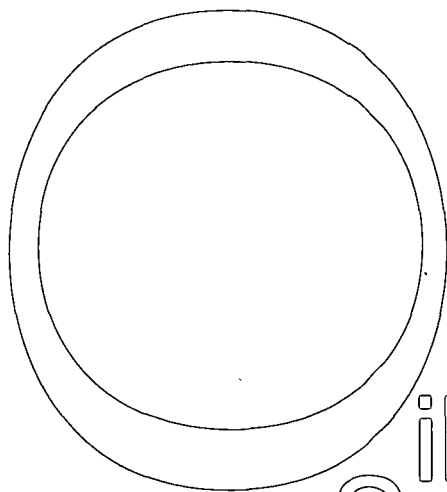
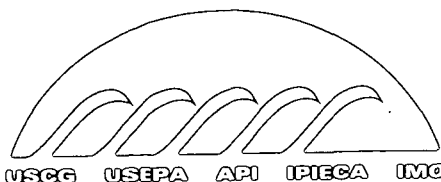


International



Oil Spill 1999 Conference

Beyond 2000
-Balancing
Perspectives



Proceedings

1999 International Oil Spill Conference

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March 8–11, 1999
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FOREWORD

This 1999 International Oil Spill Conference is the 16th biennial event since the first conference held in December 1969. The conference is sponsored jointly by the following:

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The theme of the conference, "Beyond 2000—Balancing Perspectives," reflects on the milestones and achievements to this point while stressing the importance of balancing perspectives of all stakeholders as we look beyond the year 2000. Our goal remains "...to delineate the overall dimensions of the oil spill problem, explore the present state of prevention and control of oil spills, and review the relevant research and development efforts of government and private industry around the world."

This conference continues to be the world's premier symposium on oil spill issues. We continue to push the envelope of our performance to bring you better conferences. This year saw the introduction of a conference CD-ROM for all attendees. In the CD-ROM, we included abstracts extending back to 1969 and full Proceedings for 1995–1999. This modern research aid is our largest searchable database ever.

The sponsors of this conference thank each of the authors and reviewers of the papers that constitute these proceedings. Special thanks to those who provided meeting space for several key meetings. We also thank all panel members, session chairs, course instructors, and members of planning committees, along with all others who have made extraordinary contributions to ensure a successful conference.

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Section I

MONDAY, MARCH 8, 1999

Session M1A: Planning US3

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Law Offices of Shellman & Ornitz

Session M1B: Spill Funding

Chairman: Linda Burlington
National Oceanic and Atmospheric Administration

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Chairman: Ken Bitting
U.S. Coast Guard

Session M1D: Spill Management II

Chairman: James Irvine
Shell

INTEGRATED APPROACH TO REGIONAL CONTINGENCY PLANNING IN LATIN AMERICA

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ABSTRACT: *The risk of oil spills in Latin America and the Caribbean is significant. The area comprises more than 500 million inhabitants, 40 countries, more than 40 state-owned, private, and mixed petroleum companies, and numerous marine and land-based international transportation routes. An integrated approach is required to ensure that all oil spills, regardless of size and location, are responded to in an efficient and cost-effective manner while minimizing political and bureaucratic factors.*

Since 1995, the Regional Association of Oil and Natural Gas Companies in Latin America and the Caribbean (ARPEL) has been unifying the approach to oil spill response with the production of response guidelines, workshops, and spill training exercises.

In 1998, ARPEL initiated the development of a regional integrated approach to management and response to oil spills. This regionalization project provides a common approach for developing response arrangements, spill contingency plans, sensitivity mapping, and risk assessments. The integrated approach also takes advantage of sharing equipment, manpower, and technology between petroleum companies, countries, and any other stakeholders.

The end result of the project will be a guideline (expected to be published by mid-1999) that will provide the user with a systematic approach for:

- Analyzing the need for regional response requirements based on geographical and industry production and transportation data
- Utilizing bilateral agreements and conventions
- Developing and administering national and sub-regional spill response cooperatives
- Activating a regional spill response plan
- Considering the trans-boundary movement of equipment and manpower
- Addressing regional differences in regulatory requirements for spill response capabilities and response methods

This paper's purpose is to highlight the objectives of the project and the primary components of the guideline. The value of this project relies in the fact that the conclusions and recommendations are based on the analysis of actual and up-to-date information and procedures. The guideline will be useful as a template for discussion between government and industry to review and pursue sug-

gested activities for the sake of a cost-efficient regional approach to the oil spill contingency planning process in the region.

Introduction

The ARPEL regionalization project identifies cost effective, standardized methods for developing joint oil spill response strategies among Latin American petroleum companies, governments, response contractors, and industry associations.

The project develops a sound technical basis on which improved, cooperative oil spill response planning and actions will be possible throughout Latin America. It provides opportunities, benefits, and challenges to having a regional approach towards contingency planning, management, and spill response.

The term "regionalization" can be applied to the overall Latin American region or to subregions such as the Caribbean, Central America, Southwest Atlantic, and Southeast Pacific. Hence, regions can range from local operational areas to international situations involving two or more countries or companies. The most beneficial approach will result from an analysis of available data as detailed in the guideline.

The regionalization methods described in the guideline reflect specific information and procedures developed in other ARPEL reports for oil spill contingency planning (Wotherspoon and Counterspil, 1997b), sensitivity mapping (Wotherspoon and Counterspil, 1997a), spill trajectory modeling (Counterspil 1998), risk assessment (Wotherspoon, 1998), and an oil spill expert and inventory database (ICL, 1997).

Oil spill management

Petroleum industry operations in Latin America. A review was conducted of petroleum industry operations in Latin America. Information sources included established industry publications and associations and specific information supplied directly from the petroleum operating companies through a survey questionnaire that was completed by ARPEL member companies. The review identified:

- Companies and government agencies
- National on-shore and off-shore exploration, production, processing, refining, transportation, and distribution facilities and systems
- International road, rail, pipeline, and marine petroleum transportation routes
- Approximations of frequency and transportation capacities (based on available data)
- Types and properties of products handled
- Overview of coastal shore types and resources

The information is presented in various formats of tables, charts and maps which suggest optimum spill response regions. Regional boundaries are selected that facilitate response in each region based on the identification of such factors as adjoining bodies of water, transportation facilities, and spill risk.

Guidance is given on the factors that an operating company should consider when establishing a localized regional response strategy either within its own operations or with another operator or government jurisdiction.

International oil spill response conventions. Bilateral and multilateral conventions and agreements have been in place throughout Latin America (and internationally) for some time. These agreements formalize and encourage mutual cooperation in spill response planning.

The project reviewed the various conventions, sponsoring organizations, status of ratifications, topics, and geographical areas of interest regarding oil spill management and response. The document subsequently provides a synopsis to utilize the conventions when developing local and regional spill response strategies.

Effects of privatization. The privatization of national oil companies has a direct effect on the management of spill response issues and capabilities. The guideline highlights:

- Management strategies to ensure that spill response capabilities are maintained, if not improved, during and following a privatization process
- Oil spill response requirements that should be included in prospectuses for privatization or change of ownership
- Effects on spill response management and response from a reduced government involvement in a petroleum company's operations
- Financial commitments for response equipment that becomes privately owned or remains public
- The establishment of independent controls and policies with the reduction of direct communication and financial links to government. Policies may be required for maintaining response equipment, the usage of dispersants, in situ burning, shoreline cleanup methods and priorities

Regulatory. Applicable national regulations are identified for oil spill responsibilities and response methods (e.g., policies on dispersants, in situ burning, incineration, cleanup).

Legal aspects of regional oil spill contingency plans. Regionalization may require the harmonization and understanding of regulatory requirements across national boundaries. Suggestions to incorporate these areas of potential legal disputes are summarized in the guideline. Other legal aspects include compensation requirements as well as administration, identification, and ownership of potential pollutant sources.

Response planning

Regionalizing oil spill contingency plans. It is important that a common approach to spill response planning is in place in Latin America to ensure that contingency plans can be effectively implemented. This necessitates the identification of alerting systems and response team organizational structure that are reasonably

similar. Personnel in different companies within one region must be able to communicate with one another and be familiar with an incident command structure that will be used during emergencies.

The guideline calls for ISO 14000 formatting and updating, graphics, maps, and other features that allow personnel within various organizations to quickly familiarize themselves with required operational procedures and protocols, available equipment, and priority resources at risk.

The ARPEL Oil Spill Management and Contingency Planning Guidelines (Wotherspoon and Counterspil, 1997b) are used as a basis from which all oil spill contingency plans, including regional plans, should be developed.

Structure of response organizations and equipment cooperatives. The guideline provides alternatives for structuring joint and tiered response organizations, associations, and cooperatives between petroleum operating companies, countries, and other industries. Reliance is placed on optimizing the resources within a region or from outside the region rather than the creation of new organizations.

Response team structures are addressed that emphasize the importance of simplifying the management hierarchy of a spill response team so that it is consistent with the nature of the spill concerns in a specific region.

Risk assessment. A six-step risk assessment method was previously developed earlier in the ARPEL program (Wotherspoon, 1998). Its application is basic to the establishment of regional response capabilities and is utilized in the regionalization guideline. Applied aspects of risk are stressed rather than more complex, probabilistic (numerical) methods with a view to identifying situations of concern that can be reasonably addressed by ARPEL members.

The guideline emphasizes the standardization of risk evaluations among petroleum companies and countries on a regional basis. This allows for a reasonable comparison of spill risks and response priorities.

Sensitivity mapping and trajectory modeling. The use of standardized sensitivity mapping methods and computerized trajectory models allows different countries to readily communicate data during a spill so that information is understood by all parties. This approach facilitates the actual transmission of electronic and visual data in terms of the formats, symbols, scale, etc. The regionalization guideline analyzes the means to tackle this issue.

Both mapping and modeling are integral elements of risk assessment and response planning. By participating in a regional program, ARPEL members will be better able to develop this aspect of response capability so that the level of achievement is relatively consistent throughout Latin America. In particular, the resources at risk from spills will have to be identified throughout the coastal systems of Latin America.

Oil spill response

Activating a regional oil spill contingency plan. The guideline includes typical activation formats that are currently operative or being proposed in plans. The formats focus on being straightforward structures designed to reduce delays and bureaucracy.

Reference is made to the implementation of the relevant international oil spill response conventions.

Trans-border movement of equipment and manpower. Equipment and manpower must be efficiently expedited across international boundaries and within countries. The guideline addresses the requirements for:

- Aircraft landing permits
- Customs and immigration
- Waivers of duties and bonds



Documents

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- Transportation permits
- Work permits, visas, passports, and travel restrictions

Training and exercises. Conducting spill response training at local, regional, and national levels are a necessity for the implementation of regional response plans.

The guideline provides suggestions for conducting joint field exercises involving two or more companies or countries within a region(s), including mechanical oil recovery, dispersant application, and in situ burning. Ongoing seminars and workshops are addressed along with post-appraisal of actual responses to identify issues for improvement.

Scheduled training provides continuity in response capability as personnel change, companies develop new areas of interest, and economic situations fluctuate.

Response capability. The guideline's review of responsibilities focuses on operational, environmental, and coordination aspects that must be assumed during a spill. This applies to both company and government responsibilities and the benefits and current faults in the response network. As an example, although a typical Latin American country's marine authority assumes an operational responsibility during a spill, its knowledge of effective response and cleanup responsibilities requires examination.

Response equipment is examined as a separate issue, starting with the basic requirements of response and progressing to the more comprehensive capability of regional cooperatives (e.g., Clean Caribbean Cooperative) and other Three-Tiered Centers.

An additional concern is that in Latin America, complex ecosystems exist that include mangroves, coral reefs, wetlands, extensive stretches of sand beaches, lagoons, and many rare species of birds, fish, reptiles, and invertebrates. Responsibilities for the effective management of these resources during a spill situation has to date been minimal.

