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Supporting Information for

Net community production in the bottom of first-year sea ice over the Arctic spring bloom

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Introduction

This document contains additional text outlining i) details on the collection and processing of ice samples, ii) the set-up and procedure of calculating net community production from oxygen optodes, and iii) methods for determining variables associated with light intensity. Also

included is a table that summarizes biological and environmental variables in Phases I and II of this study.

S1. Ice core collection and processing

The bottom 0.05 m of six to eight ice cores were collected under a uniform snow cover using a 0.09 m *Mark II Kovacs* core barrel, as the majority of chlorophyll *a* (chl *a*) is typically located in the bottom 0.03 to 0.05 m [Horner, 1985; Mundy et al., 2005; Galindo et al., 2014]. Core segments were pooled together, transported to laboratory facilities and diluted with 0.2 µm filtered seawater at a ratio of about three parts filtered seawater to one part ice, to minimize osmotic stress during the 24 h melt period in darkness [Garrison & Buck 1986]. Although, we note that the extended time period in darkness required for diluted melt could have affected algal photophysiology and amplified any potential impacts of grazing. The melted sea ice and filtered seawater solution was subsampled for all biological parameters, where measurements represent an average response of the bottom-ice community at that particular sample location. Unfortunately, due to the destructive nature of ice core sampling, variability may have been introduced into our time series of results from the routine selection of new sites. However, the standard deviations of chl *a* from 6 to 8 ice cores were characteristically <50%, which suggests that this was an adequate number of samples to characterize the mean.

S2. Oxygen optode incubations

Melted ice samples were incubated at approximately -1.5°C for 70 hours in four 500 ml *Wheaton* borosilicate glass bottles equipped with routinely calibrated 10 mm robust *Firesting* oxygen optodes. One bottle was incubated in darkness, while the other three were exposed in sequence to a *Hiralite* full spectrum Light Emitting Diode (LED) that created incubation light

intensities of approximately 10, 21 and 55 µmol m^{-2} s^{-1}, respectively. These light intensities were specifically measured for every incubation using a scalar PAR probe (*Walz* model US-SQS/L). Throughout the incubations customized stir plates mixed samples and oxygen concentration was recorded every second by the optodes. These measurements were later averaged on an hourly basis before net community production was calculated as the change in oxygen over time relative to initial concentrations (T_0) (µmol O_2 l^{-1} h^{-1}) [Campbell et al., 2016]. Campbell et al. [2016] found no statistical difference between measurements of gross primary production from this oxygen optode setup and traditional ^{14}C incubations, suggesting that the incubation method used in this study is a reliable means of assessing production. That is, factors beyond algal and bacterial responses were not significant. This includes the potential bottle effects from grazer activity, supported by observations that no ciliates, meiofauna or metazoan larvae were documented during the microscopy analysis of samples in this study [Campbell et al. subm.].

S3. Measurements of light intensity

The percent transmittance of photosynthetically active radiation (T_{PAR}) was estimated from opportunistic measurements of average downwelling irradiance between 9 and 12:30 h local time, that were made above the snow cover and approximately 0.3 m below the ice subsurface using 2π quantum sensors (*LI-COR*). Transmittance on dates of ice core collection was estimated from these sampled T_{PAR} measurements by averaging data typically within ± 2 days. Hourly averages of downwelling PAR incident to the snow surface were also recorded over a diurnal period at a nearby meteorological station (µmol m^{-2} s^{-1}, *Kipp & Zonen PAR-Lite*). Estimates of downwelling PAR transmitted through the ice were obtained by applying T_{PAR} to surface downwelling PAR. To produce estimates comparable to scalar incubation light

intensities, the estimates of under-ice PAR were used with corresponding chl *a* concentrations to calculate hourly average scalar irradiance for the ice algal layer ($\bar{E}_o$) or the volume averaged scalar irradiance ($\hat{E}_o$) according to Ehn and Mundy [2013]. Downwelling PAR measurements on, or within ± 3 days of ice core collection were used in calculations of $\bar{E}_o$ and $\hat{E}_o$. This is with the exception of 21 April where the first possible recording by the station on 26 April was used. Daily averages of scalar irradiance were determined by averaging $\bar{E}_o$ or $\hat{E}_o$ over the 24 h diurnal period, and are reported as $\bar{E}_{o(daily)}$ or $\hat{E}_{o(daily)}$, respectively.

