1) **Deployment of BGC ARGO Floats LEG2A-AN19**
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Cruise participants : Claudie Marec and José Lagunas.

2) **Introduction and objectives**

During the Amundsen's AN19 legA cruise, we deployed 2 BGC (biogeochemical) Argo floats (Proice), as well as 2 Arvor-ice Argo floats provided by CORIOLIS. Proice floats are autonomous platforms used to record the "ice edge spring and fall blooms", equipped with numerous sensors dedicated to characterize the water column. During its life (at least 3 years depending on the frequency of profiles) a float drifts following oceanic currents (Lagrangian ARGO float) and profiles between the surface and down to the bottom (or a programmed depth: 1000m in our case) then back to the surface. When in the surface, the float is geo-localized and transmits its data using the Iridium communication system.

Basically, two Ice detection systems are implemented on the Proice floats to ensure a safer navigation in icy waters (avoid surfacing when ice is present). An upward-looking altimeter will detect thick ice and icebergs, additionally an algorithm based on sea-water temperature (ISA Ice Sensing Algorithm) will be an indicator of the presence of sea-ice.

3) **Operations conducted during leg2A**

2 Proice floats and 2 Arvor-ice floats were deployed from the ship's A frame. Two different areas for deployment were previously chosen after a study of the global Baffin Bay circulation (thanks to E.Rehm's simulations-Takuvik). Taking into account the global cyclonic circulation in BB, the chosen strategy is to avoid the floats to be ejected from BB through Davis' straight.
These theoretical positions were chosen according to those discussions and previous studies about the currents in the area (Tang et al, 2003). A daily study of geo-referenced Radarsat ice maps received onboard helped (thanks to Philipp Mann) to survey ice conditions in the center East of Baffin Bay and make sure our deployments take place within an ice-free area. Besides composite maps from remote-sensing (AMSR2 for sea-ice concentration and MODIS for chl*a* concentration) were daily generated by Takuvik (thanks to P.Massicote-Takuvik).
It was decided to deploy 2 batches of floats (2 in the first area (GreenEdge cruise) and 2 in the central Baffin Bay (this site is located in the very center of the cyclonic gyre in Baffin Bay).

Previously, 4Argo floats were deployed in the same areas as during the Greenedge cruise in 2016, 7 floats during AN172B and 2 more during IPS18. Hereafter, is the description of their parameters.

Description of the floats and their scientific payload:

Each float is equipped with the following sensors:

- CTD,
- Radiometer: OCR wavelengths:380, 412, 490nM, PAR,
- fluorescence chla,
- fluorescence CDOM,
- Backscattering,
- Suna (nitrates),
- Optode (Oxygen)

- **Proice takapm018b** (WMO 6902967) deployed on 14th, July 2019
lat: 69°29,985'N / Long 61°00,046'W bathymetry 1780m

- **Arvor-ice** (WMO6902952) deployed on 14th, July 2019
lat: 69°29,987'N/ Long 60°59,921W bathymetry 1782m

- **Proice takapm004B** (WMO 4901806) deployed on 17th, July 2019
lat: 72°45,464'N / Long 66°59,723'W bathymetry 2369m

- **Arvor-ice** (WMO 6902727) deployed on 17th, July 2019
lat: 72°45,385'N / Long 67°00,598'W bathymetry 2369m