Biography

Paul Wotherspoon is President of Wotherspoon Environmental Inc. and has been involved with petroleum industry environmental

programs since 1977. His on-shore and offshore oil spill management, contingency planning, and oil spill research projects have been conducted in Canada, the Arctic, the Middle East, Russia, the Caribbean, and Latin America.

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¹ Asociación Regional de Empresas de Petróleo y Gas Natural en Latinoamérica y el Caribe.

CONSIDERING "BEST RESPONSE" CAPABILITIES IN AREA CONTINGENCY PLANS¹

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ABSTRACT: *The paper proposes that planning should focus on those critical success factors inherent in a "Best Response." Our common objective is to be prepared to clean up a spill while doing the least harm to people and the environment. Despite this common goal there are considerable differences across the United States in the commitment of resources to the oil spill planning and preparedness process. These differences result in a wide variety of Area Contingency Plans (ACPs) that may indicate different response capabilities. On the West Coast, oil spill plans contain detailed resource information and response strategies. By comparison, the East Coast plans are considerably less detailed. However, any demand that both West Coast and East Coast plans should have the same level of detail should first consider the question, "What kind of planning leads to success?" This paper stresses that we must first identify priorities and important factors needed to achieve success and produce a "Best Response." In our opinion, ACPs should be evaluated based on their capability to achieve Critical Success Factors during an actual response.*

Introduction

Area Contingency Plans (ACPs), written to satisfy the 1992 requirements (U.S. Coast Guard, 1992), now serve as an important repository for resource information and a record of community consensus based on local concerns and priorities. However, based on a review of a number of ACPs for this paper, many ACPs do not prepare the response community to accomplish tasks that are critical to success during a complex spill.

There is a big difference between the resources available for oil spill planning between the West and East Coasts of the United States. Along the 7,863 miles of the West Coast (NOAA, 1975), over 200 full-time, state-employed spill response personnel demonstrate a large commitment to oil spill planning and response. This commitment has enabled federal, state, and local responders and the oil industry to form an extensive network for cooperative planning. The West Coast's large commitment of planning resources resulted in detailed response strategies that included geographic information systems that could correlate lists of available response resources to protect sensitive areas.

On the other hand, along the 9,880 miles of the Chesapeake Bay and North Carolina (NOAA, 1975), there are less than 10 state employees assigned to even part-time oil spill response planning. This much smaller commitment along the Mid-Atlantic results in comparatively less detailed planning, including a lack of central focus for government and oil industry cooperation at the planning and preparedness level. The Mid-Atlantic response planners were only able to assign general planning priorities within a large complex bay and estuarine environments.

West Coast and East Coast plans are clearly different, but there are no standards for measuring a successful ACP. Before asking any Area Committee to consider committing more resources to future planning we must ask, "What kind of planning leads to a successful response?"

The paper invites discussion of the ACP process in four steps. Step 1 considers the increased complexity of planning for a spill in our democracy. Step 2 considers the kinds of planning efforts that are useful in the event of a complex spill. Regrettably, current or proposed guidelines do not include a mechanism to measure the success of an organization's ACP. For example, will this ACP result in the organization achieving success during a complex spill? Step 3 describes the "Best Response" model and proposes a set of "Key Business Drivers" and "Critical Success Factors" necessary to achieve success during a complex spill. Step 4 discusses a process for applying those "Critical Success Factors" to assess ACPs—none of which are now evaluated.

The paper's conclusions are straightforward:

- Planning to accomplish Critical Success Factors is important and should be given high priority in the ACP process.
- Measurement of the planning process is important to determine whether appropriate planning has actually been accomplished.
- Finally, planning resources for Coast Guard Marine Safety Offices could also focus on critical success factors in many of the other Coast Guard port activities.

Planning in a democracy is complex

Emergency response in the United States occurs against a backdrop of a democratic society. The demands of a democratic

society, such as the public's right to know, stakeholder participation, and open discussion of possible risks and benefits, require extraordinary levels of communication on the part of the response organization. Figure 1 illustrates that, as spill size and complexity increase, the types of preparedness planning required of the response organization also increases. During routine spills the response organization consists of a small (usually experienced) staff who handles the entire spill; thus, their preparedness planning consists mainly of good training that includes experience, practice, and performance of basic but critical response tasks (Ott and Stalfort, 1997).

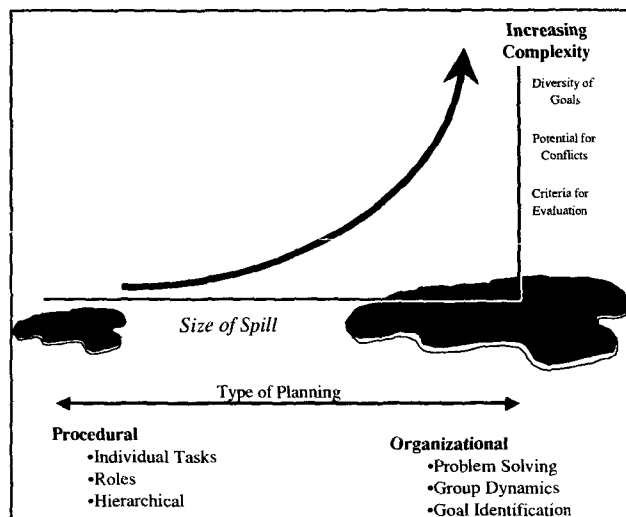


Figure 1. Range of complexity and planning needs.

During a complex spill, however, the response organization typically becomes increasingly larger, requiring more and more complex management and tasking to efficiently and effectively respond. This complexity is, in part, due to the dramatic increase of the public's awareness and interest in the spill's impact (Stalfort, 1995).

To respond effectively to complex spills, a response organization must already have well-grounded skills in organizational dynamics, group problem-solving, and risk communications delivered with success in mind (Covello, 1996; Sandman, 1995). Consequently, response planning must tend away from a simple resource listing strategy and/or narrow-task orientation, to a more success-based planning orientation that helps the organization resolve conflicts, solve response resource problems, reach consensus on priorities, and skillfully communicate with the public. The Area Committees are the logical groups to perform this type of problem-solving and success-based planning.

"Success" and Area Contingency Plans

There is no connection between success and current ACPs. Current ACP guidelines provide basic guidance on how to draft and assemble an ACP—guidance that was developed post-*Exxon Valdez* and was a best effort in bringing response plans into compliance with the new Oil Pollution Act of 1990 (OPA, 90). The guidance focuses on planning as a process. It identifies the planning documents themselves as a repository for consensus agreements related to spill risk, sensitive areas, response priorities, cleanup strategies, and organization for response. The guidance urges each Area Committee to address all of these issues based on local concerns and priorities. The guidance leaves decisions as to

planning effectiveness to the local community. The guidance does not provide any suggestions on evaluating the resulting plans or response strategies in terms of most effective or efficient response. An unstated premise of the guidance is that, if the plan is based on community consensus (if it represents what "feels good" to the community) then it is likely to produce a successful response.

In order for this process to result in successful plans, several things are necessary. First, the entire response community (federal, state, and local agencies; industry; and concerned environmentalists and marine resource users) must participate in an ongoing dialogue that leads to consensus decisions. Second, participants in the planning process must have the technical competence to reach appropriate consensus decisions. Third, because the tasks are complex and priorities and concerns are dynamic, planning must be approached as an iterative process, with each planning cycle validating or modifying previous consensus and then further refining estimates of risk, sensitivities, response strategies, etc.

All of this results in a sort of socio-scientific process whose benefits are difficult to quantify, especially outside of the immediate community. On a national level, without a gauge to measure the effectiveness of the process, federal agencies and the corporate offices of industry plan holders are unable to estimate whether a given area is able to mount a "Best Response" or even an effective response. Hard science and technical solutions are much more quantifiable and defensible. Is there hard science like criteria behind the current batch of ACPs? Is this kind of criteria recognizable, consistently developed, and consistently employed?

To a certain extent, these concerns and questions are warranted. Our anecdotal observations comparing resources for planning on the West and East Coasts illustrates that the ACP process has progressed unevenly across the country. In some areas, the entire response community is involved proactively and routinely. In other areas, only a few members of the community participate regularly in planning activities. In a few areas, the entire planning process has been left to the Coast Guard On-Scene Coordinator with the rest of community becoming involved only during response or an occasional exercise. The questions that we should ask before committing more planning resources include: Which plans are effective? What are their deficiencies? How can they be improved?

Recently, several university-based studies looked at best-response concepts and identified critical success factors common to responses to oil discharges and hazardous materials releases (Harald, 1993). However, ACP guidelines have not kept pace with these new concepts and thus continue to promote regulatory and format compliance over development of demonstrably successful response strategies (Abordai, 1997). This lack of success-based planning guidance may prevent Area Committees from developing ACPs that promote "Best Response" when activated and followed.

Current ACP guidelines. Today's guidelines for Area Committees and the format for ACPs are contained in a 1992 Coast Guard policy document (COMMANDANT NOTICE 16471, 30 Sep 92). These guidelines helped to establish and define the role of the Area Committee in the National Response System's contingency planning process. At that time, the required format became the standard nomenclature in all ACPs. The only known measurement guidelines for ACPs were contained in a 1993 Coast Guard Headquarters letter (*Area Contingency Plan Review Guidance*, 1993). These guidelines focused on format, participation levels, development of three scenarios, and addressing topics such as dispersants and bioremediation.

Proposed ACP guidelines focus on format, not success. An update of the Area Committee guidelines was proposed and in

culated as a draft on May 29, 1997. An important objective was to ensure nationwide uniformity of ACPs by converting the format of all the Plans into the incident command system (ICS) format rather than a military style such as the Joint Operational Planning & Execution System (JOPES) nomenclature (i.e., Annex, Appendix, Tab, and Exhibit). Some Coast Guard units enthusiastically welcomed the proposed format changes. However, a number of comments on the draft proposal suggested that the Coast Guard's need for uniformity did not necessarily meet the needs of the Area Committees and/or did not significantly enhance the planning effort. Overall, the message from the response community was loud and clear: there may be problems with the planning process, but format is not one of them. Objections to format changes also acknowledged the value of ICS in organizing for response, but objected to the implied push to force planning to concentrate on implementing a response management structure over striving for consensus on risks, response priorities, and sensitive area identification and protection.

Recommended planning process. Good preparedness planning shapes the desired direction of a response by focusing on pre-planned actions that establish clear goals and achievable objectives. Careful preparedness planning involves determining in advance what must be done, how to do it, when to do it, and who should do it. Thus, a truly successful response organization is one that systematically enhances its ability to accomplish predetermined critical success factors. The basic steps are diagrammed below (Figure 2).

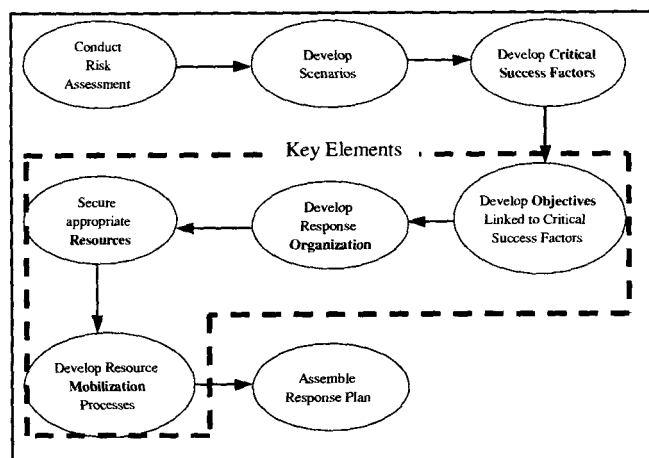


Figure 2. Basic planning process.

To initiate this planning process, the response community must first conduct an accurate risk assessment of the area, which allows the community to understand the risks that are present. Risk assessment provides for easier and more accurate scenario development, because knowing the risks illuminates both what to plan for and the required level of preparedness. Identifying risks validates the possible incident scenarios, which are then used in developing the critical success factors and objectives. Once all the Key Elements (Objectives, Organization, Resources, and Mobilization) and any other preparedness issues are resolved, the Area Committee adds any regulatory requirements and then assembles the ACP into the required format.

