Final report for *CircA* (2012-2015)

Project title: Circadian rhythms of Arctic zooplankton from polar twilight to polar night – patterns, processes, and ecosystem implications

Acronym: CircA

Project leader: Professor Jørgen Berge (UiT and UNIS)
Project owner: UNIS
Project number: 214271

Homepage for the project: www.mare-incognitum.no

CircA was funded by FriPro for the period 2012-2015, and was based upon a paper published by Berge et al in 2009; *Diel vertical migration of Arctic zooplankton during the polar night* (in Biology Letters 2009(5):69-72):

Abstract from Berge et al 2009: **High-latitude environments show extreme seasonal variation in physical and biological variables. The classic paradigm of Arctic marine ecosystems holds that most biological processes slow down or cease during the polar night. One key process that is generally assumed to cease during winter is diel vertical migration (DVM) of zooplankton. DVM constitutes the largest synchronized movement of biomass on the planet, and is of paramount importance for marine ecosystem function and carbon cycling. Here we present acoustic data that demonstrate a synchronized DVM behavior of zooplankton that continues throughout the Arctic winter, in both open and ice-covered waters. We argue that even during the polar night, DVM is regulated by diel variations in solar and lunar illumination, which are at intensities far below the threshold of human perception. We also demonstrate that winter DVM is stronger in open waters compared with ice-covered waters. This suggests that the biologically mediated vertical flux of carbon will increase if there is a continued retreat of the Arctic winter sea ice cover.**

This paper was not only the first paper to document that Arctic zooplankton perform diel vertical migration during the polar night, it was also the first paper in a long series of papers that have later dealt with patterns and processes occurring during the Arctic polar night (see review in Berge et al 2015). At the time, active zooplankton during the polar night was a totally new phenomenon, and little was known about the mechanisms behind, its influence on the system, and even which organisms were performing the migrations. Therefore, the primary objective of *CircA* was to determine the primary physical and biological factors that are responsible for the DVM patterns of zooplankton in the high Arctic during the polar night and twilight period, and to elucidate the resultant ecosystem. In order to meet this primary objective, the project was built up based on five main questions:

WHO – which species are perfoming DVM during the polar bight?

WHY – why are organisms conducting energetically costly migrations at a time of year when there is no available food?

HOW – how do the migrating organisms retain a strict circadian (24hrs) cycle in an environment where the sun is below the horizon for several months?

WHERE – are the patterns seen in the fjords of Svalbard relevant for other parts of the Arctic?

WHAT – what are the ecosystem implications of the migrations?

The project therefore had a set of very clear questions and hypotheses, and were basically structured around the work of four PhDs / postdoc positions:

PhD Student Julie Grenvald (employed at UNIS): Focus on the WHO and WHY questions, planned defence in autumn 2016.
PhD Student Laura Hobbs (employed at SAMS in Scotland): Focus on the WHERE question, planned defence in March 2016.
Postdoc Gerald Darnis (employed at APN): Focus on the WHAT question.

The last remaining question – HOW – was originally embedded into another project funded at NTNU with PhD student Anna Båtnes, but later became the focus of the entire team. Båtnes defended her PhD thesis in 2013.

Budget – overview

	2012	2013	2014	2015	Ikke mottatt Rest NFR 2016	Sum
Budsjett fra NFR	2 839 000	4 606 000	4 360 000	830 000		12 635 000
Regnskap 2012-2015	**2012**	**2013**	**2014**	**2015**		**Sum**
Inntekt:						
Innbetalt fra NFR	1 419 500,00	6 025 500,00	4 365 000,00	553 333,00	276 667,00	12 640 000,00
Innbet fra UiTø	144 794,00					144 794,00
Overført til kick off		-99 784,34				-99 784,34
Andre inntekter, refusjoner			7 458,52			7 458,52
Refusjon fra NAV				166 803,00		166 803,00
Sum inntekt	1 564 294,00	5 925 715,66	4 372 458,52	720 136,00	276 667,00	**12 859 271,18**
Kostnader:						
Personal og indirekte kostnader	368 571,44	1 121 189,62	1 443 629,15	689 609,49		3 622 999,70
UNIS kostnader PhD/ NFR sats		100 000,00	100000			200 000,00
Feltkostnader	25 405,85	69 765,54	42 534,42	704,00		138 409,81
Utstyr	66 744,59	60 912,30	450 106,79	17 659,30		595 422,98
Materiell/ rekvisita	57 748,25	293 742,46	53 332,86	111 870,21		516 693,78
FoU tjenester	1 263 175,04	2 447 820,00	2 359 923,56	449 788,50		6 520 707,10
Reiser	62 840,86	199 794,24	324 358,10	73 288,67		660 281,87
Annen drift	110 110,73	46 377,79	159 763,20	146 934,33		463 186,05
Sum på året	1 954 596,76	4 339 601,95	4 933 648,08	1 489 854,50	0,00	**12 717 701,29**
Resultat 2012-2015						**141 569,89**

The budget overview as of January 31st 2016 has a surplus of 141 569,- NOK. However, this does not take into account that PhD Julie Grenvald will be employed in 50% position until July 2016. In reality, the budget is therefore in the red. But despite the fact that costs for the PhD position were increased dramatically, we have managed to keep up the most important

activities, both through downscaling of some of the planned campaigns and through a close coordination with other related projects (especially Marine Night, project nr 226417).

Research - the five main questions

1 - Who?

During winter (October-February) the acoustic data (moored ADCPs, 307 kHz) showed patterns of synchronized vertical migration in the water column, characterized by increased or decreased values of backscatter (Sv). A classical DVM pattern was evident throughout the polar night but strongest in the beginning/end (October and February) of the winter and weakest during middle of the polar night (December and January). To compare with the acoustics patterns zooplankton nets were deployed during the darkest part of winter. The mesozooplankton community was mainly dominated by *Oithona similis*, *Pseudocalanus* spp., *Microcalanus* spp., *Calanus* spp. and *Metridia longa*. All copepods were found throughout the water column (January and February 2013, January 2014), but the smaller copepods (e.g. *O. similis*, *Pseudocalanus* spp. and *Microcalanus* spp.) were more abundant in surface waters (0-50 m). We did not observe any classical DVM patterns in depth distribution for any of the mesozooplankton species.

Within the macrozooplankton community (0-30 m) the most abundant species were euphausiids of the species *Thysanoessa inermis* followed by chaetognaths. No classical DVM behavior was observed in January. Thus, a distinct DVM pattern of *T. inermis* was observed in February with species abundance being markedly higher at surface during night compared to day. Interestingly, we also observed significant differences in length frequency distribution of *T. inermis* and *P. elegans* in February, where larger individuals were at surface during nighttime but disappeared during daytime, showing evidence of longer krill individuals being responsible for the classical DVM signal observed in both zooplankton nets and acoustic data.

Conclusions:

Short answer to the "who" question: Krill

Main publications on the "who" question:

Grenvald et al. Diel vertical migration (DVM) in the polar night: which zooplankton species are active during the dark Arctic mid-winter? To be submitted in February 2016 to Polar Biology.

