

Changing Arctic Ocean

Arctic PRIZE

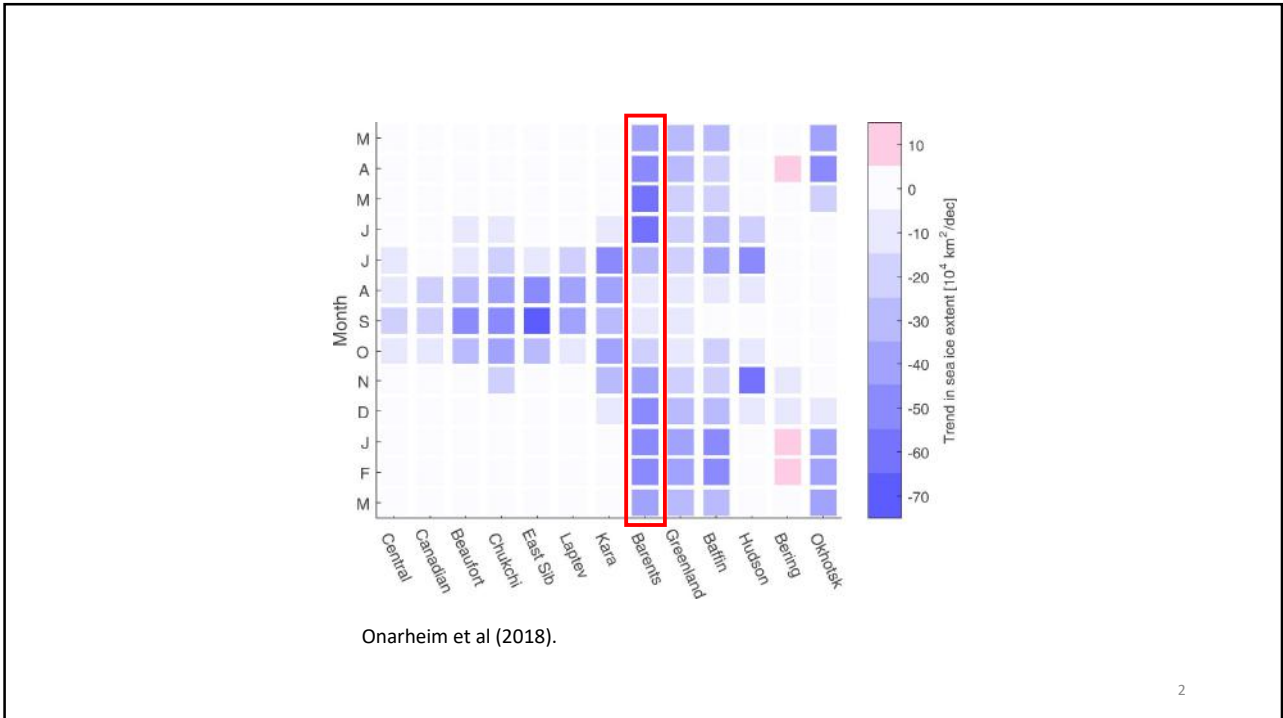
Arctic PRoductivity in the Seasonal Ice ZoneE

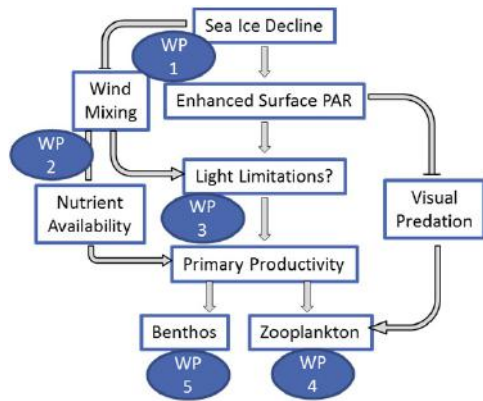
2018: From Darkness to Light in the Barents Sea

NERC
SCIENCE OF THE ENVIRONMENT

7 UK Institutes: Scottish Association for Marine Science
University of Strathclyde
University of Edinburgh
St Andrews University
Oxford University
National Oceanography Centre
British Oceanographic Data Centre

10 Intn'l Partners: University of Tromsø
NTNU University of Trondheim
Norwegian Polar Institute
Institute of Marine Research
Akvaplan-NIVA
SINTEF
University of Washington
....

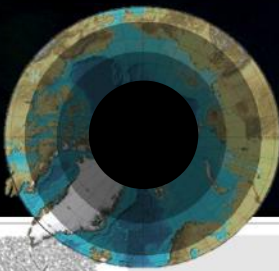




How will projected shifts in the spatial distribution of sea ice in the Arctic Ocean modify mixing and light in the surface ocean, and what is the net effect of these physical changes on the quantities, timing and rates of primary production, phytoplankton taxonomic composition, and their pelagic and benthic consumers?"

"How does more light in an ice-free Arctic Ocean affect productivity?"

Polar Night



The black box becomes darker at higher latitudes

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)


Progress in Oceanography

journal homepage: www.elsevier.com/locate/pocean





In the dark: A review of ecosystem processes during the Arctic polar night

Jørgen Berge^{a,b,*}, Paul E. Renaud^{b,c}, Gerald Darnis^c, Finlo Cottier^d, Kim Last^d, Tove M. Gabrielsen^{b,e}, Geir Johnsen^{b,f}, Lena Seuthe^a, Jan Marcin Weslawski^g, Eva Leu^{c,h}, Mark Molineⁱ, Jasmine Nahrgang^a, Janne E. Søreide^b, Øystein Varpe^{b,c}, Ole Jørgen Lønne^b, Malin Daase^a, Stig Falk-Petersen^{a,c}




UiT / THE ARCTIC UNIVERSITY OF NORWAY

<http://site.uit.no/arcticsize/>

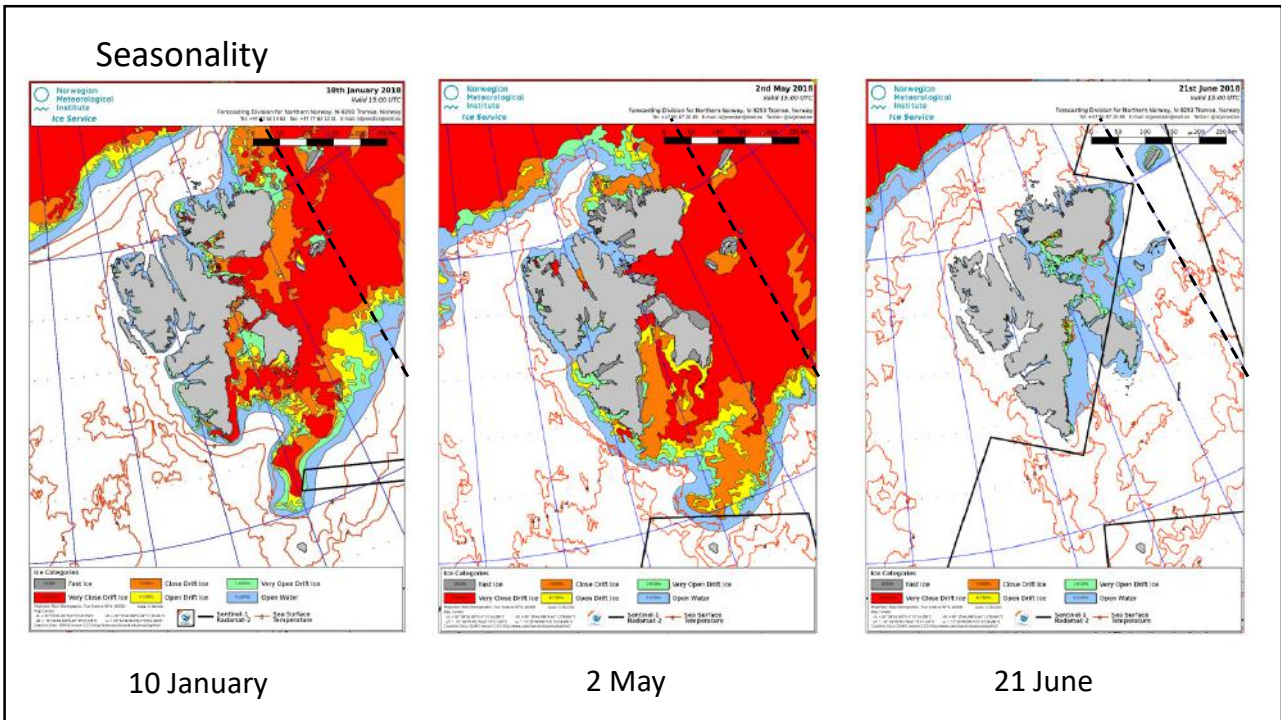


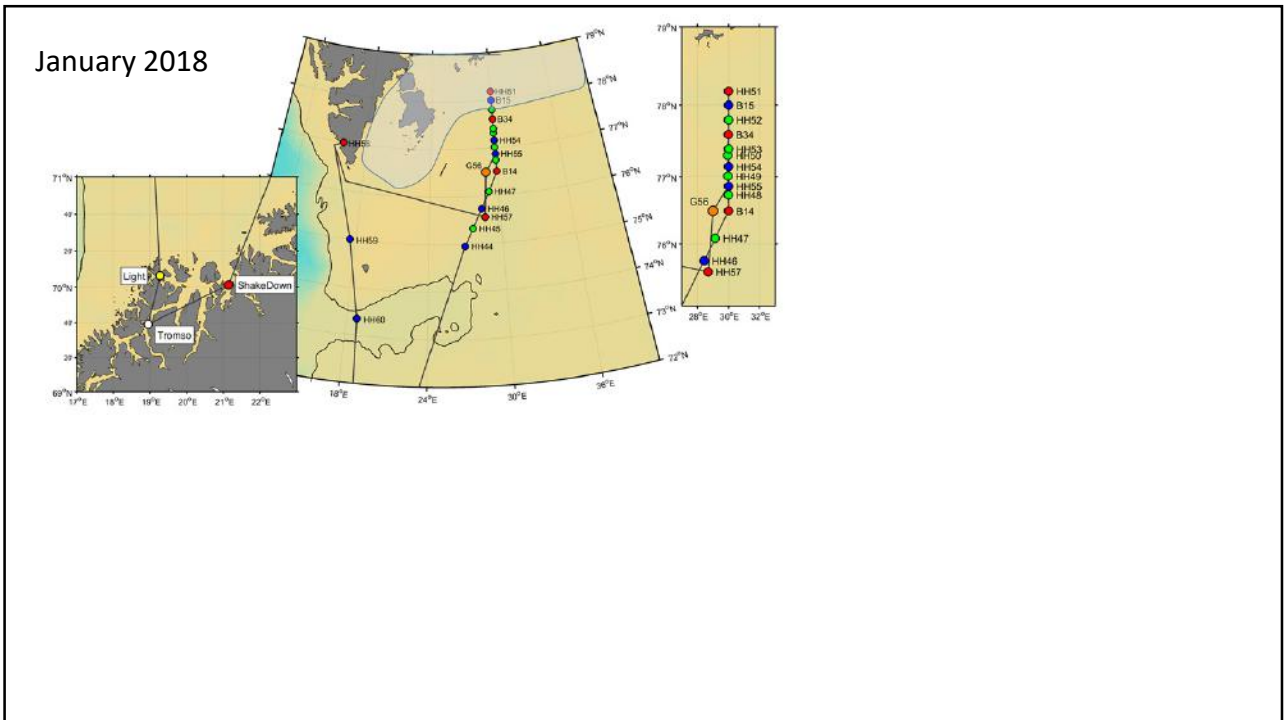
About
Members
Activities and News
Publications and Outreach
Living Ice Project
Scientific focus

