MEIO- AND MACROBENTHOS POPULATION CHANGES DURING BIOREMEDIATION OF AN EXPERIMENTAL OIL SPILL

by M.Schratzberger[1], C.M. Wall[1], R. Kilbride[1], F. Daniel[2], D. Mitchell[2], S.E. Boyd[1], H.L. Rees[1], S.J. Macnaughton[2], R. Swannell[2]

CEFAS The Centre for Environment, Fisheries & Aquaculture Science

Introduction

Natural oil biodegradation is limited in most marine environments by sub-optimal levels of nutrients such as biologically available nitrogen and phosphorus. Bioremediation of oil spills has focused on alleviating this limitation through addition of fertilisers to oiled shorelines.

Much of the research into bioremediation has concentrated on establishing the potential of the technology for reducing oil pollution but, to date, relatively little attention has been directed toward determining the effects of bioremediation treatments on the recovery of the natural shoreline biota although any effects may have important operational implications.

Therefore, a field experiment was designed at a hydrodynamically active beach in Somerset, UK (Figure 1) to assess the effects of fertiliser treatments on estuarine meio- (63 to 500 µm) and macrobenthic (> 500 µm) assemblages recolonising oiled sediments.

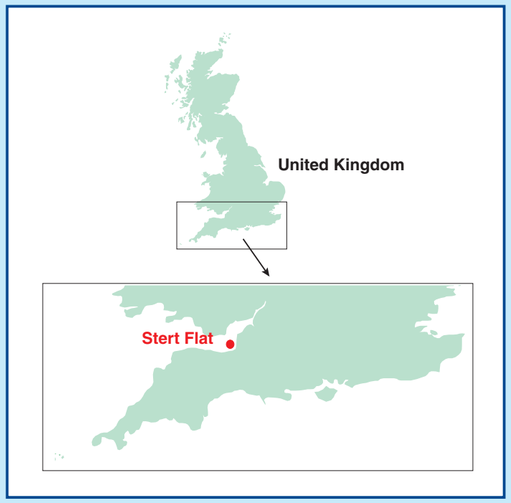

Figure 1: Experimental site at Stert Flat in Somerset, UK

Meio- and macrofauna

Meio- and macrofauna are vital links in the food webs of the marine and estuarine environments. Because most species are relatively immobile, they cannot avoid the direct consequences of an oil spill (Figure 2 and 3). Therefore, these organisms are good indicators of the amount and extent of damage caused by an oil spill and the effects of bioremediation treatments on the recolonisation process of oiled sediments.

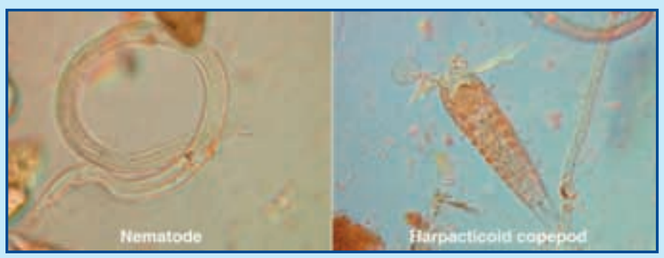

Figure 2. Dominant meiofaunal taxa

Figure 3. Dominant macrofaunal taxa

Experimental set-up

The experimental design had to balance the need to retain oil within designated plots for the experimental period, with a requirement to avoid restricting the ability of benthic meio- and macrofauna to recolonise the oiled areas.

A randomised block design utilising Nitex mesh enclosures (1000 µm mesh size) was used as this approach allows for spatial variation in both treatment effect and efficacy of bioremediation to be ascertained. Three blocks with five treatments each (Table 1) were set up along the beach (Figure 4):

Treatment	Code	Description
Untreated control	UC	No oil, no bioremediation treatment
Defaunated control*	DC	No oil, no bioremediation treatment with the natural fauna removed at the beginning of the experiment
Oiled control	OC	Oil only, no bioremediation treatment
Liquid fertiliser	LF	Oil and regular addition of liquid inorganic fertiliser
Slow-release fertiliser	SF	Oil and slow-release pelleted fertiliser

*Table 1: Experimental treatments (*The defaunated control enabled a separation of the effects of the experimental set-up from possible treatment effects)*

