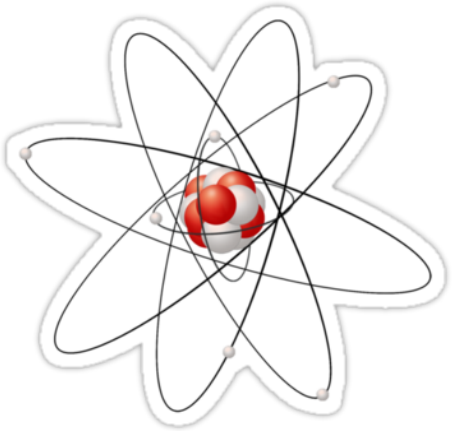
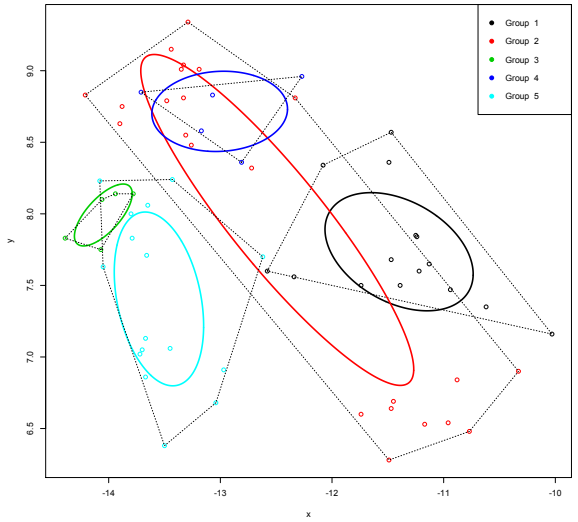
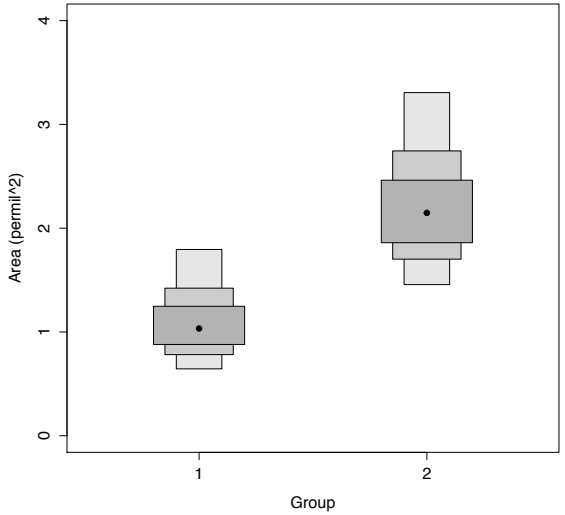


# Stable isotopes as descriptors of trophic niches



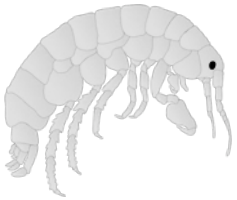

Loïc MICHEL – Lab of Oceanology, Ulg – loic.michel@ulg.ac.be

Specialist course "Stable isotopes: analysis and application in food web ecology" – 25/03/2014

# What's a trophic niche?

Concept of **ecological niche** (*sensu* Hutchinson, 1957):

A hypervolume set in n-dimensional space where each of the axes represents an environmental parameter




Concluding Remarks

G. Evelyn Hutchinson

Cold Spring Harbor symposia on quantitative biology 22: 415-427

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Concept of **ecological niche** (*sensu* Hutchinson, 1957):

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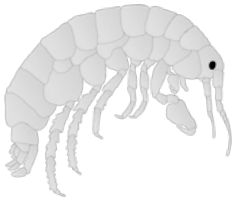

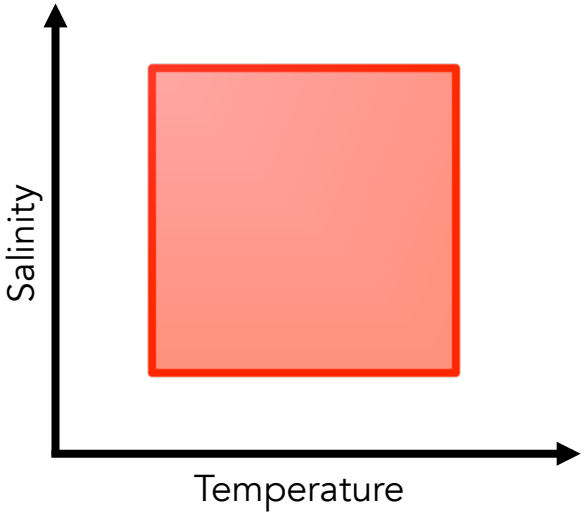


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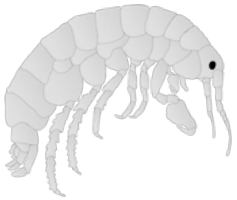

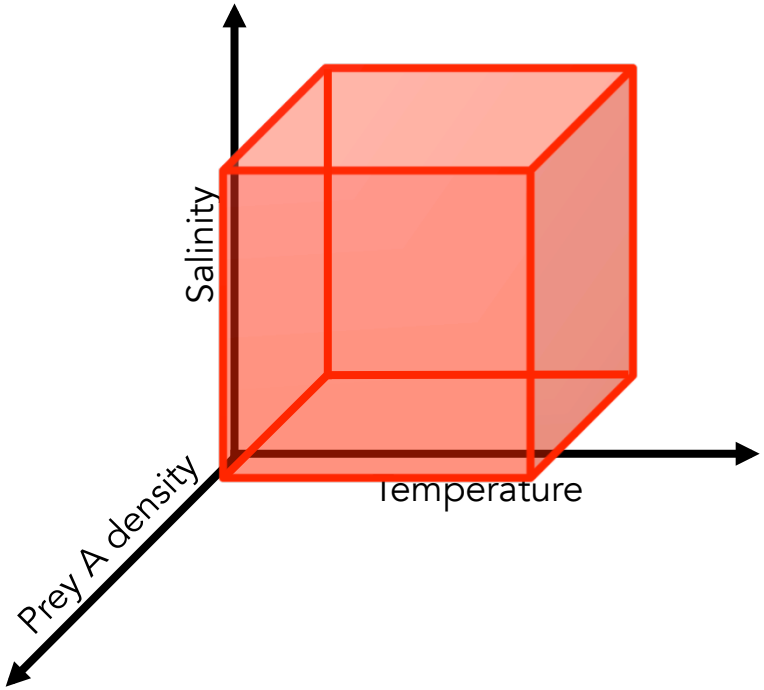


**Concluding Remarks**

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Cold Spring Harbor symposia on quantitative biology 22: 415-427

2 categories of dimensions: **habitat**- and **resource**-related

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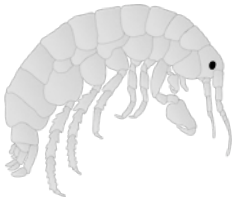
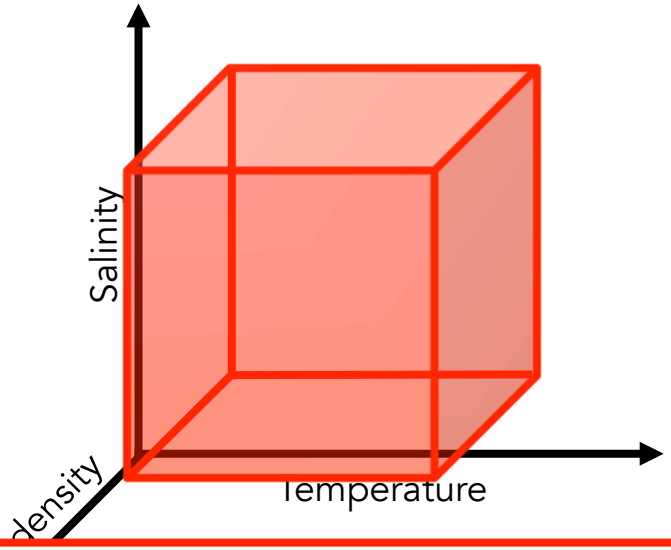





**Concluding Remarks**

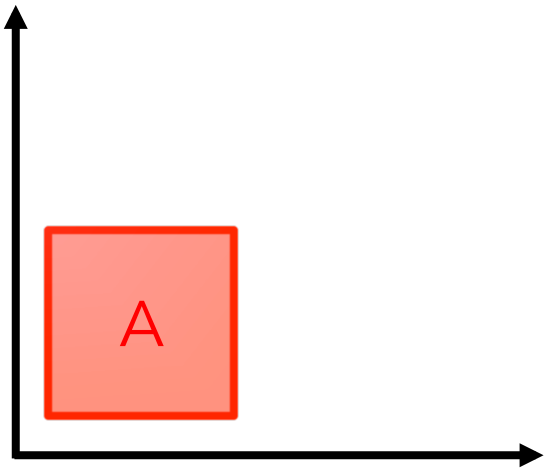
G. Evelyn Hutchinson

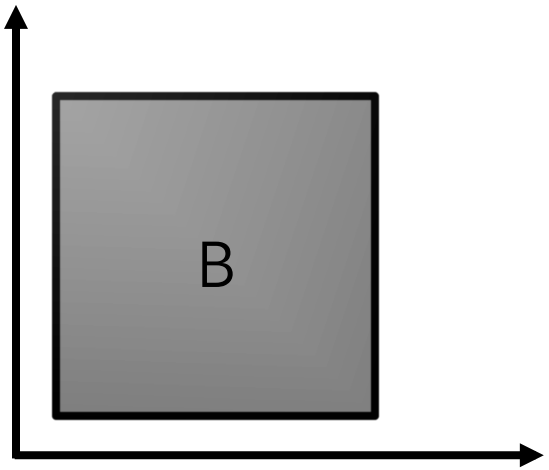
**Trophic** niche = part of the ecological niche built using the **subset** of dimensions related to trophic resources

2 categories of dimensions: **habitat**- and **resource**-related

# Trophic niche study: why ?

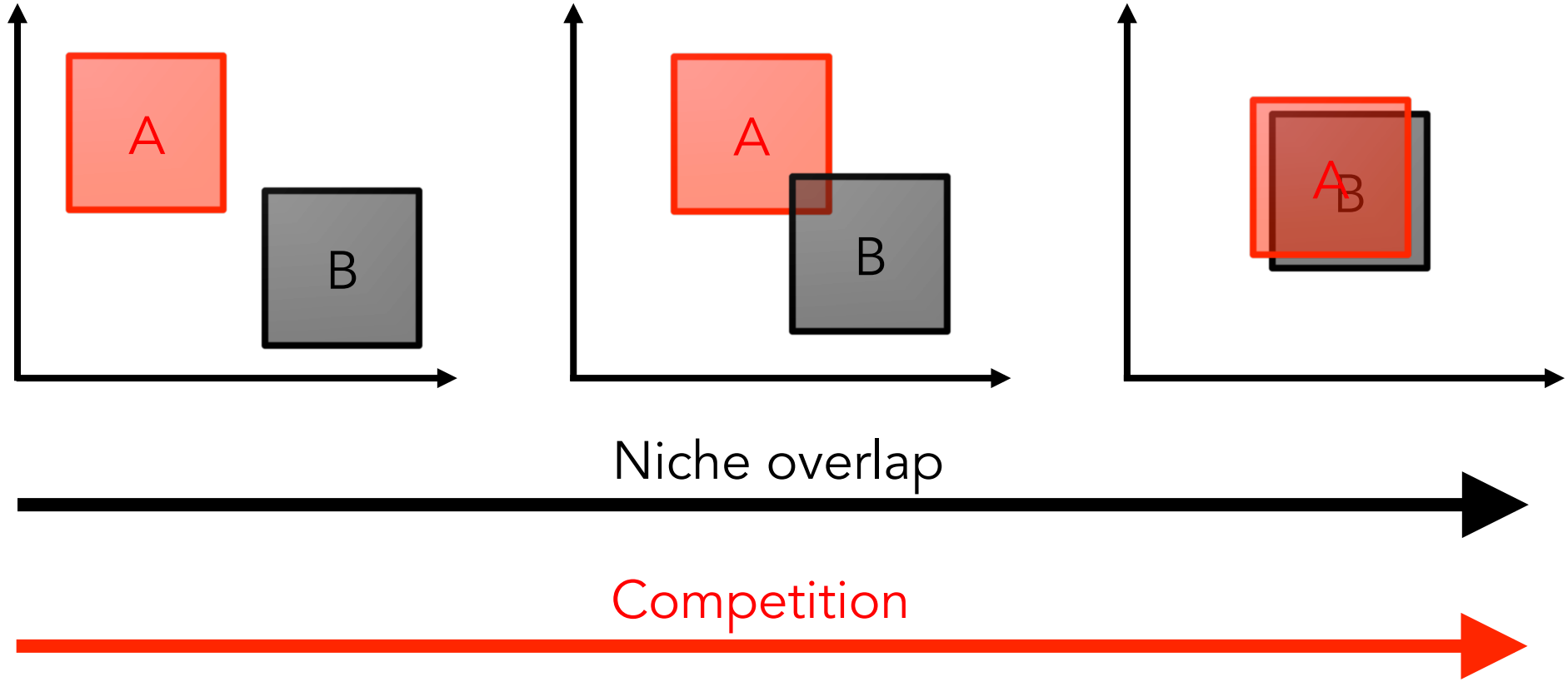
- Identify **feeding strategies**: specialists (narrow trophic niches) vs. generalists (wide trophic niche)



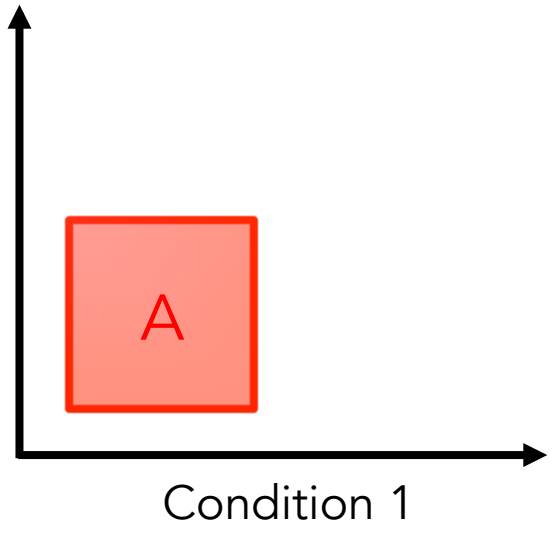
# Trophic niche study: why ?