Planning for success requires a connection between actual planning and critical success factors

Best Response. The term Best Response means that the oil spill response organization will effectively, efficiently, and safely respond to oil spills or hazardous materials releases and that, having done so, the response will be perceived as a success. Thus, Best Response equals a successful response based on achievement of all critical success factors. Best Response depends on the best efforts of the three components of the National Response System:

- **Companies**—those responsible for producing, handling, storing, and transporting oil and hazardous materials, and for arranging for mitigation of an accidental discharge or release
- **Contractors**—those who carry out response and cleanup in the event of a discharge or release
- **Government**—those federal, state, and local agencies with oversight responsibility for the safe handling of oil and hazardous materials and for ensuring protection of the public and the environment in the event of a discharge or release

Best Response protects our national interests. Each component must act responsibly, effectively, and cooperatively to accomplish the shared goal of minimizing the consequences of pollution incidents. Finally, Best Response demands that a response community build an ability to measure its own capability to achieve success. To do this kind of self-assessment the community must be able to recognize success.

Companies, contractors, and the government are each critical to response, and their operations are interdependent. Therefore, these groups must cooperate as equals to arrive at a mutually agreeable, fully implementable set of Best Response measures. The remainder of this paper describes a template for Best Response measurement, which is intended as a possible starting point for that process. The underlying assumptions are founded on academic research and Coast Guard experience. However, these concepts have yet to undergo rigorous examination by the response community as a whole. Until that rigorous examination is completed it is unlikely that Best Response will be successfully implemented.

Key Business Drivers. Key Business Drivers are the major requirements for accomplishing the goals of Best Response.

Critical Success Factors. Critical Success Factors are the specific things that a response must accomplish to be considered successful. The Critical Success Factors suggested here were compiled from expert-based surveys, which generated lists of things in a response that must go right. (Harrauld, 1993; Walker, 1995). There are a number of Critical Success Factors for each Key Business Driver. An oil spill response that achieves all or most of these factors will, according to the Best Response precepts, be judged as a success. Table 1 is an example of the Best Response model.

Key Elements: There are four key element categories, all linked to critical success factors: objectives, organization, resources, and mobilization. An organization must focus on these elements in order to prepare for a Best Response.

- **Objectives.** Objectives help the organization understand its responsibility and define priorities for achieving the critical success factors and other tasks that may be assigned. Objectives should answer the question, "What is

Table 1. Best Response model.

Goal	Key Business Drivers	Critical Success Factors
Minimize consequences	Human health	• No public injuries • No worker injuries • Accurate timely information provided
	Natural environment	• Source of discharge minimized • Source contained • Sensitive areas protected • Resource damage minimized
	Economy	• Economic impact minimized
	Public communication	• Positive media coverage • Positive public perception
	Stakeholders' Support	• Minimize impact • Stakeholders well informed/involved • Positive meetings • Prompt handling of claims

expected?" Clear, specific, realistic, result-oriented, and measurable objectives increase the organization's commitment to achieving the Critical Success Factors and facilitates further development of response strategy and tactics. Objectives provide the organization with an internal feedback loop that continually signals its progress toward critical success factor achievement. All objectives must focus on accomplishing the critical success factors.

- **Organization.** An effective response organization uses a response management system as a tool for the command and control of the response. A core response management system doctrine must help achieve the critical success factors. The response management system must be properly organized, trained, exercised, and facilitated to ensure unity of effort, centralized control, and functional decentralization (Walker, 1995).
- **Resources.** Resources required in response to a spill include personnel, equipment, and finances, all of which require thoughtful planning if they are to be used effectively and economically.
- **Mobilization.** Mobilization is the capability to coordinate, assemble, and put into motion the organization and all necessary resources assigned to it. Effective mobilization of response resources is a critical core element in reducing the cost and environmental impact of an incident.

Assessment of ACPs around the country

ACPs in the United States do not support Critical Success Factors. A basic assessment of various ACPs from across the

country (reviewed for this paper) indicates that ACPs are not designed to achieve Critical Success Factors. This is not surprising as the current guidelines were developed before the advent of the Best Response model and its identification of critical success factors. Coast Guard and state regulatory organizations have not developed evaluation methodologies to ensure that contingency planners capture essential information rather than simply mass-producing documentation for bureaucratic review. In most cases, plans are evaluated using basic checklists designed to ensure completeness rather than to evaluate content. This approach encourages an increase in plan size, not plan quality, since only a plan that omits something is likely to be rejected (Abordaif, 1997). ACPs have become a repository for quantities of environmental and resource data, spill histories, generic response policies, and organizational authorities. While ACPs do record community consensus, many plans do not prepare the response community to accomplish factors that are critical to the success of response.

Development of an ACP scorecard. The Coast Guard Training Center (Yorktown), the National Strike Force Coordination Center, and Coast Guard Headquarters have developed a scorecard to measure the planning for Critical Success Factors. Each of the Key Elements of each of the Critical Success Factors is evaluated based on similar methods used in the U.S. Department of Commerce's Malcolm Baldrige National Quality Award Program (ASOQ, 1997). The key in the evaluation is linking the Critical Success Factors to the desired outcome. The end result is to determine to what degree the Key Elements are present, understandable, and achievable.

Proposed measurement criteria. Table 2 provides examples of the criteria scale used to measure each Key Elements.

Table 2. Key Elements.

High/green	• Meets the Key Elements criteria by demonstrating clear, strategic, and cohesive planning with sufficient detail: is easily located and clearly linked to the Critical Success Factors. • Provides an overall sense that if implemented there is a high likelihood of achieving the associated Critical Success Factors.
Moderate/yellow	• Meets some of the Key Elements Criteria, but demonstrates evidence of only basic/generic planning and lacks sufficient detail; is difficult to locate and will faintly/subtly lead to Critical Success Factors. • Provides an overall sense that if implemented there is a moderate likelihood of achieving Critical Success Factors.
Low/red	• Fails to meet the Key Elements Criteria by showing little or no evidence of basic/generic planning; or unable to locate. • Provides overall sense of low likelihood of achieving the Critical Success Factors.

Sample scorecard. The proposed ACP Scorecard is on a temporary web site at <http://204.182.113.35>. The goal is to provide the Area Committee with a straightforward way to assess its own ACP's ability to help the organization accomplish a Best Response. The proposed method measures the organization's planning to accomplish the Critical Success Factors. Table 3 is an example of the scoring sheet for the key business driver Natural Environment.

Proposed final scorecard

Table 4 is an example of the final scorecard that would summarize an Area Committee's measurement of their own ACP. If most of the marks are, for example, green, their ACP will probably help that response organization achieve the critical success factors. On the other hand, scores that are mostly red indicate that the ACP will not help that organization accomplish many of the Critical Success Factors.

Conclusion

In 1992, the Area Committee process began to build the team and develop the plans that organize a response to an oil spill emergency. Each Area Committee used its own experiences and resources to develop its ACP. Rather than demand from each

Area Committee with different resources the same kind of ACP we should first identify priorities and important factors that plans need to achieve success.

ACPs should address achievement of critical success factors. Good area contingency planning should increase a response community's ability to achieve success. Thus, true preparedness ensures that there is a high probability of success. If Critical Success Factors are important, then resources for planning and focusing on the accomplishment of critical success factors should also be important. In fact, if planning to accomplish critical success factors is done in one aspect of a response organization's planning efforts then it ought also to be used in other planning process. Knowing and using critical success factors should drive the Area Committee to enhance planning efforts and focus on achieving them.

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Table 3. ACP scoring sheet: Natural Environment.

Key Business Driver	Critical Success Factors	Objectives criteria	Organization criteria	Resources criteria (people, finances, equipment)	Mobilization criteria
Natural Environment	• Response occurs expeditiously. • Spread of oil is minimized. • Sensitive areas are protected. • Proper and least environmentally disruptive cleanup methods are used.	• Offers clear, specific, realistic, results oriented, and measurable Natural Environment response objectives designed to prevent or minimize harm to the environment. • All Natural Environment response objectives are directly related to CSF achievement. • All objectives are scenario based.	• Establishes clear and effective authority, chain of command and organization in which response members will collect, verify, decide, and disseminate Natural Environment information and response tasking. • Describes clear, effective, and measurable processes or strategies that will ensure the Natural Environment is protected. • Has complete, accurate, and up-to-date list of required permits, agreements, and or contracts necessary to immediately respond within the Natural Environment.	• Identifies and ensures availability of the necessary people, finances, and equipment for on-water, shoreline, and sensitive area response. • Identifies all available and capable response facilities, including all necessary command post equipment best suited to collect, verify, and disseminate Natural Environment information and response tasking. • Identifies and assigns or designates by • Name or position the necessary Natural Environment response personnel and any alternates and or replacement members for 24-hour operations. • Defines a clear and enforceable process and policy for selection and assignment of trained and experienced Natural Environment response personnel. • Provides clear guidance on the procurement of additional supplies, points of contact and special contracting procedures.	• Establishes clear and effective notification and recall processes for all assigned environmental response personnel. • Establishes clear and effective procedures for requesting additional environmental response professionals, specialists, and or specialists within local, state, and other federal agencies. • Clearly describes and accounts for all logistical needs and concerns for organizing, equipping, feeding, and housing environmental response personnel.

Table 4. Final scorecard.

Critical Success Factors Measurement													
Key Business Drivers	Critical Success Factors	Key Element Measures											
		Objectives			Organization			Resources			Mobilization		
		H	M	L	H	M	L	H	M	L	H	M	L
Human Health	- No public injuries - No worker injuries												
Natural Environment	- Source discharge minimized - Source contained - Sensitive areas protected - Resource damage minimized												
Economy	Economic impact minimized												
Public Communication	- Accurate timely information provided - Positive media coverage - Positive public perception												
Stakeholder support	- Minimize impact - Stakeholders well informed - Positive meetings - Prompt handling of claims												
-	- Appropriate authority assigned - Stakeholder concerns addressed - RMS employed, organized, directed - Response objectives established - Sufficient resources brought to bear												

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¹ The opinions expressed in this paper are solely those of the authors and do not necessarily represent the views of the organizations noted above.

A NEW PLANNING APPROACH TO THE PROTECTION AND MONITORING OF SENSITIVE RESOURCES: A CASE STUDY—THAILAND

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ABSTRACT: *An integrated Environmental Recovery Plan has been developed to assist in decision making during the response to sensitive resources impacted by a marine oil spill. The Plan is contained in a field handbook with six clearly defined stages. Implementation of the Plan commences with a definition of the impacted area, supported by use of oil spill models. The overall priority of the region, followed by the priority of individual resources is then assessed with supporting data provided by a detailed GIS. This permits individual resources to be assessed through sensitivity summaries, key consideration summaries, priority decision trees, response guidelines, and finally, guidelines for monitoring and assessment. The Plan has been specifically designed to provide rapid advice to response teams during emergency incidents ensuring that sensitive resources receive the optimum response to minimise damage and enhance recovery.*

Introduction

Although Thailand has been fortunate not to suffer a major oil spill in recent years, there have been many smaller spills and the volumes of oil being moved in and out of Thailand are increasing. The Thai Government has responded to the threat of oil spills with the Committee on the Prevention and Combating of Oil Pollution formed under the Prime Minister's Regulation on the Prevention and Combating of Oil Pollution. In 1995 the Regulation and the Committee were revised and a National Oil Spill Response Plan was implemented. Under this Plan the Pollution Control Department (PCD) under the Ministry of Science, Technology and Environment holds responsibility for providing all academic and technical support during oil spill response.

In order to ensure that PCD can properly execute its role during an oil spill, a major project was commissioned to develop a set of plans and handbooks supported by integrated software systems. This paper describes the development of an Environmental Recovery Plan for Thailand. This Plan forms one of a set of plans and software which taken together provide an integrated planning tool for the PCD in Thailand.