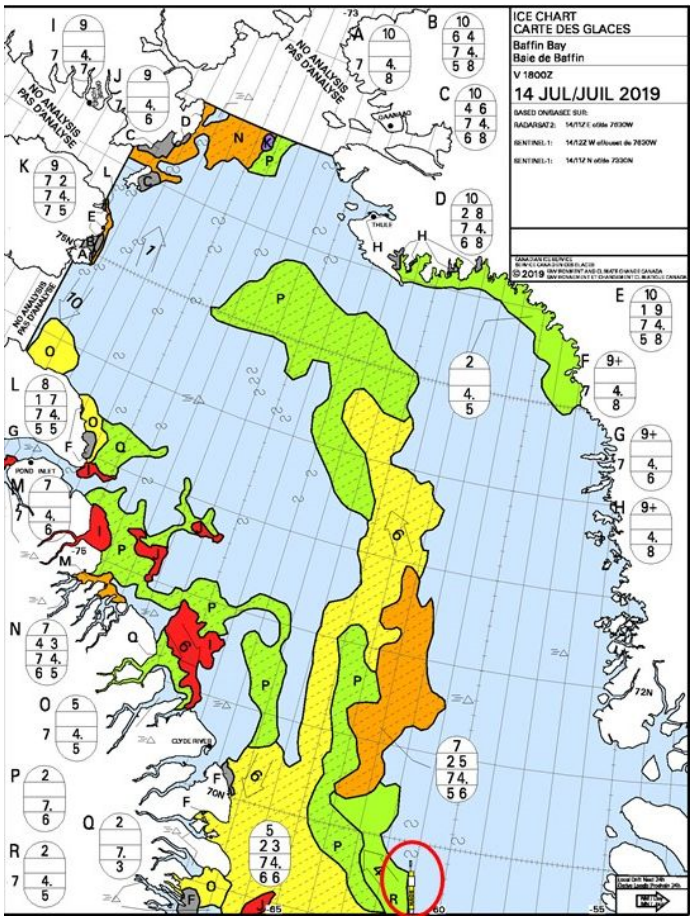


Figure 1: 1st area for deployments: ice cover (based on Radarsat) courtesy P.Mann

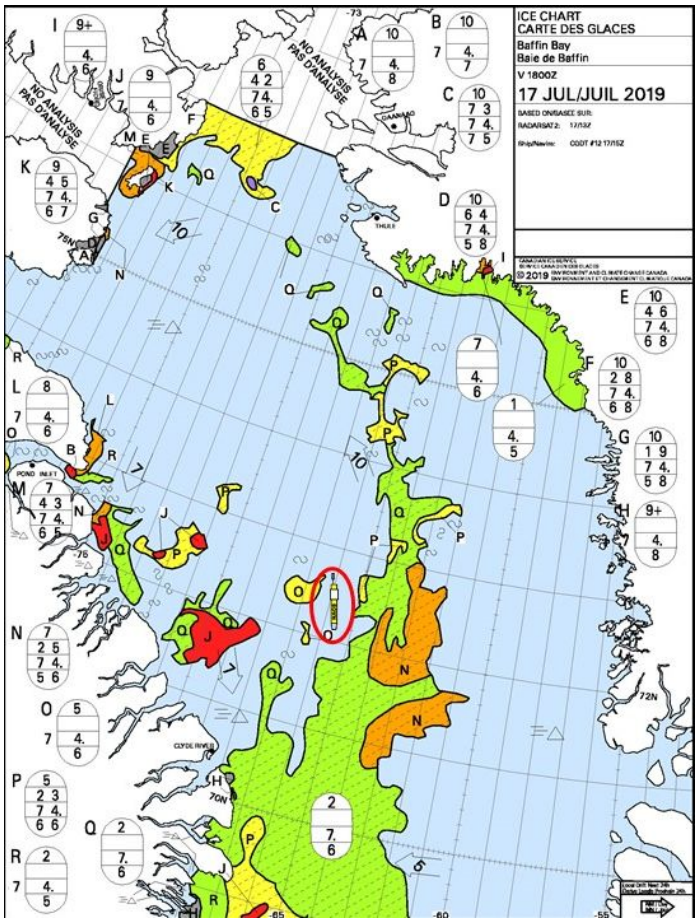


Figure 2: 2nd area for deployments in Central Baffin Bay: ice cover (based on Radarsat) courstesy P. Mann

CTD casts were performed at both sites of deployment; as well as sampling for HPLC, chl*a* , Ultrapath (CDOM) . Nutriments, CDOM and chl*a* analysis were performed onboard to cross-calibrate sensors. Oxygen samples are analysed by the CTD team to verify the response of the CTD (helpful to cross-check the optode response of the float). BB2 is a full station were different operations and CTD casts were performed.

During this period, 2 Proice floats, came back to surface after their wintering period, the former after its second wintering period, the latter after its first.

