Study of Gulf Coast Oil Spill Contingency Plans with Respect to Remediation and Restoration

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1.0 Introduction

The report describes the results of a research effort commissioned by the U.S. Corps of Engineers to study the current role of the oil spill contingency planning process in addressing two key elements of spill response: shoreline remediation and restoration. These two processes occur at or near the end of the spill response, and may continue for months or even years depending on the severity of the spill. Each is addressed as a separate issue although remediation efforts can clearly impact the success of future restoration efforts. The analysis focused on the role of contingency planning in optimizing the success of these two processes, and specifically how key shoreline remediation and restoration decisions were addressed including:

- When should specific remediation techniques (e.g. dispersants, bioremediation, shoreline in-situ burning, shoreline washing) be employed, and what are the anticipated positive and negative impacts on the environment?

- To what degree should they be implemented to minimize the threat of ongoing pollution without complicating restoration efforts (either natural or technology-assisted).

- When should efforts be made to rescue, rehabilitate and repopulate specific species, and when should actions be taken to restore a specific habitat or ecosystem.

- When is it more beneficial to not undertake an aggressive response action, but rather monitor the situation and let nature take its course (the " natural recovery" option).

In conducting the study, the research team collected and analyzed contingency plans and related documents at the federal, state and local level for the states bordering the Gulf of Mexico including Texas, Louisiana, Mississippi, Alabama and Florida. The team interviewed key federal, state and local spill response managers and resource trustees within these states to gather information on the current approachs and requirements for successfully implementing remediation and restoration efforts. A workshop was held to discuss agency, private organization, and industry issues and concerns with regard to shoreline remediation and restoration. A survey was conducted to determine the need for contingency planning protocols and guidelines and supporting technical information, and where in the contingency planning process they should be addressed (national, regional, state of local level). Scientific and technical information was gathered to determine the state of technology for remediation and restoration, and the effectiveness and environmental impact of current techniques.

Criteria were developed and an analysis conducted to determine how well the current contingency planning process addresses key functions including:

- assigning agency responsibilities

- defining the decision-making process for restoration and remediation

- specifying procedures and protocols for implementation and monitoring,

- providing the necessary scientific and engineering information to support the planning process.

Specific shortfalls in the process were identified and specific procedural and policy, and research and technology initiatives recommended to improve the effectiveness of contingency planning in ensuring the success of remediation and restoration efforts, and optimizing the results of one with respect to the other. In conclusion, specific research projects were proposed, and research priorities assigned based on the feedback from the study participants, and consensus international and national research priorities identified for this area.

The research grant for this project was awarded through the National Sea Grant Office and administered through the Florida Sea Grant Program at the University of Florida. The project was undertaken by a multi-university/laboratory research team that included investigators from the University of Miami and Nova Southeastern University in Florida, the Marine Environmental Resources Consortium at the Dauphin Island Sea Lab in Alabama, and McNeese State University in Louisiana. Project management and reporting was coordinated by the University of Miami, College of Engineering with assistance from the Nova University Oceanographic Center.

2.0 Overview of Oil Spill Contingency Planning, Shoreline Remediation and Restoration

2.1 - The Contingency Planning Hierarchy

The research effort focuses on the role of contingency planning in addressing two key elements of the spill response process: shoreline remediation and restoration. Before describing the specific methodology and results of the effort, it is useful to quickly review the contingency planning doctrine established in the United States, and the nature of shoreline remediation and restoration as spill response functions. This will provide background information and insight in understanding the analysis, results and recommendations described throughout this report.

Contingency planning is the process by which government agencies and the potential responsible parties determine how a response effort will be initiated, organized, managed and terminated in the event of a spill. Contingency planning in the U.S. has evolved over the past three decades since the Santa Barbara Channel spill in 1969, and has been continuously refined as its role in ensuring a timely and effective response has become more apparent. Most recently the national contingency planning doctrine has been restructured and expanded following the EXXON VALDEZ spill by the Oil Pollution Act of 1990 (U.S. Congress, 1990).

The Oil Pollution Act of 1990 (or OPA 90) mandates the development of a three-tiered contingency planning structure within the Federal government. At the national level, the National Contingency Plan (EPA, 1994), which is contained in 40 CFR Part 300, Annex E, specifies the overall national strategy for dealing with oil spills. The National Contingency Plan (or NCP) defines the responsibilities and functions within the Federal response community, outlines the desired sequence of events for a response effort, and sets forth various review and approval processes that may be required in the course of the response effort. It further specifies how the Federal contingency planning strategy will be implemented at the regional and local level, and how the Federal agencies will interface with state and local agencies in planning for and executing a successful response effort. The hierarchy and interfacing of various plans are depicted in Figure 2.1.

At the regional level, contingency planning doctrine and procedures are set forth in the Regional Contingency Plans (RCPs) as specified in the NCP. The regions referred to here are the standard Federal regions within the continental United States. Prior to OPA 90, the Regional Contingency Plans constituted the actual implementation plan for Federal activities during a spill response. Since OPA 90, which mandated a more local implementation mechanism in the Area Contingency Plans (ACPs), the RCPs have become more of a linkage mechanism between the NCP and the ACPs. They specify agency responsibilities at the Federal region and state level through designation of the Regional Response Team (RRT), determine lines of demarcation for the Area Contingency Plans, and provide a review process for the ACPs to ensure consistency at the regional and state level. The RRT provides guidance on the use of specific countermeasures within the region, and specifies pre-approval criteria. However, the implementation planning, in terms of specific responsibilities and actions taken by Federal, state, and local agencies during a spill, is now left to the Area Committees which formulate the ACPs.

The Area Contingency Plans are a unique product of OPA 90, and recognize that a clearer strategy and improved tactical coordination is required at the local level, particularly in dealing with major and even catastrophic spills (Spills of National Significance). The ACPs tailor the implementation strategy and tactics to the anticipated spill scenarios, environmental resources at risk, available response assets, and the expectations and policies of agency officials within the designated response area. Within the coastal zone, these ACP areas correspond to the responsibility zones of the Coast Guard Captain of the Port.

It is at the ACP level that the NCP requires that the implementation of countermeasures and cleanup activities be fully addressed. These activities include shoreline remediation and restoration which generally occur after the notification, preliminary assessment and initial response phases of the spill. Accordingly, much of the analysis and many of the recommendations in this study focus on the Area Contingency Plans as the appropriate level where shoreline remediation and restoration activities can be best specified based on the shoreline environment, the response resources available, and the constraints posed by state and local regulations, policy and public expectations.

In addition to the Federal contingency planning process (NCP, RCP and ACP), spill response contingency plans are generally developed by the state governments and local communities as well. There are no set criteria for state and local plans. They vary in format and content at the discretion of individual states, counties and municipalities. Local spill response plans are generally focused on hazardous substances spill in accordance with SARA Title III. To ensure that Federal oil spill response plans are consistent with state and local plans, the NCP specifies that the Federal On-Scene Coordinator will consult with State Emergency Response Committees (SERC) and Local Emergency Response Committees (LERC) to ensure that the ACP provides for a well-coordinated response that is integrated and compatible to the greatest extent possible with all appropriate response plans of state, local, and non-Federal entities.

2.2 - Remediation and Restoration in Oil Spill Response

When an oil spill occurs, the immediate actions of responders are focused on mobilizing resources, containing the oil at the source of the spill, and recovering as much oil as possible in open water before it can impact the shoreline. Because these actions must occur quickly to be effective, much of the contingency planning process is devoted t this initial response. A number of techniques have been developed for the collection and removal of oil at sea including mechanical removal (booming and skimming), the use of dispersants, and in-situ burning. In most spills these countermeasures result in removing only a small percentage of the oil from the water. In many cases a significant portion of the remaining oil ends up on the shoreline which requires mounting an often long and labor-intensive cleanup process.

The removal of oil on the shoreline and repairing the environmental damage can be viewed as two separate processes. The first process, shoreline remediation, is addressed in some detail in the contingency planning process and usually takes place within a few days to several weeks following the spill . The process includes the removal and treatment of surface oil, and the collection and removal of readily accessible oiled material and debris, to a point where further shoreline contamination is prevented, and a point of diminishing return is reached. This process is depicted in Figure 2.2. It begins with a formal survey of the impacted shoreline by Shoreline Cleanup Assessment Teams (SCAT) to map the extent of contamination and develop a cleanup strategy based on oil properties and toxicity, shoreline morphology, shoreline environmental sensitivity, and available cleanup techniques and resources. Techniques employed to remove oil from shorelines can include:

- surface washing with hot or cold water,
- washing with chemical cleaning agents,
- the excavation and removal of oiled material (sand and gravel) and debris,
- the cutting and removal or burning of oiled vegetation,
- and treatment of oiled surfaces with agents to promote biological degradation of the oil (bioremediation).

As shoreline remediation techniques are used, the results are monitored and the results are assessed. At some point the benefits of removing additional oil are outweighed by the environmental impact of the cleanup operation itself, and the associated costs. At this point a decision must be made as to whether further cleanup is worthwhile (the "how clean is clean" decision) and the cleanup extended or terminated. This decision often involves political, as well as environmental and economic considerations. The scientific, technical and political issues involved in this determination are described in detail by Baker (1997).

After the shoreline cleanup operation is formally concluded, further efforts are sometimes undertaken to stabilize the impacted shoreline, and speed recovery of the shoreline ecosystems. This process, depicted in Figure 2.3, may continue for months or even years following the spill. Restoration activities are undertaken by the Natural Resource Trustees following a formal Natural Resource Damage Assessment. Restoration activities undertaken may include habitat replacement (e.g. replacing beach material removed during cleanup), species repopulating, and restrictions to human use to allow recovery. In some cases restoration activities may be undertaken as part of the cleanup phase before a formal Natural Resources Damage Assessment has been completed. These activities occur in conjunction with or immediately after the cleanup is completed, and can be described as "emergency restoration".

Contingency planners must also recognize that although shoreline remediation and restoration can be described as two separate phases of a response effort, they are directly linked in actual practice. Shoreline cleanup activities can either preclude or necessitate the need for restoration. For instance the removal of oiled beach material to prevent further contamination may require sand replacement and replanting of vegetation to prevent beach erosion. Leaving the oil in place and treating it with bioremediation agents may preclude immediate human use of the beach or harvesting of nearshore marine resources (e.g. shellfish). Understanding the linkage between remediation and restoration, and ensuring that this linkage is addressed during a spill response, requires coordination between initial responders and resource trustees during the contingency planning process.

2.3 References

Baker, J.M., 1997, Differences in Risk Perception: How Clean Is Clean?, American Petroleum Institute, Publication No. 4652C, Washington, DC.

EPA, 1994, National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Part 300, U.S. Environmental Protection Agency, Washington, DC.

U.S. Congress, 1990, Oil Pollution Act of 1990, Public Law 101-380.

Figure 2.1 Oil Spill Contingency Planning Hierarchy in the U.S.

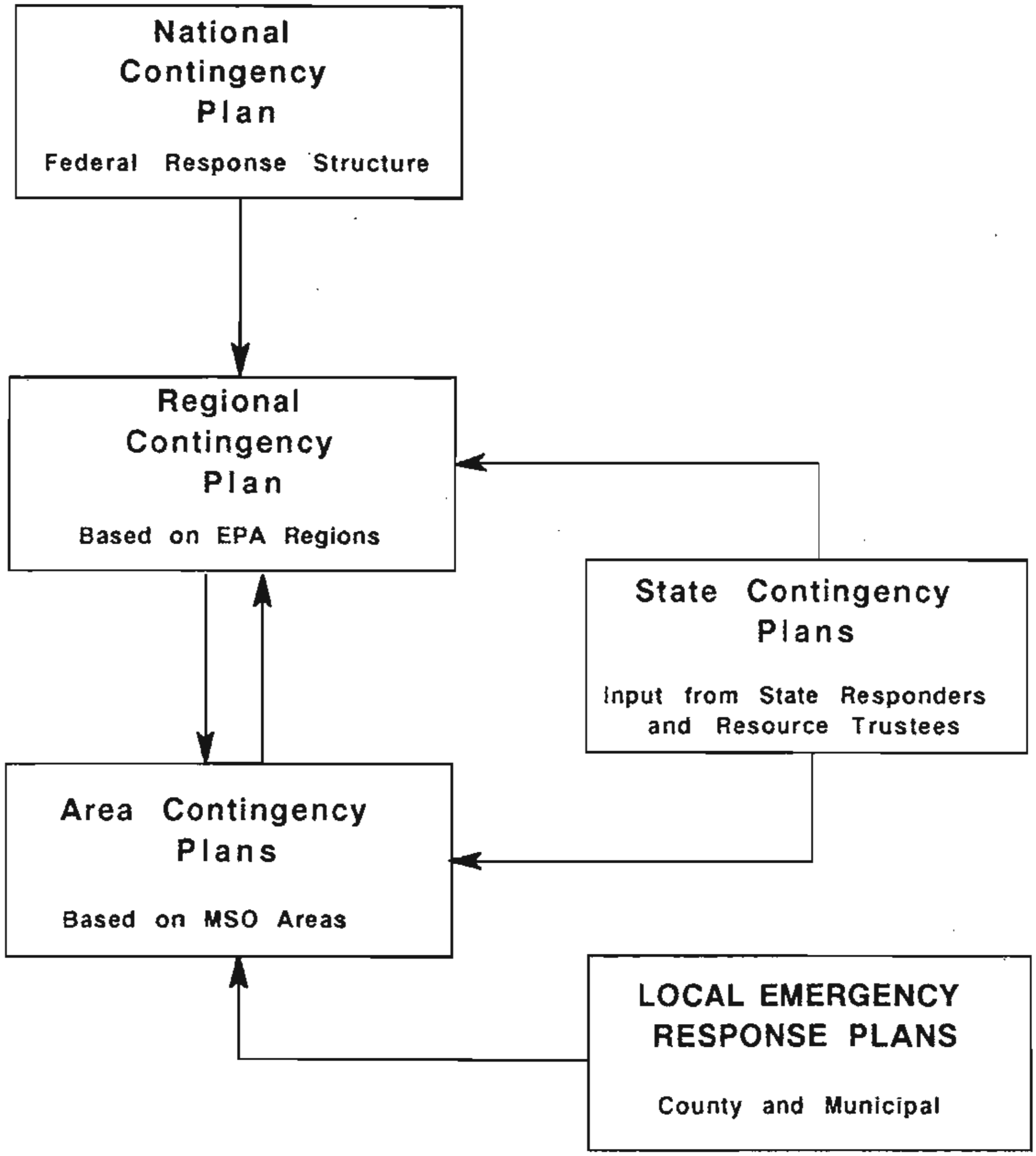
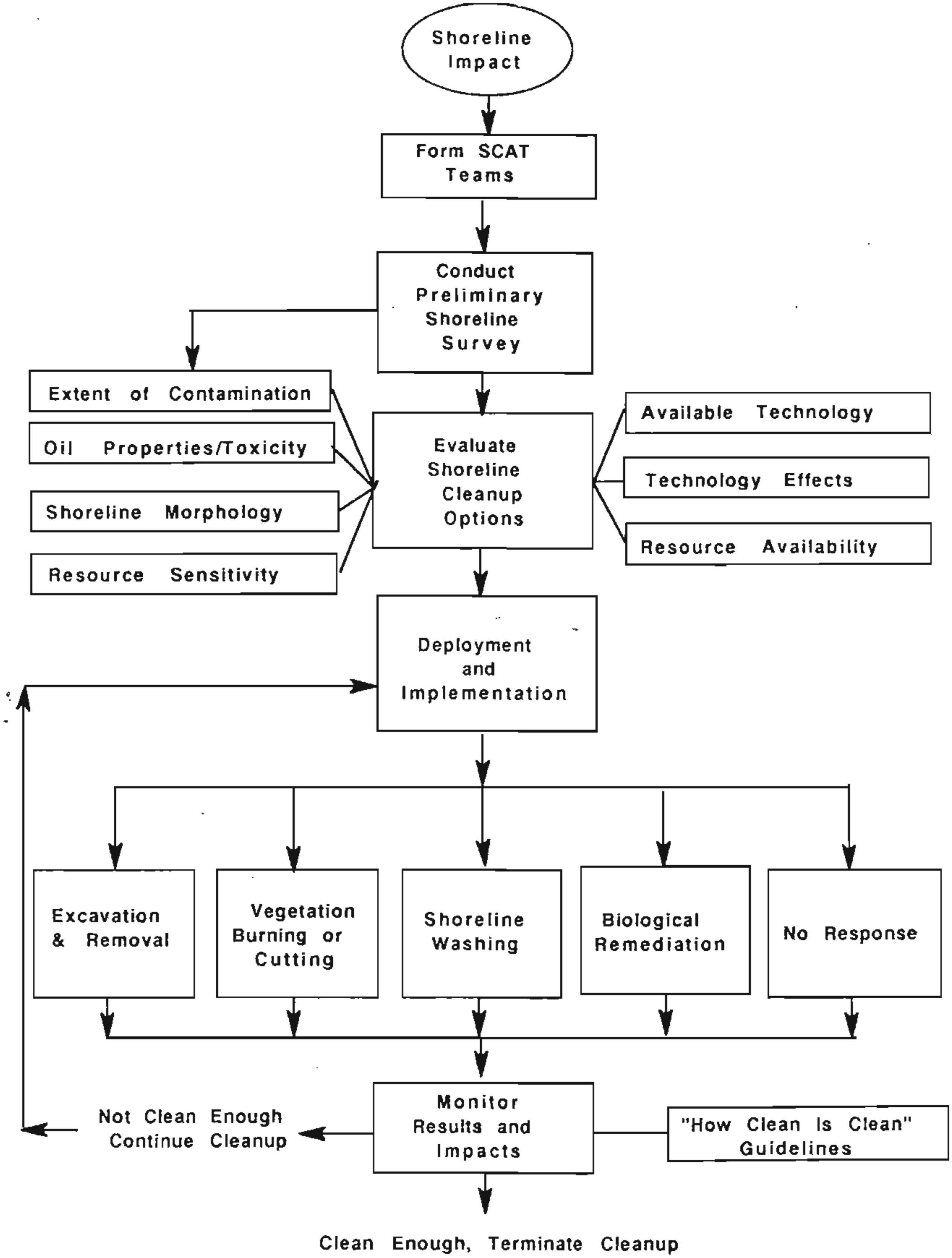
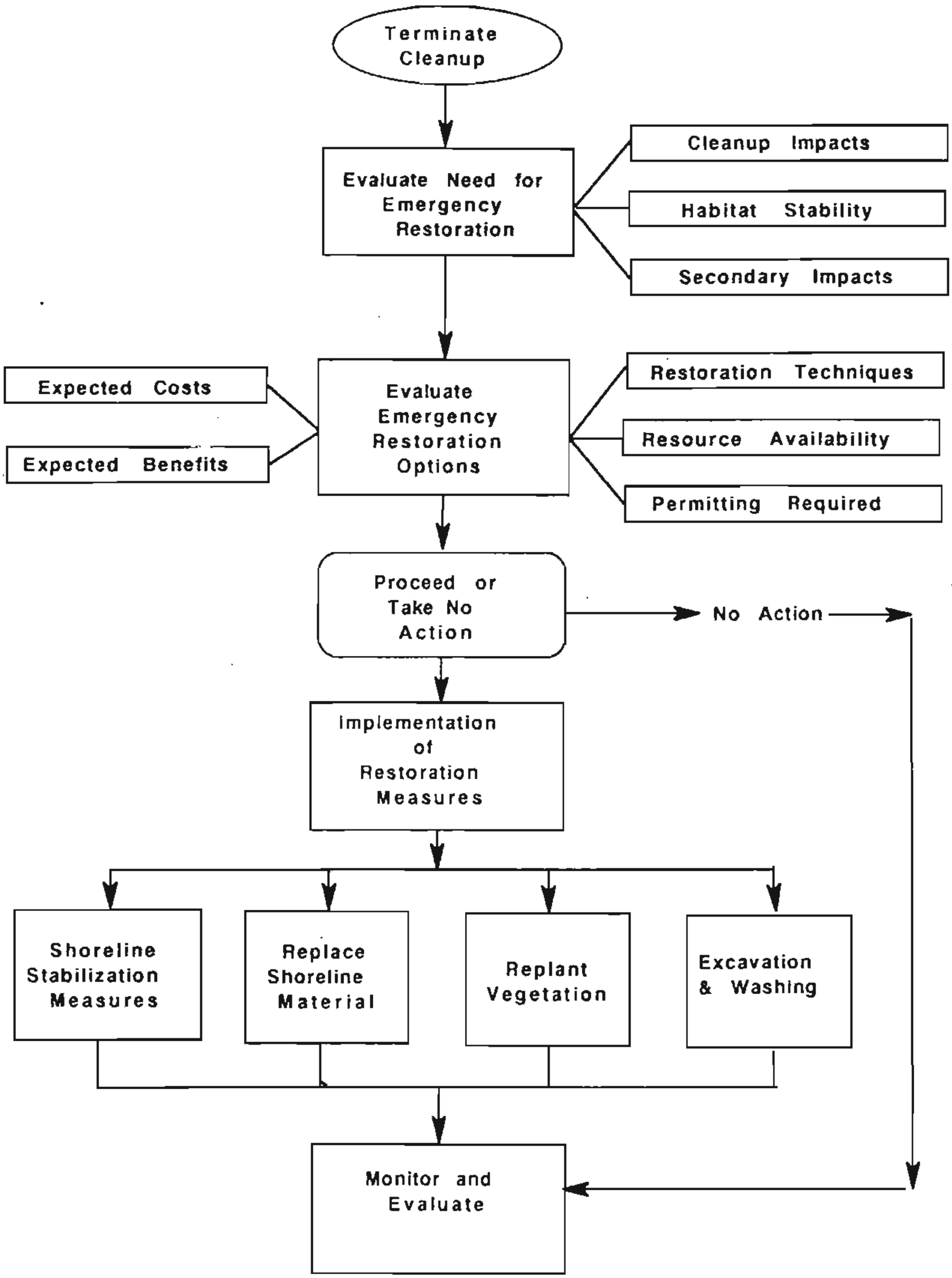


Figure 2.2 Decision Process and Information Needs for Shoreline Cleanup and Remediation



2.3 Decision Process and Information Needs for Emergency Restoration



3.0 Requirements for Shoreline Remediation and Restoration in the Contingency Planning Process

3.1 Requirements Specified by Federal Regulations and Directives

In determining how well remediation and restoration are addressed in the contingency planning process for the Gulf of Mexico, it is first necessary to establish criteria as to what aspects of shoreline remediation and restoration should be addressed within the context of contingency planning, at what level of detail, and in what format. The most obvious source of guidance in establishing these criteria is the Federal regulations and agency directives on contingency planning, which were significantly revised in accordance with OPA 90. These published criteria, when found to be somewhat cursory in nature, were expanded based on insight solicited from spill responders in the Gulf coastal region during interviews, a workshop, and during a survey of contingency planning needs and priorities.

Some guidance on addressing shoreline remediation issues is contained in the National Contingency Plan when outlining the general requirements for Area Contingency Plans. There is no requirement for addressing shoreline remediation issues in the Regional Contingency Plans. Guidance is contained in Section 4.1.4 of the National Contingency Plan, which requires the preparation of a Fish and Wildlife and Sensitive Environments Plan Annex for each ACP. To facilitate an effective shoreline remediation effort, the NCP specifies that this Annex will contain the following information:

- Identify and establish priorities for the protection of sensitive shoreline environments including fish, wildlife and important habitats that may be threatened by a discharge.

- Identify the potential environmental effects of various countermeasures on shorelines, including the "no removal" option. Establish a mechanism for expeditious evaluation and appropriate consultation on these potential environmental effects.

- Provide for the pre-approval of specific countermeasures and removal actions which, if expeditiously applied, will minimize adverse spill-induced impacts to fish and wildlife resources, habitats and sensitive environments.

- Provide monitoring plans to evaluate the effectiveness of countermeasures and removal actions. Set forth procedures for establishing set aside areas, where no mitigating actions are undertaken, by which to judge the impact of countermeasures and removal actions on the environment.

- Identify and plan for the acquisition and utilization of resources to protect, rescue and rehabilitate fish and wildlife and their habitats.

