Liège, May 3-7 2004

Inorganic Carbon Cycle in the Inner Scheldt Estuary

Laure-Sophie Schiettecatte[1], Michel Frankignoulle[1], Lei Chou[2] and Alberto Vieira Borges[1]

[1] Unité d'Océanographie Chimique (B5), MARE, Université de Liège, B4000 Liège.
(Laure-Sophie.Schiettecatte@ulg.ac.be, phone: +32. 4 366. 33.67)
[2] Océanographie Chimique et Géochimie des Eaux, Université Libre de Bruxelles, Bruxelles.

International Liège Colloquium on Ocean Dynamics

Liège, 3-7 May 2004

Fig. 2: Station Sainte-Anna, located on the left bank of the Scheldt estuary, seaward of Antwerp.

INTRODUCTION

The Scheldt estuary has a total lenght of 160km extending from Gent to Vlissingen where it opens to the North Sea (see **Fig.1**). Its catchement area is highly polluted in tems of organic matter and nutrients originating from industrial, domestic and agricultural waste products. From a hydrological point of view, the Scheldt estuary can be divided in 3 sections: the lower estuary, or marine zone (**zone 1**, from the mouth of the estuary to Hansweert), a brackish zone (**zone 2**) and a freshwater zone (**zone 3**). Zone 2 can also be distinguished in a mesohaline zone (from Hansweert to the Dutch-Belgian border) and an oligohaline zone also called the High Turbidity Zone (HTZ), which is the last part of the maximum turbidity zone located upward. Because of hydrodynamics, the residence time of the water masses in the HTZ is long (from 1 to 3 months) which leads to important biogeochemical transformation of carbon and nutrienst during estuarine transit and subsequent atmospheric CO_2 emissions.

In order to better understand the cycle of the **dissolved inorganic carbon** cycle (DIC) in the HTZ, the partial pressure of CO_2 (pCO_2) of surface brackish water is measured continuously (every minutes) since november 2002 until nowadays, at the Sainte-Anna station near the city of Antwerp (see **Fig. 1** and **Fig. 2**). Results presented here show in a first part the **pCO_2 seasonal cycle in 2003**, and in a second part **relations between DIC and oxygen**.

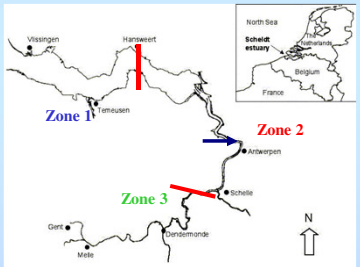


Fig. 1: The Scheldt estuary can be divided in 3 zones: **marine** (from the mouth, km 0 to km 40), **brackish** (km 40 to km 97) and a **freshwater zone** (km 97 to km 160). The Blue arrow shows the position of the station of pCO_2 measurements.

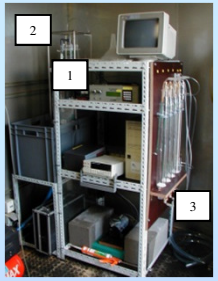


Fig.3: system for the measurment of surface brackish water pCO2, salinity and temperature.

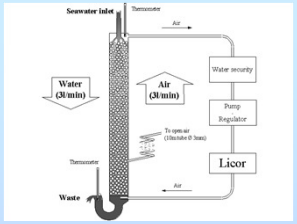
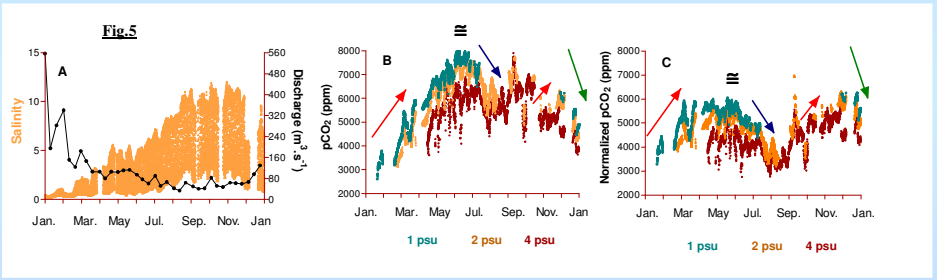


Fig.4: The equilibrator from Frankignoulle et *al.* 2001, Wat. Res., 35 (5), 1344-1347.

RESULTS AND DISCUSSION

Figure 5A shows the annual salinity cycle and the Scheldt discharge during year 2003. Salinity amplitude signal is inversely correlated to the Scheldt discharge. Highest run-off is observed in winter leading to a decrease of salinity amplitude signal. On the contrary, from spring to fall, run-off decreases, intrusion of seawater along the estuary becomes important as shown by the wide salinity amplitude signal.

Figure 5 B and C shows the seasonal cycle of pCO_2 in the HTZ for surface brackish water of salinities 1, 2 and 4. The observed decrease of pCO_2 along the salinity range is due to a dilution and ventilation effect. The Scheldt estuary is through the year strongly oversaturated with respect to the atmospheric pCO_2 (**up to 2200%**). Highest pCO_2 values are observed from spring to early summer, principally due to a temperature effect as the temperature normalized pCO_2 is stable during that period. Nevertheless, some part of this increase during spring, shown by red arrows, could also be explained by bacterial activity as a consequence of temperature increase (see **Fig. 6**). In summer, the pCO_2 decrease down to 2000ppm related to primary production (Gazeau et *al*. 2004, in preparation). During late summer and early fall, increase of both pCO_2 and normalized pCO_2 could be due to a decrease of gross primary production and maintained strong heterotrophic activities. In winter, the decrease of temperature and bacterial activity lead to the decrease of pCO_2 and normalised pCO_2.



Figures 6 show the annual cycle of temperature, salinity, oxygen and pCO_2 for the weekly samples. **Physical processes** (tides and run-off, see Fig.5) strongly affects the variables from spring to summer, the mixing between seawater (more oxygenated and poor in DIC) and freshwater (less oxygenated and rich in DIC) occuring along the estuary can be observed on the pCO_2, oxygen and salinity profiles. **Bacterial activity** is responsible from late February to April to a decrease of oxygen (10% to 50% saturation in winter), and pCO_2 increases from 4000 to 8000ppm. In summer, increase of oxygen and decrease of pCO_2 are both explained by the seawater intrusion in the estuary (marine waters are more oxygenated) but also by the **primary production**. Finally during fall through winter, **thermodynamic processes** (temperature drop) lead to a decrease of pCO_2 and bacterial activities.

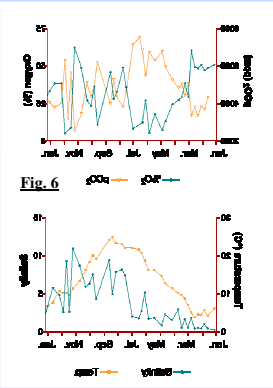


Fig. 6

CONCLUSION

This work showed that the DIC cycle in the HTZ of the strongly heterotrophic Scheldt estuary, is governed on an annual scale by a complex combination of physical (tides, run-off), thermodynamical and biological factors at different time scales. Among them, the most important are temperature and its effect on heterotrophic activities.

Acknowledgments

We gratefully thank the Ministerie van de Vlaamse Gemeenschap for the Scheldt discharge data.
Thank to Sarah Ferron-Smith, Teodora Diaz, Emile Libert and Nicolas Canu.
This research is funded by the Fonds National de la Recherche Scientifique (FNRS), Belgium (contract n° 2.4545.02, 2002-2004) and EUROTROPH (EVK3-CT-200-00040).

http://www.ulg.ac.be/oceanbio/co2