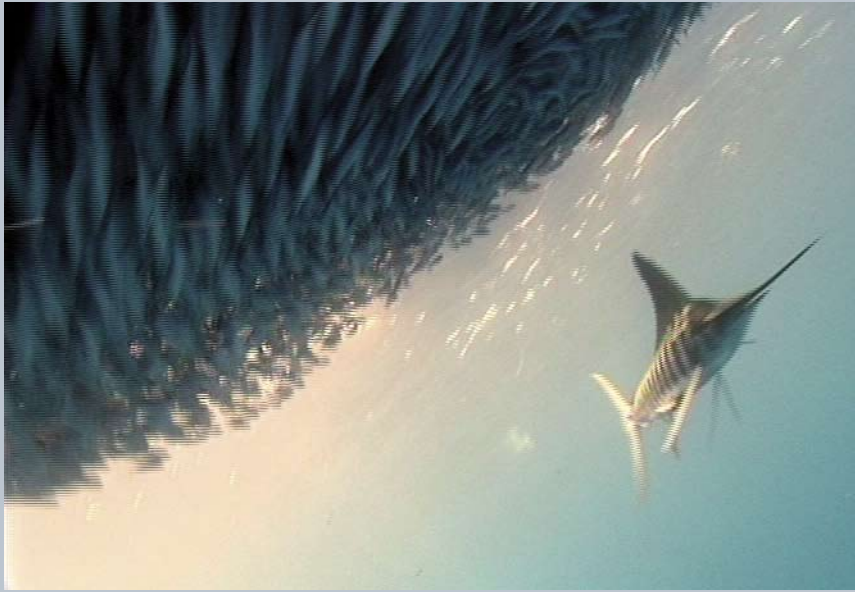


Why do fish swim in circles?

How are decisions made when one million fish swim together and act as one unit?



Fish schools often swim in circles when attacked by predators. Photo: BBC.

BY GRO NILSSON AND RUNE VABØ

A fish school can be understood as a leaderless, self-organised system, where the dynamics of the school emerges from mutual local interactions between individual fish simultaneously across the entire school. When there are millions of fish there are also millions of small decisions and responses every second, each decision being based on internal motivation, the configuration of nearby fish but, importantly, also by imitation of the responses of neighbouring fish. This process results in what can be observed from the outside: the collective behaviour of the school.

A collective decision of a school originates from this type of self-organising process, not as a democratic agreement among individuals, but as an emergent outcome of all the interactions and responses within the school. This principle is not very different from what happens when humans with mutual interactions in a community collectively decide to speak the same dialect or engage in the same cultural practices.

AN ADVANTAGE FOR THE INDIVIDUAL

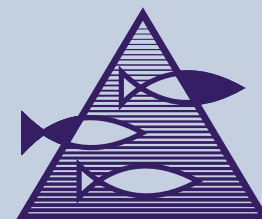
Fish often swim in circles when the school wants to stay put: due to wintering, before spawning or forced to by predators. The understanding of this behaviour may provide us with important general insights regarding interactions between predators and prey.

The most dominating advantage of schooling is understood to be protection against enemies. An extreme but common response of schools attacked by predators is the formation of a circle. This behaviour is peculiar and has therefore often been seen as an artefact by scientists, even though it is very common across several species and ecosystems. We believe it must have a functional and evolutionary basis, where the circling group behaviour has benefits to the individual fish.

PREDATORS MAY TAKE ADVANTAGE OF THE COLLECTIVE BEHAVIOUR

Sometimes it may seem stupid of the fish to swim in a circle. Both killer whales and baleen whales often force the schooling fish to the surface and





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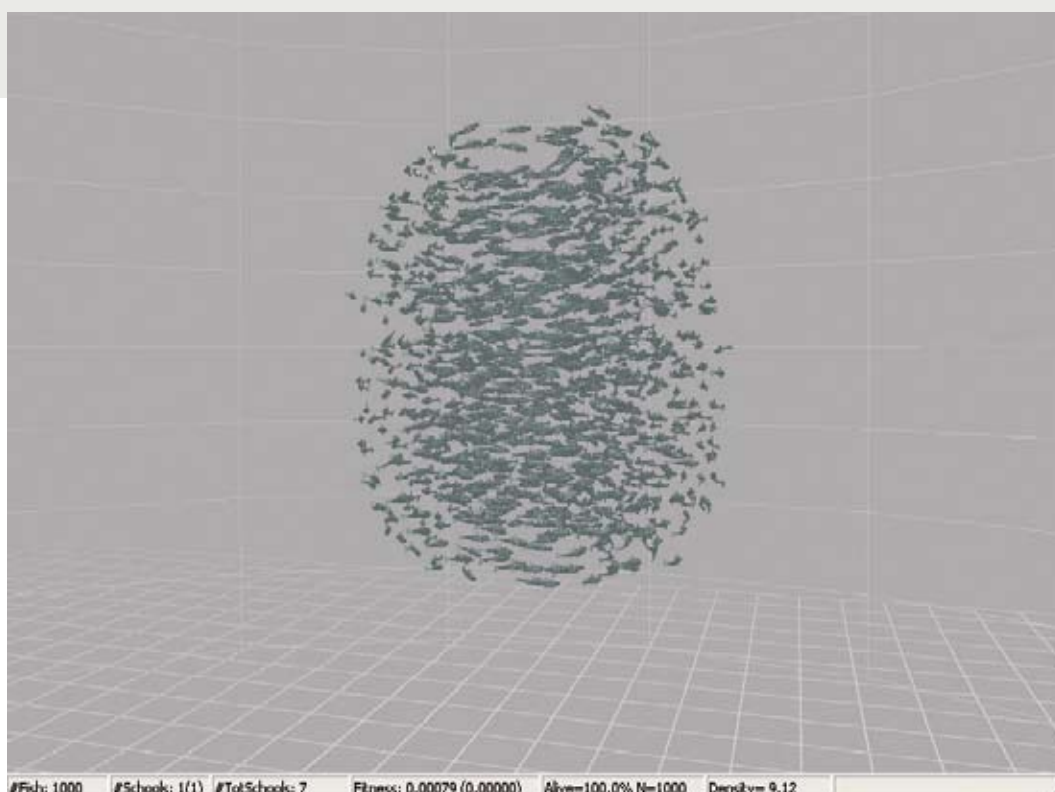
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Norwegian and North Sea
Ecosystems and Fish Stock



#Fish: 1000 #Schools: 1(1) #TotSchools: 7 Fitness: 0.00079 (0.00000) Alive=100.0% N=1000 Density= 9.12



Photo: BBC

Results from video analyses are used in models to help us understand the relationship between individual and collective behaviour.

This material provides us with the possibility to do video analysis of the circular swimming behaviour of different species in different ecosystems. The aims of the video analysis are to measure different factors such as density, swimming speed, shape and size of the school as well as direction and state of the fish, and to describe the interactions between schools and predators.

The results from the analysis will be used to gain new understanding of schooling fish. How the individuals interact and how the fish schools act in different situations will be described and put into system. The results will be implemented in existing individual-based models, used to better understand the relationship between individual and collective behaviour.

take advantage of the packed circling fish. While a baleen whale may eat the whole school in mouthful, the killer whales and other predators eat the fish one by one until there are none left.

The question is whether this is some kind of evolutionary arms race between predators and prey. Is it the predators that shape the schools? Or is it the schooling fish that benefits from the behaviour?

UNIQUE FILM MATERIAL TO STUDY

Several hours of video footage of predators such as jacks, marlins, dolphins and seabirds attacking different schooling fish have been collected from the BBC Natural History Unit.