Berge, J., Daase, M., Renaud, PE., Ambrose, WG., Darnis, G. et al. (2015). Unexpected levels of biological activity during the polar night offers new perspectives on a warming Arctic. *Current Biology* 25:1-7. http://dx.doi.org/10.1016/j.cub.2015.08.024

Berge J, Cottier F, Varpe Ø, Renaud PE, Falk-Petersen S, Kwasniewski S, Griffiths C, Søreide JE, Johnsen G, Aubert A, Bjærke O, Hovinen J, Jung-Madsen S, Tveit M, Majaneva S. (2014). Arctic complexity: a case study on diel vertical migration of zooplankton. *Journal of Plankton Research* 36:1279-1297. Doi 10.1093/plankt/fbu059

Berge, J, F. Cottier, KS. Last, Ø. Varpe, E.Leu, J. Søreide, K. Eiane, S. Falk-Petersen, K. Willis, H. Nygård, D. Vogedes, C. Griffiths, G. Johnsen, D. Lorentzen, AS. Brierley. 2009. Diel vertical migration of Arctic zooplankton during the polar night. *Biology Letters* 5(1): 69-72, doi:10.1098/rsbl.2008.048

2 - Why?

Despite expensive experimental work on conducting predation experiments with krill, we have not been able to document any active feeding by krill in the lab (Daase et al, unpublished and part of the Marine Night project). However, fecal pellets produced by both krill and

appendicularians were present in sediment traps deployed during the polar night (Berge et al 2015b, Last et al *in prep*), providing evidence of active predation by macrozooplankton. Also the high respiration rates by macrozooplankton (Berge et al 2015b) support this.
As part of the PhD work by J Grenvald, a molecular approach to detect predation have been employed. Guts from krill and *Calanus* spp have been dissected and DNA from its content extracted. At the moment, and because the PhD period of Grenvald is extended by 1 year due to an extensive sick leave, this dataset is not yet analyzed.

Conclusions:
Short provisional answer to the "why" question: Migrations during the polar night are driven by predation
Main publications on the "why" question:
Grenvald / Gabrielsen et al. Feeding of polar night active krill - using molecular tools. Manuscript under preparation.
Berge, J., Daase, M., Renaud, PE., Ambrose, WG., Darnis, G. et al. (2015). Unexpected levels of biological activity during the polar night offers new perspectives on a warming Arctic. *Current Biology* 25:1-7. http://dx.doi.org/10.1016/j.cub.2015.08.024
Callesen et al (to be submitted to PoBi for the Kongsfjorden SI). Distribution and abundance of small copepods and protozooplankton during the polar night: potential prey of migrating zooplankton?

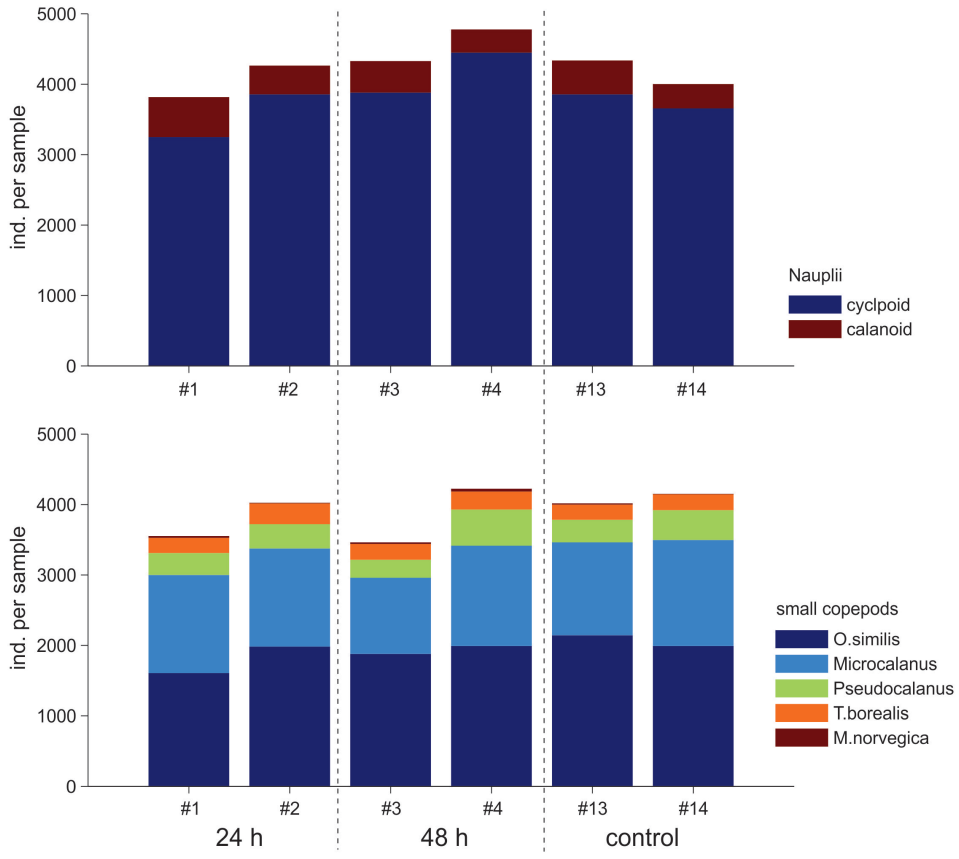

Figure 1: Feeding experiments with *Thysanoessa inermis* carried out in January 2016 by M Daase. Results indicate no or little predation of krill. The work was carried out as part of the Marine Night project.

3 - How?

During the project period, and especially following the initial field campaigns in the winters of 2012/13 and 2013/14, insight on the complex nature of the light climate during the polar night emerged (Cohen et al 2015, Berge et al 2015a). The first experimental work on *Calanus* spp demonstrated their ability to detect (and potentially respond to) extreme low levels of solar irradiation (Båtnes et al 2012). However, in order to examine the "how" question, extensive field measurements of natural light influenced by both the moon, aurora and solar background irradiance became a necessity. The work carried out from 2013/4 was performed in combination with the new UNIS course AB334 and three NFR projects (Marine Night - 226417, Arctic ABC – 244319 and Sensitivity of vision in high Arctic krill – 240721):

Light climate. Skylight measurements made during this project show clear changes in light intensity and spectral composition over the diel light cycle, even when the sun remains below the horizon (Figure 2). We used light measurements to parameterize a radiative transfer model that characterized the underwater light field during polar night. This is a major advance, as the hyperspectral light data needed for such models have never been collected from polar night time periods previously due to a lack of sensitivity in such instruments. The measurement approach we employed in this project should become a standard for obtaining such data in the future.

