Impacts of unusually high sea ice cover on Antarctic coastal benthic food web structure

Loïc N. MICHEL, Philippe DUBOIS, Marc ELEAUME, Jérôme FOURNIER, Cyril GALLUT, Philip JANE & Gilles LEPOINT

Contact: loicnmichel@gmail.com

IsoEcol 2016 – 03-08/04/2016 – Tokyo, Japan

Context: sea ice in Antarctica

Antarctic littoral is circled by a fringe of sea ice (up to 20 millions km^2)

Sea ice is a major environmental driver in Antarctica, influences

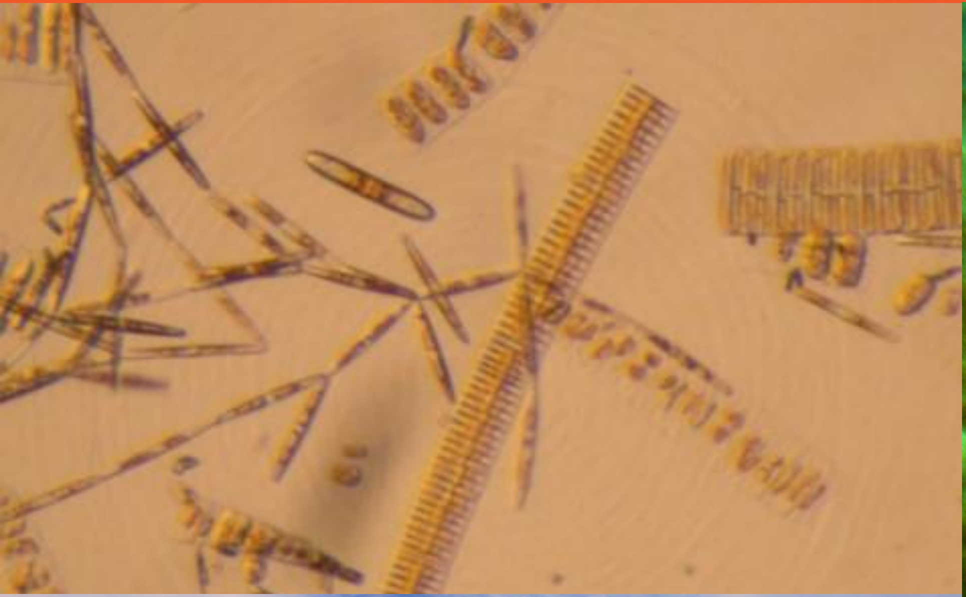
- Air/Sea interactions
- Water column mixing
- Light penetration
- Organic matter fluxes
- …

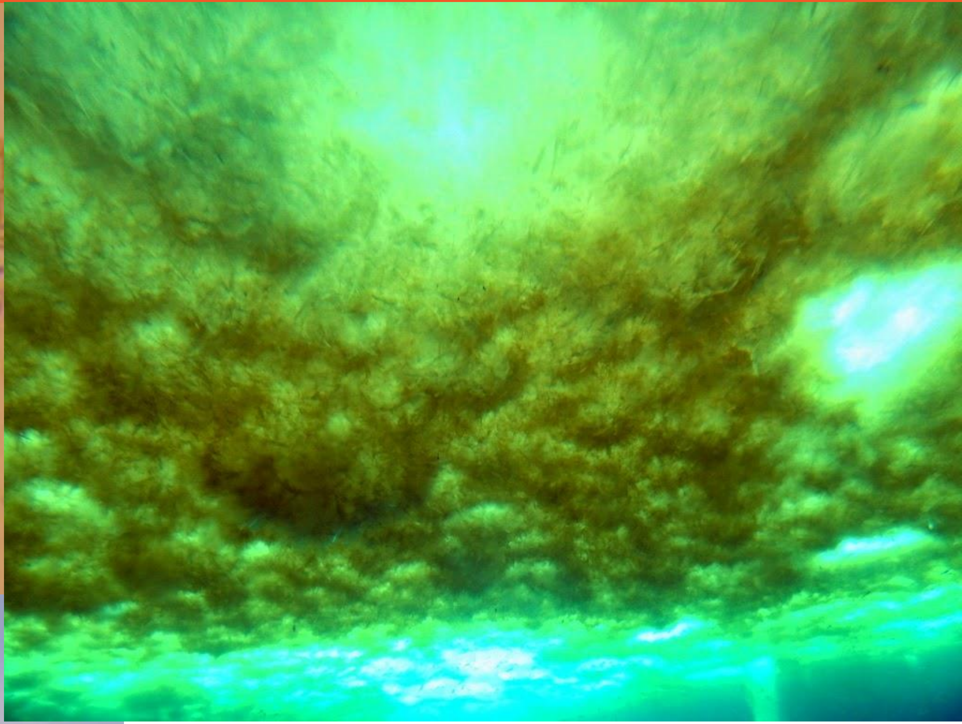
Sea ice is highly dynamic

Sea ice hosts sympagic organisms

Image: NASA

Context: sea ice in Antarctica





Source: Australian Antarctic Division

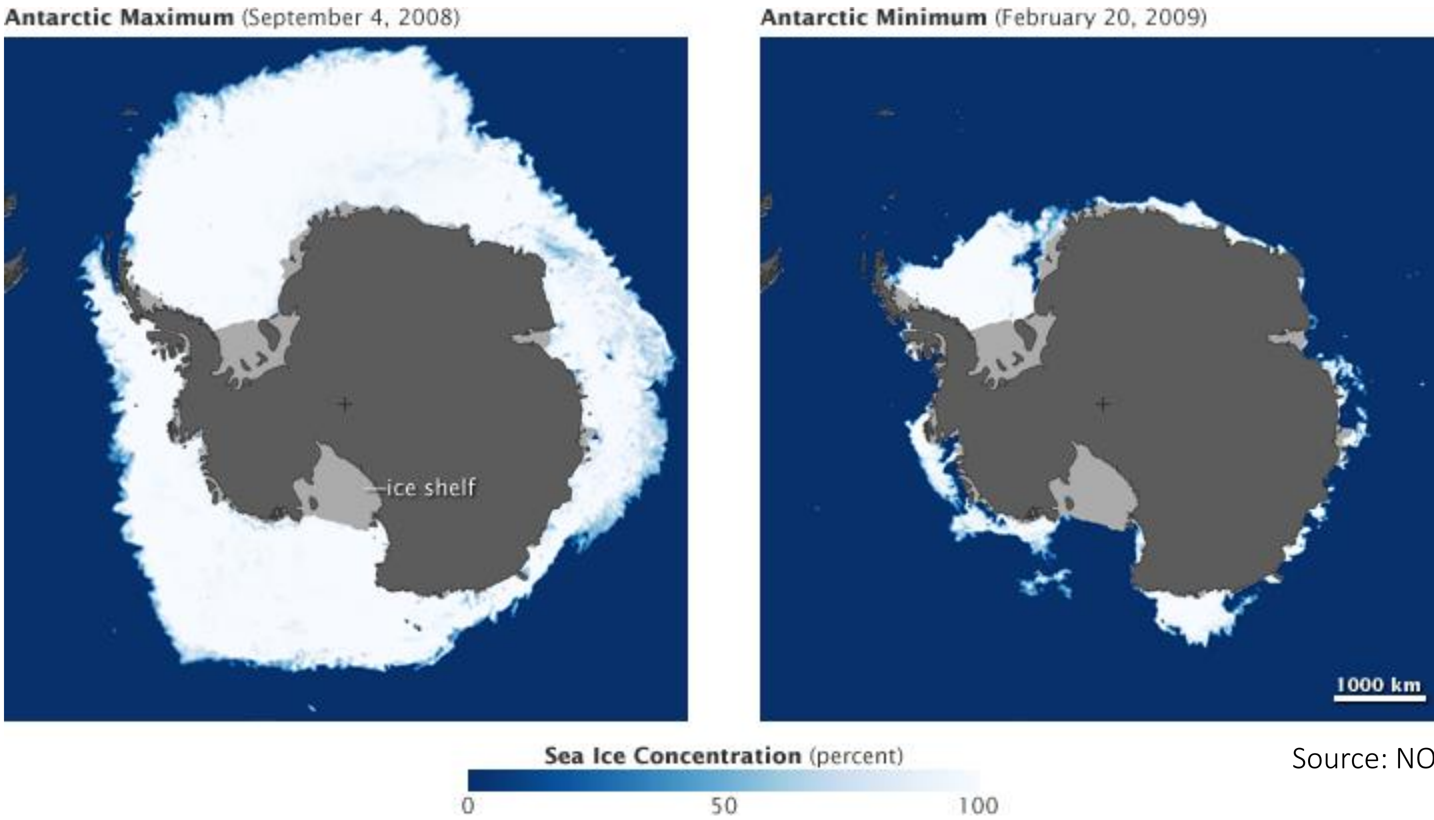
Sympagic algae:

Mostly diatoms

Form thick mats

Filaments up to several cm

Seasonal patterns of sea ice cover



Source: NOAA

Normal cycle:

Austral winter

Thick sea ice cover

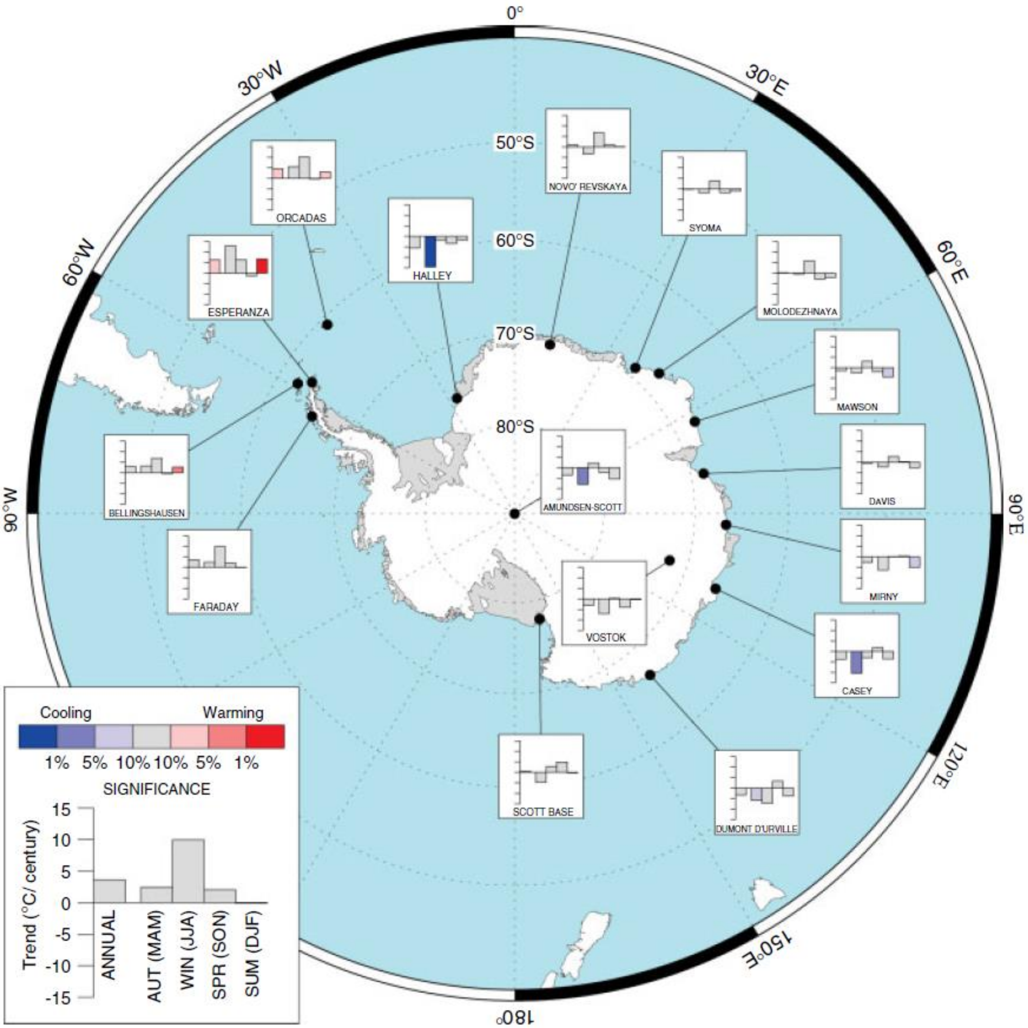
Austral summer

Thinning and breakup of sea ice

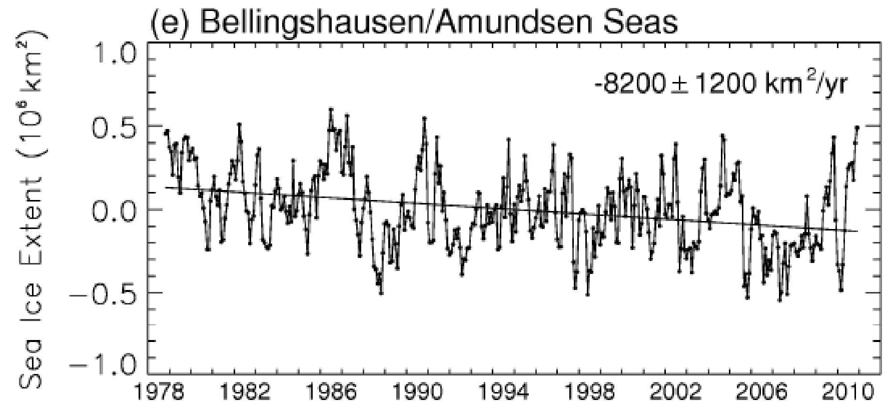
Release of sympagic material

High productivity events

Climate change and sea ice cover

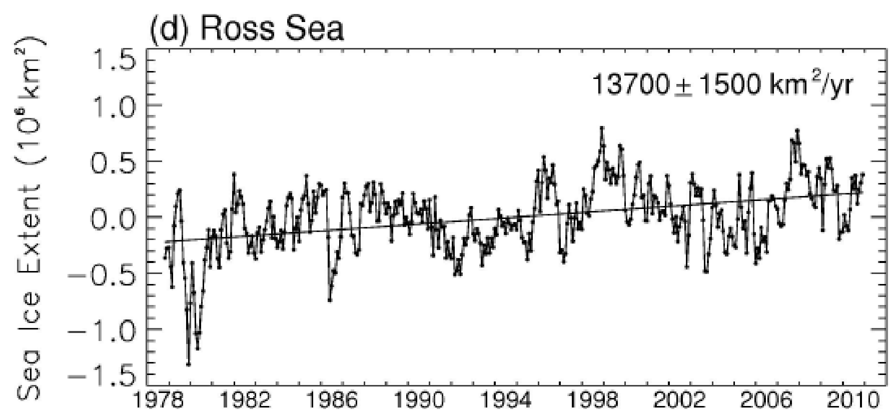


Turner et al. 2005 Int J Climatol 25: 279-294
(Data 1971-2000)



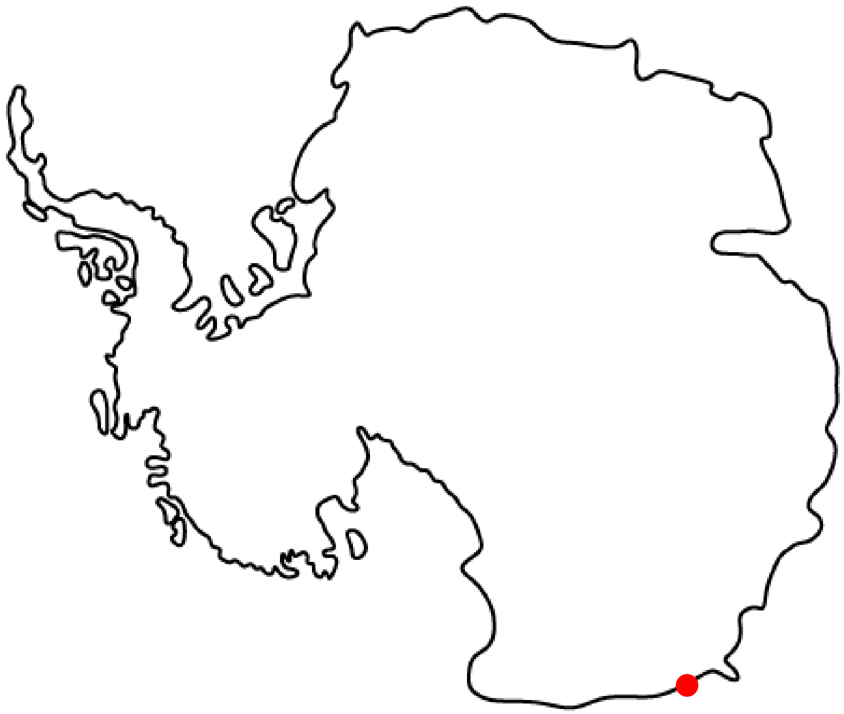
West Antarctic Peninsula — T° ↗ — Ice cover ↘

East Antarctica — T° → ↘ — Ice cover ↗



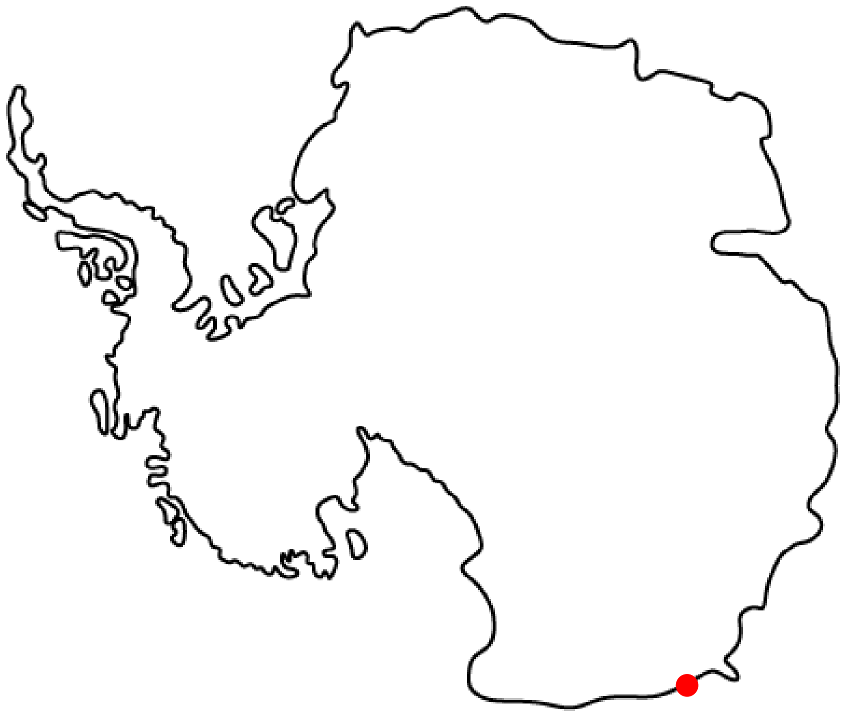
Parkinson & Cavalieri 2012 Cryosphere 6: 871-880

Study site: Dumont d'Urville station



East Antarctica, Adélie Land
Petrels Island

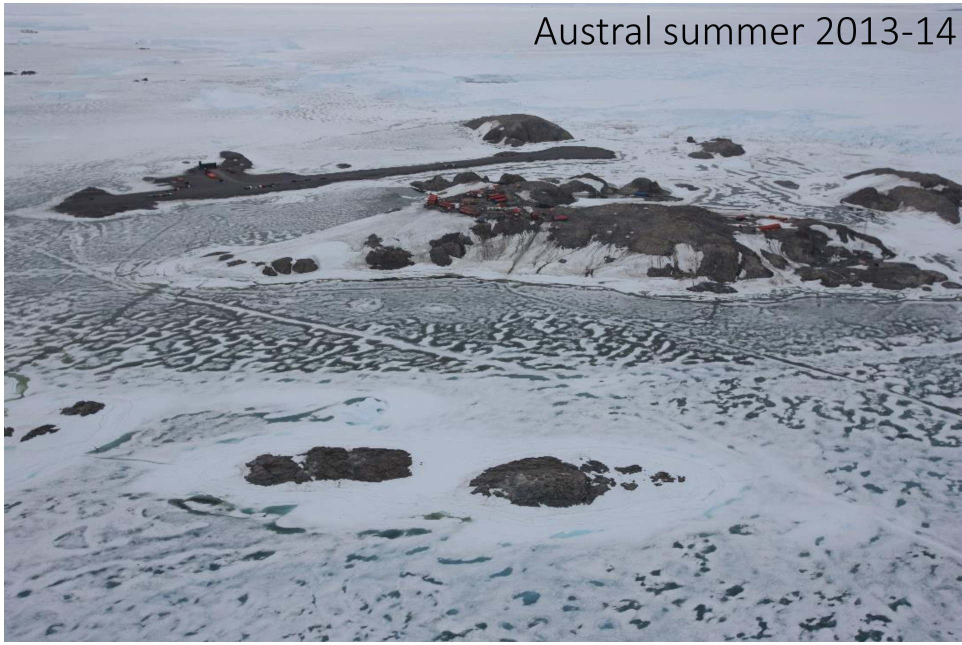
Study site: Dumont d'Urville station



East Antarctica, Adélie Land
Petrels Island

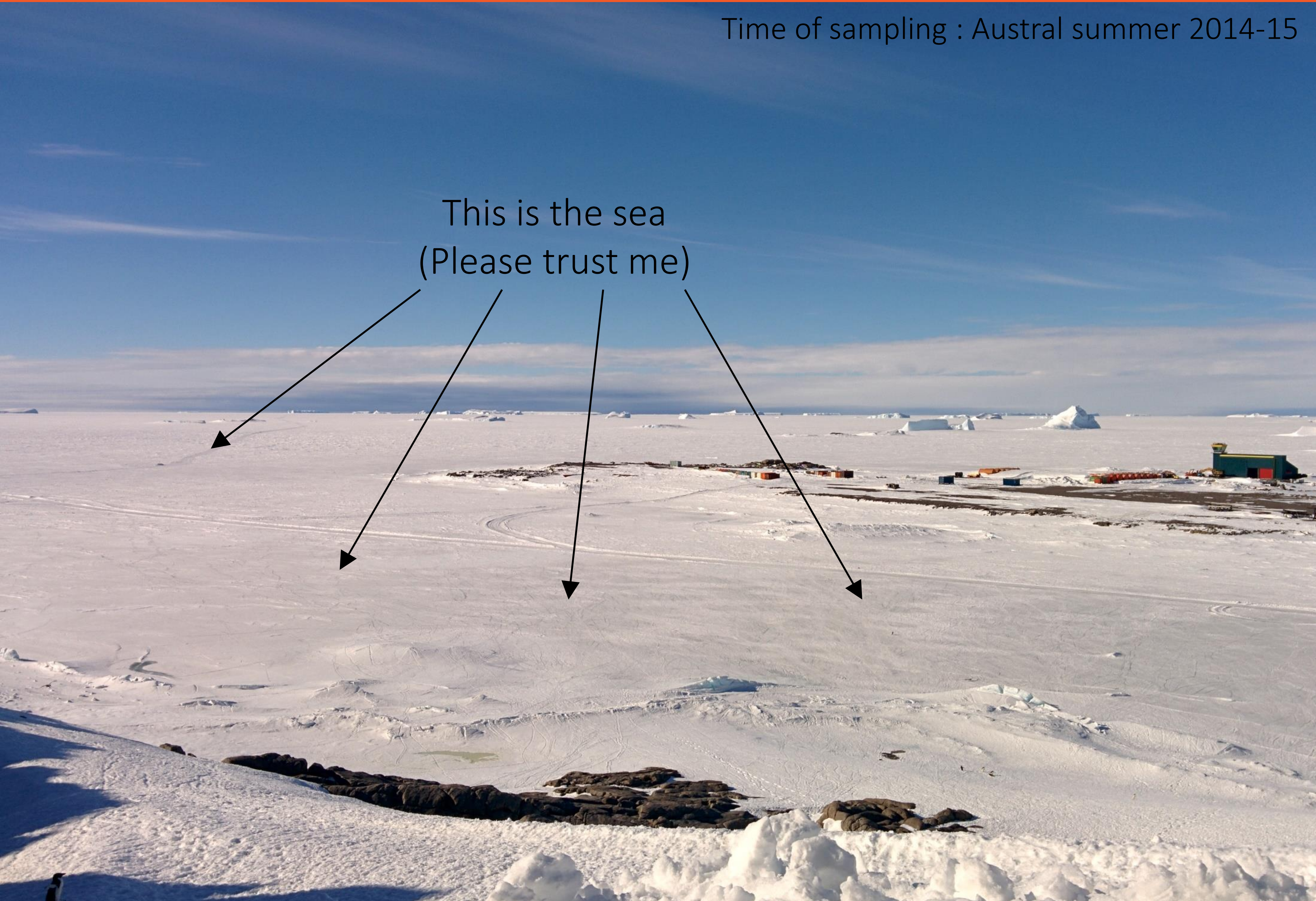
2013-2015: Event of high spatial and temporal sea ice coverage

No seasonal breakup during austral summers 2013-14 and 2014-15



Study site: Dumont d'Urville station

Time of sampling : Austral summer 2014-15



Objectives

How will Antarctic communities respond to such environmental changes?

