

Project information

Project title

OA-1/Ocean acidification state and drivers in Arctic waters (OAsate/OAdriver)

Year

2018

Project leader

Agneta Fransson (NPI) and Melissa Chierici (IMR)

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

70°N-90°N; 20°W to 35°E, Arctic Ocean/Nansen Basin, Svalbard fjords, Fram Strait, East Greenland Current, Barents Sea.

Participants

Kai Sørensen; Andrew King, Marit Norli (NIVA)

Helene Hodal Lødemel (IMR), Elizabeth Jones (IMR)

Mats Granskog (NPI)

Flagship

Ocean Acidification

Funding Source

1. Amount of funding from the Fram Centre (and in kind), and any internal institutional **and/or external funding (i.e. NRC, EU):**

	NPI	IMR	NIVA	WP SUM
WP1	1210 (650)	1050 (1000)	100 (100)	2360

Fram Centre funding/KLD is the original and in kind contribution in brackets include funding from NMD (Nærings og Fiskeridepartementet)

This is the sum for the projects OA^{STATE} (including former OA^{DRIVERS}) and OA^{pteropod}

Summary of Results

- **Time-series of chemistry data 2011-2018** from Arctic outflow waters in the Fram Strait clearly show integrated **changes in the chemistry**, pH and ocean acidification state in the Arctic Ocean due to climate change.

- Eight years of carbonate chemistry data (IMR/NPI) in Fram Strait reveals the seasonal and inter-annual variability of pH, pCO₂ and OA state in the Arctic outflow water in East Greenland Current. Results from the 8 years of data show increased temperature, salinity, total dissolved inorganic carbon and total alkalinity, and decreased pH.

-The **lowest pH and aragonite saturation** in Fram Strait were found in the upper halocline (20 to 200m) outflow waters (to the west), coinciding with high brine content (negative sea-ice melt) and high pCO₂. Possible mechanisms for the origins of the low pH layer could be due brine transport of CO₂ as a result of sea-ice dynamics in the Arctic Ocean

- **Continued water column sampling and chemical analyses** by IMR and NPI from several parts of the Arctic 2011-2018, resulted in a **unique data** set covering ocean acidification data and tracers for studies on the effect of freshwater on OA state, using the Fram Strait annual cruises, MOSJ cruises, A-TWAIN section, SI Arctic, N-ICE 2015 and AeN cruises.
- **Several Svalbard fjords are affected by glacial water runoff, which affects the fjord chemistry**, decreasing pH and the calcium carbonate saturation state (NPI/IMR),
- **Combined modelling (BGC and physics) and carbonate chemistry** resulted in seasonal data for extended data set on the **variability in air-sea CO₂ exchange** and OA state with changes in freshwater (collaboration with KongCarbon).
- **Unique automatic surface water pCO₂ measurements in 2018** from new pCO₂ instrument installed onboard RV Kronprins Haakon (NPI/IMR) in the Arctic Ocean, Fram Strait and around Svalbard. Results are quality controlled and will be used in 2019.
- **New preliminary results from the unique winter-to-spring data of the sea-ice and under-ice water carbonate chemistry (NPI/IMR)** from north of Svalbard (80 to 83°N) from January to June 2015 during the N-ICE 2015 expedition, show that **ikaite (CaCO₂ mineral) precipitation** in the ice affects the underlying water and partly mitigate the effects of ocean

acidification. New manuscript in progress.

- **Storms in winter affects vertical mixing, gas and heat exchange**, resulting in open leads in the ice cover and large **ocean CO₂ uptake** in winter. New storm paper submitted in 2018.
- **NIVA has continued development of shipboard pH and pCO₂ sensors on MS Norbjørn** as part of the underway FerryBox system that makes observations in the Barents Sea opening between Tromsø and Longyearbyen. The sensor data has been compared to DIC and AT measured on discrete samples taken on the FerryBox system (4x per year). This year a sensor measuring colored dissolved organic matter (cDOM) fluorescence has been installed, in addition to discrete samples for lab based spectrophotometric analysis. This new data will help to constrain non-carbonate contributions to measured AT.