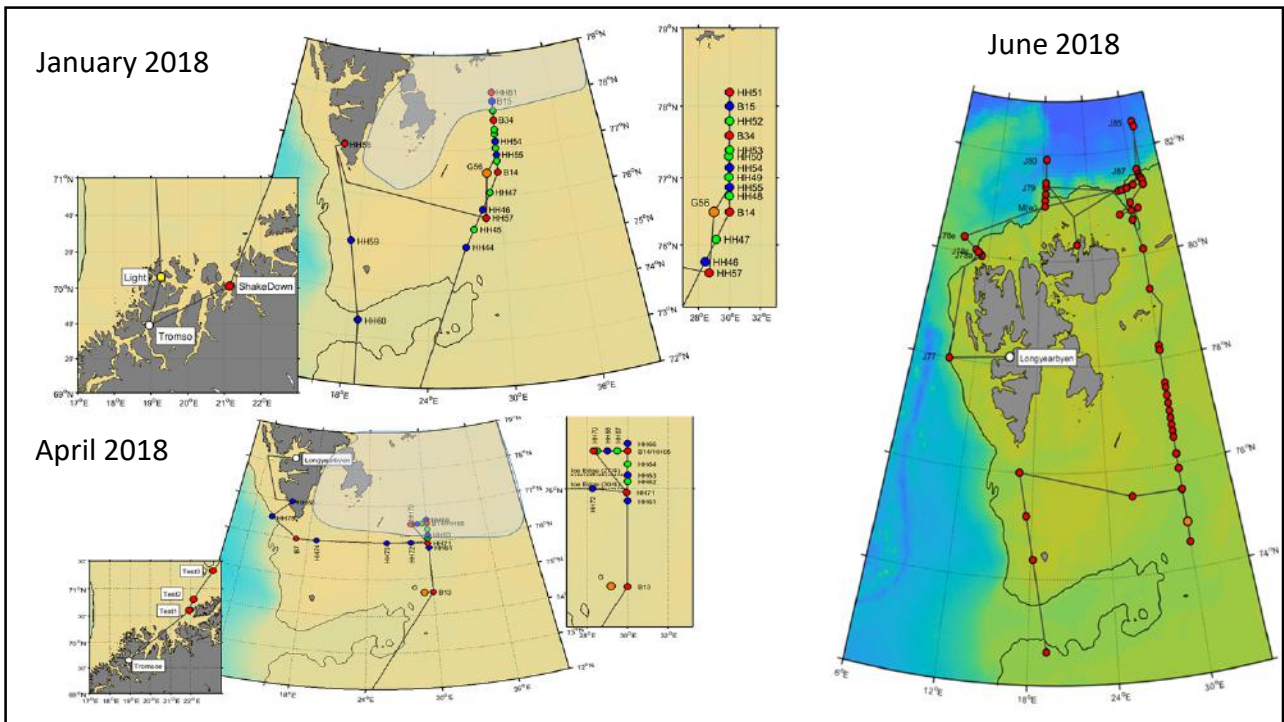
Arctic Size Home

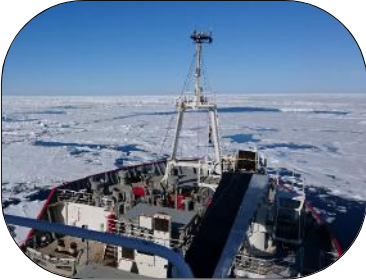




In 2015 the Norwegian Government released a funding competition with the goal to support promising university-based research initiatives that had the potential and stated goal to develop into world leading groups. Evaluated and selected by an international panel the competition at UiT The Arctic University of Norway was won by a group of 4 professors in marine ecology, under the leadership of Paul Wassmann. The main focus of the group is research on the seasonal ice zone in the Arctic Ocean, promoting the comprehension of the present functioning and future development. The group selected the title "Seasonal Ice Zone Ecology (ArcticSIZE)". In 2016 Prof. Rolf Gradinger was employed. In 2017 followed 4 PhD students and 2 post docs. Associated to ArcticSIZE are also 5 adjunct professors in arctic marine ecology. The expertise of ArcticSIZE comprises ice biota, phyto- and zooplankton, vertical flux and pelagic-benthic coupling, benthos, biodiversity and C flux modelling.





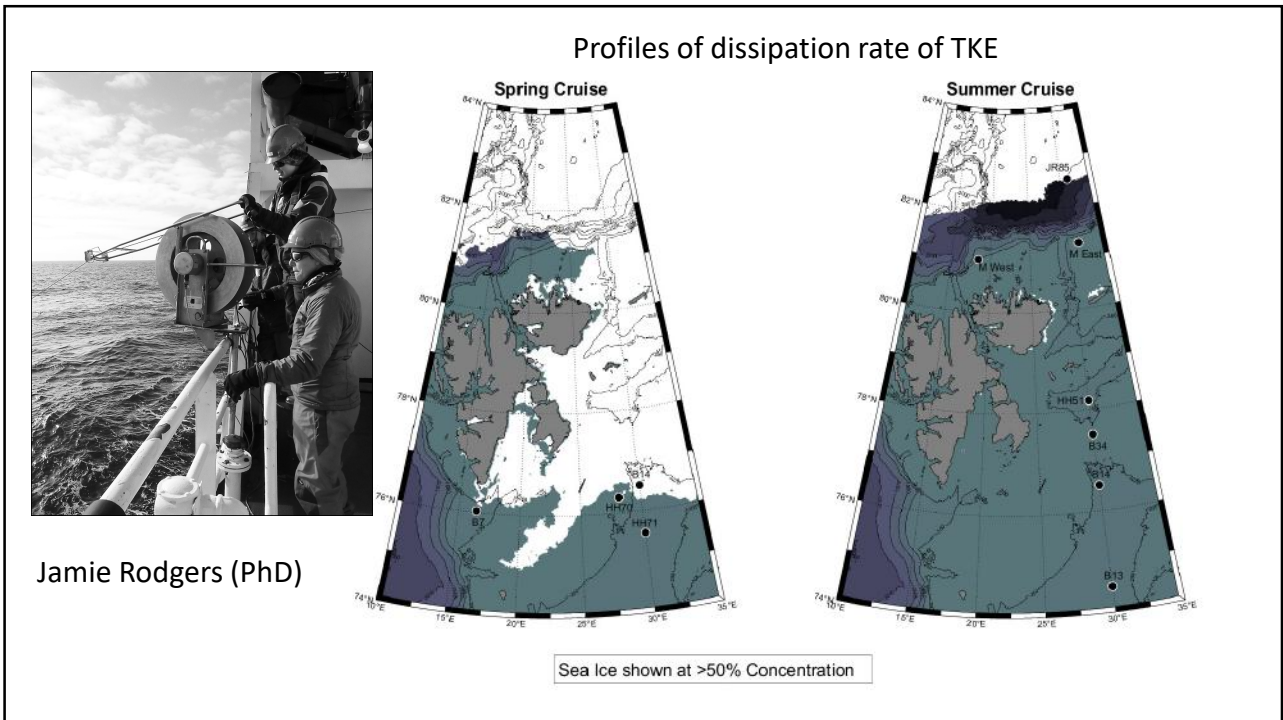
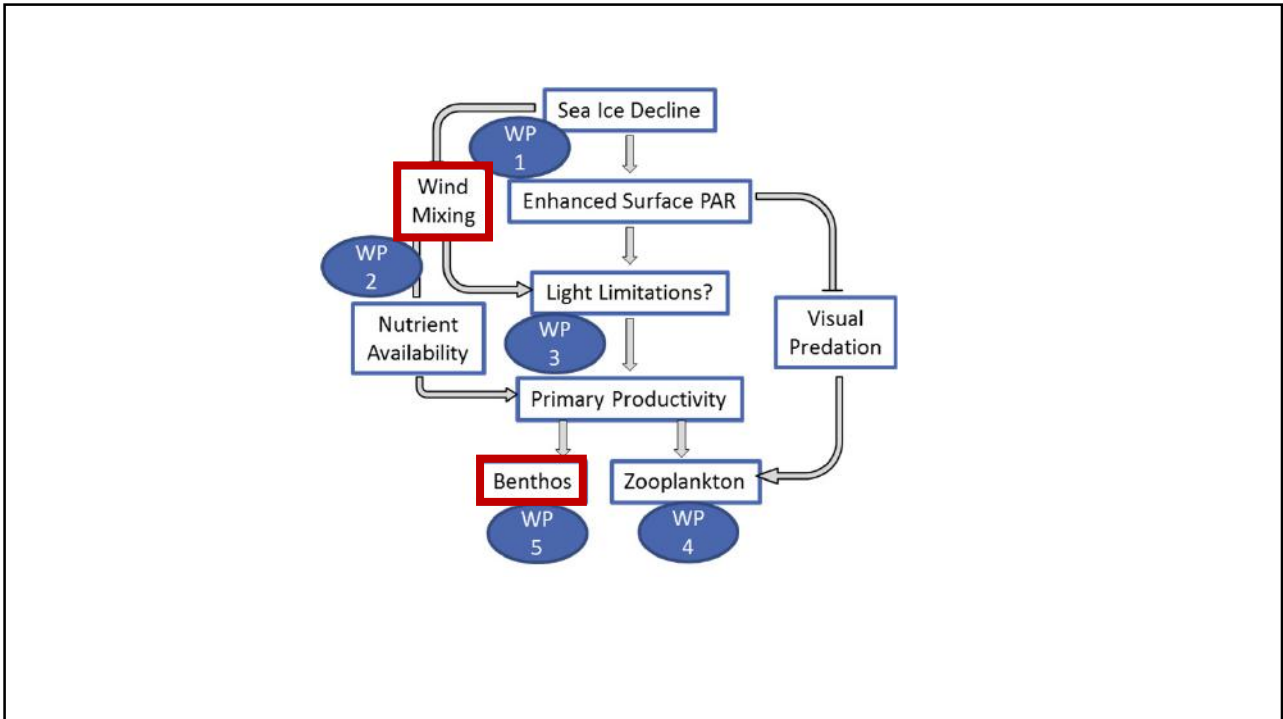


