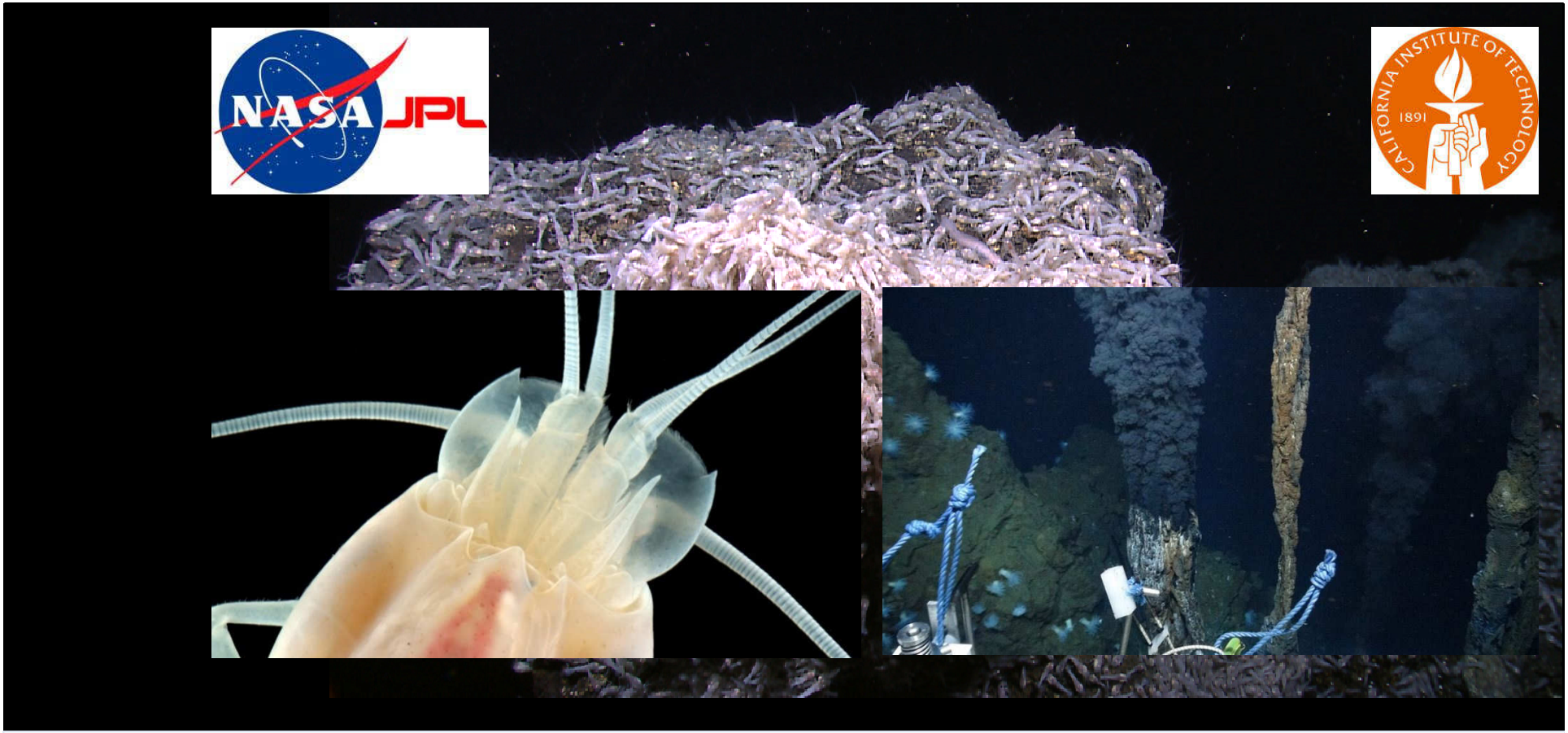
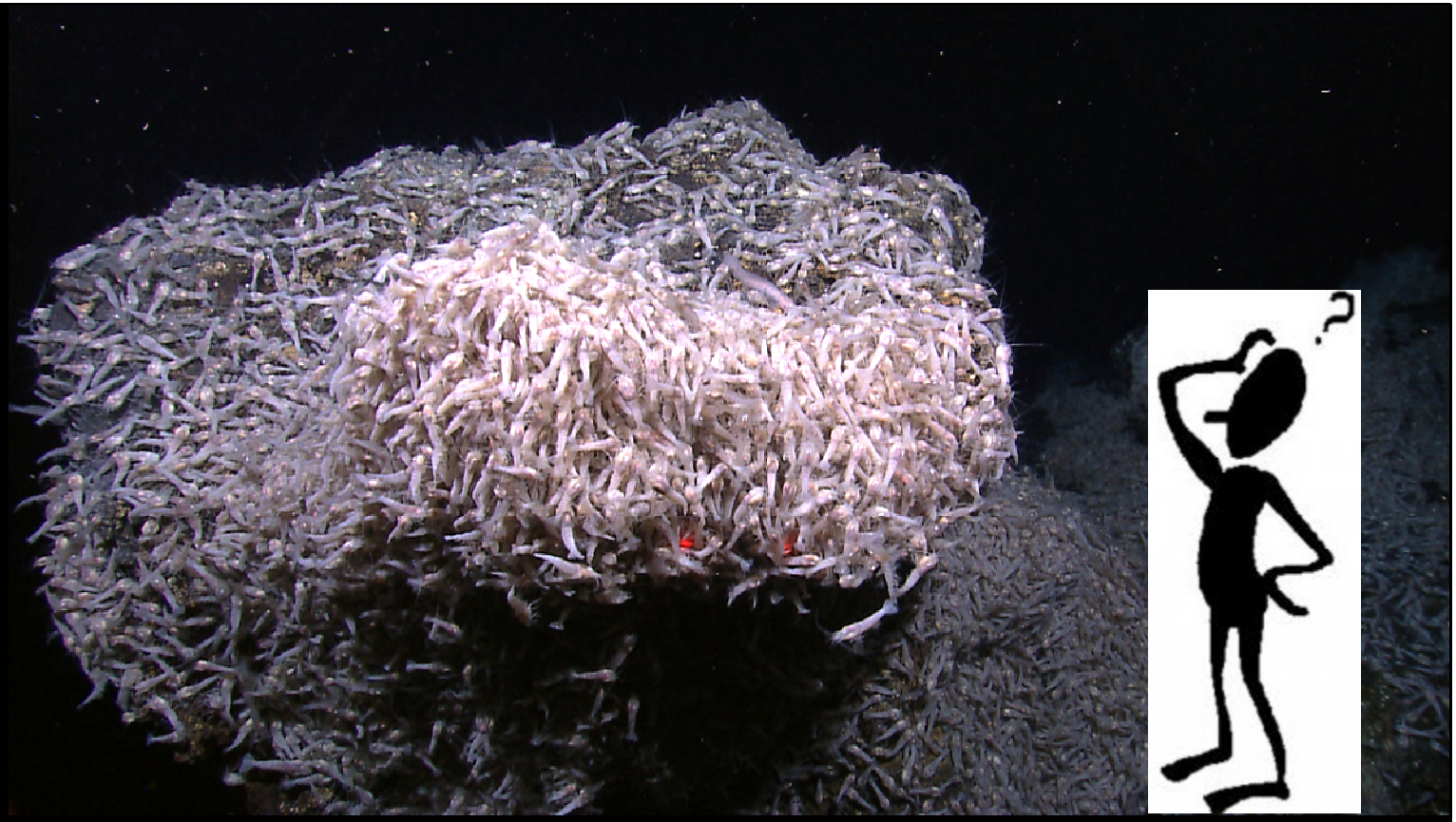


C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*

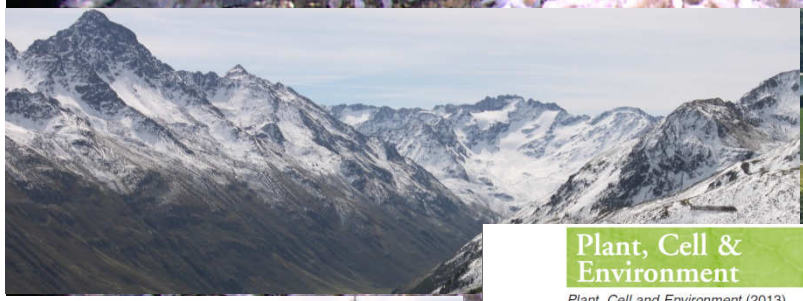
Kathrin Streit

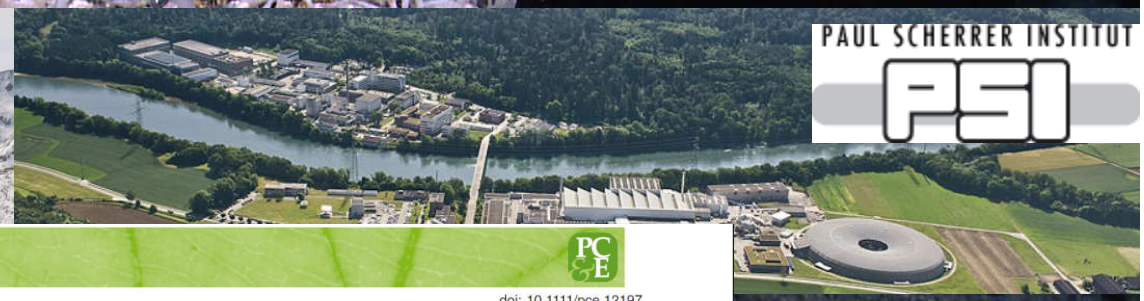


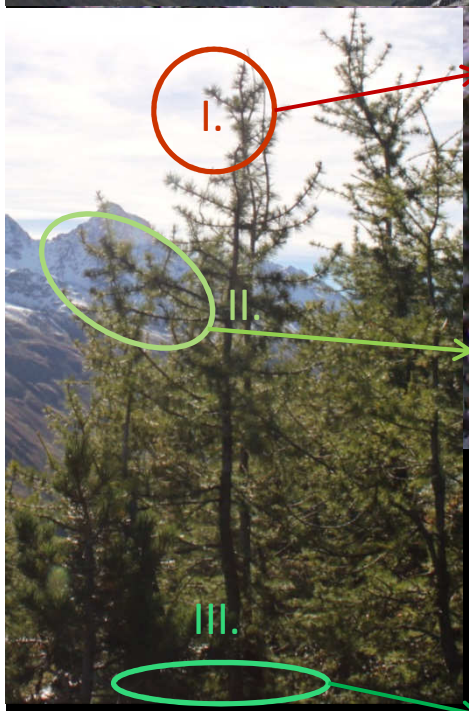
I am a terrestrial ecologist.
What am I doing working in JPL on Oceanography and Planetary Sciences?

