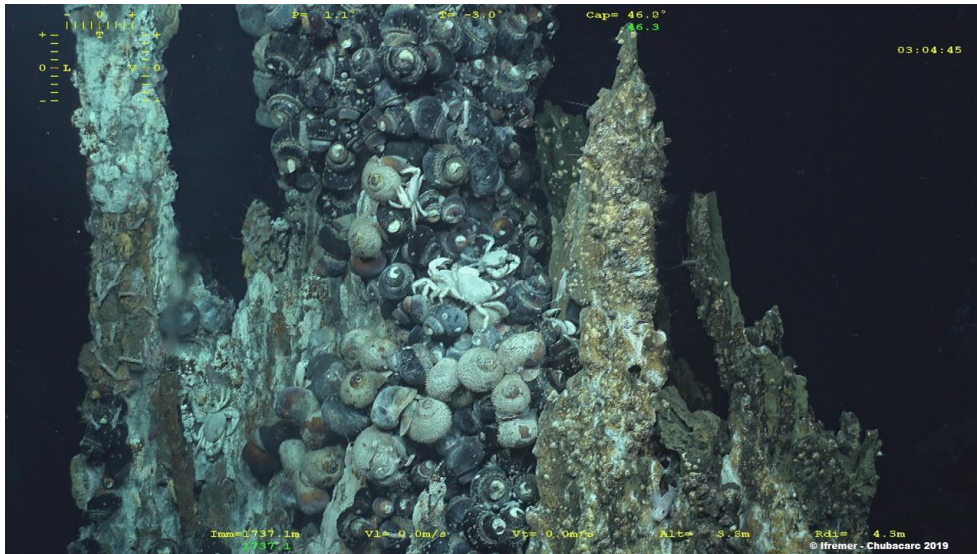


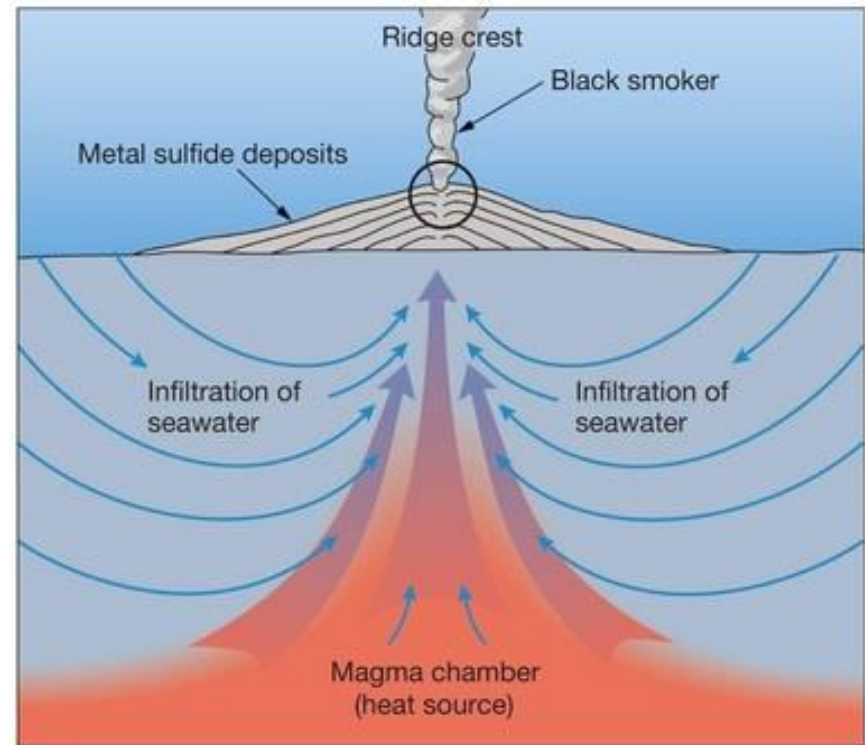
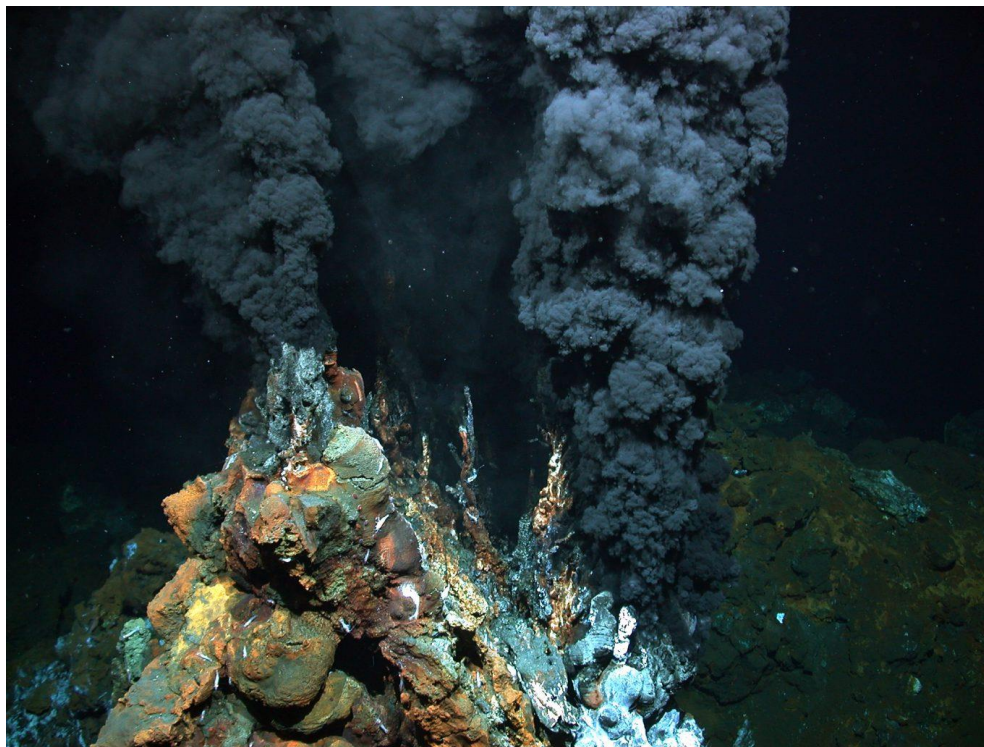
Food web structure and trophic interactions at the recently discovered deep-sea La Scala hydrothermal vent field (SW Pacific)



Loïc N. MICHEL, Simon GOURDON, Alizé BOURIAT, Eve-Julie PERNET, Eric THIEBAUT, Didier JOLLIVET & Gilles LEPOINT

Hydrothermal vents

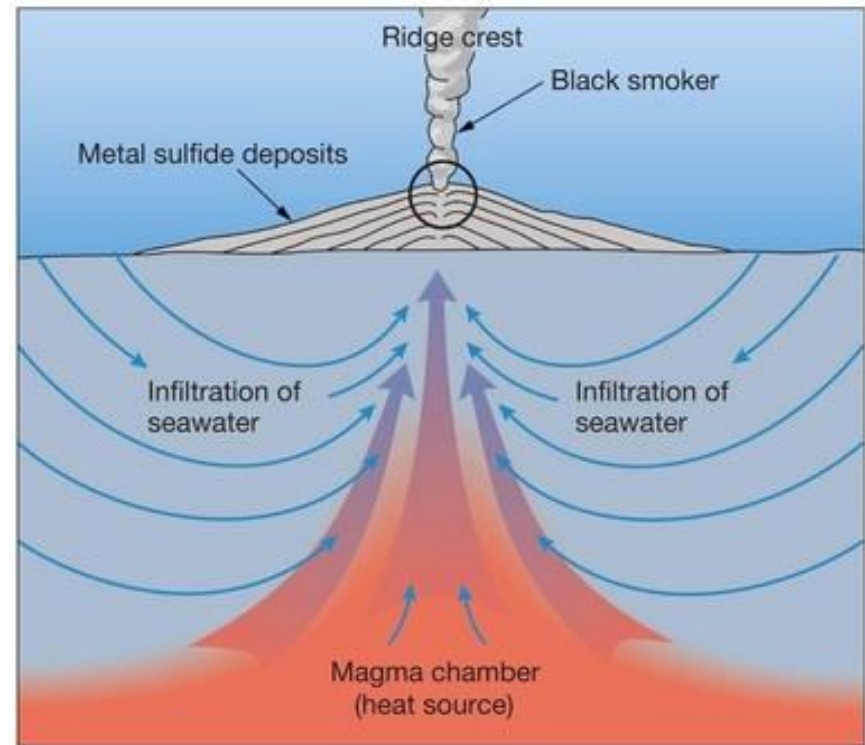
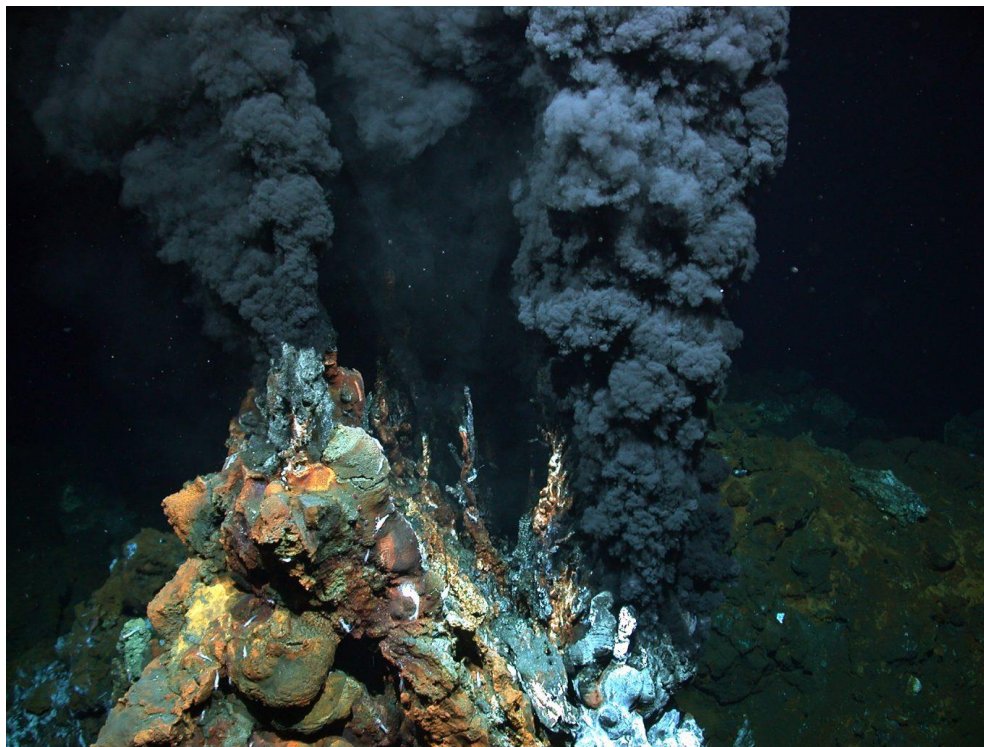
Hydrothermal vents are fissures in the seafloor found in geologically active areas (e.g. oceanic ridges), where **seawater** infiltrates and, after interaction with **magma**, resurfaces as **hydrothermal fluid**.



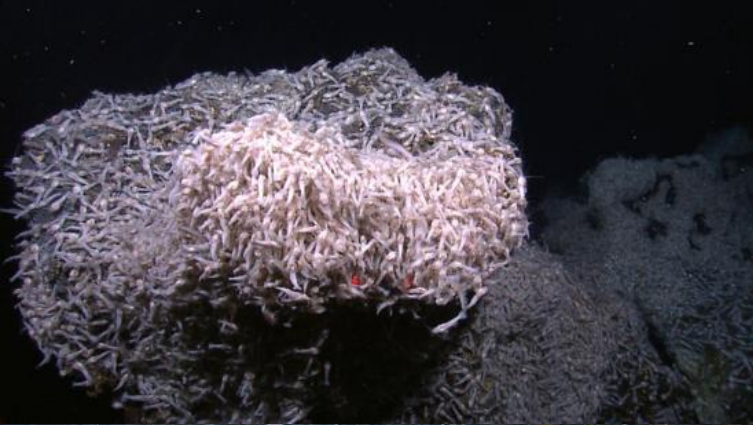
Hydrothermal vents

Hydrothermal vents are fissures in the seafloor found in geologically active areas (e.g. oceanic ridges), where **seawater** infiltrates and, after interaction with **magma**, resurfaces as **hydrothermal fluid**.

This hydrothermal fluid is **hot** (sometimes several hundreds of degrees), **anoxic** and rich in **sulfides** and **metallic compounds**.

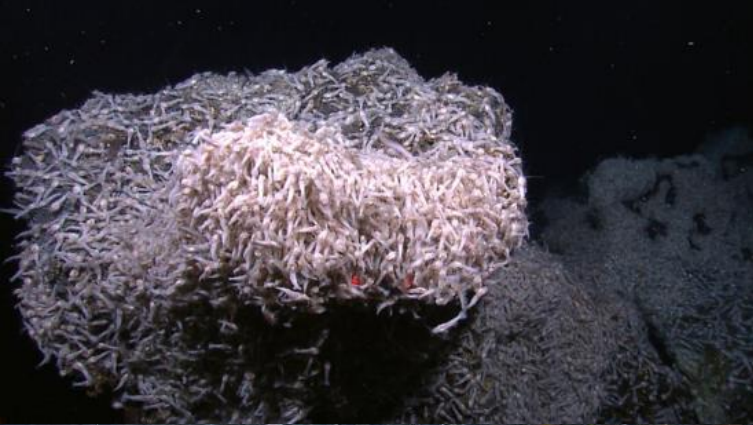


Hydrothermal vents



The mixing of hydrothermal fluid with cold and oligotrophic deep seawater creates environmental gradients where **chemosynthetic micro-organisms** thrive

Hydrothermal vents



The mixing of hydrothermal fluid with cold and oligotrophic deep seawater creates environmental gradients where **chemosynthetic micro-organisms** thrive

Those micro-organisms in turn **support**, through symbiosis or otherwise, dense **communities** of **specialized organisms** that can withstand the extreme environmental conditions

Hydrothermal vents



≠

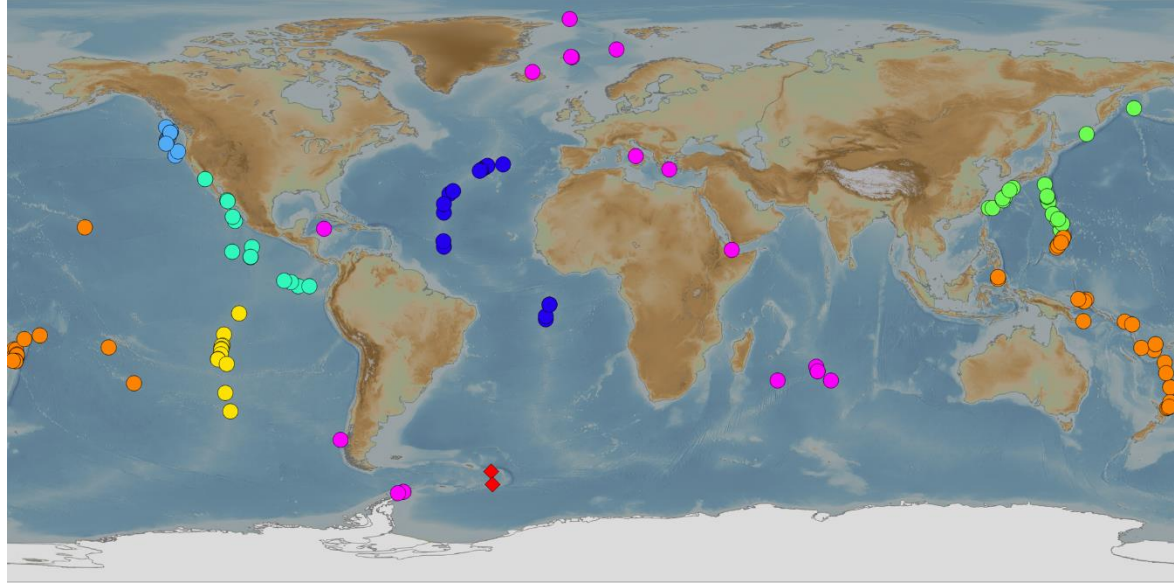


In the deep sea, hydrothermal vents form **highly productive** and specific habitats **strongly contrasting** with other ecosystems such as abyssal plains

Hydrothermal vents

Discrete distribution along
oceanic ridges

Biological **connectivity**?

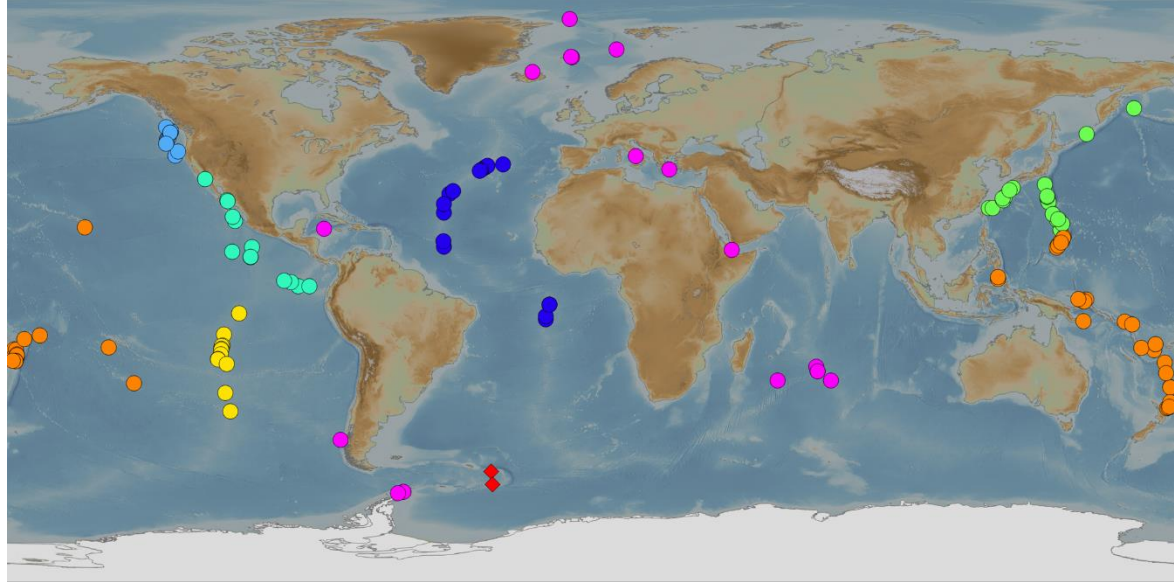


Energy flux towards surrounding
habitats?

Hydrothermal vents

Discrete distribution along
oceanic ridges

Biological **connectivity**?



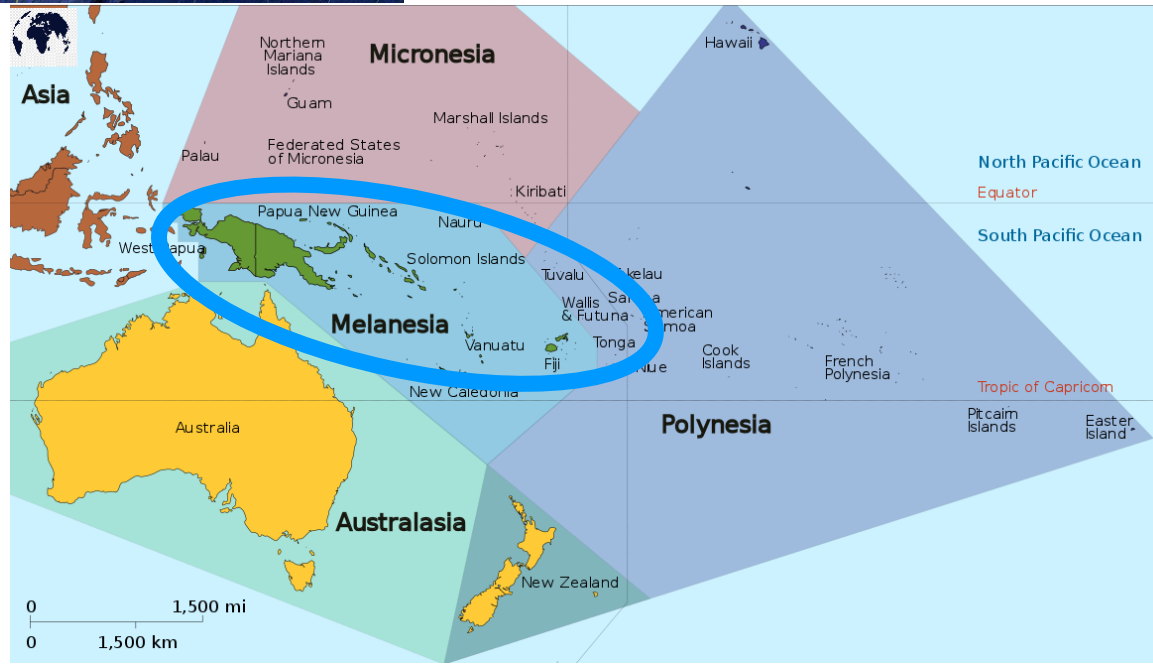
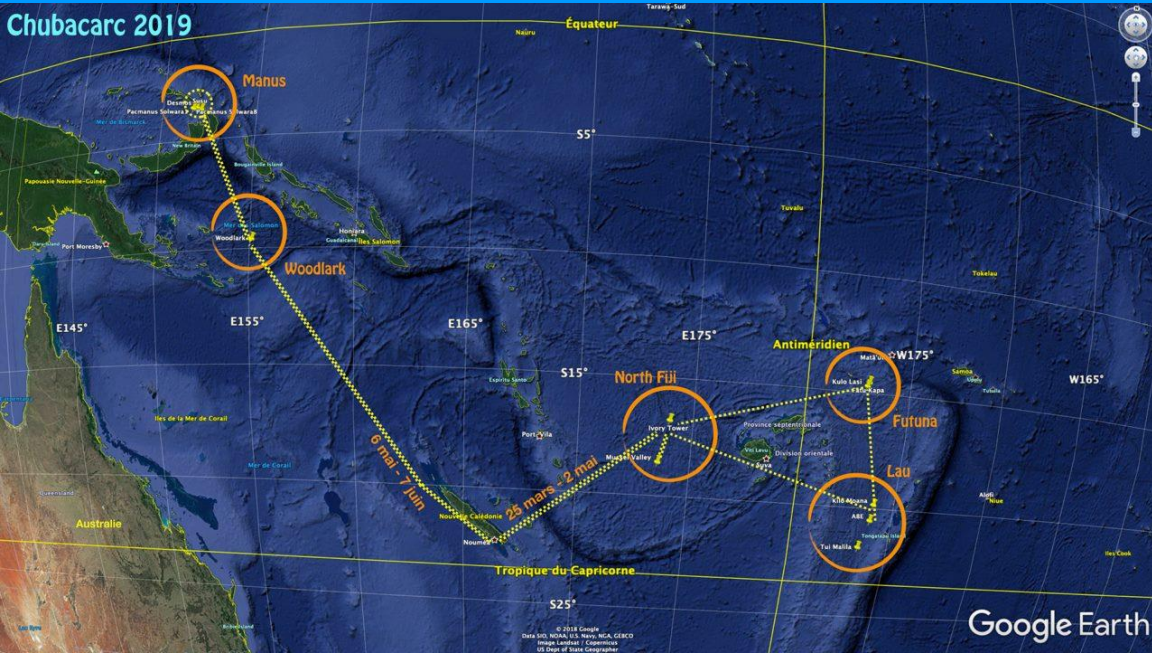
Energy flux towards surrounding
habitats?

