Auxiliary material for

The multiple fates of sinking particles in the North Atlantic Ocean

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Introduction

Contained in this file are three types of Auxiliary Material. The file includes (1) three figures, (2) two tables, and (3) text describing our remote sensing data analysis and Winkler titration methods.

Figure S1. Summary statistics for bacterial production data.

Figure S2 Contour plots of water column bacterial production rates along the two cruise tracks.

Figure S3. Mixed layer community respiration rates at four process stations calculated using two different methods

Table S1. Tabulation of Average Particle Sinking Velocities (W_{avg}) Previously Reported for the North Atlantic Ocean.

Table S2. Water Column Respiration Rates Measured in the Mixed Layer Using Two Methods, April-July 2012..

Remote sensing data. Description of the MODIS AQUA data we used to generate the surface reflectance image in Fig. 1b.

Use of Winkler titrations to validate respiration rate calculations. Text containing a detailed description of methods.

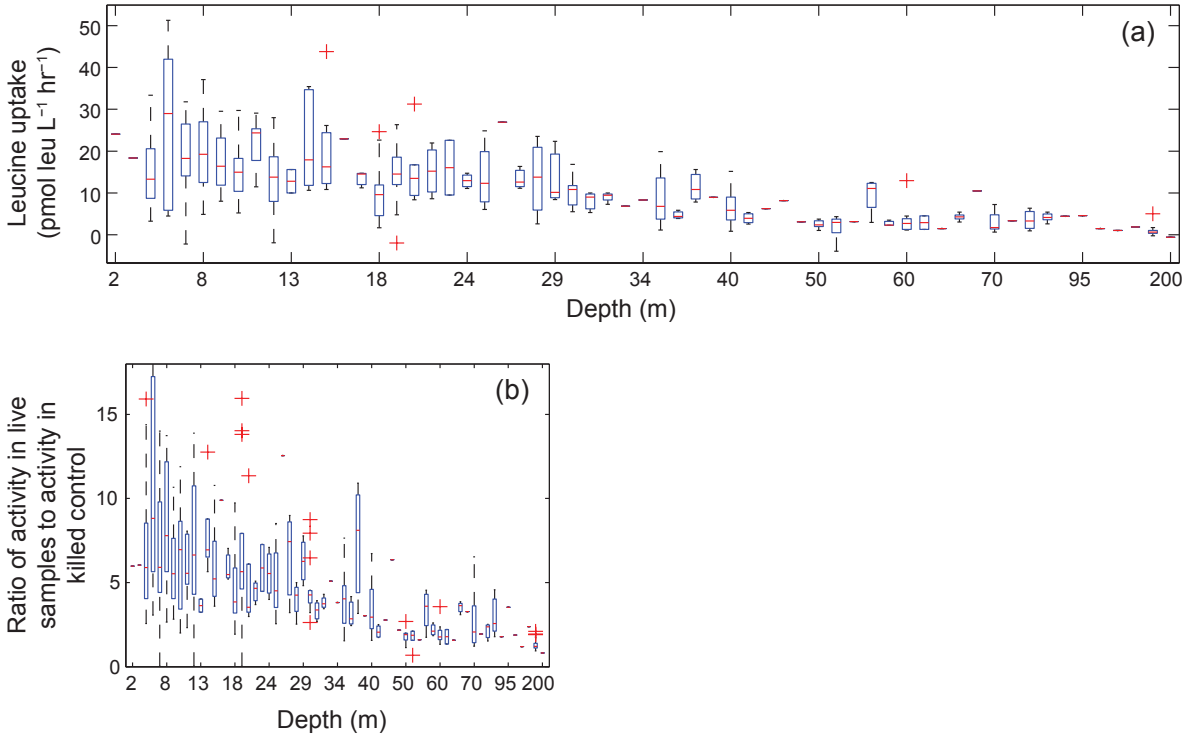

Figure S1. Summary statistics for bacterial production data. (a) Box-and-whisker plot by depth of all leucine incorporation observations, corrected for activities in killed control samples. (b) Box-and-whisker plot by depth of the signal-to-noise ratio, i.e., the ratio of the mean of the activity measured in the three live replicates to the activity in the killed control. Red lines represent the median values for each depth, box extremities are the 75th and 25th quartiles, whisker tails are 95th and 5th quartiles, and red + symbols represent outliers.