Note:

An incident occurred while lifting one of the floats with the crane from the fore-storage onto the starboard side of the front deck. The box was lifted using slings, however these were secured using the box's handles which are not certified for large charges. At a height of 2m, the handles detached from the box and the box fell. The float came out of the box and the following damages were assessed: Metal cage bent and outside bladder protector broken. After testing the system for further mechanical or internal damages in both the float's body and sensors, no harm was found other than what was already described. However; weak spots were found around the lower bladder, deep as 1mm and completely independent from the incident described before. Following the manufacturers's advise, a decision was made not to deploy this float due to the state of the bladder.

At this time, one the ship's senior engineer had already repaired the metal-cage and provided a solution for the outside bladder protection. The float will be returned to the manufacturer's where it will be made fit for deployment next year.

4) Preliminary results

Since their deployment, the sampling and navigation functionalities of all floats have worked as expected and continue to do so (see figure underneath). Data are daily collected on a remote server and made available to the scientific and general community. Their diving pattern was adapted because of a drifting foe arriving on their proximity zone. However, a mis-programming of takapm004b will delay its 1srt surfacing to mid-August.
The Proice floats are programmed on a seasonal pattern and profile the water column daily down to 1000m until fall (ice covering) arrives. During wintertime, they will park profiling once per week (without surfacing due to seasonal ice-cover). Thanks to a bi-directional satellite (Iridium) communication system, it is possible to modify the pattern of the floats and the resolution of their sensors.

