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

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Antarctic littoral is circled by a fringe of **sea ice** (up to 20 millions km²)

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**
Sympagic algae:
Mostly diatoms
Form thick mats
Filaments up to several cm

Source: Australian Antarctic Division
Seasonal patterns of sea ice cover

Normal cycle:

**Austral winter**
- Thick sea ice cover

**Austral summer**
- Thinning and breakup of sea ice
- Release of sympagic material
- High productivity events

Source: NOAA
Climate change and sea ice cover

(Data 1971-2000)

Parkinson & Cavalieri 2012 Cryosphere 6: 871-880

- West Antarctic Peninsula: $T^\circ \uparrow$, Ice cover $\downarrow$
- East Antarctica: $T^\circ \Rightarrow \Rightarrow$, Ice cover $\uparrow$

(e) Bellingshausen/Amundsen Seas

(d) Ross Sea

13700 $\pm$ 1500 km$^2$/yr
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

This is the sea
(Please trust me)
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*?

1. Sympagic algae

2. Suspended particulate organic matter (SPOM)
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

- SPOM
- Biofilm
- Himantothallus blades
- Sympagic algae

δ¹³C (%) vs δ¹⁵N (%)
Results: isotopic biplot
Results: isotopic biplot

-2 5
-2 0
-1 5
-1 0
2
4
6
8
10

δ¹³C (‰)

Food items
- SPOM
- Biofilm
- *Himanthothallus* blades
- Sympagic algae

Polychaetes
- *Harmothoe* sp.
- *Flabelligeramunda*ta
- *Polycirrus* sp.
- *Perkinsiana* sp.

Molluscs
- *Trophon longstaffi*
- *Marseniopsis* sp.
- *Laterula elliptica*
- *Adamussium colbecki*

*Note: The diagram shows a biplot with isotopic values for different food items and marine invertebrates, illustrating the trophic positions and isotopic signatures. The images depict representative samples of each taxon.*
Results: isotopic biplot
Results: isotopic biplot

- Results of isotopic analysis
- Biplot showing isotopic values for different organisms
- X-axis: $\delta^{13}C$ (‰)
- Y-axis: $\delta^{15}N$ (‰)
- Food items: SPOM, Biofilm, Harmothoe sp., Flabelligera mundata, Polycirrus sp., Perkinsiana sp.
- Polychaetes: Trophon longstaffi, Marseniopsis sp., Laternula elliptica, Adamussium colbecki
- Molluscs: Ophiura sp., Sterechinus neumayeri, Diplasterias brucei, Odontaster validus
- Echinoderms: Heterocucumis sp., Staurocucumis sp.
Results - SIAR modelling

Sympagic algae

Suspended Particulate Organic Matter (SPOM)

Benthic algae + Biofilm

Results - SIAR modelling

Contribution to consumer diet

Results - SIAR modelling

Contribution to consumer diet

Sympagic algae

Suspended Particulate Organic Matter (SPOM)

Benthic algae + Biofilm

Results - SIAR modelling

Contribution to consumer diet

Sympagic algae

Suspended Particulate Organic Matter (SPOM)

Benthic algae + Biofilm

## Discrepancies in resource use

<table>
<thead>
<tr>
<th>Species</th>
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<tbody>
<tr>
<td><em>Laternula elliptica</em></td>
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### Main food items

- Sympagic algae
- Benthic algae / Biofilm
### Discrepancies in resource use

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### Main food items

- Orange: Sympagic algae / Ice POM
- Green: Benthic algae / Biofilm
- Blue: Plankton / SPOM
- Brown: Sediment POM
- Cyan: Animal-based diet
- White: No data

### References:

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**Main food items**

- Sympagic algae / Ice POM
- Benthic algae / Biofilm
- Plankton / SPOM
- Sediment POM
- Animal-based diet
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Main food items

- Sympagic algae / Ice POM
- Benthic algae / Biofilm
- Plankton / SPOM
- Sediment POM

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

High **trophic plasticity** of Antarctic invertebrates?

References:
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
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!

JOINT EUROPEAN STABLE ISOTOPES USER group MEETING

Ghent University
Belgium • 4-9 Sept 2016
www.jesium2016.eu
Submission deadline: 29 April 2016

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 on how to submit your abstract, please visit our conference website.

Sessions
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: Pedro Hervé • Keynote and co-chair: Jeffrey McDonnel (CA)
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   Chair: Gerard van der Petj • 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 4.2 in R 3.2.2

No concentration dependencies

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

$10^6$ iterations

Burn-in size: $10^5$
<table>
<thead>
<tr>
<th>Sample nature</th>
<th>N</th>
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<tbody>
<tr>
<td>SPOM</td>
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<td>Biofilm</td>
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<td>Sympagic algae</td>
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<td>Himantothallus grandifolius blades</td>
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<td>Harmotohe sp.</td>
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A glimpse at secondary consumers

- Saliasterias brachiata
- Acodontaster sp.
- Isotealia antarctica
- Decolopoda australis
- Ammothea carolinensis
- Parborlasia corrugatus

Image: NASA