DIC dynamics in the Bay of Palma (NW Mediterranean)

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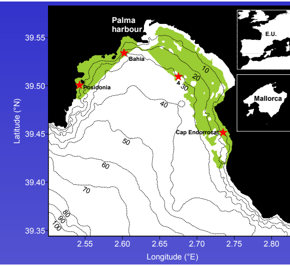

Fig. 1: The Bay of Palma

The Bay of Palma located in the Mallorca Island is characterized by the presence of an extensive *Posidonia oceanica* meadow extending from the coastline to a depth of about 30 m. Red stars indicate the stations where O_2 incubations were carried out for the determination of benthic and pelagic metabolic rates.

✓Abstract:

The Bay of Palma was sampled for Dissolved Inorganic Carbon (DIC) variables during 11 surveys in March 2002 (EUBAL I) and June 2002 (EUBAL II) in the framework of the EU project EUROTROPH. In June 2002, DIC values were systematically lower over the *Posidonia oceanica* meadow. The difference of DIC between the *Posidonia* meadow and the rest of the Bay of Palma, allowed the computation of the Net Ecosystem Production (NEP). The short-term variability of NEP was related to light availability. This allowed to integrate NEP for the sampling period based on continuous light measurements and the integrated value is in fair agreement with the estimates based on concomitant pelagic and benthic O_2 incubations.

✓Introduction:

Seagrass ecosystems are among the most productive coastal ecosystems and tend to be autotrophic with an excess of organic carbon production relative to community respiration (Duarte and Cebrián 1996 Limnol. Oceanogr. 41:1758–66; Gattuso et al. 1998 Annu. Rev. Ecol. Syst. 29: 405-433). The seagrass excess organic carbon can be grazed by herbivores, exported outside the system, buried within the sediment, or enter the detrital pathway. Carbon and nutrient flows in seagrass systems are further complicated by the interactions with the pelagic compartment.

One of the aims of the European project EUROTROPH (EVK3-CT-2000-00040) is to compare various methodologies to determine the trophic status of an ecosystem. In the present work we used the distribution of Dissolved Inorganic Carbon (DIC) to determine NEP in the Bay of Palma (Fig. 1) and we compare this estimate to Net Community Production (NCP) in the benthic and pelagic compartments based on O_2 incubations

✓Results:

During the June surveys, pCO_2 minima were systematically observed near-shore above the *P. oceanica* meadow, in particular on the Western side of the Bay of Palma (Fig. 2). Figure 3 shows that average DIC is lower over the *Posidonia* meadow than in the rest of the Bay during all the surveys. This systematic feature allows the computation of NEP according to the following equation:

$$NEP = \rho . h_{pos} . \frac{\left(DIC_{bay'} + t_{bay'} . \frac{F_{bay'}}{\rho . h_{bay'}}\right) - \left(DIC_{pos} + t_{pos} . \frac{F_{pos}}{\rho . h_{pos}}\right)}{t_{pos}}$$

where ρ is the water density (kg m^{-3}), DIC_* is DIC_{37} (mmol kg^{-1}), t_* is the water residence time (day), h_{pos} is the average water column height over the *Posidonia* meadow (m), $h_{bay'}$ is the average mixed layer depth in the Bay of Palma (excluding the Posidonia meadow), F_* is the air-sea CO_2 exchange computed using the Wanninkhof and McGillis (1999) gas transfer velocity formulation, subscript pos denotes data over the *Posidonia* meadow and subscript bay' denotes data over the rest of the Bay of Palma (excluding the *Posidonia* meadow).

NEP estimates are highly variable and encompass an order of magnitude (Fig. 4). The day-to-day variability of NEP seems to be mainly related to light availability as shown in Figure 5. Indeed, incoming solar radiation explains about 91% of the NEP variance. Based on the linear regression from Figure 4, NEP over the *Posidonia* meadow was integrated for the full duration of the June 2003 cruise (19-27 June): 21±9(std) mmolC m^{-2} day^{-1}.

This approach is attractive because it is based on large data-sets that adequately resolve the spatial variability, but it is based on the assumption that DIC is homogeneous in the water column (no vertical gradients). Vertical profiles of DIC were obtained at the four reference stations (Fig. 1) and the vertical gradients are smaller than the spatial gradients. We attempted to adjust the surface DIC values to represent the whole column values of these variables. Based on these, the recomputed NEP is 35±8(std) mmolC m^{-2} day^{-1}.

Integrated daily metabolic rates based on benthic and pelagic O_2 incubations over the *P. oceanica* meadow are summarized below (CR = Community Respiration ; GPP = Gross Primary Production).