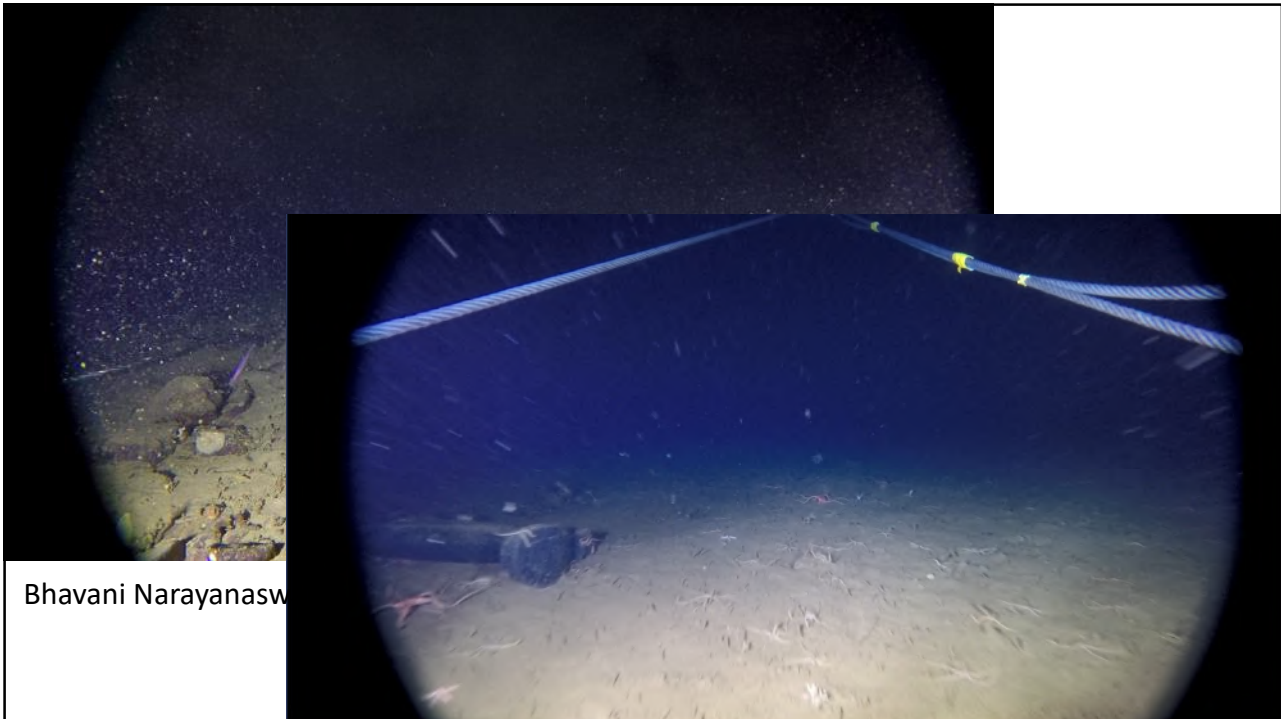


Days at Sea	49
Science Days	43
Distance Sailed (nm)	5400
Stations	104
CTDs	139
Events	930

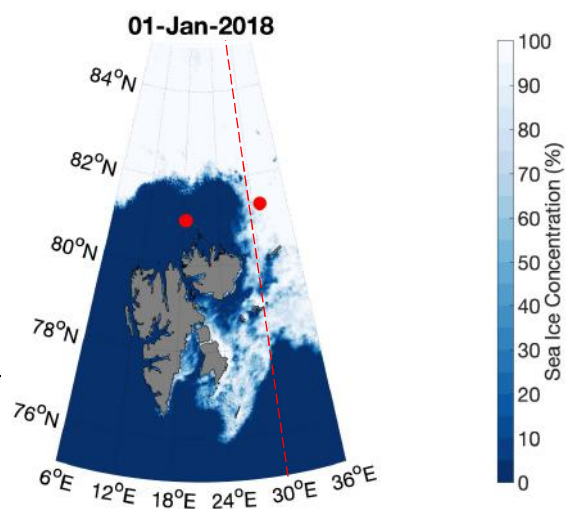







Capturing Seasonality: Moorings

- Two moorings with identical instrumentation
- $\sim 81^\circ \text{N}$
- Similar depths
- Similar distance from shelf break
- One 'ice-free', one 'ice-influenced'
- Physical parameters (Cottier/Porter), Nitrate analyser (Henley), Zooplankton/Fish profiler (Hobbs/Brierley/Las), Sediment trap (NL/SIZE)



Capturing Seasonality: Moorings

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ARCTIC PRIZE
WEST
DEPLOYED
2017

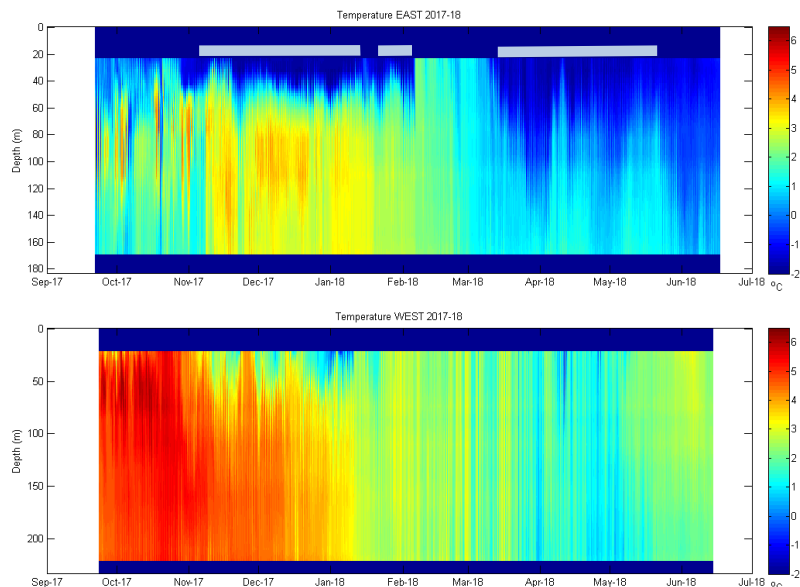
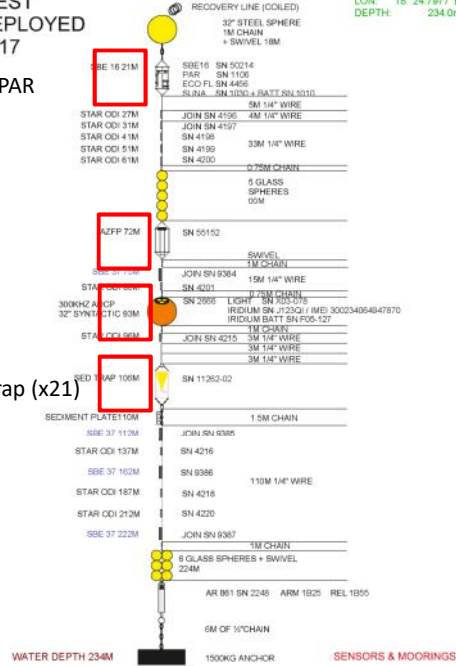
DEPLOYED 23-SEP-2017 09:43 UTC
LAT: 81° 02.0349' N
LON: 18° 24.7977' E
DEPTH: 234.0m

Nitrate/Chl/PAR

4f AZFP

ADCP

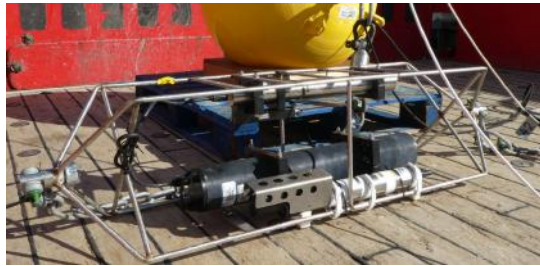
Sediment Trap (x21)



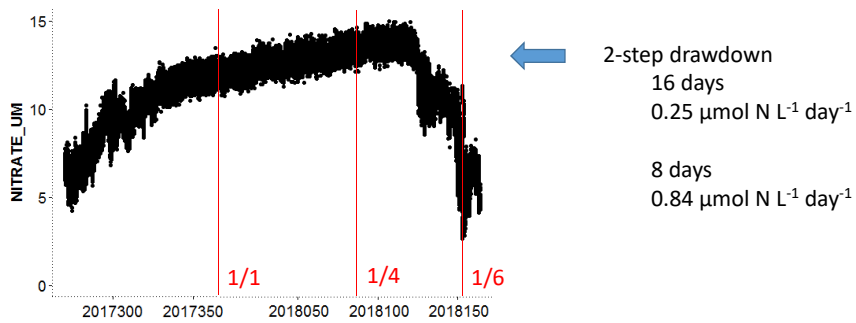
Arctic PRIZE WP2: Nutrients

Sian Henley, Keith Davidson, Judith Braun, Tim Brand, Sharon McNeil,
Elaine Mitchell, Emily Venables

- Winter, spring and summer cruises
 - Water column nutrient measurements
 - $\delta^{15}\text{N}$ and $\delta^{18}\text{O}$ of nitrate \longrightarrow nitrogen cycling processes
 - ^{15}N uptake experiments: nitrate, ammonium, urea, DFAA (^{14}C primary production)
 - Moored nitrate sensors: SUNA V2, 21 m

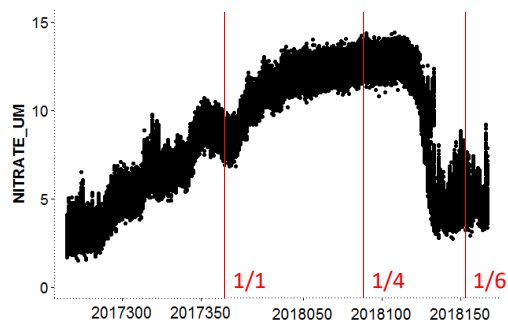


Western mooring: "year-round ice-free"



Eastern mooring \longrightarrow "ice-covered in winter"

Monotonic drawdown
12 days
 $0.65 \mu\text{mol N L}^{-1} \text{ day}^{-1}$





Changing Arctic Ocean NERC

Glider 101

2 km, 2 hrs

200 m

Oil and air inside the glider and battery pack forwards. Low buoyancy

Oil and air outside the glider (pressure hull) and battery pack backwards. High buoyancy

Surface communications
 - getting GPS fix
 - sending data
 - Receiving updated mission

