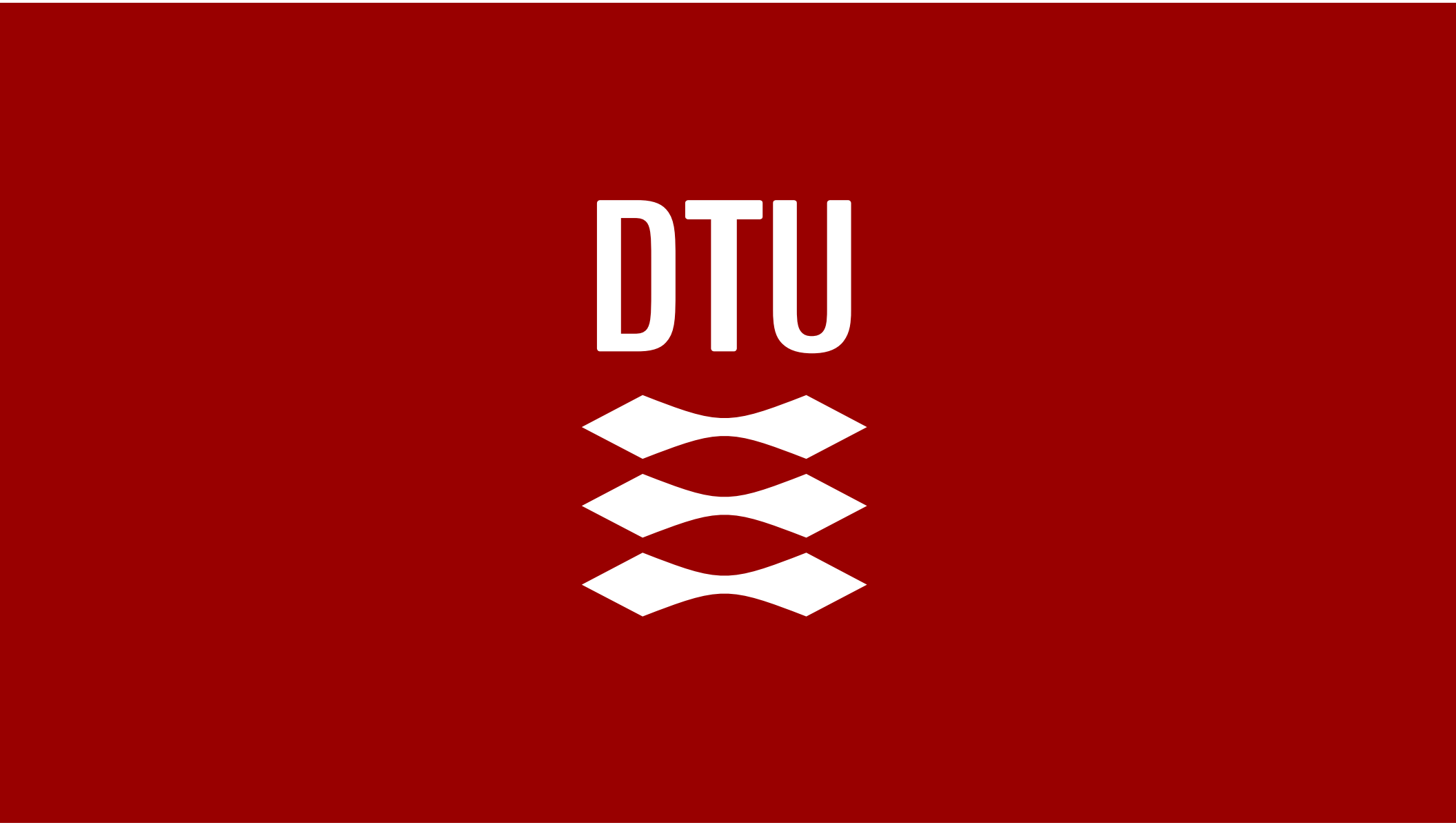
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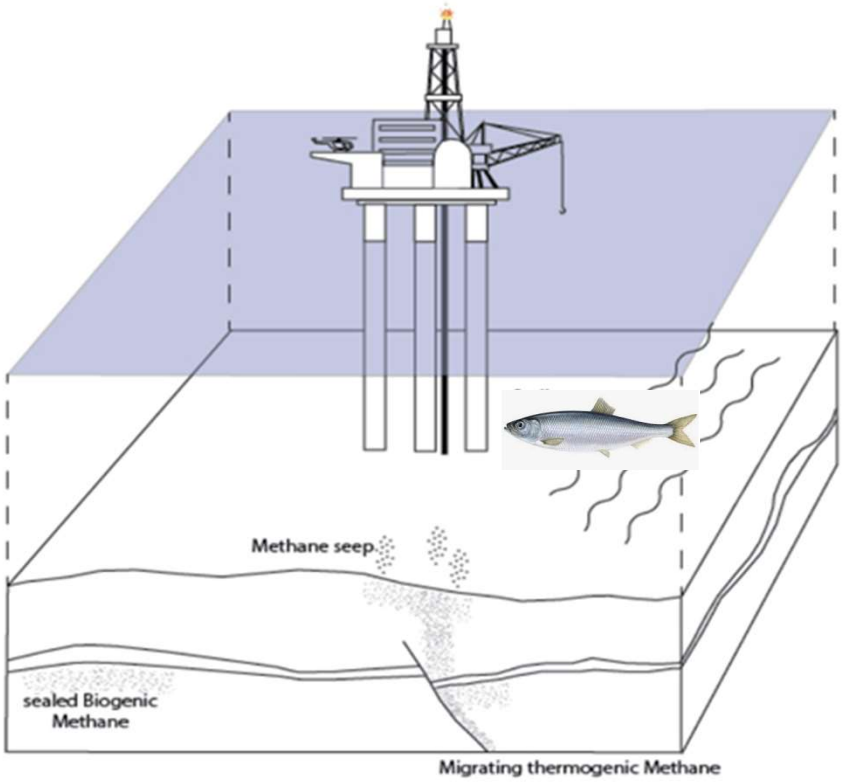
Abandonment Research for reduced Environmental Impact

