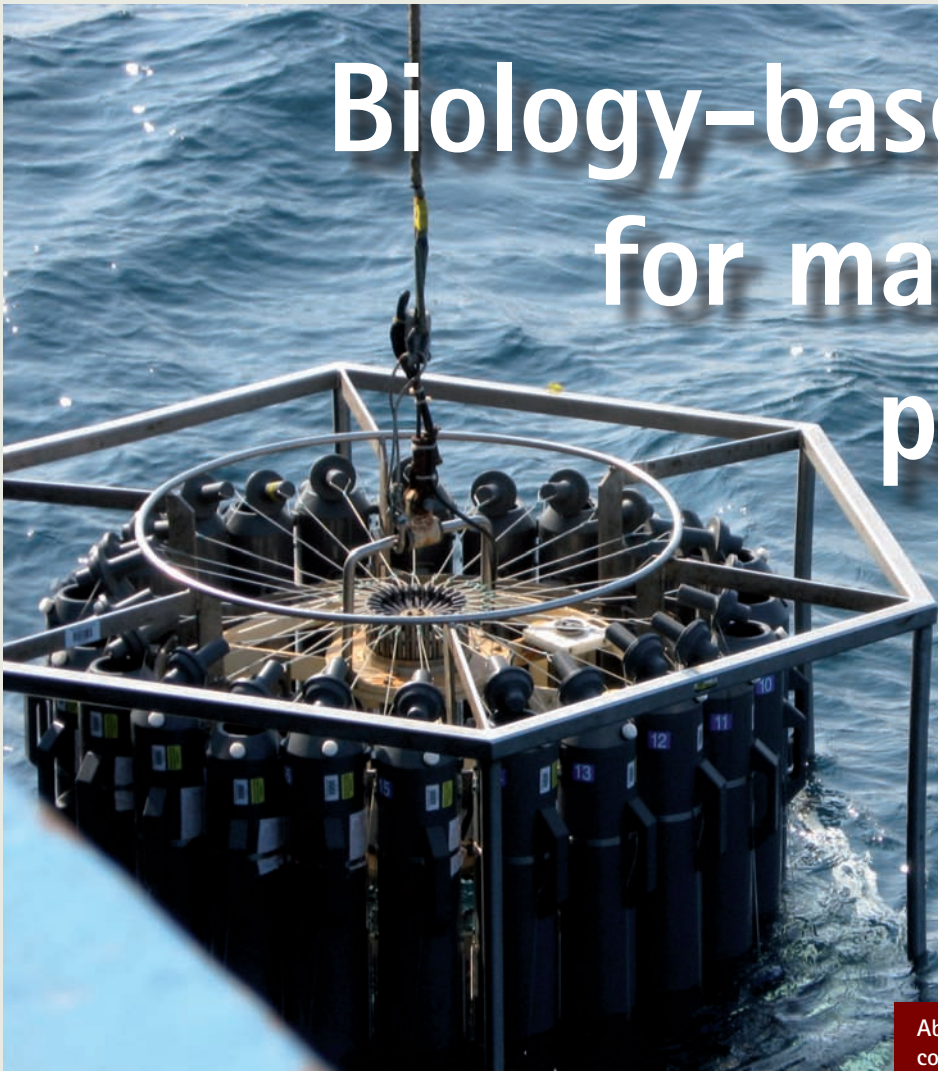


Biology-based tools for man-made problems



Above: The Nifkin device to sample non-contaminated seawater at different depths

★ Oil spills represent a significant threat to the long-term health of marine and freshwater ecosystems. **Dr Jan Roelof Van Der Meer**, of the FACEiT project, explains how his initiative's work in developing biology-based analytical tools is helping to minimise the environmental impact of such incidents

While oil spills may not be the single biggest threat to the long-term health of marine and freshwater ecosystems, the dramatic images such incidents often produce stand as a vivid illustration of the impact human activities are having on our natural environment. The names Exxon Valdez, Prestige and Erica – all ships involved in large-scale oil spills – continue to resonate, and while in all cases great efforts were made to minimise the environmental impact of these disasters, many believe that a lack of coordinated action after the event meant the effects were not contained as effectively as they could

have been. This is an issue of particular concern to Dr Jan Roelof Van Der Meer, the coordinator of the Fast Advanced Cellular and Ecosystems Information Technologies (FACEiT) project. “The main objective of the FACEiT project is to develop biology-based tools to analyse the effects of oil spills and disasters,” he says. “We have chosen to work on a number of systems, including bacteria, that will be genetically engineered to produce easily detectable signals when faced with toxic compounds from oil. We are also looking at endogenous marine bacteria and phytoplankton, which

we can rapidly interrogate for cellular malfunctioning by a technique called ‘flow cytometry’, as well as the full bacterial marine ecosystem, which we hope will tell us something about the long-term changes caused by oil pollution.”

