ASSIGNING INTERTIDAL PRODUCTION AND RESPIRATION TO BENTHIC ORGANISMS DURING EMERSION WITH AN IN SITU METHOD: response of microbes to seasonal changes in coarse and muddy sediments and effects of natural eutrophication caused by macroalgal deposits

C. Hubas (1), D. Davoull (2), L.P. Arigas (2), T. Carious (2)

(1) SFRM, Université de Lorraine, Centre de Paléontologie et d’Écologie, 57045 Nancy, France
(2) UMR 6219, INRA, École Nationale Supérieure de Techniques Avancées, 38856 Saint Paul en Forêt, France

INTRODUCTION

Studies relying on air-sea interface and assessment of respiration budget including all benthic compartments (from microbes to macrofauna) have seldom been attempted. In this study, a small benthic influence by both terrestrial and water column inputs was studied in order to (i) measure the contribution of microbes to benthic production and respiration during emersed conditions and (ii) to estimate effect of eutrophication caused by seasonal macroalgal deposits on benthic metabolism. A complete descriptive analysis (including bacteria, microphytobenthos, meiofauna and macrofauna) was completed by in situ measurements, within benthic microcosms (Migné et al., 2002), of the bulk benthic production and respiration. Results were compared with NO3, NO2, NH4 concentrations in pore water sediment and granulometry.

STUDY SITE

The Roscoff Aber Bay is a small intertidal bay (about 2 km long and 1 km wide) almost completely located above mideast level (Charusis, 1998). This bay includes three different types of intertidal sediments (Rallier, 1959) and represents a very complex ecosystem: (i) in the southern part a low spit in a lake allows deposition of terrestrial particles and (ii) the bay is also regularly influenced by macroalgal deposits (i.e. Enteromorpha sp. and Fucus sp.). Sampling sites (corresponding to 3 different intertidal areas) representative of the entire bay were studied during emersed period. The “river station” (A. 4°48' 42.82", W. 4°06' 04") located at the river entrance, characterized by muddy sediments, the “Lagendemer station” (B. 48° 42.96", W. 5° 59' 59") characterized by sandy sediments and the “Rock Krausen station” (C. 48° 43.44", W. 5° 58' 76") characterized by coarse sediments. Sample sites were located near the river along a strong environmental gradient (granulometry, nutrient concentrations).

BENTHIC RESPIRATION

Respiration variability: respiration clearly showed a seasonal pattern (figure 3A) with maximum respiration rate in summer. Higher rates were recorded in muddy sediments. Nevertheless, respiration appeared globally poorly linked to nutrient concentration (table 2). Bacteria, meiofauna and macrofauna biomass were strongly correlated to ammonia.

Contribution of benthic organisms: results confirmed the importance of environmental gradient in governing spatial distribution of benthic organisms: bacteria, meiofauna and macrofauna biomass were always higher in muddy sediments than in coarse ones. Respiration was compared to biomass of the bulk benthic autotrophic and heterotrophic organisms in order to measure their own contribution to benthic metabolism and specially benthic respiration. Correlations were calculated (table 2) and showed that all compartments were significantly linked to respiration.