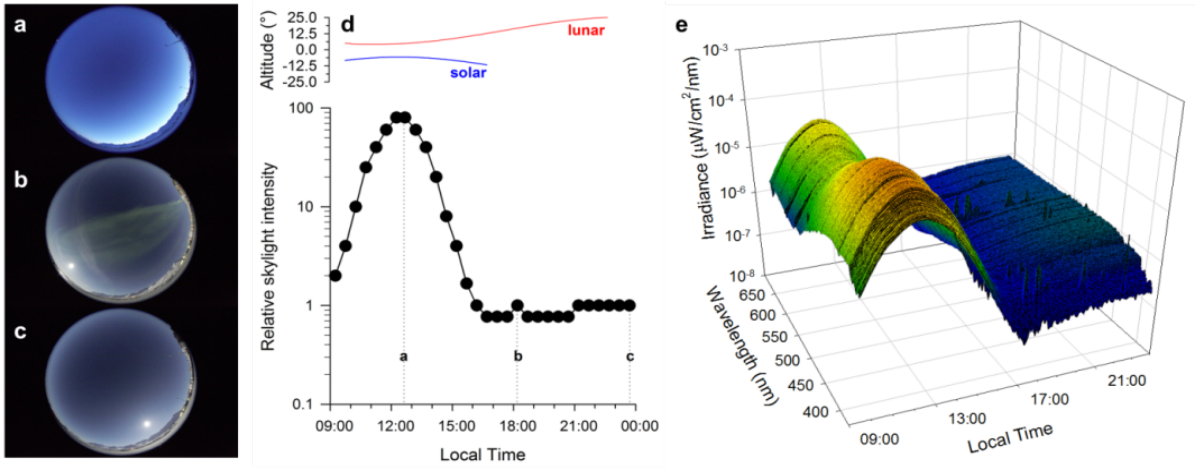

Figure 2. Irradiance over the diel cycle during polar night at Ny-Ålesund, Svalbard (79°N). a-c, All-sky images taken at 12:15 during solar noon (**a**), 18:15 during aurora activity (**b**), and at 23:45 during lunar noon (**c**); all are local time on February 2, 2015. **d**, solar (blue) and lunar (red) altitude over the measurement period, as related to relative skylight intensity calculated from full-sky camera images as the inverse shutter speed, with dotted lines showing time of images in **a-c**. **e**, Hyperspectral irradiance of diffuse skylight measured with the spectroradiometer concurrent with full-sky imagery in panels **a-d**. Color relates to irradiance, not wavelength; warm colors are higher irradiance. Spectral irradiance peaks at solar noon, and increases toward midnight as a full moon rises, with clear differences in spectral composition. Aurora peaks (558 and 630 nm) are evident in the spectral irradiance time series when there is aurora activity in all-sky images (e.g., **b**).

Krill vision under light and temperature treatments. Krill were collected in January 2015 from Kongsfjorden by oblique casts of a WP2 net from a Polar Cirkle. Immediately upon recovery of the net, animals were placed in a sealed bucket and kept in darkness until return to the Kings Bay Marine Laboratory at Ny-Ålesund. Once there, *Thysanoessa* were sorted under dim red light, and held in darkness for less than 2 weeks in flow-through water pumped from Kongsfjorden. Krill were held together without supplemental food, and individuals selected sequentially for use in visual physiology experiments. Temperature measured in the holding

tank at 5 s intervals throughout the holding period was 2.6 °C (± 0.1 °C, s.d.). Following electrophysiological experiments described below, each experimental subject was identified to species; all were *T. inermis*. Electroretinogram (ERG) recording was used to characterize (1) krill visual sensitivity from response-irradiance (V-LogI) curves, and (2) krill temporal resolution by maximum critical flicker fusion frequency (CFF_{max}). Equipment and experimental details were as described in detail elsewhere. Briefly, under dim red light an individual *Thysanoessa inermis* (body length = 13.0 ± 1.04 mm, SE, n=11) was glued by its dorsal carapace and eye stalk to an acrylic support with cyanoacrylate adhesive. The specimen was submerged in a temperature-controlled water bath within a light-tight Faraday cage, and then an epoxy-insulated tungsten microelectrode was positioned subcorneally by micromanipulator. Temperature in the water bath at the position of the animal's eye was measured constantly by thermocouple thermometer and maintained at either 1°C (± 0.5, n=6 replicate krill preparations) or 5°C (± 0.5, n=5 replicate krill preparations) throughout the duration of each experiment. For each temperature, an individual krill was initially acclimated to darkness, defined by a constant ERG magnitude over a period of 1 h in response to a dim test flash. A sensitivity (V-LogI) experiment was then conducted at the wavelength of maximum spectral sensitivity for *T. inermis* (490±7 nm, full width at half maximum; Cohen et al. 2015). Peak-to-peak response heights of the ERG waveform (V) were measured over a range of 100 ms light intensity flashes (Log irradiance; Log I) spanning several orders of magnitude, and modelled to determine the log irradiance evoking 50% of the maximum response amplitude (Log K). A temporal resolution experiment immediately followed, where the critical flicker fusion frequency (CFF) was determined from ERGs in response to square pulses from a flickering stimulus light. The frequency at which the eye could no longer respond to individual light flashes at a given irradiance level of 490 nm light was defined as the CFF for that intensity, and this was repeated at half-log intensity increases until CFF increased to a maximum and plateaued, yielding the maximum CFF (CFF_{max}). After Log K and CFF_{max} were determined for a dark-acclimated krill, that individual was acclimated to broadband blue light yielding $3x10^{10}$ photons cm^{-2} s^{-1} measured at the position of the krill eye. After a constant ERG magnitude was observed over a period of 1 h in response to a dim test flash, Log K and CFF_{max} were again determined for this individual, which remained in a constant state of light acclimation. Temperature and light treatments were compared by 2-factor ANOVA, and changes in CFF_{max} as a function of Log K were modelled by linear regression.

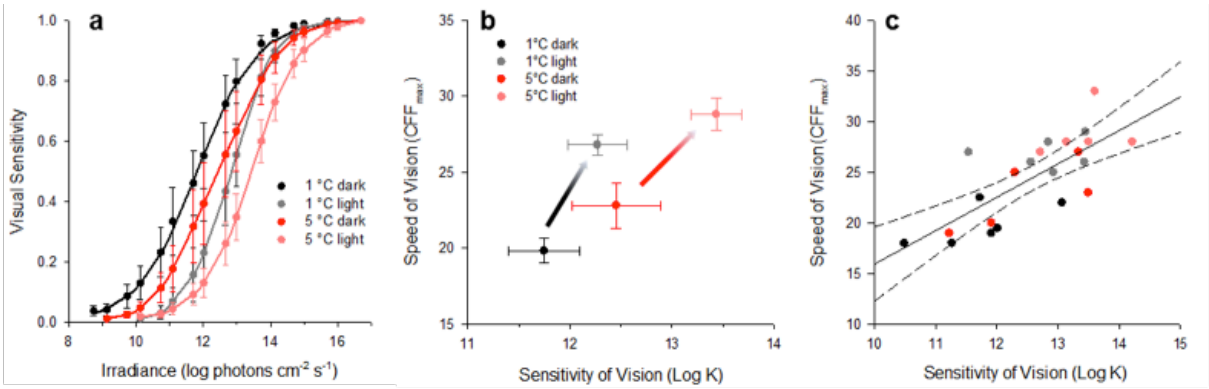

Figure 3. Visual physiology of Arctic krill *Thysanoessa inermis* under light and temperature acclimation. a-c, Experiments done in January 2015 at Ny-Ålesund show irradiance sensitivity in the form of VLogI curves that is dependent on temperature and light acclimation level (**a**), and temporal resolution (speed of vision, CFF_{max} in units of Hertz) that increases with reductions in irradiance sensitivity (i.e. increases in Log K, the half-saturation of curves in panel **a**) caused by temperature and light increases (**b**, **c**).