"**Stepping stone**" hypothesis



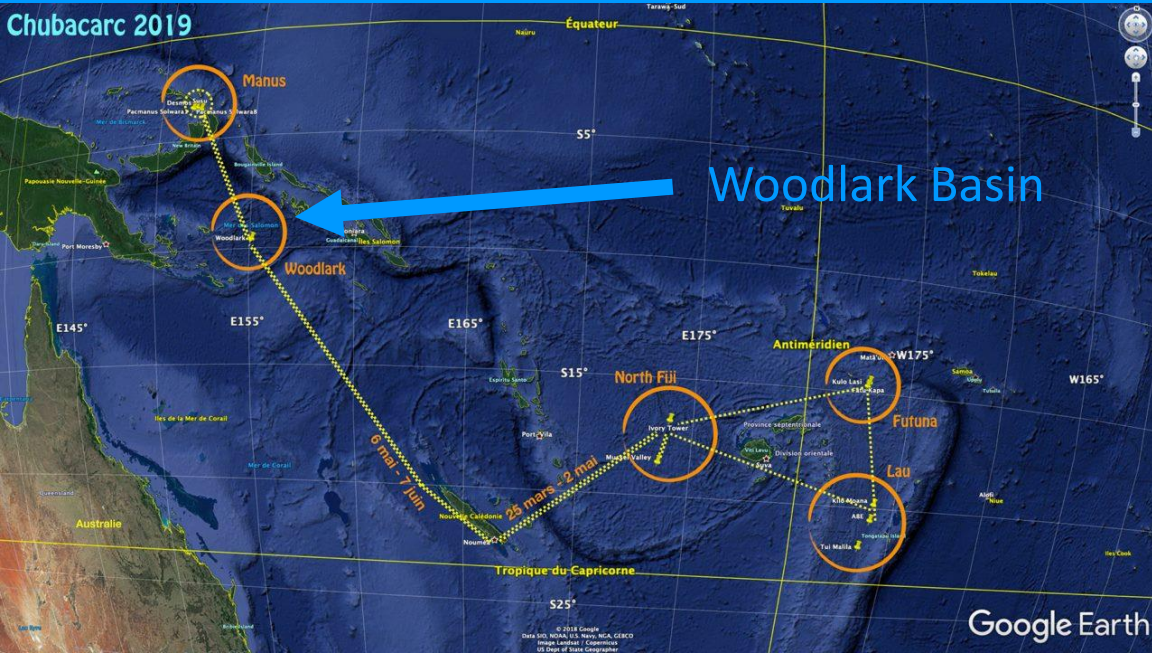
Geographical context: SW Pacific

Chubacarc 2019



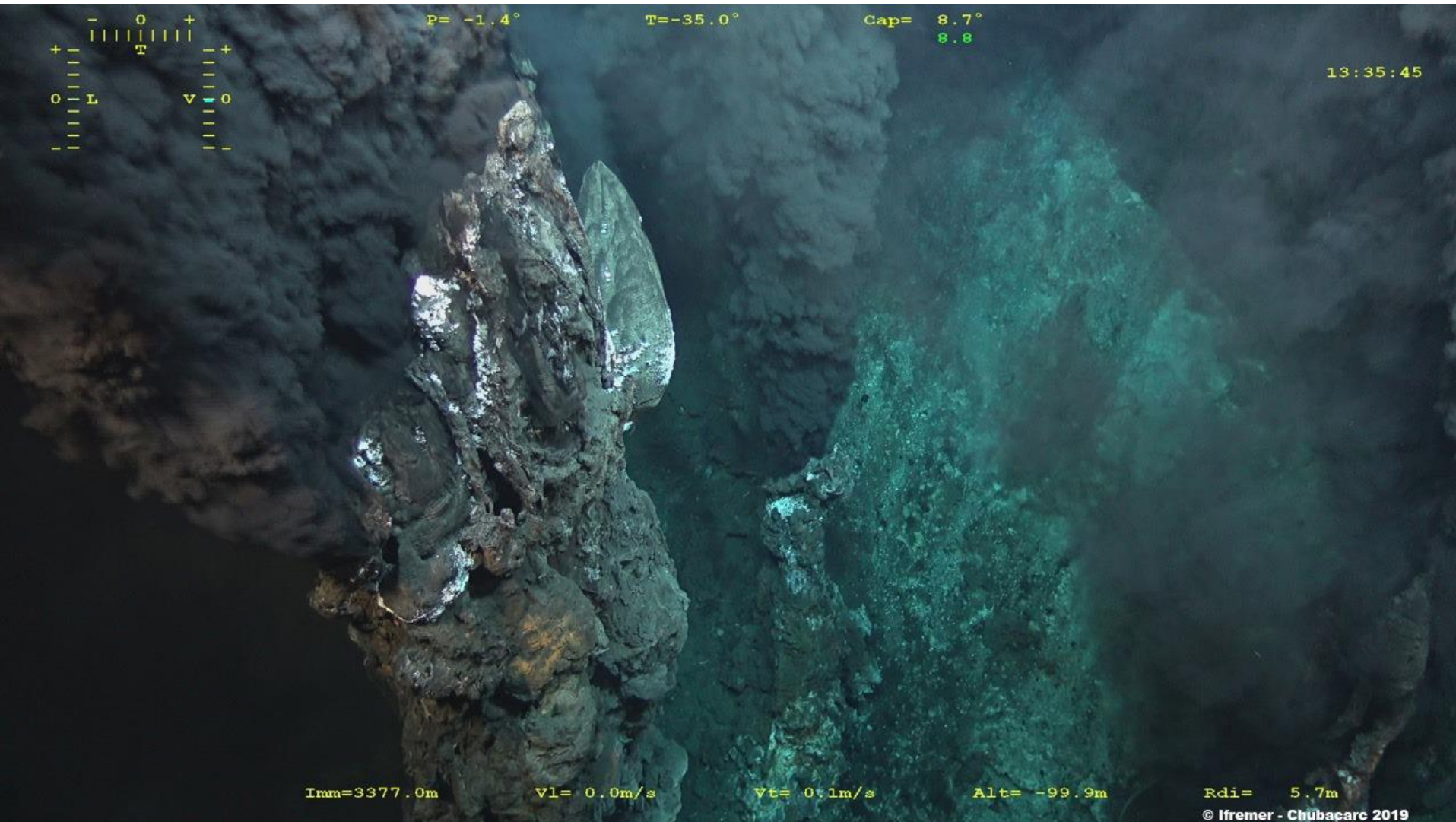
Geographical context: SW Pacific

Chubacarc 2019



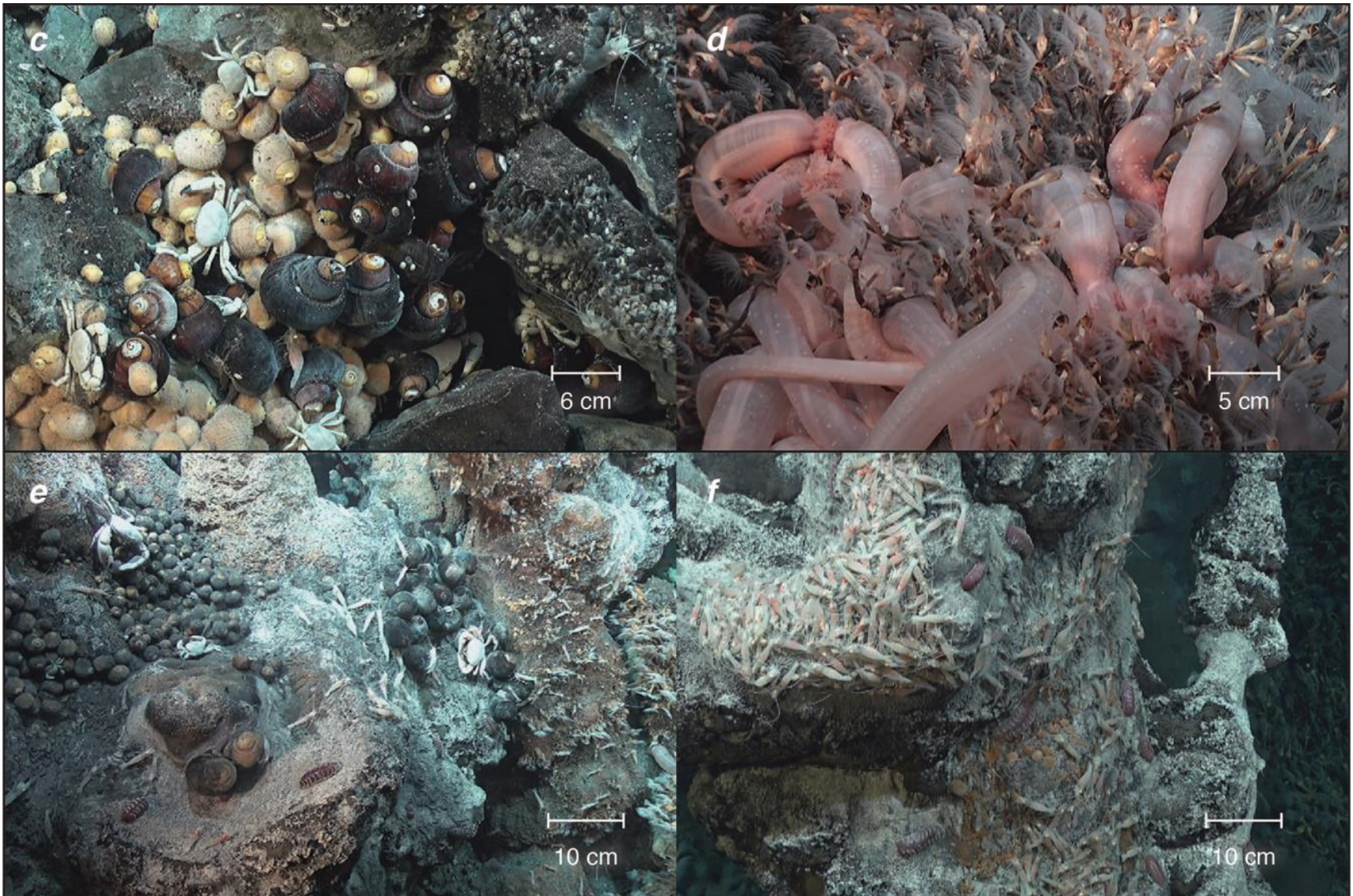
New hydrothermal field: La Scala

Several active smokers, depth ≈ 3400 m

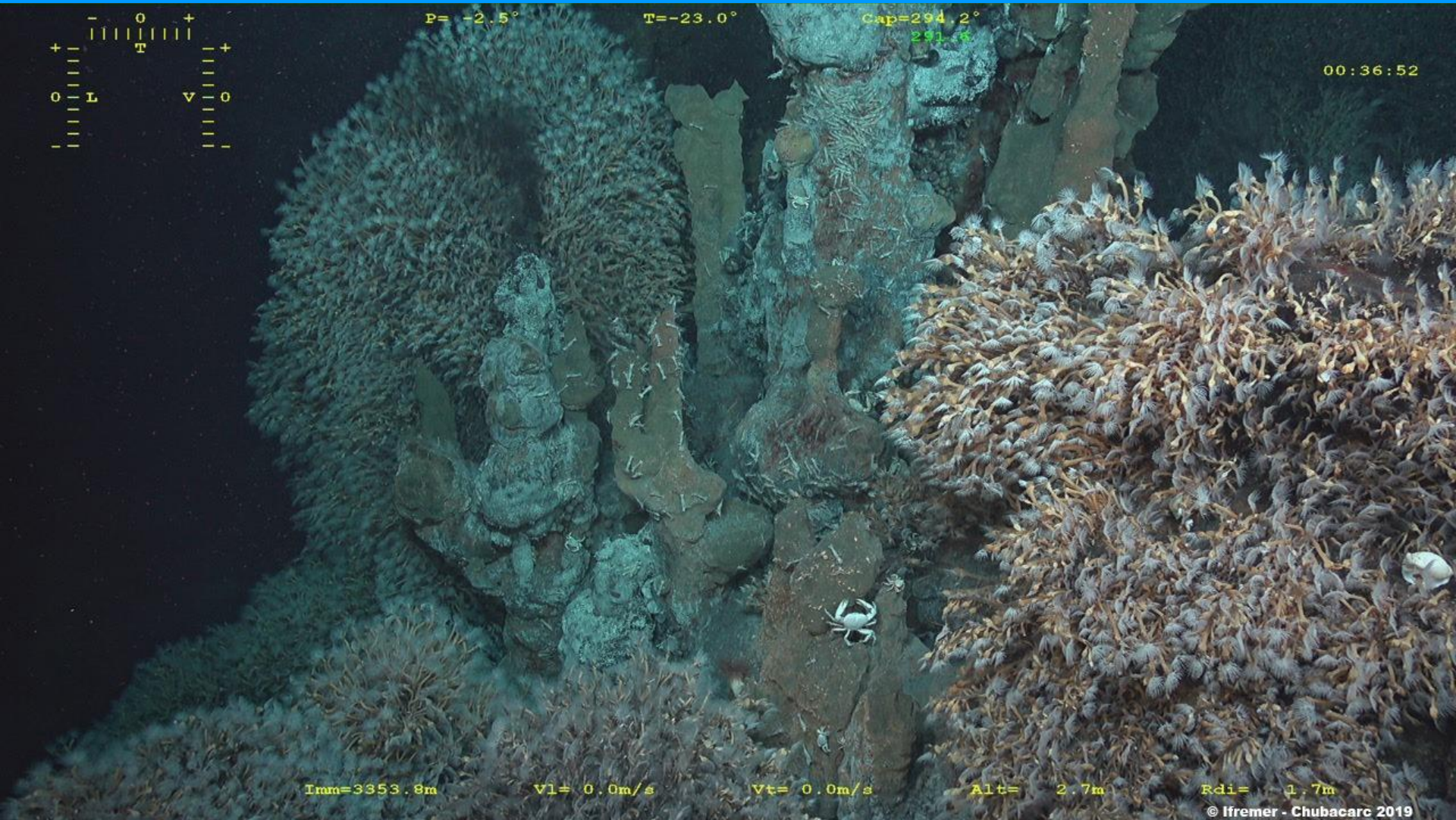


New hydrothermal field: La Scala

Close to active chimneys: communities dominated by **symbiont-bearing gastropods** that act as **foundation species**



New hydrothermal field: La Scala



On inactive chimneys and peripheral zones: dense **cirriped bushes**
Unique in SW Pacific hydrothermal vents, but described in nearby oceanic trenches
(e.g. Tonga)

Objectives

Document **functional ecology** of this newly discovered system



Objectives

Document **functional ecology** of this newly discovered system

Identify main **production pathways** supporting animal populations

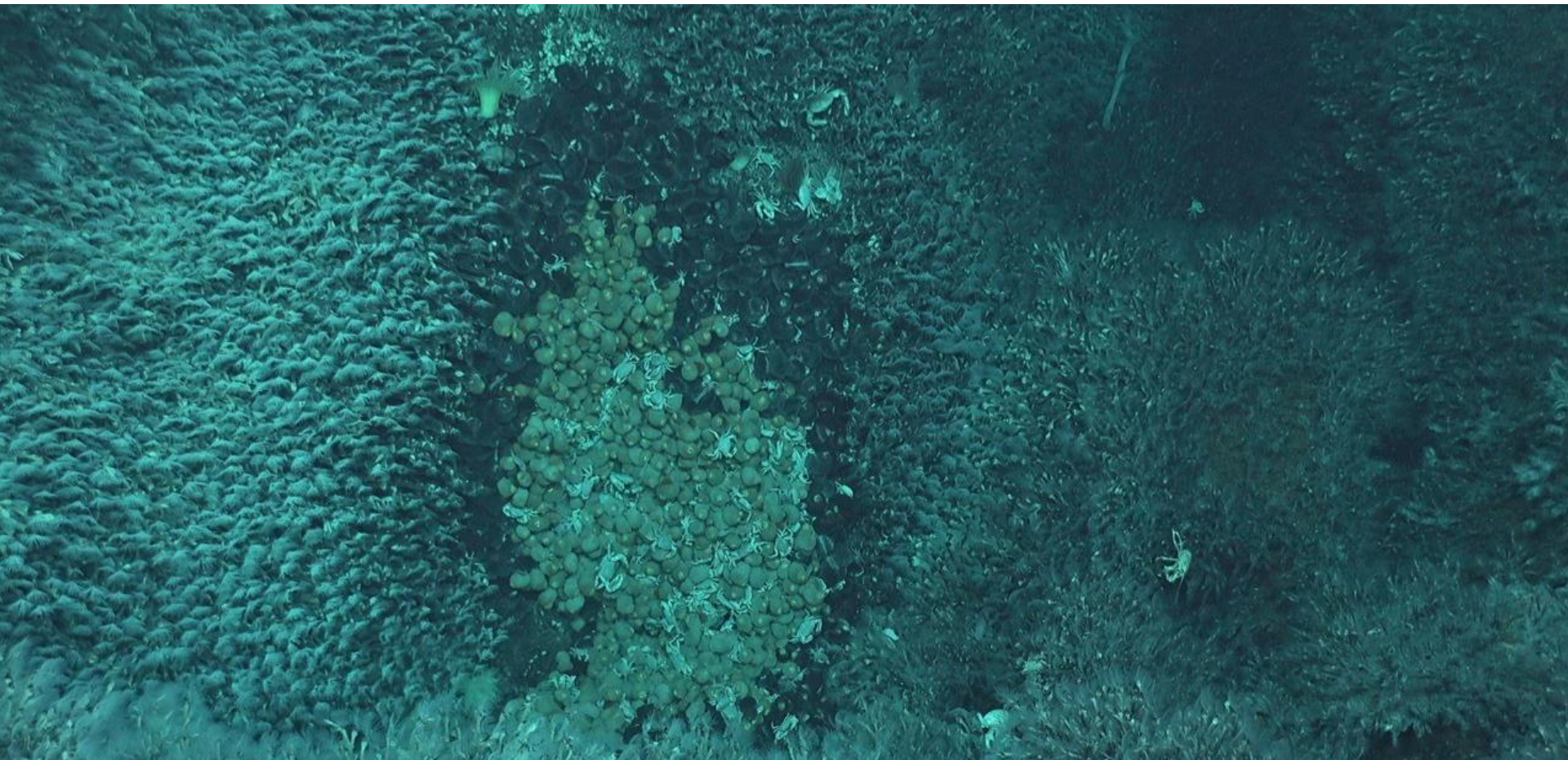


Objectives

Document **functional ecology** of this newly discovered system

Identify main **production pathways** supporting animal populations

Assess potential **energy fluxes** between **active** sites and **inactive**, peripheral habitats



Objectives

Document **functional ecology** of this newly discovered system

Identify main **production pathways** supporting animal populations

Assess potential **energy fluxes** between **active** sites and **inactive**, peripheral habitats

Compare **trophic ecology** of **foundation species** with better known **adjacent basins**



