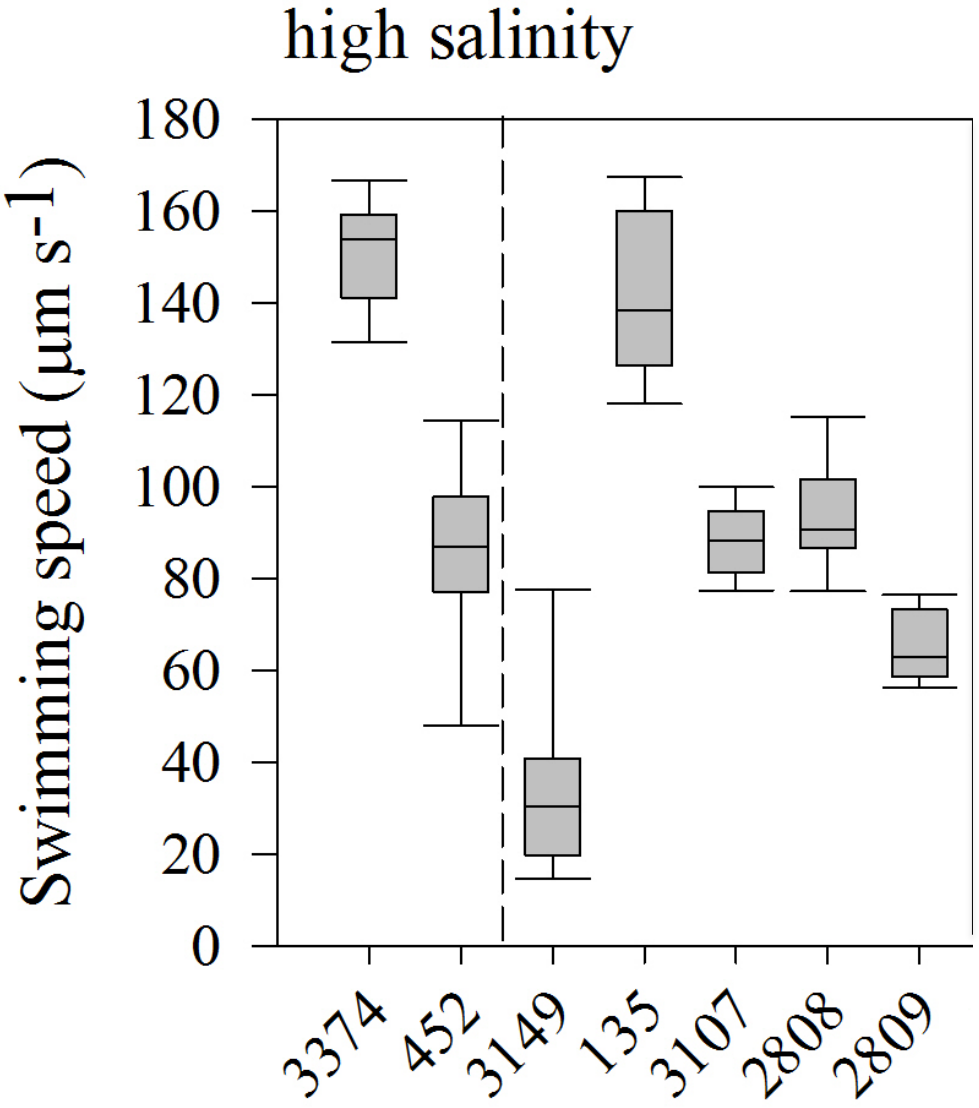
2. Swimming Behaviors



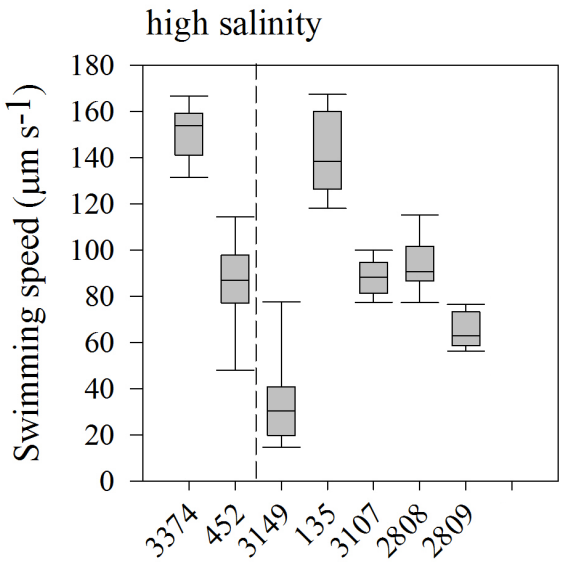
Experimental set-up

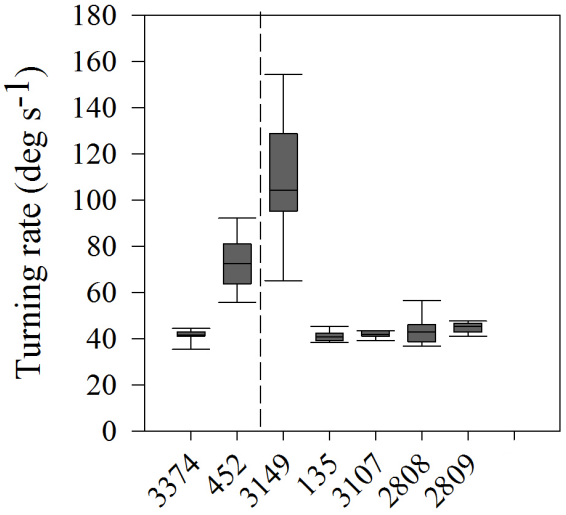