Introduction
Methods
Results
Conclusions

PhD: C cycling in an alpine treeline ecosystem in a warmer world







Plant, Cell & Environment
Plant, Cell and Environment (2013) doi: 10.1111/pce.12197

Lack of photosynthetic or stomatal regulation after 9 years of elevated [CO_2] and 4 years of soil warming in two conifer species at the alpine treeline

KATHRIN STREIT[1], ROLF T. W. SIEGWOLF[1], FRANK HAGEDORN[2], MARCUS SCHAUB[3] & NINA BUCHMANN[4]

Research
New Phytologist

Tracing fresh assimilates through *Larix decidua* exposed to elevated CO_2 and soil warming at the alpine treeline using compound-specific stable isotope analysis

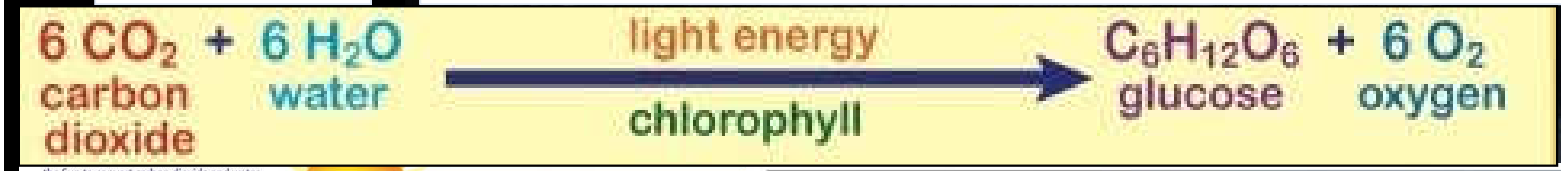
Kathrin Streit[1], Katja T. Rinne[1], Frank Hagedorn[2], Melissa A. Dawes[3], Matthias Saurer[1], Günter Hoch[4], Roland A. Werner[5], Nina Buchmann[5] and Rolf T. W. Siegwolf[1]

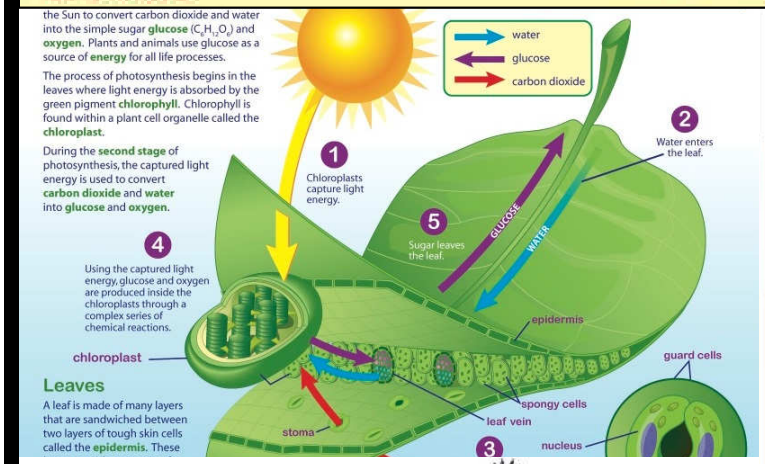
Global Change Biology
Global Change Biology (2014) 20, 1327–1338, doi: 10.1111/gcb.12396

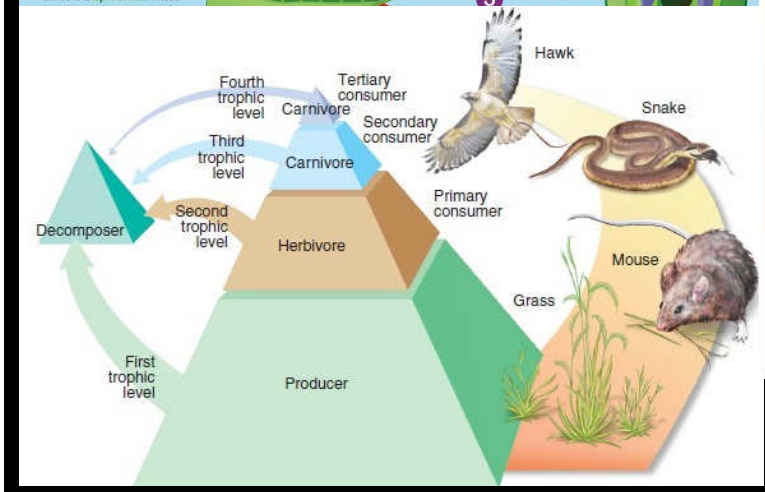
Soil warming alters microbial substrate use in alpine soils

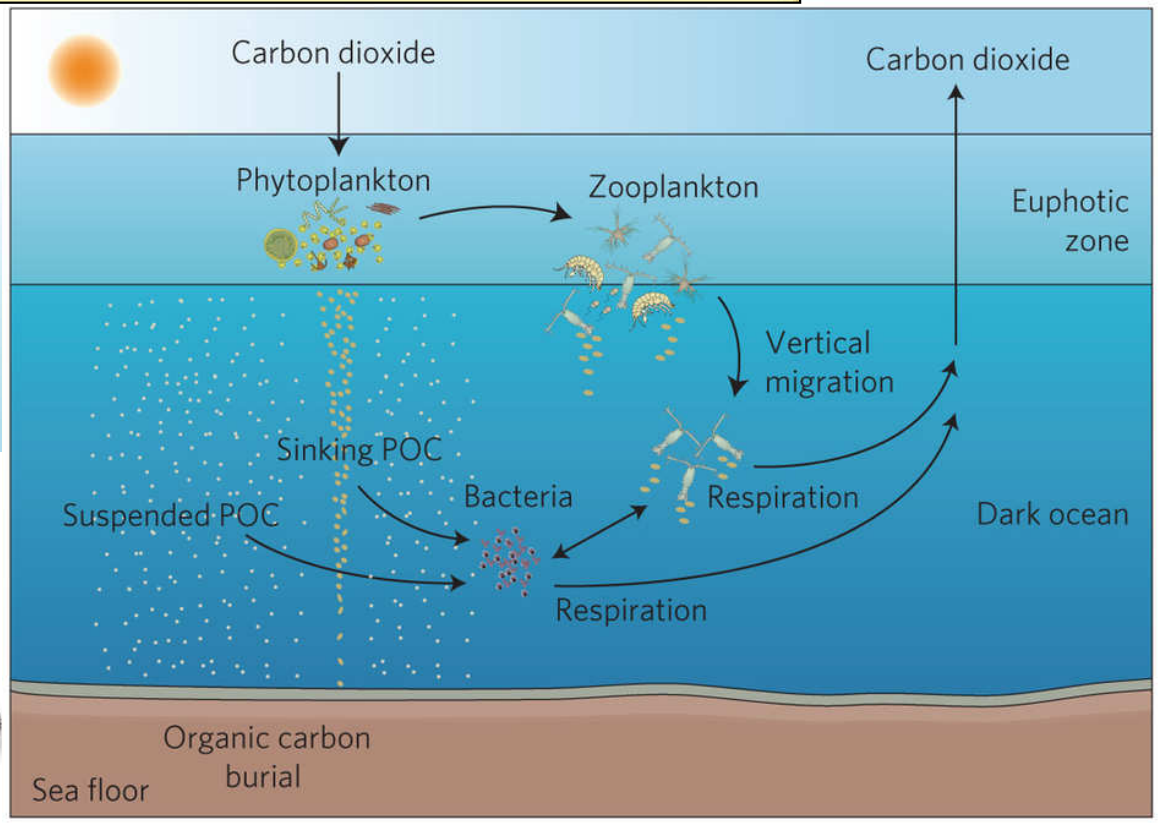
KATHRIN STREIT*, FRANK HAGEDORN†, DAVID HILTBRUNNER†, MAGDALENA PORTMANN‡, MATTHIAS SAURER*, NINA BUCHMANN§, BIRGIT WILD¶, ANDREAS RICHTER¶, SONJA WIPF** and ROLF T. W. SIEGWOLF*

Why is a terrestrial ecologist working in JPL?



