3rd Science Meeting of the GreenEdge Consortium
May 24-26, 2017, Hotel 71, Québec, QC

Welcome and Introduction

Marie Helene Forget gave a quick overview of the objectives of the GreenEdge project and a review of the field work variables that were studied during the 2015 and 2016 Ice camps and aboard the 2016 Amundsen oceanographic cruise. She also gave a quick overview of the 7 work packages (Coordination and 6 science WP) as well as the list of the consortium member labs in France, Canada and USA.

Objectives of the 3rd science meeting are:

- share information about ongoing activities
- identify gaps and priorities (i.e. phytoplankton diversity)
- coordinate activities between labs
- update the publication plan established in December 2016
- discuss the special proposed GreenEdge session at Arctic Change December 2017,
- identify potential journals in which to publish a GreenEdge special issue

Flavienne Bruyant: Amundsen Leg 1 database

Flavienne thanked everybody for submitting data. A large quantity has arrived over the past week! Flavienne will ask Catherine Schmechtig to upload the data onto the site. Instructions were given for accessing the data. Some people have requested that their data remain protected. If you require access to the data, you will have to contact Joannie or Flavienne for the password.
Flavienne reminded everybody about how the data website is organized. GE participants are encouraged to use the data from the site rather than contacting the researcher directly. New versions of data are being uploaded regularly, so researchers should check the site often.
It is preferable to refer to NISKIN bottle number rather than depth. This will facilitate data comparison and utility.
Flavienne's ultimate goal is to create a massive dataset (as was done with Malina data).
Philippe Massicotte has provided data about wind speed, ice coverage history (March-July), which will be useful.

The fluorimeter used during the cruise required different cables, depending on the chlorophyll concentration. However, cables for 0-50 mg/L and 50+ are not calibrated the same manner. Therefore, no HPLC data for 50+ is available.
There is no fluorescence data in the bottle files. These will be uploaded in the coming weeks.

Flavienne will update the list of available data and encourages people to continue to send data to her.

Catherine Ribeiro
Catherine provided an overview of sampling at both the ice camp and on the Amundsen cruise. Different isolation treatments were employed on more than 1000 cultures. A new Ochraphyta species was identified. Microscopy and gene markers were used to characterize stains. All cultures have been sent for sequencing.
Presently, results are available for 532 isolates and 394 strains. Results for remainder will be available before the end of May. Next steps are to use gene markers with higher resolution to find diversity. This should be down over the summer (2017).

DNA/RNA extraction: 290 samples from Amundsen extracted at Banuyls, however, there was a problem with extraction method – Maxwell process didn't work – and samples from different size fractions were lost from transects 1 and 5. Therefore there is only DNA for transacts 1,2,3,5. Both RNA and DNA are available for transects 4,6,7.
DNA/RNA will be extracted from about 500 samples from the ice camp by September 2017 and the metabarcoding data should be ready by January 2018.

LOMIC: DNA from 60 samples from biodegradation samples 16S rRNA will be available by the end of May 2017. One hundred bacterial strains have been isolated from Amundsen cruise, 30 strains were identified by 16S rRNA sequencing, the rest will be available mid-June 2017.
12 samples are being analyzed for the determination of the proportion of bacteria infected by viruses.

Pierre Luc Grondin:
Pierre Luc explained the functioning of the IFCB and its use for sampling at the Ice camp (2015, 2016) on the 2016 Amundsen GE cruise. The IFCB is very useful for monitoring phytoplankton succession during the bloom. Snow melt is the main variable controlling bloom development.

All of the images have been put in Ecotaxa – PLG can provide people with access codes. The Ice camp data has been validated (including melt ponds) for both years, about 400K images (Ice camp 2015: ice 121, water 201; Ice camp 2016: ice 63, water 263). The Amundsen 2016 data has not been processed.

PLG described how he interprets the images. In the ice: 80-90% pennate diatoms in both years, whereas in water samples there are more centric diatoms. There is variability with depth in the water column, salinity and nutrients as the bloom evolves. There is also a variation in species over time and space.

Limitations and technical challenges related to the IFCB include the automatic identification of small cells, trade-offs between taxonomic resolution and time (need for better algorithms), the presence of dead/empty cells and the size spectrum sampled. The 150-micron mesh on IFCB may bias sampling. Perspectives for the future include studying the relationship between species and abiotic factors and comparing diversity to genomic data.

There was a difference in the production vs biomass at the ice camp 2015 vs 2016. Especially for ice algae. However, the ice algae bloom was late in 2015. Could grazing account for this difference?

Annick Bricaud: Pigments

Annick presented the phytoplankton and ice algae HPLC pigment distribution from the 2016 Ice camp. Chla in the ice peaks at the end of May (reaching 200mg/m3), while Chla in water shows 5 distinct periods: A) pre-bloom (dino, nano), B) 6 May -1st June: stable conditions,
C) beginning of activity, D) initiation of bloom, E) peak of bloom.
The photoprotection index in the ice rose to 0.4 in early July, but was always lower in the water column.
Fucoxanthin is an indicator of the presence of diatoms, and Chlc pigment levels distinguish pennate and centric diatoms. In ice cores, the pennate diatoms decrease with time, whereas there is an increase in centric diatoms with time. This was compared to IFCB data.
Chlb, an indicator of the presence of Chlorophytes, was present in ice cores throughout May, and showed highest levels in the water column during the initiation of the bloom.
Alloxanthins are indicators of Cryptophytes, some populations of which moved from the ice into the water. The presence of Nanoflagellates is indicated by 19'HF and 19'BF, whereas Dinoflagellates are associated with perifinin, which was highest at the beginning of the bloom.
Phaeopigments (indicative of grazing or other senescence) show levels of 10% in ice core, which is indicative of grazing. Levels in the water column are also rather high at the end of the bloom.
All analysed sample data available on the website, but there is still a need to compare 2015-2016 ice camp and Amundsen data. Comparisons should also be made with other types of measurements (IFCB, low cytometry, microscopy) to get a better picture.