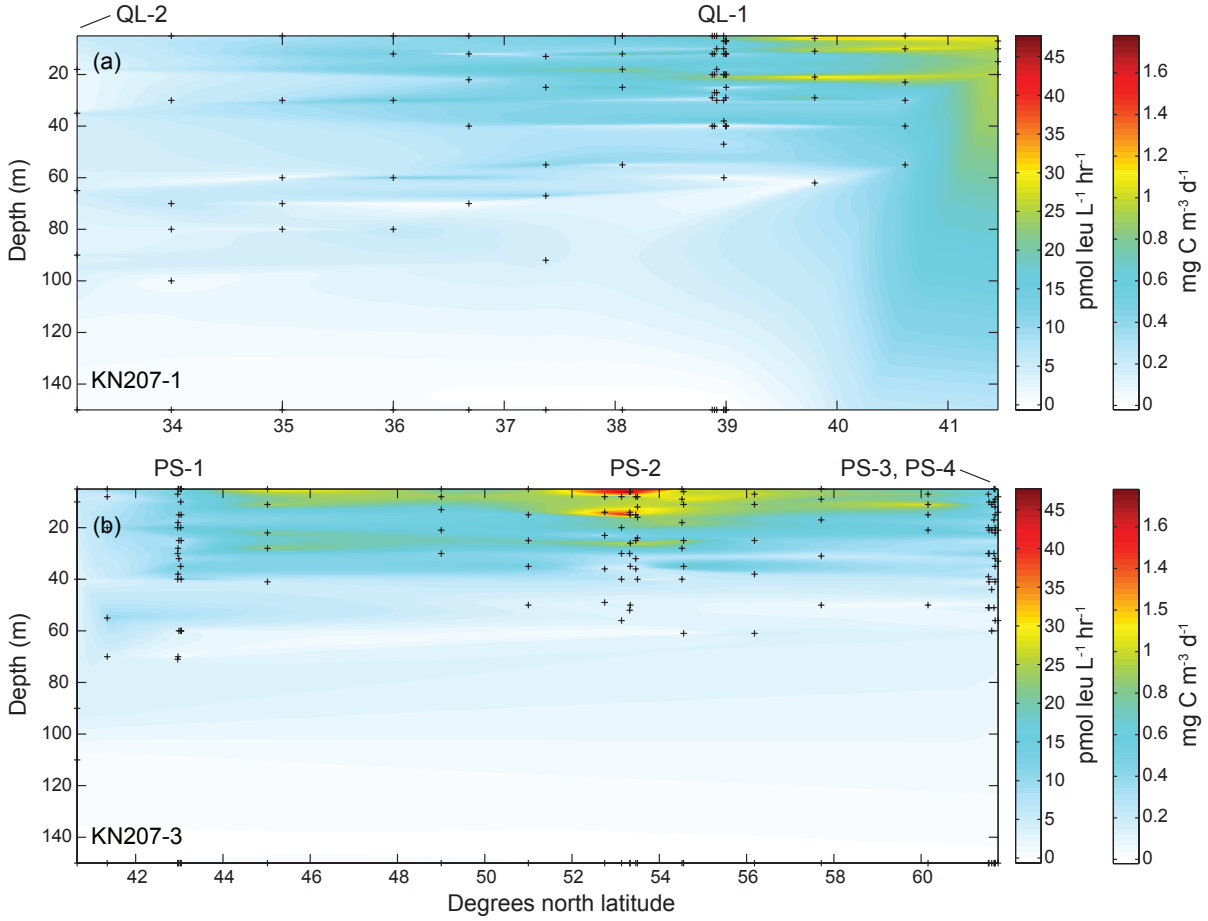

Figure S2. Contour plots of water column bacterial production rates measured using the ^{3}H-leucine incorporation method along the (a) KN207-1 and (b) KN207-3 cruise tracks. Data are presented in volumetric units of leucine uptake and in mg C m^{-3} d^{-1}. For conversion to units of C in these plots (on secondary axis), an isotope dilution (*ID*) of 1 and a conversion factor $\nu_{C:leu}$ of 1.5 kg C (mol leu)$^{-1}$ were assumed, making the rates a minimum estimate of bacterial carbon turnover. Superimposed (+) are locations of our discrete observations, which we used to generate the contour plots. Also superimposed are the locations of the six process stations.