EUTROPHICATION

Both benthic production and respiration were measured on macroalgal deposits and bare sediments. Such deposits increased gross primary production and respiration (figure 7) which showed a seasonal pattern on macroalgal mats with maximum production rates in spring and autumn and minimum in summer for primary production and maximum in summer for respiration. Gross primary production decreased with increasing degradation of stranded macroalgal deposit (figure 8) indicating that macroalgae played an important role on benthic metabolism. Nevertheless, the response of photosynthesis to irradiance should be then calculated in order to estimate impact of stranded macroalgae deposit on primary production and respiration during emersion. The Roscoff Aber Bay was stranded macroalgae by bacterial population, macrofauna and meiofauna (Riera and Hubas, 2003) inhabiting sediment. A carbon budget at the bay scale was completed by bacterial population, macrofauna and meiofauna (Riera and Hubas, 2003). In this study, a small intertidal bay (about 2 km long and 1 km wide) almost completely located above mideast level (Charusis, 1998). This bay includes three different types of intertidal sediments (Rallier, 1959) and represents a very complex ecosystem: (i) in the southern part a low spit in a lake allows deposition of terrestrial particles and (ii) the bay is also regularly influenced by macroalgal deposits (i.e. Enteromorpha sp. and Fucus sp.). Sampling sites (corresponding to 3 different intertidal areas) representative of the entire bay were studied during emersed period. The “river station” (A. 4°48' 42.82", W. 4°06' 04") located at the river entrance, characterized by muddy sediments, the “Lagendemer station” (B. 48° 42.96", W. 5° 59' 59") characterized by sandy sediments and the “Rock Krausen station” (C. 48° 43.44", W. 5° 58' 76") characterized by coarse sediments. Sample sites were located near the river along a strong environmental gradient (granulometry, nutrient concentrations).

BENTHIC RESPIRATION

Respiration variability: respiration clearly showed a seasonal pattern (figure 3A) with maximum respiration rate in summer. Higher rates were recorded in muddy sediments. Nevertheless, respiration appeared globally poorly linked to nutrient concentration (table 2). Bacteria, meiofauna and macrofauna biomass were strongly correlated to ammonia.

Contribution of benthic organisms: results confirmed the importance of environmental gradient in governing spatial distribution of benthic organisms: bacteria, meiofauna and macrofauna biomass were always higher in muddy sediments than in coarse ones. Respiration was compared to biomass of the bulk benthic autotrophic and heterotrophic organisms in order to measure their own contribution to benthic metabolism and specially benthic respiration. Correlations were calculated (table 2) and showed that all compartments were significantly linked to respiration.

EUTROPHICATION

Both benthic production and respiration were measured on macroalgal deposits and bare sediments. Such deposits increased gross primary production and respiration (figure 7) which showed a seasonal pattern on macroalgal mats with maximum production rates in spring and autumn and minimum in summer for primary production and maximum in summer for respiration. Gross primary production decreased with increasing degradation of stranded macroalgal deposit (figure 8) indicating that macroalgae played an important role on benthic metabolism. Nevertheless, the response of photosynthesis to irradiance should be then calculated in order to estimate impact of stranded macroalgae deposit on primary production and respiration during emersion. The Roscoff Aber Bay was divided into three equal areas, each represented by a sampling site (A, B and C) and the area covered by macroalgal mat was estimated to be about 15% of the Roscoff Aber Bay in spring and autumn and about 20% in summer. When deposits were taken into account, primary production and respiration increased (figure 8) indicating that macroalgae played an important role on benthic metabolism. Nevertheless, the response of photosynthesis to irradiance should be measured in order to propose a carbon budget at the bay scale including day-night and tidal cycles (Migné et al., 2002).

REFERENCES


CONCLUSION

The present study pointed out the importance of entrapped intertidal areas in coastal ecosystems. The bay appeared to be highly productive and influenced by both inputs from the water column and the river, which could influence production and respiration rates: the bay was regularly affected by both macroalgal deposits (originate from rocky shores near the bay) and nutrients inputs (from the river) which considerably increased primary production and respiration and could potentially change the carbon budget at the bay scale.

The bay appeared to be a very complex ecosystem: benthic metabolism was influenced by several environmental variables which fluctuated both in space and time. However, the study pointed out the great importance of benthic respiration which accounted for up to 48% of annual benthic respiration variability. The present study also pointed out the importance of environmental gradient which governed the distribution of benthic autotrophic and heterotrophic organisms.

These results indicated that benthic bacterial populations play a key role in intertidal sediments. Further functional analysis of production and respiration in intertidal areas, should focus mainly on macrofaunal meiofauna population but on microbes inhabiting sediments (microphytobenthos and benthic bacteria population respectively for benthic primary production and respiration).