	Pelagic			Benthic
mmolO_2 m^{-2} d^{-1}	GPP	CR	NCP	NCP
P.oceanica meadow	61	-52	9	26

Benthic NCP over the *Posidonia* meadow was measured at 2 stations (Posidonia and Cap Enderrocat; Fig. 1). Four different depths were investigated at Posidonia station enabling the construction of NCP vs. irradiance curves. NCP rates were then extrapolated to the whole *P.oceanica* meadow area using GIS-based bathymetric data and a mean benthic NCP rate of 26 mmolO_2 m^{-2} d^{-1} was estimated. Pelagic GPP and CR were measured at 3 stations (4 depths) over the *Posidonia* meadow (Posidonia, Bahia and Cap Enderrocat; Fig. 1) and integrated using a simple trapezoïdal procedure. A significant linear relationship was found between GPP rates and integrated Chlorophylla concentrations (GPP = 19.4 [Chla]; r^2 = 0.90). This procedure allows a better extrapolated estimate of pelagic GPP from Chlorophyll*a* concentration measurements at 5 stations during two surveys in June. Integrated CR rates measured at the 3 incubation stations were averaged leading to a pelagic NCP over the Posidonia meadow of 9 mmolO_2 m^{-2} d^{-1}. Based on these integrated rates, we estimated that the area covered by *P. oceanica* in the bay of Palma was autotrophic in June with a NEP of 35 mmolO_2 m^{-2} d^{-1}.

✓Conclusion:

NEP estimates over the *P.oceanica* meadow in June 2002 based on a DIC budget and spatially integrated pelagic and benthic O_2 incubation approaches give very consistent values. A better agreement is found when the vertical gradients of DIC are accounted for in the DIC budget approach.

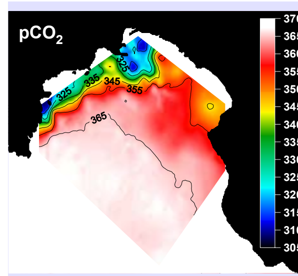

Fig. 2: pCO_2 in the Bay of Palma in June 2002

Partial pressure of CO_2 (pCO_2) data in surface waters were obtained during 6 surveys (19th, 21st, 25th, 26th and 27th June 2003) using the equillibration technique. During all surveys, pCO_2 values were systematically lower over the *P. oceanica* meadow.

The lower near-shore values pCO_2 observed on the western side of the Bay are consistent with the counter-clockwise pattern of residual currents leading to an impoverishment in CO_2 as the water mass is advected above the Posidonia meadow

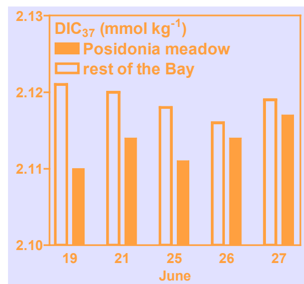

Fig. 3: DIC_{37} evolution over the Posidonia oceanica meadow and the rest of the Bay of Palma in June 2002

Evolution of DIC normalized to a constant salinity. The normalization to a constant salinity allows to remove the signal related to the evaporation/dilution and mixing of different water masses. DIC was computed from pCO2 and from the linear regression of Total Alkalinity as a function of salinity (not shown). The *P. oceanica* meadow is characterized by lower DIC_{37} values than the rest of the Bay of Palma. This systematic feature allows the computation of NEP over the *P.oceanica* meadow

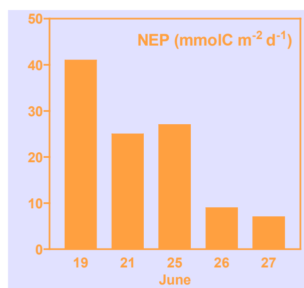

Fig. 4: Evolution of NEP over the P. oceanica meadow in the Bay of Palma in June 2002

The range of variation of NEP over the *P. oceanica* meadow encompasses one order of magnitude ranging from 7 to 41 mmol m^{-2} d^{-1}

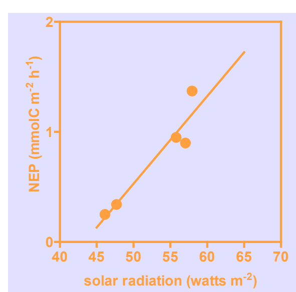

Fig. 5: NEP over the P. oceanica meadow versus solar radiation, in June 2002

NEP data were adjusted linearly to 12:00 UT (all surveys ended in mid-afternoon, ranging from 14:30 to 16:45 UT). Incoming solar radiation was averaged from dawn to 12:00 UT.
Solid line corresponds to the linear regression that yields:

NEP = -3 + 0.08*SR (r^2 = 0.807).

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