Aims

Oil spills are one of the most complex maritime emergency situations to deal with due to the diversity and volume of information generated and required to make informed decisions. Seldom are all the necessary experts available in-country to support the oil spill response, particularly during the early stages. As a result, it is vital to produce detailed plans for dealing with emergencies and to support these plans with data and information in a readily available format.

The key objectives of the Environmental Recovery Plan are:

- To describe the vulnerability of the various coastal and marine resources to oil spills
- To provide a simple system for prioritising each resource for protection and cleanup
- To provide guidelines on the most appropriate techniques for protecting and cleaning sensitive resources
- To provide guidelines for conduct of impact surveys and monitoring recovery
- To integrate with key sources of data and information contained within oil spill models, GIS and shoreline cleanup decision support systems

Structure

The overall structure of the Environmental Recovery Plan is summarised in Figure 1. The Plan has been designed to follow a highly prescribed process. This assists personnel in dealing with the Plan during emergency response situations where they may be working rapidly and under pressure. The diagram shows the key stages that have been established for environmental recovery. It also shows the interactions between the Plan and the other systems and data sources.

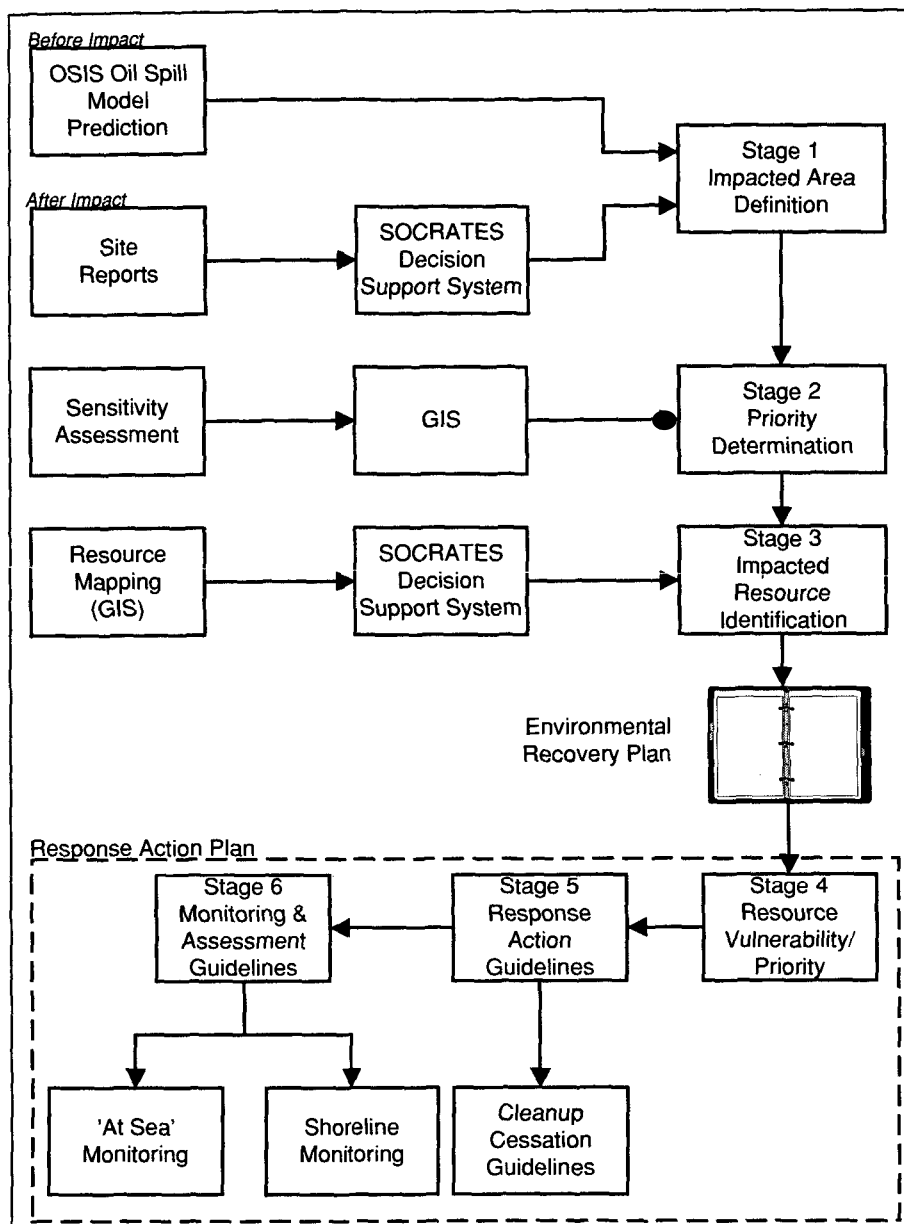


Figure 1. Overall structure of the Environmental Recovery Plan.

Two software systems, implemented under this project are of relevance to the Environmental Recovery Plan; the Oil Spill Information System (OSIS)—an integrated oil spill trajectory, weathering and fate model—and the Shoreline Oil Cleanup, Recovery And Treatment Evaluation System (SOCRATES) shoreline cleanup decision support system. These two integrated systems, coupled with their shared Geographical Information System (GIS), provide the user with a large amount of the information required to support decision making during the response. Starting with the initial reported spill, the systems continue to provide support throughout the prediction of oil spill movement and fate, coastline impact, impacted resources, cleanup method selection, resource requirements and sourcing and damage assessment.

The defined stages in the Plan are summarised as follows and discussed in more detail in the next section:

- Definition of the area impacted by the oil spill
- Determination of the priority of areas impacted by the oil spill

- Identification of specific resource types impacted by the oil spill
- Assessment of the vulnerability/priority of the identified resources
- Guidelines on suitable response measures on a resource-specific basis
- Guidelines on on-going monitoring and assessment

Use of the plan

The Environmental Recovery Plan is published as an A5 field handbook. The Plan is supported by a more detailed reference publication but the handbook contains everything required for the field assessment.

The summary content of the Plan is as follows:

- *Instructions for Use.* Includes definition of each stage and summary guidance on the use of the associated software systems.
- *Summary of Resource Sensitivities.* Brief overview of the sensitivity of the resource.
- *Important Factors.* Factors that need to be taken into account when considering the vulnerability of the resource and its protection.
- *Prioritisation Decision Tree.* Step-by-step question based decision tree which evaluates the vulnerability of the resource.
- *Response Guideline.* List and description of the major "Dos" and "Don'ts."
- *Monitoring and Assessment.* Description of the environmental monitoring programme that should be put in place to evaluate the extent of the damage and properly monitor recovery.

The Instructions for Use guide the user through six primary stages which, if followed methodically, will provide the necessary guidance to ensure that most appropriate measures are taken in the approach to sensitive resource cleanup. The stages are defined as follows:

Stage 1: Impact area definition. In an operational situation Impact Area Definition would be the first task. If the spill is a marine spill that is yet to impact the coastline, the OSIS oil spill model would be used to simulate the spill conditions and to determine the likely coastline impact area of the spill. As the situation develops and oil reaches the shoreline, the predictions from the model will be replaced by real data collected by site impact

survey and reported in the SOCRATES data management system. A detailed Shoreline Survey Evaluation Form has been designed for recording in the field. This is then directly compatible with the SOCRATES database allowing its storage and retrieval as well as its use in the decision support system.

Stage 2: Priority determination. Following the Impact Area Definition, the next stage is to determine the priority of the coastal area that may be, or has been, impacted by the oil spill. This stage of the Plan relies on the resource priority maps presented in the GIS. The resource priority maps, based on the highly detailed GIS mapping of resources, have been assessed to determine the relative sensitivity of each section of coastline (see example, Figure 2). The information is presented in the GIS as coloured sensitivity bands along the coastline which are coloured according to their overall sensitivity. The prioritisation of the coastline is then used to advise response teams on the optimal deployment of resources.

Stage 3: Impacted resource identification. The third stage of the Environmental Recovery Plan is to provide a listing of all impacted resources within the spill impact zone. This is carried out using SOCRATES together with the GIS database of resources. The spill impact area (determined in Stage 1) is transferred to SOCRATES (if OSIS has been used for the spill prediction) or entered directly in SOCRATES (if site impact reports have been completed). SOCRATES then interrogates all the layers in the GIS to generate a listing of the resources which are within the spill impact area. All appropriate attribute data associated with these resources in the GIS is also reported.

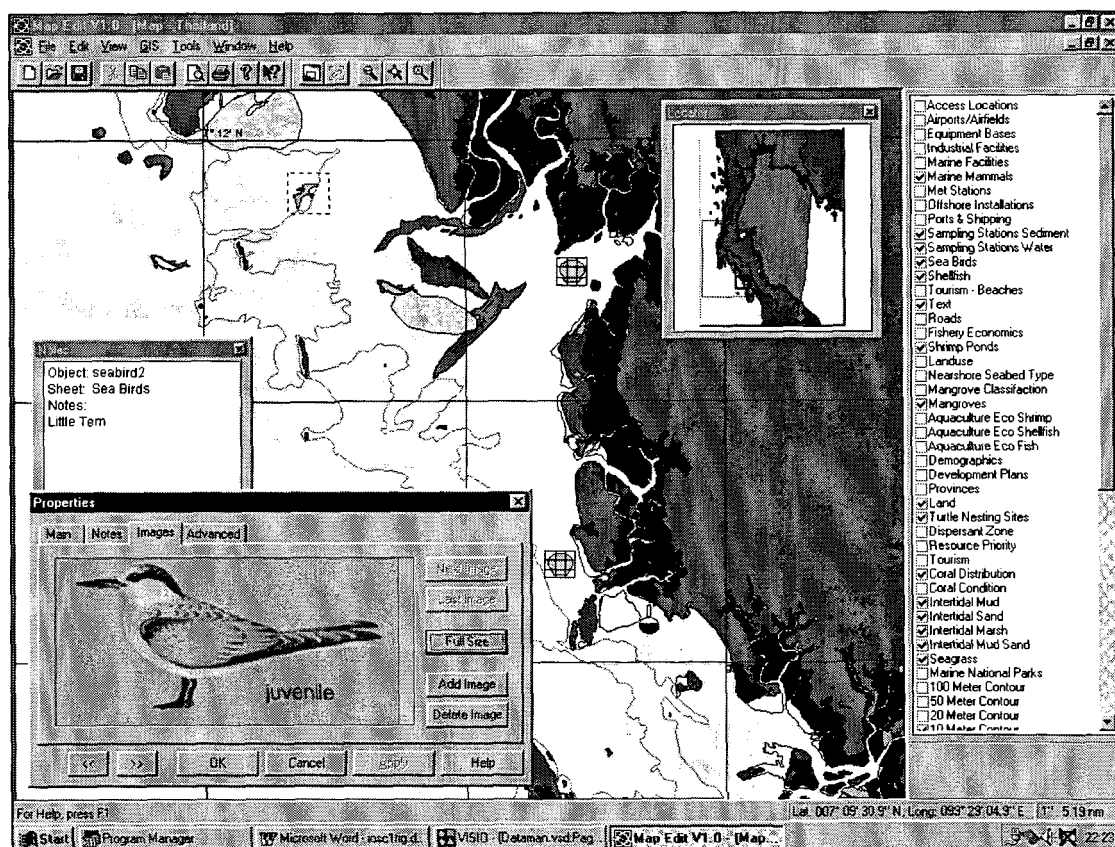


Figure 2. Typical display from GIS showing mapping of sensitive resources.

Stage 4: Resource vulnerability and priority assessment. In Stage 4 the vulnerability and priority of individual resources that may be impacted is assessed on an individual resource category basis. Twenty-three resource categories have been defined for Thailand and these are listed in Table 1.

Table 1. Environmental Recovery Plan Resource Categories for Thailand.