Master and PhD-students involved in the project

PhD student for Svalbard fjord study: Y. Ericson, UNIS (E. Falck UNIS, M. Chierici IMR)

For the Management

- Time-series of chemistry data 2011-2018 from Arctic outflow waters in the Fram Strait clearly show integrated changes in the chemistry, pH and ocean acidification state in the Arctic Ocean due to climate change.
- In 2018, unique automatic surface $f\text{CO}_2$ measurements using new CO₂ instrument onboard RV Kronprins Haakon (NPI in collaboration with IMR) in the Arctic Ocean, Fram Strait and around Svalbard.
- Variability of the carbonate chemistry due to freshwater such as glacial drainage water in Svalbard fjords. Data showed that calcium carbonate saturation, pH and OA state decreased near the glacier front due to freshwater.

- Unique seasonal data of the carbonate chemistry in the sea ice and water, from winter to spring, north of Svalbard (between 80 and 83°N) obtained during the N-ICE 2015, new results in progress 2018.
- Large and successful sampling campaign in several parts of the Arctic, resulting in a unique data set covering ocean acidification data and tracers for studies on the effect of freshwater on OA state. Time series (2011-2018) in Arctic for OA studies in the water column during Fram Strait annual cruises, MOSJ/KF, A-TWAIN, SI-Arctic cruises continued and Nansen Legacy (AeN) cruises (2018). Winter data of the carbonate chemistry was sampled North of Svalbard in January 2014-2015 in collaboration with CarbonBridge project and N-ICE in 2015. Eight years of carbonate chemistry data in the Fram Strait shows variability in pH and CaCO₃ (aragonite) saturation between the years with more river runoff and Pacific water of the Arctic outflow (to the west). These studies direct to large interannual variability which motivates further field sampling to establish and continue the first OA time series in the Arctic.

The clear seasonal changes in the seawater carbonate chemistry from the Tromsø-Svalbard transect (MS Norbjørn FerryBox) emphasizes the need for long time series in order to separate a climate trend from the seasonal variation.

- Need for writing scientific publications on Arctic data collected during the eight years and compare with other Arctic studies, resulting in pan-Arctic studies, such as the MOSAiC campagn 2019-2020.
- Investigations of OA state in Svalbard fjords in winter and summer and the relation to abundance and shell structure of the aragonite forming pteropod *L.helicina* motivate further investigations of methods and the use as indicator for ocean acidification.

Expertise/advice:

-ICES/PICES Workshop on understanding the impacts and consequences of ocean acidification for commercial species and end-users (WKACIDUSE), Copenhagen 2016. (J. Falk-Andersson, M. Chierici)

- AMAP Arctic Ocean Acidification reports both 2013 and 2018 (R. Bellerby, H. Browman, M. Chierici, A. Fransson)
- ICES-Marine Chemistry Working Group , MCWG (M. Chierici),
- ICES-OSPAR-Study Group of Ocean Acidification, SGOA (M. Chierici),
- Biogeochemistry of Sea Ice (BEPSII) SCOR Forum (A. Fransson, M. Chierici)
- Monitoring Jan Mayen and Svalbard (MOSJ) (A. Fransson, H. Hop)
- ICOS (Integrated Carbon Observing System) expert meeting in Bergen, 2018.
- BEPSII expert meeting in Davvos, Switzerland 2018 (Chierici/Fransson poster presentations)
- Several contributions to OceanObs19 white papers on ocean and climate change (A. Fransson, M. Chierici)

Published Results/Planned Publications

Peer-viewed publications in 2018

Yasunaka S. (M. Chierici, A. Fransson) et al (2018) Arctic Ocean CO₂ uptake: an improved multiyear estimate of the air–sea CO₂ flux incorporating chlorophyll a concentrations. *Biogeosciences*, 15, 1–18, 2018 <https://doi.org/10.5194/bg-15-1-2018>.

Ericson Y, E. Falck, M. Chierici, A. Fransson, S. Kristiansen, S.M Platt, O Hermansen, C.L Myhre (2018) Temporal variability in surface water pCO₂ in Adventfjorden (West Spitsbergen) with emphasis on physical and biogeochemical drivers. *Journal of Geophysical Research: Oceans*. <https://data.npolar.no/publication/bcdb12d4-2dae-4c4b-b197-18c8b449bb32>

Nomura D, M. A. Granskog, A. Fransson, M. Chierici, A. Silyakova, B. Delille, ,L. Cohen, S.R. Hudson, K.I. Ohshima and G.S. Dieckmann (2018). CO₂ flux over young and snow-covered Arctic pack ice in winter and spring. *Copernicus GmbH. Biogeosciences*. <https://doi.org/10.5194/bg-15-3331->

2018.