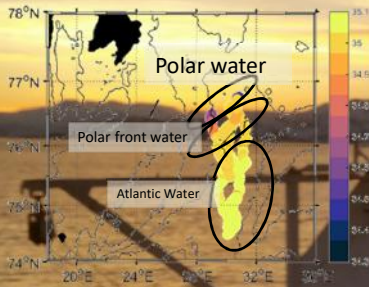
The Arctic PRIZE gliders collected data in:

- Temperature, salinity, pressure
- Depth averaged velocity
- Optical – chlorophyll, CDOM and backscatter
- Oxygen
- PAR (only 1 glider)



Gliders in Arctic PRIZE

Between the 11/1/18 and 30/6/18 the gliders completed roughly 8000 profiles, crossing the polar front 4 times, always returning to Atlantic Water after



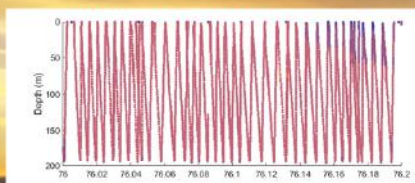
The path taken by the glider coloured by the surface salinity (between January and early March)

The full glider path, with winter/spring in red and spring/summer in blue

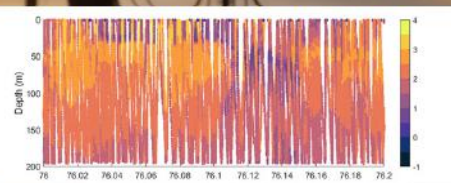


Why we used gliders

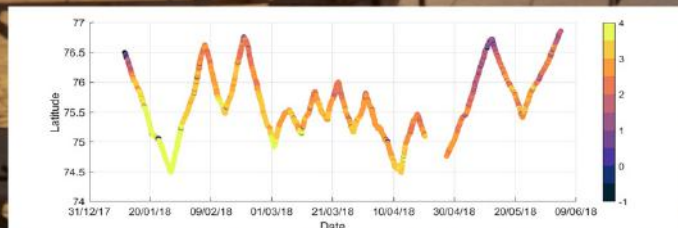
1 transect



3 transects

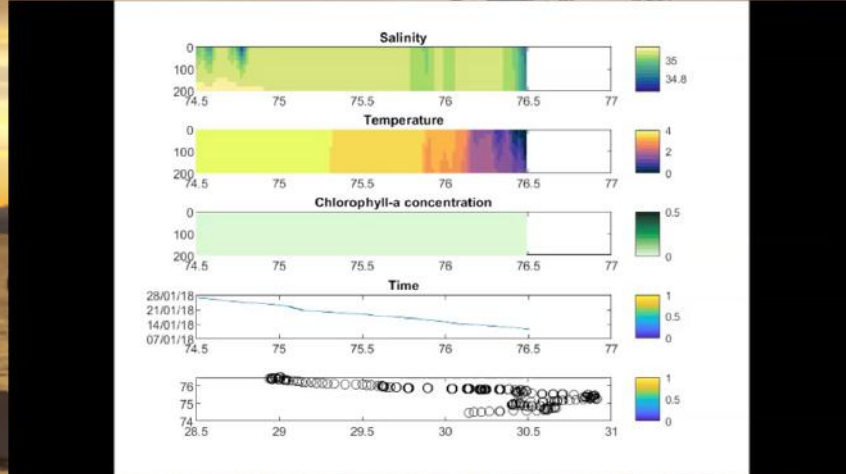


The spatial and temporal coverage of the whole mission





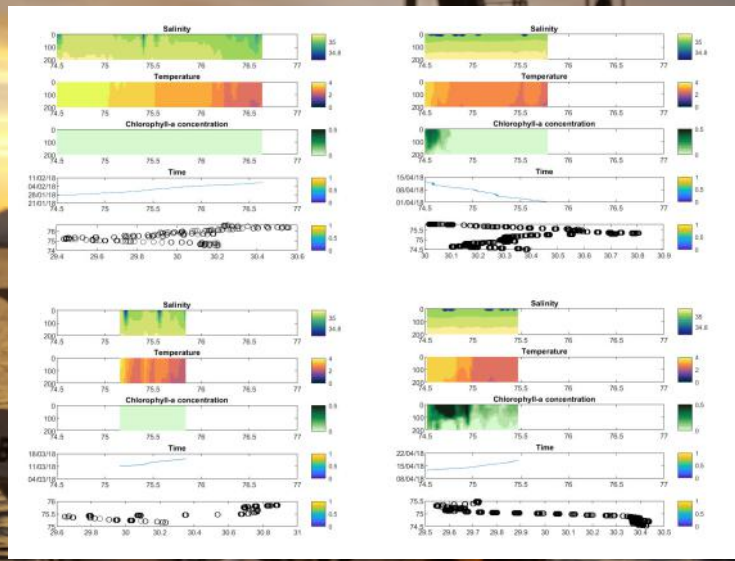
The glider transects



Winter to spring

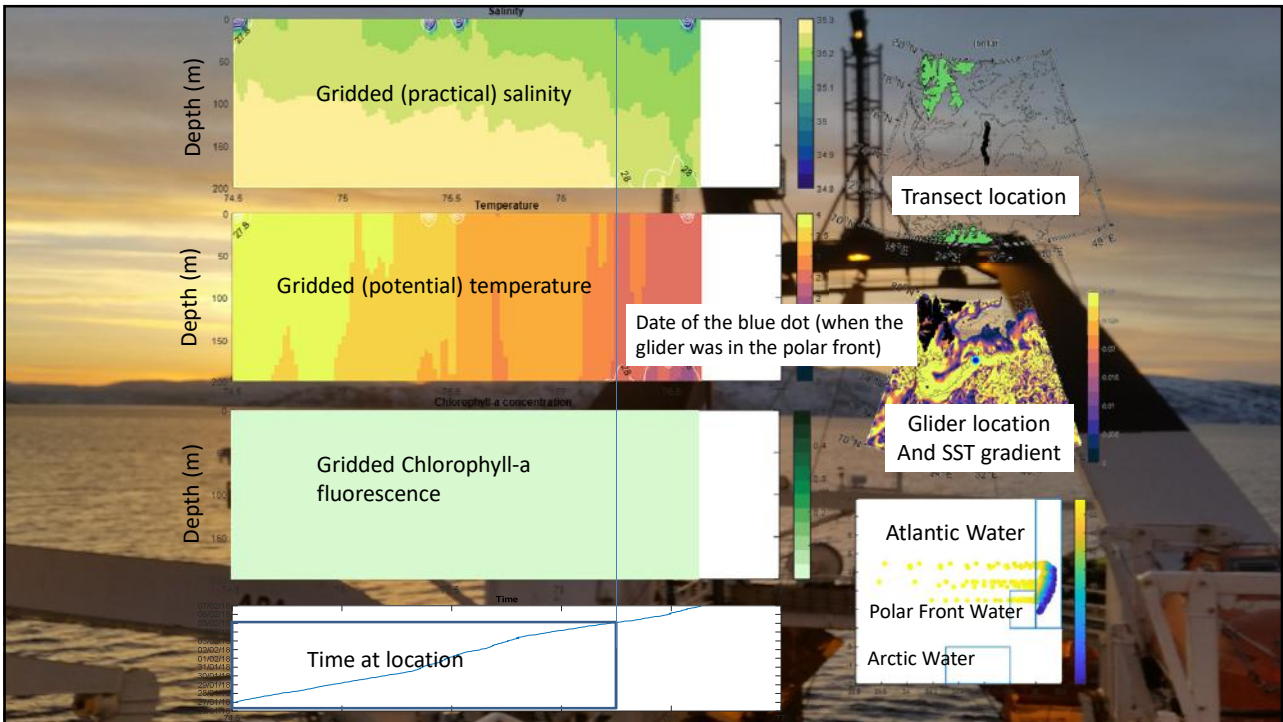
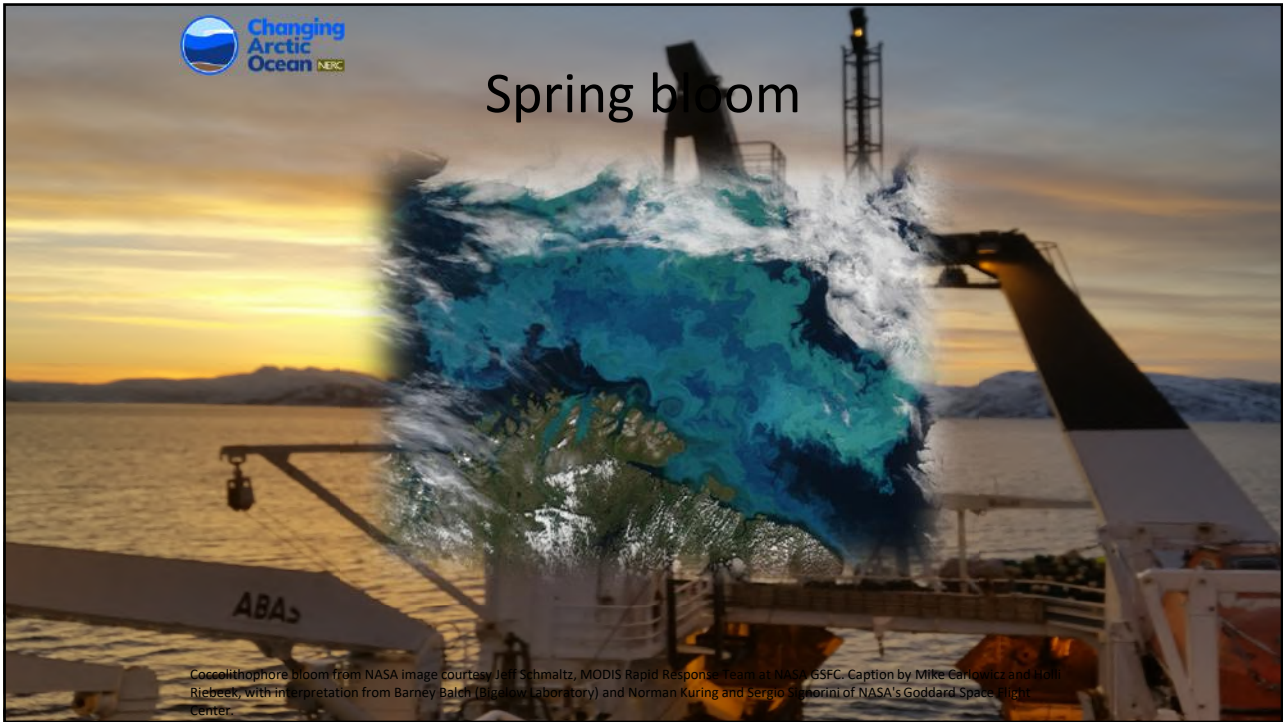
28/1/18 –
20/2/18

