MASTS Small Grant Scheme

SG452 Funding Report: Effects of pile driving noise and cadmium co-exposure on the early-life-stage development of the Norway Lobster, *Nephrops norvegicus*.

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Project overview

Marine organisms face many natural challenges to their survival including predation, and conspecific competition for food and shelter. However they are also under increasing pressure from anthropogenic pollutants, both those of historical notoriety such as heavy metals, but also more recently acknowledged pollutants, including noise arising from shipping and construction.

Whilst the effects of chemical pollutants are well documented for a wide variety of compounds and organisms, the potential impacts of marine noise are far less understood. To date, research addressing the potential impacts of marine noise have been heavy biased towards marine mammals, whereas the effects on vastly more prevalent invertebrates, and particularly their early-life stages, are comparatively unknown. Furthermore, many previous studies have only assessed impacts of stressors acting in isolation, which lacks the complexity and realism of natural environments where organisms invariably face multiple concurrent stressors. As a result, current risk assessments fail to account for interaction between multiple stressors (i.e., antagonism and synergism), and risk producing misestimating potential impacts.

To assess how the impacts of noise and chemical exposure combine, an experiment was conducted whereby Norway Lobster larvae (*Nephrops norvegicus*) were concurrently exposed to a regime of pile driving noise and waterborne cadmium. The experiment was undertaken at St Abbs Marine Station throughout July-

Table 1: Breakdown of Small Grant expenditure

Expense	Cost
Vehicle hire:	£408.99
Fuel costs:	£90.26
Total:	**£499.20**

September 2017, with funds from the MASTS Small Grant facilitating travel between Edinburgh Napier University (ENU) and St Abbs Marine Station (Table 1).

Results

Preliminary results of the experiment were debuted as both an E-poster and oral presentation at the MASTS ASM 2018, and a further poster abstract is being submitted for considerations at Scotland's International Marine Conference 2019.

Mortality

Preliminary analyses evidenced that exposure to pile-driving noise had both beneficial and detrimental effects on the ability of *N. norvegicus* to tolerate cadmium toxicity. Noise exposure resulted in significantly reduced larval mortality at low and medium cadmium concentrations, whilst a significant increase in mortality was observed at high cadmium concentrations in noise. It is hypothesised that this concentration-dependent shift in the stressor interaction reflects differing thresholds of oxidative stress damage/response resultant of each stressor, though this cannot be corroborated using existing samples. A repeat study is planned for next year with the intent of assessing oxidative stress responses in an attempt to establish the mechanisms involved.

Developmental duration

Pile-driving noise in combination with medium concentrations of cadmium significantly decreased larval developmental duration, whilst no such significant effect occurred in the other cadmium concentrations. No suitable explanation for this decrease is currently forthcoming, though correlation of developmental data against as-of-yet unprocessed biometric data may provide additional insight.

Behavioural fitness

Surviving metamorphosed larvae (now juveniles) were subjected to a behavioural fitness assessment. Juveniles were exposed to a simulated threat in the form of a foreign object placed immediately in front of them. Provoked escape responses were recorded, and provocation repeated until juveniles became exhausted.

Video analysis is yet to be conducted, but juvenile stamina and swimming dynamics will be analysed to assess ecologically relevant differences in fitness between larvae raised in different treatments.

Future direction and required research

Having established the presence of various interactions between pile driving noise and cadmium exposure in *N. norvegicus*, priority needs to be given to understanding the mechanisms driving these effects. Only by establishing the biological mechanisms by which organisms mitigate exposure to cadmium and noise can we begin to understand the observed interactions. A mechanistic understanding of these factors would also allow better predication of expected contextual interactions, which would in turn inform more accurate environmental risk assessments and mitigation strategies.

The upcoming repeat study will focus on these mechanisms by using molecular techniques to establish how larvae experience and regulate oxidative stress in response to both noise and cadmium exposures. This molecular data would complement current results and should provide a more comprehensive understanding of potential impact.

Summary

- Results demonstrated context-dependent interactions between pile-driving noise and cadmium exposure.
- A potential mechanistic explanation for these interactions has been hypothesised, but requires assessment during a future repeat study.
- Failure to consider roles of multiple stressors may lead to over- or under-estimation of environmental risk
- Presence of stressor interactions highlights the need to consider more integrative modelling for environmental risk assessment