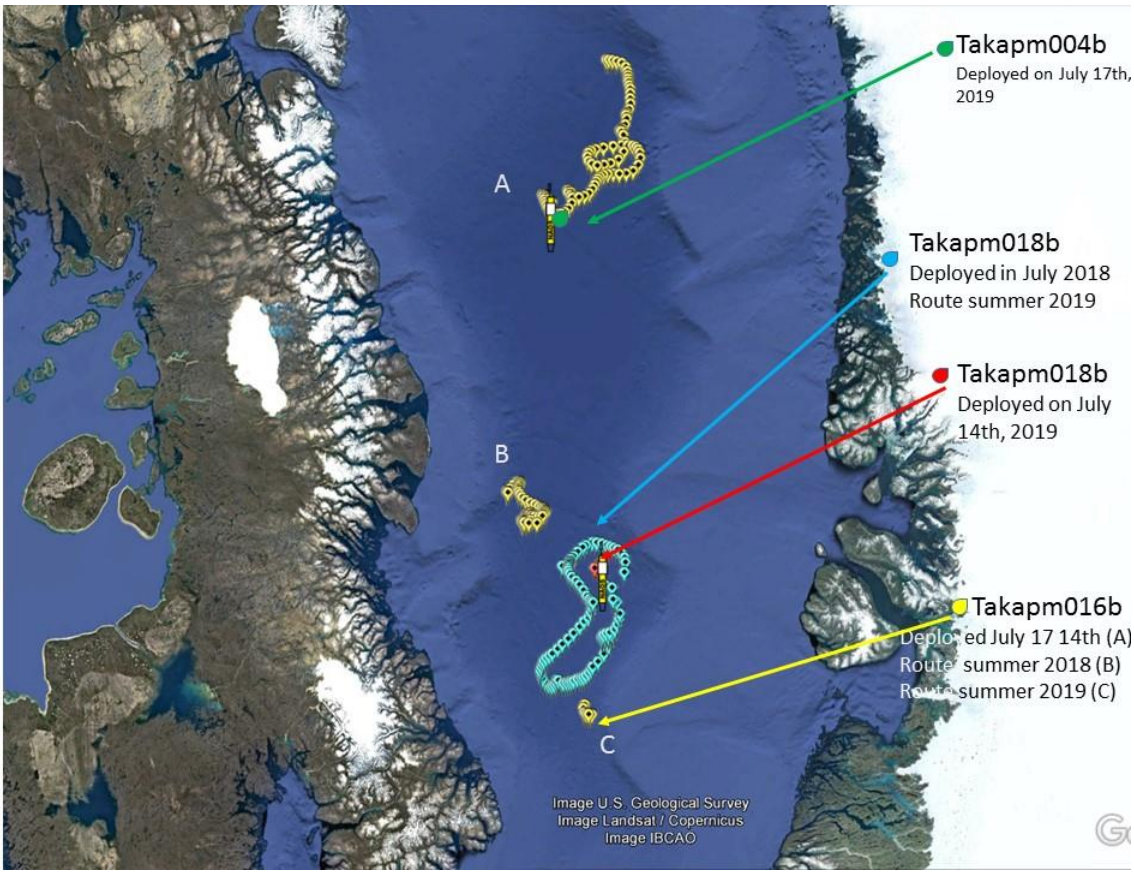


Figure 3: Routes of the Proice from deployment until the end of leg2A (takapm016b deployed in 2017, takapm020b, deployed in 2018 and takapm004b /takapm018B deployed in 2019), Arvor-ice floats are not represented here

Amount and type of data collected

Geo-localized data from the floats are presently being collected once a day. The frequency of the profiles will vary accordingly to the month, as described in Table 1. The criteria used to produce this schedule were ice cover conditions in Baffin Bay throughout the year and phytoplankton bloom period. This year, the plan for drifting and profiling accounts for a total annual number > 150 profiles per float.

Month	No. of Profiles/month	Month	No. of Profiles/month
January	3 to 4	July	17*
February	3 to 4	August	31
March	3 to 4	September	30
April	3 to 4	October	30
May	3 to 4	November 1-15	15*
June	3 to 4	November 16-30	2*
		December	3 to 4

*ice cover dependant

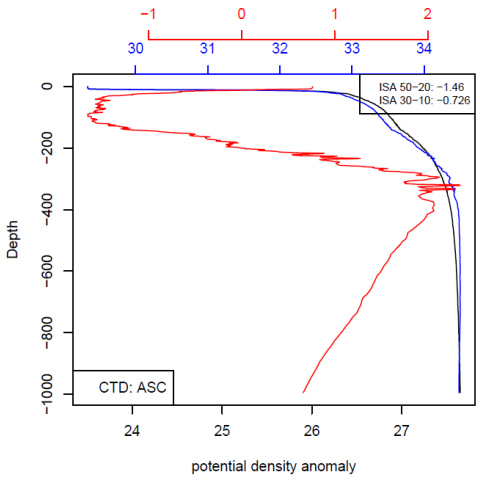
Table 1 - Profiling schedule for deployed ProIce floas, in number of profiles per month.

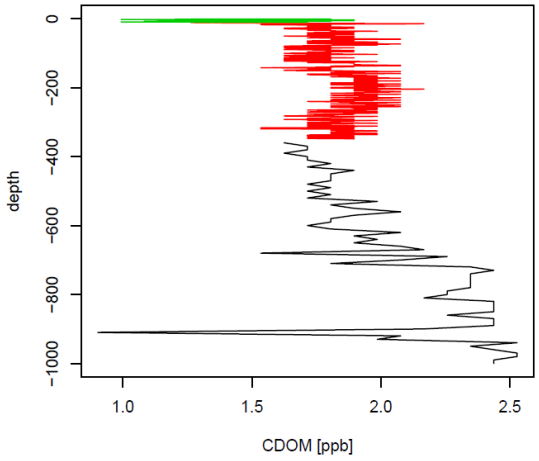
These profiles will provide data from the different sensors measuring the water column between 1000m and surface. The resolution of each sensor is set accordingly to specific depths, for instance high resolution in the euphotic zone, compared to the depth layer between 1000m and 350m. This is best described in Table 2, where the sampling rate of the sensors previously commented are modified while ascending through the water column. The last depth zone is activated whenever a 2000m bathymetry is available.

