



# The mechanics of range shifts in a warming world

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Who will shift,  
when?

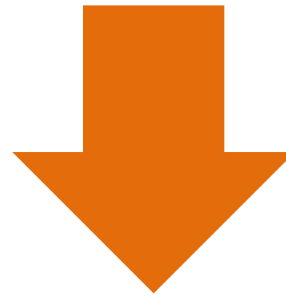
What sets  
geographic  
distributions in  
the first place?

Understanding the factors that determine species distributions has been a central goal of ecology for many years

Darwin, 1859

Andrewartha and Birch, 1957

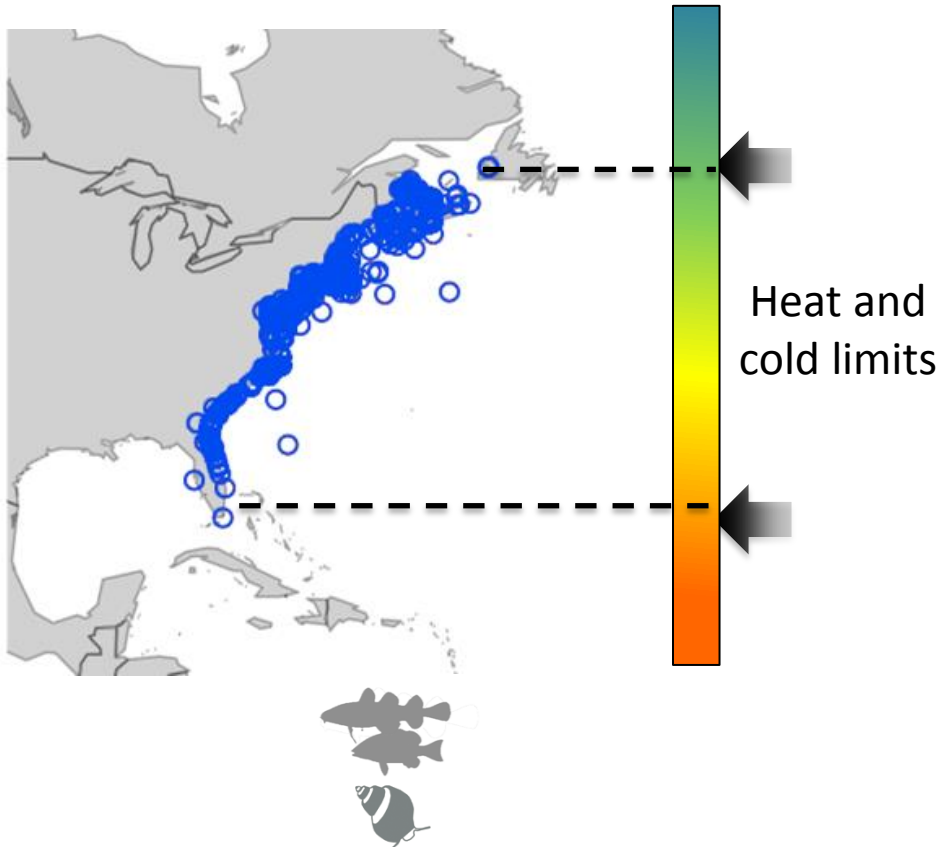
MacArthur, 1970



Climate change responses

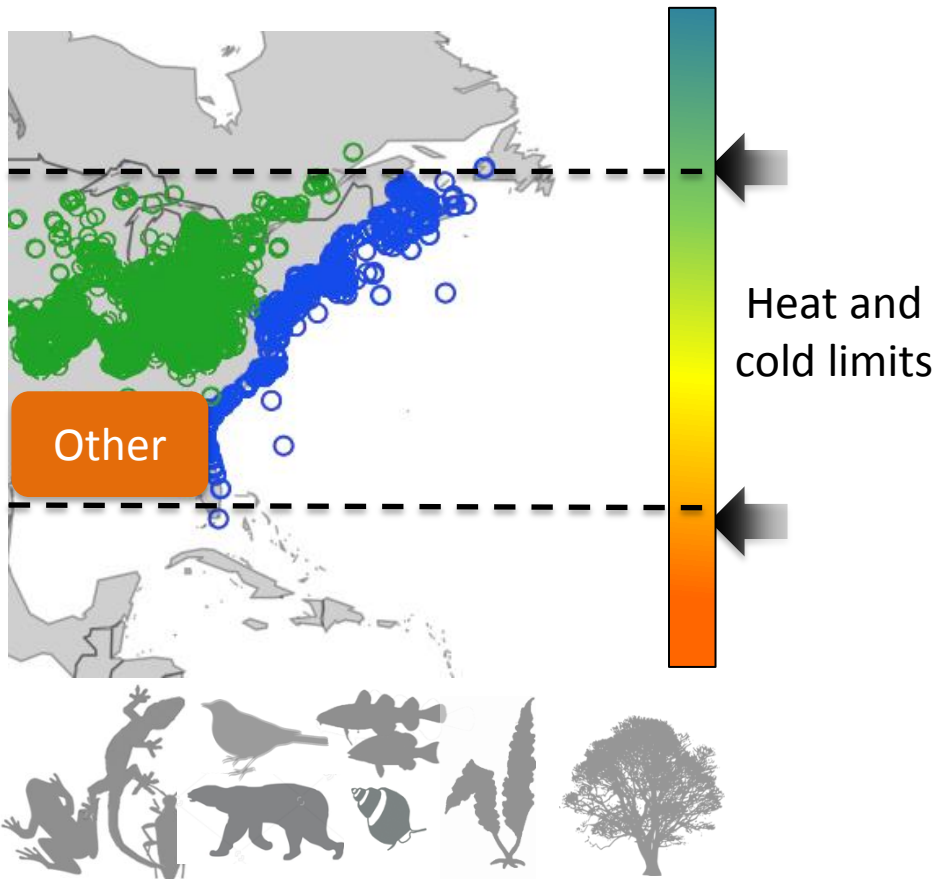
# Understanding range limits

Geographic distribution      Physiology



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Geographic distribution      Physiology

