Envision Developing next generation leaders in environmental science

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The role of sea ice in the entrapment, processing and release of persistent organic pollutants: experiments in a sea ice facility

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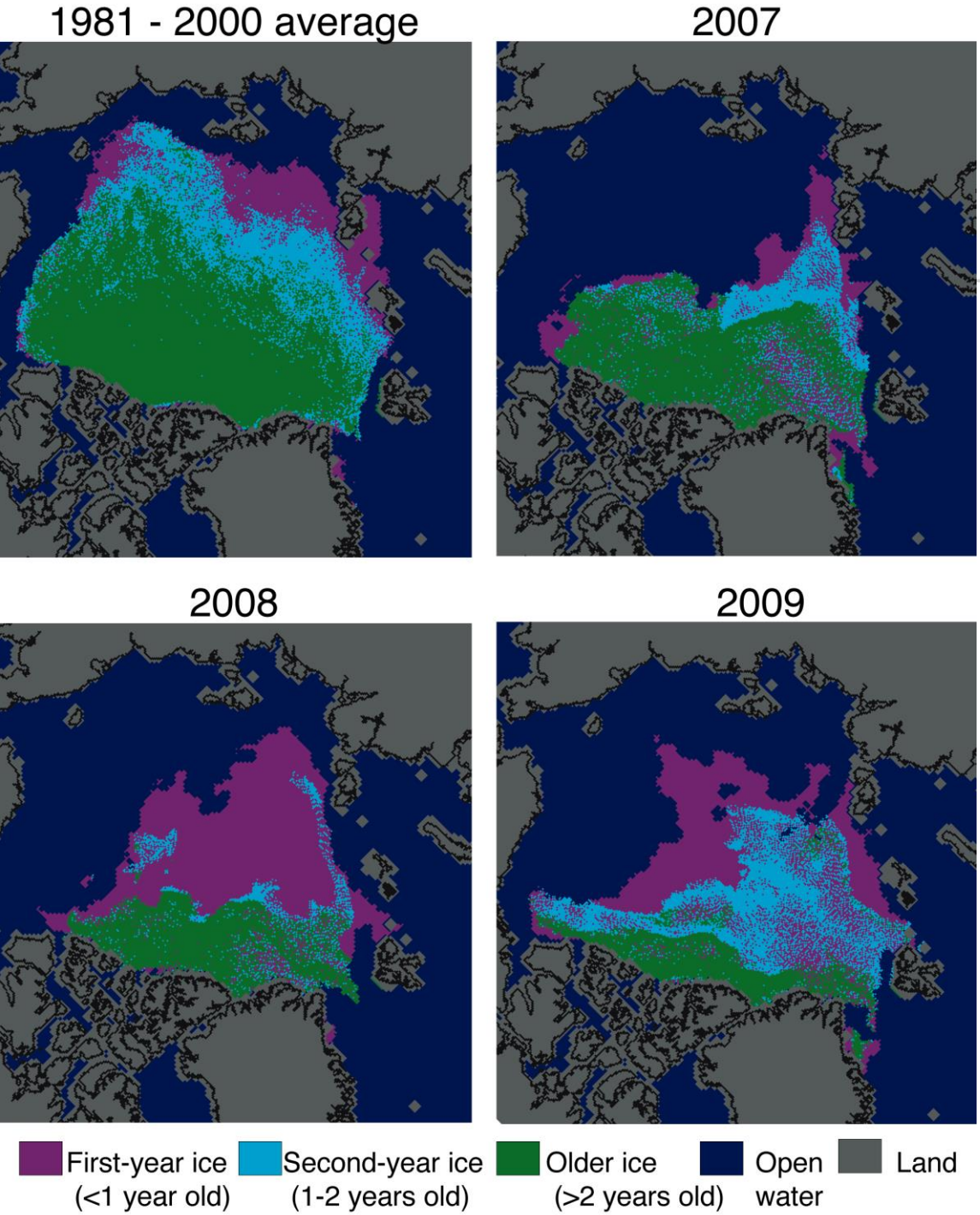