Potential environmental impacts of field abandonment

Abandonment aim: reduce Environmental Impact over time



Drawing by Lasse Prins, GEUS

Long term effects:

- Leaking wells - leaks from either O&G reservoir or shallower hydrocarbon bearing layers, due to O&G activities

- Impact of removing structures on marine habitats

Temporary effects:

- Impacts of the abandonment operation (emissions, unintentional discharge, noise ….)

Note: Reducing the temporary effects is likely to also reduce operational cost

Facilitating rigless abandonment on wells with scale build up

Temporary Environmental Impacts

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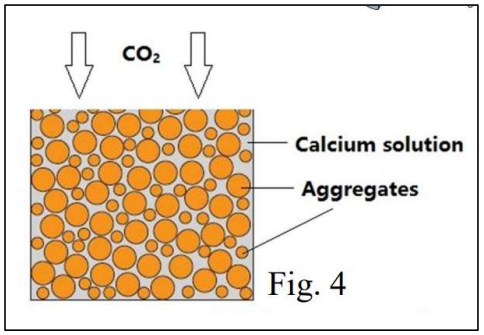
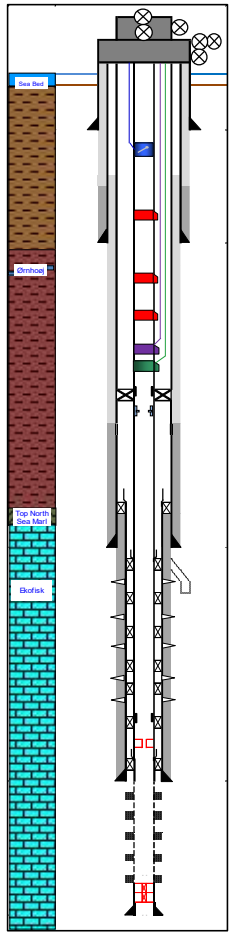


Fig. 4



Challenge:

Rigless abandonment can reduce both abandonment cost and the environmental footprint of the abandonment operation. However, on wells with scale build up the scale have to be removed using coil tubing before the rig less abandonment operations is initiated.

Hypothesis/Expected Outcome:

The scale can be left in the well both when depressuring the wells prior to abandonment and as part of the well barriers

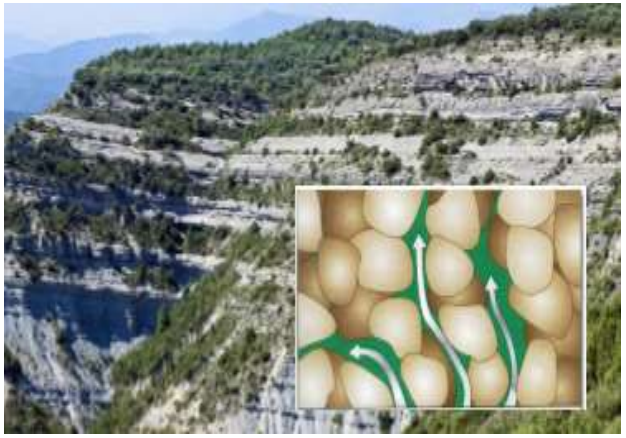
Value:

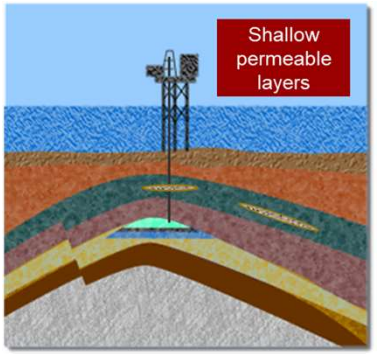
- Save time and cost of scale milling operation prior to abandonment

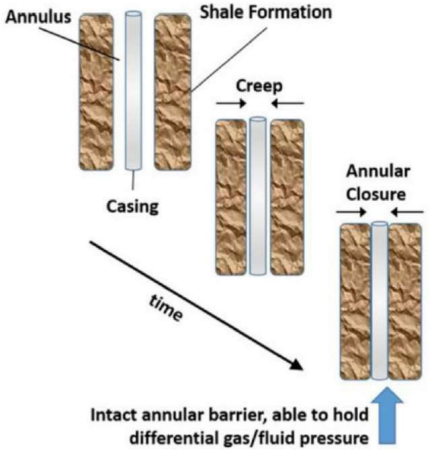
- Prevent shipping of scale to shore and potential storage of Norm material

Overburden Risk Management vs Abandonment

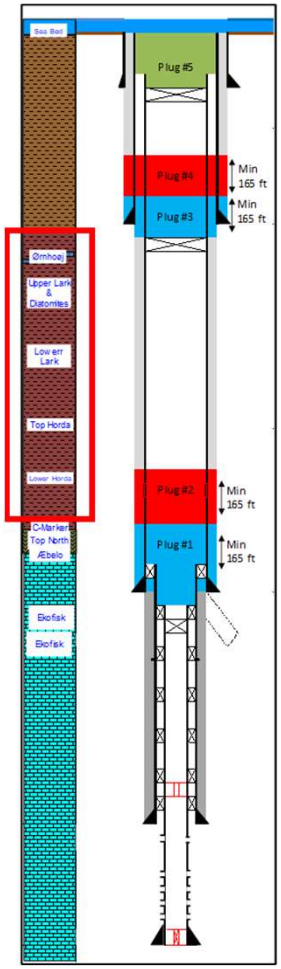
Temporary Environmental Impacts







Shale formation blocking an uncemented annulus and forming a barrier.
Adapted from van Oort et al. (2020)



Challenge:

When abandoning a well all zones with flow potential will have to be plugged with barriers. In the Danish part of the North Sea this includes both the reservoirs and the shallow permeable zones like the Diatomite intervals

Hypothesis/Expected Outcome:

An increased understanding of the Diatomite permeability linked with flow modelling and improved stratigraphic understanding can lead to a new understanding of where the Diatomite's do and do not have flow potential.

The overburden shale formations can be used as part of the abandonment well barriers

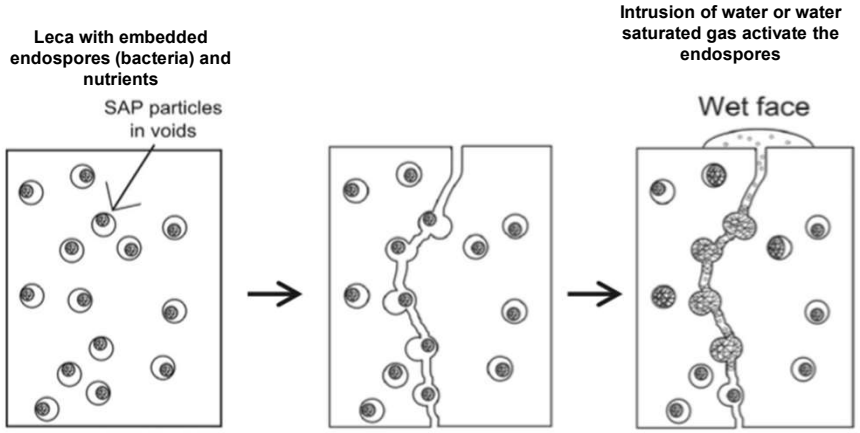
Value:

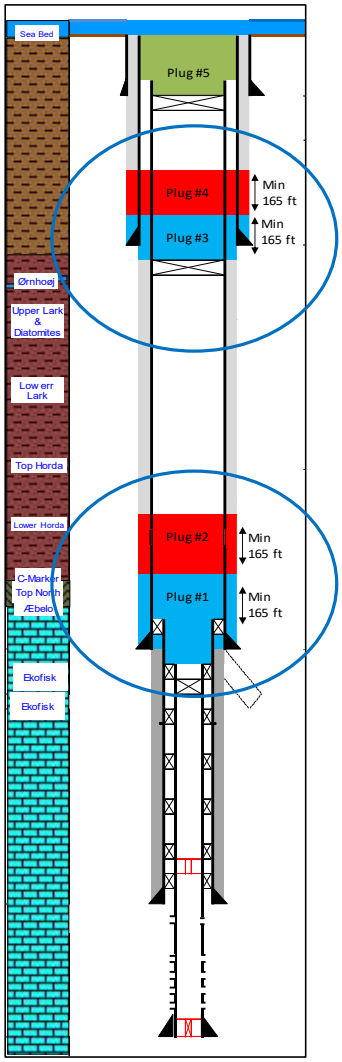
Facilitate informed discussions on where the shallow permeable zones need to be abandoned and the definition of 'no flow potential'

Where barriers have to be installed the shale formations can help secure a permanent barrier over geological time

Degradation of barriers over time

Longterm Environmental Impact





Challenge:

The long-term performance of cement-based materials may be impaired due to exposure to aggressive aqueous environments, resulting in

- *microstructural changes and subsequent degradation of physical properties of the cement matrix, which may ultimately lead to potential pathways for the leakage*

Hypothesis/Expected Outcome:

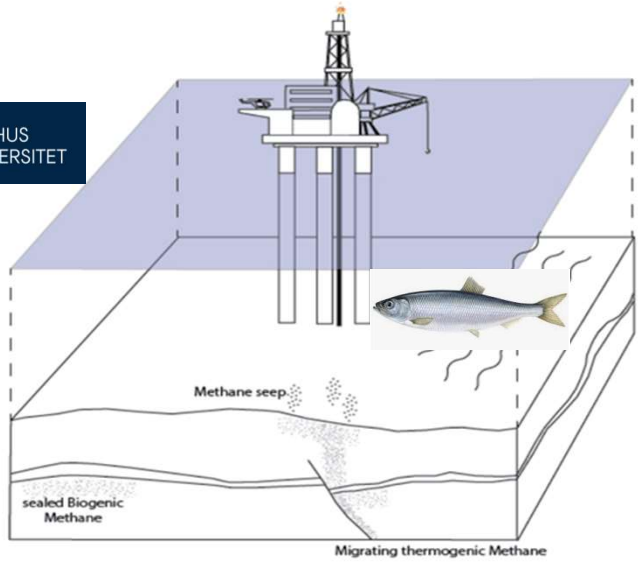
Project exploring key parameters determining durability and permeability of cement used as a barrier material for plug and abandonment.
Project to develop self healing cement, absorbent leca pearls with embedded CaCO3-precipitating bacteria and nutrients for growth are mixed into the cement. Bacteria will start to precipitate when exposed to fluid.

Value:

Understanding the long term behaviour of the abandonment cement is important to ensure optimal design,
In-situ healing of the cement without interventions ensures long term durability of barrier

Environmental baseline and monitoring

Longterm Environmental Impact



Challenge:

There is a concern that when oil/gas producing wells in the North Sea are permanently abandoned they could potentially lead to future leakages of hydrocarbons (HC) - however, natural seepage might mask monitoring results