Coral reefs	Aquaculture: Fin fish farms (cages)
Seagrass beds	Aquaculture: Mollusc and seaweed farms
Mangroves	Aquaculture: Hatcheries
Sandy/muddy beaches	Tourism: Amenity beaches
Rocky shores	Tourism: Water sports areas
Industrial facilities: Ports	Marine mammals: Dugong
Industrial facilities: Seawater intakes	Marine mammals: Cetaceans (inc. Turtles at sea)
Industrial facilities: Salt pans	Turtles: Nesting sites (exc. Turtles at sea)
Fisheries: Coastal fishing grounds	Birds: Seabird colonies and feeding grounds
Fisheries: Offshore fishing grounds	Birds: Wetland birds
Fisheries: Commercial fish breeding and nursery area	Marine National Parks
Aquaculture: Prawn/fish ponds	

Each resource category is presented in a self-contained section of the Plan with indexing for quick reference to a specific resource (see Figure 3).

The resource vulnerability and priority assessment is conducted with the first three sections of the resource summary: summary of resource sensitivities, important factors, and the prioritisation decision tree (Figure 3). The Summary of Resource Sensitivities provides an appreciation of the sensitivity of a particular resource to the oil spill, the important factors section then briefs the user on the factors that should be considered in the assessment and what information should be sought. Finally, the prioritisation decision tree guides the user through a number of questions which, when answered, provide an assessment of the priority for protection or cleanup.

From this assessment, the comparative vulnerability of various resources impacted by the spill can be assessed thereby allowing resources to be directed at the most vulnerable resources.

Stage 5: Response action guidelines. The resource action guidelines are in the form of a concise list of actions to take and action that should not be taken. this advice is not designed to replace the important role of on-scene experts, but it can provide

essential early advice to response teams, particularly to ensure that no further damage is inflicted on already impacted resources by inappropriate response. An example of such guidelines is given in Figure 3.

Termination of cleanup is one of the most difficult decisions made during oil spill cleanup. Definitions of "clean" were taken from Baker (1997), but this was not enough to provide guidance on when cleanup activity should stop. This decision making process was summarised in a decision tree which guides the users in the key considerations and questions to be answered in determining cleanup termination.

Stage 6: Monitoring and assessment. The monitoring and assessment stage of the Environmental Recovery Plan is also presented on a resource specific basis because the monitoring/assessment techniques tend to be specific to particular resources. The shoreline monitoring and assessment follows from the Response Action Plan with guidelines for monitoring each resource. Where appropriate, this is presented as decision trees and standardised site impact reporting formats. Standard sampling and analytical methodologies are provided for hydrocarbon determination in each environmental media.

Conclusion

A comprehensive Environmental Recovery Plan has been developed which will considerably enhance the decision making ability of the Thailand PCD during major oil spills. The Plan, linked to oil spill models, GIS and a shoreline cleanup decision support system, provides a structured approach to ensuring that sensitive resources are correctly prioritised and receive an appropriate response action.

Biography

Andrew Tyler is the Managing Director of BMT Marine Information Systems Ltd. He has a background in marine environmental science with specialisation in marine pollution and environmental software systems. Over 8 years, Mr. Tyler has been responsible for the development of marine information systems for environmental/safety management and planning and pollution control. He has worked extensively in the ASEAN region for national governments and the oil and gas industry.

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Mangroves

Summary of resource sensitivities

Mangroves provide a number of important services to the environment and to local communities, all of which may be severely damaged by an oil spill. The mangrove trees and shrubs which form the basis of the forest are very sensitive to oil on their roots. Thick black oil is particularly damaging because it can cover the breathing pores on aerial roots and stop oxygen getting to the subsurface roots. Toxic oil can also kill mangrove plants by damaging the cells in the roots. Many of the fish, crabs, shrimps, molluscs, and other marine animals are also killed directly by the oil. Furthermore, when the trees and shrubs die the rest of the ecosystem in that area of the forest deteriorates quickly. Some plants are less sensitive to oil than others, but the dominant species in Thailand mangrove forests are all to a certain extent sensitive. However, these plants are less sensitive to chemically dispersed oil, so it may be possible to reduce impacts to the forest by spraying dispersant on the slick before it reaches the forest.

Important factors

- The amount, type and weathering of the oil
- Types, ages, and diversity of mangrove species present—*Avicennia*, *Rhizophora*, *Sonneratia*, *Ceriops* or *Bruguiera*
- Known importance for biological diversity and abundance
- Statutory conservation status—National Park, other protection designation, or not protected
- Forestry Dept. classification—Conserved, Economic 1, Economic 2
- Known importance as fish nursery area
- Local importance for timber and firewood
- Presence of large bird colonies (see 4.21 and 4.22)

Prioritisation decision tree

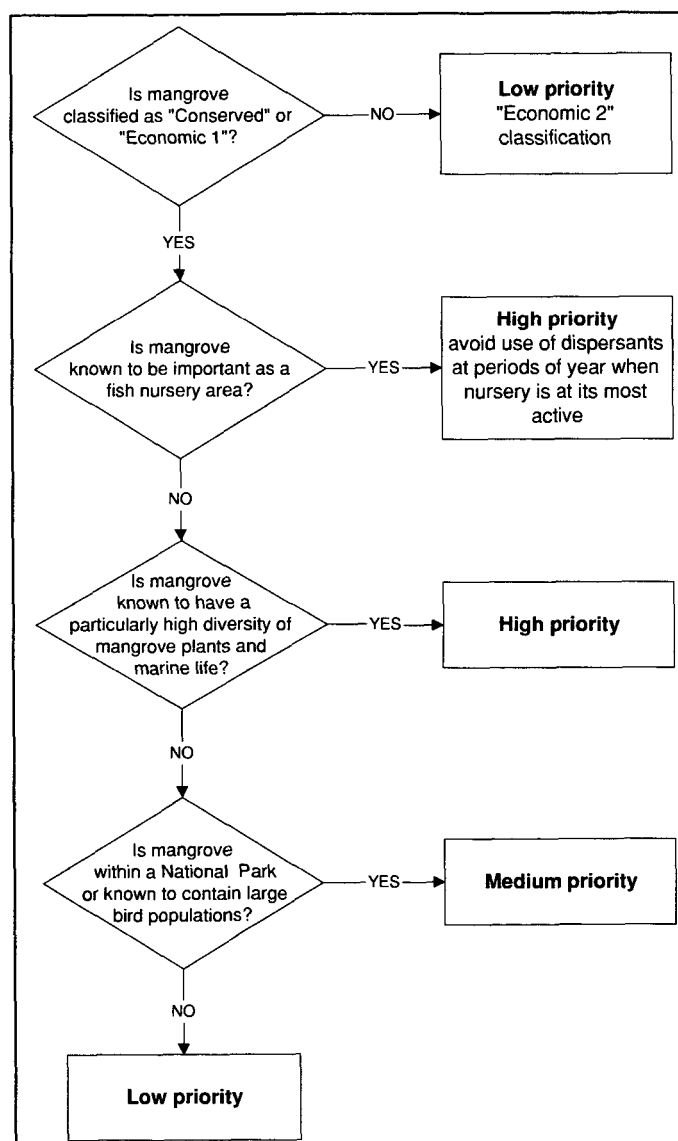


Figure 3 Continued



Documents
Document Sharing Hub

Figure 3 Continued

Response guidelines

- Where feasible and appropriate to prioritisation given above, attempt protection of oil slicks, with booms, from the entrance to creeks. Placement of sorbent boom along the mangrove forest fringe may also help to protect the edges of thick forest.
- Critical decisions need to be made on whether chemical dispersants are used to disperse oil slicks on the water near a mangrove. Consider the prioritisations of sensitive shallow water resources nearby—e.g., Coral Reefs and Seagrass beds, Fish Nursery Areas and Fish Farms. Also consider the likely effectiveness of dispersant spraying operation. Only allow spraying if it is likely that the dispersants would significantly reduce oiling of mangroves without causing significant long-term damage to other important subtidal resources (see Oil Spill Chemical Use Plan for more information).
- **Do not** spray dispersants within the mangroves.
- If oil contaminates the mangrove, it is normally best practice to allow natural cleanup. Do not make rushed decisions. **Wait** until you can assess the potential for natural recovery.
- **Do Not** attempt any cleanup operations within the mangrove forest, unless it is possible to gain access over **firm** ground to large quantities of stranded bulk oil. For example, it may be feasible to remove bulk oil stranded along the high water line without creating deep ruts in the soft mud.

Monitoring and assessment

- Take aerial photographs (preferably vertical views and geo-referenced) of the oiled mangrove and surrounding area. Photographs should be taken in the early stages of the spill after bulk oil movement has stopped and then at intervals as defoliation progresses.
- Collect samples of crustacea and molluscs (preferably species of economic importance) for analysis of total hydrocarbon content (THC) and PAH (see Methods section 8.7). Samples should be collected from various localities within the spill affected area and from control areas outside.
- Carry out rapid assessment surveys of mangroves (from edges of forest and creeks) to record and collate evidence of oiled mangrove plants and dead animals. This could be incorporated with the SCAT surveys (see Section 8.4).
- Carry out detailed studies on a number of individual mangrove trees from various localities within the spill affected area and from control areas outside. Record key parameters relevant to the health of the plant and the impacts of oiling (e.g., level of blackened or curled leaves) (see Methods section 8.7).
- Establish baseline transects across the spill affected area and in control areas outside, and collect samples of sediments for analysis of total hydrocarbon content (THC) (see Methods section 8.7).

Figure 3. Example section from the Environmental Recovery Plan.

TOTAL INDONESIE CONTINGENCY PLANNING IN THE MAHAKAM DELTA

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ABSTRACT: TOTAL Indonesie has been active for 25 years in the Mahakam delta, an area with high ecological and socio-economic sensitivity. The last decade was characterised by an outstanding development of aquaculture activities closely overlapping the oil and gas operations, themselves expanding throughout the delta. To avoid potential conflicts arising from divergent interests and to ensure a harmonious coexistence between the different delta users, TOTAL Indonesie has developed a sound environmental management including a quick and effective Tier 1 spill response system based on a permanent brigade of skilled operators fitted with a large set of spill control equipment, and supported by risk assessment computerized tools allowing the optimisation in real time of the counter-measures to be applied. Additional resources can be made available at local, national and international levels thanks to the vertical integration of TOTAL Indonesie's spill response system into the vast national Oil Spill Response Network.

TOTAL Indonesie, a subsidiary of TOTAL, a French international oil company, is one of the production-sharing contractors of PERTAMINA, the Indonesian state-owned oil company. TOTAL Indonesie (T.I.) has been active in the Mahakam Delta area since 1974, both in exploration and production. With its dense mangrove cover, the delta is characterised by a high sensitivity in terms of ecology and socio-economy.

Since 1990, the extension of T.I.'s activities throughout the delta and the burst of aquaculture, especially in the coastal fringe (Figure 1), led T.I. to revise its antipollution strategy and to reinforce its contingency planning and its capability of response to achieve a high level of preparedness whatever the diversity of its operational environment (offshore, delta, onshore) or of the potential pollutants.