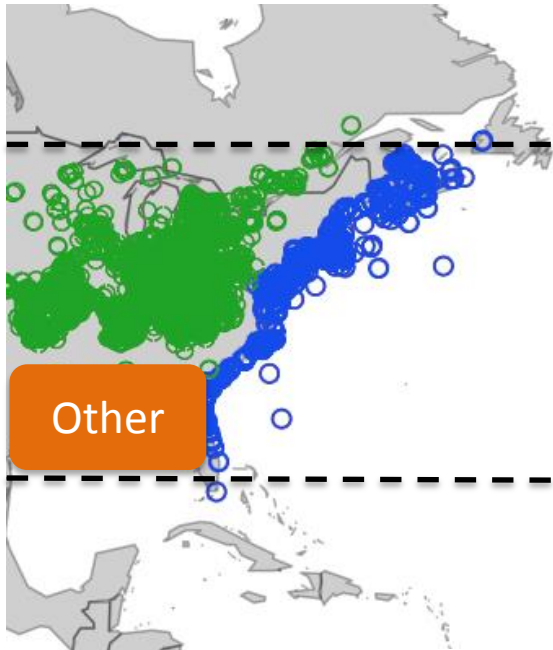




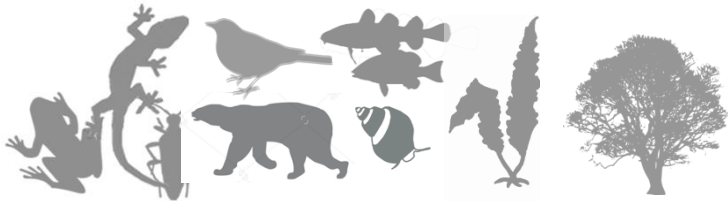
# Understanding range limits

Geographic distribution

Physiology



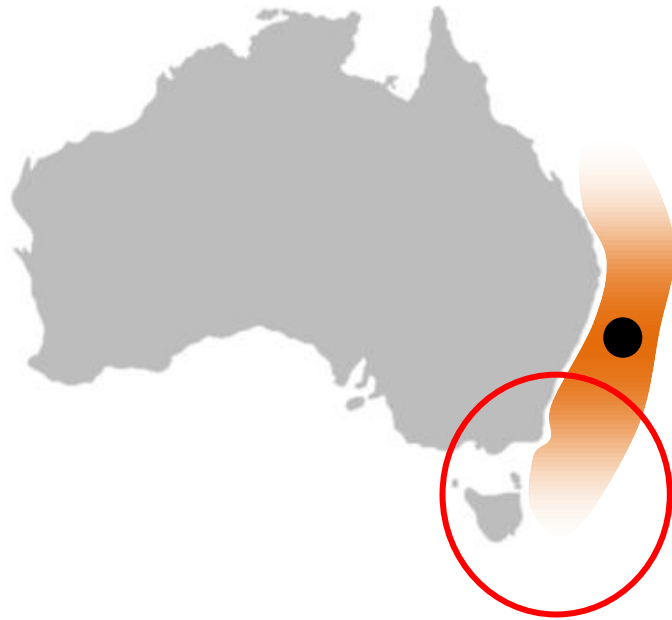
Heat and cold limits



Traits?



# Mechanics differ at trailing and leading edges



## Range contractions

### Extinction vulnerability

- Physiological sensitivity
- Life-history resilience
- Habitat buffering
- Adaptation