Gabrielle Filteau et al Nutrients, PP and nitrogen cycling

Gabrielle presented the objectives, methodology, available data and preliminary results of the primary production and nitrogen cycling experiments conducted during the GreenEdge ice camps (2015, 2016) and Amundsen cruise (2016).
Primary production is usually limited by N limitation, new production is fueled by nutrient inputs from outside the eutrophic zone. Regenerated production is based on organic and inorganic nutrients that are recycled from organic matter in the eutrophic zone. The objectives of the GE experiments were to i) quantify primary production and N fluxes with an emphasis of N assimilation by microalgae and microbial N recycling and ii) evaluate the impacts of light availability (snow, sea ice, atmospheric conditions), water mass properties and nutrient availability on PP and N cycling.
The following were measured: Nitrate, Nitrite, Ammonium, Phosphate, Silicate, Particulate organic matter (COP, NOP, POP), dissolved organic matter (COD, NOD, POD), regeneration (NO3, NH4), sedimentation and exports of detrital matter (COP, NOP, POP) and DOM (COD, NOD, POD). For inorganic nutrients, concentrations were determined on fresh samples after filtering (ice camp and Amundsen). All samples were analysed within hours of sampling.

Incubation studies were used to assess primary production (NO3, NH4, N-Urea uptake), and nitrogen cycling (NH4 regeneration, nitrification, DON excretion). Other studies included i) effects of irradiance on N uptake, ii) accumulation of nutrient pools in phytoplankton (extraction of POC and TN) and iii) evaluation of impact of addition of N on PP (dual 13C/15N isotope technique).

Information about the currently available data was provided. The remaining data should be available in September 2017. Information about evolution of PAR and DIC concentrations is lacking for completion of P-E curves with 13C.

Preliminary results:

- water column nutrients decreased around day 160;
- active period in ice day 140-160;
- highest amount of nutrients in 0-1cm of ice core;
- accumulation of POC in the ice at the end of the ice-algae bloom;
- more productivity in the ice in 2015 vs 2016;
- more productivity in the water column in 2016 vs 2015;
- 60 mg/L/day at height of the bloom
- stations with high productivity have low nutrients concentrations in the surface water

Bernard Queguiner et al. Diatoms and the silica cycle (Amundsen)
The objectives of the studies were to i) quantify stocks and fluxes of Si in the particulate and dissolved phases, leading to a better understanding of the Si budget and ii) describe the diversity and contribution of diatoms to phytoplankton production (Si/C coupling).

BSi (biogenic silicate) were maximum at the ice edge for first few transects, and in open water for last transects:

- transects 100 and 200, BSi max (1.5 µmol L^{-1}), ρSi max (0.12 µmol L^{-1} d^{-1});
- transect 300 E-W, BSi max (2 µmol L^{-1}), ρSi max (0.19 µmol L^{-1} d^{-1});
- transect 400 E-W, BSi stocks (<0.5 µmol L^{-1}), ρSi values (<0.2 µmol L^{-1} d^{-1});
- transect 500 E-W, BSi max (2.1 µmol L^{-1}), ρSi max (0.15 µmol L^{-1} d^{-1}), extended towards the ice edge;
- transect 600 E-W, moderate BSi max (0.8 µmol L^{-1}), weak ρSi max (≤0.1 µmol L^{-1} d^{-1})
- for transect 700 E-W, moderate BSi maximum (0.8 µmol L^{-1}), very low residual ρSi values

Compared to other ecosystems, the Si production rate (ρSi) was very low. Diatom cell counts were variable between first few transect and last transects. There was a variability in the diatom diversity/community composition at the BSi maximum location for each transect, with a marked transition from pennate to centric diatoms. Eastern Baffin Bay exhibited the maximum Si production, where the surface concentration followed the shelf break. The 0-200 and 0-350 integrated BSi were associated with bathymetry. In general, Si production in Baffin Bay is relatively low (min 0.3, max 2.1mmol/m^{-2}/day), representing an oligotrophic situation. There was a temporal trend to an increase in resting spore formation as well as an increase in empty frustules (grazing by micro zooplankton, pathogens?). There may be a seasonal succession, with a replacement of *Fragilaria/Fragilariopsis*, by *Chaeteoceros*. There is also a transition from ice edge bloom to moderate bloom in open water.

The dissolution experiments failed to show shifts in isotopic ratios. This is indicative of a weak dilution in the euphoric zone, and is probably related to low temperatures. Dissolution experiments on sinking material were also inconclusive.

Work remaining:

- estimate Si budget, vertical H_4SiO_4 fluxes
- PDMPO analyses and imagery, refine taxonomy (SEM observation), identify of main actors in siliceous communities
- data treatment of enrichment and kinetics, limitation of diatom communities

Questions raised:

- are the diatoms/bloom more silicate or nitrate limited
- is the deepening of Chla subsurface maximum related to silicate maximum?

Remi Amiraux: Biodegradation of ice biota in the Arctic

A reduction in the duration and extent on seasonal ice cover, as predicted in recent models, should reduce primary production by ice algae in favour of that by phytoplankton. The objective of the study is to determine the i) source and the fate of the OM reaching the seafloor, ii) degradation processes involved and iii) efficiency of bacterial remineralization.

The following parameters were analysed to determine the source and fate of OM reaching the seafloor:

- photodegradation of algae and associated bacteria
- salinity stress experienced by bacteria in sea ice (adaptive response to high salinity-maintain fluidity of membrane)
- bacterial stress in sinking particulate organic matter
- bacterial stress in the underlying sediment (same value of salinity induced stress in sinking particles and sediment; OM reaching seafloor derived from ice biota under stress; CTI activity confirm bacterial community in poor physiological state)

Conclusions:

- sea-ice biota is the main contributor to sediment with high burial potential due to poor bacterial physiological state and high sinking rate, this can be extrapolated to the entire Arctic;

GE 2016 cruise provided the lowest values of sea-ice OM input – is this an indication of a switch to primary producers under a warmer Arctic Ocean and that the CO2 sink potential of AO is decreasing?

Where did the salinity stress occur within the sea-ice?