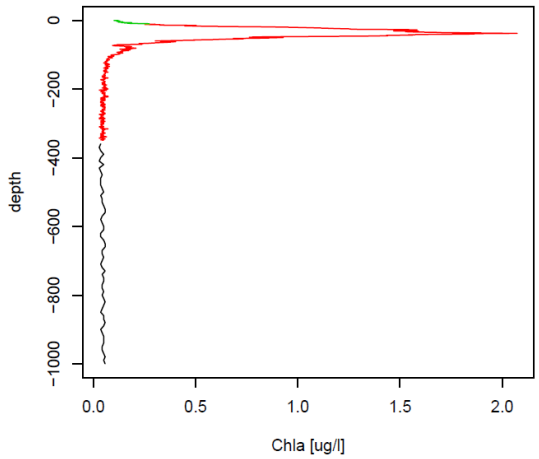
Sensor	0-10	0-15	10-350	0-70	15-200	70-350	350-1000	200-1000	1000-2000 (occas.l)
CTD	1	-	1	-	-		10	-	50
OCR	-	0,2	-	-	1		- nightcast=1	-	-
ECO	0,2	-	1	-	-		1	-	10
Optode	1	-	1	-	-		10	-	50
Suna	-	-	-	2	-	10	50	-	50

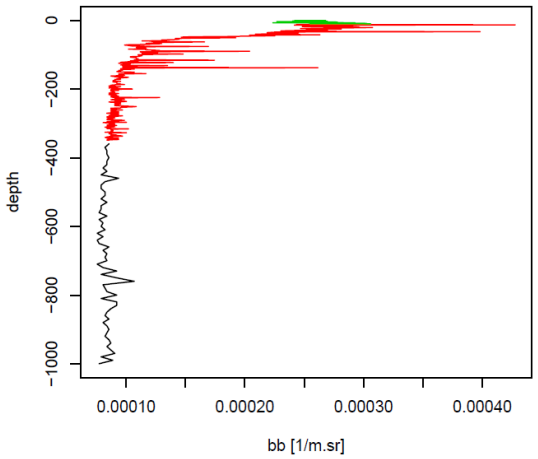
*Table 2 - Scientific payload sampling rate for the month of September, the last zone is **enabled** whenever a 2000m bathymetry is available .*

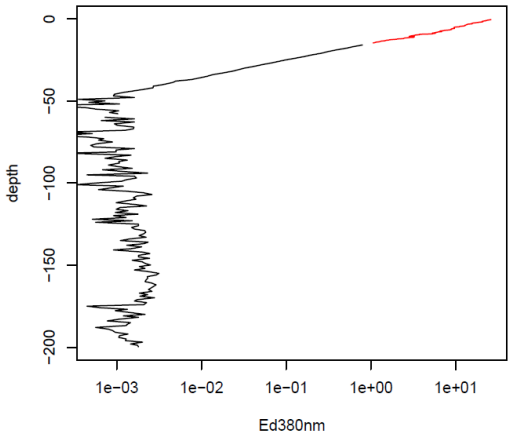
Data from the floats have been readily available since their deployment. Figure 5 and 6 show an example of preliminary of data sent back by the **takapm018b** (July, 17th 2019).