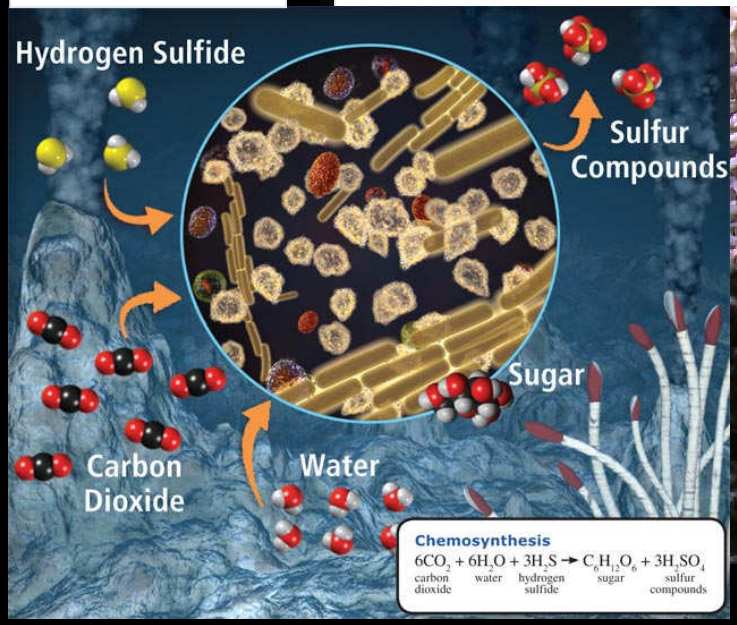


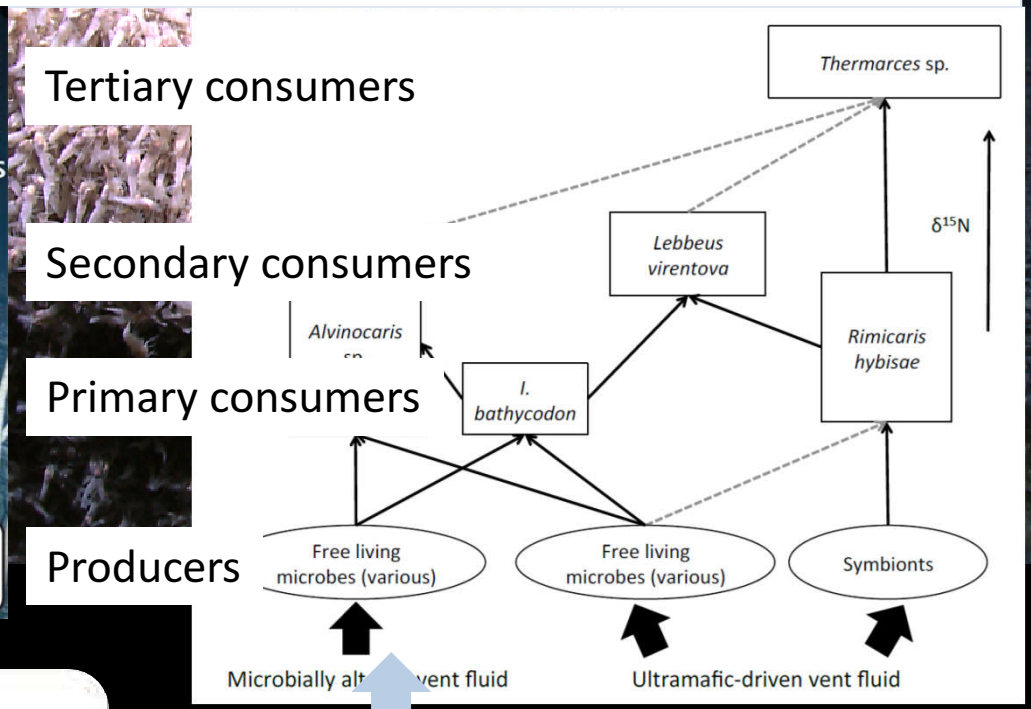




Herndl 2013 Nature

Why is a terrestrial ecologist working in JPL ?



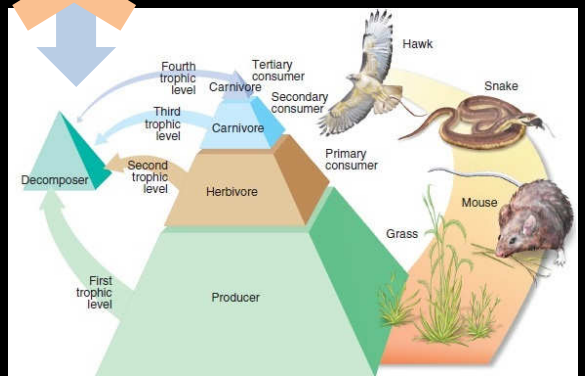


Bennett et al., submitted

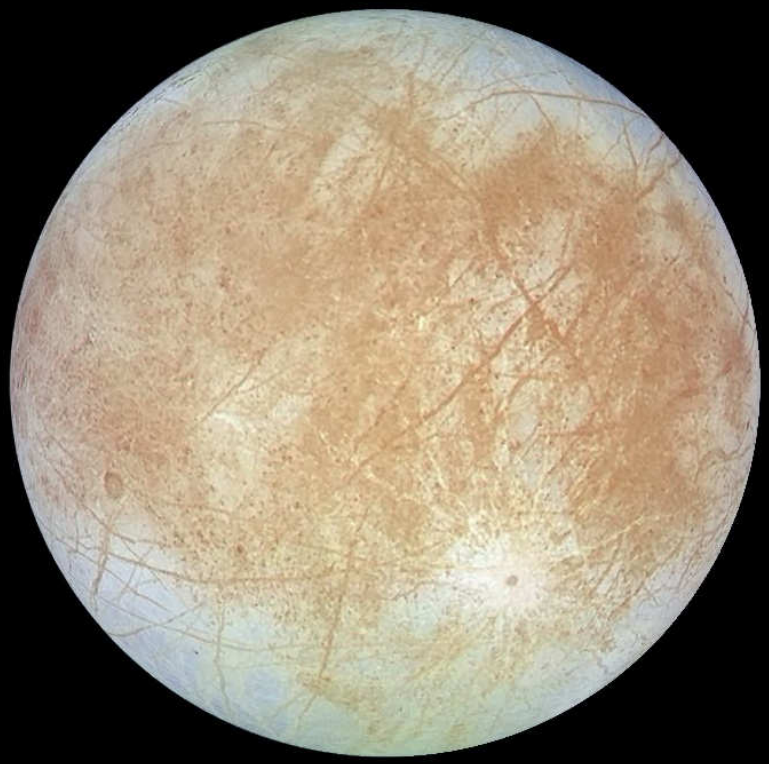
Chemosynthesis

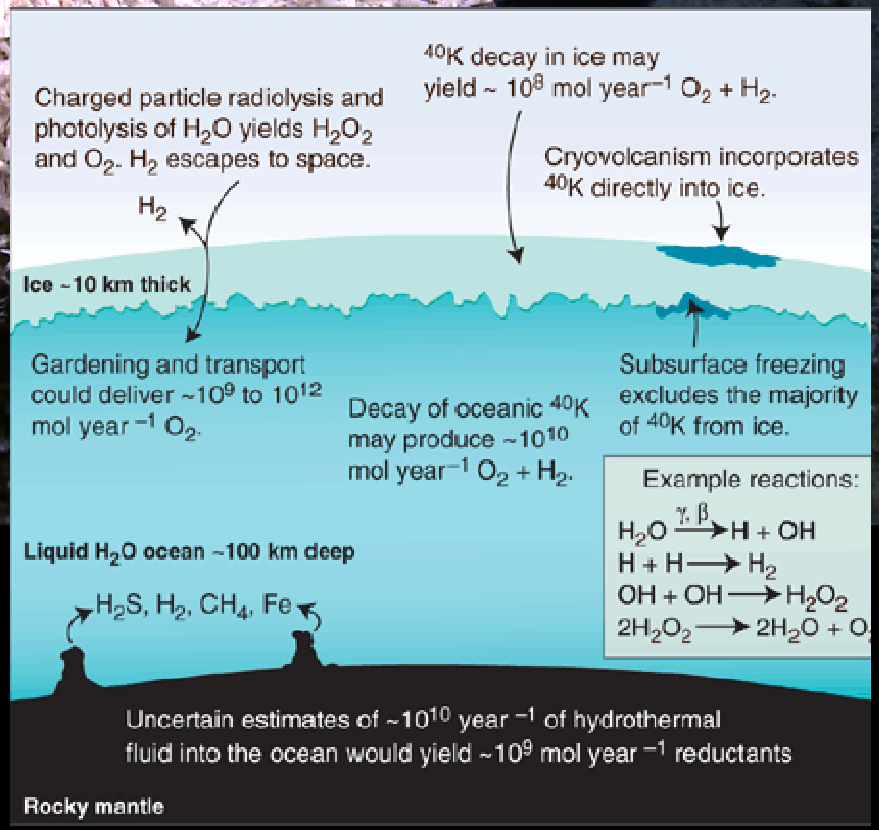
$$6CO_2 + 6H_2O + 3H_2S \rightarrow C_6H_{12}O_6 + 3H_2SO_4$$

carbon dioxide — water — hydrogen sulfide — sugar — sulfur compounds



Why is a terrestrial ecologist working in JPL?





Chyba and Hand, 2001, Science

C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*

Objective 1: "To what extent does *Rimicaris hybisae* rely on the photosynthetic C source in diet relative to the chemosynthetic C source?"

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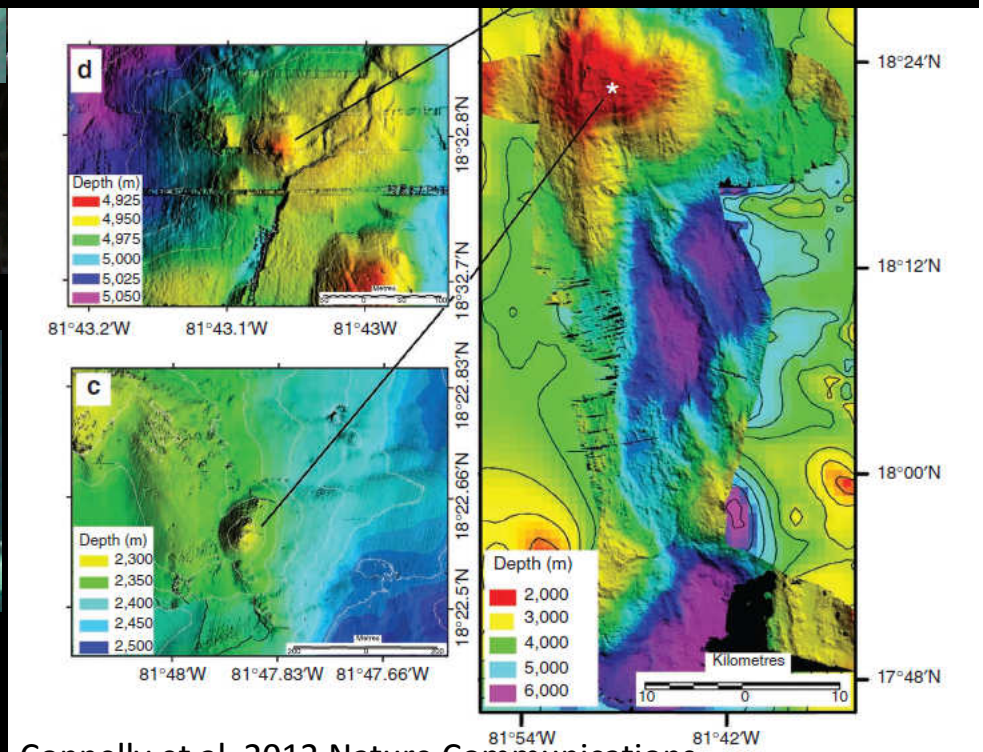
C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*

