Ocean acidification modifies the impact of warming on sediment nitrogen processing by enhancing the benthic microbial loop

Michelle N. Simone[1,2,*], Joanne M. Oakes[2], Kai G. Schulz[2], Bradley D. Eyre[2]

[1]School of Science, Auckland University of Technology, Auckland 1010, New Zealand

[2]Centre for Coastal Biogeochemistry, Faculty of Science and Engineering, Southern Cross University, Lismore 2480, NSW, Australia

Michelle.simone@scu.edu.au, *mnhsimone@gmail.com

Kai.schulz@scu.edu.au

Bradley.eyre@scu.edu.au

Joanne.oakes@scu.edu.au

Supplementary materials

Table S1. DIN concentrations (μM) (mean ± SD) at the start (minimum) and end of the full incubation cycle.

Treatment	Current-pCO_2		High-pCO_2	
	Start	End	Start	End
Δ-3 °C	1.19	2.02	1.85	6.66
	(± 0.01)	(± 0.45)	(± 0.27)	(± 1.36)
Control	1.85	4.00	2.42	6.11
	(± 0.16)	(± 0.27)	(± 1.01)	(± 1.39)
Δ+3 °C	1.88	4.47	1.97	9.61
	(± 0.42)	(± 2.10)	(± 0.31)	(± 1.36)
Δ+5 °C	2.37	15.52	2.40	14.68
	(± 0.18)	(± 1.81)	(± 0.58)	(± 4.42)

Table S2. Overlapping mean (± SD) control rates (μmol-N m^{-2} h^{-1}) in current and high-pCO_2 incubations for dark and light cycles. Scaled means (± SD) applied to significantly different means (*) only.

Flux	Dark			Light		
	Current	High	Scaled	Current	High	Scaled
NH_4^+	*144.50	*80.34	62.87	28.31	34.93	
	(±38.83)	(±9.91)	(±15.68)	(±8.38)	(±6.43)	
NOx	0.04	1.57		-6.10	-3.94	
	(±1.31)	(±2.98)		(±1.14)	(±2.80)	
Dissolved O_2	*-1018.02	*-787.07	-1172.76	*700.20	*934.16	817.18
	(±38.20)	(±16.23)	(±46.99)	(±11.66)	(±90.73)	(±91.47)

Table S3. Scaled means (± SD) for Dark NH_4^+ in current and high-pCO_2 incubations.

Treatment	Current	Scaled	High	Scaled
CON	145.05	112.69	80.35	112.69
	(±38.83)	(±30.17)	(±9.91)	(±13.90)
Δ-3	32.09	24.94	89.94	126.15
	(±38.79)	(±30.14)	(±39.60)	(±55.55)
Control	145.05	112.69	89.98	126.20
	(±89.97)	(±30.17)	(±5.69)	(±7.99)
Δ+3	154.08	119.72	131.23	184.06
	(±17.98)	(±13.97)	(±10.55)	(±14.80)
Δ+5	459.25	356.81	170.86	239.64
	(±119.63)	(±92.95)	(±38.72)	(±54.31)

Table S4. Statistical results of two-way ANOVAs for net fluxes.

		df	F	P	Significance
$n\text{-}NH_4^+$	Temperature	3,16	34.66	0.000	***
	pCO_2	1,16	0.042	0.840	
	Interaction	3,16	7.523	0.002	**
$n\text{-}NO_x$	Temperature	3,16	0.774	0.525	
	pCO_2	1,16	66.578	0.000	***
	Interaction	3,16	11.933	0.000	***
		Current-pCO_2			
$n\text{-}NH_4^+$	Temperature	3,16	48.516	0.000	***
	Cycle	1,16	23.575	0.000	***
	Interaction	3,16	2.566	0.091	
$n\text{-}NO_x$	Temperature	3,16	7.703	0.002	**
	Cycle	1,16	8.612	0.010	*
	Interaction	3,16	3.528	0.039	*
		High-pCO_2			
$n\text{-}NH_4^+$	Temperature	3,16	8.745	0.001	**
	Cycle	1,16	38.615	0.000	***
	Interaction	3,16	0.213	0.886	
$n\text{-}NO_x$	Temperature	3,16	3.884	0.029	*
	Cycle	1,16	4.788	0.044	*
	Interaction	3,16	8.408	0.001	**