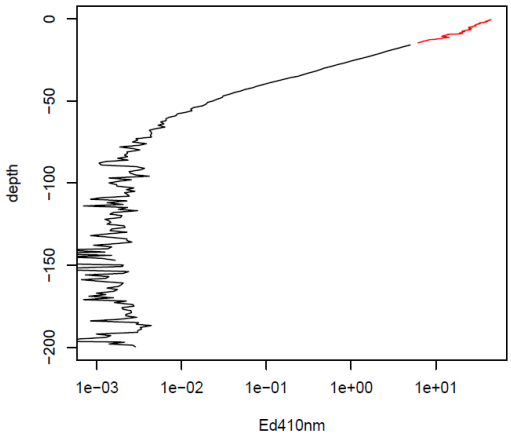












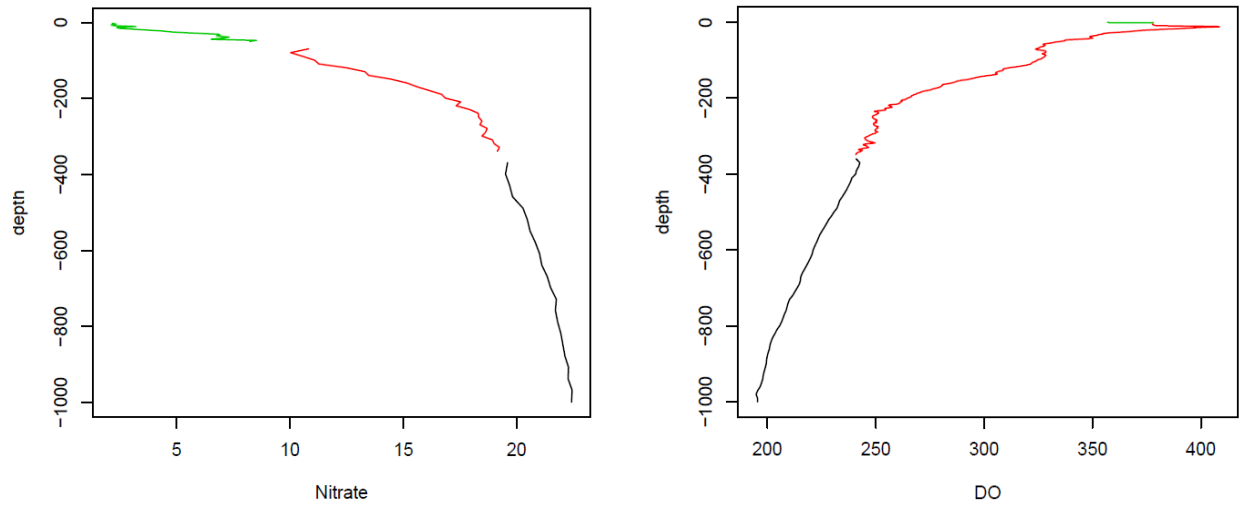


Figure 4: Top left: temperature, salinity and potential density anomaly Top right: CDOM (Colored dissolved organic matter). Middle left: proxy of Chlorophyll-a concentration. Middle right: back-scattering.. Data from the 3 radiometers and the PAR sensor (Photo-synthetically Available Radiation). Bottom left: Nitrate. Bottom right: Dissolved Oxygen

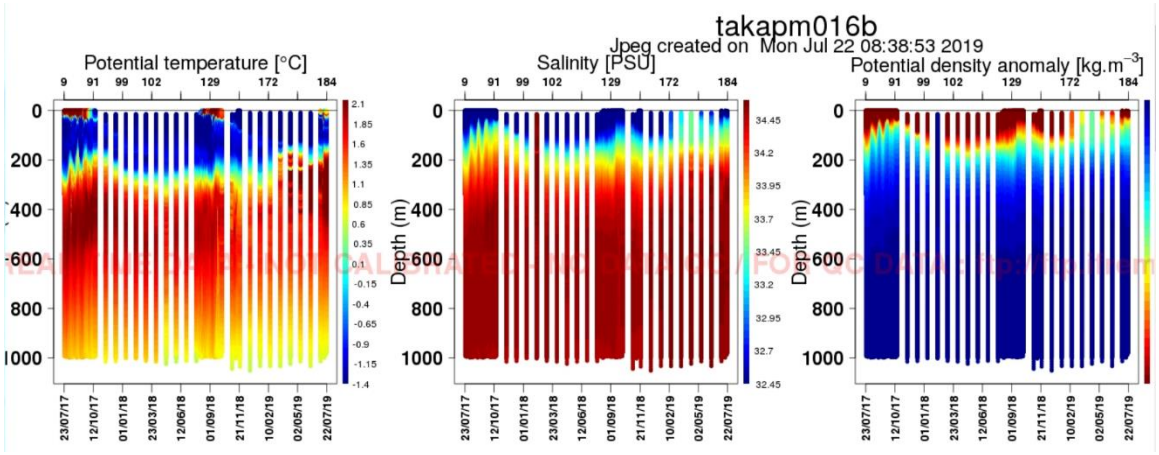


Figure 5: A 2 years duration time series (Temperature, Salinity, Density) recorded by Takapm016b since its deployment until July 22th, 2019

Plans for scientific analysis and publication

Several publications are expected to follow with the readily available data sent back by the floats launched in 2016, in 2017, 2018 and 2019. Since these are the first Argo floats to be deployed in Baffin Bay, their data is greatly expected and it will join the large data base of the Argo community.