Piccard, 4987 m, 398° C, basalt hosted, metal, sulfide and hydrogen rich

Von Damm, 2300 m, 232° C, ultramafic hosted, sulfide, hydrogen and methane rich

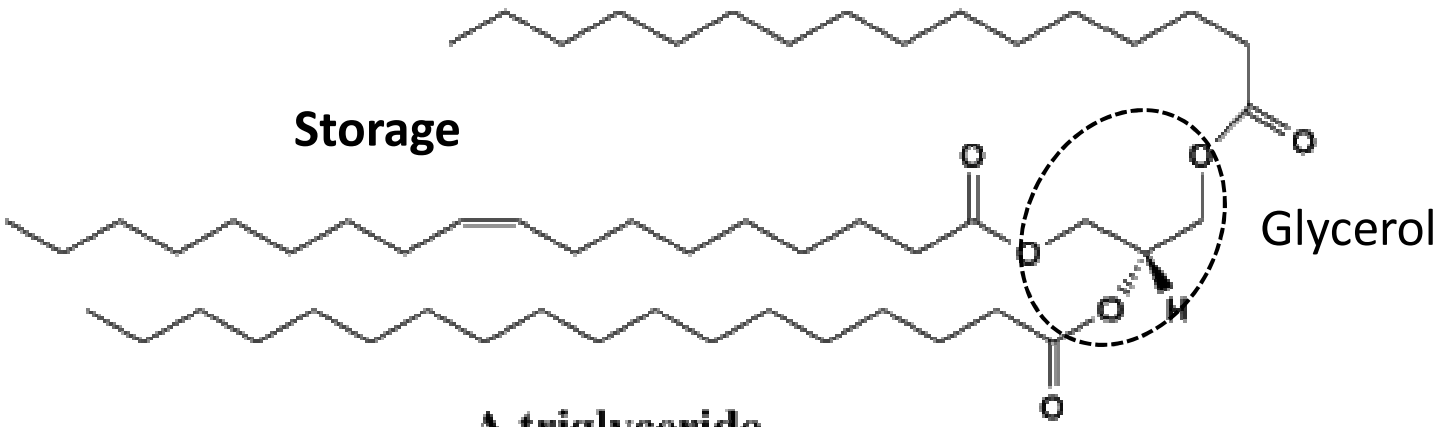
Objective 2: "How does vent chemistry and vent depth affect *R. hybisae* nutrition?"



Connelly et al. 2012 Nature Communications

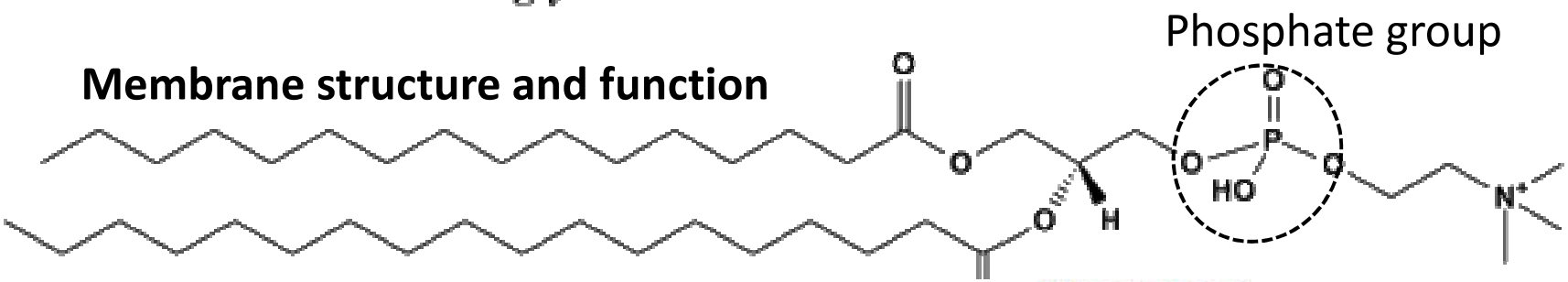
C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*

Storage



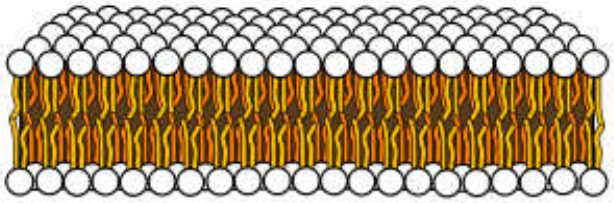
A triglyceride

Membrane structure and function



A phospholipid

Bilayer sheet



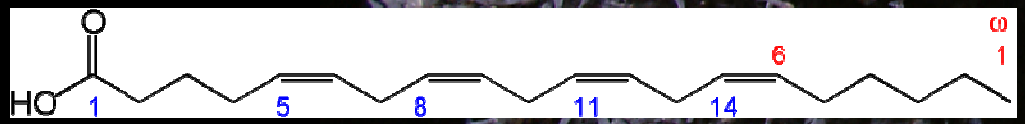
C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*

Fatty acids of photosynthetic origin

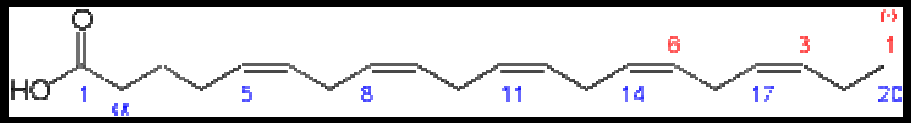
Considered essential for cell membrane structure and function

Polyunsaturated long chain fatty acids of n3 and n6 family

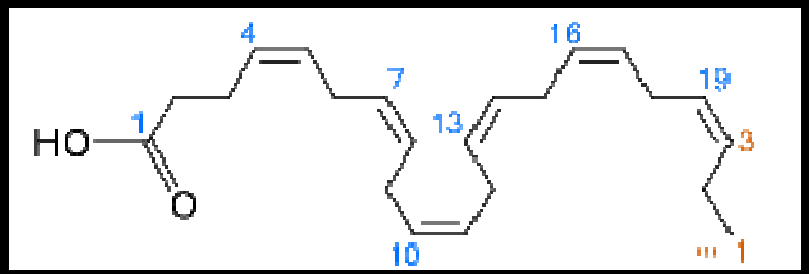
C20:4n6



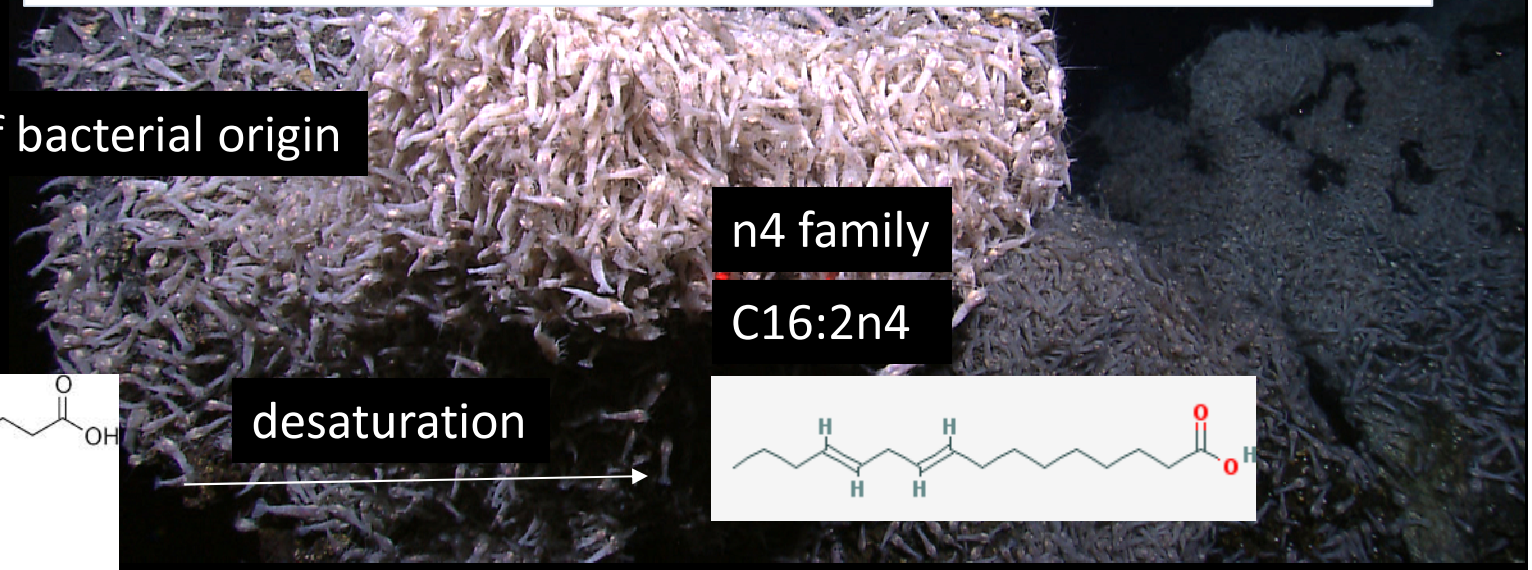
C20:5n3



C22:6n3



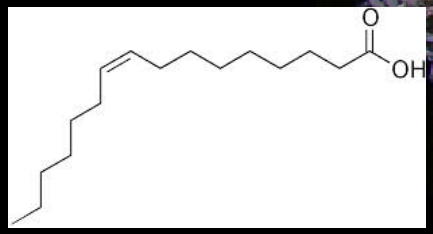
C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*



