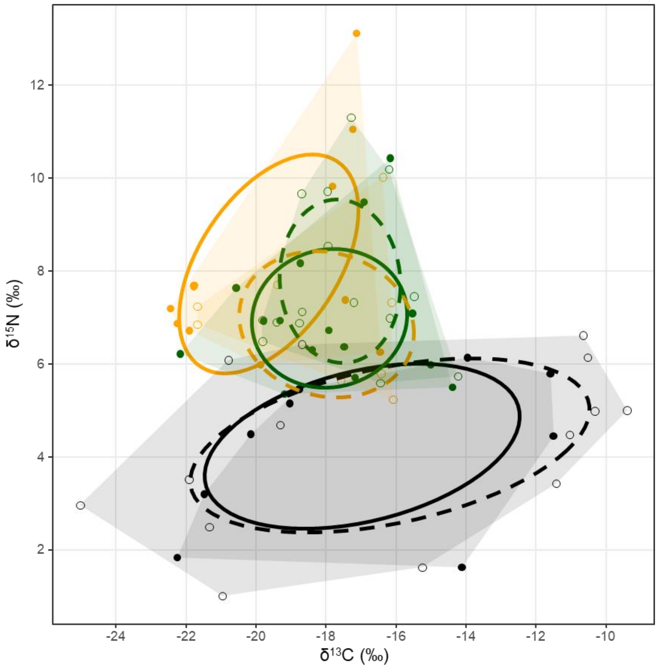
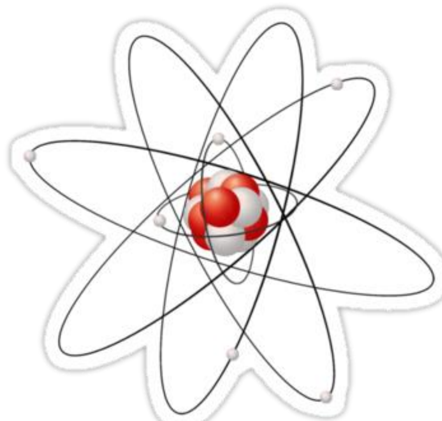
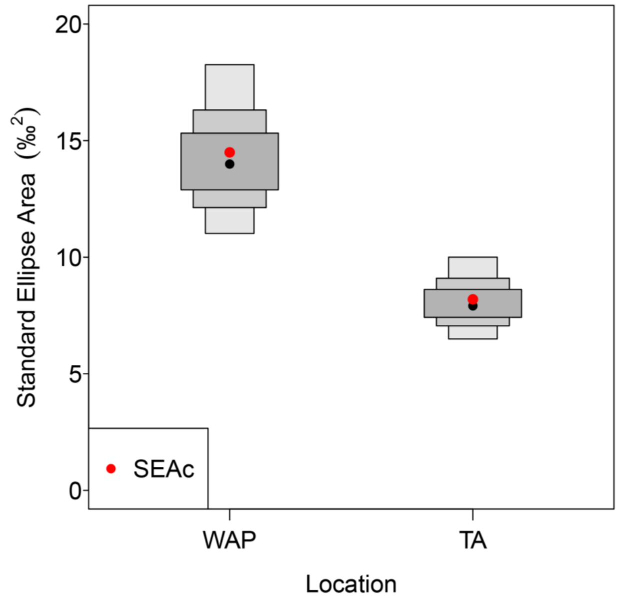
# Stable isotopes as descriptors of ecological niches







Loïc MICHEL – loicnmichel@gmail.com


Course "Etude des isotopes stables et applications au milieu marin" – University of Liège

# What’s an ecological niche?

Joseph Grinnell (1917): "habitat niche"

The niche of a species is the sum of the habitat requirements and behaviors that allow it to persist and produce offspring

THE NICHE-RELATIONSHIPS OF THE CALIFORNIA THRASHER.[1]

BY JOSEPH GRINNELL.

*The Auk* 34: 427–433

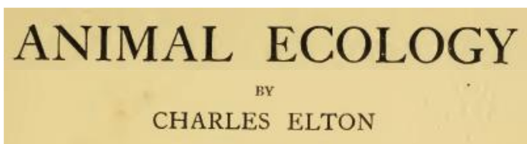
Chaparral

# What’s an ecological niche?

Charles S. Elton (1927): "functional niche"

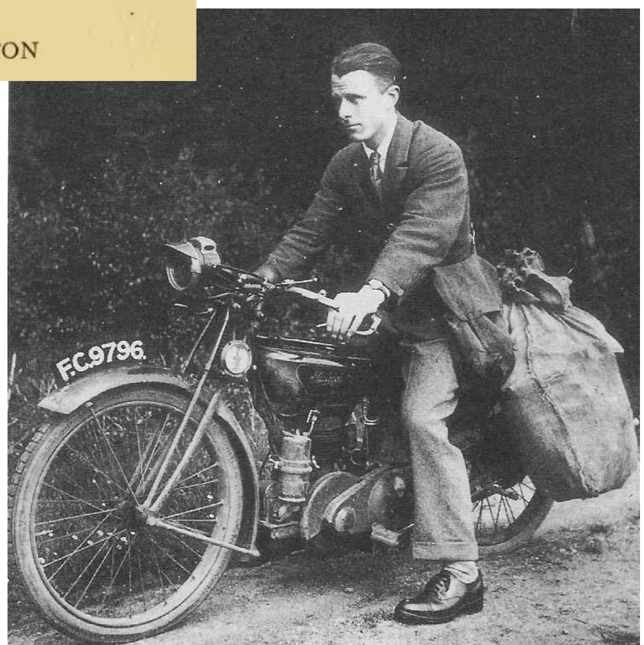
"The "niche" of an animal means its place in the biotic environment, its relations to food and enemies."

Species respond to their environment and affect it: their niche is the role they perform in the ecosystem they live in


ANIMAL ECOLOGY

BY

CHARLES ELTON





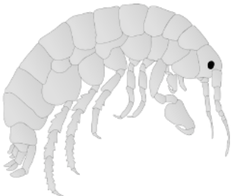
White rhinoceros (*Ceratotherium simum*)

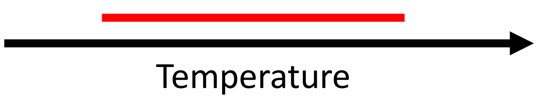

Black rhinoceros (*Diceros bicornis*)

# What’s an ecological niche?

Conceptual definition by George E. Hutchinson (1957):

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






**Concluding Remarks**

G. Evelyn Hutchinson

*Yale University, New Haven, Connecticut*

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

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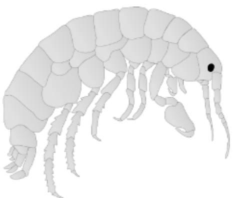

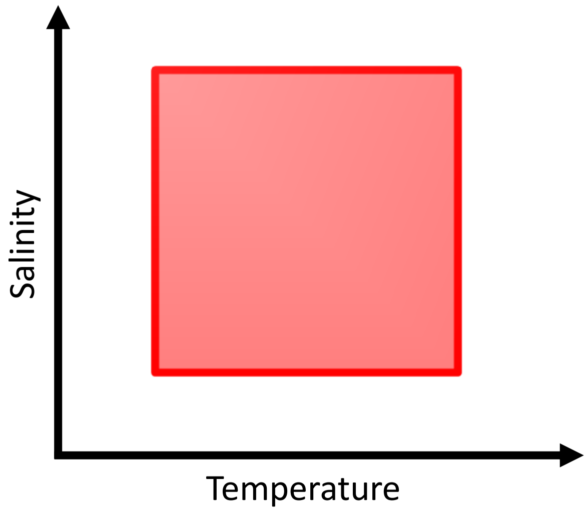


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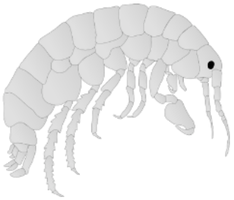

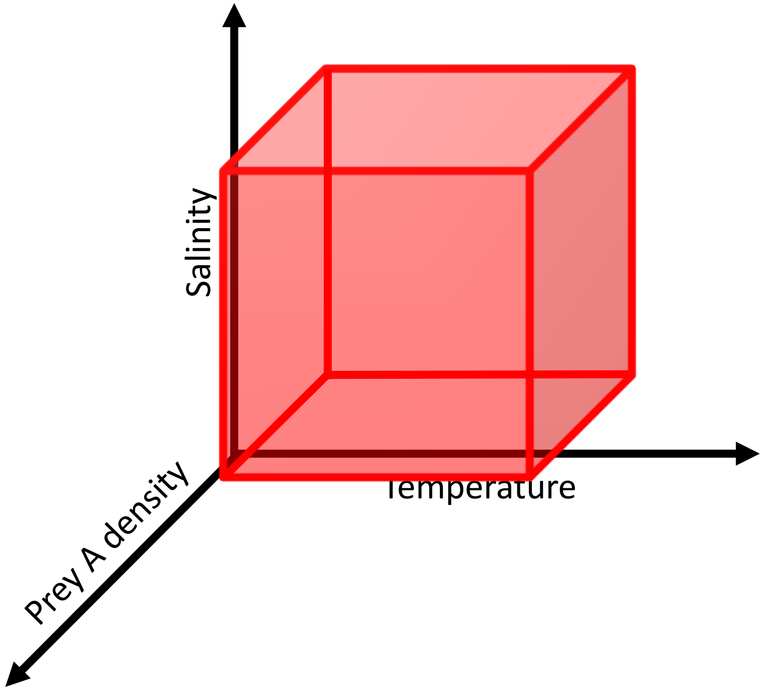


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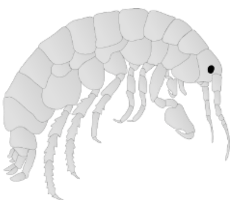

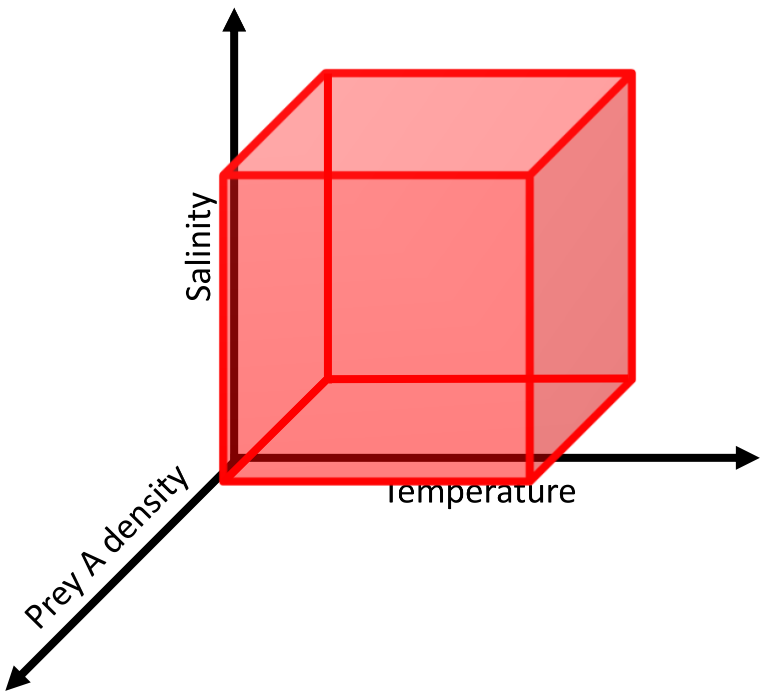


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2 categories of dimensions: habitat- and resource-related

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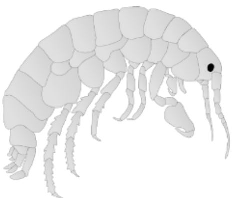
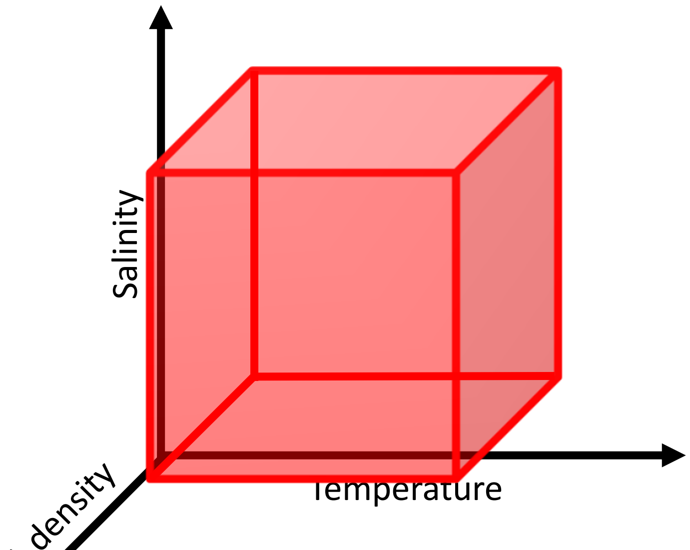





Concluding Remarks

G. Evelyn Hutchinson

*Yale University, New Haven, Connecticut*

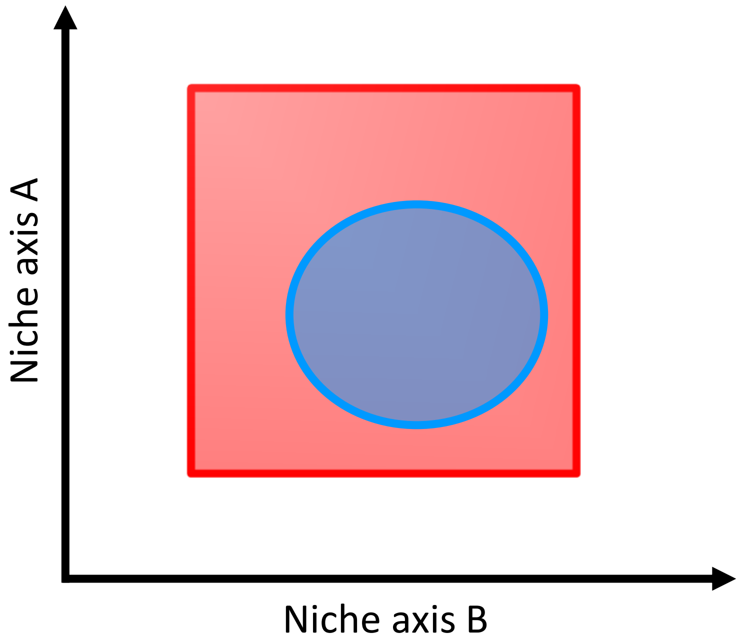
Trophic niche = part of the ecological niche built using the subset of dimensions related to trophic resources

2 categories of dimensions: habitat- and resource-related

# What's an ecological niche?

Fundamental niche: full range of conditions and resources in which an organism could survive and reproduce if free of any interference

Realized niche: narrower space that an organism is "forced" to occupy as a result of interactions with other species




Concluding Remarks

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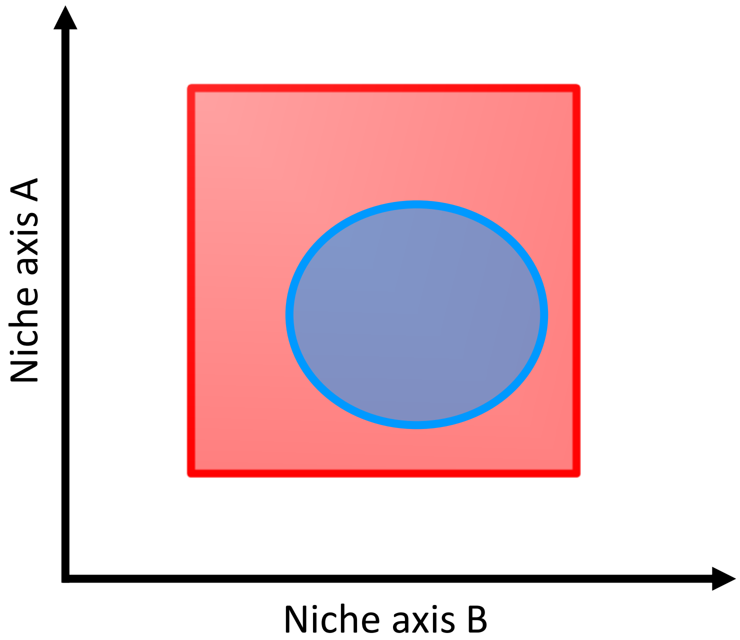
Cold Spring Harbor symposia on quantitative biology 22: 415-427

# What's an ecological niche?

Fundamental niche

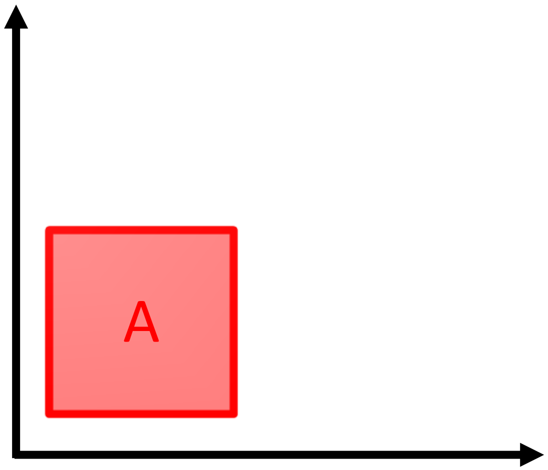
Realized niche

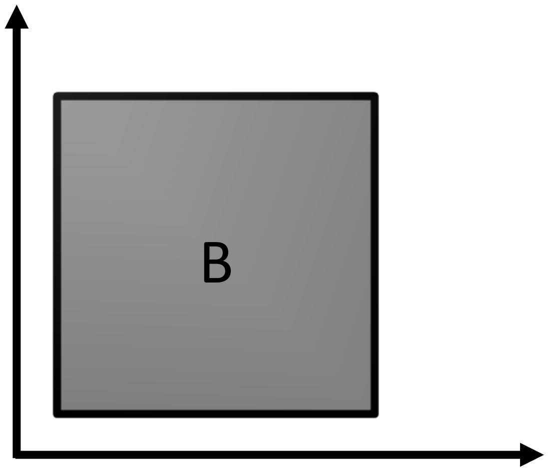
Importance of competition as a driving mechanism




# Ecological niche study: why?

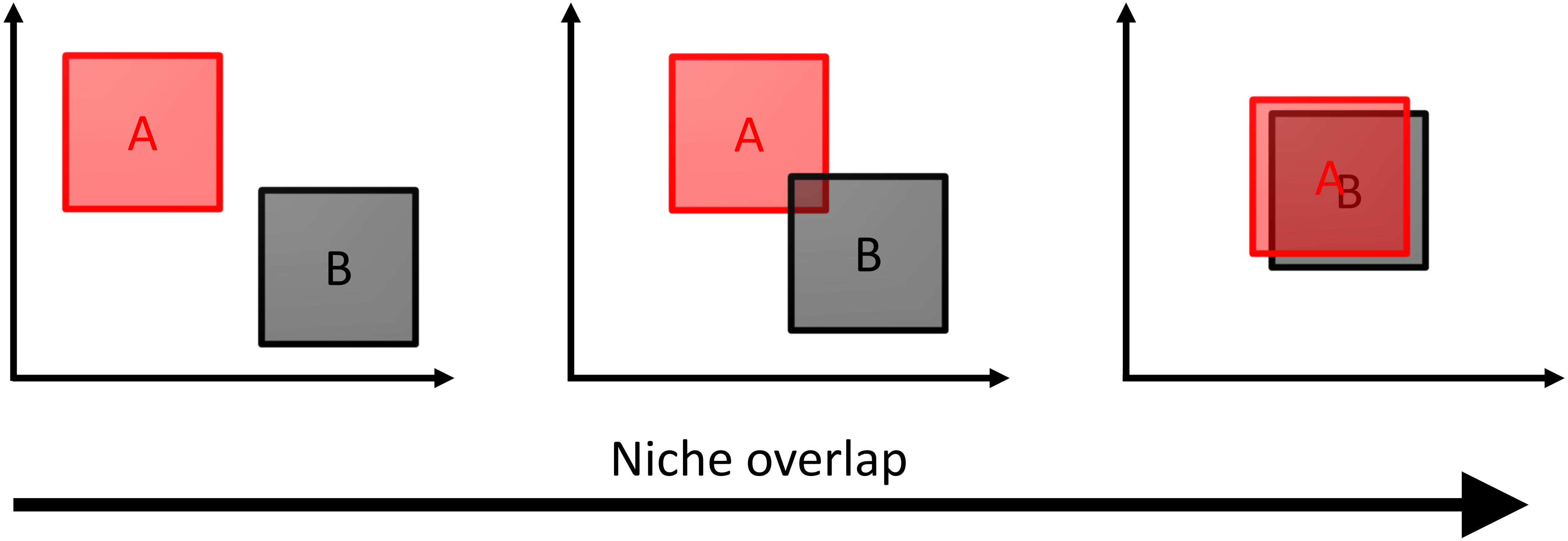
- Identify ecological strategies: amount of resources and habitats used by animals (narrow vs. wide niches)



# Ecological niche study: why?

- Identify ecological strategies
- Understand how ecological interactions can affect community structure



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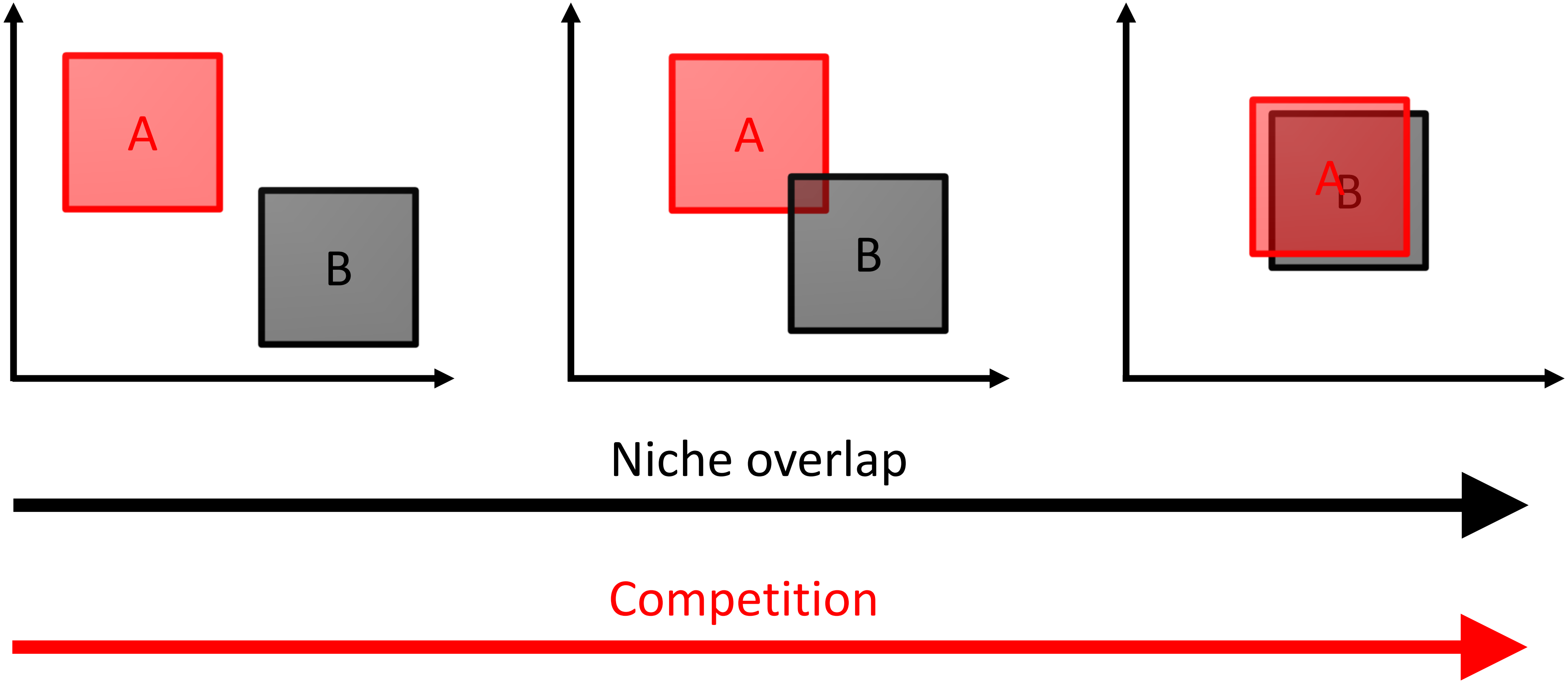
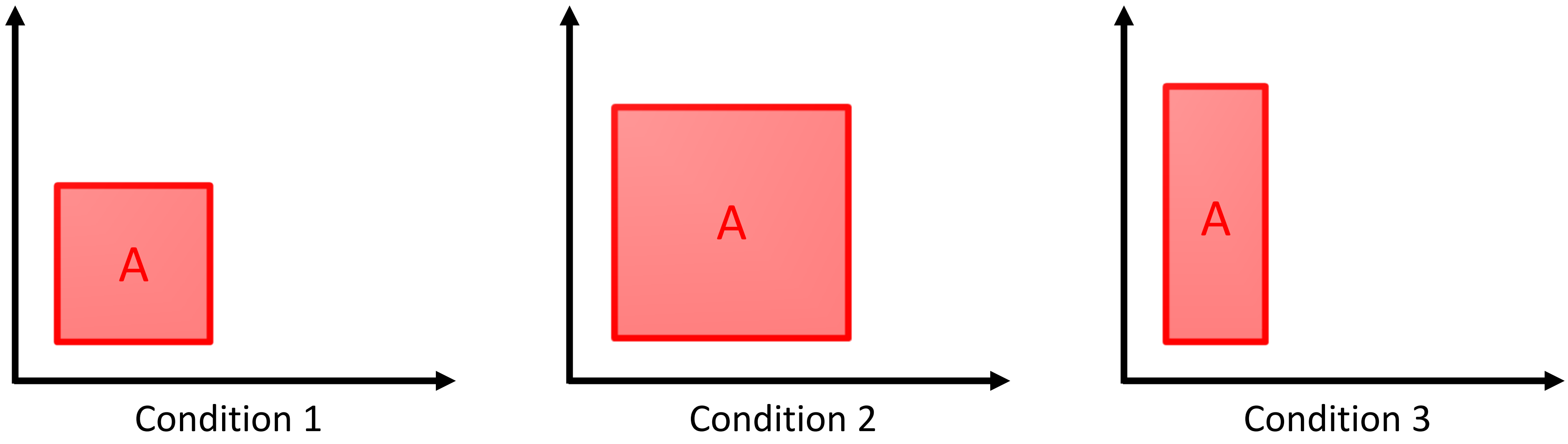


# Ecological niche study: why?

- Identify ecological strategies
- Understand how ecological interactions can affect community structure
- Highlight ecological shifts and study ecological plasticity



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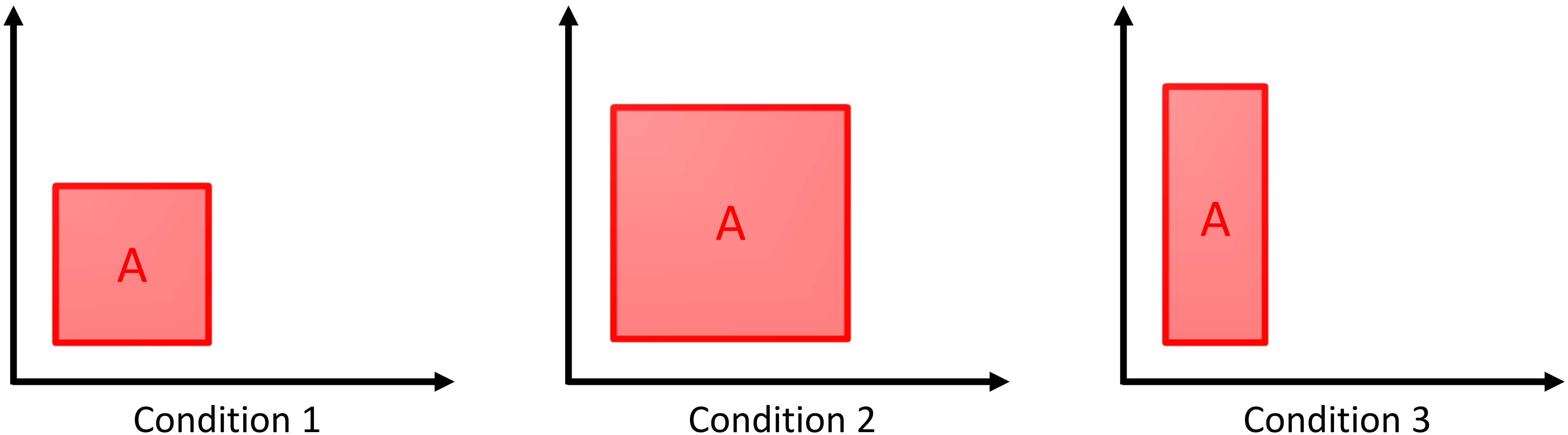


➔ Powerful theoretical concept but practical use limited (complicated or impossible to provide direct quantitative estimates for niche parameters)

➔ Development of ecological niche proxies, including methods based on stable isotope ratios

# Ecological niche study: how?

FORUM

**Determining trophic niche width: a novel approach using stable isotope analysis**

STUART BEARHOP*† COLIN E. ADAMS‡ SUSAN WALDRON§, RICHARD A. FULLER¶ and HAZEL MACLEOD‡

*Journal of Animal Ecology* 2004 **73**, 1007–1012

➔ Variance of stable isotope ratios in animal tissues can be used to compare trophic niches among species

# Ecological niche study: how?

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➔ Variance of stable isotope ratios in animal tissues can be used to compare trophic niches among species

REVIEWS REVIEWS REVIEWS

# A niche for isotopic ecology

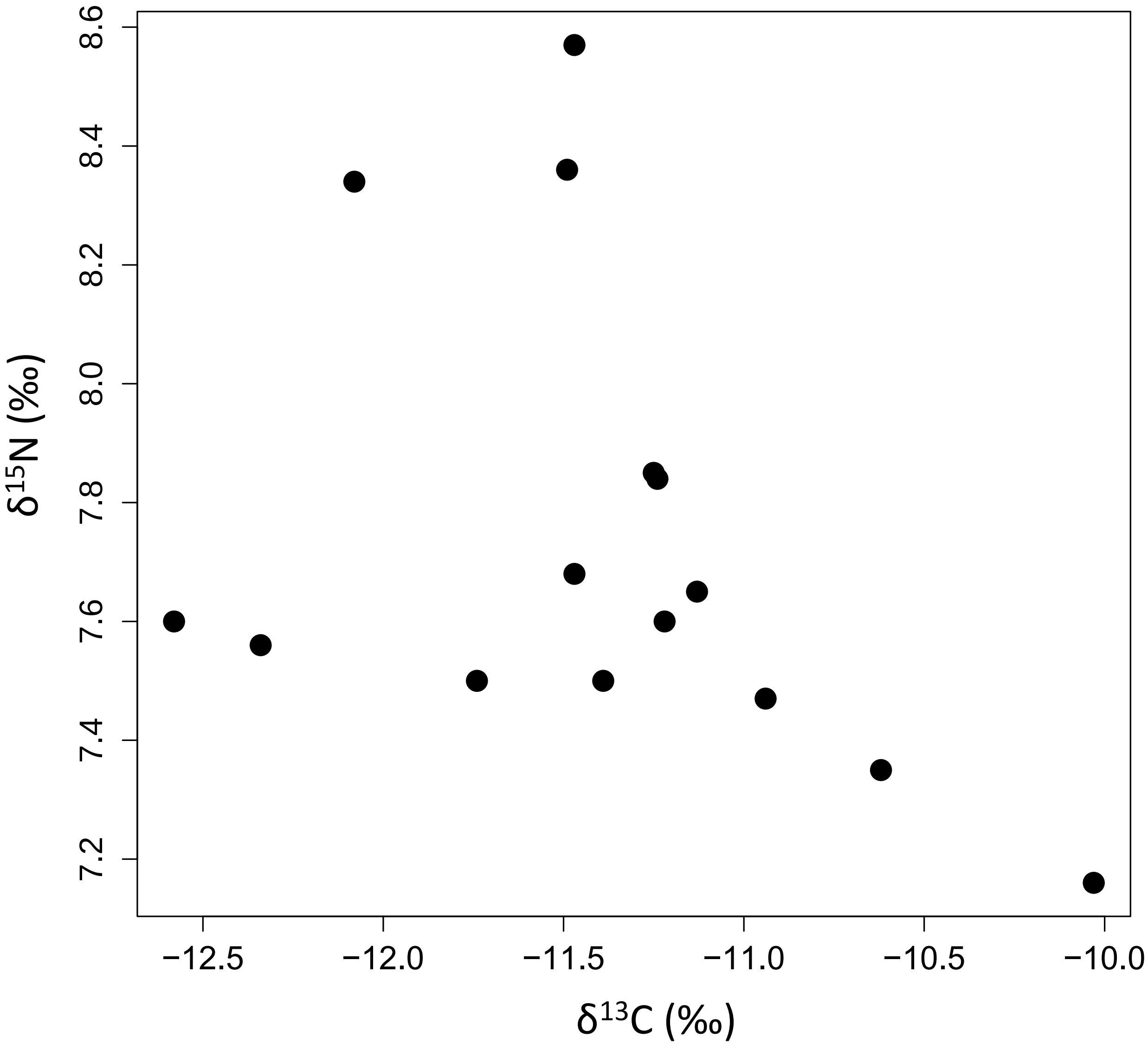
**Seth D Newsome[1*], Carlos Martinez del Rio[2], Stuart Bearhop[3], and Donald L Phillips[4]**

*Front Ecol Environ* 2007; 5(8): 429–436, doi:10.1890/060150.01

➔ The "isotopic niche" can provide quantitative information on both resource and habitat use by animals

# Ecological niche study: how?

Typical SI analysis output : points in "δ-space"



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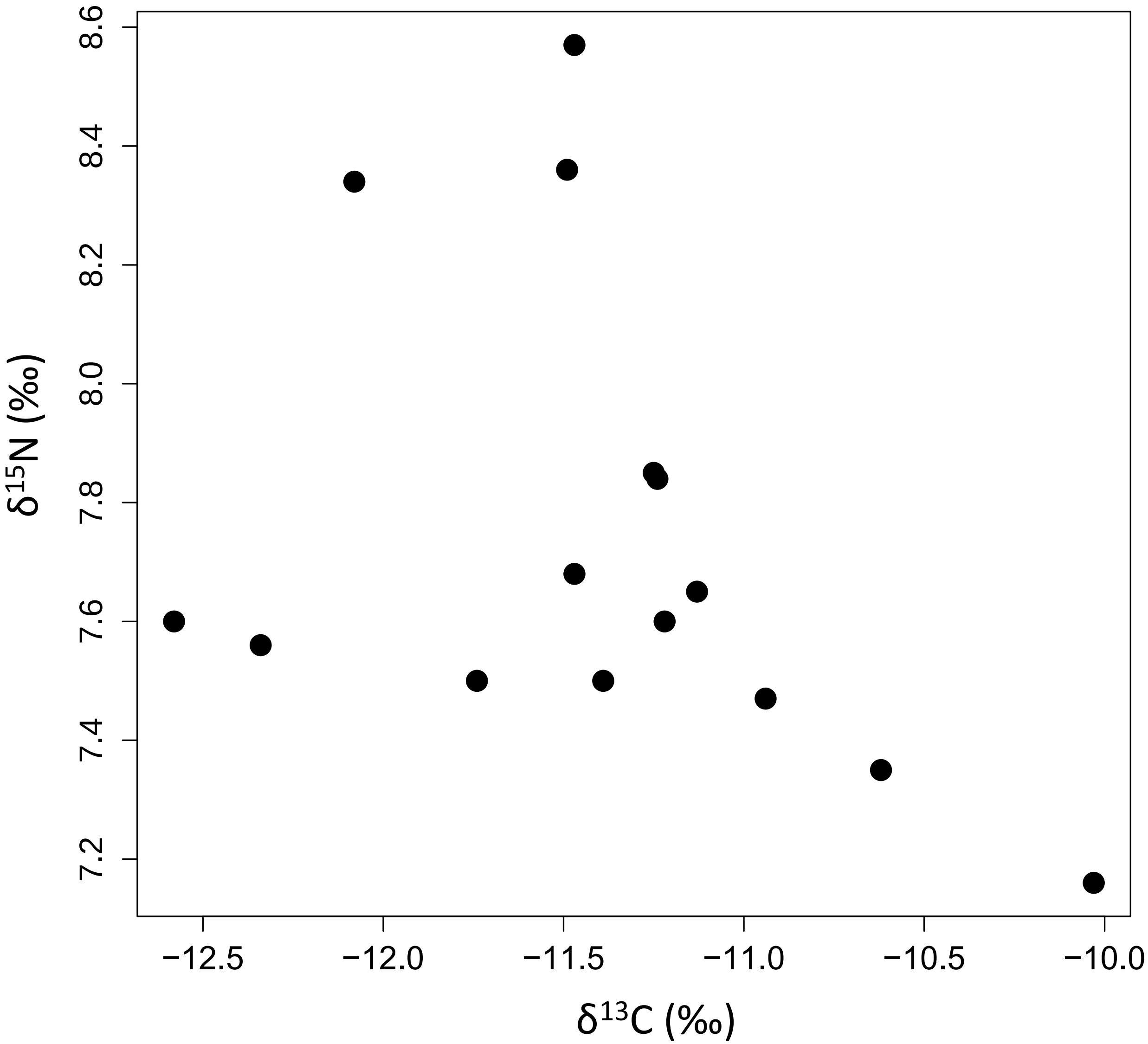


Position of consumers in the δ-space is driven by

1) Differences in consumed resources (different preys can have different isotopic compositions)

