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CARBON AND NITROGEN ISOTOPE RATIOS IN THE ANTARCTIC LIMPET NACELLA CONCINNA FROM ROCKY COASTAL HABITATS, MARIAN COVE, KING GEORGE ISLAND

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ABSTRACT

The Antarctic limpet *Nacella concinna* successfully colonizes intertidal and subtidal rocky shores and tide pools of Marian Cove, King George Island, Antarctica in the austral summer. $\delta^{13}C$ and $\delta^{15}N$ of the limpet tissues and their potential food sources were measured to determine their dietary origins and their movements between diverse habitats. $\delta^{13}C$ and $\delta^{15}N$ of the organic matter sources of epilithic microalgae, macroalgae, and suspended particulate organic matter (SPOM) were readily distinguishable to discern their relative contribution to the limpet diets, with the most depleted values being found in SPOM and the most enriched in macroalgae. The limpets exhibited a spatial trend in distribution due to their seasonal migration, with smaller individuals in the subtidal zone as compared with larger ones on the intertidal sites. The limpet isotopes had relatively broad ranges of $\delta^{13}C$ and $\delta^{15}N$ (−26.6 to −12.8‰ and 2.6 to 7.1‰, respectively), suggesting a dietary shift between habitats as well as size classes. The stable isotope ratios for each habitat seem likely to reflect the differing availabilities of the three potential food sources. Isotope mixing model results indicate a spatial shift in dietary mixture between habitats as well as limpet size classes. Epilithic microalgae and phytoplankton made great contributions to the diet of the subtidal limpets. Together with epilithic microalgae, macroalgae were significant contributors to the intertidal limpets where macroalgae were abundant. A higher contribution of macroalgae to the limpet diets was found in the tide pools. In contrast, while phytoplankton was an important food source for the limpet spats, a great dietary dependence on epilithic microalgae was found in the small-size limpets from the lower intertidal zone. Our results suggest that limpet grazing (i.e., top-down control) can determine microalgal and/or macroalgal abundance and coverage on the Antarctic rocky-shore ecosystem, and trophic structure of benthic food web can change along environmental gradients even at spatial scales of dozens or hundreds of meters in the Antarctic.

INTRODUCTION

The patellid limpet *Nacella concinna* (Strebel 1908) is one of the most common macrobenthic invertebrates colonizing the Antarctic and sub-Antarctic rocky shores (Picken 1980; Davenport 1988). The Antarctic limpet, which is a benthic grazer, displays the most important biomass of intertidal invertebrates in King George Island (Fraser 1989). This limpet resource represents an important dietary component to the energy requirements of Antarctic kelp gulls (Fraser 1989; Favero et al. 1997). Limpets may, therefore, play a crucial role as a trophic mediator between primary producers and predators in the Antarctic rocky-shore food web.

Growth performance of the Antarctic limpets decreases towards higher latitudes (Clarke et al. 2004). Although their annual growth rate is relatively low, their seasonal growth rate and condition are maximized in the austral summer (December–February). Spawning occurs during the time when both the water temperature and the food availability are increased (Brêthes et al. 1994; Kim 2001). These authors demonstrate a direct relationship between the somatic and gonadal mass of the limpets and the abundance of microphytobenthos. In particular, Kim (2001) found that no clear spawning events occurred in the limpet population of the King George Island coast during an austral summer when filamentous algae and benthic diatoms were poorly developed in the spring.

In the present study, we investigated the stable isotope ratios of carbon and nitrogen in the dominant organic matter sources of epilithic microalgae, macroalgae, and phytoplankton, together with the limpet tissues in Marian Cove, King George Island, Antarctica. The Antarctic limpets successfully colonize the intertidal and subtidal rocky bottoms and the tide pools during the austral summer. Tide pools are rocky pools that are filled with seawater even at low tide on the intertidal zone. The tide pools are unique habitats, which are separated from exposed intertidal habitats only at low tide, and colonized by various flora and fauna. High densities of the Antarctic limpets also can be found within the tide pools. The aim of the present work was to determine the food sources of the limpet populations and to examine their dietary shift according to site conditions among different habitats.

RESULTS AND DISCUSSION

A dual isotope plot of $\delta^{13}C$ versus $\delta^{15}N$ for the potential food sources and the consumers enables us to interpret the food sources assimilated (Fig. 1). The $\delta^{13}C$ values of the limpet spats were very close to those of SPOM as shown by the suspension feeder *L. elliptica*. The limpet $\delta^{13}C$ values from the subtidal B zone, the intertidal W, and the smaller-size creatures from the intertidal B zone were aligned with those of epilithic microalgae. However, the values of the limpets commonly collected in the intertidal B and tide pools were shifted towards those of macroalgae and positioned between those of epilithic microalgae and macroalgae.