- Identify feeding strategies: specialists (narrow trophic niches) vs. generalists (wide trophic niche)
- Understand how **trophic interactions** can affect **community structure**

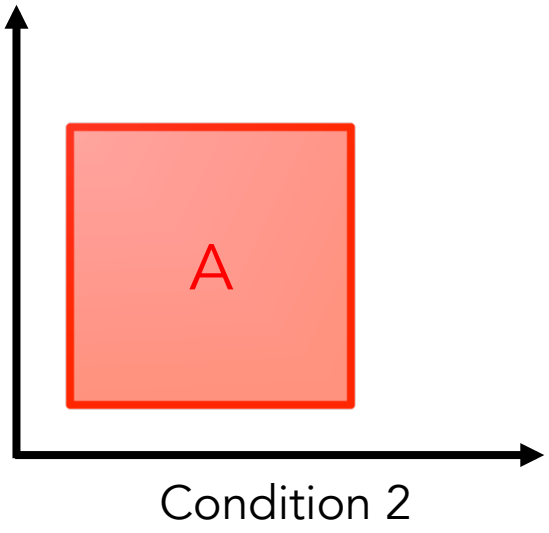


# Trophic niche study: why ?

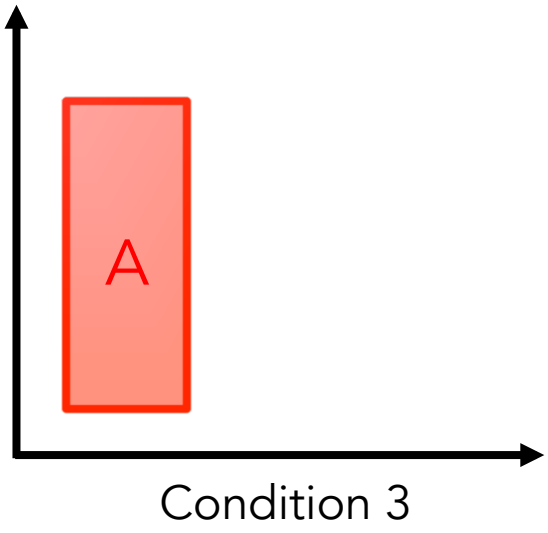
- Identify feeding strategies: specialists (narrow trophic niches) vs. generalists (wide trophic niche)
- Understand how trophic interactions can affect community structure
- Highlight **diet shifts** and study **trophic plasticity**




Condition 1



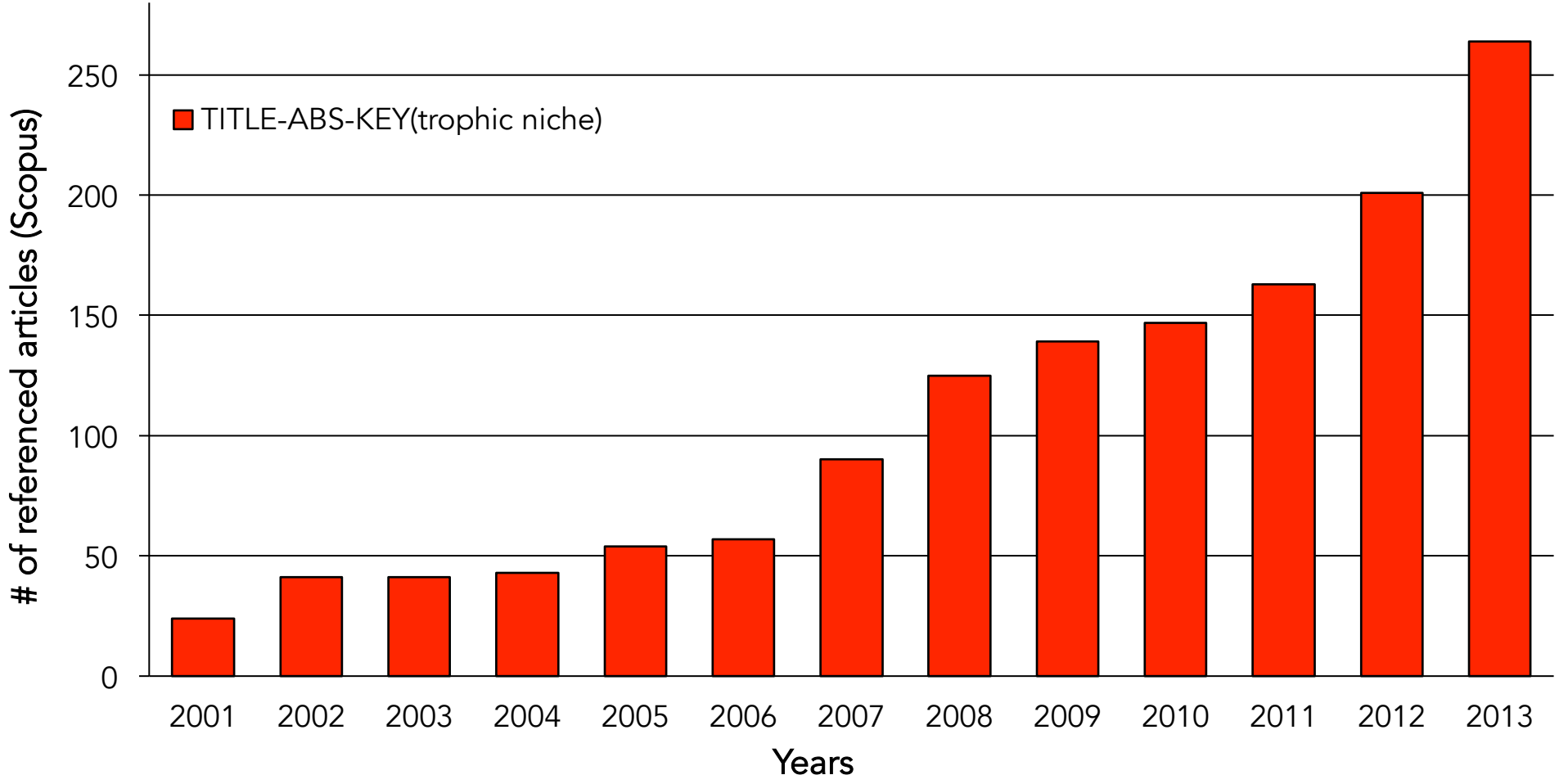

Condition 2




Condition 3

# Trophic niche study: why ?

- The trophic niche concept is useful to address many fundamental ecological questions
- For decades: practical issues to provide quantitative estimates of niche parameters



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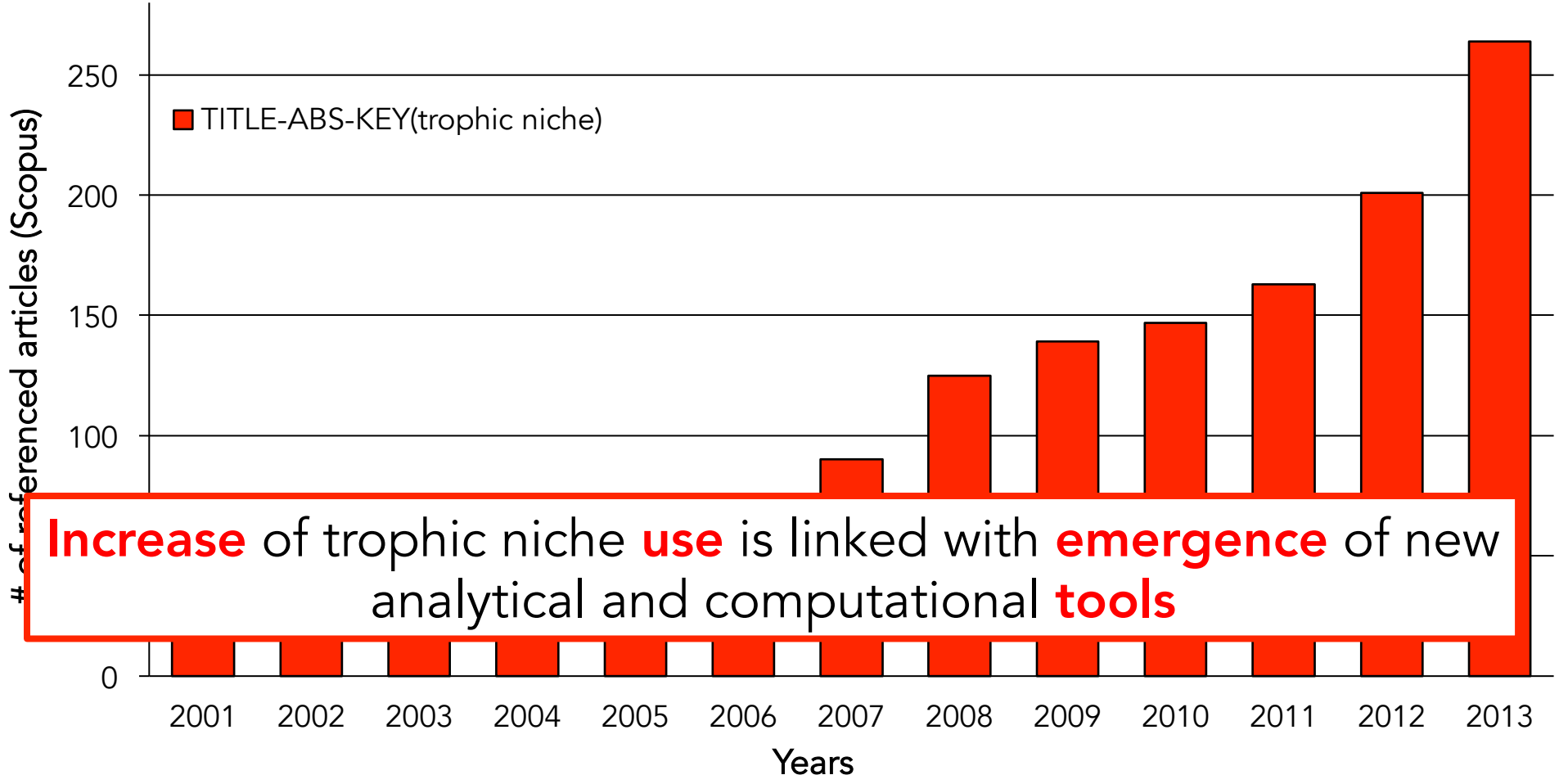
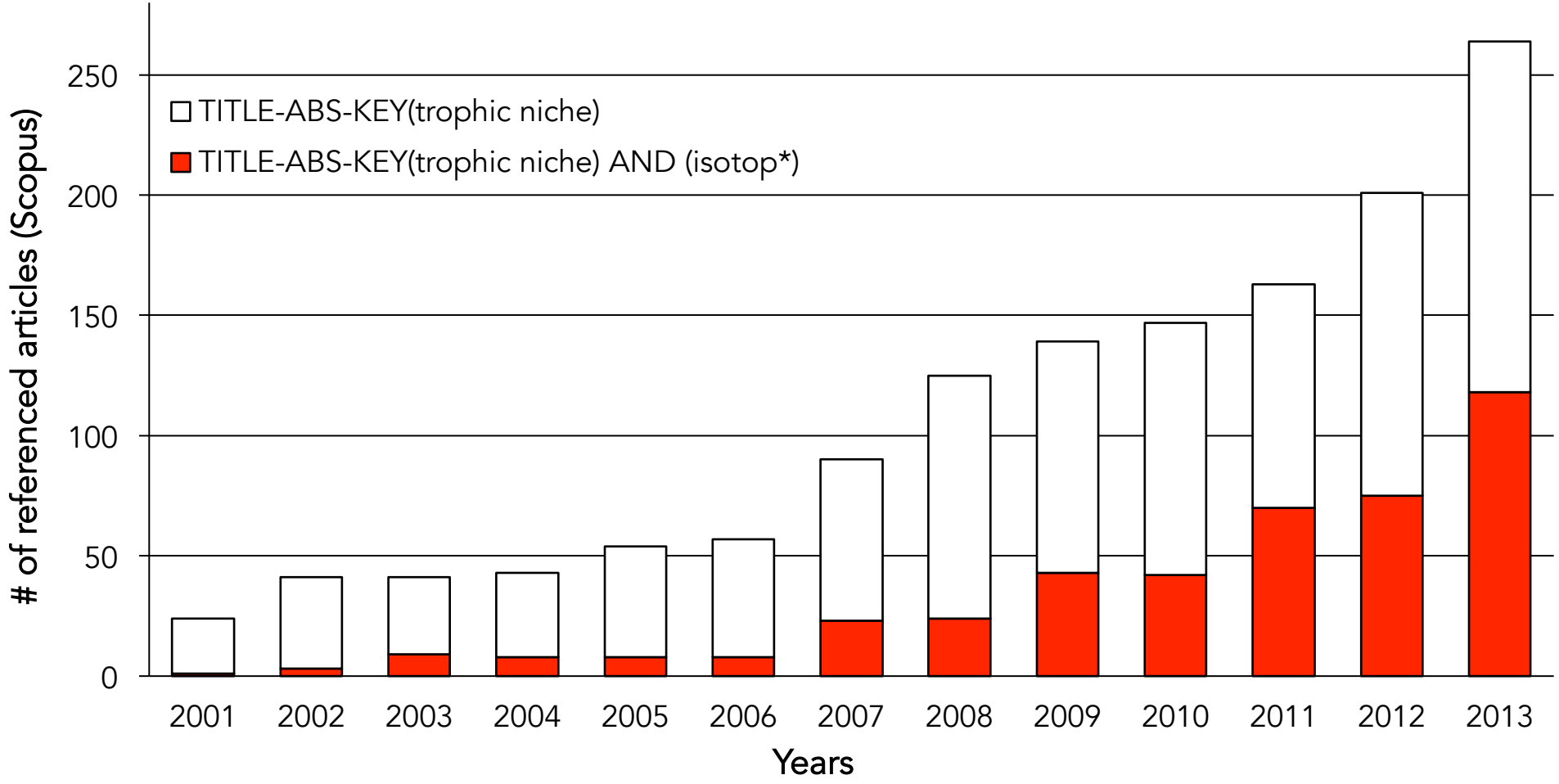



