Numerical simulation-based hydrodynamic interaction of bottom-set gillnet with current and ecological implications

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INTRODUCTION

- Gillnets are an effective gear for size-selective fishing, but selectivity of non-target species is indiscriminate. This lack of selectivity results in incidental catch or bycatch.
- Compared to rigid marine structures, the hydrodynamic response of gillnets is characterized by significant netting deformation, primarily caused by external loads from currents and interactions with entangled fish
- Therefore, a numerical model based on the mass-spring model was employed, enabling the spatial configuration, mesh opening, and tension distribution to be derived. Meanwhile, a series of model testing was conducted to capture the shape of the bottom-set gillnet and three-dimensional coordinates of tracer points at corresponding current velocities were collected.

MATERIALS AND METHOD

Physical model establishment → Node matrix construction → Dynamic analysis → Kinematic equation → Numerical solution → Model testing

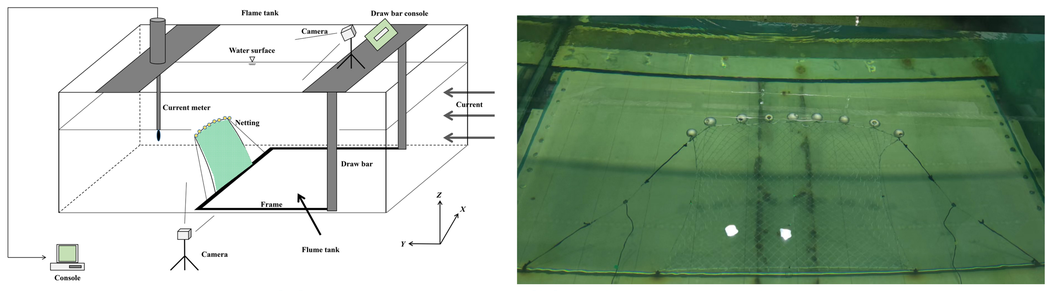

Fig. 1. Laboratory setup: (a) layout sketch and (b) a photograph taken during the experiment

RESULTS AND DISCUSSION

Determining the computation steps

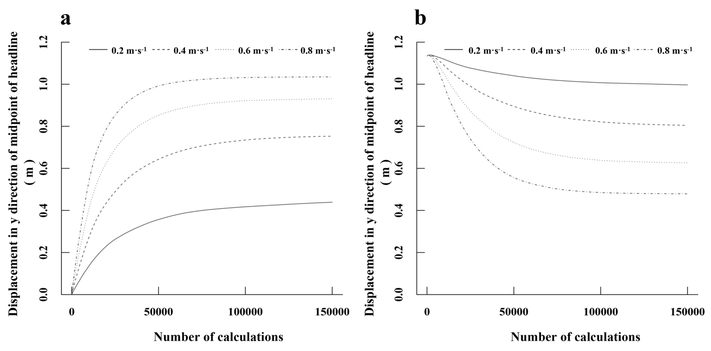

Fig.2. Displacement changes with number of calculations: (a): in Y direction; and (b): in Z direction

Simulation results verification

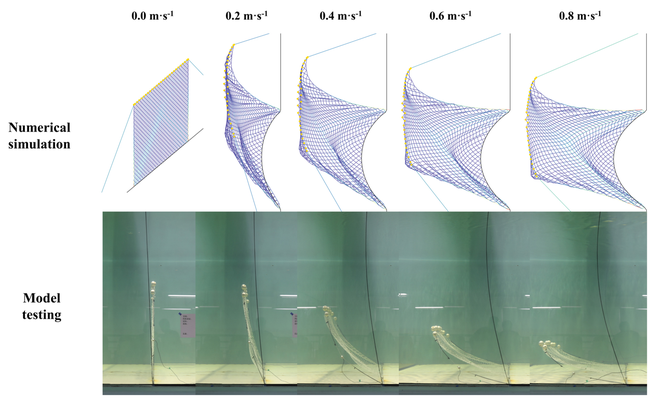

Fig.3. The comparisons of schematic diagrams between numerical simulation and model testing

