The Effect of Ocean Acidification on Iodine Cycling by Micro-organisms in Surface Waters

By Eleanor Barton, July - September 2017

Laidlaw Scholars — Undergraduate Research and Leadership Programme

UNIVERSITY of York

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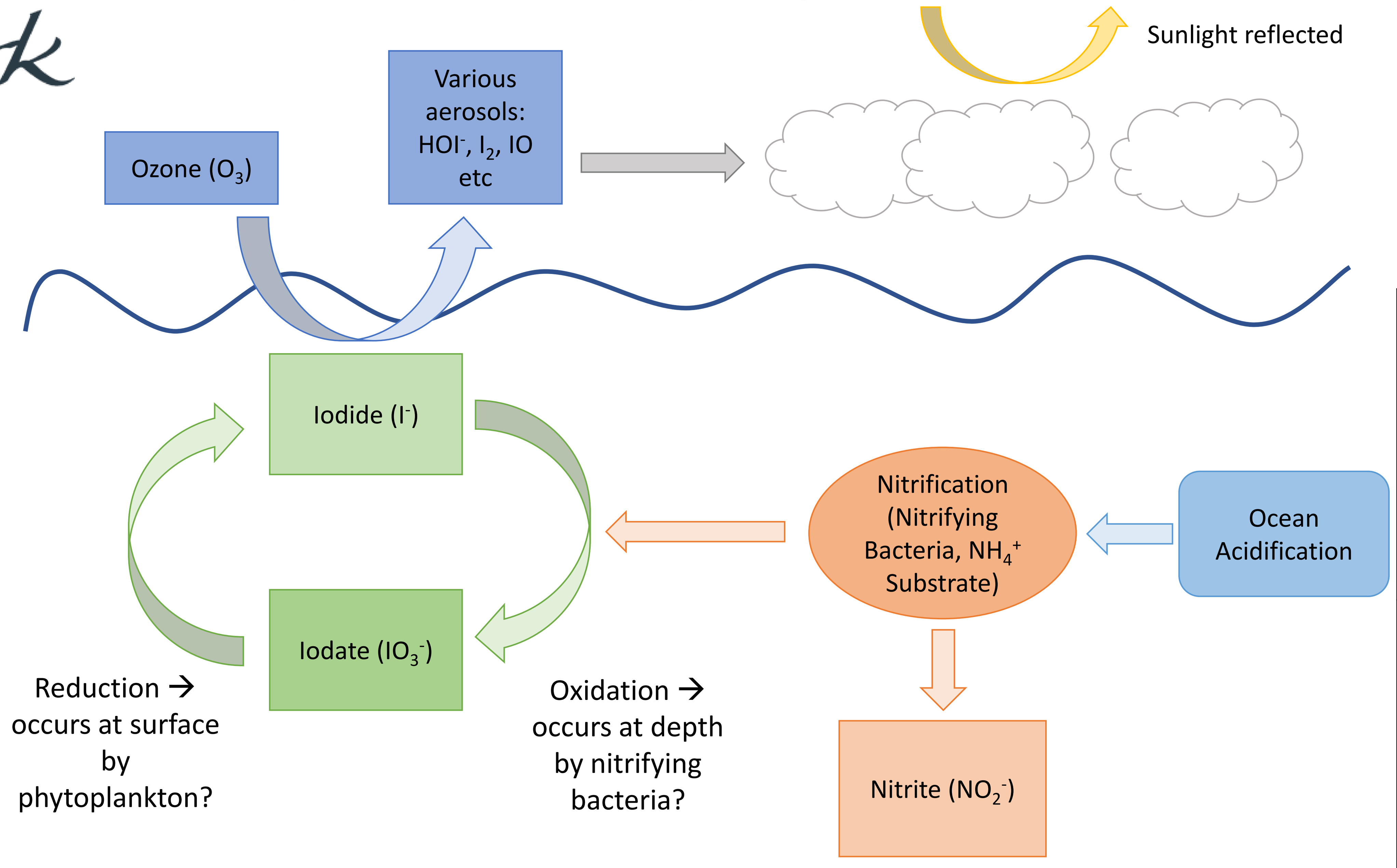

Figure 1 : An overview of the process of iodine cycling in the surface ocean, and its links to nitrification and atmospheric chemistry.