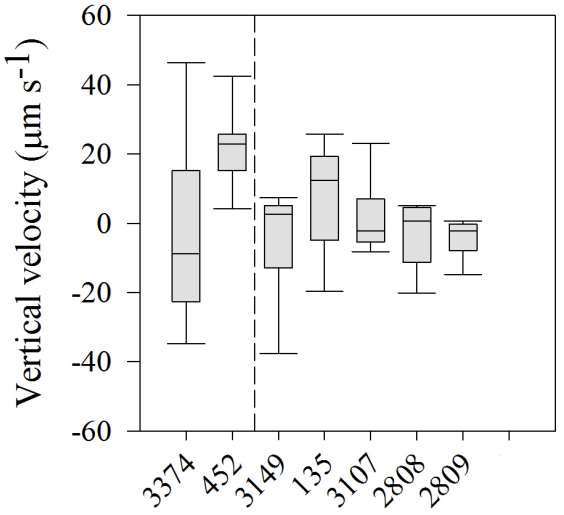
Strains exhibit significantly different movement behaviors



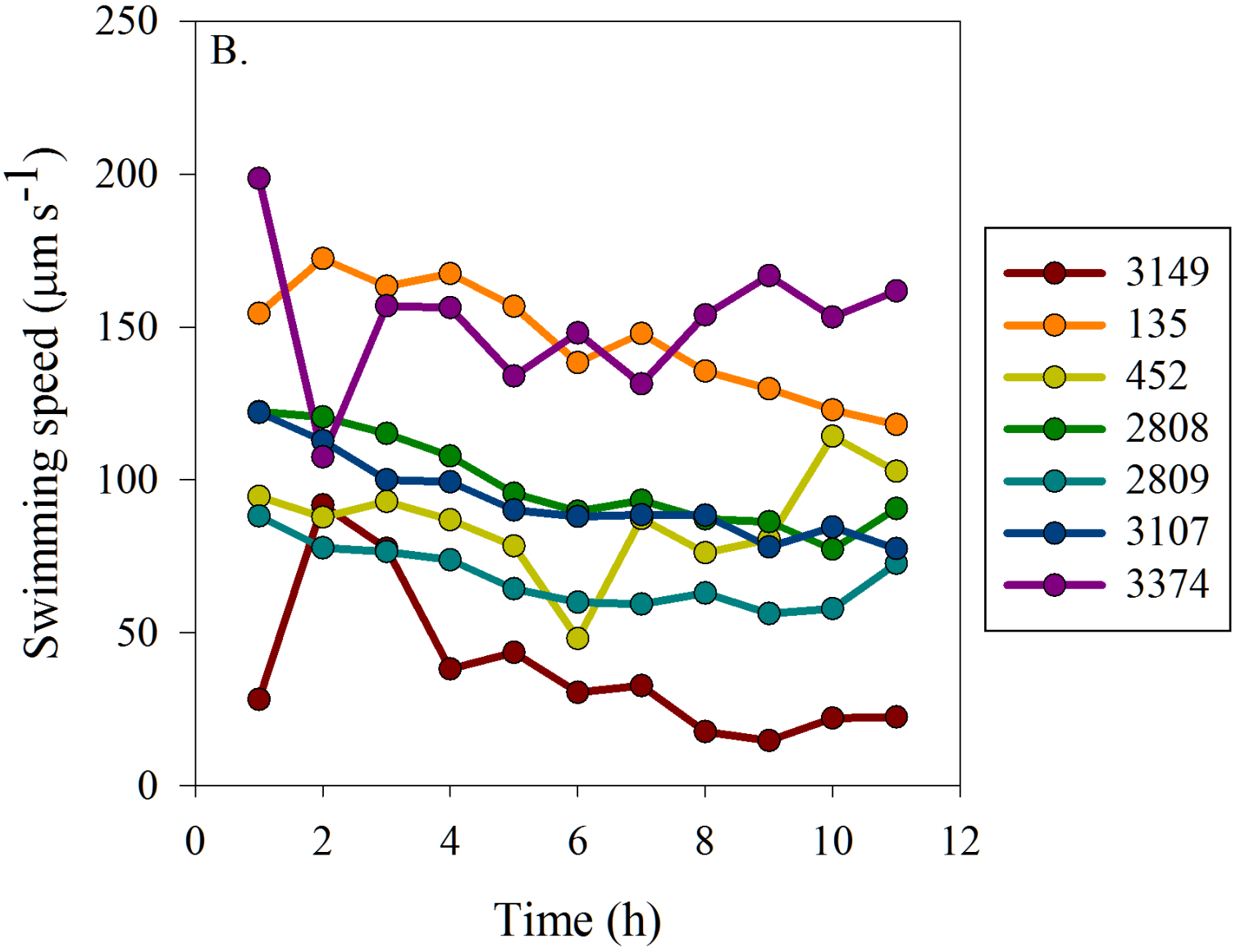
Strains exhibit significantly different movement behaviors