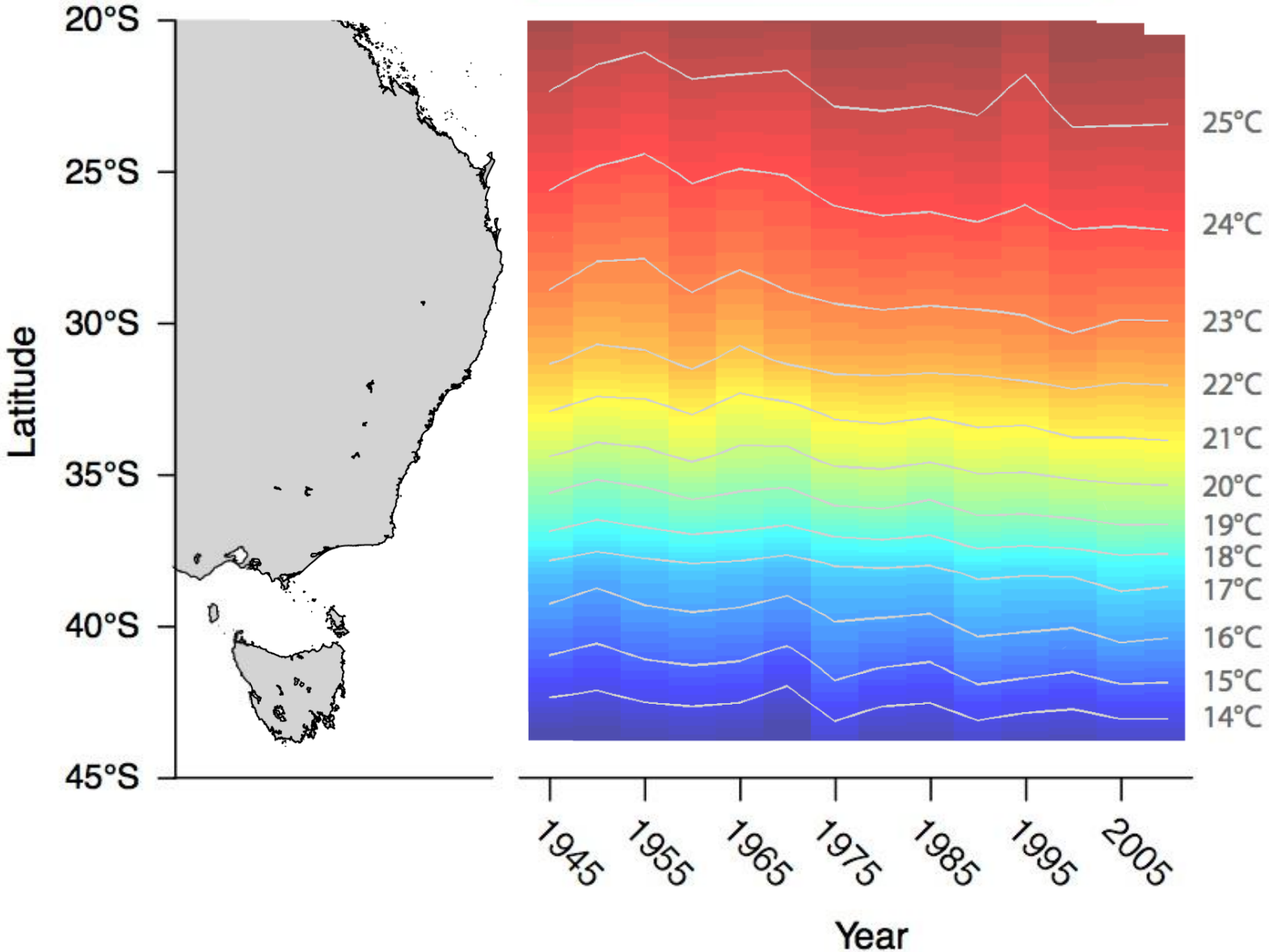
## Range extensions

### Invasion opportunity

- Arrival
- Establishment

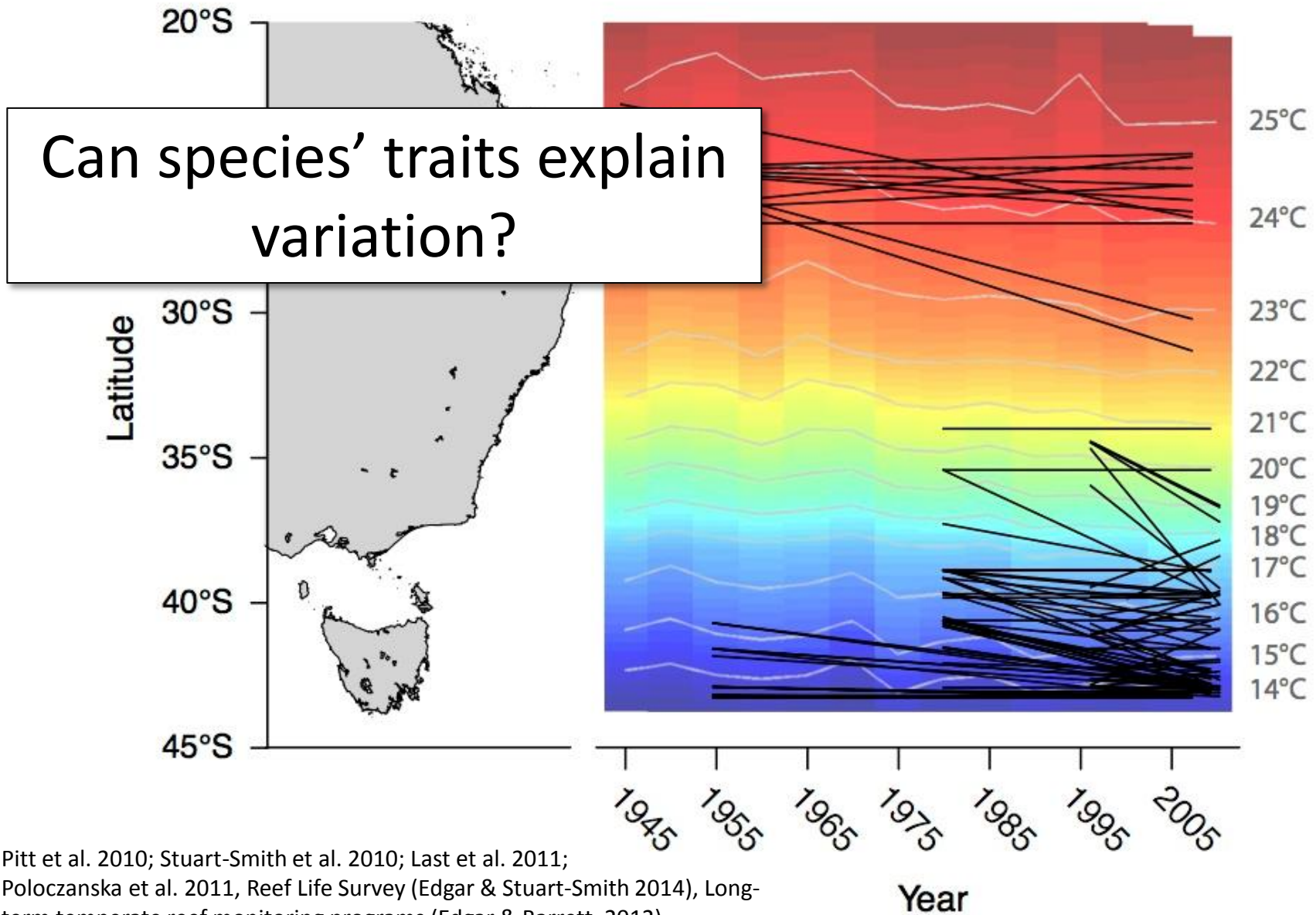


# Climate velocity





# 110 poleward range boundaries through time



Pitt et al. 2010; Stuart-Smith et al. 2010; Last et al. 2011;  
Poloczanska et al. 2011, Reef Life Survey (Edgar & Stuart-Smith 2014), Long-term temperate reef monitoring programs (Edgar & Barrett, 2012)

# Hypothesized factors promoting range extensions

Variation explained

## **Extrinsic driver**

Climate expectation 23.1%

## **Arrival**

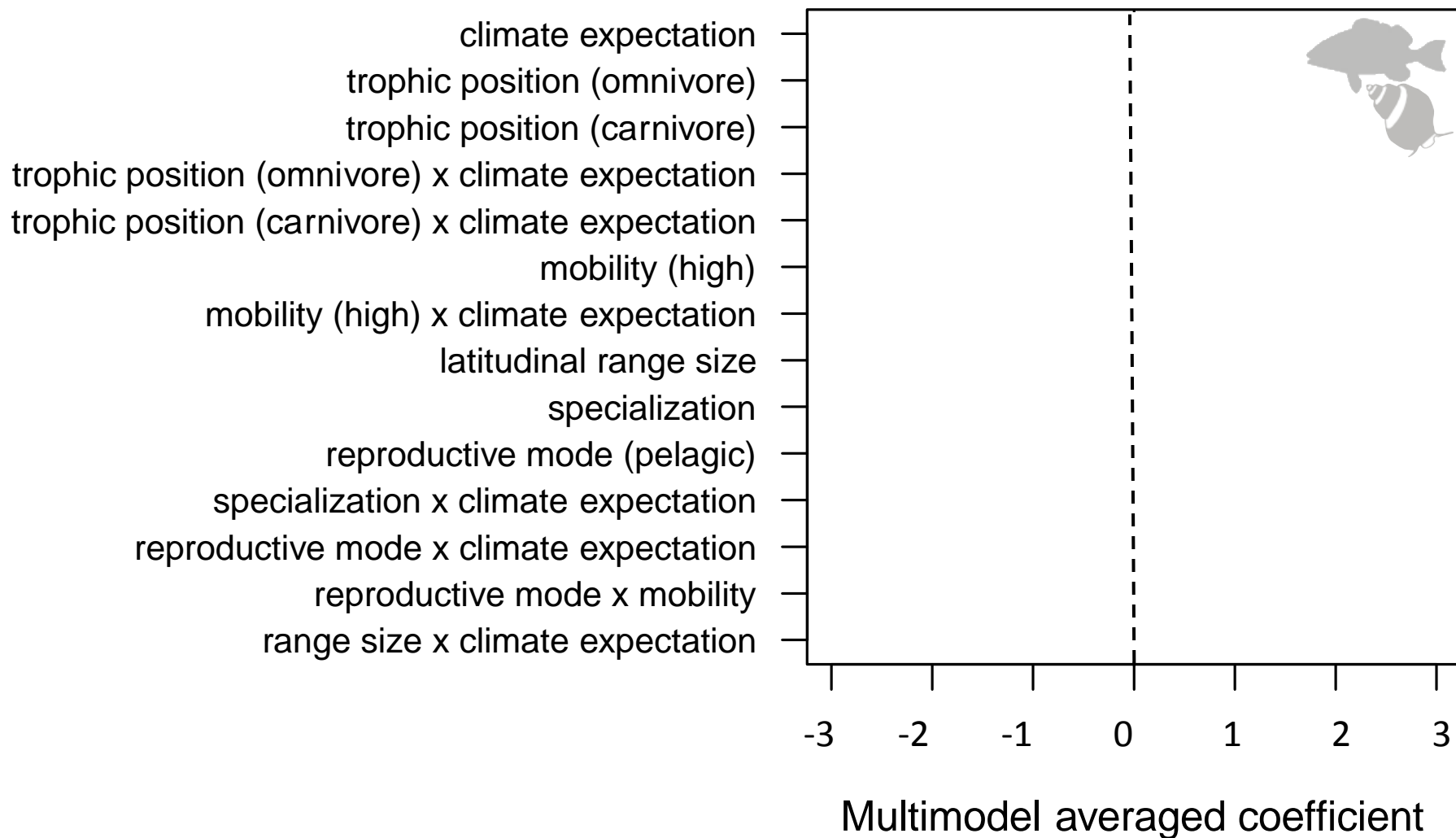
Adult mobility  
Reproductive dispersal  
Body size