**Increase** of trophic niche **use** is linked with **emergence** of new analytical and computational **tools**

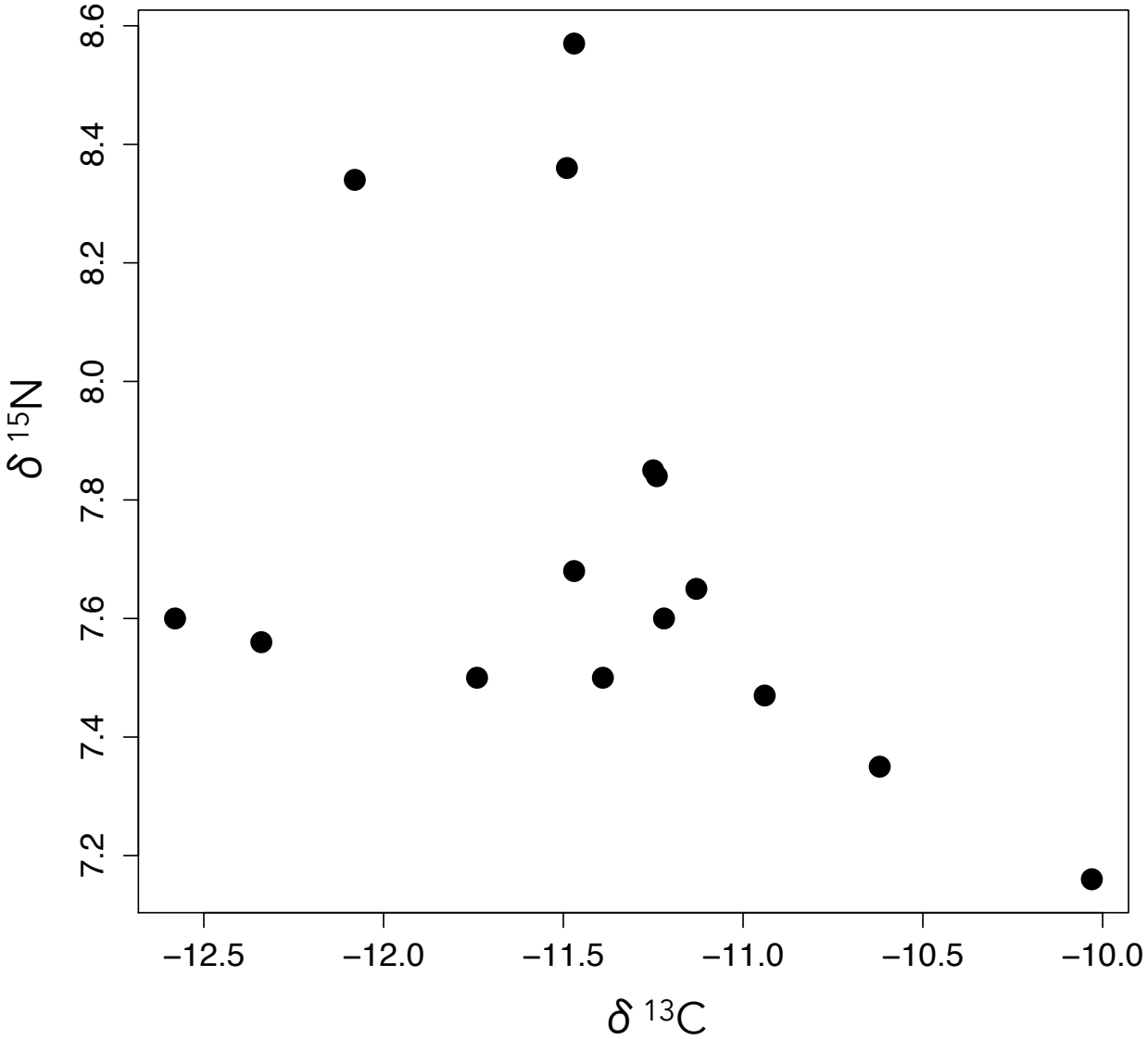
# Trophic niche study: why ?

- The trophic niche concept is useful to address many fundamental ecological questions
- For decades: practical issues to provide quantitative estimates of niche parameters



# Trophic niche study: how?

1. δ-space plots and convex hulls




**Position** of consumers in the **δ-space** (= isospace) is mainly driven by differences in foraging habits and **resource use**

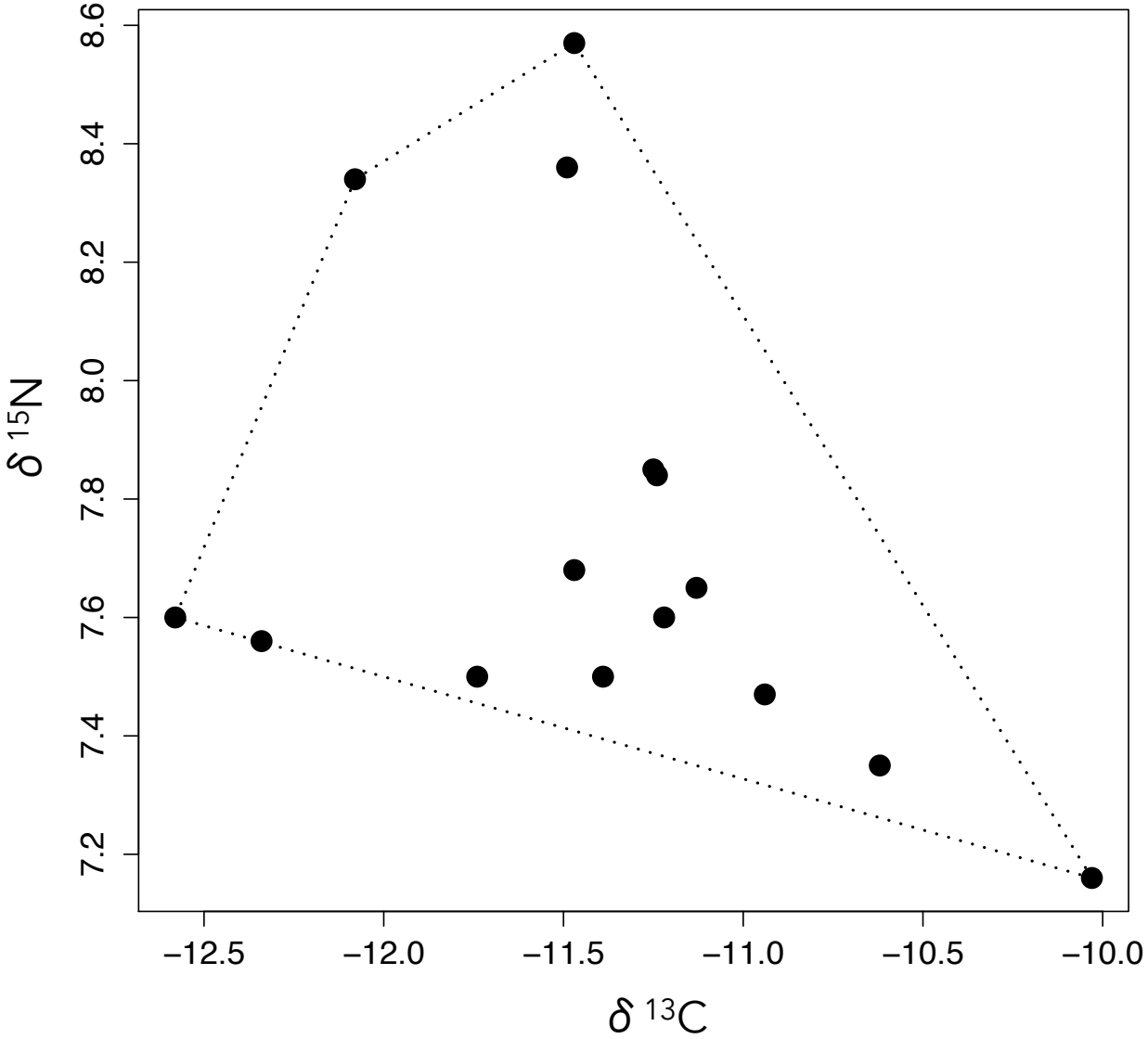
**Metrics** based on these positions can provide insights about **trophic niche**

# CAN STABLE ISOTOPE RATIOS PROVIDE FOR COMMUNITY-WIDE MEASURES OF TROPHIC STRUCTURE?

1. δ-sp

Craig A. Layman,[1,5] D. Albrey Arrington,[2] Carmen G. Montaña,[3] and David M. Post[4]

*Ecology*, 88(1), 2007, pp. 42–48




**Geometric approach** (Layman *et al.*, 07):

Fit a **convex hull** (*i.e.*, the smallest possible surface that encompasses all points) to the 2D data

This convex hull represents the **isotopic niche** of the group of consumers (**proxy** for their **trophic niche**)