Light acclimation of the krill eye resulted in an overall decrease in their visual sensitivity and an increase in their visual speed (i.e., an increase in both Log K and CFF_{max}) (Figure 3). The effect of light acclimation on visual sensitivity was independent of temperature, and temperature alone did not result in sensitivity differences between 1°C and 5°C acclimations (2-factor ANOVA, $p = 0.007$ for light, $p = 0.060$ for temperature, $p = 0.924$ for light *x* temperature). Consistent with this, temperature coefficients for the mean increase in Log K suggest a minimal temperature effect ($Q_{10} = 1.2$ and 1.1, for dark- and light-acclimated eyes, respectively). In contrast, visual speed increased in krill with both light and elevated temperature acclimation, but again these effects were independent (2-factor ANOVA, $p = <0.001$ for light, $p = 0.024$ for temperature, $p = 0.622$ for light *x* temperature). Temperature coefficients for the mean increase in CFF_{max} ($Q_{10} = 1.4$ and 1.2, for dark- and light-acclimated eyes, respectively) suggest a greater temperature effect in dark-acclimated krill, but overall indicate a minor temperature effect on visual speed. Collectively, these measurements show that elevated light and temperature acclimation results in a concomitant increase in visual speed at the expense of visual sensitivity ($F_{1,20} = 26.474$, $p < 0.0001$) (Fig. 3b). Implications of this work are that seasonal and/or climatic changes in the light acclimation state and thermal state of krill will influence their ability to perceive light. A warmer and brighter environment leads to krill vision that is faster and less sensitive to illumination. We are currently developing numerical models to translate this physiological result into ecological consequences during the polar night period. Such changes to visual sensitivity could mean that krill are better able to perceive food and approaching predators. However, fish and bird predators might be better able to see krill prey if krill are shallower during the day due to these visual changes we predict.

Conclusions:

Short answer to the "how" question: Migrations during the polar night are directly regulated by small variations in ambient light

Main publications on the "how" question:

Grenvald et al. Does Arctic krill possess an internal clock gene involved in circadian rhythms during the polar night? Manuscript in preparation

Cohen, J.H., J. Berge, M.A. Moline, A.J. Sørensen, K. Last, S. Falk-Petersen, P.E. Renaud,E.S. Leu, J. Grenvald, F. Cottier, H. Cronin**, S. Menze, P. Norgren, Ø . Varpe, M. Daase, G. Darnis, G. Johnsen (2015) Is ambient light during the high Arctic polar night sufficient to act as a visual cue for zooplankton? *PLOS One* 10(6): e0126247. DOI 10.1371/journal.pone.0126247.

Berge, J., M. Daase, P. Renaud, W.G. Ambrose, Jr., G. Darnis, K.S. Last, E. Leu, J.H. Cohen et al (2015) Unexpected levels of biological activity during the polar night offers new perspectives on a warming Arctic. *Current Biology* 25:1-7.

Cohen, J.H., J. Berge, M.A. Moline, G. Johnsen (2016, upcoming) Elevated ambient light and temperature constrain light perception in Arctic krill. *Ocean Science Meeting*, New Orleans, LA.

4 – Where?

As part of the original *CircA* proposal, a project funded in the UK named "PanArchive" headed by Dr F Cottier (SAMS and UiT) was included. The main idea was to take advantage of any available data sets across the Arctic to examine wether the patterns of DVM observed in Svalbard is of relevance at a large geographical scale. Using a wide set of acoustic data from Acoustic Doppler Current Profilers, we have been looking into the behaviours of zooplankton during the Polar Night, with particular focus on these behaviours on a pan-Arctic scale. One of the most interesting observations was that zooplankton respond to two lunar cycles – both the moon phase and the lunar altitude. This observation was first made at Kongsfjorden, but was then detected at mooring stations right across the Arctic Ocean. The existence of a lunar mediated cycle for a few days every month suggests a more active community than previously thought, and will alter the carbon transport and predator-prey interactions within the system. We also see variation in how strong the lunar response is, found to be related to the timing of the full moon and how high the moon is in the sky. These fine details of the effect of the moon were not understood prior to the CircA project. Multi-frequency acoustics have been used to investigate the type of zooplankton remaining active in the winter, and whilst there is variation in the strength of synchronicity, we see that all abundant groups (euphausiid, copepods, chaetognaths) perform synchronized DVM in January. Working with other members of the CircA project, there has also been extensive work to link together acoustic, VPR, net, and sediment trap data to gain an overall "multi-platform" understanding of Arctic fjord ecosystems. The pan-Arctic approach of my PhD has contributed primarily to the original "where" aspect of the CircA project, and we see that winter lunar responses occur right across the Arctic Ocean, suggesting that communities remain active to at least some extent irrelevant of location, water depth, or ice cover.

<u>*Conclusions:*</u>

Short answer to the "where" question: The patterns first detected on Svalbard has relevance across the entire Arctic and in all marine habitats including fjords, shelf, deep sea and ice covered waters.

Main publications on the "where" question:

Last, K., Hobbs, L., Berge, J., Brierley, A., Cottier, F. (2016). Moonlight drives ocean scale mass vertical migration of zooplankton during the Arctic winter. *Current Biology*. 26, 1-8. DOI 10.1016/j.cub.2015.11.038

Hobbs, L. Thesis to be submitted in Feb/March 2016.

5 – What?

We assessed the role of zooplankton synchronized DVM in the functioning of the biological pump of the high-Arctic Kongsfjorden marine ecosystem. In particular, we studied the active transport to depth of dissolved carbon (C) and nitrogen (N) during the transition from polar night to early autumn (January-September 2014). The multifrequency acoustics time series from a moored echosounder revealed that the two periods of clear synchronous DVM occurred before and after the season of intensive primary production and maximum sinking flux of particulate carbon (POC) and nitrogen PON. The mismatch between DVM periods and peak biological production likely reduces the contribution of DVM to vertical fluxes of elements at high latitudes. However, climate change is expected to increase the DVM-phytoplankton bloom coupling and, thus, the function of DVM in the biogeochemical cycling of C and N in and around Svalbard fjords. The euphausiids *Thysanoessa* dominated largely (>90%) the zooplankton diel migrant biomass and contributed 75% of the 0.8 C m^{-2} d^{-1} transported by DVM below 80 m during winter. However, large copepods DVM contributed 73% of the N transported to depth. The total DVM-mediated translocation of C and N represented 22 and 33% of the sinking POC and PON flux, respectively. This suggests that, despite much complex migration patterns due to the extreme Arctic light regime, the importance of the active C and N transport accounted for by DVM in the biological pump of Kongsfjorden is similar to what is found in lower latitude regions of the global Ocean.

Conclusions:

Short answer to the "what" question: DVM of zooplankton may have a significant impact on the biological carbon pump, but its effect depend to a large degree on the physical environment with stratification being one of the main factors.

Main publications on the "what" question:

Darnis, G., Hobbs, L., Geoffroy, M., Grenvald, J.C., Renaud, P.E., Berge, J., Cottier, F., Daase, M., Søreide, J., Kristiansen, S., Wold, A., Morata, N., Gabrielsen, T., (in preparation for Limnology and Oceanography). From polar night to midnight sun: diel vertical migration, metabolism and biogeochemical role of zooplankton in a high Arctic fjord (Kongsfjorden, Svalbard).