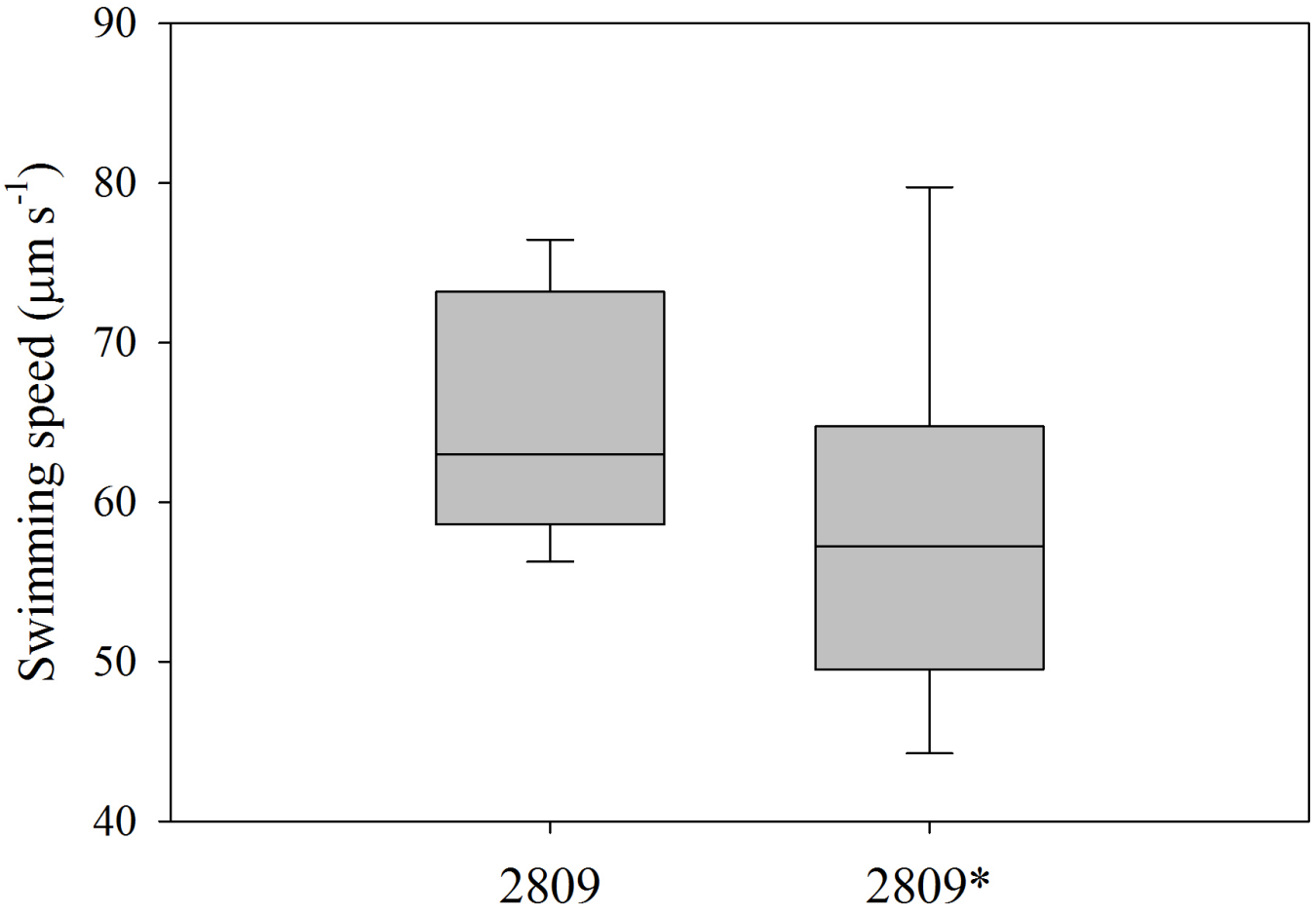




Movement behaviors stable over different temporal scales



Movement behaviors stable over different temporal scales

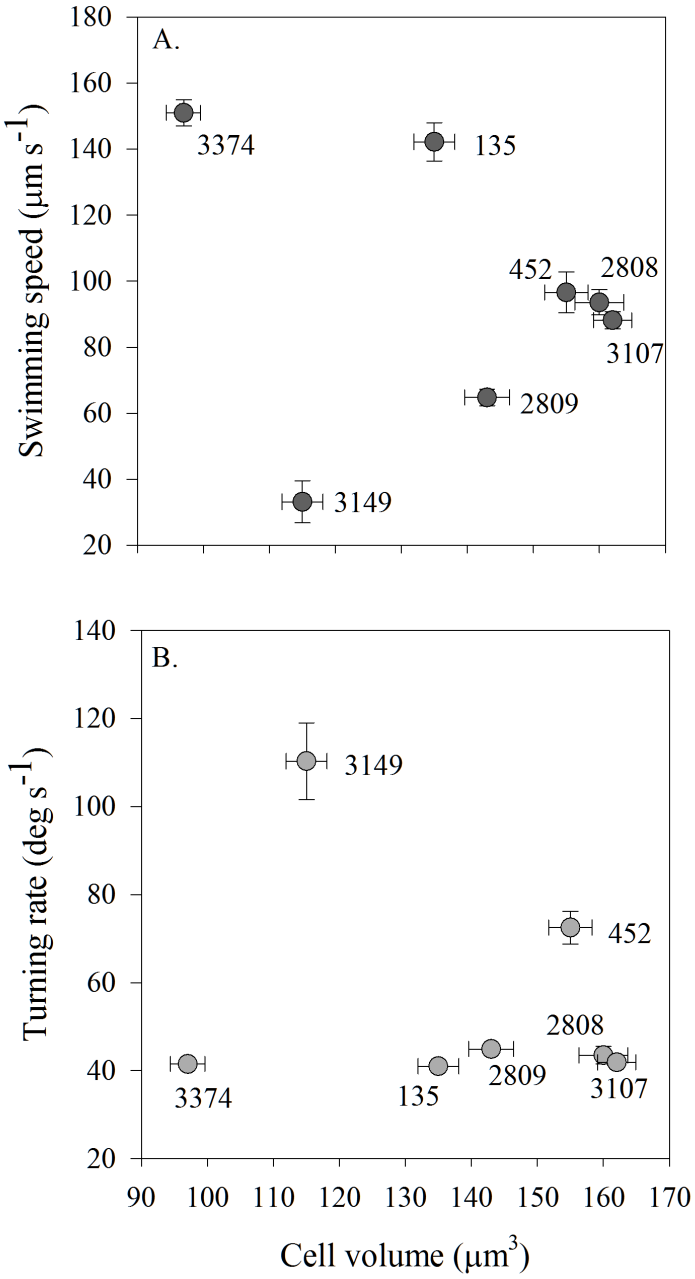