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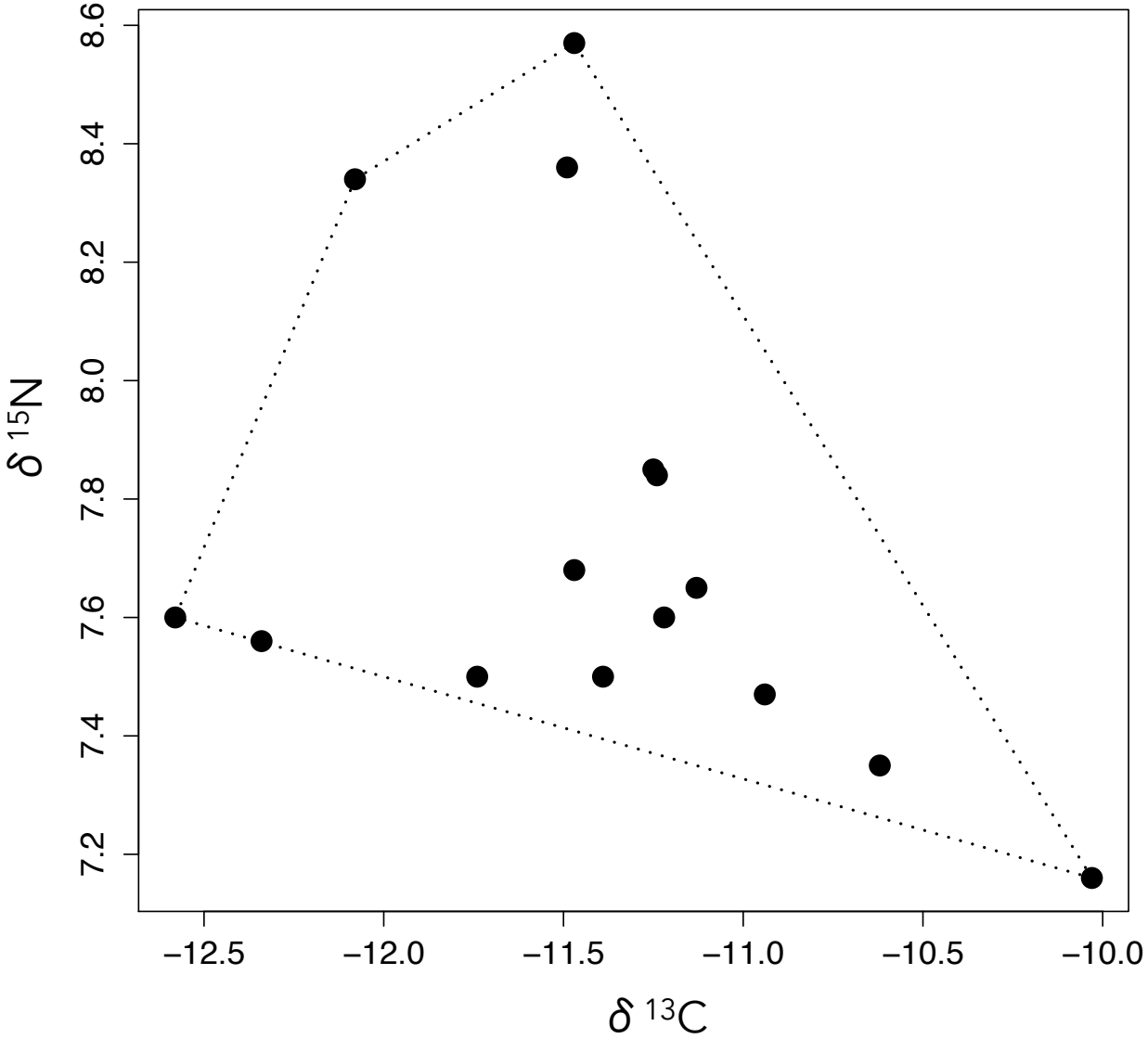


**Geometric approach** (Layman *et al.*, 07):

Fit a **convex hull** to the 2D data

Calculate **6 parameters** used as **descriptors** of the **trophic niche**

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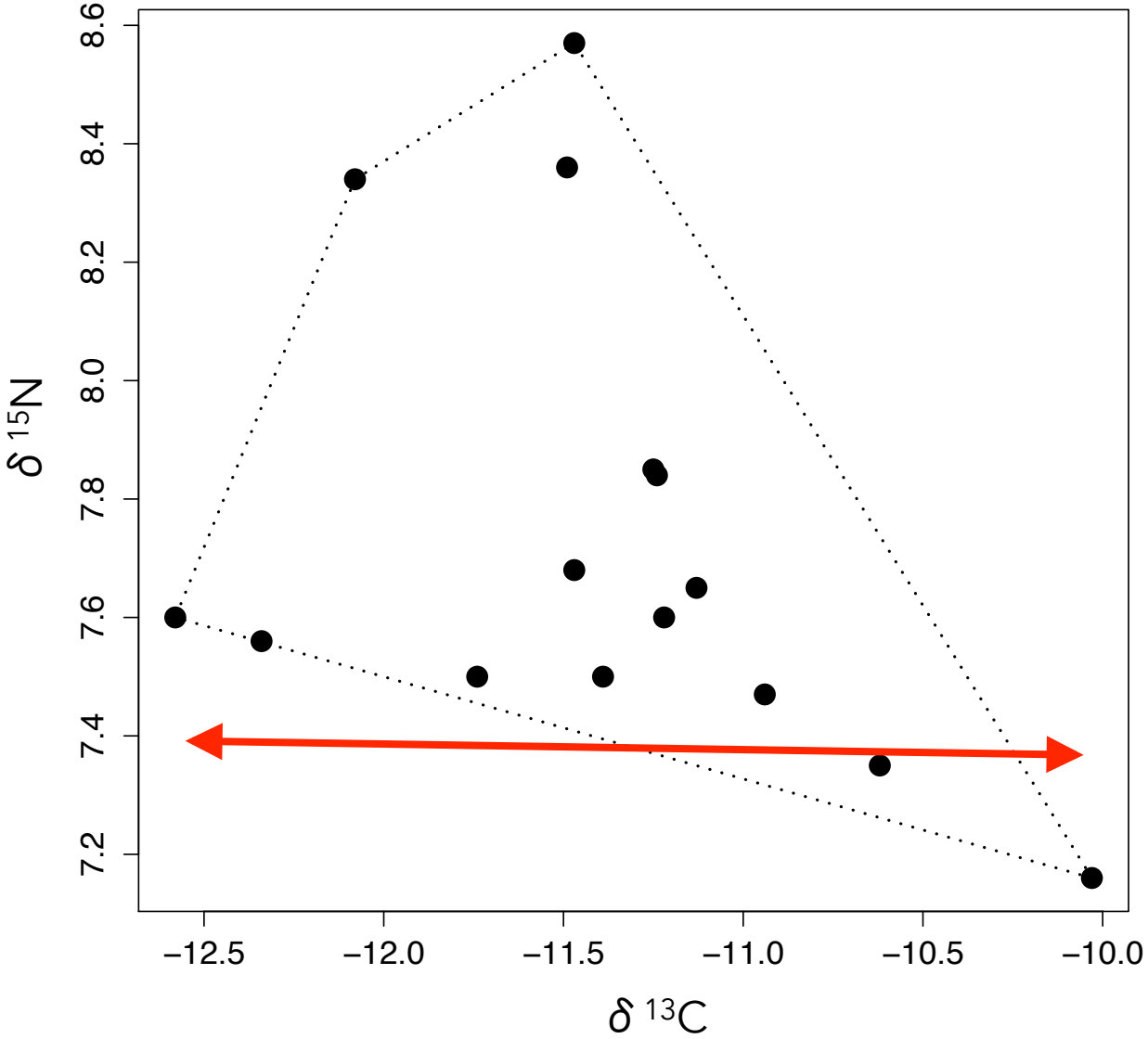


Descriptors
("Layman metrics")

δ 13C range

Greater when multiple resources support the consumers

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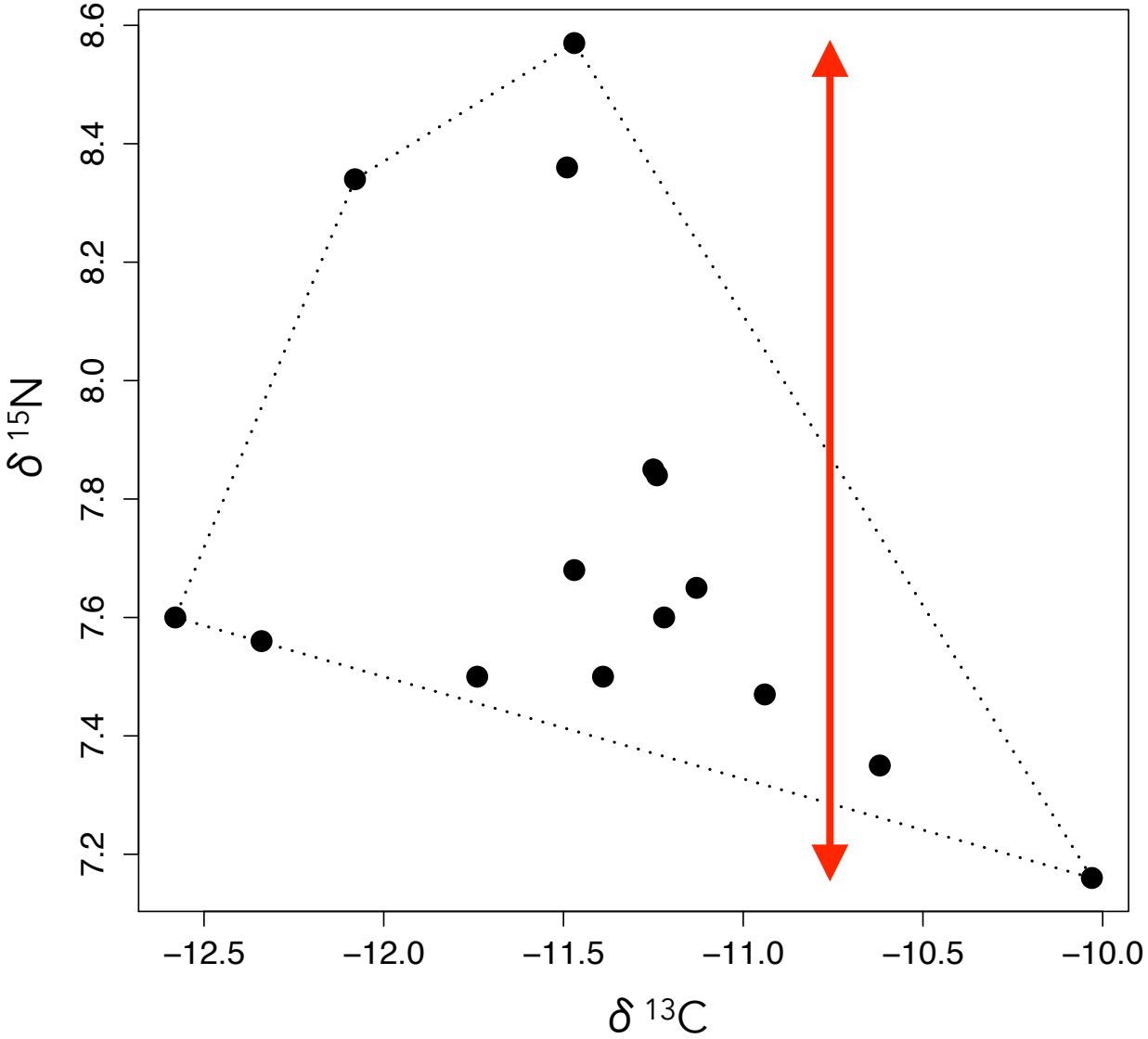


Descriptors
("Layman metrics")

$\delta^{13}C$ range
$\delta^{15}N$ range

Greater when consumers belong to more "trophic levels"

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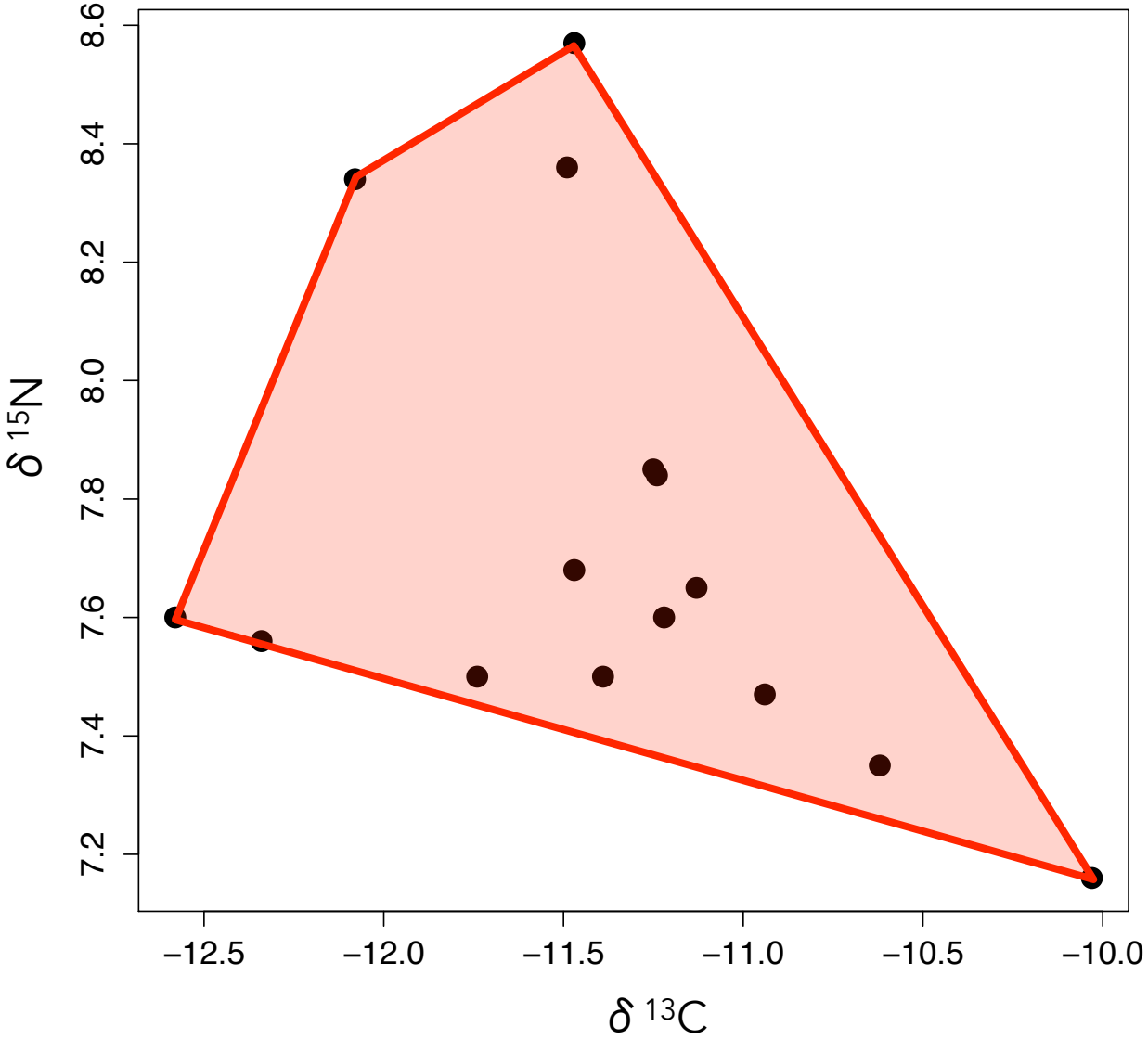