Darnis, G., Daase, M., Geoffroy, M., Renaud, P.E., Berge, J. (in preparation). Zooplankton fecal pellet sinking flux during the transition from winter to spring in a high-Arctic Svalbard fjord, Kongsfjorden.

List of publications, outreach and talks associated to the project:

Peer reviewed papers (all project members) and MSc/PhD theses:

2016

Kim S. Last, Laura Hobbs, Jørgen Berge, Andrew S. Brierley, Finlo Cottier. Moonlight Drives Ocean-Scale Mass Vertical Migration of Zooplankton during the Arctic Winter. Current Biology (2016).doi:http://dx.doi.org/10.1016/j.cub.2015.11.038

2015

Berge J, Daase M, Renaud PE, Ambrose Jr WG, Darnis G, Last KS, Leu E, Cohen JH, Johnsen G, Moline MA, Cottier F, Varpe Ø, Shunatova N, Bałazy P, Morata N, Massabuau J-C, Falk-Petersen S, Kosobokova K, Hoppe CJM, Węsławski JM, Kukliński P, Legeżyńska J, Nikishina D, Cusa M, Kędra M, Włodarska-Kowalczuk M, Vogedes D, Camus C, Tran D, Michaud E, Gabrielsen TM, Granovitch A, Gonchar A, Krapp R, Callesen TA (2015). Unexpected Levels of Biological Activity during the Polar Night Offer New Perspectives on a Warming Arctic. Current Biology. doi:10.1016/j.cub.2015.08.024

Kraft A, Graeve M, Janssen D, Greenacre M, Falk-Petersen S (2015). Arctic pelagic amphipods: lipid dynamics and life strategies. Journal of Plankton Research. doi:10.1093/plankt/fbv052

Varpe Ø, Daase M, Kristiansen T (2015). A fish-eye view on the new Arctic lightscape. ICES Journal of Marine Science. doi: 10.1093/icesjms/fsv129

Jonathan H. Cohen, Jørgen Berge, Mark A. Moline, Asgeir J. Sørensen, Kim Last, Stig Falk-Petersen, Paul E. Renaud, Eva S. Leu, Julie Grenvald, Finlo Cottier, Heather Cronin, Sebastian Menze , Petter Norgren, Øystein Varpe, Malin Daase, Gerald Darnis, Geir Johnsen (2015). Is Ambient Light during the High Arctic Polar Night Sufficient to Act as a Visual Cue for Zooplankton? PLoS ONE 10 (6). DOI: 10.1371/journal.pone.0126247

Sam Eglund Newby: Feeding activity and diet of Arctic and boreal fish species during the Polar night (2015), MSc thesis. PDF

2014

Polar Biology special issue on Polar Night, coordinated by Ole Jørgen Lønne (online first articles)

Falk-Petersen S, Pavlov V, Berge J, Cottier F, Kovacs KM, Lydersern C. At the rainbow's end: high productivity fueled by winter upwelling along an Arctic shelf (2014). DOI: 10.1007/s00300-014-1482-1

Johnsen G, Candeloro M, Berge J, Moline M. Glowing in the dark: discriminating patterns of bioluminescence from different taxa during the Arctic polar night (2014). DOI 10.1007/s00300-014-1471-4

Båtnes AS, Miljeteig C, Berge J, Greenacre M, Johnsen G: Quantifying the light sensitivity of

Calanus spp. during the polar night: potential for orchestrated migrations conducted by ambient light from the sun, moon, or aurora borealis? (2013). DOI: 10.1007/s00300-013-1415-4

Brown TA, Hegseth EN, Belt ST: A biomarker-based investigation of the mid-winter ecosystem in Rijpfjorden, Svalbard (2013). DOI:10.1007/s00300-013-1352-2

Morata N, Søreide JE: Effect of light and food on the metabolism of the Arctic copepod Calanus glacialis (2013). DOI:10.1007/s00300-013-1417-2

Morata N, Michaud E, Włodarska-Kowalczuk M: Impact of early food input on the Arctic benthos activities during the polar night (2013). DOI:10.1007/s00300-013-1414-5

Webster CN, Varpe Ø, Falk-Petersen S, Berge J, Stübner E, Brierley AS: Moonlit swimming: vertical distributions of macrozooplankton and nekton during the polar night (2013). DOI:10.1007/s00300-013-1422-5

Not in special issue:

Berge, J, F. Cottier, Ø. Varpe, P.E. Renaud, S. Falk-Petersen, S. Kwasniewski, C. Griffiths, J.E. Søreide, G. Johnsen, A. Aubert, O. Bjærke, J. Hovinen, S. Jung-Madsen, M. Tveit, S. Majaneva (2014). Arctic complexity: a case study on diel vertical migration of zooplankton. Journal of Plankton Research. DOI: 10.1093/plankt/fbu059

Sainmont J., A. Gislason, J. Heuschele, C. N. Webster, P. Sylvander, M. Wang, Ø. Varpe. Inter- and intra-specific diurnal habitat selection of zooplankton during the spring bloom observed by Video Plankton Recorder (2014). Marine Biology. DOI: 10.1007/s00227-014-2475-x

Darnis, G. and Fortier, L. (2014) Temperature, food and the seasonal vertical migration of key arctic copepods in the thermally stratified Amundsen Gulf (Beaufort Sea, Arctic Ocean). *J. Plankton Res.,* DOI:10.1093/plankt/fbu035.

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Wallace M, Cottier F, Brierley A, Tarling G (2013) Modelling the influence of copepod behaviour on fecal pellet export at high latitudes. Polar Biology 36:579-592. DOI:10.1007/s00300-013-1287-7

Weydmann, A., J.E. Soreide, S. Kwasniewski, E. Leu, S. Falk-Petersen, J. Berge (2013). Ice-related seasonality in zooplankton community composition in a high Arctic fjord. *Journal of Plankton Research* 2013; DOI: 10.1093/plankt/fbt031

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Berge J, Båtnes AS, Johnsen G, Blackwell SM, Moline MA (2012). Bioluminescence in the High Arctic during the Polar Night. *Marine Biology* DOI 10.1007/s00227-011-1798-0

Berge, J., Gabrielsen, TM., Moline, M., Renaud, P.E. (2012). Evolution of the Arctic Calanus complex – an Arctic marine Avocado? Journal of Plankton Research 34(3):191-195. DOI: 10.1093/plankt/fbr103

Berge, J., Varpe, Ø., Moline, M.A., Wold, A., Renaud, P.E., Daase, M., Falk-Petersen, S. (2012). Retention of ice-associated amphipods: possible consequences for an ice-free Arctic Ocean. *Biology Letters* DOI: 10.1098/rsbl.2012.0517

Talks and posters

2015

Oban project meeting (CircA, Marine Night, ArcticABC)

UK-Norway cooperation workshop: All 5-min talks in one zip-file (ZIP)

Asgeir Sørensen: Automated vehicles in Arctic marine research (PDF)

Anya Gonchar: Svalbard seabird parasites as seen during the marine night (PDF)

Paul Wassmann: On pan-Arctic future production scenarios (PDF - password protected, meeting participants only, 65 MB!)