## **Establishment**

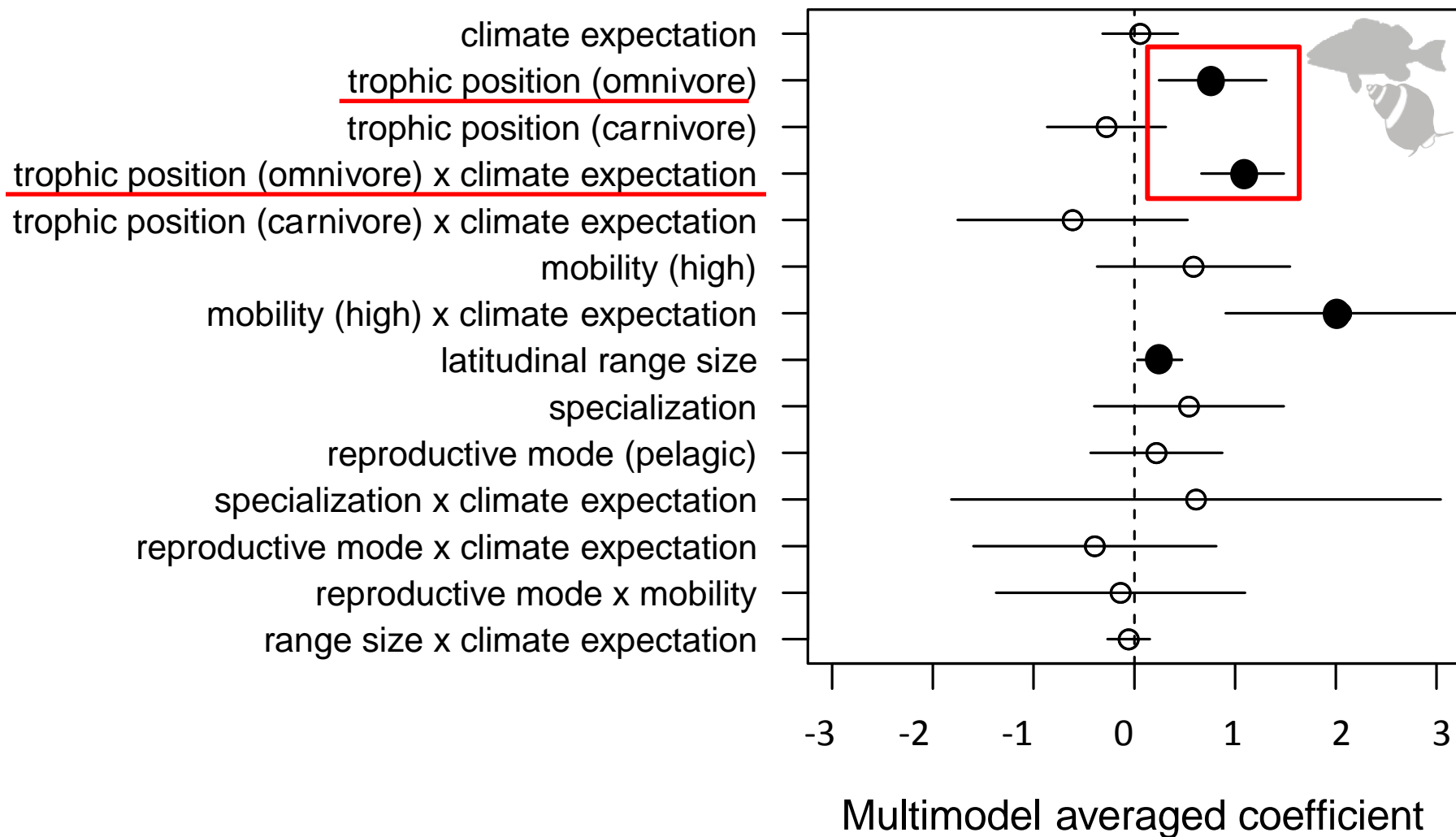
Trophic position  
Body size  
Latitudinal range  
Diet specialization