# Ecological niche study: how?

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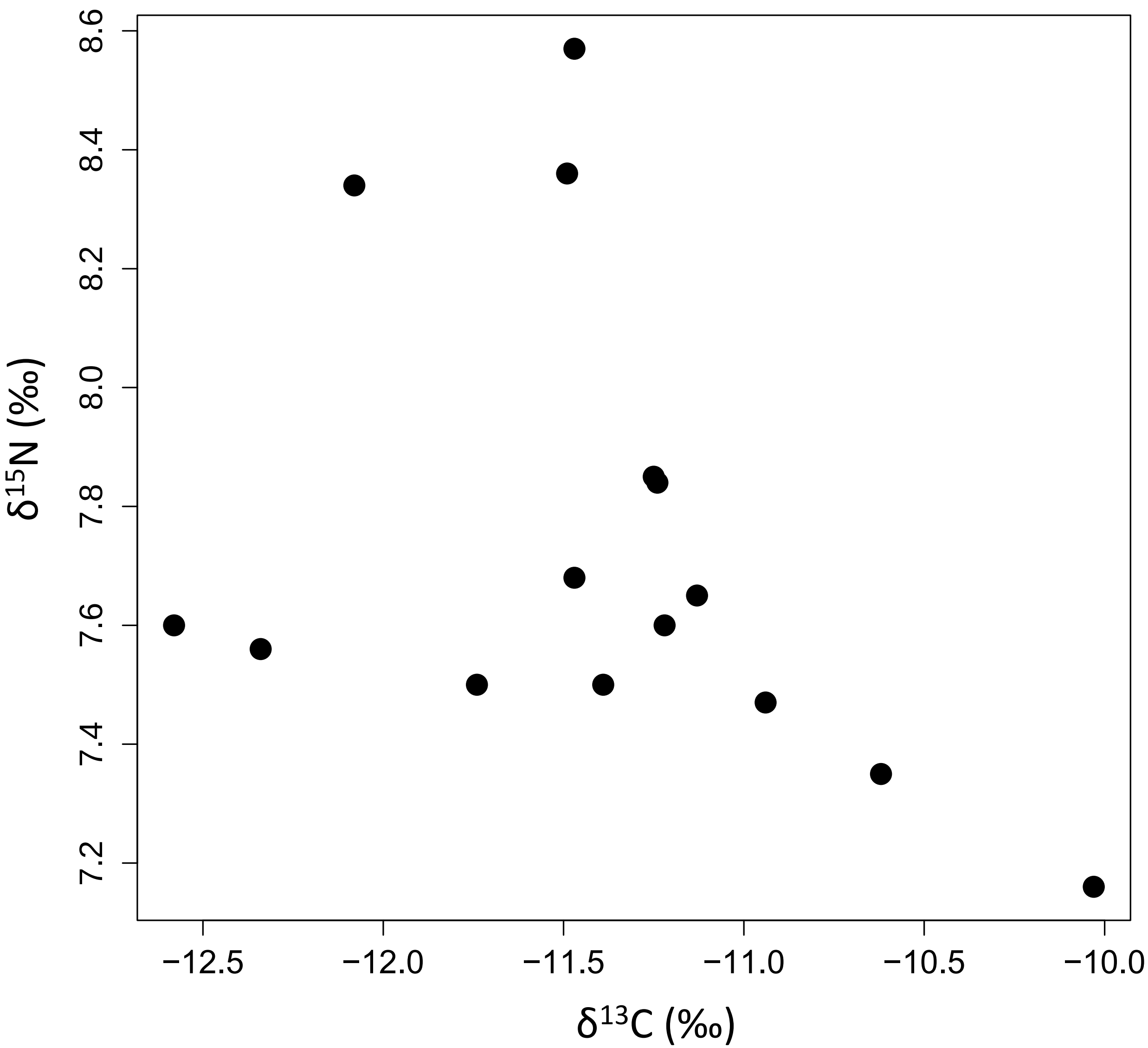


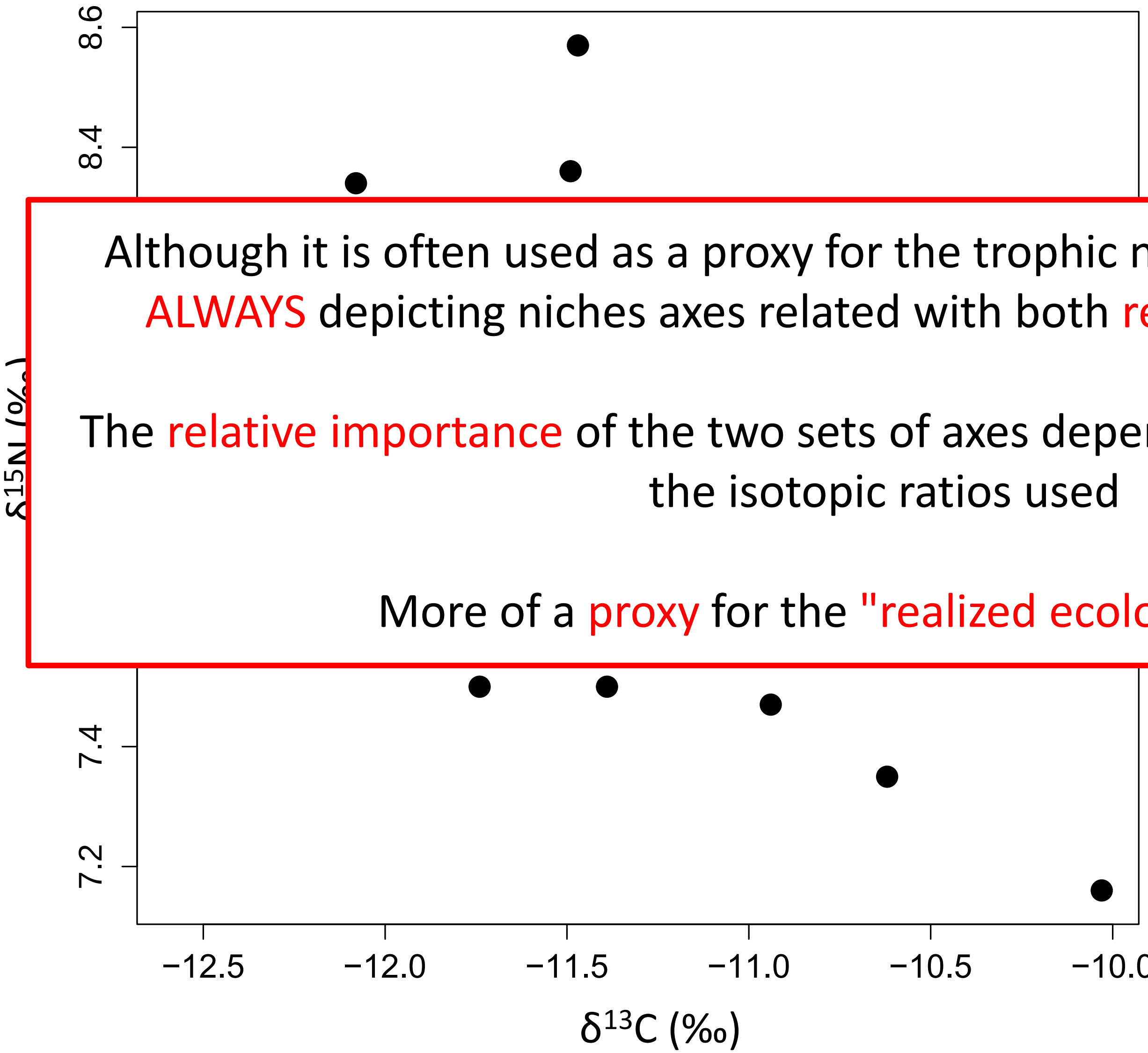

Position of consumers in the δ-space is driven by

1) Differences in consumed resources (different preys can have different isotopic compositions)

2) Differences in habitat used for foraging (the same prey can have different isotopic compositions in different habitats)

# Ecological niche study: how?

Typical SI analysis output : points in "δ-space"




Position of consumers in the δ-space is driven by

Although it is often used as a proxy for the trophic niche, the isotopic niche is ALWAYS depicting niches axes related with both resource and habitat use

The relative importance of the two sets of axes depend on the studied system + the isotopic ratios used

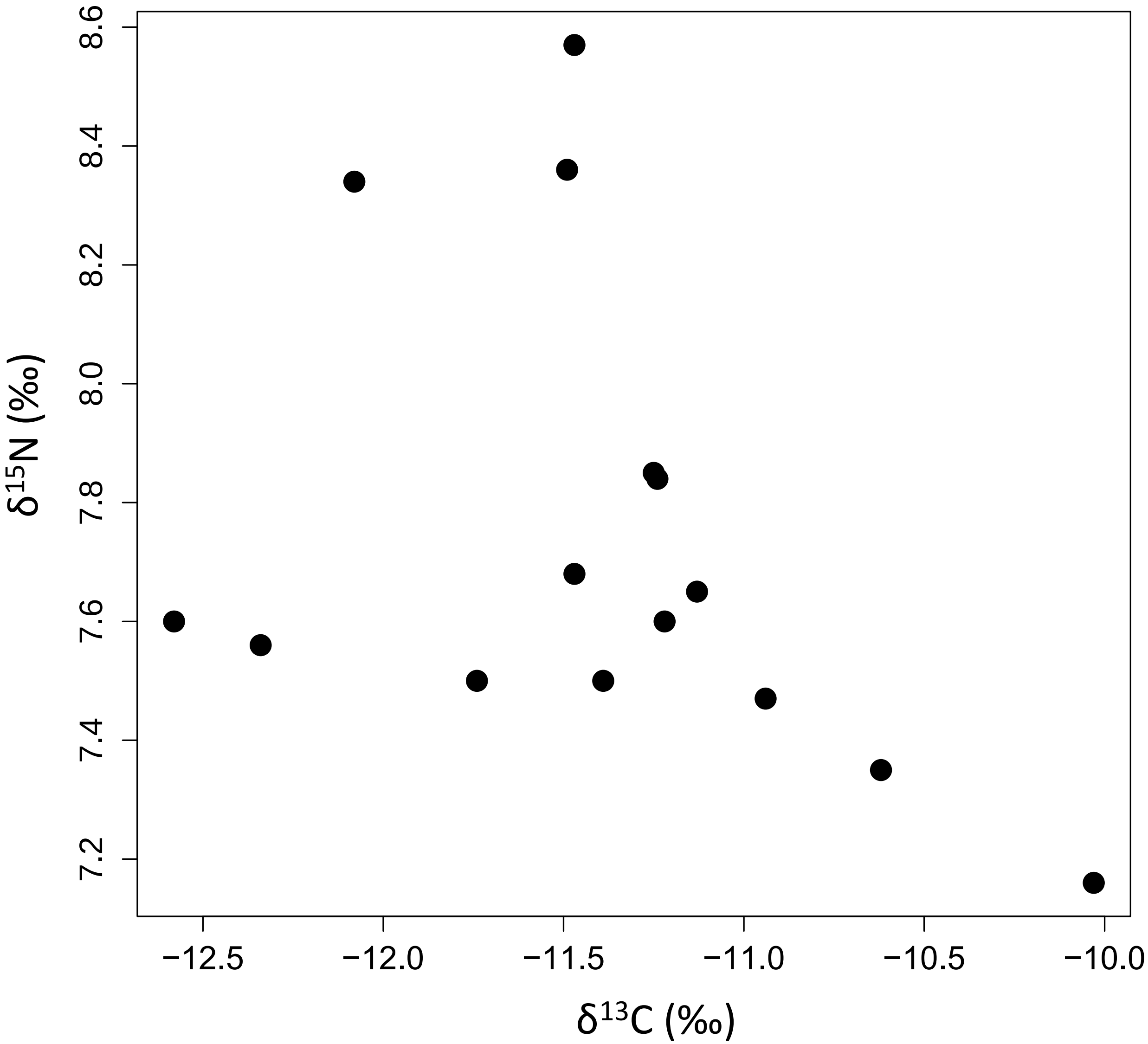
More of a proxy for the "realized ecological niche"

(the same prey can have different isotopic compositions in different habitats)

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

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):

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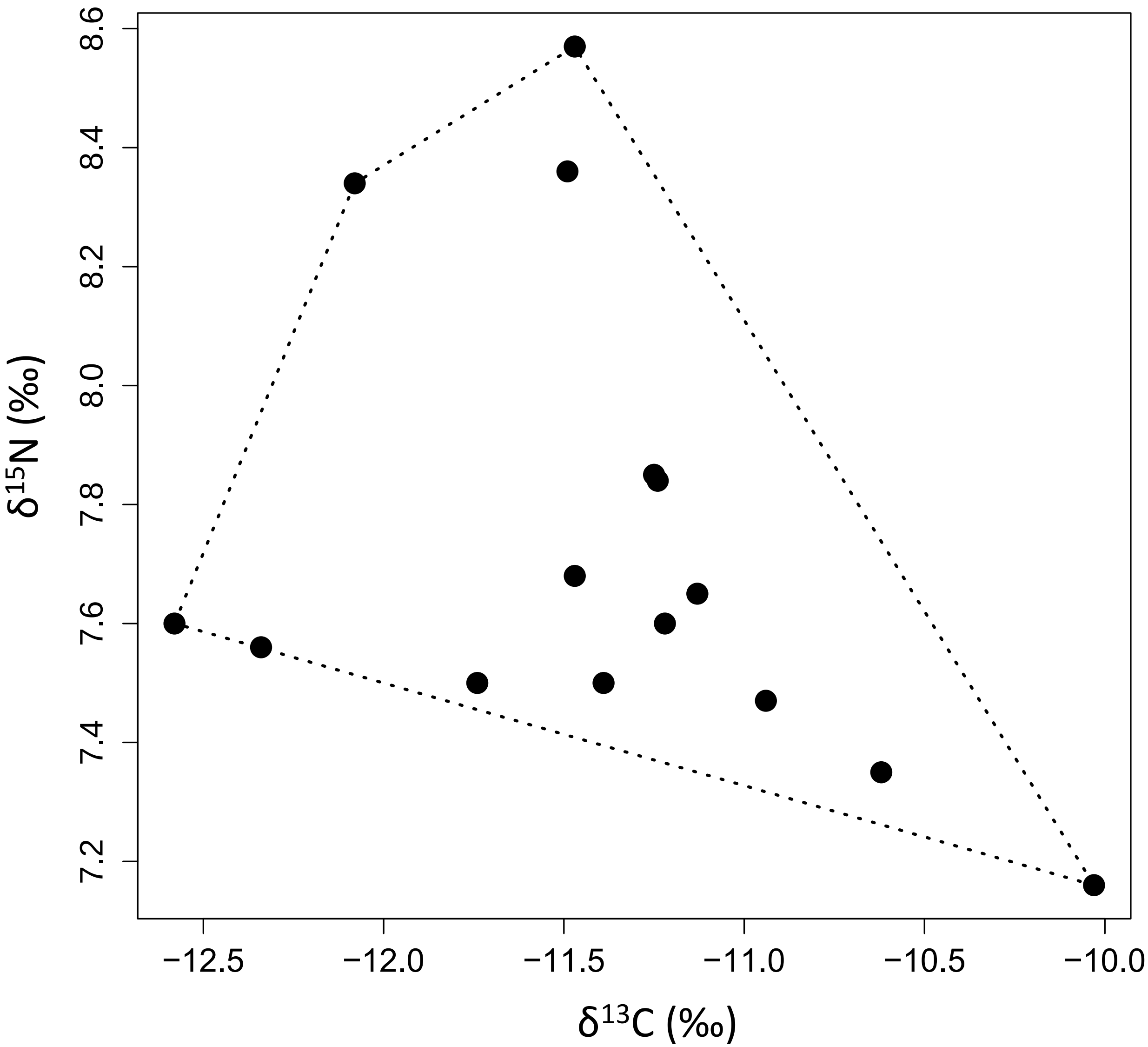


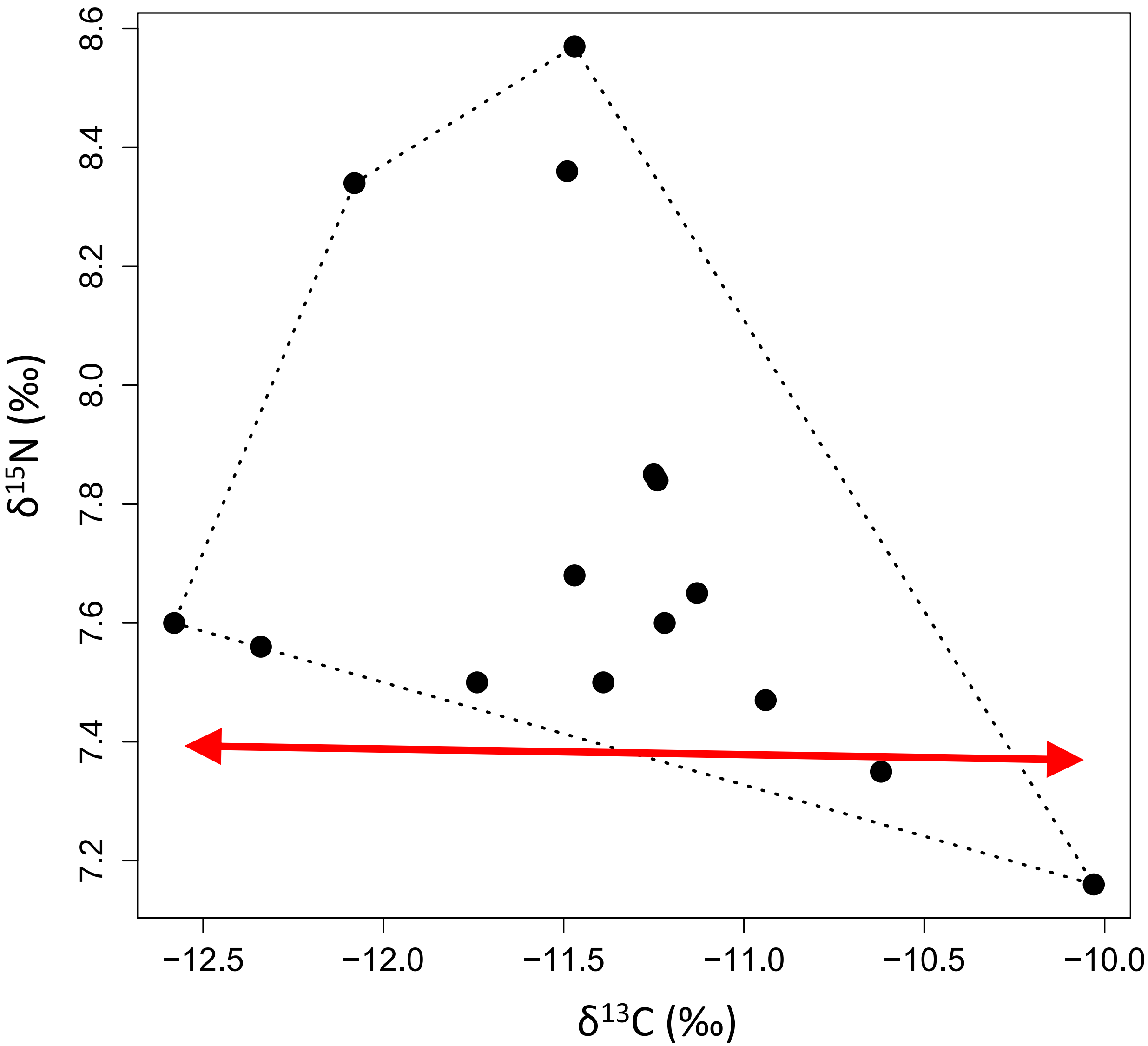

Geometric approach
(Layman *et al.*, 07):

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)

# Layman metrics

Set of descriptors based on convex hull



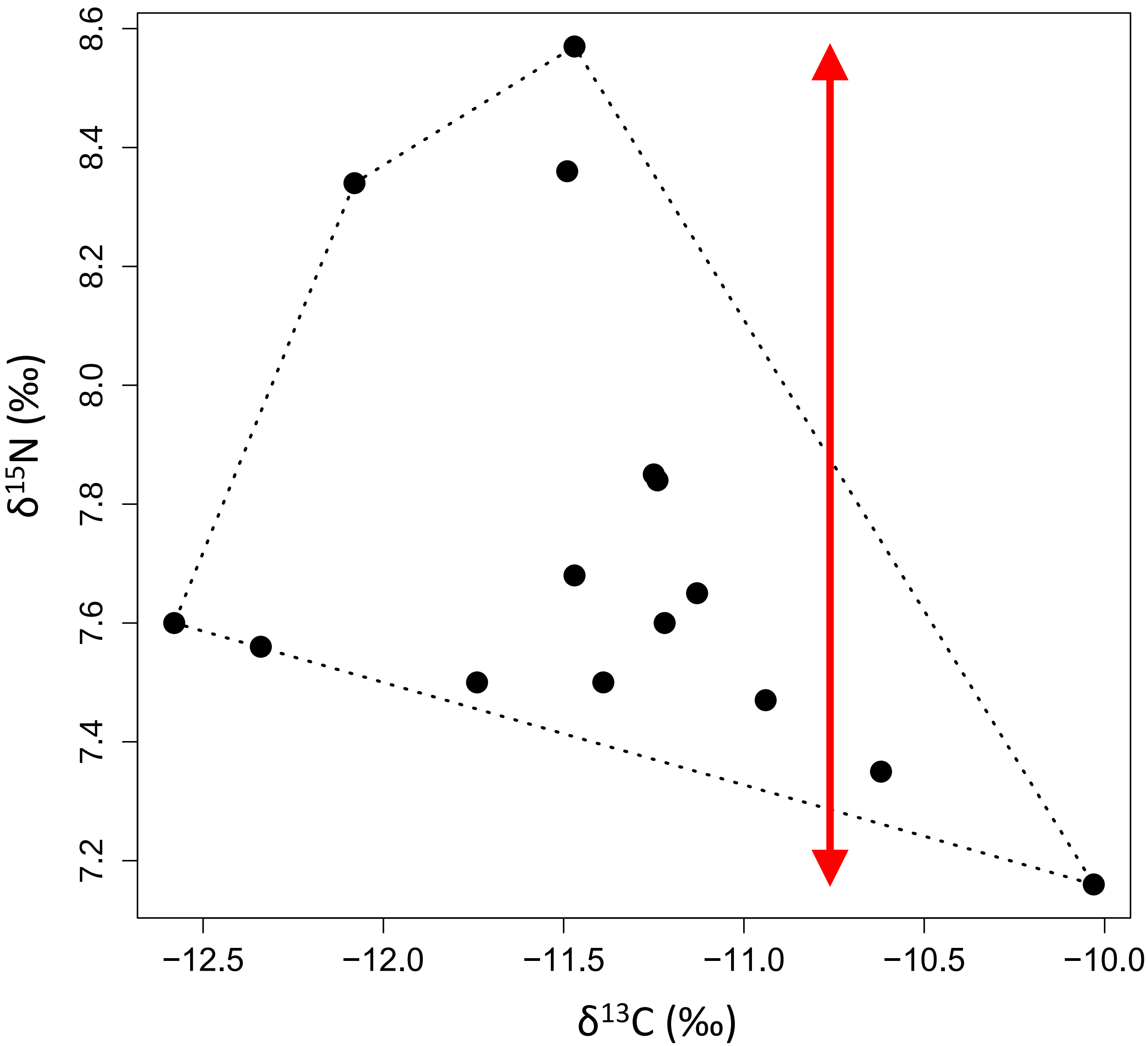

1) $\delta^{13}$C range

Proxy of the diversity of resources supporting the consumers

Greater when more primary producers are important for the community

# Layman metrics

Set of descriptors based on convex hull




1) $\delta^{13}C$ range

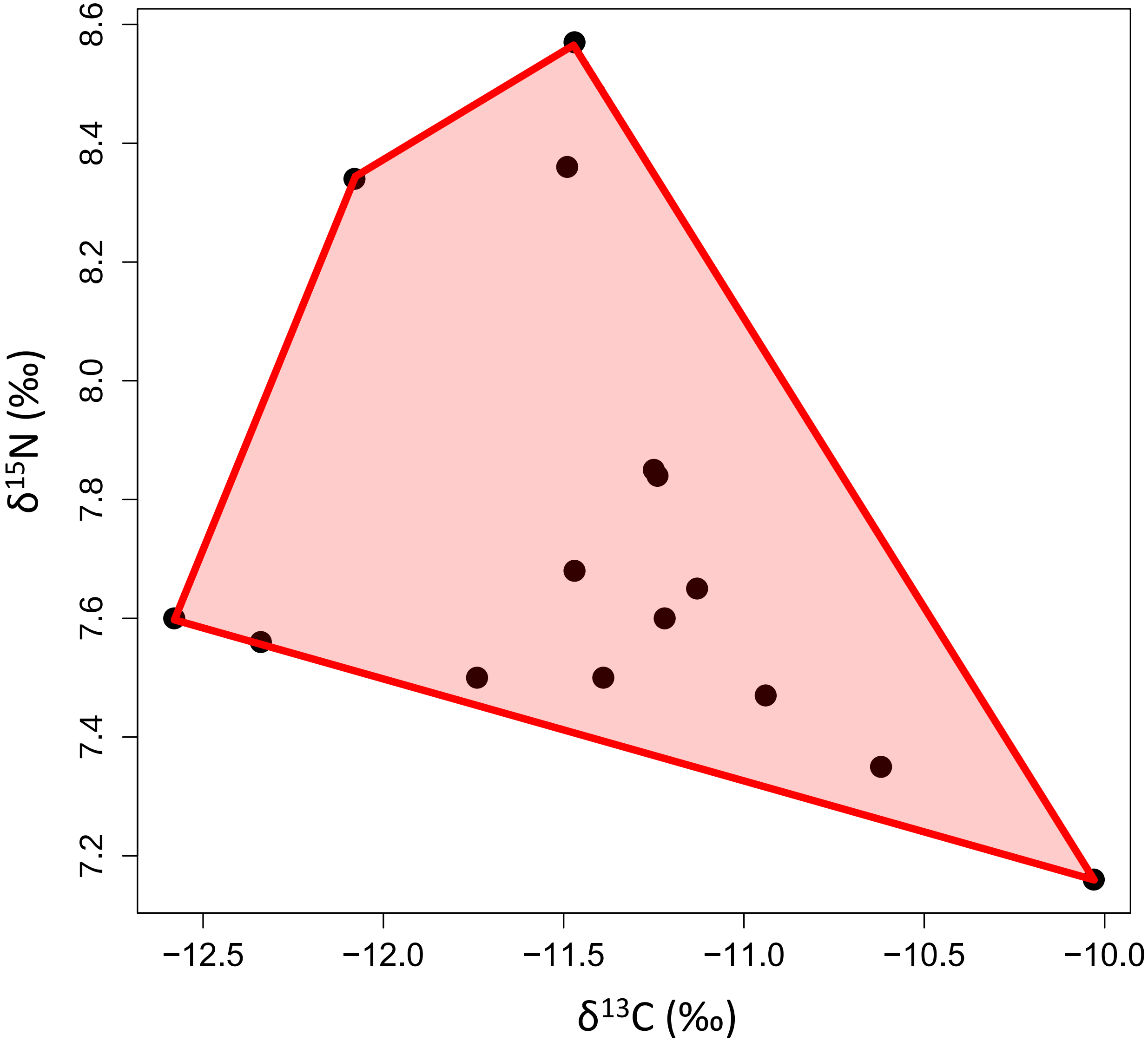
2) $\delta^{15}N$ range

Proxy of the vertical trophic structure of the community

Greater when consumers belong to more "trophic levels"

# Layman metrics

Set of descriptors based on convex hull

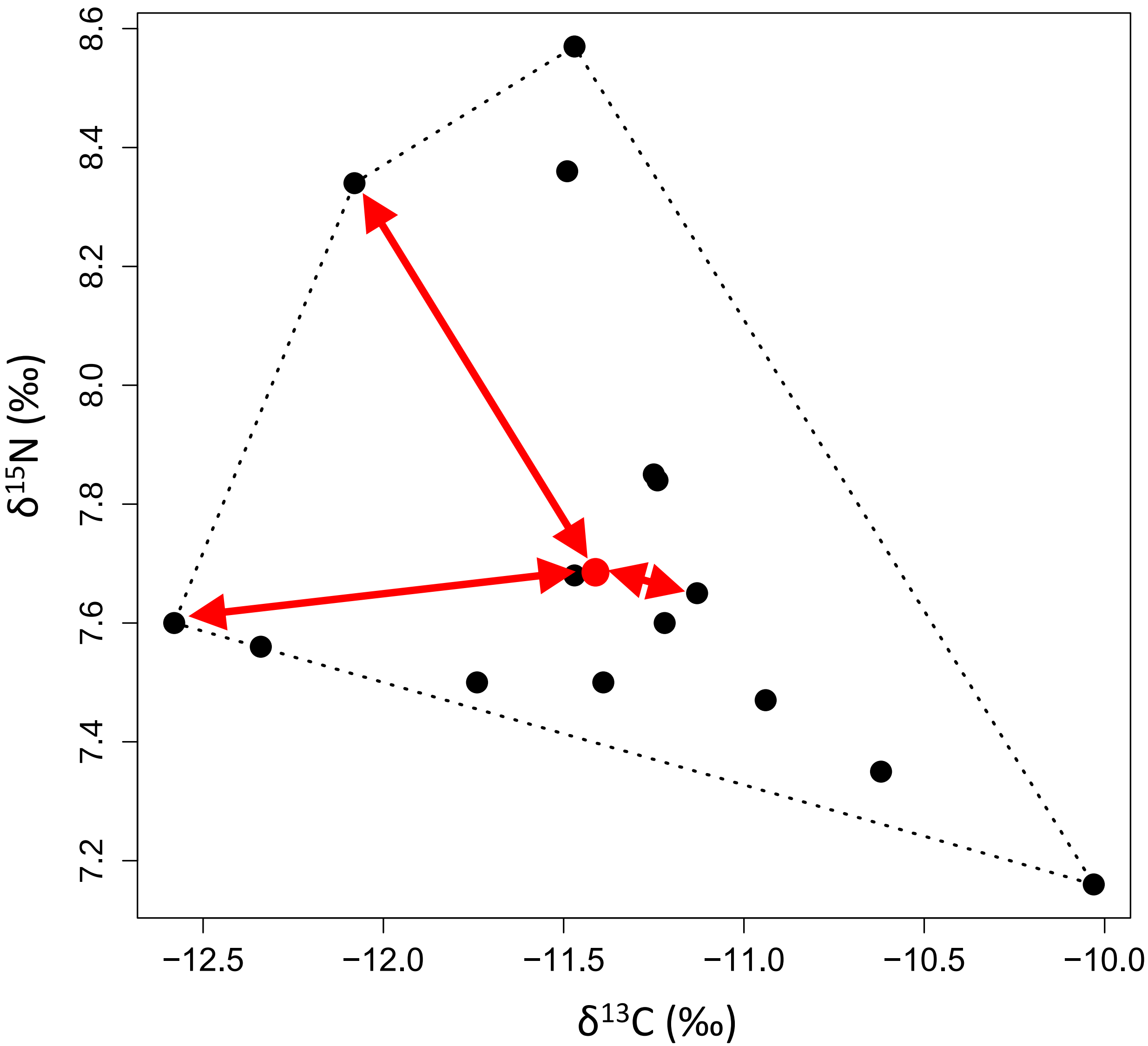



1) $\delta^{13}$C range
2) $\delta^{15}$N range
3) Total area of the convex hull

Proxy of the total diversity of resources used by the community

# Layman metrics

Set of descriptors based on convex hull



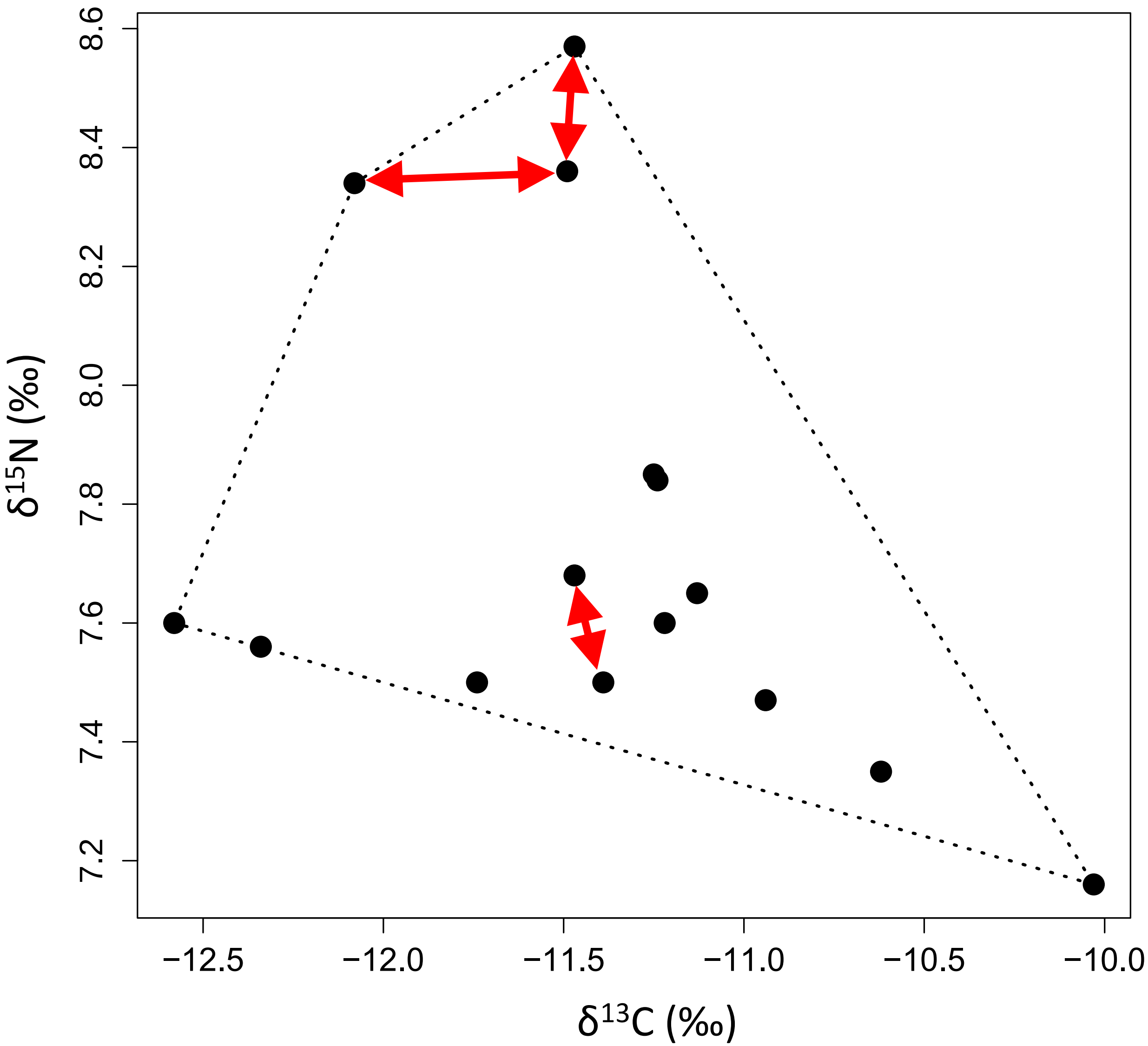

1) $\delta^{13}C$ range
2) $\delta^{15}N$ range
3) Total area of the convex hull
4) Mean distance to centroid

Averaged measure of ecological diversity among consumers

Greater when many consumers have "extreme" isotopic ratios, i.e. very specific ecological habits

# Layman metrics

Set of descriptors based on convex hull




1) $\delta^{13}$C range
2) $\delta^{15}$N range
3) Total area of the convex hull
4) Mean distance to centroid
5) Mean nearest neighbor distance

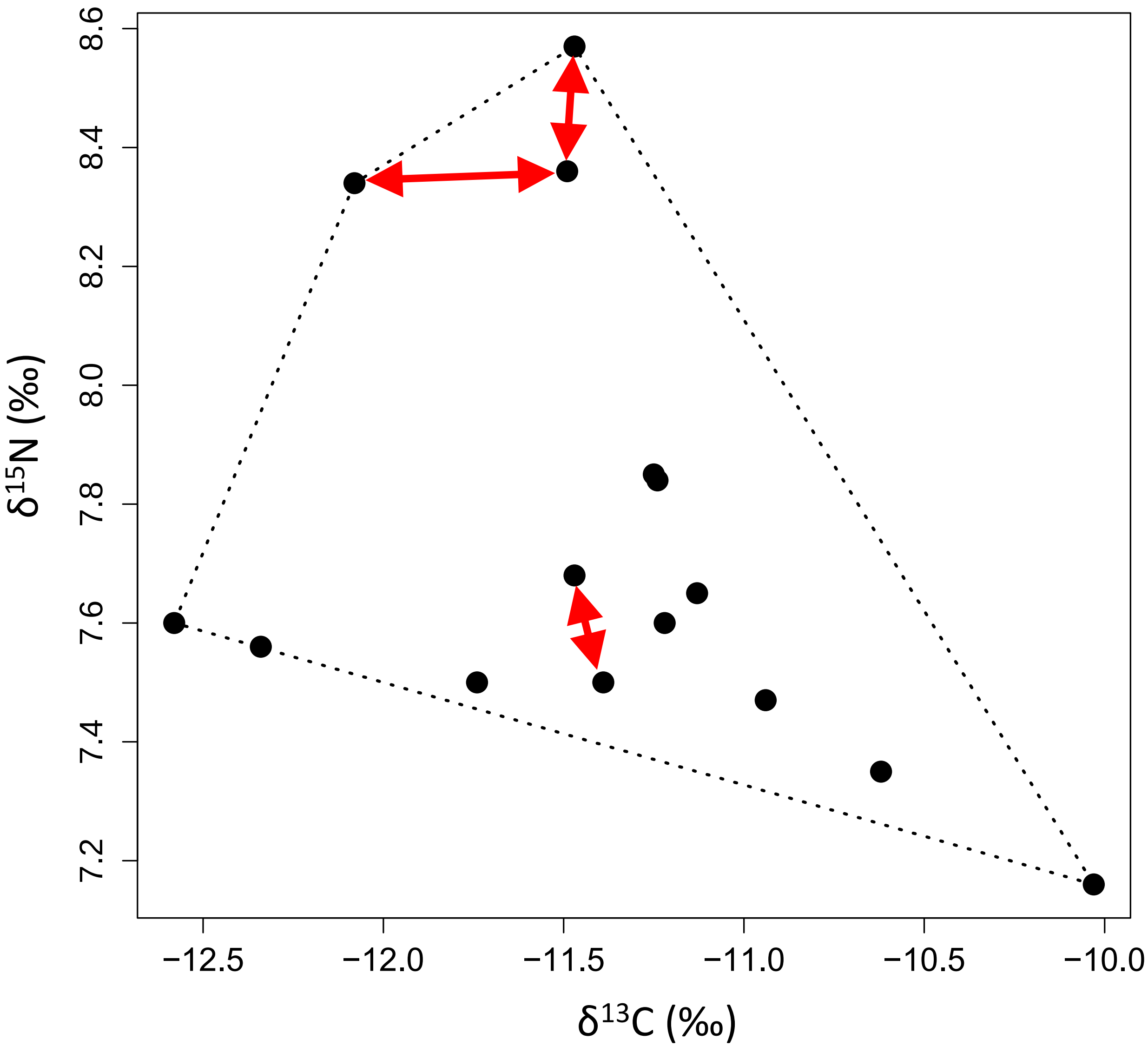
Overall density of point packing

High when consumers are more divergent in terms of ecological niche

Low when ecological habits of consumers are similar (ecological redundancy)