Table S1. Test statistic (*t*) and significance (*p*) of Student independent *t*-tests (df = 10) performed on variables including: daily average of $\bar{E}_o$ ($\bar{E}_{o(daily)}$) and $\hat{E}_o$ ($\hat{E}_{o(daily)}$), the community compensation point (C_{IC}), chlorophyll *a* (chl *a*), particulate organic carbon (POC), numerical abundance of centric (C_N) and pennate (P_N) diatoms, and percent abundance of centric (C_P) and pennate (P_P) diatoms, salinity of the ice-ocean interface, nitrate + nitrite (NO_x) in the bottom ice, bottom-ice temperature, hourly net community production in darkness (NCP_{dark}), at 10 µmol m^{-2} s^{-1} (NCP_{10}), 21 µmol m^{-2} s^{-1} (NCP_{21}) and 55 µmol m^{-2} s^{-1} (NCP_{55}), daily integrated net community production calculated from $\bar{E}_{o(daily)}$ ($NCP_{\bar{E}o}$) and $\hat{E}_{o(daily)}$ ($NCP_{\hat{E}o}$), and bacterial production (BP). Data were grouped based on collection date (≤ 8 May, >8 May), where the mean and standard deviation (brackets) for each time period are presented. Bold values indicate $p > 0.05$.

	Variable	Mean (SD)		*t*	*p*
		≤ 8 May	> 8 May		
Light	$\bar{E}_{o(daily)}$ (µmol m^{-2} s^{-1})	13.84 (5.92)	27.65 (10.61)	-2.61	0.026
	$\hat{E}_{o(daily)}$ (µmol m^{-2} s^{-1})	109.49 (55.50)	188.47 (70.06)	-2.08	**0.063**
	$\bar{E}_{o(daily)}$ (µmol m^{-2} s^{-1}) *	13.84 (5.92)	32.47 (6.57)	-3.67	0.006
	$\hat{E}_{o(daily)}$ (µmol m^{-2} s^{-1}) *	109.49 (55.50)	222.09 (40.34)	-4.71	0.002
	C_{IC} (µmol m^{-2} s^{-1})**	20.65 (8.93)	10.33 (3.32)	2.83	0.020
Biomass	Chl *a* (mg m^{-2})	6.26 (1.15)	8.43 (1.59)	-2.60	0.027
	POC (mg m^{-2})	658.62 (143.68)	1797.59 (355.83)	-6.70	0
Community composition	C_N (× 10^6 cells l^{-1})	55.6 (12.4)	165.6 (58.9)	-4.80	0.002
	P_N (× 10^6 cells l^{-1})	93.1 (20.8)	9.51 (15.7)	-0.19	0.851
	C_P (%)	36.68 (8.57)	59.02 (11.50)	-3.66	0.004
	P_P (%)	59.49 (8.43)	36.07 (9.23)	4.49	0.001
Environmental variables	Salinity (psu)	28.02 (0.19)	28.14 (0.13)	-1.25	**0.256**
	NO_x (µmol l^{-1})	0.74 (0.41)	0.31 (0.07)	2.31	**0.080**
	Temperature (°C)	-1.45 (0.44)	-1.44 (0.15)	-0.02	**0.985**
Hourly production	NCP_{dark} (µmol O_2 l^{-1} h^{-1})	-2.34 (0.72)	-2.17 (0.50)	-0.49	**0.635**
	NCP_{10} (µmol O_2 l^{-1} h^{-1})	-1.33 (0.68)	0.07 (0.76)	-3.285	0.008
	NCP_{21} (µmol O_2 l^{-1} h^{-1})	-0.52 (0.80)	2.52 (1.28)	-4.65	0.001
	NCP_{55} (µmol O_2 l^{-1} h^{-1})	0.70 (0.10)	5.98 (1.92)	-5.56	0.000
Daily production	$NCP_{\bar{E}o}$ (µmol O_2 l^{-1} d^{-1})	-27.87 (16.99)	47.28 (35.53)	-4.34	0.001
	$NCP_{\hat{E}o}$ (µmol O_2 l^{-1} d^{-1})	6.28 (30.08)	141.40 (45.61)	-5.75	0
Bacterial production	BP (µg C l^{-1} h^{-1})	0.22 (0.15)	0.15 (0.05)	0.98	**0.379**

* Measurements on 5 and 9 June excluded

** C_{IC} on 8 May not defined, df = 9

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