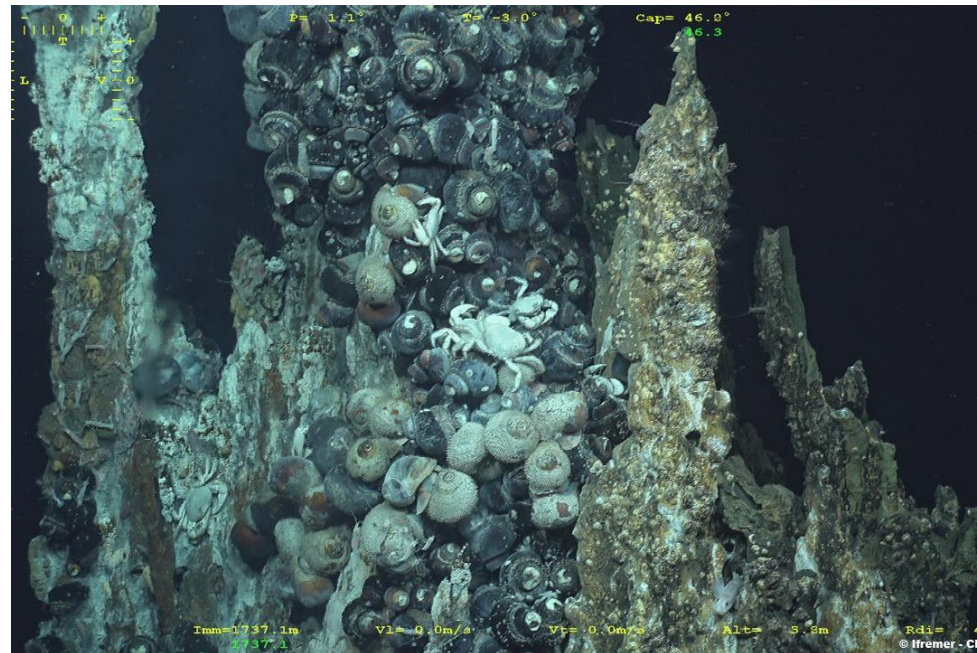
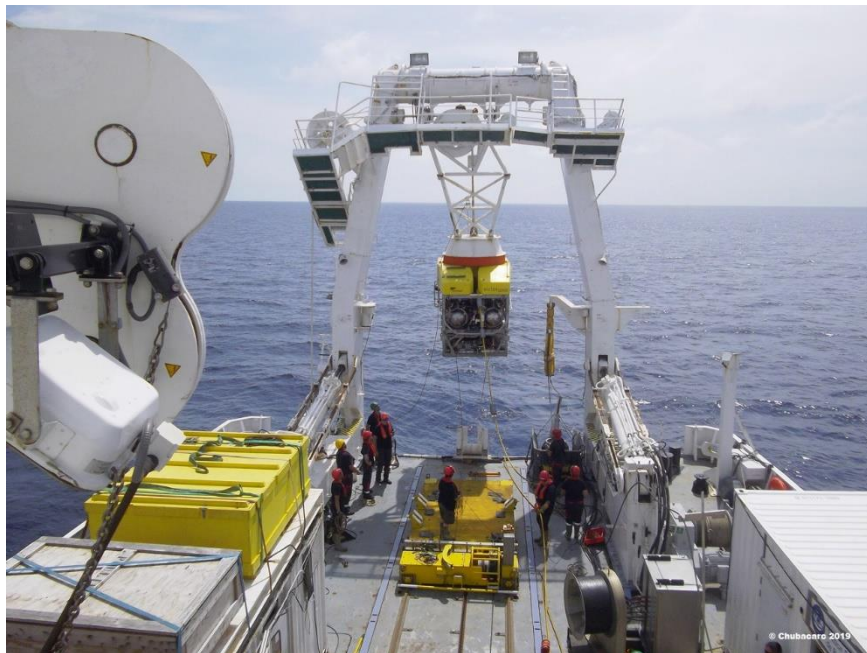
Strategy



ROV sampling of biomass-dominant benthic fauna

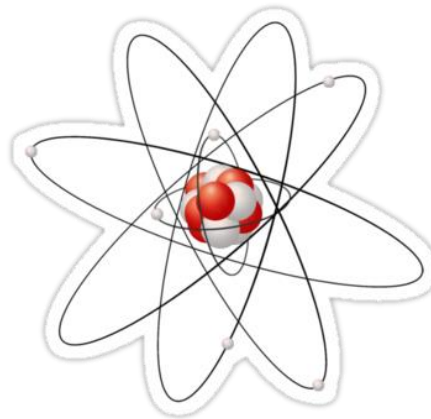
Dissection and extraction of relevant tissues

Use of stable isotope ratios of C, N and S



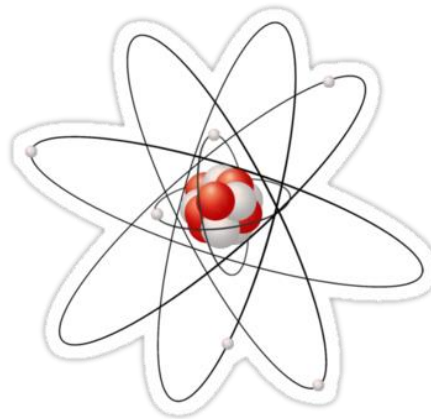
Stable isotopes: you are what you eat

Stable isotope ratios in animals can be used as integrative **trophic markers** (indirect info on animal diet)



Stable isotopes: you are what you eat

Stable isotope ratios in animals can be used as integrative **trophic markers** (indirect info on animal diet)

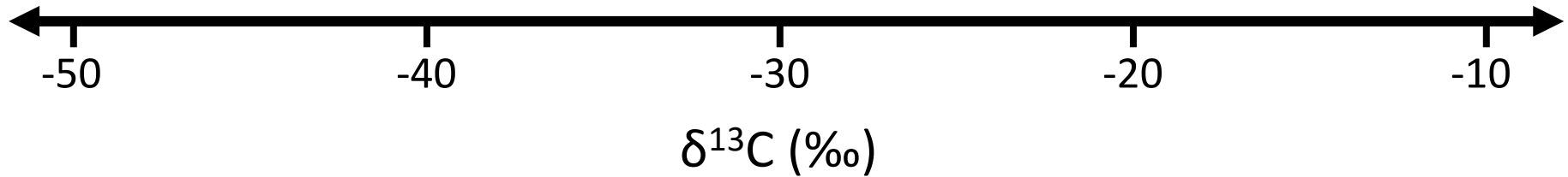


Mixing law: stable isotope composition of an **animal** is a **proportional mix** of its **food sources'** isotopic compositions



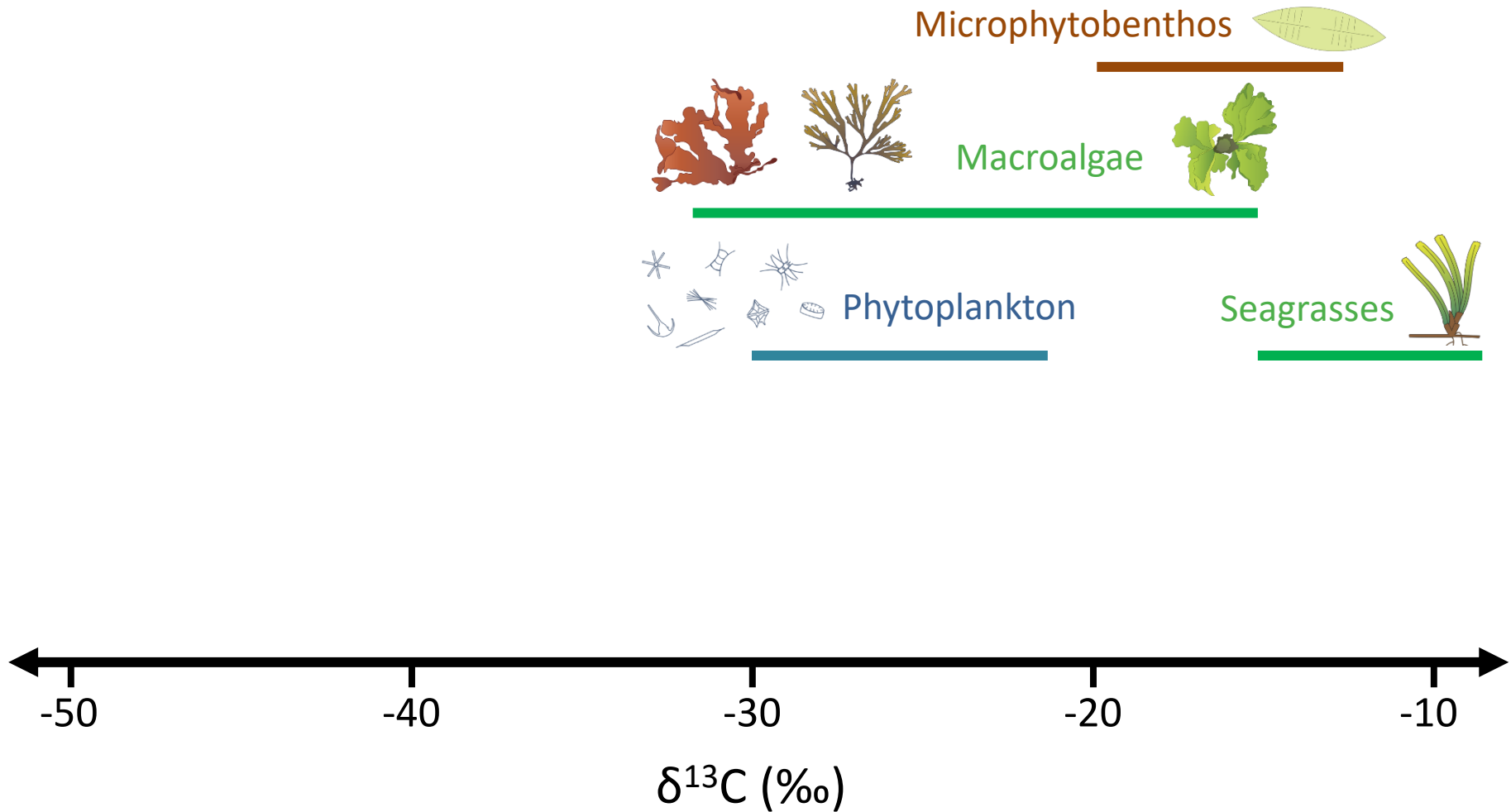
By measuring the **isotopic compositions** of an animal and those of its food sources, it is possible to estimate the **contribution** of each **food source** to the animal's diet

Carbon stable isotopes



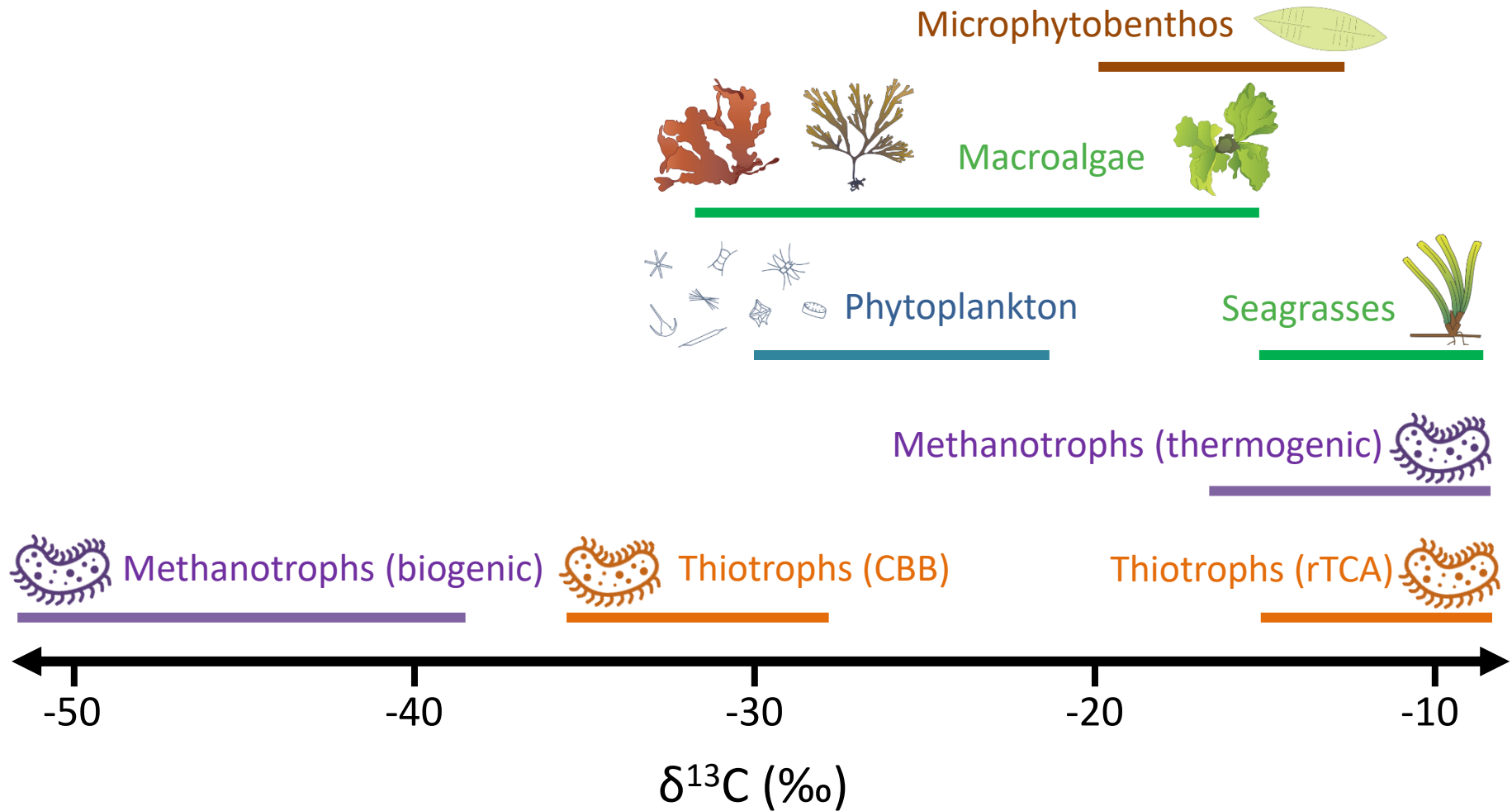
$\delta^{13}\text{C}$ of marine producers is **variable** and mostly **conserved** throughout the food web

Carbon stable isotopes



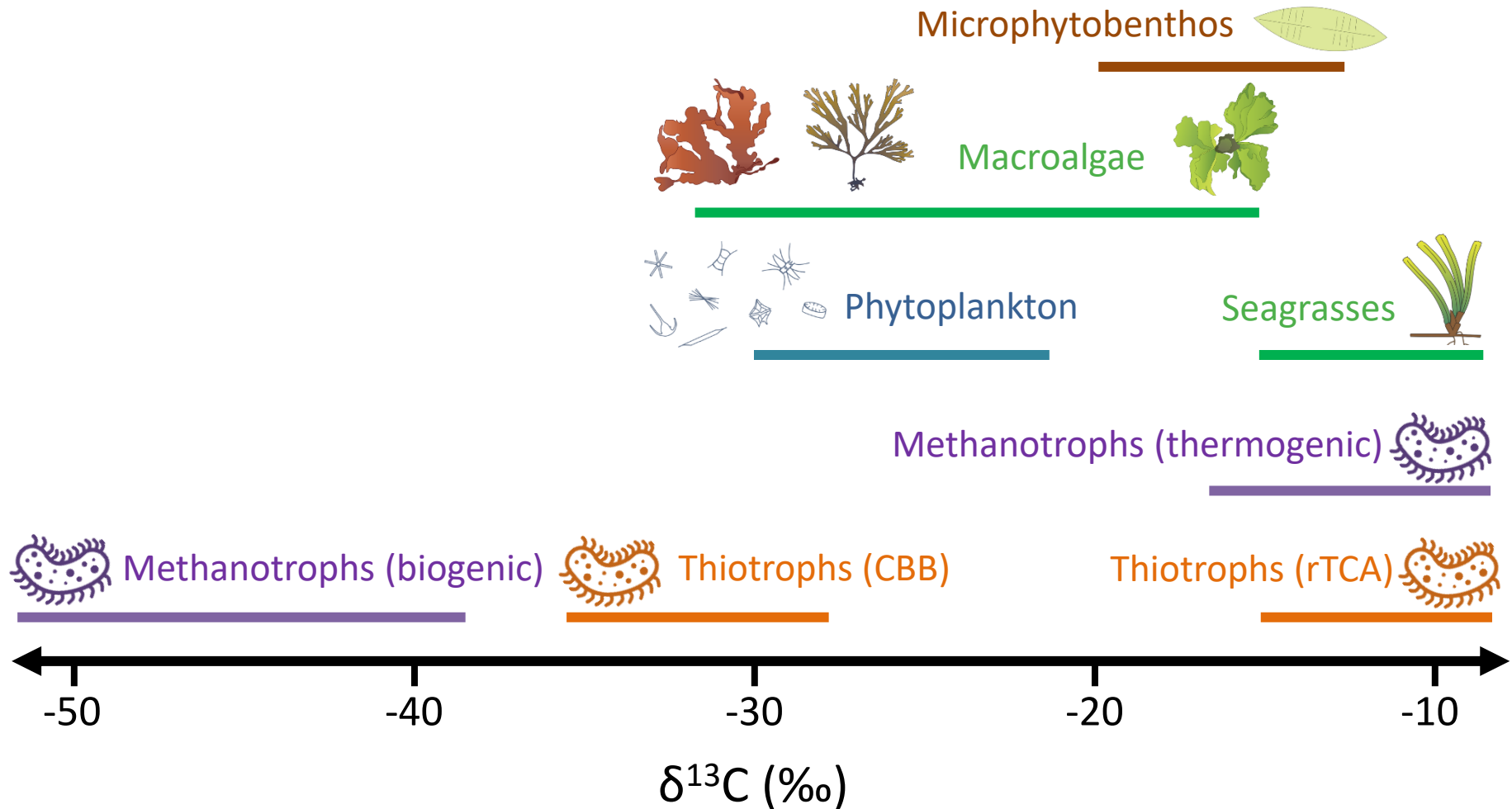
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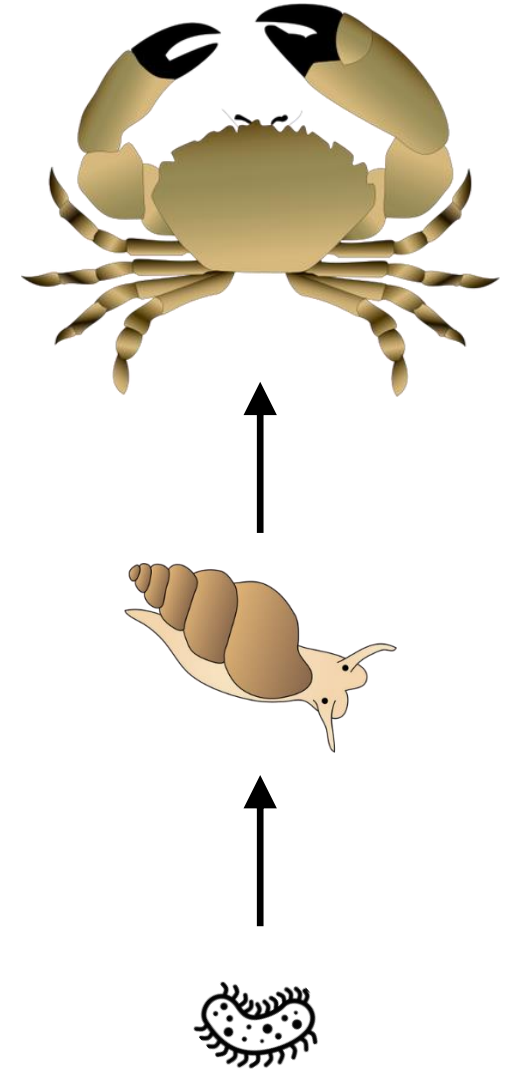
$\delta^{13}\text{C}$ of marine producers is **variable** and mostly **conserved** throughout the food web

$\delta^{13}\text{C}$ can be used to **identify** and **quantify** relative contributions of **production mechanisms** supporting animal populations in marine ecosystems

Nitrogen stable isotopes

Higher trophic position

Higher
 $\delta^{15}\text{N}$ (‰)
Lower

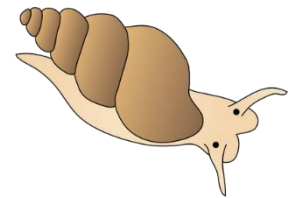
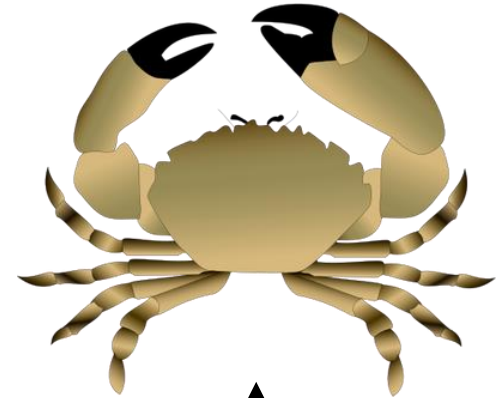


Lower trophic position

Nitrogen stable isotopes

Higher trophic position

Higher
 $\delta^{15}\text{N}$ (‰)
Lower



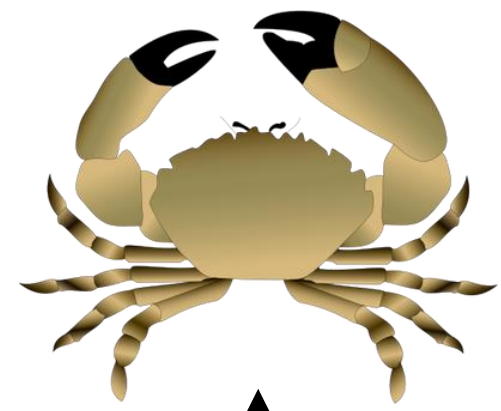
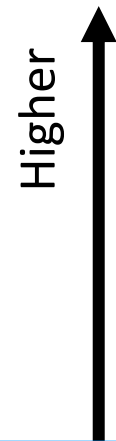
Lower trophic position

