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Zentrum für Material- und Küstenforschung

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Effects of ice stressors and pollutants on the Arctic marine cryosphere (EISPAC)

Crispin Halsall **Kirstin Dähnke**

Cefas

Stockholm University

UEA University of East Anglia

Federal Ministry of Education and Research

NERC SCIENCE OF THE ENVIRONMENT

Aim of EISPAC

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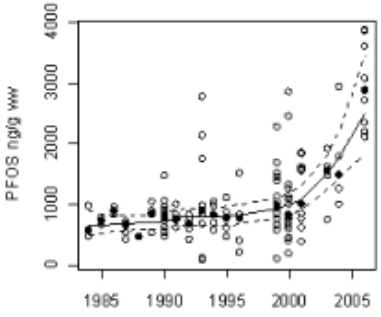
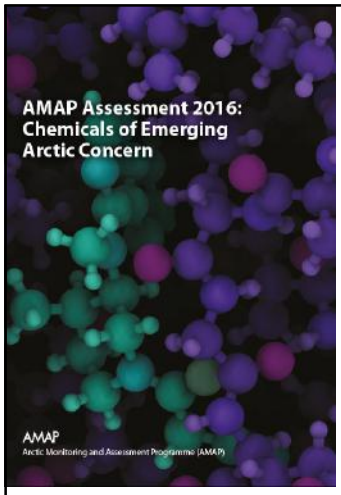
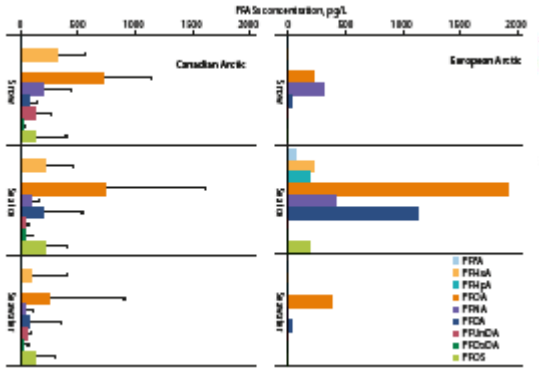
Evaluate whether ice-associated contaminants serve as stressors on ice habitat functioning in relation to cryosphere dynamics and in comparison to the behaviour of key nutrients.

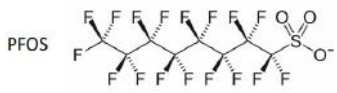


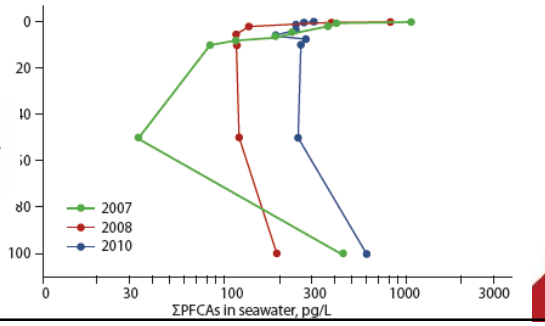
PFOS

Dietz et al. ES&T, 2008, 42: 2701-2707









AMAP
"POPs - climate change interactions"
workshop ~ April 2019

Objectives

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(i) Quantify the entry and behaviour of emerging organic contaminants and micro-plastics to the Arctic sea ice system.

(ii) Mechanistically understand contaminant accumulation and transfer processes during ice growth and melt.

(iii) Understand key nutrient (N and C) entry, transformation and behaviour in the sea ice system in comparison to contaminant behaviour.

(iv) Model contaminant uptake into the pelagic Arctic foodweb and identify key affected marine ecosystem services

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Work packages:

WP1 Contaminants in the Arctic: entry and fate in the sea ice system of the MIZ.

WP2 Mechanistic fate and behaviour studies of contaminants in an experimental sea ice facility

WP3 Nutrient input and biogeochemistry in the Arctic marine cryosphere

WP4 Understanding the impact of multiple stressors and the repercussion for ecosystem services

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Key researchers

EISPAC PDRA/researcher, **Dr Tina Sanders** (HZG)
EISPAC researchers **Dr Odile Crabeck** (UEA), **Dr Max Thomas** (UEA)
EISPAC PhD student, **Rui Shen** (HZG)
ENVISION PhD student, **Jack Garnett** (Lancaster Uni)
EISPAC PDRA, **TBA** (Lancaster Uni/CEFAS/Stockholm Uni)
ENVISION PhD student, 'microplastics' **TBA** (Lancaster/Bangor Uni/UEA)

Cefas

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Hypotheses

(a) Sea ice amplifies organic contaminants and micro-plastic particles above levels observed in surrounding seawater;

(b) there is co-mobilisation and biological utilisation of cryospheric N and contaminants during seasonal ice melt;

(c) The lower marine foodweb is more strongly affected by changing nutrient dynamics than contaminant exposure.