Experiment 1

- *Nitrosomonas sp. Nm 51*
- *8 days*

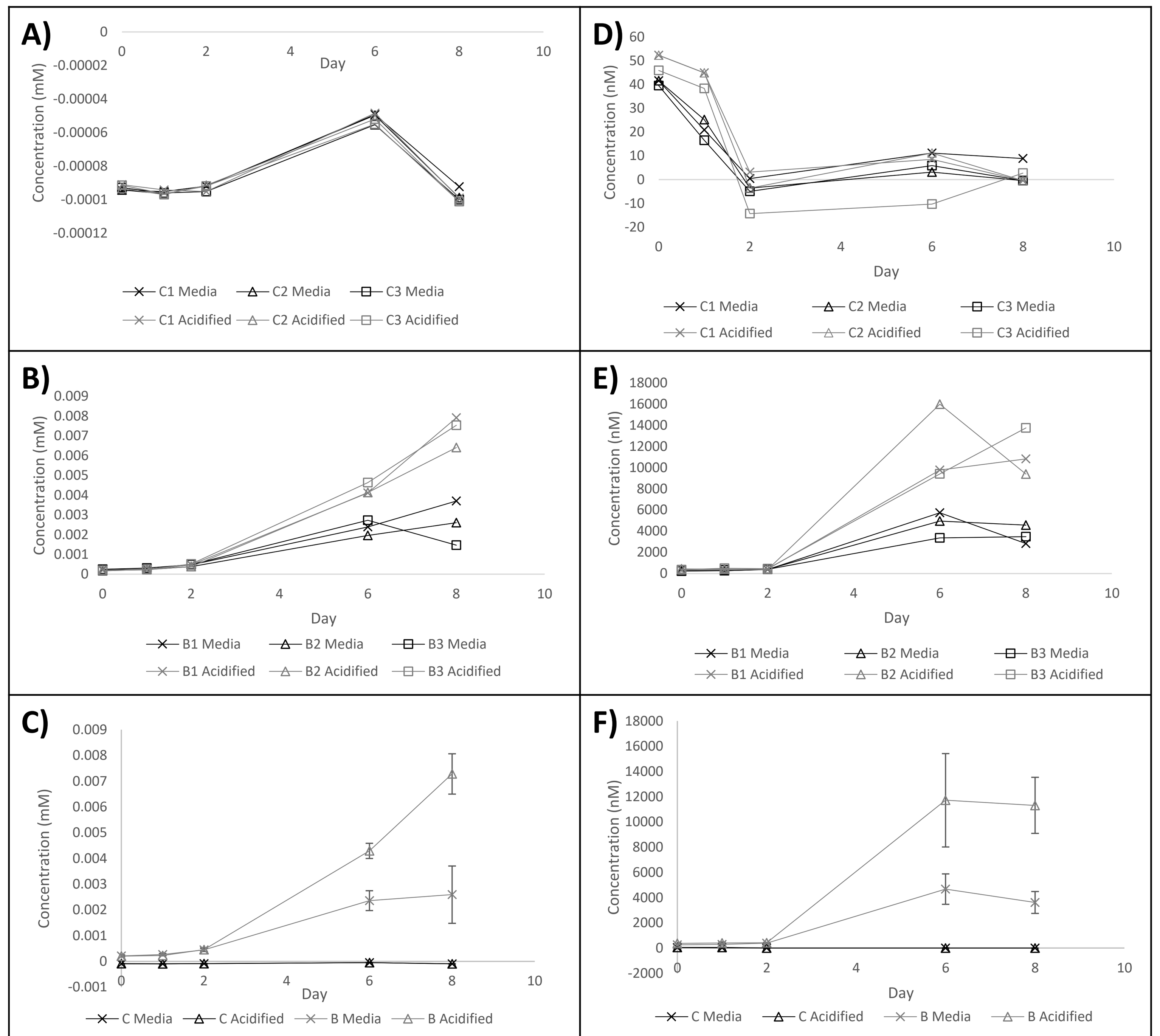

Figure 2. Nitrite and Iodate concentration results for Experiment 1. **A)** Nitrite concentrations (mM) over time for control treatments; **B)** Nitrite concentrations (mM) over time for bacteria treatments; **C)** Average nitrite concentrations (mM) (± Standard Deviation) over time for Control and Bacteria Media and Acidified Treatments; **D)** Iodate concentrations (nM) over time for control treatments; **E)** Iodate concentrations (nM) over time for bacteria treatments; **F)** Average iodate concentrations (nM) (± Standard Deviation) over time for control and bacteria media and acidified treatments.

