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δ^{15}N mapping of POM and marine biota from the Murter Sea (Central Adriatic): implications for the evaluation of aquaculture and municipal waste on marine coastal ecosystems

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The isotopic compositions of nitrogen in particulate organic matter (POM) and organisms (sea grass *Posidonia oceanica*, sea anemone *Anemonia sulcata*, sponge *Aphlysina aerophoba*, barnacle *Balanus perforatus* and molluscs *Mythilus galloprowincialis*, *Arca Noae*, *Ostrea edulis*) were used to investigate the effects of particulate and dissolved nutrients deriving from aquaculture and urban sources (septic tanks, waste water treatment plant) of the Murter Island and the semi enclosed Pirovac Bay to the local ecosystems. The isotope data revealed a significant ^{15}N enrichment of the POM (representing a mixture of phytoplankton, bacteria, microzooplankton and detritus), the sea grass and the organisms collected in impacted areas of the Pirovac Bay, coastal parts of the Murter Sea and around fish cages at Vrgada Island compared to an unaffected, pristine offshore reference location at the Lumbarda Reef Flat (Kornati Islands).

The ^{15}N enrichment was as high as 7.7 permil in *Anemonia sulcata*, 7 permil in POM and *Aplysina aerophoba*, and between 4.4 and 5.6 ‰ in sea grass *P. oceanica*, *B. perforatus*, *M. galloprovincialis*, *A. noae* and *O. edulis* soft tissue samples. The observed enrichment is significantly larger than the natural δ^{15}N variability of the same species at unaffected locations. The highest δ^{15}N values were measured in the POM, as well as in the sea grass and other marine organisms from the coastal part of the Murter Island and Pirovac Bay affected by faecal organic matter from septic systems.

Slightly lower ^{15}N enrichment (up to 2 permil) was observed in biota samples from the impacted sites around the fish cages. The observed variations in the POM, the sea grass and the marine organisms' δ^{15}N values are primarily explained by a seasonal variation in the discharge of urban waste (sewage) and aquaculture-derived effluents.

Geochemical maps of the δ^{15}N values for the POM and biota were constructed. It was found that the distribution-transport patterns identified with this study are strongly influenced by the main water currents, locally affected by the prevailing tidal and wind-driven current regime. Such maps can successfully be used to support monitoring of the influence of fish farm activities and/or human sewage impact in marine environments, and in planning wastewater management in the region.