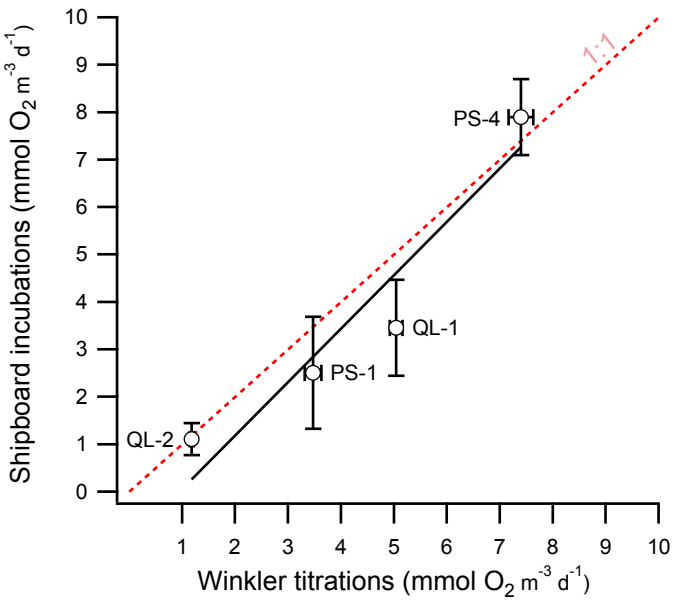

Figure S3. Mixed layer community respiration rates at four process stations calculated using two different methods. *x*-axis: Rates calculated from a series of 300 mL shipboard incubations using optode sensor spots. *y*-axis: Rates calculated using a traditional two-point Winkler titration method. A type II (major axis - orthogonal distance) linear regression was fit to the data (solid black trace; $y = 1.13\ x - 1.07$; $r^2 = 0.95$). A 1:1 line (dashed red trace) is superimposed for reference. Error bars represent uncertainties from replication (Winkler method) or the standard error of regression (incubations).

74 **Table S1.** Average Particle Sinking Velocities (W_{avg}) Reported for the Mesopelagic Subtropical and Subpolar North Atlantic Ocean[a]

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Location	Depth or depth range for which reported (m)	Average particle sinking velocities (W_{avg}; m d^{-1})	No. individual observations (n) tabulated	Notes	Reference
Bermuda-Atlantic Time Series (BATS) study site, Sargasso Sea (31° 40'N, 64° 10'W)	150-500	13-70	4	Individual observations	McDonnell et al. [2015]
Porcupine Abyssal Plain (PAP) site (48°N, 16.5°W)	50-500	30-250	29	Individual observations; only one observation > 200 m d^{-1}	Villa-Alfageme et al. [2014]
Multiple sites along E-W cruise transect from Massachusetts to NW Africa	0-500	0.2-22	22	Individual observations for lithogenic particles from Aeolian inputs	Ohnemus and Lam [2014]
PAP site	50	9 ± 9	—	Mean for slow sinking particle size pool (< 10 m d^{-1})	Riley et al. [2012]
		181 ± 8	—	Mean for fast sinking pool (> 350 m d^{-1})	
Coastal Norway (60° 16'N 5° 12°E)		9	—	Mean value for all sediment trap material between 80-400 μm	Bach et al. [2012]
		12.5 ± 4.8	—	Mean value for fecal pellets	
Canary Current (27° 30'N, 016° 15'W; 27° 30'N, 15° 45'W)	260	0.7-11	—	Range given for slow-sinking particle fraction comprising ~ 60% of total POC	Alonso-González et al. [2010]
POMME study area, NE of Azores (39–45ºN, 15–21ºW)	< 1000 m	10	—	Mean value estimated for particle size fraction > 100 μm diameter; largely based on observations in mesoscale eddy features	Guidi et al. [2007]
N-S JGOFS cruise transect from NW of Azores (40º 37'N, 20º 5'W) to Iceland (63º 1'N, 22º 25'W)	< 1025 m	137.8-162.5	—	Lower and upper limits for bulk sinking particle material from coccolithophore blooms	Knappertsbusch and Brummer [1995]
		123-156 with $\bar{x}$ = 141 ± 11	6	Estimates for particles from individual coccolithophore species	
NABE site W of Madeira Island (34ºN, 21ºW	< 1000 m	46	1	Individual observation	Honjo and Manganini [1993]
NABE site in central N. Atlantic (48ºN, 21ºW)	< 1000 m	32-116	3	Individual observations	Honjo and Manganini [1993]
Porcupine Seabight (50ºN, 13ºW)	Surface to deep ocean	100-150	—	Range of values for diatom aggregates	Billett et al. [1983]

[a]We restricted our reporting of the literature to values measured for depths < 1000 m for the region between 22°N and 66°N latitude. From these 9 studies, we gathered 72 individual observations of the average particle sinking velocity; these were used to generate the histogram in Fig. 5. Where values were reported for multiple depth ranges, we used the observations most applicable to the range of depths (50-300 m) we evaluated in our study. An extensive compilation of sinking speed data for Atlantic tropical systems (Cape Blanc, E. and W. Equatorial Atlantic, Benguela Current) and the Southern Ocean can be found in Fischer and Karakas [2009].