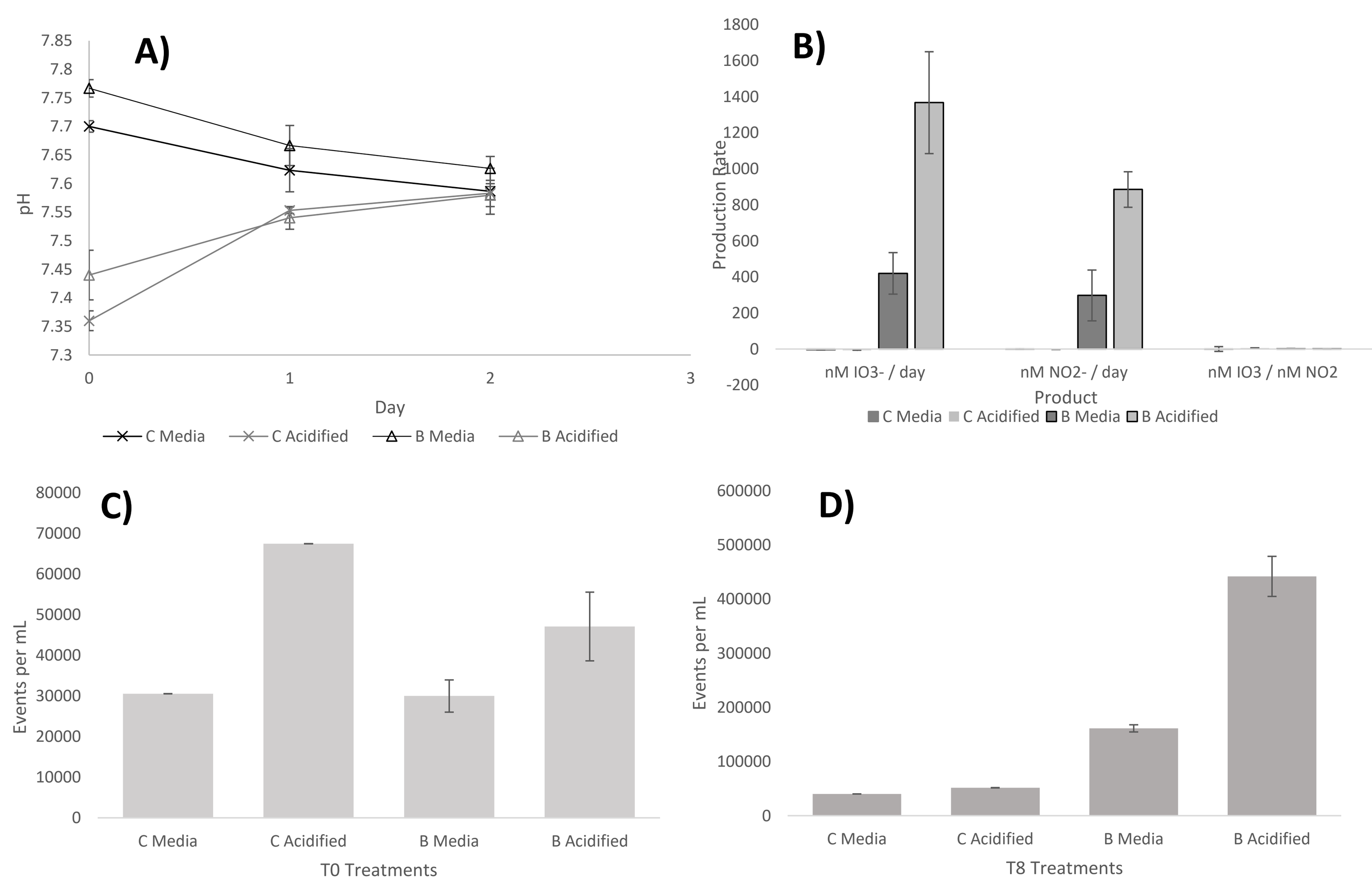

Figure 4: **A)** The average pH (± Standard deviation) of each treatment over time. **B)** The average production rates (± Standard deviation) of iodate per day, nitrite per day, and iodate molecule per nitrite molecule. **C)** The average biomass (± Standard deviation) in each treatment at T0. **D)** The average biomass (± Standard deviation) in each treatment at T8. All figures refer to Experiment 1.