Fatty acids of bacterial origin

n7 family

C16:1n7



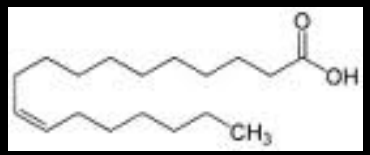
desaturation

n4 family

C16:2n4

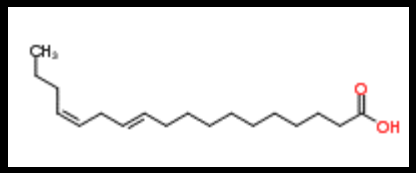
elongation

C18:1n7

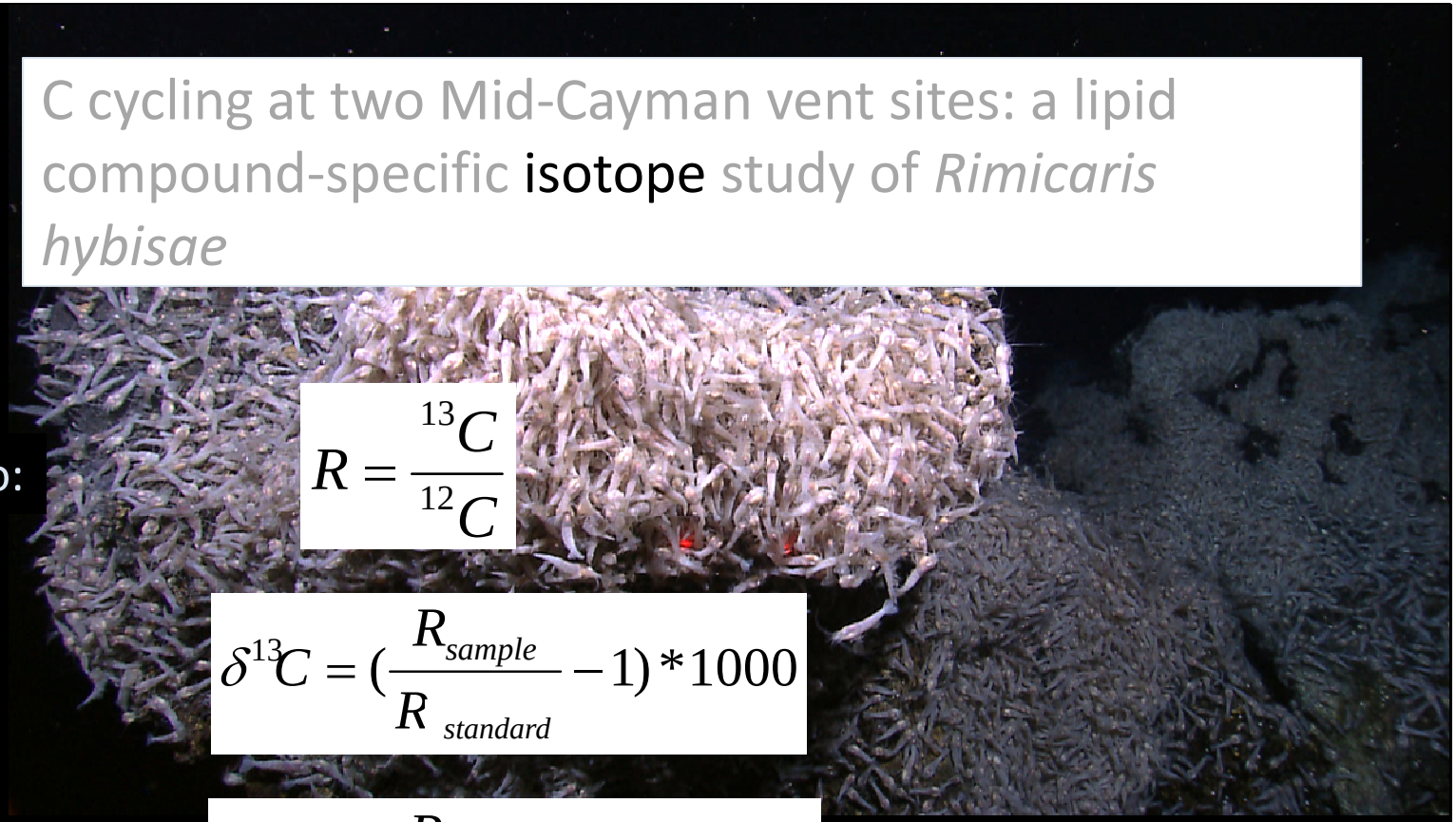


elongation

C18:2n4



C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*



Isotopic ratio:

$$R = \frac{^{13}C}{^{12}C}$$

δ- notation

$$\delta^{13}C = \left(\frac{R_{sample}}{R_{standard}} - 1\right) * 1000$$

Isotopic fractionation:

$$\Delta^{13}C = \left(\frac{R_{substrate}}{R_{product}} - 1\right) * 1000$$

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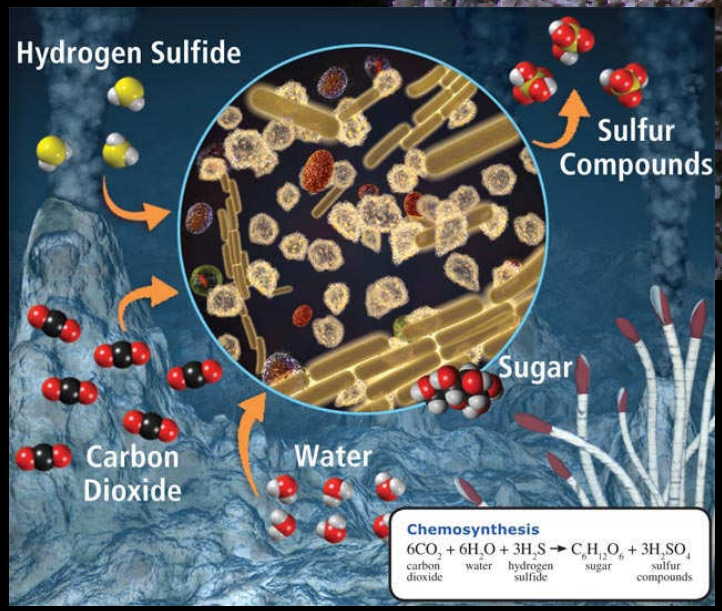
C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*

~-18 to -22‰ particulate organic matter of photosynthetic origin

Goericke and Frey, 1994



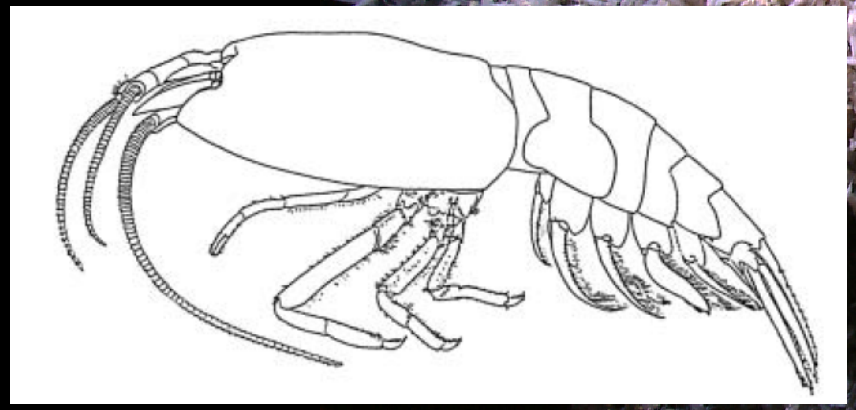
Sulfur and hydrogen oxidizing autotrophs
Reductive tricarboxylic acid cycle (rTCA)
Between -13 to -2‰

Sulfur and hydrogen oxidizing autotrophs
Reductive pentose phosphate cycle (CBB)
Between -30 and -20‰

Methanotrophs
Reductive acetyl CoA pathway (WL)
Below -30‰

Berg, 2010

C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*



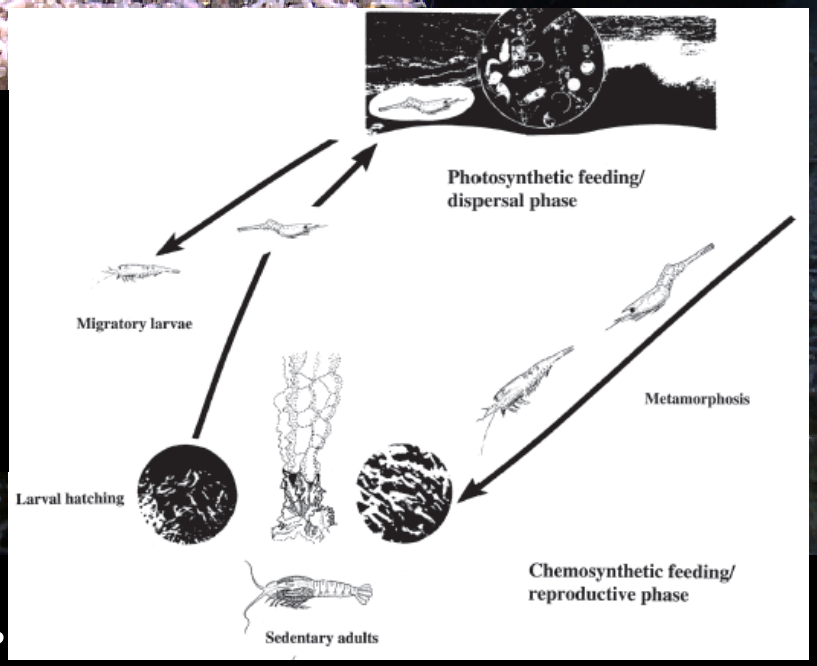
Zbinden et al. 2004

Ectosymbiotic chemosynthetic bacteria build a biofilm on gill cover and in the mouth: organic matter is taken up by host by permeation across the gill chamber integument

Ponsard et al. 2013

C cycling at two Mid-Cayman vent sites: a lipid compound-specific isotope study of *Rimicaris hybisae*

Objective 3: "How is distribution (dense vs. sparse) affecting *R. hybisae* nutrition?"