Opstad, I., P. Dalpadado., A. Mangor Jensen, E. Speerfeldt., A. Fransson., M. Chierici Effects of high pCO₂ on the northern krill *Thysanoessa inermis* in relation to carbonate chemistry of its collection area, Rjippfjorden, *Marine Biology* (2018) 165:116 <https://doi.org/10.1007/s00227-018-3370-7>.

Hendry K.R., M. Kimberley, M. Pyle. G. Butler, A. Cooper¹, A. Fransson, M. Chierici et al (2018) Spatiotemporal Variability of Barium in Arctic Sea-Ice and Seawater. *JGR-Oceans*, 123, 3507–3522, doi: 10.1029/2017JC013668.

Torstensson A., A. Fransson, K. Currie, A. Wulff, M. Chierici (2018) Microalgal photophysiology and macronutrient distribution in summer sea ice in the Amundsen and Ross Seas, Antarctica. *PLoS ONE* 13(4): e0195587. <https://doi.org/10.1371/journal.pone.0195587>.

Carstensen, J., M. Chierici., B.G. Gustafsson., E. Gustafsson, (2018). Long-term and seasonal trends in estuarine and coastal carbonate systems, *Global Biogeochemical Cycles*, GBC20639, DOI:10.1002/2017GB005781.

Wulff, A., M. Karlberg., M. Olsson., A. Torstensson., L. Riemann., F.S. Steinhoff., M. Mohlin., N. Ekstrand., M. Chierici, (2018). Ocean acidification and desalination - Climate-driven change in a Baltic Sea summer microplanktonic community, *Marine Biology*, 165:63, doi.org/10.1007/s00227-018-3321-3.

Randelhoff, A., M. Reigstad., M. Chierici., A. Sundfjord., V. Ivanov., M.R. Cape., M. Vernet., J-E Tremblay., G. Bratbak and S. Kristiansen, (2018). Seasonality of the Physical and Biogeochemical Hydrography in the Inflow to the Arctic Ocean through Fram Strait, *Frontiers in Marine Science*, doi: 10.3389/fmars.2018.00224.

Sanz- Martín, M., M. Chierici., C. E. Mesa., P. Carrillo-de-Albornoz., A. Delgado-Huertas., S. Agusti., M. Reigstad., S. Kristiansen., P. F. J. Wassmann., and C. M. Duarte, (2018). Episodic Arctic CO₂ limitation in the west Svalbard shelf, *Frontiers in Marine Science*, ID:347348.

Charrieau, L.M., H.L.Filipsson., K. Ljung., M. Chierici., K. L. Knudsen & E. Kritzberg., (2018). The effects of multiple stressors on the distribution of coastal benthic foraminifera: a case study from the Skagerrak-Baltic Sea region, *Marine Micropaleontology* 139:42-56.

Olofsson, M., A. Torstensson., M. Karlberg., F. S. Steinhoff., J. Dinasquet., L. Riemann., M. Chierici., A.Wulff, (2018). Limited response of a spring bloom community and inoculated filamentous cyanobacteria to elevated temperature and pCO₂. Accepted, *Botanica Marina*.

In review

Graham, Itkin, Granskog et al (Fransson, Chierici) Storm events in winter, N-ICE2015, submitted to *Scientific Reports*, 2018.

Ericson Y, M. Chierici, E. Falck, A. Fransson, E. Jones, S. Kristiansen, Evolution of the marine CO₂ system in a West Spitsbergen fjord with emphasis on seasonal drivers of the calcium carbonate saturation state, *JGR* in review 2018

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Ericson Y, E. Falck, M. Chierici, A. Fransson, S. Kristiansen, Marine CO₂ system variability in a high Arctic tidewater-glacier fjord system, Tempelfjorden, Svalbard, submitted to *Cont. Shelf Res.* 2018

In progress

Fransson A, M Chierici, P Dodd, M Granskog, C Stedmon, et al. Feedbacks of freshwater and primary production on the carbonate system, air-sea CO₂ fluxes and ocean acidification state in the Djimphna Sound, NE Greenland. To be submitted, 2018.