57.8%

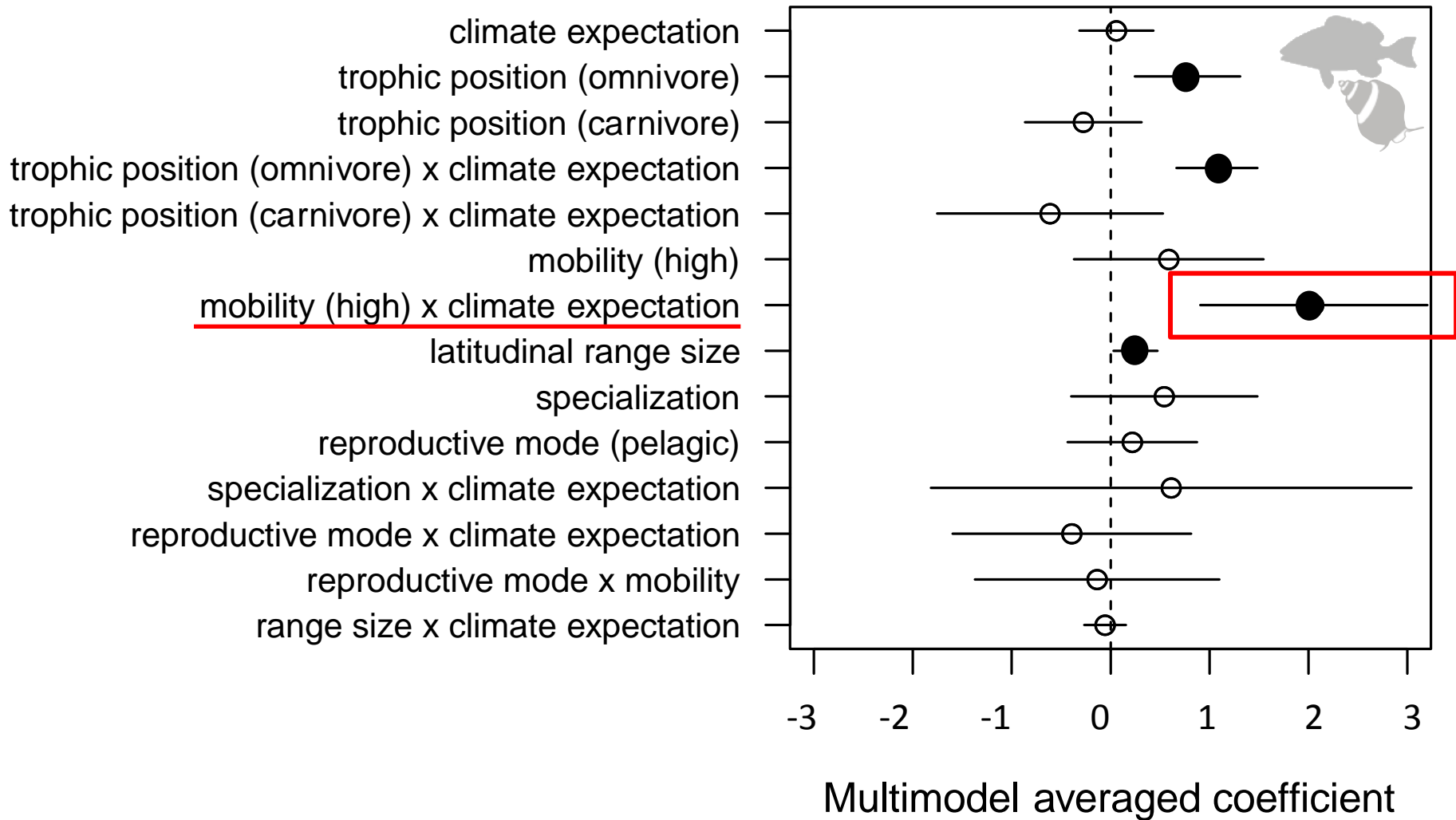
# Fish and invertebrate traits related to range extensions