# Layman metrics

Set of descriptors based on convex hull



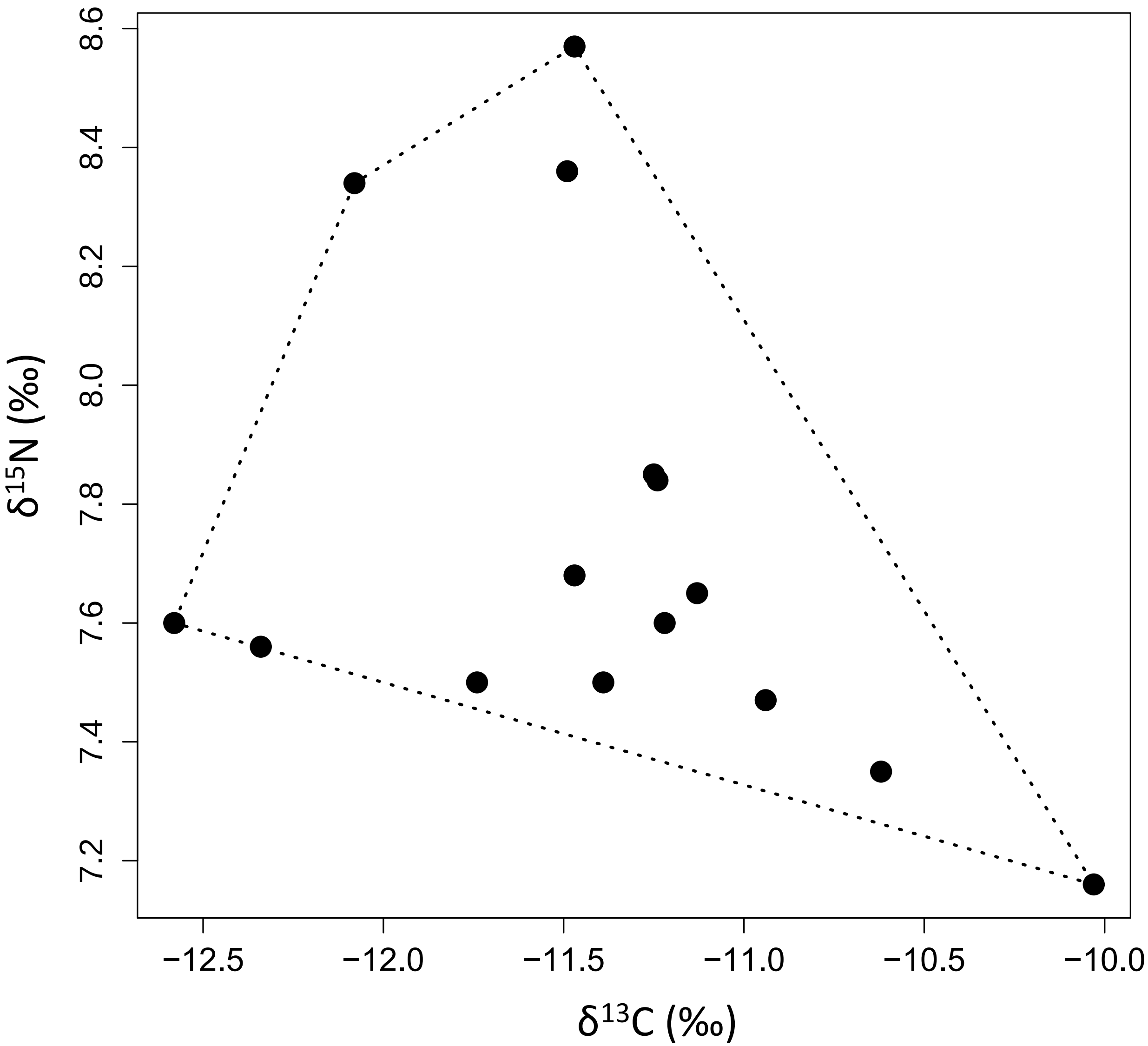

1) $\delta^{13}$C range
2) $\delta^{15}$N range
3) Total area of the convex hull
4) Mean distance to centroid
5) Mean nearest neighbor distance
6) Standard deviation of nearest neighbor distance

Measures how evenly ecological diversity is distributed among consumers

Low when space is evenly filled, high when "high density regions" are present

# Layman metrics

Set of descriptors based on convex hull




1) $\delta^{13}C$ range
2) $\delta^{15}N$ range
3) Total area of the convex hull
4) Mean distance to centroid
5) Mean nearest neighbor distance
6) Standard deviation of nearest neighbor distance

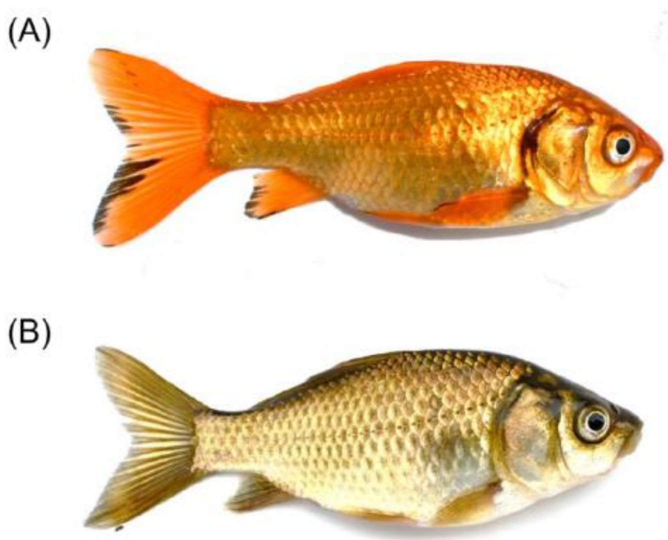
Comprehensive set of complementary (and partly redundant) tools that provide global information about the ecological niche

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

# Layman metrics: an example

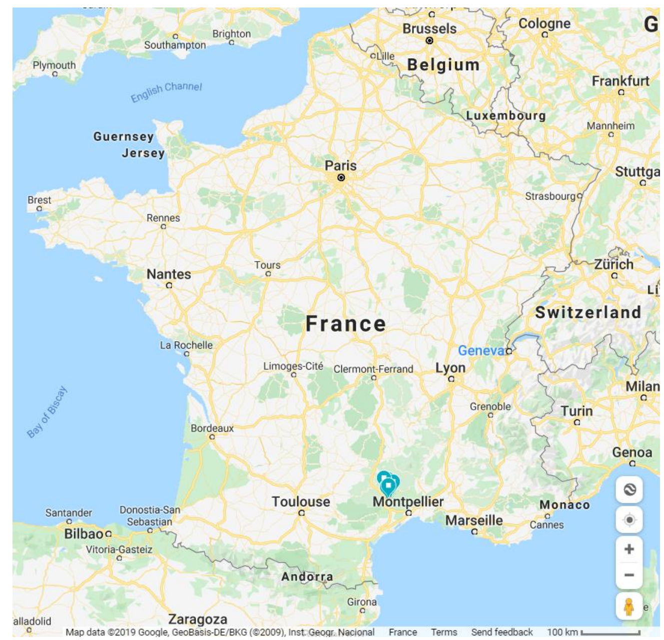

▲ *Lissotriton helveticus* (female / male)

*Carassius auratus* (ornamental / wild morphotypes) ▼



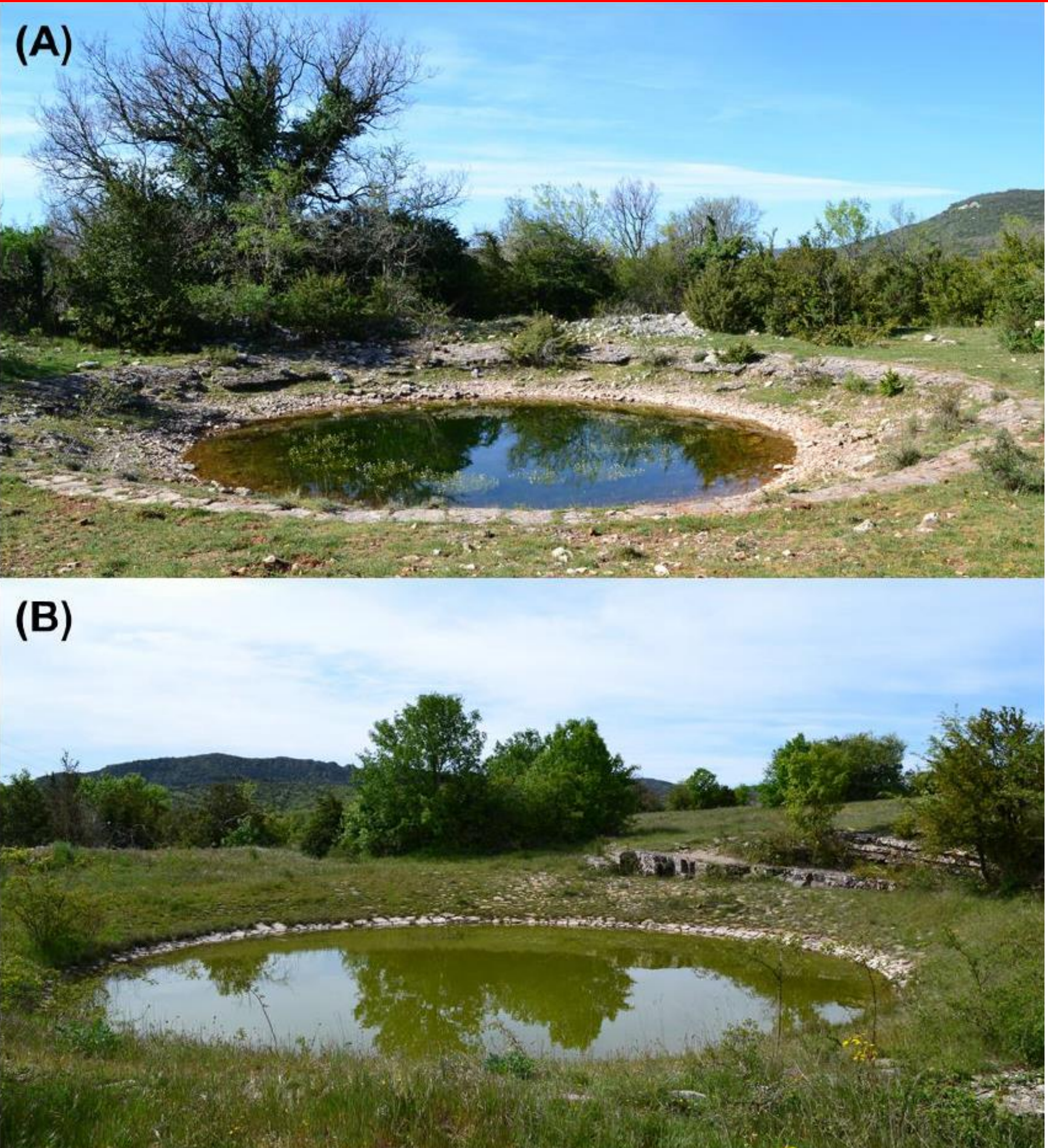

Benjamin LEJEUNE
PhD at ULiège

Ponds of the Larzac Plateau (Southern France): Traditionally dominated by palmate newts, but increasing presence of goldfish (invasive species)




Lejeune 2019 – http://hdl.handle.net/2268/234127
Lejeune *et al.*, In Prep.

# Layman metrics: an example




Human-mediated goldfish introduction cause newt exclusion

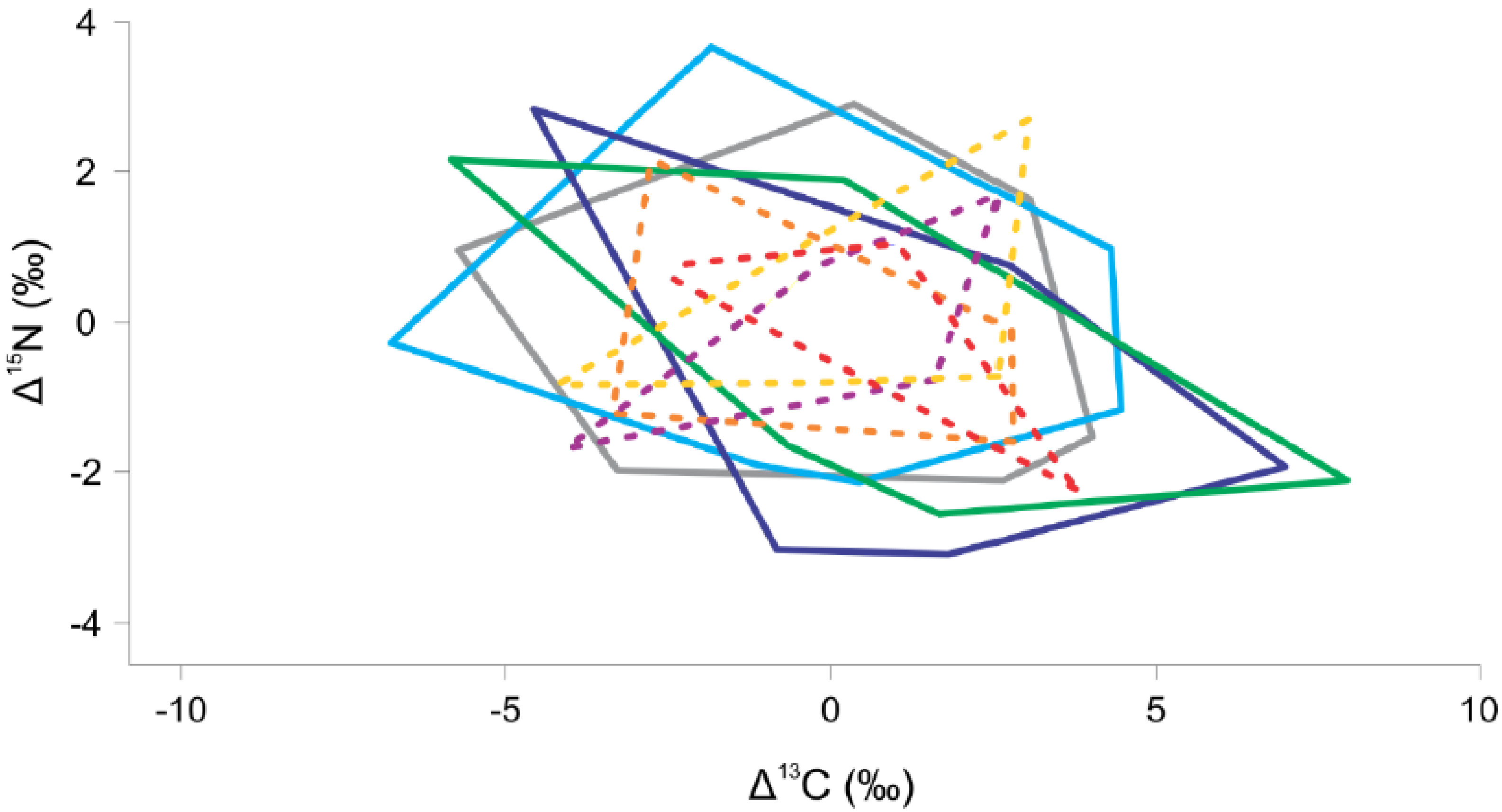
Mechanism not well understood…
Behavioural interference?
Predation on eggs/larvae?
Competition for food?

Ecosystem changes? (macrophyte depletion, phytoplankton blooms facilitation, turbidity increase)

How does goldfish introduction influence food web structure and ecological interactions?

Lejeune 2019 – http://hdl.handle.net/2268/234127
Lejeune *et al.*, In Prep.

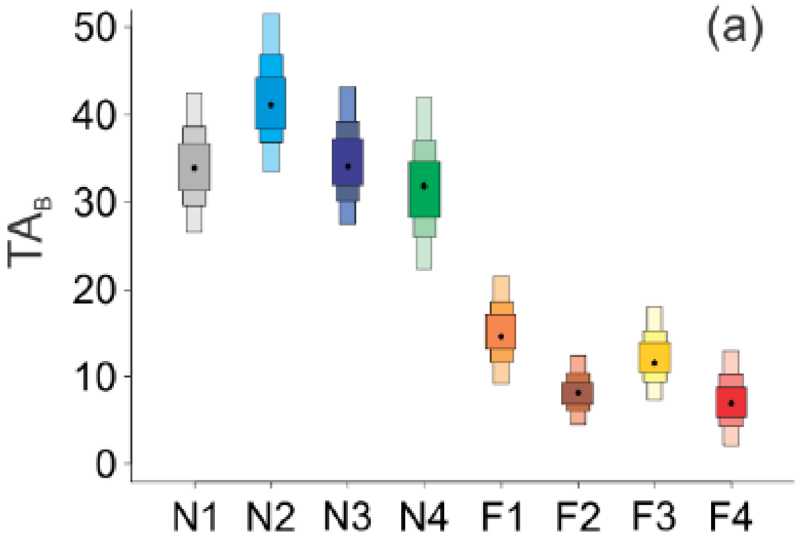
# Layman metrics: an example




Standardised convex hulls associated with each pond's consumers (built using species means, not taking into account newts or goldfish).
Solid lines: newt-dominated ponds.
Dashed lines: goldfish-dominated ponds

Lejeune 2019 – http://hdl.handle.net/2268/234127, Lejeune *et al.*, In Prep.

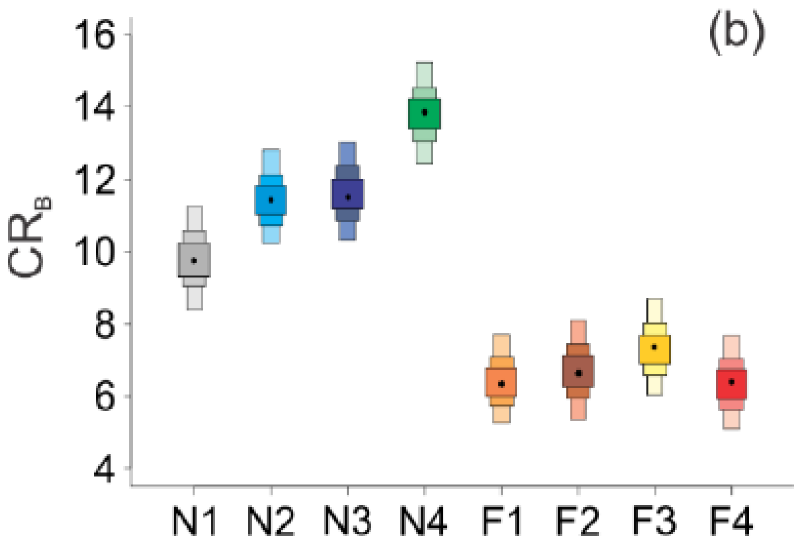
# Layman metrics: an example




Lower total area of the convex hull in invaded ponds: lower overall diversity in resources used by the community

Lejeune 2019 – http://hdl.handle.net/2268/234127, Lejeune *et al.*, In Prep.

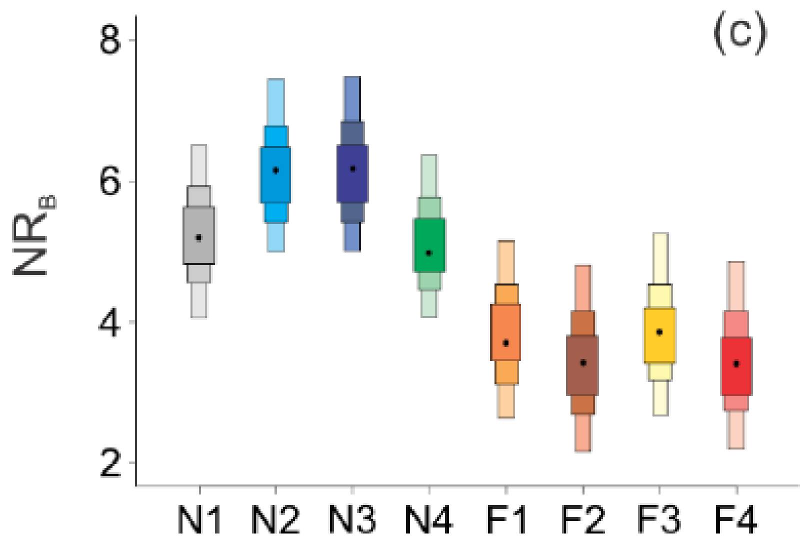
# Layman metrics: an example




Lower $\delta^{13}C$ range in invaded ponds: consumers depend on less basal resources (primary producers, organic matter pools) and/or exploit less feeding habitats

Lejeune 2019 – http://hdl.handle.net/2268/234127, Lejeune *et al.*, In Prep.

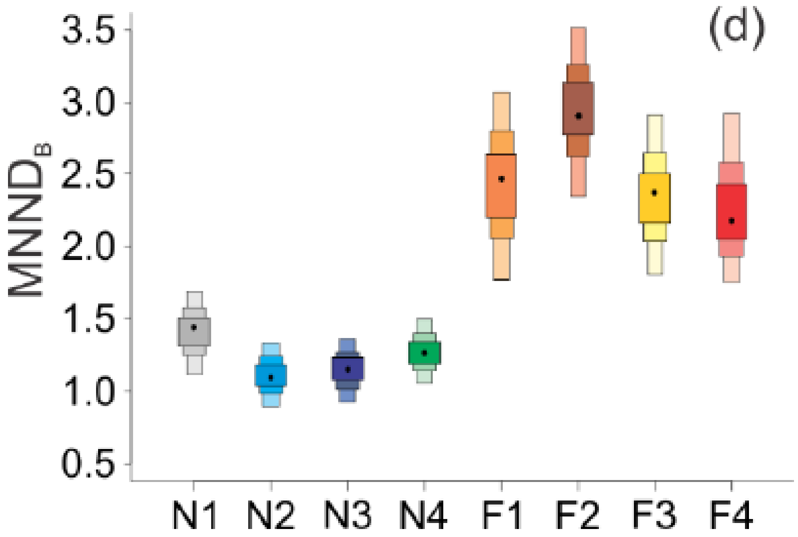
# Layman metrics: an example




Lower δ$^{15}$N range in invaded ponds: consumers belong to less different trophic levels, food chain length is lower

Lejeune 2019 – http://hdl.handle.net/2268/234127, Lejeune *et al.*, In Prep.

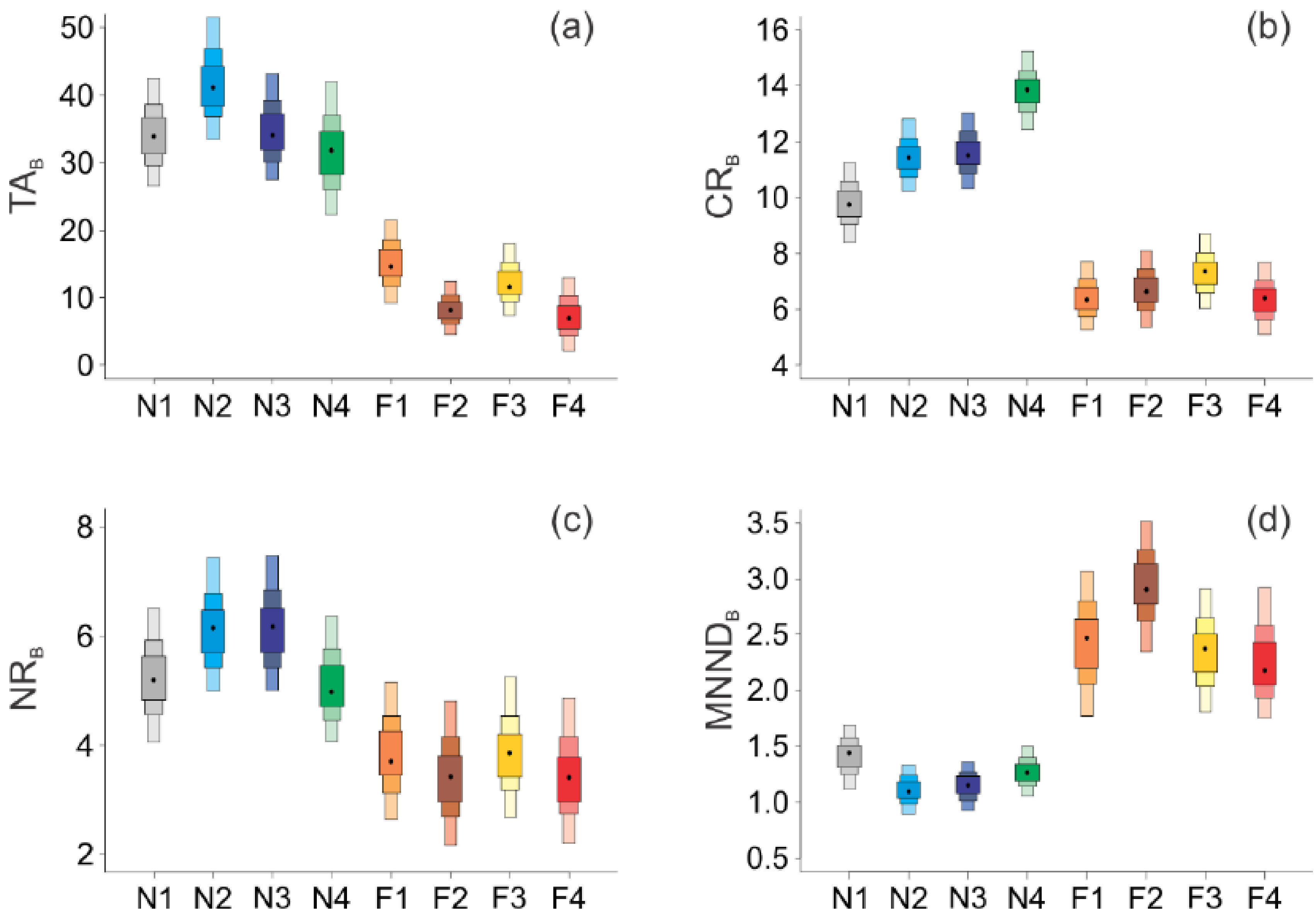
# Layman metrics: an example




Higher mean distance to nearest neighbour in invaded ponds: consumers are more divergent in their ecological habits, lower trophic / ecological redundancy

Lejeune 2019 – http://hdl.handle.net/2268/234127, Lejeune *et al.*, In Prep.

# Layman metrics: an example

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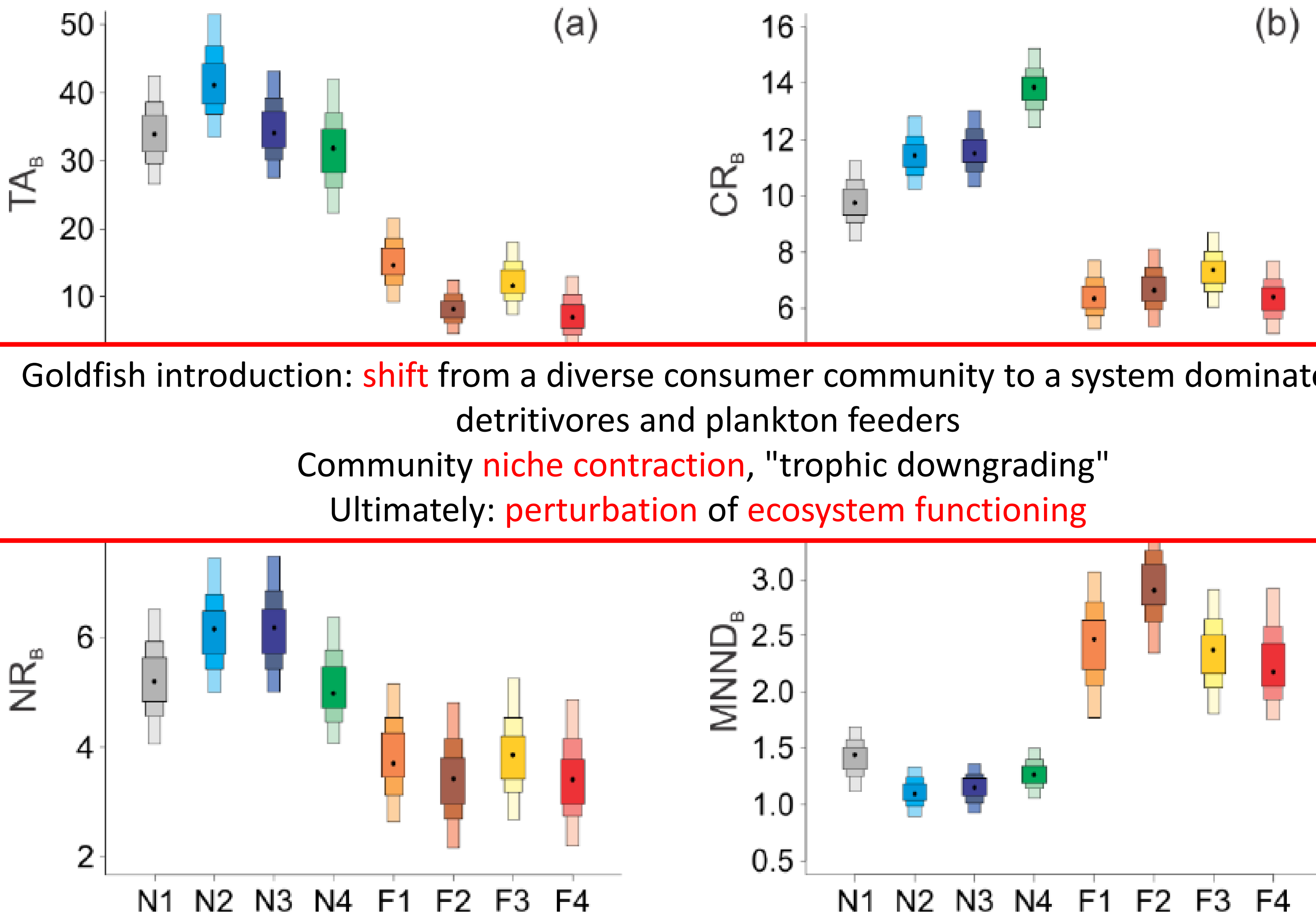


Goldfish introduction: shift from a diverse consumer community to a system dominated by detritivores and plankton feeders

Community niche contraction, "trophic downgrading"

Ultimately: perturbation of ecosystem functioning

Lejeune 2019 – http://hdl.handle.net/2268/234127, Lejeune *et al.*, In Prep.

# Other hull-based metrics

Ecological Indicators 56 (2015) 152–160

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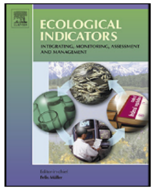
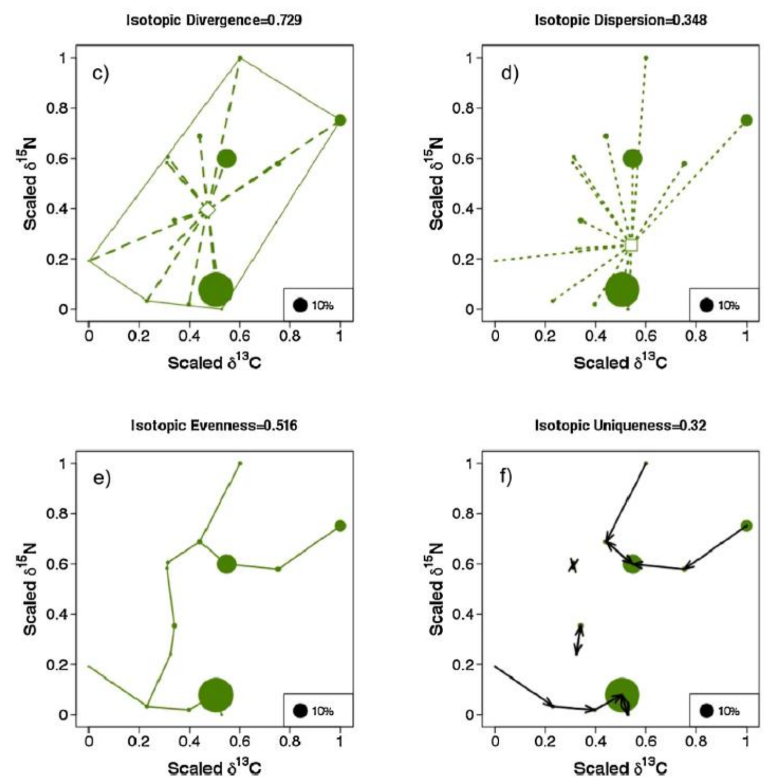


Quantifying the multiple facets of isotopic diversity: New metrics for stable isotope ecology

Julien Cucherousset[a,*], Sébastien Villéger[b]

## Isotopic diversity indices

Computed differently, but conceptually similar to Layman metrics



# Other hull-based metrics

| Layman metrics | Isotopic diversity indices |
|---|---|
| Total area of the convex hull | Isotopic richness |
| Mean distance to centroid | Isotopic dispersion |
| Mean nearest neighbor distance | Isotopic divergence, Isotopic uniqueness |
| Standard deviation of nearest neighbor distance | Isotopic evenness |
| Hull overlap | Isotopic similarity, isotopic nestedness |

# Other hull-based metrics

Ecological Indicators 56 (2015) 152–160

Contents lists available at ScienceDirect

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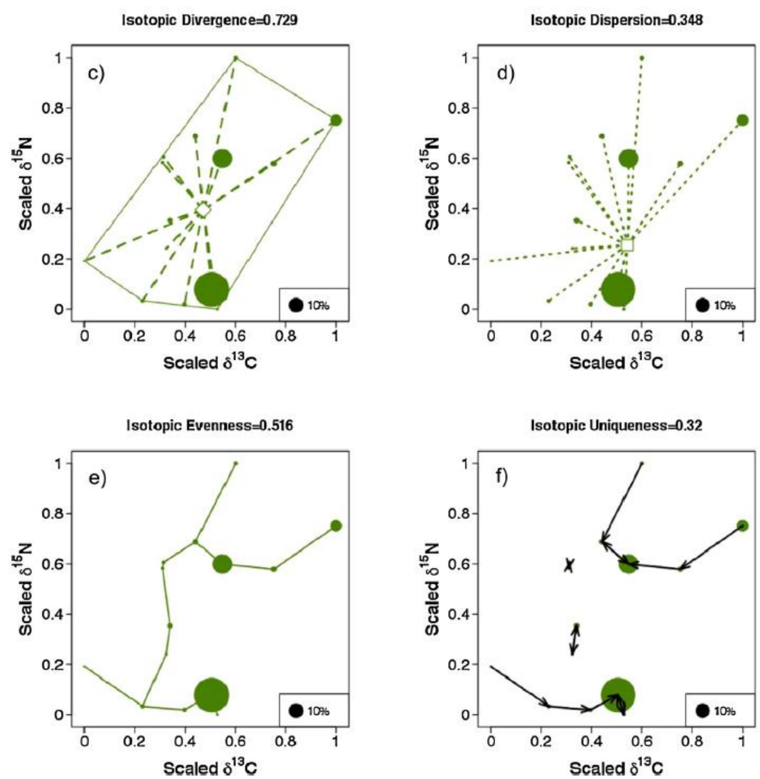
## Isotopic diversity indices

Computed differently, but conceptually similar to Layman metrics

Can be applied to more than 2 dimensions and take biomass/abundance into account



# Isotopic diversity indices: an example



- Oyster reefs: important constitutents of estuarine systems worldwide
- Promote species diversity and food web complexity through habitat provision: refuge from predators, limitation of competition
- Up to 90% lost due to anthropogenic activities: restoration efforts

Mar Biol (2017) 164:54
DOI 10.1007/s00227-017-3084-2

ORIGINAL PAPER

**How does a restored oyster reef develop? An assessment based on stable isotopes and community metrics**

Ryan J. Rezek[1] · Benoit Lebreton[2] · E. Brendan Roark[3] · Terence A. Palmer[1] · Jennifer Beseres Pollack[1]

# Isotopic diversity indices: an example



Can restored reefs harbour an ecological diversity similar to the natural ones? How long would that diversity take to establish itself?

