**SUPPORTING INFORMATION**

**Box S1: How to estimate trophic transfer efficiency**

According to the metabolic theory of ecology (Brown & Gillooly, 2003; Brown et al., 2004), the VDH predicts that TTE depends on size distribution of communities (Wang & Brose, 2018). TTE can also be empirically estimated from the allometric relationships between body mass, biomass, and TP for a member of size-based food webs (Jennings et al., 2002). The allometric scaling of mass-specific production against body mass across diverse invertebrate taxa was empirically formulated by (Banse & Mosher, 1980) as follows:

log (P*i*/B*i*) = –0.16 – 0.34 × log (M*i*) (S1)

where P*i* denotes the production for taxon *i* with body mass M*i* and biomass B*i*. From Eq. S1, we attempted to estimate production for each taxon of local communities based on the M*i* and B*i* measurements. By plotting the production of each taxon against its TP for each local community, TTE (%) can be estimated from the slope *a* of production against TP as 100 × 10*a* (Jennings et al., 2002).

In our system, most local communities did not show significant slopes, and TTE was estimated as 9.77% only for a community with a significant slope (Table S6), which is within the range of literature values reported for benthic communities. Many other communities demonstrated positive slopes, resulting in TTE exceeding 100%. With high uncertainty, the insignificant slopes can be partly due to weak correlations among body mass, biomass, and TP for benthic macroinvertebrate communities with the narrow size range (Fig. 2a, d). In theory, TTE of more than 100% is unrealistic in closed systems but likely in open systems in which allochthonous resources subsidize consumers (Polis et al., 1997). This is true if plankton products are regarded as an allochthonous resource for benthic communities, as is the case for suspension-feeding bivalves with higher biomass and TPs than other primary consumers relying on benthic algal production (Fig. 2d). In benthic communities, plankton productivity negatively affects benthic algal grazer biomass directly through habitat degradation because of organic matter loading (Paerl et al., 1998; Wolowicz et al., 2007) and indirectly through the depression of benthic microalgal production by phytoplankton from reduced light penetration to the lake bottom (Vadeboncoeur et al., 2003; Vadeboncoeur et al., 2001; Vadeboncoeur et al., 2008). Such benthic–pelagic interactions make benthic food webs more complex, which limits the testability of the VDH in size-based food webs.

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