Producers using NO_3^-

Producers using NH_4^+

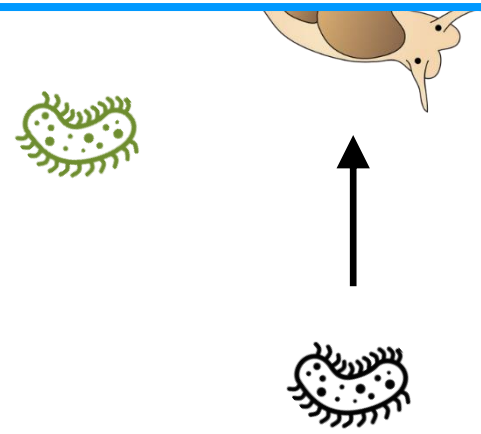
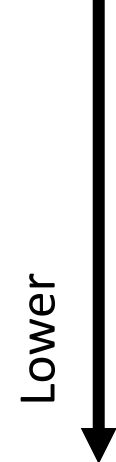
Nitrogen stable isotopes

Higher trophic position



$\delta^{15}\text{N}$: tracer of trophic position + inorganic nitrogen source(s) of baseline producers

$\delta^{15}\text{N}$



Producers using NO_3^-

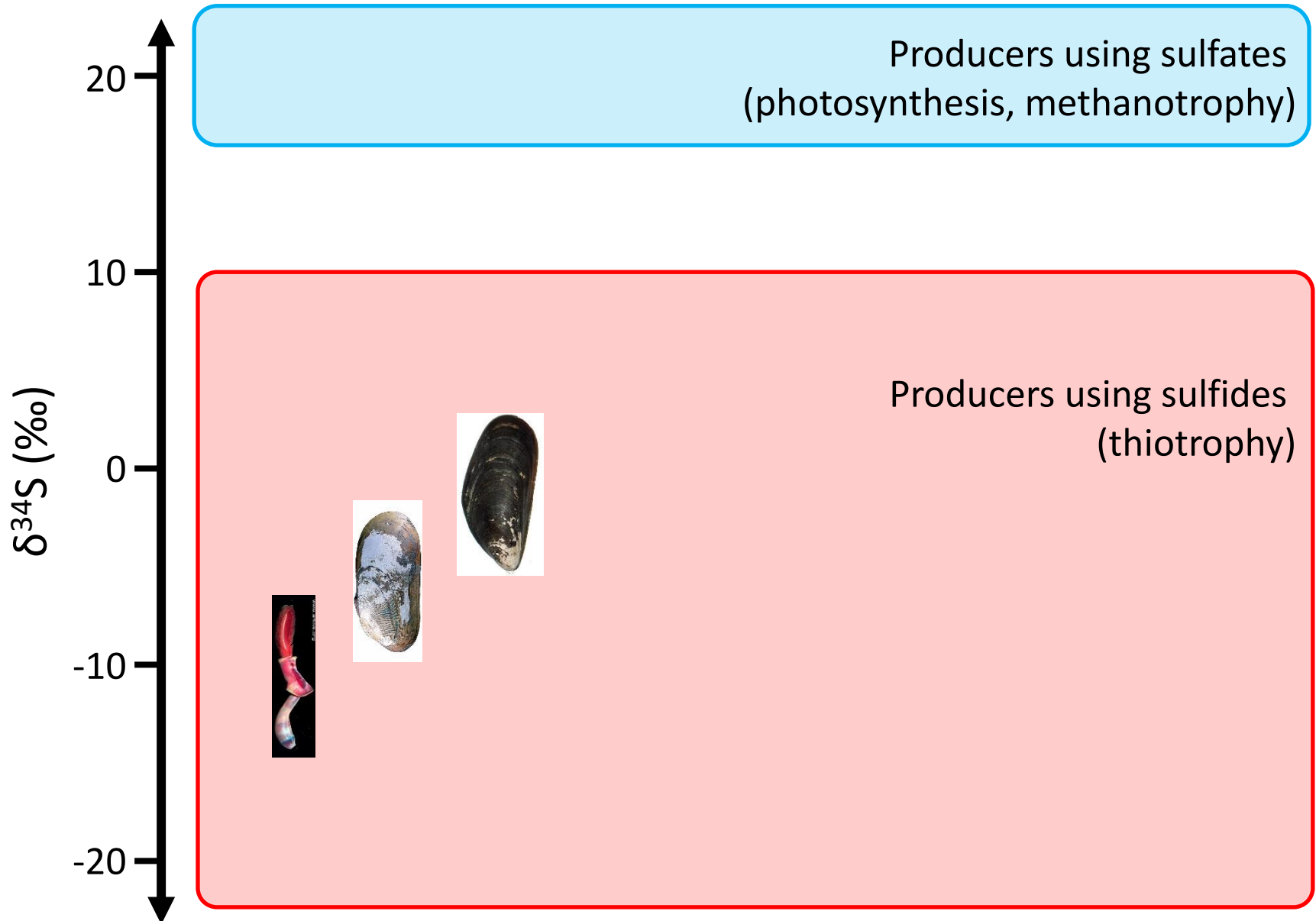
Lower trophic position

Producers using NH_4^+

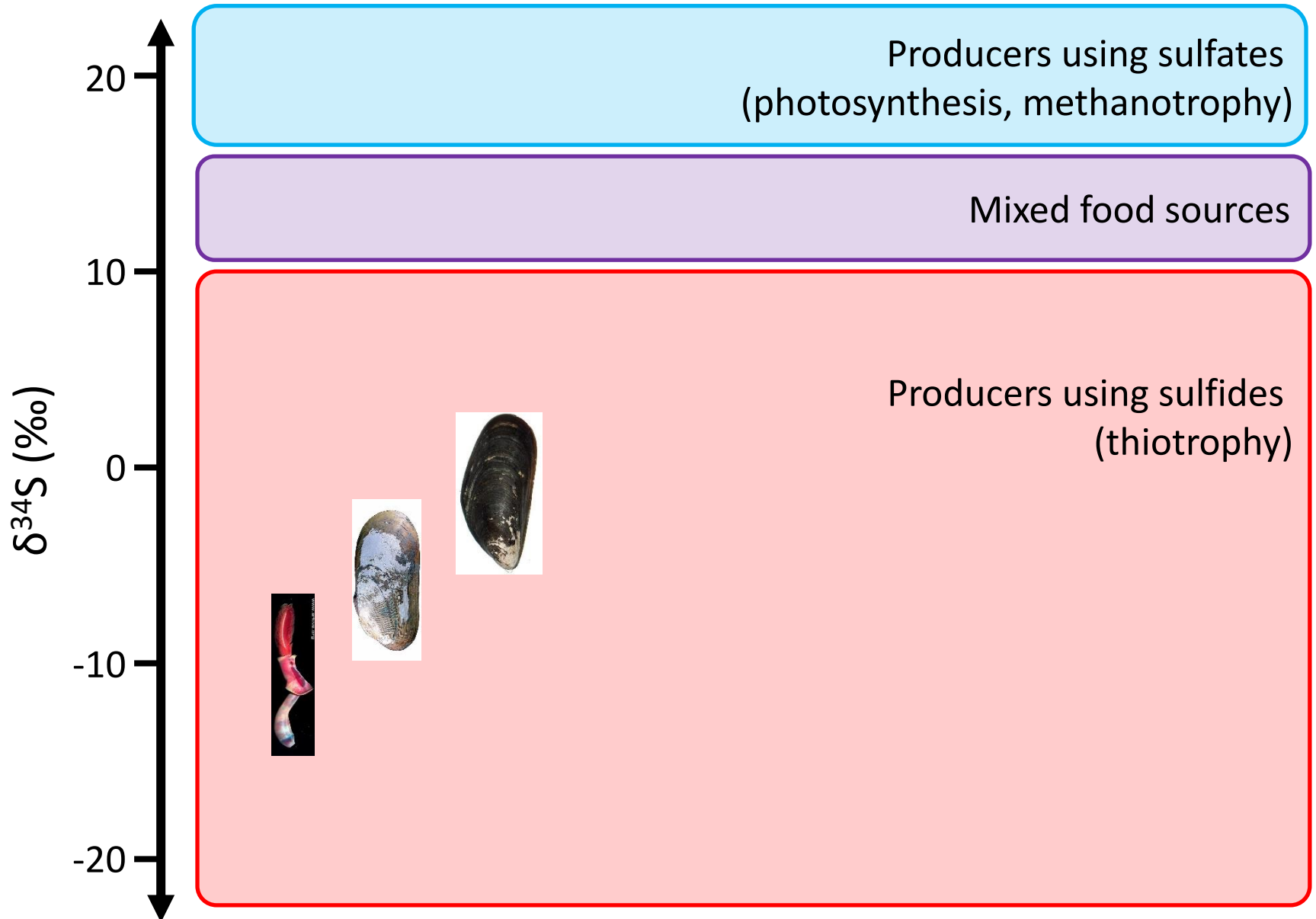
Sulfur stable isotopes



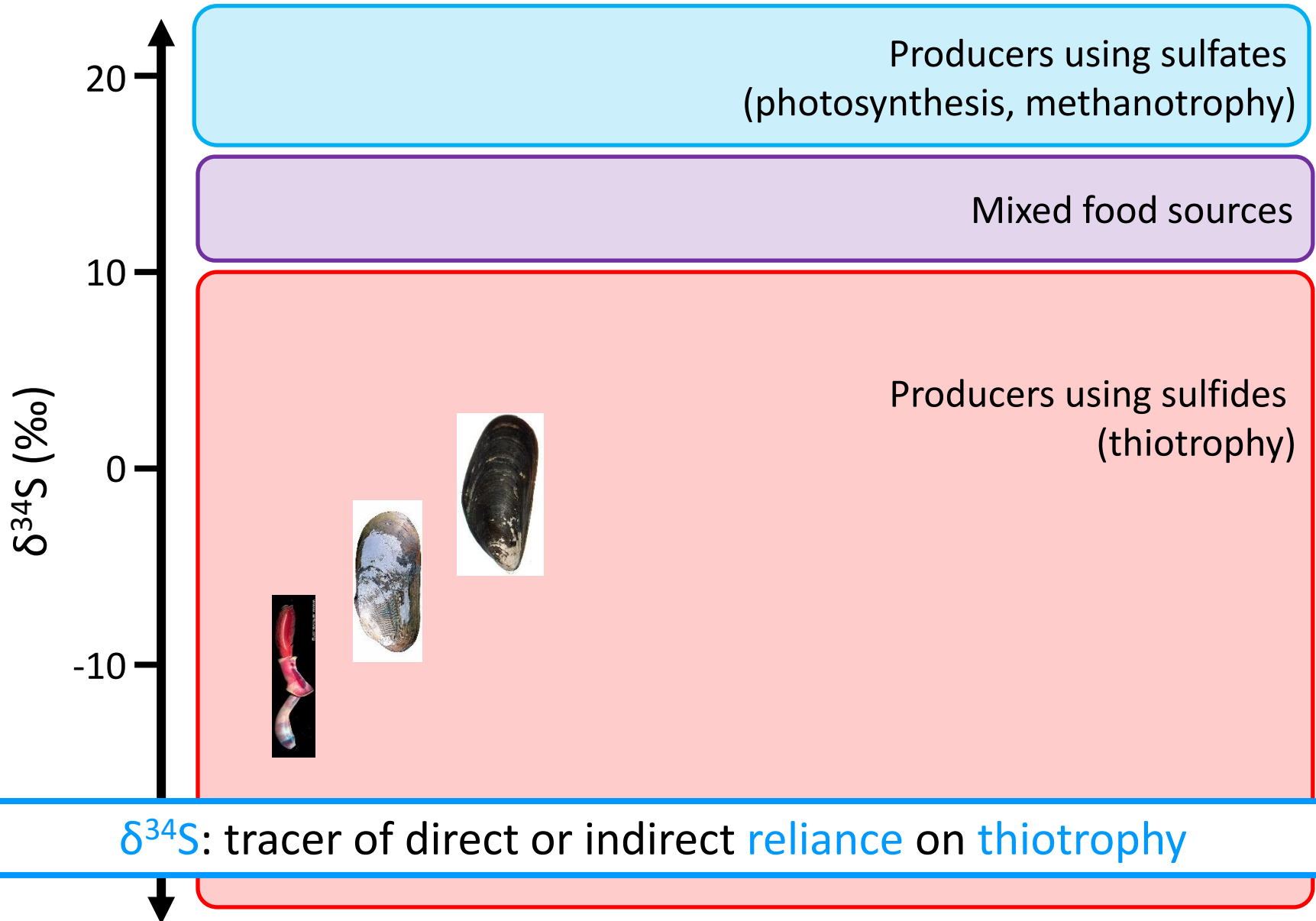
Sulfur stable isotopes



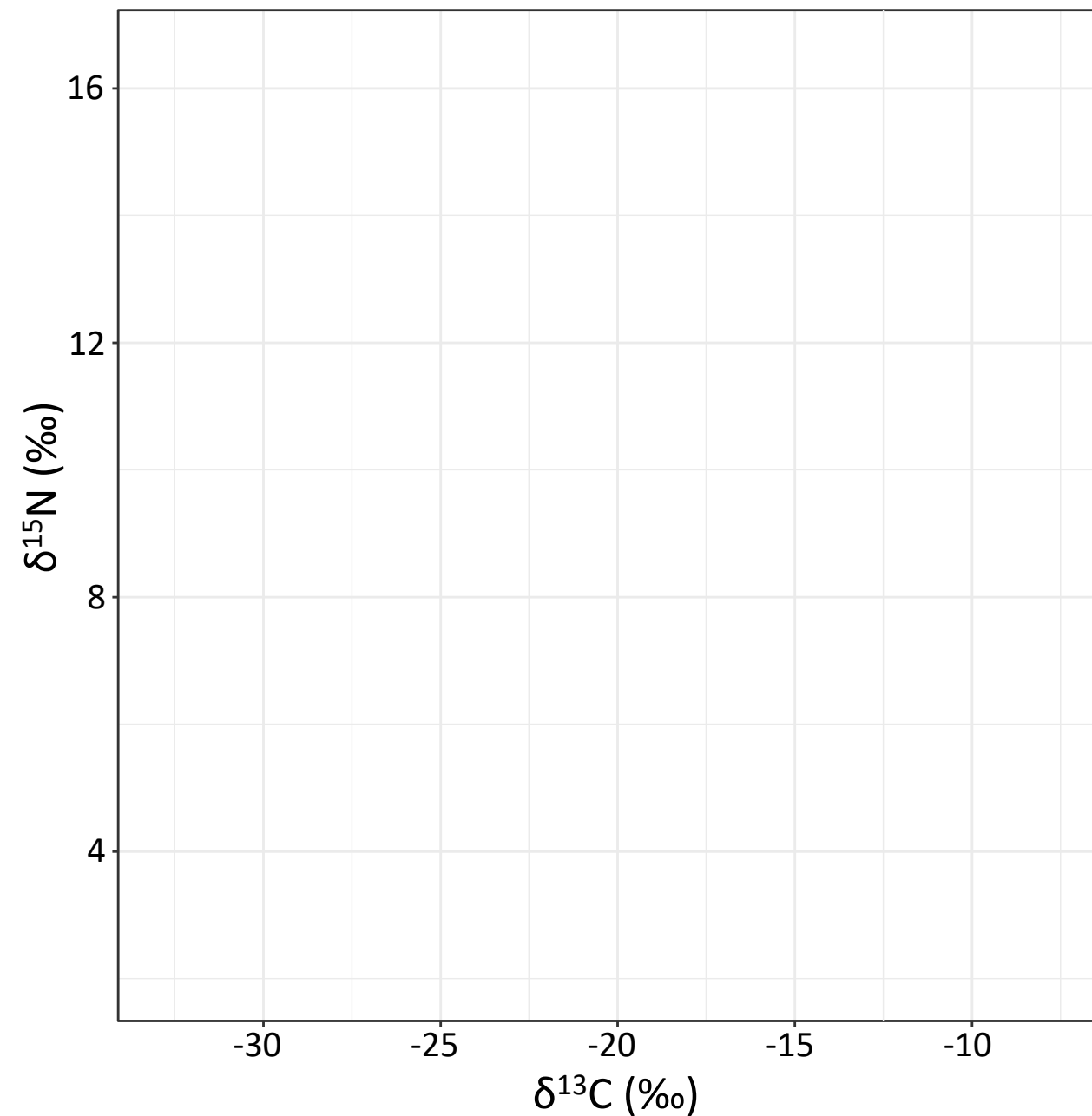
Sulfur stable isotopes



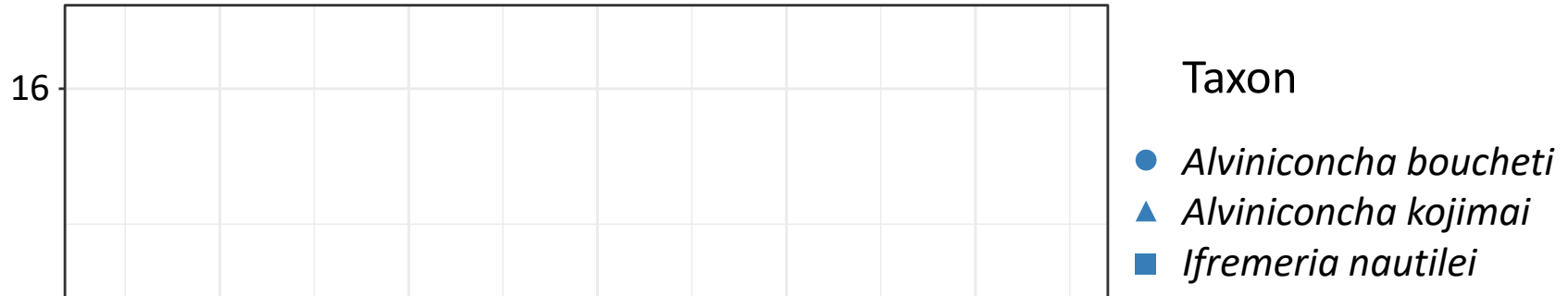
Sulfur stable isotopes



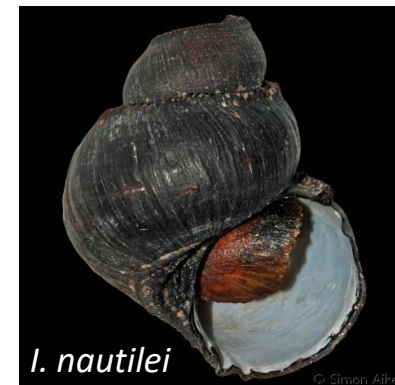
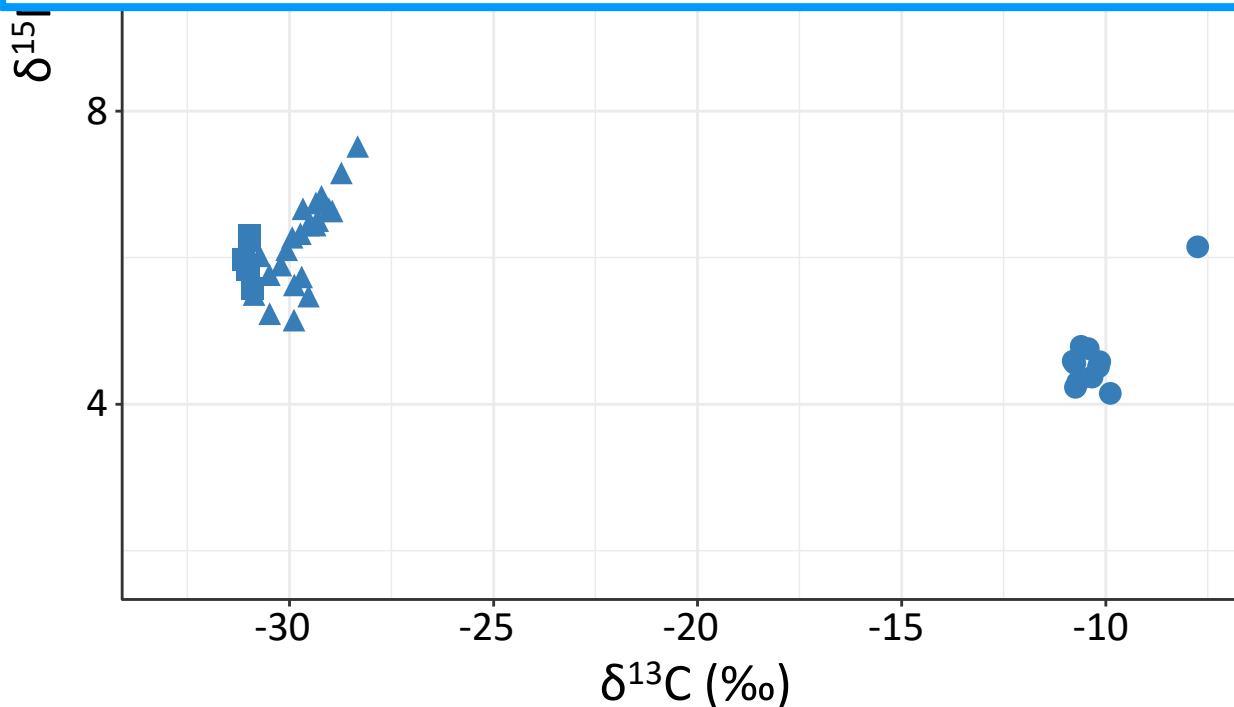
Food web structure: La Scala (Woodlark basin)