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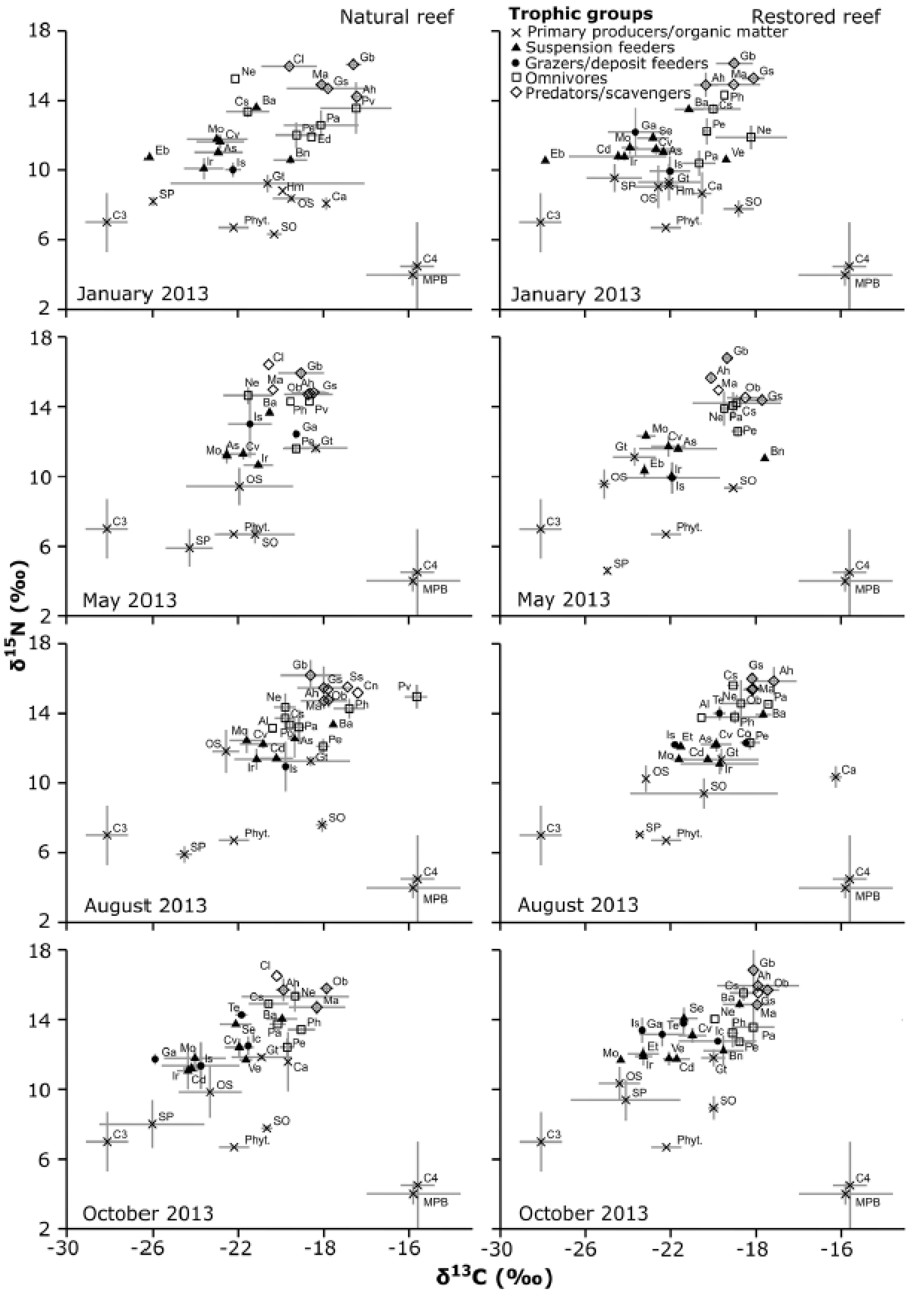
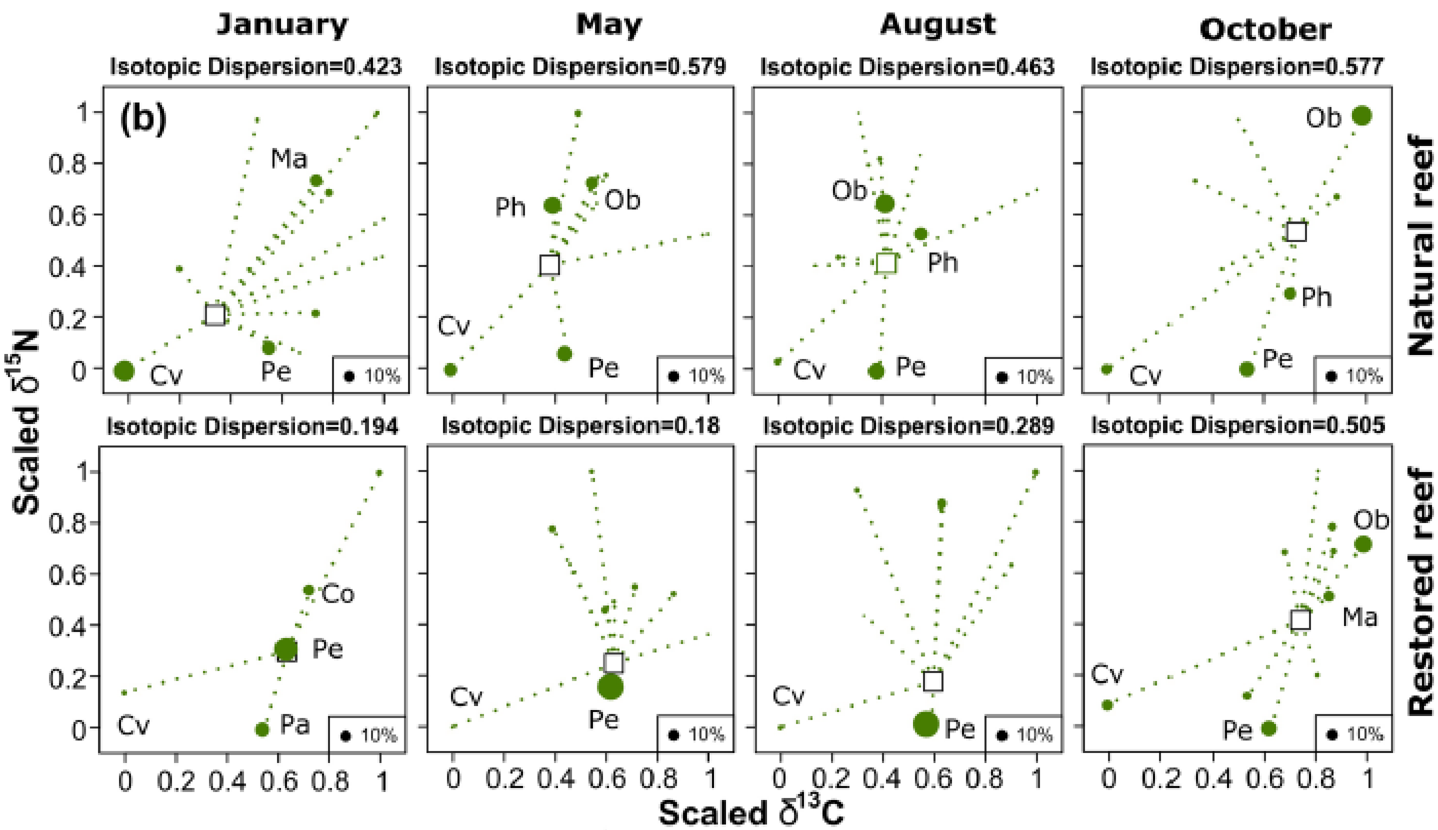



Sampling of consumers at 5, 9, 12 and 15 months post-restoration

Computation of biomass-weighted isotopic diversity indices

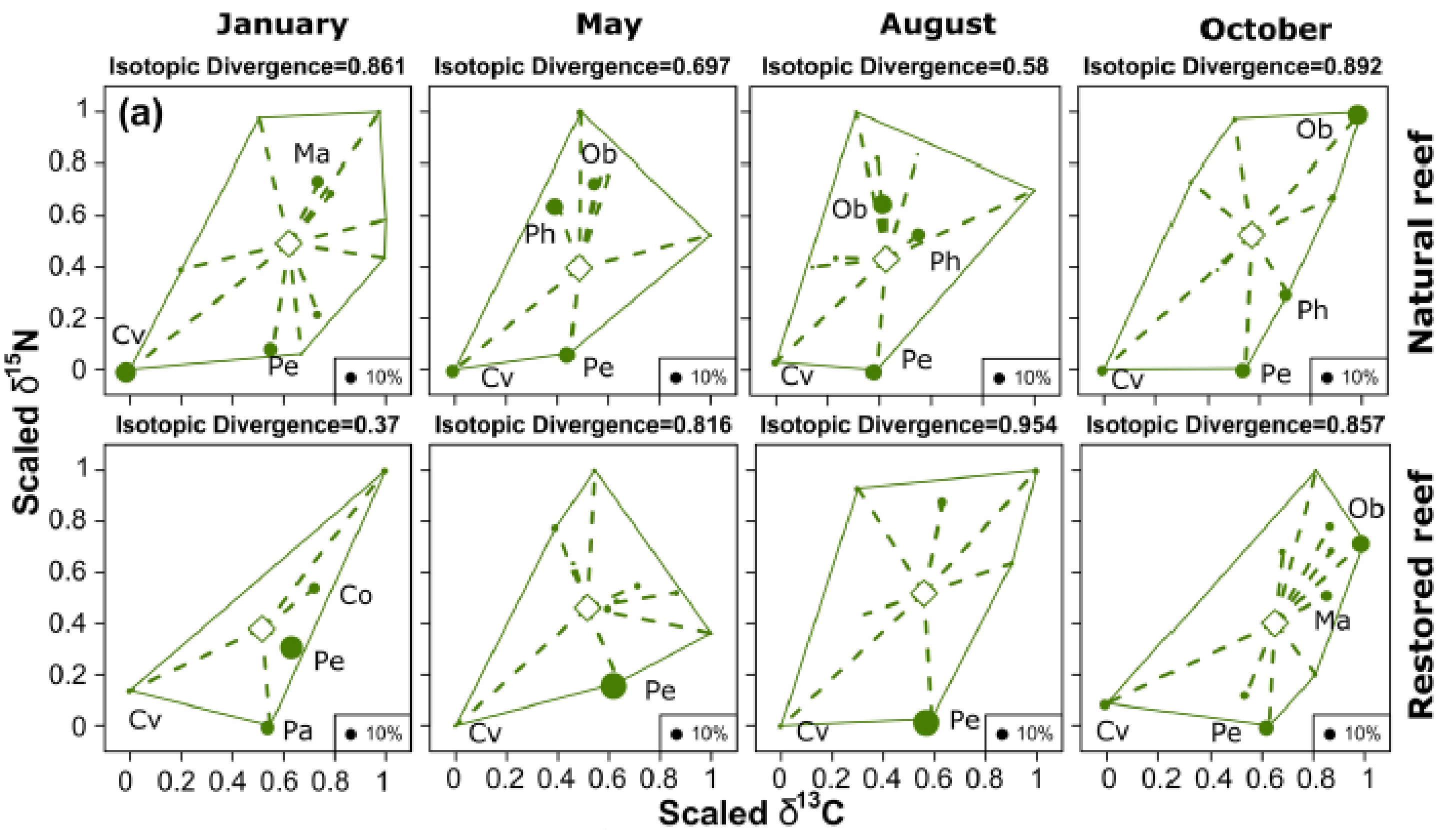
Rezek *et al.* (2017) Mar. Biol. 164:54

# Isotopic diversity indices: an example




After 15 months: isotopic dispersion (i.e. the importance of species with "extreme" ecological habits) similar in natural and restored reefs.

# Isotopic diversity indices: an example




After 15 months: isotopic divergence (i.e. the degree of contrast between ecological habits of the consumers) similar in natural and restored reefs.

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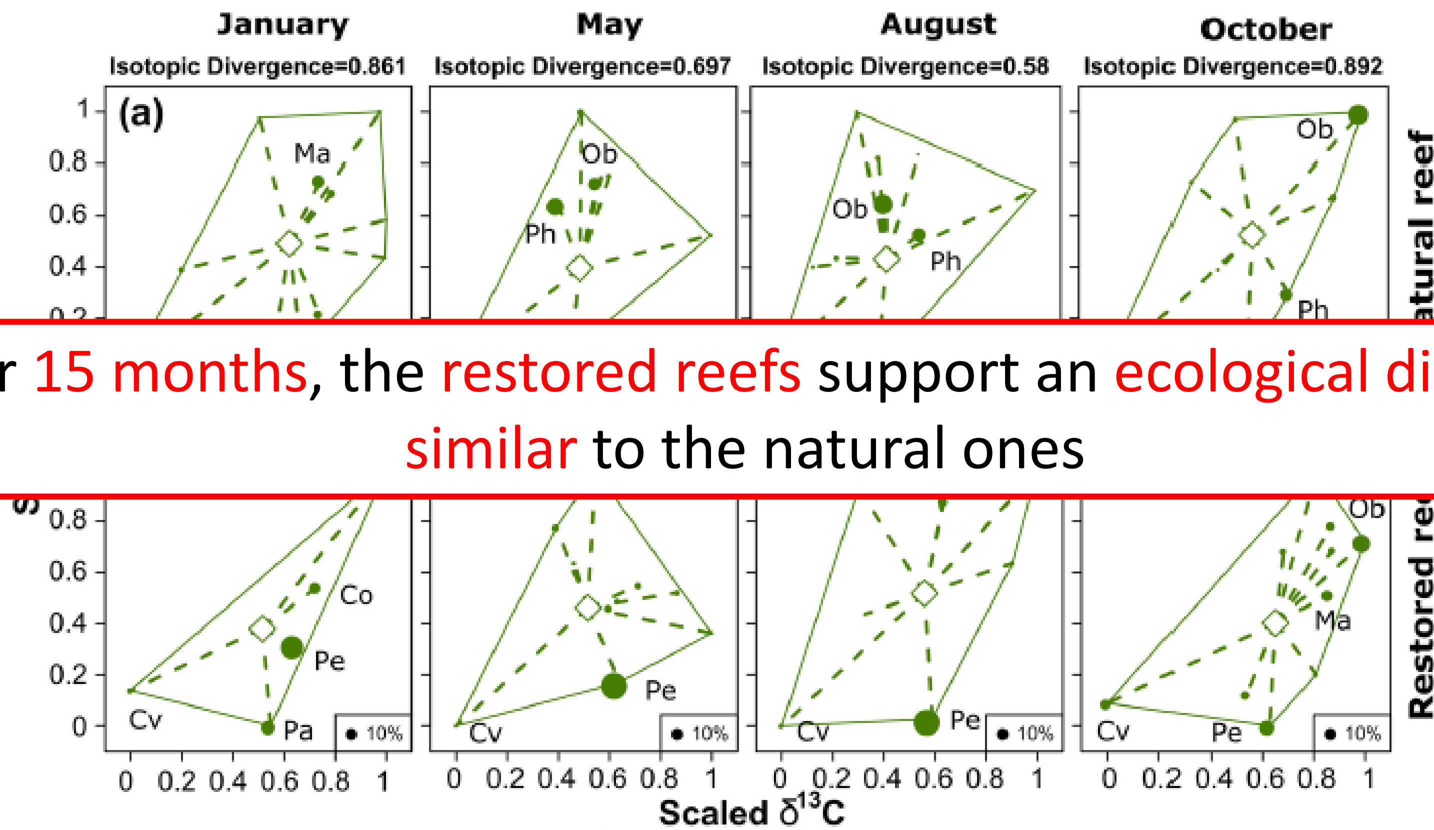
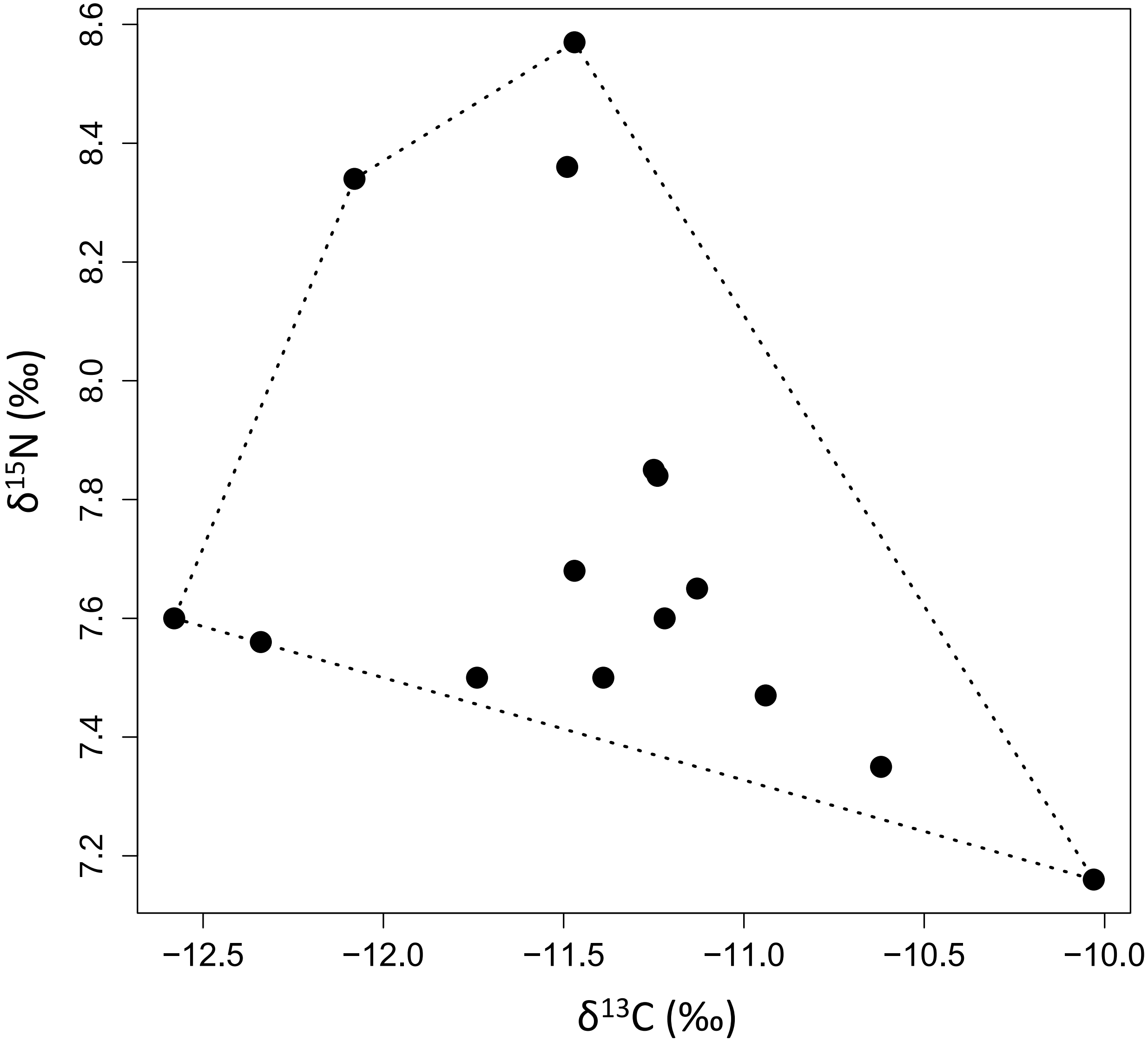



After 15 months, the restored reefs support an ecological diversity similar to the natural ones

After 15 months: isotopic divergence (i.e. the degree of contrast between ecological habits of the consumers) similar in natural and restored reefs.

# Ecological niche study: how?

Some hull-based metrics are highly sensitive to small sample size and to the presence of extreme points




According to your research question, it can be a good or a bad thing…

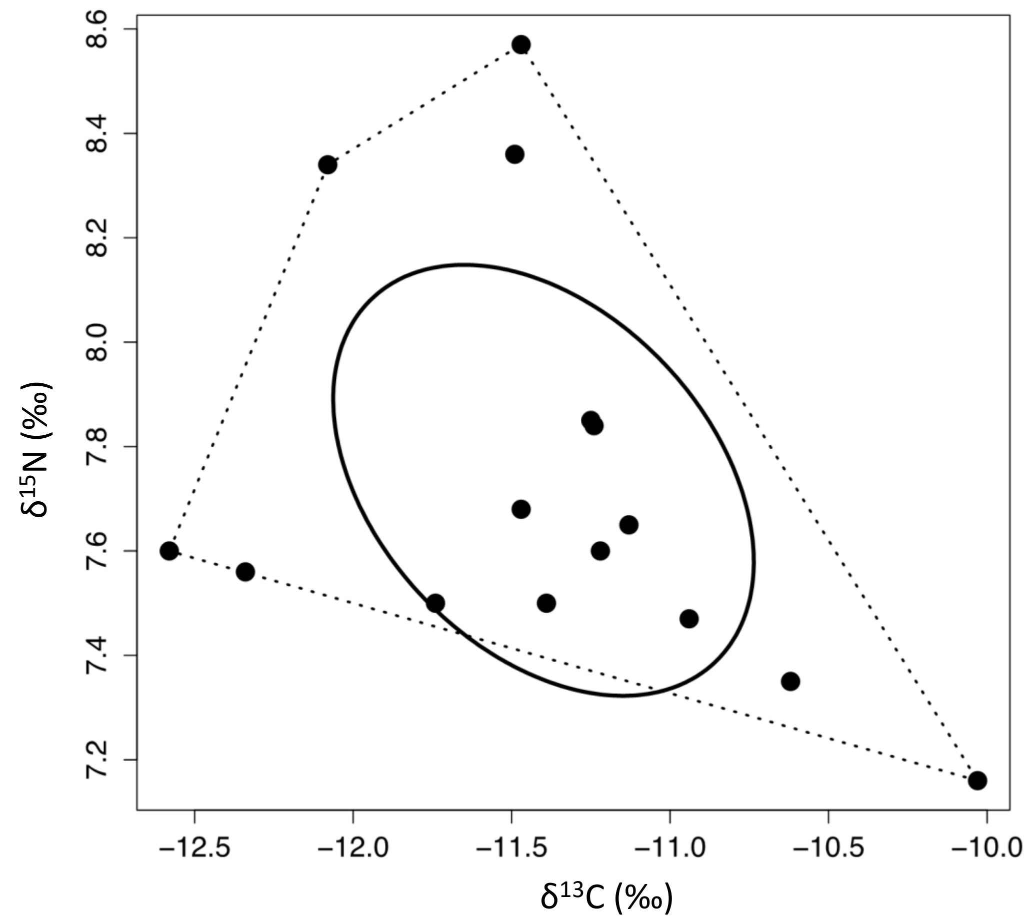
# δ-space plots and standard ellipses

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

Represents "core isotopic niche" of the group of consumers

Main metric: standard ellipse area (SEA)

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**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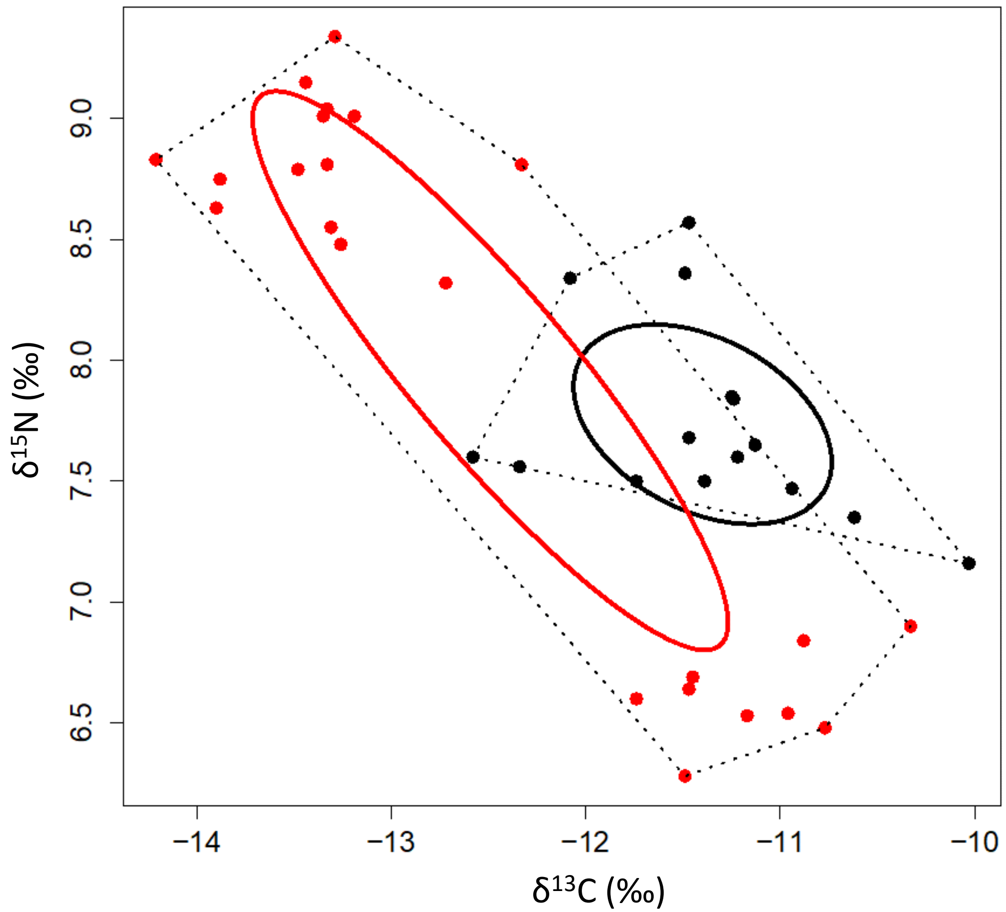
# δ-space plots and standard ellipses

Comparisons of groups





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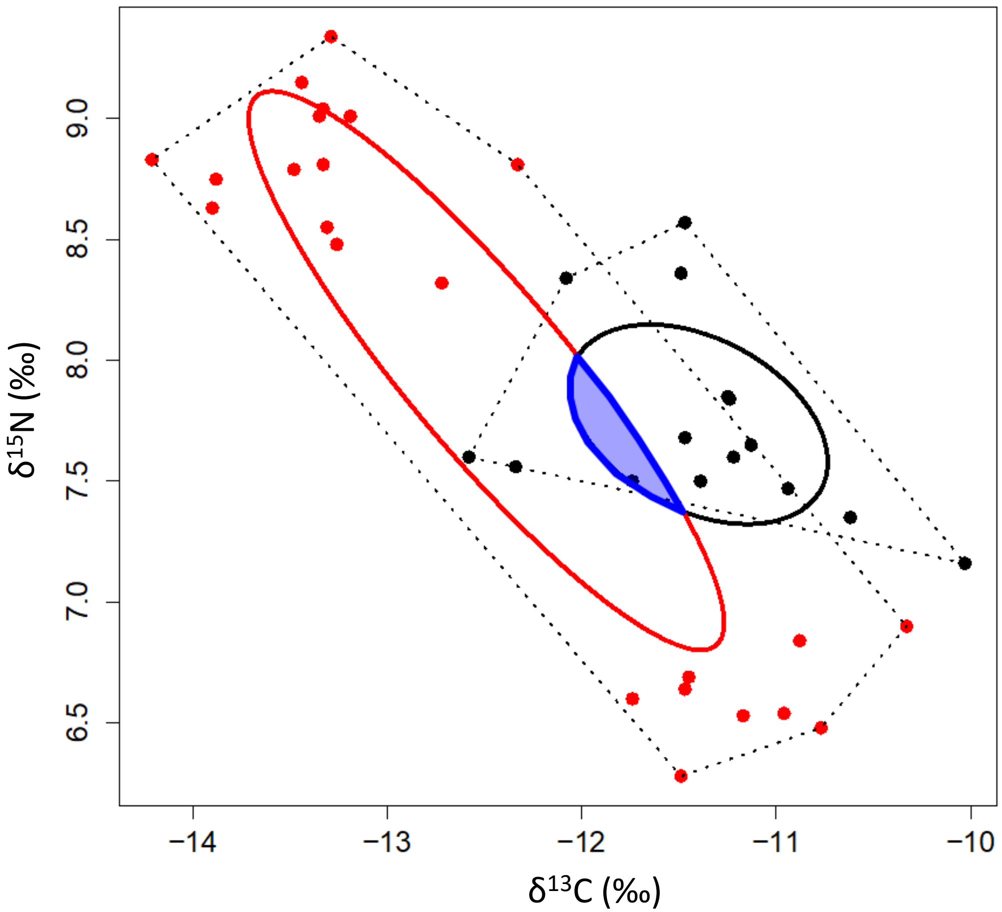


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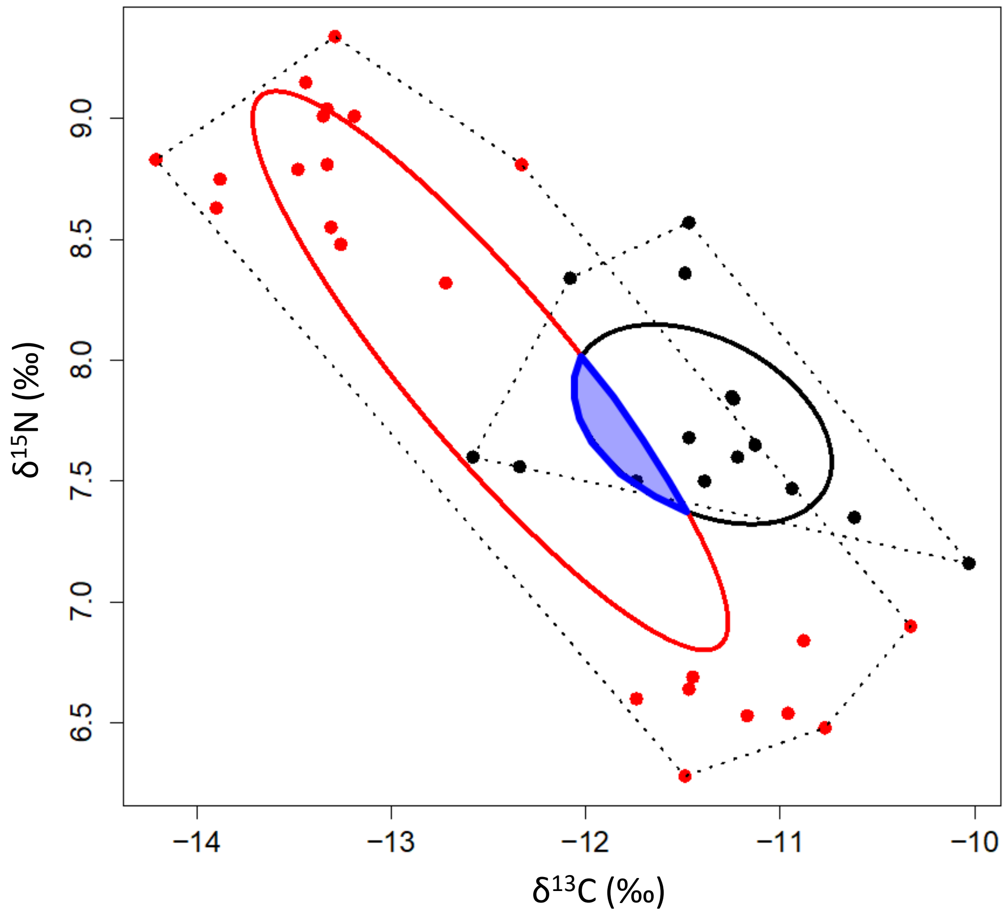
Ellipses and convex hulls can be complementary





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

MARINE ECOLOGY PROGRESS SERIES
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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]

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

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


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Negative impact on prey populations

Competition with native predators? Trophic niche overlap?

Schoolmaster snapper (*Lutjanus apodus*)

Grey snapper (*Lutjanus griseus*)

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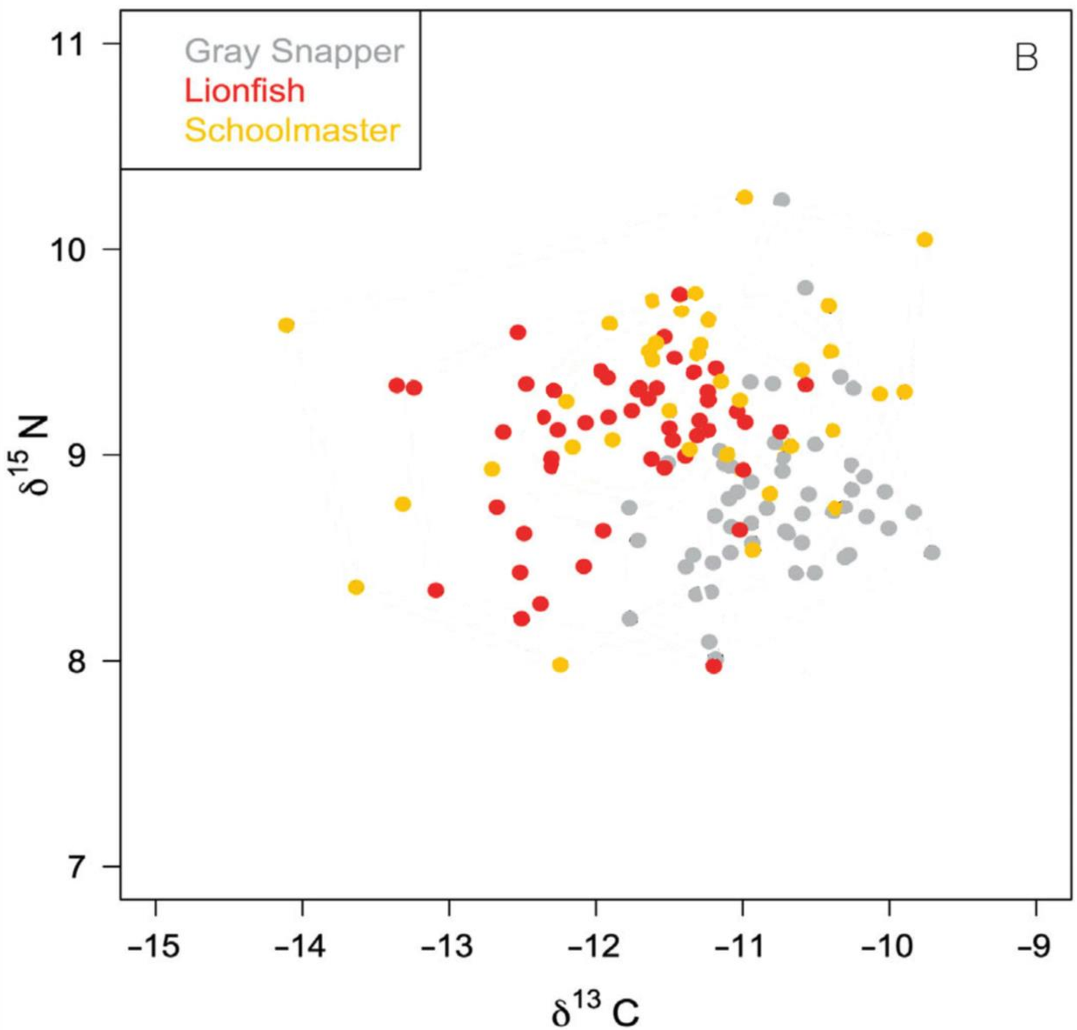

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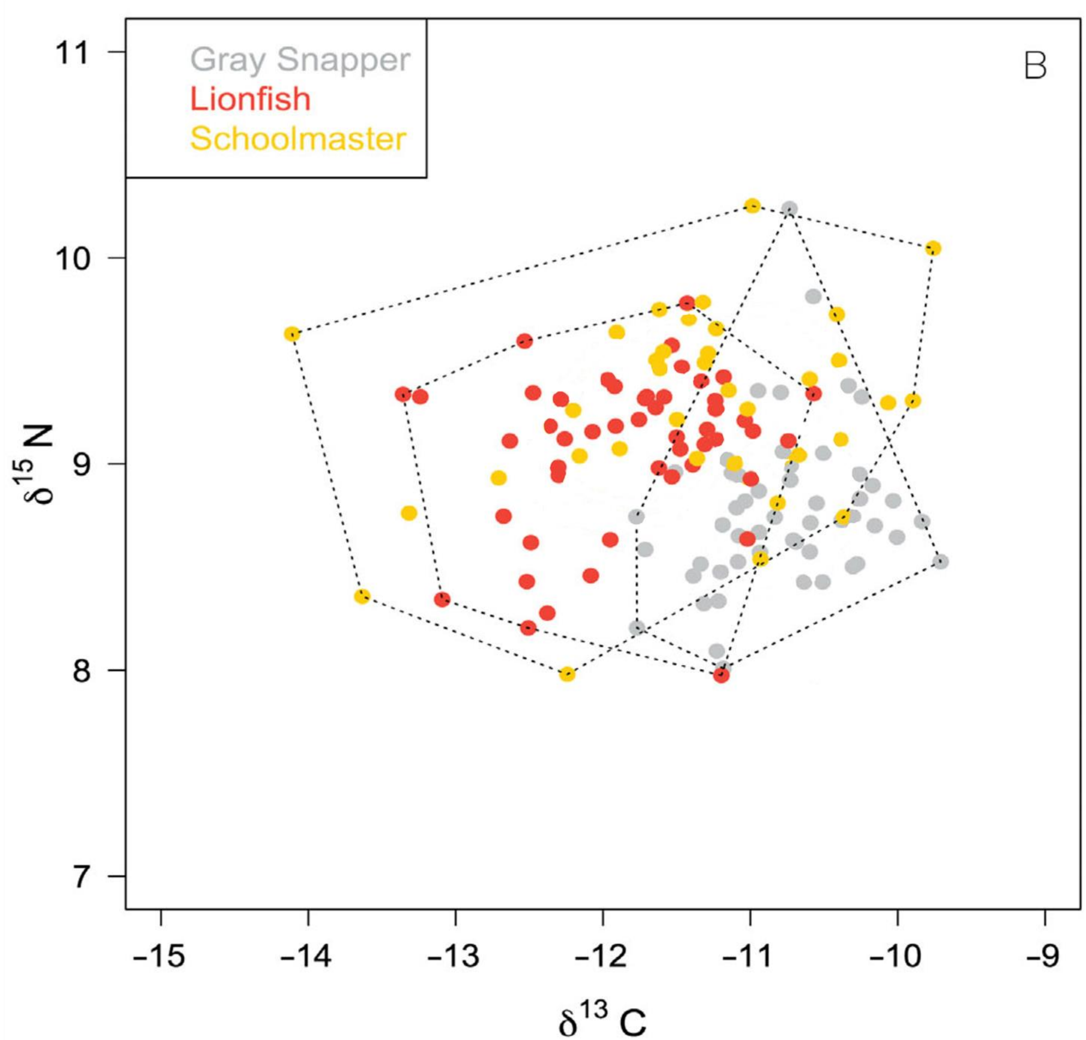

