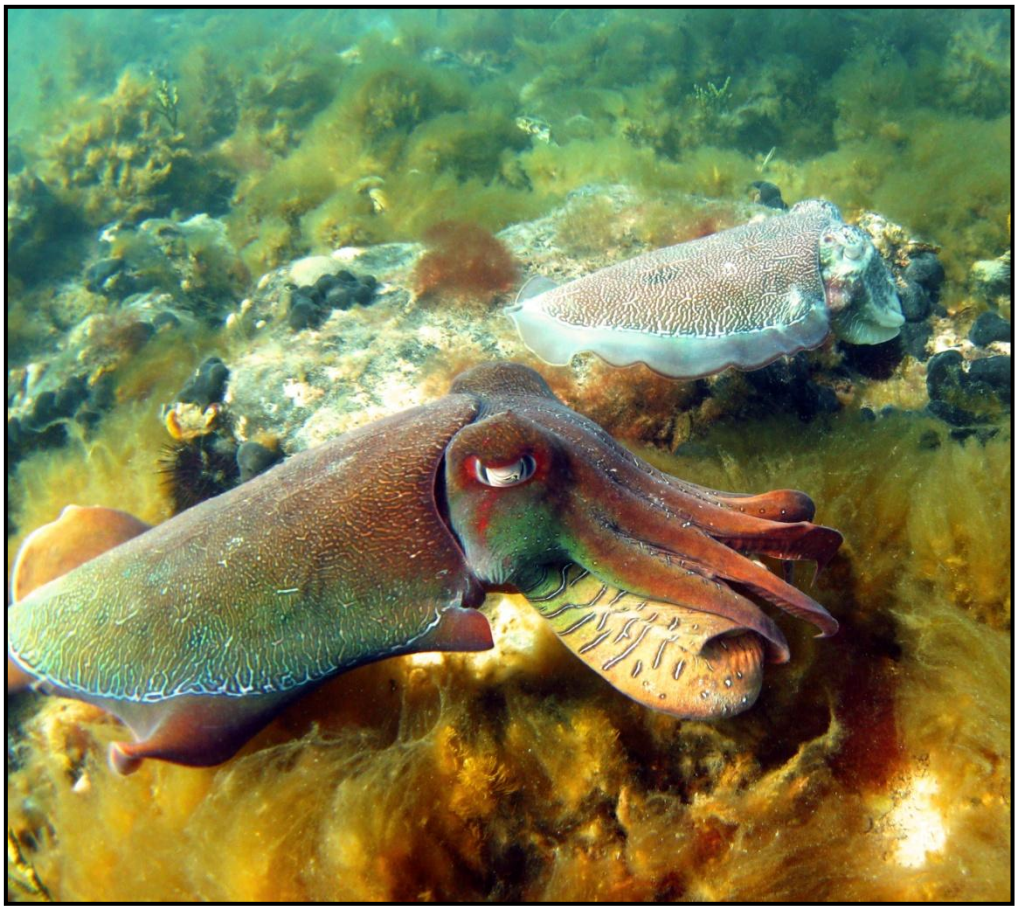
APPROACHES TO UNDERSTANDING THE POPULATION DYNAMICS AND BEHAVIOUR OF *SEPIA APAMA* IN NORTHERN SPENCER GULF



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Nicholas Leslie Payne
October 2010

Cover image: a pair of giant Australian cuttlefish, *Sepia apama*, at the Point Lowly breeding grounds. Photo credit: Nicholas Payne.

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ABSTRACT

Understanding the behaviour, physiology and energetic status of organisms in their natural environment is fundamental to ecology. For the unique breeding aggregation of giant Australian cuttlefish *Sepia apama* in northern Spencer Gulf, South Australia, a poor understanding of population dynamics and field energetics represents a hindrance to effective management. We used a combination of approaches to address these shortcomings, and to provide for a greater understanding of this species at the individual and population levels.

Although the operational sex ratio (OSR) of the aggregation is strongly male-biased, it is not known whether this is a result of disparate residence times between sexes, or a male-biased adult sex ratio (i.e. a relative paucity of females); such information is critical for predicting population viability. Using acoustic telemetry, we compared residence times between sexes, and found that the adult sex ratio is likely unbiased, with the skewed OSR due to gender differences in breeding durations. Regardless of sex, the relative brevity of residence times (compared to the 4-month breeding season) suggests that annual density-based population surveys may significantly underestimate population size.

Given the semelparous, protein-catabolising reproductive strategy of *S. apama*, knowledge of energy expenditure rates should provide for estimates of maximum breeding durations. With a view to better explain the relatively short breeding durations, the emerging „accelerometry" technique (which measures partial body acceleration as a proxy of metabolic rate) was used to estimate metabolic rate and describe activity patterns of *S. apama* during breeding. Daily energy budgets allowed protein catabolism rates to be estimated, and these rates correlated well with observed breeding durations. Accelerometry also revealed significantly higher activity levels during the day, which is consistent with the visual mating strategy of this species.

Examining rhythmic activity patterns is common among marine ecologists, and with acoustic telemetry, a leading approach is to search for rhythmic patterns in the relative frequency of acoustic detections. We compared patterns in detection frequency from tagged cuttlefish with those of fixed-location reference tags, and found that strong diel patterns seen in cuttlefish tags were also seen for the fixed-location tags. We used these results to highlight

the danger of making inferences about behaviour without controlling for external factors such as wind speed, water currents and biological noise.

Whilst acoustic telemetry and accelerometry can provide valuable information for mature individuals, alternative techniques are required for understanding the dynamics of early life-history stages of cephalopods. Significant advances in chemical mass-marking techniques have recently been made for juvenile and larval fish, but little attention has been paid to developing similar techniques for cephalopods. We evaluated the use of ^{137}Ba for mass-marking *S. apama* eggs, finding that several combinations of isotope concentration and immersion time produced high mark success rates, but that the mark was only incorporated in later developmental stages. The development of this technique will hopefully provide the impetus for field application of mass-marking techniques to *S. apama* and cephalopod populations globally.

In summary, several different approaches were described in an effort to improve our understanding of the population dynamics, energetics and behaviour of the *S. apama* breeding aggregation. Observing the dynamics and behaviour of marine animals has traditionally been difficult, but further development of techniques such as those employed throughout this thesis promises to provide important insights into the operation of cephalopods and fish worldwide.

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