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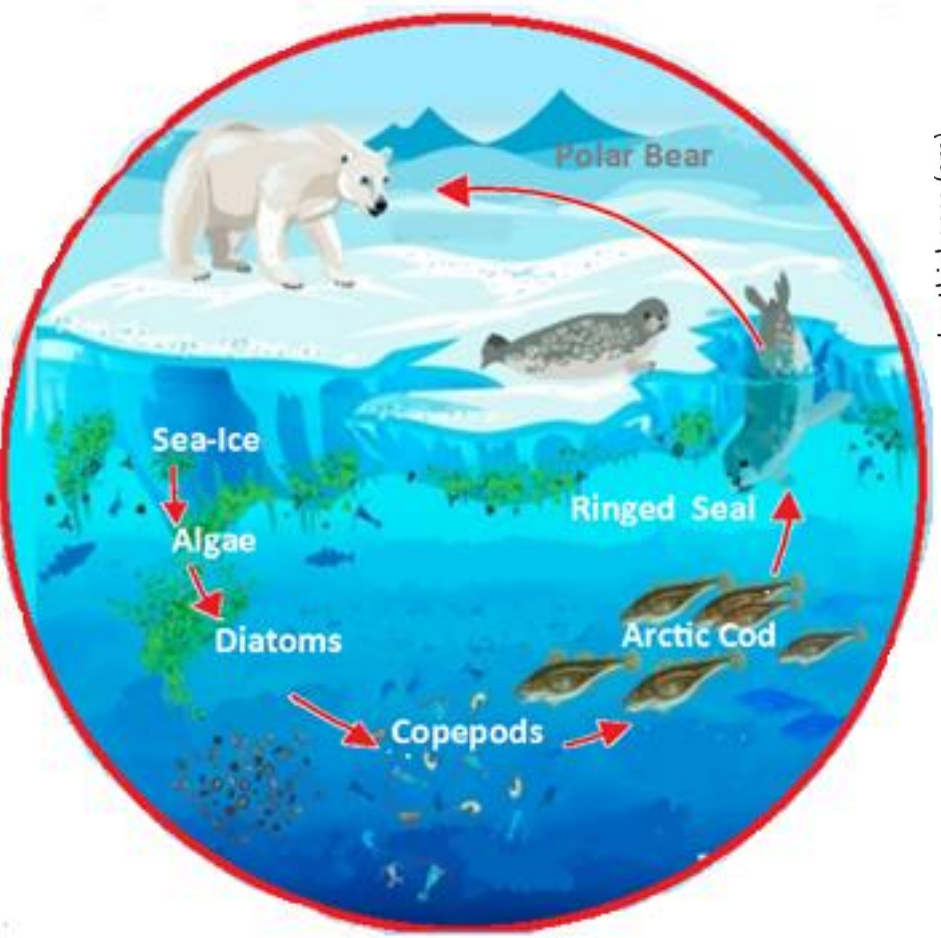
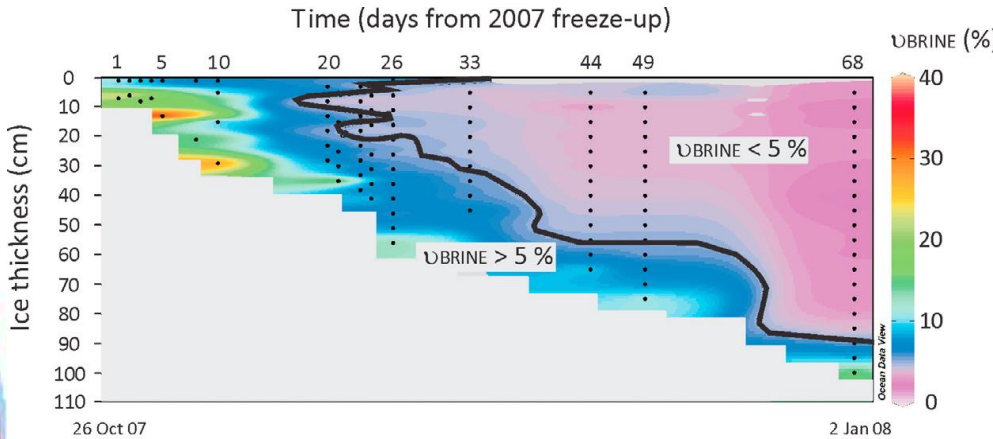
Diminishing sea-ice cover and quality by the end of the Arctic summer

