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Viewpoint

The principles of effective post-spill environmental monitoring in marine environments and their application to preparedness assessment

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ABSTRACT

Understanding the fate and effects of marine spills is essential if the scientific and response communities are to develop best practices. The effective deployment of environmental monitoring activity can be complex and requires planning and coordination but the levels of preparedness to deliver the necessary expertise, coordination and funding are often low. This paper identifies and describes the importance of 8 principles of effective post-spill monitoring programmes. These principles are then used in the assessment of monitoring preparedness through the generation of a monitoring preparedness assessment score (MPAS). This approach can be used by local, regional or national authorities to establish the level of preparedness for environmental monitoring and prioritise areas for improvement. It also has value to responders, policy makers, environmental scientists and planners as a tool to assess preparedness and capability for specific scenarios. The approach is demonstrated through the assessment of previous incidents and potential future scenarios.

1. Introduction

Most authorities, backed up by statistical data, generally agree that major spills of oil and chemicals into the marine environment are historically in decline (e.g. Schmidt-Etkin, 2011). A recent review (Musk, 2012) provides compelling evidence of the improvements made in terms of volumes of oil spilled from tanker incidents over the past decades despite a steady increase in oil transported by sea (Purnell, 2009). Equivalent global statistics for spills from the offshore oil and gas industry are more difficult to source but data, for example in the USA (Anderson et al., 2012), also indicate improvements over recent decades. This positive trend was brought to a decisive end as a result of the Macondo spill in 2010 but this could be viewed as an exceptional incident and that the underlying trend in terms of spills is one of improvement.

The situation for spills of chemicals, more commonly referred to by responders as hazardous and noxious substances (HNS), is less well defined in comparison to incidents involving oil but, with international marine transport of a wide range of chemicals (Radović et al., 2012; Neuparth et al., 2012), the risk of HNS spills occurring is potentially ever present. It remains inevitable, however, that major marine spills will occur, with their associated environmental impacts and even modest spills can have major environmental consequences if the receiving environment is particularly sensitive.

In general, however, the marine environment has a substantial capacity to assimilate contaminants without major impacts and can demonstrate a high resilience through recolonisation and recovery. However, Kirby and Law (2010) list several marine accidents where the marine impacts were measurable, significant and, in some cases, long-term. Therefore, in addition to effective national and regional procedures for search and rescue, salvage and counter pollution, there is also a need to ensure that procedures for the implementation of effective post-spill monitoring and impact assessment are in place. Kirby and Law (2010) set out the key reasons why this was necessary;

- *Primary impact:* the need to provide early evidence of potential environmental and economic impact to key stakeholders, e.g. government and the general public.
- *Wider effects:* the need to apply an appropriate and effective method of investigating the impact on the wider marine environment and its resources.
- *Best methods:* impact assessment methodology needs to be considered that not only assesses the short-term impacts, but also allows the prediction of potential longer-term impacts.

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- *Efficient resource use:* the need to ensure effective use of resources during monitoring so that unnecessary procedures are avoided but that potentially useful ones are not overlooked.
- *Mitigation effectiveness:* the need to provide an assessment of the effectiveness of spill response and clean-up activities, including the use of dispersants.
- *Compensation/liability:* the need to provide monitoring and assessment input to the determination of compensation and/or liability issues as necessary.

There are three core elements that constitute a fully effective post-incident monitoring capability; (i) science quality, (ii) coordination and organisation, and (iii) preparedness and responsiveness. If any one of these is missing or sub-standard then the ultimate programme and the information it produces may be flawed and the overall effectiveness compromised.