Dissemination of the results so far:

- Lagunas, J. et al. Sea-ice detection for autonomous underwater vehicles and oceanographic lagrangian platforms by continuous-wave laser polarimetry. SPIE Proceedings, **2018**

- Smith, G.C., R. Allard, M. Babin, L. Bertino, M. Chevallier, G. Corlett, J. Crout, F. Davidson, B. Delille, S.T. Gille, D. Hebert, P. Hyder, J. Intrieri, J. Lagunas, G. Larnicol, T. Kaminski, B. Kater, F. Kauker, C. Marec, M. Mazloff, E.J. Metzger, C. Mordy, A. O'Carroll, S.M. Olsen, M. Phelps, P. Posey, P. Prandi, E. Rehm, P. Reid, I. Rigor, S. Sandven, M. Shupe, S. Swart, O.M. Smedstad, A. Solomon, A. Storto, P. Thibaut, J. Toole, K. Wood, J. Xie., Q. Yang, and the WWRP PPP Steering Group, **2019**. Polar Ocean Observations: A Critical Gap in the Observing System and its effect on Environmental Predictions from Hours to a Season. Frontiers in Marine Science. Frontiers. DOI:10.3389/fmars.**2019**.00429

- Randelhoff A. et al., In prep. Year-long time series in phytoplankton phenology and physico-chemical forcings in the Arctic Ocean. GRL

- Babin M et al. In prep. The role of light and mixing in triggering and stopping the phytoplankton fall bloom in the Arctic Ocean. GRL

- Xing X., Lagunas-Morales J. Laboratory results on the dependence of dark current upon environmental temperature variability for Satlantic's OCR504 radiometers (Conference dec 2018: Optical Precision Manufacturing, Testing, and Applications)

- Lacour L. Australian BGC-Argo workshop nov**2018** Unexpected phytoplankton blooms in polar and subpolar environments as revealed by BGC-Argo floats (Australian Biogeochemical-Argo workshop (nov 2018)oral)

- Lacour L. Australian BGC-Argo workshop nov**2018** Canadian contribution to the international BGC-Argo program in the Arctic (Australian Biogeochemical-Argo workshop (nov 2018)oral)

- Babin M., (pres. by Marec C.) Préliminary scientific results with PRO-ICE BGC-Argo (2018 NAOS Annual meeting, Paris, 13-14 september **2018**)

- Marec C., Lagunas J. (pres. by Marec C.) PRO-ICE BGC-Argo in Arctic (2018 NAOS Annual meeting, Paris, 13-14 september **2018**)

- Contribution to a presentation of INTAROS by Stein Sandven (Arctic Summit Science Arkangelsk, Russia 202-30mai **2019**).

- Randelhoff A. Contribution to a presentation Scientific evaluation of Takuvik by CNRS 17-19 April **2019** "le phytoplankton sous la banquise: plus que l'efflorescence printannière"

- Contribution to a presentation by Blair Greenan "BGC-Argo activities in Canada " (BGC Argo-ST Hangzou March **2019)**

- Poster (Tejana Ross 6th Argo Science Workshop, Tokyo October **2018**): contribution of TAKUVIK/NAOS to BGC Argo Canadian effort.

- Newsletter #5 biogeochemical ARGO (C.Marec , M.Babin) september **2018** http://biogeochemical-argo.org/

Thanks to:
Alexandre Forest, Jonathan Gagnon, Rémi Amiraux, Philipp Mann, the CTD operators and crew members of the Amundsen other for their help regarding this operation and Emmanuel Devred (BIO).

Problems encountered (e.g., degree of satisfaction with research platform)

- Operations on board of the Amundsen have been satisfying. Help and support of the crew was timely and precise. The advice of officers concerning ice-management was essential.
- Intermittent access to the internet and to the remote server with the floats. This was a recurrent issue for float deployments and to follow up of their drift. Fortunately, we were given an exceptional access to the internet through the Iridium service for file recovering and for the transmission of new instructions.
- We are very satisfied. Thanks a lot!