Table S2. Water Column Respiration Rates Measured in the Mixed Layer Using Two Methods, April-July 2012[a]

Cruise	Station	Location	Deploy-ment Dates	Euphotic Zone Depth[b] (m)	Depth of Obser-vation (m)	Respiration Rate[c] (mmol O_2 m^{-3} d^{-1} ± uncertainty)		Method Precision (error as % of rate estimate)	
						Shipboard Incubations[d]	Winkler Titrations[e]	Shipboard Incubations	Winkler Titrations
KN207-1	QL-1	38° 52' 47.4" N, 69° 6' 19.2" W	24-27 Apr 2012	38	29	3.46 ± 1.01	5.04 ± 0.12	29.2%	2.39%
	QL-2	32° 57' 2.4" N, 65° 44' 58.8" W	30 Apr-3 May 2012	—	14	1.11 ± 0.34	1.18 ± 0.04	30.6%	3.39%
KN207-3	PS-1	43° 1' 58.6" N, 27° 15' 31.8" W	17-19 Jun 2012	58	20	2.51 ± 1.18	3.47 ± 0.16	47.0%	4.73%
	PS-2	53° 29' 43.0" N, 30° 45' 2.6" W	23-27 Jun 2012	26	7	4.03 ± 0.46	—	11.4%	—
	PS-3	61° 37' 9.22" N, 34° 6' 9.64" W	1-5 Jul 2012	42	21.5	2.55 ± 1.11	—	43.5%	—
	PS-4	61° 41' 40.4" N, 33° 46' 21.7" W	7-11 Jul 2012	41	20	7.90 ± 0.80	7.40 ± 0.23	10.1%	2.92%

[a]Community respiration rates of free-living microorganisms in unfiltered water samples. Rates from both methods are based on dissolved oxygen data. For conversion to units of C, a molar respiratory quotient of 117/170 was used.

[b]The depth at which photosynthetically active radiation (PAR) was equal to 1% of surface irradiance, as determined by CTD. We were unable to obtain PAR data for station QL-2 due to a sensor failure.

[c]We report rates here in volumetric units of dissolved oxygen; to convert to units of mg C m^{-3} d^{-1}, multiply these rates by the respiratory quotient (e.g. 117/170) × 12.01 g mol^{-1}.

[d]Mean of ≥ 5 replicates; rate calculated by linear regression of measurements taken at multiple time points in replicate incubations. Uncertainty is reported as the standard error of regression.

[e]Mean of 3 replicates; rate calculated as difference of titrations at $t = 0$ and conclusion of incubation. Uncertainty is reported as standard error.

Remote sensing data analysis

To generate the image in Fig. 1b, we used 8-day average, level 3 MODIS AQUA satellite data of surface reflectance at 555 nm. A 4 km resolution data file (A20121772012184.L3m_8D_RRS_Rrs_555_4km.hdf) was retrieved using the NASA GSFC OceanColor Level 3 Browser at http://oceancolor.gsfc.nasa.gov/cgi/l3. The false-color image was generated in ArcGIS 10.1 after geographical indexing.

Use of Winkler titrations to validate respiration rate calculations

To validate the water-column respiration rates we derived from our shipboard incubations, we used a simple method based on a series Winkler titrations. Winkler titration remains the standard analytical method for determination of dissolved oxygen in water [EPA Method 360.2 as modified for shipboard determination in seawater; *U S EPA*, 1983]. For the comparison, we chose the depth in each respiration profile (Fig. 3) that corresponded to the middle of the mixed layer (Table 3). We determined the respiration rate at this depth using triplicate samples sacrificed at two timepoints. A $t = 0$ dissolved oxygen concentration was determined immediately in samples collected from the same CTD cast used for the respiration profile. A final concentration was determined using 300 mL samples that had been incubated alongside the optode sensor spot bottles. The respiration rate was determined by simple difference of the mean concentrations at the two timepoints.

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