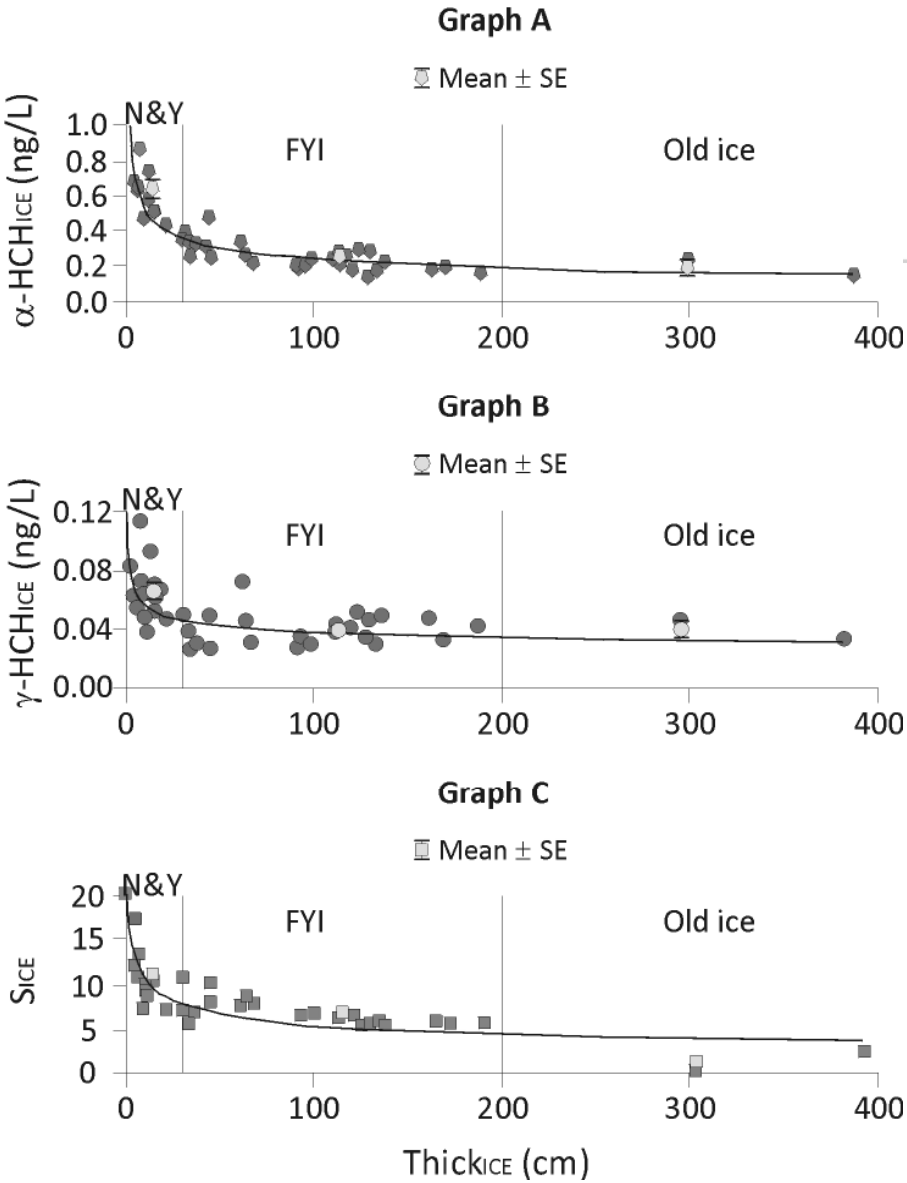
National Snow & Ice Data Centre (University of Colorado at Boulder)