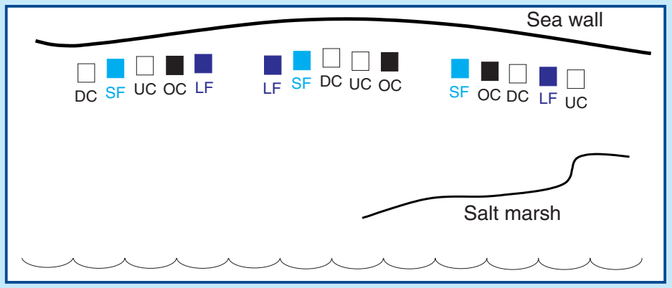

Figure 4: Position of experimental treatments along the beach

The Nitex bags (Figure 5) were filled with unoiled and oiled (at an initial concentration of 3.5 l Forties crude oil m^{-2}) sediments and all plots were buried at a depth of 0.15 m, 4 m apart to avoid cross-contamination, (Figure 6). Samples were collected 0, 2, 3, 7, 11, 16 and 45 weeks after the first nutrient addition and analysed for oil chemistry, microbiota and benthic fauna.

Figure 5: Nitex bag (1000 µm mesh size)

Figure 6: Experimental site

Meio- and macrofaunal abundance

Results from chemical analyses revealed that all oiled sediments presented a trend of decreasing Total Petroleum Hydrocarbons (TPH) over time. The decrease in oil concentration can be attributed to

- physical effects (e.g. wave action) and
- biological processes (e.g. microbial activity).

At the end of the study, 45 weeks after the initial fertiliser application, the oiled controlled plots contained approximately four times as much oil (≈ 8000 mg kg^{-1}) than the fertilised plots (≈ 1000 - 2000 mg kg^{-1}).

Total nematode and macrofaunal densities were significantly ($p < 0.05$) lower in the oiled sediments compared to the unoiled controls 11 weeks after fertiliser addition (Figure 7).

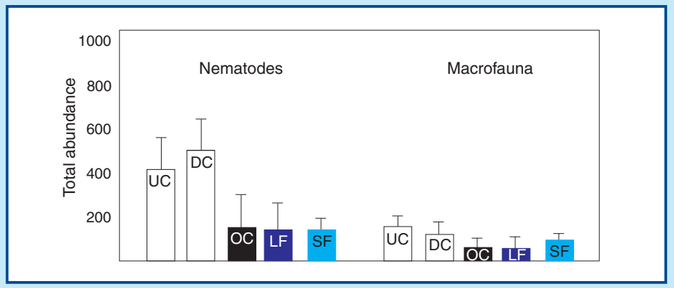

Figure 7: Means (± 95 % pooled confidence intervals) of meio- and macrofaunal abundance (0 - 5 cm) 11 weeks after fertiliser application

Meio- and macrofaunal assemblage structure

Results from multivariate statistical tests (Figure 8) revealed that

- there were no statistically significant differences between the two types of controls
- assemblages collected in the unoiled control sediments were more similar to each other than to any of the oiled sediments
- differences in the assemblage structure observed for both types of fertiliser were not statistically significant within the first three months of the experiment.

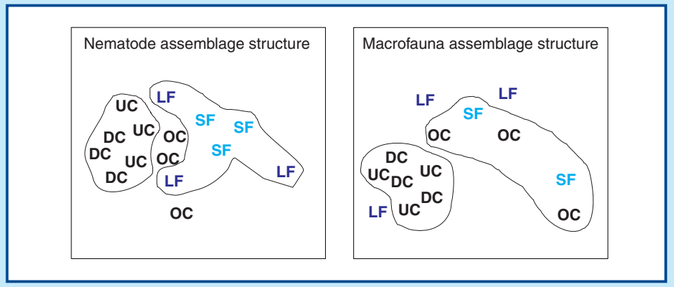

Figure 8: Non-metric multi-dimensional scaling (MDS) ordination based on square-root transformed abundance data (0 - 5 cm) 11 weeks after fertiliser application (The distances between pairs of samples reflect their dissimilarity in species composition. Circled groups of samples have similar faunal assemblages)

Conclusions

- Both fertiliser treatments stimulated oil biodegradation in comparison to non-fertilised oiled sediments but this did not result in faster recolonisation rates of fertilised versus non-fertilised oiled sediments by the benthic fauna.
- The lack of statistically significant differences between untreated and fertilised oiled sediments in terms of species composition might have been a result of the generally high ecological tolerance of estuarine benthic infauna to perturbations.

Acknowledgements

The work was supported by the Department for Environment, Food and Rural Affairs, the Maritime and Coastguard Agency and the Environment Agency.

[1] The Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Burnham Laboratory, Remembrance Avenue, Burnham on Crouch, Essex CM0 8HA, UK. http://www.cefas.co.uk
[2] AEA Technology Environment, Culham, Abingdon, Oxfordshire OX14 3ED, UK.