Modeling fish group swimming to optimize underwater vehicle performance

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Investigating the hydrodynamic performance of manta rays under staggered propulsion provides insight into the group formation setting of bionic underwater vehicles.

Many species of fish swim in groups to hunt, avoid predators, and increase their chances of reproduction. Their organized movements allow individuals to improve their hydrodynamic performance and thus conserve energy.

Understanding fish group swimming can help inform multivehicle marine environment surveys to optimize vehicle group formation and regulate movement parameters. However, there are fewer studies on fish propelled by the MPF (Medial Pectoral Fin) model compared to the BCF (Body Caudal Fin) model. Additionally, most studies do not simulate realistic swimming motions and use NACA foils instead of 3D, real organisms. To fill these gaps, Gao et al. conducted simulations on double manta rays under staggered propulsion.

“We carried out the first numerical simulation of manta ray group swimming, obtained the law of spacing influence on manta ray group swimming hydrodynamics, and combined with the evolution of the flow field to reveal the physical mechanism behind the change of group hydrodynamics with spacing,” said author Qiaogao Huang.

The leader manta ray’s hydrodynamic performance always exceeds that of individual swimming as streamwise spacing increases. The follower, on the other hand, experiences greater volatility in performance. The team also obtained the spacing required to maximize the system’s average thrust and efficiency gain. These results could have widespread applications in marine tasks.

“This work breaks the long-standing restriction of keeping the group formation in the same plane, extending the range of fish group swimming formation setups,” said Huang. “This provides a theoretical basis for the group formation setting of bionic underwater vehicles.”

Source: “Research on the swimming performance of two manta rays under staggered propulsion on the same frequency: When the follower is above the leader,” by Pengcheng Gao, Xushun Tian, Qiaogao Huang, and Guang Pan, Physics of Fluids (2024). The article can be accessed at https://doi.org/10.1063/5.0180621.

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