SEAFISH

The Demography and Reproduction of Commercially Exploited Crustaceans in UK Waters

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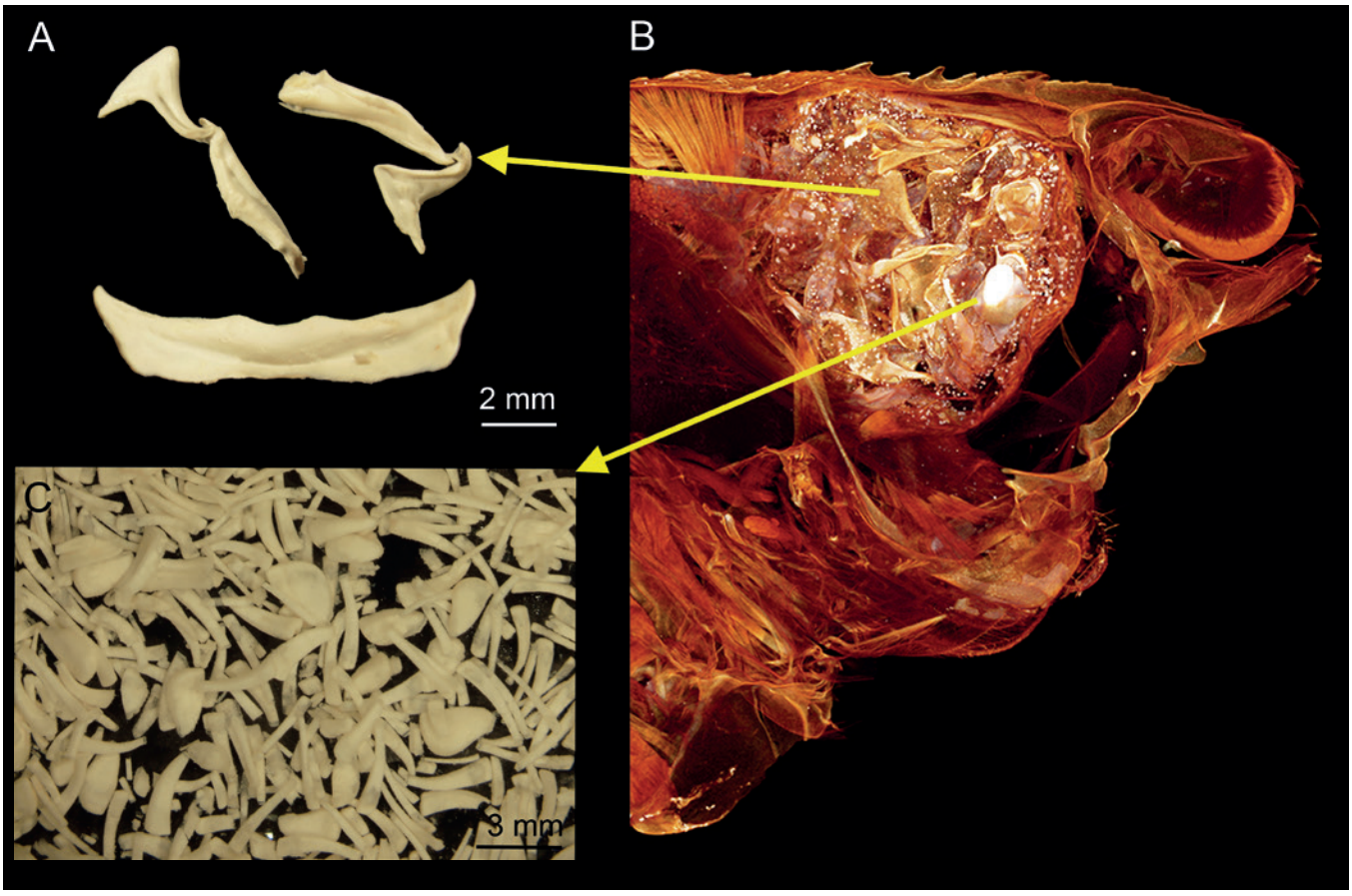
Project aims

Fisheries management measures are based on assessments of exploited populations which use estimates of growth, reproduction, maturity and mortality of the population to gain an understanding of demographics. Effective evidence-based management measures are of increasing importance because of the need to harvest seafood in a sustainable manner to maintain resources and market share. The aim of this project was to improve the scientific basis for understanding stock dynamics and hence management of crustacean fisheries. State-of-the-art anatomical methods are used to provide key tools to facilitate evidence-based fisheries management.