Movement behaviors stable over different temporal scales

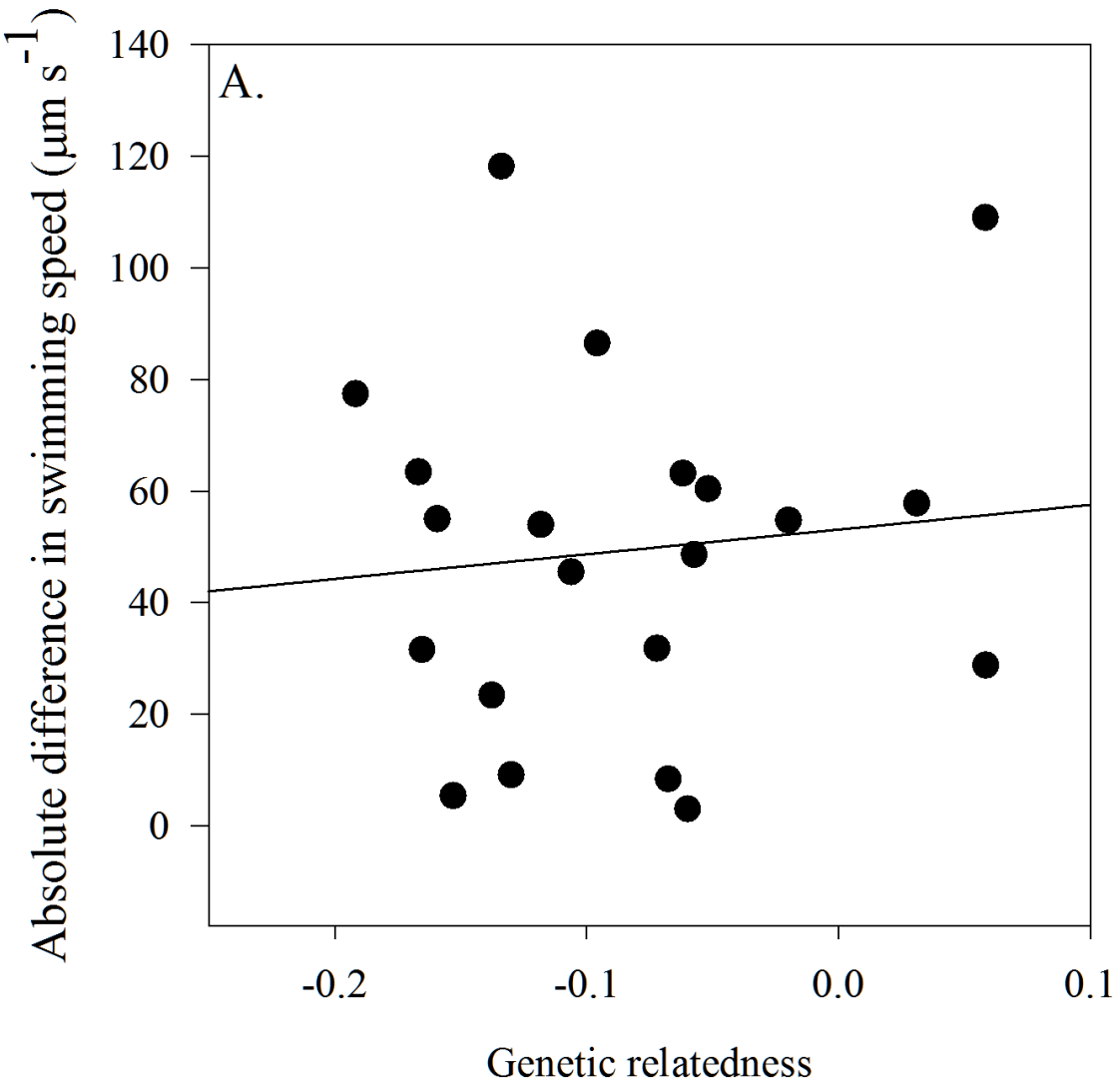
Strain 452

- Vertical velocity measured in this study: 25 – 72 $\mu m\ s^{-1}$
- Tobin et al. 2013: 36 $\mu m\ s^{-1}$