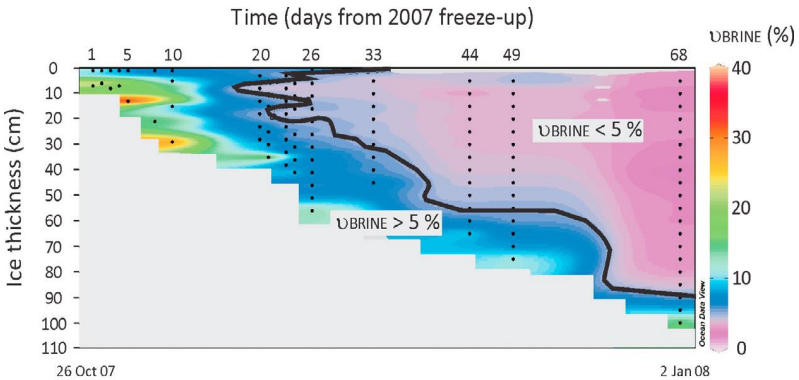
Contaminant behaviour in sea ice





Pucko et al. JGR 2011, ES&T 2012

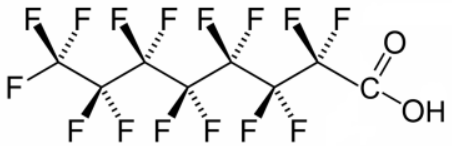




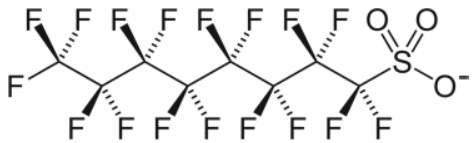
Pucko et al. JGR 2011, ES&T 2012

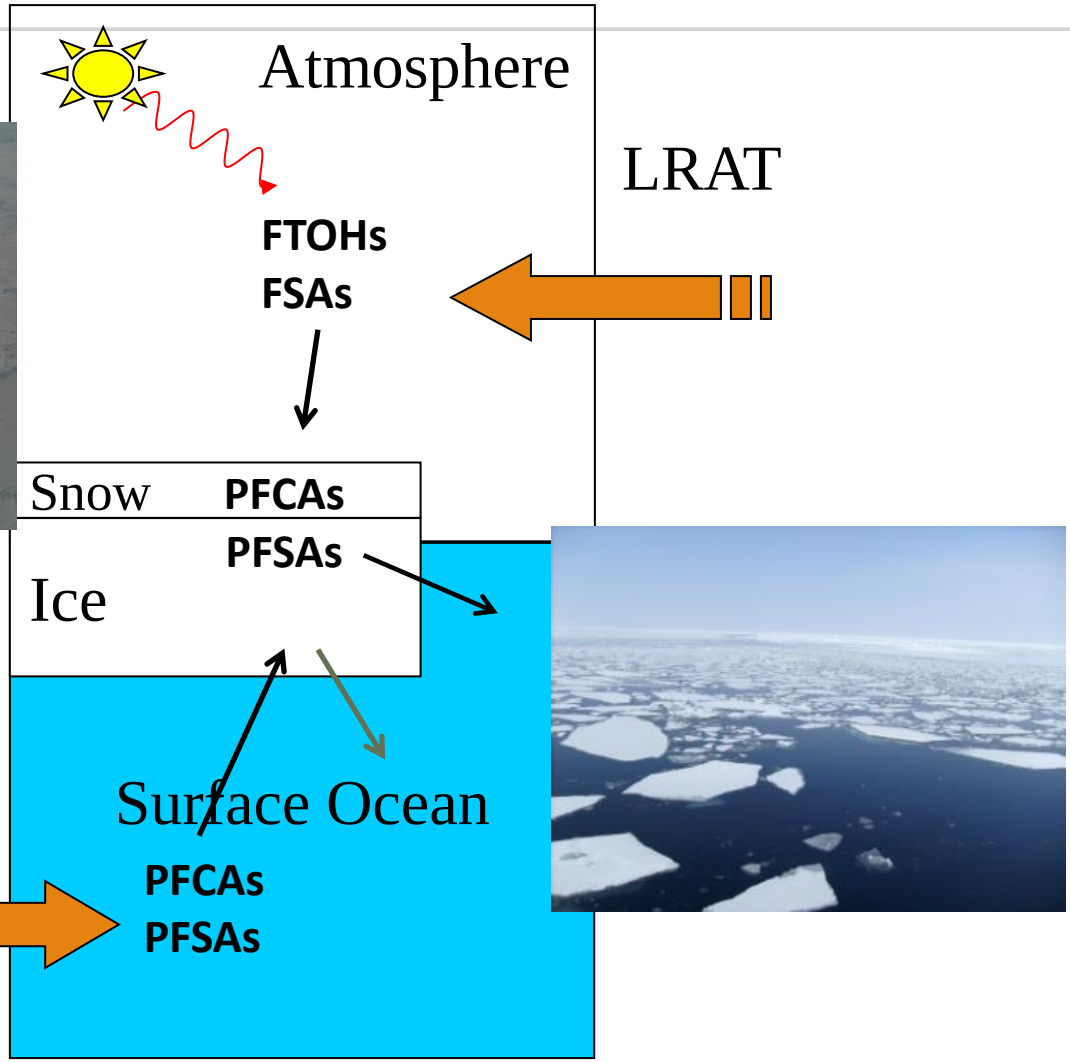
PUĆKO ET AL.: HEXACHLOROCYCLOHEXANES IN THE ARCTIC CRYOSPHERE
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 116, C02035, doi:10.1029/2010JC006614, 2011