- Delineate procedures for the capture, transport, rehabilitation and release of wildlife threatened by oil. Determine and document the necessary federal and state permitting requirements for these activities.

Shoreline remediation requirements are also addressed in Section 5.3.3 of the NCP which discusses general considerations in managing containment, countermeasures and cleanup operations. It specifies that of the numerous physical and chemical methods that may be used, the chosen methods shall be most consistent with the protecting the public health and welfare and the environment. This implies that the necessary decision protocols and technical data be available for making these choices.

As for shoreline restoration activities, these are considered outside the purview of spill response contingency planning and are not addressed in the National Contingency Plan. In addition, there is no requirement or guidance in the NCP for addressing shoreline restoration in the Regional or Area Contingency Plans.

To provide more detailed guidance in the preparation of Area Contingency Plans, the U.S. Coast Guard has issued Commandant Notice 16471 (USCG, 1992) which goes into more detail on content and format of the ACPs. The original version of this instruction, issued in September of 1992, addressed only oil spills, and provides the requirements for the Area Contingency Plans that were reviewed in the course of this study. As with the NCP, it addressed shoreline remediation activities but not shoreline restoration.

Commandant Notice 16471 does not require a separate section entitled the Fish and Wildlife and Sensitive Environments Annex in the ACP, but deals with shoreline remediation and wildlife and habitat protection by specifying requirements for Annex E - Area Assessments, Annex G - Chemical Countermeasures and Annex J - Operations. In Annex E of the ACP, the Area Committees are expected to carefully assess the risk and anticipated consequences of most probable, maximum most probable, and worst case discharges within the areas, and develop specific strategies for dealing with these spills. These strategies should include shoreline cleanup. In addition, in Appendix V of Annex E, sensitive areas are to be identified and mapped out, and response strategies for containing, removing and mitigating the impacts of oil in each sensitive area outlined in as much detail as possible. Commandant Notice 16471 states that the Sensitive Areas Appendix "is probably the most important and critical appendix in your plan".

Annex G - Chemical Countermeasures should describe the Area Committees decisions and pre-authorization plans for using dispersants, surface washing agents, surface collecting agents, bioremediation agents, or other miscellaneous oil control agents listed in the NCP Product Schedule. The Annex also addresses the use of burning agents. Shoreline remediation can involve the use of surface washing agents, bioremediation and in-situ burning. Pre-authorization protocols should address both the specific oil types that may be spilled, and the sensitive areas that may be impacted.

In Annex J - Operations, Area Committees are expected to outline in detail the specific response strategies that will be employed, actions that will be taken, and issues that will be addressed in the course of the response effort. With regard to shoreline cleanup, this includes determining set aside areas for research purposes and countermeasures effectiveness determination, monitoring and refining cleanup strategies during the course of the spill response, and developing criteria /guidance for the termination of the response effort, often referred to as "how clean is clean" criteria.

In June of 1996, the Coast Guard revised Commandant Notice 16471 (USCG, 1996) to address the development of hazardous substance response planning criteria within Area Contingency Plans. In doing so, the Coast Guard revised the format and content requirements from the original notice making them less specific, and leaving more discretion to the Area Committees. It is particularly noteworthy that the suggested format no longer requires a separate Annex E, Annex G and Annex J as in the original version. However, there is nothing to preclude the incorporation of these procedures, protocols, and planning information within the context of the combined oil and hazardous substance contingency plan.

In summary, the National Contingency Plan and the implementing Coast Guard directives collectively provide the following guidance on specific protocols, procedures, and information which should be contained in the Area Contingency Plans:

- Identify and prioritize sensitive shoreline environments

- Provide information on effects of shoreline countermeasures and cleanup techniques

- Set forth protocols for consultation on the effects of shoreline cleanup

- Establish monitoring protocols for shoreline cleanup

- Set forth procedures for establishing "set aside" areas

- Develop area specific strategies for cleaning up sensitive shorelines

- Pre-authorize the use of surface washing agents, bioremediation and in-situ burning for shorelines as appropriate. Establish procedures for authorization at the time of spill when not pre-authorized

- Develop specific strategies for protection and cleanup of sensitive shoreline habitats

- Identify procedures and resources for the protection and rehabilitation of fish, wildlife and habitats

- Identify procedures and resources for the capture, transport, rehabilitation and release of wildlife adversely affected by the oil

- Develop procedures and criteria for the smooth termination of shoreline cleanup activities

As for shoreline restoration, Commandant Notice 16471 has virtually no reference to, or requirements for developing contingency plans for this activity.

3.2 Key Attributes Identified through Interviews and Project Workshop

As discussed in the previous section, the published regulations and directives on oil spill contingency planning provide only limited guidance on how shoreline remediation should be addressed in the contingency planning process, and little or no guidance on shoreline restoration. To provide additional guidance in this area, the research team decided to meet with selected spill response officials in the Gulf region both in individual meetings and in a workshop format to determine what should ideally be included in the contingency planning process to properly address shoreline remediation and restoration.

Accordingly, during the period September 16-20, 1997, Dr. Bart Baca and Mr. Austin Ives visited spill response officials in Louisiana and Texas, briefed them on the objectives, scope, and desired output of the project, and solicited their input. Officials visited included the Eighth Coast Guard District Response Assistance Team (CGD8 DRAT) Coordinator, the NOAA Scientific Support Coordinator (NOAA SSC), the Natural Resources Subcommittee of the Texas Natural Resources Conservation Commission (TNRCC), and the Texas General Land Office (TGLO) in LaPorte and Port Arthur. The officials both individually, and sometimes collectively, provided the following input and suggestions on what should be addressed in the contingency planning process. A complete summary of the interviews is attached as Appendix A.

- The Coast Guard is trying to downsize the ACPs and suggested that remediation and restoration be addressed in a companion manual. (CGD8 DRAT)

- Creating a standard remediation plan for Louisiana shorelines may be difficult as there are varying opinions among state agencies on marsh type and sensitivity. (NOAA SSC)

- Longer term restoration planning should be addressed by resource trustees under NRDA. However, emergency restoration guidance is needed. Development of a remediation and emergency restoration plan/manual for the spill response phase would be useful . (TNRCC)

- Criteria for when shoreline is clean enough should be included. TNRCC has developed a methodology. (TNRCC)

- Long-term monitoring of remediation sites is required to determine the effectiveness of various techniques. Texas has initiated an aggressive program to monitor oil spill sites undergoing remediation. (TGLO)

These initial interviews provided input from officials in Texas and Louisiana. To obtain input from officials in Mississippi, Alabama, and Florida, and expand the scope of the interview process, a two-day intensive workshop was set up involving government agencies, environmental groups, private industry and individuals with direct involvement and/or expertise in contingency planning. The workshop was organized and facilitated by

Dr. William Graham and his colleagues at the Dauphin Island Sea Lab (DISL). The workshop was set up in four sessions, each session focusing on a different stakeholder group, that is, Planning and Response Agencies, Industry Representatives, Environmental and Fishing NGOs and Environmental Consultants. A complete workshop summary is attached as Appendix B. The following is a compilation of their input and suggestions with respect to remediation and restoration.

Session 1 - Planning and Response Agencies

- All Area Contingency Plans need to follow the same format and be based on the Incident Command System as outlined in Commandant Notice 16471.
- Emergency Restoration is an important concept in spill response.

Session 2 - Industry Representatives

- Annexes to the ACPs should address both in-situ burning and Hazmat response.
- The Gulf Coast has numerous sensitive areas; these must be clearly delineated and prioritized so that most sensitive areas can be protected.
- Inland environmental sensitivity maps are needed for Region IV
- All agreed that emergency restoration could be set up as a response option. Restoration techniques and associated costs should be determined. There is also a need to establish substrate replacement criteria for shoreline restoration. Responsible parties would be willing to undertake emergency restoration activities if they receive due credit in damage assessment process and do not have to fund long-term monitoring and maintenance efforts (3-5 years).

Session 3 - Environmental and Fishing NGOs

- Oyster reef areas and artificial reefs should be added to environmental sensitivity maps. Restoration plans should be developed for these resources.
- Contingency plans should address low API gravity oils which can sink and pose a major threat to oyster reefs, artificial reefs and seagrasses.

Session 4 - Environmental Consultants

- Emergency restoration is an important process. An Emergency Restoration Protocol should be developed providing general guidelines, rationale, decision process and methodology for the full range of shoreline habitats (freshwater swamps, marshes, dunes, beaches, reefs, seagrass beds, wildlife habitats). Signoff criteria need to be developed whereby agencies agree that emergency restoration actions are adequate and complete.

The interview and workshop process was valuable in establishing a dialogue with Federal and state spill response agencies and various interested stakeholders. The most significant finding in this process was the consensus opinion that "emergency restoration" is an important aspect of spill response, and should be clearly delineated as such in the contingency planning process. This should be accomplished within the ACPs themselves and also by development of manuals and other supporting technical information.

3.3 Key Attributes Identified through Survey of Responders

The review of the various regulations and directives, together the interviews and workshop, provided valuable input into key requirements for adequately addressing remediation and restoration in the contingency planning process. However, in reviewing the full scope of shoreline remediation and restoration as outlined in Figures 2.2 and 2.3, it is clear that these published and suggested requirements do not address all issues that may be important in the response process. The provide a more comprehensive look at these requirements in finer detail, a survey was undertaken to solicit input from federal and state officials in a more comprehensive fashion. This input was used to expand and supplement requirements already identified.

The survey form (provided as Appendix C) was developed by studying the shoreline remediation and restoration processes depicted in Figures 2.2 and 2.3, and identifying all of the decision protocols and supporting technical information that might be needed to support these processes. The survey form was distributed to selected federal and state oil spill response officials in Texas, Louisiana, Mississippi, Alabama, and Florida. The survey requested their input on three specific aspects of oil spill contingency planning relative to shoreline remediation and emergency restoration:

1) the overall "priority" or importance of various procedures and technical information in supporting the contingency planning process;

2) whether providing better procedures or technical information was a policy issue, scientific issue, or both; and

3) at what level in the contingency planning process (National Contingency Plan, Regional Contingency Plan, State Contingency Plan, Area Contingency Plan, or Supporting Technical Information) these procedures should be specified and the information provided.

Responses to the survey were received from seven spill response agencies in Louisiana, Mississippi, Alabama and Florida. These included:

- Eighth Coast Guard District (MEP)
- NOAA Scientific Support Coordinator, Gulf Region
- Coast Guard MSO Mobile

- Louisiana Oil Spill Coordinator's Office
- Mississippi Dept. of Environmental Quality
- Alabama Dept. of Environmental Management
- Florida Dept. of Environmental Protection

Appendix C provides a complete tabulation of the results of the survey on the form that was originally distributed, and an explanation of how the results were interpreted to produce the summary in Tables 3.1 and 3.2. Table 3.1 provides the results for the Shoreline Remediation form; Table 3.2 provides the results for the Shoreline Restoration form. The first column of Tables 3.1 and 3.2 lists the various decisions, protocols and technical information that could be addressed in the contingency planning process. Column 2 provides the total numerical score assigned to each item, indicating its overall importance, which was computed as described in Appendix C. All items scored in the range of 21 through 12, with 21-17 being designated "high" priority, and 16-12 being designated "medium" priority. Column 3 gives the priority for each item. No items were judged to be in the low priority category by the reviewers as a whole. Columns 4 and 5 show whether addressing the decision, protocol or information is considered a technical or policy issue by the survey responders. Column 6 indicates at which level in the contingency planning process the responders felt each item should be addressed.

In reviewing the results of the survey, it was interesting to note that many of the higher priority items identified through the survey, were also specifically addressed in National Contingency Plan and Commandant Notice 16471, and identified during the interviews and workshop. It is also interesting to note that the officials responding to the survey had a range of opinions on where in the contingency planning hierarchy items should be addressed. However, in general, the results indicate that the agency responsibilities, response decision processes and approval protocols should be addressed at the upper levels of the hierarchy (NCP, RCP, and SCP), while technical information should be provided on a local level in the ACPs and as supporting technical information (STI).

Table 3.1 Results of Gulf of Mexico Contingency Planning Survey

SHORELINE REMEDIATION					
Item	*Score*	*Prior.*	*Policy*	*Tech*	*Plan Level*
<u>Response Guidelines</u>					
Federal agency roles	21	H	X		NCP,ACP
State agency roles	21	H	X		NCP,SCP,ACP
Responsible party roles	21	H	X		NCP,SCP,ACP
Technique Pre-Approval	17	H		X	RCP,ACP
Test protocols (Effect/Toxic)	13	M		X	NCP,STI
Approved BioRem. Agents	14	M		X	NCP,STI
Monitoring Protocols	14	M		X	Various levels
How Clean Is Clean	17	H	X	X	NCP,RCP,ACP
Test application proced.	16	M		X	Various levels
Set Aside Areas	13	M		X	NCP,RCP
Oil Properties & Toxicity	14	M		X	STI
Shoreline Morphology	13	M		X	ACP,STI
Shore Resource Sensitivity	18	H		X	ACP,STI
Socio-Economic Resource	15	M	X	X	ACP
Rem. Technology Suitability	15	M	X	X	ACP
Rem. Tech. Effectiveness	15	M		X	Various levels
Rem. Resource Availability	13	M		X	ACP
Remediation Impacts	14	M		X	ACP
<u>Wildlife Rescue Info</u>					
Wildlife species priority	16	M	X	X	RCP,SCP,ACP
Rescued species survival	16	M		X	RCP,SCP,ACP
Wildlife rescue resources	14	M		X	ACP

Table 3.2 - Results of Gulf of Mexico Contingency Planning Survey

SHORELINE REMEDIATION					
Item	*Score*	*Prior.*	*Policy*	*Tech*	*Plan Level*
General Guidelines					
Federal agency roles	18	H	X		NCP,RCP,ACP
State agency roles	18	H	X		Various levels
Responsible party roles	16	M	X		Various levels
Test application procedures	15	M	X	X	RCP,ACP
Set aside area procedures	15	M	X	X	RCP,ACP
Monitoring protocols	13	M	X	X	Various levels
Evaluation					
Feasibility analysis proced.	16	M	X	X	NCP,ACP,STI
Impact of techniques	14	M		X	ACP,STI
Persistence/toxicity of oil	15	H		X	ACP,STI
Impacts with/without restor.	16	M		X	ACP,STI
Rest. Tech. Effectiveness	15	M		X	Various levels
Rest. Resource Availability	13	M	X	X	ACP

3.4 Summary of Issues, Procedures and Information Needed for Shoreline Remediation and Restoration

Given the information contained in Sections 3.1 through 3.3, it is possible to compile a consensus list of procedures and general guidelines that should be addressed, and technical information that should be provided in the context of the contingency planning process. This list will be used as benchmark criteria against which the current planning process can be evaluated.

General Guidelines and Protocols for Remediation and Restoration

- Establish priorities for the protection of sensitive shorelines (including habitat and wildlife).

- Establish specific strategies for the remediation of sensitive shoreline environments.

- Provide for pre-approval of shoreline remediation techniques where it will expedite application and minimize damage.

- Establish protocols for the evaluation of the environmental effects of shoreline remediation and restoration options, including the "no removal" option.

- Develop protocols for test application of shoreline remediation techniques.

- Provide monitoring protocols for evaluating the effectiveness of shoreline remediation techniques.

- Establish procedures for designating "set aside" areas, where no remediation actions are taken, to facilitate evaluation of the effectiveness of remediation techniques which are utilized.

- Establish procedures for the cleaning and rehabilitation of wildlife in the shoreline environment.

- Develop guidelines for terminating shoreline remediation (How Clean Is Clean Criteria), and incorporate into the contingency planning process.

- Develop guidelines and protocols for emergency restoration and incorporate into the contingency planning process. Clarify roles and responsibilities of response agencies, responsible parties and resource trustees for initiating, performing and monitoring emergency restoration activities.

- Develop protocols for test application of emergency restoration techniques.

- Develop monitoring guidelines for emergency restoration efforts.

- Establish procedures for designating "set aside" areas, where no restoration actions are taken, to facilitate evaluation of the effectiveness of restoration techniques which are utilized.

- Develop signoff criteria for determining when restoration actions are adequate and complete.

Technical Information on Shoreline Remediation and Restoration

- Provide information on shoreline morphology, resources and sensitivity to various types of oil that may be spilled. This information should be provided in map format.

- Compile technical information of remediation technologies including suitability by shoreline type, implementation criteria, anticipated removal effectiveness and impact on the shoreline. To control the size of contingency plans, this information should be provided as readily accessible supplemental data.

- Provide technical information on the capture, transport and rehabilitation of oiled wildlife.

- Compile technical information to aid in determining if emergency restoration should be undertaken including long-term persistence and toxicity of the oil, and natural recovery times for different oils in the various shoreline environments.

- Compile information on the suitability, implementation procedures and anticipated positive and negative impacts of various restoration techniques. To control the size of contingency plans, this information should be provided as readily accessible supplemental data.

3.5 References

USCG, 1992, Commandant Notice 16471 - Establishment of Area Committees and Development of Area Contingency Plans dated 20 Sept. 1992, U. S. Coast Guard Headquarters, Washington, DC.

USCG, 1996, Commandant Notice 16471 - Establishment of Area Committees and Development of Area Contingency Plans dated 24 June 1996, U. S. Coast Guard Headquarters, Washington, DC.

4.0 Evaluation of the Current Contingency Planning Process with Respect to Shoreline Remediation and Restoration

Section 3.0 discussed the key guidelines and procedures, and the technical information that should be provided in the context of the contingency planning process, to support shoreline remediation and restoration. As indicated in the previous section, the consensus of response agencies and resource trustees is that "emergency restoration" in particular should be addressed in contingency planning process. This following discussion examines the extent to which the current contingency planning process addresses these requirements, and suggests initiatives that can enhance the process.

4.1 Shoreline Remediation and Restoration in the National Contingency Plan

In evaluating the contingency planning process at the national, regional, state, and local level, the research team found that it addresses shoreline remediation at a strategic level in the National, Regional and Area Contingency Plans. At the state level, shoreline remediation is not addressed with the exception of the Texas plan.

The National Plan addresses shoreline remediation in a general sense by assigning overall response agency and natural resource trustee responsibilities. It further tasks the RRTs with developing pre-approval guidelines for shoreline countermeasures such as chemical use, in-situ burning and bioremediation; and establishes the protocol for approving specific chemicals and bioremediation agents for us in the U.S. (in the NCP Product Schedule). It addresses the protection of sensitive shorelines and rehabilitation of wildlife by requiring the development of a Sensitive Environments Annex within the Area Plans. It specifies that shoreline remediation be included in development of an overall spill response strategy. At a national, strategic level, the NCP adequately addresses guidelines and procedures for shoreline remediation.

With respect to restoration, the NCP only addresses the responsibilities of and necessary coordination between responders and resource trustees in carrying out damage assessment activities during the spill response process. The implementation of restoration efforts, and particularly "emergency restoration" as a response activity, is not addressed.

4.2 Shoreline Remediation and Restoration at the Regional and State Planning Level

At the regional level, the Regional Response Teams provides generic guidance to the Area Committees on the use of specific technologies for shoreline remediation. A good example is the Region VI guidelines for Inshore/Nearshore In-Situ Burning (published on January 8, 1996) and the guidelines for Bioremediation (currently in draft form). These guidelines contain criteria for use, approval mechanisms, and monitoring protocols for determining technique effectiveness and environmental impacts. There are currently no similar RRT guidelines for other shoreline remediation techniques (such as mechanical removal or water washing (with and without chemical additives), or generic guidelines for terminating shoreline remediation (How Clean Is Clean Criteria - HCIC). Generic HCIC guidelines have been developed for specific spills, and could be modified and adopted as regional guidelines to be further modified and adapted by the Area Committees. As with the NCP, restoration activities are not addressed as a component of spill response within the Regional Plans.

At the state level, neither shoreline remediation nor restoration are discussed in the Gulf Plans, with the exception of the Texas Contingency Plan, which is developed and maintained by the Texas General Land Office (TGLO). In this plan, which was still at the draft stage during this writing, an Emergency Restoration section is included under Annex X - Natural Resource Trustee Roles and Responsibilities. The current suggested language concerning emergency restoration is as follows:

"If response actions undertaken by the lead response agency or RP are insufficient to prevent additional injury to natural resources, the trustees may undertake emergency restoration actions to reduce the threat of additional injury. Prior to undertaking any emergency restoration actions, the Trustee will first ask the OSC to undertake the needed actions. Emergency restoration activities initiated by the Trustees will not interfere with the ongoing response."

Regardless of the final language, the concept is that the OSC would perform the restoration (unless the OSC was too busy with the spill response or had insufficient resources available) following a request by the SSC, RP, or other Trustee. No further guidelines exist, but the NRDA team would appear to be a good resource for information or resources.

4.3 Shoreline Remediation and Restoration in the Area Contingency Plans

As described in Section 2.0, the Area Contingency Plans, introduced by OPA 90, constitute the focal point at which national spill response policy is translated into a tactical plan. In the ACPs, the Area Committees consider the specific spill scenarios anticipated, and develop detailed strategies and procedures for carrying out a response effort. Within the ACPs, the responders also match countermeasures and cleanup techniques to specific sections of shoreline based on shoreline sensitivity, the effectiveness of techniques, and the anticipated impacts of response operations. As such, the ACPs are the real blueprint for carrying out a response effort.

The Area Contingency Plans for the Gulf of Mexico Region provide general guidelines and procedures for shoreline remediation in varying degrees and formats, but generally address remediation in only a cursory manner. The seven plans reviewed addressed shoreline remediation activities almost entirely within Annex E - Area Assessments, which to varying degrees fulfills the requirements for the Fish and Wildlife and Sensitive Environments Plan Annex required by the National Contingency Plan. Other shoreline remediation issues are addressed and technical information provided only sporadically in other annexes of the ACP.

4.3.1 Guidelines and Procedures for Shoreline Remediation and Restoration

In comparing the general guidelines and procedures for shoreline remediation and restoration listed in Section 3.4, the following observations were made on the manner and extent that Gulf ACPs provide this guidance.

- *Establish priorities for the protection of sensitive shorelines (including habitat and wildlife).*

Most of the ACPs reviewed delineate shoreline sensitivity and protection strategies in Annex E - Area Assessments. This is usually accomplished through text descriptions of sensitive resources at specific locations, with the general locations marked on annotated navigation charts, or in some cases using computerized mapping tools. Protective booming strategies are discussed in general in all plans, and location specific booming strategies are provided in map format in the Tampa ACP.

- *Establish specific strategies for the remediation of sensitive shoreline environments.*

The ACPs reviewed all address strategies shoreline cleanup at some level, primarily in Appendix IV of Annex E. A few plans (such as the Port Arthur plan), provide detailed response strategies for specific sensitive areas (description, sensitivity, protection priority, access, and containment and recovery plan). Most plans address shoreline cleanup strategies in only a cursory manner.

- *Provide for pre-approval of shoreline remediation techniques where it will expedite application and minimize damage.*

Approval guidelines for dispersants and in-situ burning are provided at the regional level for Region VI. However, these have not been translated into location and scenario-specific, pre-approval criteria within the ACPs. The final decision rests with the On-Scene Coordinator in consultation with the RRT and Area Committee. The pre-approval of other shoreline protection and remediation techniques is not covered within the current ACP structure, with the exception of draft bioremediation guidelines in Region VI.

- *Establish protocols for the evaluation of the environmental effects of shoreline remediation and restoration options, including the "no removal" option.*

Such protocols would provide procedures and information for conducting a Net Environmental Benefit Analysis of proposed shoreline remediation and restoration options, including the "no response" option. At present there are no such protocols delineated in the contingency planning process. It is assumed that such an analysis would be conducted on an ad-hoc basis by responding officials and resource trustees at the time of the spill. Although this has been successfully accomplished on an ad-hoc basis at previous spills, developing a formal protocol, perhaps at a regional level, would facilitate and expedite the process.

- Develop protocols for test application of shoreline remediation techniques.

Test application procedures shoreline remediation techniques are not formally addressed in the Area contingency planning process, except for reference to the draft bioremediation guidelines for Region VI.

- Provide monitoring protocols for evaluating the effectiveness of shoreline remediation techniques.

