ESCAPE FROM PREDATORS: THE TAIL FLIP RESPONSE OF THE BROWN SHRIMP, *CRANGON CRANGON*

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Benthic organisms are vulnerable to predation by fish, and they offset this risk using a variety of defences. *Crangon crangon*, a common epibenthic shrimp living on sediment bottoms, reduces its chances on encountering predators by being cryptic, burying within the substratum, and co-ordinating its activity with times when it is least likely to be detected (i.e. night-time). However, when an attack by a fish does occur, the shrimp has to rely upon its rapid 'tail flip' escape response in order to avoid being caught (tail flip swimming is brought about by a series of rapid flexions and re-extensions of the abdomen). This behaviour has been studied in the laboratory using conventional and high-speed video techniques to film encounters between shrimps and predatory juvenile cod.

High-speed video has revealed that *C. crangon* roll to their left or right during the first few milliseconds of an escape, and thereafter tail flips usually occur with the shrimp swimming on its side. As shrimps increase in length from 5 to 50mm, their mean escape swimming velocity increases from 0.4 to 1 $m.s^{-1}$. Therefore, for a given size of cod, the chance of a shrimp being caught during an encounter decreases as shrimps become larger. However, the burst speed of cod is greater than the tail flip swimming speed of shrimps, and so it is particularly important for shrimps to escape along trajectories which optimise their escape chances. This may be confounded by the fact that fish are able to modify their attack if they learn to predict which way a shrimp will escape.

Escapes by *C. crangon* are usually directed away from the line of attack (agreeing with theoretical models derived by other workers), but when approached from certain directions, shrimps can also escape to the side of, as well as behind, the predator. Trajectories therefore have an unpredictable ('Protean') element which counteracts the compensatory behaviour of the cod, but this randomness nevertheless operates within a defined set of escape rules. Shrimps therefore minimise their likelihood of being caught using variety of escape trajectories, and combine this with speed in order to out-manoeuvre predators during a pursuit.

** This contribution is an abstract of the paper which was the SAMS Prize Lecture at the Scottish Marine Group Spring Meeting 1996, for which we congratulate Stephen Arnott.

The following paper was also presented at this meeting.