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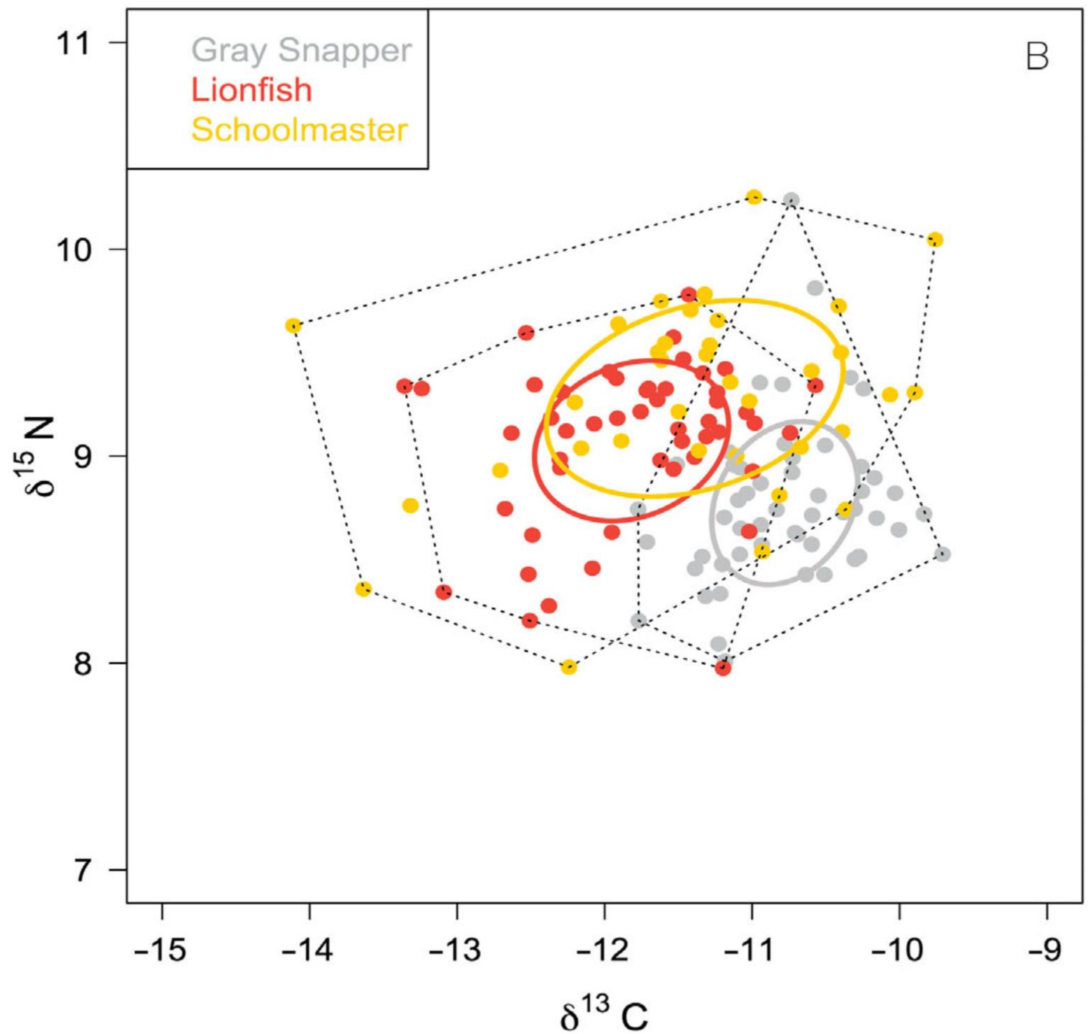

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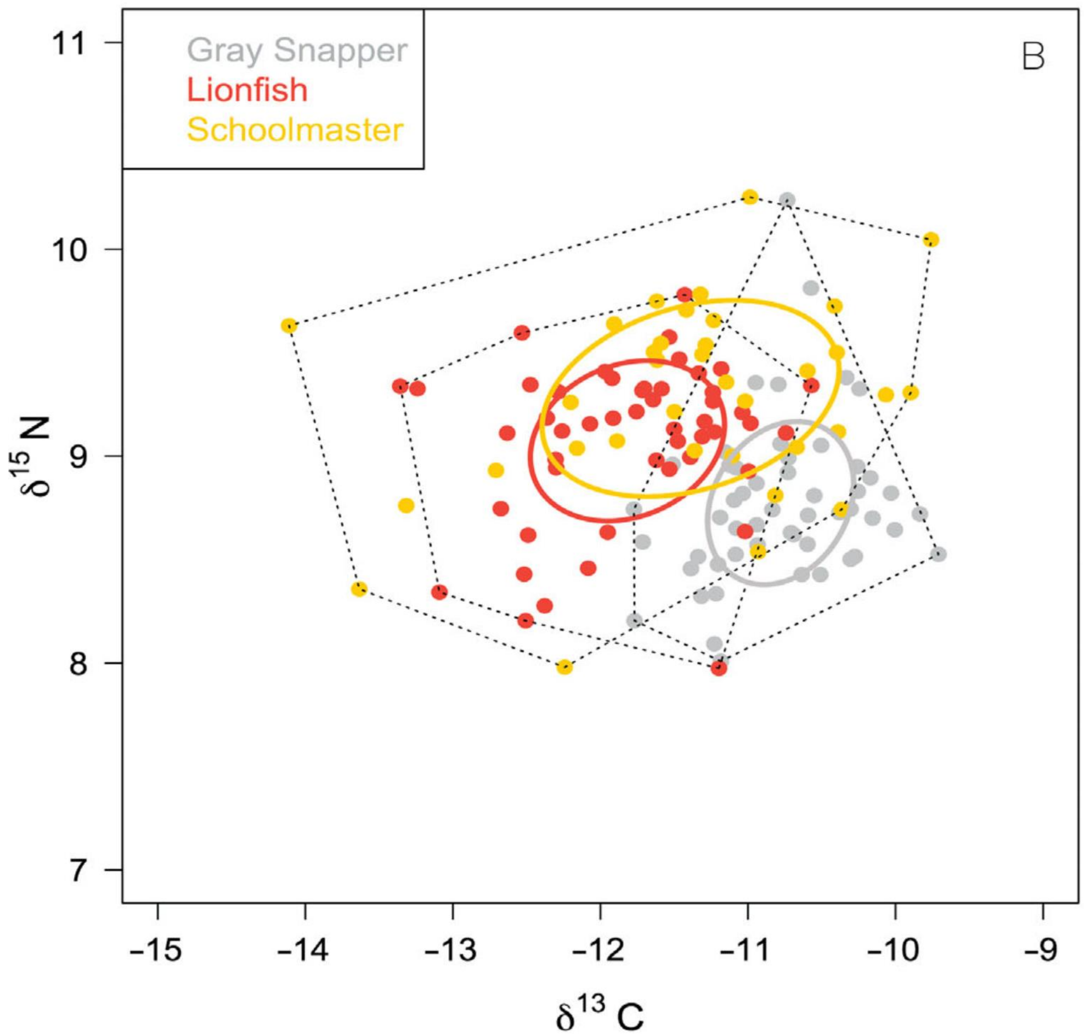
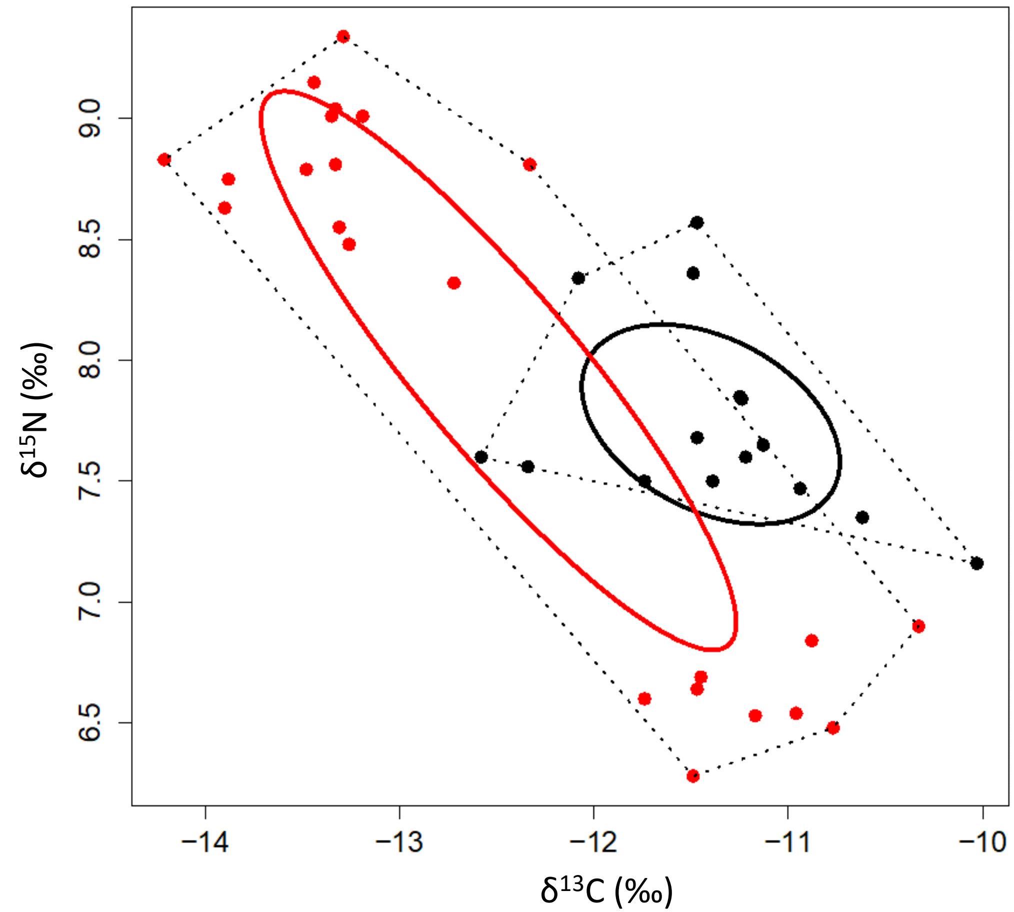
Supported by gut contents: grey snappers ingest more benthic crustaceans



# δ-space plots and standard ellipses

Instead of calculating SEA from covariance matrix: estimation using bayesian inference

More robust + takes uncertainty into account





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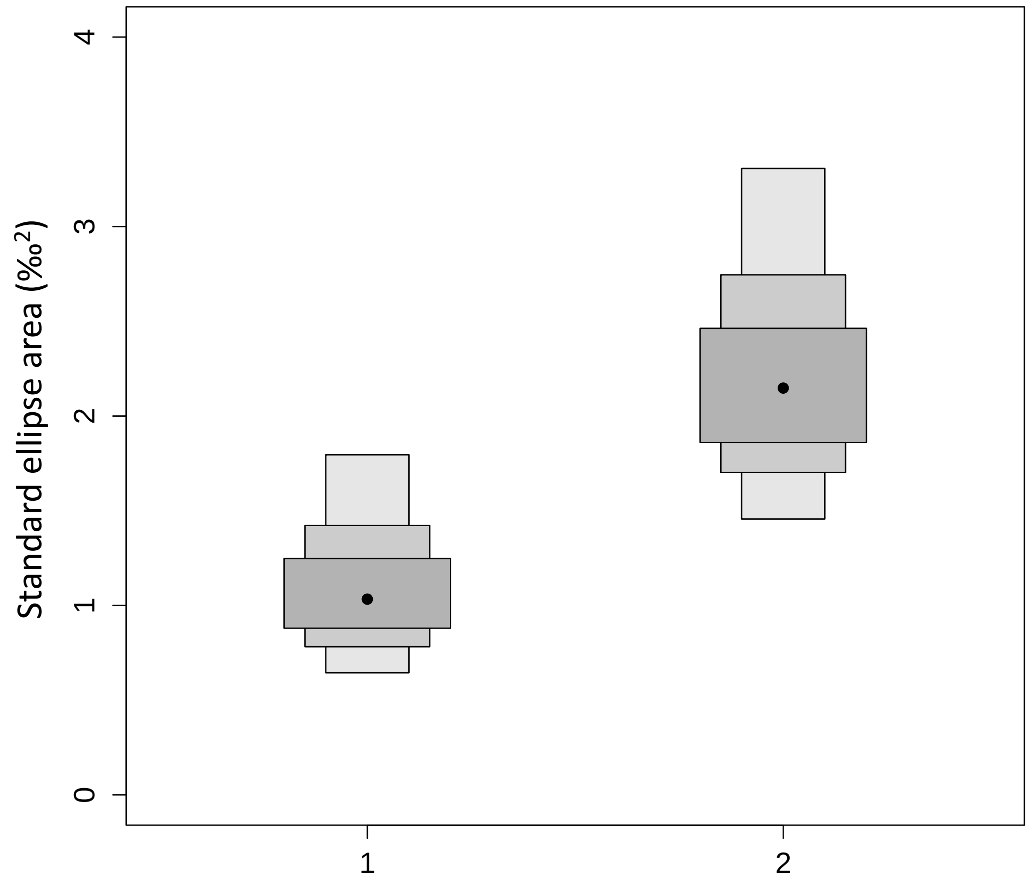
Outputs: frequency distribution of model solutions

Statistical comparisons of SEA across groups





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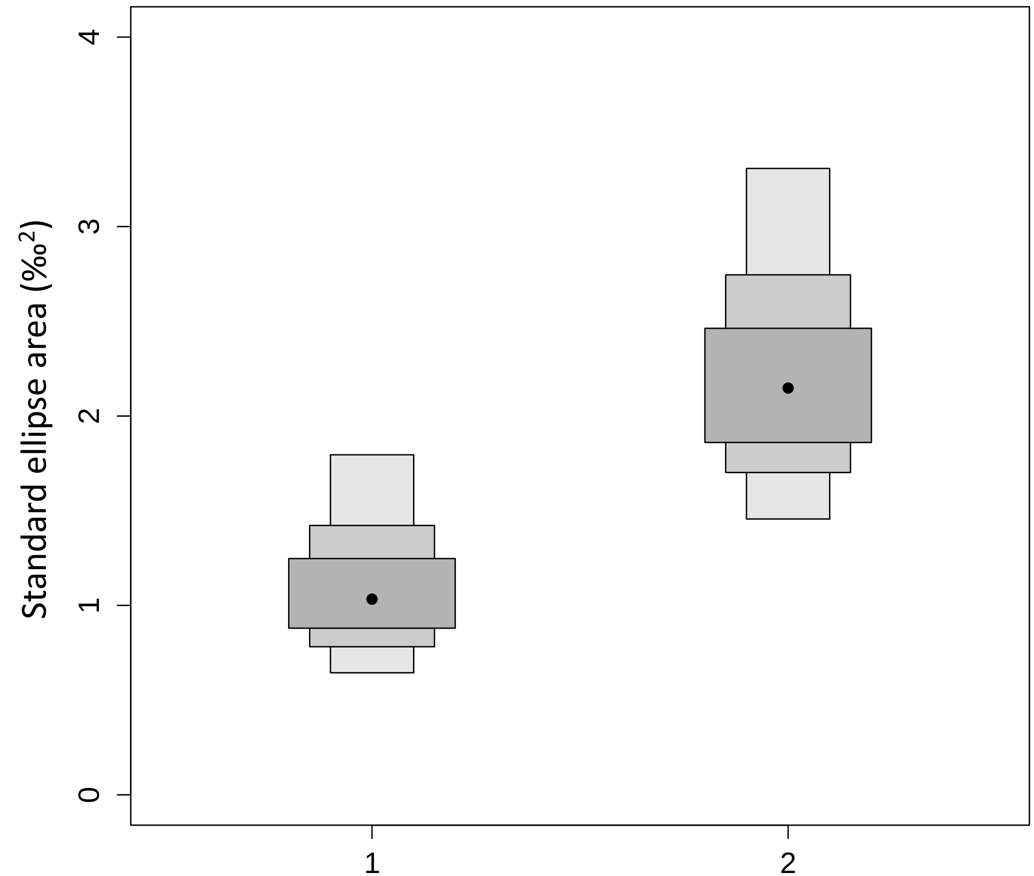


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$10^6$ solutions

$SEA_1 < SEA_2$ in 98.14 %

P-value analogy

# Example: Iphimediidae amphipods

Marie VERHEYE
PhD at UCLouvain / RBINS
Now postdoc at ULiège


Iphimediidae in the Southern Ocean: widely distributed and common family with high ecological diversity


How do environmental parameters influence their ecological features? How will they react to current and future environmental changes?

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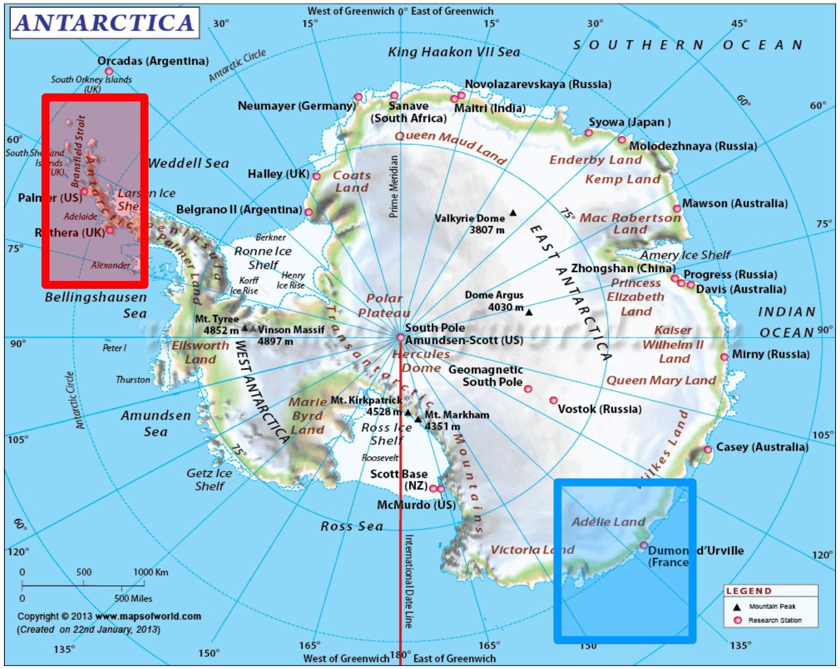
In the framework of vERSO and RECTO BELSPO projects: comparison between West Antarctic Peninsula (rapid warming + sea ice loss) and Adélie Land (moderate changes in water temperature and sea ice cover)



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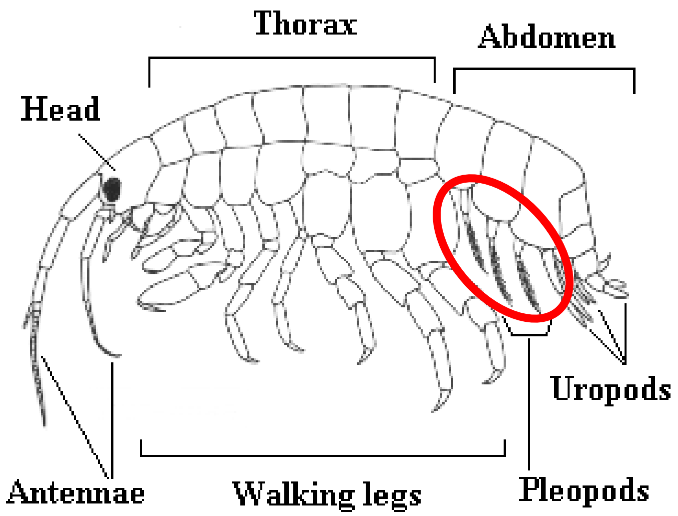
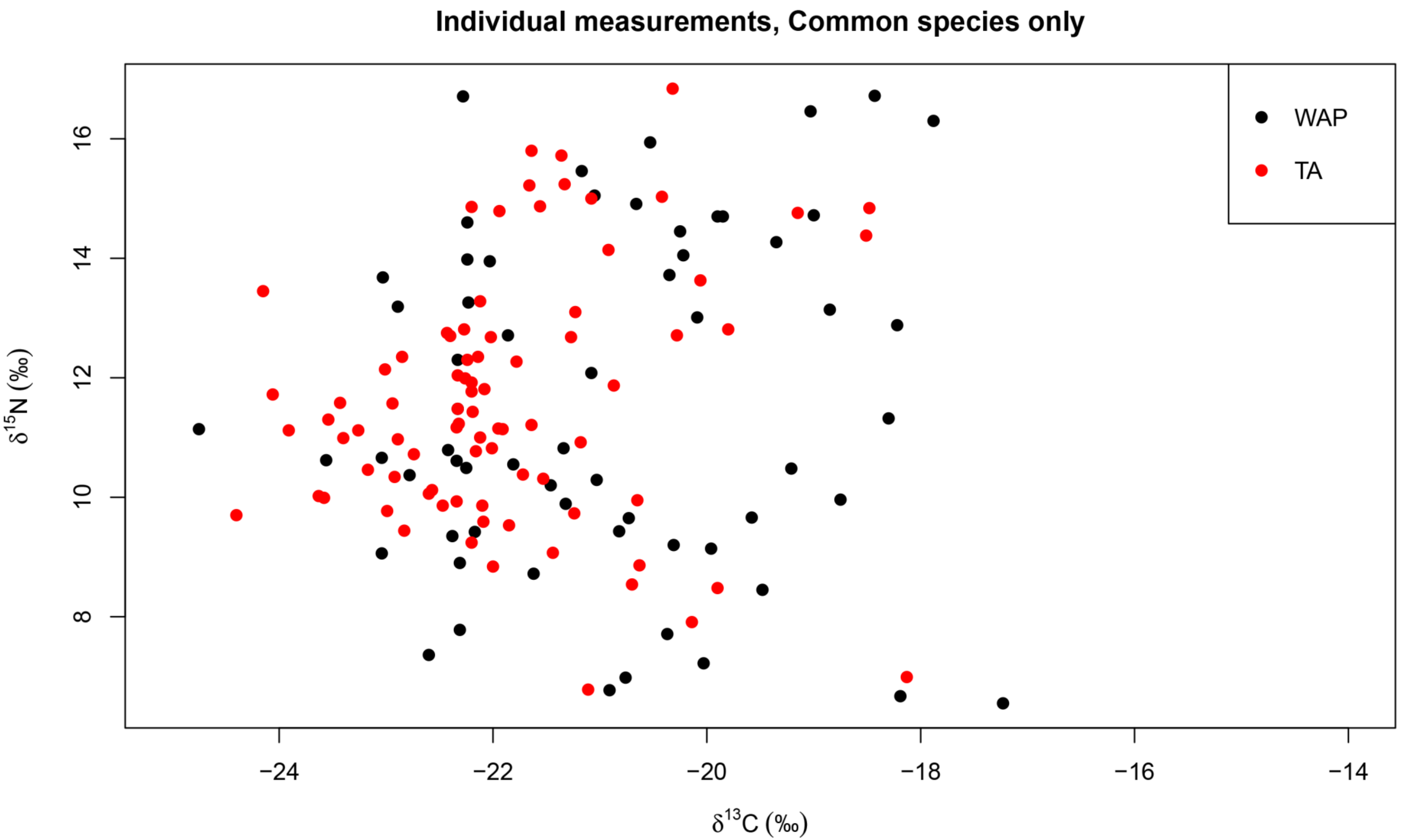
Use of museum specimens: isotopic measurements made on pleopods to limit destruction of samples



# Example: Iphimediidae amphipods

Common species only ($N_{species}$ = 11, $N_{individuals}$ = 145)



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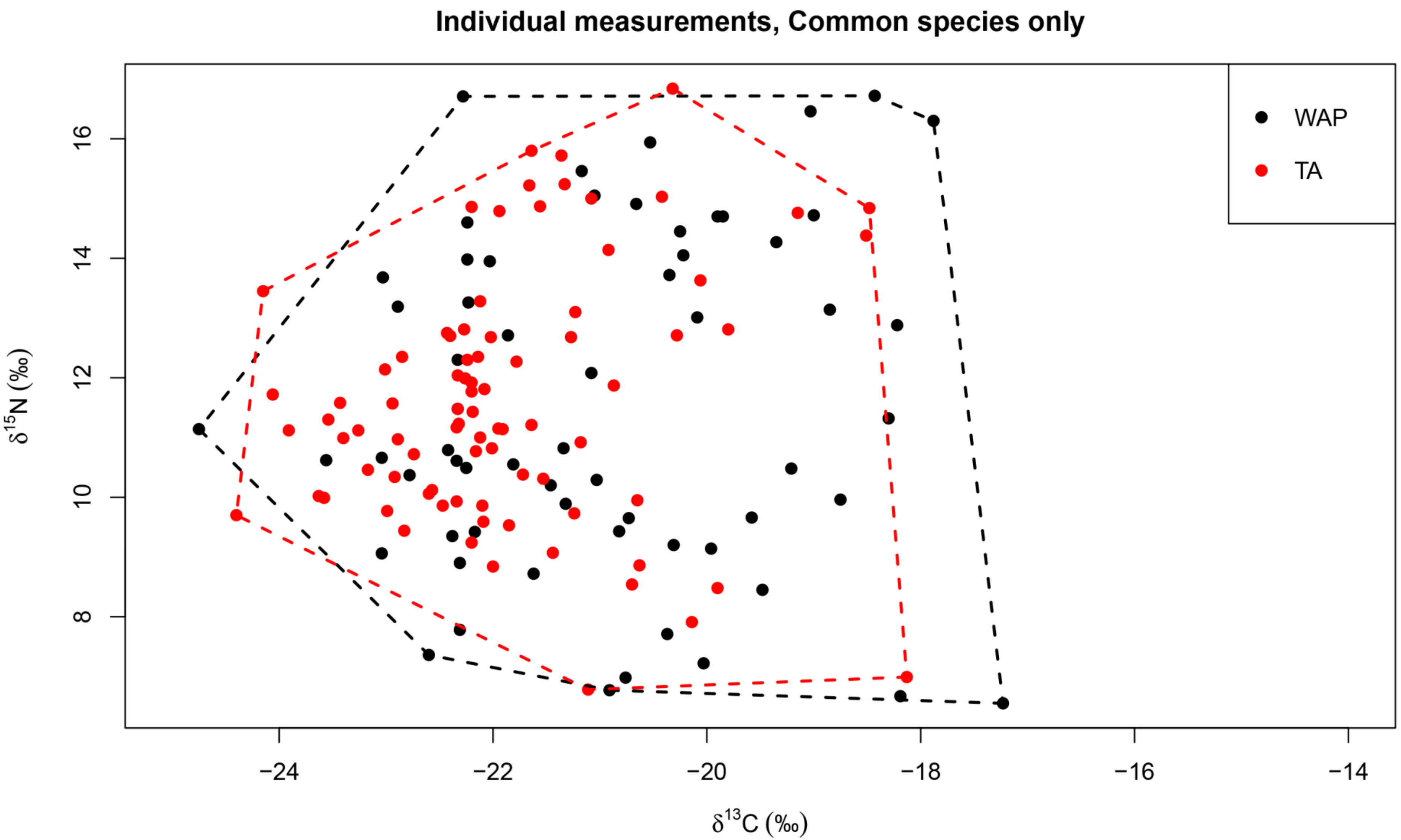

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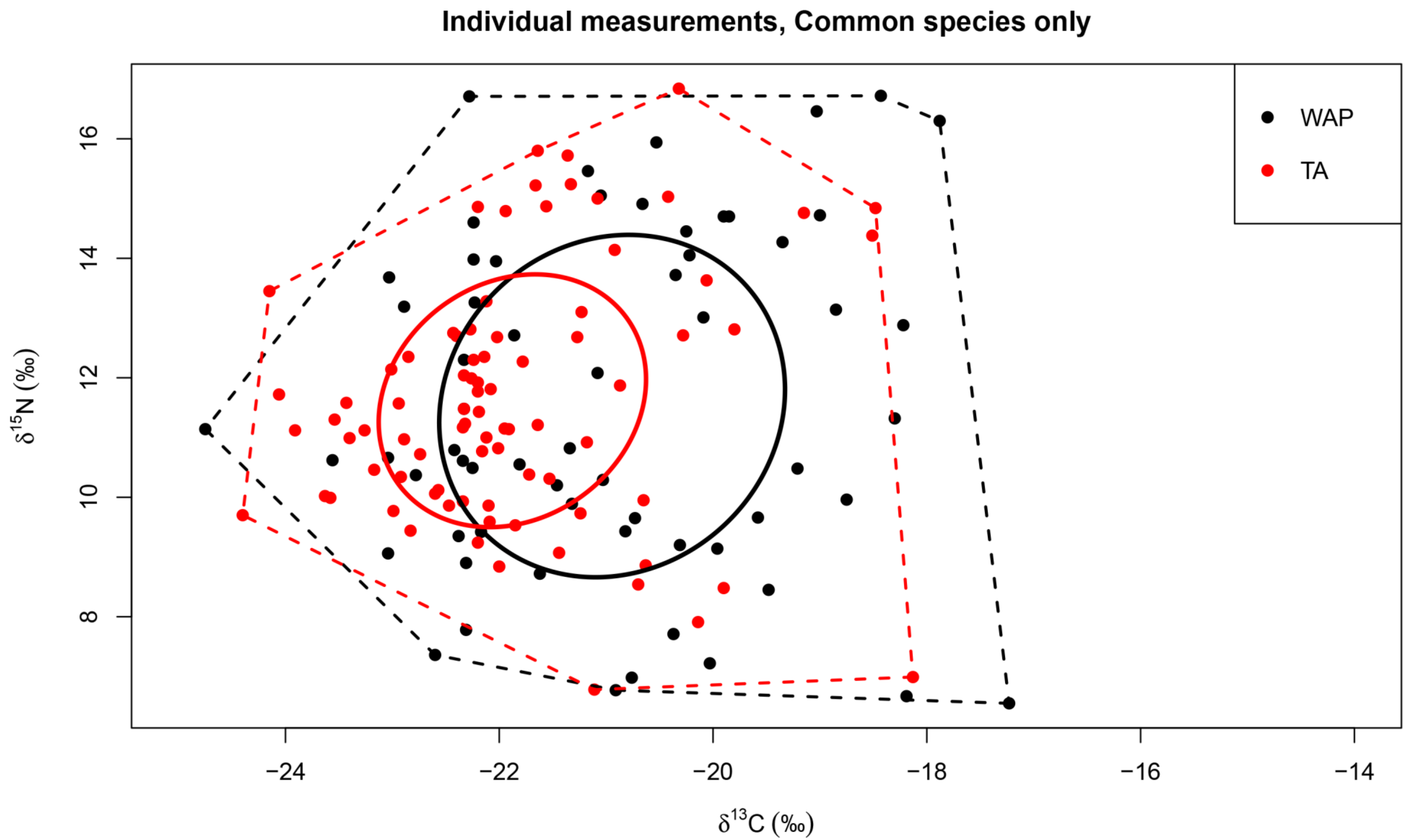

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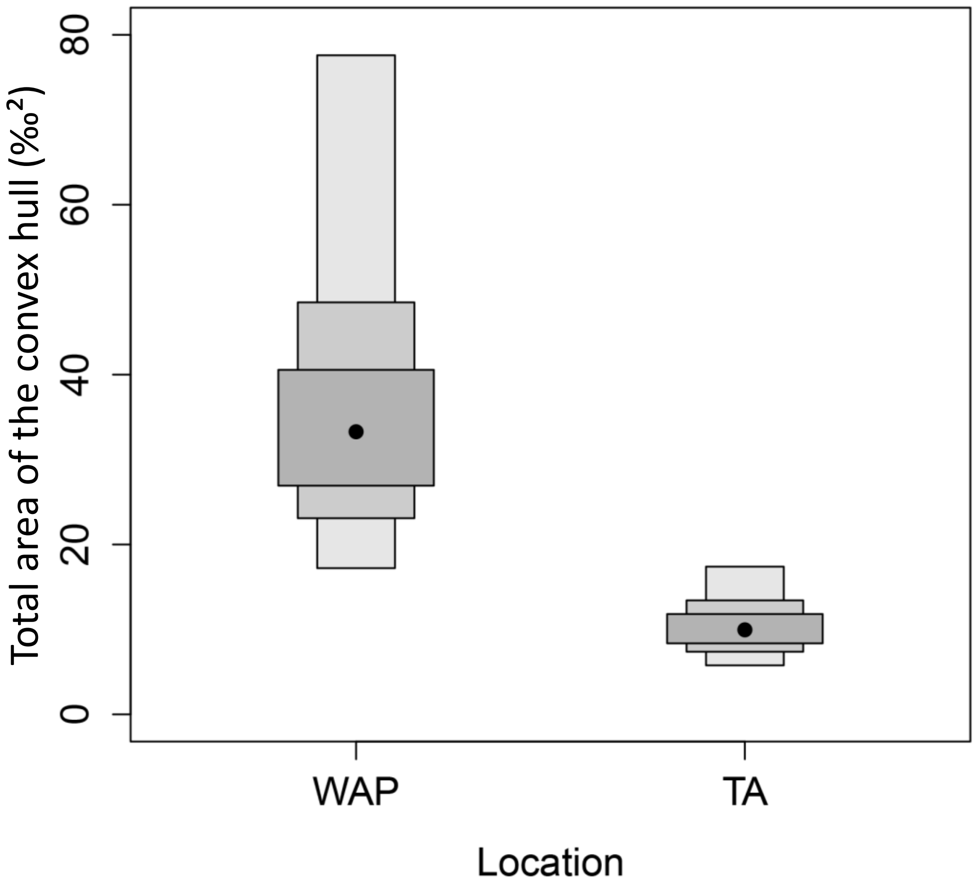
Total niche: Yes
(99.84% of model runs)



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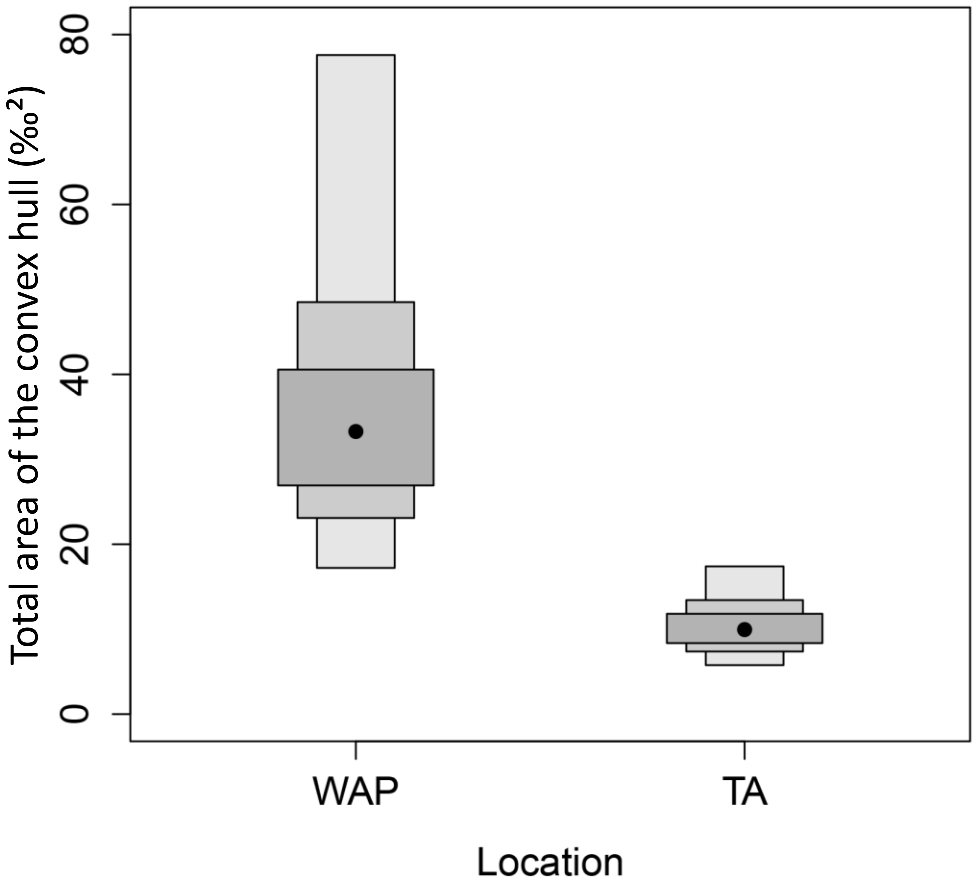
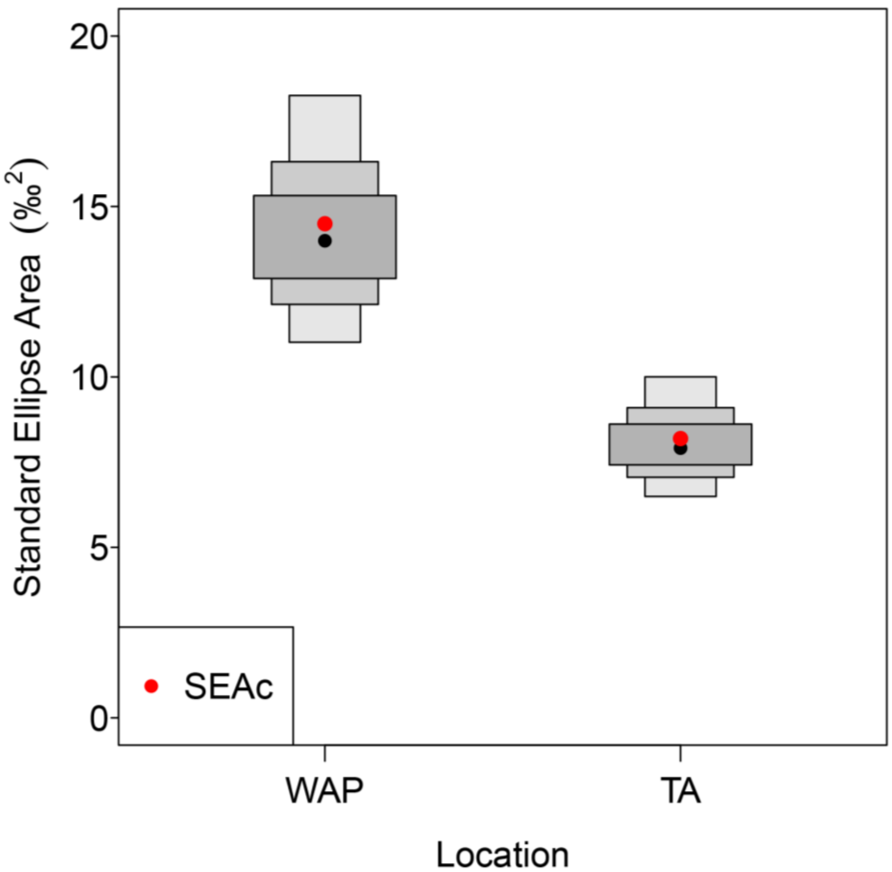