CTI and 10S-DOX activity are present in the sea-ice, but they are not correlated. The values are lower than those of sinking particles. Could this be due to leaching? *Pseudoaltermonas* is the most abundant genus in common between ice samples and sediment traps at GE 2015 – known to exhibit stress signal

Connie Lovejoy warned that we have to be careful not to compare the Beaufort Sea and Baffin Bay ecosystems, due to different composition of species.

Richard Sempéré – MIO chemistry group (organic carbon dynamics, sugars) - given by MHF
In the absence of the authors, this presentation was given by Marie Hélène Forget. Sea-ice cores and sea water (ice camp 2015, 2016, Amundsen 2016) and aerosols (ice camp 2016 and Amundsen 2016) were sampled to study carbon and sugar dynamics and the distribution of sugars in aerosols. Total organic carbon (TOC) data are available for the ice camp 2015 and for the sea ice from ice camp 2016. Dissolved organic carbon (DOC) data are available for seawater from the ice camp and for the 2016 oceanographic cruise. 2016 TOC data from the cruise, sediment trap data from the ice camp and aerosol data both the ice camp and cruise are being analysed and should be available soon.

Results:
Ice camp 2015

- Ice core samples diluted in sea water, which caused slight contamination;
- High TOC values (430-550 μMC) were observed around June 15, and are probably due to ice break up and its subsequent entry into the water column;
- Monosaccharides < polysaccharides, which is typical of oceanic systems;
- TOC: high OC in 0-3 cm of ice core;
- TCHO: high sugar content in 0-3 cm of core

Ice camp 2016

- Ice core samples were not diluted;
- Monosaccharides < polysaccharides, which is typical of oceanic systems;
- Total sugars accounted for 18-45% of DOC;
- Sugar and DOC values were not always correlated in time and space;
- TOC: high OC in 0-3 cm of ice core;
- TCHO: good agreement with TOC

Four papers will be produced by the MIO chemistry team:

- Ice camp 2015/2016 TOC, DOC sugars: Panagiotopoulos et al.
- Aerosols (ice camp+ cruise) diacids/sugars: Sempéré et al.
- Sugars in sediment traps (ice camp 2015/2016): in collaboration with other colleagues:
- Cruise data (DOC, sugars) – at a later date

Marti Gali-Tapias et al. : DMS
The processes associated with DMS formation were explained. There has been a renewed interest in studying Arctic DMS due to advancement in measurement technology (i.e. NetCARE). DMS production was studied from ephemeral sources (ice, under ice, melt ponds, dome water, snow by Margaux Gourdal at the 2015 GE icecamp. Arctic Ocean DMS emission North of 70^{o} lat has more than doubled since early 2000s. Low emission from ice-free seasonal ice zone has been remote sensing data, but the marginal ice zone remained little studied before the GreenEdge 2016 oceanographic cruise.

Preliminary data related to the distribution of DMS concentrations during the GE cruise were presented:

- Transect 400: Low surface DMS (<3nM) except for Stn 400 (20nM);
- Transect 500: very high surface DMS (10-20 nM), decreasing with depth, sharp SCM at Stn 512;
- Transect 600: moderate to high surface DMS (2-11 nM), sharp SCM at Stn 615;
- Transect 700: high surface DMS (4-11 nM), decreasing with depth;

High DMS concentration is related to phaeocystis abundance as estimated with IFCB. Mechanisms for the removal of DMS are photolysis, ventilation and bacteria, whereas phytoplankton and bacteria contribute to DMS production. Light drives net DMS production. Given that there is more DMS in open water and ice edge than under ice conditions, light is a driving factor
Future work includes a complete DMSPt analysis and the factors controlling DMS and DMSP distribution/flux:

- Physical: wind, spectral irradiance, mixed layer depth, water masses;
- Photochemical: CDOM, nitrate, spectral irradiance;
- Biological control: phytoplankton – IFCB, flow cytometry, pigments, photoacclimation; heterotrophic bacteria 16S-rRNA, zooplankton, spatiotemporal bloom dynamics

Could the SCM peaks result from decaying Phaeocystis?

Lisa Matthes: Spectral light transmission, ice camp 2015, 2016
An outline of the measurements taken during the two ice camp campaigns was provided.

Ice camp 2015:

- Irradiance profile from L-arm and related measurements (downwelling, upwelling, spectral irradiance)
- Ice cores: particulate absorption(a_p), pigment concentration (HPLC)
- Surface measurements: incident radiation, snow depth, ice thickness
- publication planned: bio-optical characterization of snow covered ice in Baffin Bay
- multiple scattering in the ice matrix;
- ice algae biomass and snow had a significant effect on the optical depth in the PAR range;

- the spectral distribution and magnitude of the measured inherent Chla specific absorption coefficient did not match with the estimated apparent algal biomass attenuation coefficient;
- ice algae were found to be concentrated in the bottommost millimeters instead of equally distributed in the bottom 3 cm, which increases algal absorption
- After concentration and inclusion of backscattering coefficient to initially measured $a_p^*(\lambda)$ curve, the discrepancy between the modeled attenuation coefficient and the spectral Chla a specific absorption coefficient was minimal.

Ice camp 2016:

- Studied transition from snow cover (> 30cm) to bare ice and melt ponds (∅ 5 cm);
- L-arm: 10 vertical profiles (0-20 m depth); downwelling, upwelling, spectral irradiance;
- ROV: 39 vertical profiles (0 -50 m), 13 horizontal transects (130 m length 2 & 4 m depth; (Spectral downwelling (planar) irradiance, Downwelling radiance, salinity, temperature, sonar and video footage of ice bottom)
- Surface: incident radiation, snow depth, melt ponds, bare ice, ice thickness, aerial photos with drone;
- 3 publications planned
    1. Monitor and classify the increase in spectral light transmission through first year ice with the change in surface properties and sea ice thickness over the spring melt progression **(**ROV dataset 2016)
    2. Describe the variability in the apparent optical properties and the resulting heterogeneity in the propagation of photosynthetic active radiation in the upper water column from a thick snow cover to a mixture of bare ice and melt ponds (L-arm dataset 2015 & 2016)
    3. Estimate spatial and temporal variability of ice algae biomass via spectral transmittance measurements (ROV dataset 2016, Spectral light measurements at ice algae sampling sites 2015 & 2016; Statistical analysis: NDI, EOF)

THURSDAY May 25

Dany Dumont/Philippe Massicotte et al: Upper ocean physics of Baffin Bay MIZ
Background paper – physical context in which the PSB observed during GE with an emphasis on air-ocean fluxes and upper ocean dynamics. The presence of ice dictates frontal dynamics. Primary production is large in coastal zones, near topographical features and ice edges.