How could increased sea ice cover impact benthic food webs?

Objectives

How will Antarctic communities respond to such environmental changes?

How could increased sea ice cover impact benthic food webs?

↓

Use of stable isotope ratios to identify resources supporting dominant benthic invertebrates (primary consumers & omnivores)

Quantification of relative importance of 4 producers / organic matter pools

Objectives

How will Antarctic communities respond to such environmental changes?

How could increased sea ice cover impact benthic food webs?

Objectives

How will Antarctic communities respond to such environmental changes?

How could increased sea ice cover impact benthic food webs?

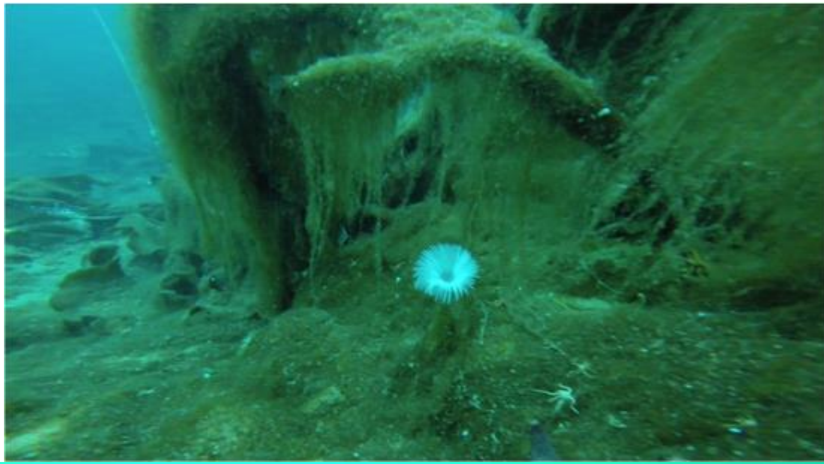
3. Benthic brown algae *Himantothallus grandifolius*

Objectives

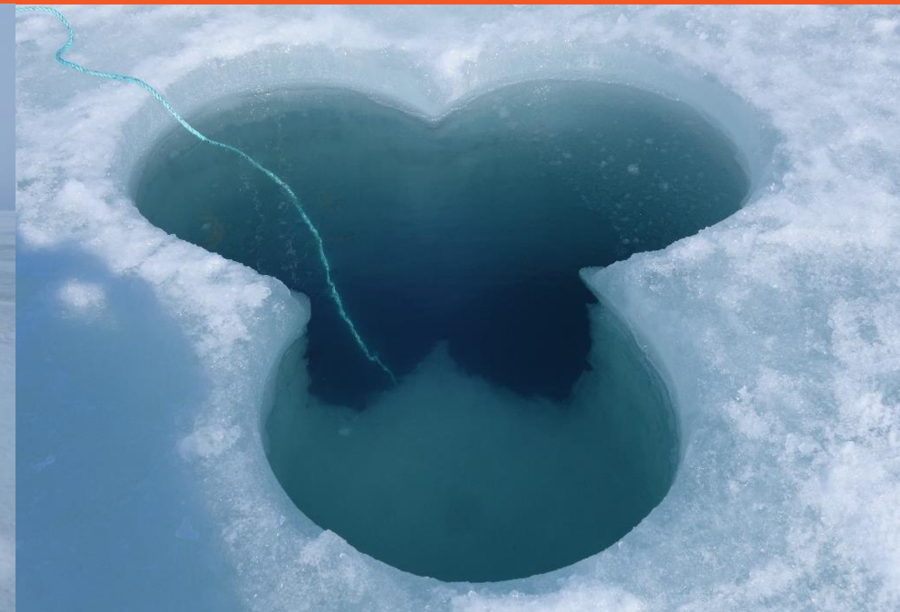
How will Antarctic communities respond to such environmental changes?

How could increased sea ice cover impact benthic food webs?

