

Bioturbation and bioirrigation by benthic fauna can partially moderate these impacts, but also alter ecosystem functioning near farms. Work at the edge of an allowable zone of effect found that higher bioturbation potential near cages reshaped microphytobenthic communities and trophic structure, shifting dominance toward euglenophytes and scavenging macrofauna while still supporting diverse trait combinations. Long-term observations of meiofaunal recovery after farm removal indicate that, although densities may begin to rebound within months, community structure and taxa richness remain altered, revealing time-lagged ecological feedbacks between past organic loading, benthic communities, and subsequent ecosystem resilience.

6 External Environmental Drivers of Water Quality Dynamics

6.1 Ocean hydrodynamic exchange processes

Ocean hydrodynamics govern how wastes and nutrients from cage-cultured grouper are diluted, transported, or retained around farms. Numerical simulations in the North Yellow Sea showed that suspended cages create low-velocity zones inside farm areas, with current speed reduced by up to about 45% under high-density culture, which in turn inhibits pollutant transport away from cages (Jiang et al., 2022). Similar modeling work in Sansha Bay found that near-surface current speed in cage-free areas was more than three times that inside cage areas in deep channels, indicating strong cage-induced drag that can slow horizontal water exchange.

Three-dimensional hydrodynamic studies further show that cages modify both horizontal and vertical flow structures, affecting the dispersion of dissolved and particulate effluents. High-resolution modelling demonstrated complex perturbations to tidal flows around cage arrays and revealed that altered currents strongly influence redistribution of passive tracers such as feed, faeces, or dissolved markers through and within cages. Observations in a semi-enclosed bay similarly identified a “double-drag” structure, with cage-induced surface friction reducing current velocities by up to 54% and hindering horizontal water exchange, while enhanced shear and turbulence below cages locally improved vertical mixing (Figure 2) (Jiang et al., 2022).

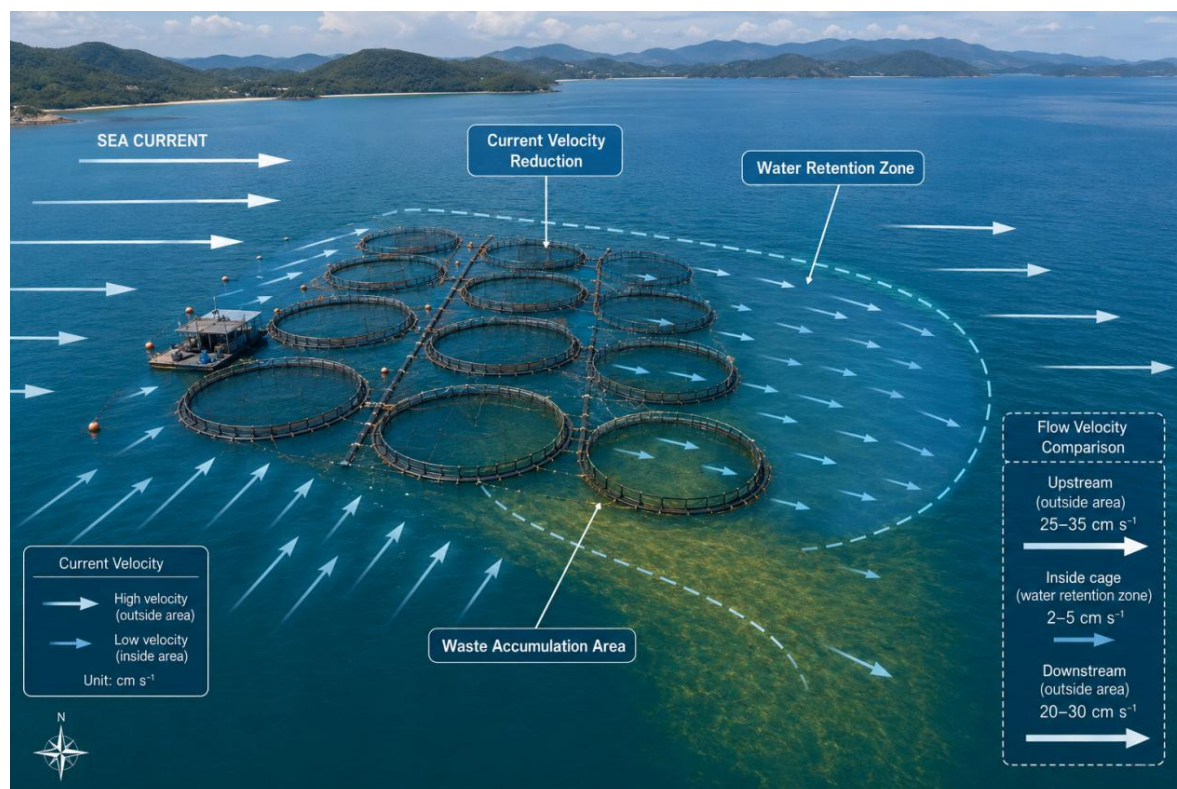


Figure 2 Hydrodynamic interaction between grouper cage arrays and surrounding coastal waters

Note: Cage structures obstruct water movement and create low-velocity zones within farming areas. Reduced current speeds increase water retention and may promote local accumulation of nutrients and organic wastes