Data collected during GreenEdge 2016 field season:

- CTD
- SCAMP
- MVP
- Gliders
- Floats,

- To come:
- L-ADCP
- 360 cameras – not too interesting
- Remote sensing

The presence of icebergs near stations has to be taken into consideration– create polynyas, which are good for sampling, but may create biases

Preliminary Scamp data, collected by Caroline Sevigny and Anda Vladoiu, was presented. It is a lot more complete than that collected on previous Arctic missions

S_ADCP data for transects 100 and 300 are available. However, there are no data for transect 200). There is a large variability during the day and the tidal signal and velocity are visible. Data will be compared with that from L-ADCP

MVP data appear very good, showing front and other tropic structure (large eddies). Need to be validated with CTD data. Data from transects 100, 200 and 300 seem to be OK- intrusions, entrainment, detrainment, indication of mesoscale and sub mesoscale circulation –

Remote sensing:

- Sentinel-1 and -2, icebergs, ice features, ice drift
- MODIS (Aqua & Terra): mean ice drift, shape of ice edge
- AMSR-E: ice concentration
- SST – only coarse data available, higher resolution data has potential for detecting mesoscale and submesoscale features as well as confirm water column observations.

Wave climate was less than optimum – for a researcher who wants to study effect of waves on ice!!

Marcel Babin et al.: Profiling ARGO floats
Four floats were deployed from the Amundsen on July 9, 2016 and provided profiles every day until mid-October. After which, they began transmitting every three days. Currently, the floats are still below the ice but will surface and start profiling on a daily basis on June 1, they have been parked at 1000m all winter.
All of the floats are equipped with CTD, radiometer with OCR wavelengths, ECO, O2 optode, and a SUNA (nitrates). In addition, one float included an optical ice detector developed by the Takuvik team.

Three of the floats followed the shelf edge, it is likely that these floats are working in the same water mass. The forth float encountered a different water mass and got trapped in eddies and went in circles.

Salinity data was similar for the three floats. There was a mixing event near the end of the season, probably driven by wind. The mixed layer deepened in October. The depth (thickness) of the ML is about 40m

Irradiance is inversely related to the depth at which light must penetrate to reach certain number of photons

Maximum temperature was recorded at the beginning of September, then cooled due to wind-induced mixing.

The isolume is driven by incident radiation and was equal to 0.415 mol photons per day. It describes the DCM. Subsurface Chla, as estimated by fluorescence, is present throughout the season and it goes up in the fall, following the isolume. When looking at the particles, the bloom is found closer to the surface in July.

Xiaogang Xing: Growth rate modelling with Bio-Argo data
Two models for modelling growth rate were presented. GammaT (for temperature), GammaN (for nutrients) and GammaLight variability were presented and the computed growth rate for model 1.

- Triplets did not work well on the two floats with SUNA
- Lack of resolution of Nitrate observation
- Nitrate observation has some difficulties in Quality Control
- $Gamma_{N-T}$ from Behrenfeld's modelling has the "saturation" issue
- Neither Growth Rate could match the time series of backscattering or chlorophyll-a very well.

System not a steady state, nutrient concentration has proven to not be a good metric for growth rate, particularly during bloom. Backscattering may be a better measure. Phytoplankton and microbial carbon should be considered in the model.

Guislain Becu et al.: Marine Optics
A summary of the sampling conducted during the ice camps and oceanographic campaigns was provided as well as the current status of the data processing and data availability. Guislain acknowledged the long list of people that operated instruments and/or provided optical data.

Light profiles: (good) COPS data

- 386 profiles, 108 stations
  - ice camp 2015: 173 profiles/38 days (high snow and low snow sites)
  - ice camp 2016: 74 profiles/24 days
  - Amundsen 2016 open water: 102 profiles/35 stations
  - Amundsen 2106 ice floe: 36 profiles/11 stations
- Full cleaning and quality control finished (removal of useless data)
- Monitoring of dark currents to spot drift
- Monitoring cross comparison of instrument data

- Available COPS data:
    - Downwelling and upwelling irradiance (resolution at top of water column =1cm
    - Computed PAR profiles, daily PAR values

- PAR (at sea and ice surface)
    - *In situ* PAR times series
        - ice camp 2015 - pyranometer,
        - ice camp 2016, Amundsen - PAR sensor
    - Data gaps 22/40days in 2015; 6/36 in 2016)
    - Tools: satellite data + atmospheric radiative transfer model
        - SBDART plane parallel radiative transfer model, comparison between model and *insitu* PAR overall works well, except when there's fog.
        - 5D precomputed look-up tables
        - weighted mean of cloudless and cloud covered fraction
    - Processed data will be available on the site next week – in Excel or normal ODV/Tidy R format
    - Daily PAR: 1st choice continuous in situ PAR, 2nd Choice satellite/RT model, 3rd choice C-OPS

- Future work
    - Estimate mean PAR profiles under the ice,
    - Correct PAR estimation with average cosines (we do not measure scalar irradiances).

Atsushi Matsuoka et al.: Light absorption properties of particles and CDOM, icecamp 2015, 2016

Chlorophyll-specific phytoplankton absorption coefficient, $a^*\phi(\lambda)$, is a key factor for:

- Estimating primary productivity
- Examining physiological condition of phytoplankton

CDOM absorption plays role in biogeochemical processes:

- Provides information about sources/processes of organic matter
- Produces labile C, N, P through photochemical processes
- Reduces light penetrating into the water column
- Stores heat

The objectives of the study were to examine the variability in particulate and CDOM absorption properties throughout the spring bloom period.