Monitoring protocols shoreline remediation techniques are not formally addressed in the Area contingency planning process, except for reference to the draft bioremediation guidelines for Region VI.

- Establish procedures for designating "set aside" areas, where no remediation actions are taken, to facilitate evaluation of the effectiveness of remediation techniques which are utilized.

Set aside sites to study the longer-term impacts of spilled oil and remediation measures have been established following several spills in Texas and Louisiana. However, the criteria and procedures for doing so are not delineated in the Area contingency planning process, but treated on an ad-hoc basis at the time if the spill. As long as this method is effective, "set aside" procedures need not be addressed in detail in the RCPs and ACPs, but the responsible agencies for doing so should be identified.

- Establish procedures for the cleaning and rehabilitation of wildlife in the shoreline environment.

This aspect of spill response is addressed at a very cursory level in the ACPs. For the most part the ACPs simply identify the agencies responsible for dealing with oiled wildlife and in some cases provide contact points for obtaining assistance.

- Develop guidelines for terminating shoreline remediation (How Clean Is Clean Criteria), and incorporate into the contingency planning process.

None of the ACPs reviewed provide specific procedures for assessing adequacy of cleanup (How Clean Is Clean), and terminating cleanup activities. Most plans simply indicate that this decision will be made by the On-Scene Coordinator in consultation with the appropriate federal and state response agencies. The Tampa ACP did include a sample form for making a How Clean Is Clean determination on shoreline segments, but did not provide criteria. Such criteria have been developed for past spills. Guidelines could be formulated on a regional basis by the RRTs in consultation with state response agencies and resource trustees, providing specific HCIC criteria for predominant shoreline types within the region. These could then be adopted as is, or modified by the Area Committees for inclusion in the ACPs.

In Section 3.4, the following requirements were identified for addressing "emergency restoration" in the Area contingency planning process:

- Develop guidelines and protocols for emergency restoration and incorporate into the contingency planning process. Clarify roles and responsibilities of response agencies, responsible parties and resource trustees for initiating, performing and monitoring emergency restoration activities.

- Develop protocols for test application of emergency restoration techniques.

- Develop monitoring guidelines for emergency restoration efforts.

- Establish procedures for designating "set aside" areas, where no restoration actions are taken, to facilitate evaluation of the effectiveness of restoration techniques which are utilized.

- Develop signoff criteria for determining when restoration actions are adequate and complete.

The review of the seven Gulf ACPs revealed that restoration activities are not addressed in the contingency planning process, and are not currently considered part of spill response. However, the interviews with Gulf spill response officials and the workshop revealed that there is a growing awareness that "emergency restoration" may be needed in the latter stages of spill response. There is also a growing awareness of the linkage between shoreline remediaton and follow-on activities in that certain shoreline remediation activities undertaken during the response effort may necessitate "emergency restoration" (such as shoreline stabilization after mechanical removal of oil or sediment). Other remediation measures may preclude the use of other restoration techniques.

It is clear that serious consideration should be given to including "emergency restoration" as a relevant phase of the spill response effort. Whether or not emergency restoration need be formally defined in the National Contingency Plan should be addressed by the National Response Team. Agency roles should be identified and the follow-on responsibilities of the responsible party for maintenance and monitoring should be defined. In the meantime, RRTs and Area Committees may formulate strategies and procedures by treating emergency restoration as the final stage of shoreline cleanup. These strategies and procedures could include test application procedures, monitoring protocols, set aside procedures, and criteria for determining when emergency restoration efforts are sufficient (similar to the HCIC criteria).

4.3.2 Technical Information on Shoreline Remediation and Restoration

In comparing the technical information requirements for shoreline remediation and restoration listed in Section 3.4, the following observations were made on the manner and extent that Gulf ACP process provides this information .

- *Provide information on shoreline morphology, resources and sensitivity to various types of oil that may be spilled. This information should be provided in map format.*

All of the ACPs reviewed address shoreline sensitivity to some degree . In some cases these are text descriptions of sensitive resources with the general location indicated on maps and navigational charts. Some of the plans provide more detailed descriptions and more exact locations noted on maps. The ACP for the New Orleans area provides detailed descriptions of shoreline types in the Louisiana coastal zone, and shoreline maps showing the location of each shoreline type. Information on the sensitivity and anticipated impact of an oil spill is also provided. The Tampa ACP provides the most detailed shoreline sensitivity maps which were generated by NOAA. These maps also provide protective booming strategies. In addition, the Tampa ACP will eventually incorporate GIS generated maps from the Florida Marine Spill Analysis System, an ARCVIEW GIS based system specifically tailored for spill contingency planning and response.

It is clear that computer generated environmental sensitivity maps, similar in content and format to those in the Tampa plan, would improve the treatment of environmental sensitivity and resource protection strategies in the ACPs. Ideally the format for these maps should be standardized in all ACPs (adopting a format such as that specified by NOAA). Hard copy detailed Environmental Sensitivity Maps have been prepared by NOAA HAZMAT, but these have not been incorporated directly into ACPs. They are available as supporting technical information. Their utility will be greatly enhanced when they are available in digitized format.

- *Compile technical information of redemption technologies including suitability by shoreline type, implementation criteria, anticipated removal effectiveness and impact on the shoreline. To control the size of contingency plans, this information should be provided as readily accessible supplemental data.*

Several of the ACPs reviewed provide generic shoreline cleanup technical guidance extracted from publications such as the NOAA HAZMAT Shoreline Cleanup Manuals (NOAA 1992 and 1993), Exxon Oil Spill Response Manual (Exxon, 1992), and API Shoreline Cleanup Manual (API, 1995). The New Orleans ACP contains information from the Texaco Manual on "The Coastal Geologies and Processes, Habitat Types, and Shoreline Cleanup Methods for Louisiana" (Texaco, 1992). This manual provides detailed guidance on shoreline cleanup and remediation specific to Louisiana.

Although the material extracted from generic shoreline cleanup manuals is useful, it does not in itself define working strategies for undertaking shoreline remediation efforts at specific sensitive shoreline areas in an ACP area. The inclusion of such material in the body of the ACP also increases the size of the plan and makes it cumbersome to use. These manuals should be made available as supporting technical information, and the information distilled to develop detailed technical guidance for the predominant shoreline types found in each ACP area. It may be possible to compile these at a regional level for the Gulf Coast, or at the state level in coordination with state response agencies and resource trustees, to provide region specific templates, which could be adopted and/or modified by the Area Committees

- *Provide technical information on the capture, transport and rehabilitation of oiled wildlife.*

This technical information is not included in the ACPs reviewed. Technical information on the capture, transport and rehabilitation of oiled birds and marine mammals is readily available in a number of manuals, as well as in the scientific literature. It would be desirable to have information available on rehabilitation techniques for species in a particular area, and resources and personnel available for conducting wildlife rehabilitation efforts, available to responders. This information could be available as supporting technical information to limit the size of the ACPs.

- *Compile technical information to aid in determining if emergency restoration should be undertaken including long-term persistence and toxicity of the oil, and natural recovery times for different oils in the various shoreline environments.*

This information in not now provided in contingency plans as restoration is not considered part of the spill response process. A number of studies are underway in the Gulf to monitor the longer-term impacts of oil spill and the effectiveness of various restoration efforts. Information on the recovery of oiled shorelines around the world, including those where remediation efforts have been undertaken and those that have been left for "natural remediation", have been compiled by AURIS Ltd. (1994). Such information could be compiled specifically for the Gulf to provide criteria for undertaking restoration efforts. More detailed case study data can be provided as supporting technical information.

- *Compile information on the suitability, implementation procedures and anticipated positive and negative impacts of various restoration techniques. To control the size of contingency plans, this information should be provided as readily accessible supplemental data.*

This information is not now provided in the contingency planning process. Some information on shoreline restoration is available in manuals and the technical literature, and could be compiled and made available as supporting technical information.

4.4 Overall Assessment of the Adequacy of the Current Contingency Planning Process for Shoreline Remediation and Restoration

The discussions in this section have provided a cursory assessment as to how the current contingency planning process addresses the topics of shoreline remediation and restoration. The comments have been summary in nature, and have not involved detailed evaluations of specific State and Area contingency plans. The objective of this analysis is to assess the adequacy of the process, and provide some general recommendations as to how the process might be improved, not critique specific plans.

In summary, the National Contingency Plan appears to adequately address shoreline remediation at a strategic level through the requirement for the Fish and Wildlife and Sensitive Environments Annex. In addition, guidelines for certain shoreline remediation measures (including approval criteria and monitoring protocols) have been developed for in-situ burning and bioremediation at the regional level in Region VI. However, it is not clear that the range of shoreline remediation topics and level of technical guidance intended by the NCP in prescribing the Fish and Wildlife and Sensitive Environments Annex has ever been reached.

There are several suggested reasons for this shortfall. First, Commandant Notice16471 did not fully outline the requirements for the Sensitive Environments Annex as a stand-alone component to the Area Contingency Plans, but rather called for various topics to be addressed in several sections of the ACPs. In addition, Commandant Notice 16471 did not provide guidance on specific content, format and level of detail. This was left to the discretion of the Area Committees, consistent with the overall intent of OPA 90 in establishing the Area Committees and Area Contingency Plan process. However, this has caused the wide variation in the level to which each individual ACP provides guidance on shoreline remediation.

Another possible reason for the disparity is that shoreline remediation, as well as shoreline restoration, involves both the federal and state response agencies, and particularly the resource trustees. Because of this, it appears more appropriate that guidelines for the application of specific techniques, effectiveness monitoring protocols, set-aside procedures, and How Clean Is Clean criteria are more efficiently formulated at the regional level by the RRT. These guidelines and protocols, or at least a region specific generic template, could be provided to the Area Committees.

With regards to the availability of the technical data called for in the Sensitive Environments Annex, it appears that although there are various generic shoreline remediation manuals available, they are voluminous and not necessarily tailored to the specific environments covered by the Area Plans. When incorporated in whole or in part into the plan, they provide general guidance but greatly expand the size of the plan. However omitting them leaves little or no guidance on the advisability, effectiveness, and impacts of remediation techniques. A possible solution is to use the generic material to develop area specific guidelines for shoreline protection and remediation, that can be made available as supporting technical information and incorporated by reference into the Area Contingency Plans.

In many cases, the shortfall in technical information is due to the fact that the data do not exist. This is particularly true with regards to the effectiveness and impacts of shoreline remediation activities, particularly in the longer-term. There is also little data on how shoreline remediation measures facilitate or preclude follow-on restoration efforts. There are a number of studies underway monitoring the longer-term effectiveness and impacts of shoreline remediation at past spill sites, both in the U.S. and throughout the world. However, the results of these efforts are reported in individual conference papers and journal articles, and various agency technical reports. At present there is no prescribed mechanism for collecting this information on a regional, national and international basis; and distilling and compiling it in a format useful in managing spill response operations.

With respect to "emergency restoration" , this phase of spill response is simply not addressed in the contingency planning process. It appears to fall in a "gray area" between the shoreline cleanup phase of response, and longer-term restoration efforts that take place under direction of resource trustees following the Natural Resource Damage Assessment process. Therefore, the first step in providing guidance, protocols and technical information for emergency restoration is to formally define what constitutes emergency restoration, and delineate responsibilities among response agencies, resource trustees, and responsible parties. Assuming that this can be accomplished, many of the deficiencies described above for shoreline remediation contingency planning, will also apply to the shoreline emergency restoration.

4.5 References

API, 1995, Options for Minimizing Environmental Impacts of Freshwater Spill Response, produced by the American Petroleum Institute and NOAA Hazardous Materials and Response Assessment Division, API Publication No. 4558, API, Washington, DC.

AURIS, Ltd., 1994, Scientific Criteria To Optimize Oil Spill Cleanup and Effort, unpublished report, Aberdeen University Research and Industrial Services, Aberdeen, Scotland.

Exxon, 1992, Exxon Oil Spill Response Field Manual, Exxon Production Research Company.

NOAA, 1992, Shoreline Countermeasures Manual Template for Temperate Coastal Environments, NOAA Hazardous Materials and Response Assessment Division, Seattle, WA.

NOAA, 1993, Shoreline Countermeasures Manual Template for Tropical Coastal Environments, NOAA Hazardous Materials and Response Assessment Division, Seattle, WA.

Texaco, 1992, The Coastal Geology and Processes, Habitat Types, and Shoreline Cleanup Methods for Louisiana, Texaco Gulf Region Oil Spill Response Team - Shoreline Protection and Cleanup Training, New Orleans, LA, published by Texaco Exploration and Production, Inc.

5.0 Recommended Approaches for Improving the Contingency Planning Process With Respect to Remediation and Restoration

Section 4.0 evaluated the current contignecy planning as to how well the issues of shoreline remediation and restoration were addressed. Shortfalls were identified both in terms of the guidelines and protocols that are needed to support deceisionmaking and implementation by responders, as well as technical (scientific) information and technology required to support the process. In this section, several approaches will be discussed for upgrading the process. Based on these approaches, specific policy development and research initiatives will be proposed in Section 8.0.

5.1 Providing Guidelines and Protocols to Support Shoreline Remediation and Restoration

The analysis in Section 4.0 shows a clear need for translating the strategic requirements for shoreline remediation contingency planning in the National Contingency Plan (primarily specified in the requirements for the Sensitive Environments Annex in the Area Contingency Plans), into tactical contingency plans at the local level in the Area Contingency Plans). The desirable attributes and constraints in providing these guidelines and protocols complicate the situation:

- Implementation guidelines, monitoring protocols, and HCIC criteria must be specific enough to the predominant local shoreline types to directly facilitate shoreline remediaton decision making on a site by site basis, taking into account differences in shoreline morphology, sensitivity, technique effectiveness and predicted impacts.

- Implementation guidelines, monitoring protocols, and HCIC criteria must be consistent with both federal (particularly EPA) and state requirements for the selection, application and monitoring of specific technologies. HCIC criteria must meet both federal and state expectations, and be flexible enough to accommodate municipal expectations when they become important.

- The specific areas of the shoreline to which various guidelines and protocols apply must be clearly identified in advance in as much detail as possible.

- Guideline must be incorporated in the Area Contingency Plans in a manner such that the size of the ACPs does not become overly cumbersome.

The requirement for concise and flexible guidelines and protocols that provide the necessary level of detail without significantly expanding the size of the ACPs presents a unique challenge. One suggested approach is to develop technique approval, monitoring, and HCIC templates at the regional level, which provide clear Federal and state policy guidance, but which can be adopted and expanded to meet local decision making requirements by the Area Committees. These templates could be published as a separate policy document at the regional level, and incorporated by reference into the ACPs. A more effective approach; however, is to publish the generic guideline and protocol templates on a Web Page on the Internet so that they can be easily updated and modified by the RRTs based on recent spill experience and new scientific information, and easily accessed by Area Committees. In this way the guidelines would always be available, but not unduly increase the physical size of the plans.

Ideally, the Area Committees will tailor the guidelines and protocols to the shoreline types and environments in a given ACP Area, and link them with the specific shoreline sections, so that shoreline remediation decision making can be focused on the specific site in question. The rapidly advancing GIS technology offers a powerful tool in accomplishing this in that geographic maps of a shoreline section, providing the location and attributes of environmental resources, can be dynamically linked with the guidelines and protocols applicable to the shoreline. This will provide easy access key decision making information that is tailored to a specific site, without having to deal with a variety of maps and hard copy documents. In a larger application, integrated GIS-based decision support systems (such as the Florida Marine Spill Analysis System) could be developed as an electronic Sensitive Environments Annex to the Area Contingency Plans, such that the hard copy plans need only provide the organizatonal responsibilities and blueprint for carrying out shoreline remediation activities.

5.2 Providing Scientific Information and Technology To Better Support Shoreline Remediation

5.2.1 The Concept of Shoreline Remediation

Remediation may be defined as actions taken (process or technology) to counteract or remove the effects of contamination (Kucharski and Kostecki in Proffitt and Roscigno, eds. 1985). The actions taken to remedy the contamination problem can be physical, chemical, biological, or a combination of these. Relative to shoreline contamination, remediation must deal with water and/or soil media. In addition, since many shorelines are dominated by vegetation such as marsh grasses, sedges, and rushes, and mangroves, consideration should be given to remediation of these plants and communities as well.

5.2.2 Current Shoreline Remediation Practices

Kucharski and Kostecki (in Proffitt and Roscigno, eds. 1995) list a number of technologies or methods for remediation of contaminated soil and water (Table 5.1). These are being used today with varying degrees of success. Thermal and vacuum methods often require expensive equipment and have limitations for the type of contamination they can treat. Soil washing is likewise limited by the type of contamination, but a variety of solvents and surfactants have been used to address this problem, including new surfactants which contain nutrients to enhance bioremediation.

Table 5.1. Technologies and Methods for Remediation of Soil and Water (Proffitt and Roscigno, eds. 1995).

Category	Method	Medium
Physical Separation	Thermal Desorption Vacuum Extraction Soil Washing Air Stripping	Soil Soil Soil Water
Physical Reaction/Incorporation	Solidification Asphalt Incorporation Incineration Vitrification	Soil Soil Soil Soil
Chemical/Biochemical Reactions	Bioremediation	Soil/Water

Limitations which remain are inability to clean fine particle soils and to deal with cost-effective cleaning of the large volume of wash water. Air Stripping (a.k.a. Sparging) technology has continued to improve such that it is widely used (e.g., in contaminated gas stations with leaking underground storage tanks). Although costly, the equipment is coming down in price, and smaller, portable units are available. Its limitation is the requirement the iron (Fe^{+2}) levels in the water be less than 10 mg/l. Solidification is an older method using materials such as cement or fly ash to stop or reduce the movement of contamination in soils. The method is restricted by fine soils and disposal or use of the final, solidified material. Incorporation into asphalt allows productive use of contaminated soil, its limitation being soil particle size and organic content. Bioremediation is a natural process that begins as soon as petroleum products and other bio-degradable contaminants enter the water or soil. Aerobic and sometimes anaerobic microbes break down the contaminants over time. The main drawbacks are the long time required for the process to work and the requirement for oxygen and added nutrients.

Remediation of herbaceous (i.e., marsh) and woody (i.e., swamp, mainly mangrove) vegetated shorelines does not have the same number of options as unvegetated shorelines. This is primarily due to the fragile nature of the vegetation which suffers from harsh remediation techniques. The basic action of sediment removal haw been shown to be damaging to marsh, slowing recovery (Baca et. al. 1987) and resulting in erosion. (Vandermeulen and Jocham 1986). In terms of cleanup, the no response option is frequently used, relying solely on bioremediation for recovery. Even cleanup options such as vacuuming or flushing must be used with caution and prior testing. Cutting of oiled marsh vegetation has been controversial, with most studies finding quicker recovery in uncut marsh (e.g., Baca et. al 1983, Hoff in Proffitt and Roscigno, 1995; exception in NOAA 1993). Questions also remain as to whether the burning of marsh can have long-term impacts. (Hoff in Proffitt and Roscigno, eds. 1995). Based on recent reports reviewed which address in-situ burning (Mendelssohn et al. 1995, Henry 1996) the option appears to have much promise as a marsh remediation (a.k.a. mitigation) technique.

Remediation of petroleum in mangrove-dominated shorelines may be even more difficult than in marshes, and many questions arise about when to cleanup and about the effects of bioremediation nutrients on mangroves and the mangrove community. Although many post-spill studies have been done, very little data exist on natural recovery and human-facilitated remediation in mangrove-dominated shorelines. A single controlled experiment with oil and dispersed oil showed that bioremediation in mangroves is a very slow process, requiring upwards of ten years for natural revegetation by mangroves (Dodge et al. 1993 and Baca et. al. 1996).

In a recent workshop (Proffitt and Roscigno, eds 1995) a panel provided guidelines for needed research in mangroves. One of the big questions was determining when effects had ended. Suggested end-point characteristics are given in the following section. Although beyond the scope of this project, a summary of oil spill effects on mangroves is given in Appendix E to correlate with and provide a background for the end-point research given here.

5.2.3 Effects Endpoints

The effects endpoints are derived from the following suite of morphological parameters developed from observations of the responses of mangroves to petrogenic compounds (Odum and Johannes 1975; Chan 1977; Page *et al.* 1979; Gundlach *et al.* 1979a,b; Lewis, 1979; Getter *et al.* 1980a,b; Hayes, Gundlach and Getter 1980; Getter, Snedaker and Brown 1980; Jagtap and Untawale 1980; Lugo, Cintron and Goenaga 1981; Snedaker, Jimenez and Brown 1981; Getter 1983; Ballou *et al.* 1987; Thomas 1987; Rielinger 1991; Quilici *et al.* 1995). These morphological effects endpoints are supplemented with physiological measurements including, but not limited to, leaf water potentials and chlorophyll fluorescence induction (Katusky effect). An * identifies those parameters best suited for use in short term experiments.

Responses of mangroves to petrogenic stress

<u>Foliage and Canopy</u>

reduced leaf number per branch
*reduced leaf size, twisting or curling
*increased variability in leaf size and shape
*altered leaf maturation sequences
change in leafing and shedding patterns
*abscission of buds and immature leaves
*spotty chlorosis or necrosis
reduced leaf area index

<u>Reproductive Structures</u>

absent or grossly excessive flowering
change in timing of flowering or fruit set
developmental failure of fruit
*abortion of flowers or immature fruit
deformed seeds or propagules

*failure to change floating orientation

Regeneration
*failure to establish primary root system
*failure to initiate primary branching
*failure in geotropic orientation in propagules
*abnormal growth forms in young seedlings
*chlorosis or necrosis of propagules

Trunks and Branches
top-dying and lowering of canopy height
mortality in outer-most sun branches
*cessation of terminal shoot growth
fissuring and cracking of bark
*expanded or more numerous lenticels
*shortened internode distances
appearance of trunk sprouts

Aerial Roots Structures
proliferation of undersized prop roots
twisting or curling of pneumatophores
*presence of adventitious aerial roots
*death of prop root tips
fissuring or pealing of periderm
*abnormal branching of prop root tips

Gross Physiology
*abnormal increase or decrease in osymolytes
*increased stomatal resistance - decreased stomatal conductance
*reduced transpiration and carbon dioxide uptake
*delayed chlorophyll activitation in response to light
*abnormal increase or decrease in respiration
*reduced rate of sap flow in primary trunk
*increased salt concentration in soft tissues, e.g., leaves
*increased tissue concentration of abscisic acid

5.2.4 Information and Technology Needed for Shoreline Remediation Activities

Recent ACPs were reviewed for Texas, Louisiana, Alabama-Mississippi, and Florida relative to shoreline remediation. In Texas, remediation procedures were addressed under shoreline cleanup techniques/strategies, and included sediment removal, flushing (various methods of washing), vacuum, sediment reworking, sediment removal- cleansing-replacement, and cutting vegetation. Low pressure washing and cutting vegetation were listed as applicable to marsh remediation. Methods requiring RRT approval included oil stabilization with elastomizers, chemical pre-treatment of beach shorelines, chemical cleaning of beaches, in-situ burning of shorelines, nutrient enhancement, and microbial addition.

Louisiana ACPs (e.g., Morgan City and New Orleans) contained Shoreline Cleanup Matrices under which remediation techniques were listed and evaluated, by oil categories and shoreline type. Oil categories were very light, light, medium, and heavy. Shoreline types were ranking from least sensitive (coastal structures) to most sensitive (e.g., swamps, marshes). Use of most remediation techniques were listed as "approved" or "possible" for least sensitive shorelines but "do not use" for most sensitive shorelines. Cold water (deluge) washing was the preferred method of oil removal, on vegetated shorelines, for light-to-heavy oils.

The Alabama/Mississippi ACP used a similar Shoreline Countermeasures Matrix; however, the "no action" option was the only one recommended for tidal flats and vegetated shorelines.

The ACP for the West Coast of Florida (MSO Tampa Area) covers shoreline remediation in a cursory manner. General strategies are provide for three generic shoreline types including marshes, tidal flats, and seagrass beds; sand beaches; and islands. The shoreline sensitivity summaries provided with the sensitivity maps provide broad guidance on shoreline protection strategies and oil collection points, but do not address remediation techniques. It is anticipated that further guidance will be provided through incorporation of the FMSAS GIS maps into the ACP.