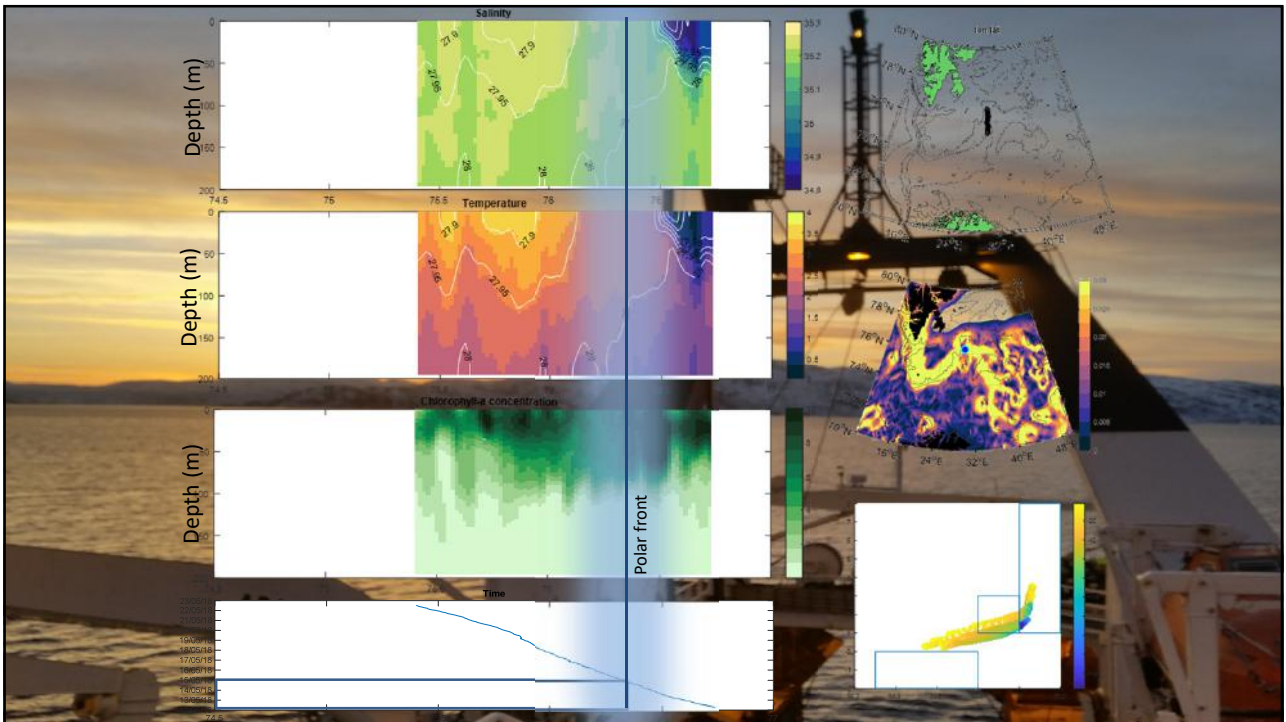
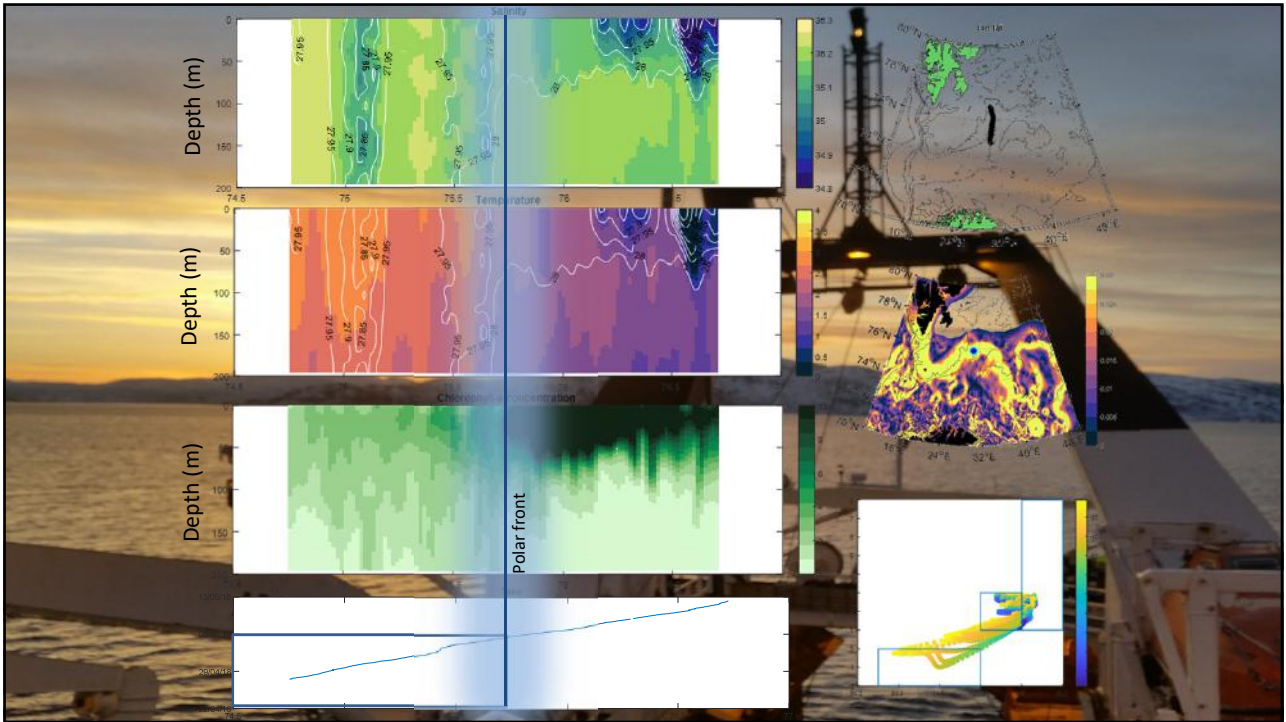
11/3/18
17/3/18

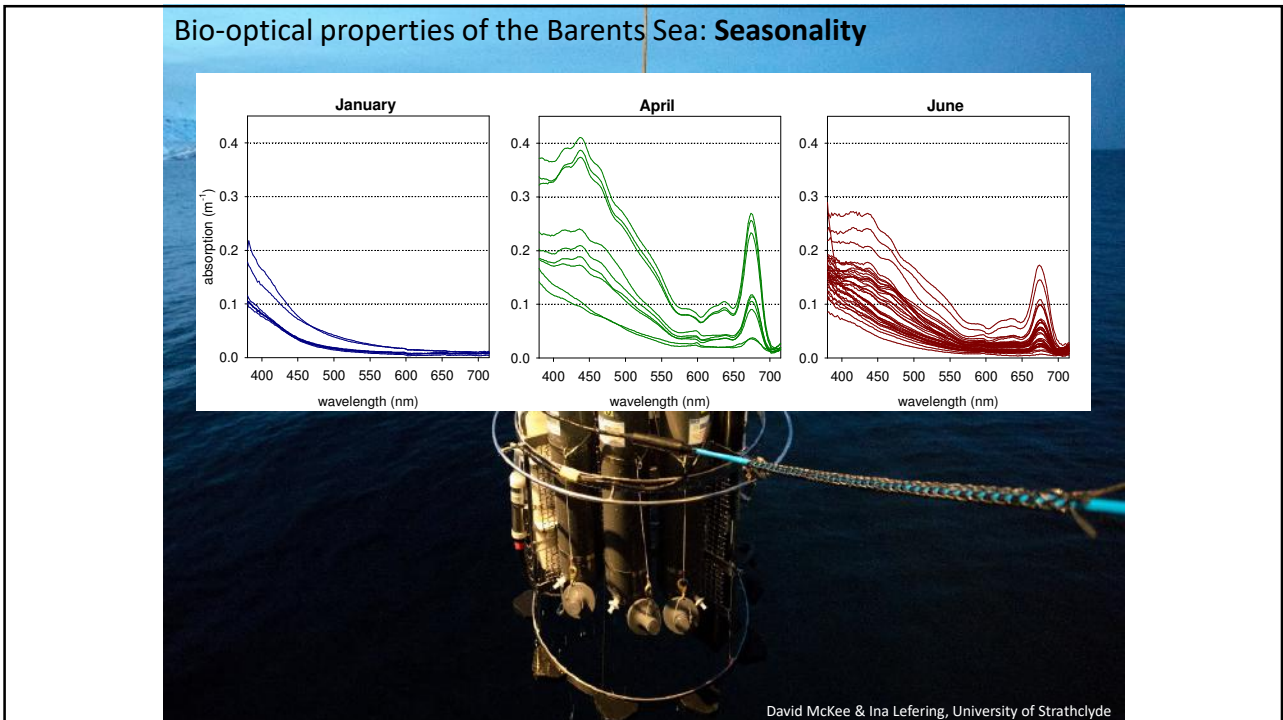
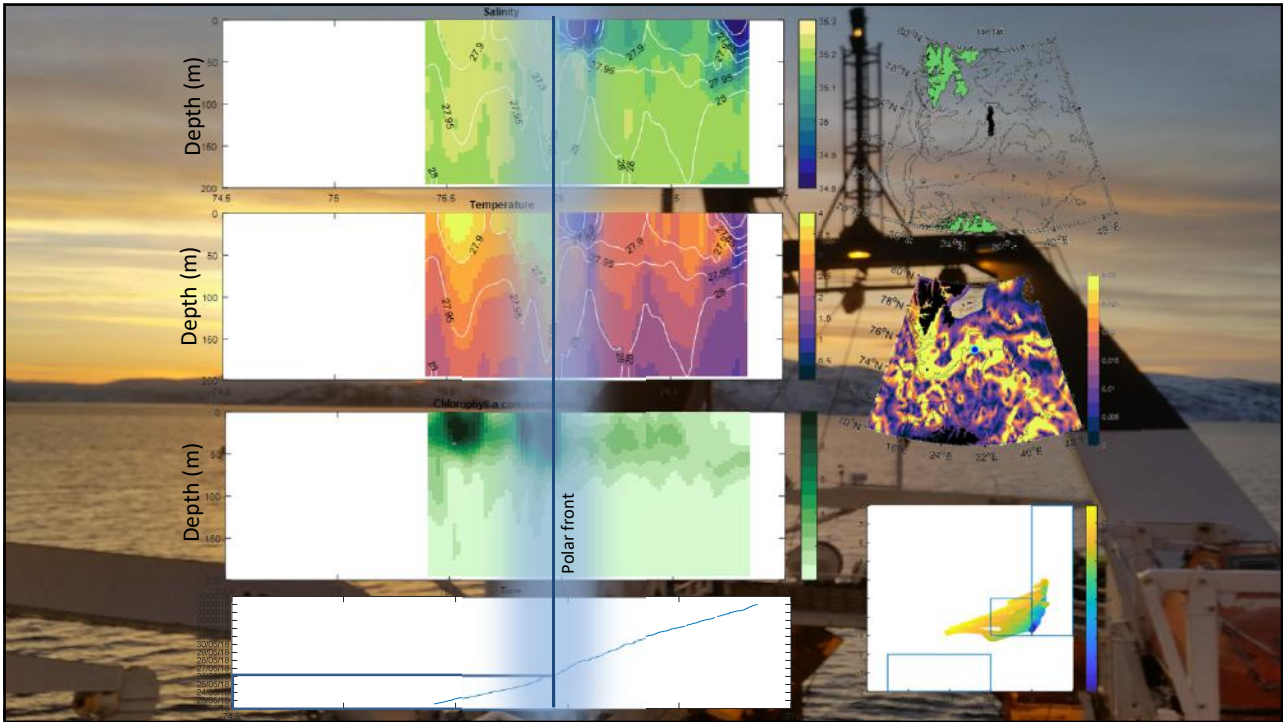


