Travelling band solutions for a non-local model of fish schooling

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One of the most striking patterns in biology is the formation of animal aggregations. Social aggregations occur at all sizes from the microscopic colonies of bacteria to the macroscopic schools of fish. The effects of sociability, and the mechanics of how social groups assemble and operate in nature are the subjects of a large body of biological and mathematical literature. Several hypotheses have been made in the literature to predict the schooling behavior. Schooling fish perform a weet organized collective motion by some kind of social interaction even in the absence of leaders or external stimuli. Parr (1927) discussed the maintenance of fish school in terms of the balance of two counteracting forces attraction and repulsion, between individual fish. The school is modeled as an interacting particle system with behavioral and environmental stochasticty. So, the individual fish can be regarded as particles having autonomous locomotion and inbuilt response with respect to one another which is the social behavior such as attraction or repulsion. Most simulation models of animal aggregations in the literature assign a set of forces that act on the speed and direction of each individual are modulated in response to other individuals or the local environment. Typical force components include locomotory (e.g., biomechanical forces such as drag), aggregative (e.g., long-range attraction, short-range repulsion), arrayal (e.g., velocity matching), and random (e.g., individual stochasticity) forces (Parrish, 2002). According to the selfish herd hypothesis (Hamilton 1971), aggregations form because individuals try to reduce their predation risk at the expense of others. A member of a group can decrease its predation risk simply by moving towards the centre, because central positions are more likely to be safe (Bumann et al. 1997). It was noted that the attraction forces between animals are a result of avoidance of predators or instincts for aggregation to minimize exposure to predation. Similarly, it was noted that competition for food and resources would lead to repulsion or spacing behavior. It appears from a number of studies that front positions provide higher net food intake. The hungry individuals prefer to be at the outside of a group where there is a greater chance of obtaining food (Krause, 1993;

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Romey, 1995). The nature of the relationship between social forces and inter-individual distance has received some treatment in the literature (Grunbaum et al.,), and it is not the main subject here. In this work, we assume as first suspected by observations that individual fish have position preferences for different parts of the school (Patridge, 1982, Pitcher et al., 1982). These position preferences appear to be explained by two things: different feeding and predator avoidance probabilities in different parts of the group. For example, the hungry fish are often found in front positions of schools. The other individuals move towards one another, and this behavior will minimize predation risk. The danger of being alone would lead each individual to move towards flockmates. The modelling framework developed in this paper is the development and analysis of a model which allows for aggregation in one-dimension. We are mainly interested in exploring the phenomenon of travelling band solutions.

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