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Abstract

Dead zones are described as areas where few organisms can survive. We estimated the material cycle in dead zones to study the adverse effects of such areas on the bay-wide ecosystem function in Mikawa Bay, Japan. Material cycles were analyzed using the ecosystem model, which incorporates information of macrobenthos biomass variation, reflecting fluctuations in the levels of dissolved oxygen. This study was conducted at an area which was chosen from four types of dead zone, that is, small-scale port, loch, borrow pit, and large-scale port and its associated waterway. The amount of PON (Particulate Organic Nitrogen) outflow from the dead zones in small-scale ports and lochs in Mikawa Bay was estimated to be 25.2 tons between June 6th and September 29th of 2009. This value indicates the amount of PON to be removed across 1.39 km^2 of tidal flats in Mikawa Bay. The PON outflow from the small-scale port was estimated to decrease by 23% due to the addition of bivalves in the shallow parts of the small-scale port as a remedial measure. The loch changed from a PON source to a PON sink after an open-cut was made at the head of the loch and the subsequent addition of bivalves in the developed shallow areas as remedial measures. The maximum volume of hypoxic water accumulated in the dead zones at the borrow pits and the large-scale ports and its associated waterway, was estimated to be 6.9×10^7 m^3 in total. This value is equivalent to 25% of the volume of coastal waters shallower than 5 m, in Mikawa Bay. The maximum volume of hypoxic water accumulated in the borrow pit decreased by 78% as a result of recontouring of the borrow pit as a remedial measure. The amount of oxygen demand units ODU (Mn^{2+}, Fe^{2+}, H_2S, and CH_4) upwelling from the bottom of the large-scale port and its associated water way was reduced by 12% by the installation of underwater dikes as a remedial measure. Our results suggest that environmental restoration of dead zones is essential to the recovery of the bay-wide ecosystem function.