Table 5.2. Remediation techniques which are not adequately tested, or for which additional information is needed, or which require new technology; summary is based on review of Gulf Coast ACPs and Proffitt and Roscigno, eds. (1995).

Remediation Technique	*Information Needed?*	*New Technology Needed?*
<u>From ACPs</u>		
Vegetation cutting	Y	N
Beach cleaners, chemical treatments	Y	Y
In-situ burning	Y	Y
Bioremediation	Y	Y
<u>From MMS</u>		
Soil washing	N	Y
Air stripping	Y	Y
Incineration/Burning (duplicate of above)	Y	Y
Bioremediation (duplicate of above)	Y	Y
Cutting (duplicate of above)	Y	N

Review of Gulf Coast ACPs indicated that information and/or technology was lacking for several remediation activities. A number of activities were not recommended because inadequate information was available on them or because technology had not advanced at the time of ACP preparation. Remediation techniques which, based on the ACPs, require additional data or technology are shown in Table 3.2. (Proffitt and Roscigno, eds. 1995). These techniques are discussed in the following section.

Vegetation Cutting

Although the majority of publications on this method show that it usually causes more impacts than leaving the marsh alone, there are a few exceptions. Careful cutting of marsh at the Canadian Liberty spill, in the Delaware River, did not result in obvious adverse impacts to marsh (Hoff in Proffitt and Roscigno 1995). The decision to cut was based on reducing impacts to birds which use the marsh. Because of the concern for wildlife, the cutting of severely oiled marsh may be a viable trade-off; however, further studies should be performed of previously cut sites, or by the use of experimental field plots, to determine the long-term effects on a variety of vegetation species and conditions. It appears that the simple technology of using monofilament line weeders is adequate to do the job.

Beach Cleaners, Chemicals

A variety of shoreline cleaning chemicals are available and in use. ACPs describe chemicals that may be used (with RRT approval) in advance of oil impacts and for oil removal (e.g., Southwest Louisiana-Southwest Texas ACP). Cleaning of weathered oil with weak dispersant would require testing before implementation to determine potential impacts to biota. To speed up the process, testing can be conducted on experimental plots using various petroleum products, chemicals, and substrate types. Besides this test information, data need to be assembled on the different chemicals and their effectiveness in various temperatures, salinities, sea states, and so on. The technology is continuing to advance in this area as new products are manufactured and tested.

In-Situ Burning

Burning of oiled, combustible materials (including marsh) has been the subject of much recent research, and this has added to a previously weak data base. A report on in-situ burning in wetlands (Mendelssohn et al. 1995), based on results of case studies, provided the following relevant conclusions/recommendations:

1) decision to use must be made on a case-by-case basis

2) should not be done if high water levels occur afterwards or if soil is exposed

3) should not be done in winter and (especially not) in summer

4) works better in freshwater marshes than saltwater or brackish marshes

5) can reduce species richness

These are listed because they provide an insight into information needs. Specifically, site-specific information can be obtained on the first four items, for areas at high risk from spills, in advance of spills. Further studies would be needed to answer questions about impacts on the biological community. The recommendations of a report panel (Proffitt and Rosignol, eds. 1995) for burning were that studies should be conducted to determine 1) the environment effects of the residue which remains and 2) factors which control the overall success of a burn. A recent study (Year 1 monitoring) of an in-situ burn of marsh in Louisiana (Henry 1996) answered some of the questions and concerns, and ongoing study of this burn site should answer others above. The main problem seen in this year 1 study was the inhibition of oil biodegradation, and the author suggested the need for additional studies in this area.

The information needs of this report are those given above by previous researchers, relying mainly on field experiments and followup studies of burn sites to obtain the information.

<u>Bioremediation</u>

This is an area where information has been gathered for many years and from countless spills. However, both new information and new technology are needed. Since actions which enhance bioremediation are undertaken primarily in wetlands and other sensitive areas which are difficult to clean, concerns about its use relate to these habitats. Concerns/questions include:

1) What is the potential for eutrophication in these habitats

2) What is the efficiency of remediation in low-oxygen sediments

3) What research is necessary to determine effects of varying oil types, marsh/sediment types, and physical conditions

Basically, research on accidental spills and experimental field trials is needed to answer basic questions about enhanced bioremediation. Work by Mendelssohn et. al. (<u>in</u> Proffitt and Roscigno, eds. 1995) outlines experimental methods under greenhouse bioremediation trials followed by field testing. The work of these and other researchers will provide ongoing information to evaluate bioremediation techniques.

Technology is also improving, but manufacture and testing is needed in both microbial seeding and fertilization products.

<u>Soil Washing</u>

Unlike most of the previous remediation practices which occur in sensitive shoreline habitats, soil washing with solvents, detergents and so on is used in treating excavated or non-environmentally sensitive substrates. Some research is needed in testing various chemicals and procedures; however, more efficient products are necessary which can work in deep or clay soils. Product availability and testing are similar to that needed in beach cleaners/chemical treatment previously discussed.

Air Stripping

The technology for various methods under this heading has improved greatly due to its use in contaminated gas stations as well as hydrocarbon spills. Research needs involve testing the efficiency of various equipment under varying hydrocarbon, water, temperature and other conditions. Also, research is needed in the use of air stripping in combination of other remediation methods. Lastly. technology is needed to operate in heavy soils, iron-bearing soils, and with less volatile hydrocarbons.

5.3 Development of Restoration and Remediation Manuals

Rationale

During the interview process, it was determined that a need existed for field manuals on restoration, and possibly, remediation. Responders and responsible parties wanted a manual that provided details on these practices which could be used during remediation or emergency restoration. A few manuals (handbooks) already exist on response and cleanup, and these are very popular because of their useful information, handy size, and low cost of production. A "Shoreline Restoration Manual", "Shoreline Remediation Manual", or combination "Shoreline Remediation and Restoration Manual" could be produced by a team of experts using available information, and printed by Sea Grant or the Corps of Engineers. Both groups have experience in production of such "how-to" manuals.

Similar Products

Several manuals are currently in use (e.g., API, in prep. and Exxon 1992), which contain many cleanup/response methods, including some which may be considered remediation. They either have been in use or are about to come into usage. Although it is not a handbook, the Sea Grant manual entitled An Introduction to Planting and Maintaining Selected Common Coastal Plants in Florida (Barnett and Crewz, eds. 1990). The manual contains an introduction to coastal communities followed by planting and maintenance guidelines for 17 coastal species (see example, Table 5.3), and illustrations of the species. In the example shown in Table 5.3, important characteristics are provided, as well as availability (a list of nurseries is also included with the manual), planting, and maintenance guidelines. Relevant literature is included so that the user can get more details, background, and references to the species given. Although the manual gives full-size pages for each species, Table 5.3 is reduced to show what might be the appearance in a handbook.

Table 5.3. Sample page from vegetation planting and maintenance manual (Barnett and Crewz, eds. 1990), reduced to field manual size.

Juncus roemerianus, bullrush, black needlerush PLANT CHARACTERISTICS Ecological Function/User Applications - shoreline protection and sediment stabilization; contribution to detrital-based food web; habitat for marine organisms; water-quality maintenance. Natural Geographic Distribution/Cold Hardiness - low-energy, coastal marshes; Maryland to Florida and Gulf states; rarer in south Florida; tolerates lowest temperatures throughout Florida; zones 2-7. Optimum Soil Type - saturated organic muck or sandy clay loam. Resistance to Erosion - fair; waterward edge subject to undermining. Potential Growth Rate - slow; several growing seasons required to attain coalescence of a fairly dense planting.
PLANT AVAILABILITY Nursery Sources - limited availability in two- and four-inch pots, one-gallon pots. Natural Sources - bare-root, plugs.
PLANTING GUIDELINES Elevation - MHW to high spring-tide levels. Ground Slope - up to 10 degrees (1 to 5). Depth - top of root-ball two inches below soil surface. Planting Window - March through November south of Tampa Bay/Cape Canaveral and April through October northward. Density - one foot O.C. for coalescence within one growing season, two feet O.C. will require considerably longer to coalesce.
MAINTENANCE GUIDELINES Watering - not required. Fertilization - some response to time-release, nitrogenous fertilizer incorporated when plants. Weeding - not required. Pruning - clipping results in temporary stand of green plants, reverting to grey-brown colors, mixed with green, within one to two months.

5.4 Development of a Historical Database for Shoreline Remediation and Restoration

Perhaps the best source of data on the effectiveness and impact of various shoreline remediaton and restoration techniques is the documented experience from past spills. As remediation and restoration actions are undertaken both in connection with major spills, and in some cases medium spills, the knowledge base is steadily growing. This is particularly true in the Gulf where the individual states have initiated monitoring programs at past spill sites along the coast (particularly in Louisiana and Texas). Unfortunately the results of these monitoring efforts are reported intermittantly in the scientific literature, and not in a concise format for easy reference during spill response. It is therefore suggested that a database be established summarizing the results of past shoreline remediation and restoration activities in the Gulf, as well as at spills around the world in environments that resemble Gulf coastal environments.

Such an Oil Spill Case Histories Database was compiled by NOAA HazMat and captured historical data for significant U.S. and international spills during the period 1967-1991 (NOAA, 1992). This database should be updated to include significant spills in the past five years, and sections added for shoreline remediation and restoration.

To make the database easy to update and readily accessible, it should be converted from hard copy and implemented on the World Wide Web. Software is now readily available which will allow rapid searching of the database, and inclusion of pictures and graphics. This would permit responders at the local level to quickly access data on past spills that are similar to the one that they are facing, and download the relevant information. Web software to implement such a web-based Spill Histories Database has been recently developed and tested by the University of Miami as part of the Oil Spill Information Management System (OSIMS) Development Effort.

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6.0 Case-Study of the Mobile Area Contingency Plan Review

6.1 Background and Goals

A summarization of existing contingency planning for remediation and restoration in the 7 GOM ACPs was provided in the preceding section. The present section builds upon the general findings of this review in a manner that is intended to guide federal and state agencies, resource trustees and responsible parties through the review and recommendation process. In doing so, a case-study of one of the seven Gulf of Mexico ACPs has been created to address the following goals:

- Assess the extent to which guidelines for remediation and restoration set forth by the NCP are followed by the ACP
- Provide a detailed review of the Area Committee's prodecures for specific remediation and restoration practices within the ACP
- Describe how the ACP currently relates to the Consensus Items (identified earlier in Section 3)
- Provide a set of recommendations which should aid in developing additional plans for remediation and restoration within the ACP

As has been emaphasized throughout this document, the intent here is not to criticize the ACP for its short-comings with respect to remediation and restoration, but simply to characterize the extent by which these aspects are, or could be, covered within the dynamic ACP process.

A review of the 7 ACPs in this study reveals a high degree of variation in both content and format. The nature of this variability is traced back to the open-ended nature of the National Contingency Plan as it sets no standard in format. Moreover, the NCP is intended to provide maximum flexibility in the ACPs owing to special needs (i.e., environmental sensitivities, management resources, threats, etc.) of each defined Area. Additional variations are due to the timing of plan updates (currently a 5-year cycle) with respect to the cycling of USCG personnel responsible for updating the plans. Therefore, without specific formats to be followed, the Mobile ACP is certainly expected to reflect a different individual's concept on every update cycle.

Though the Mobile Area Committee of Region IV does not face the same magnitude threat of Region VI (i.e., Texas and Louisiana Coasts), this ACP does serve a particularly useful function as a case-study. Firstly, the fact that this is not an extreme oil producing area means that the Mobile ACP is more likely to represent the 'average' plan – thus it will serve as a good model for reviewing most other plans. Secondly, within the Mobile Area there is a wide range of shoreline habitats ranging from the least sensitive vertical seawalls and bulkheads to extremely sensitive sheltered freshwater marshes – this yields a wide range of spill scenarios which should be planned for in a good ACP. Thirdly, the Mobile ACP encompasses shorelines of three state (MS, AL and FL) making coordination and planning of spill responses sensitive to varying state agency roles.

6.2 Coherence between Mobile ACP and the NCP

As prescribed by the National Contingency Plan (NCP) authorized under the Oil Pollution Act (1990), an Area Committee was established to create, maintain and update a combined Area Contingency Plan (formerly separate Alabama/Mississippi and Florida plans) for the coastal region of northwest Florida (west of Apalachicola), Alabama, and Mississippi (east of Long Beach). The designated Federal On-Scene Coordinator (FOSC) for this area is located at the USCG Port of Mobile – henceforth, this ACP is referred to as the 'Mobile' Plan. In accordance with OPA 1990, the Mobile ACP has undergone annual revisions up to 1997. After 1997, the Mobile ACP will undergo scheduled 5-year revisions. Given that an updated plan is forthcoming, the present review has been based on the latest (1997) iteration; and, where applicable, references to planned updates for the future have been made.

The USCG Marine Safety Office of Mobile is currently revising the response system to oil spills from one centered on the ACP itself to a Unified Command/Incident Command System (ICS) to cover decision-making and delineate responsibilities during a spill. The ICS is not prescribed by the National Contingency Plan. The ICS is intended to provide a response system that is focussed on tasks of individuals rather than on general strategy alone. Therefore, pertinent individual responsibilities as they relate to remediation and restoration are briefly described below:

I. Operations Section
Wildlife Branch Director - Tasked with minimizing wildlife losses *during the spill response only.*

II. Planning Section, Technical Specialists
Scientific Support Coordinator – Obtain a consensus with the Natural Resource Trust Agencies; Compile trajectory data, information on resources-at-risk, and available meteorological data to evaluate and prescribe alternative response technologies.
Geographical Information System Specialists – Provide updated map resources indicating spill patterns and trajectories.
'Resources-at-Risk Specialists – Identify resources thought to be at risk to oil exposure. These include natural, cultural and economic resources.
Sampling Specialists – Provide sampling plan; develop monitoring location coordinated with Scientific Support Coordinator and the NRDA representative.
Alternative Response Technology (ART) Specialists – Evaluate the opportunities to use ART given location and nature of the spill, weather and sea-state, and resources-at-risk. ART includes dispersants, in situ burning, and bioremediation.
National Resources Damage Assessment (NRDA) Representative – Coordinates assessment activities which meet NRDA and various trustee needs. OPA (1990) contains an element for the recovery of costs associated with damage to natural resources (including land, fish, wildlife, biota, air, and drinking water supplies). The assessment of damage to natural resources by NRDA trustees are intended to cover the costs of restoring, rehabilitating or replacing these damaged resources as well as costs due to devaluation of the resources while restoration is occurring.

III. Area Sensitivity Maps
In accordance with the NCP requirement, the Mobile ACP contains an annex identifying the sensitivity of areas with respect to Fish and Wildlife resources and habitats. The NCP requires that the ACP prioritize habitats and fish and wildlife species to be protected, rescued or rehabilitated in the event of a spill. The Mobile ACP utilizes the conventional format of the Environmental Sensitivity Index (ESI) maps. The NCP does not establish a format for the presentation of sensitive areas, therefore the Mobile ACP ESI maps are different in format than other ACPs around the Gulf of Mexico. The following is a brief description of the ESI maps and information associated with the Mobile ACP – it is not an evaluation of the effectiveness of these maps.

The Mobile ACP sensitivity atlases cover the three states (MS, AL and northwest Florida) in separate volumes. These ESI maps contain the traditional color-coded shoreline sensitivity index. These maps extend beyond convention by including additional reference material which can be used to make appropriate decisions for recovery operations. Each shoreline habitat type is described in detail (with color photographs) according to sediment type, vegetation type, tidal range and exposure. For each shoreline type, the ESI atlas presents the predicted oil behavior and the appropriate recovery considerations (incuding preferred methods and trafficability of the shoreline). These atlases do not cover non-conventional methods of recovery and remediation.

Each state is sub-divided into blocks with dimensions of approximately 7 km by 6 km on 11" x 17" laminated sheets (i.e., able to resolve small streams and bayous). In addition to shoreline type and sensitivity, each map is iconographically labeled to show biological resources by broad taxonomic grouping (i.e., pelagic birds, diving birds, shorebirds; alligators, snakes, turtles, etc.). On the reverse side of each map is a species list of important Fish and Wildlife located within that specific area. Also identified on these maps are the locations of submerged and emergent aquatic vegetation. Accompanying the species lists are identifiers for endangered or threatened status, concentration, seasonality (by month), nesting periods, larval/juvenile periods, migratory patterns and mating periods.

6.3 Review of the Area Committee's remediation and restoration practices within the Mobile ACP

In accordance with the NCP, priorities of the Mobile ACP include (1) protecting human life and health, (2) minimizing ecological impacts, and (3) minimizing economic and public impacts (in order of priority). The focus of the Mobile ACP is clearly at the level of incident response up to the point of shoreline cleanup:

> "In the effort to protect human life, the environment, and economic interests steps should be taken:
> (1) To stop further pollution at the source.
> (2) To contain the pollutant discharged.
> (3) To remove the product."

Coincidental with, or immediately following, the incident, the NRDA is to occur. While NRDA representatives may play a crucial role in prioritizing sensitive areas, the role of ICS is limited to the response phase itself and not to subsequent restoration activities.

6.3.1 Remediation

The Mobile ACP basically draws on five methods for the remediation of a catastrophic oil spill: (1) 'do nothing', (2) mechanical recovery, (3) dispersants, (4) bioremediation, (5) in-situ burning. The selection of the appropriate technique is dependent upon the type and amount of oil, the nature of the coast, the depth of oil penetration into the sediment, accessibility of the shoreline, and potential ecological damage due to the treatment itself. The Mobile ACP utilizes the Shoreline Countermeasures Matrix (NOAA Shorelines Countermeasures Manual, 1993). Under most circumstances of shoreline and oil types, the Mobile ACP recommends conventional methods of remediation (e.g., no action, manual removal, sorbents, trenching, washing vacuuming or cutting). Use of dispersants, in situ burning and bioremediation (by either microbial addition or nutrient addition) are possible under appropriate cir!cumstances. Guidelines for use of conventional countermeasures are covered in the companion 'Shoreline Countermeasures Manual'.

Pre-authorization: The NCP requires that the RRTs and Area Committees address the 'desirability' of dispersants, bioremediation agents, and burning agents, and that ACPs include plans for pre-authorization of these non-conventional methods. Pre-authorization plans should include the nature of the spilled oil, the nature of environmental sensitivity, the nature of products to be used (including their storage and application equipment), and the means by which the agents effectiveness will be monitored. The NCP does not require the OSC to monitor environmental resources during application of these agents.

Mechanical recovery: This remains the primary means of oil recovery and includes the use of pumps, skimmers, booms, earth-moving equipment, mechanical devices and sorbents. The specific mechanism of manual recovery depends largely on the shoreline habitat and the nature and type of spilled oil. Decision-making steps are included in the Mobile ACP and supplemented with habitat-specific information in the accompanying Environmental Sensitivity Index Atlases. *No pre-authorization is required for the use of mechanical recovery techniques.*

In Situ Burning: The RRT IV recognizes that in-situ burning of oil is often the best response to a catastrophic spill. However, careful planning and implementation are necessary, and thus the Mobile ACP contains detailed decision-making steps for the use of in-situ burning. Pre-authorization for in-situ burning exists within RRT IV; however, the USCG District 8 (MS, AL, northwest Florida) maintains a 3 mile limit to burning while USCG District 7 (southern Florida) restricts burning beyond 9 miles. However, even pre-approved in situ burn plans require authorization from the FOSC on a case-by-case basis. In situ burning along the MS/AL/FL coasts would be most applicable during a relatively narrow window of opportunity during winter when cold-front passage would keep harmful smoke products away from populated areas. In situ burning is unlikely either close to shore or during seasons when southerly winds would move smoke onshore. The Mobile ACP requires constant monitoring during the in-situ burn to evaluate the effectiveness of the burn and to assess risk to human health and safety.

Dispersants: The NCP requires that each Area Committee describe in detail procedures for the decision to use dispersants. The RRT IV has pre-authorized the use of chemical dispersants in offshore waters greater than 10 m depth and beyond 3 miles from shore. Approval of the use of dispersants within 3 miles and shallower than 10 m is on a case-by-case basis. A decision-tree for the use of dispersants is currently being developed by the Area Committee. Monitoring of environmental impact, required by law, does not fall under the purview of the USCG and would be contracted out.

Bioremediation: The Mobile ACP requires authorization from the FOSC in order to proceed with bioremedial steps (including fertilization, microbial seeding, enzyme additions and supplemental agents). Because of the longer response time required for bioremediation, this method is unlikely to be usable under time-critical circumstances. The Mobile ACP provides strict guidelines for the authorization, use and monitoring of bioremediation of spilled oil. One of the larger facilities in this region (Chevron U.S.A. of Pascagoula, MS) currently has an in-house bioremediation plan in effect. Maps indicating pre-approval locations and decision-trees for the use of bioremediation are currently being developed by the Area Committee.

6.3.2 Restoration

As indicated earlier in this document, the National Contingency Plan does not mandate restoration activities as a functional part of an oil spill response plan. However, it should also be emphasized that the NCP does not preclude the incorporation of restoration in ACPs. The Mobile ACP is well in line with other Gulf Coast ACPs in its very cursory treatment of restoration within the response plan: aspects of restoration are simply not viewed as a part of spill response.

<u>6.4 Consensus Items as Reflecetd by the Mobile ACP</u>

- ***Establish priorities for the protection of sensitive shorelines (including habitat and wildlife).***

Sensitivity of shoreline habitats and those Fish and Wildlife species (including threatened and endangered species) are well identified within the new ESI Atlas format. However, there are currently no guidelines for prioritizing specific habitats or wildlife for protection, rehabilitation or replacement. The USCG Marine Safety Office in Mobile recognizes that resources are limited and reaction time may be constrained in the event of a major spill. Ongoing communications with resource trustees are identifying and prioritizing those areas of special importance; however, these priorities are not yet part of the ACP.

<u>Recommendation:</u> Protection priorities could be worked into the map format of the existing ESI map annex without adding to complexity of the information. However, because priorities will likely shift from year to year, it is recommended that priorities remain a separate entity from the ESI atlases. Furthermore, planning for priority protection areas should be closely linked to the decision process of establishing

permanent boom anchors. No recommendations are provided beyond this as protection falls outside of remediation and restoration.

6.4.1 Items specific to remediation:

- ***Establish specific strategies for the remediation of sensitive shoreline environments.***

Specific conventional and non-conventional remediation strategies are covered in the form of a countermeasures vs. shorelines matrix based upon the template of NOAA's 'Shoreline Countermeasures Manual' (1993). These developing strategies are well explained in the most current iteration of the Mobile ACP.
Recommendation: None

- ***Provide for pre-approval of shoreline remediation techniques where it will expedite application and minimize damage.***

Pre-approval exists only for the application of in situ burning and dispersants in offshore environments. Even with RRT pre-authorization, use of these techniques still requires authorization from the FOSC. Pre-authorization of bioremediation agents is likely to provide little advantage owing to the longer time-frame of action.
Recommendation: Continue to develop pre-authorization plans for use of non-conventional remediation techniques onshore. Maintain mandatory authorization requirement of the FOSC.

- ***Establish protocols for the evaluation of the environmental effects of shoreline remediation and restoration options, including the "no removal" option.***

The NCP does not require Area Committees to evaluate or monitor environmental effects of remediation (or restoration) methodologies. However, the NCP does authorize (but not mandate) Area Committees to create set-aside plots for scientific utility. The Mobile ACP does not establish such evaluation protocols nor does it specify the role of set-aside plots in the event of a spill.
Recommendation: This is likely to remain a gray area within the domain of the ACP. Clearly there is a need to monitor environmental effects of chosen techniques in addition to monitoring the effectiveness of the technique. In reality the two are very related. Therefore it is recommended that the Area Committee expand the responsibilities of the Gulf Strike Team's Special Response Operations Monitoring Program (SROMP) to include environmental effects of the chosen remediation technique without extending itself into monitoring environmental impacts of the spill. Protocols for such monitoring should be established and placed into a companion document so as to minimize the size and complexity of the ACP.