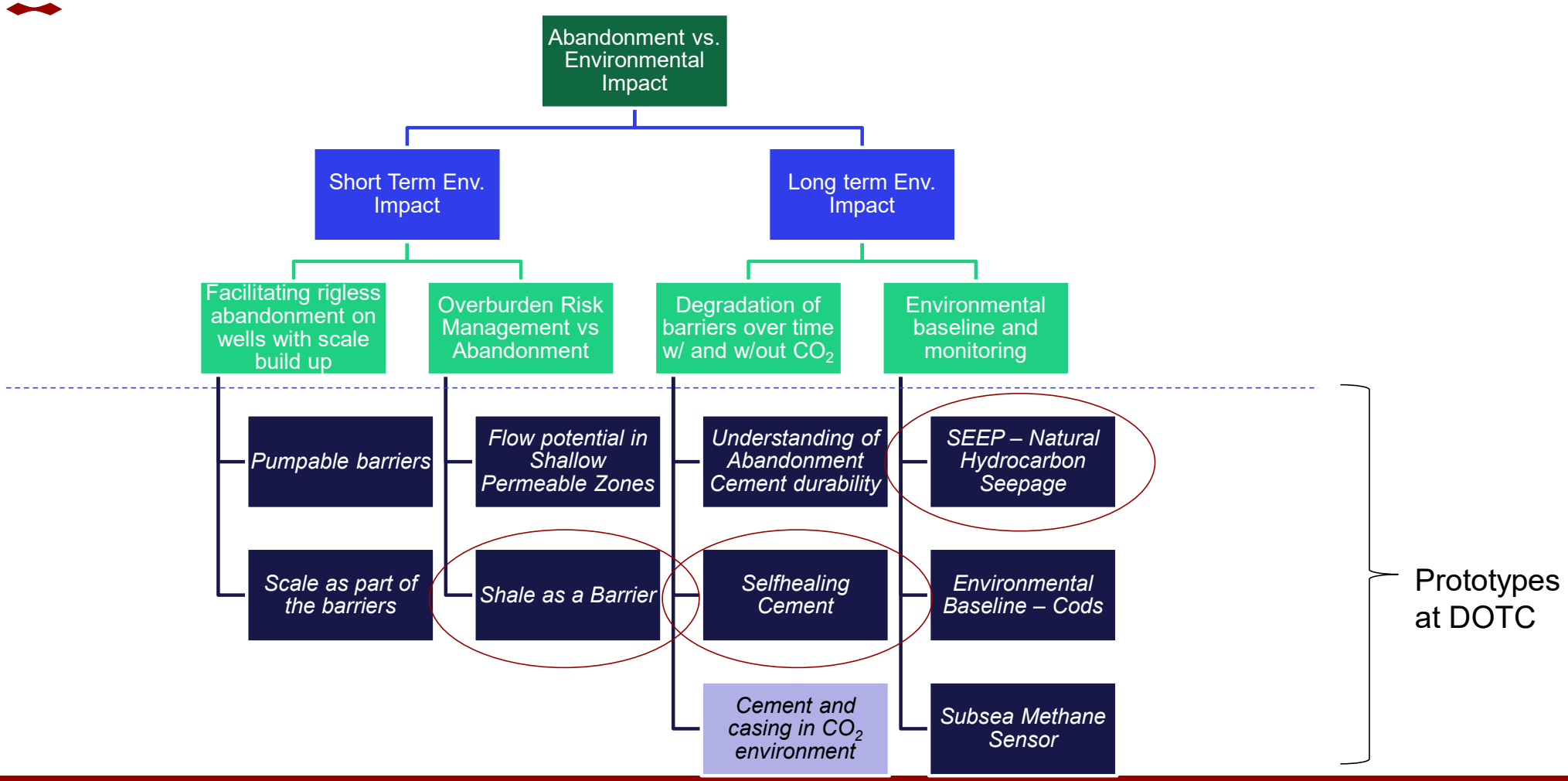
There is a concern that removing the structure could impact the marine life

Hypothesis/Expected Outcome:

A natural hydrocarbon seepage baseline prior abandonment enables the future surveillance to distinguish between a well leak and natural seepage. A sensor for subsea measurement of dissolved methane levels can be developed.

A marine environmental baseline for Cods around the platforms can be developed – both population and use of platform

Abandonment Research Programme

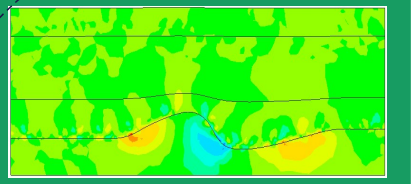


Synergies between Abandonment and CO_2 storage

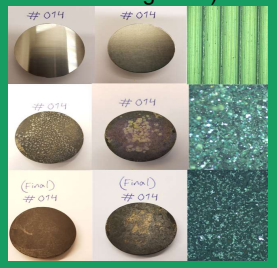
CO_2 Storage Research Programme (Research kicked off January 2022)

Is Chalk suitable for CO_2 storage?

Monitoring (Leak detection and Plume movement)



Wells (Legacy wells and Reuse of existing wells)



Abandonment Research Programme (Research kicked off Summer 2021)

Post Abandonment Environmental Impact

Well Abandonment Barriers