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ABSTRACT

Weihs theoretically revealed that during the movement of fish with negative buoyancy, more kinetic energy is saved in the glide and upward (GAU) swimming mode than in the continuous horizontal swimming mode. Because kinetic energy saving depends on dynamic parameters such as the drag and lift of the body, the effects of variations in these parameters on energy saving for different species remain unknown. Here, the kinetic energy saving of Pacific bluefin tuna (PBT), *Thunnus orientalis*, exhibiting the GAU swimming mode was investigated. The dynamic properties of PBT were estimated by carrying out CFD analysis. The CFD model was produced by using a three-dimensional laser surface profiler, and the model was controlled such that it exhibited swimming motion similar to that of a live PBT swimming in a flume tank. The drag generated by tail beating, which significantly affects the kinetic energy during motion, was twice that generated in the glide mode. The faster the upward swimming speed, the lesser is the kinetic energy saving; therefore, when the upward swimming speed is more than twice the glide speed, there is no gain in the GAU mode. However, when SMR (Standard Metabolic Rate) is considered, if the energy based on SMR is assumed to be 30% of the total energy spent during motion, the most efficient upward swimming speed is 1.4 times the glide speed. The GAU swimming mode of PBT leads to energy saving during motion, and the upward swimming speed and the lift force produced by the pectoral fins for the most efficient drive are unique for different species of different sizes.

Highlights

- We investigated swimming techniques that save kinetic energy in the Pacific bluefin.
- The dynamic properties of the Pacific Bluefin were analyzed using a CFD model.
- The drag during tail-beating was twice that in the glide mode.
- Kinetic energy is saved when upward swimming speed is more than twice glide speed.
- The upward speed and lift force for the most efficient drive are unique.