

A network analysis approach to understanding shark behaviour

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ABSTRACT

The mechanisms and functions of shark grouping behaviour have received relatively little scientific attention to date. The current widespread use of social network analysis to study animal groups, in concert with rapid advances in animal tracking technology, now allows us to test specific hypotheses about how and why sharks form groups. This thesis uses replicated laboratory experiments to investigate some of the mechanisms underpinning aggregation in a model species of benthic, oviporous elasmobranch, the small spotted catshark (*Scyliorhinus canicula* L. 1758; Scyliorhinidae). Acoustic tracking of this species in the wild is also conducted to explore how network analyses can be adopted to study the localized movements, habitat connectivity and ranging behaviour of adult sharks.

Groups of juvenile *S. canicula* were characterized by non-random social preferences, crucially, only when individuals were familiar with one another suggesting social recognition is important in young sharks of this species. Genetic analyses of parent and offspring DNA revealed very high levels of multiple paternity in this species, likely due to male sexual harassment and multiple mating, which leads to increased genetic diversity between juvenile sharks. Perhaps unsurprisingly, there was no evidence of kin relatedness structuring social interactions between conspecifics. Furthermore, testing the effects of environment on social behaviour provided evidence that these juveniles aggregated more in structurally complex environments than simple ones. However, at the individual level sharks showed consistency in their social network positions through time and across different habitat types. This result is indicative of personality traits in *S. canicula*.

Using data gathered via passive acoustic telemetry of wild shark behaviour, network analysis provided a useful tool with which to quantify movement between receivers. One chapter has been dedicated to the application of these methods, highlighting a number of different analyses for predicting movement behaviour from such data. Finally, these methods were adopted to address ecological questions in this sexually segregated species. Persistent site fidelity to a localised inshore area by both male and female sharks suggested that segregation occurred at a relatively small spatial and temporal scale. Despite strong evidence of segregation, analyses of movement networks and individual co-occurrences revealed distinct periods of behavioural synchronicity during the months of March, April and May. In addition, habitat complexity appeared to be a significant driver of female behavioural strategy. Enhancing our knowledge of the social and environmental drivers of aggregation and movement in sharks is of great importance given the ecological threat facing many of our ocean's top elasmobranch predators.

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Chapter III: NH helped create the null model used to test for assortment in juvenile shark association data.

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Chapter VII: SC set up the acoustic array in which the sharks were tracked and NH handled the import and cleaning of raw telemetry data prior to use.

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Chapter I was published in **Fish and Fisheries**

Jacoby, D. M. P., Croft, D. P. & Sims, D. W. (2012) Social behaviour in sharks and rays: analysis, patterns and implications for conservation. *Fish and Fisheries*, **13**(4), 399-417.

Chapter III was published in the **Journal of Fish Biology**

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