Core niche: Yes
(99.97% of model runs)



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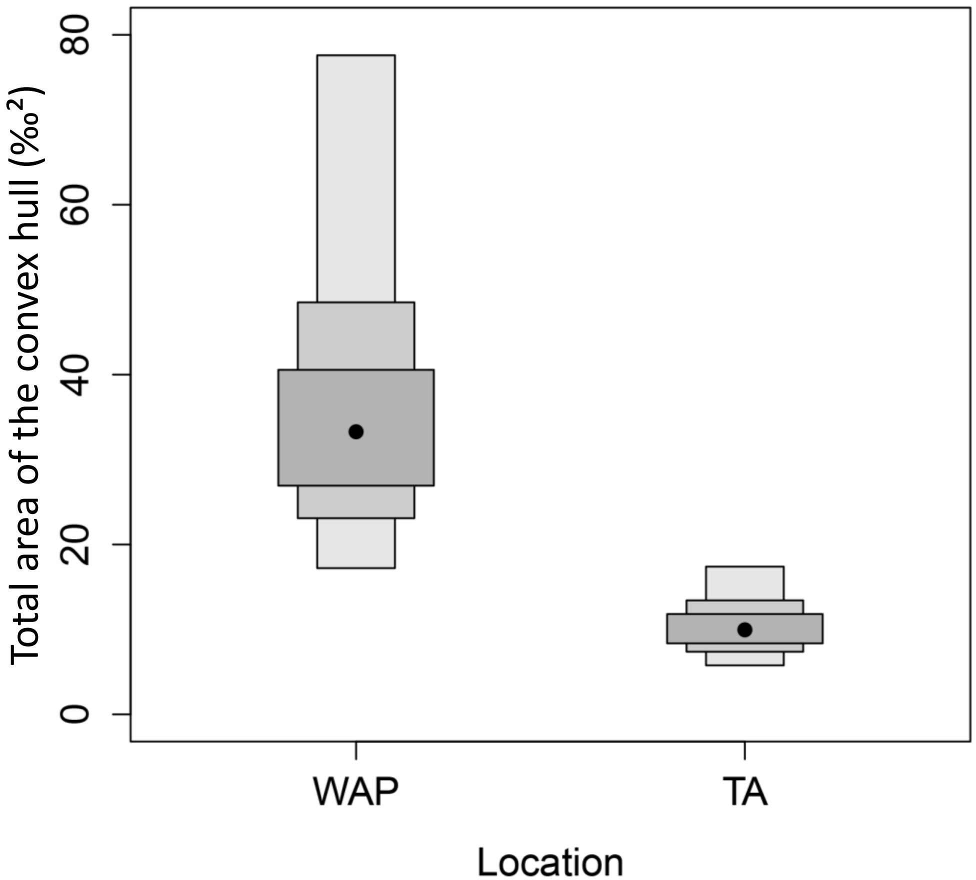


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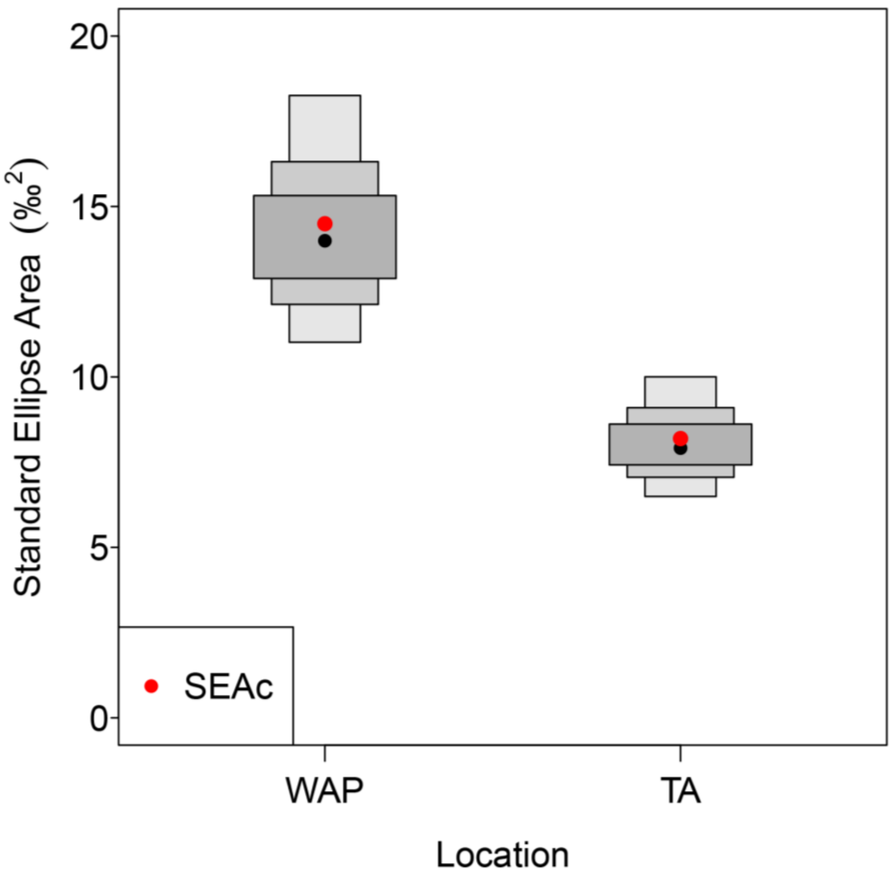


➔ Iphimediidae amphipods exploit more resources in WAP than in AL

# Example: Iphimediidae amphipods

Is this trend of wider isotopic niche found at the species level?

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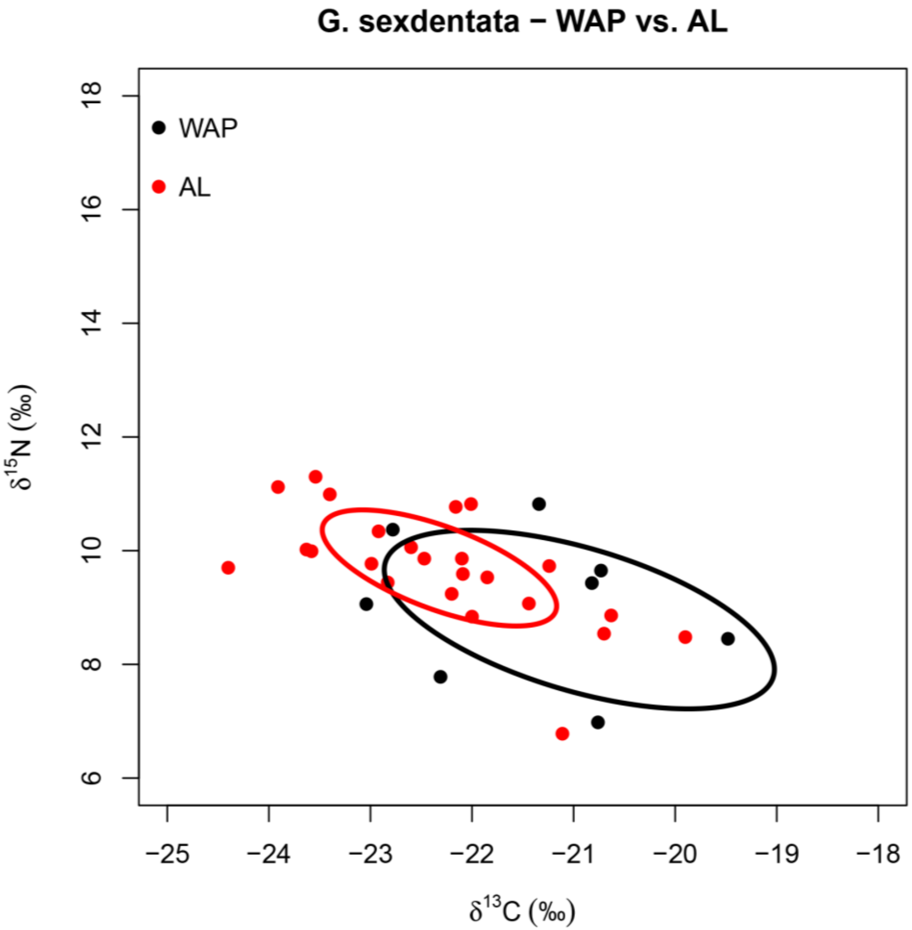
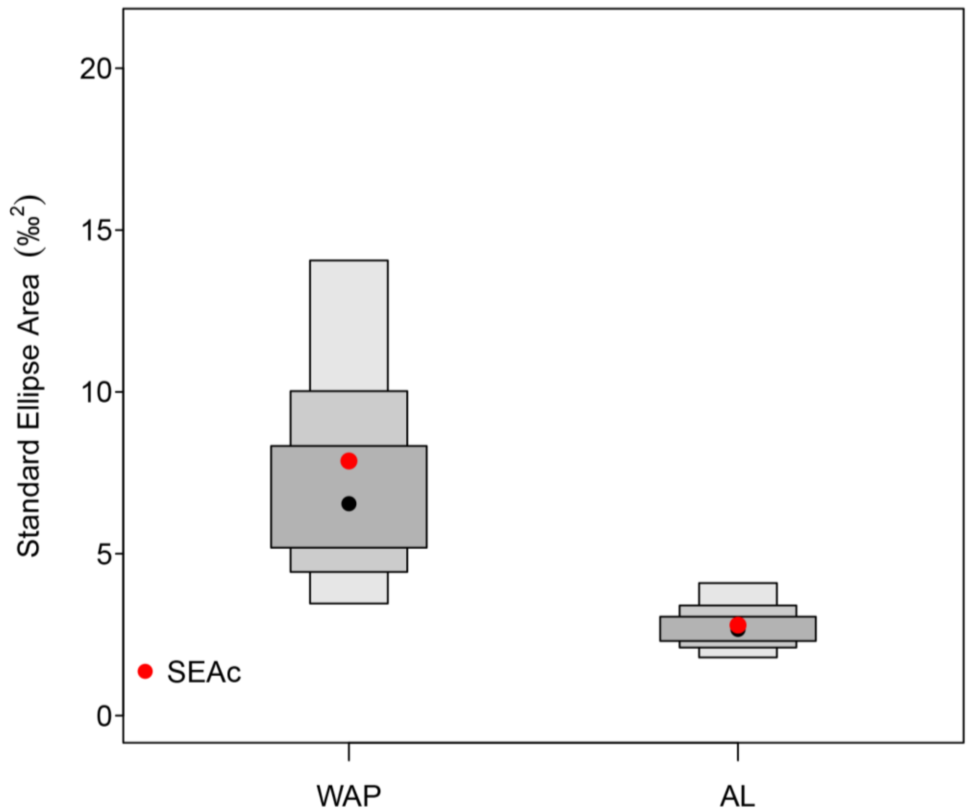
Is this trend of wider isotopic niche found at the species level?

*Gnathiphimedia sexdentata*: Yes
Trend present in 99.56% of model solutions


Image source: d'Udekem d'Acoz & Verheye 2013



# Example: Iphimediidae amphipods

Is this trend of wider isotopic niche found at the species level?

*Echiniphimedia echinata*: No
Trend present in only 80.64% of model solutions

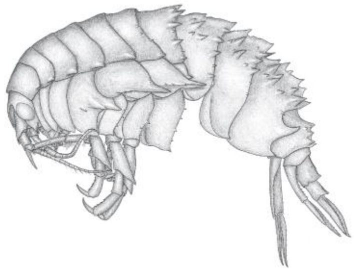
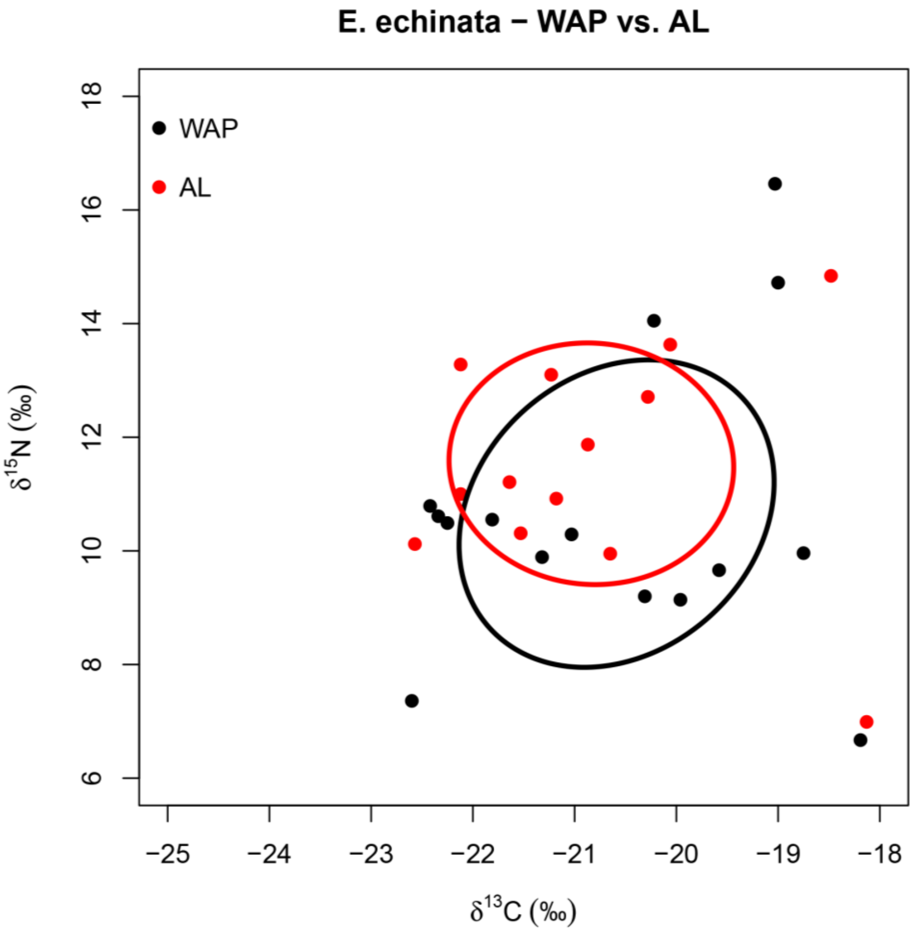
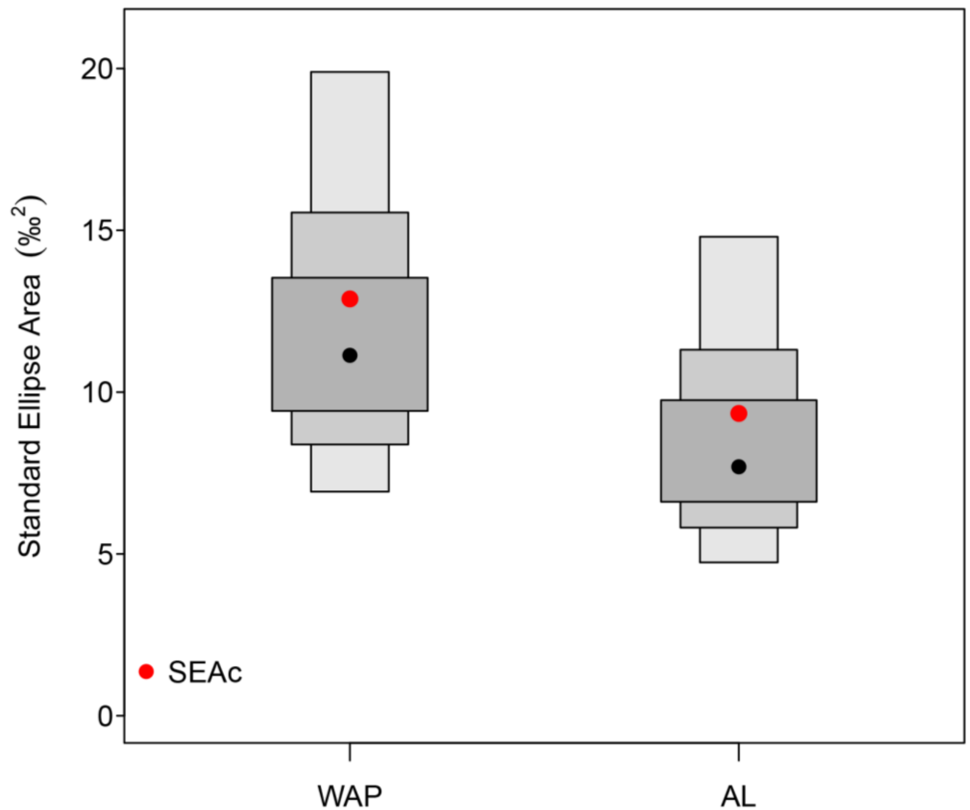


Image source: Coleman 2007



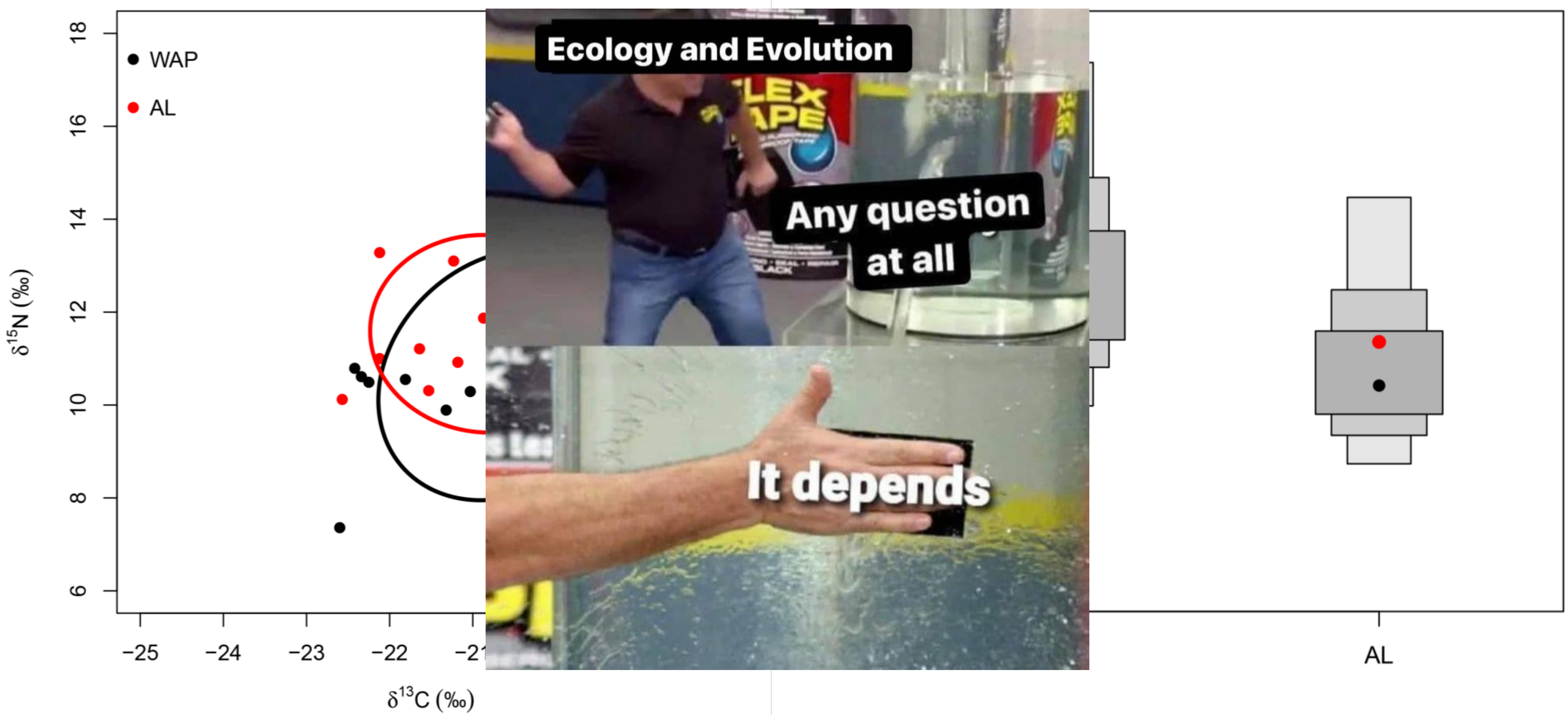



# Example: Iphimediidae amphipods

Is this trend of wider isotopic niche found at the species level?

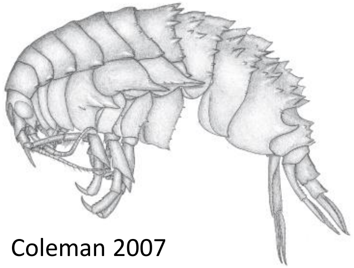
It depends…

→ Species-specific patterns of ecological plasticity among amphipod assemblage



# Example: Iphimediidae amphipods

Is niche overlap between close species the same in both regions?



Coleman 2007

← *Echiniphimedia echinata*

and

*Echiniphimedia hodgsoni* →

d'Udekem d'Acoz & Verheye 2013

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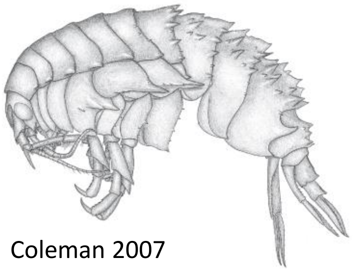

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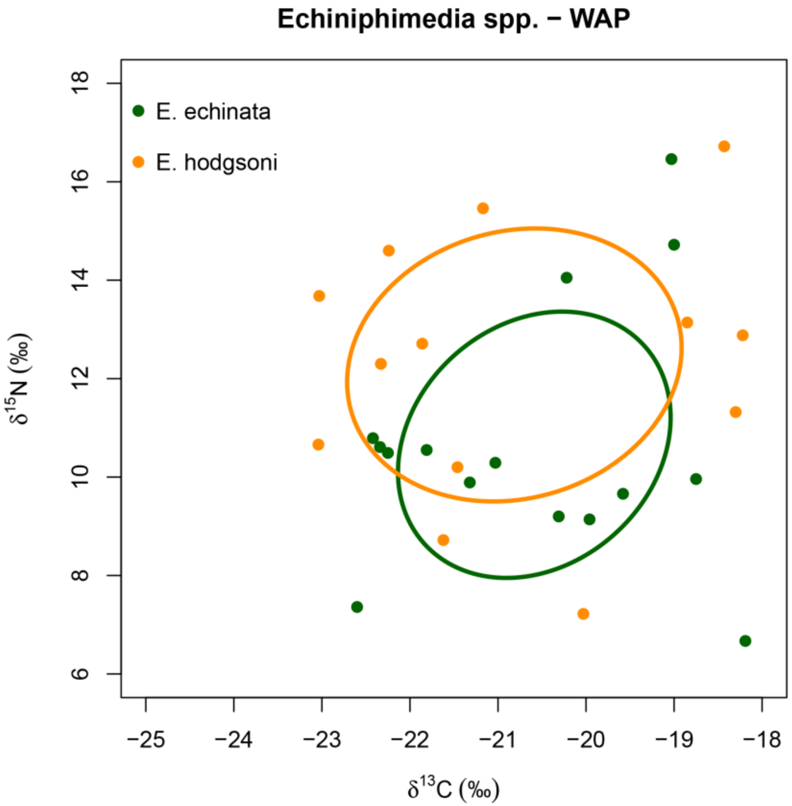
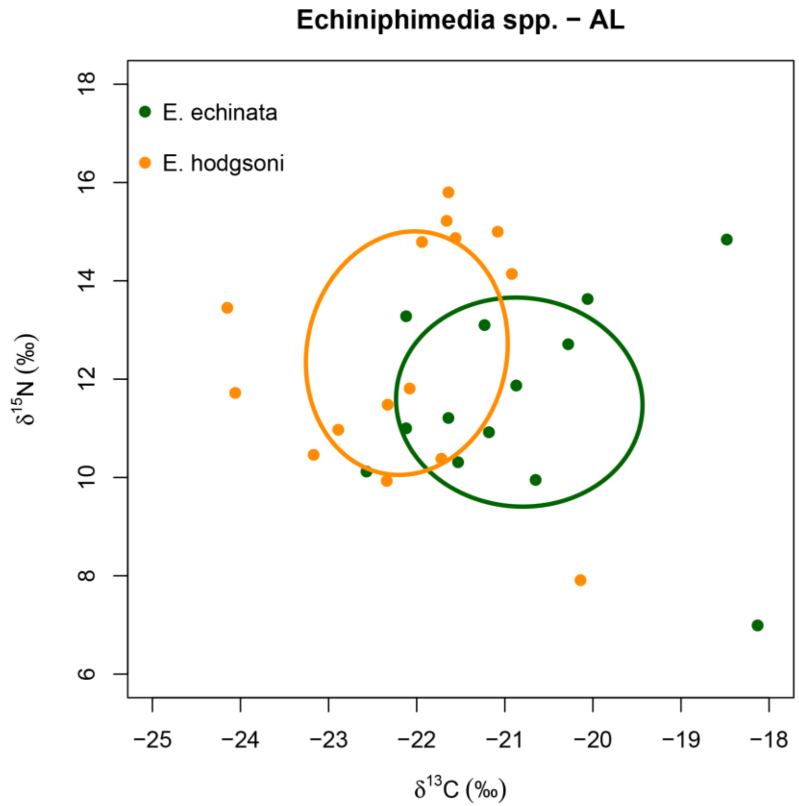
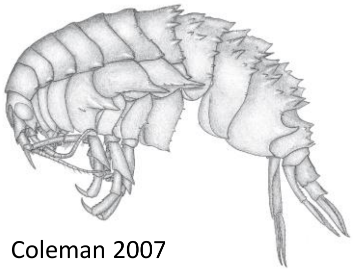


# Example: Iphimediidae amphipods

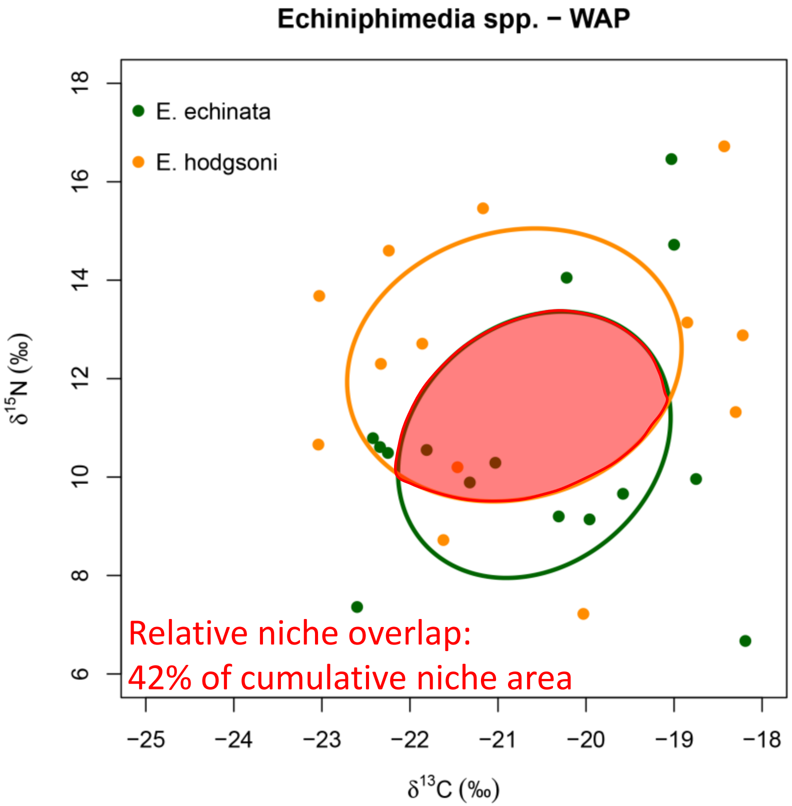
Is niche overlap between close species the same in both regions?

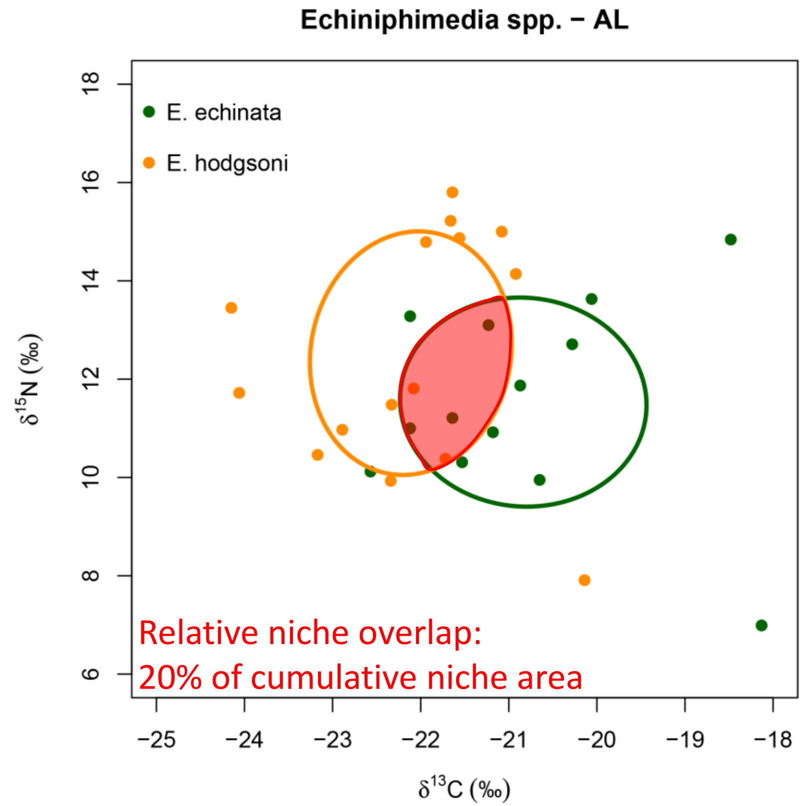


Coleman 2007

**←** *Echiniphimedia echinata*
and
*Echiniphimedia hodgsoni* **→**

d'Udekem d'Acoz & Verheye 2013



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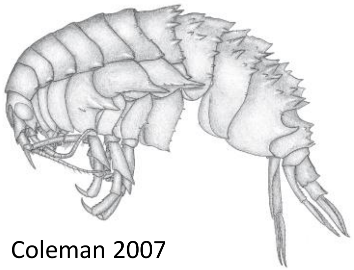

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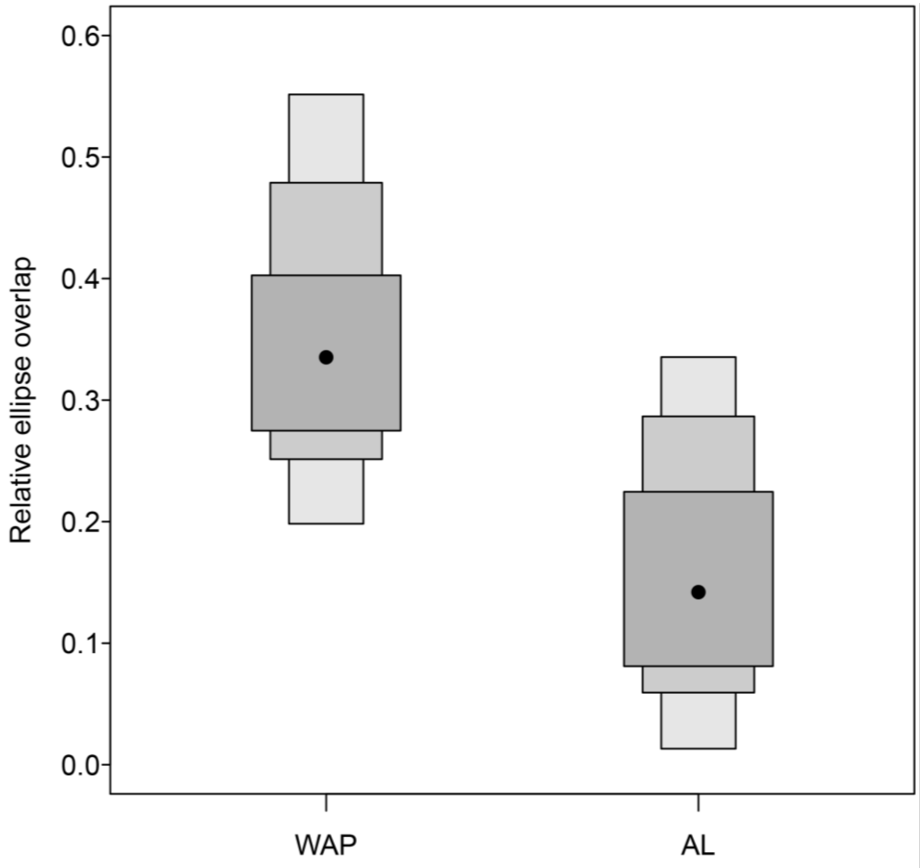
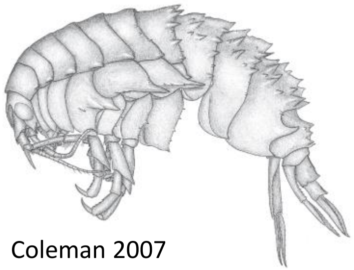



$\text{Overlap}_{\text{WAP}} > \text{Overlap}_{\text{AL}}$

Probability = 99.00%

# Example: Iphimediidae amphipods

Is niche overlap between close species the same in both regions?



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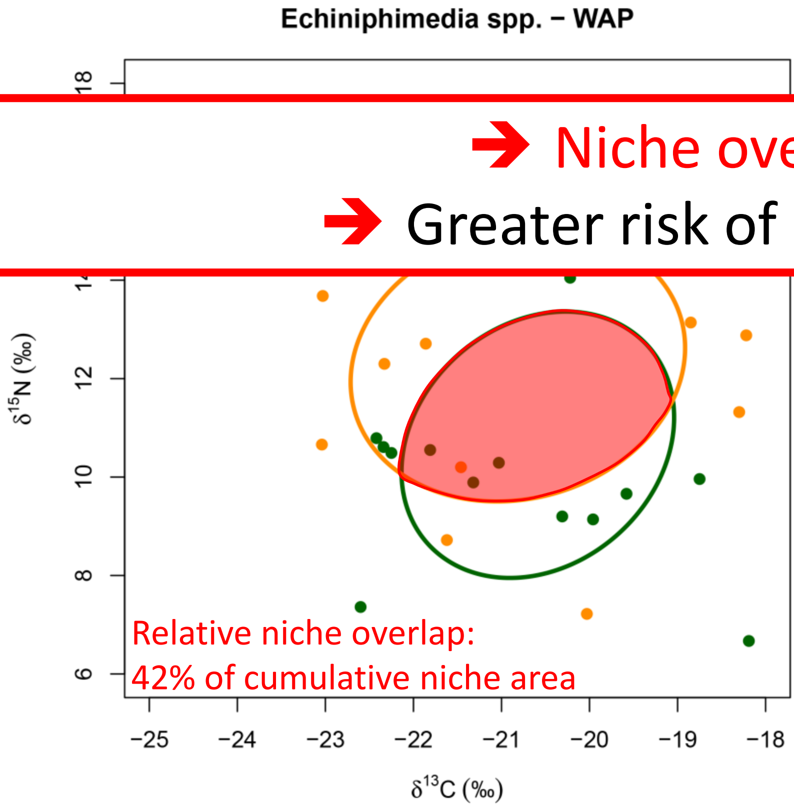
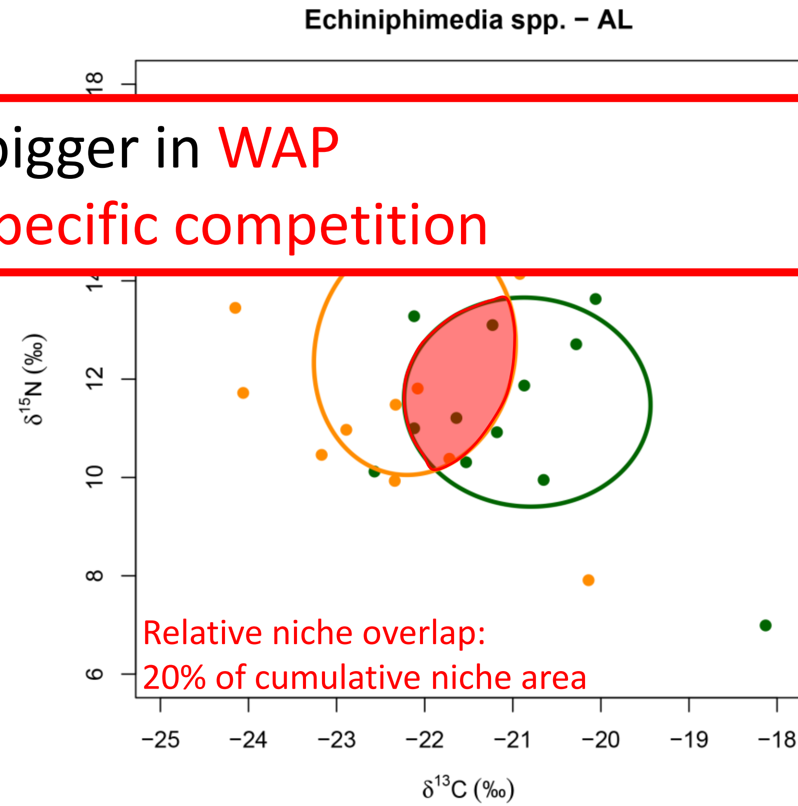



→ Niche overlap bigger in WAP

→ Greater risk of interspecific competition

# *Velella velella* niche shifts

By-the-wind sailor, *Velella velella*

Cosmopolitan neustonic organism

Colonial hydrozoan (not a jellyfish)

Gilles LEPOINT

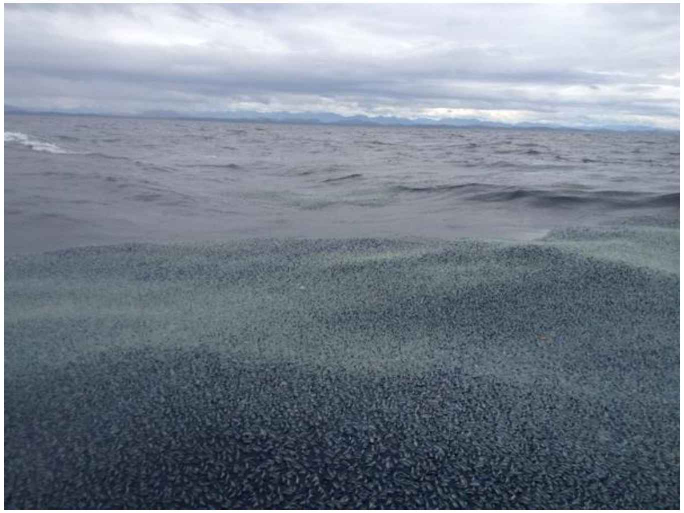
# *Velella velella* niche shifts

By-the-wind sailor, *Velella velella*

Cosmopolitan neustonic organism

Colonial hydrozoan (not a jellyfish)

Able to form huge swarms



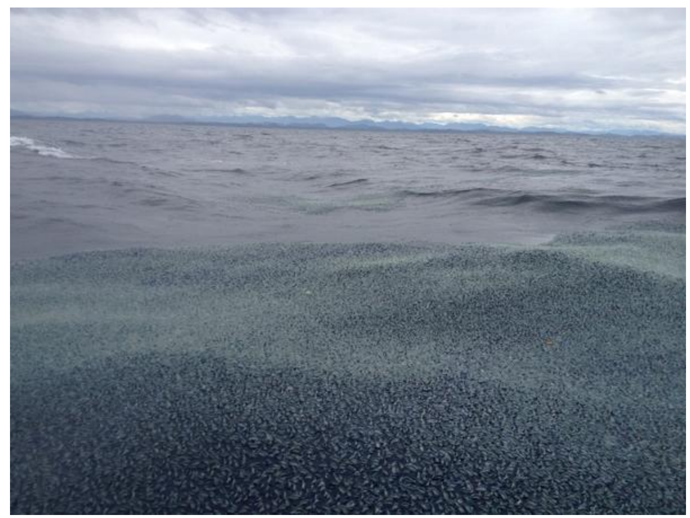
Gilles LEPOINT

# *Velella velella* niche shifts

By-the-wind sailor, *Velella velella*

→ Which resources sustain such large populations?