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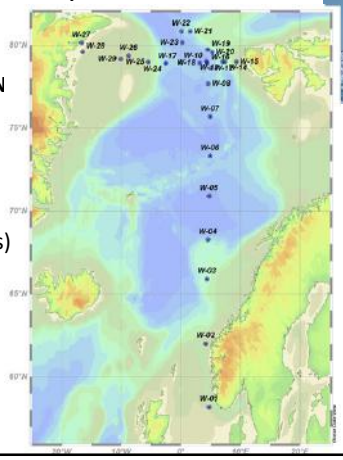
WP1 – Ralf Ebinghaus, Zhiyong Xie, Crispin Halsall

Field work – contaminant entry & fate

Expedition PS114
of the Research Vessel POLARSTERN
to the Fram Strait in 2018



- halogenated flame retardants
- Dechlorane Plus (DP)
- organophosphate esters (OPEs)
- phthalate esters (PEs)
- per- and polyfluoroalkyl substances (PFASs)

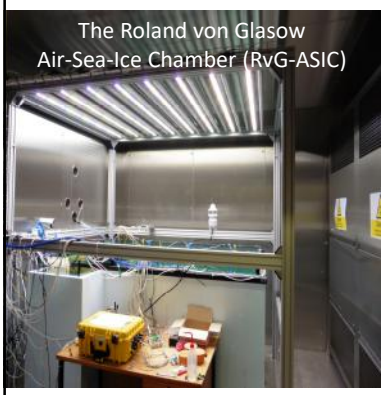
- CTD samples: Nisotopes, DON

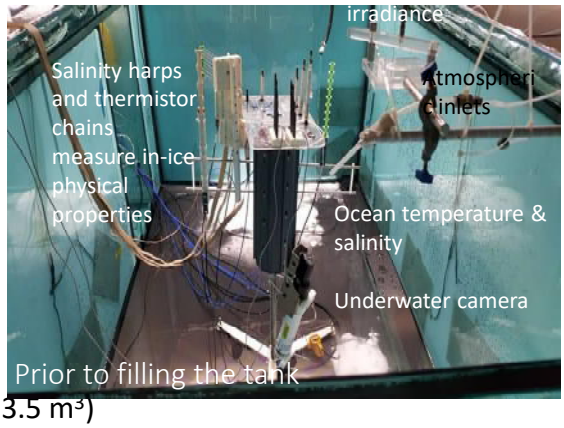
Current plans:
May 2019 –
Svalbard 'in-situ fjord'

Villlum Research Station - NE. Greenland??

Ship-based work?

WP2 Mechanistic fate and behaviour studies of contaminants in an experimental sea ice facility





- Tank: 2.4 m × 1.4 m × 1 m (3.5 m^3)
- Environmental chamber: –55 to +35 ºC at ±0.3°C

UEA COAS Centre for Ocean and Atmospheric Sciences | Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research | Cefas | Lancaster Environment Centre | Lancaster University

How are Persistent Organic Pollutants (POPs) taken up into sea-ice?

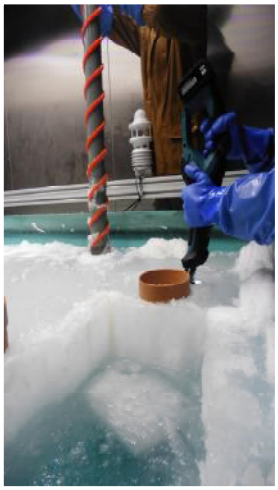
Chemical	Type
NaCl	"Conservative tracer"
Fulvic acid	DOC model compound
α/γ-HCH	Legacy-use Pesticide
C_4–C_{14} perfluorocarboxylates	Fluoropoymer processing aids
Phthalate esters	Plasticisers
BDE-47 & BDE-99	Halogenated flame retardants
Polyester, nylon, PE frag	

Decreasing aqueous solubility

Conditions	Experiment 1	Experiment 2
Atmospheric temperature (°C)	–18	–35
Ice depth (cm)	15 to 30 cm	15 to 30 cm
Growth duration (d)	7	3
Ice growth rate (cm d^{-1})	2 t o 4	5 to 10