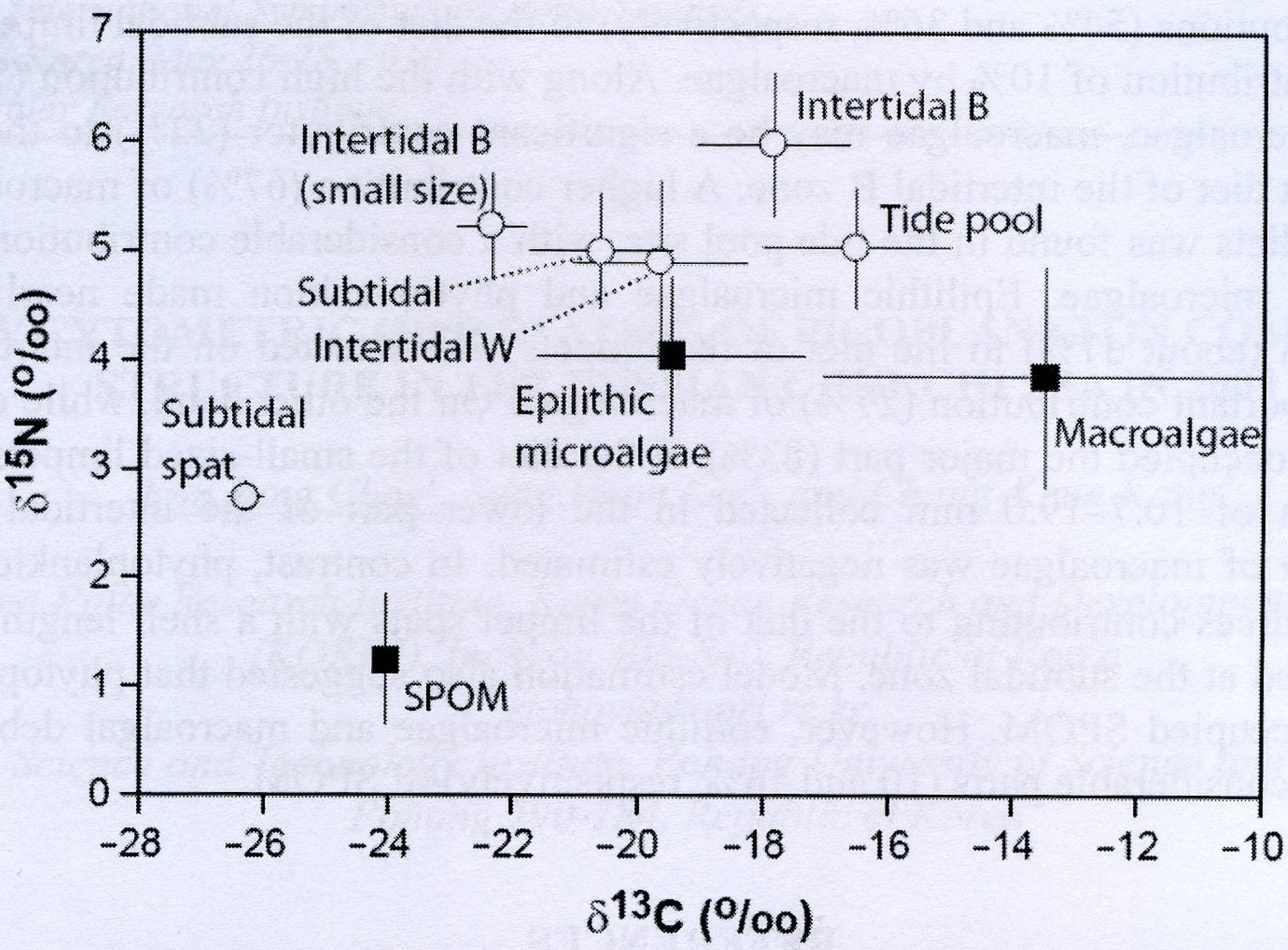

Fig 1. *Dual plot of $\delta^{13}C$ and $\delta^{15}N$ values of organic matter sources (square) and the limpets (circle) collected in different habitats of King George Island in February 2008.*