PFOA



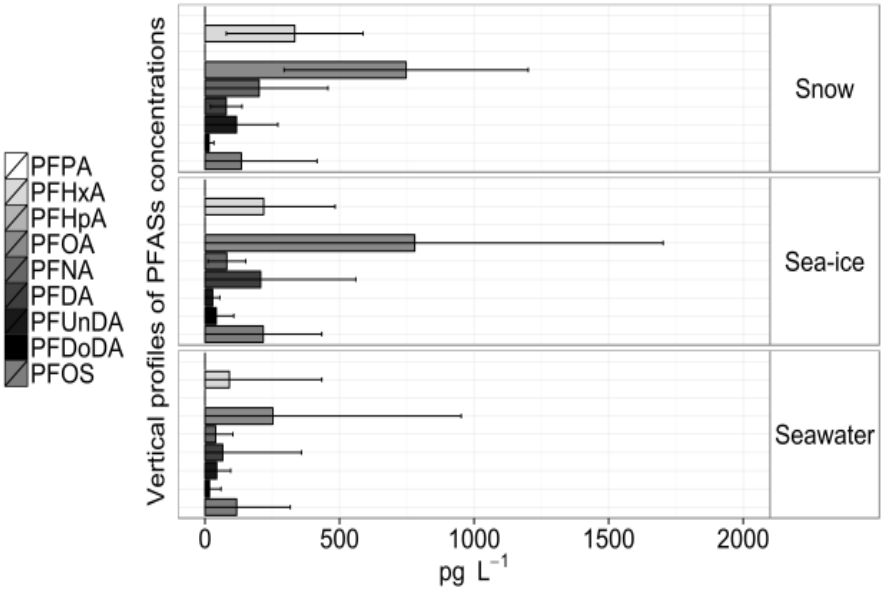
PFOS



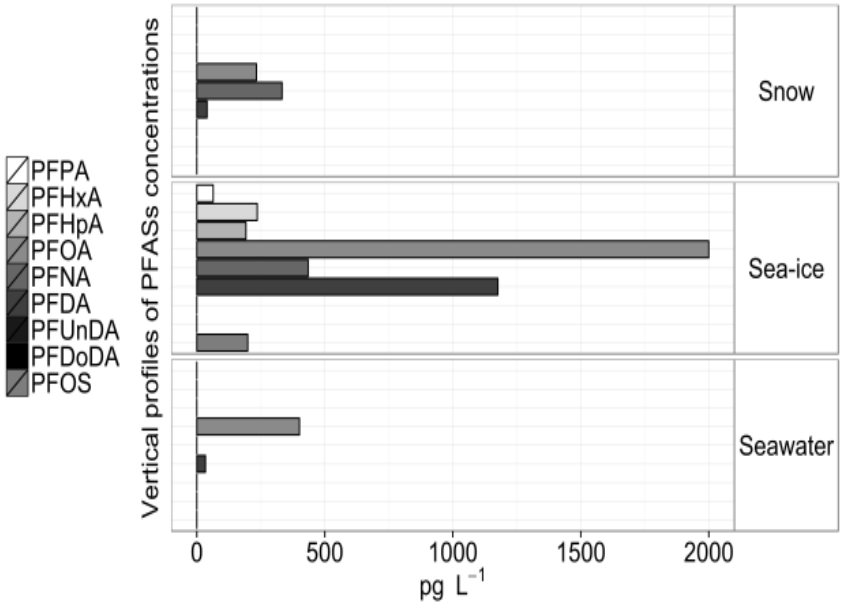

Atmosphere
LRAT
FTOHs
FSAs
Snow
PFCAs
PFSAs
Ice
Surface Ocean
LROT
PFCAs
PFSAs

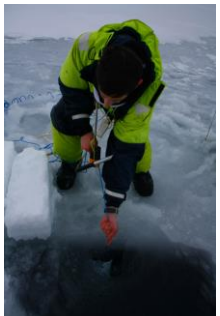
PFASs concentrations in the sea ice system

Canadian Arctic (Amundsen Gulf)



Barents Sea – east of Svalbard





PFOA enrichment in the marine cyrosphere??

	Concentration (pg L^{-1})			Ratio	
	seawater	snow	bulk-ice	Snow/water	Ice/water
YOUNG ICE	100	300	130	~3	~1.3
FIRST-YR ICE	300	700	750	~2.2	~2.5
MULTI-YR ICE	300	350	3000	~1.2	~10