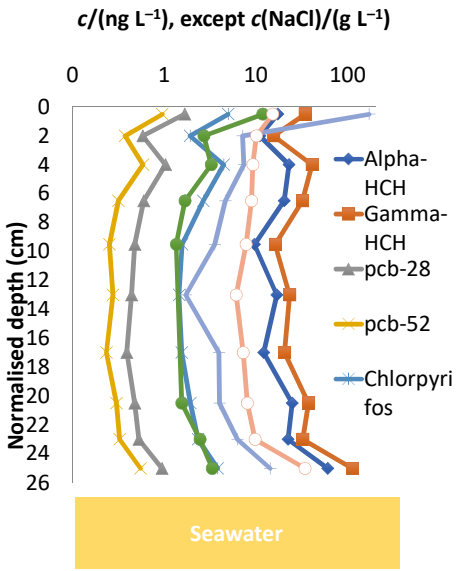
Freeze / melt experiments over 10 days

- Water sampling 2/d
- Ice and brine sampling at end of growth period

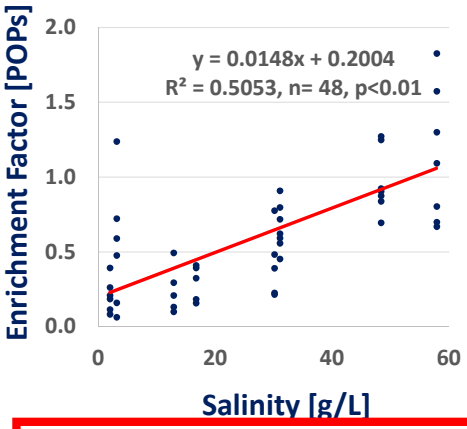


Dr Odile Crabeck

Results: The vertical distributions of chemicals in bulk ice follow C-shaped curves similar to salt.

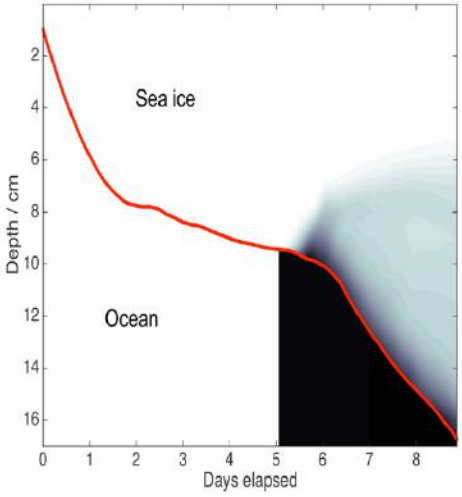


Results: Chemicals appear enriched in the early melt water fractions of sea ice.

