3-dimensional computational assessment of the fluid flow around coasting mature male *Prionace glauca* (Linnaeus, 1758) with respect to functional biology

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**Introduction:**
Fish swim by transferring momentum to the surrounding water through drag, lift and acceleration. During coasting (forward movement from momentum alone), a net drag force acts to reduce forward velocity [1]. Coasting induces vortex production anterior to the caudal fin. Energy lost to the surrounding fluid could be recovered by manipulation of these anterior vortices by the caudal fin during active swimming. Fluid flow is essential for many aspects of shark physiology including respiratory efficiency and mechanosensing [2]. In this study we have examined morphology induced vortex production and the effect of the dorsal fin on flow regime using computational fluid dynamics modelling in the pelagic blue shark, *Prionace glauca* (fig 1) during coasting in relation to functional biology.

**Method:**
Morphology data (fig 2) was input into the meshing software Gambit™ using Cartesian co-ordinates. A cuboid was created around the models to represent the flow tank in the model simulation. The effect of body morphology on flow regime was investigated by producing shark models devoid of fins (fig 3). Control simulations were run by comparing shark models with cylinders of the same length (nose to peduncle) and maximum radius. The effect of the dorsal fin on vortex creation along the lateral line was assessed using dorsal fin sections. These sections (and their controls) were run in Fluent™ both with and without the dorsal fin attached to investigate the difference in flow regime (fig 4).

**Results:**
*P. glauca* body morphology causes an increase in the mean flow velocity over the gill slits and a reduction in mean flow velocity along the lateral line (figs 5 and 6). This acts to enhance the efficiency of ram ventilation by increasing the difference in partial pressure of O₂ between the seawater and the blood. The reduction in velocity along the lateral line was caused by the interaction of the flow fields induced by the shark body and the dorsal fin (figs 7 and 8). This decreased mean velocity will reduce damage to superficial neuromasts thereby enhancing sensitivity to lower frequencies. The vorticity produced by the dorsal fin was enhanced by the body morphology of *P. glauca* illustrating fin-body interactions and suggesting the possibility of further vortex manipulation by the caudal fin during active swimming. Vorticity spikes at other fin positions suggest all the fins have evolved to interact with the body in a similar way (fig 9).

**Conclusion:**
*P. glauca* body morphology was found to manipulate dorsal fin and body induced vortices (and thus increase the mean vorticity regime around the shark) in order to dissipate turbulent kinetic energy and reduce the velocity magnitude along the lateral line. It is suggested that the water flow is thus channelled along the lateral line (fig 10) in vortices in order to create a baseline flow to facilitate the biological function of the lateral line (particularly in the lower frequencies) and the ampullae of Lorenzini. A large relative velocity magnitude was found over the gill slits, due to anterior body morphology accelerating the flow, in order to increase O₂ uptake efficiency. In this way the body morphology is not only found to reduce drag (due to annihilation of fin induced turbulence) but has also evolved to increase the efficiency of *P. glauca* functional biology.