Chierici M., A. Fransson, M. Granskog et al . Ocean acidification in Arctic outflow waters. In progress 2018

Chierici M. and A. Fransson, Barents Sea CO₂ variability 2012-2016, in progress, 2018.

Fransson A. et al., Seasonal impact of sea-ice processes and freshwater on calcium carbonate saturation in the Svalbard fjords. Submit in 2018/2019

Publications (reports)

AMAP, 2018. AMAP Assessment 2018: Arctic Ocean Acidification. Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway. vi+187pp R. Bellerby, P. Wallhead, M. Chierici, A. Fransson, H. Browman contributing authors

MOSJ status report, 2018: Assessment of the marine climate system around Svalbard and Jan Mayen, Renner A., P. Dodd, A. Fransson. 2018

State of the Polar Oceans, 2018, J.Francis, O-A Misund., British Antarctic Survey, M. Chierici contributing author

Faglig Forum: Polarfrontens fysiske beskaffenhet og biologiske implikasjoner En verdi- og sårbarhetsvurdering av polarfronten i Barentshavet, Ed:V. Lien, Institute of Marine Research and Norwegian Polar Institute, 2018. M. Chierici contributing author

Jones, E., Chierici, M., I. Skjelvan, M. Norli, K. Y. Børsheim, S. K. Lauvset, H.H. Lødemel, K. Sørensen, A.L. King, T. Johannessen, (2018). Monitoring Ocean Acidification in Norwegian waters/Overvåking av havforsuring i norske farvann i 2017 Report, Norwegian Environment Agency/Miljødirektoratet, M-|2018.

Public report/outreach

Surere vann endrer livet i havet, (Fransson, Hop, Bailey), Forskning.no, 2018

Nansen Legacy blogg, Undersøker klimagass i havis og havsvann i Barentshavet. Fransson, Chierici, Jones, 2018

News NRK about Nansen Legacy cruise and Kronprins Haakon, 2018

Pteropod research presented in Forskning.no Havforsuring påvirker skallet til vingesneglen, (Fransson NPI/Chierici IMR)

In addition the OA state and OA Flagship have been involved in public presentations, school visits, interviews, radio, blogs, webinars and popular articles in newspapers and social media. The OA state and OA Flagship have contributed with photos, films and other material for the science days and other forums.

Field activity:

Nansen Legacy (AeN) joint cruise August 2018

Fram Strait expedition with RV Kronprins Haakon, August-September 2018

MOSJ/KF, RV Lance, July 2018

AeN/UiT/CAGE calcifiers and OA and paleo 2018. NPI, IMR collaboration

Kongsfjorden field work in May 2018

MS Norbjørn March, June, August, November 2018

Communicated Results

Conferences/workshops 2018

Nansen Legacy workshops 2018

Nansen Legacy kick-off meeting 2018

N-ICE workshop, November 2018, Tromsø, Norway

Open section meeting presentation (Fransson), 2018

OA flagship meetings, 2018

Fram Centre Flagship meetings, 2018

Fram Day, 2018

Dialogue meeting, 2018

Arctic Frontier (posters Fransson, Chierici), January 2018

BEPSII meeting in Davvos, 2018 (Fransson and Chierici poster presentations)

ICOS meetings, 2018 (Fransson and Chierici)

EuroGOOS General Assembly, 2018 (King, Sørensen, Norli)

EU Directorate General - Maritime Affairs and Fisheries (DG MARE), 2018 (King, Sørensen, Norli)

Conferences/workshops abstracts in 2018

Main conferences

Ocean Science Meeting, Portland, USA, January, 2018

ECCOWO, Washington DC, USA, June 2018

Polar2018, Davvos, Switzerland, June, 2018

Nansen Legacy workshops, Bergen, November, 2018

Nansen Legacy kick-off meeting, Tromsø, March, 2018

Fransson Agneta, Melissa Chierici, Ingunn Skjelvan, Are Olsen, Philipp Assmy, Algot K. Peterson, Gunnar Spreen, Brian Ward. Effects of sea-ice and biogeochemical processes and storms on under-ice water $f\text{CO}_2$ from winter to spring in the high Arctic Ocean: Implications for sea-air CO_2 fluxes.

Abstract submitted to the Ocean Science Meeting, Portland, USA, 2018.