- ***Develop protocols for test application of shoreline remediation techniques.***

It is required that any remediation technique (conventional and non-conventional) be monitored for its effectiveness. Therefore, it is expected that testing of a particular pre-approved method is adequate prior to its use. The Mobile ACP requires thorough documentation of the likelihood of success of a specific non-conventional technique prior to its authorization. Though specific protocols for test application do not exist, the

Mobile ACP requires documentation that the technology will most likely be effective.
Recommendation: The Mobile ACP has an inherent check safe-guarding against application of ineffective or exacerbating remediation techniques. No additional recommendation is made.

- ***Provide monitoring protocols for evaluating the effectiveness of shoreline remediation techniques.***

These protocols are covered under the auspices of the Gulf Strike Team's Special Response Operations Monitoring Program (SROMP). Their responsibility is to monitor effectiveness only (not health and safety). Reference to evaluating effectiveness areas is made within the Response Strategy Checklists (Annex J).
Recommendation: None.

- ***Establish procedures for designating "set aside" areas, where no remediation actions are taken, to facilitate evaluation of the effectiveness of remediation techniques which are utilized.***

Though authorized by the NCP, the Mobile ACP does not establish protocols for creating set aside areas. Reference to creating set aside areas is made within the Response Strategy Checklists (Annex J).
Recommendation: The creation of 'set aside' areas representing both impacted (i.e., oiled) habitat and proximally located unimpacted habitats should be a priority of spill response. Having both types of reference locations will facilitate decision-making with respect to effectiveness of a particular remediation technique, to terminating or extending recovery efforts, and to future restoration progress and habitat recovery. Future iterations of the Mobile ACP should develop protocols for establishing set aside areas.

- ***Establish procedures for the cleaning and rehabilitation of wildlife in the shoreline environment.***

The cleaning and rehabilitation of wildlife is the responsibility of the Wildlife Branch Director (see above) within the Incident Command System structure. While these protocols are not detailed within the body of the ACP, specific techniques are located in other documents.
Recommendation: None.

- ***Develop guidelines for terminating shoreline remediation (How Clean Is Clean criteria) and incorporate into the contingency planning process.***

No specific guidelines exist within the Mobile ACP for determining when remediation should be terminated. The only reference to recovery termination is within the Response Strategy Checklist (Annex J) which uses the step "Develop criteria/guidance for terminating cleanup". This indicates that termination is case-specific and the decision to terminate most likely is made on the basis of 'diminishing returns'.
Recommendation: In its current form, the decision-making process towards terminating a recovery/remediation effort is very ambiguous. While decisions to terminate or continue an effort are likely guided by many factors (including socio-political factors and public sentiment), a specific guideline used by the FOSC to decide when to terminate would be beneficial to all parties involved with spill recovery and remediation. A decision-tree

much like that used to decide specific techniques and strategies should be established with the ACP.

6.4.2 Items specific to emergency restoration

- ***Develop guidelines and protocols for emergency restoration and incorporate into the contingency planning process. Clarify roles and responsibilities of response agencies, responsible parties and resource trustees for initiating, performing and monitoring emergency restoration activities.***

In the Mobile ACP restoration falls outside the realm of spill response. While restoration activities may begin before remediation is complete, restoration is considered only as the last step of the Response Strategy Checklist (Annex J) and reflects the transition between spill response and habitat recovery or replacement. Emergency restoration, as a tool for stabilizing shoreline habitat or wildlife against immediate threats due to the spill (i.e., a response tool), is not covered within the Mobile ACP.
Recommendation: "Emergency restoration" should be treated as a response tool and, thus, included with other remedial techniques as a means to prevent further environmental damage. It is most critical that 'emergency restoration' be clearly defined as a technique and that a distinct line be drawn between the point when 'emergency restoration' ends and long-term habitat restoration begins. Therefore, like any other remedial technique, 'emergency restoration' should be held to the highest standards of authorization, implementation and monitoring.

- ***Develop protocols for test application of emergency restoration techniques.***

Emergency restoration is not covered within the Mobile ACP.
Recommendation: As a tool, 'emergency restoration' techniques should be thoroughly tested for effectiveness prior to their use in the field. Authorization of 'emergency restoration' techniques should include documentation of effectiveness by test application. Protocols should be established in a companion document.

- ***Develop monitoring guidelines for emergency restoration efforts.***

Emergency restoration is not covered within the Mobile ACP.
Recommendation: Strict guidelines should be established for the monitoring of any 'emergency restoration' activities. These guidelines should be developed and maintained under the auspices of the SROMP.

- ***Establish procedures for designating Aset aside≅ areas, where no restoration actions are taken, to facilitate evaluation of the effectiveness of restoration techniques which are utilized.***

Emergency restoration is not covered within the Mobile ACP.
Recommendation: Like other remedial techniques, the effectiveness of any 'emergency restoration' technique is best evaluated when compared against a reference 'set aside' area. The creation of 'set aside' areas representing both impacted (i.e., oiled) habitat and proximally located unimpacted habitats should be a priority of spill response. Having both types of reference locations will facilitate decision-making with respect to effectiveness of a particular restoration technique, to the decision for terminating or

extending emergency restoration efforts, and to future restoration progress and habitat recovery. Future iterations of the Mobile ACP should develop protocols for establishing set aside areas.

- ***Develop signoff criteria for determining when restoration actions are adequate and complete.***

Emergency restoration is not covered within the Mobile ACP.
Recommendation: This is likely to be the most critical aspect of 'emergency restoration' as there should be a clear stopping point in 'emergency restoration' efforts *regardless of whether the habitat is completely recovered or restored.* Very clear decision-making protocols must be in place such that there is no question about where the duties of the FOSC are distinct from long-term NRDA and scientific restoration activities.

6.4.3 Items specific to technical information:

- ***Provide information on shoreline morphology, resources and sensitivity to various types of oil that may be spilled. This information should be provided in map format.***

This information is well documented within the ESI Atlases for MS, AL and FL.
Recommendation: None.

- ***Compile technical information of remediation technologies including suitability by shoreline type, implementation criteria, anticipated removal effectiveness and impact on the shoreline. To control the size of contingency plans, this information should be provided as readily accessible supplemental data.***

The Mobile ACP has compiled the removal technique by shoreline type and oil type within the Countermeasures Matrix described above. However, information on implementation criteria, effectiveness and shoreline impact is located separately from this information within both the ACP itself and the accompanying ESI Atlases.
Recommendation: Compile information in a companion document.

- ***Provide technical information on the capture, transport and rehabilitation of oiled wildlife.***

This information is not covered within the Mobile ACP.
Recommendation: Compile information in a companion document.

- ***Compile technical information to aid in determining if emergency restoration should be undertaken including long-term persistence and toxicity of the oil, and natural recovery times for different oils in the various shoreline environments.***

These data are not compiled within the Mobile ACP, though the information certainly exists in other documents readily available to the decision-making process.
Recommendation: Compile information in a companion document.

- ***Compile information on the suitability, implementation procedures and anticipated positive and negative impacts of various restoration techniques. To control the size***

of contingency plans, this information should be provided as readily accessible supplemental data.

This information, compiled in a format suitable to field operations, exists in other published documents for other locations. Otherwise, information is accessible from the primary literature.

Recommendation: Compile information in a companion document.

6.5 Summary

The National Contingency Plan establishes no standard format that Area Committees must follow in creating Area Contingency Plans. Because of this lack of standard format, the seven ACPs reviewed in this study show a great deal of variability over both format and content. It is, therefore, necessary to step through the process of a detailed review of one of the Gulf Coast ACPs. We have chosen, as a case-study, the ACP for the 8th USCG District (Region IV) Area Committee (Mobile, Alabama) covering most of coastal Mississippi, Alabama, and northwest Florida. The Mobile ACP follows the USCG Unified Command / Incident Command System structure, thus emphasizing spill response at the level of personnel responsibilities.

The Mobile ACP was reviewed with respect to remediation and restoration. Specifically, the plan was evaluated for completeness within the expectations, authorizations and requirements established by the NCP. In accordance with the NCP, the Mobile ACP presents area sensitivity maps in the format of a three-volume ESI atlas that references shoreline type, oil behavior and recommended remediation techniques. The maps also overlay species distributions and seasonality of species and habits (e.g., mating, nesting, larval occurrences, etc.). Also, we found that special emphasis is made on the decision-making process to authorizing and using non-conventional remediation techniques (i.e., in situ burning, dispersants, and bioremediation). As there is currently no utilization of "emergency restoration" within spill response activities, this technique was evaluated on the basis of whether it could or could not be effective as a tool during a spill response. Each of the Consensus Items derived in the previous section was evaluated with respect to the Mobile ACP. Recommendations have been offered to strengthen the Mobile ACP based upon the review findings.

6.6 References

NOAA (1993). Shoreline Countermeasures Manual. Tropical Coastal Environments. NOAA Hazardous Materials Response and Assessment Division. 80 pp.

Chevron U.S.A. (1992). Bioremediation plan, Chevron U.S.A. Products Company, Pascagoula Refinery. 31 pp.

USCG (1997). Northwest Florida and Mississippi and Alabama Area Contingency Plan.

National Contingency Plan, 40 CFR, Part 300.

7.0 GIS and Risk Assessment Linkages to Improve ACPs

7.1 Introduction to Risk-Based Analysis

A number of Geographic Information Systems (GIS) applications exist in contingency planning. In fact, GIS is often seen as the most important development in assuring usefulness, updating, and application of contingency plans. A side project of this work was to look at GIS use in contingency planning as it relates to quantitative risk assessment, an important aspect of contingency planning.

Federal and State agencies have recently advocated risk-based analysis as a mechanism for advancing regulatory reform and safety determination in marine systems (Karaszewski 1996 and Garrick 1996). However, ACP risk assessments, which influence protection strategies, spill drills, and the location of response equipment, although required, are rarely quantitative (Iakovou et al. 1996). Instead, these planning measures are often generated from local knowledge of general shipping volumes and spill incidents.

Quantitative risk assessment (QRA) models, also called paradigms, attempt to provide a scientific basis for determining management practices (Liming 1996). Science-based risk analysis techniques were first employed in the early 1970's when the US Environmental Protection Agency (EPA) and Nuclear Regulatory Commission (NRC) sought to quantify the risks to human health and the environment from particular chemicals and substances (Karaszewski 1996). Within the context of the oil industry, risk analysis is used to predict potential systems failure, enhance human safety, and maintain regulatory compliance, among other concerns. The federal government also uses QRA's to grant and evaluate ocean drilling licenses and to estimate program costs. To a modest and inconsistent degree (Benggio, personal communication, Nov. 96), quantitative risk analyses are used in constructing oil spill scenarios for Area Contingency Plans and in developing environmental protection strategies. Components of the analysis may include (1) the oil transport volume, (2) frequency of transport, (3) type of oil, and (4) the proximity of the route to sensitive natural resources.

7.2 Risk Analysis in Contingency Planning

Under the auspices of the Ports and Waterways Safety Act of 1972, the USCG Marine Safety Manual, and the USCG Business Plan for Marine Safety and Environmental Protection, port commanders are required to assess and maintain acceptable levels of risks in the ports and waterways within their area of responsibility (Card 1996).

In conducting contingency plan evaluations consistent with The Oil Pollution Act of 1990 (OPA '90), Title VII, § 5(A), the US Coast Guard recognized a need for the design and implementation of a generic system for port risk assessment, forming the basis for contingency plan development. The standardized approach to this planning element would allow for quantitative comparisons of risk between different port settings irrespective of port size, volume traffic, and other peculiarities and would aid in the development of risk reduction techniques. The Coast Guard also initiated the crafting of a strategic plan to educate personnel in risk application techniques and for steering the implementation of risk-based methods. In a brief article stating the Coast Guard's position on risk analysis, Rear Admiral Card (Card 1996) reported:

"It's absolutely essential that we become more adept at systematically identifying and quantifying risk. A risk-based approach is critical to achieving a higher degree of marine safety and environmental protection within available resource constraints and without stifling competition or innovation."

The present investigation promotes this objective through the development of risk-based planning strategies for oil spill contingency plans; its purpose, to provide planners with an objective basis for determining environmental management strategies (first proposed by Ives et al. 1997). This alternative approach to environmental contingency planning departs from conventional means by employing quantitative risk assessment methodology to first identify, and then combine, hazardous oil spill zones with sensitive environmental areas. The product of this coalescence, produced by this research, is referenced on a single "Risk" layer within a Geographic Information Systems (GIS) framework, allowing coastal managers to simultaneously evaluate natural resource data with associated elements of oil spill risk.

7.3 Methods

7.3.1 Framework and Development

The framework of this investigation was developed following interviews with Gulf coast oil spill professionals including federal and state agency representatives, industry specialists, and academians, who voiced concerns over the present lack of standardization for ranking resource protection priorities, developing protection strategies, and selecting oil spill drill locations. The resulting dialogue indicated that a model containing a scientific rationale for drafting environmental management strategies would be beneficial not only to contingency planners but would reflect positively on marine and environmental safety.

The framework for an environmental component for port risk assessments was designed to address the following considerations brought to light by the oil spill professionals interviewed: (1) a simplified yet standardized, quantitative approach for assessing oil spill and environmental risk was sought because complex evaluations can over-work the planner and tax resources, (2) the degree of response and planning assets are usually limited and therefore require obtainable (both financial and physical) resources, (3) the ability for managers to update database information as need requires, and (4) integration potential with existing oil spill information systems.

The environmental risk component consists of two parts: (1) a GIS database with natural resource and habitat coverages (layers), and (2) historical oil spill data. When the two parts are combined into the environmental risk component (as modeled in the study), risk-based environmental planning strategies can be performed.

7.3.2 Study Area

Tampa Bay, Florida was chosen as the study site out of convenience for data collection. The proposed model can be applied to Area Contingency Plans of any region where the pertinent oil spill and natural resource information is accessible. Florida's Department of Environmental Protection (DEP) Florida Marine Research Institute (FMRI) made their GIS coverages for the Tampa Bay region available. The Tampa plan breaks down spill history into monthly spills with a percentage of mystery cases; oil spills where the responsible party was not identified. Area spill histories also provide the volume of an average oil spill and its most probable cause. The Tampa plan reports an average spill of 10 to 25 gallons, most likely being marine gasoline or number two diesel fuel. The sources of the average spills are most likely to result from bilge pumping, improper fueling operations, sunken vessels, and ruptured transfer hoses.

The Sensitive areas section of the Tampa plan provides information regarding the: (1) setting of protection priorities, (2) use of dispersants, (3) archaeological and tribal use areas, and (4) sensitive habitats and species. Together, the Strategies and Sensitive areas sections represent the textual body of environmental protection in the ACP.

Natural and economic resources vary in their susceptibility to damage from oil spills. Typically, the more susceptible the resource, the higher its protection priority. In emergency situations, decision-makers consult contingency plans to determine what resources to protect in priority order. The Tampa Plan provides a ranking of resources in terms of high, medium, and low priorities for protection (Table 7.1). Area Response Plan Maps in the Tampa Plan display the rankings by designating high priority areas with triple diamond icons (Figure 7.1). The Tampa Plan provides flexible guidelines for clean-up and mitigation procedures. The plan notes that if oil reaches the most sensitive shorelines (mangroves or sheltered tidal flats) clean-up is not recommended for fear of further entrainment of the oil into the substratum.

Mangroves, seagrass beds, tidal flats, and sandy beaches are the sensitive habitats specifically addressed by the Tampa Plan. The plan explains why these areas are ecologically significant and makes general recommendations on how to protect them. Cleanup methods for exposed and sheltered sandy beaches are also suggested.

This study focused on the generation of risk-based environmental planning strategies for oil spill contingency plans. In establishing this methodology, four subtasks were identified as necessary for the completion of project objectives: (1) Database acquisition, (2) ESI condensation, (3) Risk assessment, and (4) Final evaluation.

Table 7.1 Protection priorities in the Tampa ACP (ACP for Oil and Hazardous Substances Pollution Response, MSO Tampa 1996)

High (A)	Protection of public health Exposed tidal flats and shallow seagrass (< 1 meter) and oyster beds Fringe mangrove forests Public drinking water intakes Industrial water supplies potentially impacting public needs and/or safety Endangered or threatened species and their habitats Seasonal breeding, spawning, foraging, nesting, and migratory resting areas Mangroves (large area/extensive forests and salt marshes) National parks, Monuments, Seashores, Estuarine Reserves State and County Parks, National and State wildlife refuges, State recreational areas and fisheries
Medium (B)	Sheltered rocky shores and seawalls with riprap All other beaches
Low (C)	Public parks without sensitive shorelines Recreational areas without sensitive shorelines Facilities Storm drain outlets Industrial water supply not impacting public needs and/or safety Other tourist/recreational areas Exposed vertical rocky shores and seawalls without riprap Other developed land Industrial facilities

7.3.3 Database acquisition

Oil spill and natural resource database and habitat coverages were obtained from various private and state institutions, discussed as follows:

- Oil spill information was obtained from the South Florida Oil Spill Research Center (SFOSRC) of the University of Miami, and the US Coast Guard. The Coast Guard Marine Safety Information Systems (MSIS) database, housing all technical information on oil spills occurring in the Gulf of Mexico, was obtained and edited to reflect the study area, Tampa Bay, Florida. The database stores information such as: the spill incident name and date, the latitude and longitude of the spill, nature of the incident and its environmental impact mode, and when available, the volume of product lost, among other spill incident characteristics.

- Natural resource and habitat coverages for Tampa Bay were provided by the Florida Marine Research Institute (FMRI) and the US Coast Guard. ArcInfo coverages: base map, ESI, manatee, seagrass, and oil spill coverages were obtained and imported into ArcView® 2.1 and edited to produce the necessary output coverages, as needed.

To make risk-based environmental strategies an efficient planning tool, the original 10+ ESI shorelines normally used to generate Area Response Plan Maps (Figure 7.2) were condensed and grouped into five new categories: high priority (red), medium-high, medium, medium-low, and low priority (pink) shorelines, or ecotypes (Figure 7.3 and Table 7.2). This was accomplished by editing the GIS database. The ESI layer legend that stored the original shoreline designations was replaced with the new ESI conversions (a five-point as opposed to the traditional ten-point scale). In cases where shorelines were denoted by two numbers (i.e.,10E/6 or 3/8) the ecotype was placed into the highest condensed group, corresponding to the higher of the split designations. For instance, a shoreline designated 10E/6 was placed into the *high priority* category. This was done to afford the shoreline the greatest level of protection. The reconfigured ESI legend was then entered back into the GIS database; the ESI layer (and maps produced therefrom) reflect the changes made.

Once the categories were condensed, they were color-coded for visual identification. This process, facilitated through the use of ArcView® software, would later aid in R_e determination.

Table 7.2 Condensation of 10+ Tampa ESI categories into five more usable ones.

ESI SHORELINE DESIGNATION	SHORELINE ":ECOTYPE"	NEW ESI CATEGORIES	PRIORITY
10E	sheltered mangroves and marshes	5	High
10A	exposed mangroves and marshes	5	
9	sheltered tidal flats	5	
8	sheltered rocks/seawalls/vegetated banks	4	Medium High
7	exposed tidal flats	4	
6	gravel beaches/riprap	3	Medium
5	mixed sand and gravel beaches	3	
4	coarse grained sand beaches	2	Low/Medium
3	fine sand beaches	2	
2	exposed rocky platforms	1	Low
1	exposed vertical rocky shores/seawalls	1	

7.3.4 Oil Spill Risk Determination

The model for an environmental component for port risk assessments is based on the computation of two independent risk values, R_o and R_e, oil spill and environmental risk, respectively. It needs to be noted that this is an experimental model developed for testing only; improvements and testing are ongoing. The first step in risk value determination was to establish quantitative methodology for procuring a single risk value from historical oil spill frequency and volume data, the sole criteria for R_o determination. Output from this computation establishes the oil spill risk zone magnitude, the areas within which natural resources are quantified and evaluated.

Historical oil spill frequency and volume data were evaluated using Equation (1),

$$Eq.\ (1):\ R_o = Laf * Lav,$$

where Laf (Log adjusted frequency) = $\log[(freq/5)/n_f]+1$ and Lav (Log adjusted volume) = $\log(vol/n_v)$ were used to yield the oil spill risk value, Ro. The frequency and volume variables, n_f and n_v respectively, refer to the number of oil spills over a five year period per location and the amount spilled per incident, respectively. A $\log_{10}$ scale was used to normalize data in the computation because of the wide range of oil spill volumes, 10 - > 1,000,000 gallons. The *n-term* in the Laf and Lav equations represents a scaled weight factor designed to give greater emphasis to higher oil spill frequencies and volumes. The magnitude of R_o then defined the circumference of the oil spill risk zone; the zone radii increasing one quarter mile for every increment of four risk values. Oil spill frequency and volume raw data per latitude/longitude, and the subsequent R_o determination appear in Table 7.3. Risk contours were also developed to illustrate the relationship between oil spill frequency and volume data and R_o determination. The significance of risk contours is discussed later.

Table 7.3 Oil spill frequency and volume data adjusted to yield risk value R.

Lat/Long	Frequency	Laf	Volume(gal)	Lav	Oil spill risk value, R.
27.95, 82.43	63	3.1	78000	5.415	16.787
27.91, 32.43	57	3.057	50570	5.228	15.982
27.91, 82.41	22	1.865	29100	6.163	11.494
27.90, 82.41	58	3.064	1080	3.431	10.513
27.90, 82.43	28	1.97	24260	4.907	9.667
27.86, 82.53	21	1.778	30210	5.003	8.895
27.91, 82.58	16	1.66	35000	5.067	8.411
27.93, 82.45	21	1.778	9210	4.362	7.755
27.75, 82.62	31	2.093	310	2.792	5.844
27.71, 82.71	28	1.97	280	2.748	5.414

7.3.5 Environmental Risk Determination

Environmental risk values (R_e) were computed by quantifying the natural resources that fall within the oil spill risk zones. Equation (2) is a summary of the method for determining R_e,

$$Eq.\ (2):\ R_e = Lal + Las + Lam,$$

where: Lal (Log adjusted length) = $\log[\Sigma(ESI|1...5|/n_{|1...5|})]$ is the adjusted shoreline distance in feet; Las (Log adjusted seagrass) = $[\log(sea\%/n_s)]$, is the percentage of seagrass coverage; and Lam (Log adjusted manatee) = $\{\log[(man/5)/n_m]+1\}$ is the number of sightings of manatees in the area.

The method for calculating the shoreline component (Lal) of the environmental risk value (R_e) involved a relatively simple procedure making use of GIS's analytical capabilities, specifically the segment length function. Shoreline lengths falling within each oil spill risk zone were measured (risk zones occurring in the middle of Tampa Bay away from shorelines did not incorporate this element.) This was facilitated by color-coded shorelines; for instance, each high priority, red-colored shoreline was measured, if there was more than one shoreline segment in an individual risk zone then the lengths were summed for a total. Measurements were made in this manner for each of the five priority shorelines. Table 7.4 demonstrates how for georeferenced (referenced by latitude/longitude) risk zones, shoreline segment lengths were measured (in feet) according to the priority classification. The total shoreline segment length for each class was then adjusted using the appropriate scaled weight factor and calculated to yield Lal.

The method for calculating the seagrass component (Las) of the environmental risk value followed a similar procedure to that of determining Lal. The first step was to determine the area of the oil spill risk zone. This was accomplished by another measuring function of ArcView® software. The radii of the risk zones were measured (in feet), and using the standard equation, $A = \pi r^2$, for calculating the area of a circle, the area of the risk zones were determined (Figure 7.4). Because of the way basemap and oil spill coverages are viewed simultaneously portions of some risk zones appeared on land (Figure 7.5). These portions were subtracted out of the total area of the risk zone when calculating R_e. The area of seagrass bed coverage was then measured and converted into a percentage of the total area of the risk zone. The percentage was then adjusted using the appropriate scaled weight factor to yield the Las value.

A manatee component (Lam) was considered for use in calculating the environmental risk value. Because manatee data were taken over a five year period, the total number of manatees appearing in any one oil spill risk zone was divided by five to yield the frequency of manatee sightings per year (Figure 7.6). This value was adjusted according to the proper scaled weight factor to give the Lam value.

Table 7.4 ESI classification of shoreline segment lengths with associated Lat value.