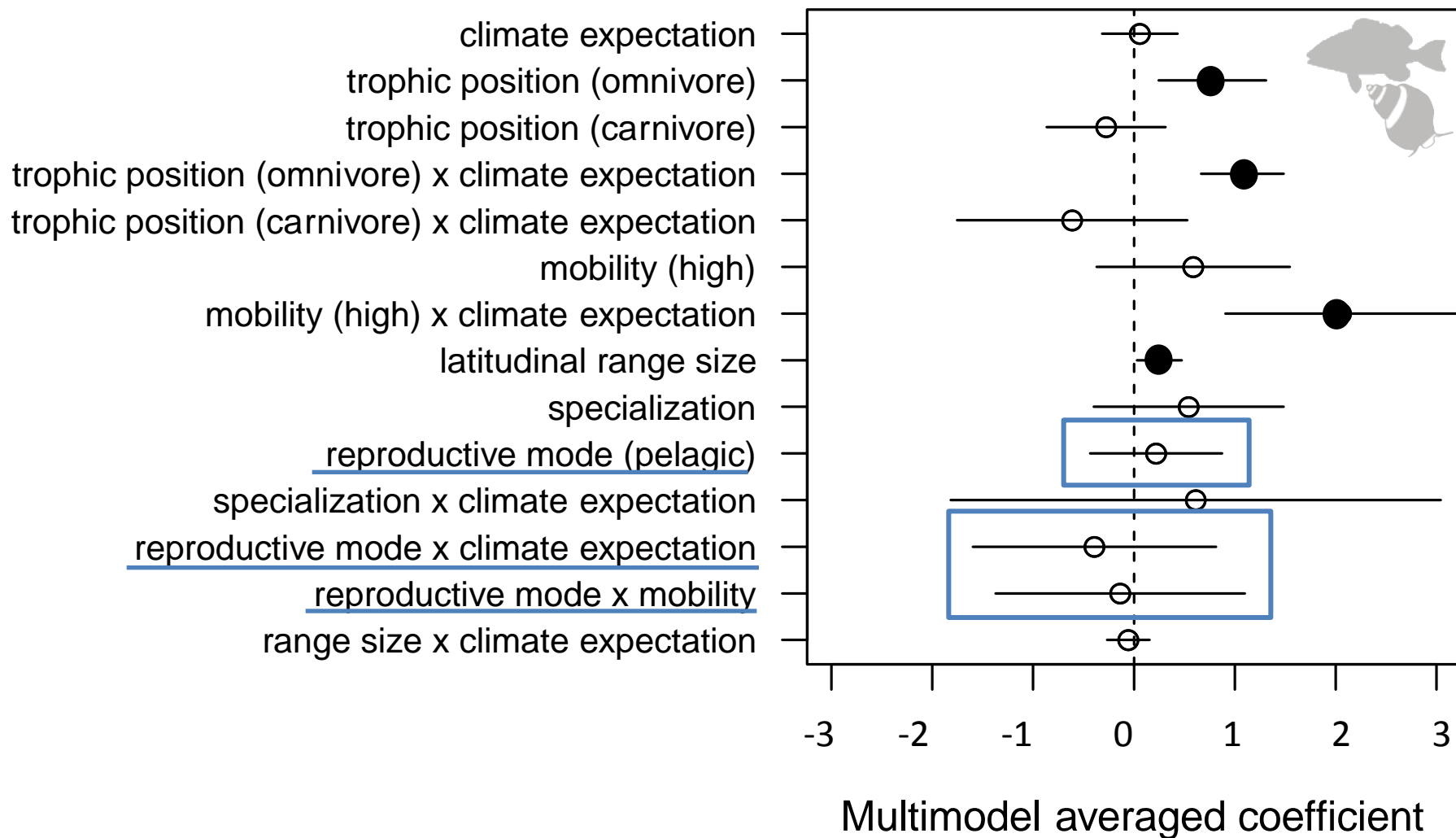
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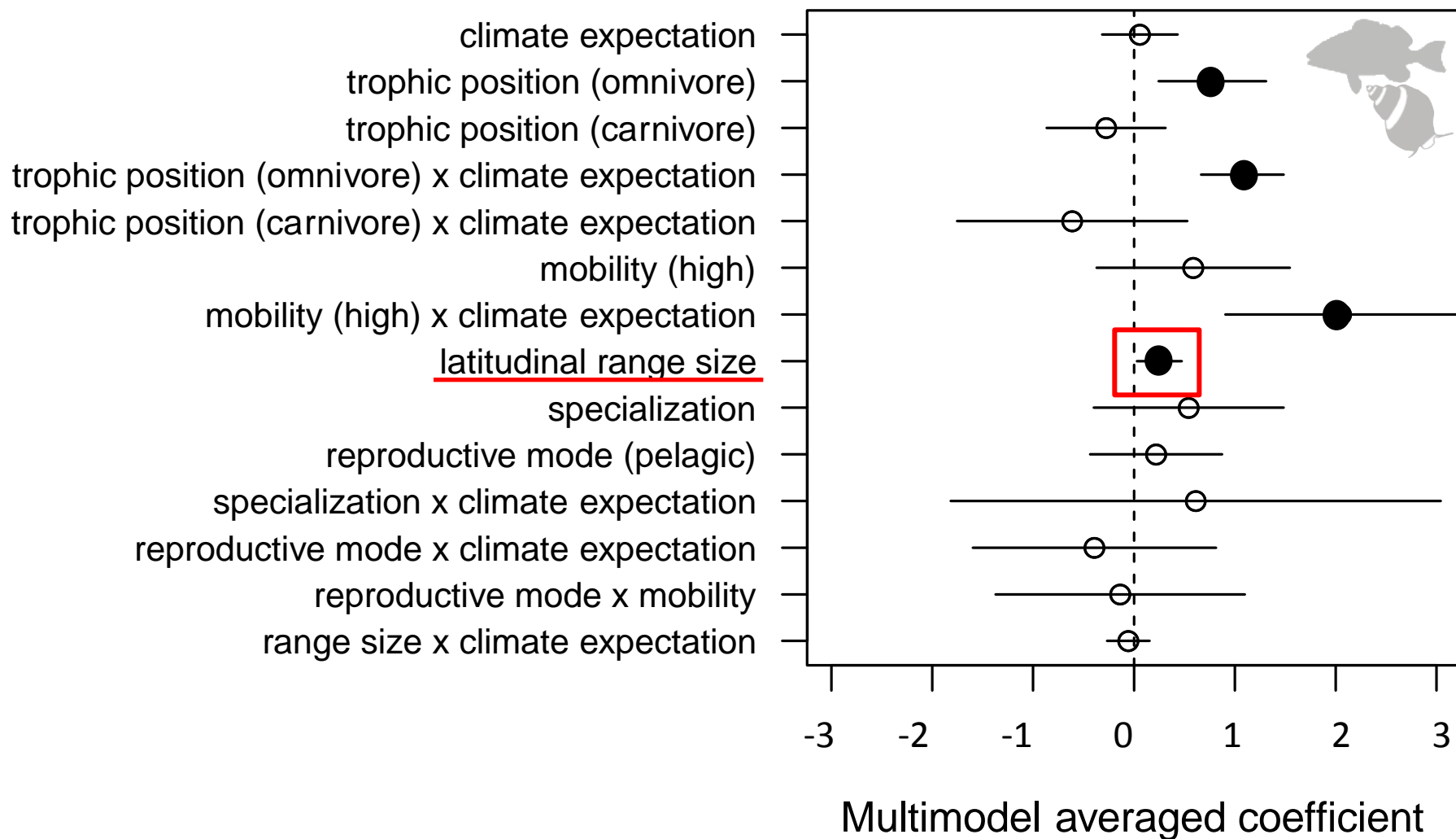


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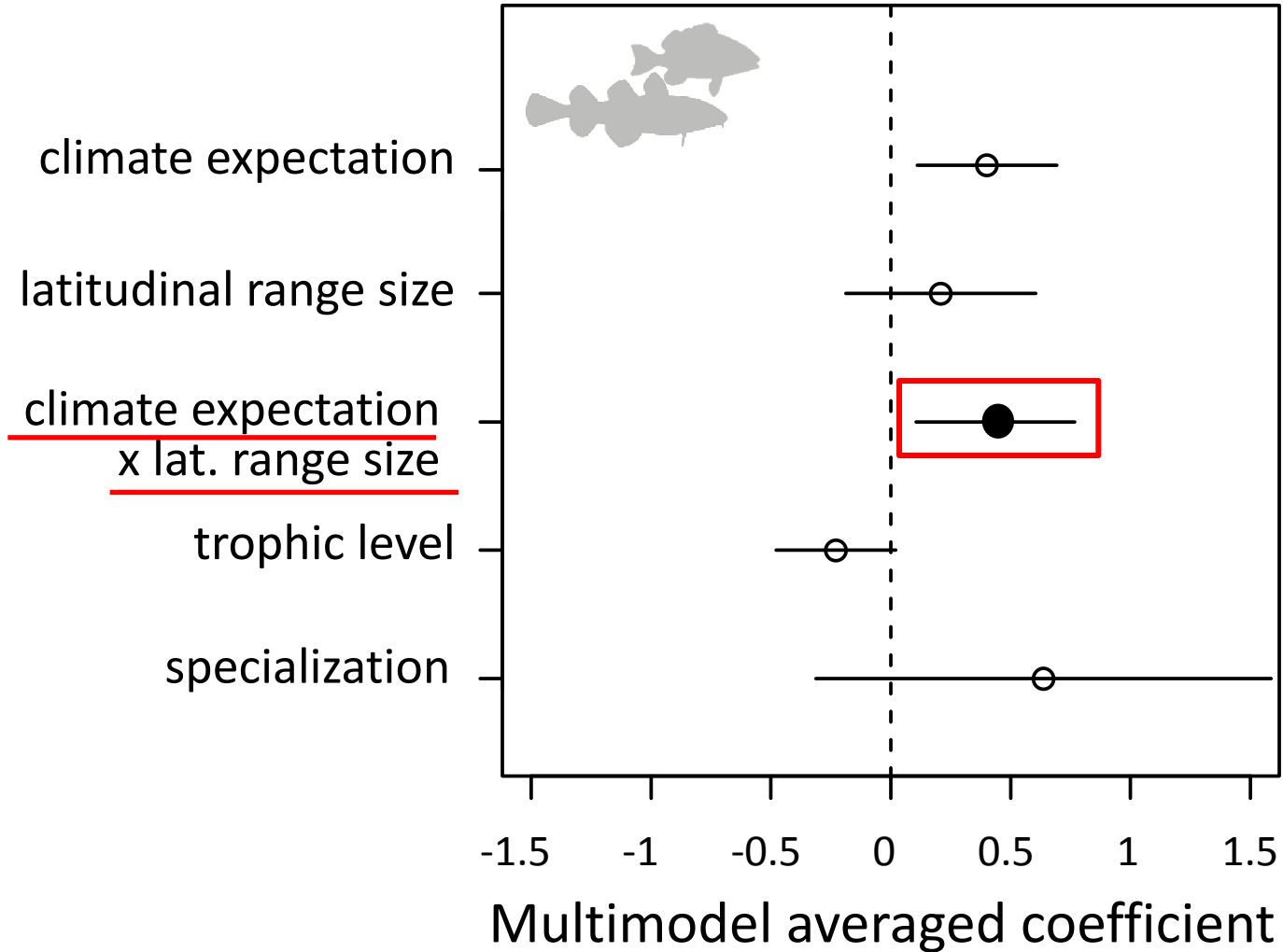