Background and evolving activities

The Mahakam delta is located on the eastern coast of Kalimantan (Indonesian part of Borneo Island). Its size is approximately 70 by 40 km. The delta is covered with coastal swampy forests which represent key areas for biodiversity conservation. These types of

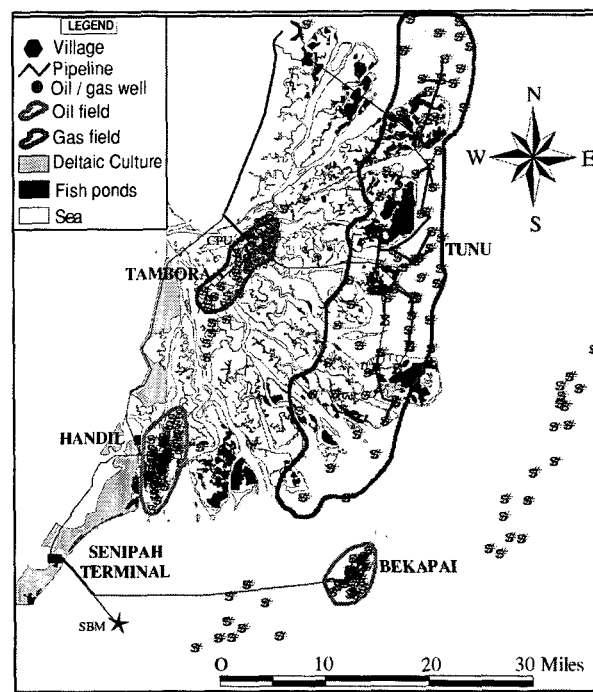


Figure 1. E&P and aquaculture coexisting in the Mahakam Delta (1996 status).

habitats constitute vital nurseries for a large number of marine fish species and shrimp larvae, but also play a significant role in providing a protective screen against fluvial or marine erosion. Owing to the progressive mixing of fresh water and salt water throughout

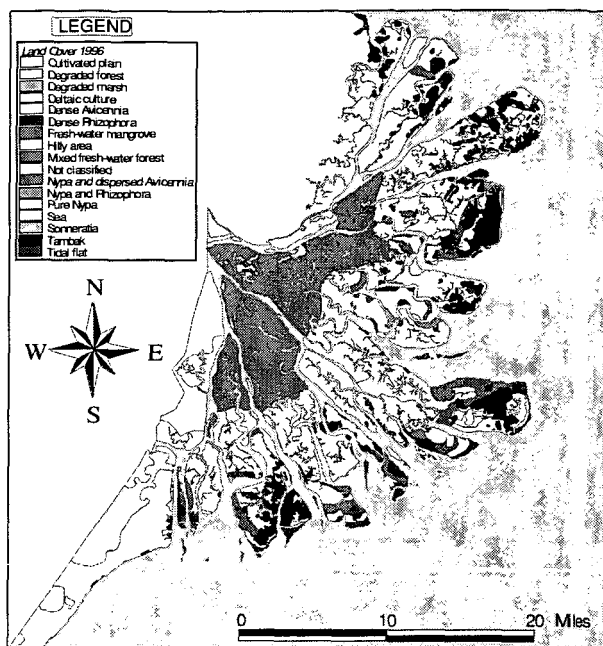


Figure 2. Mahakam Delta land cover.

whose influence on the ecosystem has been steadily increasing during this last decade, especially in the delta front where most of the fishermen villages are located.

The last 10 years have seen a real burst of aquaculture in the coastal fringe. In 1986, very few shrimp farms were to be found in the area. Today more than 150 km² of aquaculture ponds are being exploited (Figure 1), and many more ponds are under development, to the detriment of mangrove and especially the most sensitive part of this one (Alamsya Ch. *et al.*, 1996).

In the same time, T.I.'s activities spread from the southern tip of the delta, where the first oil facilities are located, to the central part (Tambora), and then almost to the whole delta with the ongoing development of the giant gas field of Tunu. In addition, several offshore fields are going to be developed in the next few years. However, the land occupancy and deforestation induced by T.I.'s activities are quite minor compared to those resulting from shrimp farm development (T.I. has used only 1.3 percent of the delta surface).

Environmental management

Thus, several activities are being carried out in the same area, creating potential environmental conflicts, especially where the oil industry is concerned. The sound management of all these factors requires two different types of tools:

- A geographical information system to allow better management of all the data available about the delta.
- A spill contingency system, including dedicated intervention team and equipment, for immediate response in case of accidental pollution.

TOTAL Indonesia has developed an analytical software called "GisOil Mahakam" (IARE, 1997) for better assessing and monitoring the environmental impacts of its operations in the sensitive zones of the Mahakam delta (Alamsya Ch. *et al.*, 1996). GisOil™ is an integrated software specially designed to facilitate the management of oil and gas fields, while "GisOil Mahakam" system contains an extremely large amount of data concerning the environment, the socio-economic situation and the activities in the delta. It represents the ideal supporting tool to manage the inter-

faces between the natural environment, the oil industry and the local fishing/aquaculture activities.

On the other hand, T.I., since the origin, has been deploying important efforts in oil spill preparedness. Considering the recent developments in its activities and the variety of situations in which they take place, T.I. has reworked its Oil Spill Contingency Plan (TEP/SEV and CEDRE, 1998) with the purpose, among others, of including the support of computerized tools such as GisOil Mahakam and OSIS™ (*Oil Spill Information System*, a drift modeling tool which is a registered trademark of BMT Marine Information System). This job has been performed with the assistance of CEDRE, a French public agency specialised in oil spill response.

TOTAL Indonesia Tier 1 spill response strategy

In terms of oil spill response, T.I. has to face the following challenges:

- Various contexts of operation: offshore, coastal/delta, on-shore
- Several types of possible pollutants with different behaviour and impact: waxy crude, light oil, emulsion, condensates
- Multiple potential sources of spillage scattered throughout the delta (wells, pipelines, processing units, rigs)
- A complex system of currents strongly influenced by the tidal pattern and the Mahakam River flow
- A sensitive natural environment in which effective clean-up is quite impossible to undertake
- A close overlapping of highly sensitive aquaculture activities with T.I.'s operations

From the above constraints, the only possible strategy is to implement an immediate response in order to ensure a quick control of the spill spreading and to minimise its adverse effects. So, T.I. decided to develop a high Tier 1 capability of response based upon an in-house dedicated brigade of skilled operators having at their disposal a large stockpile of antipollution equipment fitted to the specific characteristics of the delta and the potential pollutants. This supposes a great reactivity from the team and adequate logistic means accordingly. Moreover, in case of major spillage overwhelming T.I.'s brigade capability, or for consolidating the first-response counter-measures, T.I. can rely on additional resources to be mobilised at a local, national or/and international level.

Supporting tools

The Oil Spill Contingency Plan (OSCP) represents the basic framework for the spill response. It establishes the organisation to be set up to tackle the problem and provides the decision-making processes for a correct risk assessment of the situation and for the right action plan(s) to be implemented, whatever the type and location of the spill. It contains as well all the useful information about the means and their mobilisation, the methodology to be applied and several typical action plans to respond the most classical type of spillage likely to be experienced.

In matters of risk assessment and of spill response strategy, the OSCP is supported by two interactive softwares working in real time, GisOil Mahakam for identifying the sensitive resources at risk, and OSIS™ for spill trajectory modeling. Measurements made at different locations in the delta and in the Macassar Strait were entered into a database to allow the computation of current patterns on which are based the OSIS™ simulations of spill drift. Figure 3 displays an example of expected drift for an offshore spill in the Bekapai area. Similar simulations can be carried out for incidents occurring in Mahakam channels, but the tidal pattern with current

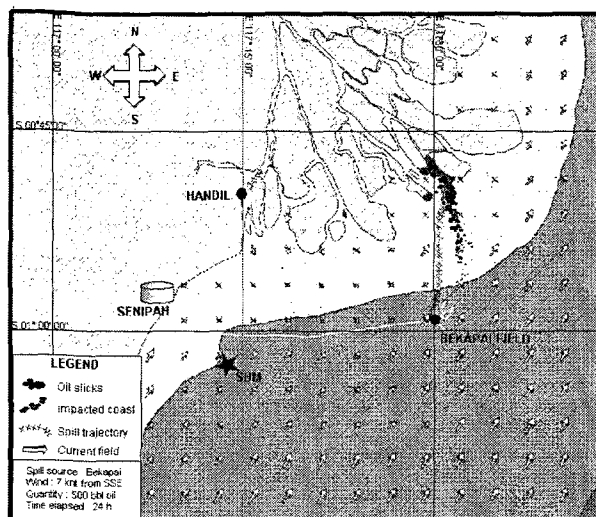


Figure 3. Drift modeling of an offshore spill (OSIS 2.2 software).

reversal four times a day and the presence of multiple secondary channels strongly increase the complexity of the problem. Nevertheless, these simulations can be available within a few minutes and provide, with a fairly acceptable accuracy, the foreseeable trajectory of the slicks, enabling T.I. to determine the areas under the direct threat of the spill.

At the same time, the sensitivity of the endangered sectors can be evaluated through GisOil Mahakam. According to ecological criteria, the sensitivity of the natural environment is rated from 1 to 9. For operational reasons, this accurate index is merged into three categories: low, medium and high sensitivity. In addition, human settlements and their dependencies, which are considered to be potentially the highest sensitive item, are given the sensitivity value of 10. The general sensitivity map of the delta is presented in Figure 4. But local sensitivity assessments can be carried out on a finer

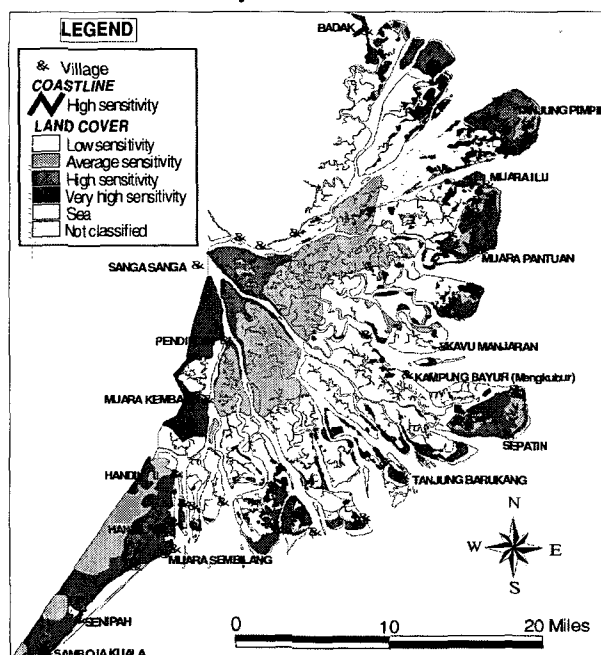


Figure 4. Sensitivity map of the delta.

scale and provide details such as the type of fishing performed or the gears employed as well as the average productivity or income.

The combination of both softwares quickly provides an accurate assessment of the potential consequences of any spill incident and allows to optimise the action plan to remediate the problem. Of course, these softwares have both been used in a preventive way during the Oil Spill Contingency Plan revamping. Stochastic simulations have been performed on the basis of the most credible types of incident likely to occur on each facility.

First response brigade and equipment

The antipollution brigade is constituted of permanent personnel mobilisable at any time for immediate intervention. The brigade *sensu stricto* includes 11 persons, with at least 5 skilled operators and 2 supervisors on duty. Moreover, the antipollution vessel crews can provide 10 helpers. On the whole, 17 people are on duty, but up to 25 persons can be mobilised. Additional helpers and supervisors can also be made available from other departments when necessary.

The oil production and loading activities represent the main spill risk and are located in the southern part of the delta, so the antipollution base has been settled in Handil (Figure 1). The brigade members have at their disposal three antipollution vessels, one for offshore which is permanently based in the Bekapai area, the second for shallow water intervention, moored at Handil. The third one is a barge which can be used in both situations for equipment transportation and/or for oily waste recovery and storage. Moreover, they can rely on a large fleet of extra boats (from supply to speed boat) easily mobilizable by the Logistics Department from the Handil area.

The specific antipollution equipment is mainly stored in the Handil warehouse but some pieces are distributed on board the antipollution vessels or at other production sites. The Indonesian regulations do not allow the use of dispersant as primary spill response, even in offshore incidents. So, the first response is essentially based on mechanical containment and recovery. TOTAL Indonesia is equipped with a large set of offshore, coastal and river booms and dynamic or static skimming units. Dispersant gears are however, available, as well for offshore treatment of non-recoverable slicks. Equipment and personnel are assembled in different pollution fighting modules, the nature and number of which are defined according to the characteristics of the incident. It can be reasonably stated that T.I. is able to successfully face a spillage up to 1,000 barrels with its own resources.

The brigade is self reliant and ensures the maintenance of the equipment. Training is maintained as well through frequent drills or full scale exercises, either in an internal way or in joint programs with other regional operators. T.I.'s first generation equipment has been recently renewed. In order to homogenise the pool of equipment and to allow their compatibility, suitable standards have been adopted by the different regional operators (Suwasono and Putri, 1997).

