

closed-loop freshwater ponds essentially integrate pond ecological structure, trophic configuration, and circular economy principles, providing a basis for water quality improvement, yield enhancement, and green aquaculture.

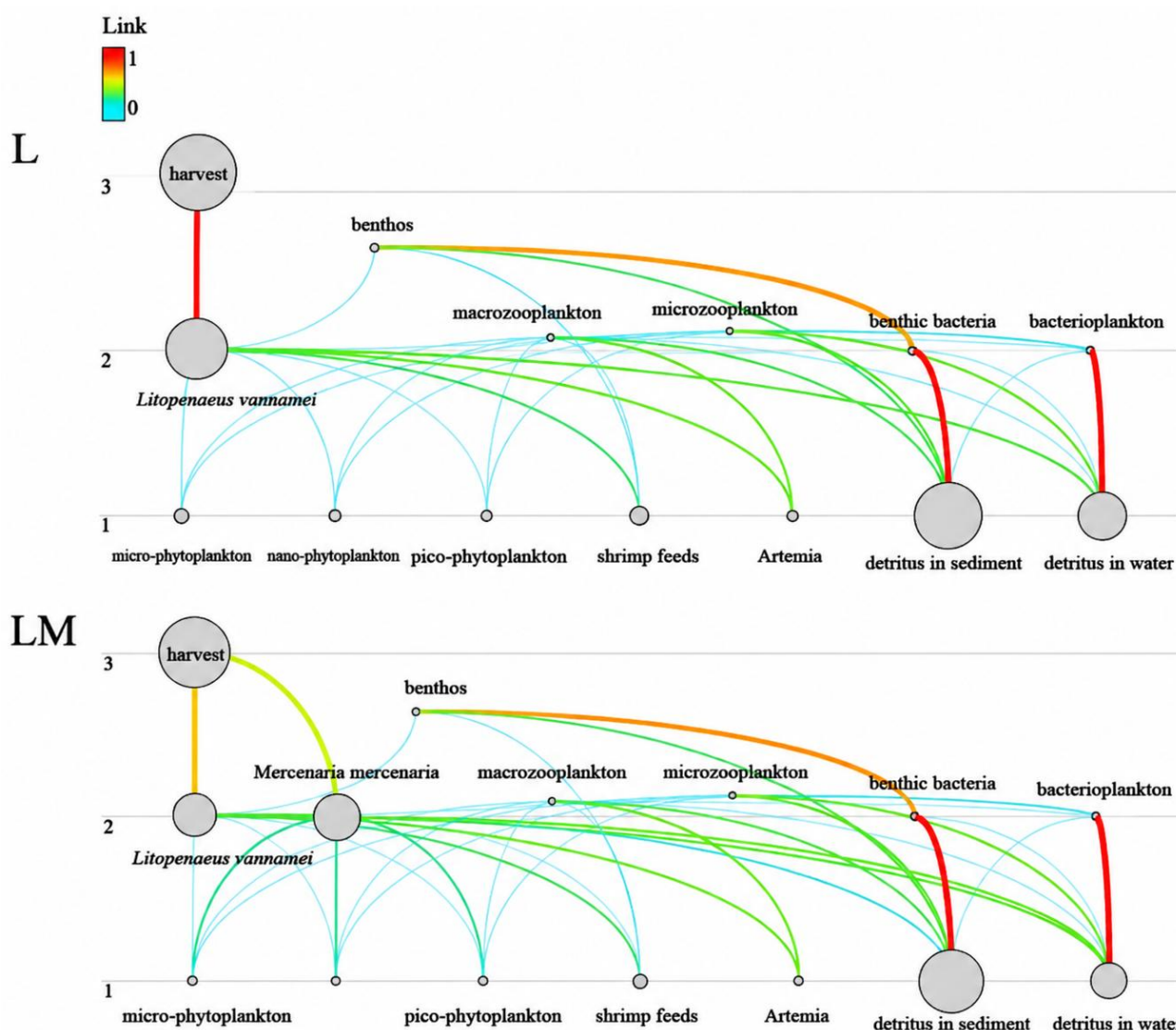


Figure 1 Trophic relationships between functional groups in the two aquaculture ecosystems (Adopted from Dong et al., 2022)
Image caption: L-a monoculture system of *L. vannamei*; LM-an integrated aquaculture system of *L. vannamei* with *M. mercenaria*. Each circle represents the corresponding functional group, the connecting line represents the energy transfer process, and the circle size represents the biomass volume of each group (Adopted from Dong et al., 2022)

3 Application Mechanisms of Ecological Food Chain Closure in Freshwater Pond Aquaculture

3.1 Nutrient recycling and utilization mechanism

In freshwater pond aquaculture, feed input is the main source through which nutrients such as nitrogen (N) and phosphorus (P) enter the system. After cultured organisms such as main cultured fish, shrimp, and crabs consume feed, part of the nutrients is converted into body biomass and eventually forms aquatic products; the remaining part enters the water column and sediment in the form of residual feed, feces, metabolic products, and dead organisms. If these materials cannot be transformed and utilized in a timely manner, they will continuously accumulate in the pond, causing increases in ammonium nitrogen, nitrite, total nitrogen, and total phosphorus, which further leads to water quality deterioration, eutrophication, and increased disease risk. Relevant studies have shown that a considerable proportion of input nitrogen and phosphorus in traditional ponds accumulates in sediments or is discharged with tailwater, resulting in low nutrient utilization efficiency and increasing the risk of