Descriptors
("Layman metrics")

δ 13C range
δ 15N range
Total area of the convex hull

Greater when trophic niche is wider, *i.e.* when overall trophic diversity is greater

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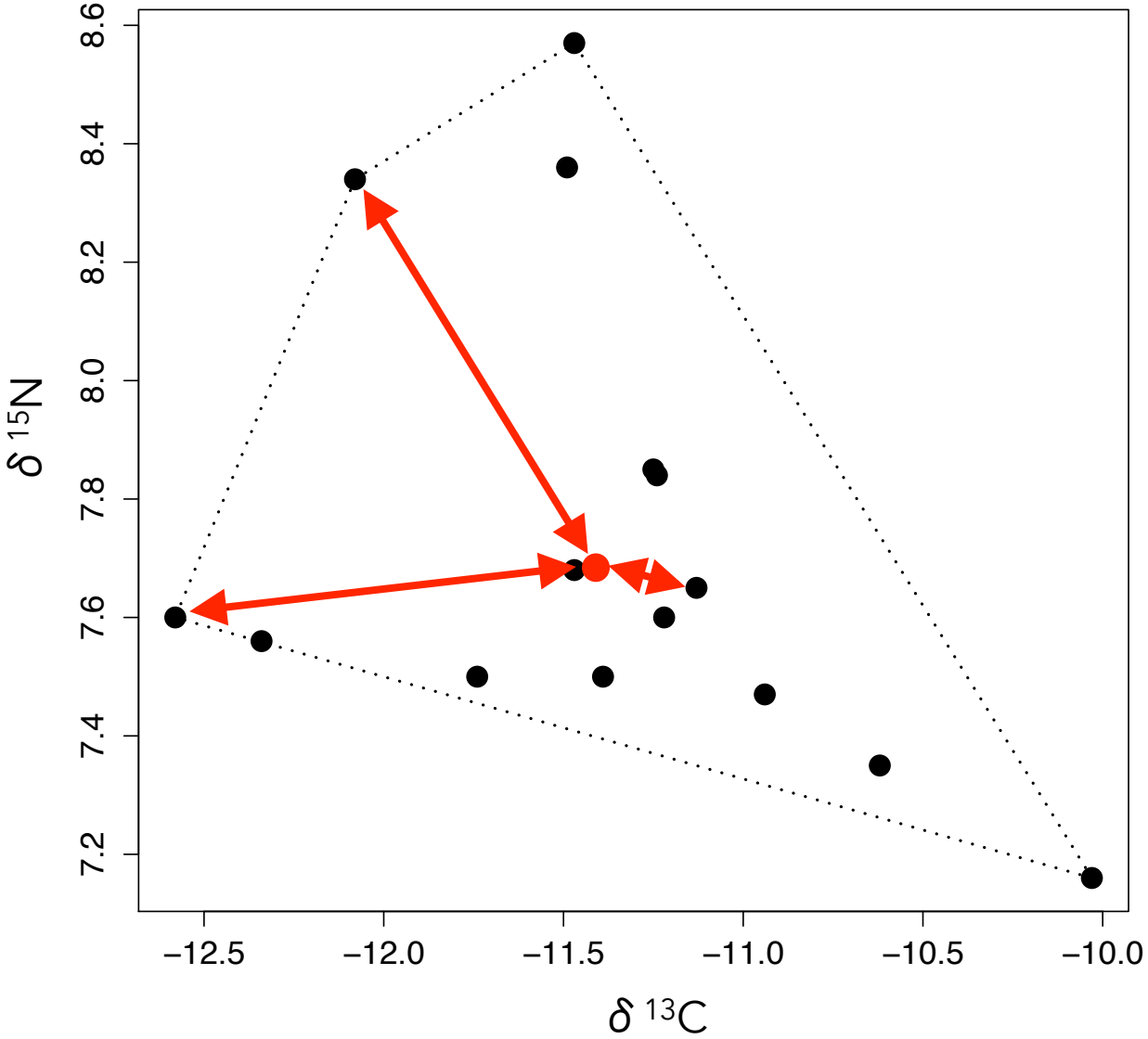


Descriptors
("Layman metrics")

δ 13C range
δ 15N range
Total area of the convex hull
Mean distance to centroid

Averaged measure of trophic diversity among consumers

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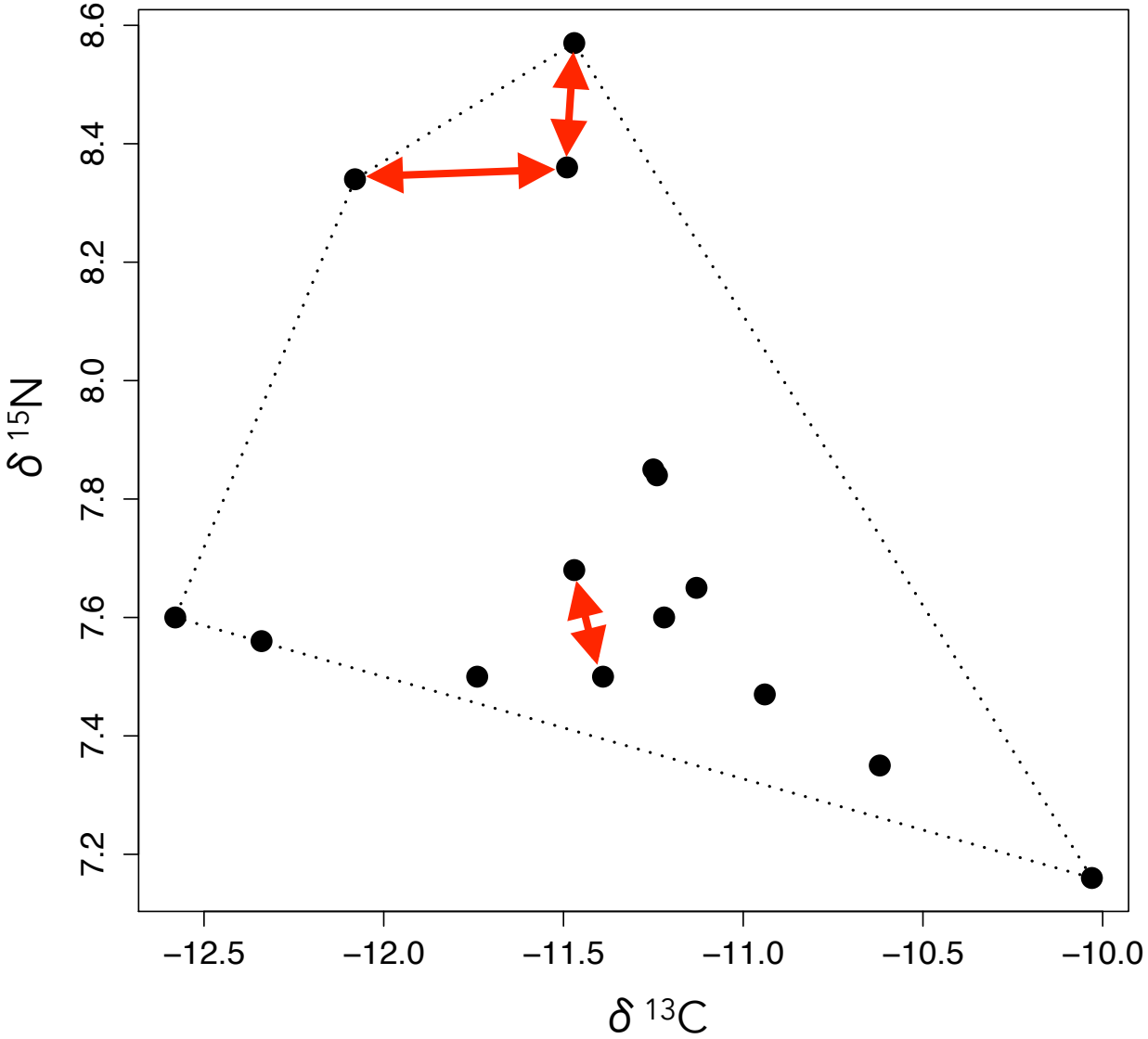


Descriptors
("Layman metrics")

δ 13C range
δ 15N range
Total area of the convex hull
Mean distance to centroid
Mean nearest neighbor distance

Lower when trophic niches of consumers are similar (trophic redundancy)

# CAN STABLE ISOTOPE RATIOS PROVIDE FOR COMMUNITY-WIDE MEASURES OF TROPHIC STRUCTURE?

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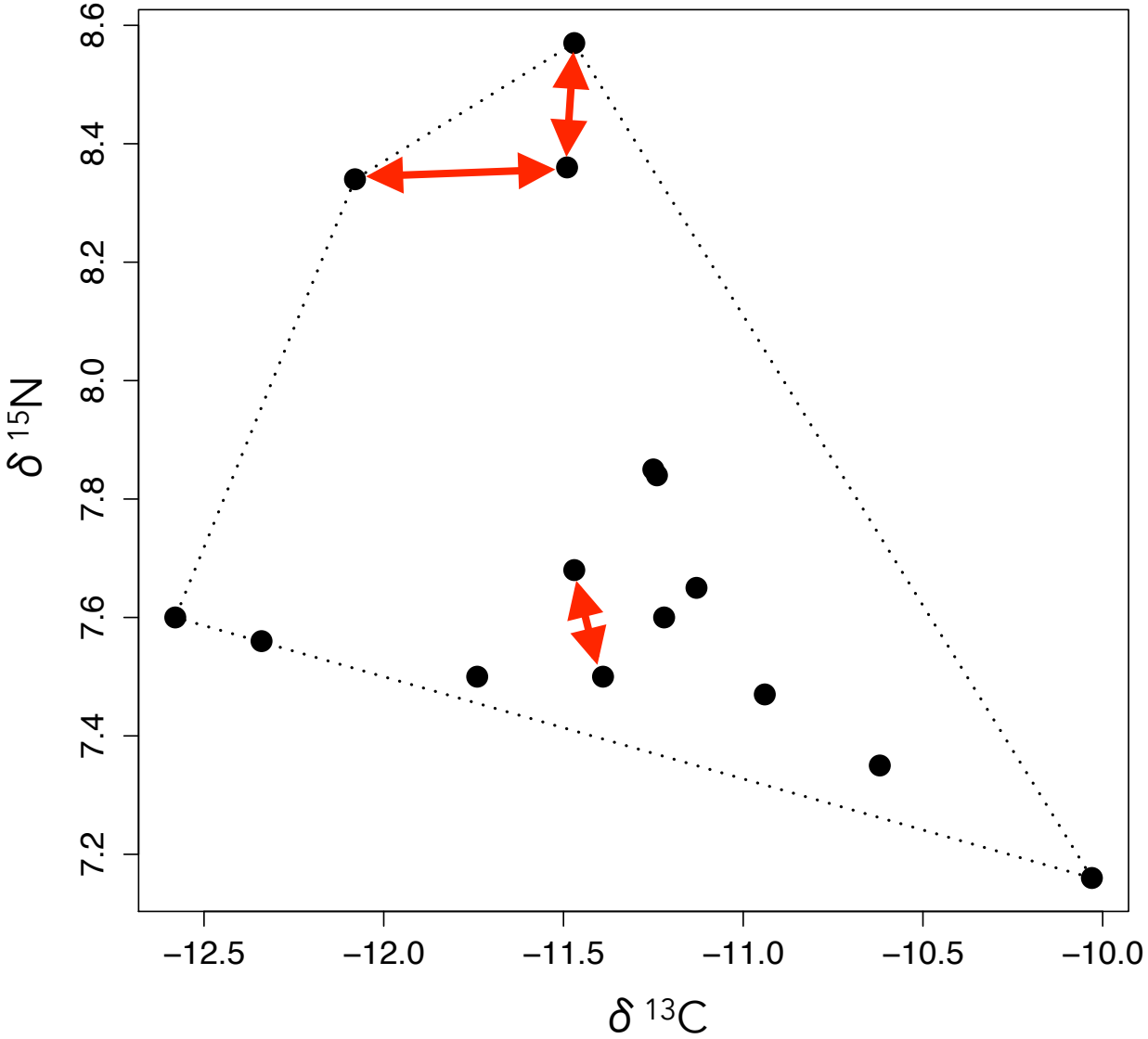