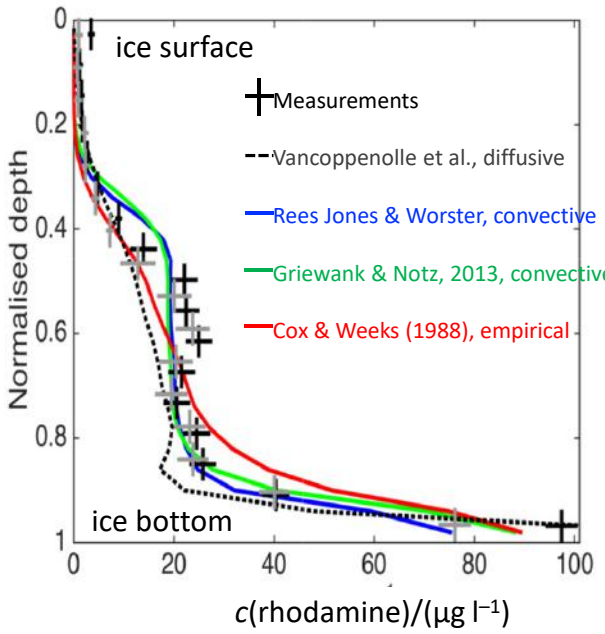


Late fractions [Fresher water] ⇐ **Early Fractions [Brine]**

Modelling of contaminant transport in sea-ice using simple models and LIM 1D



Dr Max Thomas



Comparison of gravity drainage parameterisations with tracer measurements

Convective schemes perform best for biogeochemical tracers

WP3 Nutrient input and biogeochemistry in the Arctic marine cryosphere

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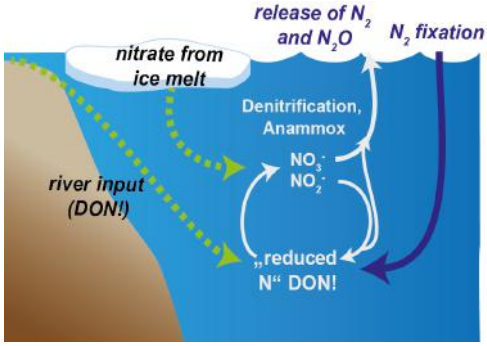
EISPAC –hypothesis to be investigated: *…(b) There is co-mobilisation and biological utilisation of cryospheric N and contaminants during seasonal ice melt;*



3-fold approach:

→ Measurement of DIN + isotopes to investigate nutrient turnover

→ Investigate river-borne inputs to the shelf sea (include DON in the budget)

→ Incubations of co-mobilization of nutrients + contaminants in lab-based experiments

Preliminary results – PS 114

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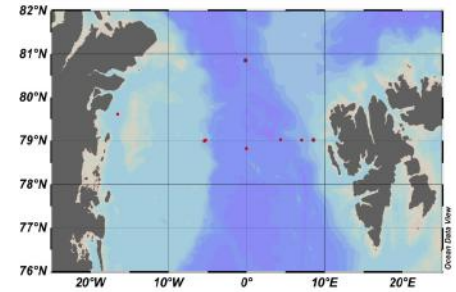

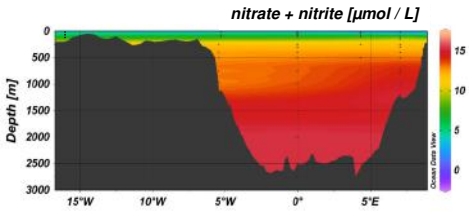

Polarstern 114

… with help from APEAR and PETRA

- 9 Stations, 64 samples
- Nutrients (ammonium, nitrite, nitrate, phosphate, silicate)
- Stable isotopes of nitrate (if present)
- Dissolved organic nitrogen (DON)

➢ **Land-based inputs from Greenland?**

➢ **Water column turnover**

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Future plans in EISPAC WP 3

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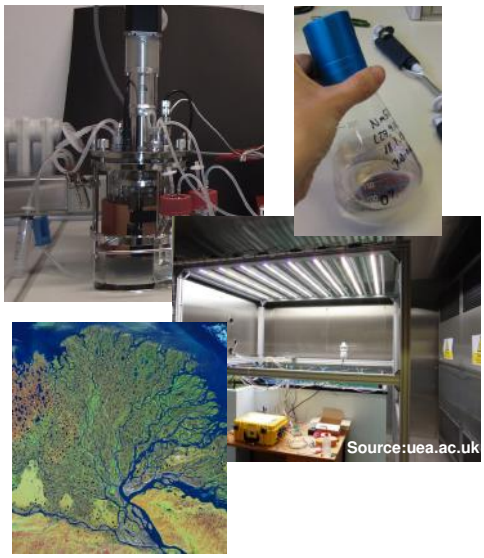
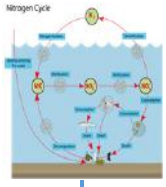
- Spring / summer 2019: first experiments in sea-ice chamber
- Investigations in Lena Delta (CACOON)
- Participation in cruise with PV James Clark Ross (PETRA)
- Incubations of sensitive microorganisms for impact of nutrient+ contaminants
- ? co-operation with other projects – ARISE?

➢ ***Combination of stable isotope, microbiologcal expertise and the contaminant perspective***



Work package 4 – point of departure



Synthesis

Work Package 4:
Synthesis of knowledge: Understanding the impact of multiple stressors on the Arctic marine environment and its repercussions for ecosystem services

Synthesis

Ecopath with Ecosim

- Use data from WP1 – 3 (as well as literature) in ecosystem models
- Identify which observed environmental stressors are main drivers for ecosystem responses

Source: Metro Vancouver

- Identify impacted ecosystem services
  - identify priority areas for regulatory input, research needs

Outcomes

Work Package 4:
Synthesis of knowledge: Understanding the impact of multiple stressors on the Arctic marine environment and its repercussions for ecosystem services

- Identify major expected ecosystem responses for the observed stressors
- Identify research needs

Source: UNESCO Bangkok

- Identify policy needs
- Create (interactive) policy advice documents

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Thank you!