	ESI segment length (ft):					
Lat/Long	ESI 1	ESI 2	ESI 3	ESI 4	ESI 5	Lat
27.95, 82.43	0	0	8987	13217	16265	5.413
27.91, 82.43	1257	534	0	16143	8673	5.227
27.91, 82.41	0	0	9194	8976	6543	5.153
27.90, 82.41	0	0	221	3752	10824	5.106
27.90, 82.43	1674	0	14574	8514	2732	5.083
27.86, 82.53	0	790	1891	1794	9973	5.088
27.91, 82.58	0	657	2905	3898	8466	5.062
27.93, 82.45	0	2373	2702	19840	0	5.057
27.75. 82.62	910	0	0	10244	4045	4.962
27.71, 82.71	0	0	11783	0	3217	4.874

Final evaluation consisted of applying the model for an environmental risk component (represented by R_o and R_e determination) for port risk assessments to the process of contingency planning. The procedure included taking various aspects of the contingency planning process (i.e., the development of protection strategies, resource prioritization, etc.) and comparing them against both traditional assessments of oil spill and environmental risk (as presented in ACP Area Response Plan Maps), and alternative risk-based planning strategies developed as a result of the present study.

7.4 Results and Discussion

7.4.1 Primary Usage

Risk-based planning allows environmental managers to identify oil spill protection priorities. When two regions are of equal environmental importance, oil spill risk defines protection priority. When two regions are at equal risk from oil spills, economic/environmental sensitivity defines protection priority. Figures 7.4 and 7.6 illustrate the usefulness of risk-based planning measures with respect to prioritizing areas and resources for protection. Figure 7.4 (note the Las value) depicts three areas (A, B, and C) of similar seagrass coverage. Compare this illustration to Figure 7.1 from an Area Response Plan Map (ARPM) of the Tampa Bay ACP. The Area Response Plan Map does not make a quantitative evaluation of coastal resources. Seagrass distribution is absent from the diagram as are the ESI shorelines. If responders had only enough resources to rank two of the three seagrass beds for protection, the risk-based planning map could provide rationale for making the decision. The area of highest seagrass coverage in the zones of highest oil spill risk will assume priority over other seagrass resources. Area C, having a comparable Las value to those of Areas A and B, has a negligible R_o value. For this reason, Area C, although it may be an important seagrass resource, will not be prioritized for protection. Area Response Plan Maps cannot make this distinction without a quantitative evaluation of oil spill and environmental risk.

Similarly, when different regions are of equal oil spill risk (Figure 7.6 Areas A, B, and C; note R_o and R_e values) the quantitative evaluation of natural resources helps define protection priority. In the case of Figure 7.6, environmental managers can view the map and identify objective rationale for determining resource protection priorities; the rationale being three areas of equal oil spill risk having different environmental risk values. Objectivity would thus mandate Area A have the highest priority for protection, having the highest R_e value. In this manner, a quantitative assessment of oil spill and environmental risk provides objective rationale for prioritizing resource protection. This type of evaluation is not possible with conventional Area Response Plan Maps.

Quantitative evaluations of sensitive resources falling within oil spill risk zones will permit planners to develop environmental protection strategies catered to the specific needs of each identifiable risk zone. The GIS framework permits managers to query risk zones for the amount and kind of petroleum spilled as well as the abundance of natural resources in the area. In this manner, managers can estimate and plan for the equipment needed to protect and clean natural resources within defined risk zones.

Protection strategies with respect to ESI shorelines exemplify this point. Area Response Plan Maps do not classify shorelines (see Figure 7.1) according to the environmental sensitivity index. Instead, icons are placed in the general vicinity of a shoreline resource. This procedure makes only a vague allusion to the location and type of shoreline encountered during the planning stages of spill response. For instance, the *Tidal flats* in the center of Figure 7.1 make no reference to the specific flat ecotype (e.g., mud flat, sand bottom, seagrass bed); and protection strategy may depend upon this classification. Dispersant use is generally not recommended in shallow water, particularly over seagrass beds; however, if the flats were to be identified as sand, dispersant use may be considered. Therefore, the non-description of tidal flats in Figure 7.1, and in ARPM's in general, make planning for seagrass protection nearly impossible. As Figure 7.4 indicates, the tidal flat is in fact composed of seagrass beds.

The tidal flat ecotype, being positively identified through the use of GIS, allows for the analytical assessment of areas covered by a particular natural resource. This will aid in more specific protection strategies; for instance, measurement of seagrass bed coverage may help planners determine the length of protective boom to dedicate to one specific region. Similarly, knowing the length of a particular shoreline ecotype may allow planners assign oil collection points more efficiently. In this manner, a more accurate assessment of response resources can be determined, assisting in the development of protection strategies.

7.4.2 Other Applications

Designation of Pre-staging Areas

Based on quantitative analysis of oil spill and environmental risk, planners can identify the areas most likely to be impacted from oil spills and pre-stage response and clean-up equipment accordingly. Such stations should be designated in areas of both high wildlife concentration and oil spill risk. Figure 7.7 demonstrates this point. In the figure, several risk zones lie within a three mile radius of one another. Also shown is a region of heightened manatee occurrence. If the planning task is to identify an efficient location for a response station, the risk-based planning map can accomplish this with objectivity. The preferred location based on the described criteria would be Area A or B. Both positions are central to the five other risk zones and is in an area frequented by manatees. Area Response Plan Maps, without having a quantitative assessment of manatee occurrence and oil spill risk, cannot designate pre-staging areas and stations in this manner.

Updating Information

The GIS database framework supplies the user with a simple means for entering new data pertaining to oil spills and natural resources as the information becomes available. For instance, if a region of Tampa Bay were to experience increased vessel traffic leading to more frequent releases of oil, the information could be added to a GIS database and instantly recalculate the magnitude and position of oil spill risk zones. Presumably, as the oil spill risk zone increases it will encompass a greater number of natural resources; so too will the R_e value change. Similarly, if a marsh area was destroyed or mitigated, updates to the database would result in a automatic modification of the R_e value. In this manner, as new data changes the magnitude of oil spill and environmental risk, ACP planning elements such as resource prioritization and protection strategies can be amended as needed.

Information System Integration

Risk-based environmental planning strategies in a GIS framework promote integration with existing oil spill information systems. The three most prominent oil spill information systems (1) Gulf-Wide Information Systems (G-WIS), (2) Oil Spill Information Management System (OSIMS), and (3) the Minerals Management Service's Gulf Region GIS Database for Oil Spill Contingency Planning (Penland et.al. 1995) use GIS as the backbone of their analytical capabilities ((1) *http://flotant.csi.lsu.edu/* and (2) *http://exxon.eng.miami.edu/presentation/osims/*, for G-WIS and OSIMS, respectively). If integrated with any system, the usefulness of risk-based planning would be greatly augmented. For instance, these information systems provide rationale for assigning protection weights to natural resources. They also supply background ecological data for natural resources upon which management decisions can be made. Also important are the Internet links to other oil spill planning and response resources. FMRI recently published a pamphlet (ESRI 1996) on the development of the Florida Marine Spill Analysis System (FMSAS). Its GIS capabilities allow users to perform analyses, generate maps and reports, and in general, manage oil spill information for coastal Florida. FMSAS even provides cultural data sets for consideration when planning oil spill response strategies. In this manner, the utilization of GIS technology far exceeds the limitations of traditional ESI mapping programs. The integration potential for risk-based planning strategies with these and other data management systems will permit environmental planners greater access to supplemental information when formulating contingency plans.

7.5 Recommendations

A model for an environmental risk component for port risk assessments has been created by applying quantitative risk assessment techniques to historical oil spill frequency and volume, and natural resource data, and by modifying GIS coverages. Risk-based environmental management strategies, generated as a result of the present study, have been effective in creating a framework with which to standardize the approach towards environmental management in oil spill contingency plans.

The US Coast Guard has made a commitment to bring risk-based analysis to the forefront of marine safety and environmental protection (Card 1996, Karaszewski 1996, and Modarres 1996). The present study has promoted and furthered this national objective by exploring alternative risk assessment techniques for oil spill contingency plans. While the investigation only considered environmental concerns using historical data as the primary predictor, other areas of interest and possible application for the proposed framework would include environmental risk assessments for vessel collisions and groundings with navigational hazards.

At the national level of oil spill planning and response, risk-based analysis leading to environmental management strategies for entire regions is practical for the same reasons stated throughout this study. Existing oil spill databases and developing natural resource coverages would satisfy all information requirements.

Continue research on quantitative risk assessment, based on the preliminary results of this study, is recommended. Separation of the catastrophic oil spills from the localized areas of chronic oil spillage would be a next step. This may give a more accurate assessment of both the oil spill and environmental risk value. Investigation into the feasibility of expanding the present framework for adaptation to larger regional areas, and to include spill transportation data, are also recommended.

7.6 References

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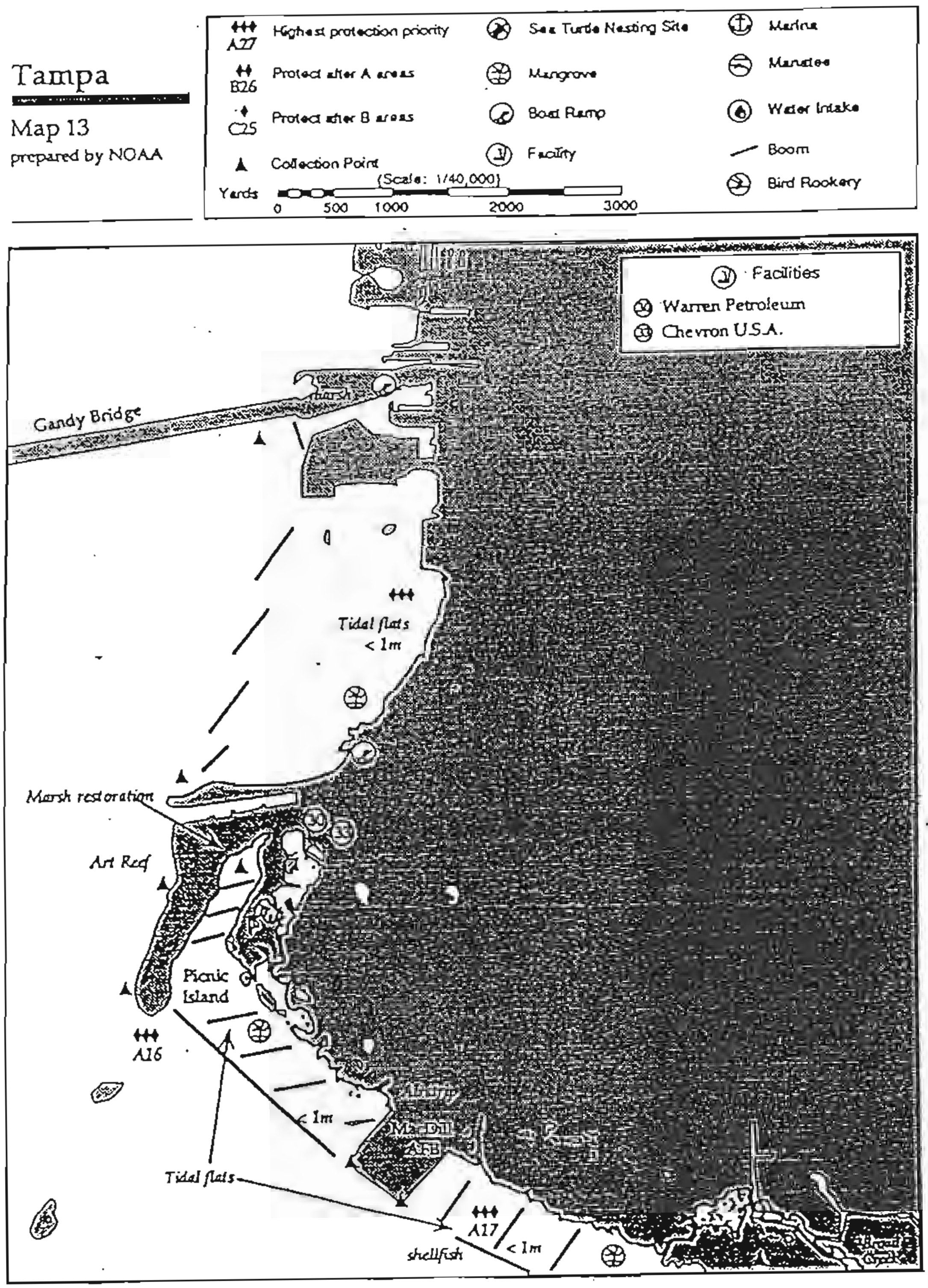


Figure 7.1 Area response plan map depicting protection priorities and natural resources (ACP for Oil and Hazardous Substance Pollution Response, MSO Tampa Bay 1996).

Figure 7.2 Shoreline ESI categories for Tampa Bay (FMRI coverage 1996).

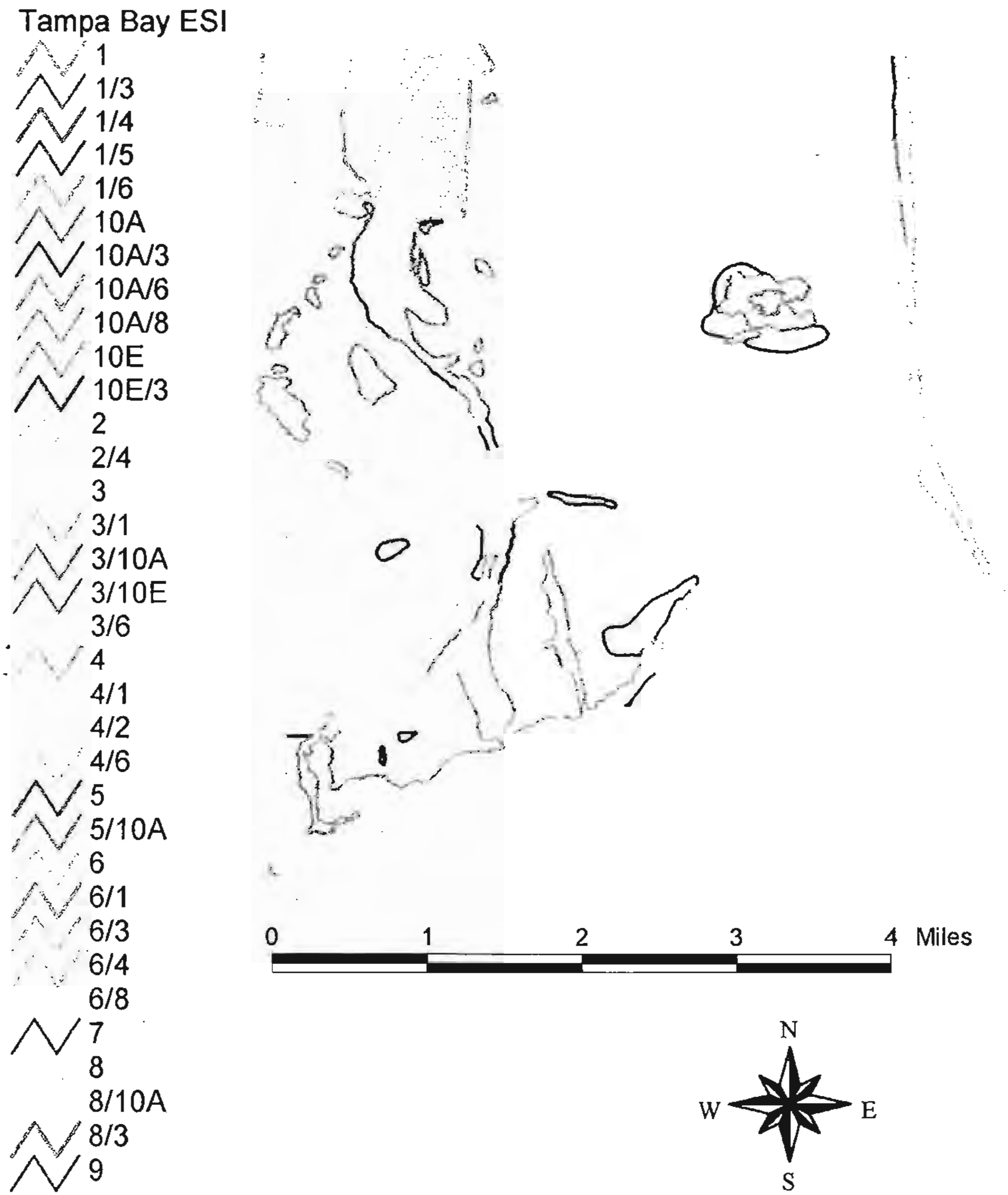


Figure 7.3 Condensed Tampa Bay shoreline categories.

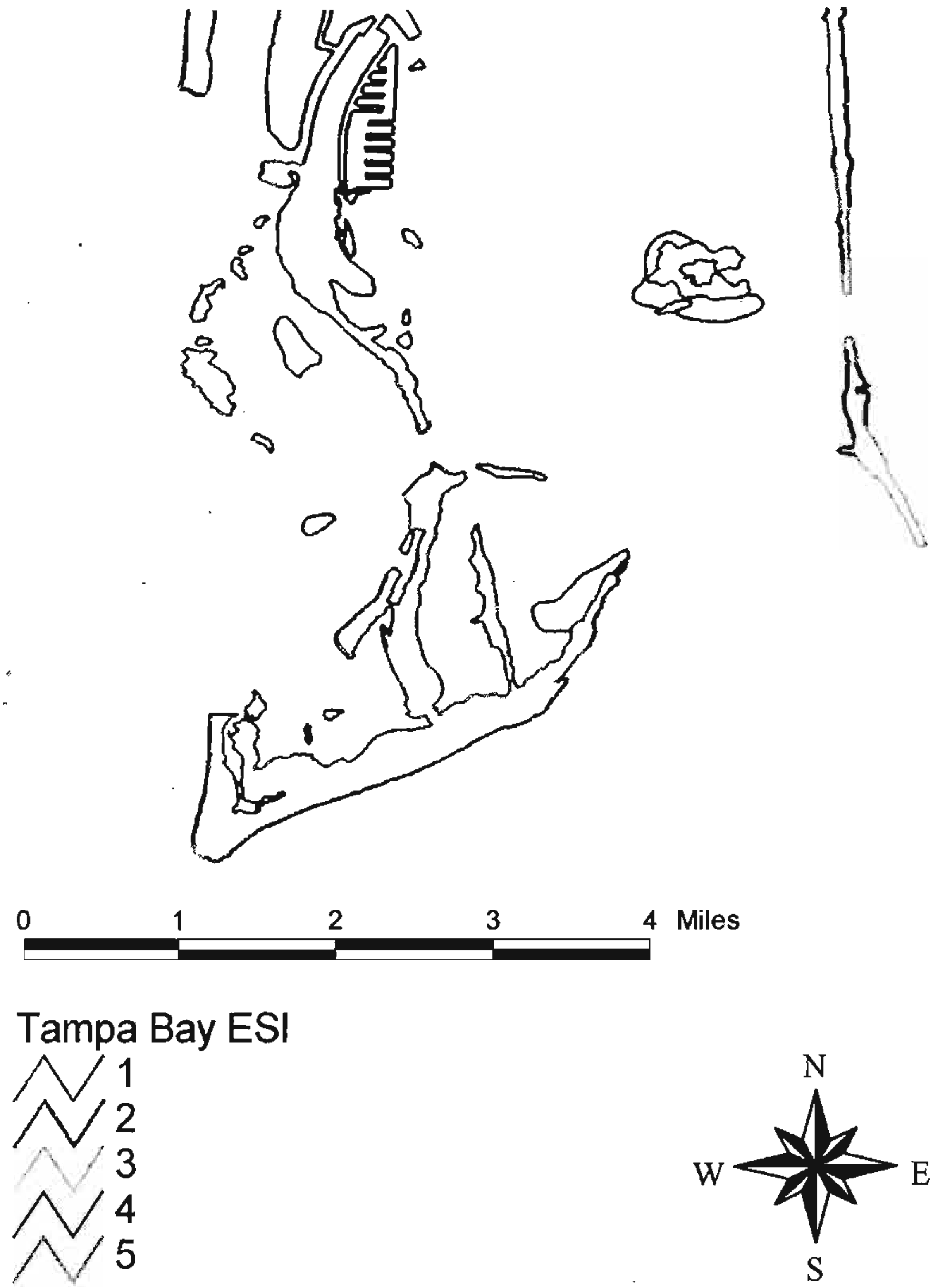


Figure 7.4 Rationale for determining protection strategies, showing seagrass coverages and with computed Las and Ro values.

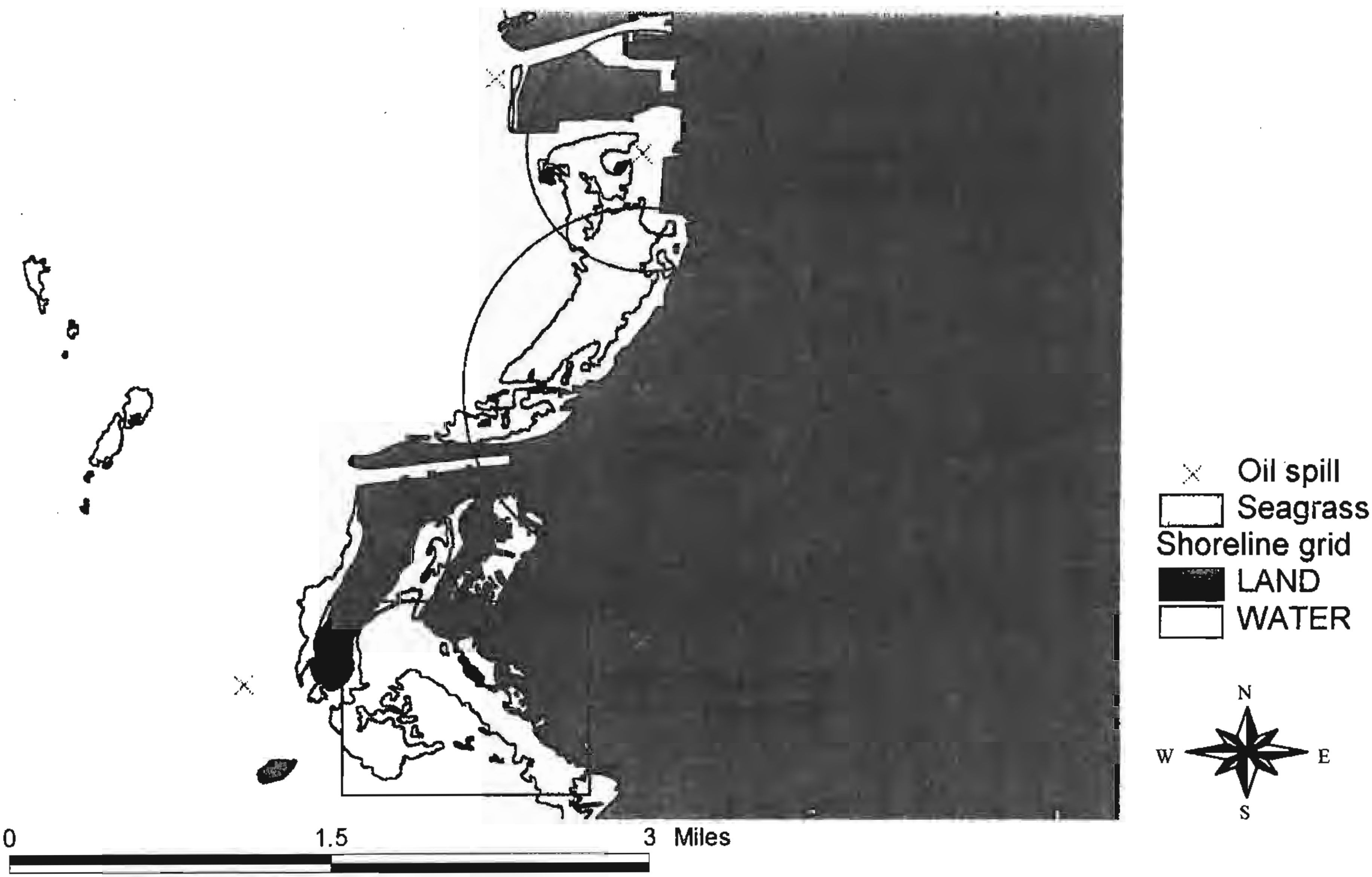


Figure 7.5 Example of coverage inconsistencies and mismatching between various Tampa Bay maps.