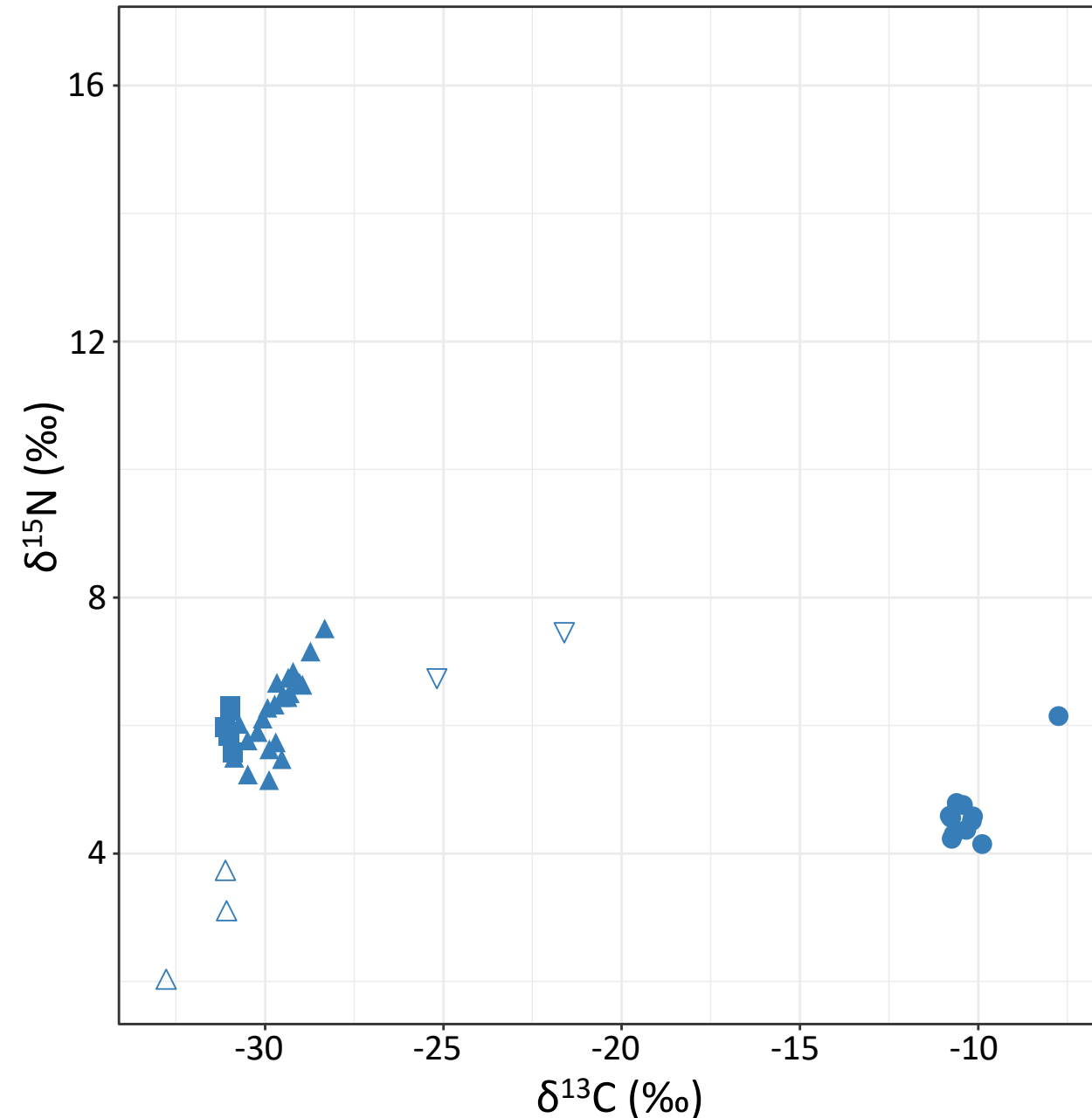
Food web structure: La Scala (Woodlark basin)



Symbiotrophs relying on different bacterial sulphur oxydation metabolisms: Calvin-Benson-Bassham (CBB) and reverse tricarboxylic acid (rTCA) cycles



Food web structure: La Scala (Woodlark basin)



Taxon

- *Alviniconcha boucheti*
- ▲ *Alviniconcha kojimai*
- *Ifremeria nautili*
- △ *Provanna* sp.
- ▽ *Phymorhynchus starmeni*



Provanna sp.



Phymorhynchus sp.

Food web structure: La Scala (Woodlark basin)

16

Taxon

Relatively low trophic positions: most likely bacterial grazers and/or deposit feeders

12

△ *Provanna* sp.

▽ *Phymorhynchus starmeni*

$\delta^{15}\text{N}$ (‰)

8

4

$\delta^{13}\text{C}$ (‰)

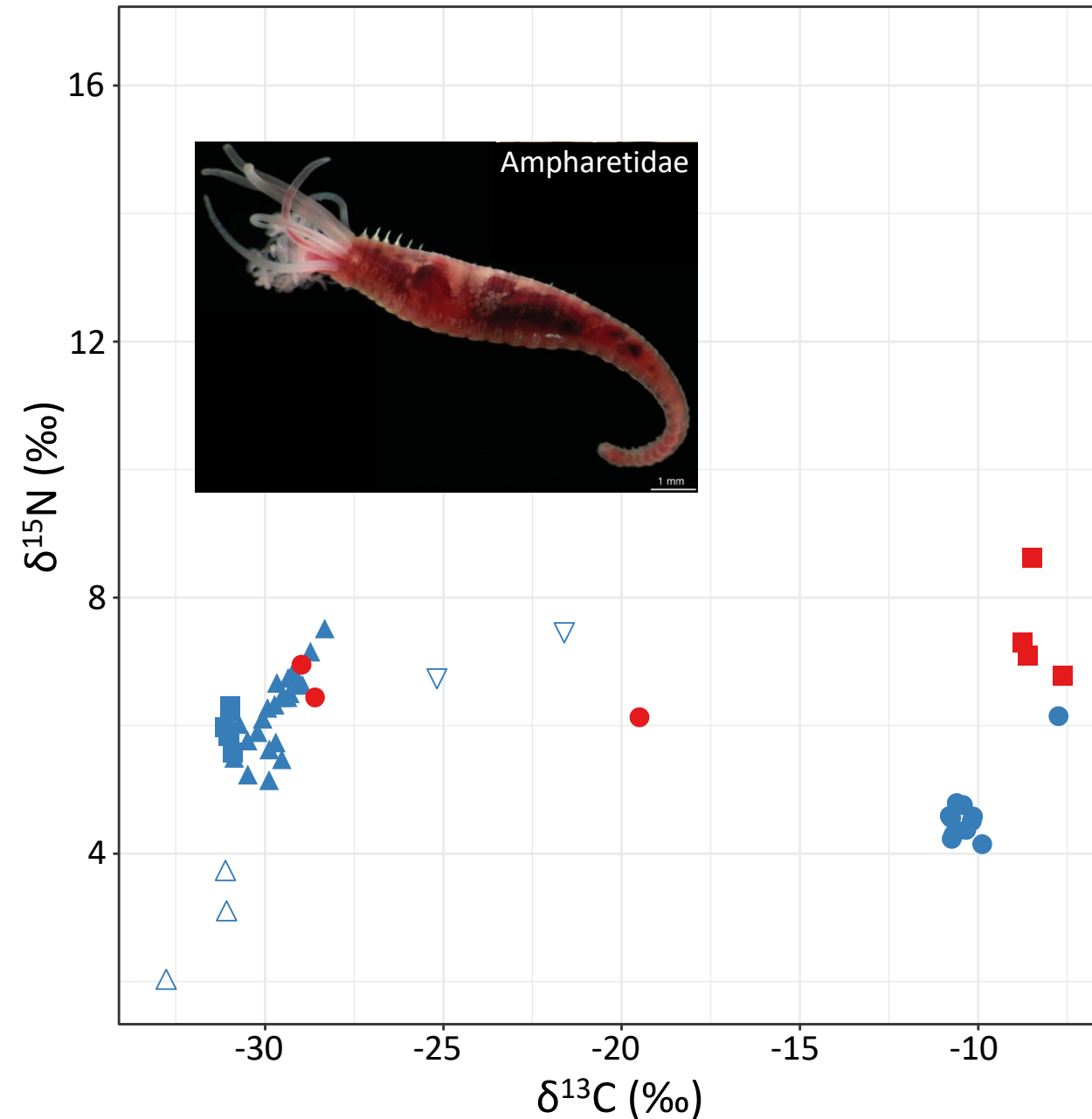


Provanna sp.



Phymorhynchus sp.

Food web structure: La Scala (Woodlark basin)

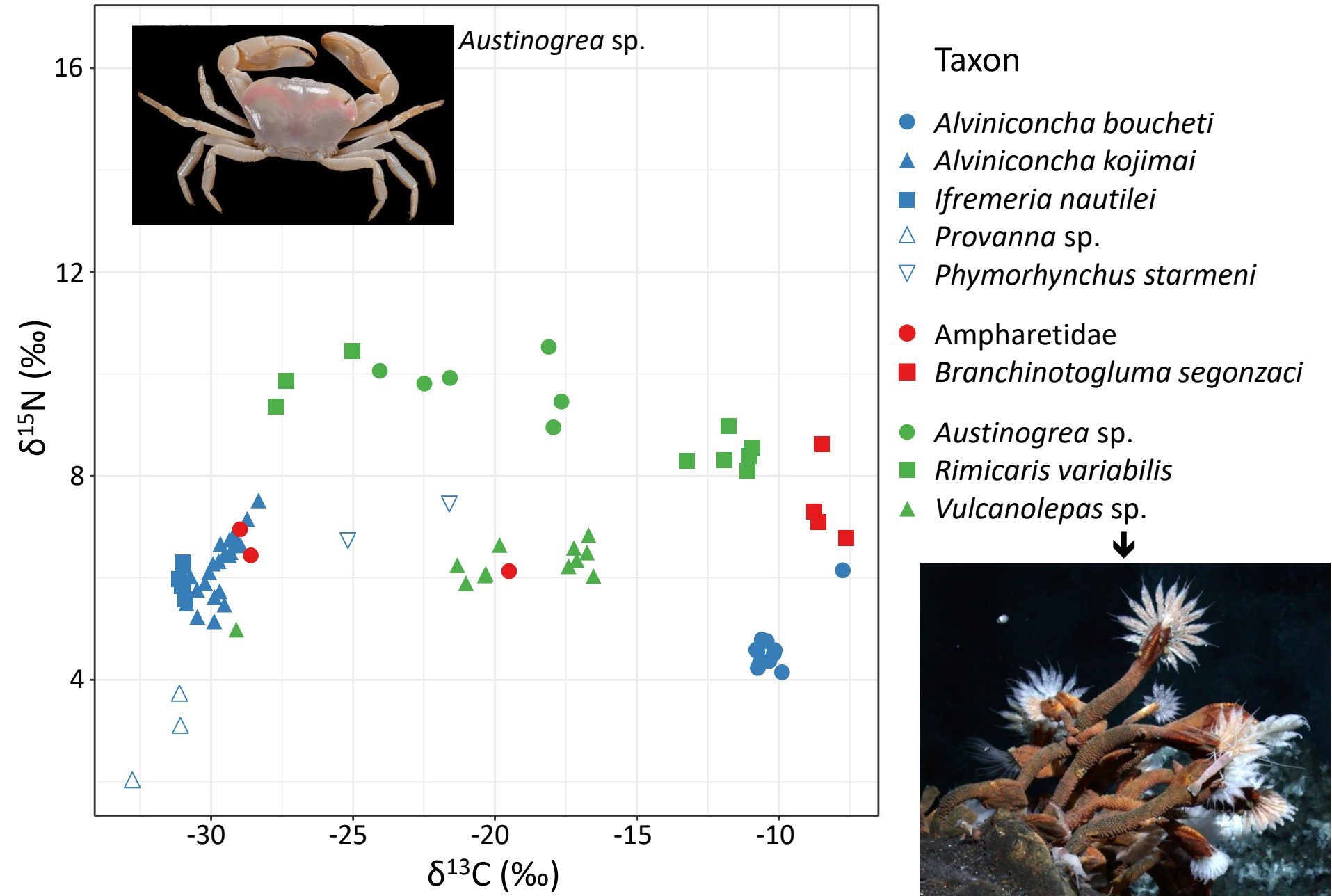


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- △ *Provanna* sp.
- ▽ *Phymorhynchus starmeni*
- Ampharetidae
- *Branchinotogluma segonzaci*



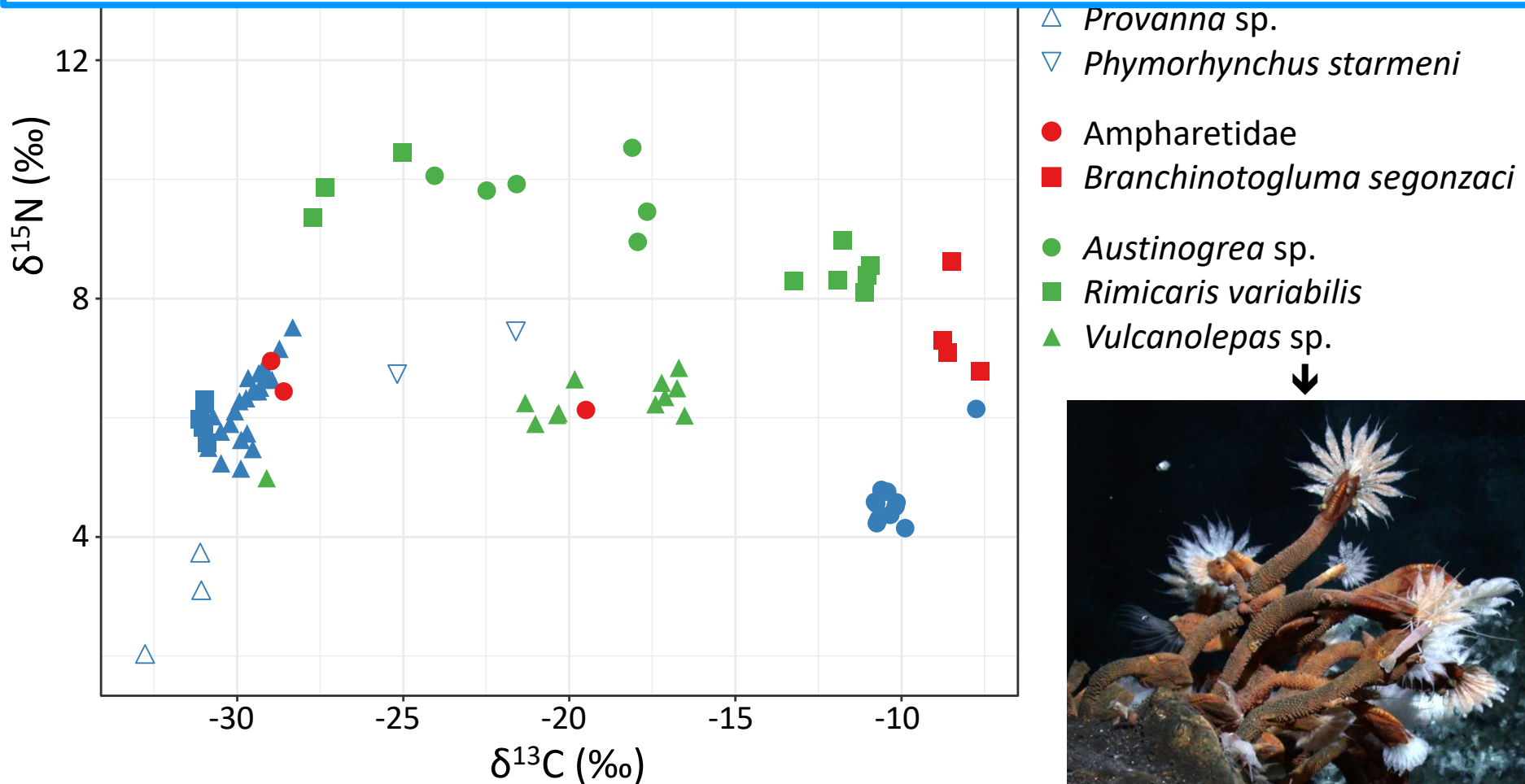
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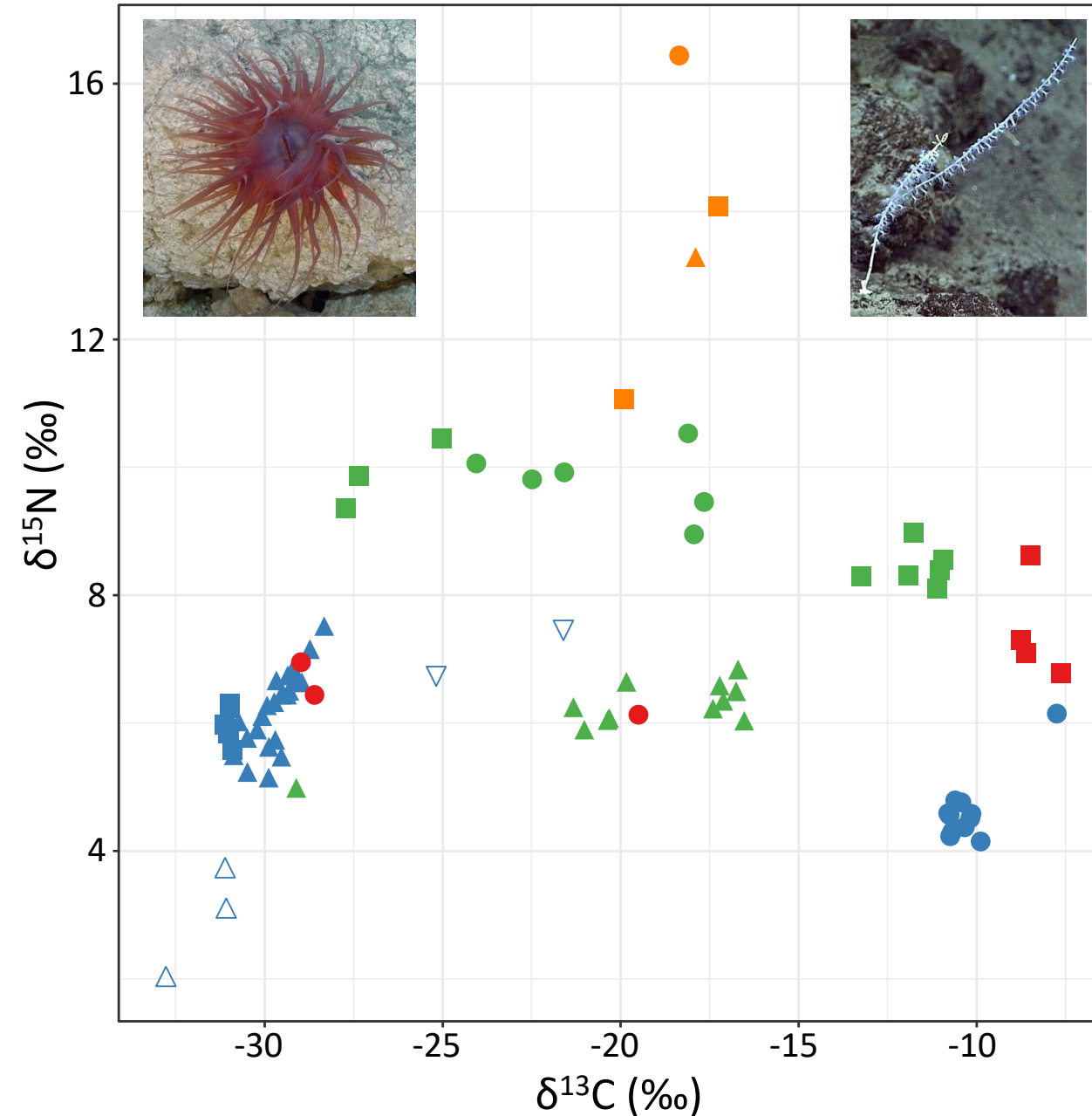
Food web structure: La Scala (Woodlark basin)

Slightly higher $\delta^{15}\text{N}$ in crabs and shrimp: omnivores?

Marked $\delta^{13}\text{C}$ differences among shrimps: intraspecific trophic diversity? (semi-)cryptic species?