Crustacean age determination

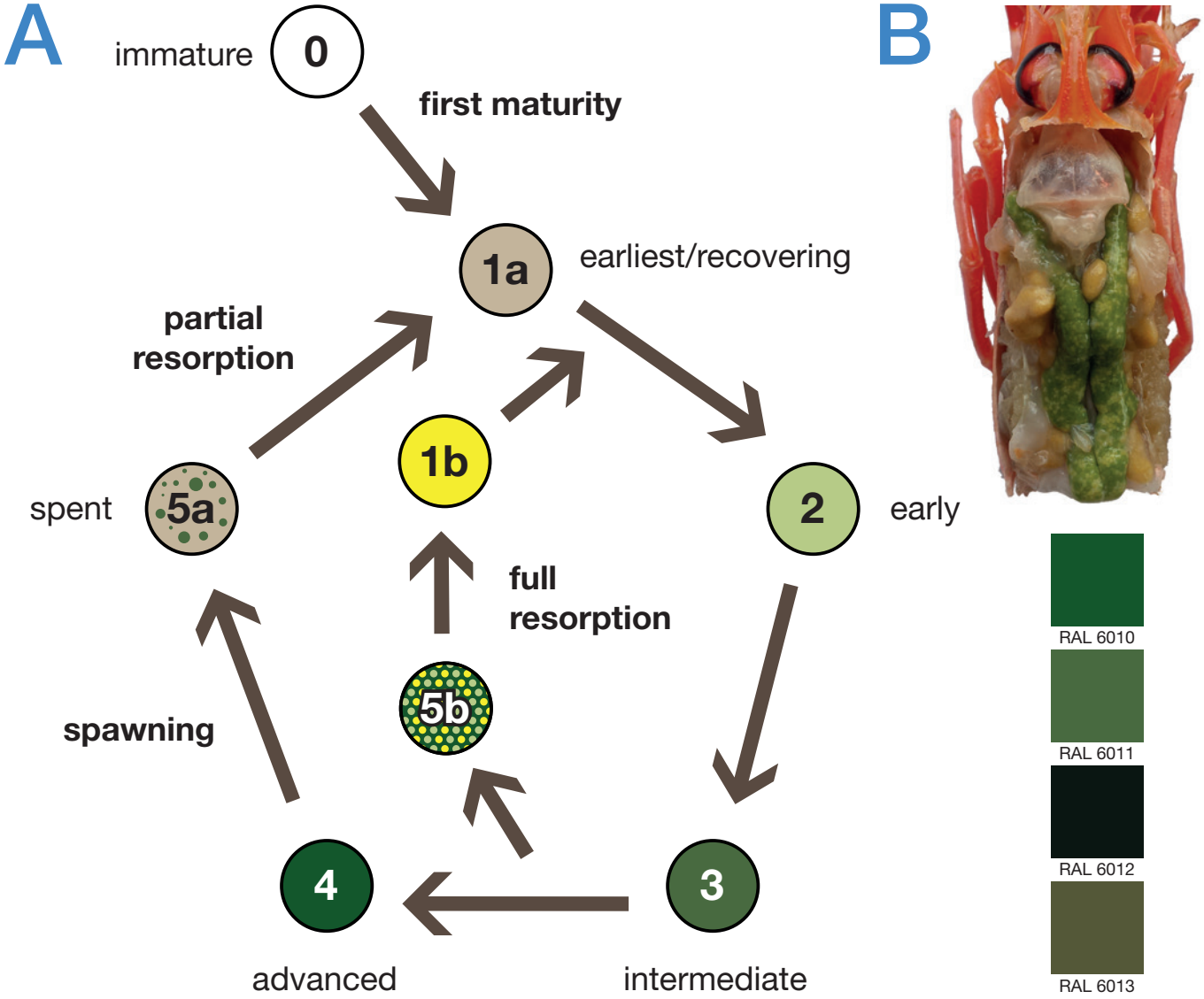
Understanding the chronological age of exploited crustaceans is important to fisheries management, because it is used to estimate growth, mortality, age at first sexual maturity, and so describe population demography including the reproductive capacity of target populations. Fisheries' scientists use annual rings in skeletal structures such as bivalve mollusc shells or fish otoliths to age individual specimens and therefore infer the age structure of the population. However, crustaceans grow by moulting. Unlike bivalve molluscs' shells or fish otoliths, which grow by accretion and form seasonal or annual rings, the crustacean skeleton is replaced at each moult.

