An *in situ* examination of carbon fluxes in the estuarine environment at high temporal resolution

and their relationship to aqueous and sedimentary nutrient composition

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Introduction

Estuarine systems are highly active biological communities, and are known to produce and consume key greenhouse enhancing gases including CO_2. The importance of these systems as producers or consumers of inorganic carbon, and their links to changes in the nitrogenous nutrient composition of the system is an area of current environmental investigation and concern. However, in situ studies of carbon processing with high temporal frequency are rare, especially of the Australian environment.

This study investigated the balance between the production and consumption of inorganic carbon in situ while quantifying diurnal and seasonal changes in CO_2, CH_4 and N_2O fluxes. These changes were examined alongside the sedimentary and aqueous nutrient composition of the estuary in order to identify changes in the carbon processing occurring within the system.

Methods

- Hourly gas flux measurements during summer and winter 2006-2007
- Three sites in the near shore zone of Lake Illawarra, NSW, Australia, (an estuarine lagoon)
- Flushed chamber system (Figure 1).
- Coincident measurements of key environmental parameters - pH, dissolved O_2, temperature, photosynthetically active radiation (PAR) and salinity.
- Concentrations of a variety of key carbon and nitrogen compounds in the water and sediment were also measured.

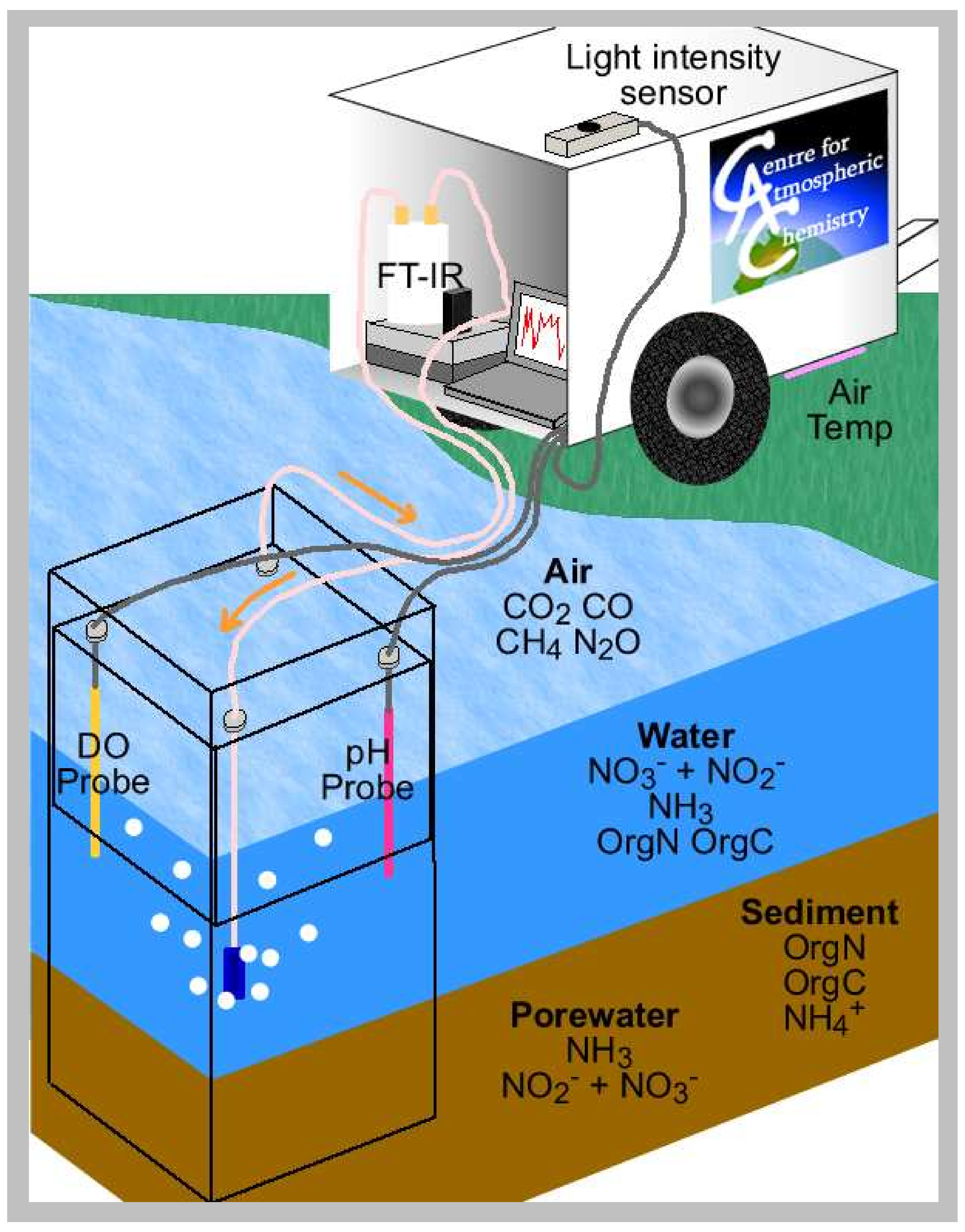

Figure 1: Diagram of *in situ* system incorporating a Nicolet Avatar 360 Fourier Transform Infrared spectrometer (FT-IR) and a Multiple Atmospheric Layer Transmission (MALT) fitting approach [1,2] and the parameters measured: pH, dissolved O_2, temperature, photosynthetically active radiation (PAR) and salinity.