- Bearon et al. 2004: 35 – 60 $\mu m\ s^{-1}$

Movement behaviors are not related to size



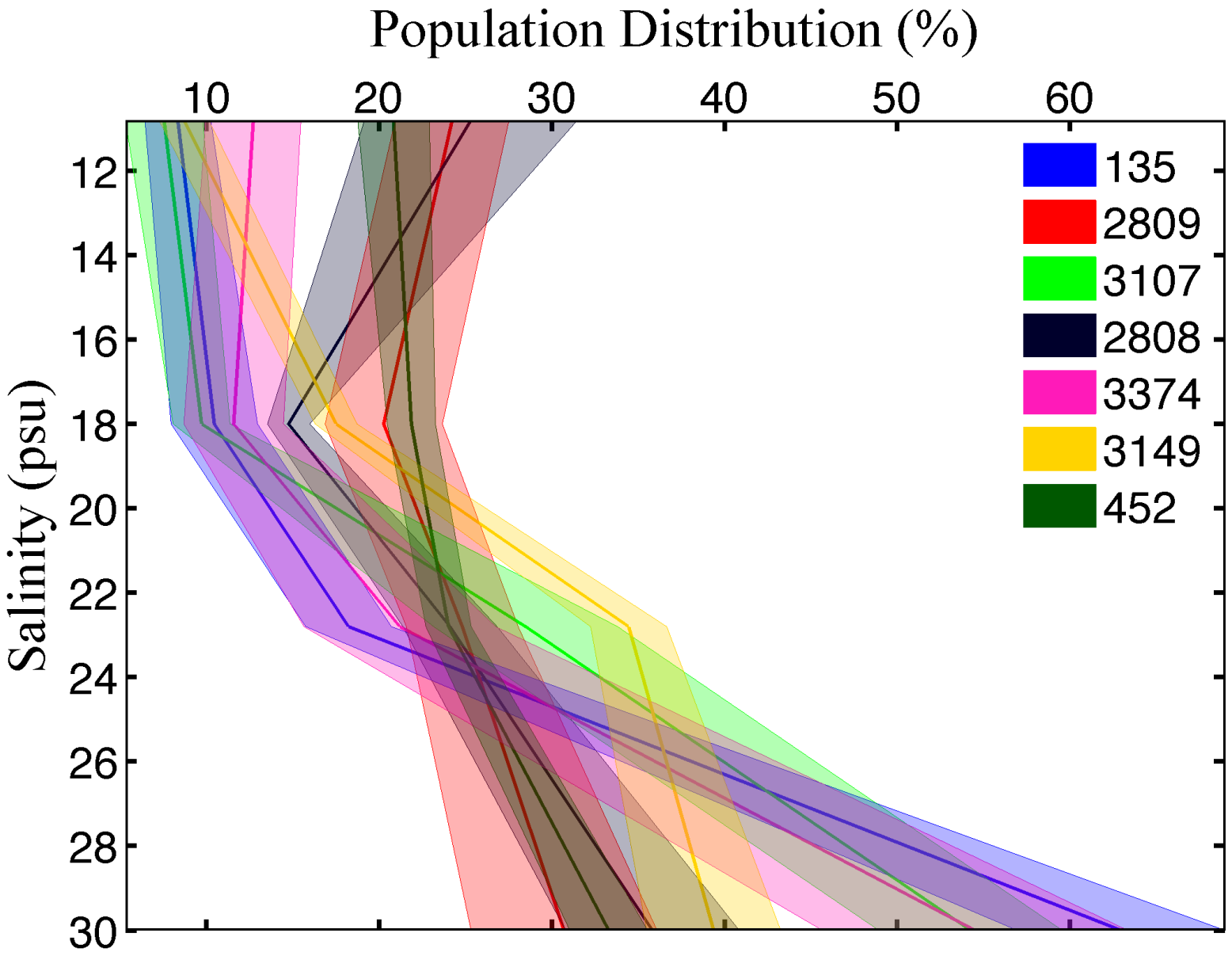
Movement behaviors are not correlated to genetic differences