Background

- Iodine is a potential key element in climate change, as it can produce halogens and aerosols with ozone, aiding cloud formation. (Bluhm *et al*, 2010), but reactive iodide can be removed from surface waters through nitrification in nitrifying bacteria.
- Ocean acidification caused by the absorption of carbon dioxide could reduce surface ocean pH by 0.77 by 2300 (Caldeira & Wickett, 2003), and this will have massive effects on biogeochemical cycles (Berman *et al.*, 2011).
- Past experiments have generally seen a decrease in nitrification rates with acidification.
- **Aim:** To determine whether and how ocean acidification impacts the iodide oxidation controlled by ammonium-oxidising bacteria.

Results

- All data analysis was undertaken on IBM SPSS Statistics 24 (confidence limit: $p \leq 0.05$)
- All data was normally distributed, and most had equal variances
- Experiment 1:
  - Significant difference between nitrite production rates and iodate production rates in the acidified and non acidified treatments (t=-5.381, df=4, p=0.006; t=-5.909, df=4, p=0.004)
  - No significant difference between the ratio of nitrite to iodate in the acidified and non-acidified treatments (t=0.296, df=4, p=0.782)
- Experiment 2 gave the same results, although the difference in iodate production rates wasn't significant.

Table 1: The average and range of ammonium and iodide concentrations (mM) at the start and end of each experiment.

Experiment & Day	Ammonium Concentration (mM)		Iodide Concentration (mM)	
	Average	Range	Average	Range
1 T0	7.68	0.49	9.72	0.78
1 T8	7.65	0.49	9.80	1.11
2 T0	7.61	0.56	9.96	0.71
2 T12	7.62	0.55	9.51	0.81

- **Conclusions**: Ocean acidification increases the rate of nitrification, which also increases the rate of iodate production. This could be due to the increased availability of inorganic carbon.
- **Wider implications:** The increased rate of iodide oxidation through nitrification would reduce atmospheric reactions with iodide, creating fewer aerosols and potentially reducing cloud formation, allowing more sunlight to reach Earth's surface (impacting climate).

Purpose of Addition	Chemical Added	Volume of each chemical added to each treatment			
		C Media	C Acidified	B Media	B Acidified
Provides nutrients	Media	250mL	250mL	250mL	250mL
Provides iodide to oxidise	2.5M KI	1mL	1mL	1mL	1mL
Acidification	1M HCl	0	130µL	0	130µL
	0.5M $NaHCO_3$	0	1.323mL	0	1.323mL
Add Bacteria	Bacteria Inoculum	0	0	3mL	3mL
Phosphate buffer – regulate pH (Experiment 2 only)	Na_2HPO_4	1.32mL	1mL	1.32mL	1mL
	NaH_2PO_4	1mL	1.92mL	1mL	1.92mL

Variables and Methods

- **pH** – spectrophotometric method
- **Nitrite Concentration** – spectrophotometric method
- **Iodate Concentration** – spectrophotometric method
- **Iodide Concentration** – ion chromatography
- **Ammonium Concentration** – nutrient auto-analyser
- **Biomass** – flow cytometry

Table 2: The set-up additions for each treatment and the purposes for them; C indicates that the treatment contains no bacteria, whereas B treatments do. There were 3 replicates of each treatment.