Gerald Darnis: From polar night to midnight sun: diel vertical migration, metabolism and biogeochemical role of zooplankton in a high Arctic fjord (Kongsfjorden, Svalbard) (PDF)

Ingrid Ellingsen: SINMOD - Consequence module-coupled physical and biological models (PDF)

Paul Renaud: Norwegian (and Polish) contribution to Marine Night campaigns 2014-2015 (PDF)
Nathalia Shunatova: Marine Night: Russian activities (PDF)
Marine Cusa: Effects of seasonality and spatial heterogeneity on Polar cod (*Boreogadus saida*) diet in Svalbard waters (PDF)
Kathrin Keil: Overview Arctic Governance & Workplan ArcticABC (PDF - password protected, meeting participants only)
Maxime Geoffroy: AUV-based acoustic observations of the summer distribution and patchiness of zooplankton in Spitsbergen (PDF)
Maxime Geoffroy: Does zooplankton react to solar eclipses? (PDF)
Jon Cohen: Light and vision in the polar night (PDF - password protected, meeting participants only)
Njord Wegge: ArcticABC and geopolitics (PDF)
Kim S Last: Where the sun doesn't shine (PDF)
Neil Banas: From climate to top predators via a diverse, adaptable plankton community: new model approaches (PDF)
Jørgen Berge: Arctic Ocean Ecosystems - Applied technology, Biological interactions adn Consequencess in an era of abrupt climate change (Arctic ABC) (PDF)
Hans Kristian Djuve - The Arctic 4 km model and particle tracking (PDF)

2014

Arctic Change conference in Ottawa (Canada):

Kim S. Last: Werewolves in the dark - moonlight structures Arctic zooplankton communities in space and time during the polar night (PDF)
Finlo Cottier: Winter vertical migration across the Arctic: Seeking the pan-Arctic view (PDF)
John Cohen: There is light in the dark: Bioluminescence in the high Arctic polar night (PDF)
Jørgen Berge: In the dark: paradigms of Arctic ecosystems during polar night challenged by new understanding (PDF)
Maline Daase: How much for the night? - Energetic costs of overwintering for the Arctic copepod *Calanus glacialis* (PDF)
Øystein Varpe. Session organisation: Integrated studies of the impact of climate change on marine ecosystems. IMBER, Bergen. April 2014.
Gérald Darnis, Julie Cornelius Grenvald, Laura Hobbs, Finlo Cottier, Jørgen Berge, Paul Renaud, Janne Søreide and Stig Falk-Petersen. 2014. Diel variation in the vertical distribution of arctic mesozooplankton during the polar night. IMBER Open Science Conference, Bergen, Norway, 23-27 June (Poster, IMBER, Bergen. PDF).

2013

Malin Daase, Stig Falk-Petersen, Øystein Varpe, Vladimir Pavlov, and Jørgen Berge 2013. Polar night ecology and oceanography: findings from the January cruise at 82°N. Arctic Frontiers 2013.
Anna Maria Kubiszyn, Katarzyna Blachowiak-Samolyk, Józef Maria Wiktor, Else Nøst Hegseth and Stig Falk-Petersen. 2013. Winter Tales - a dark side of planktonic life. Poster at Arctic Frontiers 2013.

Janne E. Søreide, Michael L. Carroll, Haakon Hop, William G. Ambrose Jr., Else N. Hegseth, and Stig Falk-Petersen 2013.Trophic structures and carbon flows in Arctic and Atlantic waters around Svalbard revealed by stable isotopic and fatty acid tracers. Arctic Frontiers 2013. Oral presentation
Julie C. Grenvald 2013. Diel vertical migration (DVM) of marine zooplankton in the polar night: who, how and why? (PDF)
Jørgen Berge 2013. Retention of ice associated fauna in a future Arctic Ocean void of summer sea ice (invited seminar). Invited lecture at Scottish Association of Marine Science, May 2013
Jørgen Berge 2013. Polhavet. Invited talk at the Norges Vitenskabs Akademi, Oslo April 2013
Øystein Varpe 2013. Optimal life-histories in seasonal environments: modeling copepod strategies. International workshop on Trait-based approaches to ocean life. Copenhagen 26-28 August 2013. Link for poster: http://www.trait-based-workshop.dk/upload/oceanlife/workshop-august2013/poster-oysteinvarpe.pdf
Øystein Varpe, Eike Stübner, Jasmine Nahrgang, Clare Webster, Paul E Renaud, Stig Falk-Petersen, Jørgen Berge 2013. The diet of a polar-night fish community: visual predators feeding in darkness? Arctic Frontiers, January 2013, Tromsø, Norway.
Finlo Cottier 2013. Fjord Exchange Processes: Gordon Research Conference on Coastal Ocean Circulation

2012

Jørgen Berge. Retention of ice associated fauna in a future Arctic Ocean void of summer sea ice (invited seminar). Framcenter, Dec 2012
Jørgen Berge. Retention of ice associated fauna in a future Arctic Ocean void of summer sea ice (invited talk). Arctic Days, Brest (France) Nov 2012
Finlo Cottier 2012. Arctic Oceanography - A view from the coast: Arctic Days 2012, European Institute for Marine Studies (IUEM, France) workshop on Arctic marine ecology.

Outreach

2016

Mørkets fyrster - med påskrudd lys (Framsenteret 29.01.2016)
Nye mysterier avdekkes i Polhavet (Aftenposten Viten 12.01.2016)
News stories about the findings presented in the Current Biology paper about "werewolves" in the Polar Night
Moonlight helps plankton escape predators during Arctic winters (New Scientist 07.01.2016)
Do blame it on the moonlight: Arctic plankton boogie to the moon (Scimex 08.01.2016)
Tiny Marine Critters Migrate In The Arctic Winter Using Moonlight (IFLScience 07.01.2016)
Arctic Winter: Marine Creatures Migrate By Moonlight During Arctic Winter, Study Says (HNGN 08.01.2016)
Moonlight Drives Zooplankton’s Winter Migrations (The New York Times