Results and Discussion

- The fluxes ranged from - 4.0 to 42.4 mmol $CO_2/m^2/h$, -1.7 to 3.1 µmol $N_2O/m^2/h$ and -0.007 to 1.6 mmol $CH_4/m^2/h$.
- The sediments were rich in organic carbon and nitrogen.
- The estuarine system was found to act as a net CO_2 source to the atmosphere which varied seasonally and diurnally.

System Carbon balance – Net ecosystem production (NEP)

- Determined by examining the change in O_2 or the change in the inorganic carbon content (TIC) (Figure 2).

NEP_{O2} =	Mass of O_2 produced (Gross Primary Production)	-	Mass of O_2 consumed (Aerobic Respiration)
NEP_c =	Mass of TIC consumed (Gross Primary Production)	-	Mass of TIC produced (Total Respiration)

Figure 2: Calculating net ecosystem production using an O_2 based or a total inorganic carbon (TIC) based approach.

Calculating the change in total inorganic carbon

A simple equilibrium model based on established techniques was developed to determine the ΔTIC based on the CO_2 flux.

Measured

$$CO_2Flux = \alpha K\left(P_{CO_2aq} - P_{CO_2air}\right)$$

Calculated using wind speed, salinity, temperature and/or pH

$$K_H P_{CO_{2aq}} = [H_2CO_3{}^*]$$

$$[TIC] = \left(1 + \frac{K_1}{[H^+]} + \frac{K_1K_2}{[H^+]^2}\right)[H_2CO_3{}^*]$$

Figure 3: Schematic outlining the equilibrium model used to predict total inorganic carbon concentration based on water-to-air CO_2 flux, atmospheric CO_2 concentration, wind speed, salinity, temperature and ph.

Comparing O_2 and TIC approaches

- NEP_{O2} tended to be negative (O_2 uptake i.e. TIC production) while NEP_C varied diurnally with light and temperature (Figure 4).
- NEP rates were higher than those noted in other studies of deeper water environments [3,4].