Experiment 2

- *Nitrosococcus oceani Nc10*
- *12 days*

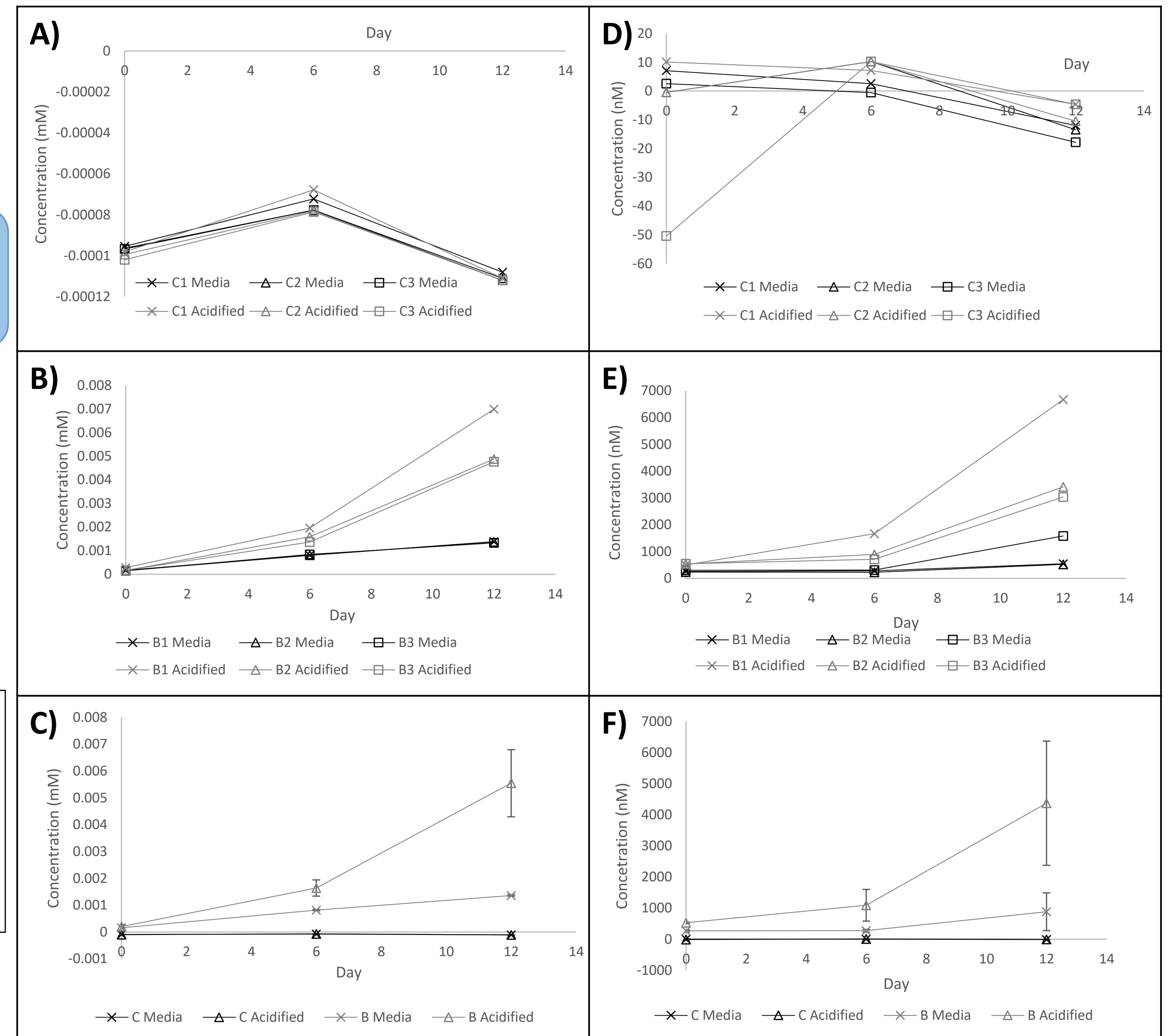

Figure 3. Nitrite and Iodate concentration results for Experiment 2. **A)** Nitrite concentrations (mM) over time for control treatments; **B)** Nitrite concentrations (mM) over time for bacteria treatments; **C)** Average nitrite concentrations (mM) (± Standard Deviation) over time for Control and Bacteria Media and Acidified Treatments; **D)** Iodate concentrations (nM) over time for control treatments; **E)** Iodate concentrations (nM) over time for bacteria treatments; **F)** Average iodate concentrations (nM) (± Standard Deviation) over time for control and bacteria media and acidified treatments.

