MASTS Small Grant Report Summary (MESG5 & TPSSG3)

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Project title: Advancing our understanding of oil-spill biodegradative processes using an in-situ based system.

Background and aims of this project

The logistics of working in the deep-sea are a real challenge, and this was clearly highlighted by the Deepwater Horizon (DWH) oil spill of 2010. This massive spill was testament to how profoundly the health of marine ecosystems and the livelihood of its coastal inhabitants can be severely impacted by spilled oil. Oil spills at sea are one of the most disastrous of anthropogenic pollution events as they cause acute detrimental effects and potentially lasting chronic effects to natural ecosystems. Due to the ability of oil to spread for many miles in seawater their impact on ecosystems far exceeds that of spills in terrestrial environments. With surging oil prices and sophisticated technological developments, exploration and production in deeper water provinces has accelerated in recent years, with the pace of deep water drilling having increased by 40% in the last 5 years. With oil exploration moving more into deeper waters, the unpredictability of the behaviour of spilled oil and current lack of experience and know-how in dealing with a deep-sea spill raises considerable concerns.

The Faroe Shetland Channel (FSC) lies north of Scotland and is a region receiving much attention recently as it is a frontier for deepwater oil exploration. Recognised as an area of 'high risk' for oil contamination, there is a prescient need for fundamental research in this region. Considering that microorganisms are fundamental to the ultimate removal of petrochemical pollutants in the marine environment, it is surprising that there is a paucity of information on the microbiology for the FSC – acknowledged as a major "knowledge gap" in a number of reports, including OSPAR Commission and the preliminary assessment of the recent EU Marine Strategy Framework Directive (MSFD) (2008/56/EC). Importantly also, information on the microbial response to oil is a prerequisite for the design of effective (bio)remediation strategies that would help government authorities (e.g. Marine Scotland Science), that are tasked with responding to maritime oil spills, to reduce the environmental impact of a spill.

In order, therefore, to obtain a critical understanding of the microbiology in the FSC and how it may be expected to respond to a major oil spill, laboratory-based experiments are an important approach to improve our understanding in this respect. However, many of the microorganisms found in deep waters, such as in the FSC, are so well adapted to low temperature and elevated hydrostatic pressure that some are obligate barophiles. Decompression and temperature fluctuations during sampling can severely alter the physiology and normal functioning of barophiles. In the event of a large oil spill in the deep waters of the FSC, a large fraction of the oil could become

entrained as a subsurface plume(s) in the water column, reminiscent to that which formed during the DWH spill in the Gulf of Mexico. Therefore, in order to achieve a realistic understanding of microbial processes and their response to oil in deep waters, we require an unobtrusive way of minimizing artefacts introduced through sampling and other manipulations.

To this end, the laboratory of Dr. Tony Gutierrez aimed to study the response and dynamic of microbial communities, with particular focus on oil-degrading bacteria, to crude oil contamination in the FSC. The method employed was a modification of a previous design that was used for measuring *in-situ* bacterial productivity. Referred to here as the Dialysis Bag In-Situ method (DiaBIS), it comprised the use of durable cellulose-based dialysis bags (acting as incubation chambers), nine of which were attached to a custom-designed high-density polyethylene (HDPE) frame. The DiaBIS system was deployed *in-situ* in the FSC during a research cruise on R/V *Scotia* in the spring of 2015 to specified depths using weights attached below the frames and maintained in position from a mooring. After an incubation period of several days *in-situ*, the contents of each bag was sampled for microbiological and molecular analyses.

How money was spent and activities completed

This MASTS Small Grant provided partial funding to offset some of the costs for materials and consumables required in the construction of the DiaBIS frame and mooring.

Work completed so far included:

- Construction of the DiaBIS frame and its deployment in the FSC during a research cruise during the spring of 2015.
- Sampling from the DiaBIS systems and subsequent Illumina-based analysis of microbial community response to crude oil using the iTag approach.

Outputs and/or expectations and future plans

This work is still ongoing and is in collaboration with scientists from the United States and Marine Scotland Science. To-date, iTag sequencing has shown a rich diversity of bacterial communities in the water column of the FSC, including the presence of oil-degrading bacteria, albeit in relatively low abundance. These organism may be assumed to stand at the ready to respond in the event of an oil spill in this region. As we uncover further information on the diversity of these organisms and how they respond in the presence of oil under natural conditions, including how to enhance their activities for degrading oil hydrocarbons (e.g. by the use of dispersants or nutrient amendments), we expect this information will help guide our efforts to become better prepared to combat a major oil spill in this hydrodynamic NE Atlantic region and adjacent waterways.