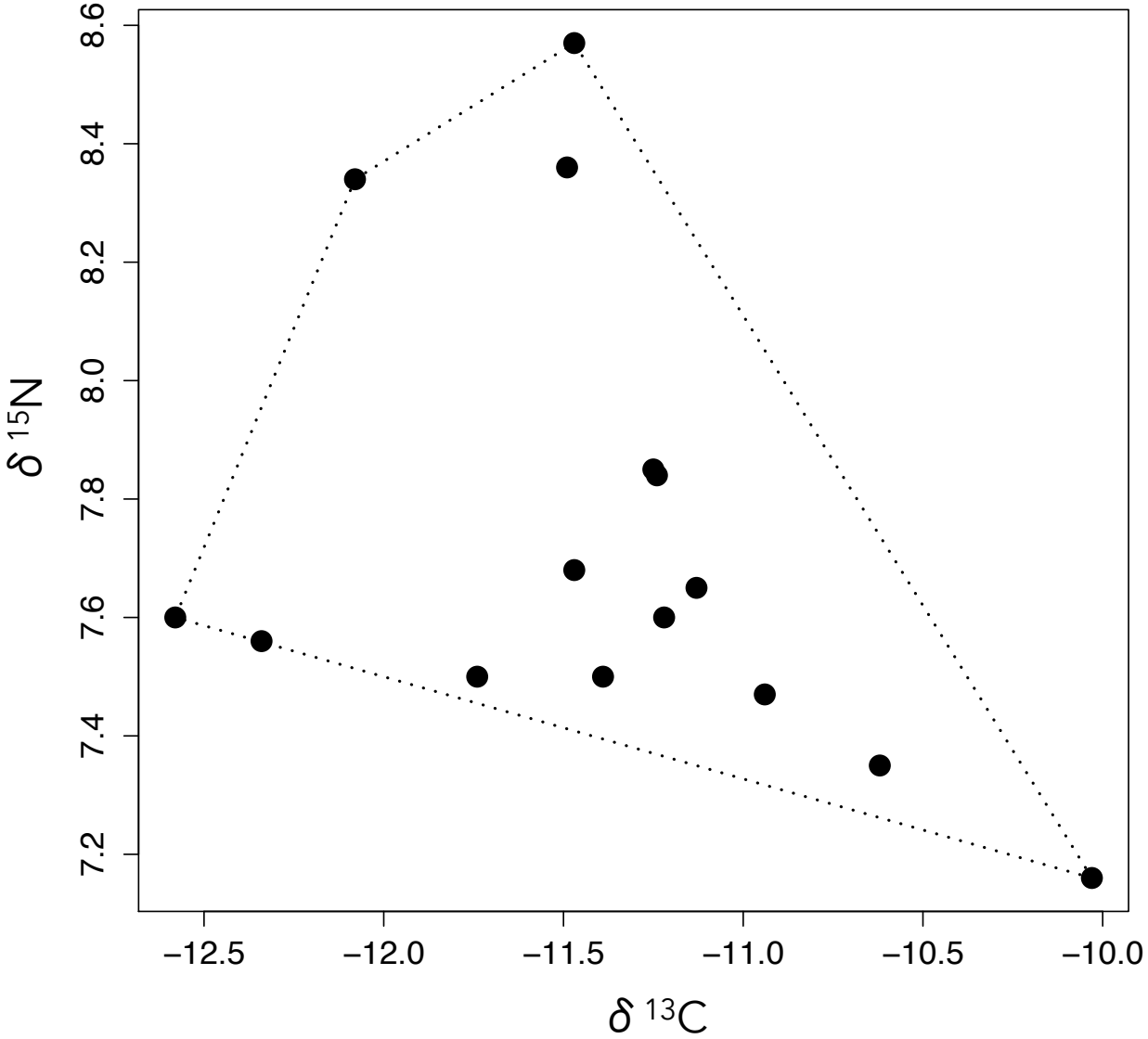

Descriptors
("Layman metrics")

$\delta^{13}C$ range
$\delta^{15}N$ range
Total area of the convex hull
Mean distance to centroid
Mean nearest neighbor distance
SD of nearest neighbor distance

Measures how evenly trophic diversity is distributed among the studied group

# Trophic niche study: how?

1. δ-space plots and convex hulls




Designed for study of whole **communities**, but can also be used for **populations**

Useful set of tools that provide **complementary information** about trophic diversity and niche extent, but…

Metrics (especially TA) **sensitive** to **sample size** and presence of **"extreme" points**

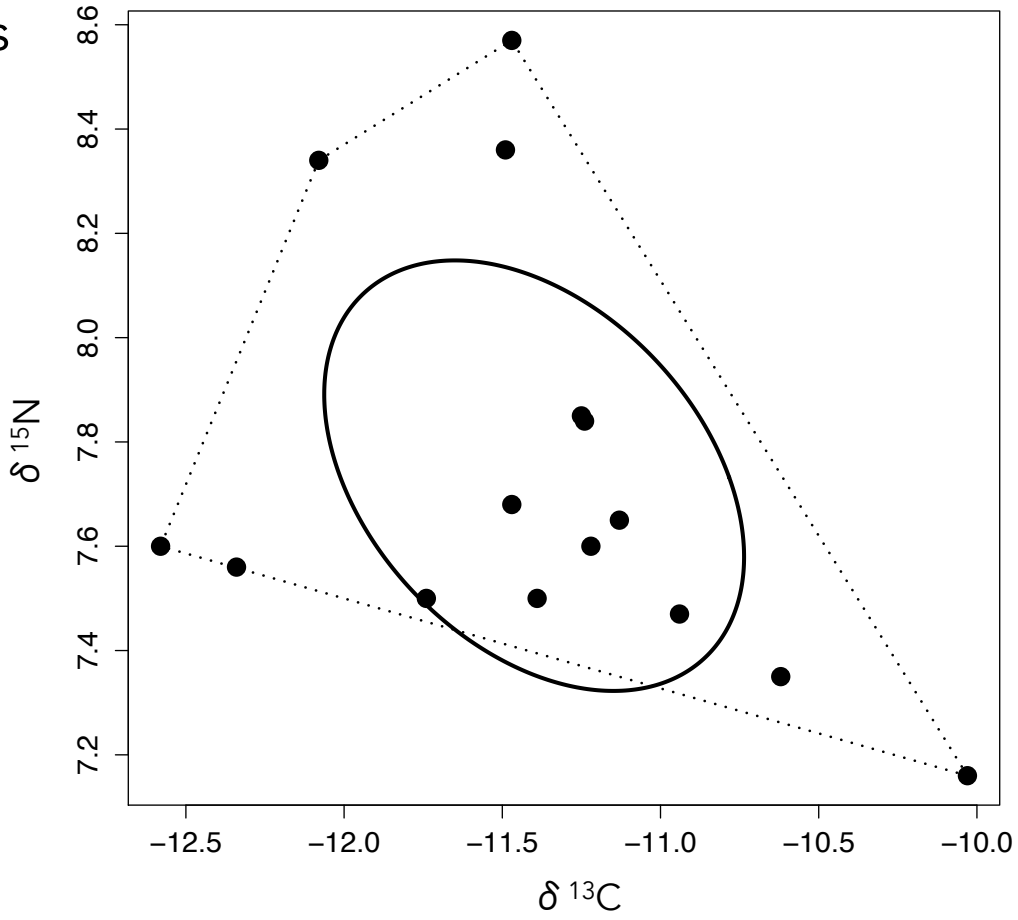
# Trophic niche study: how?

2. δ-space plots and standard ellipses (Jackson *et al.*, 2011)

**Standard ellipse** vs. convex hull (SD vs. full range)

Single metric: **standard ellipse area**
Represents "core isotopic niche" of the group of consumers

More **robust** and less sensitive to extreme values and small sample size (SEAc)




Journal of Animal Ecology

British Ecological Society

*Journal of Animal Ecology* 2011 doi: 10.1111/j.1365-2656.2011.01806.x

**Comparing isotopic niche widths among and within communities: SIBER – Stable Isotope Bayesian Ellipses in R**

Andrew L. Jackson[1]*, Richard Inger[2], Andrew C. Parnell[3] and Stuart Bearhop[2]

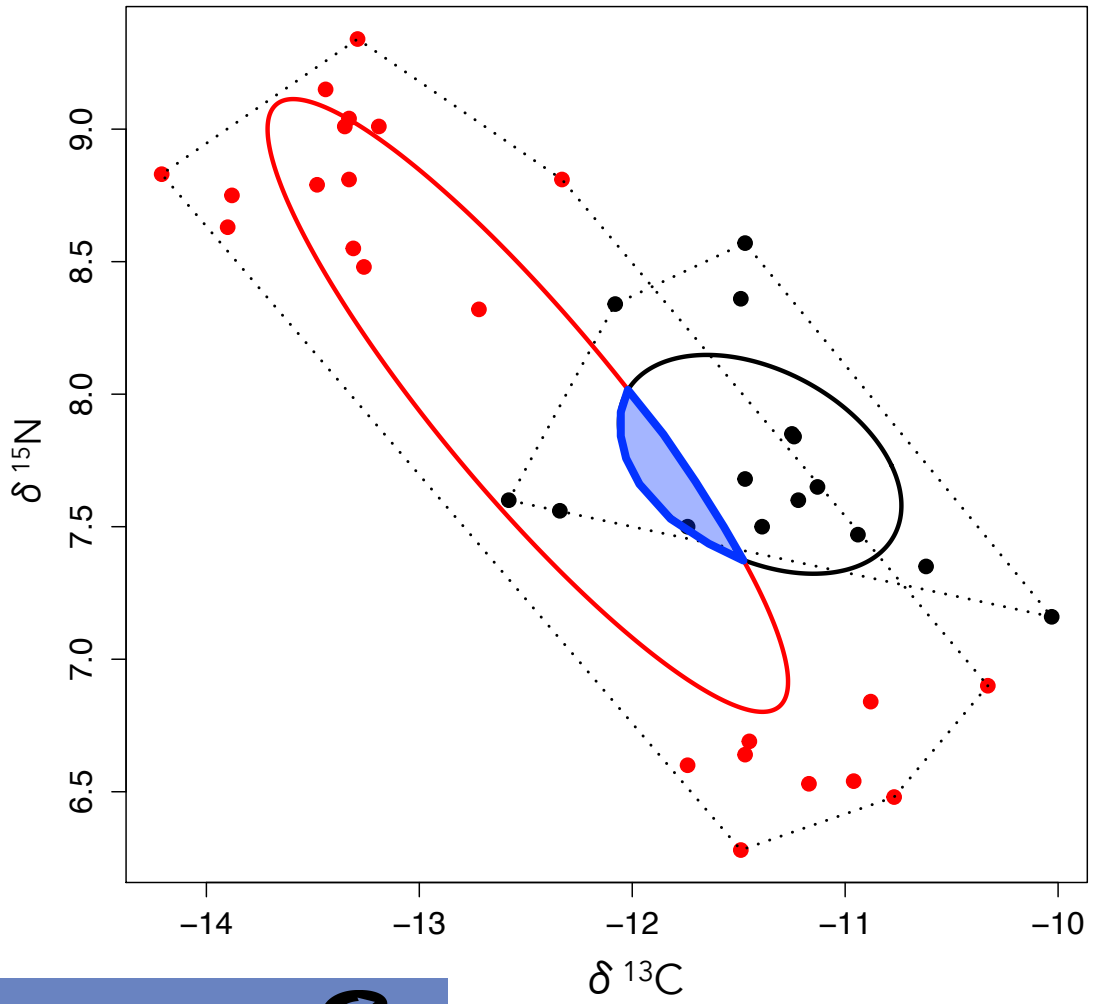
# Trophic niche study: how?