→ Are there any intraspecific (e.g. size-related) resource segregation mechanisms?

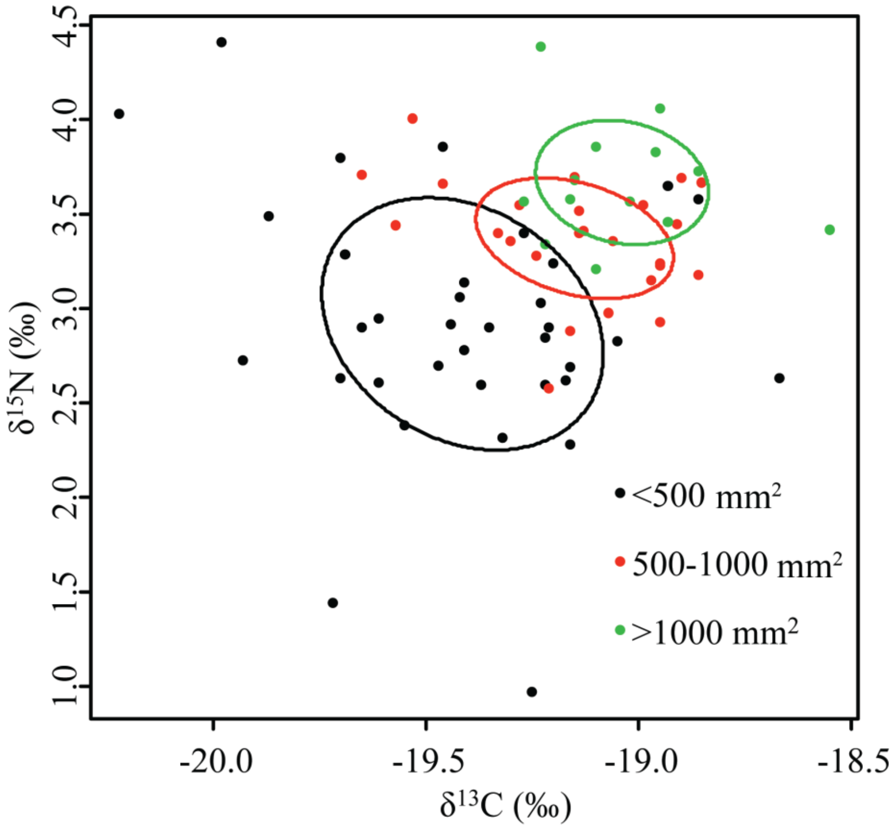


Belg. J. Zool., 146 (2) : 123–133 July 2016

**Trophic interactions between two neustonic organisms: insights from Bayesian stable isotope data analysis tools**

Gilles Lepoint[1,*], Laurent Bernard[1], Sylvie Gobert[1] & Loïc N. Michel[1]

# *Velella velella* niche shifts




◀ Little to no overlap between niches of small colonies and other size classes: size-related shift in resource use

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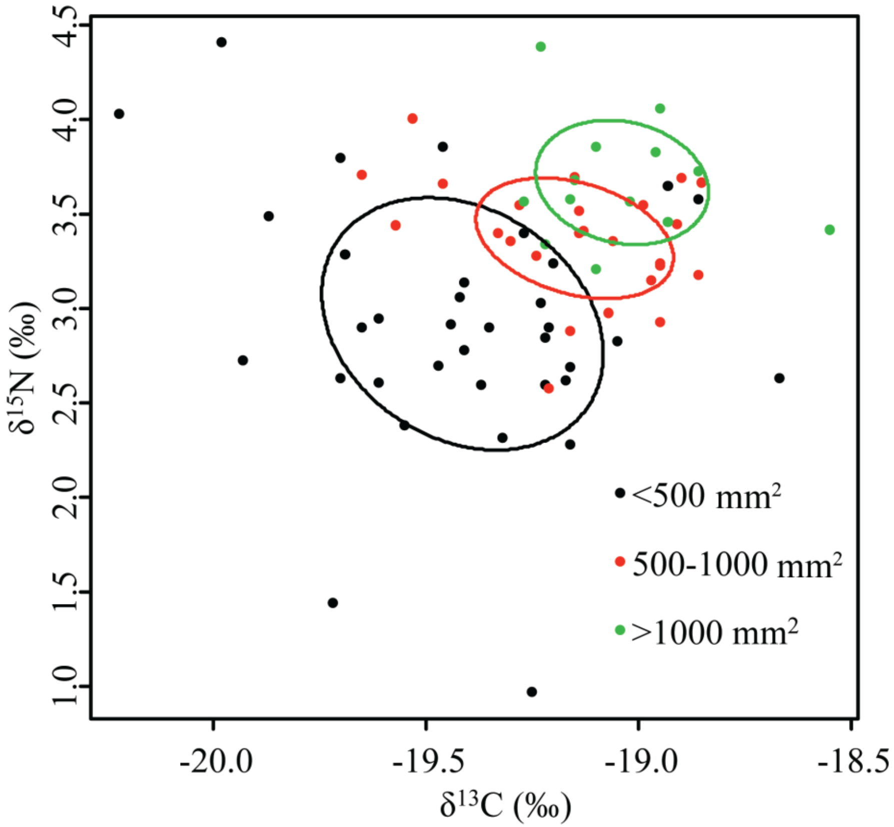
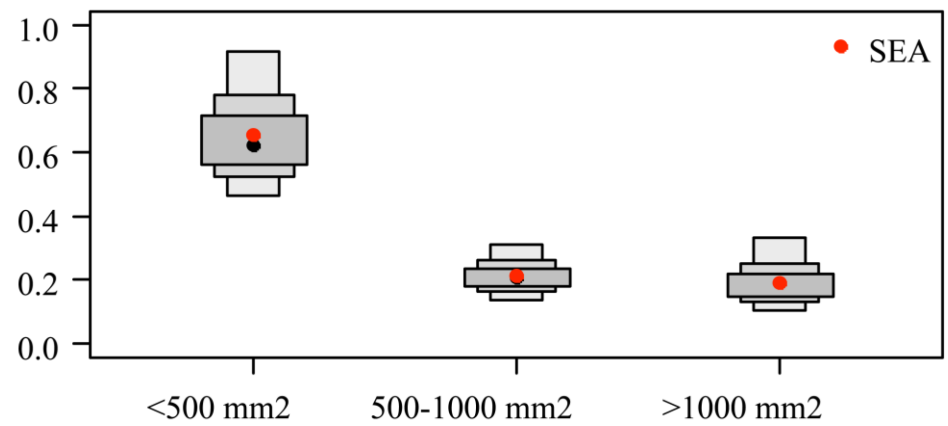



◀ Little to no overlap between niches of small colonies and other size classes: size-related shift in resource use

Larger ellipse area (*i.e.* higher ecological diversity) in small colonies ▼

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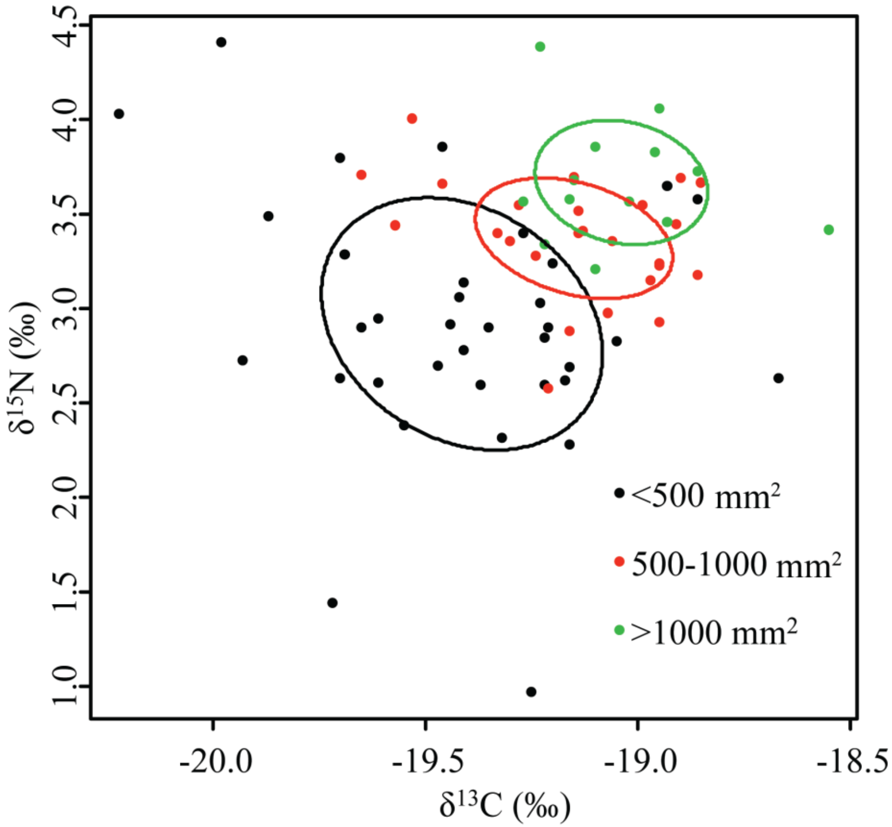


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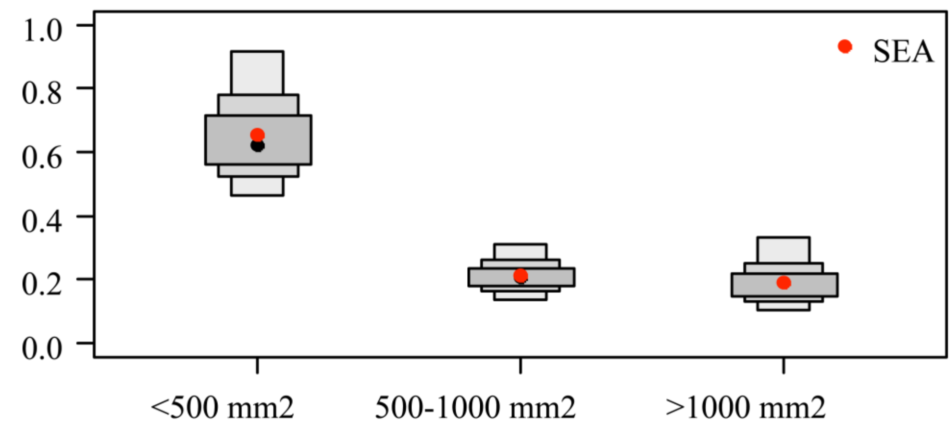


➔ Smaller colonies rely on different and more diverse resources

Belg. J. Zool., 146 (2) : 123–133 July 2016

**Trophic interactions between two neustonic organisms: insights from Bayesian stable isotope data analysis tools**

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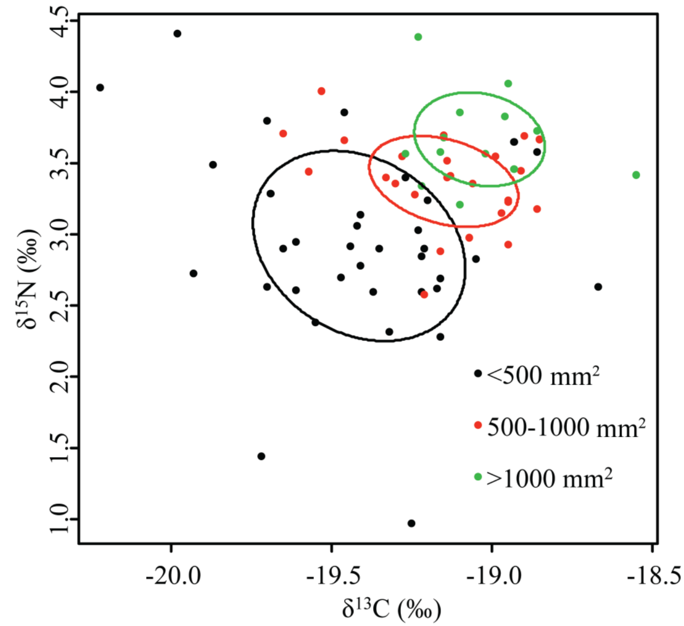
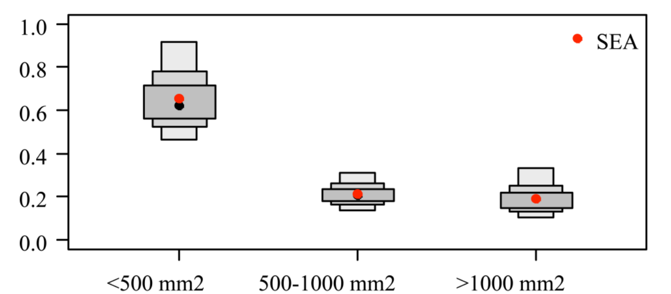
# *Velella velella* niche shifts

Several non-exclusive hypotheses:

1) *V. velella* is a generalist species with size-related prey selection: large colonies favour high trophic level prey (e.g. copepods, fish larvae, fish eggs) while smaller feed on more diverse items at a lower trophic level.

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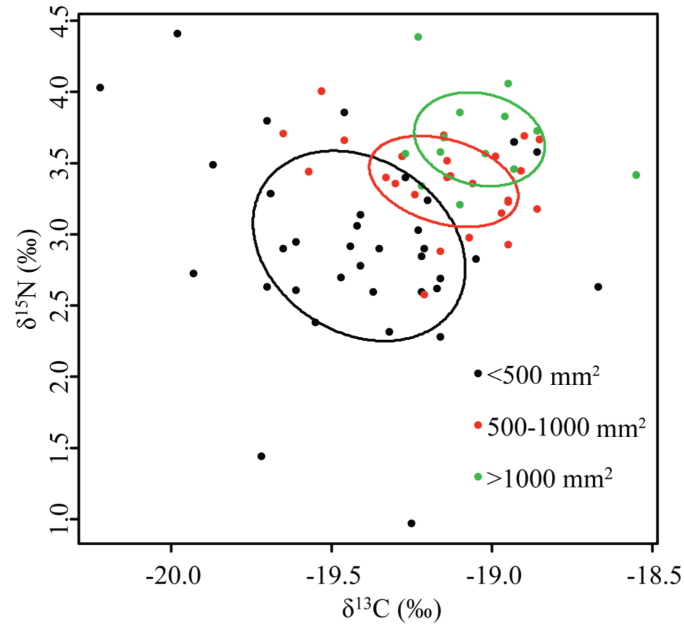
Gilles Lepoint [1,*], Laurent Bernard [1], Sylvie Gobert [1] & Loïc N. Michel [1]

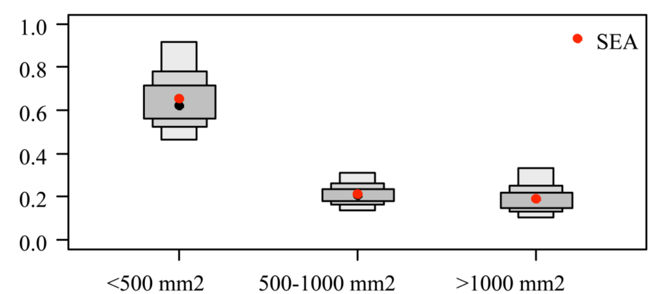
# *Velella velella* niche shifts

Several non-exclusive hypotheses:

1) *V. velella* is a generalist species with size-related prey selection.

2) Smaller colonies rely more on alternative energy acquisition pathways (e.g. symbiotic zooxanthellae), resulting in lower apparent trophic position.

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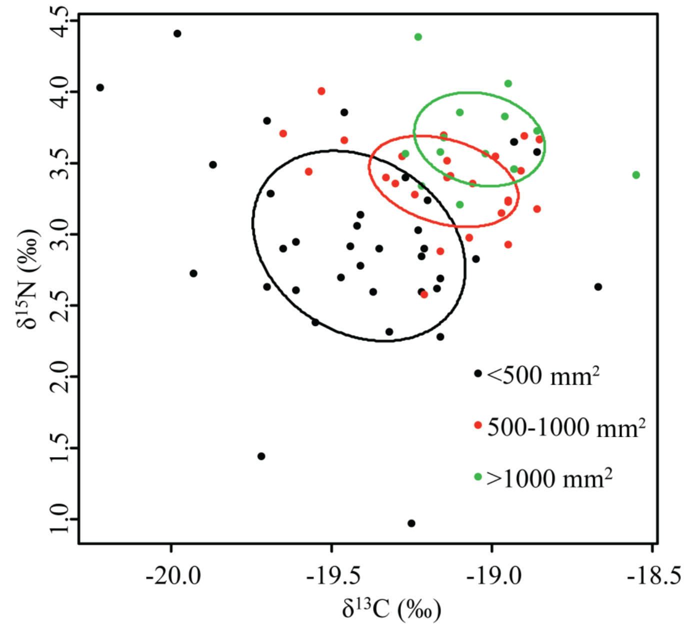
# *Velella velella* niche shifts

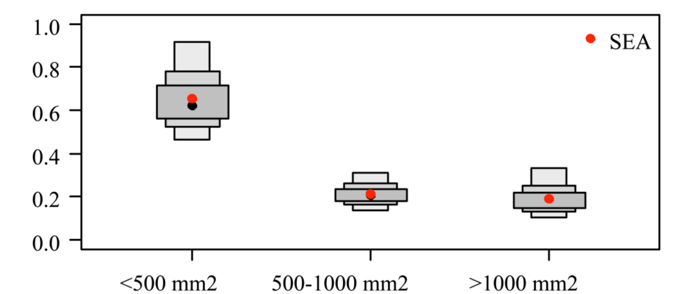
Several non-exclusive hypotheses:

1) *V. velella* is a generalist species with size-related prey selection.

2) Smaller colonies rely more on alternative energy acquisition pathways.

3) Smaller colonies still bear the "signature" of deep water layers (800-1000 m) where colony founders are produced through sexual reproduction. Since swarms are formed through passive accumulation, colonies from multiple areas could be present together (hence the higher isotopic variability).

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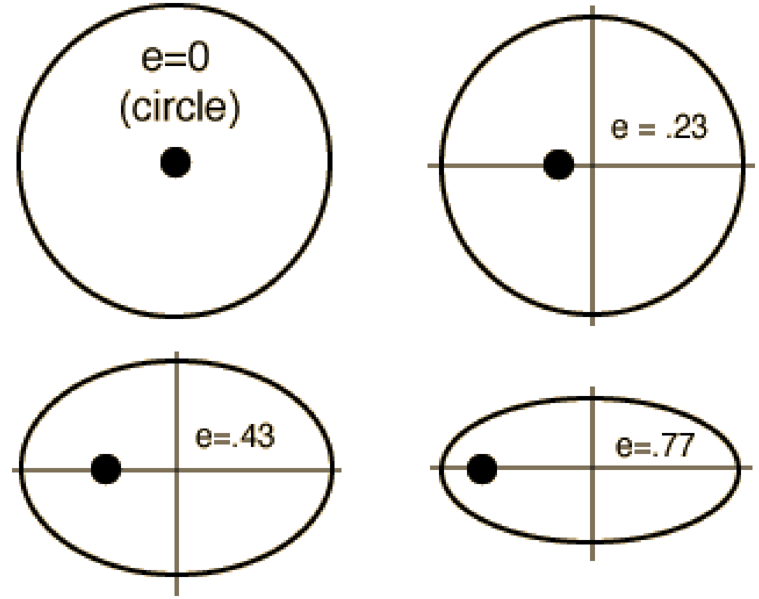
# Other ellipse-based metrics

Other metrics :

Eccentricity (deviation from circular shape) : e

Estimating relative contributions of each axis to isotopic niche size





Vol. 542: 13–24, 2016
doi: 10.3354/meps11571

MARINE ECOLOGY PROGRESS SERIES
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Published January 19


**Isotopic niche variability in macroconsumers of the East Scotia Ridge (Southern Ocean) hydrothermal vents: What more can we learn from an ellipse?**

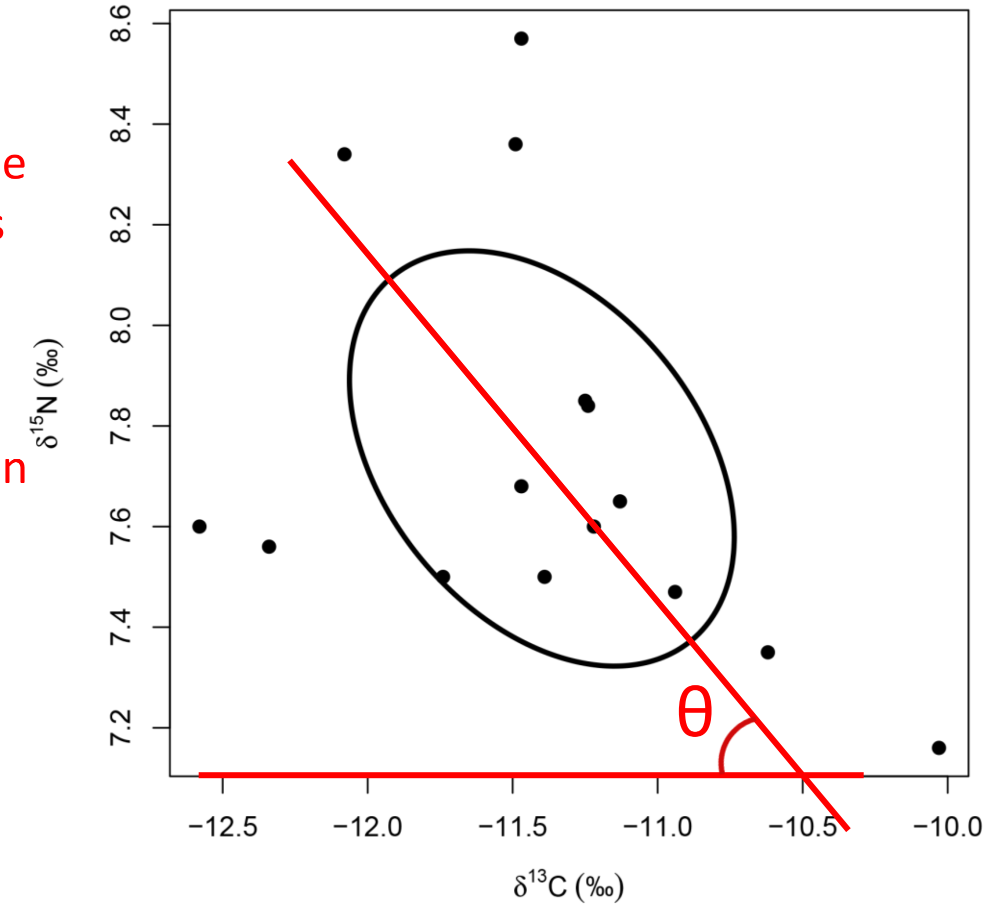

W. D. K. Reid[1,*], C. J. Sweeting[2], B. D. Wigham[3], R. A. R. McGill[4], N. V. C. Polunin[5]


# Other ellipse-based metrics

Other metrics :

Eccentricity (deviation from circular shape) : e
Estimating relative contributions of each axis to isotopic niche size

Angle between major axis and x-axis: θ
Understand which axis drives the variability in isotopic niche size

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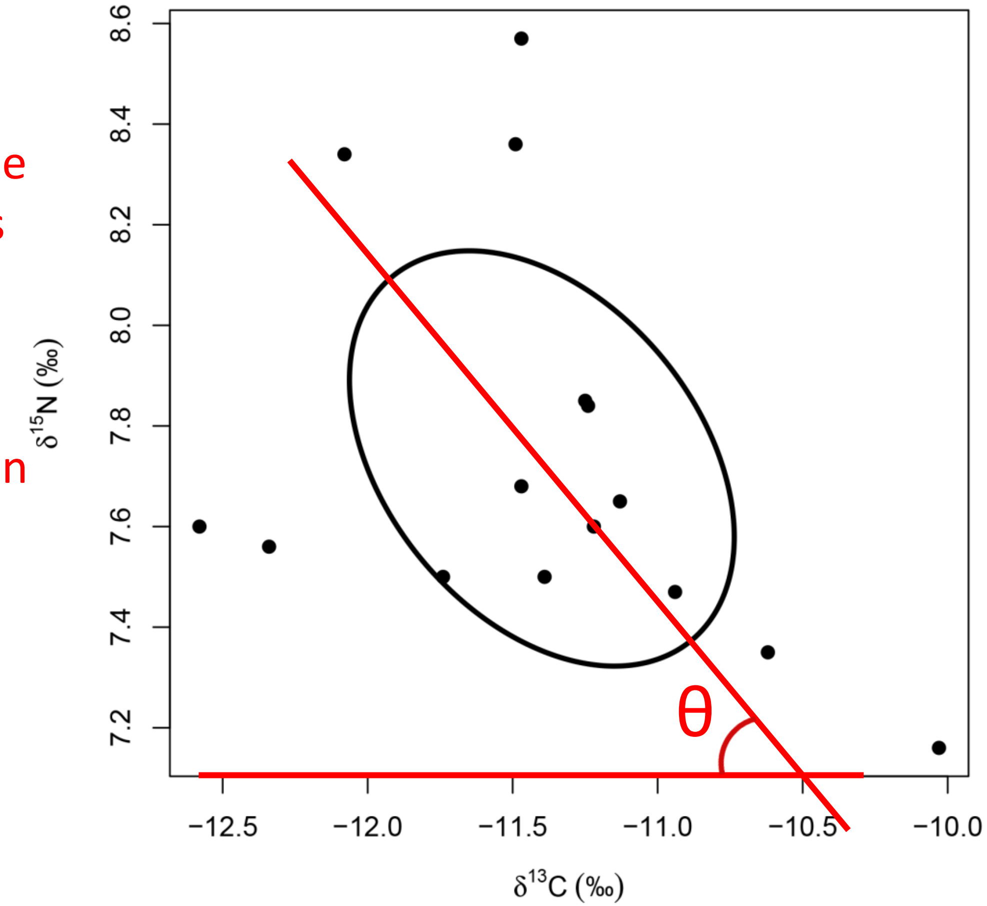
Angle between major axis and x-axis: θ
Understand which axis drives the variability in isotopic niche size

➔ Relate isotopic niche parameters to specific ecological processes (trophic level change, resource shift, etc.)





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# SIBER R package

Journal of Animal Ecology

*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]

SIBER (Stable Isotope Bayesian Ellipses in R): R package, freely available from the CRAN repository

Allows

- Fitting of convex hulls and standard ellipses to isotopic data
- Computation of hull- and ellipse-based metrics
- Overlap calculations
- Model estimations of these parameters and statistical comparisons
- …

Example scripts: https://cran.r-project.org/web/packages/SIBER/vignettes/
More info & help: https://github.com/AndrewLJackson/SIBER

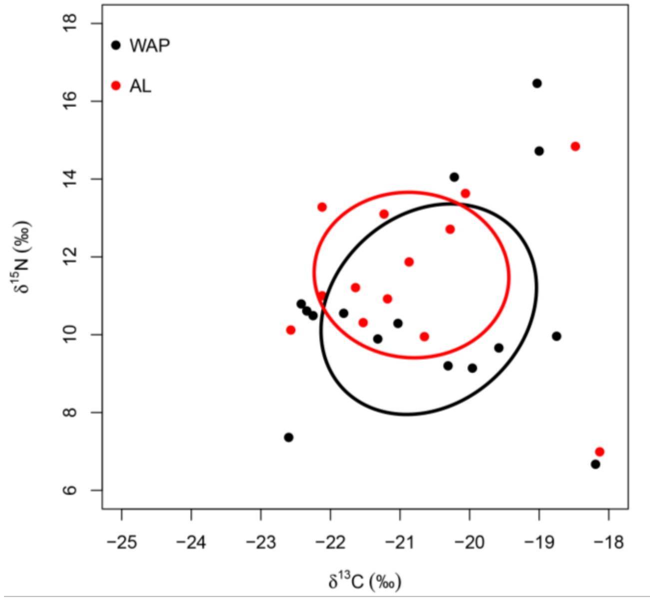
# SIBER R package

Input data requirements

# SIBER R package

Input data requirements

- 2 continuous variables
  - Stable isotope ratios, but also others
  - If more: *a priori* selection or ordination method (*e.g.* PCA)

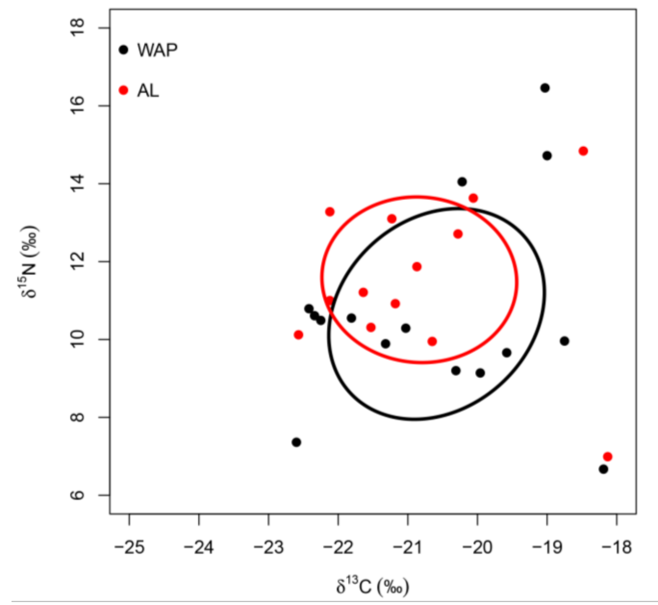


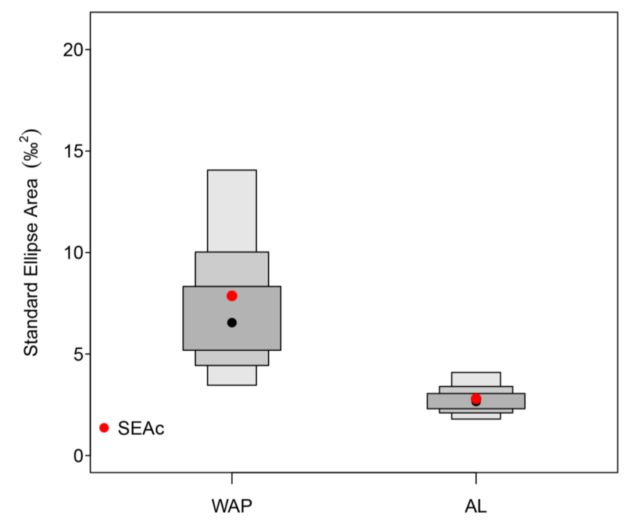
# SIBER R package

Input data requirements

- 2 continuous variables

- Groups or modalities to compare
  - *e.g.* compare different populations of a species sampled in different zones and/or years, or different species living together
  - Spatial and temporal scope of the comparisons can be adapted to the question

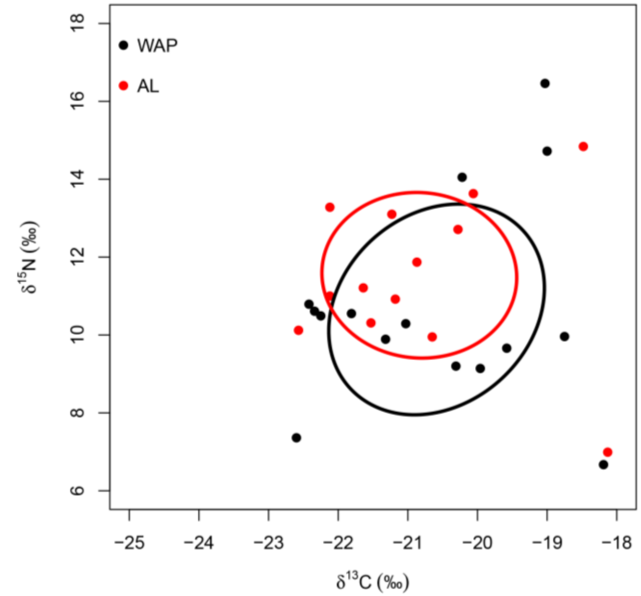


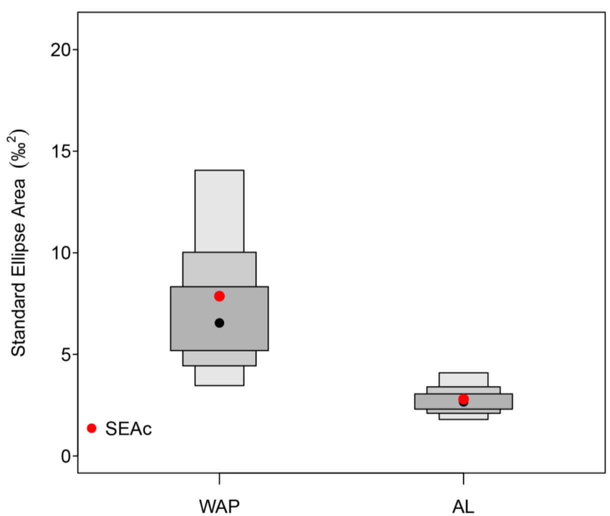



# SIBER R package

Input data requirements

- 2 continuous variables
- Groups or modalities to compare
- Sufficient replication for each group
    - minimum n = 6
    - 10-12 points (or more) provide better results



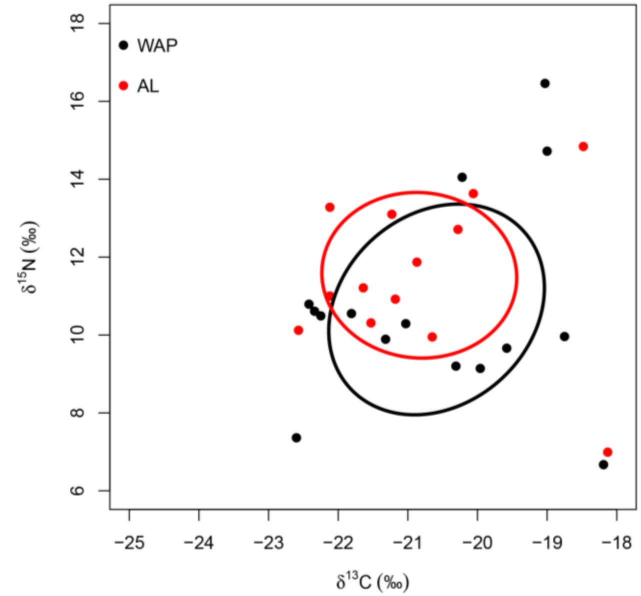
# SIBER R package

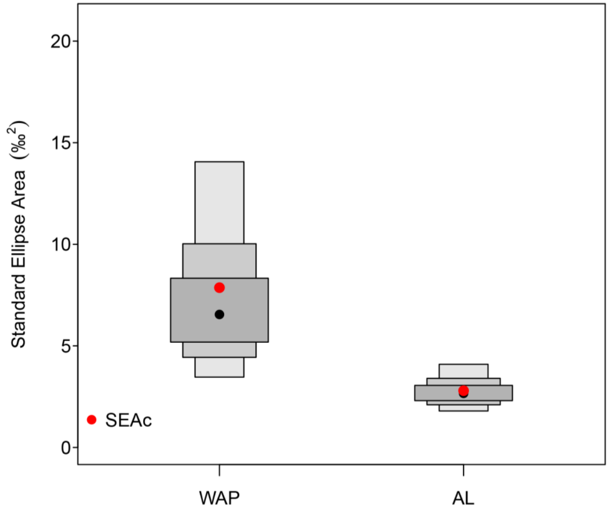
Input data requirements

- 2 continuous variables
- Groups or modalities to compare
- Sufficient replication for each group