Regional integration

To ensure additional resources to the operating companies in case of major spillage, the national authorities have set up a federating process between the companies' own resources. T.I. has entered mutual assistance agreements with the other local operators (Unocal, Vico...) and is a key partner in the East Kalimantan Oil Spill Contingency Plan established by the national company, PERTAMINA. In addition, T.I. may have access to international backup resources, either through PERTAMINA (e.g., EARL, Singa-

pore), or through TOTAL Group direct membership in OSRL (Southampton).

Conclusion

All the interfaces between the different in-house or external resources presented above are managed through T.I.'s Oil Spill Contingency Plan. With such a vertically structured plan, T.I. can deploy a very significant spill response backed by modern tools and, in addition, can rely on the assistance of local, national and international extra resources. As part of T.I.'s strong commitment to a sound environmental management, the spill response system contributes to support a harmonious coexistence between the E & P operations and the traditional or developing activities such as fishing and aquaculture.

Biography

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REGULATORY DIFFERENCES: FREIGHT SHIP AND TANK SHIP POLLUTION RESPONSE PREPAREDNESS¹

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ABSTRACT: *There is an ancient maritime adage that says "a collision at sea can ruin your whole day." While that is undoubtedly as true today as it ever was, the modern mariner would likely express a similar opinion about oil spills. This paper is about how the shipowner's degree of preparedness affects the quality of his response once his day has been ruined by an oil spill—or a potential spill.*

The authors will compare two responses to potential major oil spills associated with vessel groundings. These occurred in the same geographic area, approximately 1 year apart, and involved many of the same government and industry responders. The primary difference between the two cases is vessel type: one vessel was a freight ship, which posed a significant pollution threat due to the quantity and location of its fuel, while the other was a laden tank vessel. Because the spill response planning requirements of the Oil Pollution Act of 1990 differ for freight ships and tank vessels, the quality of the owners' environmental response preparedness varied dramatically. The fact that these two cases occurred in the same geographic area is significant only because it tends to highlight the differences in response planning as a function of vessel type, while at the same time limiting the effect of other potential response variables. The focus of the paper is not bound by the geography of the case examples. The authors contend that the same preplanning requirements in effect nationally for tank vessels are also needed for freight ships which pose a substantial threat to the environment, and advocate national and/or international regulatory changes to close the preparedness gap.

Background

Before examining the case studies, some background is in order. Under the Oil Pollution Act of 1990 (OPA 90), tanker operators are required to preplan and have response capability secured by contract. OPA 90 also requires that there be a Qualified Individual (QI), who is authorized to make decisions and financial commitments related to the response. The QI must be on scene within a stated minimum period of time. All procedures and resources used to respond to a spill are spelled out in the required Vessel Response Plan (VRP)².

In contrast, freighter operators are not required to preplan for environmental contingencies to anywhere near the extent required of tank vessels. Unlike the vessel response plan required for tankships, the only document which addresses spill response procedures is the Shipboard Oil Pollution Emergency Plan (SOPEP) required by international regulation for all vessels above certain

tonnages³. Although the plan contains procedures for ship personnel to follow so as to mitigate the effects of a spill, the SOPEP serves primarily as a notification check off list. It contains points of contact for spill response resources, but there is no requirement for contracts to be in place. Nor is there a requirement for a QI.

Without question, tank vessels carry the greatest volume of oil, and in a worst case discharge, they pose the greatest potential for environmental harm. Yet, large freight vessels also carry a significant quantity of fuel oil (the number of freighters operating in U.S. waters exceeds the number of tankers fourfold⁴). And, unlike tank vessels, which are required to be fitted with double hulls according to a time table established by law, freight ships will continue to carry fuel in double bottoms beneath their cargo holds, often the most vulnerable area of the ship in the event of a grounding. Consequently, a major oil spill from a freighter may be as likely as a tanker spill and, perhaps even more so, due to fuel tank location.

Spill response organization and preparedness

Oil spills, and potential oil spills, pose a host of environmental and legal concerns to the shipowner. In the case of ship related casualties, such as groundings, these environmental concerns must be managed in connection with the very obvious problem of ensuring the safety of the passengers and crew, and, if possible, salvaging the ship and its cargo. The range of issues can easily become overwhelming. If the ship operator does not adopt an aggressive environmental response posture with the ability to address the broad range of issues, in addition to all of his other concerns, the Federal On-Scene Coordinator (FOSC) will! And while the FOSC will not hesitate to act if the Responsible Party (RP) is unprepared to do so immediately, there is a catch: the actions taken by the FOSC will ultimately be charged to the RP, most likely costing the RP more than if he had acted directly. The ability to mobilize resources immediately therefore is critical to the RP's ability to control events and costs. Moreover, the RP's ability to work with the FOSC and other involved agencies will greatly influence the nature of the response.

The FOSC for coastal areas will always be a Coast Guard officer, typically the Captain of the Port. The FOSC is a "coordinator" because many federal, state, and local organizations have jurisdiction in pollution (and potential pollution) cases. Each is entrusted with public responsibility for natural, economic, and cultural resources. When an oil spill occurs, or threatens, they all have a voice, and a legal right to participate in the response. The FOSC coordinates these potentially competing interests to ensure that the

response is conducted as efficiently as possible with all legitimate concerns addressed. To help manage the inevitable plethora of issues, the FOSC will typically establish a Unified Command Structure (UCS), which brings all stakeholders, including the ship operator, into a single response organization⁵. UCS is an adaptation of the Incident Command System (ICS) which allows for multiple incident commanders. In addition to the FOSC, there will invariably be a State On-Scene Coordinator. Typically, there will also be an OSC representing the RP.

ICS/UCS has come into widespread use throughout the nation, by government agencies at all levels and within industry. It has become the common language of emergency responders. In fact, many large ship management companies, particularly those responsible for tank ship operations, have spill management teams organized along ICS/UCS lines to comply with the vessel response plan regulations. Without question, the shipowner's familiarity with UCS, and his ability to organize his response using such a structure, will greatly influence his ability to successfully manage all of his responsibilities. The complexity of spill response is such that an unorganized effort will fail.

The key point here is that the shipowner who is not prepared in advance is at a disadvantage. In Marine Safety Office San Juan's experience with several groundings of large vessels, each of them representing potential major oil spills, the tank vessel owners were, by virtue of the requirements of the OPA 90, far better prepared to respond to the emergency. In contrast, the freight ship operators were not well acquainted with their responsibilities under the law. While they feverishly attempted to cope with all of the environmental issues confronting them, it was clear they were not well equipped organizationally to do so. Not only were freight ship operators less aware of their responsibilities under the law than tanker operators, they experienced greater difficulty in mounting an effective response to the environmental threat. The following two cases will serve to illustrate these issues⁶.

Fortuna Reefer case

The 326-foot long freight ship *Fortuna Reefer* ran aground just southeast of Mona Island, about 300 yards offshore sometime in the early morning hours of 24 July 1997 (Figure 1). The vessel was not carrying cargo at the time of the grounding but it had approximately 90,000 gallons of intermediate fuel oil 180 (IFO-180) stored in the double-bottom tanks. No oil was spilled as a result of the grounding, the vessel was lucky enough (or unlucky enough) to go aground in soft coral. The environmental damage to that coral community as a result of the grounding, was significant. The threat of an oil spill was high due to the dynamic wave action in that area (right at the surf line). The island is a natural reserve owned by the Commonwealth of Puerto Rico and has numerous endangered, threatened, and rare species. The owner of the vessel paid a brief visit to the Coast Guard Marine Safety Office and then went to the vessel where he remained during the entire response. He appointed a local surveyor to represent him at the Incident Command Post meetings but that representative had no authority to commit resources, was not trained in the Incident Command System, and had no responsibility for the protection of environmental resources. He served only to keep the RP informed. The FOSC, concerned about the potential impact to the critical habitats in Mona Island, asked the RP to institute certain protective measures prior to lightering the vessel and prior to an extraction attempt. The owner's Protection and Indemnity (P&I) Club⁷, however, was reluctant to fund all of the resources deemed necessary on scene in the event of a spill. Thus, the FOSC and State OSC



Figure 1. *Fortuna Reefer*—View from the bridge, looking forward, with Mona Island in the background. A Coast Guard helicopter is overhead.

proceeded with the pre-placement of dispersant assets using federal funds. By choosing not to participate in the Unified Command Structure, the RP abdicated his authority to choose the most economical yet effective response posture. His absence was also detrimental to public perception of the response. A day after the extraction of the *Fortuna Reefer* from the coral reef, the Commonwealth had the ship arrested for damage to the reef. It was released several weeks later after payment of an agreed upon fee for restitution.

Kapitan E. Egorov case

The 679-foot long *Kapitan E. Egorov* was a Russian tank ship that ran aground on its approach to Guayanilla Harbor, Puerto Rico on June 21, 1998 (Figure 2). The double-bottom vessel was carrying 12.5 million gallons of No. 6 fuel oil as cargo. No discharge of oil occurred as a result of the grounding. Within 4 hours of the initial report the vessel representative was in contact with the FOSC and agreed to fund all costs for appropriate protection of the environment and for transportation to and from the vessel. A salvage master and QI arrived at the Incident Command Post (ICP) within 24 hours of the initial report. The QI assumed responsibility for all decisions made within the Unified Command Structure on behalf of the vessel owners. All costs for protective equipment were borne by the RP. A commercial helicopter was hired and overflights were scheduled on a regular basis to transport personnel and conduct environmental assessments. The QI, having knowledge of the vessel owner's responsibilities and the FOSC authority under the law, was responsive to trustee and state concerns. Having the QI physically participate within the ICP was extremely beneficial. Most logistical arrangements were made by

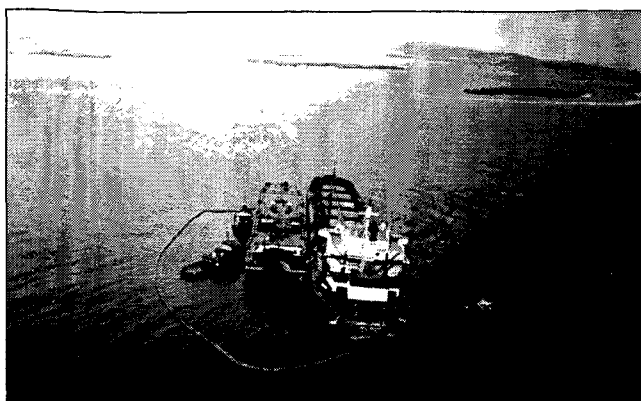


Figure 2. *Kapitan E. Egorov*—Aground near Guayanilla Puerto Rico, in the process of being off-loaded to a barge.

the QI and staff, thus freeing the Coast Guard ICS staff to arrange for the logistical needs of on scene monitoring personnel. The Joint Information Center (JIC) also benefited by clearing all press releases through the Unified Command as intended, effectively and truthfully representing the RP as prepared and concerned about the potential for environmental damage. Positive public perception was later affirmed by the Commonwealth's approach to collecting restoration fees.

Conclusions:

Several conclusions are obvious from the above case comparisons (Table 1):

- The RP is the greatest variable in an Incident Command System/Unified Command Structured response. Lack of familiarity with ICS is a handicap to an effective, well-coordinated response. It may even result in greater costs for the RP.
- Public perception of the RP's concern for the environment can suffer if the RP is not fully engaged and visibly reassuring the public, as only the RP can, that they are taking actions to make things right.
- Preplanning is enormously beneficial to the vessel owner who is faced with an actual or potential spill.
- The OPA 90 recognizes the need for preplanning for tankers, but is silent regarding the need for freighters. However, freighters pose a threat of significant pollution due to their fuel bunkers.
- Owners/operators of freight ships are liable for pollution from their vessels but they typically have little familiarity with their legal responsibilities. This is attributable to no specific preplanning requirements under OPA 90. As a result, there is a tendency to focus on salvage of the ship and its cargo, and only tangentially upon environmental issues.
- Owners who are unprepared to participate in the Incident Command System are at a distinct disadvantage. Decisions will be made by federal and state responders, if necessary without the RP's input. However, the RP will still be liable for expenses.

