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The Great Noarlunga Fish Circle

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Introduction

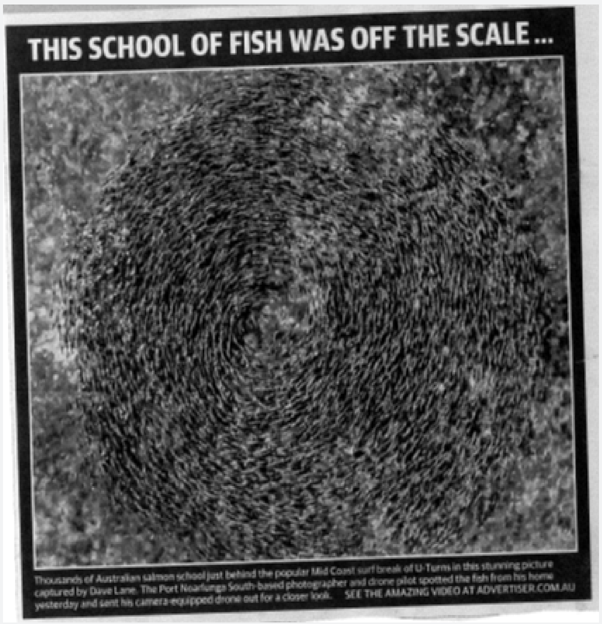

Figure 1: This School of Fish was off the Scale

Figure 2:

http://www.adelaidenow.com.au/news/south-australia/schools-out-for-salmon-drone-camera-captures-school-of-fish-off/news-story/28e3404ebe65116483954d14fbd4643b

The pelagic phenomena discussed in this note were inspired by an event in Gulf St. Vincent, South Australia, which occurred on the weekend of November 10 – 11 2018, in which the exodus of a school of Australian salmon [Brown Trout (Salmo trutta)] through the mouth of the Onkaparinga River and southwards on to the shore platforms of the coastal cliff escarpment at Port Noarlunga South gave rise to the formation of a great fish circle. This fish circle was spotted by Dave Lane on Saturday, November 10, 2018, who launched a drone to obtain still and video imagery, which were reported to the Adelaide Advertiser who published a classic image of the fish circle in the Sunday November 11 edition of the newspaper Figure 1, and uploaded superb video imagery provided by the drone Figure 2. This note gives a brief interpretation of these remarkable observations (Figure 1).

Fish that Swim in Circles

Consider a plane disk just under the water surface which consists of an assembly of powered elements each of which exerts a frictional force on the water column of the form, $dF = \rho K u^2 dA$ where dA is the surface area of the element, ρ is the water density, u is the swimming speed and K is a quadratic drag coefficient, and it has been assumed for simplicity that the undisturbed water is at rest and that u>0. On now constructing a fish circle by causing the powered elements to rotate as a solid body of constant angular velocity ($\omega = d\theta/dt$), the assembly exerts a power, $dP = \rho K r^3 \omega^3 2 \pi r dr$ in the annulus, dr, at the radius, r. On integrating this expression over the disk ($0 < r < R$), we obtain the total power exerted by the assembly, $P = 2/5 \rho K U^3 A$, where $A = \pi R^2$ is the area of the disk and U= R ω is the circumferential swimming speed, and assuming that the power is produced by N individuals, each exerting a power (P_o),

$$P_o = 2/5 \rho K U^3 A/N \quad (1)$$

The Noarlunga Fish Circle

The radius (R) of the Noarlunga fish circle is about 5 m and the visual imagery Figure2 suggests that the angular speed of rotation is about 30° in 5 s, which indicates that the circumferential speed of the fish motion, $U \approx 0.5\ ms^{-1}$. As a trial, suppose that the individuals in the assembly are capable of a foraging power output (P_o) of ¼ W, appropriate for a 1 kg fish [1]. Then on substituting, $\rho = 10^3$ kg/m^3 and $K = 2\ 10^{-3}$ in (1), we obtain, N = 31. This population is somewhat less than that observed in the video footage Figure 2, from which we deduce that the individual fishes may be smaller and take time off to explore as is apparent in the video footage. For example, 200 individuals each exerting a mean power output of 0.04 W, would also be able to maintain the fish circle. The reasons for the occurrence of the great fish circle and its initiation are open for speculation.

References

1. Bye JAT (1988) Energy dissipation by the biomass. Ocean Modelling 76: 6-8.

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