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The Numerical Simulation on the Tension Distribution in the Fishing Net in Steady Current

Yunpeng ZHAO [1,], Yucheng LI [1,2], Guohai DONG[1], Yuxiang Ma[1], Fukun GUI [3]*

1.State Key Lab of Coastal and Offshore Engineering, Dalian University of Technology, Dalian China;

2. R&D Center for Civil Engineering Technology, Dalian University, Dalian, China;

3. Marine Science and Technology School, Zhejiang Ocean University, Zhoushan, China

ABSTRACT

Fishing net should have enough strength to withstand the loading due to current and stormy waves and avoid fishing escape. Differing from other structures made from rigid materials, the intrinsically flexible nets undergo large deformation under external and internal forces. In addition, the length of netting twine undergoes extensional deformation as a result of various loads during fishing operation. The aim of this paper is to investigate the shape and tension distribution of fishing nets in current only. Herein, a numerical model is developed, based on lumped mass method. The fishing net can be modeled as a series of lumped point mass that are interconnected with springs without mass. Lumped point mass are set at each knot and at the center of the mesh bar. We can estimate net shape and tension distribution by calculating the displacements of these point masses under boundary and current conditions. According to our simulated results, the tension distribution in plane and cage net is demonstrated by images and positions where maximum of tension occurs are pointed out for the reference of practical application.

KEY WORDS: Tension distribution; Net cage; Numerical simulation

INTRODUCTION

As wild fish stocks decline, marine aquaculture is expected to play an increasing role in satisfying the global need for seafood. Since the expansion of near-shore aquaculture is becoming more difficult because of multi-use issues and environmental impact concerns, the feasibility of moving aquaculture into the open ocean is being studied. Fishing net is an important component part of net cage applied widely in open ocean aquaculture, which takes part in holding breed space. Fishing net should have enough intensity to withstand the attack of current and stormy waves to avoid fishing escape.

Fishing nets are mainly composed of supple netting and ropes. Differing from other structures made from rigid materials, the intrinsically flexible nets undergo large deformation under external and internal forces. In addition, the length of netting twine undergoes extensional deformation as a result of various loads during fishing operation. Hence, tension distribution in fishing net is an important part to be investigated for the safety of sea cage.

In the recent decades, some scientists have attempted to simulate the dynamic behavior of fishing net and put forward many useful methods. Théret (1993) proposed an original 3D numerical model for modeling fishing nets. He succeeded in developing software for calculating the shapes and tension forces of a trawl towed at a constant speed. Bessonneau and Marichal (1998) chose to use and generalize the assumptions adopted by Théret (1993) and developed a dynamic study of submerged and reticulated structures. Huang et al. (2006) developed a numerical model to simulate the dynamic properties of a net-cage system in current. In their model the cage net was divided into several plane surface elements to calculate the external forces. Tsukrov et al. (2003) described the theoretical models and calculation methods of nets, using the consistent net element method, compared the results of previous research with those of their models and applied them to interpreting the movement of the cage system. Lader et al.(2003) proposed a dynamic model for 3D net structures exposed to waves and current, based on a supper-element formulation. Physical model tests were carried out to verify the validity of their model. Li et al (2006a,b) developed a lumped mass method to simulate the hydrodynamic behavior of the plane net in current. In their method the lumped masses were set at each mesh knot and the center of each mesh bar, and the mesh grouping method was applied to reduce the number of lumped masses.

Although many researches, as mentioned above, about hydrodynamic behaviors of cage net in current have been carried out, a special analysis of tension distribution in cage net is lacking in the literature. The aim of this paper is to investigate the shape and tension distribution of fishing nets in current only, using our numerical model which has been set up and validated in our previous papers (Li et al. 2006a,b and Zhao et al. 2007). Herein, our numerical model is introduced first, and then based on lumped mass method, the deformation and tension distribution of plane net and net cage are simulated. According to our simulated results, the tension distribution in cage net is demonstrated by color images and positions where maximum of tension occurs are

* Corresponding author: Tel: +86-411-84708974 Fax: +86-411-84708526
E-mail address: zhaoyp18@hotmail.com