In the present work, we developed a numerical model for fluid-structure interaction analysis of flow through and around an aquaculture net cage. The numerical model is based on the coupling between the porous media model and the lumped mass structural model. A novel interface was implemented to ensure efficient data exchange and element mapping between the fluid and structural solver via random-access memory. The main idea is to apply a static mesh in the fluid model, in case that large deformation of the net structure reduces the quality of the mesh. Then the geometry of the net cage was approximated by a set of dynamic porous zones, where the grid cells were updated at every iteration based on the transferred nodal positions from the structural model. A time stepping procedure was introduced, so the solver is applicable in both steady and unsteady conditions. In order to reduce the computational effort, sub-cycling was applied for the structural solver within each time step, based on the quasi-steady state assumption. The numerical model was validated against experiments in both steady and unsteady conditions. In general, the agreement is satisfactory.