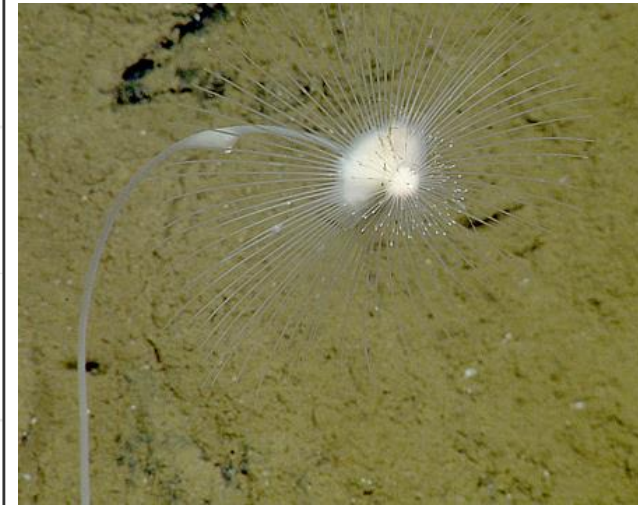


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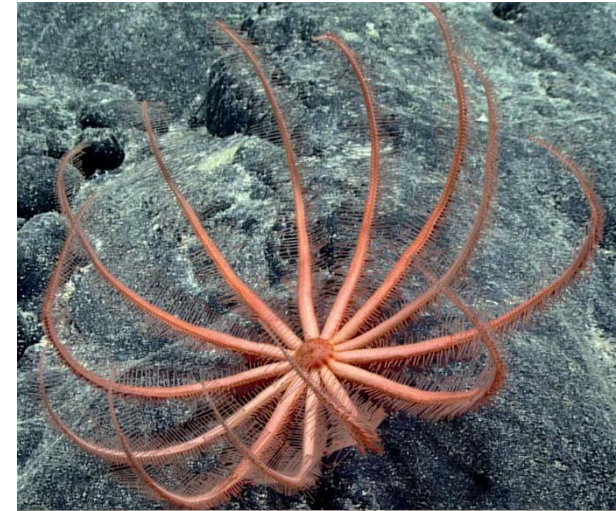
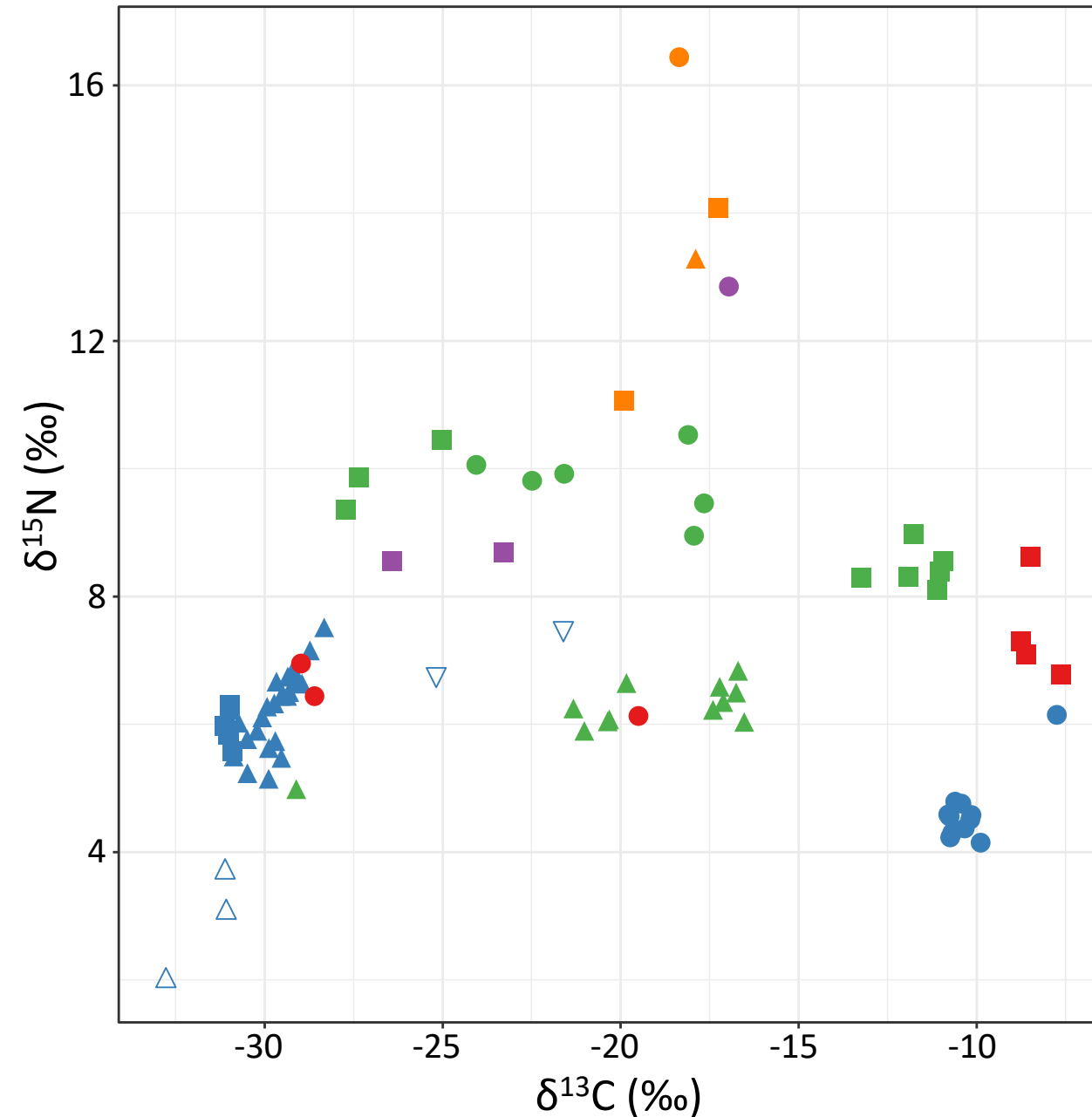
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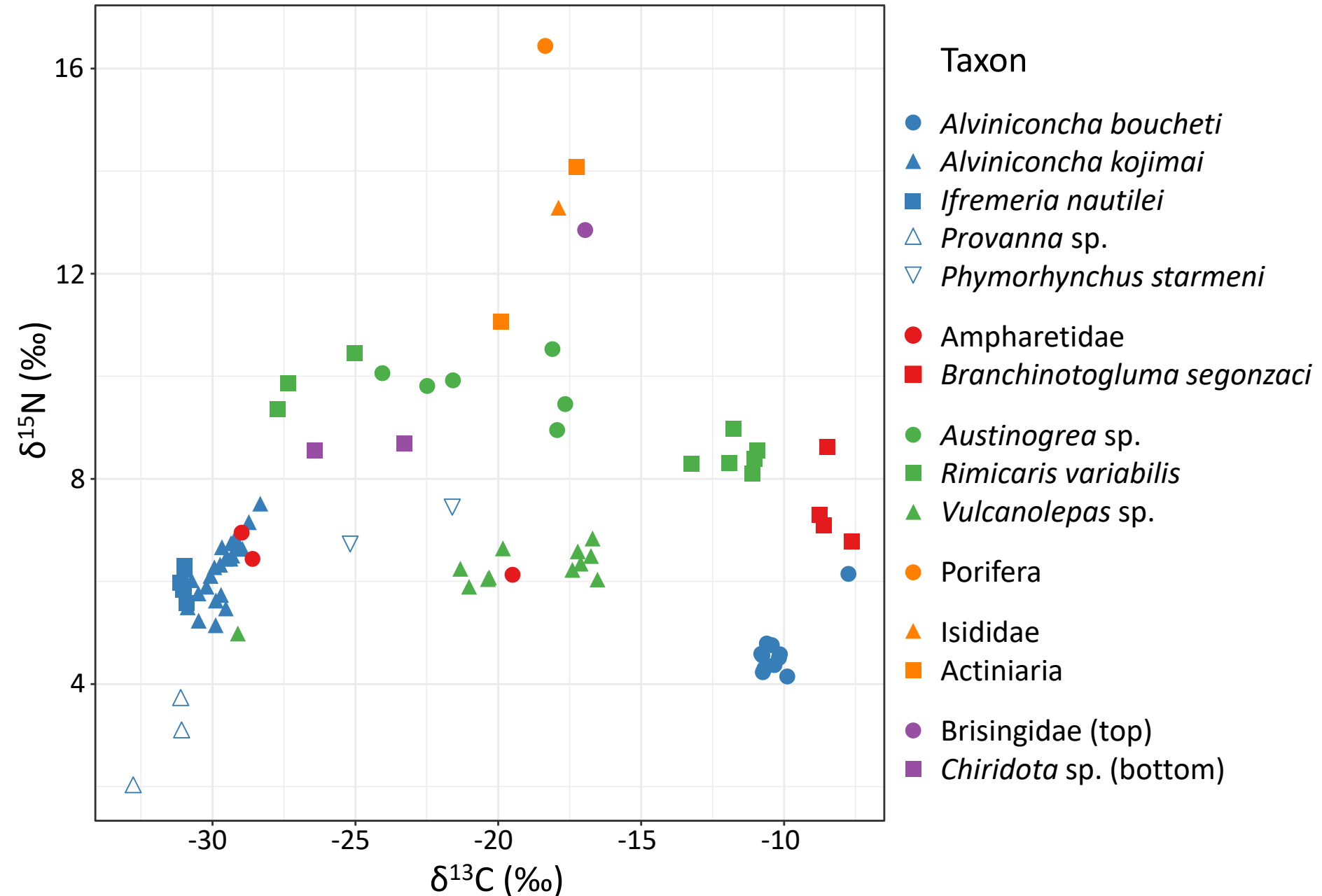
- Porifera (right)
- ▲ Isididae (center)
- Actiniaria (left)

Food web structure: La Scala (Woodlark basin)

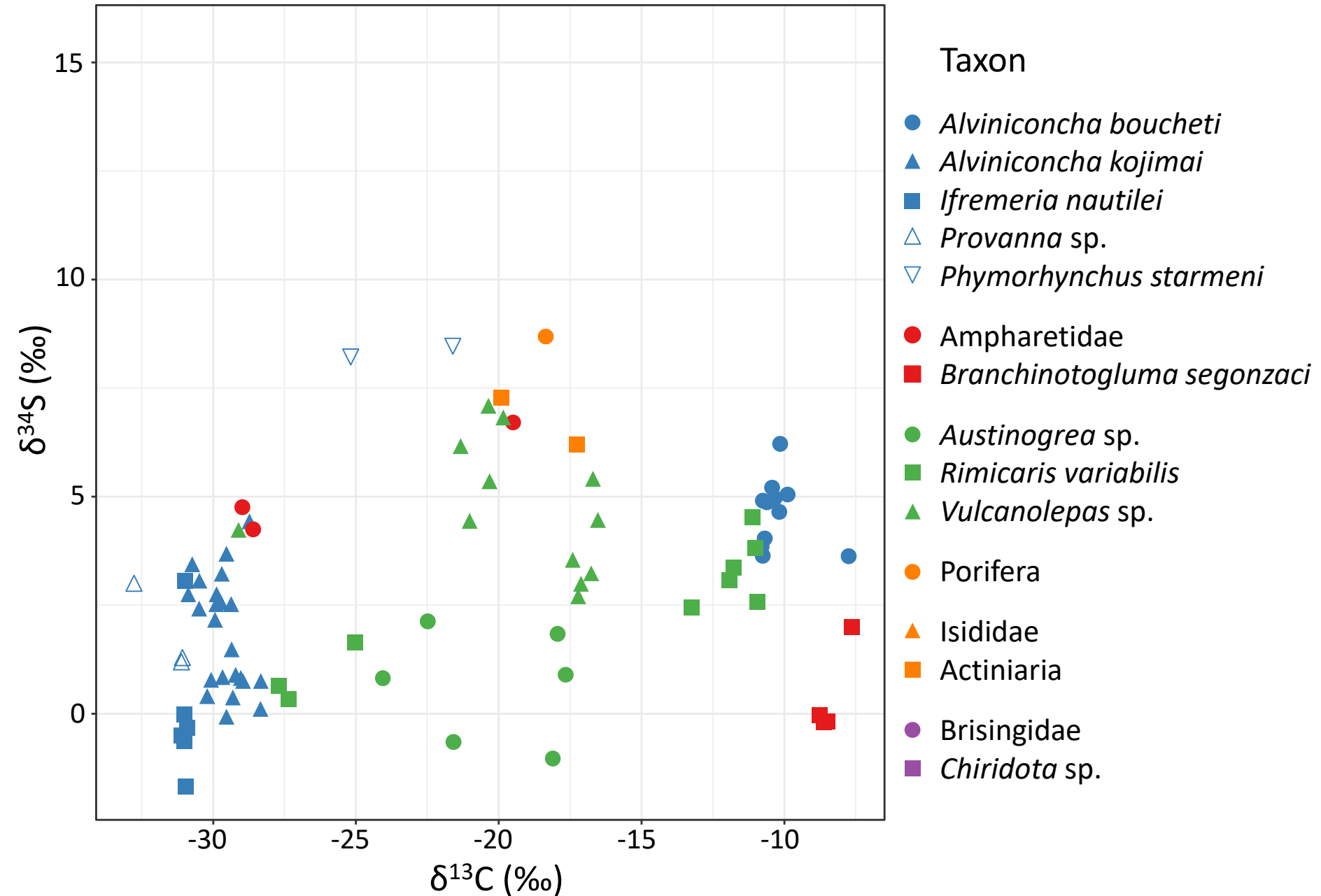


- Brisingidae (top)
- *Chiridota* sp. (bottom)

Food web structure: La Scala (Woodlark basin)

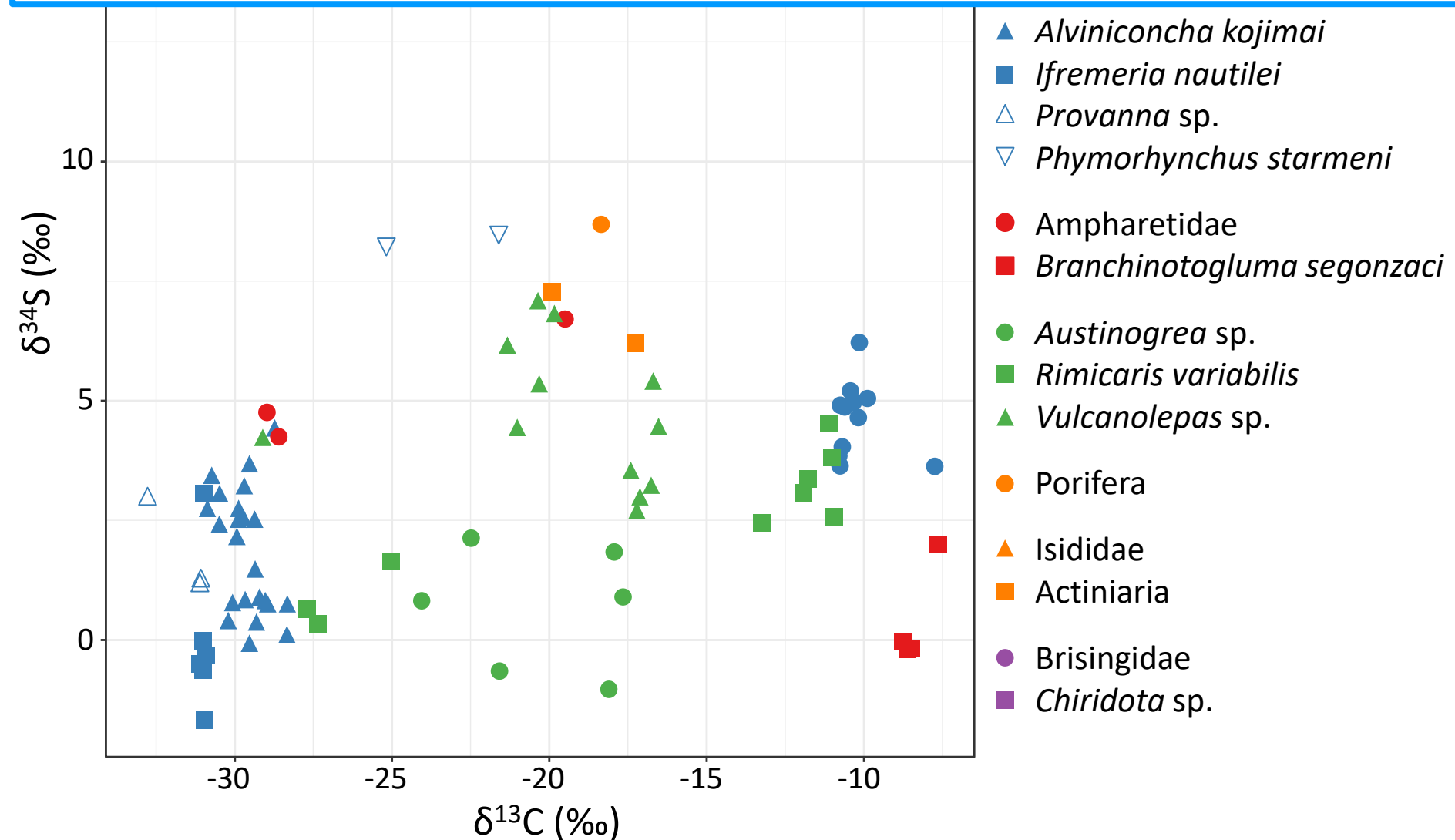


Food web structure: La Scala (Woodlark basin)

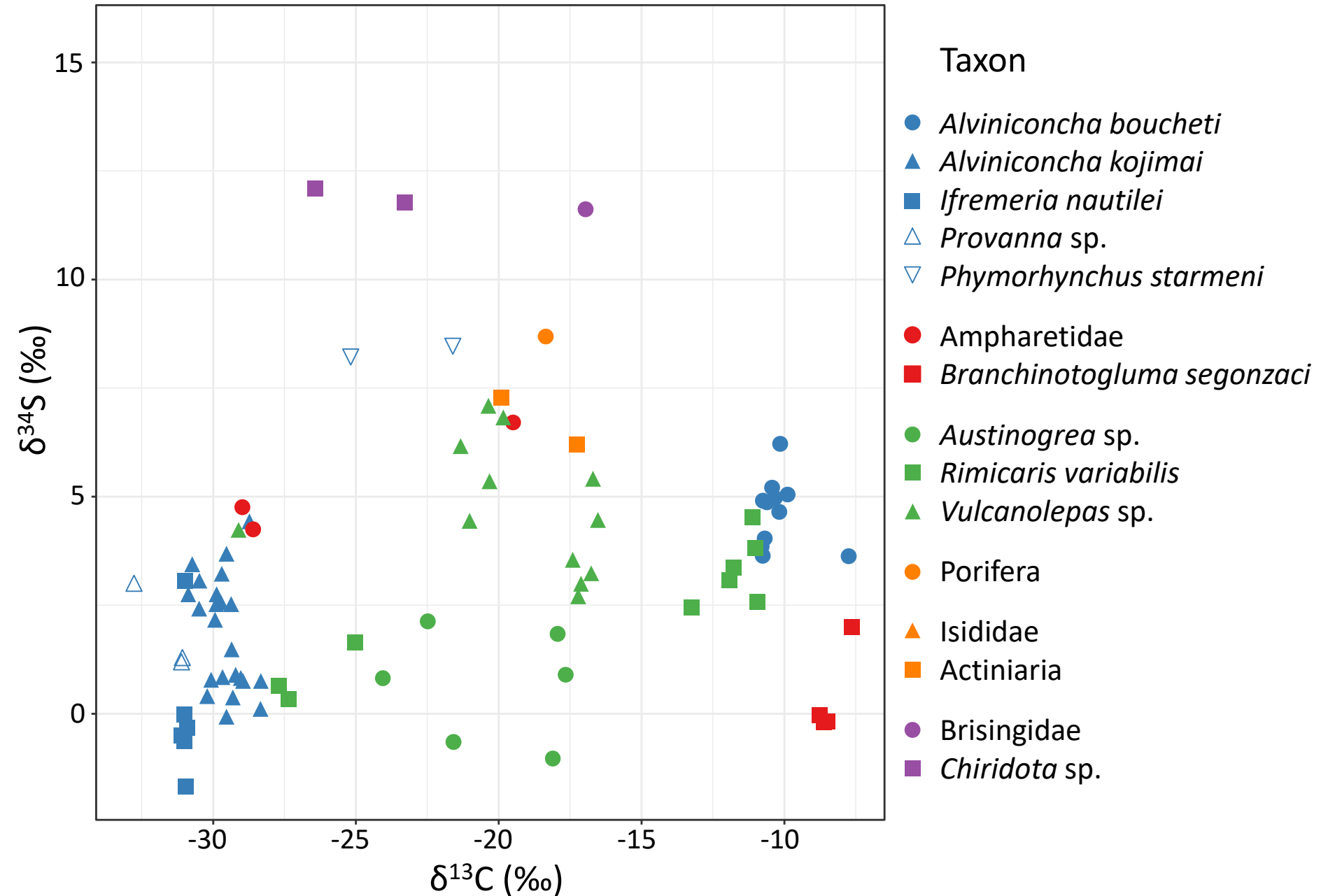


Food web structure: La Scala (Woodlark basin)

Low $\delta^{34}\text{S}$ in most fauna, from known symbiotrophs to facultative vent dwellers found in inactive or peripheral zones

