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NORM scale in the ocean: Assessing ecotoxicological and radiological effects on aquatic organisms

Background

Successful decommissioning of subsea oil and gas infrastructure requires an effective and safe approach of assessing and managing chemical and radiological residues. Scale residues frequently accumulate on the interior surfaces of pipes and other structures, and may persist long after extraction operations have ceased. Within such scale materials are naturally occurring radioactive materials (NORM), dominated by the U-238 and Th-232 decay series as well as co-occurring metal contaminants (e.g. mercury and other metalloids). On older, uncleaned pipes, the resulting accumulation of scale, can be substantial enough to reduce the internal diameter of a typical pipe by >20%.

The persistent nature of 'NORM scale' can provide a substantial radiological dose to the organisms living on, or near the pipe (Fig. 1a). Eventually, pipe corrosion could lead to scale contaminants and NORM constituents being directly available to organisms in situ or released into the surrounding benthic environment (Fig. 1b), where bioaccumulation and subsequent ecotoxicological effects from the chemical and radiological properties of the scale material could occur beyond the site of the pipe. There has been little work in defining specific chemical and radiological effects to organisms from scale materials in subsea oil and gas infrastructure.

Project objectives

The project will provide for a more valid assessment of the risk posed by sub sea oil and gas scale to aquatic organisms as compared with current methods which rely on default/reference parameters which may greatly misinterpret the risk. It is intended that this will enable improved strategies to be developed and potentially implemented, creating large cost-saving for both industry and government, whilst demonstrating environmental protection (stakeholder acceptance). Specifically, the project will address a critical step in achieving this goal: developing a data set of bioaccumulation (transfer) and organ distribution of NORM scale within pipe to bottom-dwelling (benthic) organisms from oil and gas distribution lines under several scenarios of pipe usage. The project will also seek to assess the relative importance of the chemotoxicity and radiotoxicity of scales to colonising marine organisms.

ANSTO Capabilities

ANSTO is perfectly aligned to perform this research as we have dedicated laboratories for conducting aquatic organism exposures that are licensed for use with radiological materials. Furthermore, we have analytical capabilities for qualifying and quantifying radiological constituents of NORM and significant experience in environmental radiological dose modelling.

Proposed project activities

1. Conduct chemical and radiological analyses of typical NORM scale waste to determine chemical and radionuclide constituents of a variety of scales.
2. Conduct laboratory studies to determine uptake of NORM by organisms from 3 scenarios: i) constantly suspended material; ii) settled material associated with sediment and iii) if possible, conduct exposures using in-tact pipe sections to investigate a 'leave in place' decommissioning strategy for pipelines.
3. Conduct chronic ecotoxicity studies for chemical and radiological effects associated with NORM scale. This will consider both chemical and radiological effects.
4. Use experimental exposure and bioaccumulation data to determine dose to typical Australian organisms through the development and modification of internationally-used environmental dose models.