4. Benthic biofilm
(heterogeneous mix of microalgae, amorphous material and detrital items)



Material & methods: sampling



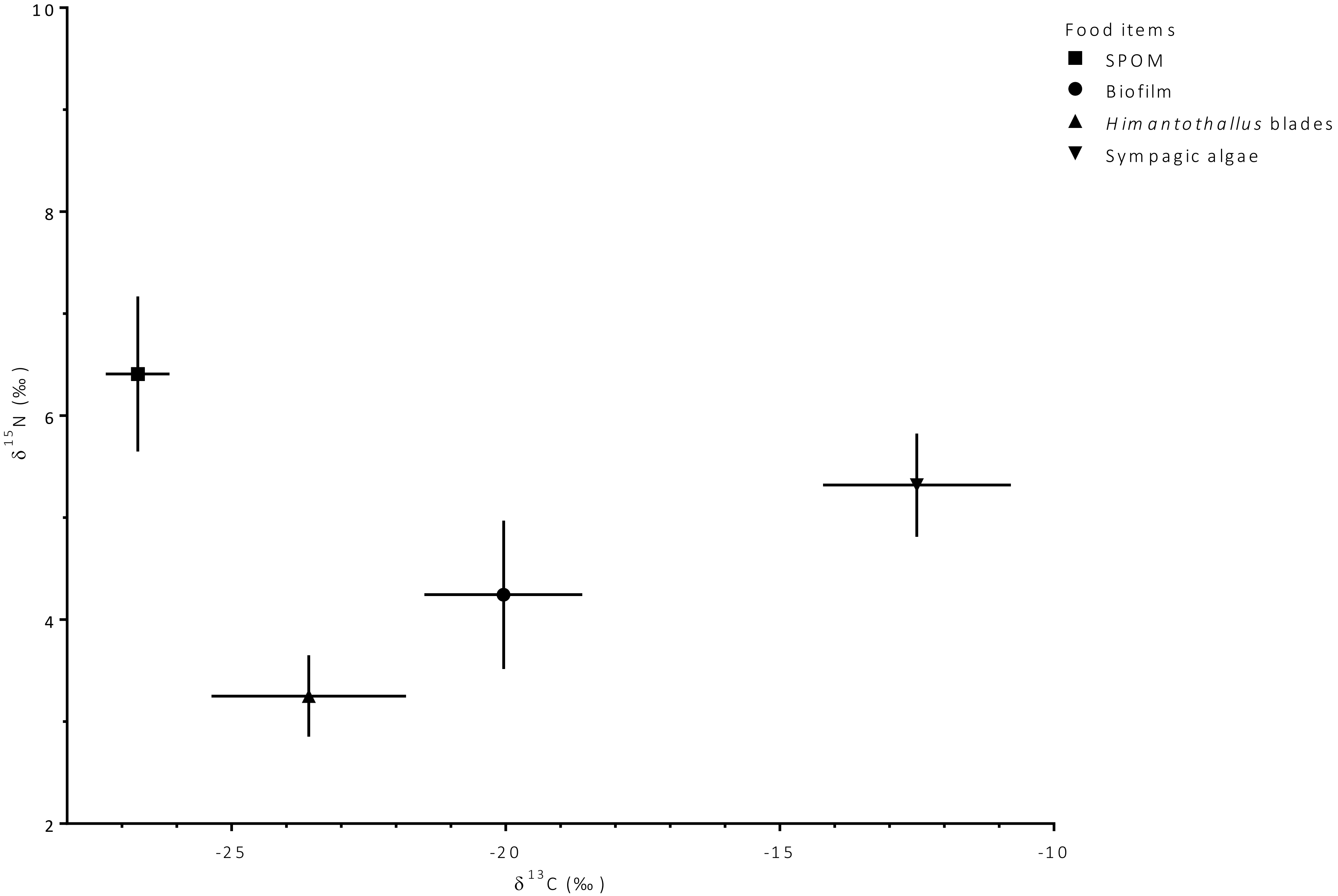
Hand collection

SCUBA diving under fast ice

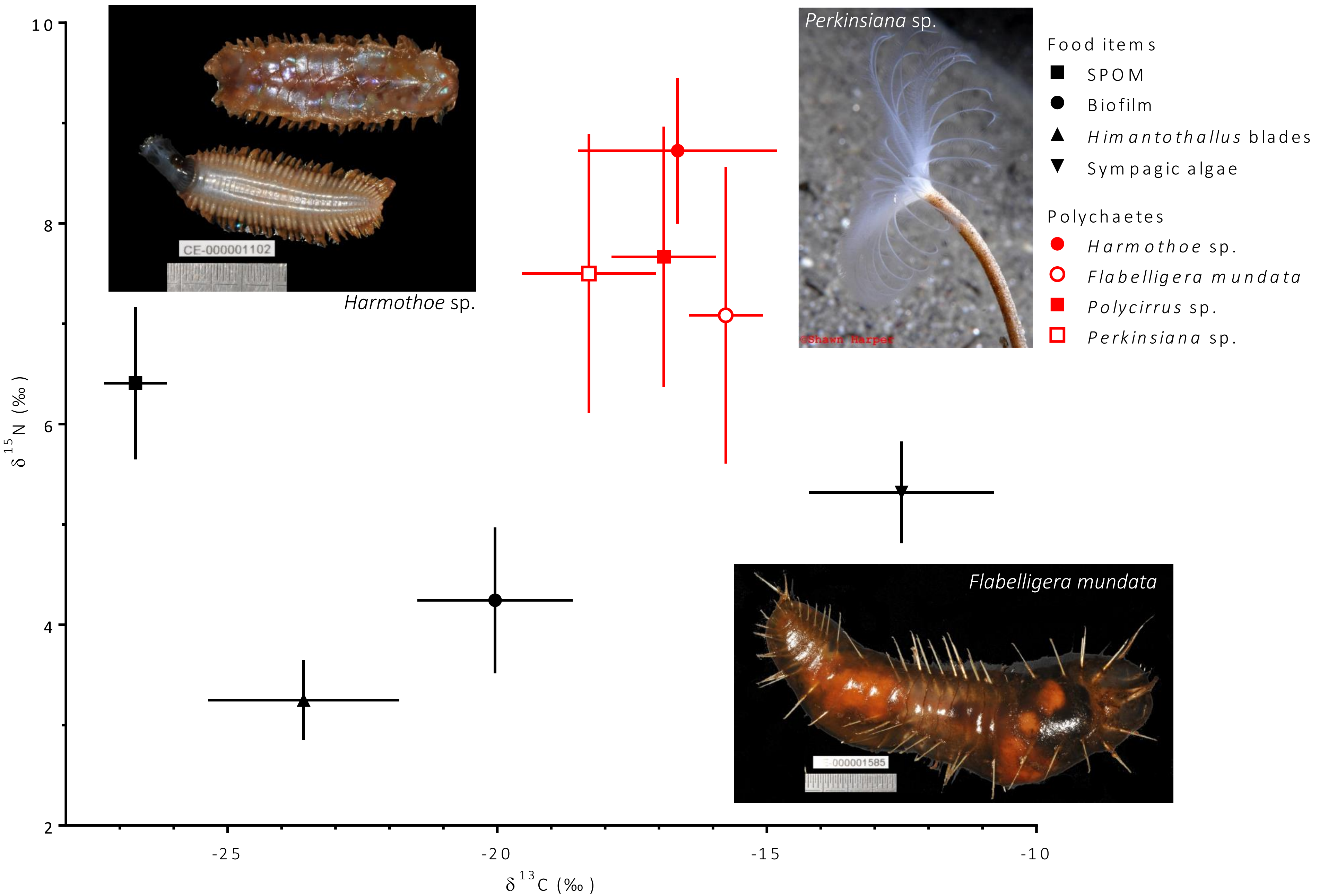
Material & methods: analysis

University of Liège's setup:
Vario MICRO cube EA coupled to an Isoprime 100 IRMS

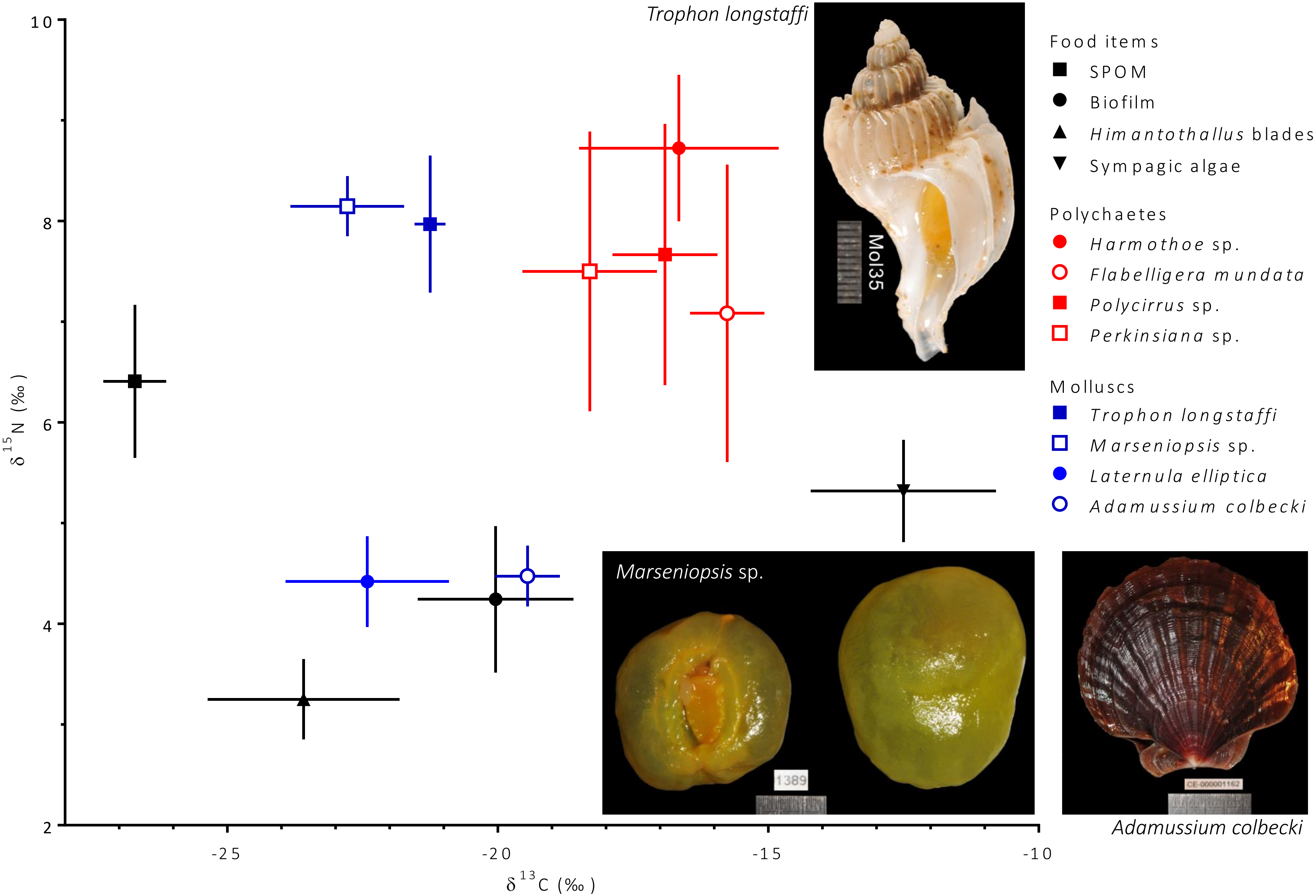
Results: isotopic biplot



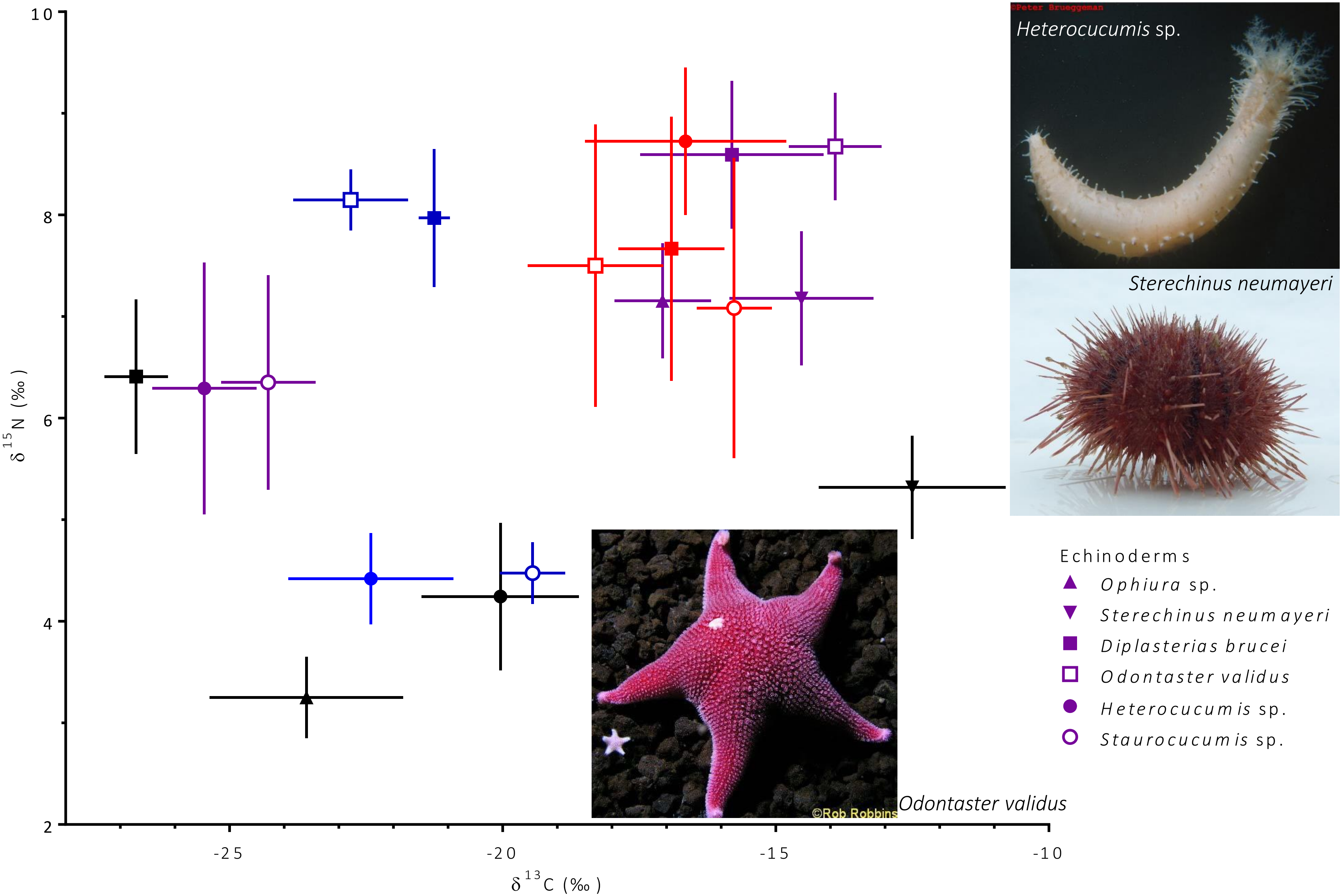
Results: isotopic biplot



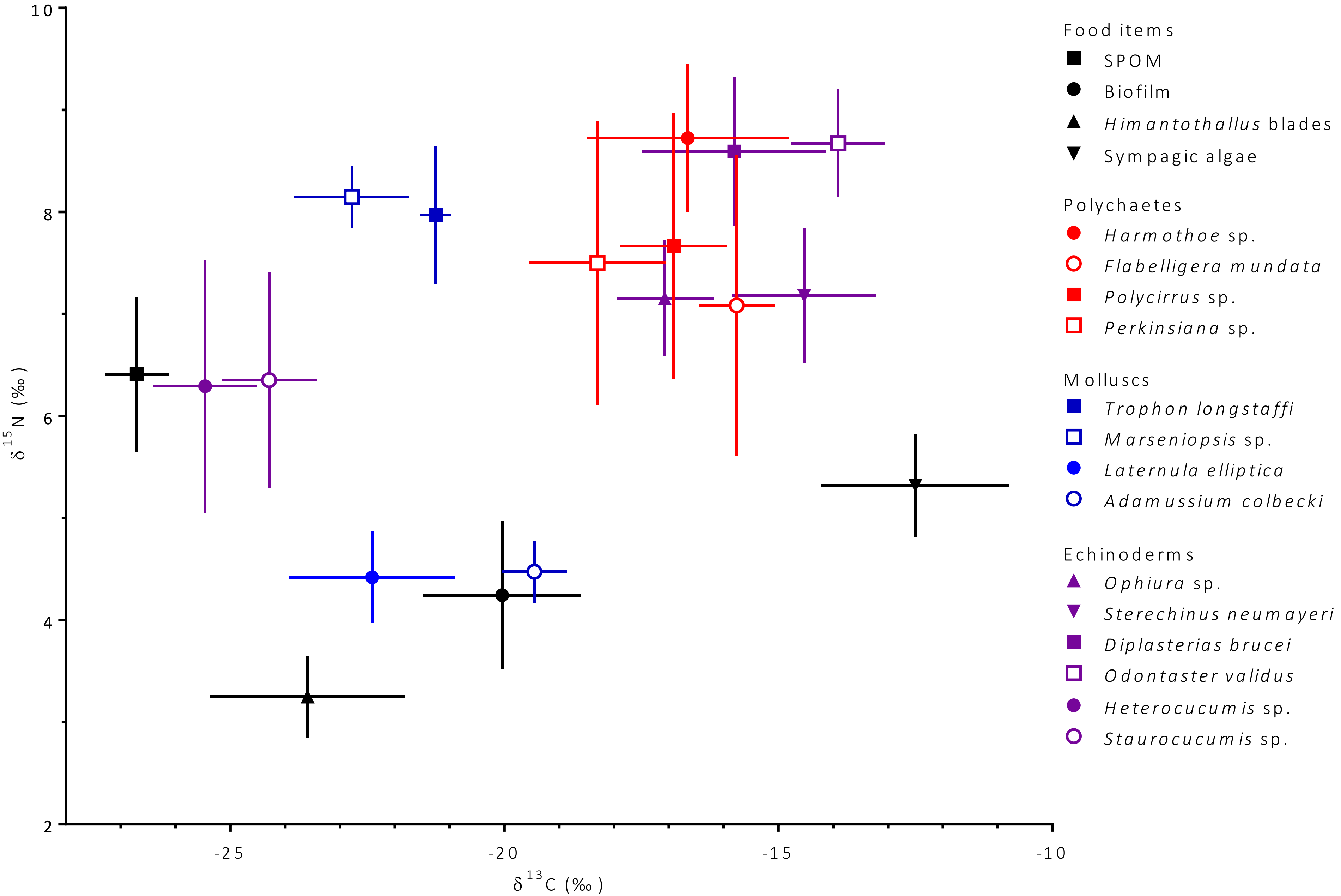