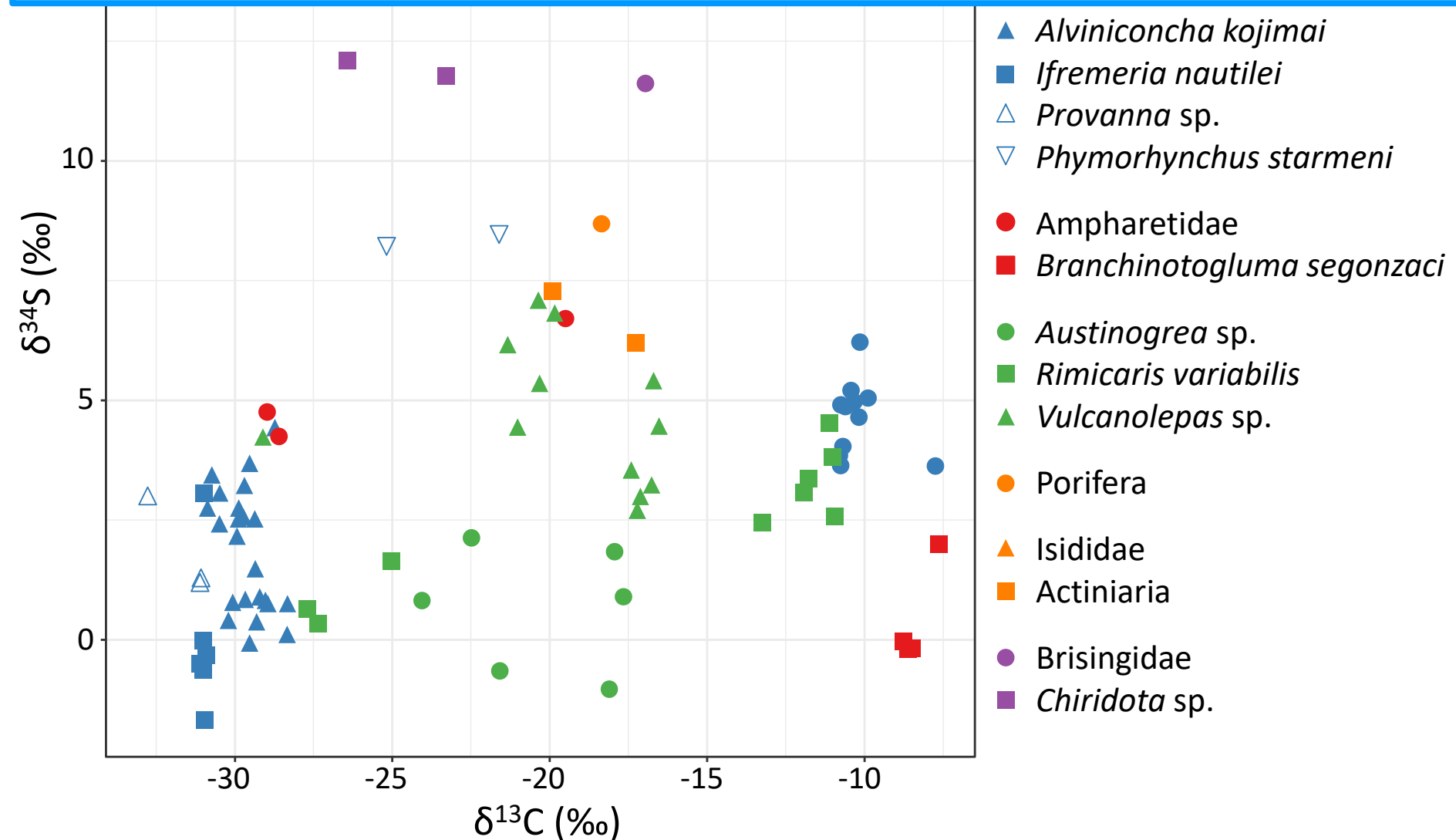


Food web structure: La Scala (Woodlark basin)

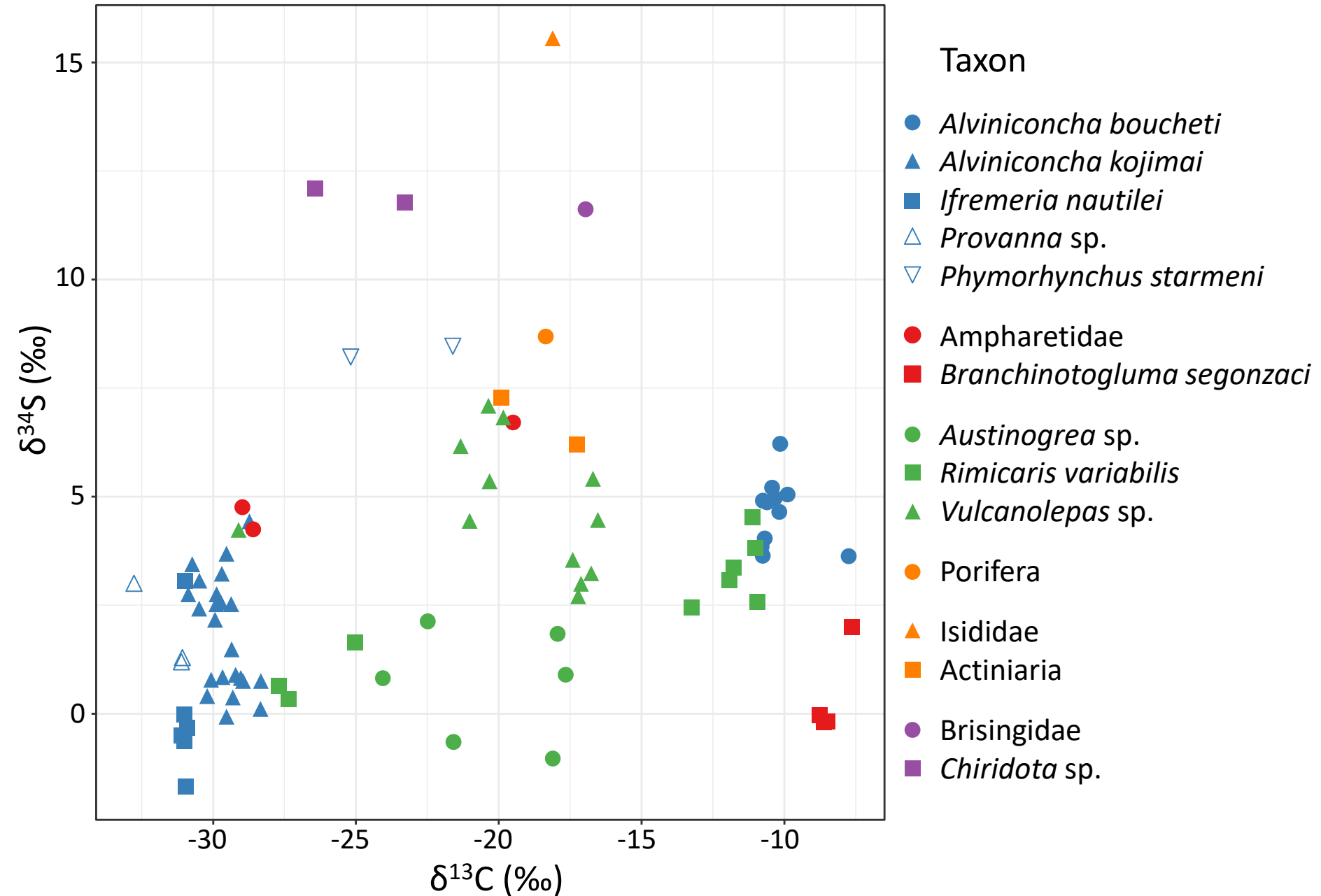


Food web structure: La Scala (Woodlark basin)

Intermediate $\delta^{34}\text{S}$ in echinoderms: reliance on both chemosynthesis- and photosynthesis-derived organic matter



Food web structure: La Scala (Woodlark basin)

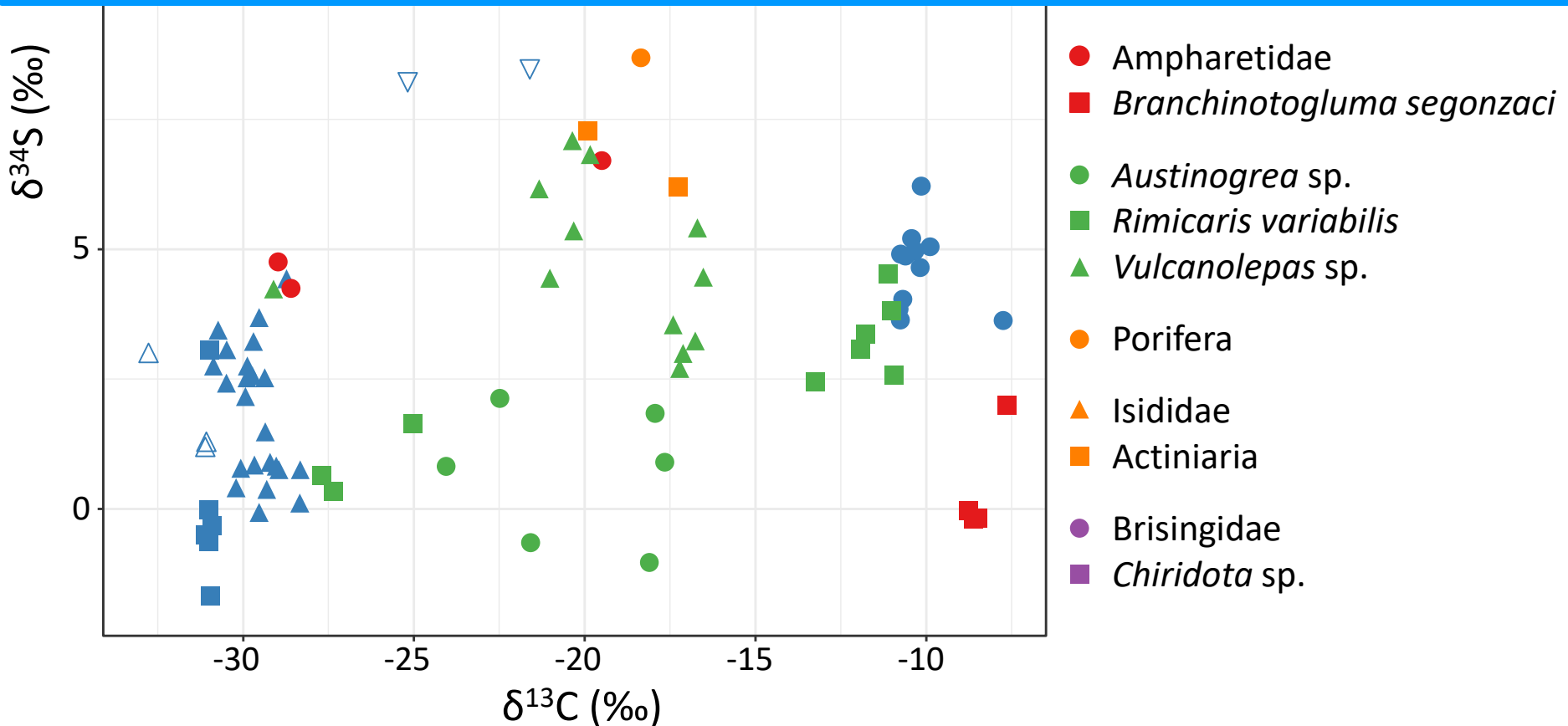


Food web structure: La Scala (Woodlark basin)

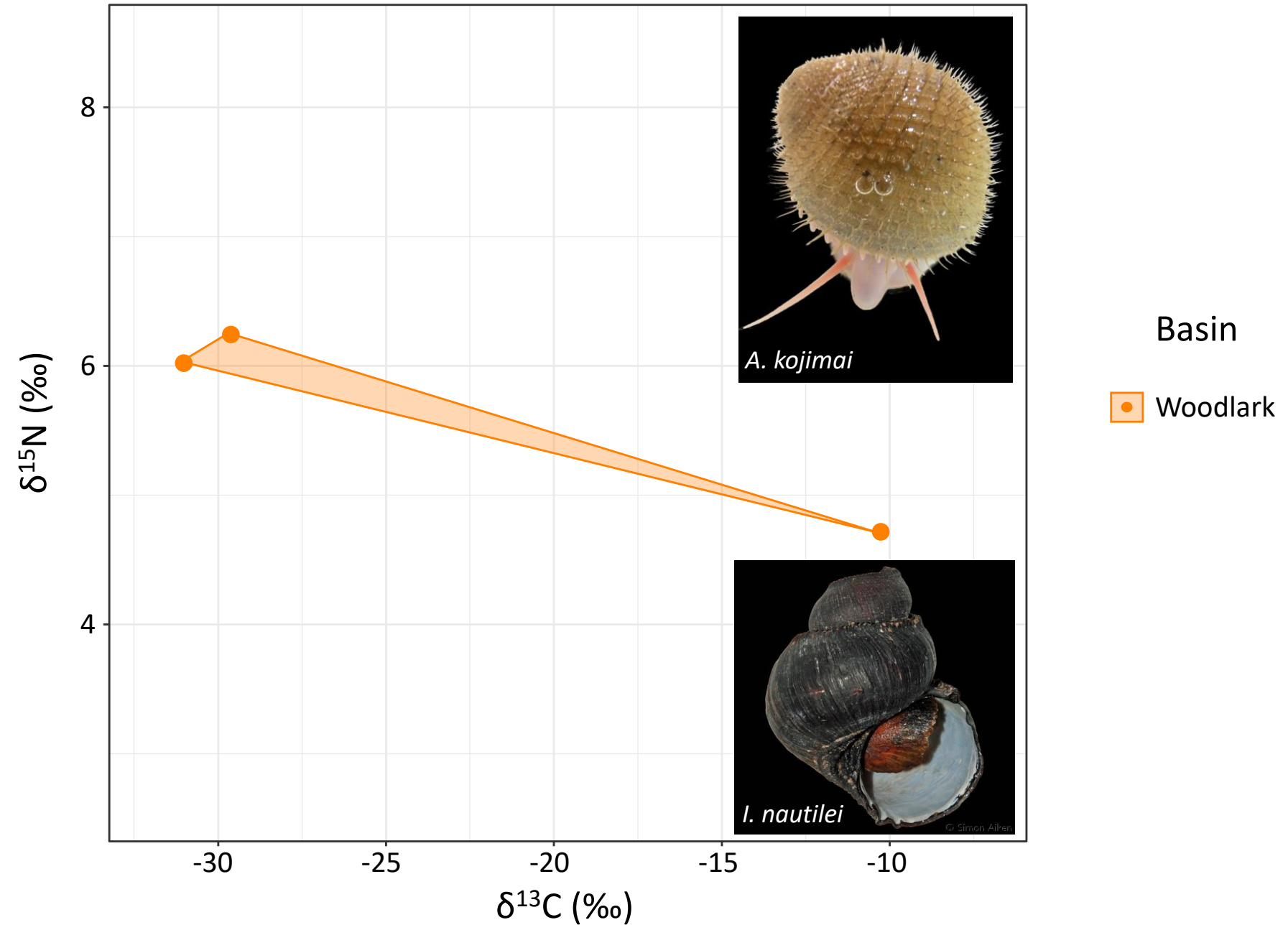
Community mostly fueled by **thiotrophy** (sulphide oxydation)

No evidence of methanotrophy, photosynthetic inputs limited

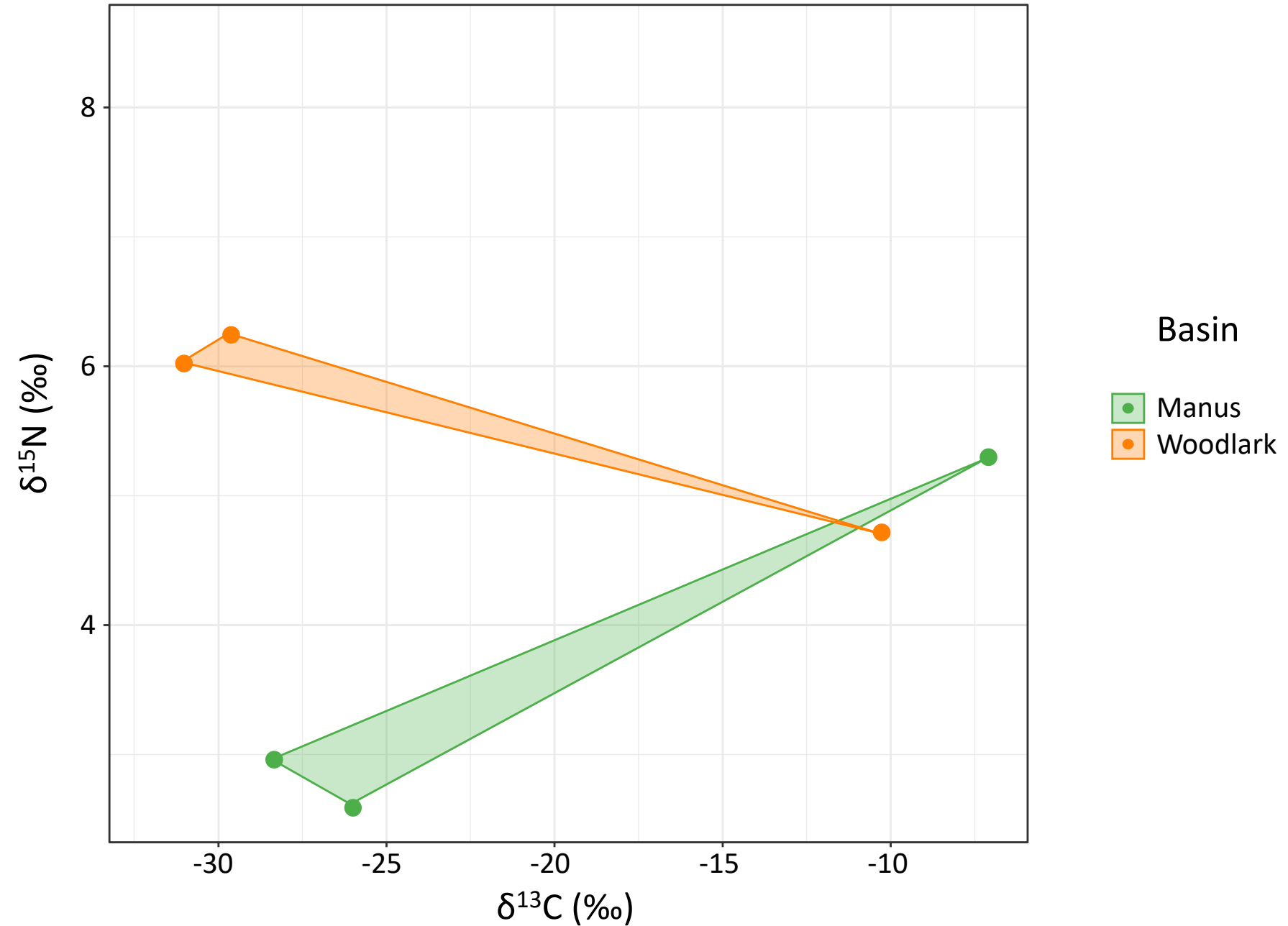
Continuum of $\delta^{13}\text{C}$ values: **co-reliance** on **CBB** and **rTCA** cycles, with inter- and intraspecific differences in feeding habits