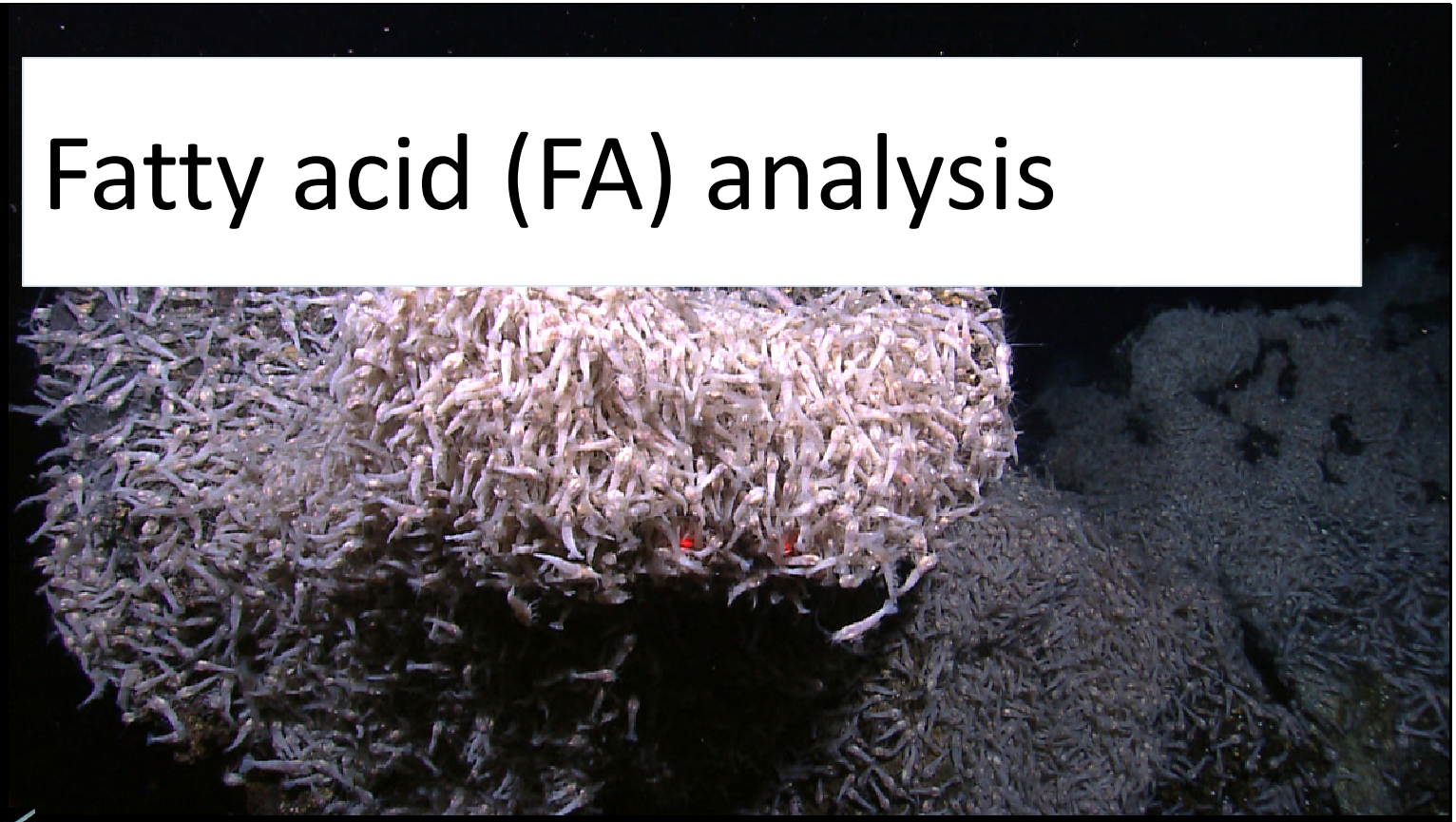


Dixon et al. 1998

Densely vs. sparsely distributed *R. hybisae*

Cobari et al. 2008

Fatty acid (FA) analysis



Adult *R. hybisae*

Abdominal tissue

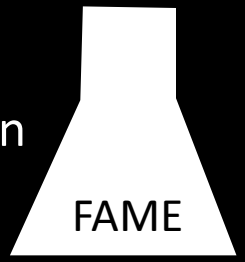
Gill cover

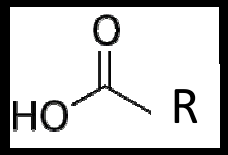
Gill cover membrane

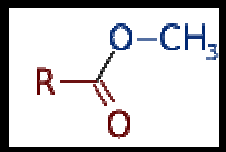
extraction →

saponification →

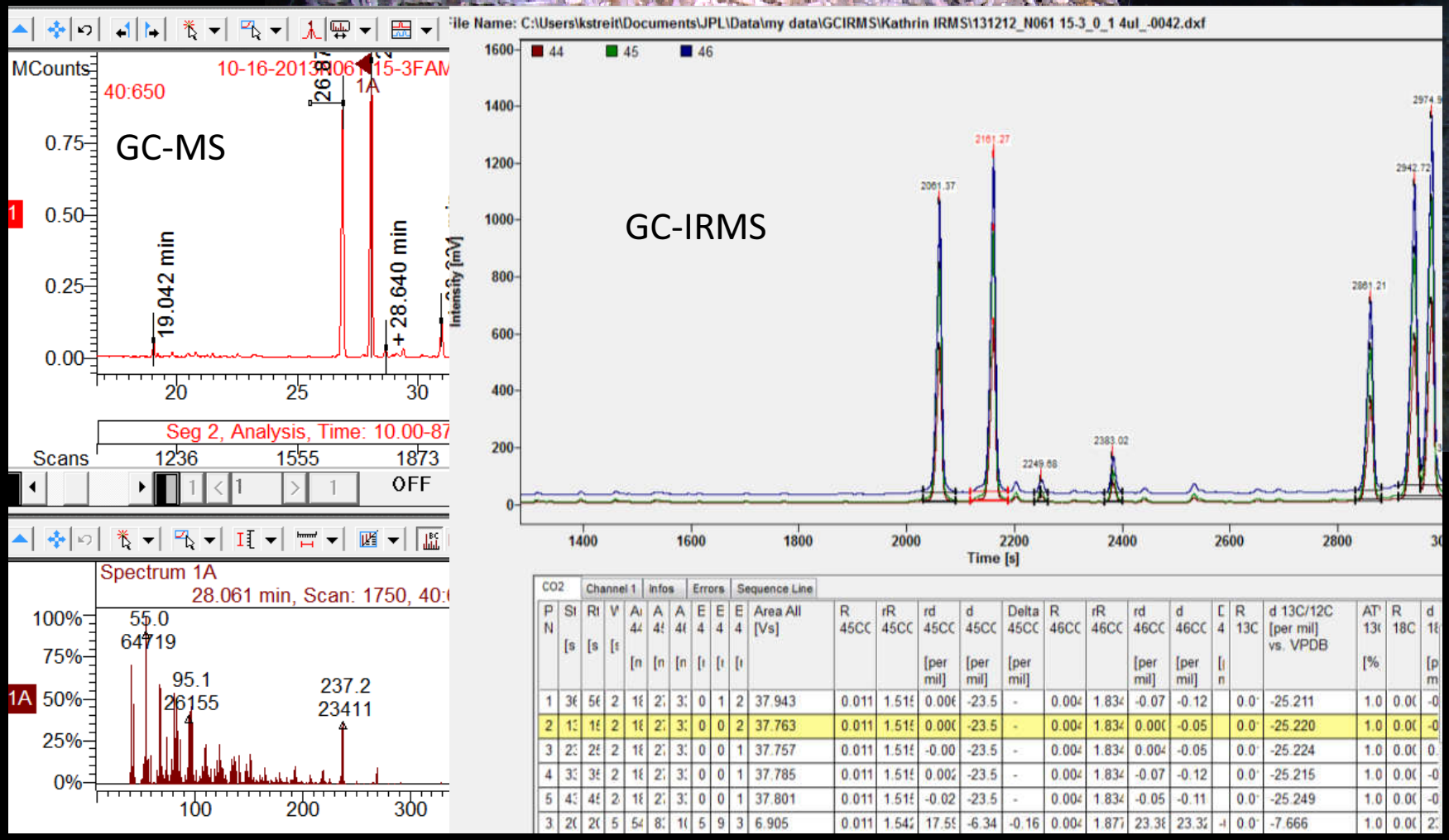
derivatization →



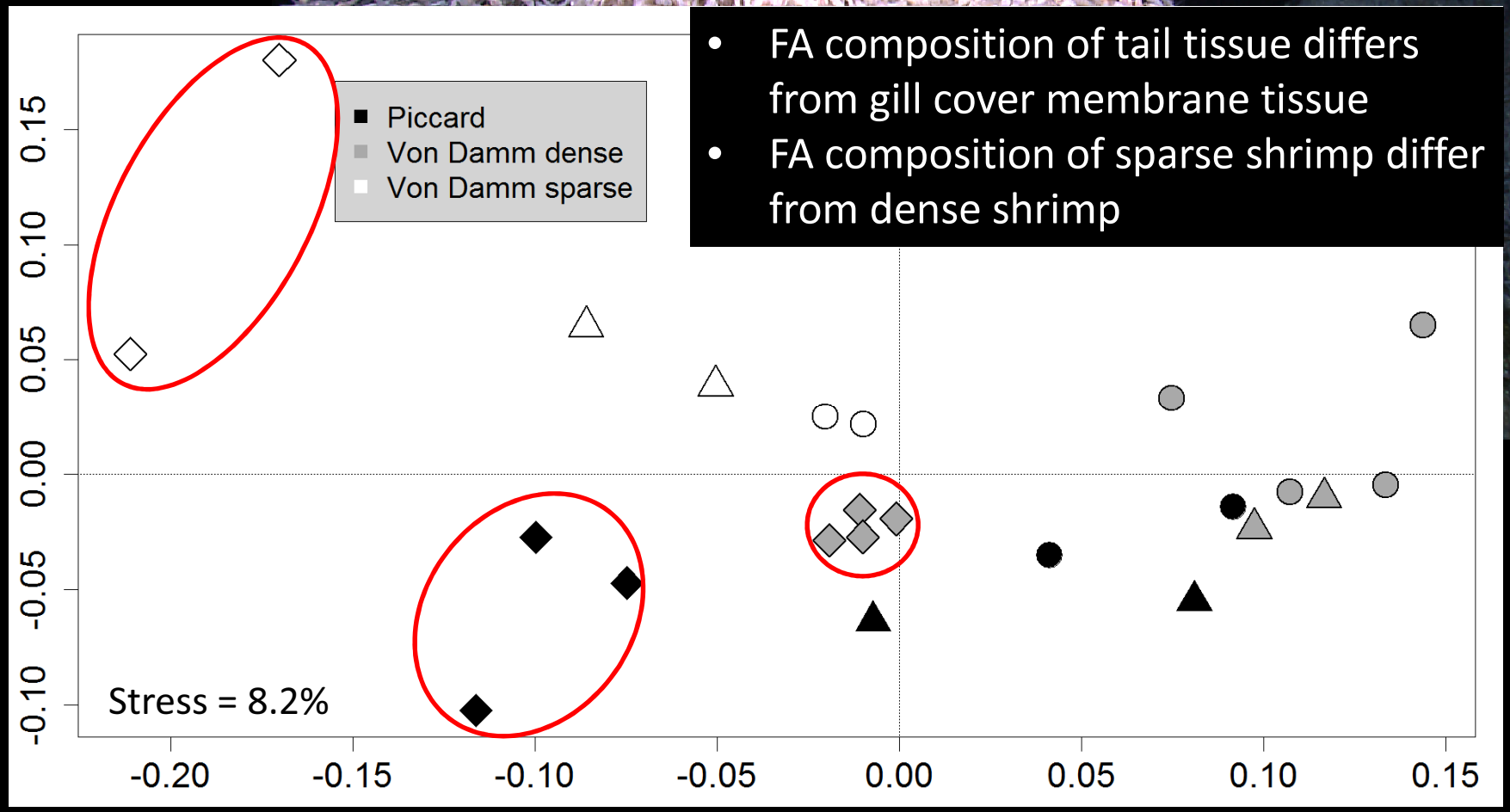




Fatty acid (FA) analysis



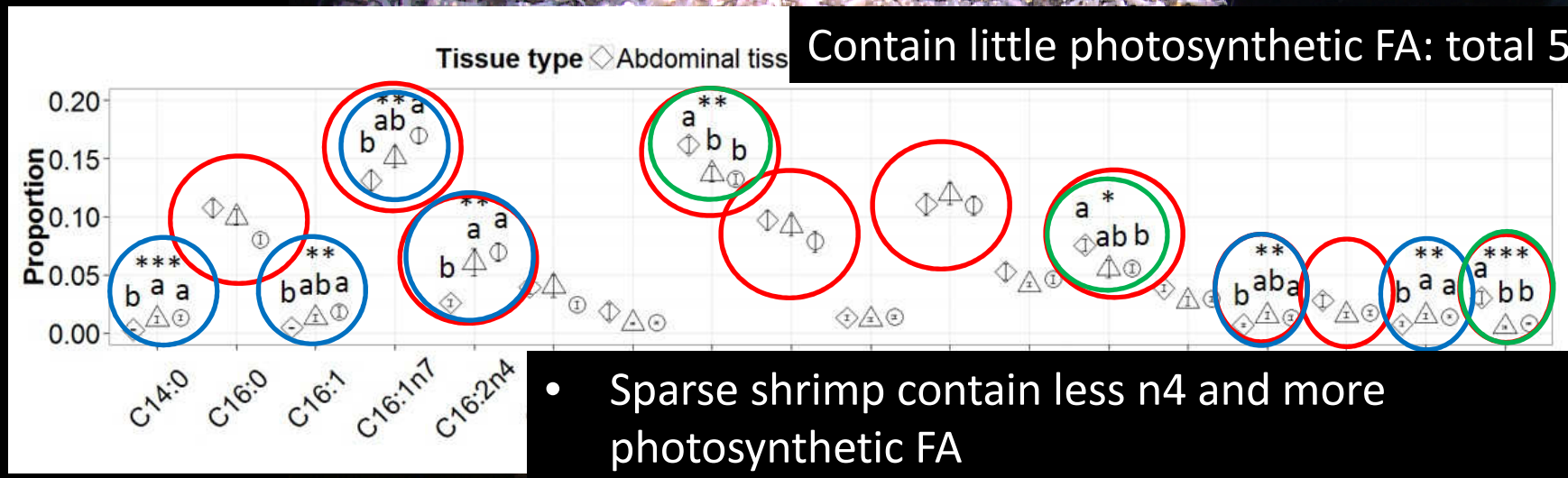