Fate of POPs in sea ice

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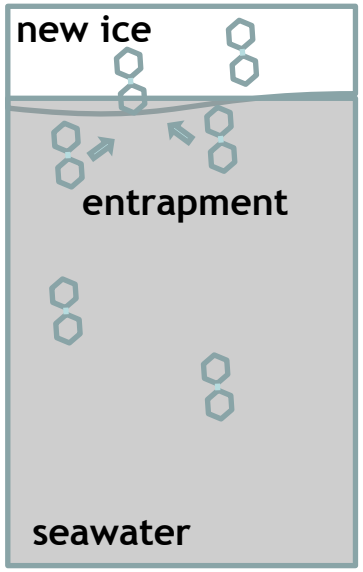
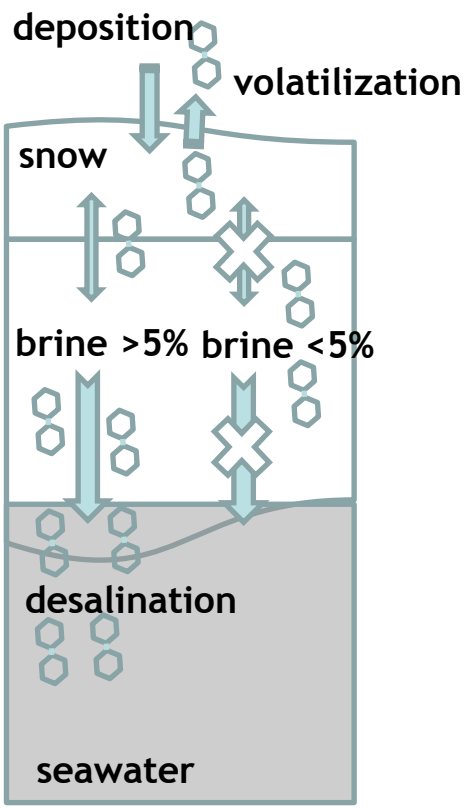
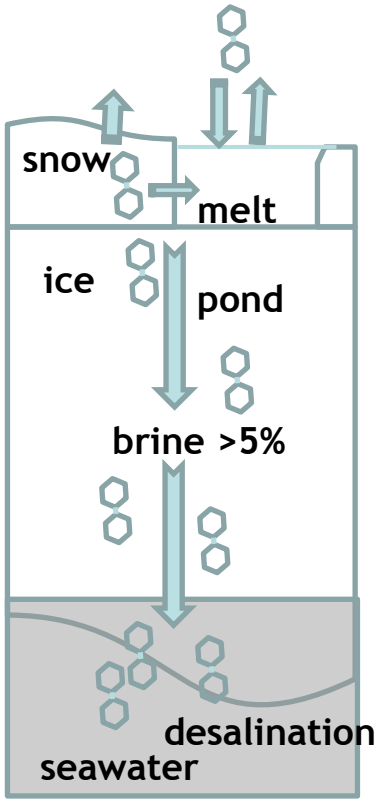
FALL



WINTER



SPRING



Pucko et al. JGR 2011, ES&T 2012

POPSICLE: Persistent Organic PollutantS In a Controlled Laboratory Environment

Aims:

- Understand the physical and chemical factors responsible for governing the fate and behaviour of chemicals in sea-ice and the crysopheric environment.

Objectives:

- Test how the rate of sea-ice formation/decay affects the levels of pollutant in the various polar compartments.
- Investigate various physical and chemical mechanisms related to the chemical enrichment of contaminants in sea-ice.

University of East Anglia

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ROLAND VON GLASOW - AIR-SEA-ICE CHAMBER (THE RVG ASIC)

Sea-Ice instrumentation:

•In-ice salinity (derived from resistance) and solid fraction profiles (1cm resolution)

•In-ice temperature chains (1-4cm resolution)

•Post sea-ice formation sampling tools (coring & sectioning)

"Ocean" instrumentation:

• CTD (conductivity, temperature and depth) sensor

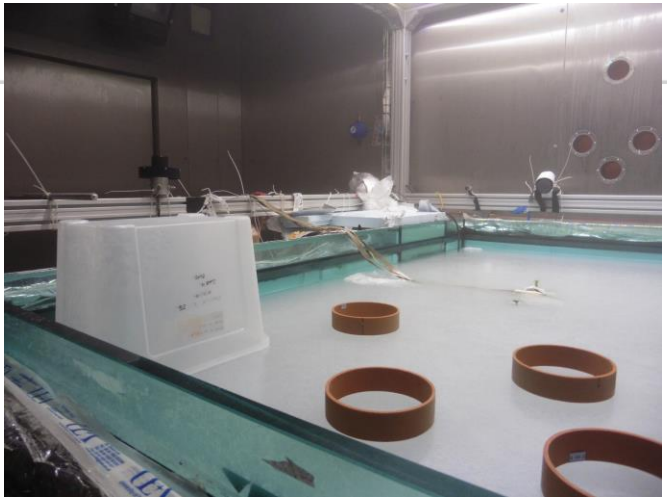
• Controllable aquarium circulation pumps, UV filtration system, capable of overturning the water every 2 hours.