Sampling:

2015 ice camp:

- $a_p(\lambda)$ and $a_{CDOM}(\lambda)$ in ice core (0-1cm, 0-3 cm; 3-10cm in LS and HS sites) and water column (1.5m)

2016 ice camp:

- $a_p(\lambda)$, $a_{NAP}(\lambda)$, $a\phi(\lambda)$, and $a_{CDOM}(\lambda)$ in ice core (0-1cm, 0-3 cm; 3-10cm in LS and HS sites) and water column (6 depths, + deep cast)

$a\phi(\lambda)$+ $a_p(\lambda)$- $a_{NAP}(\lambda)$,

Results:

- 2015 $a_p(\lambda)$ data looks good for both ice core and water column,
- Variability in $a_p(\lambda)$ over time- more variability in ice core 0-3 (up until jday 160), after 160 (2016), ice melts, variability is in water column.
- In general, majority of $a_p(\lambda)$ and $a_\phi(\lambda)$ spectra for water column and sea ice samples are acceptable within the visible spectral domain (400 – 700 nm).
- Relatively high scatter around regression line for $a_p(\lambda)$ versus Chla at 443nm was observed for both GE2015 and GE2016 ice camp data, bias around 670nm, will have to account for this
- Spring bloom was well captured in $a_p(\lambda)$ values, but not in $a_{CDOM}(\lambda)$ values.

Further work:

- Data (V1) will be available on database by June 2
- Numerical decomposition method (Zhang & Stramski 2014) for $a_p(\lambda)$ spectra will be evaluated using 2016 data
- Combined dataset will be interpreted together with environmental data
- Results will be compared to those of SUBICE 2014

Annick Bricaud et al.: Light absorption properties of particles and phytoplankton in Baffin Bay (2016 Amundsen cruise)

The objectives of the study were presented:

- Parametrization of IOPs for study area – analysis of bio-optical anomalies for Arctic Ocean and development of a regional bio-optical model;
- Estimation of photosynthetic parameters and primary production (P vs E);
- Estimation of variable fluorescence parameters (FLASH)

Sampling:

- 304 water samples (10 depths / profile);
- 9 ice core (0-3 or 3-10 cm);
- 43 samples for FLASH
- Quality controlled data available in GE database

Preliminary results:

- Absorption maxima (in methanol) 19'HF (448, 470nm) and chl-c3 (457, 590nm)
- Tight relationship between a_p (443) and Tchl*a* concentrations at all depths – average relationship close to that derived by Matsuoka et al. 2014 and Bricaud et al. 1998 – preliminary conclusions on 40% of samples
- a_{nap} (443) increases with Tchl*a* concentration, high scatter
- (a_{nap}/a_p) (443) decreases with increasing Tchl*a* concentration
- (a_{nap}/a_p) (443) varies between 5-25% in surface layer, increases to 100% in deep layer
- Tight relationship between a_{phy} (443) and Tchl*a* concentration – similar to Matsuoka et al. 2014 (Arctic waters), but contrary to Bricaud et al. 1998 (Temperate/tropical waters) – differences may be due to differences in pigment composition rather than differences in average cell size
- In clear waters: for a given Tchl*a* concentration, lower a_{phy} values in the Arctic, but the effect on a_p values is cancelled out by larger a_{nap} values
- The a_{phy}(676) vs. Tchl*a* concentration relationship is very close to the relationship for temperate/tropical waters (Bricaud et al. 1998)
- The a_{phy}(443) vs Tchl*a* concentration
- Absorption coefficients for ice algae are in good agreement with relationships for the water column (with Tchl*a* concentrations up to 100 mg m^{-3})

Future work:

- Analysis of the a_p and a_{CDOM} datasets (cruise and ice camps) with respect to environmental data
- Analysis of the sources of bio-optical anomalies in Baffin Bay
- Examine the potential of hyperspectral IOPs/AOPs to distinguish some PFTs (*e.g.*, *Phaeocystis vs.* Diatoms)
- Use of a_{phy} spectra for the FLASH experiments and P *vs.* E curves

Laurent Memery

The Work Package 6 objectives from the ANR funding demand were outlined.

- Pan Arctic (NEMO/LIM2/PISCES 1D / 4° 1960-2015
    - 1-D modelling NEMO/LIM2/PISCES: OK
    - Ready to start with ice camp series (Gaetan Olivier, PhD student)
- 3-D physics modelling (1/ 4 NEMO/LIM2)
    - Marie Noelle Houssais is working on mixed layer dynamics (LOCEAN)
- 3-D PISCES: there was a change of computing centre last year and subsequent problems with compatibility (versions 3.2 vs 3.6). This should be sorted out by mid June, otherwise will use NEMO 3.6. A basic run will be completed by the fall.
- 3-D pan Arctic data sets (V. Le Fouest)

The following points arose as a result of discussions at the GreenEdge meeting in Nice in December 2016:

- Phytoplankton
  - PISCES species: diatoms vs small
  - What to do about Phaeocystis: we can handle this, although most work has been done in Southern Ocean or North Sea
  - Coccolithophorids: nobody knows how to model – need physiologists to supply info
  - Links with genomics – HPLC –Imagery
  - Problem of the dark period return to threshold values
- Zooplankton behavior
  - PISCES: micro/meso zooplankton without behavior: winter diapause, vertical migration
- Export (Remi Amiraux): sea ice biology?

Modelling results will be ready for next GE meeting (early 2018) should provide a more integrated vision.
A question was raised about the impact of nutrient stoichiometry on the Phaeocystis bloom.

Blanche Saint Béat: Baffin Bay functioning – from in situ sampling to modelling
Is the ecosystem able to sustain Inuit needs despite climate change? Four components are involved in food security issues: quality, access, quantity and preferences. This study focuses on the quantity of food available. Inputs of in situ data on living components of the marine ecosystem will be fed into the holistic ecosystem model. Outputs will address indigenous issues. Both descriptive (static snapshot of carbon transfer in the system) and predictive (dynamic, evolution of carbon fluxes over time) methods are employed using Ecopath, which focuses on fishing and integration of stocks and linear inverse modelling (LIM), which focuses on carbon flow. Four compartments are identified in Arctic ecosystems: top predators, fish, zooplankton and primary producers. GreenEdge will concentrate on the planktonic component of this ecosystem especially on primary producers and their fate. To this end, the LIM, which takes into account compartments from primary producers (sea ice algae and phytoplankton) to Arctic cod larvae will be coupled with an ECOPATH model. The rest of the food web will be integrated in an ECOPATH model.