1/4/18 –
13/4/18

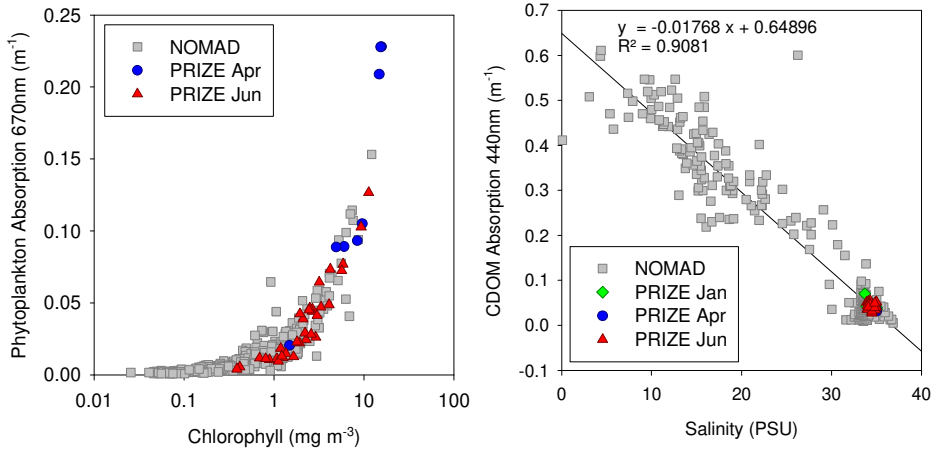
13/4/18 –
20/4/18







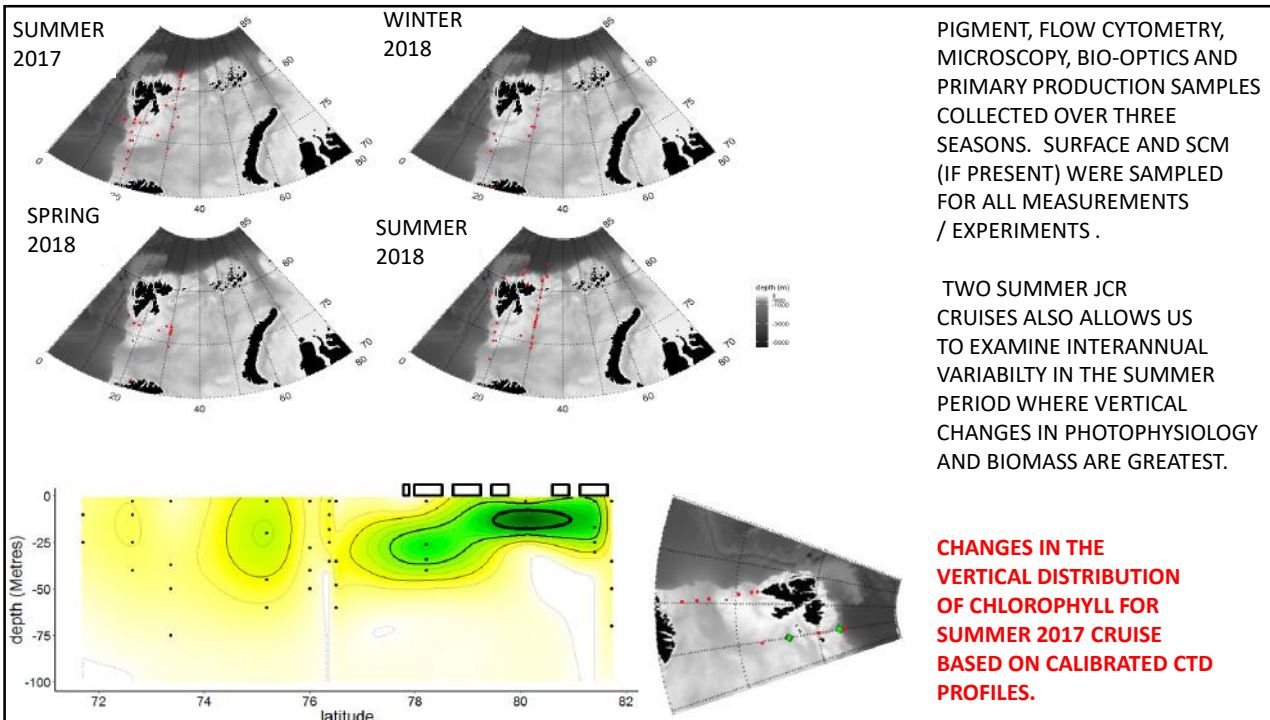
Bio-optical Properties of the Barents Sea: Model Development



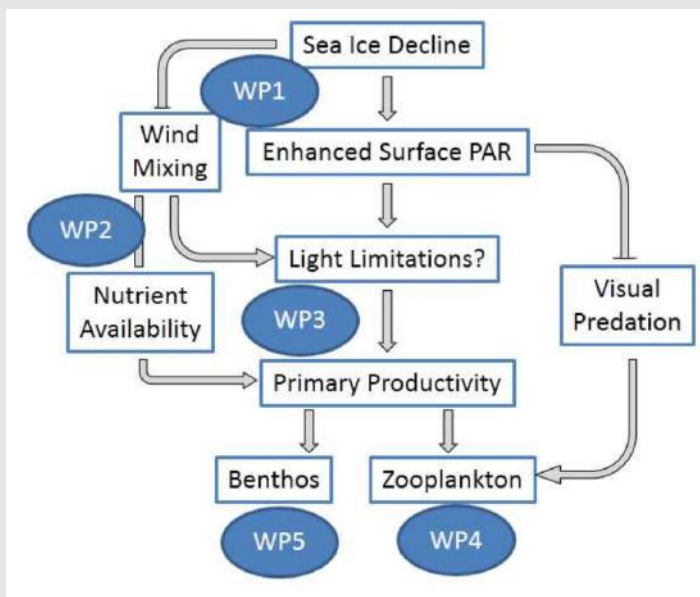
New bio-optical model for the Barents Sea (in preparation) with applications in:

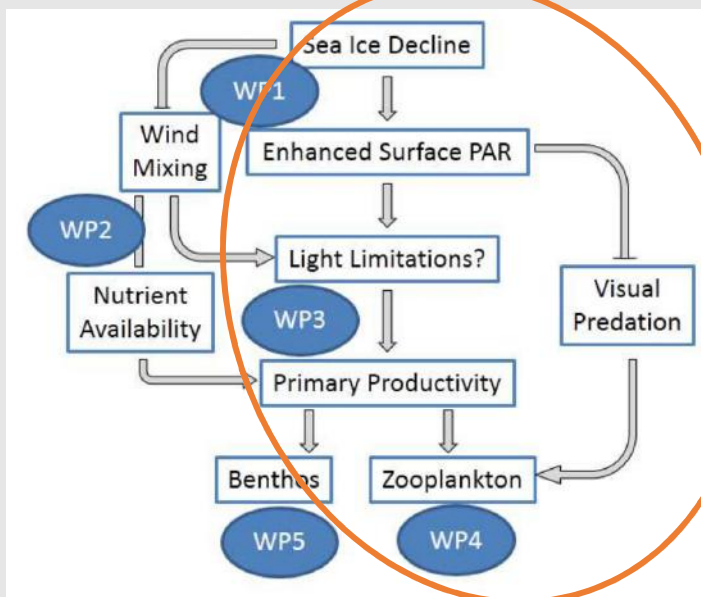
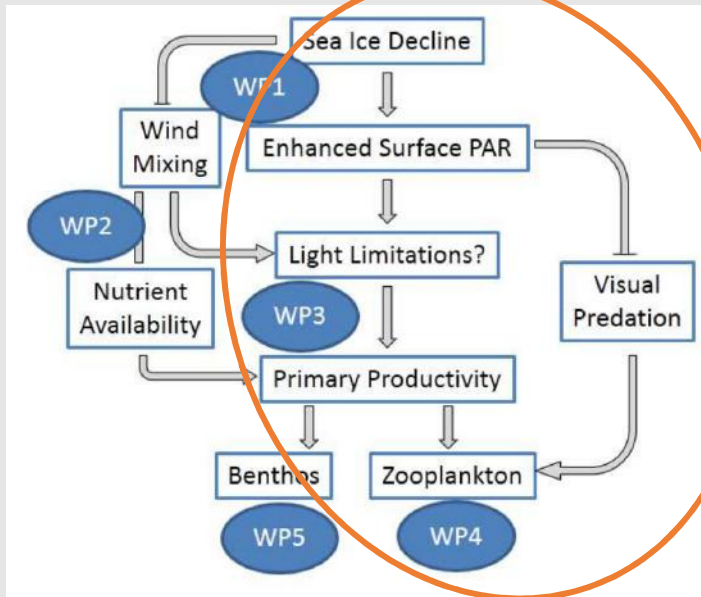
- Light fields for photosynthesis
- Ocean colour remote sensing
- Enhanced glider data products

David McKee & Ina Lefering, University of Strathclyde



How are zooplankton migratory behaviours modified by vertical gradients of stratification, light, phytoplankton and predation?





1. Application of a life history model to investigate winter strategies of copepods
2. Pan-Arctic observations of diel vertical migration during the Polar Night
3. The effect of light on zooplankton vertical positioning

1. Life history modelling

Calanus

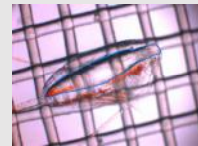
Large copepods

Numerically dominant

Important for transfer of energy through the food web



arcodiv.org



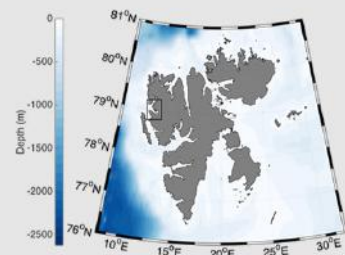
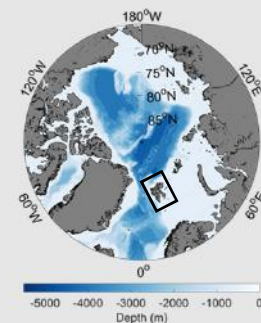
Sarah Reed (SAMS)

1. Life history modelling

Normally entering diapause period

Calanus in Kongsfjorden seen to be active either throughout polar night, or are exiting diapause very early.

