15th International Conference on Greenhouse Gas Control Technologies GHGT-15

5th -8th October 2020, Abu Dhabi, UAE

Impact potential of hypersaline brines released into the marine environment as part of reservoir pressure management.

Jerry Blackford[a]*, Marius Dewar[a], Tony Espie[b], Sarah Wilford[c], Nicolas Bouffin[c]

[a]*Plymouth Marine Laboratory, Prospect Pl., Plymouth, PL1 3DH, UK.*
[b]*BP International Limited, Chertsey Road, Sunbury on Thames, Middlesex, TW16 7BP, UK.*
[c]*BP Exploration Operating Company Ltd, Chertsey Rd, Sunbury-on-Thames, Middlesex, TW16 7LN, UK.*

Abstract

Pressure management of reservoirs used for carbon dioxide storage is a key component of maintaining cap rock and reservoir integrity of the storage complex. Where storage utilizes saline aquifers, pressure management may potentially require production of reservoir brines and their dispersion in over-lying seawater or re-injection to a secondary storage facility. Whilst the characteristics of these brines vary greatly, some may be hypersaline (exceeding 200 PSU), hot (exceeding 50°C), anoxic and / or with elevated levels of heavy metals. In their undiluted form, such brines have the potential to be detrimental to ecosystems. However, dispersion and dilution in well mixed shelf sea environments act to reduce this impact potential.

In marine systems away from estuaries salinity varies between approximately 33 PSU (in polar regions with ice melt) to 39 PSU (enclosed basins such as the Mediterranean); species tend to be adapted to either brackish or oceanic conditions with only highly specialized communities able to tolerate metahaline (>45 PSU) systems. Marine temperature – varies between -2.0°C (Polar) to 30°C (tropical), although site specific ranges tend to be less than 10°C at the sea bed; above 35°C enzyme function becomes sub-optimal and rapidly declines as temperature increases, however most species are adapted to regional temperature ranges. Severe hypoxia is generally recognized as concentrations of O_2 below 2mg/l with impact thresholds of 6mg/l. Impact is also a function of species, exposure time and number of stressors acting on an individual, with many species able to tolerate infrequent short lived exposures to restricted numbers of stressors.

In this study we use a very high resolution hydrodynamic model system, utilising the Unstructured Grid, Finite-Volume Coastal Ocean Model (FVCOM) to assess the dispersion of hypersaline brines in the natural environment. This model system allows for very high resolution in the vicinity of the release point, such that the dynamics and dispersion of plumes can be modelled in detail. Lower resolution towards the model domain boundaries restricts computational cost but maintains the ability of the model system to accurately simulate the primary physical mixing process acting on shelf seas. The model system has been adapted to enable the simulation of sea-surface and seabed hypersaline brine releases, potentially at multiple points. and we use two contrasting domains in terms of physical conditions within the North Sea, a deeper site (>100m) which thermally stratifies anda shallow site (<40m) which remains vertically mixed during the year. Detailed bathymetry enables the assessment of any impact seafloor morphology may have on dispersal or retention of brines. The model is forced by realistic tidal, current, thermal and wind driven mixing, with boundary conditions supplied by reanalysis simulations of the wider area. We assess the spread, dilution and persistence of a number of realistic brine release scenarios, in terms of salinity, temperature and apply tracers to

* Corresponding author. Tel.: +44 1752 633462, *E-mail address:* jcb@pml.ac.uk

enable the estimation of other chemical characteristics of the produced water such as oxygen levels and heavy metals. Based on these results we estimate the impact potential from a range of scenarios and dispersion methods, including a combination of seabed, outcrop and sea-surface discharges, across different seasons with specific mixing characteristics.

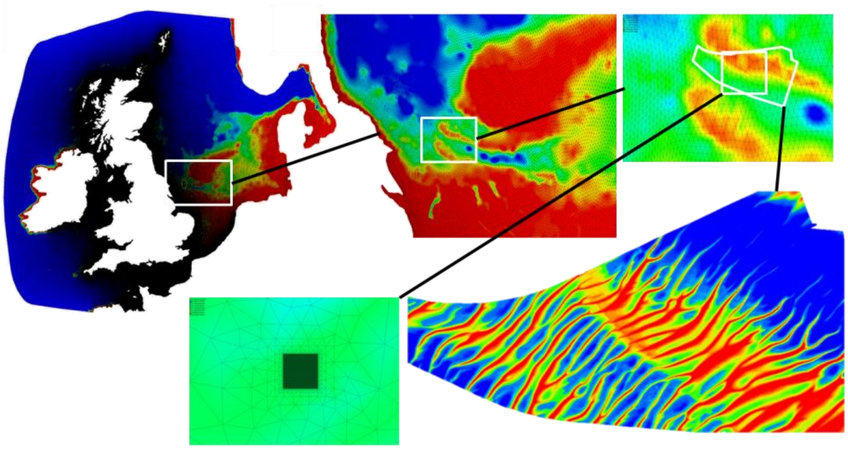

Figure 1. Schematic of the model nesting scheme, clockwise from top left; wide area model domain suppling boundary forcing; intermediate domain showing regional bathymetry features; release simulation domain; applied high resolution bathymetry showing sand waves; ultra-high resolution model center with meter scale resolution.

In relatively shallow well mixed environments we find that the natural mixing processes, dominated by tidal flow, disperse hypersaline plumes rapidly, minimizing any quantifiable impact footprints to scales of 10's of meters in any direction, depending on disposal rate. The models suggest that the mode of disposal, for example at the sea floor or the sea surface will affect impact footprint. This study allows future cost-benefit appraisal of brine disposal methodologies.

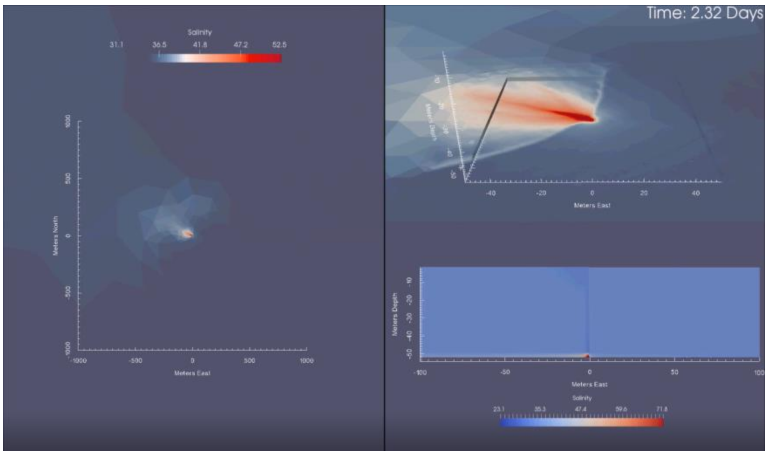

Figure 2. Snapshot of example model output, showing plume salinity after 2.3 days; left: plan view, 1x1km square; top right oblique view of 50x50m region around release; bottom right, side view across release point, 200m wide. Although colour scales for left and right plots differ, essentially pink-red regions indicate salinities with the potential to cause some effect on the local ecosystem.

Keywords: Storage; Saline aquifers, Pressure management; Environmental Impact

Acknowledgements: The authors acknowledge the support from the ACT Pre-ACT project (Project No. 271497) funded by RCN (Norway), Gassnova (Norway), BEIS (UK), RVO (Netherlands), and BMWi (Germany) and co-funded by the European Commission under the Horizon 2020 programme, ACT Grant Agreement No 691712.