Arctic PRoductivity in the seasonal Ice ZonE (Arctic PRIZE)

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Participating Institutes and PI/CoIs

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Arctic PRIZE will address a fundamental question in Arctic biology: "Will more light in an ice-free Arctic Ocean lead to more productivity?" Arctic PRIZE will conduct a programme of novel and coordinated physical, chemical and biological observations of the water column within the seasonal ice zone (SIZ) of the Barents Sea. Arctic PRIZE has a strong seasonal perspective and focuses on the critically important but under-sampled transition from polar winter into the post-bloom summer.

Overarching Question: "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 productivity (PP), phytoplankton taxonomic composition, and their pelagic and benthic consumers?" The framework for this question is illustrated in Fig 1.

Arctic PRIZE will combine detailed and innovative observations in one SIZ region with numerical experiments using a biophysical model ensemble (multiple models, multiple shelf regions) in order to identify principles that describe the net effect of competing changes brought about by sea-ice decline [Fig 1] across seasons, local spatial gradients, and regions. We will trace the impact of changes in light, mixing, and nutrient flux **(WP1, WP2)** through the phytoplankton **(WP3)** to zooplankton **(WP4)** and benthic **(WP5)** consumers. Making these links across trophic levels requires coordinated measurements and modelling focussed on several aspects of plankton physiology and ecology - phenology, plasticity in physiology and behaviour, the role of light-linked predation - which we will examine through innovative process studies and synthesize into scalable model parameterisations **(WPs 3-5)**.

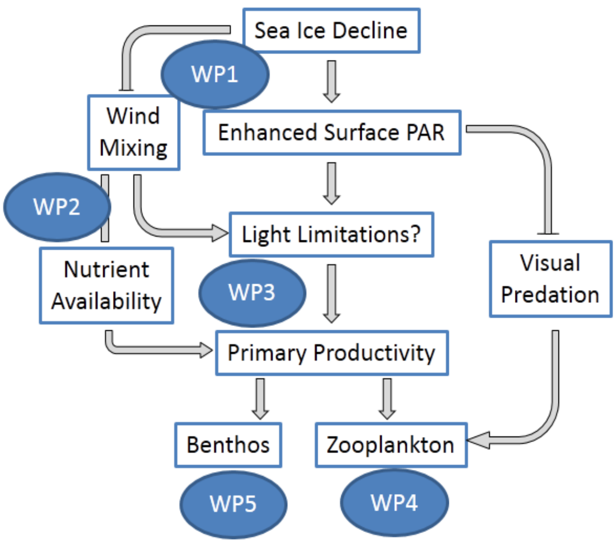

Fig 1: Key relationships that are driven by changing sea ice cover and the respective Arctic PRIZE work packages.

Arctic PRIZE will focus on the shelf area of the Barents Sea and the region to the north of Svalbard using the following techniques: **Seals** – these will be tagged each year with Fluorometry-Conductivity, Temperature, Depth - Satellite Relay Data Loggers (F-CTD-SRDL); **Gliders** – we will use Slocum gliders to record profiles of physical (T, S and O_2) and optical (chlorophyll and coloured dissolved organic matter (CDOM) fluorescence, backscattering and PAR) properties; **REMUS 600 AUV** – this will measure T, S, water velocity and chlorophyll fluorescence and incorporates a micro-structure sensing package; **Gavia AUV** – to be deployed during cruises to map benthic megafauna; **Moorings** - we will deploy two moorings on the shelf north of Svalbard in ~200 m water depth. These will be instrumented with physical (T, S and ADCP), biogeochemical (chlorophyll fluorescence and nitrate) and biological (acoustic zooplankton and fish profiler AZFP 38-125-200-455 kHz and; **Photomooring** - this autonomous bottom-mounted camera system will record long-term changes in benthic activity and near sea-bed dynamics.

Cruise Plan: *Summer 2017 (JCR)* primarily for trialling robotic systems, mooring deployments and limited supplementary sampling. Winter 2018 and Spring 2018 (Norwegian Ship), Summer 2018 (JCR) core Arctic PRIZE sampling including water column and benthos sampling, AUVs and glider deployments. The field program for Arctic PRIZE is heavily supported through partnerships with University of Tromsø, and Norwegian Polar Institute with further involvement with University Centre in Svalbard (UNIS) and Institute of Marine Research. Arctic PRIZE modelling work is in conjunction with partners at University of Washington, SINTEF, University of Rhode Island and UNIS.

Work Package 1: Cottier, Hwang, Inall, Boehme, McKee

Q1: How do the key physical parameters of mixing, stratification and light vary between open water and under ice and how do they evolve during the winter to summer transition?

Objective1.1: Compile a full suite of vertical profiles of temperature, salinity, bio-optical properties and radiometric data through the winter to summer transition across a SIZ.
O1.2: Measure the vertical turbulent fluxes across the pycnocline in open water and under varying sea ice conditions through winter to summer.
O1.3: Produce seasonal maps of PP using *in-situ* seal and glider-based observations informed by cruise data and combine these to interpret ocean colour remote sensing data for the region **(WP3)**.

Work Package 2: Henley, Davidson

Q2: How will nutrient supply, uptake and cycling respond to sea ice and ocean mixing changes in a warming Arctic?

Objective2.1: Relate variations in sea ice conditions and vertical mixing through the winter-spring transition to inorganic nutrient concentrations and fluxes and hence availability to spring-summer phytoplankton blooms.
O2.2: Relate the supply and relative availability of new and regenerated inorganic nutrients to their uptake by phytoplankton under contrasting sea ice and mixing conditions.
O2.3: Quantify the seasonal and spatial differences in the stoichiometry of dissolved and particulate organic nutrients in Arctic waters and relate them to changing sea ice and mixing conditions.

Work Package 3: Bouman, Banas, McKee, Davidson, Yool

Q3: How does pelagic phytoplankton production respond, in timing, magnitude, and taxonomic composition, to seasonal and spatial variation in nutrients and light?

Objective3.1: Determine the net effect on phytoplankton production and community composition of the two competing effects of increased exposure to wind mixing: increased nutrient supply **(WP2)** and decreased light **(WP1)**.
O3.2: Evaluate the extent to which patterns of Arctic phytoplankton production (magnitude and timing) are shaped by physiological plasticity in addition to the physical and chemical environment.
O3.3: Develop numerical schemes that capture these phytoplankton growth dynamics, and scale up from hindcasts of particular Atlantic and Pacific Arctic process studies to integration into existing large-scale models.

Work Package 4: Last, Cottier, Banas, Brierley, Yool

Q4: How are zooplankton migratory behaviours modified by vertical gradients of stratification, light, phytoplankton and predation?

Objective4.1: Determine how contrasting sea ice cover modifies the DVM behaviours of zooplankton community over an annual cycle.
O4.2: Quantify the vertical distribution of the zooplankton community in the MIZ across open water, partial and full ice cover in relation to the physical quantities of stratification and illumination.
O4.3: Test whether these observed patterns can be explained as an optimal balancing of prey ingestion and losses to predation.
O4.4: Develop a parameterisation for the emergent dependence of copepod ingestion rate with ice cover and light change and test its impact on future projections.

Work Package 5: Narayanaswamy, Last, McKee

Q5: How are variations in surface productivity reflected in spatial and seasonal temporal changes in benthic community composition?

Objective5.1: To detect spatial changes in benthic epifaunal community composition, moving between permanently ice-free to predominantly ice-covered regions.
O5.2: To resolve seasonal temporal changes in the benthic mobile faunal community in response to inputs (sympagic and pelagic) of organic material to the seafloor from ice-free to ice-covered periods.