What strategies are available to copepods over the winter?



1. Life history modelling

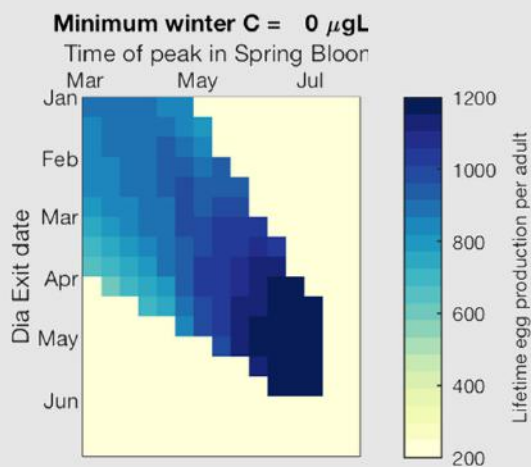
Banas et al. 2016

“Coltrane”: Copepod Life-history Traits and Adaptation to Novel Environments

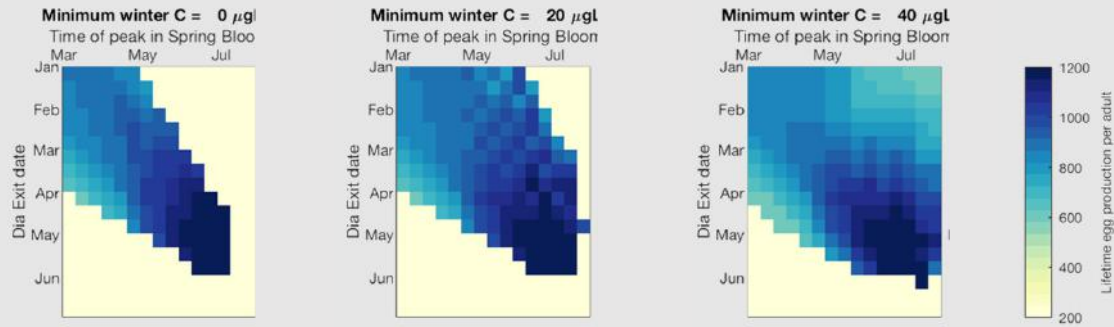
Run to investigate the effect of a non-zero winter prey field on the life-history strategies of copepods



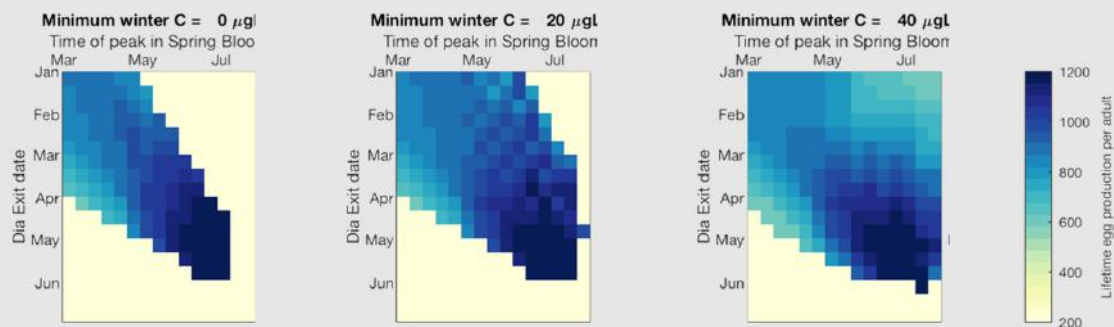
1. Life history modelling



1. Life history modelling



1. Life history modelling



Small changes in winter prey availability result in a variety of overwintering strategies being viable in high Arctic Calanoid copepods

2. Pan-Arctic observations of diel vertical migration during the Polar Night

- The occurrence of DVM during the Polar Night is predictably controlled by latitude (i.e. light regime) and sea-ice cover
- This pattern is robust across the Arctic Ocean
- Prize moorings:
 - How do different sizes of zooplankton respond to seasonal changes in light?
 - How are these groups affected by the shading effects of sea-ice?



3. The effect of light on zooplankton vertical positioning

Given the different effects that light can have on zooplankton (predation, phytoplankton), how does it affect their vertical position in the water column?

Neil Banas, Laura Hobbs, Jon Cohen (Delaware), Øystein Varpe (UNIS)



UNIS

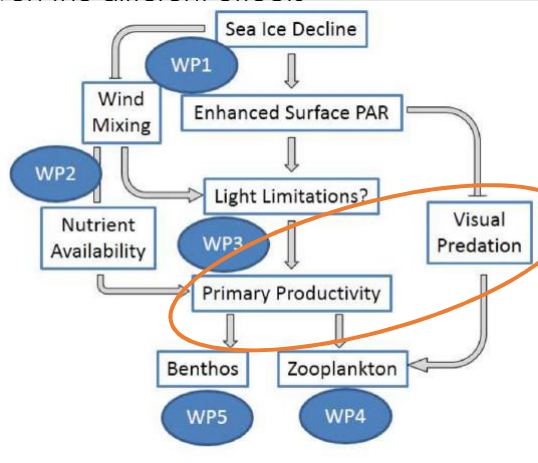
The University Centre in Svalbard



3. The effect of light on zooplankton vertical positioning

Neil Banas, Laura Hobbs, Jon Cohen
(Delaware), Øystein Varpe (UNIS)

Given the different effects
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SAMS



UNIS

The University Centre in Svalbard

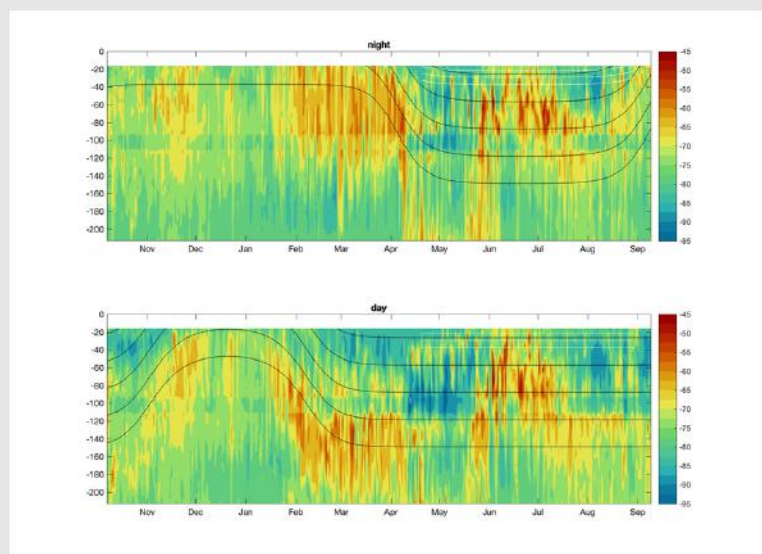


UNIVERSITY OF
DELAWARE®

Research Council
of Norway

3. The effect of light on zooplankton vertical positioning

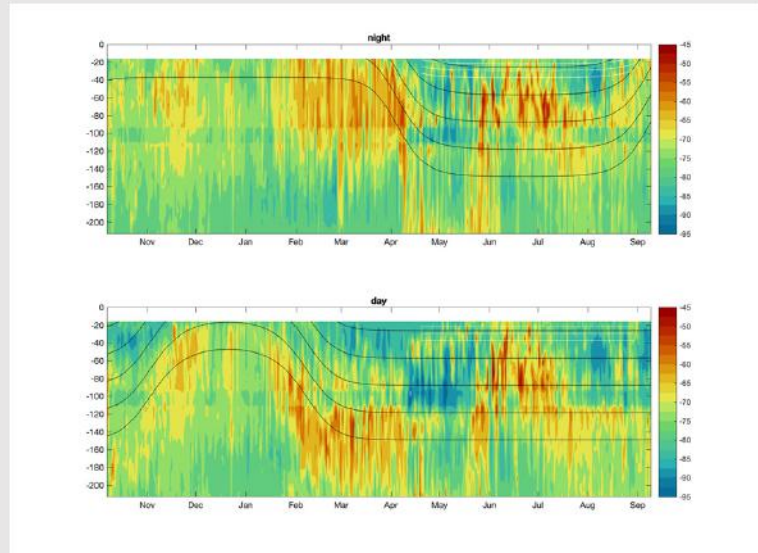
Given the different effects
that light can have on
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affect their vertical position
in the water column?



3. The effect of light on zooplankton vertical positioning

Given the different effects that light can have on zooplankton (predation, phytoplankton), how does it affect their vertical position in the water column?

Scattering populations (likely small zooplankton) follow specific isolums, consistently across diel and seasonal timescales



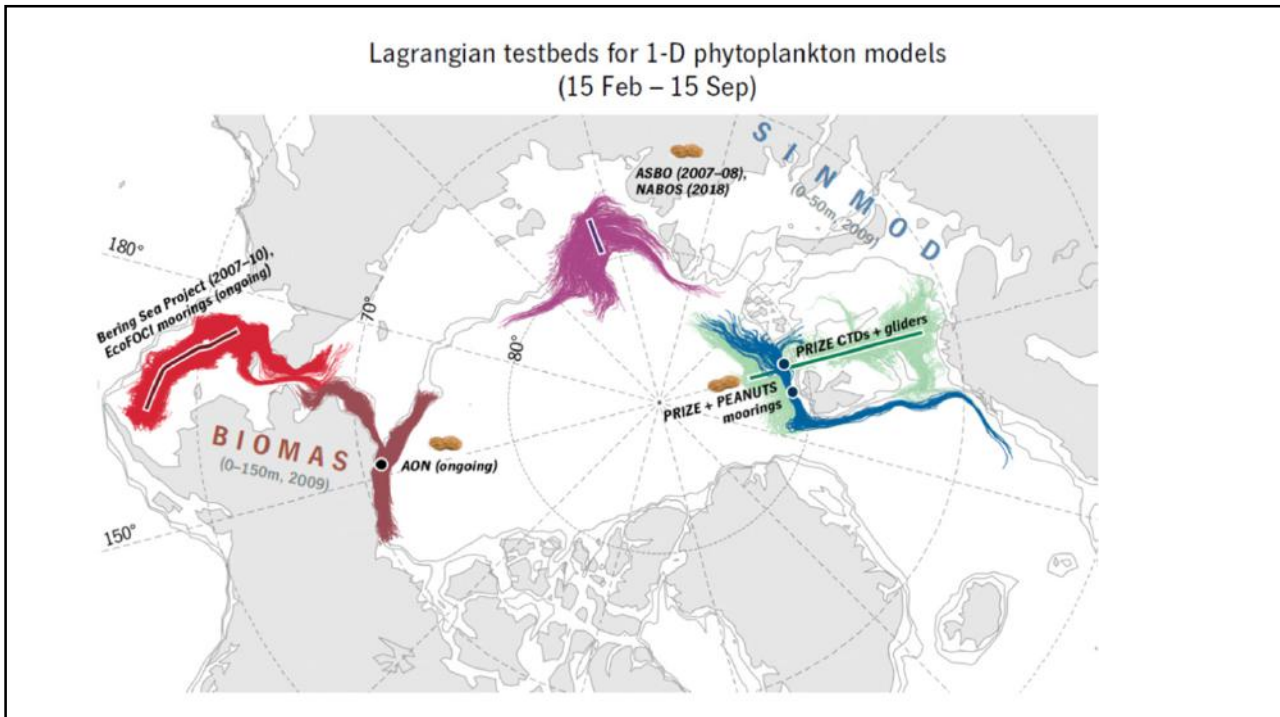
Phytoplankton modelling in Arctic PRIZE + PEANUTS