2. δ-space plots and standard ellipses
(Jackson *et al.*, 2011)

Comparisons of groups

Quantification of isotopic **niche overlap**

Comparison of isotopic **niche width**: bayesian **modelling** approach

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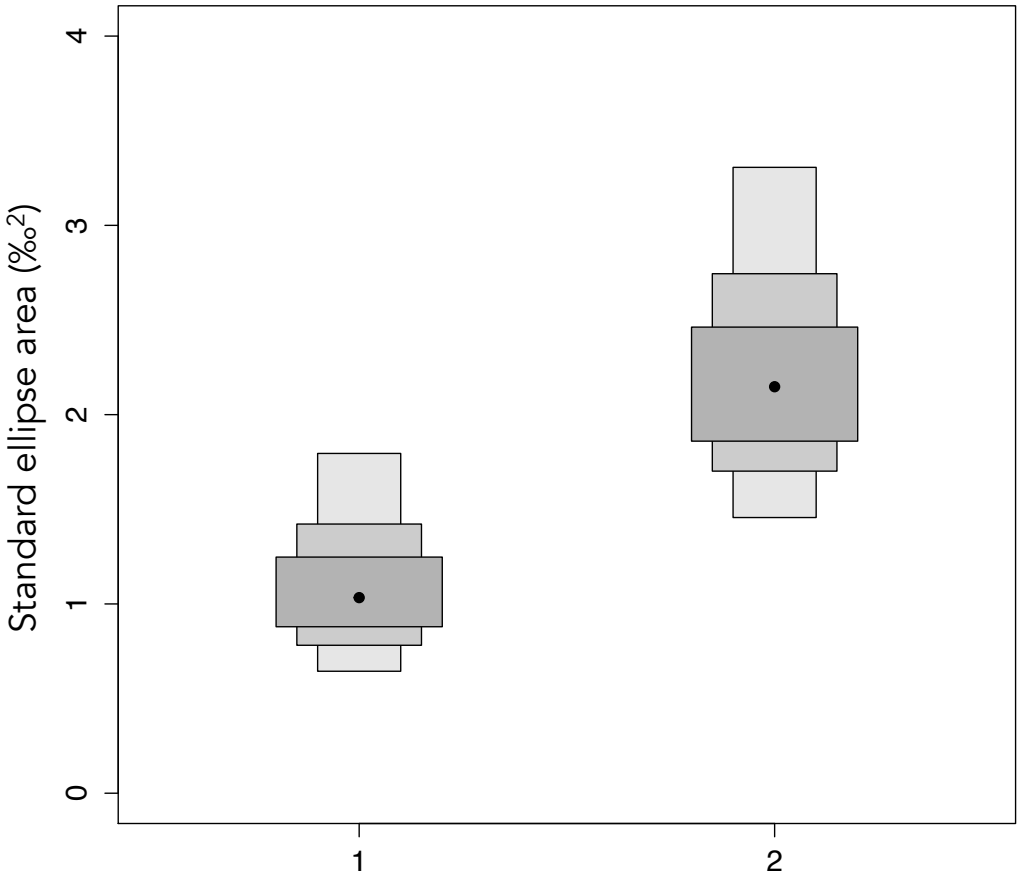
# Trophic niche study: how?

Instead of calculating **SEA** from SD: **estimation** using **bayesian inference**

More **robust** + takes **uncertainty** into account

Outputs: **frequency distribution** of model solutions

Easy to **compare SEA** across groups




$10^5$ solutions

$SEA_1 < SEA_2$ in 98.14 %

P-value analogy

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## Comparing isotopic niche widths among and within communities: SIBER – Stable Isotope Bayesian Ellipses in R

**Andrew L. Jackson[1]*, Richard Inger[2], Andrew C. Parnell[3] and Stuart Bearhop[2]**

Part of **SIAR** (**S**table **I**sotope **A**nalysis in **R**): R package, freely available from the CRAN repository

Allows

- Fitting of convex hulls and standard ellipses to isotopic data
- Computation of "Layman" metrics and SEA
- Model estimations of these parameters
- …

More info, example scripts, podcasts available at http://www.tcd.ie/Zoology/research/research/theoretical/siar.php

# Isotopic niches: an example

Vol. 448: 131–141, 2012
doi: 10.3354/meps09511

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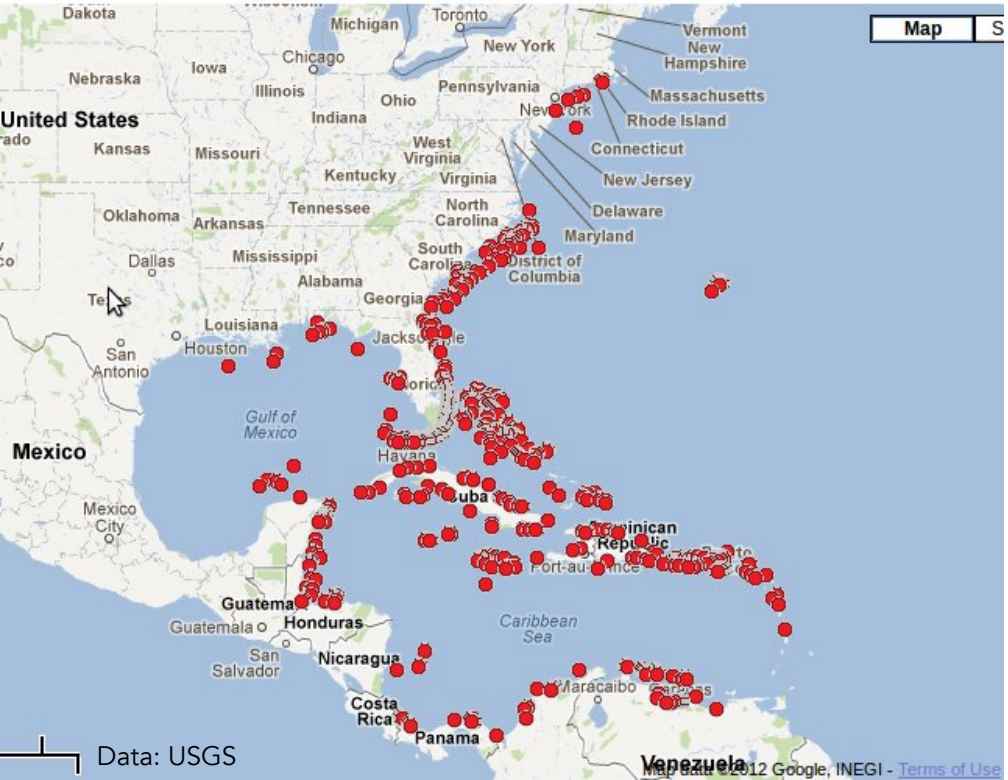
Published February 23

## Characterizing trophic ecology of generalist consumers: a case study of the invasive lionfish in The Bahamas

Craig A. Layman[1,*], Jacob E. Allgeier[2]

Present in the Caribbean and US Atlantic waters since early 2000's




Lionfish (*Pterois volitans/miles*)
Native from Indo-Pacific regions

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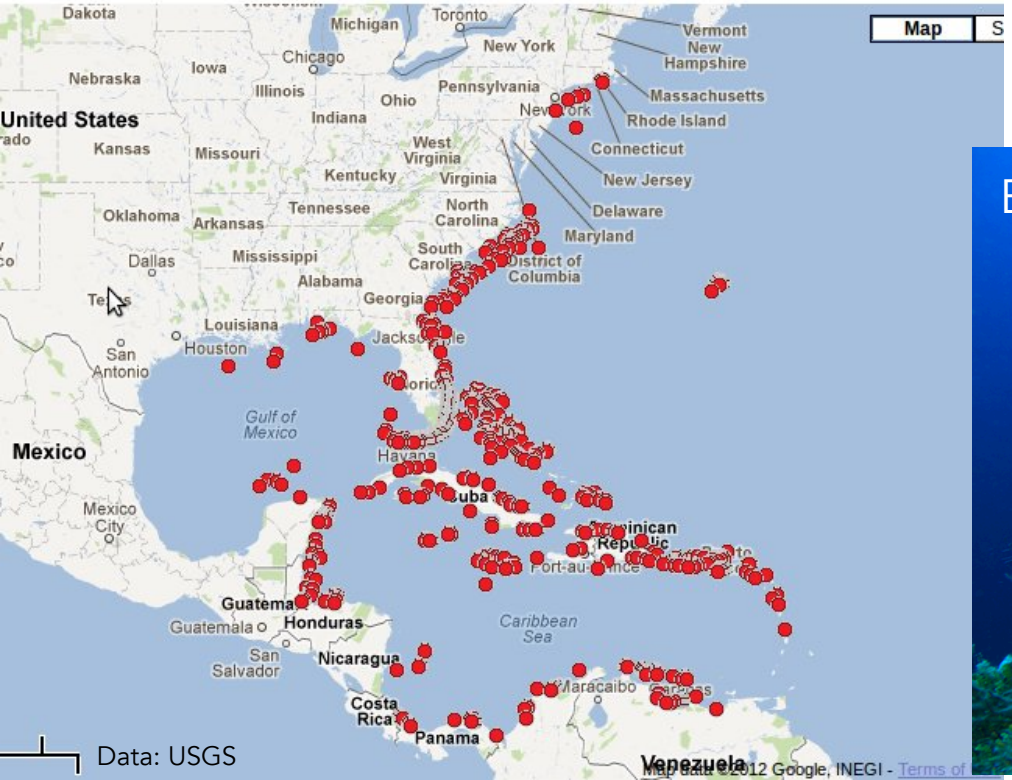


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Craig A. Layman[1,*], Jacob E. Allgeier[2]

**Generalist predator** ( > 40 fish species, benthic crustaceans)

Negative impact on prey populations

**Competition** with native predators? Trophic **niche overlap**?

Schoolmaster snapper (*Lutjanus apodus*)

Grey snapper (*Lutjanus griseus*)

# Isotopic niches: an example

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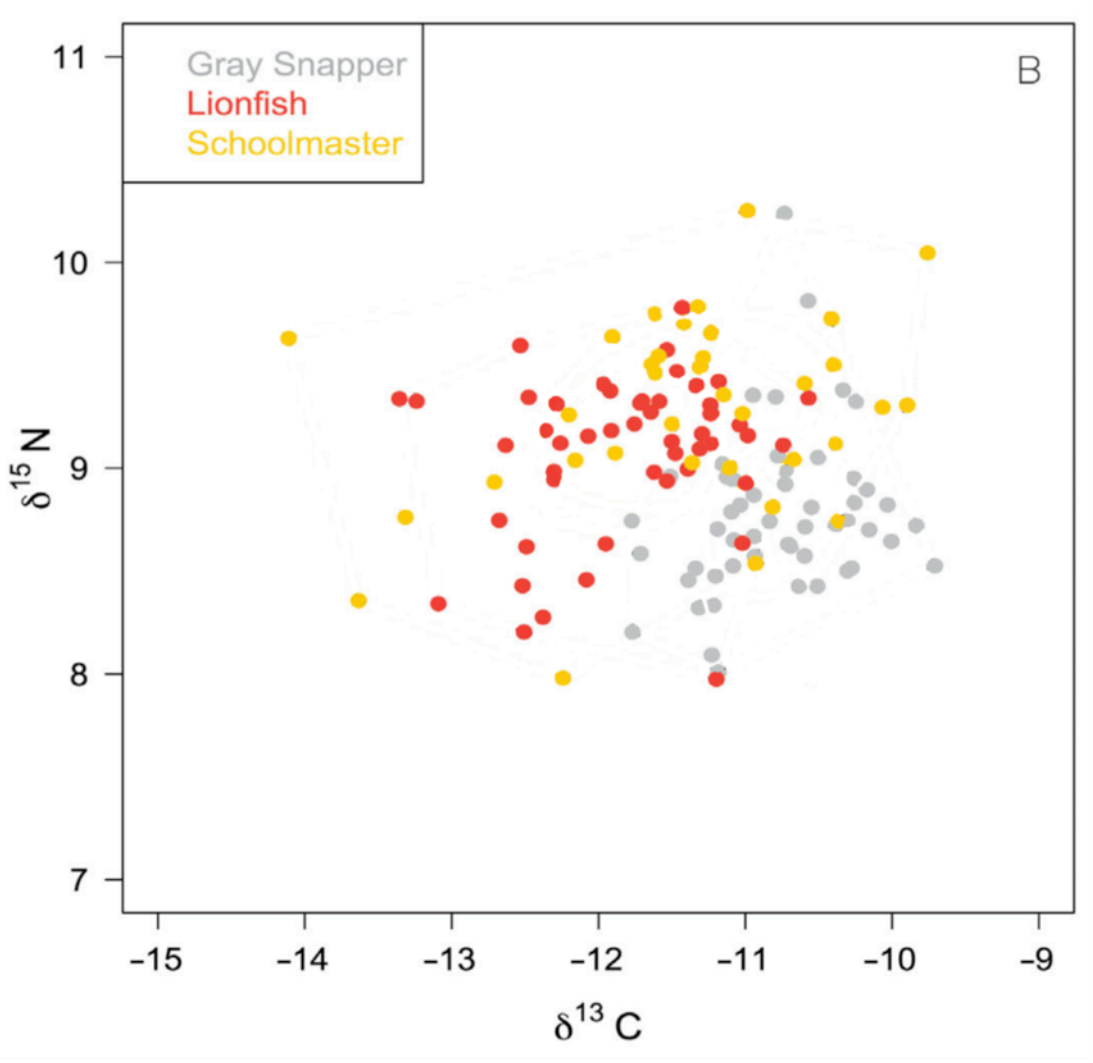
Isotopic **biplot** suggest important **similarity** in resource use