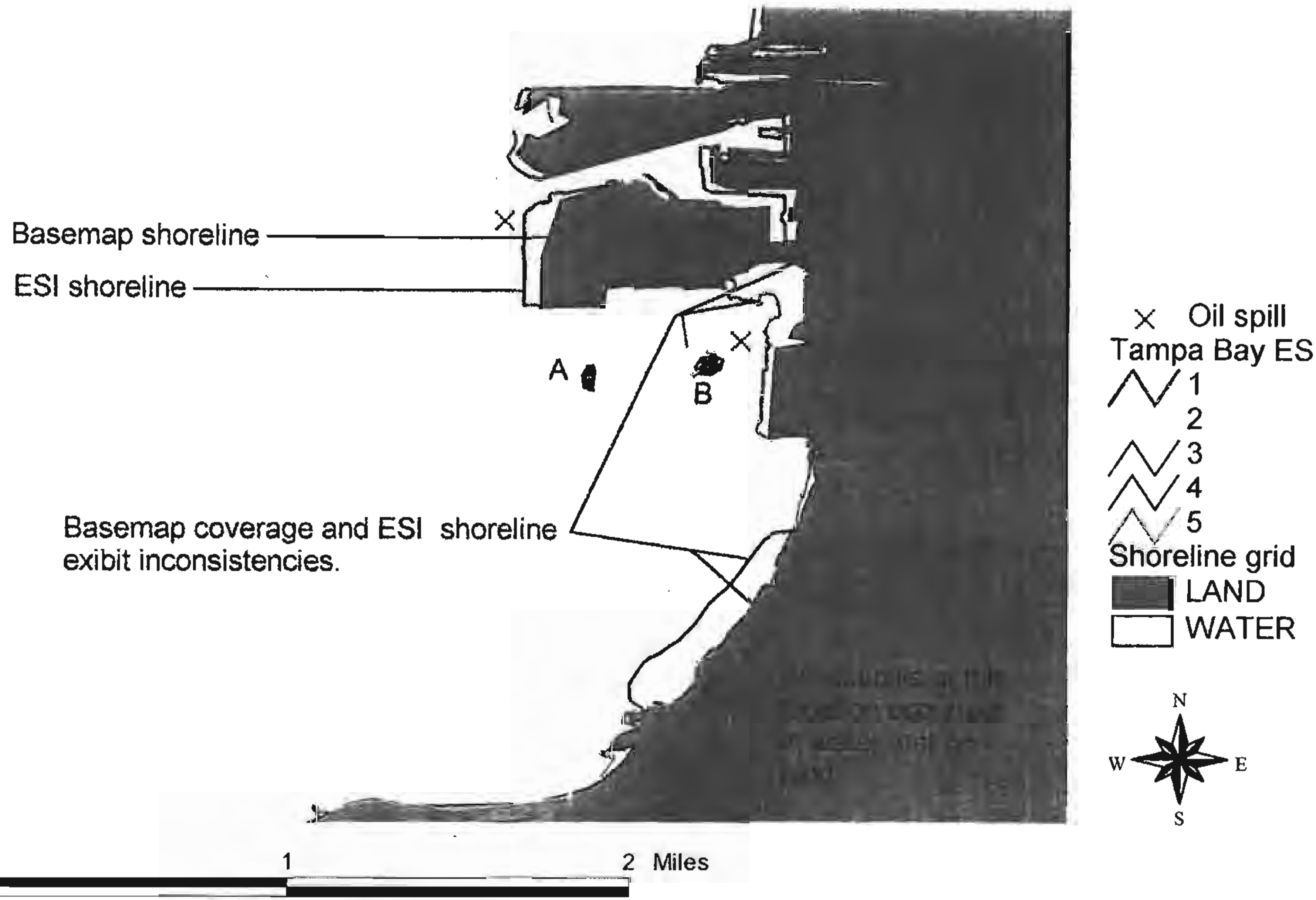


Figure 7.6 Rationale for determining protection strategies based on manatee sightings and oil spills.

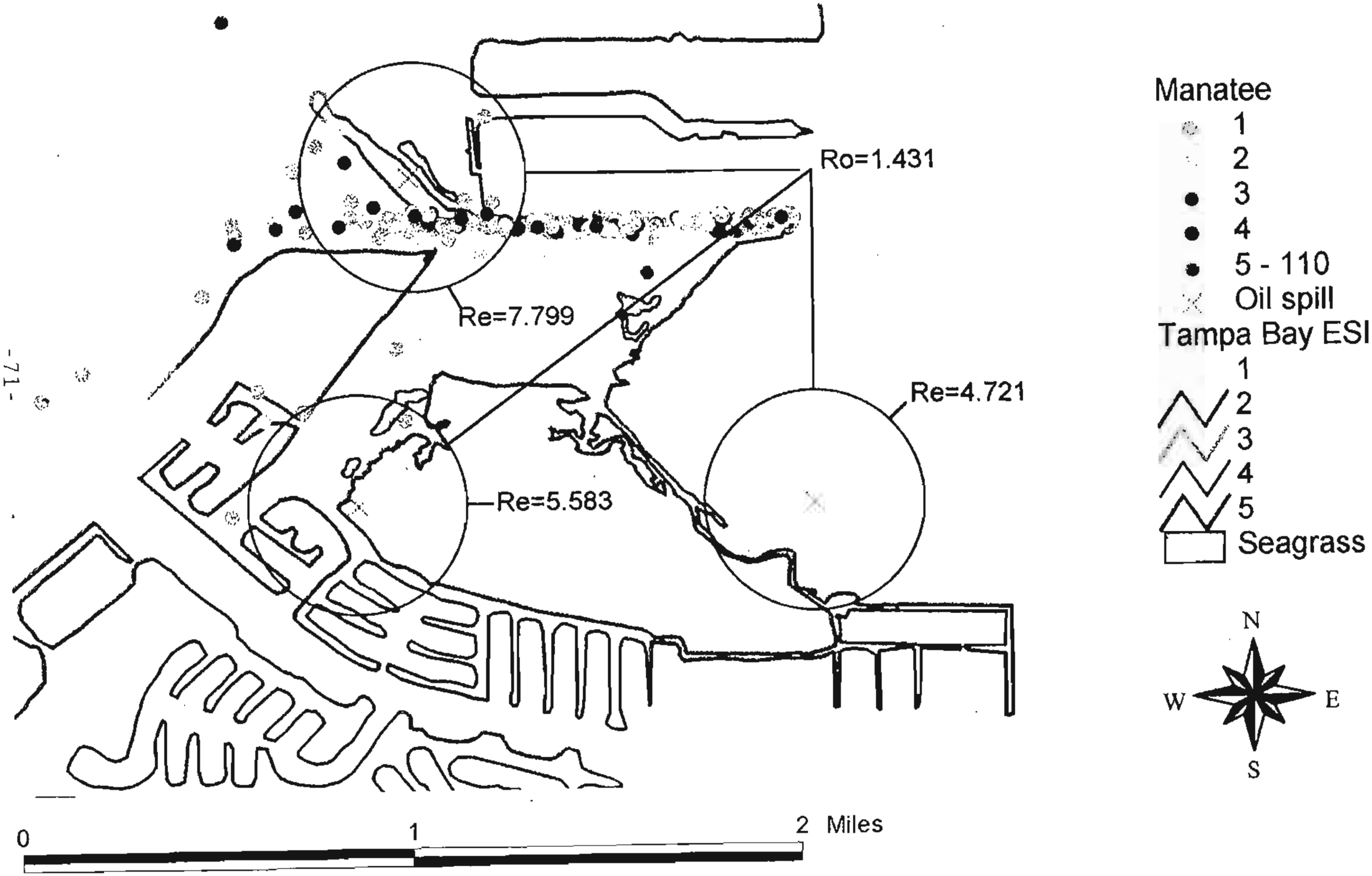
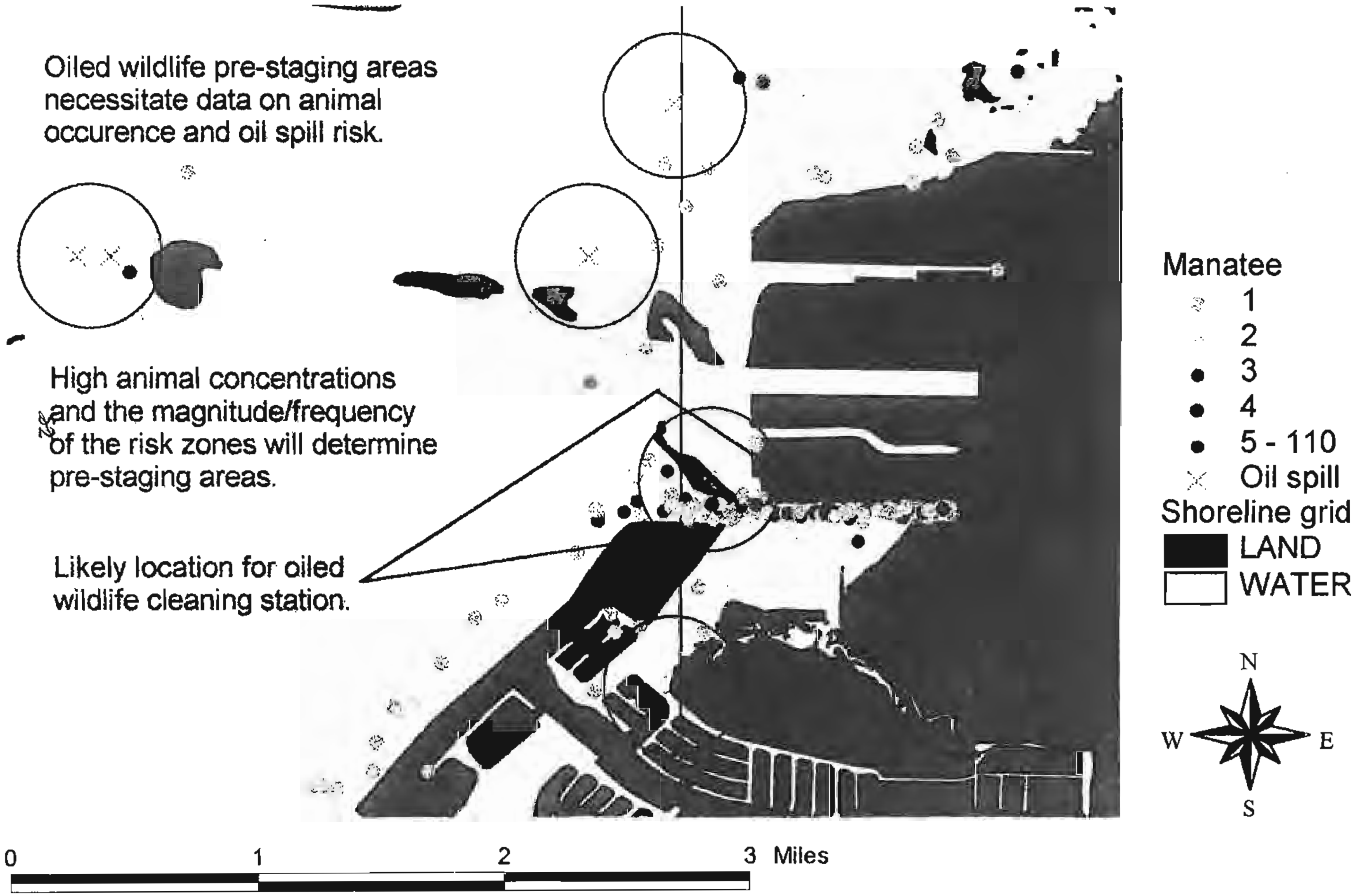


Figure 7.7 Rationale for determining pre-staging strategies based on manatee risk due to oil spills.



8.0 Recommended Research and Technology Initiatives to Enhance Shoreline Remediation and Restoration Contingency Planning.

8.1 International, National and Regional Perspective on Research and Technology Initiatives to Support Shoreline Remediation and Contingency Planning

Sections 5.0 through 7.0 explored the policy and research initiatives that could enhance shoreline remediation and emergency restoration from several different perspectives. Each section proposes initiatives that can be combined to form a research agenda that can be undertaken at the Federal and State level as part of several research and development programs currently underway. To assist in formulating and prioritizing this agenda, it has proved useful to first review the current international, national, and Gulf State R&D needs, priorities, and projects with regard to shoreline remediation and restoration.

At the international level, a list of research and technology development needs and priorities were recently developed as part of the Second international Oil Spill R&D Forum held in London on May 23-16, 1997. (IMO, 1995) This list was reported to the IMO Marine Environmental Protection Committee on 13 June 1997 (MEPC, 1997).

The specific research recommendations related to shoreline remediation and restoration were recorded under Environmental Effects and Bioremediation. Several appear to be directly applicable to shoreline remediation and restoration contingency planning as discussed in the previous sections of this report. These are:

- Develop guidelines for assessing the ecological condition and recovery of oiled shores.

- Conduct standardized studies focused on optimizing shoreline cleanup operations. This would include a comparison of the environmental consequences of different shoreline treatment, including no action and the combination and sequencing of different treatments; the development of data sets on application protocols for different shoreline techniques for varying conditions of oiled shorelines; and the definition of different protocols or methods appropriate for different uses of the environment (e.g. bathing beaches vs. remote beaches).

- Develop of field performance measures and protocols for shoreline cleanup techniques (e.g. cumulative effectiveness of performance, efficiency and effects). Standardized documentation is essential to evaluate the effectiveness of cleanup options.

- Develop guidelines for the termination of cleanup. (How much shoreline cleanup is needed to accelerate recovery or accelerate natural removal, balanced against retarding recovery?)

- Conduct research on the recovery time-scales of different environments. (What are the measures, scales of importance and endpoints for determining if an environment has recovered from a spill?)

- Conduct studies on natural removal rates and processes - physical, chemical, and biological associated with the recovery of oiled shorelines.

- Establishment of a network for improved information exchange on environmental effects of countermeasures, recovery from spill impacts, development of protocols.

- Determine, under representative field conditions, the contribution of different bioremediation techniques to a faster (and better) restoration of the original situation or to a quicker decrease in the pollutant toxicity compared with natural bioremediation.

- Produce clear and concise site documentation criteria to identify the environmental conditions, including oil characteristics, under which the application of bioremediation strategies would be recommended.

In a follow-on survey survey which involved a number of the Forum participants, general priorities were established for research topics. Several topics related to shoreline remediation and restoration were included in a list of top research priorities. These topics included:

- Establishment in representative field conditions, of the contribution of different bioremediation techniques to a faster restoration of the original situation or to a quicker decrease in pollutant toxicity compared to natural processes.

- Studies on the natural removal rates and processes - physical, chemical, and biological associated with the recovery of oiled shoreline.

- Production of clear/concise site documentation criteria to identify the environmental conditions under which bioremediation strategies would be recommended.

- Comparisons of the utility of different shoreline cleanup methods on different shoreline types. Determination of the environmental consequences and trade-offs associated with different cleanup measures and strategies.

- Guidelines for the termination of cleanup.

At the national level, research and technology development topics and priorities for Federal agencies are established by the Interagency Oil Pollution Research and Technology Plan established under OPA 90 (Interagency Committee, 1997). This Plan reviews research and technology needs, summarizes current and planned research, and establishes broad research priorities for specific topic areas.

In the Federal Plan, shoreline remediation is addressed under the topic Shoreline Countermeasures and Cleanup, which was judged to be a high priority research topic on the basis of its potential to reduce the environmental impact of oil spills in the next 5-10 years. New technology development is called for to improve removal techniques for sub-surface oil, and research is recommended to fully understand the effectiveness and efficiency of currently available techniques. Research focus areas related to shoreline remediation contingency planning include:

- Develop detailed protocols for each clean up technique for oil removal from shorelines

- Develop guidelines for sequential cleanup using multiple techniques

Shoreline restoration is addressed under Restoration Methods and Technologies, which was also judged to be a high priority topic area. The highest priority topic areas for habitat restoration are development of actual restoration methods and defining indicators of habitat impact and recovery. Research focus areas include:

- Further development of bioremediation
- Experiments on species transplant as a viable technique for habitat restoration
- Evaluation on the role and size of buffers in habitat restoration, and the role of heterogeneity
- Developing indicators and measures of effectiveness for restoration efforts
- Implementing a spill-of-opportunity research program for restoration
- Establishing a restoration case-studies database

Taken together these focus areas for shoreline remediation and restoration reflect the need for research efforts of the same general nature as those recommended at the international level (which is to some degree expected as the MEPC research priorities were taken into account in developing the latest OPA 90 Plan. In summary, the international and national research agendas suggest the following research initiatives that would provide scientific information and develop technology to support shoreline remediation and restoration:

- Conduct research, both in the laboratory and the field, to determine the optimum application procedures, sequencing, effectiveness, and environmental impact of various shoreline remediation techniques as a function of shoreline type.
- Compile and analyze data on the effectiveness and environmental impact of shoreline cleanup efforts to determine criteria for termination of cleanup efforts (How Clean Is Clean). Generic criteria should be developed for different shoreline types (e.g. mangrove, marsh, sand beach, rocky shoreline) and geographic areas (e.g. tropical, temperate and arctic conditions).
- Develop techniques and technologies for shoreline restoration including improved

bioremediation agents and techniques, and species transplant techniques.

- Conduct research, both in the laboratory and the field, to determine the specific conditions under which restoration measures should be used (e.g. shoreline type, habitat and level of contamination or disruption). Determine anticipated effectiveness, impacts, and criteria for terminating restoration efforts.

- Develop standardized databases for capturing and synthesizing experimental and spill case history data on the effectiveness and environmental impact of shoreline remediation and restoration techniques and operations.

- Set up a specific research agenda and activation plan for conducting spill-of-opportunity research on the effectiveness and environmental impacts of shoreline remediation and restoration efforts.

On a regional level, federal and state spill response managers, resource trustees and scientists within the Gulf Coast region have addressed the need for research initiatives on shoreline remediation and restoration. Specifically, in July of 1994, a symposium was convened in New Orleans to assess the state-of-knowledge on the effects and natural recovery of coastal ecosystems subject to oil spills in the Gulf of Mexico and the Caribbean, and to review progress and needed initiative for scientific research (Proffitt and Roscigno, 1995). The symposium focused on three specific shoreline environments: Mangroves, marshes, and seagrasses. A follow-up workshop was convened in August 1995 at McNeese State University to address the scientific issues related to the effects, remediation, restoration and modeling of oil spills in mangrove ecosystems (Proffitt, 1997).

The July 1994 Symposium concluded with a series of working group discussions on oil spills in each of the three predominant Gulf shoreline habitats - mangroves, marshes, and seagrasses, and on oil ad dispersants. These discussions led to several research recommendations relevant to shoreline remediation and restoration contingency planning. These included:

- Research to determine the effectiveness and environmental impact of remediation measures on mangroves, specifically the use of fertilizers and oxidants. Also determine the window of opportunity when remediation efforts are beneficial

- Research (including experimental spills) to determine the effectiveness and environmental impact of shoreline remediation techniques in marshes including physical removal, burning and bioremediation.

- Establishing mechanisms to enable response agencies to incorporate scientific evaluations of shoreline remediation methodologies into the response effort. State and Federal agencies should be responsible for directing funds needed for these evaluations.

- Developing GIS as a tool to identify sensitive environments and plan shoreline remediation activities.

- Research to determine the effectiveness and environmental impact of various remediation techniques for seagrass; and compilation of a cleanup manual that accounts for specific oil types, seagrass species, and the physical characteristics of the habitat.

8.2 Research and Technology Development Agenda Recommended by the Project Team

Based on the various recommendations and suggested research initiatives outlined in Sections 5.0 through 7.0, and the current research needs and priorities at the international, national, and Gulf regional level as delineated in Section 8.1, the project team for this study recommends that the following specific research and technology development initiatives be considered to support and enhance shoreline remediation and emergency restoration contingency planning in the Gulf of Mexico.

- Development of a Prototype Electronic Sensitive Environments Annex for Area Contingency Plans (undertaken as a demonstration project for a selected Gulf ACP Areas). This would consist of a GIS based system, such as the Florida Marine Spill Analysis System developed by the Florida Marine Research Institute, and could be an expansion of this system as currently applied to Tampa. This GIS shoud be configured to support risk-based oil spill contingency planning as described in Section 7.0.

- Continue the development of the risk-based environmental management concept as described in Section 7.0, to support oil spill contingency planning at the Area level. Implement and evaluate this concept using a specific ACP (perhaps Tampa or Mobile) as a test case.

- Development of Shoreline Remediation and Emergency Restoration Manual for the Gulf Region that compiles and synthesizes currently available data on the suitability, effectiveness, and environmental impact of various shoreline remediation and restoration techniques and technologies, as a function of shoreline geomorphology and habitat type. The manual would also include suggested protocols for effectiveness and impact monitoring. To improve accessibility and updating of the manual, consideration should be given to implementing it in electronic form on the World Wide Web. This would also allow cross-linking to other relevant web sites as they are developed

- Establishment of a Spill-of-Opportunity Scientific Monitoring Program for the Gulf of Mexico. This would involve the formation of a multi-agency team (including Federal, State, University, and Industry members) to plan, initiate and follow through on studies of shoreline remediation and restoration efforts undertaken during spills to determine effectiveness and environmental impact, and formulate criteria for the application and termination of various techniques. On-scene activities of this nature should be coordinated through the Gulf Strike Team's Special Response Operations Monitoring Program (SROMP) and the NOAA SSCs to ensure that scientific monitoring is smoothly integrated into the response effort.

- Establishment of a Shoreline Remediation and Restoration Case-History Database. This database would capture information on the experiences, successes and shortcomings of previous shoreline remediation and restoration efforts. It could be similar in format to the NOAA Spill Histories Database (which included available data on shoreline cleanup). To improve accessibility and updating of the manual, consideration should be given to implementing it in electronic form on the World Wide Web.

- Conducting focused experiments, both in the laboratory (mesoscale) and in the field (during spills-of-opportunity) to determine the applicability and effectiveness of emergency restoration techniques, both to provide scientific input to the Shoreline Restoration Manual, and facilitate the development of guidelines for application and termination.

8.3 References

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APPENDICES

APPENDIX A

TEXAS/LOUISIANA TRIP REPORT

TEXAS/LOUISIANA TRIP SUMMARY
SEPTEMBER 16-20

Monday 16:
8:30 am meeting with MSO New Orleans.
Present was Ilene Byron, NOAA Scientific Support Coordinator, Hazardous Materials Response and Assessment Division; LT Todd Bridgeman, Assistant SSC; Welcome Duncan, Environmental Protection Specialist, USCG District Response Advisory team (copies of business cards attached).

Notes:
MSO is trying to down-size ACP's, suggested not including restoration/remediation in ACP, but possibly in a separate manual. Byron's worry was that there is little consensus within the various agencies in LA over shoreline type and marsh delineation so creating a standard remediation plan for a marsh will be difficult to have accepted across the board. This will require future communication with the state of LA to further define what exactly they would find most useful.

Regarding format and due dates of ACPs, COMDNOTE 16471 will be used as a standard to evaluate them (Duncan). They are presently coming into Duncan's office for review; final copies due in July 1997. Next edited copies (1998) to stand for 5 years.

We obtained several publications from the MSO: Environmental Effects and Effectiveness of In-Situ Burning in Wetlands; RRT VI Guidelines for Inshore/Nearshore In-Situ Burn; Fate of Spilled Oil Following Application of In-Situ Burning as a Spill Mitigation Technique at LA's Rockefeller Refuge: Chemistry Results From Year One Monitoring Study, and COMDTNOTE 16471. Duncan also agreed to supply procedures/guidelines for ACP spill scenario development.

Tuesday 17:
10:00 am meeting with the Natural Resources Subcommittee of the Texas Natural Resources Conservation Commission.
Minutes and participant list attached

Notes:
Stated our case - Brian Kane of USFW suggested restoration (long term) was the job of NRDA - so there may be conflicts there. What would be most useful would be an emergency restoration plan. Something along the lines of "Manual of Remediation and Emergency Restoration Techniques".

Buzz Martin presented two series of maps: NRDA series (NRT Atlas) not used for ACP's, and Response series 1:24,000 - may be produced in CD-ROM format. Quadrats were produced in 1974. Got one map copy.