Results: isotopic biplot



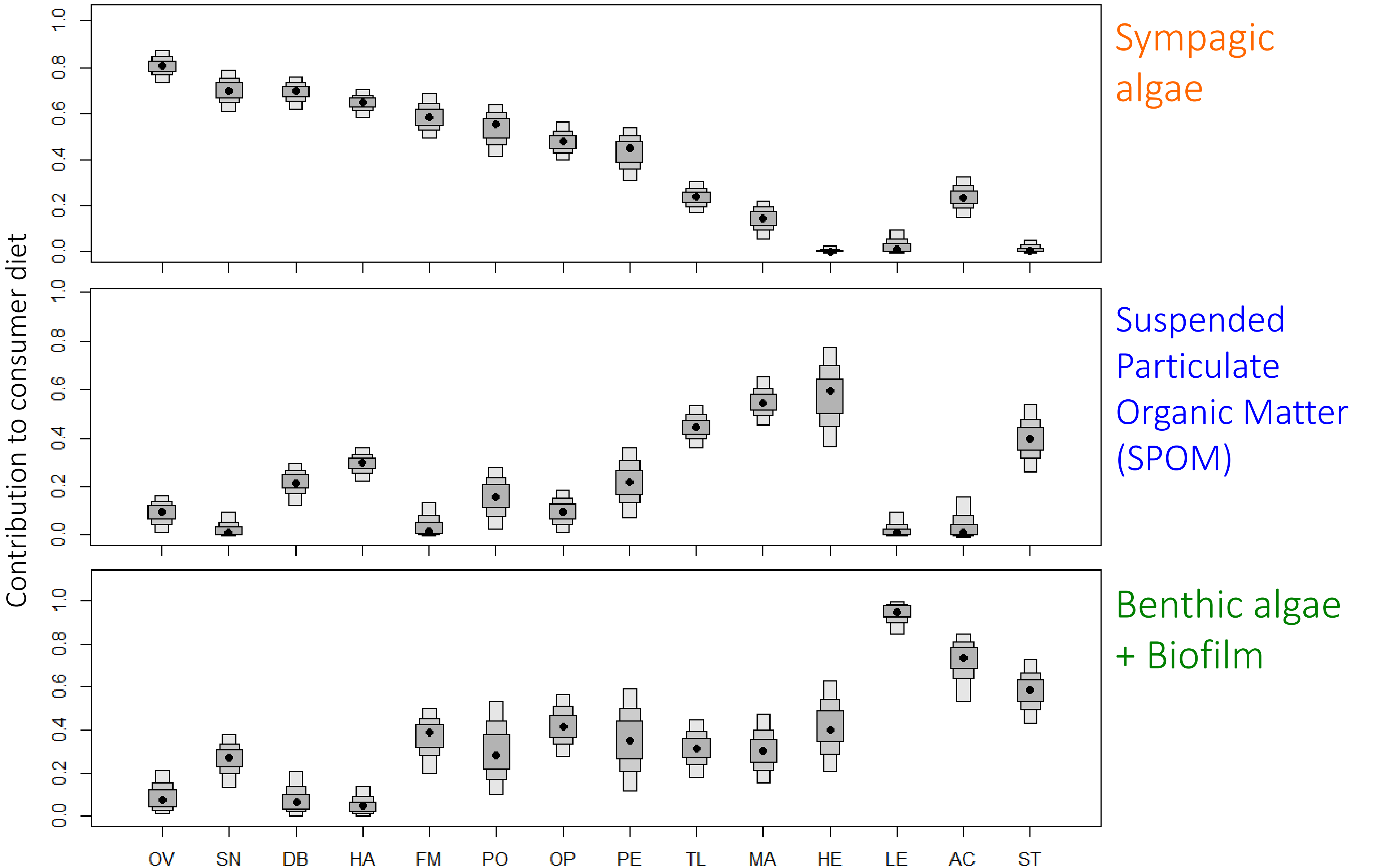
Results: isotopic biplot



Results: isotopic biplot

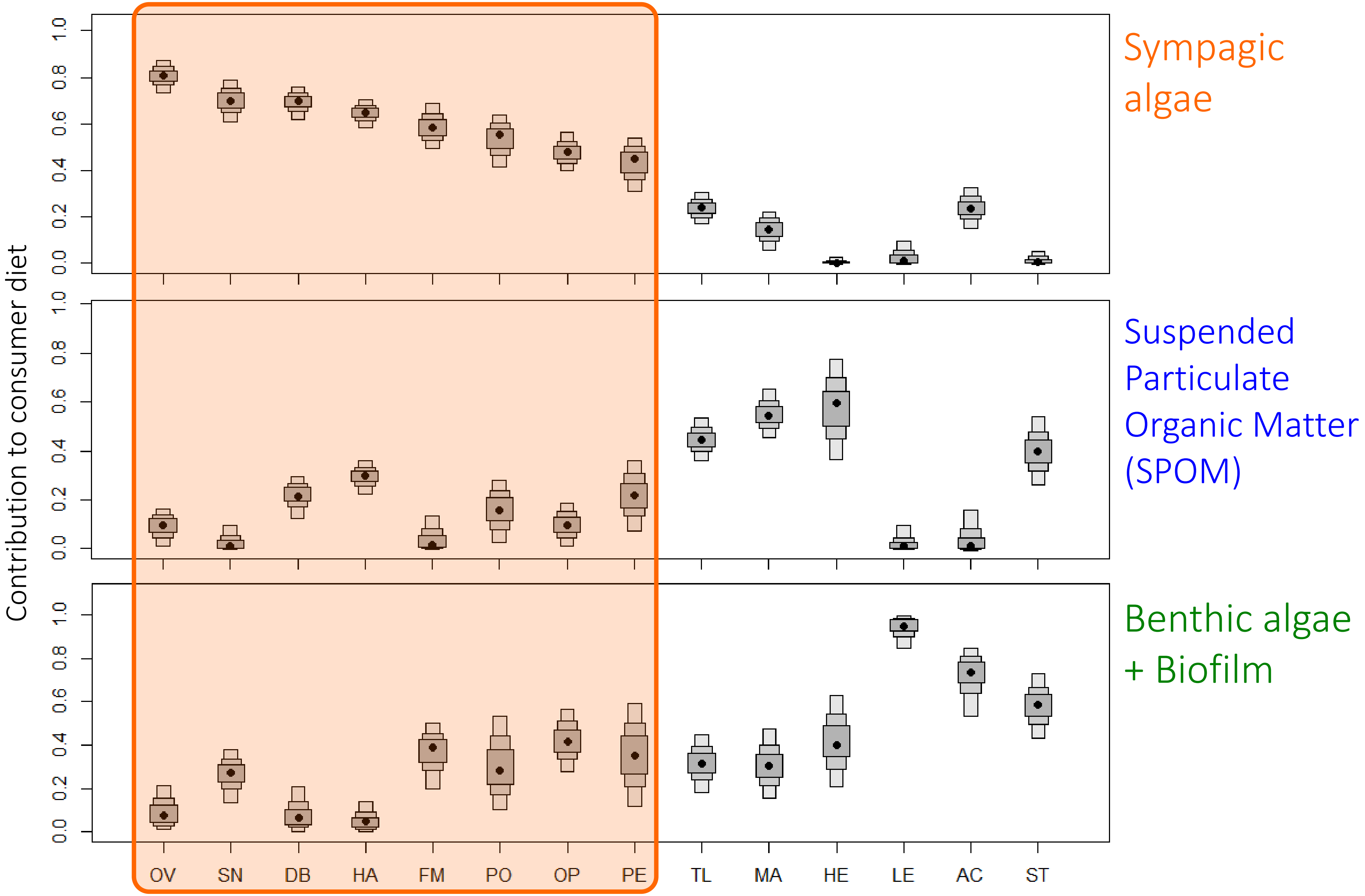


Results - SIAR modelling



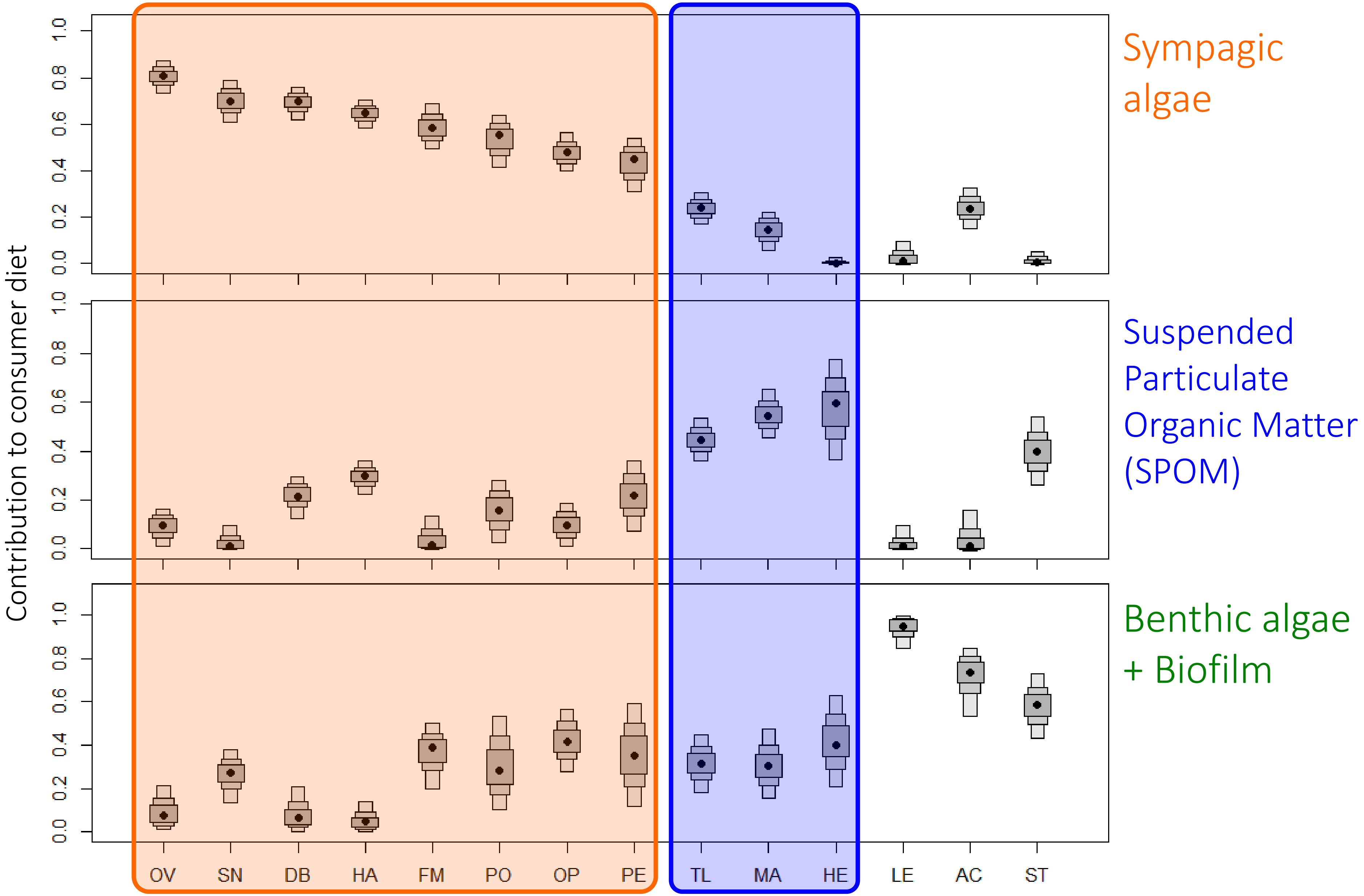
OV: *O. validus*; SN: *S. neumayeri*; DB: *D. brucei*; HA: *Harmothoe* sp.; FM: *F. mundata*; PO: *Polycirrus* sp.; OP: *Ophiura* sp.; PE: *Perkinsiana* sp.; TL: *T. longstaffi*; MA: *Marsienopsis* sp.; HE: *Heterocucumis* sp.; LE: *Laternula elliptica*; AC: *Adamussium colbecki*; ST: *Staurocucumis* sp.