The enormous complexity of marine and freshwater ecosystems makes this kind of work particularly challenging. With issues like overfishing, plastic trash and granulates, nutrient runoff and eutrophication also affecting their long-term health, linking microbial community changes directly to pollutant exposure is a scientifically complex problem. Nevertheless, it is

an area Van Der Meer is confident his project will be able to address effectively. “The way that we link community changes to pollutant exposure is, in the first instance, by tracing molecular evidence for organisms that are known to degrade oil components. For example, exposure to pollutants could make it easier for viruses to infect bacteria, phytoplankton and larger animals. Or, the increased stress caused by pollution could make it more difficult for organisms to cope with UV irradiation at the surface,” he explains. “Phytoplankton and microbial community exposure studies have been carried out with mimicked oil spills in microcosms, mesocosms and on the actual sea itself to see what types of changes we get in conditions involving multiple factors, and if this produces a diagnostic signature. We have seen a number of very sensible phytoplankton species that are specifically affected by oil.”

Clearly many factors play a part in the health of marine and freshwater ecosystems. However, with some 200,000 tonnes of crude oil being spilled at sea every year, it is equally clear that minimising the impact of oil spills will have a significant impact on marine health. Whether caused by pipeline leaks, storage facility problems or tanker accidents, oil spills invariably cause enormous problems which demand rapid action, particularly given the often sensitive locations in which examples of the latter typically occur. “Typically, accidents occur at sea but on shipping routes close to the coast,” explains Van Der Meer. “The detection of oil pollution is now mostly done with aircraft, which either constantly monitor a certain area (e.g., the North Sea), or in case of a shipping accident are the first to go out and locate the size, distribution and transport of the spill. In some cases, aircraft photography and radar can be combined with actual sampling of the slicks. This is needed to provide evidence of the nature and signature of the oil, and its possible origin. This information is then used to trace the polluting vessels and responsible companies. Unfortunately, most large accidents show that during the critical period a few days after a spill, not

much action is taken by the authorities, or if it is then it is quite chaotic and ineffective.”

Advanced biological methods

These kinds of shortcomings can have significant long-term effects on the health of the marine ecosystem. The period immediately after an oil spill is crucial to efforts to minimise its impact, as oil can quickly spread to

affect an even wider area. In this context rapid identification of the source of the slick and type of oil involved are crucial; an area in which FACEit is focused on addressing the shortcomings of the current approach, and thereby enabling a much more efficient, effective response to oil spillages. “Although visible oil slicks and tar on beaches don’t require the development of advanced biological



Getting the 1 cubic metre mesocosm vessels ready on board the RV Pelagia for a pilot oil spill

At a glance

Full Project Title:

Fast Advanced Cellular and Ecosystems Information Technologies – FACEiT

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methods, there are currently no effective methods for the rapid analysis of oil pollution on site, and all samples need to be brought to laboratories for detailed analysis,” says Van Der Meer. “This means that cleaning operations, or decisions about cleaning operations on open sea, are based on ‘visual’ information. It is here that the project has provided a number of workable solutions in the form of rapid bacterial-based tests that can be performed within two

bioreporters, systems have been developed for most of the in vitro methods, which themselves are specific for other pollutants, not necessarily related to oil. Examples include hormone-like substances, heavy metals, polycyclic aromatic hydrocarbons, arsenic or herbicides. The general idea with such in vitro bio-assays is that they can be custom engineered rapidly to the type or class of pollutants, and thus have much wider applicability.”

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hours on board a ship. The other methods and approaches the FACEiT consortium has developed will be useful in determining the ecological effects of spills, after the most obvious tar and oil surfaces have been removed. This is especially necessary because it determines the efficacy of cleaning operations and informs further decisions on what needs to happen with contaminated zones and areas.”

Of course, although oil spills commonly attract enormous publicity, oil is far from being the only pollutant to affect the world’s oceans. This has not escaped the notice of the FACEiT consortium, and although oil remains their primary concern, the methods they are developing are not limited to that area alone. “Most of the methods developed within the consortium have been used, and are still being used, to monitor other types of pollution as well,” stresses Van Der Meer. “Invertebrates can be used as pollution indicators, although it is often difficult to establish the link to an actual source or type of pollution. Here we have shown that in some cases it is easy to couple an in-situ measurement (for example, taking the urine of native crabs in a polluted area) with bacterial bioreporter analysis that can detect the type of pollutant in the urine. Cell lines, zebrafish, bacterial

Disaster management

Biological science is only one ‘actor’ in the field of disaster management. However, it is an essential one, and it has an enormously important role to play in informing the work of the other agencies involved in responding to major incidents. As such demonstrating the importance of their findings to the relevant authorities and other actors in the field is an important part of FACEiT’s overall goals. “In many cases the authorities demand an ‘integral assessment’ of some kind, in which some or several of our methods can find a place,” says Van Der Meer. “In particular we think that human and bacterial cell reporters will be very valuable, because they are cheap and rapid methods that can deliver a sort of ‘first line’ of analysis, after which decisions could potentially be made regarding more in-depth chemical analysis. On the other hand, convincing the regulatory authorities of this is a hard battle, and we can only do this by producing the best science and showing which methods it is most important to incorporate. The various SMEs in our project are working to evaluate new methodologies and in turn convince their customers and contacts, and (hopefully) incorporate FACEiT methods in their commercial programmes.” ★