Proportion of single FA as fraction of total FA - Nonmetric multi dimensional scaling analysis



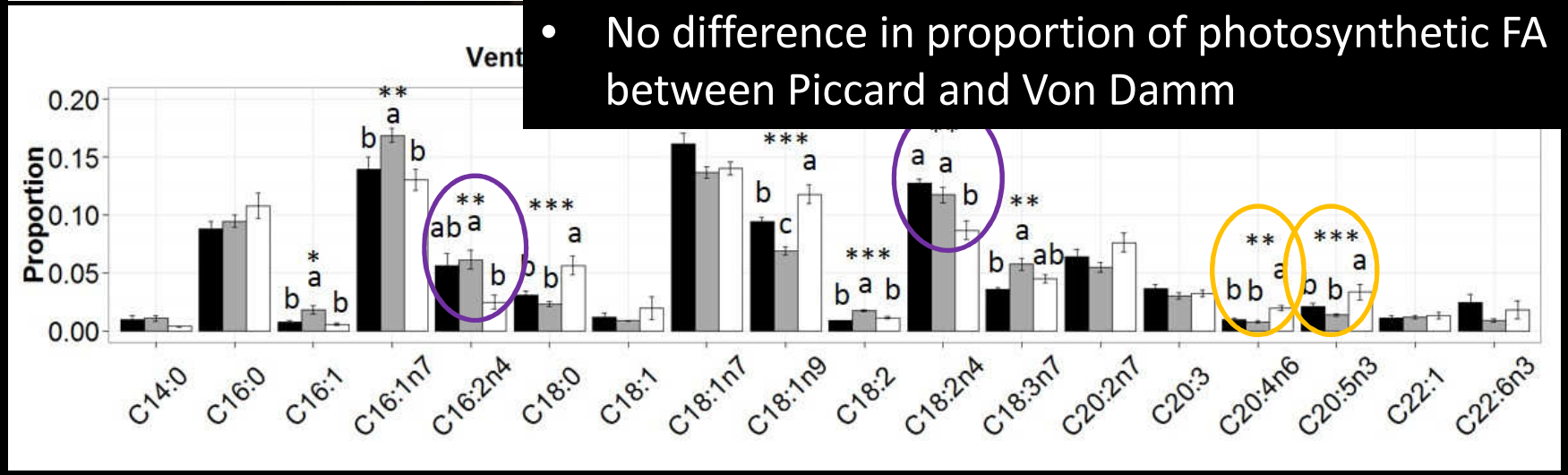
- FA composition of tail tissue differs from gill cover membrane tissue
- FA composition of sparse shrimp differ from dense shrimp

Proportion of single FA as fraction of total FA

Contain little photosynthetic FA: total 5%

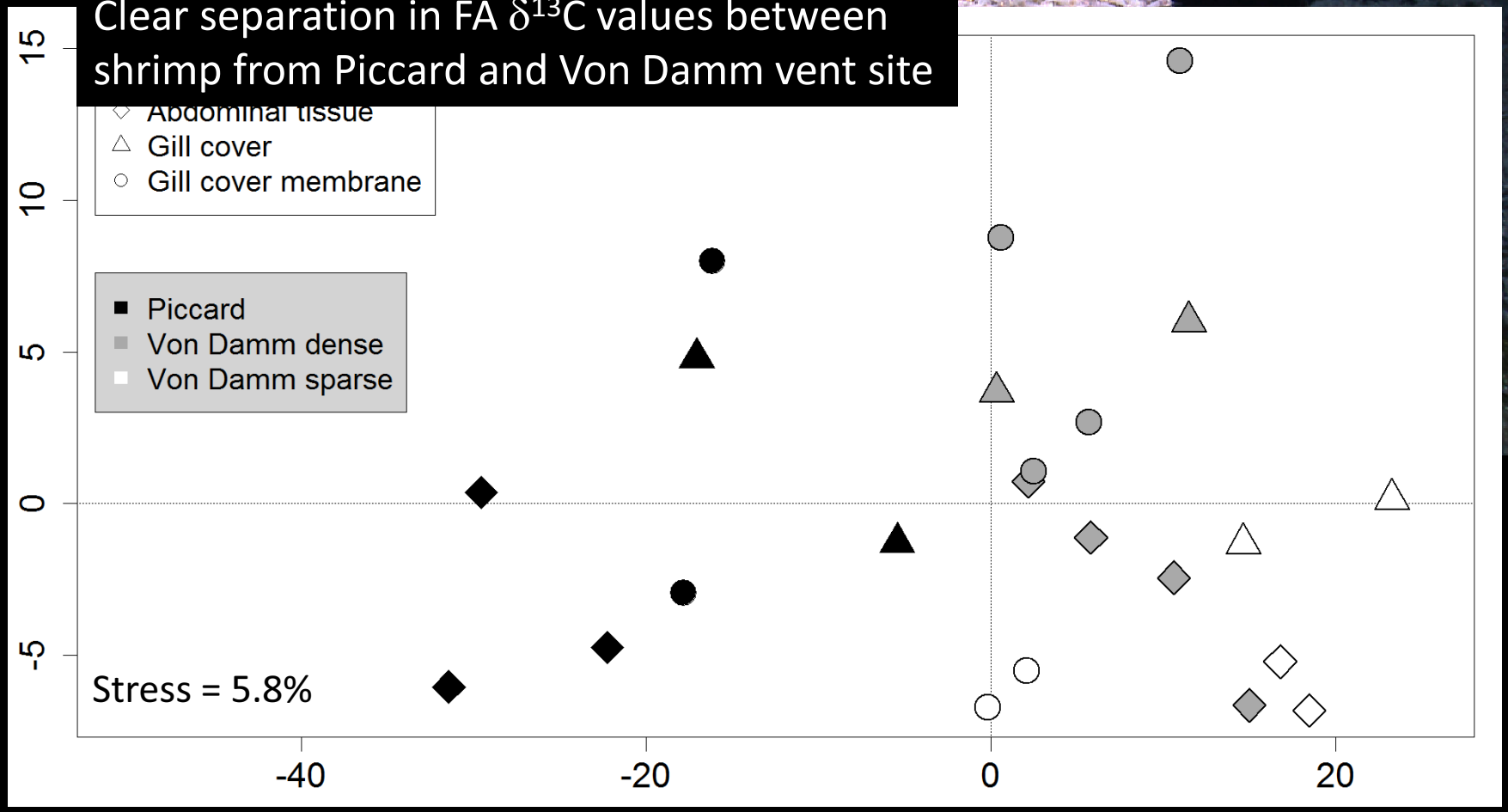


- Sparse shrimp contain less n4 and more photosynthetic FA
- No difference in proportion of photosynthetic FA between Piccard and Von Damm