Results - SIAR modelling



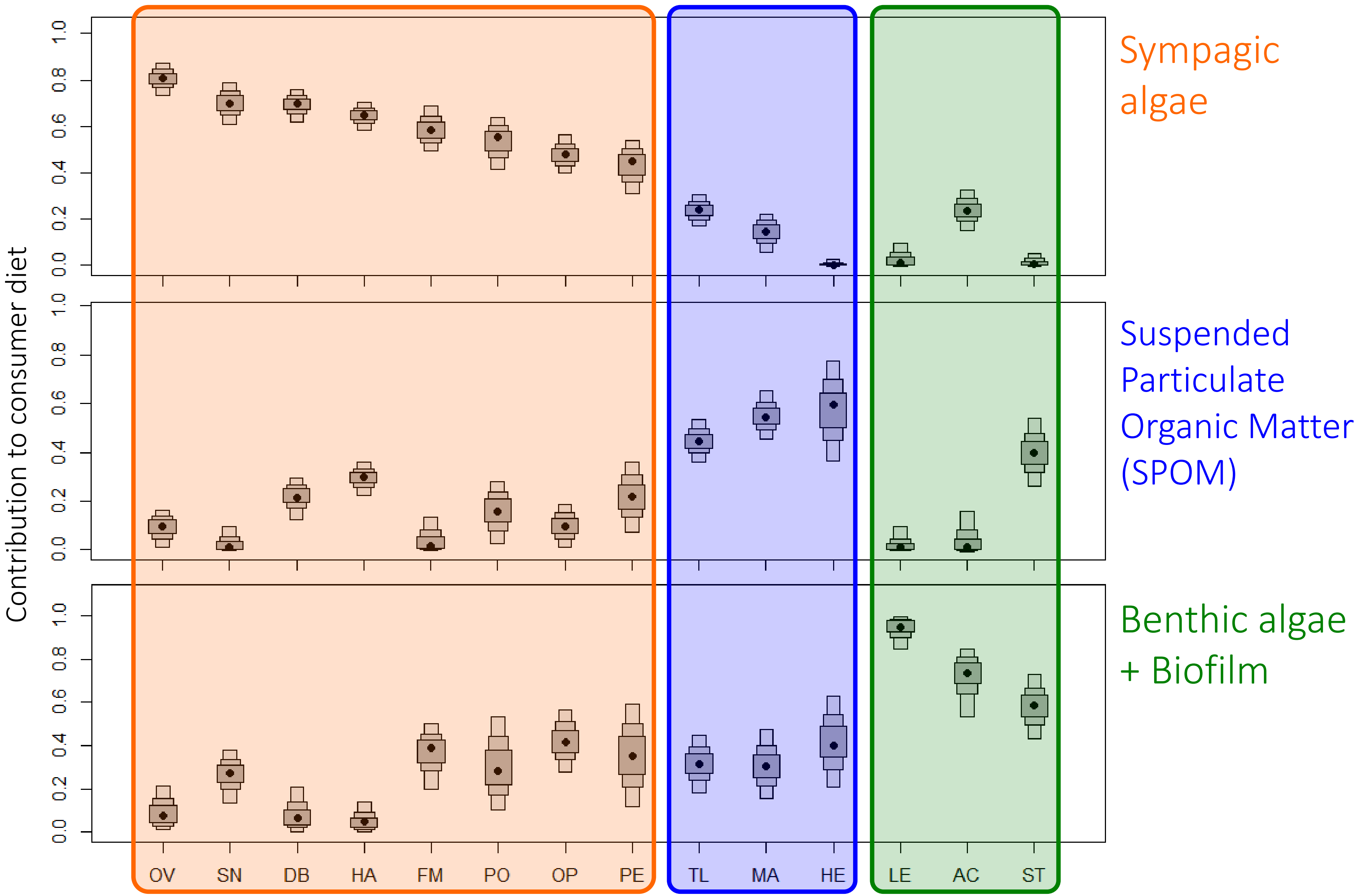
OV: *O. validus*; SN: *S. neumayeri*; DB: *D. brucei*; HA: *Harmothoe* sp.; FM: *F. mundata*; PO: *Polycirrus* sp.; OP: *Ophiura* sp.; PE: *Perkinsiana* sp.; TL: *T. longstaffi*; MA: *Marsienopsis* sp.; HE: *Heterocucumis* sp.; LE: *Laternula elliptica*; AC: *Adamussium colbecki*; ST: *Staurocucumis* sp.

Results - SIAR modelling



OV: *O. validus*; SN: *S. neumayeri*; DB: *D. brucei*; HA: *Harmothoe* sp.; FM: *F. mundata*; PO: *Polycirrus* sp.; OP: *Ophiura* sp.; PE: *Perkinsiana* sp.; TL: *T. longstaffi*; MA: *Marsienopsis* sp.; HE: *Heterocucumis* sp.; LE: *Laternula elliptica*; AC: *Adamussium colbecki*; ST: *Staurocucumis* sp.

Results - SIAR modelling



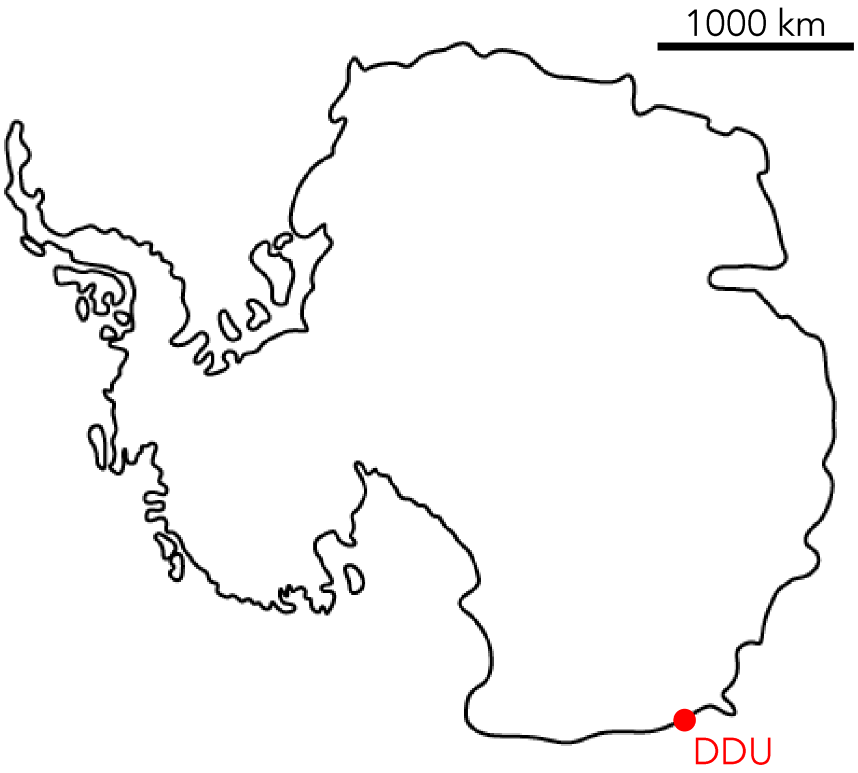
OV: *O. validus*; SN: *S. neumayeri*; DB: *D. brucei*; HA: *Harmothoe* sp.; FM: *F. mundata*; PO: *Polycirrus* sp.; OP: *Ophiura* sp.; PE: *Perkinsiana* sp.; TL: *T. longstaffi*; MA: *Marsienopsis* sp.; HE: *Heterocucumis* sp.; LE: *Laternula elliptica*; AC: *Adamussium colbecki*; ST: *Staurocucumis* sp.

Discrepancies in resource use

Species	DDU
Laternula elliptica	(green)
Adamussium colbecki	(green)
Sterechinus neumayeri	(orange)
Odontaster validus	(orange)
Staurocucumis sp.	(green)
Harmothoe sp.	(orange)

Main food items

- (orange) Sympagic algae
- (green) Benthic algae / Biofilm

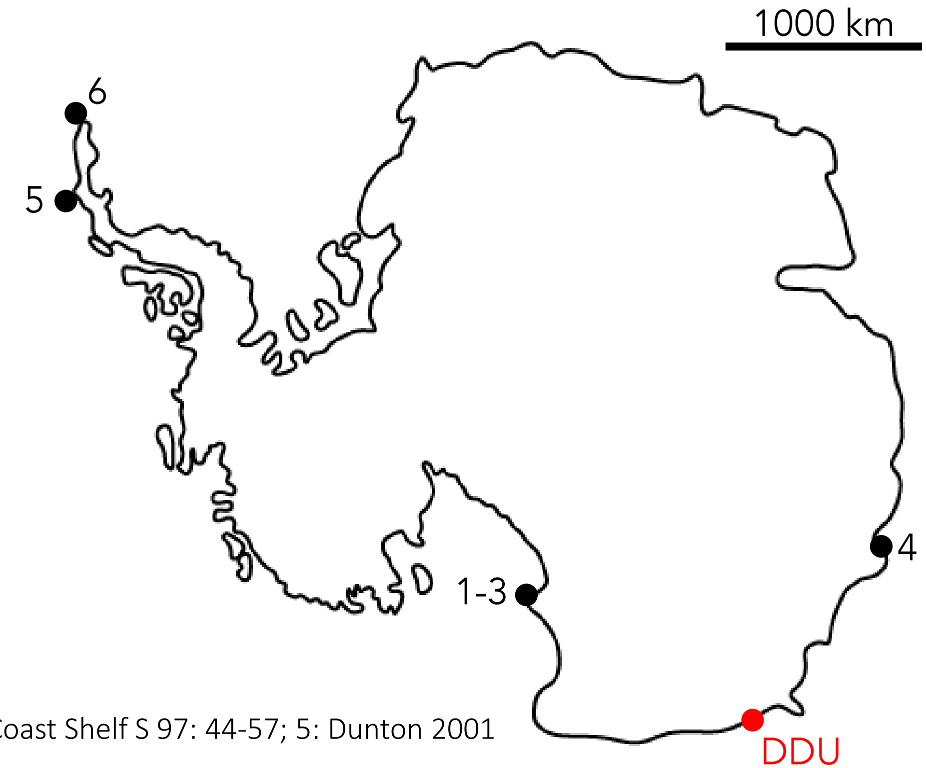


Discrepancies in resource use

Species	DDU	1	2	3	4	5	6
Laternula elliptica							
Adamussium colbecki							
Sterechinus neumayeri							
Odontaster validus							
Staurocucumis sp.							
Harmothoe sp.							

