Does radiation impact the growth of Australian marine microalgae *Tisochrysis lutea* ? Informing offshore oil and gas decommissioning

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Background

Offshore oil and gas infrastructure, such as pipelines, can be repurposed as artificial reefs after decommissioning. However, Naturally Occurring Radioactive Materials (NORMs) can deposit as scale and build up within this infrastructure. The potential exposure to marine organisms on a NORM-contaminated pipe has been estimated to be up to 34 µGy/h (MacIntosh et al., 2022[1]), exceeding the International Atomic Energy Agency's (IAEA) screening level of 10 µGy/h. This guideline is mostly derived from toxicity data from terrestrial and freshwater organisms in the northern hemisphere and is unlikely to accurately represent Australian marine organisms. More radio-toxicity data is required to improve risk assessments for offshore oil and gas decommissioning.

AIM: to measure the impact of external (gamma) radiation on the growth rate of an Australian marine microalgae *Tisochrysis lutea*

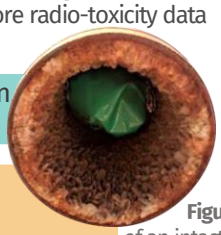

Figure 1. Hypothetical cross-section of an intact pipeline containing NORM-contaminated scale and examples of marine organisms that may be affected. The green layer represents benthic microalgae.

Methods

Cultures of *Tisochrysis lutea* were exposed to a sealed Caesium-137 source in 72-hour chronic toxicity tests (OECD guideline test 201). Growth measured daily via flow cytometry. Nickel toxicity tests ran concurrently as a quality assurance (QA) procedure to ensure algae responded as expected across multiple tests (**Figure 2**).

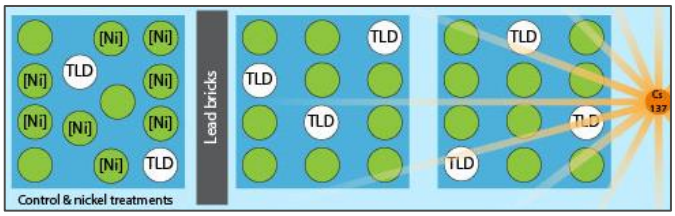

Figure 2. The experimental set up; blue squares represent orbital shakers, green circles represent algae samples, and the orange circle is the radiation source (Cs-137). Orange lines represent external radiation emitting radially and decreasing in dose with distance. The control table is shielded from radiation by lead bricks; dosimeters (TLD) measured the dose rates of each treatment.

Results

- Nickel QA performed as expected (**Figure 3**) and all radiation tests passed acceptability criteria from McKnight at al., 2023[2]
- *T. lutea* were exposed up to 7.9 mGy/h (**Figure 4**); substantially higher than what would be encountered in the environment
- The **No Significant Effect Concentration (NSEC)** was extrapolated to be 8.6 mGy/h

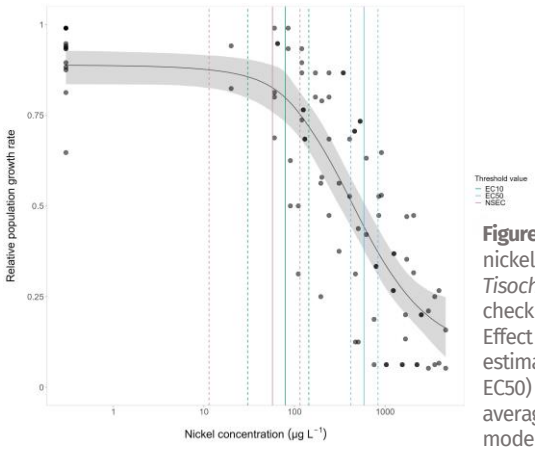

Figure 3. Dose-response of nickel toxicity to *Tisochrysis lutea* used to check QA. The plot and Effect Concentration estimates (NSEC, EC10 & EC50) are a weighted average of the best fitting models.

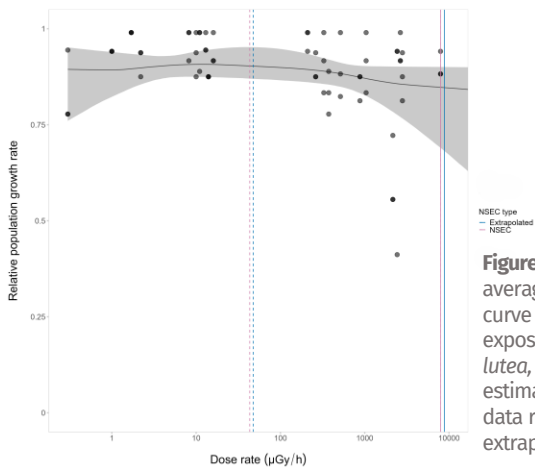

Figure 4. The weighted average dose-response curve for radiation exposure to *Tisochrysis lutea*, including the estimated (confined to the data range) and extrapolated NSEC

Conclusion

- This research suggests that the growth of *T. lutea* is unlikely to be affected at the radiation doses expected from NORM-contaminated infrastructure
- However, there may be other effects that could impact cellular processes, such as photosynthesis or DNA replication, which are not reflected by growth endpoints
- Additionally, radiation sensitivity is species-specific, thus other marine organisms are likely to have different responses to external radiation exposure compared to *T. lutea*
- These results will contribute to the efficacy of risk assessments during offshore oil and gas infrastructure decommissioning and has wider applicability to other nuclear industries such as power & submarines.

References: 1. MacIntosh, et al. (2022). Radiological risk assessment to marine biota from exposure to NORM from a decommissioned offshore oil and gas pipeline. *J. Environ. Radioact.*, 251-252.

2. McKnight, et al. (2023). The Effects of Nickel and Copper on Tropical Marine and Freshwater Microalgae Using Single and Multispecies Tests. *Environ. Toxicol. Chem.*, **42**, 901-913.

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