• Underwater camera system (with LED light)

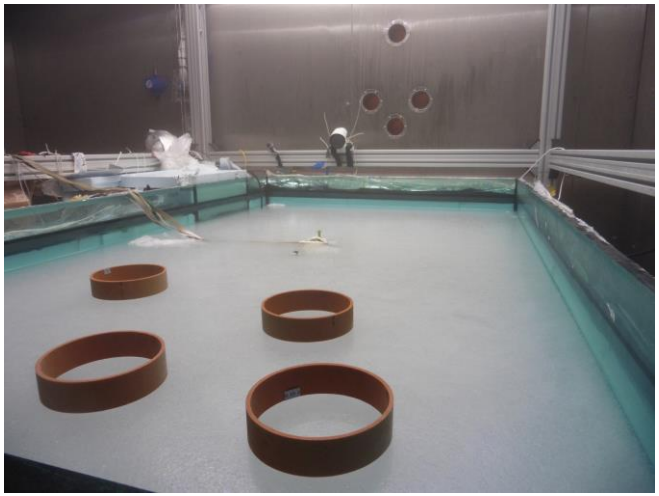
•Sea-ice temperature chains can also be extended into the ocean.

URL: https://www.uea.ac.uk/environmental-sciences/sea-ice-chamber

Coring of ice samples of ice ~ 20cm thick



Frost Flower fields grown at -30°C



POPCICLE 1.1

Phase I (sea-ice formation) @ -18°C

- Ice growth rate (3-4cm/day)
- Daily seawater samples taken (~200mL)
- Bulk-Ice slab sample taken (~1400mL)

Phase II (sea-ice decay)

- 8 random cores taken across the sheet (~28cm)
- Split into upper/lower section (~14cm) and placed into PE bags
- Left to slowly thaw and drain at -2°C
- 4 fractions collected (different salinities)

POPSICLE 1.2

Phase I (sea-ice formation) @ -30°C

- Ice growth rate (4-5cm/day)
- Daily seawater samples taken (~200mL)
- Bulk-Ice slab sample taken (~1400mL)
- Frost flowers sampled (~300mL)

Phase II (sea-ice decay)

- Daily seawater samples taken (~200mL)

