RESEARCH NEEDS IN OIL SPILL RESPONSE

Kimberly S. Newman, Coastal Response Research Center,
University of New Hampshire, 35 Colovos Road, Durham, NH 03824

Carol-Ann Manen, Coastal Response Research Center,
National Oceanic and Atmospheric Administration, 35 Colovos Road, Durham, NH 03824

Nancy E. Kinner, Coastal Response Research Center,
University of New Hampshire, 35 Colovos Road, Durham, NH 03824

ABSTRACT

As funding for spill research and development (R&D) has declined in recent years, partnerships among relevant federal and state agencies, industry and academia have increased in importance. In order to encourage thinking about spill R&D, develop agreement on research needs and foster these partnerships, the Coastal Response Research Center (CRRC), a cooperative program between the National Oceanic and Atmospheric Administration (NOAA) and the University of New Hampshire (UNH), hosted a three day workshop in November 2003 to identify applied science needs that could improve decision making across the continuum of oil spill preparedness, response and recovery. The emphasis was on research that could decrease the impact of spills on NOAA trust resources or enhance the recovery of the impacted resources.

More than 30 experts in the areas of spill processes, response techniques and habitat restoration participated in the three day workshop. The group included scientists from federal and state agencies, industry and academia. The goals of the workshop were to identify knowledge gaps in the area of spill response and restoration and determine the best approach for addressing these gaps.

Starting with six categories: Fate and Transport of Released Materials; Effects of Spills and Spill Response on Organisms; Effects of Spills and Spill Response on Habitats; Social and Economic Concerns and Needs; Quantitative Metrics for Use in Injury Determination and Restoration; and Restoration Methods, the participants identified over 80 areas of need, including a broad category of communication, and evaluated them with respect to their technical feasibility and potential impact on resource recovery.

DISCUSSION

While the number of reported spills has been in decline in the United States (U.S.) since the early 1980's, the United States Coast Guard (USCG) reported approximately 7,500 oil and chemical spills in U.S. waters in 2001. Such spills, whether catastrophic or chronic, can have major environmental impacts, cause substantial disruption of recreational and commercial activities and have unexpected short- and long-term social, as well as economic, consequences. Unfortunately, the decline in R&D funding for spill response has meant that information as to how to decrease these impacts through improved response or restoration actions has not kept pace with advances in the biological, chemical or social sciences.

The CRRC hosted a three day workshop to: encourage thinking about spill R&D; identify and develop agreement on applied research needs that could improve decision making across the continuum of oil spill preparedness, response and recovery; and foster partnerships to meet these needs. The focus of the workshop was on oil spills due to their frequency and effects on NOAA resources. It is anticipated, however, that many aspects of this work will be applicable to spills of other hazardous materials in similar environments. The emphasis was on research that could change response and restoration practices and improve protection strategies and recovery trajectories for NOAA trust resources.

The workshop was held at UNH on November 4-6, 2003. A diverse group of more than 30 experts in spill response and restoration representing NOAA, USCG, United States Environmental Protection Agency (USEPA), Minerals Management Service (MMS), Oil Spill Recovery Institute (OSRI), state agencies, academia and industry participated. Prior to the workshop, the program organizers developed a list of six broad discussion categories with emphasis on the need for quantitative rather than qualitative information that could support modeling efforts and comparison of response and restoration actions. The broad categories were:

1. Fate and Transport of Released Materials: Quantitative information needed for modeling and predicting changes in the physical and chemical composition of oil with time, as well as the surface and subsurface movement of various physical forms of the spilled oil;
2. Effects of Spills and Spill Response on Organisms: The short- and long-term effects resulting from environmentally-realistic exposures;
3. 0. Effects of Spills and Spill Response on Habitats: Changes in the short- and long-term structure and function of habitats and communities resulting from the mortality or impairment of key species;1.
3. Social and Economic Concerns and Needs: Development of sound estimates of human use values for potentially impacted resources (e.g., beach-going, hunting, recreational fishing) that can be adapted for spills of differing extent, severity and location;4.
4. Quantitative Metrics for Use in Injury Determination and Restoration: Ideal metrics to determine changes in impacted resources that are ecologically relevant, sensitive, cost-effective, widely available, and statistically based with quantifiable uncertainty suitable for scaling and monitoring restoration; and5.
6. Restoration Methods: Development of reasonable and cost-effective methods to enhance recovery, affect the restora-

tion of an injured resource or allow direct tradeoffs across differing attributes of restoration projects.

The workshop participants were divided into small breakout groups to discuss each category and develop a list of research topics that might fill the identified knowledge gaps. Plenary sessions were held to discuss other categories that should have been included on the original list and consider others ideas as to how the missing information could best be developed.

RESULTS

In many areas, the workshop participants concurred with the organizers as to what the priority research categories should be. Overall, they identified eight focus topics:

- Communication: Public and Stakeholder Participation in Response and Restoration;
- Restoration Review;
- Methods and Techniques; Physical Transport Forecasting;
- Oil Weathering: Data Developing and Modeling;
- Ecosystem Services: Identification and Valuation;
- Chronic Effects of Oil: Individual;
- Chronic Effects of Oil: Habitat; and
- New Tools for Restoration and Recovery.