To summarize the approach, LIM models output will be integrated into an ECOPATH model, the parameters from which will be used for ECOSIM simulations to look at time series of stock and flows. This approach will be applied to two research areas in Baffin Bay

Tiff-Annie Kenny and Mélanie Lemire: Qikiqtarjuaq climate change and food security project
Tiff-Annie and Mélanie plan to go to Qikiqtarjuaq in June 2017 to consult with the community and refine the objectives of the study. The aim of the project is to assess how climate-mediated changes in the abundance and access to key marine species may impact food security, nutrition, and, health in Inuit communities and to support Inuit organizations in the co-development of evidenced-based (scientific, local, and traditional knowledge) adaptation

strategies to promote food security and sustainable marine harvests in the face of global environmental changes.

The core idea is that human health is connected to food availability for both nutrition and cultural values. Ecosystem modelling (Blanche et Fred) will link the availability of local species and traditional foods to human health in the community (Lemire and Kenny)

1. Develop a conceptual model linking changes in marine environments to food security and human health
2. Investigate the potential impact of changes to species abundance and access on Inuit diets/nutrition, and health
3. Work collaboratively with community representatives to define scenarios of hypothetical futures of marine social–ecological change

Harvest and diet data are already available from Broughton Island (1988-89) and the Inuit Health Study of Qikiqtaaluk/Baffin Bay region (2007-2008). The Broughton Island study showed that ringed seal meat was a very important food source – this may have changed. Regional Inuit study (2007-2008) found caribou to be very important, but it may now be less available due to hunting restrictions. Has Arctic char or something else replaced caribou. The top sources of nutrients in Qikiqtarjuaq during the 2007-2008 study were ringed seals (iron), caribou, char, and beluga. Certain times of the year may be problematic due to availability of country food. Diet studies show the proportion of the different nutrients and protein sources to the Qikiqtarjuaq community as well as the importance of country food to the overall diet Participatory modelling is the process of incorporating stakeholders including the public and decision-makers into modeling process. Production of a model that can then be related to the conventional model.

Future work:

- Consult with the community, working with the project partners (like public health), identify the critical questions to be addressed by the models, define the temporal and spatial scale, develop a complete conceptual representation, future scenarios including outcome and intervention

The community is more interested in short term, researchers are more interested in longer term.

Atsushi Matsuoka asked about Mercury and other contaminants from permafrost thaw, but they are not being studied by team

Francis Dufour et al.: Selenium distribution and speciation within Arctic ecosystems: a multi-marker approach

Selenium is essential for human health and is a very important element in the Arctic. Inuit have a high Se concentration in their blood, 400μg /L, twice the Canadian average. Selenium interacts with methylmercury and can cause developmental problems in children.

Important species from pelagic (ice algae, phytoplankton, zooplankton, cod, char, sculpin, seal) and benthic (ice algae, phytoplankton, clams, walrus) food webs were sampled and evaluated using a multimarker approach (fatty acid trophic markers, highly branched isoprenoids, stable isotopes)

During the GE 2016 ice camp, FATM were quantified to determine ratios between water column and ice samples. There was a high ratio of Diatoms in ice compared to water. FATM are useful as dietary tracers to obtain relative contribution of food sources in diet.

Highly branched isoprenoids were studied in 2 species of clams. In mid April (initiation of bloom) IP 25 concentrations begins to increase as ice algae falls to the benthos.

The 15N and 13C content in samples of clams, zooplankton, phytoplankton and ice algae were compared. The 13C signatures of the two pools of primary producers can be distinguished. Results from stable isotope show walruses diet comes mainly from ice algae, other marine mammals show more balance diets. Zooplankton diet comes mainly from the phytoplankton sources.

Selenium and Selenoneine concentrations differed among food web components and were higher in walrus and clams than in pelagic species, indicating that there is a different contribution from primary producers.

Next:

- Comparison with Philippe Archambault's results showing different food contributions in *Mia truncate*
- Try to distinguish clam feeding directly on fresh phyto/ice algae, vs fecal pellets
- Link high concentrations of Se and Selenoneine in Inuit blood to diet component: walrus, clams

Julie Sansoulet et al. : Workpackage 7

Interviews were conducted in Qikiqtarjuaq (8) and at a hunting camp in 2016, and in Pangnirtung (8) and Clyde River (8) in 2017. The topics ranged from hunting structure, diet, and food security to climate change and invasive species. Information will be validated by community before being diffused

A 13-minute documentary containing excerpts of the interviews was presented. Hunting practices have changes. Historically, people spent more time on the land, and marked the seasons by the availability of different food species. The majority of time is now spent in fixed communities and fewer people hunt. Good hunters/fishers share their catch with the community.

Simon Lambert Girard et al.: Direct measurements of the radiance distribution during the spring transition

Improved modelling of radiative transfer with snow, sea ice and the upper water column is required to better understand energy deposition and primary production in ice covered oceans. The basic requirement for this—and the focus of many former studies—are the measurements of spectral surface albedo and transmittance for the various ice types and surface conditions present. However due to the variegated nature of sea ice, an improved understanding of the seasonal evolution of radiative interactions necessitates measurements that are set in a spatial context and conducted over time. In addition to irradiance information, measurements of the radiance angular distribution are needed to facilitate the inversion of inherent optical properties and sea ice structural properties. The design of the experiment allowed data to be gathered along four dimensions: space (40-150 m horizontal transmittance transects and 25 m vertical profiles under the sea ice), time (from dry snow to melt pond and bloom seasons), spectral (6 bands across the visible region) and angular (downwelling radiance distribution). Relationships between these dimensions and e.g. ice/water inherent optical properties, ice/water chlorophyll-a concentrations, sea ice surface conditions, sea ice thickness and salinity are discussed.