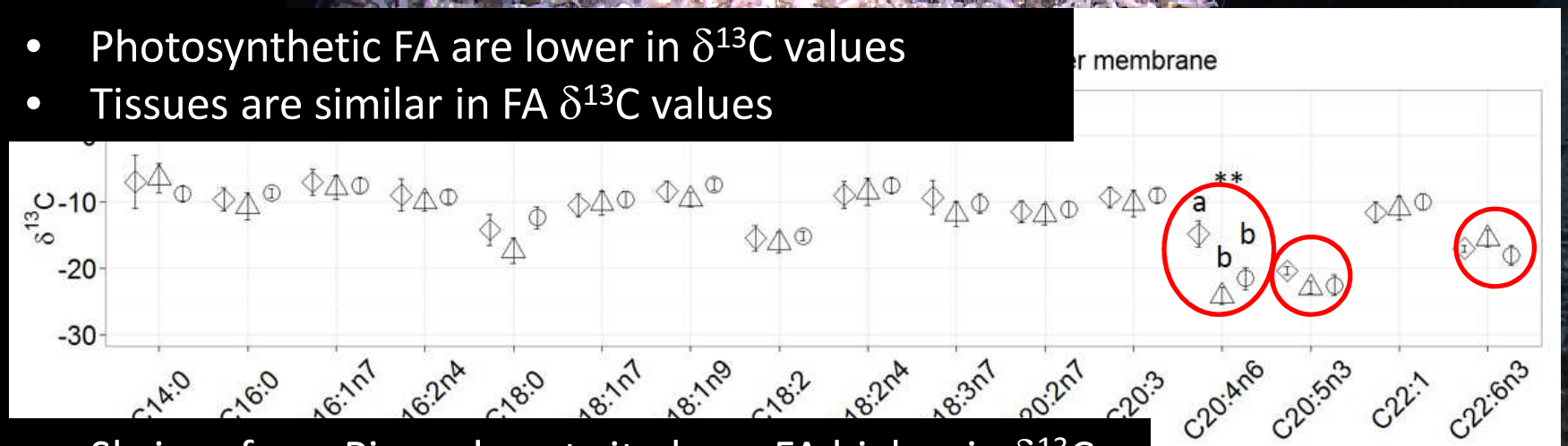
$\delta^{13}C$ values of single FA - Nonmetric multi dimensional scaling analysis

Clear separation in FA $\delta^{13}C$ values between shrimp from Piccard and Von Damm vent site

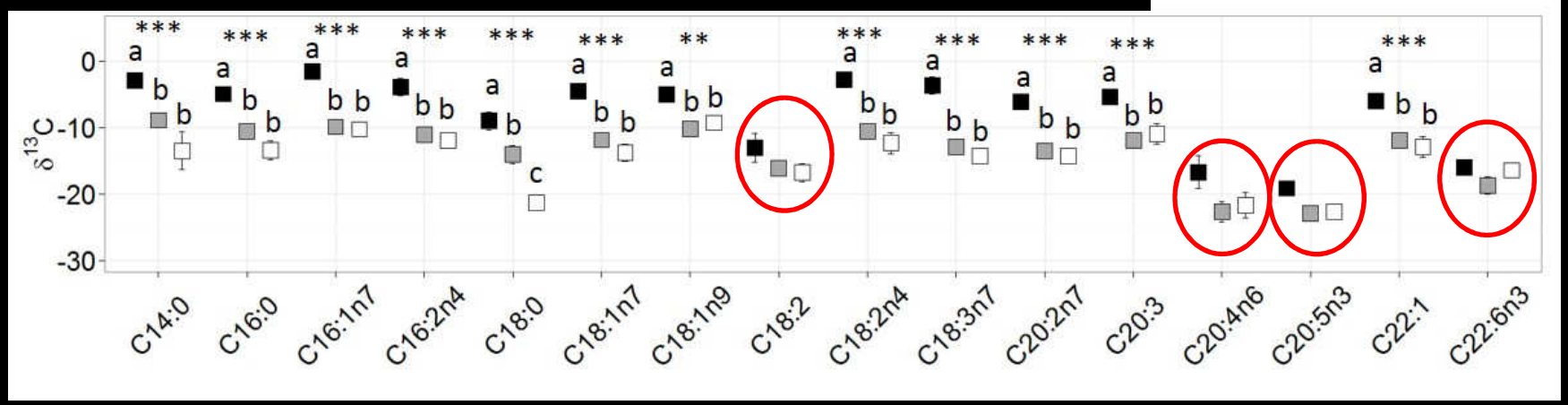


$\delta^{13}C$ values of fatty acids - differences between tissues and sites

- Photosynthetic FA are lower in $\delta^{13}C$ values
- Tissues are similar in FA $\delta^{13}C$ values



- Shrimp from Piccard vent site have FA higher in $\delta^{13}C$
- Photosynthetic FA are excluded from this rule

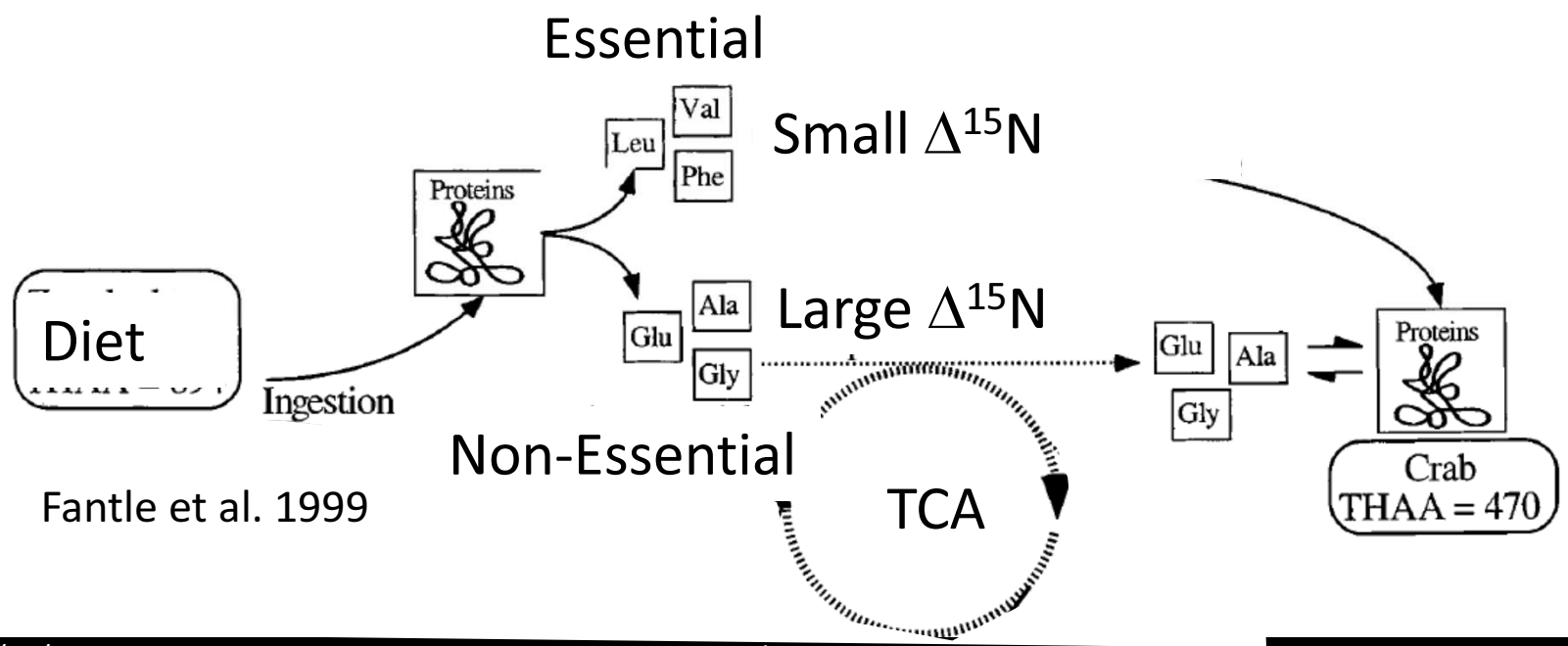


Conclusion

- Particulate organic matter of photosynthetic origin plays a minor role in the diet of adult *R. hybisae*
- Vent fluid chemistry influences bacterial community composition and, therefore, pathways of C fixation used, while vent depth has no influence on amount of particulate organic matter sinking to the ground
- Sparse shrimp show a reduced contribution of C fixed by chemosynthetic symbionts. They use an alternative food source, which is partly photosynthetic.
- While chemosynthetically driven ecosystems are possible on Europa, *R. hybisae* like organisms could not be part of it (photosynthetic FA dependency). Primary consumers would have a different membrane structure not relying on photosynthetic input.

Outlook: Amino acids $\delta^{15}N$

- $\Delta^{15}N$ -> strong fractionation between trophic levels
- Amino acids represent most N of organism



Fantle et al. 1999