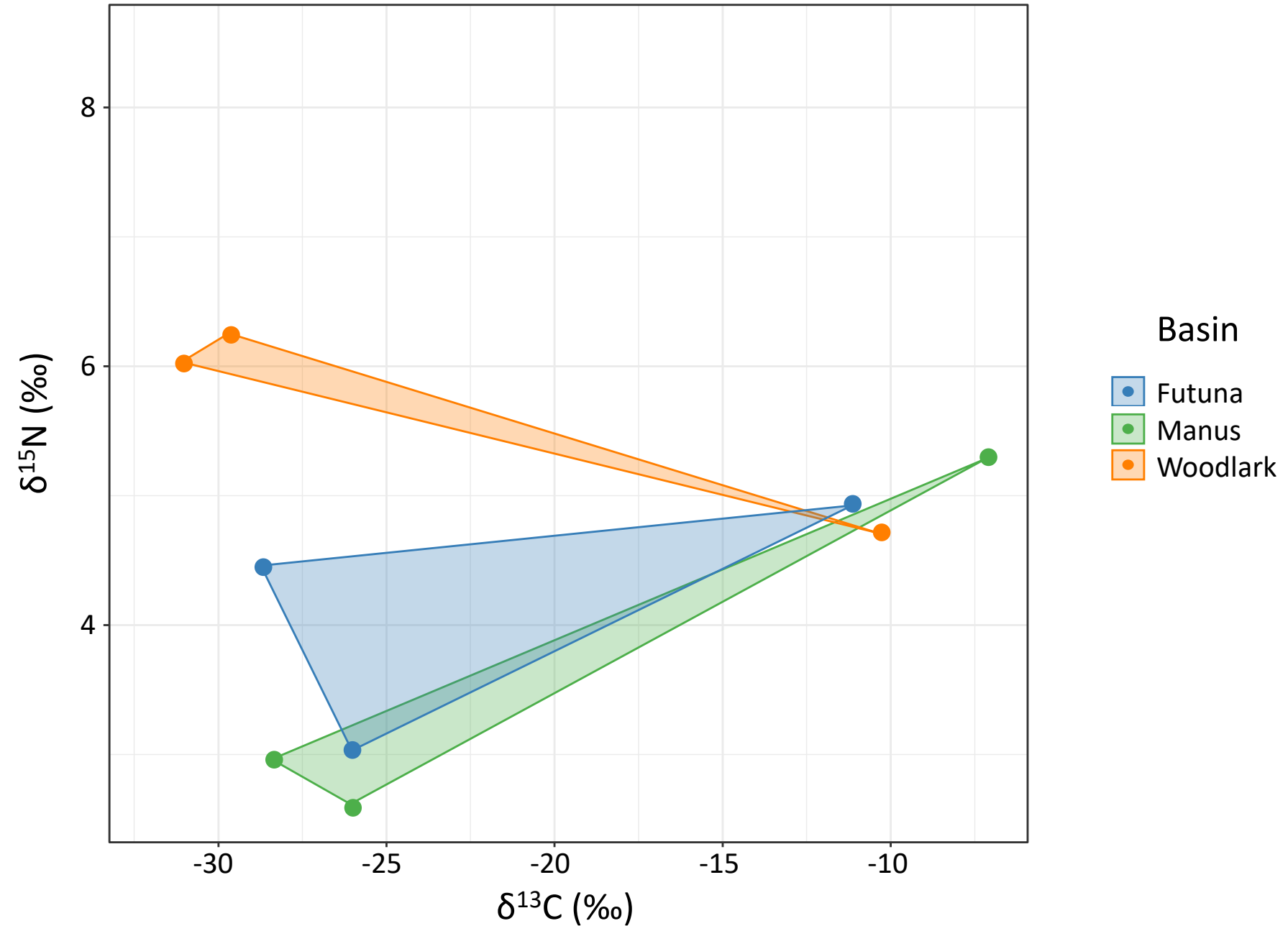
Focus on foundation species



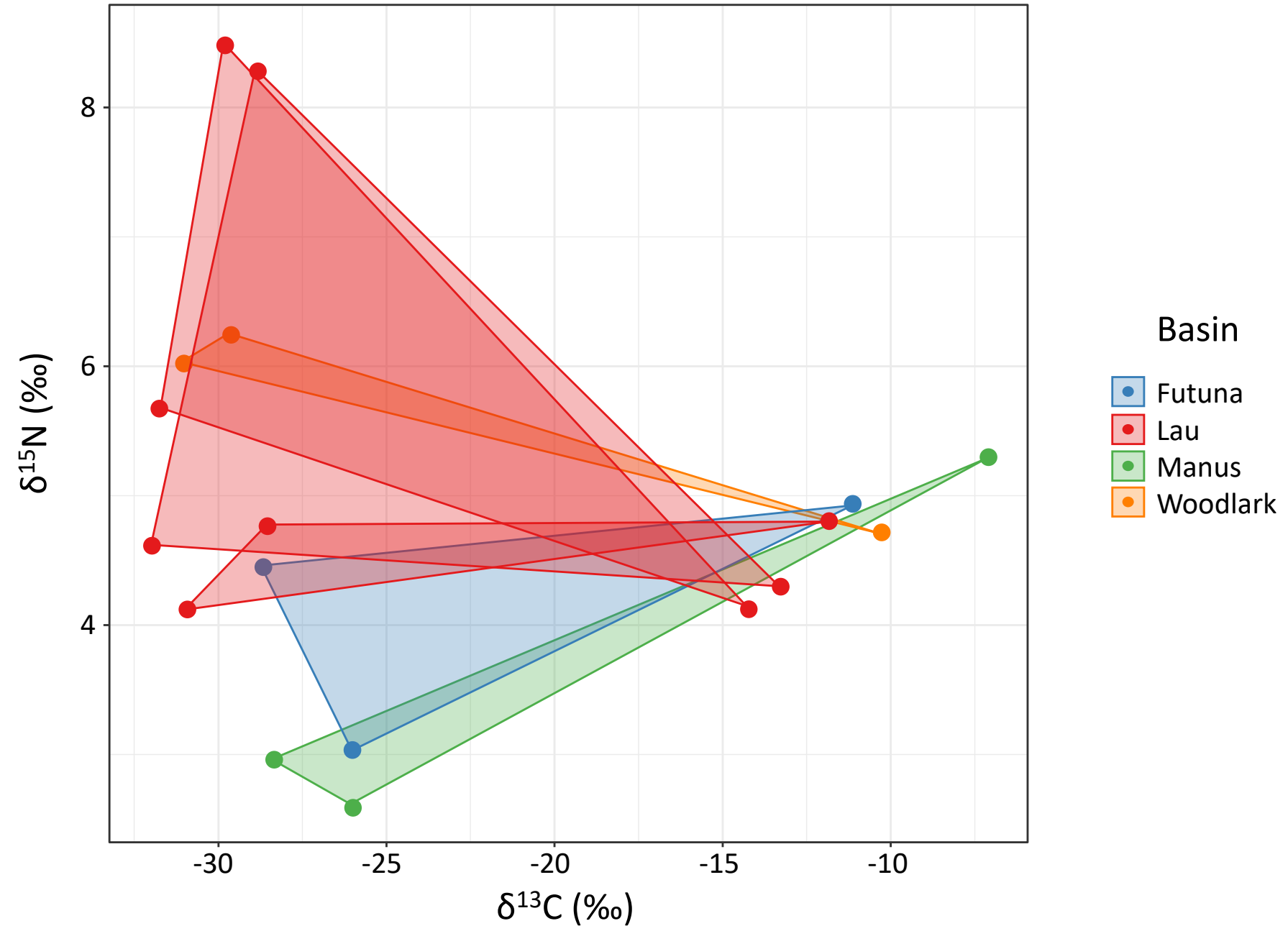
Focus on foundation species



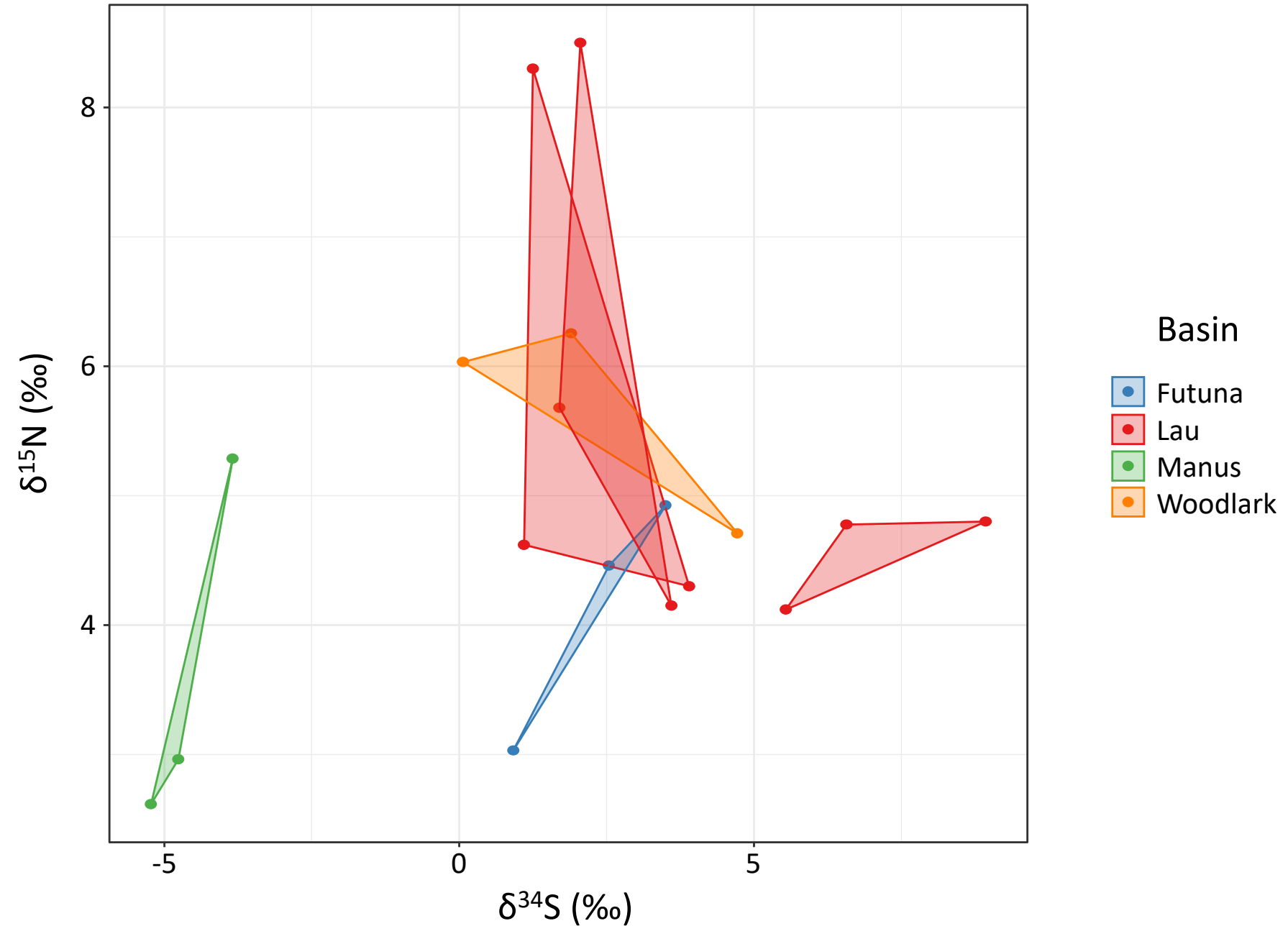
Focus on foundation species



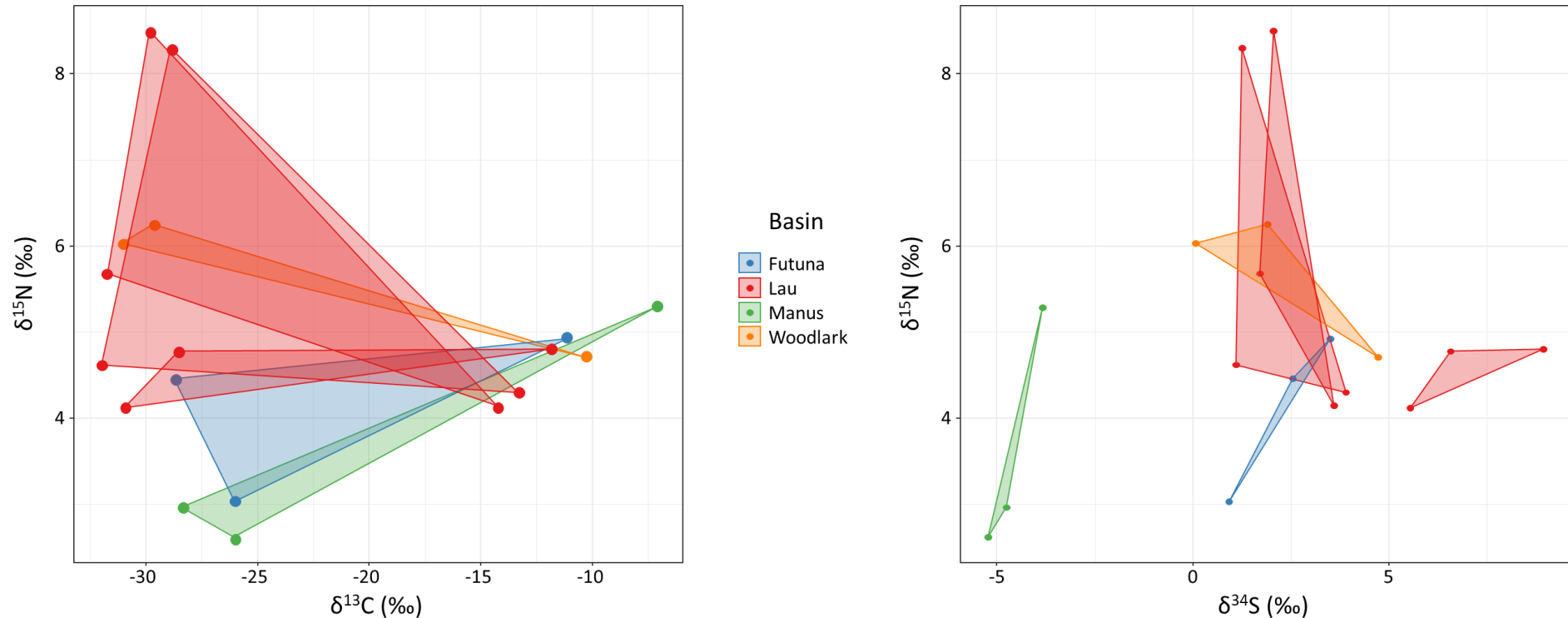
Focus on foundation species



Focus on foundation species



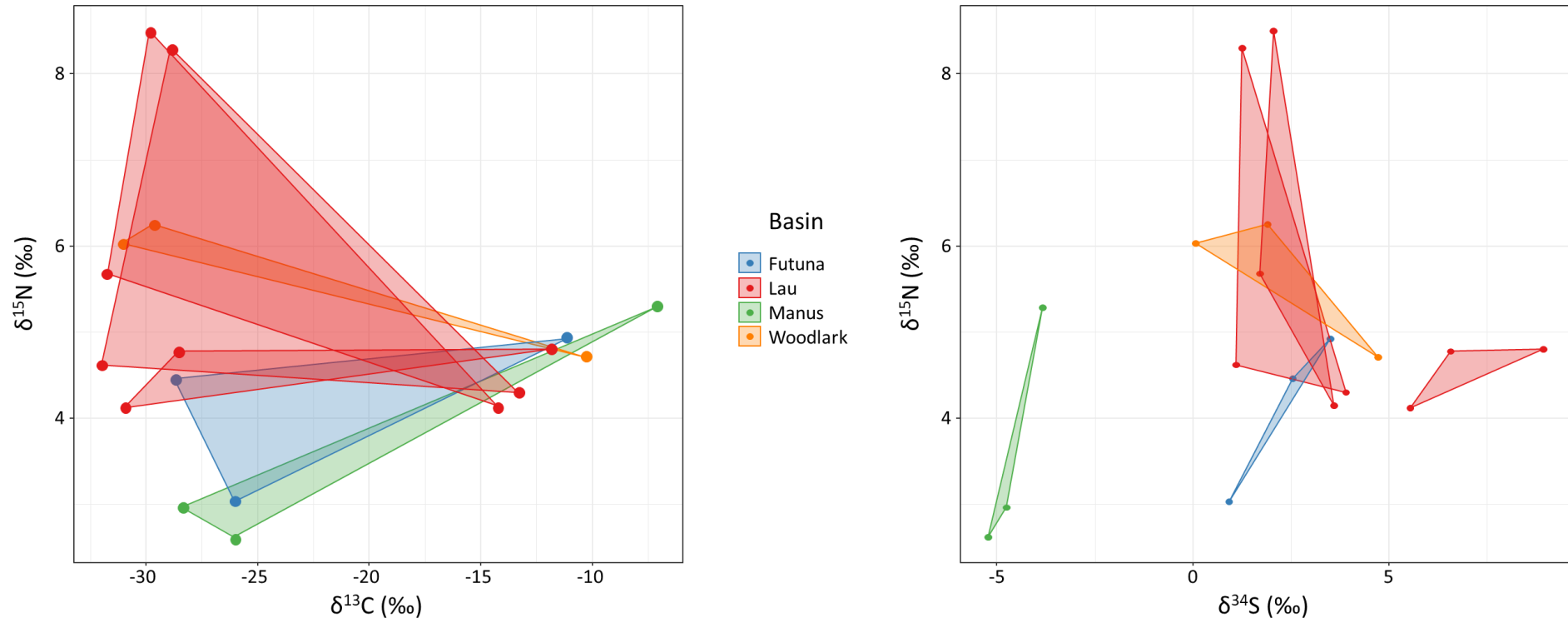
Focus on foundation species



Distance between foundation species in the isotopic space (size of each triangle), which is a proxy for **realized niche divergence**, drastically **changes** at **multiple spatial scales** (inter- or intra-basin)

Marked **positional shifts**: differences in resources used by symbionts in each location

Focus on foundation species



Variation in **identity** and/or **metabolism** of symbiotic partners?

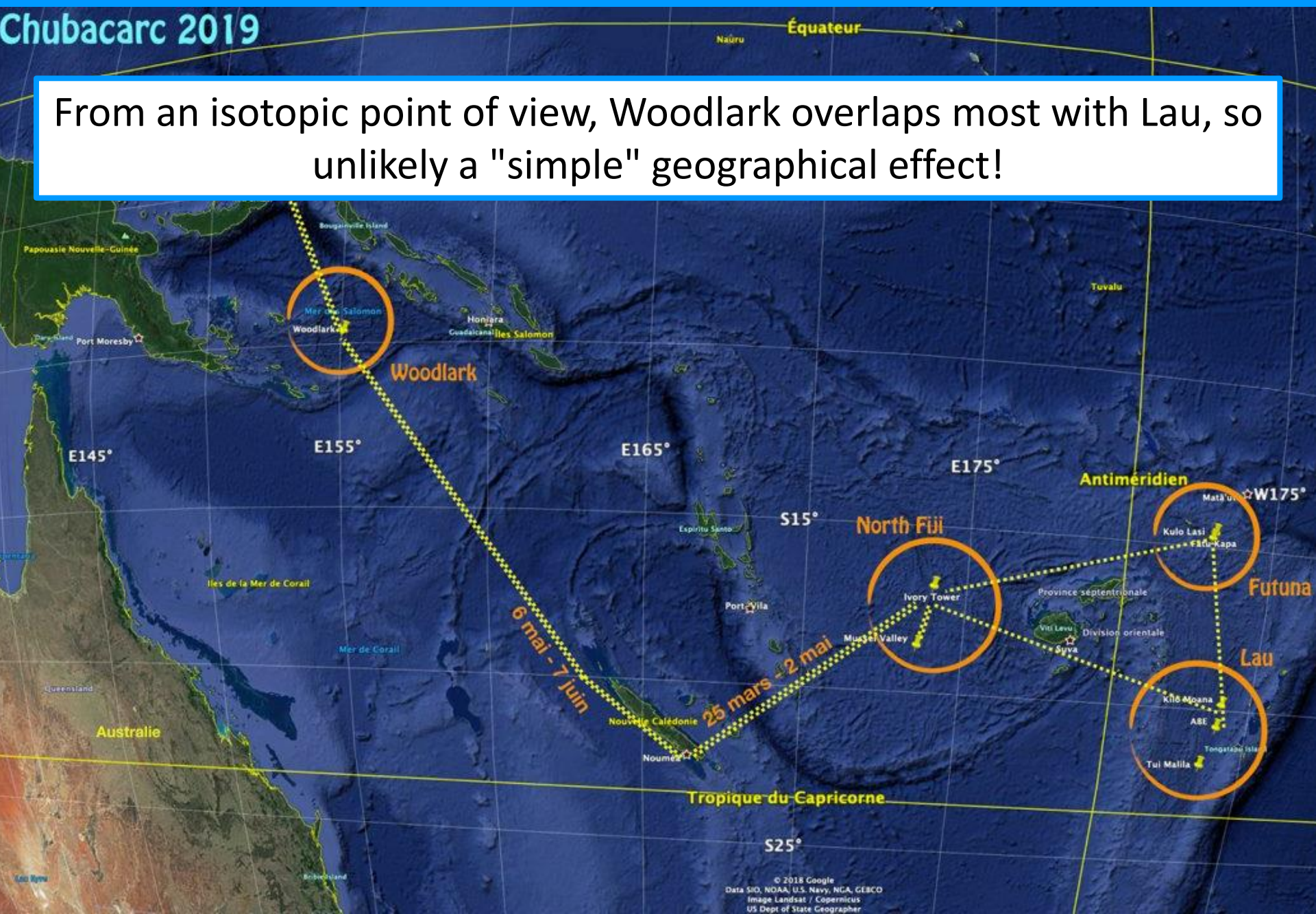
Contrasts in **environmental parameters** (geochemistry) and availability of inorganic C, N and S species?

Selection of symbiotic microorganisms by **environmental filtering**?
Relative importance of horizontal and vertical **transmission** unclear...

Focus on foundation species

Chubacarc 2019

From an isotopic point of view, Woodlark overlaps most with Lau, so unlikely a "simple" geographical effect!



Take home message

Hydrothermal communities from Woodlark Basin mostly depend on **endogenous production** from sulphide-oxidizing microorganisms for their nutrition



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Also true for fauna from **inactive peripheral zones** (target for deep-sea mining). Increasing evidence that vents are not "oases" in the barren deep sea, but are connected to surrounding ecosystems. This needs to be taken into account for **conservation**.



Take home message

Hydrothermal communities from Woodlark Basin mostly depend on **endogenous production** from sulphide-oxidizing microorganisms for their nutrition

Also true for fauna from **inactive peripheral zones** (target for deep-sea mining). Increasing evidence that vents are not "oases" in the barren deep sea, but are connected to surrounding ecosystems. This needs to be taken into account for **conservation**.



Regional **environmental parameters** influence ecology of **foundation species**, and notably niche divergence. Wider implications for community structure? Evolutionary processes?

communications earth & environment






ARTICLE



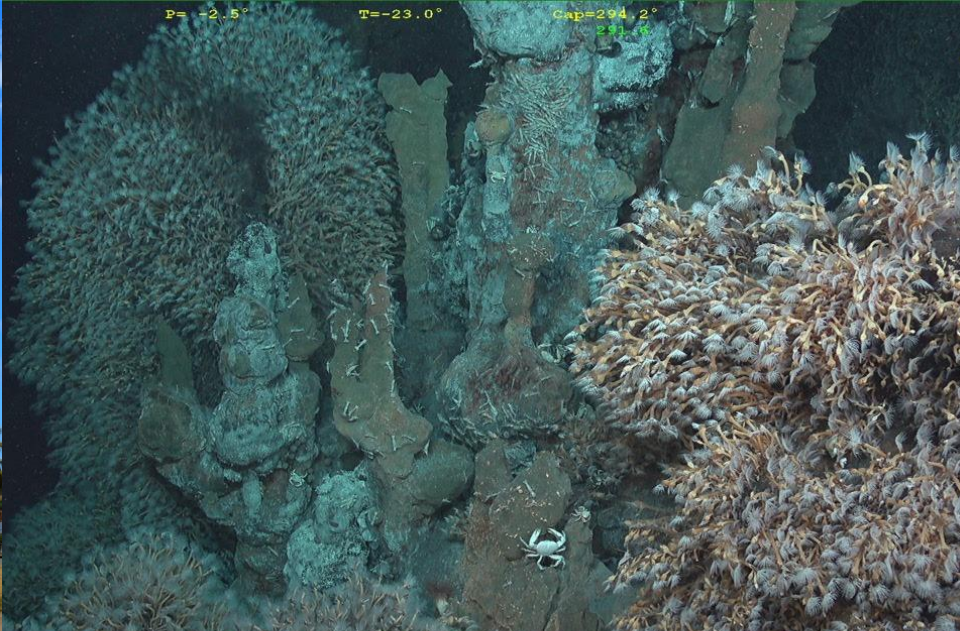
<https://doi.org/10.1038/s43247-022-00387-9>

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Active hydrothermal vents in the Woodlark Basin may act as dispersing centres for hydrothermal fauna

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Thanks for your attention