Sea ice tank spike experiment

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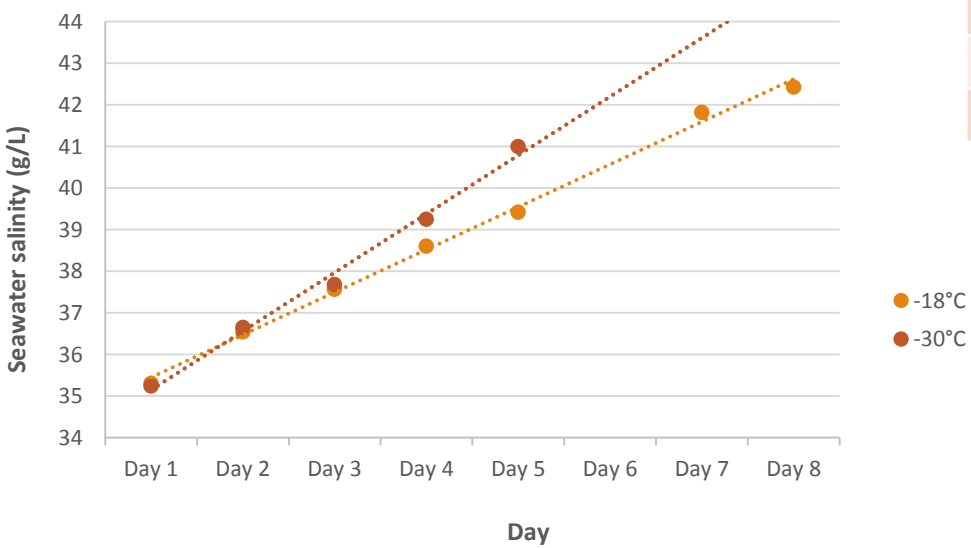
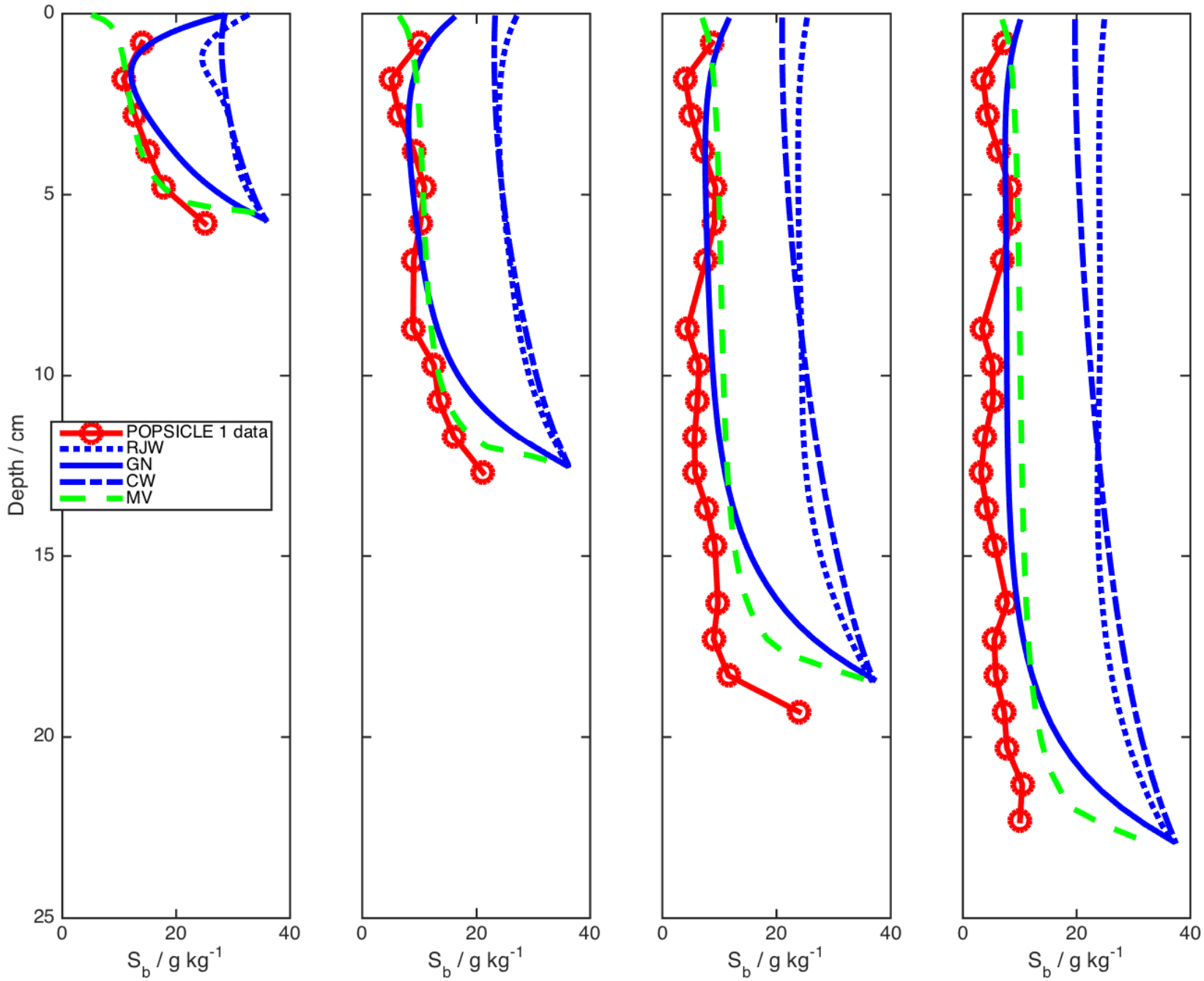
- Selected chemicals used as model compounds
- Display a broad range of chemical properties
- Spiked via a 1L 25% v/v EtOH solution
- Concentration range [pg to ng/L]

Chemical
Chlorpyrifos
α-HCH
γ-HCH
Endosulfan I
BDE (#47, 99)
PCB (#28, 52)
C_{4-12} perfluorocarboxylic acids (PFCAs)
Nonafluorobutanesulfonic acid
Heptadecafluorooctanesulfonic acid
Perfluorooctanesulfonic acid (PFOS)
9H-Hexadecafluorononanoic acid



- Two atmospheric chamber temperatures to provide different sea-ice growth regimes (-30°C & -18°C)
- The rate of sea-ice formation leads to varying degrees of salt expulsion


Depth / cm
0
5
10
15
20
25
POPSICLE 1 data
RJW
GN
CW
MV
0
20
40
S_b / g kg^{-1}