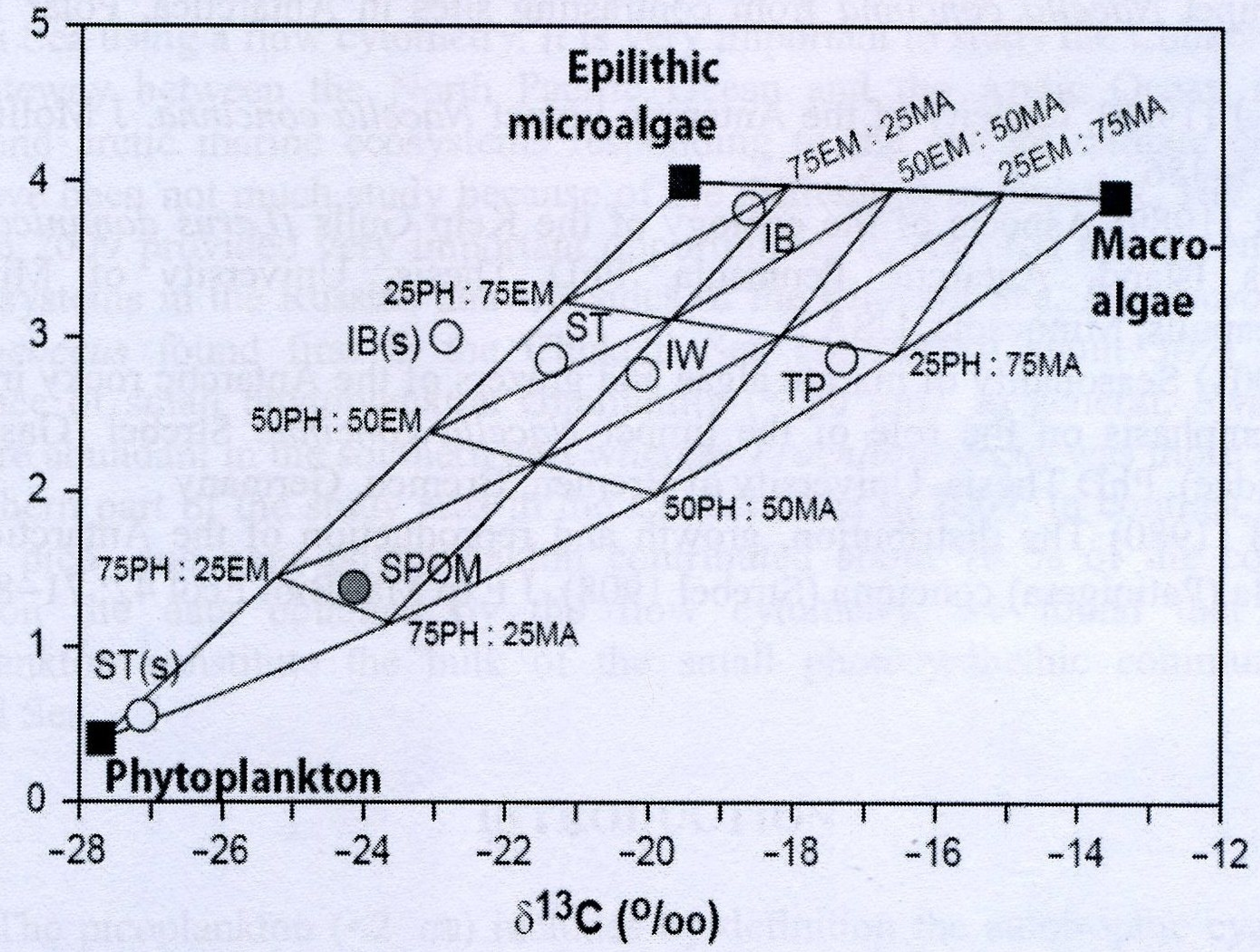

Fig 2. *Mixing triangle for the concentration-weighted model. Variations in percentage contribution of phytoplankton (PH), epilithic microalgae (EM), and macroalgae (MA) are shown along the edges of the mixing triangles.*

Based on trophic fractionation of +0.8‰ and +2.2‰ for limpet-tissue δ13C and δ15N from the diet, δ13C and δ15N plots for the presumed diet of the limpets showed considerable shifts among habitats (Fig. 2). Therefore, three-source mixing model suggested spatial variation in relative contribution of primary organic matter sources to the limpet diet. The result indicated that epilithic microalgae and phytoplankton made