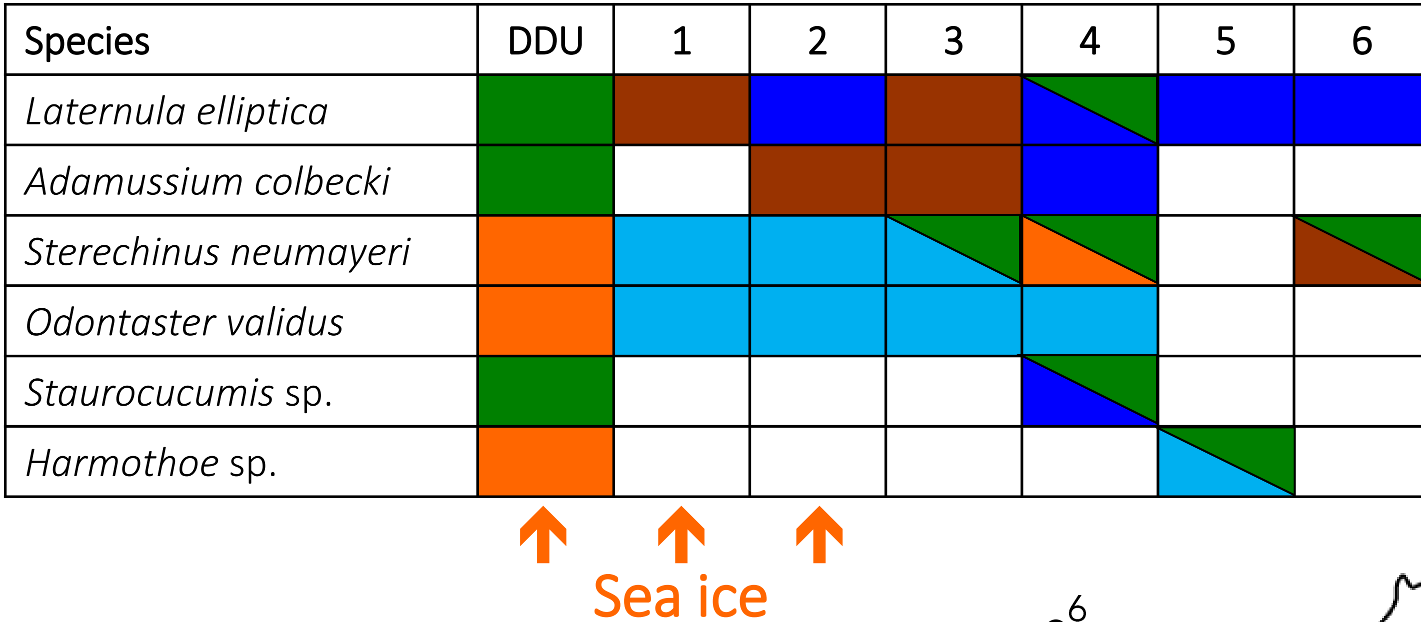
Main food items

- Sympagic algae / Ice POM
- Benthic algae / Biofilm
- Plankton / SPOM
- Sediment POM
- Animal-based diet
- No data



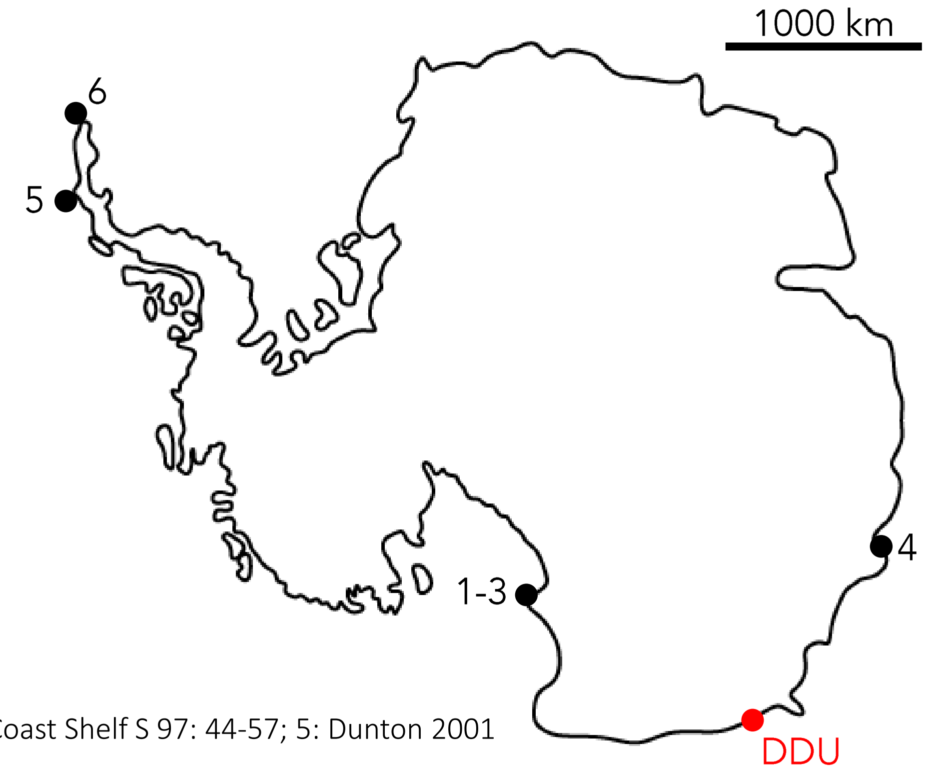
References:
1-3: Norkko et al. 2007 Ecology 88: 2810-2820; 4: Gillies et al. 2012 Estuar Coast Shelf S 97: 44-57; 5: Dunton 2001 Amer Zool 41: 99-112; 6: Corbisier et al. 2004 Polar Biol 27: 75-82

Discrepancies in resource use



Main food items

- Sympagic algae / Ice POM
- Benthic algae / Biofilm
- Plankton / SPOM
- Sediment POM
- Animal-based diet
- No data



References:
1-3: Norkko et al. 2007 Ecology 88: 2810-2820; 4: Gillies et al. 2012 Estuar Coast Shelf S 97: 44-57; 5: Dunton 2001 Amer Zool 41: 99-112; 6: Corbisier et al. 2004 Polar Biol 27: 75-82

Discrepancies in resource use

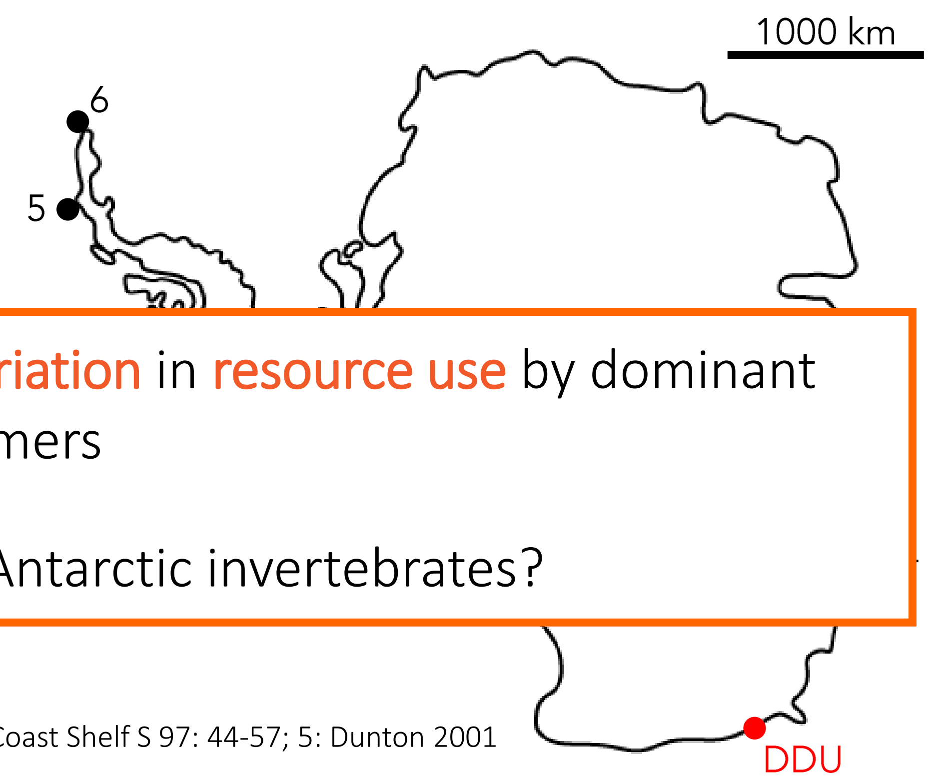
Species	DDU	1	2	3	4	5	6
Laternula elliptica							
Adamussium colbecki							
Sterechinus neumayeri							
Odontaster validus							
Staurocucumis sp.							
Harmothoe sp.							

Sea ice

Main food items

Sympagic algae / Ice POM

No data

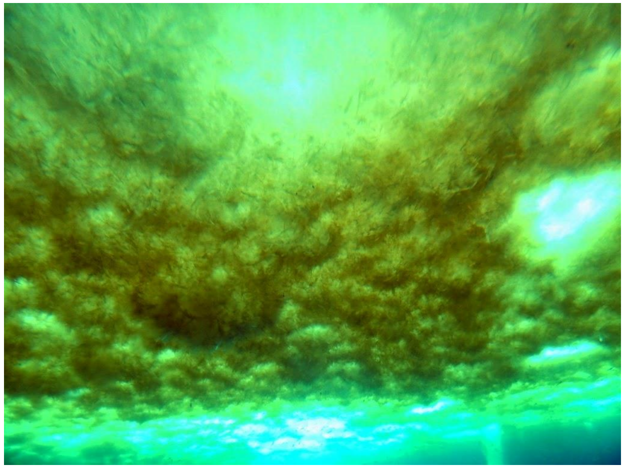


Important spatial and/or temporal variation in resource use by dominant consumers

High trophic plasticity of Antarctic invertebrates?

References:
1-3: Norkko et al. 2007 Ecology 88: 2810-2820; 4: Gillies et al. 2012 Estuar Coast Shelf S 97: 44-57; 5: Dunton 2001 Amer Zool 41: 99-112; 6: Corbisier et al. 2004 Polar Biol 27: 75-82

Sympagic algae consumption: how and why?

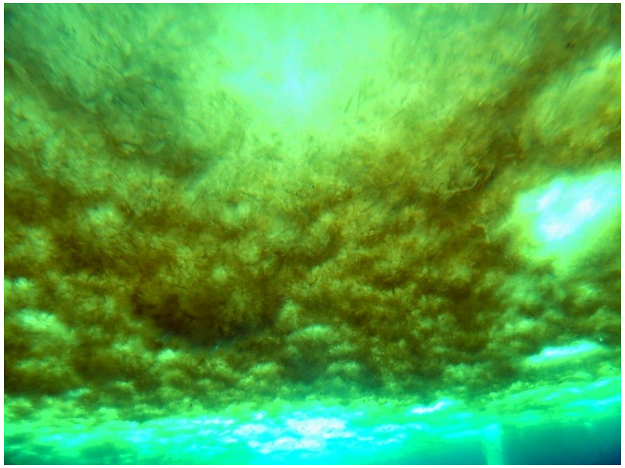


Sea ice is a dynamic system: constant melting/freezing

Sympagic algae aggregates sink quickly

Sinking speed is size-dependent and range from 100 to 500 m/day (i.e. 1-5 hours to reach a depth of 20 m)

Sympagic algae consumption: how and why?