Fransson A. M. Chierici, D. Nomura, M. A. Granskog, S. Kristiansen, T. Martma, G.

Nehrke. Wintertime sea-ice carbonate system and influence of sea-ice processes and glacial freshwater discharge during two contrasting years in a West-Spitsbergen fjord. Abstract Polar2018 conference, Davvos, Switzerland, 2018.

Chierici M., A. Fransson, M. Granskog, P. Dodd et al. Ocean acidification in Arctic outflow water. Abstract Polar2018 conference, Davvos, Switzerland, 2018.

Fransson Agneta, Melissa Chierici, Ingunn Skjelvan, Are Olsen, Philipp Assmy, Algot K. Peterson, Gunnar Spreen, Brian Ward. Effects of sea-ice and biogeochemical processes and storms on under-ice water $f\text{CO}_2$ from winter to spring in the high Arctic Ocean: Implications for sea-air CO_2 fluxes. Abstract Polar2018 conference, Davvos, Switzerland, 2018.

Fransson Agneta, Melissa Chierici, Ingunn Skjelvan, Are Olsen, Philipp Assmy, Algot K. Peterson, Gunnar Spreen, Brian Ward. Effects of sea-ice and biogeochemical processes and storms on under-ice water $f\text{CO}_2$ from winter to spring in the high Arctic Ocean: Implications for sea-air CO_2 fluxes. Abstract Arctic Frontier Conference, Tromsø, Norway 2018.

Fransson A. M. Chierici, H. Hop, S. Kristiansen, A. Wold. Seasonal variability of the carbonate chemistry and ocean acidification state in Kongsfjorden: Implications for calcifying organisms. Abstract Svalbard Science Forum, Oslo, Norway 2018

Assmy P, et al. (A. Fransson) Emerging physical and biological properties in a new Arctic ice regime. Abstract Ocean Science Meeting, Portland, USA, 2018.

Assmy P, et al. (A. Fransson) Emerging physical and biological properties in a new Arctic ice regime. Abstract Arctic Frontier Conference, Tromsø, Norway 2018.

Chierici Melissa., Agneta Fransson, Ylva Ericsson, Eva Falck, Svein Kristiansen. Influence of glacial water on carbonate chemistry and biogeochemical processes in Svalbard fjords with different characteristics. Abstract Arctic Frontier Conference, Tromsø, Norway 2018.

Chierici Melissa., Agneta Fransson, Ylva Ericsson, Eva Falck, Svein Kristiansen. Influence of glacial water on carbonate chemistry and biogeochemical processes in Svalbard fjords with different characteristics. Abstract Ocean Science Meeting, Portland, USA, 2018.

Ericson Ylva, Falck Eva, Chierici Melissa, Fransson Agneta. Temporal variability in surface water pCO₂ in Adventfjorden (West Spitsbergen): physical and biogeochemical drivers. Abstract submitted to the Arctic Frontier Conference, Tromsø, Norway 2018.

Ericson Ylva, Falck Eva, Chierici Melissa, Fransson Agneta. Temporal variability in surface water pCO₂ in Adventfjorden (West Spitsbergen): physical and biogeochemical drivers. Abstract Ocean Science Meeting, Portland, USA, 2018.

Nomura D. et al. (A. Fransson). ECV-Ice: Measuring Essential Climate Variables in Sea Ice–SCOR Working Group 152. Abstract ASAR conference, Tokyo, Japan, 2018.

Nomura D. et al. (A. Fransson). ECV-Ice: Measuring Essential Climate Variables in Sea Ice–SCOR Working Group 152. Abstract Ocean Science meeting, 2018.

Itkin et al (Fransson, Chierici, Granskog) Storm events, N-ICE, Abstract Ocean Science meeting, 2018.

Silyakova A., M. Kotovitch, B. Delille, D. Nomura, A. Fransson, M. Chierici, M. Granskog. Methane chemistry in the ice covered Arctic Ocean from winter to summer time. Abstract Ocean Science Meeting, Portland, USA, 2018.

OA flagship meetings, 2018, NPI, IMR, NIVA, Akvaplan-Niva, UiT, NINA, NORUT/SALT.