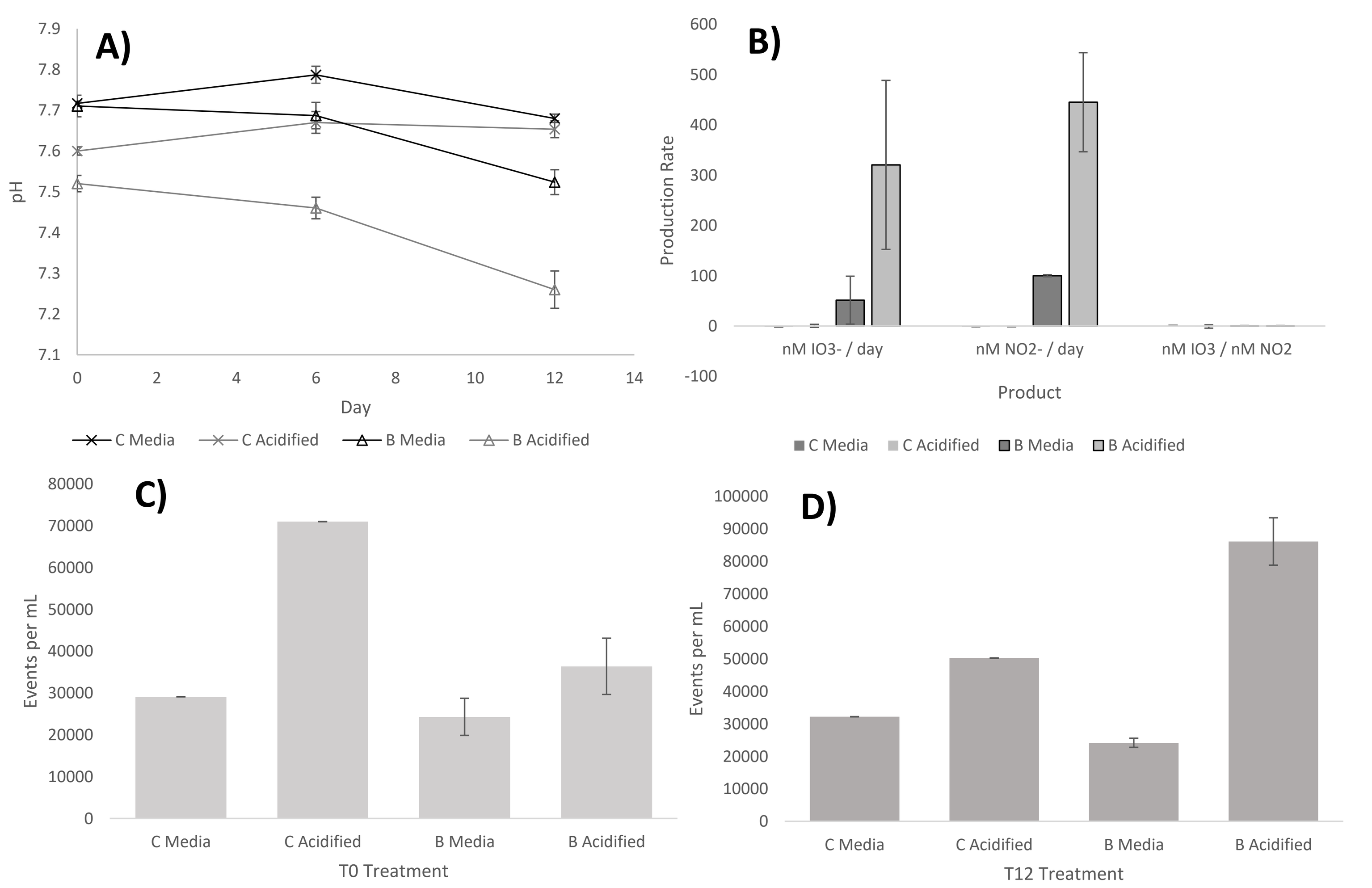

Figure 5: **A)** The average pH (± Standard deviation) of each treatment over time. **B)** The average production rates (± Standard deviation) of iodate per day, nitrite per day, and iodate molecule per nitrite molecule. **C)** The average biomass (± Standard deviation) in each treatment at T0. **D)** The average biomass (± Standard deviation) in each treatment at T12. All figures refer to Experiment 2.