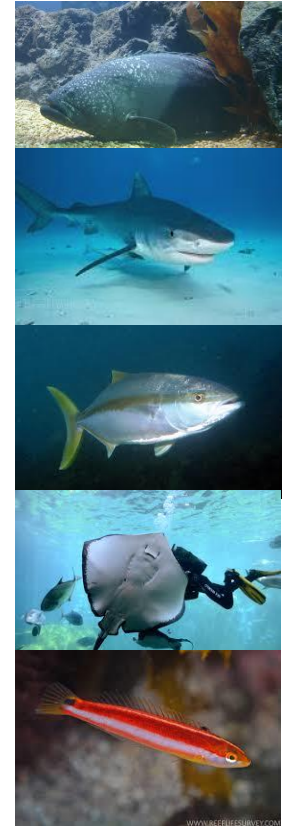
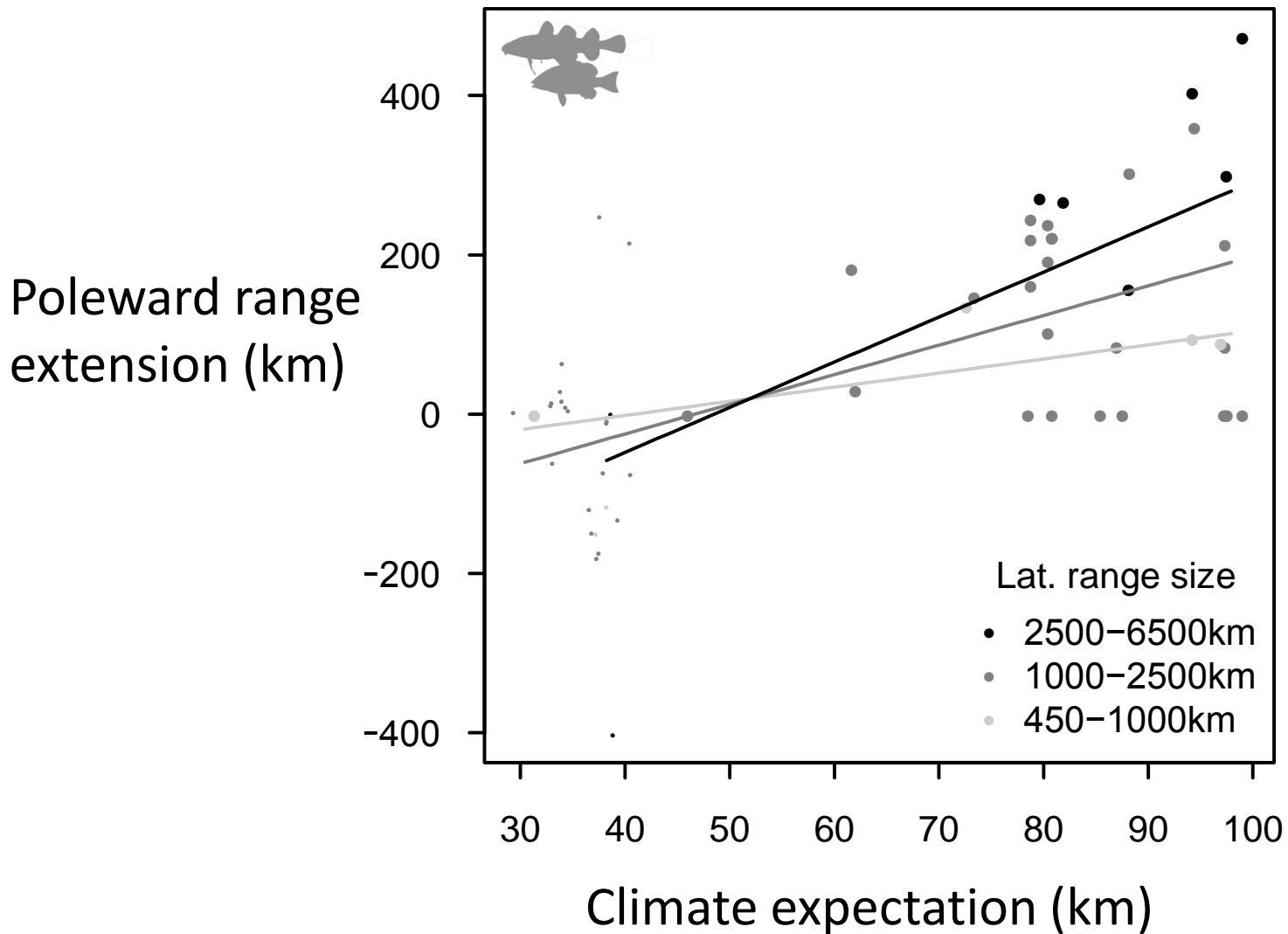
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# Fish traits related to range extensions