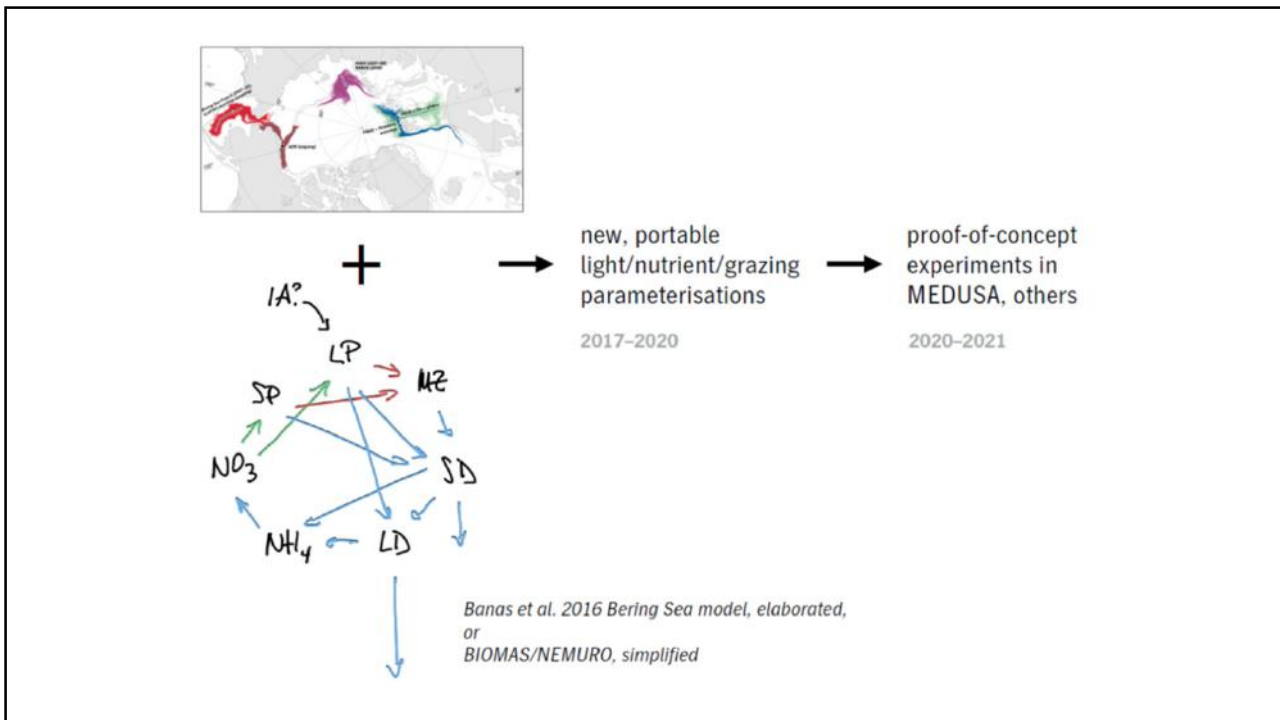
Banas, Slougher, PDRA TBN (Strathclyde)

<i>regional focus</i>	<i>physical model</i>	<i>plankton model</i>	
	NEMO 1/4°, 1/12°	MEDUSA	Yool et al. 2015
Chukchi Sea	BIOMAS	BIOMAS (NEMURO)	Zhang et al. 2015
Bering Sea	BIOMAS	Banas lab NPZD	Banas et al. 2016, Slougher et al. 2019
Barents Sea	SINMOD	SINMOD	Reigstad et al. 2011, Slagstad et al. 2011

<i>regional focus</i>	<i>physical model</i>	<i>plankton model</i>	
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Bering Sea	BIOMAS	Banas lab NPZD	Banas et al. 2016, Slaughter et al. 2019
Barents Sea	SINMOD	SINMOD	Reigstad et al. 2011, Slagstad et al. 2011

How do we translate **process insights** from one regional model study into a different model framework?





Contents lists available at ScienceDirect

Journal of Marine Systems

journal homepage: www.elsevier.com/locate/jmarsys

Seasonal variation in light response of polar phytoplankton

T.M. Sloughter^{a,*}, N.S. Banas^b, R.N. Sambrotto^b

^a Department of Mathematics & Statistics, University of Strathclyde, United Kingdom of Great Britain and Northern Ireland
^b Lamont-Doherty Earth Observatory, Columbia University, United States of America

First step, spring 2019

The Bering Sea phytoplankton community *decreases* its light sensitivity (α) in very dark, under-ice conditions; and a lit review suggests this may be quite general—on *seasonal* timescales (Sloughter et al. 2019).

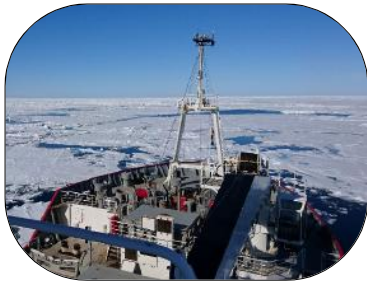
Current models don't include this. But it helps our Bering Sea model get bloom magnitude and timing right simultaneously.

What happens when we apply the Bering Sea model to the Barents Sea, with and without seasonal photoadaptation?

modelling PDRA position available
 2 years
 starting spr/summer 2019

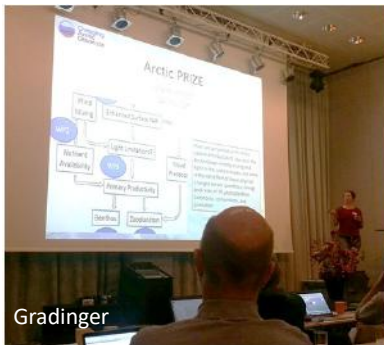
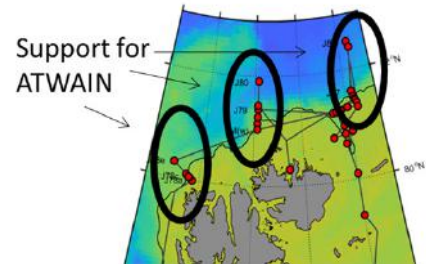
deadline 21 Jan

<http://tiny.cc/prize-peanuts-pdra>
 or contact
 Neil Banas, Strathclyde

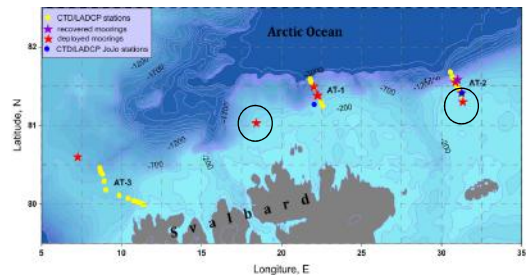


Future Plans

ChAOS 2019
 WP2: Henley/Braun
 Y2 Mooring Recovery



Gradinger





House of Commons
Environmental Audit Committee

The Changing Arctic

Twelfth Report of Session 2017-19

Report, together with formal minutes relating to the report

Ordered by the House of Commons
Environmental Audit Committee
The Changing Arctic Inquiry

Written Submissions by:

- Scottish Association for Marine Science (SAMS)
- Scottish Marine Institute
- Orkney
- RAF 115
- James Watson, an MSP (Scottish Labour)


Prepared by:

- Prof. Fido Carter (f.carter@stir.ac.uk)
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- Adjunct Professor of ST, The Arctic University of Norway
- Dr. Rowena Miller (rowena.miller@stir.ac.uk)
- Researcher Exchange and Communications Assistant
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- Senior Lecturer in Design Strategy, SAMS
- Professor Mark Triffitt (mark.triffitt@stir.ac.uk)
- Professor of Global Sustainability at SAMS
- Director of Scottish Alliance for Governance, Environment and Society (SAGES)
- Michelle Innes (m.innes@stir.ac.uk)
- Professor of Global Sustainability at SAMS
- Dr. Alan Watt (alan.watt@stir.ac.uk)
- Senior Lecturer in Marine Ecology, SAMS


Policy Engagement



Arctic Frontiers 2019
Practical International Cooperation for Marine Research: UK-Norway-Russia
Foreign & Commonwealth Office

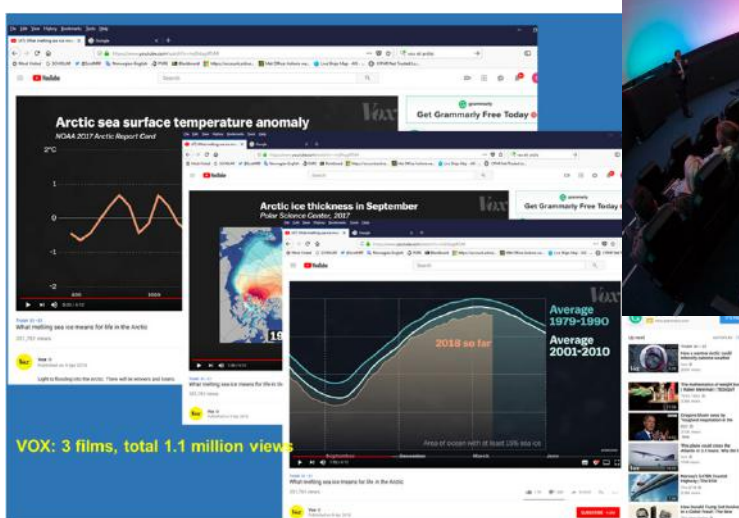


Scottish Government Arctic Strategy





Scotland's centre of expertise connecting climate change research and policy

Public Engagement



VOX: 3 films, total 1.1 million views





Thank you



Barbara Oliviera