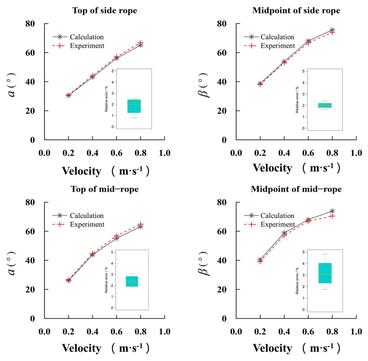

Fig.4. The comparisons of α and β between calculation and experiment

Shape and tension distribution of the set-gillnet in current

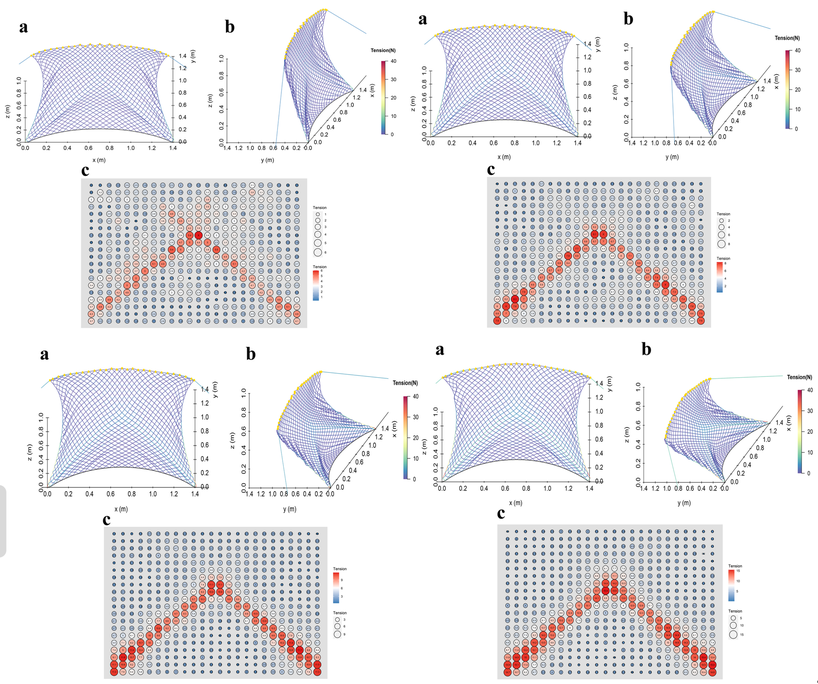

Fig.5. The gillnet shape and tension distribution when V = 0.2 m·s-1: (a): front view; (b)side view; and (c): tension distribution of mass points

Gillnet deformation of different dimensions

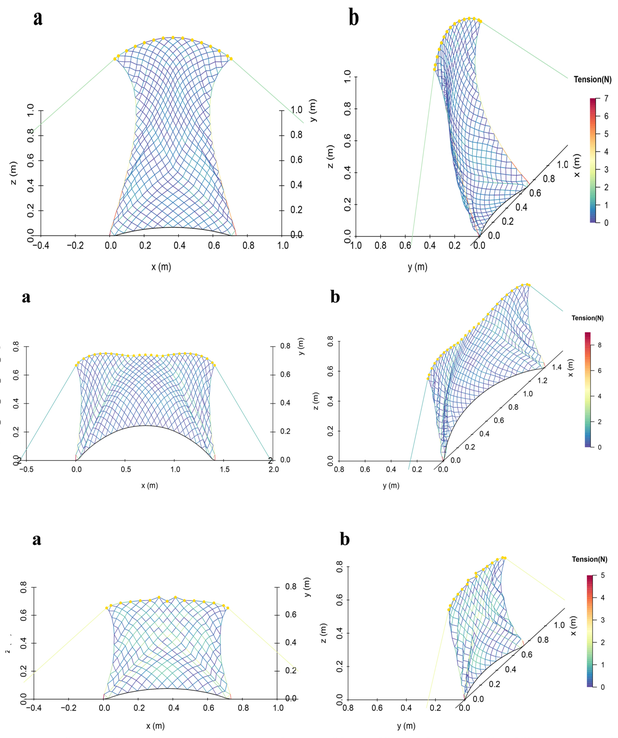

Fig.6. The shape and tension distribution of gillnets of different dimensions

- The simulation configurations of bottom-set gillnet at different velocities are in close agreement with experimental ones, although at higher current velocities, the relative errors slightly increased.
- As the current velocity increases, the hydrodynamic force acting on the gillnet system increases, resulting in gradual tilting deformation, and a backward and downward shift of the netting. Additionally, changes in current velocity can also induce alterations in the mesh opening patterns, with higher velocities causing greater disparities in mesh opening shapes throughout the gillnet system.
- As the current velocity increases, the tension at every point in the gillnet system increases increasingly, with the ropes bearing the greatest force and the anchor rope coming in second. The mesh bars near the edges of the "triangular" net bag have the higher tension, and the connecting points with the ropes also experienced relatively high tension.
- Choosing a lower and narrower gillnet can optimize its operating configuration into a vertically oriented wall, ensuring consistent mesh opening shapes and improved selectivity.

CLNCLUSIONS

A mass-spring model based on the lumped mass method was developed. By employing the implicit improved Euler method, we were able to obtain numerical solutions and comprehensive insights into the dynamic process, including the spatial configuration and tension distribution changes of the gillnet system. The effectiveness of the numerical calculation method has been rigorously validated through model testing. Furthermore, we have conducted a thorough analysis of hydrodynamic performance calculations for bottom-set gillnets under varying conditions of current velocities and dimensions, aiming to identify measures that promote more uniform stretching of the netting.