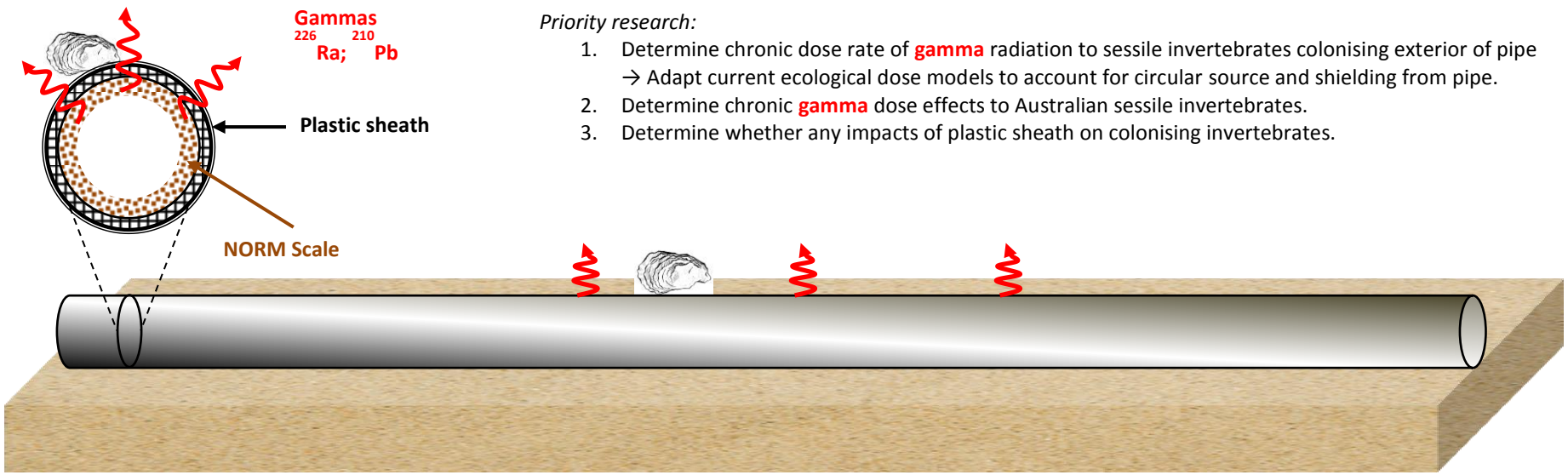
Student pre-requisites

The PhD student will have a 1st Class Hons. or equivalent in Environmental Toxicology, Chemistry, Biology or similar discipline. Experience in preparing and undertaking organism-contaminant exposure assays is beneficial but not crucial. Radiation safety training and radiation dose modelling to organism software/techniques will be provided.

Funding and supervision

Prospective PhD students in receipt of a Research Training Program (RTP) scholarship will be eligible for an ANSTO top-up scholarship ($7,500 per year). Supervision of the student will be shared between the university and Dr. Tom Cresswell at ANSTO. The study will also involve collaboration with CSIRO staff at Lucas Heights on various aspects of ecotoxicology.

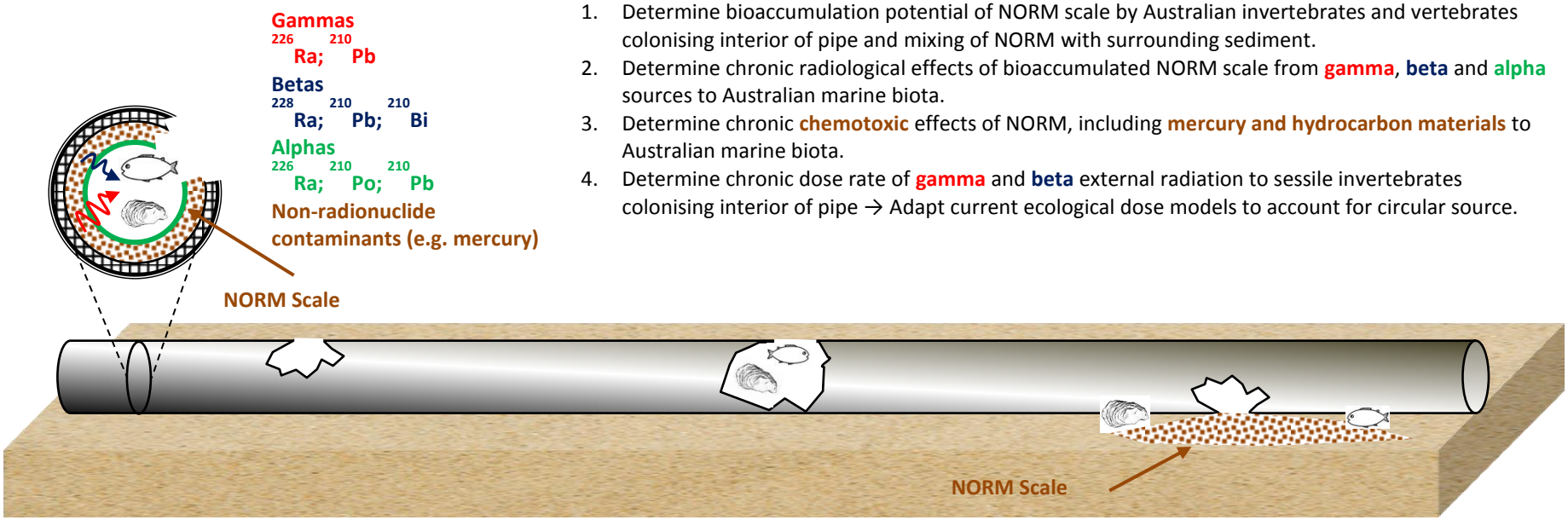
Figure 1a. Intact pipeline



Priority research:

1. Determine chronic dose rate of **gamma** radiation to sessile invertebrates colonising exterior of pipe → Adapt current ecological dose models to account for circular source and shielding from pipe.
2. Determine chronic **gamma** dose effects to Australian sessile invertebrates.
3. Determine whether any impacts of plastic sheath on colonising invertebrates.

Figure 1b. Degraded pipeline



Priority research:

1. Determine bioaccumulation potential of NORM scale by Australian invertebrates and vertebrates colonising interior of pipe and mixing of NORM with surrounding sediment.
2. Determine chronic radiological effects of bioaccumulated NORM scale from **gamma**, **beta** and **alpha** sources to Australian marine biota.
3. Determine chronic **chemotoxic** effects of NORM, including **mercury and hydrocarbon materials** to Australian marine biota.
4. Determine chronic dose rate of **gamma** and **beta** external radiation to sessile invertebrates colonising interior of pipe → Adapt current ecological dose models to account for circular source.