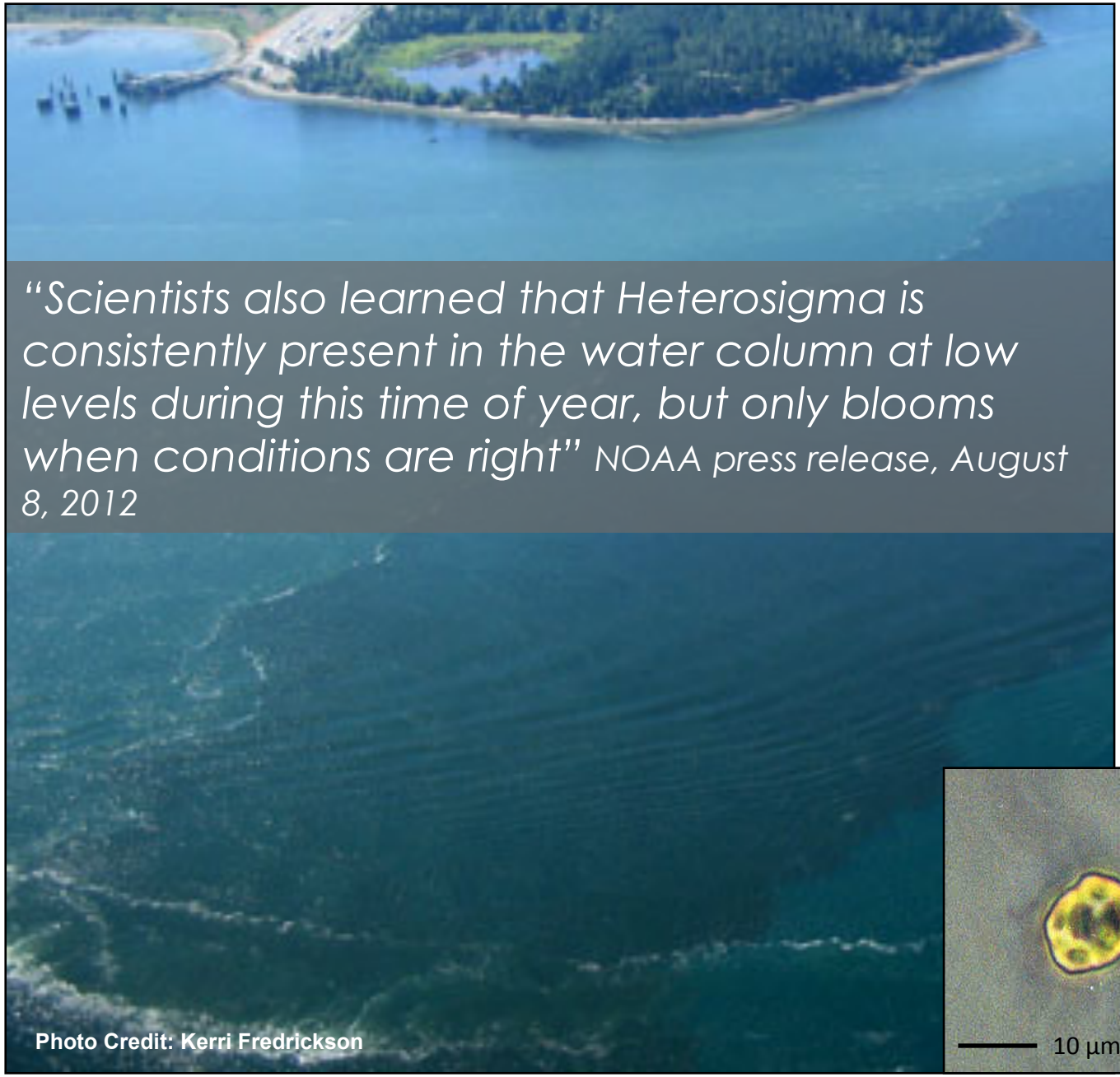
$y = 44.2x + 53.1$
$r^2 = 0.01$
$p = 0.66$