Output data

- Geometric approach: unique values
  - Total or core niche width (TA, SEAc), niche overlap
  - Easy to handle and feed to other models



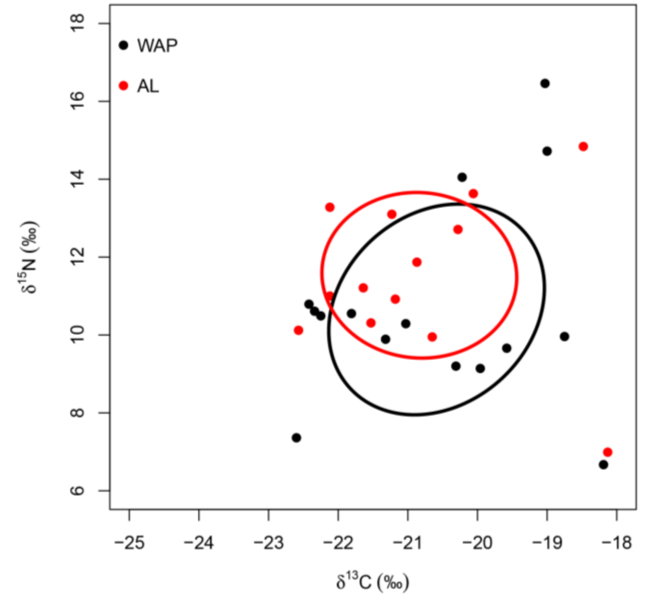
# SIBER R package

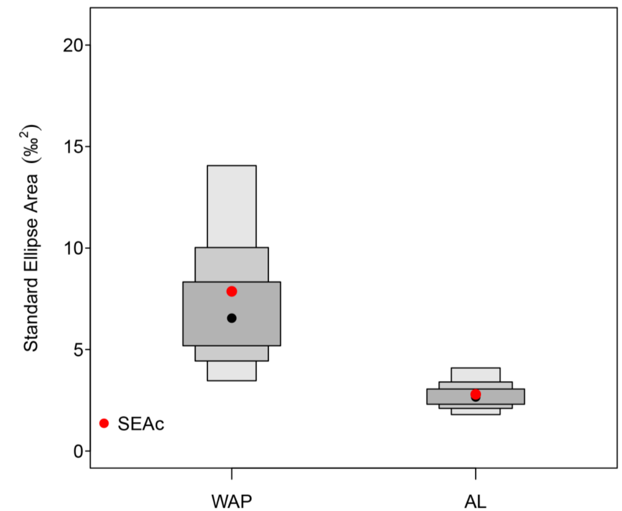
Input data requirements

- 2 continuous variables
- Groups or modalities to compare
- Sufficient replication for each group

Output data

- Geometric approach: unique values
- Bayesian approach: large sets of model solutions
  - More robust but not so easy to handle
  - Possible solution: work with percentiles of probability density function distributions



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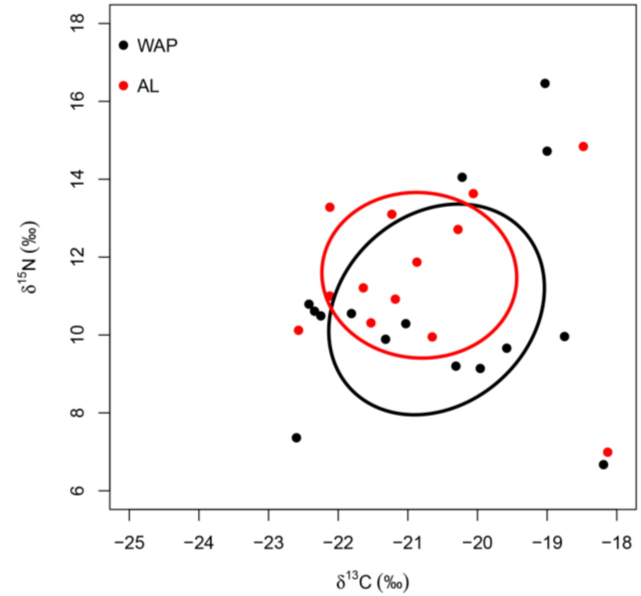


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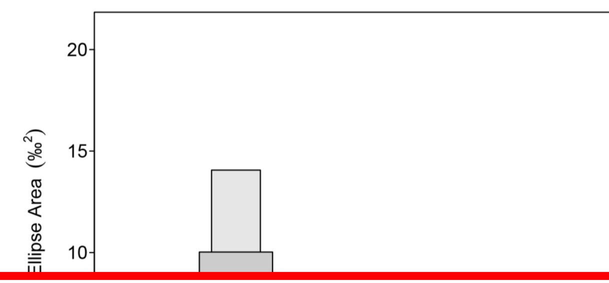
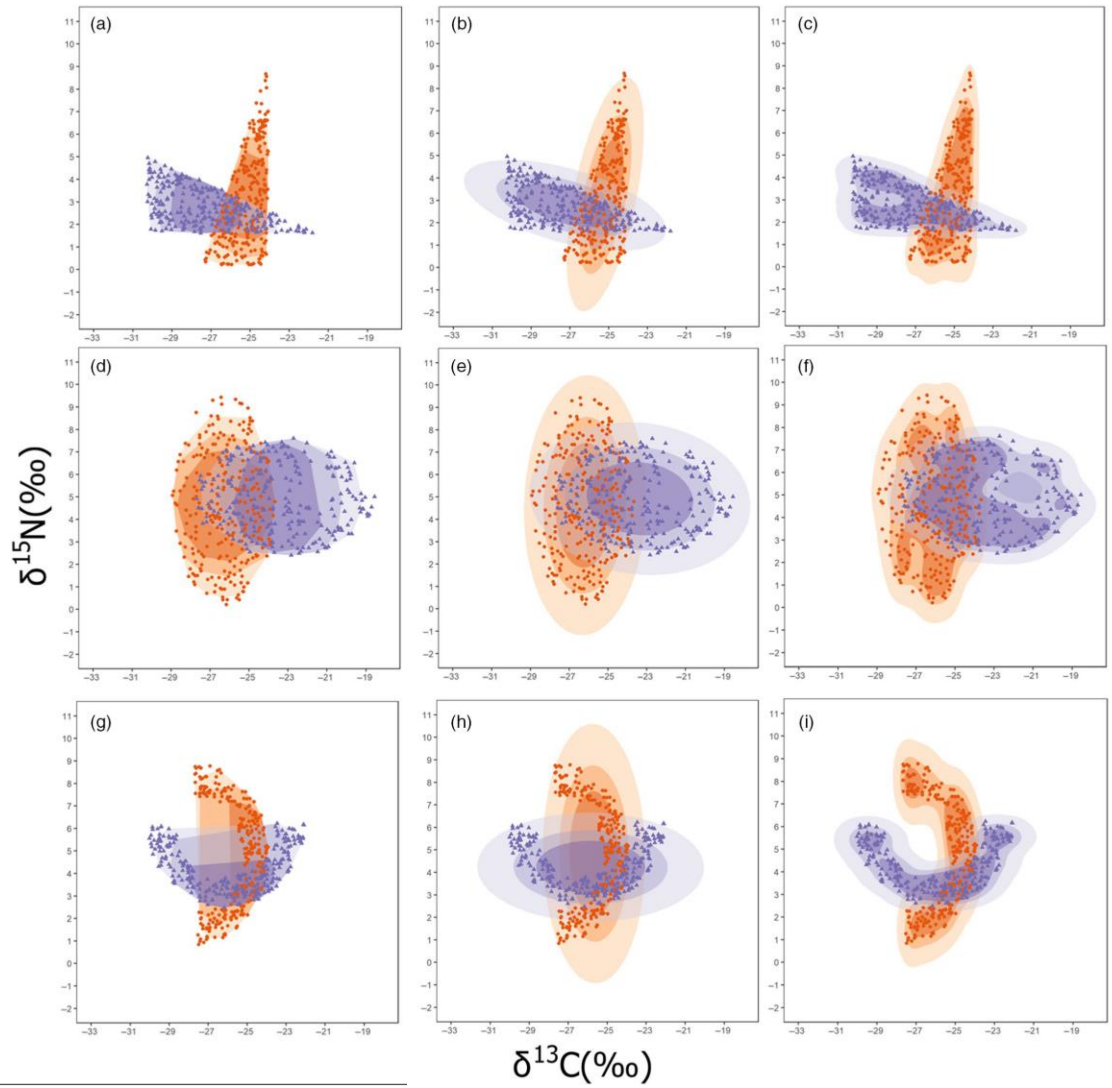



Practical course: get the files at

[doi.org/10.5281/zenodo.3903263](https://doi.org/10.5281/zenodo.3903263)

# Other methods: kernel density estimation




Received: 26 July 2018 | Accepted: 11 October 2019

DOI: 10.1111/1365-2656.13159

## rKIN: Kernel-based method for estimating isotopic niche size and overlap

Carolyn A. Eckrich[1] | Shannon E. Albeke[2,3] | Elizabeth A. Flaherty[4] | R. Terry Bowyer[5] | Merav Ben-David[3,6]

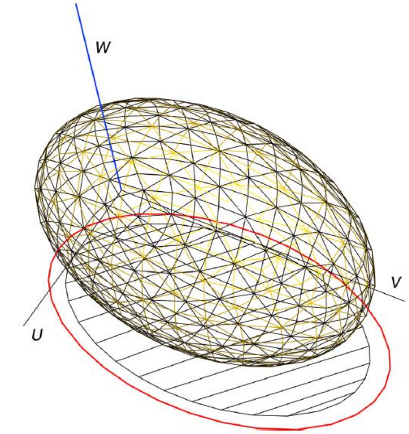
Journal of Animal Ecology

# Multi-dimensional niche analysis

A new probabilistic method for quantifying *n*-dimensional ecological niches and niche overlap

Heidi K. Swanson,[1,4] Martin Lysy,[2] Michael Power,[1] Ashley D. Stasko,[1] Jim D. Johnson,[3] and James D. Reist[3]

*Ecology*, 96(2), 2015, pp. 318–324




Ecology and Evolution
Open Access

**Beyond carbon and nitrogen: guidelines for estimating three-dimensional isotopic niche space**

Sam Rossman[1,2,3], Peggy H. Ostrom[1,2], Forrest Gordon[4] & Elise F. Zipkin[1,2]

*Ecology and Evolution* 2016; 6(8): 2405–2413

doi: 10.1002/ece3.2013

SCIENTIFIC REPORTS

OPEN **Multidimensional metrics of niche space for use with diverse analytical techniques**

Rachel E. Bowes[1], James H. Thorp[1] & Daniel C. Reuman[1,2]

SCIENTIFIC REPORTS | 7:41599 | DOI: 10.1038/srep41599

Other methods able to deal with multiple (*i.e.*, >2) dimensions exist

# Multi-dimensional niche analysis

Baptiste LE BOURG
PhD at ULiège

Trophic ecology of Southern Ocean sea stars

# Multi-dimensional niche analysis

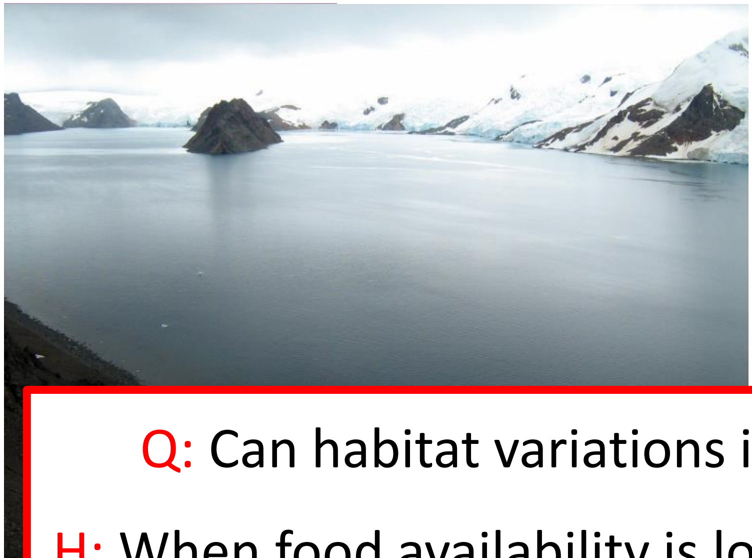
Vol. 674: 189–202, 2021
https://doi.org/10.3354/meps13821
MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published September 16

**Interactive effects of body size and environmental gradient on the trophic ecology of sea stars in an Antarctic fjord**

Baptiste Le Bourg[1,3,*], Piotr Kuklinski[2], Piotr Balazy[2], Gilles Lepoint[1], Loïc N. Michel[1,4]


Ezcurra Inlet (King George Island, WAP): strong environmental gradients. High glacier disturbance: ↗ turbidity, ↘ salinity in inner stations.

# Multi-dimensional niche analysis



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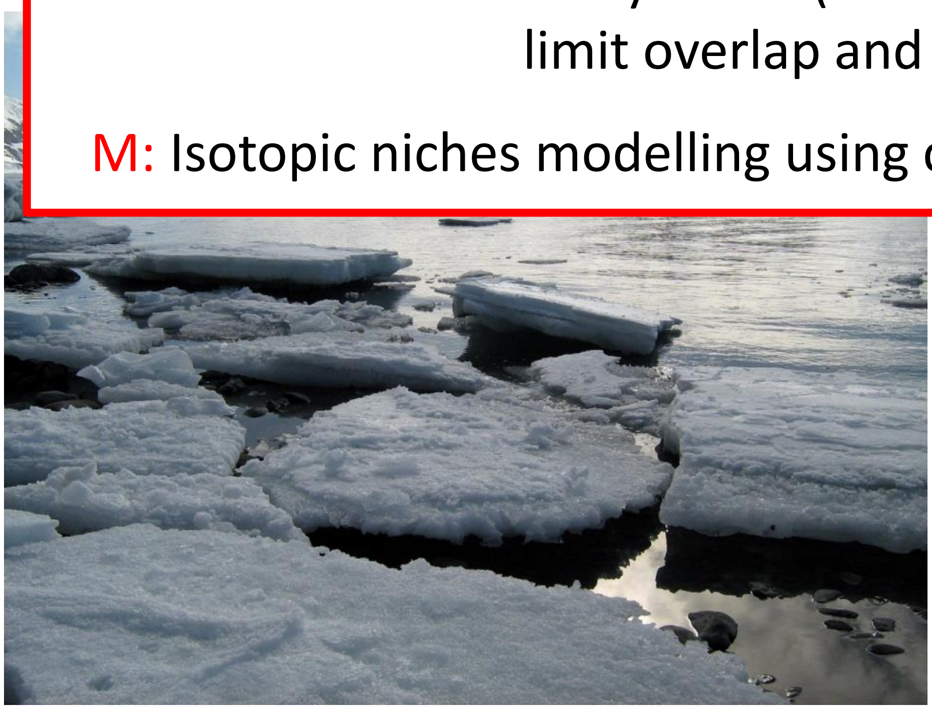
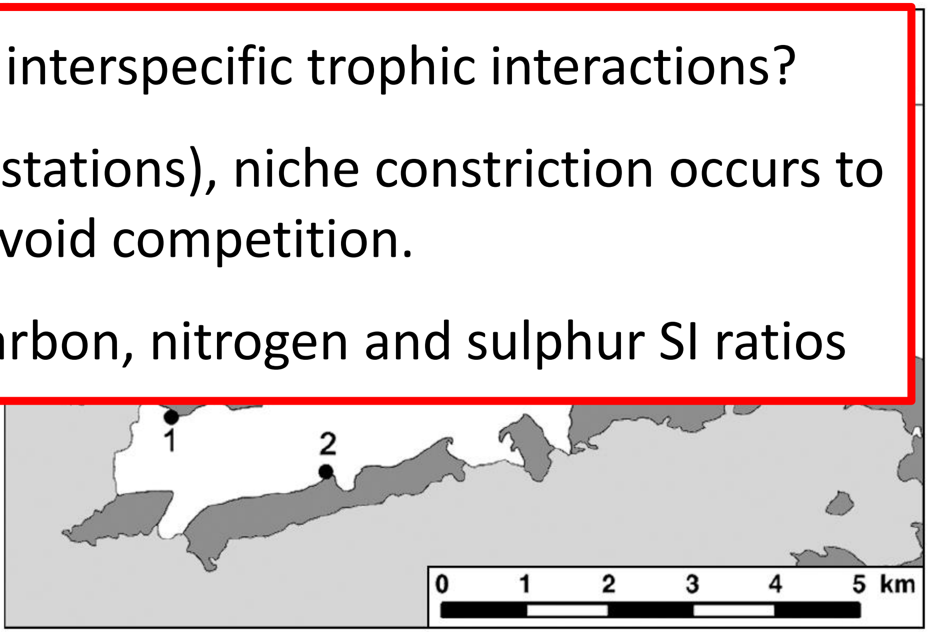
Q: Can habitat variations influence interspecific trophic interactions?

H: When food availability is low (inner stations), niche constriction occurs to limit overlap and avoid competition.

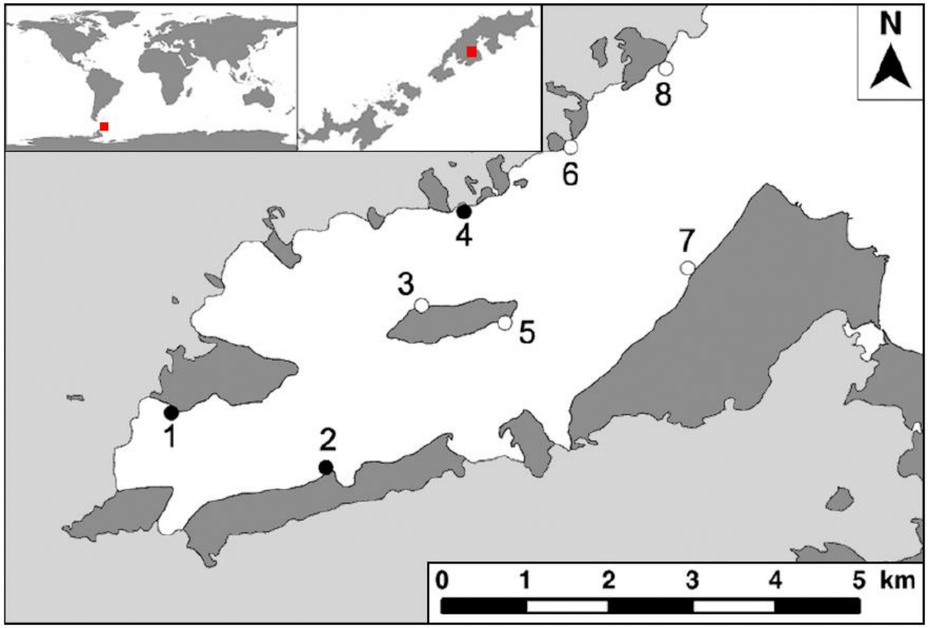
M: Isotopic niches modelling using carbon, nitrogen and sulphur SI ratios

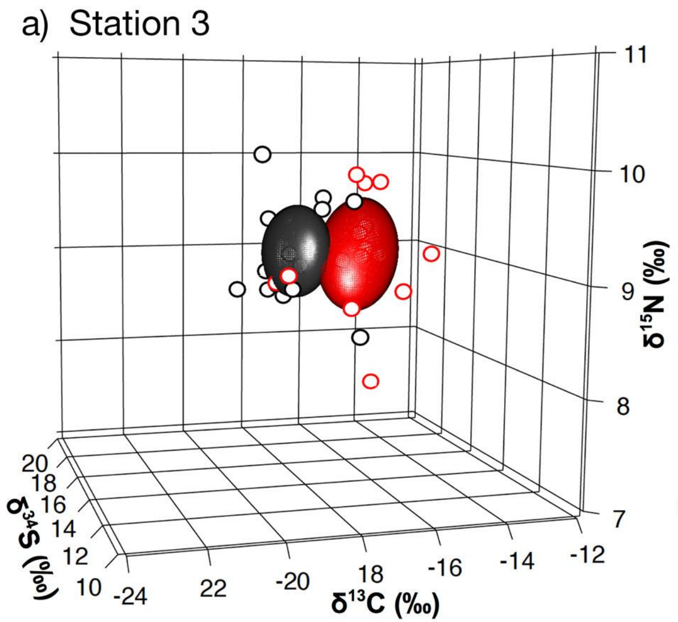


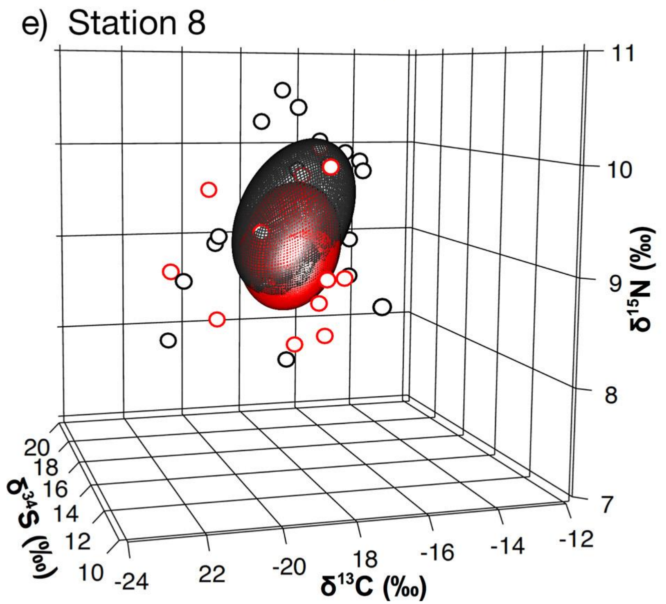



Ezcurra Inlet (King George Island, WAP): strong environmental gradients. High glacier disturbance: ↗ turbidity, ↘ salinity in inner stations.

# Multi-dimensional niche analysis



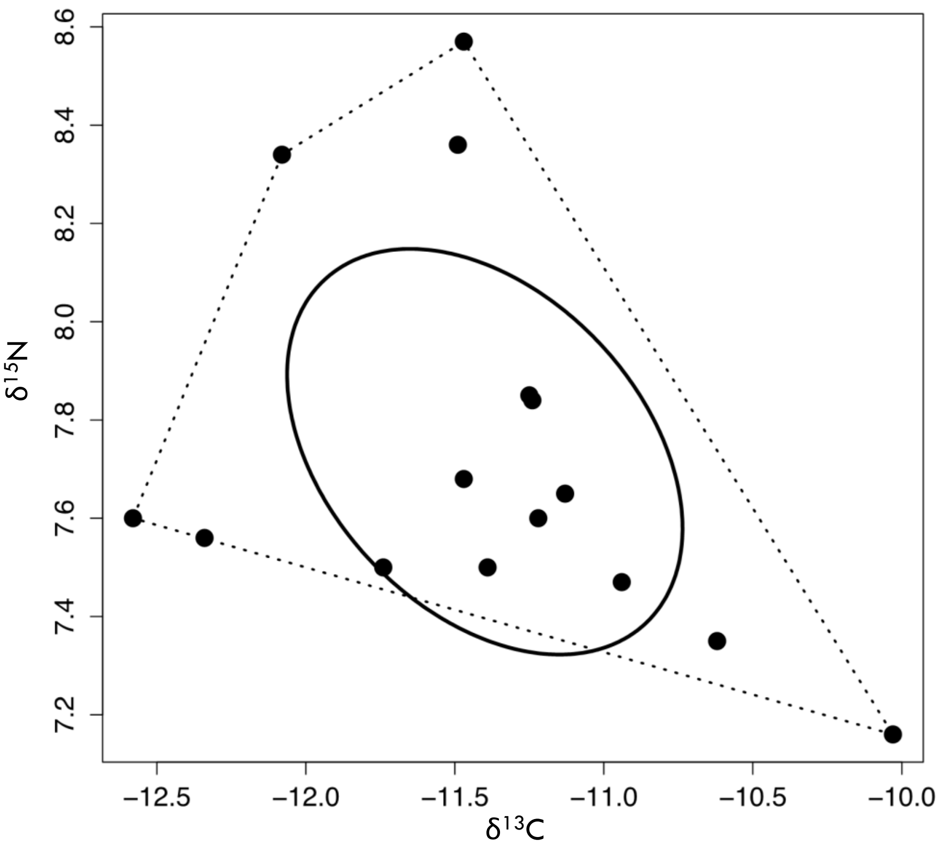




Interspecific niche overlap almost inexistent in inner stations (top) but very strong in outer stations (bottom)

Better seen at www.int-res.com/articles/suppl/m674p189_supp/m674p189_supp2.html

# Isotopic niches – a word of caution

The isotopic niche is a proxy! It is influenced by both resource and habitat use. Relative importance of those two drivers is case-dependent. Know your system.



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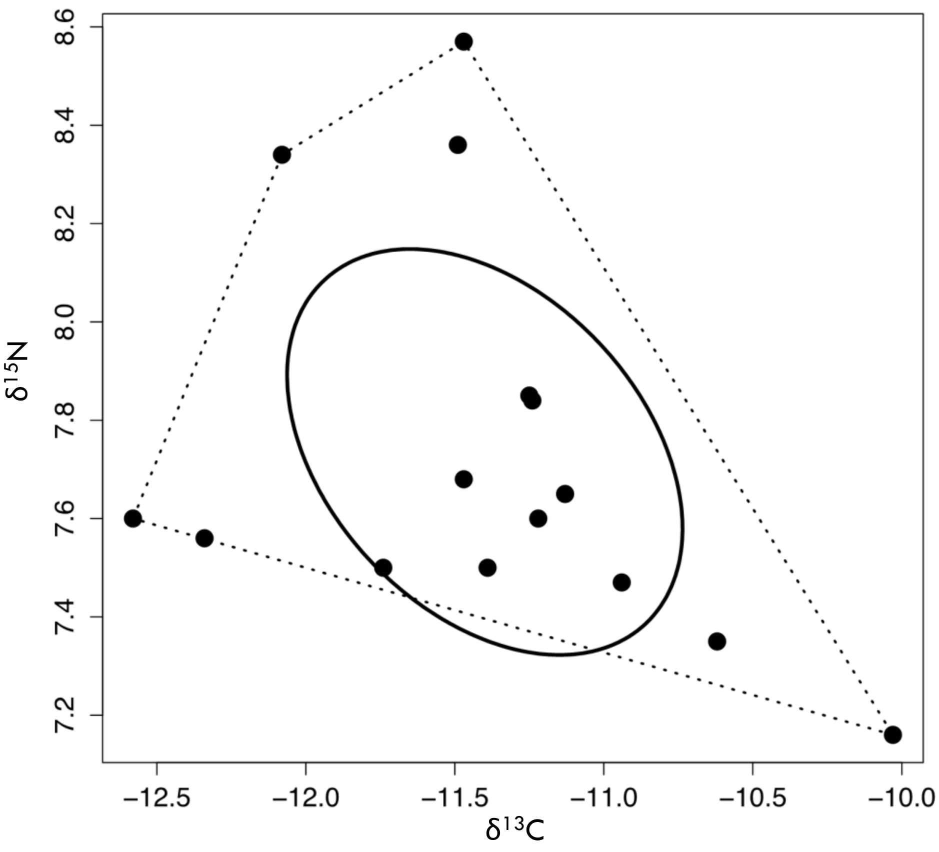

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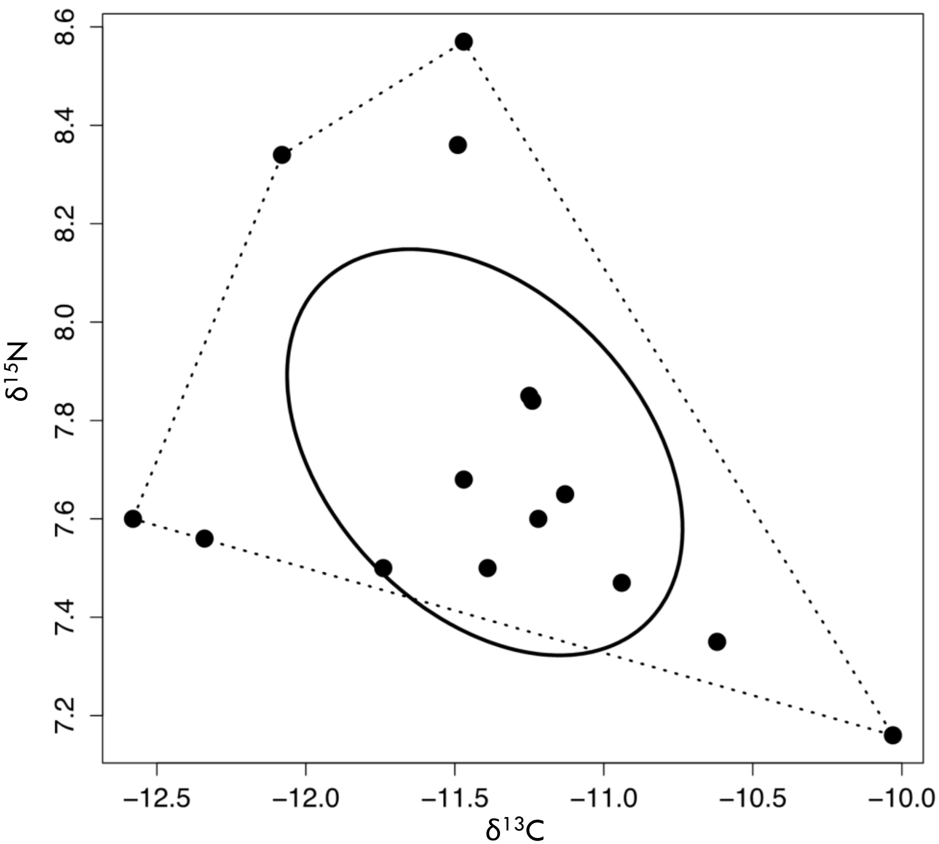


Although not necessary, isotopic data on food sources can help avoiding interpretation mistakes: adapt your sampling strategies.

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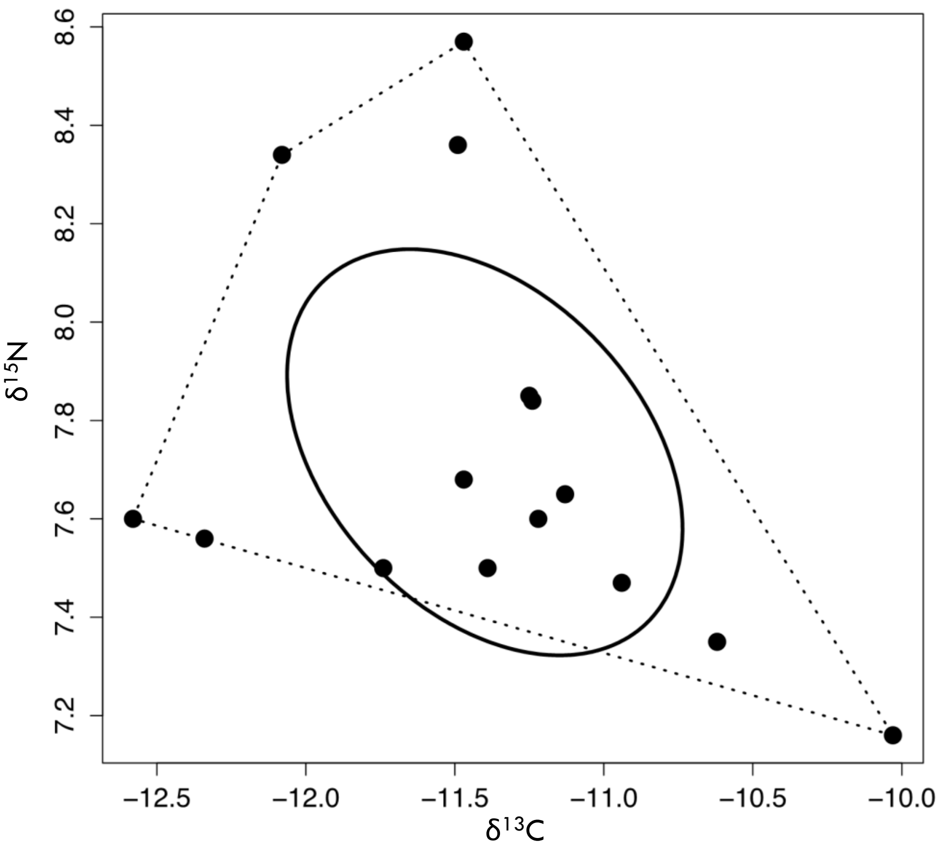


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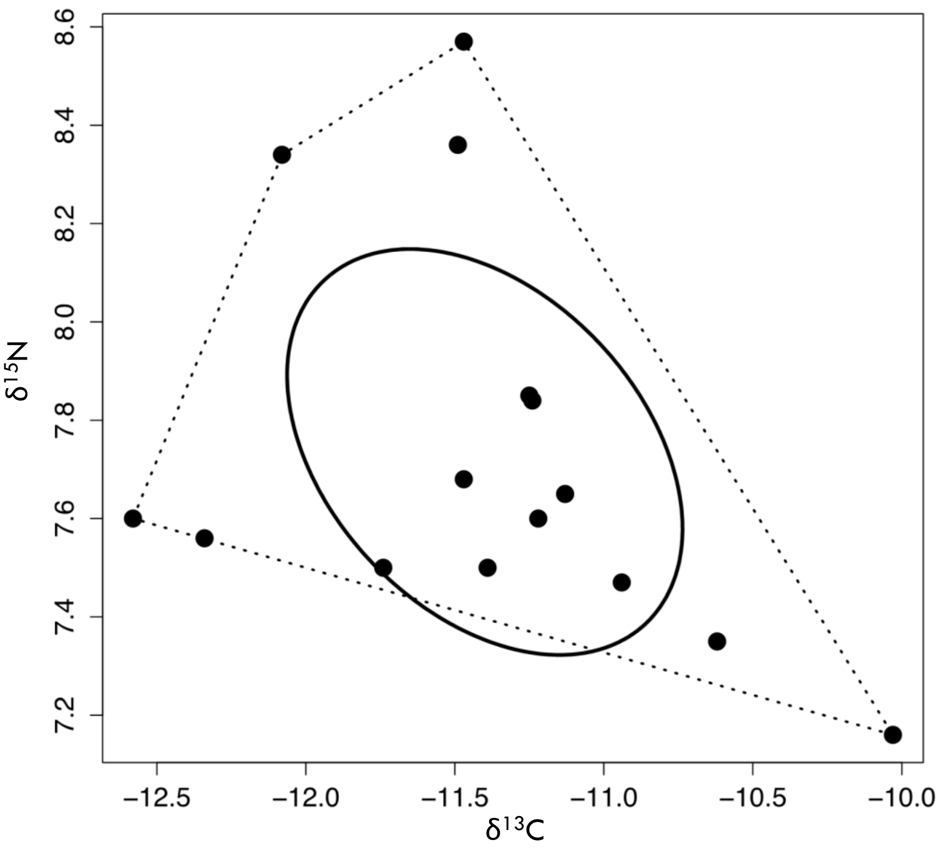
Avoid simplistic interpretations. Niche overlap does not necessarily mean competition. Large isotopic niche does not necessarily mean generalist consumer.

# Isotopic niches – a word of caution

"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



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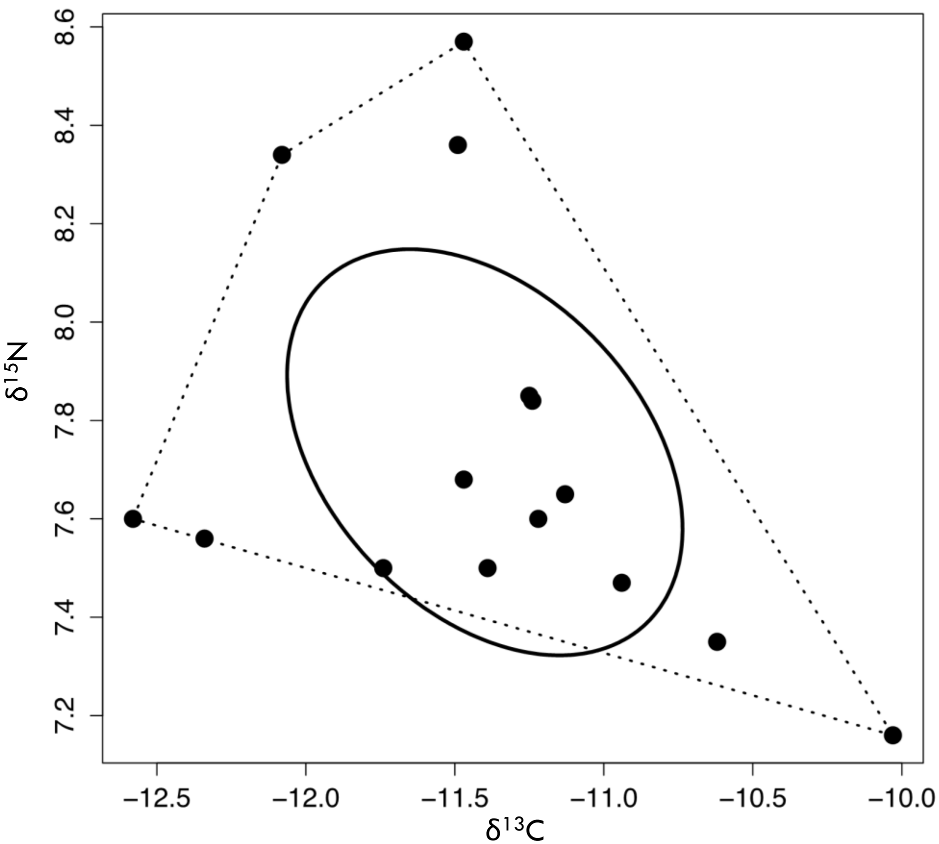


Isotopic niche study is a rapidly evolving field supported by many different approaches and concepts

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

# Thanks for your attention

Images: Kevin Ebi - livingwilderness.blogspot.com. Full sequence: vimeo.com/272024913

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