Atsushi Matsuoka et al.: Atmospheric correction schemes in icy waters – evaluation using 3D radiative transfer simulations (3DMCPOL)

The objectives of the GreenEdge project are to:

- Characterize and model the bio-optical properties of marine constituents during the phytoplankton spring bloom;
- Examine the contamination of water-leaving radiance fields due to sea ice;
- Monitor snow-ice system: observations and simulations;
- Examine the temporal and geographical evolution of the phytoplankton dynamics of the Arctic Ocean using satellite ocean colour data.

The present study aims to examine the performance of existing atmospheric correction algorithms for icy waters using a 3D radiative transfer model. After a brief explanation of the path of light in seawater and the issue of contamination of ocean colour data due to the presence of sea ice, the 3DMCPOL atmospheric correction model and POLYMER algorithm were presented. The problem of the black pixel assumption (no reflectance coming from the ocean) in the coastal waters and ice-infested Arctic ocean was also introduced. The NASA standard algorithm is based on Black Pixel with the added input that coastal waters are not black, due to backscattering. The POLYMER (POLYnomial based algorithm applied to MERIS) incorporates wind atmosphere and oceanic segments of formula.

Simulations using 3DMCPOL, NASA and POLYMER with and without sun glint and white caps were carried out. Performance of the atmospheric correction algorithms depends on the geometry of the sensor. In general, NASA STD worked best, results from POLYMER were more variable than 3DMCPOL and NASA. A varying BRDF has been implemented in the 3DMCPOL model (sea ice and sea water).

Perspectives:

- Exact POLYMER code needs to be used to compare if the same result is obtained;
- An appropriate optimization method needs to be chosen;
- Best angular pattern need to be examine to minimize the adjacency effect

Laurent Oziel et al.: – time series in remote sensing

The objective of the GreenEdge team is to produce an Arctic-adapted, homogeneous, consistent time-series from 1979 to present time by merging CZCS with modern sensors to study trends in PP. This involves using CZCS (1979-86), SEAWIS (1998-2010), MODIS (2002-2015), VIIRS (2012-2017). CZCS computation provides challenges due to the limited number of wavebands available.

Approach:

- Process all missions using CZCS AC-approach (i.e. with the old iterative atmospheric correction) from L1 to L3;
- Derive chlorophyll-*a* and primary production algorithms and assess their qualities
- Analyze trends, phenological changes.

SEAWIFS:

- Small differences between $Rrs_{CZCS\text{-}like}$ and $Rrs_{Standard}$
- Discrepancies in the near-IR wavelength Rrs_{670} are attributed to the CZCS-like atmospheric correction iteration scheme
- 670 band not used to asses Chla

Chla algorithms:

- Differences between $[\mathrm{Chl}a]^{OC4\text{-}OC3}$ standard **vs.** CZCS-like algorithms remain small.
- $[\mathrm{Chla}]_{CZCS\text{-}like}$ less than $[\mathrm{Chla}]_{standard}$ especially when concentrations are high.

Primary production validation:

$PP_{TAKUVIK}$ is an Arctic-adapted Chla based model configured with a homogeneous profile. It performs well when compared with in situ data.

Data was very sparse for the entire CZCS mission, particularly in the Russian Seas., largely due to sea ice extent. Data was binned into large pixels (28km) and derived every 8 days and 30 days to increase data availability.

For the SEAWIFS period, there was good data coverage in the Barents Sea and the Greenland-Norwegian Sea. Both areas showed a significant increase in PP over the 13-yr period. For most wavebands, the standard and CZCS-like reprocessing of SeaWiFS data agrees well, with the exception red wavebands. The objective is to use a QAA algorithm to look at Chla and CDOM variation between the 1970s and now.

What does this mean in the context of GreenEdge?

- Increase our understanding on long-term trends in the Arctic by defining the baseline of the ecosystem in the late 70's
- Put new results from 2015 & 2016 field campaigns into context, especially for Baffin Bay

Ongoing work:

- MODIS in process…, next step VIIRS
- Assess impact of yellow substances on Chla and PP retrieval

Jacques Girardeau et al: Glacio-marine sedimentation in Trinity fjord, Ellesmere Island: processes and recent history

The GreenEdge PALEO group has concentrated its work in NARES Strait, the main conduit of nutrient-rich Arctic water to the Northern sector of Baffin Bay. On a paleo perspective, it is a fascinating area where the marine and continental ices were subjected to spectacular changes in recent times (post-glacial a). In view of GreenEdge overall scientific questions, the present and past hydrological and environmental conditions in this Arctic gateway are keys to understanding present and past hydrological and productivity changes down-stream in the NOW as well as more generally in Baffin Bay. This transfer is highly dependent on i) development (or not) of blocking ice-arches in modern times and recent past and ii) melting of grounded continental ice after the last glacial period.

The CASQ corer on the Amundsen was very efficient for recovering the sediment which accumulated in front of the Trinity glacier margin. The material is well stratified, with limited horizons of coarse grained material. The 8m core is currently being analysed in Bordeaux using an x-ray imagery system (facies and sedimentary structures) and an x-ray fluorescence corescanner (elemental geochemistry). These devices will help determine the origins of the lithic material and relative contributions of lithic and biogenic materials. X Ray imaging and fluorescence analyses are particularly efficient in unravelling key-sedimentary processes and paleoclimate/paleocirculation changes in glacierproximal settings. The structure and inorganic geochemistry of post-glacial laminated units might provide critical information on the melting history of nearby ice-sheets.

Future work on Trinity core:

- Improve chronological framework, particularly within the bottom laminated unit (summer 2017);
- Mineralogical analyses (confirmation of sources of lithic material): ISMER/UQAR (spring 2018)
- Thin sections within the bottom laminated unit (microscope investigation of sediment structure): EPOC (fall 2017)

Eleanor Georgiadis et al.: Holocene paleo-productivity and paleo-sea ice in Nares Strait from benthic foraminifera and IP_{25}

Eleanor presented an overview of her PhD project, based on a set of three marine cores taken during the 2014 and 2016 campaigns in Petermann Fjord, Kane Basin and Trinity Fjord. 10,000 years ago, there was no connection between Arctic Ocean and Baffin Bay. As ice sheet melted, Bering Strait opened, bringing in nutrients and thus, affecting primary productivity in the Strait. The existence of this area North Water Polynya is entirely dependent on sea ice conditions in

Nares Strait and PP is supported by nutrient-rich Pacific water which enters the North of Baffin Bay through Nares Strait.