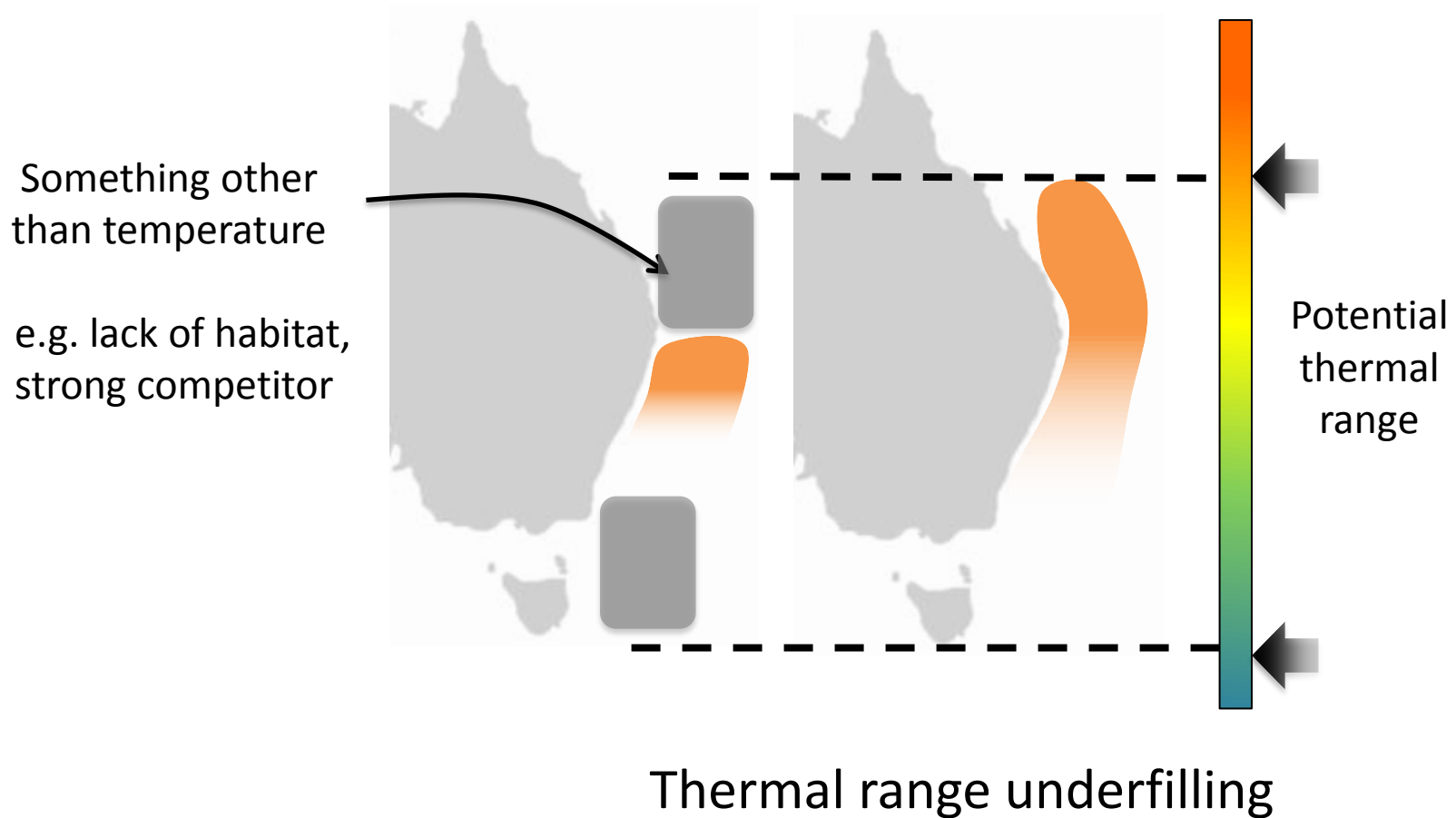


# Larger latitudinal ranges track climate better

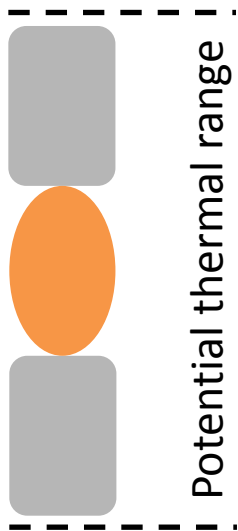


# Latitudinal range size

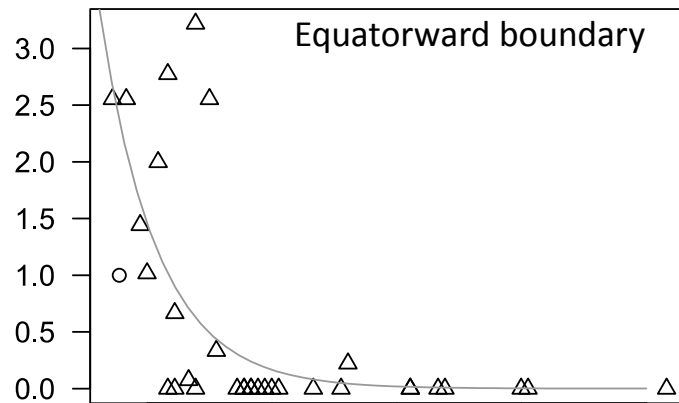
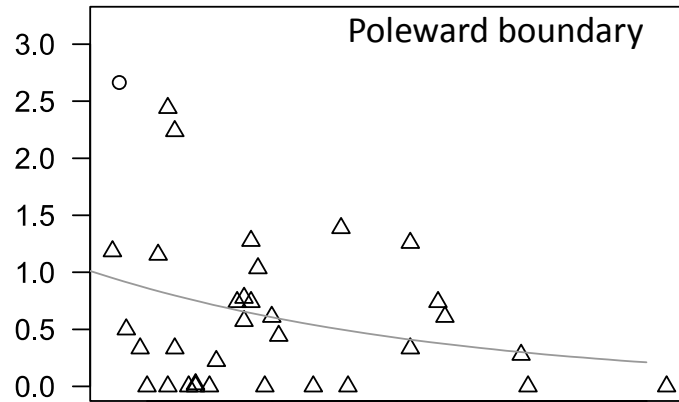
Greater local abundance or more ecologically versatile



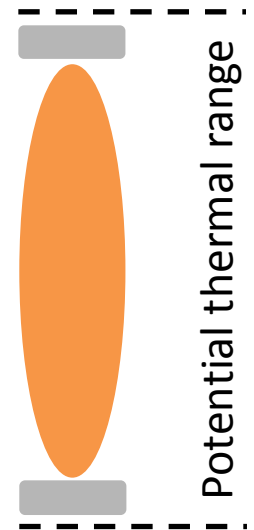
# Narrow-ranging fish are more limited by factors other than temperature



Thermal range underfilling



Latitudinal range size, 1000s km



# Range extension rate increases with range size and swimming ability

Making the most of what is available





# Across-species approach



High resolution times series of  
distribution data  
&  
Ecological traits and constraints



Tool for adaptive management  
&

Advance fundamental ecology

# Thank you

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