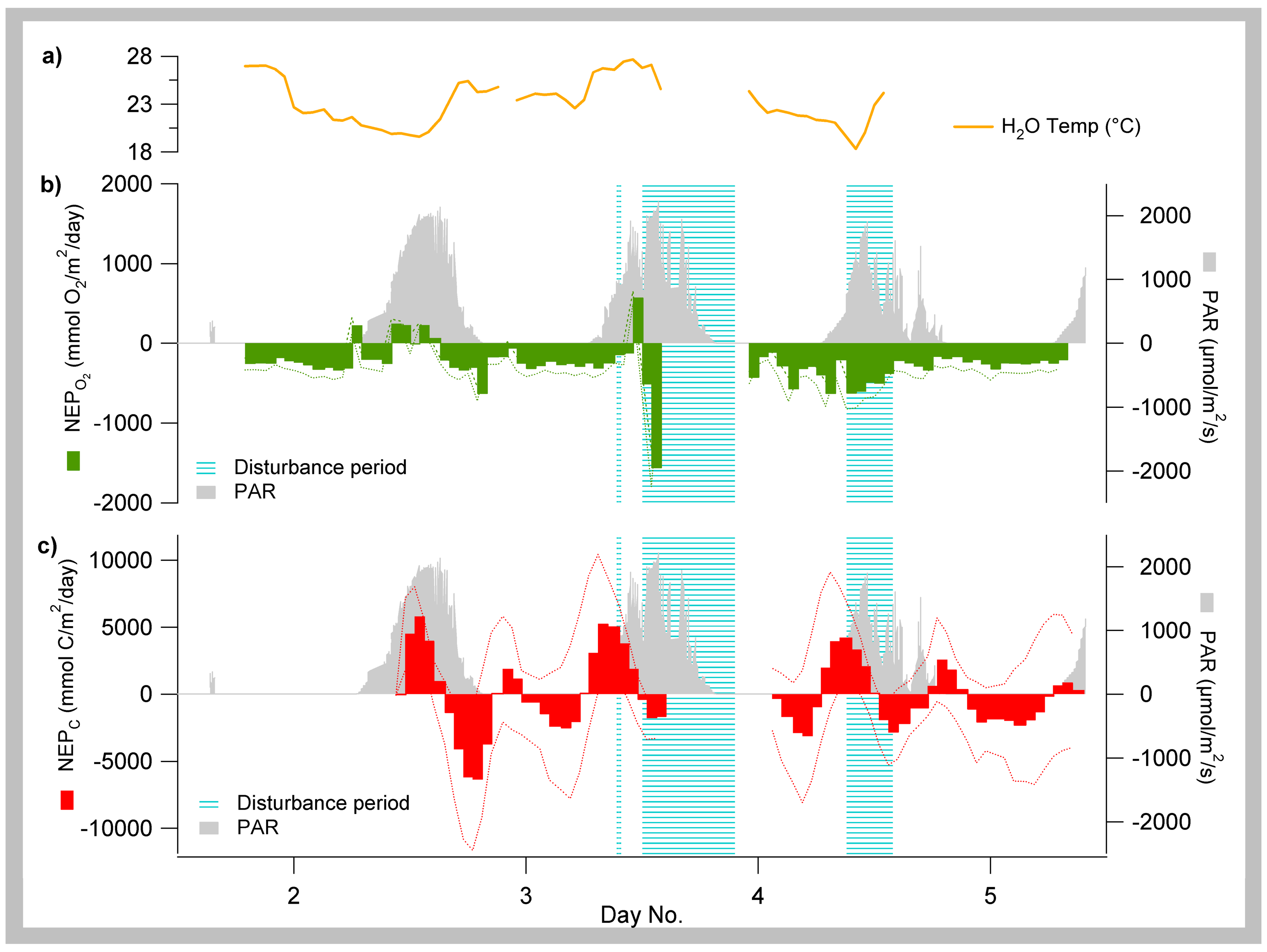

Figure 4: a) Water temperature variation, b) Net ecosystem production (NEP_{O2}) and c) Net ecosystem production (NEP_C), at an example site during summer 2007. Dashed lines are ± the standard error in the NEP. PAR and disturbance periods (e.g. wind induced wave activity) are also shown.

- **Why?** Anaerobic (non-O_2) based carbon processing played a larger role in these near shore environments than in the more studied deeper water sites
- **Why?** Nearshore sites = increased availability of C and N, PAR and temperature.

Conclusion

Near shore zones play a unique role in the carbon processing within estuarine systems, quite different to that of deeper water areas. As such, they should be carefully accounted for when studying estuarine systems as a whole.

This research was conducted at the University of Wollongong, NSW, Australia.

University of Wollongong

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