The assemblages found in the Kane2B core confirm the succession of distinct paleo-environments in the strait following the retreat of grounded ice. Multiproxy approach was used to study the cores. Bromine bonds to marine organic matter in the water column, allows the export of OM to the sea floor to be estimated. Benthic foraminiferal assemblages (N. Labridorica) is indicative of export of fresh organic matter. Previous signals show similar trend to that of IP_{25}, which is a biomarker of seasonal seaice.

From core, can see when Nare strait opened, Pacific waters entered about 8600 years ago When ice sheet lifted, seafloor raised, therefore sea level decreased 80-120 m, decreasing planktic foram abundances. Today, Atlantic waters have to pass a bathymetric high to enter the Strait, but the extra water depth following ice sheet retreat would have allowed much more Atlantic water to enter. Water depth has an effect on OM deposition. The combination of benthic assemblages with the elemental ratios of their tests could provide a better assessment of the nature of the water masses in terms of their pacific VS Atlantic sources and their respective nutrient content. Surface sediment samples collected during the 2016 ArcticNet campaign will be used to calibrate the trace element ratios and improve potential of measurements on Kane2B core.

Eleanor is currently working on an article about the on the early Holocene events following ice sheet retreat in the strait based mainly on sedimentological data and a paper on Ice sheet dynamics in Nare Strait will be published relatively soon. If the results of the nutrient tracing measurements prove to be interesting, the team will produce an article about the paleooceanography of Nare Strait, explaining the evolution of the water masses in the strait and the paleoenvironmental interpretations based on benthic foram assemblages.

Sophia Robeiro et al.: Sea ice and primary productivity in the Inglefield Bredning-NOW region during the past 4000 years

The ICE-ARC (Ice Climate and Economics Arctic Research Change) project (2014-2018) is funded by the European Union's 7th Framework Programme. The objectives of WP3 in which Sophia is involved, include the consequences of current and future changes in sea ice on the local social and economic issues in the Northwest Greenland and NOW Polynya regions. Ingefield Bredning - Qaanaaq is sensitive to warming and melting and is the largest settlement in northern Greenland. Local hunters conduct sea thickness measurements, real time instruments carried on dog sleds.

Inglefield Bredning is one of the deepest fjords in Greenland (150 km long 100-200 km wide). The Atlantic water inflow at 300-500 m depth. There are marked recent changes in sea ice cover and thickness. It is an important region in terms of production. Archives are often used (ship logs, ice surveys, …) to provide history of the are in addition to sediment cores, which are extracted from both lakes and the ocean (primarily). Marine sediment provides geochemical (lipid biomarkers, TOC BSi, XRF), microfossil (diatoms, dinoflagellate cysts and foraminifera) and biological (indicator species, living cells) record. Species that produce IP25, a special biomarker, tend to dissolve in the sediments.

Time scales and approaches:

- 26 sediment cores collected, 13 had intact surfaces (recent times), surface integration of past 5 years, 7 cores dated (^{210}Pb)
- satellite data 2010-2015 was used for locating ice edge

Results:

- biogenic silica was highest in the polynya and at the ice edge
- diatoms, brackish species in fjord, marine signal farther out.
- Inner fjord with low productivity, influence of fresh water
- Most productive in polynya
- Change from higher to lower productivity and sea ice concentration in the polynya about 5000-7000 years ago (Holocene)
- Records show that polynya has been there for about 5000yrs
- Should be looking at SST and ocean circulation to complete the picture
- Species composition (presence/absence) has remained stable, but abundance has changed over time

Marie Noelle Houssais (by skype): Annual Stratification and mixing in southwestern Baffin Bay (1979-2014)

Climatology of the mixed layer depth shows high variability. There is an especially shallow MLD on the Greenland side and it is deeper on Baffin Island side. The deepening of the MLD is linked to the freshening of the surface water. There is an annual cycle of MLD. The spring ML retreat is triggered before sea ice melt input of surface buoyancy by Arctic fresh water. The date of ice melt varies from February (SE ice edge) to the end of May (NW). Sea ice distribution is governed by transport. The east and south of the BB has seen an increase in the decline of the sea ice (break point) compared to the pan-Arctic, which started in mid 1990s. There is a tendency to earlier ice cover retreat and shallower MLD in the recent decade (compared to pre-1995)

Dany Dumont asked if advection data are available
There was also a question as to what is causing the interannual variability of sea-ice melt.

Marcel Babin: concluding remarks

The GreenEdge project *Special Issue* will be open in the fall of 2017. With window of 6-9 months for submission. Several journals are being considered:

- Frontiers publishing group
- Elementa (University of Calif press)– could include social and natural science publications in journal
- Biogeosciences

We would like to have all papers published by the end of the GreenEdge project in the fall of 2018. When considering the co-authors on a paper, please remember to include all people that contributed to the study (planning-sampling-analysing-writing)

The next GreenEdge meeting is tentatively scheduled for Paris early in 2018 (February). Marcel emphasized the need to have full participation to advance the dissemination of results.

Arctic Change will be held in Québec City 11-15 December. We have requested a GreenEdge session with 3 blocks of oral presentation (chairs: M. Babin, J.-É. Tremblay, C.J. Mundy). There will also be a joint MEOPAR/GE Concepts (prediction, concepts) session chaired by D Dumont, L. Memery and F. Davidson. We hope that the GE and MEOPAR sessions can be scheduled back to back.

There is a demand for missed layer depth and nutrient layer depth data. This will be posted/provided for both the ice camp and Amundsen cruise stations.

Taxonomic counts (phytoplankton, zooplankton): we have good flow cytobot data available for the Ice camps and leg 1B of the Amundsen cruise. Unfortunately, good data is not available for leg 1A.

The Takuvik team will work on getting complementary data for ice camp, and Amundsen cruise.

We will contact Catherine Lalande and Louis Fortier to get somebody to work on zooplankton taxonomy.