Recommendations

The disparity described above will not likely be resolved without statutory and/or regulatory changes. Although the FOSEC will always act if the RP fails to do so, or fails to do so expediently, the

Table 1. Direct comparisons between the two cases.

<i>Fortuna Reefer</i>	<i>Kapitan E. Egorov</i>
Vessel response plan not required	Vessel response plan required
No Qualified Individual—Unified Command representative had no decision-making authority	Responsible Party had Qualified Individual in Incident Command Post with full decision-making authority
Salvor unfamiliar with Incident Command System; Actions on scene were not coordinated with Unified Command	Salvor understood Incident Command System and participated fully; on scene actions fully coordinated with Unified Command.
Administrative Order had to be issued to force communication between the Responsible Party and the Unified Command regarding intended actions on scene	Administrative Order not necessary
Responsible Party inadequately represented in Incident Command Post planning & decision making	Responsible Party well represented in Incident Command Post planning and decision making
Responsible Party uncertain of need to order necessary environmental response resources based upon reluctance of P&I Club to fund, resulting in direct Government contracting	Responsible Party handled all contracts; found economical sources quickly
Responsible Party had difficulty satisfying all natural resource trustee concerns	Trustee concerns handled expeditiously
Responsible Party surrendered public affairs initiative. Federal and state looked more responsive	Responsible party was active part of Joint Information Command
Ship arrested for damage to coral reef; several weeks before released	Responsible party required to post bond for damages to reef; released within 2 days
No oil spilled	No oil spilled

intent of the law is that the RP take responsibility. Ideally, the preparedness required of a freight ship operator would be a matter of law and regulation. Therefore, the authors recommend that:

1. The OPA 90 or the regulations promulgated thereunder, be amended so as to require owners/operators of freight vessels, which have the potential to cause major oil spills (100,000 gallons or more), to:
 - a. Prepare Vessel Response Plans (VRP), similar to those required for tank vessels
 - b. Have pre-negotiated contracts with spill response organizations
 - c. Have a designated QI and Spill Management Team
2. Pending regulatory changes, owners and operators of freight ships voluntarily develop their own VRPs, contract spill management teams, and establish pre-negotiated contracts with response organizations along the lines of those required for tank vessels. To assist, recommended standards for these measures could easily be published in a Navigation Vessel Inspection Circular (NVIC) by the Coast Guard and distributed to the industry.
3. The U.S. delegation to the International Maritime Organization (IMO) consider a proposal to amend the SOPEP requirements of the International Convention for the Prevention of Pollution from Ships (MARPOL) 1973 to enhance preplanning for an oil discharge or potential discharge. At a minimum, this should include a QI, on call 24 hours a day to respond to a vessel casualty, and a spill management

team trained to operate in the Incident Command System/Unified Command Structure (ICS/UCS) framework.

4. Freight ship operators be encouraged to participate in the Preparedness for Response Exercise Program (PREP), even if only as observers. This will enable them to become familiar with how the ICS/UCS is used in managing ship emergencies that threaten the environment.
5. The benefits of preplanning for environmental emergencies be publicized in trade journals and publications.

Biography

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¹ Opinions expressed in this paper are solely those of the authors.

² Title 33, Code of Federal Regulations, Part 155, Subpart D.

³ International Convention for the Prevention of Pollution from Ships, 1973 as amended, Annex I, Regulation 26.

⁴ 1997 Coast Guard Business Plan for Marine Safety, Security and Environmental Protection

⁵ National Interagency Incident Management System (NIIMS), Commandant Instruction, 16471.2

⁶ The two cases selected are representative of MSO San Juan's experience with six large vessel groundings in the previous two years. Each of the cases fit the response preparedness profiles presented in this paper.

⁷ A P&I Club is a marine insurance carrier who protects the ship operator against claims by third parties.

BEST ACHIEVABLE RESPONSE— INTEGRATION OF POLICY, SCIENCE, AND LAW

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ABSTRACT: *In today's era of regulation and legislation, good contingency planning requires an understanding of the role and responsibility of all involved in the prevention, response, and cleanup of an oil spill. Environmental crimes, environmental damages, and implementation of the ISM Code mandate a safety culture in policy and technological prevention and response for oil spills. Just as an appreciation of the shift in policy and law is necessary for good planning, so too is a more scientifically and technologically based response. "Best Achievable Response" involves a multi-disciplinary approach to spill cleanup. "Windows-of-Opportunity" is a highly useful planning tool to achieve the optimum response in the event of a spill.*

Introduction

In the United States, the *Exxon Valdez* oil spill significantly influenced the development of the Oil Pollution Act of 1990 (OPA 90). However, subsequent regulations have been influenced by the smaller spills: the *Berman* barge spill (1994) off San Juan, Puerto Rico, and the *North Cape* oil spill in Rhode Island in January 1997. These spills have raised public awareness about the safety of U.S. waters and shaped the legislation and regulations that establish liability of the responsible party, the spiller, response cleanup operations and environmental damage assessment (Burger, 1997; Ornitz, 1996).

Oil spills are no longer considered an unavoidable "accident" of environmental conditions or a function of a catastrophic events (Ornitz, 1997). The factors influencing these changes are not apparent. They are related to: (1) changes in public opinion, (2) liability being redefined in the courts (with guilty parties being fined and serving time), and (3) better integration of science, policy and training in oil spill response and decision making. With the implementation of the ISM Code internationally and in the United States, the safety culture has become a technological and political imperative for the maritime industry. In the last few years, federal and industry research and development programs have established the basic principals underlying the relationships between the fate, behavior and effects of spilled oil and the relationships of the weathering of oils to effectiveness of response technologies (Danenberger, 1997). In the past, the lack of a sci-

entific basis for selecting oil spill response technologies has promoted the use of "Best Achievable Response" (BAR). BAR involves a multi-disciplinary approach to spill cleanup. Concern for the high costs and environmental damage of inappropriate technologies, and for criminal fines and imprisonment, mandates that decision making in oil spill response be:

- Scientifically based
- Technically and environmentally the correct response
- Able to integrate in real time a wide array of data and information
- Reflective of a process of extensive preplanning and training at all levels

Best Achievable Response. When considering the BAR, these factors should serve as a guide:

The motivators:

- Adherence to laws and responsibilities
- Shift in the law of the seas - to right of innocent passage
- Insurance—duty to limit
- The consumer and the political system

Law—regulation of the seas:

- Port state/flag state control
- Classification society control
- Insurance (P&I) control

Regulation of oil spills—international conventions:

- Convention for the Prevention of Pollution of the Seas by Oil in 1954
- Convention for the Prevention of Pollution from Ships, 1973 (MARPOL 73/78)
- Convention of Oil Pollution Preparedness, Response, & Cooperation (OPRC 90)
- SOLAS (Safety of Life at Sea Convention)
- STCW (Standards of Training, Certification and Watch Keeping Convention)
- Intervention on the High Seas

U.S. regulations:

- Oil Pollution Act of 1990 (OPA 90)
- Natural Resource Damage Assessment (NRDA)
- Clean Water Act/other legislation
- Certificates of Financial Responsibility (COFRs)
- The courtroom—where the rubber meets the road
- Environmental crimes

- Civil liability
- Oil Spill Liability Trust Fund—R&D

Science and technology and oil spill contingency planning and response:

- Historical perspective
- Effectiveness of response methodologies and technologies
- Pollution prevention strategies
- “Reasonable” available response technologies
- Best technical and environmental response technologies
- The technology windows-of-opportunity concept

Understanding the legal motivators. A working knowledge of the United States and international laws regulating the oil shipping industry and contingency planning for oil spill response is a must. While many of the treaties and federal and state regulations are complex, their practical application is not as complicated. For purposes of preparedness and response, the roles and responsibilities of all team members are defined. An example is the International Safety Management Code (ISM Code), a chapter of the International Convention on the Safety of Life at Sea (SOLAS) which became effective in July 1998 both internationally and in the United States. In summary form, the ISM Code requires shipowners to set company-wide safety policies under a comprehensive safety management system, to make sure that all those involved in operation and maintenance of the ship are familiar with these plans and necessary shipboard response equipment, to establish procedures for responding to and reporting a spill, and to conduct internal safety management audits. Failure to understand the law, may subject not only mates but also CEOs of shipping companies to civil and criminal liability, damage suits, fines, and imprisonment. Courts in the United States, and internationally are taking oil spills seriously. Knowing the downside in advance will help to avoid the human caused oil spill and to

create the right attitude for the best response when a spill does occur (Ornitz and Champ, In Preparation).

The technology windows-of-opportunity concept

For over 30 years, researchers have focused on identifying the relationships of physical and chemical properties of oils as they weather and form emulsions following a spill (Daling *et al.*, 1990; 1997). In 1995, Nordvik and Champ were able to bring data and information together to identify the relationships between weathering and the windows of technology effectiveness. These performance effectiveness data have been correlated to a wide range of viscosities of different weathering stages of tanker transported oils into a dynamic oil weathering data base to identify and estimate time periods, called “technology windows-of-opportunity.” The concept was first published in late 1995 (Nordvik, 1995; and expanded by Champ *et al.*, 1997a; Nordvik *et al.*, 1995a,b,c; 1996) (see Figure 1). Subsequent researchers working with the concept have demonstrated additional technologies (Buist, 1998; Fiocco and Lessard, 1997; Strøm-Kristiansen *et al.*, 1997).

Planning and decision making in oil spill response requires an understanding of oil weathering processes and the subsequent changes in an oils characteristics and the effect of these changes on response technologies over time. These changes have an important influence on the usefulness and effectiveness of response methods and technologies. Four major categories of response (cleanup) technologies are available:

- Chemical treatment (dispersants, emulsion breakers)
- *In situ* burning

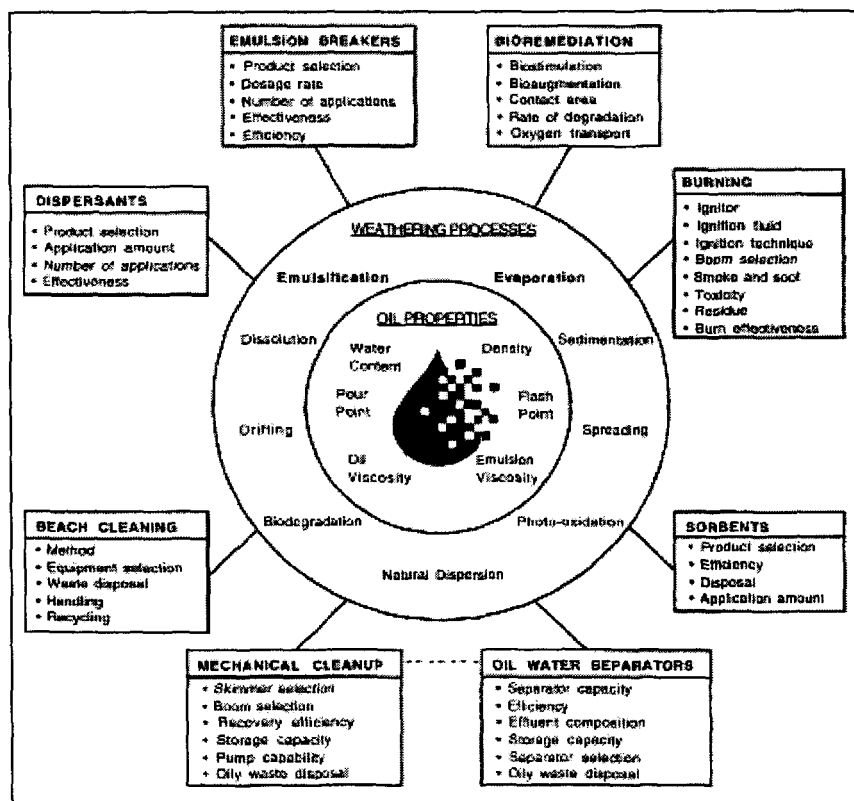


Figure 1. The effect of oil weathering processes on the effectiveness of selected technologies for oil spill response and cleanup. Source: Nordvik (1995).