08.01.2016)
Arctic animals navigate by light of the winter moon (UPI 07.01.2016)
'Werewolf' creatures in the Arctic navigate by the cycle of the MOON: During dark winter months plankton migrate in lunar cycles (Daily Mail 07.01.2016)
Artico, animali marini stregati da Luna (Corriere 07.01.2016)
Arctic animals navigate by light of the winter moon (Breitbart news 07.01.2016)
In Arctic winter, marine creatures migrate by the light of the moon (07.01.2016 MyWebMemo)
Marine Creatures Migrate by Moon's Light During Arctic Winter (Laboratory Equipment 07.01.2016)
Biologists make surprise discovery among plankton in the Arctic (Herald Scotland 07.01.2016)
'Werewolf' creatures in the Arctic navigate by the cycle of the MOON: During dark winter months plankton migrate in lunar cycles (One News Page 07.01.2016)
'Werewolf' creatures in the Arctic navigate by the cycle of the MOON: During dark winter months plankton migrate in lunar cycles (Singapore News 07.01.2016)
Moonlight drives marine creatures in Arctic winter (Siasat 11.01.2016)
Arctic animals navigate by the light of winter Moon (India Today 11.01.2016)
Arctic Animals Navigate By The Light Of Winter Moon: Study (NDTV 11.01.2016)
Arctic animals navigate by the light of winter Moon (The Economic Times 11.01.2016)
Moonlight Drives Marine Creatures in Arctic Winter (Vishwa Gujarat 11.01.2016)
Moonlight drives mass migration in Arctic winter (Infoyu 11.01.2016)
During Arctic Winters, Active Marine Creatures Migrate By Moonlight (Nature World News 08.01.2016)
Oban scientists discover moonlight winter ocean travellers (Press and Journal 08.01.2016)
Moonlight migration discovered (FishnewsEU.com 08.01.2016)
In Arctic winter, marine creatures migrate by the light of the moon (EurekAlert! 07.01.2016)
Moonlight drives marine creatures in Arctic winter (Udaipur Kiran 11.01.2016)
Zooplankton Migrate By Moon Light During Arctic Winter (Science World Report 11.01.2016)
Study finds arctic creatures navigate by the light of winter moon (Bulletin India 11.01.2016)
Arctic animals navigate by the light of winter Moon (News Nation 11.01.2016)
Migrazioni al chiaro di Luna per lo zooplancton dell'Artide (Le Scienze 12.01.2016)
In Arctic winter, marine creatures migrate by the light of the moon (Phys.org 07.01.2016)
Moonlight drives marine creatures in Arctic winter (Big News Network 11.01.2016)
Månesyke for plankton i Arktis (Forskning.no 09.01.2016)
In Arctic winter, marine creatures migrate by the light of the moon (eScience news 07.01.2016)
In Arctic winter, marine creatures migrate by the light of the moon (Science Codex

07.01.2016)
Polar Moondance: Decades of acoustic data reveal surprising migration patterns of zooplankton in the Arctic winter. (Meta Science News 07.01.2016)
El zooplancton del Ártico migra bajo la luz de la luna (Sinc 07.01.2016)
Moonlight drives marine creatures in Arctic winter (Indio Asian News Service 11.01.2016)
In Arctic winter, 'werewolves of the deep' hunt by moonlight (The Christian Science Monitor 11.01.2016)
Moonlight drives marine creatures in Arctic winter (Daijiworld 11.01.2016)
Moonlight Drives Migration Of Marine Animals In Arctic Winter (Tech Times 13.01.2016)
SAMS scientists discover moonlight driving ocean ‘werewolves’ to gather for Arctic Ocean winter odyssey (Forargyll.com 01.2016)
Forskning viser at arktiske dyreplankton er påvirket av fullmånen (Nordlys 12.01.2016)
Plankton i Arktis kan bli viktig for framtidas klimamodeller (NRK Nordland 17.01.2016)

2015

2015 Liv og lys i mulm og mørke (Biolog 04/2015 PDF)
2015 News stories about the findings presented in the Current Biology paper on biological activity in the polar night
Life bustles in the long Arctic night (Hakai magazine 04.11.2015)
L’Arctique ne dort jamais (Sciences et avenir 30.09.2015, French)
A téli éjszaka alatt is aktív a Jeges-tenger élővilága (Hirado.hu 28.09.2015, Hungarian)
No sleeping with the fishes during dark polar night (Christian Science Monitor 25.09.2015)
Arktis: Highlife in der Polarnacht (Spektrum 25.09.2015, German)
Life in the polar ocean is surprisingly active in the dark winter (Sciencenews.org 28.09.2015)
L'inaspettato fervore di vita nell'inverno polare (Le Scienze 25.09.2015, Italian)
Arctic ocean's wakeful winter revealed (BBC news 24.09.2015)
What goes on in the waters of the Arctic during the long, dark polar winter - video (BBC Science News Facebook 25.09.2015)
Creatures are busy in the polar night (Redcube 01.10.2015)
Yrende polarliv er truet av klimaendringer (Forskning.no 30.09.2015, Norwegian)
Polar Winter - Video (Bellmedia 28.09.2015, starting at 06:20, available until 27.11.2015)
'Unexpected' Arctic night life found by Bates biologist Will Ambrose and fellow researchers (Bates.edu 01.10.2015)
Liv på högvarv i polarmörkret (VF 01.10.2015, Swedish, PDF)
Unterwasser-Zeitraffervideo: Wie Raubschnecken einen Kabeljau zersetzen (Spiegel Online 30.09.2015)
The dark winter months of the Arctic found to be a hive of activity (IFLScience!

26.09.2015)
Arctic polar night isn't for sleep, researchers say (Sci-news.com 25.09.2015)
Munteres Treiben im Dauerdunkel (Die Welt 28.09.2015, German, PDF)
2015 News stories about new fish species in Svalbard waters
NRK P2 Nyhetslunsj 13.08.2015 (Stream - start at 14:00 Norwegian)
APTV Nye arter kommer med varme havstrømer 12.08.2015 (Videostream, Norwegian)
Svalbard - forskernes viktige klimalaboratorium 13.08.2015 (Forskning.no)
Nye arter kommer med varme havstrømmer (Sunnmørsposten 14.08.2015)
Nye arter strømmer til Svalbard (Nordlys ekstra 14.08.2015)
Svalbard - viktig for klimaforskerne (Tønsberg blad 14.08.2015)
I denne bøtte ser du hvordan klimaet endres (Dagen 17.08.2015)
På Svalbard ser de resultatet raskt av klimaendringene (Avisa Nordland 14.08.2015)
2015 News stories about blue mussles and what we can learn about past climate
Blåskjell forteller klimahistorie på Svalbard (Tønsbergs blad 29.06.2015)
Blåskjell forteller historie (Telemarksavisa 30.06.2015)
Forteller klimahistorie på Svalbard (Nationen 29,06.2015)
Blåskjell forteller klimahistorie (Klassekampen 29.06.2015)
Blåskjell som klimaguide (Helgelendingen 11.06.2015)
Blåskjell forteller klimahistorie (Haugesund Avis 29.06.2015)
Blåskjellene er tilbake (Nordlys Ekstra 29/06/2015 - PDF Norwegian)
2015 Circa project summary leaflet (PDF)
2015 Jørgen Berge: Svalbardposten 19/06/2015 - Det hemmelige livet i mørketida (PDF)
2015 Jørgen Berge: Labyrinth 06/2015 - Hvorfor valgte du den mørke polarnatta (PDF)
2015 Outreach cruise w/ Helmer Hanssen (blog)
2015 Jørgen Berge: Naturen (3/2015)- Et sted der ute venter noe fantastisk på å bli oppdaget! (PDF Norwegian)
2015 NRK nordnytt (TV): Polar Night i USA (Video)
2015 Anohorage Museum (exhibition): Polar NIght: LIfe and Light in the dead of night (English)
2015 Polarnatt i Alaska
(Norwegian): https://uit.no/nyheter/artikkel?p_document_id=419622&p_dim=
2015 Polar Museum Tromsø (online exhibition catalogue): "Life and light in the dead of night" (English/Norwegian)
2015 Polar Museum Tromsø (exhibition): "Life and light in the dead of night" (English/Norwegian)
2015 Enabling technology for Arctic research (Science & Technology 15, PDF)
2015 News stories about the total Eclipse and its effects on zooplankton
Svalbardposten
Fram Center (I)
Fram Center (II)
NRK