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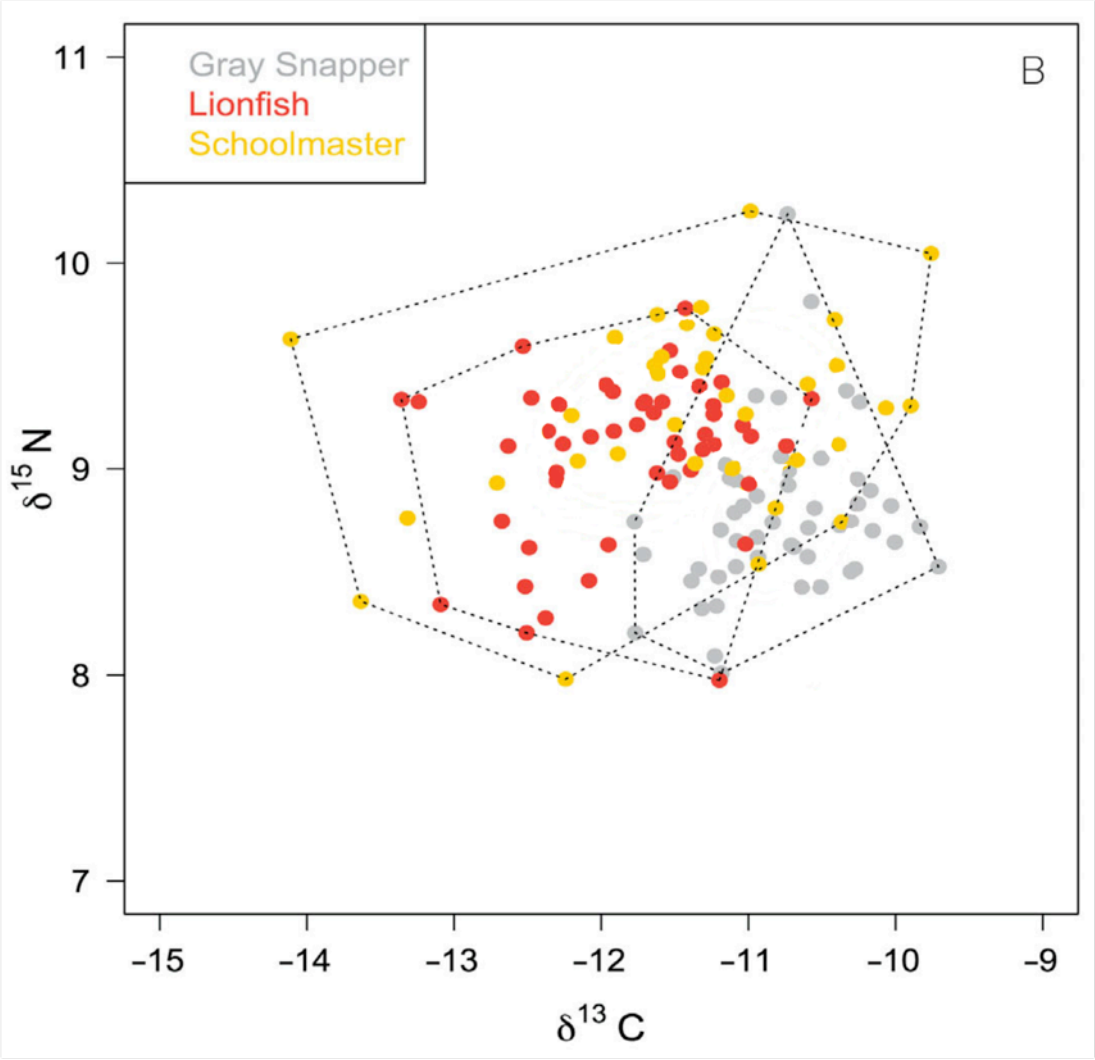

# Isotopic niches: an example

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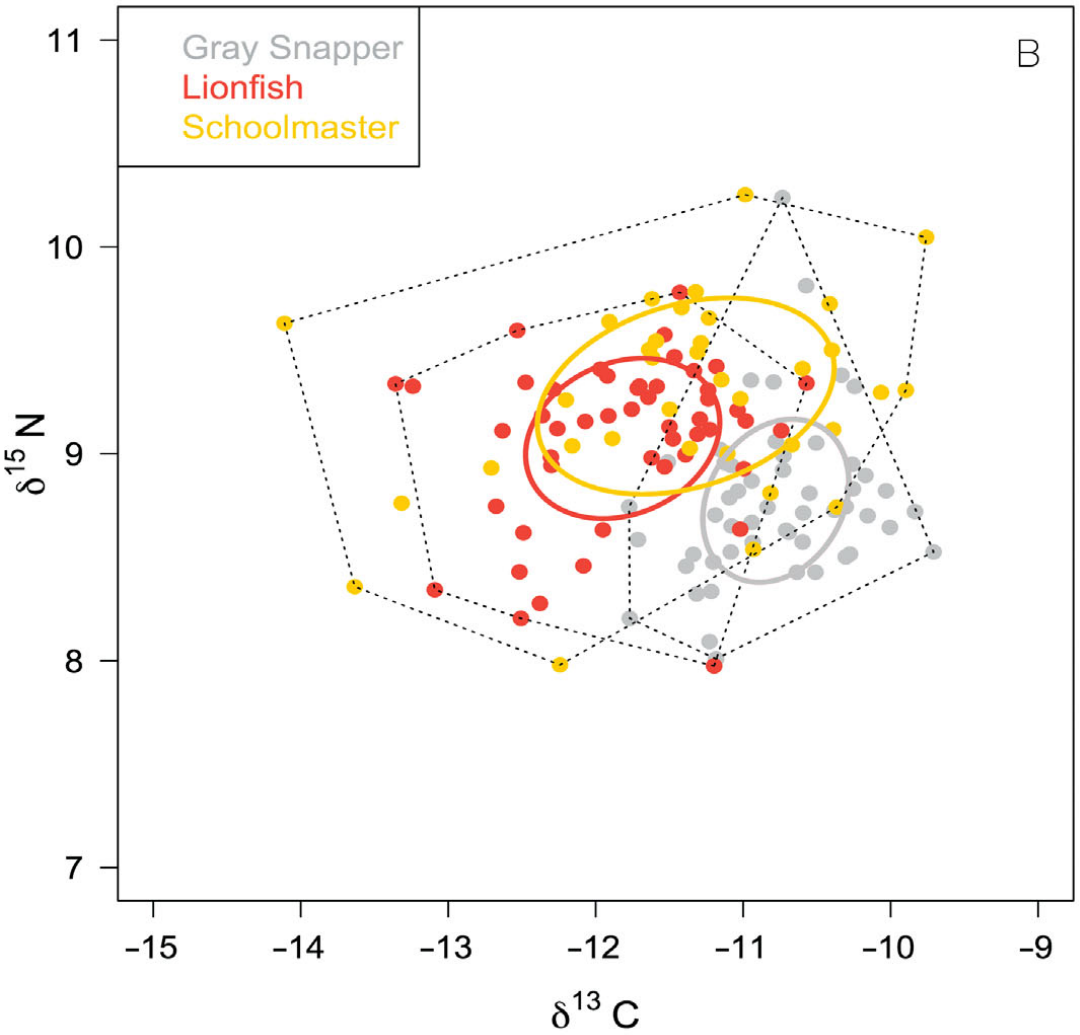
**Standard ellipses** (proxy for "core niche", *i.e.* most frequent utilization of resources): **Competition** is most likely to occur between lionfish and schoolmaster

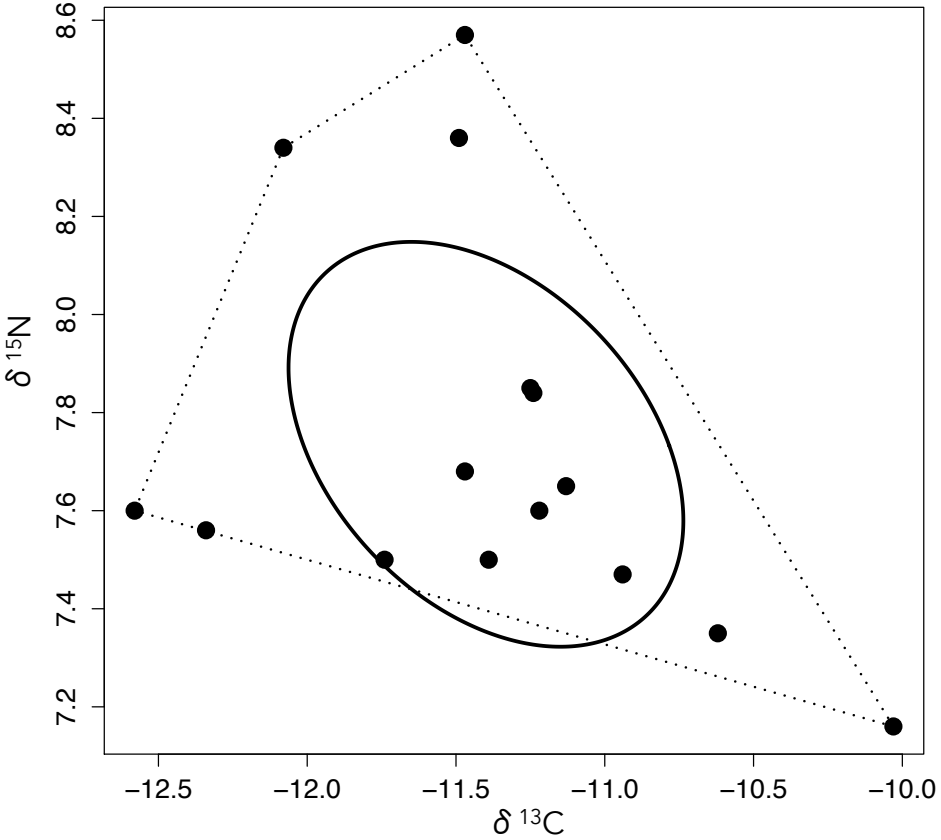
Supported by **gut contents**: grey snappers ingest more benthic crustaceans



# Caution on isotopic niche use

The **isotopic niche** is a **proxy**! It is not an actual depiction of the trophic niche, since its axes are not actual resource use (*i.e.*, not dimensions of the ecological niche)

**Position of consumers** in the $\delta$-space is mostly driven by **differences in resource use**, but other factors also influence it: **isotopic variability** of **baseline producers** and/or **prey items**



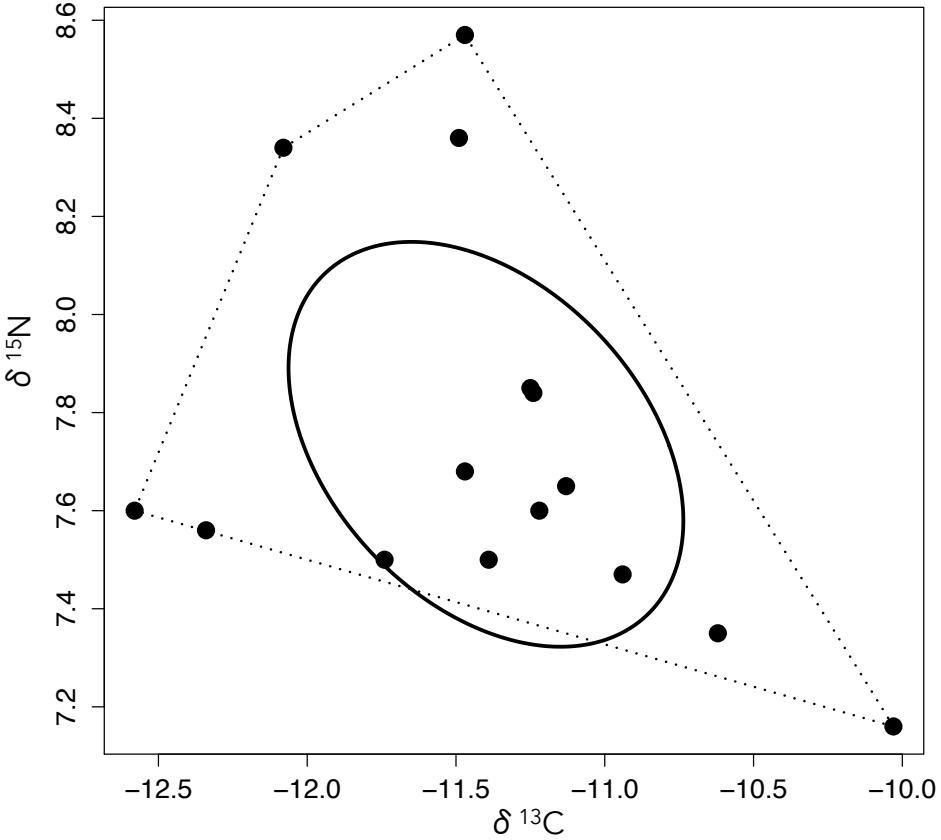

Although not necessary, **isotopic data** on **food sources** can help avoiding interpretation mistakes

Adapt your **sampling strategies**!

# Caution on isotopic niche use

"Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful."

George E.P. Box
1919-2013




**Isotopic niche study** is a **rapidly evolving** field supported by many different approaches and concepts

When used **sensibly**, it is a **robust** and **widely applicable** method that can help solving many **ecological questions** linked with **resource partitioning** among consumers