Table S5. Statistical results of one-way ANOVAs. d = dark, l = light, and n = net. Only statistical results presented in the figures are shown.

		df	F	P	Significance
Current-pCO_2					
d-NH_4^+	Temperature	3,8	22.781	0.000	***
l-NH_4^+	Temperature	3,8	36.176	0.000	***
n-NH_4^+	Temperature	3,8	34.332	0.000	***
d-NO_x	Temperature	3,8	6.614	0.015	*
l-NO_x	Temperature	3,8	3.321	0.078	
n-NO_x	Temperature	3,8	8.677	0.007	*
High-pCO_2					
d-NH_4^+	Temperature	3,8	5.625	0.023	*
l-NH_4^+	Temperature	3,8	3.547	0.068	
n-NH_4^+	Temperature	3,8	6.922	0.013	*
d-NO_x	Temperature	3,8	1.735	0.237	
l-NO_x	Temperature	3,8	9.691	0.005	**
n-NO_x	Temperature	3,8	5.272	0.027	*

Table S6. Mean (± SD) dark DIC/NH_4^+ efflux rates for each treatment. (DIC data prepared in Simone et al. (2021))

	Temperature			
	20 °C	23 °C	26 °C	28 °C
Current-pCO_2	27.13	10.65	10.38	3.80
	(± 33.99)	(± 3.14)	(± 1.82)	(± 1.11)
High-pCO_2	6.63	8.37	6.17	5.67
	(± 3.07)	(± 1.41)	(± 1.11)	(± 1.52)

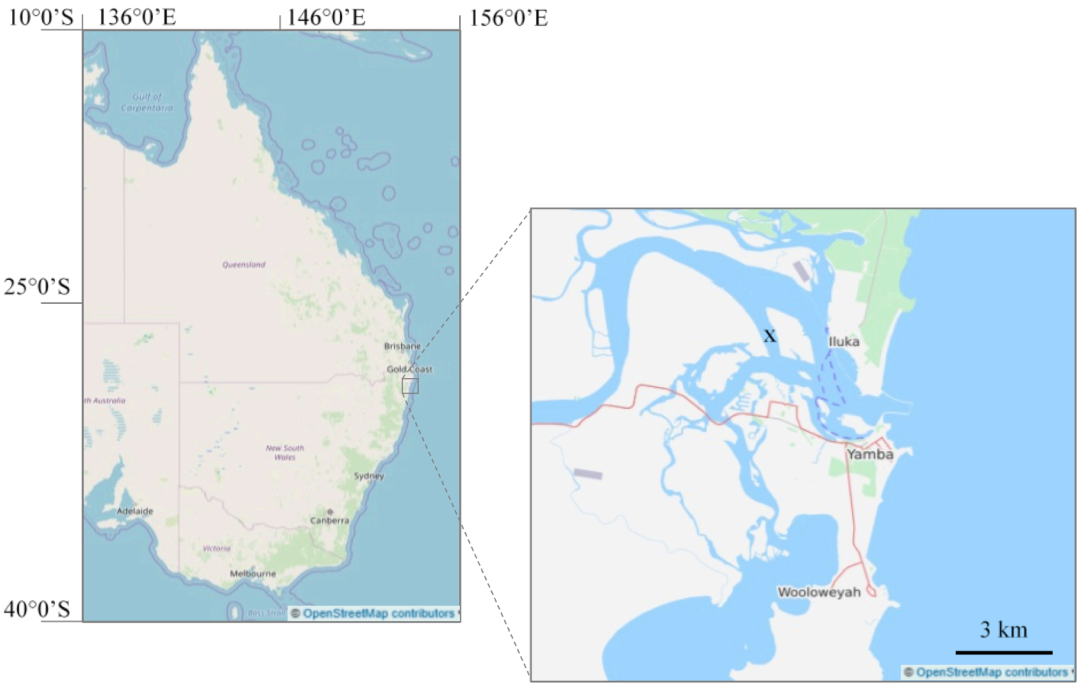

Figure S1. Map of sampling site location (×, 29°24.21'S, 153°19.44'E) in Yamba, NSW, embedded in a map of the East Coast of Australia (©OpenStreetMaps).