Forskning.no
RUV (Iceland)
Kyst og Fjord
2015 Paul Renaud: Setting the stage (Science & Technology 14)
2015 Blåskjell og makrell på Svalbard sjokkerer forskere (Aftenposten Viten online 19.01.2015)
2015 News stories about the Marine Night campaign in Kongsfjorden in January
UiT.no: http://uit.no/nyheter/artikkel?p_document_id=401056&p_dim
UiT.no
(II): http://uit.no/om/enhet/aktuelt/nyhet?p_document_id=405298&p_dimension_id=88163&p_menu=28723
UiT.no (III): "Polarnatt til USA" (Norwegian)
NRK.no: http://www.nrk.no/viten/havet-i-arktis-syder-av-liv-1.12177241
NRK (radio): Morra i NRK P1 (Norwegian)
Ny Teknik: PDF Blog 1 Blog 2 Blog 3 Blog 4 Blog 5
Svalbardposten: http://www.svalbardposten.no/index.php?page=vis_nyhet&NyhetID=5529&sok=1
Deutsche Welle (DW): Radio program English online news German online news
Nordlys: http://tinyurl.com/polarnatt-nordlys
The Wilmington News Journal: PDF
NRK radio (I): http://radio.nrk.no/serie/norgesglasset/DMPA01001815/26-01-2015#t=32m
NRK radio (II): MP3

2014

2014 Jørgen Berge: The high life. Pan European Networks. http://www.paneuropeannetworks.com/ST11/#258
2014 Jørgen Berge, Finlo Cottier: The light of cooperation. Pan European Networks. http://www.paneuropeannetworkspublications.com/ST13/#226/z
2014 Jørgen Berge. Sosialdemokratiet (i havet) står for fall? 10 Oct 2014. PDF
2014 Janne Søreide. Resilient to climate change? Pan European Networks - Science and Technology. http://www.paneuropeannetworkspublications.com/ST12/#254
2014 News stories about the Marine Night campaign in Kongsfjorden in January
Forskning.no: http://www.forskning.no/artikler/2014/januar/379682
National Geographic: http://newswatch.nationalgeographic.com/2014/02/16/the-vibrant-ecosystem-of-the-polar-night/
Gemini.no: http://gemini.no/2014/02/avslorer-mysterier-i-polarnatta/
Framsenteret: http://www.framsenteret.no/avsloerer-mysterier-i-polarnatta.5415160-146437.html#.UvicHfl5M40
Framsenteret II: http://www.framsenteret.no/framogram-9-science-in-the-dark.5415217-146436.html#.Uvibqvl5M40
High North News: http://www.highnorthnews.com/avslorer-mysterier-i-polarnatta/
Aftenposten: http://www.aftenposten.no/viten/Pa-jakt-etter-havets-morke-mysterier-i-polarnatten--7443604.html#.UuEzObQ1jIU
Svalbardposten: http://svalbardposten.no/index.php?page=vis_nyhet&NyhetID=4225

Svalbardposten II: PDF
Svalbardposten III: PDF
Mornington News (Australia): PDF / Online
Marine Night campaign on P2 radio "Ekko". 06 Jan 2014. Podcast available for download here (start at approx 00:58)
Blog by Amelia Travers: Online
Blog by the Marine Night participants: Online
2014 Mare Incognitum (Science and Technology 10, PDF)

2013

2013 Jørgen Berge. Kløna på havbunnen. Forskning.no 24 Dec 2013. Online.
2013 Jørgen Berge. Hodet under vannet. Nordlys, 09 Sept 2013. Online and PDF.
2013 Jørgen Berge. Radio interviews with NRK (P2), France Culture (three broadcasts), RTL France (four broadcasts) and France24 in relation to Arctic Frontiers 2013 and a polar night cruise with RV *Helmer Hanssen* in January 2013
2013 Jørgen Berge. Svalbardposten 22 February 2013. *Mørkets hemmeligheter*. Two-page popular science article.
2013 Jørgen Berge. Radio interview with NRK P2 regarding a news story on Antarctic isopods (March 2013).
2013 Jørgen Berge. Aftenposten May 10, 2013 “Overlever med jukselys”. Science report on bioluminescent zooplankton.

2012

2012 Jørgen Berge. “Isfauna i et isfritt Arktis” (2012) in NRK radio, Nordlys and Forskning.no. Later appeared in >15 National and International media, including BBC Magazine, Wall Street Journal, Canada Free Press, Life Science, vitenskab.dk.
2012 Polar Night cruise 8-21 January:
Interview of Stig Falk-Petersen with NRK1 by Lars Egil Mogårde - Polarnatt tokt (12/2011)
Interview with Stig Falk-Petersen by Egil Pettersen. TV 2 at 21:00 news. http://www.tv2.no/nyheter/innenriks/aate-kan-forklare-polargaate-3677139.html (01/2012)
Reports from the Polar Night. TV2 Magasinet. http://www.tv2.no/nyheter/magasinet/dette-fant-forskerne-for-foerste-gang-i-nord-3700666.html (02/2012)
Stig Falk-Petersen et al. Polar night cruise blog at University of Tromsø http://blogg.uit.no/aba001/ (12/2012)
Stig Falk-Petersen et al. Article on NRK website: "Oppdaget ukjent massedød i isødet" http://www.nrk.no/nyheter/distrikt/troms_og_finnmark/1.7960421 (01/2012)
Stig Falk-Petersen et al. News article on Norwegian Polar Institute website: Unik funn fra havets bunn http://www.npolar.no/no/nyheter/2012/2012-01-19-tokt-i-polarnatta.html (01/2012)
2012 News stories connected to the publication of the "Nemo hypothesis" by Berge et al. 2012 (>900 hits on Google and >50 hits on Bing as of 10/2013)
Lifescience.com http://www.livescience.com/23101-ice-loving-crustaceans-ride-arctic-conveyer-belt.html

MSNBC.com http://www.msnbc.msn.com/id/48995407/ns/technology_and_science-science/
Nature.com http://www.nature.com/news/ice-loss-shifts-arctic-cycles-1.11387
Discovery.com http://news.discovery.com/earth/cold-crustaceans-hitch-deep-sea-rides-120912.html
Alaskadispatch.com http://www.alaskadispatch.com/article/tiny-arctic-crustaceans-may-be-riding-wave-climate-change
Sciencedaily.com http://www.sciencedaily.com/releases/2012/09/120914082552.htm
Weatherzone.com
http://forum.weatherzone.com.au/ubbthreads.php/topics/1126935/Re_Antarctic_Sea_Ice
PanEuropeNetworks.com http://www.paneuropeannetworks.com/environment/currents-used-by-crustaceans-to-survive-ice-melts/
University of Delaware Udel.edu http://www.udel.edu/udaily/2013/sep/arctic-migration-091312.html
Sciencenordic.com http://sciencenordic.com/arctic-species-will-survive-less-ice
UNIS.no
http://www.unis.no/60_NEWS/6080_Archive_2012/n_12_09_12_reduced_sea_ice/less_consequences_news_12092012.htm
Forskning.no http://www.forskning.no/artikler/2012/september/334605