Sea ice is a dynamic system: constant melting/freezing

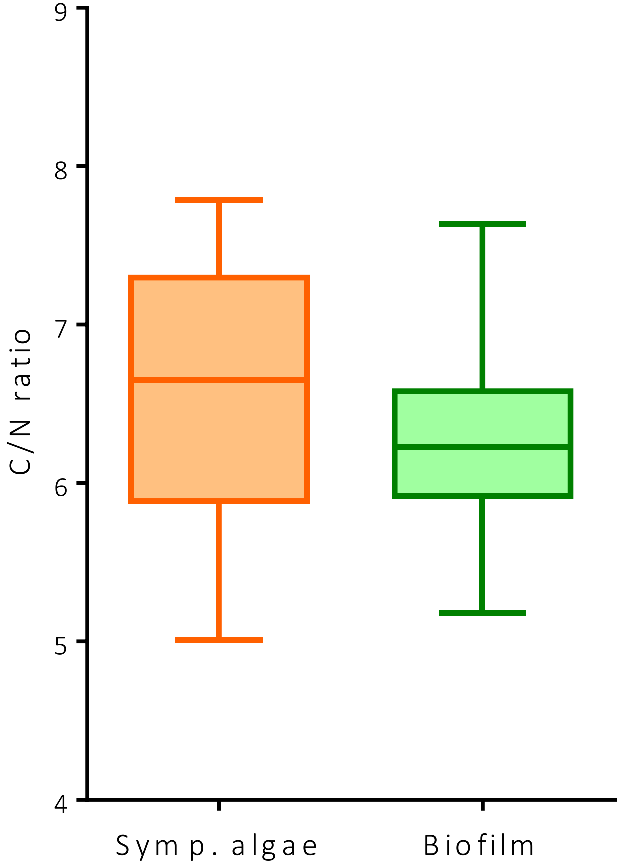
Sympagic algae aggregates sink quickly

Sinking speed is size-dependent and range from 100 to 500 m/day (i.e. 1-5 hours to reach a depth of 20 m)

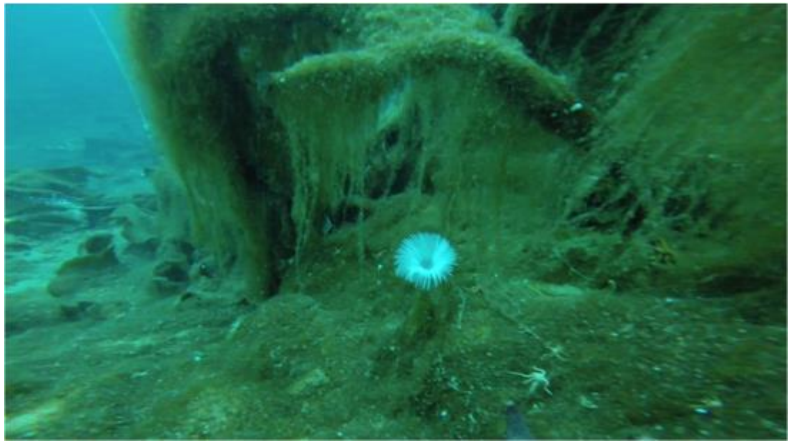
Why is it preferred by many consumers over more abundant food items such as biofilm?

Better nutritional value? Unlikely… →

Better palatability? Pure aggregates of microalgae…



Role of benthic biofilm in the food web

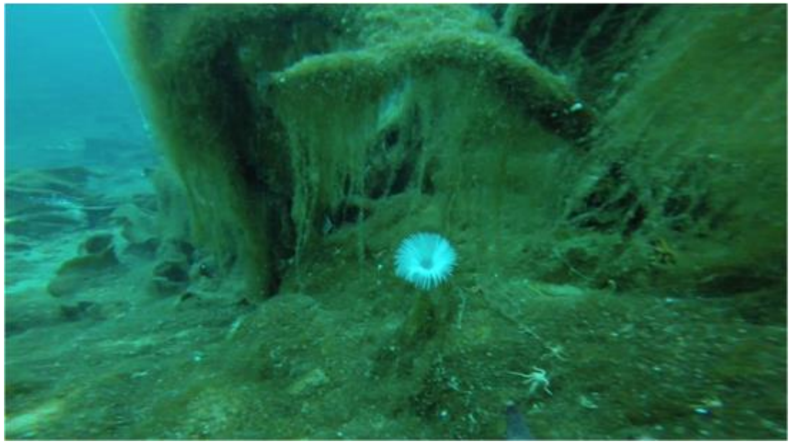


Preliminary microscopic examination:

Benthic biofilm = heterogeneous mix of microalgae, amorphous material and detrital items

Here: importance of benthic biofilm in food web comparatively limited despite high abundance

Role of benthic biofilm in the food web



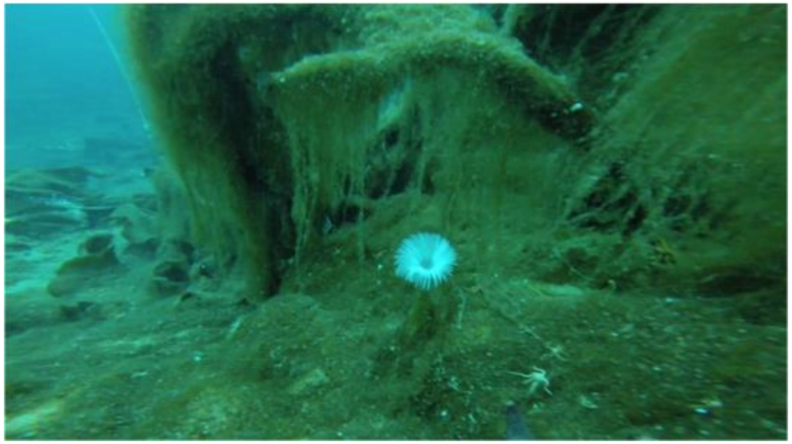
Preliminary microscopic examination:
Benthic biofilm = heterogeneous mix of microalgae, amorphous material and detrital items

Here: importance of benthic biofilm in food web comparatively limited despite high abundance

Ross Sea: Benthic invertebrates consume more detritic matter in sea-ice influenced locations
(Norkko et al. 07)

Role of benthic biofilm in the food web

Preliminary microscopic examination:
Benthic biofilm = heterogeneous mix of microalgae, amorphous material and detrital items



Here: importance of benthic biofilm in food web comparatively limited despite high abundance

Ross Sea: Benthic invertebrates consume more detritic matter in sea-ice influenced locations
(Norkko et al. 07)

Important variation in benthic ecosystem response to sea ice

However: no data about dynamics of biofilm accumulation!

Here: long-lived benthic invertebrates with low metabolic rates → low isotopic turnover? Is isotopic equilibrium reached?

Our model could underestimate actual biofilm importance for invertebrate feeding

Take home message

- Important sea ice cover is linked with **high reliance** of coastal benthic primary consumers / omnivores on **sympagic algae**

Take home message

- Important sea ice cover is linked with high reliance of coastal benthic primary consumers / omnivores on sympagic algae

- Resource use by consumers of Adélie Land markedly differs from results obtained in other locations: high trophic plasticity of Antarctic invertebrates?




Take home message

- Important sea ice cover is linked with **high reliance** of coastal benthic primary consumers / omnivores on **sympagic algae**
- **Resource use** by consumers of Adélie Land markedly **differs** from results obtained in **other locations**: high **trophic plasticity** of Antarctic invertebrates?
- Interpretation of results is **complicated** by **lack** of **background data** ("normal" conditions) and by **physiological features** of studied organisms

Funding

Belgian Federal Science Policy Office (BELSPO)

vERSO project (Ecosystem Resilience in Southern Ocean)

French Polar Institute (IPEV)

Benelux Association of Stable Isotope Scientists (BASIS)

Come to JESIUM 2016!

JESIUM 2016

JOINT EUROPEAN STABLE ISOTOPES USER group MEETING

Ghent University
Belgium • 4–9 Sept 2016
www.jesium2016.eu

CALL FOR ABSTRACTS

Submission deadline: 29 April 2016

BASIS

UNIVERSITEIT GENT

ISOFYS Isotope Bioscience Laboratory

On behalf of the Benelux Association for Stable Isotope Scientists (BASIS) we are pleased to let you know that the Call for Abstracts is open for the Joint European Stable Isotope Users group Meeting JESIUM 2016. Deadline for Abstract Submission is 29 April 2016. Please submit your talk or poster abstract online best as doc or docx using the **template** provided there (max. 550 words). For more information and guidelines how to submit your abstract, please visit our conference website.

Sessions Keynotes

1. Advances in instrumentation and analytics
Chair: Harro A.J. Meijer • Keynote and co-chair: Eric Kerstel (FR)
2. Ecology
Chair: Eric Boschker • Keynote and co-chair: Jasper M. de Goeij (NL)
3. Environmental pollution
Chair: Tom N.P. Bosma • Keynote and co-chair: Ivonne Nijenhuis (DE)
4. Paleoclimatology & archeology
Chair: Marcel van der Meer • Keynote and co-chair: Isla Castañeda (USA)
5. Geosciences & hydrology
Chair: Pédro Hervé • Keynote and co-chair: Jeffrey McDonnel (CA)
6. Forensics
Chair: Gerard van der Peijl • Keynote and co-chair: Federica Camin (IT)
7. Biogeochemistry
Chair: Pascal Boeckx (BE)
8. Nutrition, biochemistry & medicine
Chair: Henk Schierbeek • Keynote and co-chair: Dwight Mathews (USA)

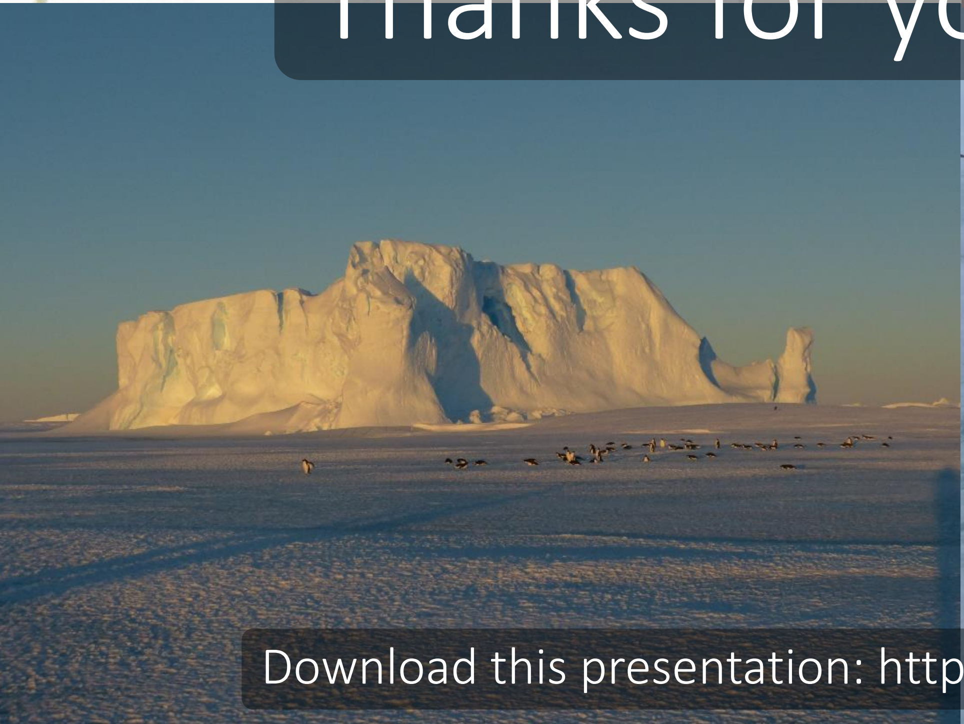
We are looking forward to interesting and numerous abstracts!
Cordially, on behalf of the JESIUM 2016 organizers,

Pascal Boeckx
BASIS chairman
Isotope Bioscience Laboratory
Ghent University
Belgium

Deadline Early Bird Payment: 27 May 2016

Conference secretary
jesium2016@fu-confirm.de

Thanks for your attention



Download this presentation: http://hdl.handle.net/2268/195134

SIAR parameters

SIAR 4.2 in R 3.2.2

No concentration dependencies

TEFs: $\Delta^{13}C = 0.40 \pm 1.20$ ‰; $\Delta^{15}N = 2.30 \pm 1.61$ ‰ (mean ± SD; TEFs for aquatic consumers from McCutchan et al. 2003 Oikos 102: 378-390)

10^6 iterations

Burn-in size: 10^5

Sample numbers

Sample nature	N
SPOM	12
Biofilm	57
Sympagic algae	20
Himantothallus grandifolius blades	16
Harmotohe sp.	30
Flabelligera mundata	22
Polycirrus sp.	19
Perkinsiana sp.	24
Trophon longstaffi	22
Marseniopsis sp.	21
Laternula elliptica	21
Adamussium colbecki	25
Ophiura sp.	23
Sterechinus neumayeri	21
Diplasterias brucei	21
Odontaster validus	23
Heterocucumis sp.	23
Staurocucumis sp.	19

A glimpse at secondary consumers