ICOS expert meeting in Bergen, Nov, and skype meetings, 2018 (A. Fransson/M. Chierici)

BEPSII expert meeting in Davvos (M. Chierici /A. Fransson, poster presentations), June, 2018

Interdisciplinary Cooperation

The inter-disciplinary cooperation between chemical, biologists and physical oceanographers offers a wide range of knowledge and contribution to the project, especially regarding the study of the water masses and Arctic outflow in Fram Strait. The carbonate chemistry and ocean acidification were added from 2011. Only positive aspects. Unique possibility to understand the underlying mechanisms if this work can continue.

During Nansen Legacy (AeN) cruises and workshops, we work interdisciplinary, the annual Fram Strait and MOSJ/KF expeditions, widely inter-disciplinary collaboration between chemical and physical oceanographers and biologists offers a wide range of knowledge and contribution to the project. The project also offers highly international and national collaboration.

Collaboration with biologists, paleoceanographers and marine geologists on expeditions organized by the University of Tromsø on historical records of carbonate system and the evolution of CaCO_3 forming organisms. Collaboration with Prof. Tine Rasmussen at University of Tromsø- the Arctic university (UiT/CAGE), also within AeN.

Collaboration with Helen Findlay at Plymouth Marine Laboratory, UK, in Kongsfjorden.

Collaboration with Claire Mahaffey at University of Liverpool on NERC UK project ArcticChange.

Disciplines involved in the project

Physical oceanography (water column studies such as stratification, water mass, freshwater)

Chemical oceanography (carbonate system and OA state in water column)

Marine geology (isotopic ratios in calcifying organisms, pH and climate records)

Marine biology (zooplankton/pteropod sampling)

We have collaboration with biological oceanographers for nutrients availability in the water column and as tracers (UiT).

Collaboration with biologists (e.g. NPI) on MOSJ/KF, SI-Arctic and N-ICE expeditions on zooplankton and phytoplankton in comparison to OAstate.

Crystal structures and CaCO₃ minerals in sea ice and water column (AWI, Germany and IOPAN, Poland),

Shell density analyses collaboration with scientists in Japan (JAMSTEC)

Methane in seawater (AWI)

Budget in accordance to results

The project funding has been fundamental to implement this project. It partly supports the hiring of technician at NPI, and the high costs associated with Arctic field work and extensive sample analysis required in the work. Part of the field expenses are covered with in-kind contribution and not taken into account here. It has also supported to acquire state-of-the-art instrument that are needed for measurements outside the time in the field. However, the funds have to be supplemented by significant external and in-kind contributions (IMR, NPI, NIVA) for successfulness.

Fram Centre funding boosted joint effort to continue the 1st Arctic time-series sections north of Svalbard with other Flagship and between institutes/universities.

Fram Centre funds have supported:

Salary for technician C. Mourgues at NPI (chemical analyses and field work)

Salary for M. Chierici (IMR) and Helene H Lødemel (IMR)

Field work and travel to cruises/workshops/conferences

Chemical analyses

Supported attendance to conference and workshops and advisory committees.

Could results from the project be subject for any commercial utilization

No

Conclusions

- **Conclusions**

- a) Indicate future research and/or perspectives which the project results have led to**

- Time-series of chemistry data 2011-2018 from Arctic outflow waters in the Fram Strait clearly show integrated changes in the chemistry, pH and ocean acidification state in the Arctic Ocean due to climate change. Need for more years data to perform trend analysis.
- Continuation of the inter-annual study of the physical and chemical properties of water masses, and outflow of Arctic water in the Fram Strait. Add chemical sensors such as CO₂ and pH sensors on the moorings in future (Fram Strait/NPI and Svalbard fjords/NPI-IMR, MOSJ/NPI and SI-Arctic/IMR).
- CAGE (UiT) collaboration on historical carbonate chemistry and palaeoceanography in Nordic seas and Barents Sea, collaboration with AeN project.

b) List and describe new methods or techniques that have been developed during the project or that the project has revealed a need for

- Additional chemical sensors such as CO₂ sensors to put on moorings are needed to obtain information on the seasonal variability of the carbonate system and ocean acidification.
- The pCO₂ and pH sensors that has been developed have been implemented and in operation along with the Ferrybox system on MS Norbjørn.
- Successful measurements of surface water fCO₂ using automated fCO₂ instrument installed on RV Kronprins Haakon in 2018