We tested a recently-proposed new anatomical approach for determining crab and lobster age through counting rings found in the gastric teeth of these species. Our study used multiple methods on several species – Norway lobster (*Nephrops norvegicus*), brown crab (*Cancer pagurus*), velvet crab (*Necora puber*) and European lobster (*Homarus gammarus*) to explore the mechanism of ring formation and whether rings provide a record of age. Our results show that gastric teeth are completely lost and reformed at moulting and, thus, rings do not represent annual growth increments. We therefore recommend that the method of ring counting should not be used in fisheries science and management. Since these rings are not formed by accretionary growth, they may present an inaccurate record of age which would potentially lead to erroneous interpretation of population demographics.



Direct age determination of crustaceans?

Gastric teeth (A) have increasingly been used to determine the age of crabs and lobsters. It was proposed that these structures were excluded from moulting, and therefore able to record accretionary growth in the form of annual rings. We conducted live experiments and studied freshly moulted *Nephrops norvegicus* using x-ray tomography (B). Our results show that gastric teeth are subject to moulting as with all other cuticle structures in the crustacean body. Gastric teeth are shed and reformed with each moult; in recently moulted *Nephrops norvegicus*, gastric teeth are found loose inside the stomach (A, B) among the disintegrated subunits of the gastrolith (B, C).



The female reproductive cycle of *Nephrops norvegicus*

A Females enter the cycle at first maturity. Stage 1a represents the earliest or recovering stage. Stages 2–4 represent progressive stages of maturation. Once, spawning occurs, a partial resorption of a few remaining oocytes in the spent ovary occurs (stage 5a). The cycle can proceed along a different pathway in females that resorb their ovaries before they are mature (stage 4) and spawning occurs. This leads to the full resorption of the ovary (stage 5b). Once the resorption is completed (stage 1b), the female resumes a regular cycle.
B Females undergoing full resorption (stage 5b) have a mottled ovary.

Reproduction and demography

High resolution microscopic studies of the reproductive cycle of target species and standardised assessments of reproductive stages have been used to produce robust tools for fisheries management. We examined the reproductive cycle and demography of two key commercially exploited species: Norway lobster (*Nephrops norvegicus*) and velvet crab (*Necora puber*). A revised, standardized maturity staging scale, based on macroscopic and microscopic observations, is introduced for female *Nephrops norvegicus* to provide better-informed tools for future stock assessments.

The phenomenon of female *N. norvegicus* resorbing their ovaries instead of spawning has been studied in detail as those females are not contributing to the annual spawning stock and the affected population may be more vulnerable to over-exploitation. The proportion of females with resorbing ovaries was 25% in the Farn Deeps in 2017, which may significantly reduce reproductive capacity. Whether a lack of insemination is responsible for ovary resorption was tested using a microscopic approach. As all studied females with resorbing ovaries had mated, this indicates that environmental conditions such as temperature or food supply, may be responsible for resorption.

Sex ratios, size distributions and the size at onset of sexual maturity (SOM) are fundamental basis for stock assessment. The mean SOM of female *N. norvegicus* in the western Irish Sea was approximately 22 mm carapace length according to our analysis, which is higher than the current minimum landing size (20 mm carapace length). There is evidence that the SOM has decreased over time since 1997. Whether this is due to females being under selective pressure to reach maturity earlier or caused by other factors is difficult to assess.

Conclusions

This project contributes an advance in the science required for effective fisheries management, both in recognising that the cuticle band aging technique is not based on biological evidence, and in recommending improved standardisation in data capture for important long-term datasets. This is an example of how fundamental investigations into the biology of target species can effectively underpin the evidence-based management required to achieve sustainable fisheries.

For further information on this project please contact either:

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