No significant correlations between dissimilarity matrices

Movement behaviors result in strain-specific population distributions



Intra-specific behavioral variability sustains *H. akashiwo*



"Scientists also learned that Heterosigma is consistently present in the water column at low levels during this time of year, but only blooms when conditions are right" *NOAA press release, August 8, 2012*

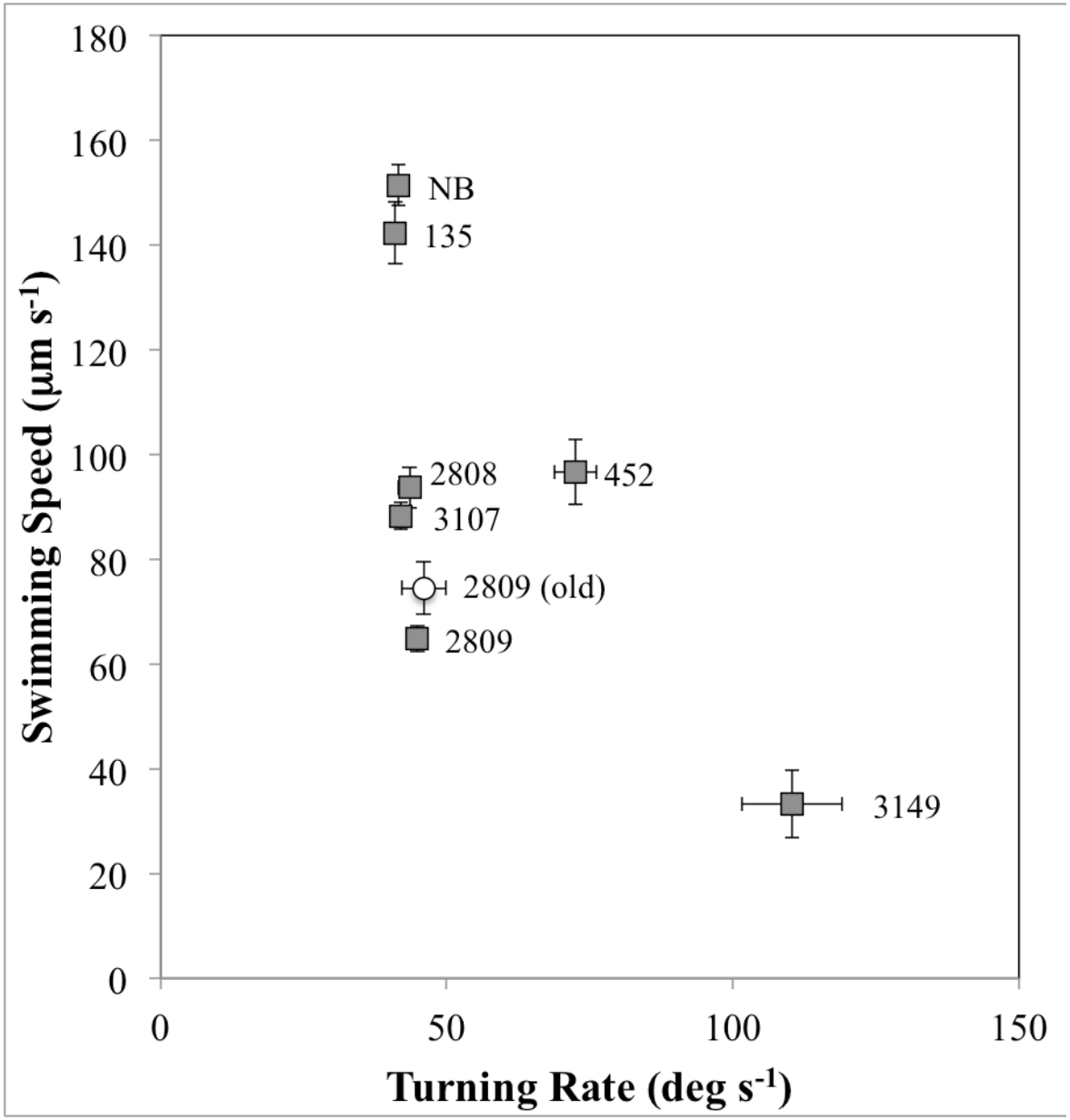
Photo Credit: Kerri Fredrickson

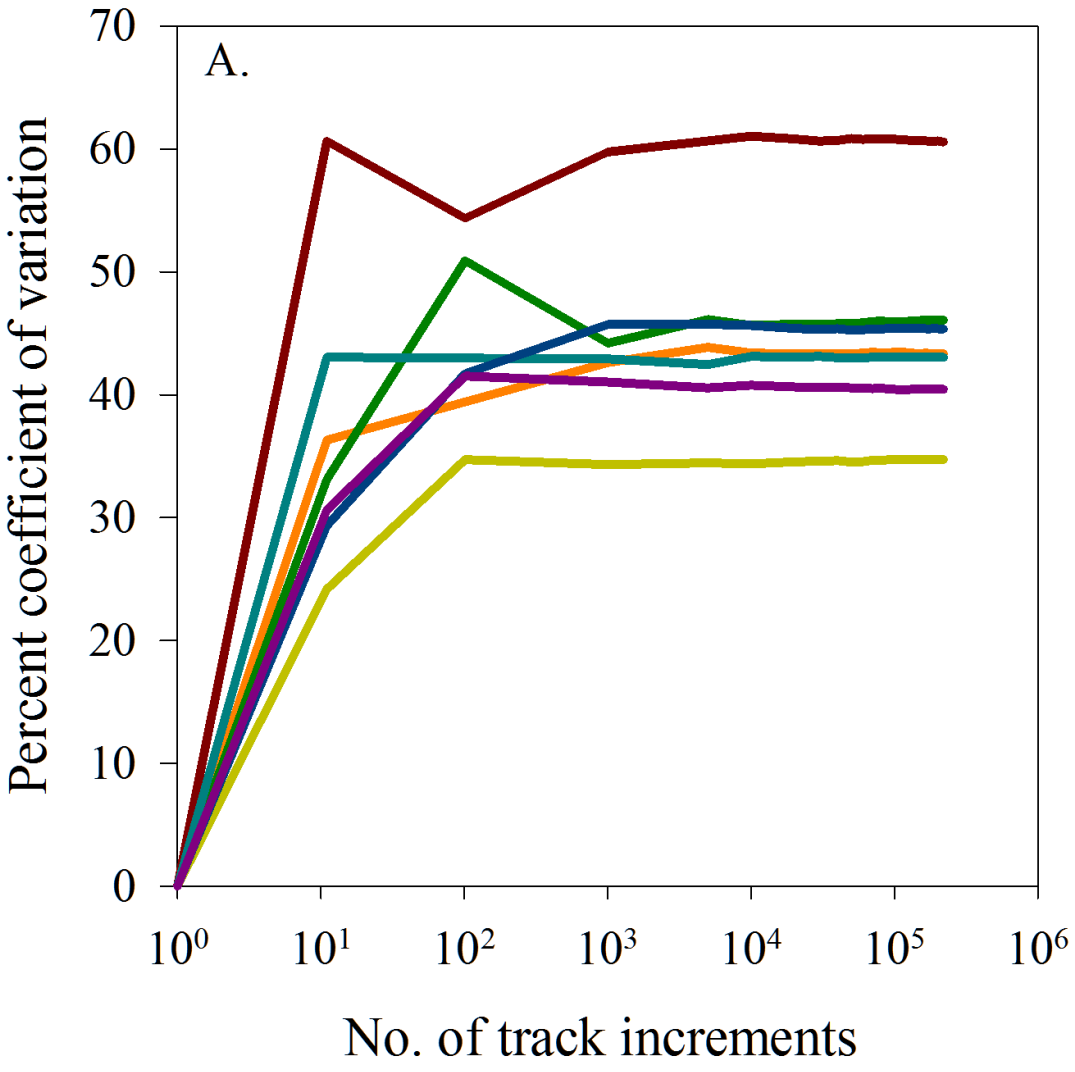
Paradox of the strain?

Movement behavior and genetic variability are high-resolution traits that can adequately capture the ramifications of intra-specific variability in order to predict and better understand the structuring of phytoplankton communities.

Thank you to:

- Steering committee of the traits conference
- Susanne Strom for sharing *H. akashiwo* cultures
- Rhode Island Genomics and Sequencing Center and the Marine Science Research Facility, supported by NSF (EPSCoR 0554548 & EPS 1004057)


180
160
140
120
100
80
60
40
20
0
Swimming Speed (μm s-1)
0
50
100
150
Turning Rate (deg s-1)
NB
135
2808
3107
452
2809 (old)
2809
3149


A.
70
60
50
40
30
20
10
0
Percent coefficient of variation
10^0
10^1
10^2
10^3
10^4
10^5
10^6
No. of track increments