There was general and strong agreement among the participants that communication with the media, the concerned public and within the response community was a major unaddressed R&D need. The ability to communicate the progress of a spill response or the need for a restoration action may strongly influence the cost and/or ability to implement such an action. It was also noted that the skills of the participants, toxicology and modeling, strongly influenced the outcome of this workshop (i.e., a similar workshop consisting of economists and social scientists would probably have identified different topics).

A second topic that the participants identified as a priority R&D need was a review of the restoration projects conducted to date under the Natural Resource Damage Assessment processes. Information as to which actions were successful and which were not would allow more reasonable restoration choices, including tradeoffs across habitats and locations, to be made in the future.

A third topic was the need for new analytical methods and techniques to assess chemical, organismal and ecosystem impacts. Recent work (Peterson et al., 2003) indicates that previously unidentified, higher molecular weight, less water soluble compounds in "oil" may exert long-term chronic effects on organisms. The ability to identify and quantify these compounds, as well as the development of sensitive, quantitative indicators of changes in metabolic processes in the chronically-exposed organisms could be a major factor in determining realistic cleanup levels.

Theme descriptions for the other topics based on workshop discussions and notes included:

- *Physical Transport Forecasting*: The ability to accurately forecast the trajectory of spilled oil and other hazardous materials is a vital tool in spill response. This ability both guides the spill response and provides data and information to update the restoration. Consequently, there is a clear need to link forecasting with data collection systems, including real-time observations from platforms (e.g., *in situ* sensors and satellites). Transport models will increasingly become site specific and require enhancements to improve sensitivity to oil type, oil interactions and transformation, 3D spatial resolution and scaling (especially under ice and in energetic near shore environments), and refinement by calibration and validation.
- *Oil Weathering—Data Development and Modeling*: Weathering processes rapidly change the physical and chemical characteristics of spilled oil and determine the type and magnitude of the oil's impact on natural resources. The majority of the quantitative research done on weathering to date has generally focused on floating oil in open water environments, leaving questions as to the effects of near shore processes on floating, submerged and stranded oil.
- *Ecosystem Services—Identification and Valuation*: Recovery/restoration of species and habitats is still a young science. Even quantifying what has been lost is difficult. Conceptual models for services lost are needed. Parameterized services recovery models can be used in decision making. Human use valuation estimation (i.e., market and non-market assessments), including subsistence use impacts, can help define recovery models. Wildlife injury assessment multipliers are needed for service loss estimations. Assessing the tradeoffs of various response plans should be the first step in the recovery process following a spill.
- *Chronic Effects of Oil—Individual*: Early studies on the effects of oil released into the marine environment were standard, short-term (96 hour) acute exposures examining the effects of different compounds and oils on individual marine organisms. While these data provide information on the relative toxicity of various oils and their components and the sensitivity of various test species, they yield little information on the results of non-standard exposure regimes (e.g., greater than 96 hours, varying concentrations over the period, end points other than mortality). Measurements of the concentrations of oil in the water column during field, laboratory and mesocosm experiments indicate that most water column biota will not be exposed to a constant contaminant loading for 96 hours, but to varying concentrations over a shorter period of time (Boehm and Fiest, 1982). There is little information available on lethal or sublethal effects of this sort of exposure regime.
- *Chronic Effects of Oil—Habitat*: Historically, studies on the effects of oil have been conducted to determine the acute toxicity of oil and its components on single species at different points in their life cycle. However, long-term studies of the effects of the *Exxon Valdez* spill indicate that single species acute toxicity is not the only mechanism by which spilled oil impacts ecosystems (Peterson et al., 2003). A loss or change in the structure or function of biogenic habitats (e.g., mussel or sea grass beds) can have cascading effects, suddenly appearing in unexpected components of the system. Alternatively, the acute mortality of a major predator can also cascade through a system as the result of a change in predator/prey relationships. These complex relationships affect the ability to:
  - assess the extent of a potential or real injury,
  - develop and implement the most effective restoration; and
  - predict when the impacted system has recovered (Peterson et al., 2003).
- *New Tools for Restoration and Recovery*: While there are undoubtedly a wide variety of approaches to post-spill site response, restoration and recovery for a specific spill, the need for innovative new ideas remains. Given the opportunity to "think outside the box" regarding seemingly standard methods, researchers are often able to uncover new facets to problems which result in insights and new solutions. Some important questions that might lead to new discoveries include:
  - How do we differentiate between spill effects and natural (i.e., baseline) variability in populations that might be induced by natural stressors?

- What lessons can be learned by spatial and temporal scaling of restoration methods and recovery assessments?o
- Are there better conceptual models of ecosystems than the ones that are presently used?o
- How can non-traditional restoration practices be identified?
- Are there ways to explore synergistic restorations that address multiple problems or enhance restoration through syntrophy?

CONCLUSIONS

The workshop offered a rare opportunity for experts in the oil spill arena to discuss the current state of knowledge with their colleagues in an informal setting, identify knowledge gaps in the area of spill response and restoration, and determine the best approach for addressing these gaps by delineating research priorities. The formation of new partnerships in areas of shared interest is already underway.

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BIOGRAPHY

Dr. Kinner is an environmental microbiologist and Professor of Civil/Environmental Engineering at the University of New Hampshire (UNH) where she is the UNH Co-Director of the Coastal Response Research Center. Dr. Kinner has worked in the field of bioremediation since 1985, recently conducting research on an oil spill contaminated salt marsh.