The conduct of post-incident marine monitoring involves the practical application of scientific process and technique under potentially difficult and unforeseen circumstances with short notice and tight delivery deadlines. Understanding what scientific methods are necessary, how they are best applied in situ and having access to appropriately skilled scientists is clearly a pre-requisite of any scientifically robust monitoring system. However, the circumstances of marine spills can be extremely complex, potentially involving the measurement of several hazardous components and a need to assess impacts in many receiving environments and at multiple trophic levels. Therefore, coordination of the response and the management of logistics, financial aspects, communications and reporting can be equally as important as the science. Finally, although marine emergencies occur without warning, there is still a need to be able to initiate monitoring activity in a timely manner, especially if there is an opportunity to collect samples to inform a baseline dataset before an area is impacted. This essential element of responsiveness is often overlooked and has resulted in delays of days, weeks or even months for monitoring programmes to be fully in place (Kirby and Law, 2010) in the absence of a preparedness strategy.

The improvement of post-spill monitoring and impact assessment, through the consideration of these core elements, is the ongoing subject of a cross-government programme in the United Kingdom called Premiam (Pollution Response in Emergencies: Marine Impact Assessment and Monitoring, see www.cefas.defra.gov.uk/premiam). This programme was initiated in 2009 and has involved a partnership of 22 UK government departments and agencies with an interest in the effective conduct of post-spill monitoring. Over this time a number of improvements have been made to national preparedness and a number of principles associated with an effective monitoring programme have emerged. These 8 principles are;

1. Scientific guidance.
2. Skills and knowledge.
3. Equipment.
4. Funding.
5. Responsibility and management.
6. Integration and coordination.
7. Support and buy-in.
8. Practice.

This paper will explain each of the principles and review how they are being addressed through a national case study (United Kingdom). Finally, a 'monitoring preparedness assessment' approach is introduced and demonstrated using the 8 principles at its core. The method can be used to generate a monitoring preparedness assessment score (MPAS) that can be a useful tool in establishing the level of preparedness at national, regional or local levels, for different types of incidents and emergency scenarios, and to indicate the specific areas for improvement.

2. The principles

2.1. Scientific guidance

Any effective environmental monitoring programme needs to be underpinned by strong scientific principles. The selection of the most effective survey approaches, analytical methods and data analysis/interpretation is essential if a programme is to be scientifically robust and stand up to later scrutiny and peer review. An in-depth understanding of post-incident monitoring methodologies is needed to develop a programme of the necessary scientific quality. The time for developing the overarching scientific principles and guidance for an environmental monitoring programme is not in the immediate aftermath of an incident.

Key areas which any guidance needs to consider include:

- Clear definitions of a programme and what it needs to achieve.
- Survey design.
- Sampling strategies and methods.
- Chain of custody, labelling, transport and storage.
- Chemical analytical methods.
- Ecological impact assessment method (for key environments and trophic levels).
- Ecotoxicological assessments.
- Quality control.
- Potential implications for human health.

Every incident is unique and requires a tailored approach to monitoring, building on a sound scientific approach such as that advocated within the Premiam guidelines (Law et al., 2011). The adopted approach should also allow for more specific, innovative and opportunistic techniques to be incorporated into the programme as necessary. Indeed sub-guides allowing for more prescriptive approaches for spill scenarios with specific chemicals or in designated areas might also be effective supplements to the overarching guidance. The scientific guidance might also provide advice on the use of oil/chemical spill trajectory modelling and sources of information on the physical characteristics of chemicals transported by sea (GESAMP, 2011; IMO, 2011) both of which can be important sources of information in the development of sampling strategies.

2.2. Skills and knowledge

The availability of scientific guidance is considered essential but the benefits it provides can only be realised if personnel and organisations with the necessary skills and knowledge are available to implement them. Skills required might include; survey managers, chemists, ecotoxicologists, marine ecologists (of several types), fisheries scientists, oceanographers and modellers. In addition to these scientific disciplines, individuals with other key skills, such as navigation, equipment deployment/maintenance, communications and project management will be equally important.

None of these skills are unique to post-spill monitoring so many will be found in individuals and organisations undertaking similar tasks for different purposes. They need to be identified and engaged as part of the preparedness strategy. Assessing the availability of key skills and knowledge is recommended so that gaps can be assessed and any necessary upskilling or training activities identified and implemented.