Risk Assessment ideas: Either get map data from TGLO on diskette or via zipped files sent over E-mail, install on ARC-VIEW and transfer map data into editable format, condense environmental sensitivity index into 3-5 categories, construct quantitative risk analysis with NMOSTM model and OSIMS spill/transport data for more realistic spill scenarios, overlay risk on sensitivity map to produce usable ACP response tool.

Thursday 19:
10 AM meeting with TGLO in La Porte. All GLO meetings set up and coordinated with Scott Benton (Austin, Tex.).
Met with Richard Arnhart, Richard Bonds, and R.E. Caraway. Copies of business cards attached.

Notes:
Discussed various local remediation sites: French site, Parker Cove (San Jac spill), Caraway's site. Bolivar flats spill cleanup stopped because of damage to bird habitat. Beaches are sensitive cleanup/restoration issues, especially shell beaches where oil penetrates fast.
Everyone sensitive to prevention of marsh damage during cleanup but sometimes it occurs. Emergency remediation/restoration is new and good concept.

When is clean? - use TNRCC method and signoff teams; TGLO doing GIS ESI maps, will show booms on pamphlet(?); in situ burning - need monitoring, can send GLO now; check with environmental groups for more restoration info: Galveston Bay Foundation, NEP, etc.

2:30 PM meeting with TGLO in Port Arthur (Nederland).
Wilton Bryant, Ross Penton, Pat ____, others in attendance (some cards attached).

Notes:
Have lots of equipment: boats, airboat, trailers (command post), skimmers (75 and 150 gal), fireboom, etc. Have dispersant (9580), more for research. In situ burns: Smith Point (1.5 yr ago); Corpus Christi (Exxon, 1/92); 2 burns in last two months; RRT's put out pamphlets on burning, Ilene has various documents.

Remediation going on and being studied (check with Robin Jamail, Galveston): Unical site - 2100 bbls 4/93, cleaned some but left alone to bioremediate; Citgo Beaumont - 350 bbls, some left, allowed to degrade; Sabine River - Maryville, 250 bbl, uncleaned, LaDEQ studying; Johnson Bayou - low water area, grass died but growing back; Buffalos (?); Florida Express (?); check with Austin GLO for ongoing NRDA's - Lisa Roberts, Peter Samuels, Diane Hyatt. Dispersant use - Chevron 700 bbls, 12/16, 20 miles offshore, being monitored.

Spill scenarios: drills un-announced, use most probable discharge amount, sometimes worst probable discharge, facilities do own scenarios based on local knowledge, discussed American Eagle 8/15, also look at high risk areas, e.g., 1000 cut intersection.

Ideas: saw Field Operations Guides (FOG, 6/96), NIIMS/ICS adopted, $2.25 ea, pocketbook size, we should do for inland/nearshore spills.

Friday 20: met again with MSO NO to discuss trip and get report copies.

APPENDIX B

Gulf of Mexico Contingency Planning Workshop

October 17-18, 1996
Dauphin Island Sea Lab
Dauphin Island, Mobile, Alabama

Summary Notes

Introduction

The involvement of the states of Mississippi and Alabama, and of nearby Florida, is necessary to complete the interview process for contingency planning analysis in the Gulf of Mexico. Through the efforts of Dauphin Island Sea Lab (DISL), led by Dr. William "Monty" Graham, a two-day intensive workshop was set up to obtain input from government agencies, environmental groups, and private industry on contingency planning and related needs. This is a summary of input from spokespersons for these groups, including attendee addresses and workshop handouts. The workshop was divided into four sessions, as follows:

Session 1. Thursday, November 17, Morning: Planning/Response Agencies

Session 2. Thursday, November 17, Afternoon: Industry Representatives

Session 3. Friday, November 18, Morning: Environmental Representatives

Session 3. Friday, November 18, Afternoon: Environmental Consultants

Meeting Notes

Session 1

The format was set wherein Dr. Graham introduced the purpose of the workshop, and attendees followed by introducing themselves and their backgrounds. Dr. Baca gave the presentation of the project using overheads and handouts (Attachment 1). He also presented the concepts of emergency restoration vis a vis decision trees sent by Pete Tebeau. Lt. Darrell Prather, USCG Marine Safety Office in Mobile, acted as advisor and coordinator throughout the two-day workshop. Lt. Prather's main comments, which he repeated throughout the conference, were:

- All contingency plans need to follow same formats
- The format should be based on the Incident Command System (ICS)
- This format is well-defined by USCG Commandant Notice 16471 (Attachment 1)
- The concept of emergency restoration is important

Generally, agency attendees reported on their current status of Environmental Sensitivity Mapping, with Mississippi providing examples of their newest maps. Alabama agencies were farther behind in contingency planning but wanted to provide input later. Mark Van Hoose working on this for Alabama. All want to review our draft final report.

The state agencies asked why the Corps of Engineers was involved in contingency planning, and although a Corps representative was there he did not comment. Dr. Baca stated that the Corps was responsible for the nation's wetlands, delineating them, permitting for their destruction, and approving mitigation for their losses. Since this project focuses on restoration (i.e., mitigation) of impacted wetlands, Corps involvement is understandable. However, we stated that we do not know all the reasons for their involvement

Session 2

This was a much more active session, with industry representatives, the "responsible parties" having much more to say. Lt. Prather was also present, and he gave a longer presentation than in the morning session, with input from the industry representatives, summarized as follows:
Annexes to the plans should include in-situ burning and hazmat information.

Attend spill drills, e.g., May 1997 Kirby Corp. on Alabama/Florida border.

Area Contingency Plan (ACP) format should be ICS.

Three main area members: Mississippi Department of Environmental Quality (MDEQ) Alabama Department of Environmental Management (ADEM), and Florida Department of Environmental Protection (FDEP).

The MSO has over 110 Facility Contingency Plans - too many to edit or keep up with.

The coast has too many (or too much?) sensitivity areas; need prioritization of most sensitive areas. For example, most of Perdido Bay is sensitive, but they can't protect all shorelines.

The Federal agencies need to deal with implementing Hazmat components of plan in 1996, but no one can say how. There are major problems. Will probably defer to Local Emergency Planning Committees (usually County) for some responsibility here.

Sensitivity maps - everyone wants copies, but are not available yet or too expensive ($500-700 each). Lt. Prather looking into cheaper printing.

Inland environmental sensitive maps are needed and Region IV is looking into it.

Relating to emergency restoration - need to establish is substrate needs replacement after contaminated substrate removed; may be easier to just replant without adding soil. State agencies find lower elevations can be more productive. Costs need to be evaluated for any emergency restoration and who will fund it. Lt. Prather said federal funds stop after cleanup. Long-term liability also was concern of industry because they want to walk away after restoration and not deal with 3-5 years of monitoring, or of having to replant contaminated sites, especially if damage assessment going on which also costs them money. The RP's agreed that they were all willing to restore habitat, especially if they got credit from the damage assessment team. All agreed that emergency restoration could be set up as a response option.

Session 3

This was a small group, but they represented large memberships (Alabama Seafood Association, Alabama Wildlife Federation, Sportsfishing Association, fishermen and environmentalists). Their issues included:

Gill net fishing - they are working out conflicts; Florida is perceived as worst case scenario. Any habitat restoration is important to them because they are losing their oyster fishery (among others). They fear spills in oyster reef areas and would like to see oyster reefs and artificial reefs on sensitivity maps. Their worst case spill scenario was one near oyster reefs at the intersection of the tug/ship channels. They agreed with restoration and want restored marshes (cheap and valuable for protection and habitat), seagrass, artificial reefs, cleaning of oiled boats and nets, and aquaculture (replace lost fisheries).

Oyster fishermen alone have 500-1000 boats they can quickly mobilize to help protection and cleanup. Lt. Prather cautioned about insurance problems. They would have to be OSHA-certified. Larger marinas are willing to respond and train their personnel.

Another issue to all - low API oil that sinks or stays neutrally buoyant - can make up over half of shipping. This is a concern to oyster fishermen.

Dispersants - 10 meter depth and 3 mile offshore distance already pre-approved.

Dog River watershed (Richard White, environmental group representative) - makes up 30% of Mobile County. Focussing on non-point source discharge; in process of labelling storm drains (Sea Grant funding); catching parking lot trash with screens across tributaries; City of Mobile helping. This group wants to be listed in plan along with all other environmental groups such as Alabama Coastal Foundation (Valerie _____, not present, tel. # 334-621-1541). Joe Taylor, Alabama Environmental Council, has lots of these contacts. Lt. Prather stated that February 1997 is his due date for the new ACPs.

Session 4

The concept of emergency restoration was developed farthest in this group because they were some of the area's top wetlands restoration consultants. An outline was produced for the protocols as follows:

Guidelines for (Emergency) Restoration
Rationale
Decision Process

Methods

- Freshwater Swamps
- Freshwater, Brackish and Salt Marshes
- Dunes
- Beaches
- Reefs
- Seagrass Beds
- Wildlife Habitat

Other comments were:

Need to establish donor sites for each type of restoration above. Minerals Management Service (MMS New Orleans, not present) is looking into sand bars for beach/dune restoration. Need top locate for availability and map.

The consultants did not mind taking responsibility for the restoration which would allow the spiller to walk away from the project. Guidelines need to be drafted by us for this process. Signoff clause needs to be in agreement wherein agencies agree when site is restored.

Appendix C - Summary Data Forms for the Gulf of Mexico Shoreline Remediation and Restoration Contingency Planning Survey

Tables C-1 and C-2 show the forms used and the responses compiled during a survey to determine the procedures and information required to support shoreline remediation and restoration contingency planning in the Gulf of Mexico.

The survey requested input on three specific aspects of oil spill contingency planning relative to shoreline remediation and emergency restoration:

1) the overall "priority" or importance of various procedures and technical information in supporting the contingency planning process;

2) whether providing better procedures or technical information was a policy issue, scientific issue, or both; and

3) at what level in the contingency planning process (National Contingency Plan, Regional Contingency Plan, State Contingency Plan, Area Contingency Plan, or Supporting Technical Information) these procedures should be specified and the information provided.

Responses were received from seven oil spill response agencies in Louisiana, Mississippi, Alabama and Florida. These included:

Eighth Coast Guard District (MEP)
NOAA Scientific Support Coordinator, Gulf Region
Coast Guard MSO Mobile
Louisiana Oil Spill Coordinator's Office
Mississippi Dept. of Environmental Quality
Alabama Dept. of Environmental Management
Florida Dept. of Environmental Protection

Tables C-1 and C-2 provide a complete tabulation of the results of the survey on the form that was originally distributed. In the column marked "Priority", the number of priority assignments in each category (e.g. 2 highs, 3 mediums, and 1 low response = H(2), M(3), L(1)) have been recorded. For the other columns, the number of times a survey participant checked the particular column is recorded

In an attempt to identify the higher priority procedures and information, a scoring system was devised for data analysis. This scoring system multiplies the number of high priority designations by 3, medium designations by 2, and low designations by 1. When the priority scorings are multiplied by these weighting factors, and added, this provides a total composite score for each item. For instance, for "Specifying How Clean Is Clean" Guidelines" in Table C-1, four participants scored this as a high priority item, two participants scored this as a medium priority item, and one participant this as a low priority item. The total score is thus (4X3) + (2X2) + (1X1) = 17. All items scored in the range of 21 through 12. In general, all items were scored as high and medium. No items were judged to be in the low category by the reviewers as a whole.

In determining whether developing the procedures and information was a policy or technical issue, and where in the planning process the procedures and information should be addressed, this was determined somewhat subjectively by looking at the scoring trends and assigning a consensus participant response in each column. The results of this preliminary analysis are provided in Table 3.1 and Table 3.2 in Section 3.

Table C-1 Tabulation of Survey Results
Procedures and Information Required for Shoreline Remediation Contingency Planning

Procedures and Information Required	Priority	Policy	Technical	NCP	RCP	SCP	ACP	STI
Shoreline Remediation - General Requirements								
- Specify Federal agency roles	H(7)	6	1	6	2	2	4	
- Specify Responsible Party roles	H(7)	5	1	6	2	4	4	
- Specify state agency responsibilities	H(6),M(1)	5	1	4	2	5	4	
- Specify technique pre-approval guidelines	H(4),M(2),L(1)	2	5		3	2	6	2
- Specify test protocols for product effectiveness & toxicity	H(1),M(4),L(2)	3	6	3	1	1	1	3
- Compile lists of approved cleaning and bioremediation agents	H(1),M(5),L(1)	2	4	4	1		1	3
- Specify monitoring protocols for application	H(2),M(3),L(2)	3	6	1	2	2	3	2
- Specify "How Clean Is Clean" Guidelines	H(4),M(2),L(1)	4	5	3	3	2	4	1
- Specify procedures for test applications of technologies	H(3),M(3),L(1)	1	6	3	2		3	2
- Specify procedures for "set aside" areas for research	H(1),M(4),L(2)	2	5	2	3	1	1	1
Oil Properties and Toxicity								
- Data on physical properties of oil	H(2),M(4)	1	6	1	1	1	2	4
- Data on persistence and adhesion properties	H(2),M(4)	1	6	1	1	1	2	4
- Data on toxicity of fresh and weathered oils	H(2),M(3),L(1)	1	6	1	1	1	2	4
Shoreline Morphology								
- General description of shoreline types	H(1),M(5)		6	1			3	3
- General description of substrate characteristics	H(1),M(5)		6	1			3	3
- Data on sensitivity of substrate to disruption	H(1),M(4),L(1)		6	1			3	2
Shoreline Environmental Resource Sensitivity								
- General description of shoreline ecosystems	H(3),M(3),L(1)		6			1	5	2
- Data on presence and sensitivity of specific organisms	H(4),M(3)		6			1	4	3
- Data on presence and sensitivity of endangered species	H(4),M(3)	1	6	1		1	4	3

Table C-1 Tabulation of Survey Results
Procedures and Information Required for Shoreline Remediation Contingency Planning

Procedures and Information Required	Priority	Policy	Technical	NCP	RCP	SCP	ACP	STI
Socio-economic Value of Shoreline Resources								
- Data on commercial resources	H(3),M(2),L(2)	5	4		1	2	5	
- Data on recreational resources	H(3),M(2),L(2)	4	5		1	2	5	
- Data on archaeological and historic resources	H(2),M(4),L(1)	5	4		1	2	5	
Suitability of Various Technologies for Shoreline Types								
- Generic guidelines for suitability	H(2),M(4)	3	5	2	4	3	4	1
- Description of pre-approved techniques by shoreline type	H(4),M(2)	3	5		4	3	5	1
Effectiveness of Remediation Technology								
- Data on surface excavation and removal of oiled material	H(1),M(4),L(1)	3	5		3	3	4	1
- Data on vegetation burning and cutting	H(3),M(3),L(2)	3	5		3	3	4	1
- Data on shoreline washing techniques and agents	H(3),M(3),L(1)	3	5		3	3	4	1
- Data on bioremediation agents and application techniques	H(2),M(4),L(1)	3	5		2	2	1	1
Remediation Resource Availability								
- Inventory of approved bioremediation and washing agents	H(1),M(4),L(1)	3	4	1	2	1	5	1
- Inventory of excavation and washing equipment	H(1),M(4),L(1)	2	4		2	1	6	1
- List of contractors available for remediation effort	H(1),M(5)	2	4		2	1	6	
- List of transport and logistics support available	H(1),M(5)	2	4		2	1	5	1
- List of scientific support personnel for monitoring	H(2),M(4)	2	4	1	1	2	3	
Impacts of Remediation by Shoreline Type								
- Data on recovery rates with and without remediation	H(2),M(2),L(2)	1	5	1	2	2	5	1
- Data on impact on shoreline stability	H(2),M(3),L(2)	1	5	1	2	2	5	1
- Data on secondary impacts on shoreline ecosystems	H(3),M(2),L(2)	1	5	1	2	2	5	1
- Data on secondary impacts on nearshore waters	H(2),M(2),L(2)	1	5	1	2	2	5	1

Table C-1 Tabulation of Survey Results
Procedures and Information Required for Shoreline Remediation Contingency Planning

Procedures and Information Required	Priority	Policy	Technical	NCP	RCP	SCP	ACP	STI
Wildlife Rescue and Remediation (R&R)								
- List of high priority species for rescue and rehabilitation	H(4),M(2)	3	5		3	2	6	
- Data on survivability of species following R&R	H(3).M(2),L(1)	1	5		3	2	5	1
- List and description of approved procedures for wildlife R&R	H(2),M(3),L(1)	2	5		3	1	4	2
- Lists of groups & organizations to support R&R activities	H(2),M(4)	2	4		2	1	6	1
- Inventory of equipment for wildlife R&R	H(2),M(3),L(1)	2	4		2	1	5	1
- Inventory of facilities for wildlife R&R	H(2),M(4)	2	4		2	1	4	1
- List of scientific support to monitor wildlife R&R activities	H(2),M(4)	2	5		2	1	5	1

Table C-2 Tabulation of Survey Results
Procedures and Information Required for Emergency Restoration Contingency Planning

Procedures and Information Required	Priority	Policy	Technical	NCP	RCP	SCP	ACP	STI
Shoreline Emergency Restoration - General Requirements								
- Specify Federal agency roles and responsibilities	H(6)	6	2	5	4	2	5	
- Specify Responsible Party roles and responsibilities	H(5),M(1)	6	2	5	4	2	5	
- Specify state agency roles and responsibilities	H(6)	6	2	4	4	3	5	
- Develop procedures for test applications of technology	H(2),M(4),L	4	5	2	4	1	4	1
- Develop procedures for "set aside" areas of no restoration	H(2),M(4),L	4	6	2	4	1	4	1
- Develop emergency restoration site monitoring protocols	H(1),M(5)	4	6	3	5	3	5	1
Evaluating the Need for Emergency Restoration								
- Develop procedures for site evaluation & feasibility analysis	H(3),M(3),L	3	5		4	2	5	4
- Data on impacts of shoreline cleanup on habitat & ecosystems	H(1).M(5),L	1	5		3	2	5	4
- Data on the persistence and toxicity of unrecovered oil	H(2),M(4),L	1	6		3	2	5	4
- Data on the stability of habitat without restoration	H(3),M(3),L	1	5		3	2	5	4
- Data on secondary impacts if restoration is undertaken	H(3),M(3),L	1	5		3	2	5	4
Availability and Effectiveness of Restoration Techniques								
- Data for shoreline stabilization techniques	H(1),M(6)		5		4	2	4	3
- Data for replacing shoreline material	H(1),M(6)		5		3	2	4	3
- Data for substrate excavation and washing techniques	H(1),M(6)		5		3	2	4	3
- Data for replanting of vegetation	H(1),M(6)		5		3	2	4	3
- Data on replacement of marine organisms	H(1),M(6)		4		2	1	3	3
Restoration Resource Availability								
- Availability of equipment	H(2),M(3),L	3	4		2	1	6	1
- Availability of personnel	H(2),M(3),L	3	4		2	1	6	1
- Availabilty of logistics support	H(2),M(3),L	3	4		2	1	6	1
- Availability of engineering and scientific support	H(2),M(3),L	3	4		2	1	6	1

APPENDIX D

ADDITIONAL INFORMATION ON OIL SPILL EFFECTS ON MANGROVES

INTRODUCTION

The term mangrove refers to a non-taxonomic grouping of woody, halophytic spermatophytes that occur along low-energy coastlines, deltas, estuaries, and embayments throughout the tropics and subtropics. Tomlinson (1986) recognizes 54 "true or strict" species of which the members of the Rhizophoraceae and Avicenniaceae are the most widely distributed. Since they dominate coastal intertidal areas that are subject to oil spill stranding and trapping, a number of researchers (cf. Hayes and Gundlach 1979) consider mangroves to be the most sensitive of all coastal ecosystem types to oil spills. In this regard, Odum and Johannes (1975) speculated that mangroves would take many decades to recover from oil spills. Research on the topic, however, has focused almost exclusively on post-spill damage assessments, in which the primary objectives are to determine the spatial area of impact, and the intensity or degree of acute damage on the impacted flora and fauna (e.g., Lewis 1979, 1980; Getter *et al.* 1980a,b; Getter, Scott and Michel 1981). This type of post-spill research has been loosely referred to as the "dripping oil and dead-body count approach". As argued in this review, the observable acute damage following a spill may be insignificant when compared to the longer-term chronic stress induced in mangroves and the contiguous nearshore fauna and flora by the residual oil.

The following summary of acute, secondary and chronic consequences is based primarily on:

(1) a review of 28 oil spills in the Caribbean and Gulf of Mexico region (see earlier listing in Getter, Snedaker and Brown 1980c),

(2) a number of independent studies (Chan 1977; Page *et al.* 1979; Gundlach, Scott and Davis 1979; Gundlach *et al.* 1979; Getter *et al.* 1980a,b; Odum and Johannes 1975; Hayes, Gundlach and Getter 1980; Lugo, Cintron and Goenaga 1981; Snedaker, Jimenez and Brown 1981; Garrity, Levings and Burns 1994; Burns *et al.* 1994; Levings, Garrity and Burns 1994),

(3) reports of experimental research findings (Jagtap and Untawale 1980; Getter 1983; Ballou *et al.* 1987; Thomas 1987; Rielinger 1991; Teas *et al.*,1993),

(4) personal observations of the author, and

(5) personal communications with knowledgeable persons.

EFFECTS OF STRANDED OIL IN THE MANGROVE ECOSYSTEM

Acute consequences

The effects of the physical stranding of oil in intertidal mangrove habitats is largely dependent on the oil type, the elapsed time between a spill and its stranding, wind and current conditions, and tidal stage. With regard to oil type, the more highly refined products tend to be relatively more toxic, but because they are also relatively volatile, they are quickly dissipated. The volatile fractions (e.g., naphtha, benzene) are also lost from the heavier oils that remain at sea for extended periods of time prior to stranding. In these regards, the stranding of relatively weathered oils that are depleted in the lighter fractions has a lesser potential to produce acute toxic effects than "fresh" oil and the highly refined products. Whether or not refugee oil eventually becomes stranded along the shoreline is highly dependent on the ambient wind and current conditions. For example, longshore winds and currents tend to move oil parallel to the shoreline, painting long stretches of the seafront, whereas strong onshore winds tend to push the oil onto a smaller length of shoreline but also further inland. Similar to wind-driven oil, oil arriving at the shoreline on incoming tides has the potential to reach deeper into intertidal and supratidal habitats. However, it also has a greater potential for washout on the retreating tide except when trapped in paludal depressions inland from the shoreline fringe. Tidal patterns are particularly important in the context of potential stranding. For example, in south Florida mean sea level is some 20 to 30 cm higher during the Fall than in the Spring (Wanless 1982) meaning that higher water levels in the latter part of the year contribute to a greater potential for inland stranding and trapping, but may also contribute to washout and removal from the intertidal zone (*vide* Levings *et al.* 1994).

Mangrove mortality tends to be highest among propagules, seedlings and juvenile trees, due to their proximity to the oil spill surface, and the potential for heavy and repeated oiling on both incoming and outgoing tides. Notwithstanding the potential for relatively intense oiling, shoreline seedlings sometimes survive the initial oiling event. Lugo, Cintron and Goenaga (1981) suggest that mangrove seedlings may be more stress resistant than adult trees based in parts on their field observations and certain of the physiological differences reported by McMillan (1974). In this regard, young-of-the-year seedlings of *Rhizophora* and *Avicennia* utilize cotelydenary reserves prior to developing an extensive root system. This may mitigate against uptake of toxic compounds.

The reported rapid mortality of mangroves following a spill is assumed to be due to mechanical suffocation and the cessation of gas exchange processes associated with the rhizosphere. However, this is somewhat equivocal for two reasons. First, one of us (SCS) has observed and photographed, heavily-oiled prop roots having clean, and presumably active lenticels. To the extent that gas exchange is relatively unaffected, "suffocation" may not be the primary cause of mortality. Secondly, in laboratory experiments using freshly excised *A. germinans* pneumatophores (which also have gas-exchange lenticels), nitrogen gas (N_2) was still able to be transported through the oil film covering pneumatophores (Melvin S. Brown, pers. comm.). Rielinger's (1991) follow-up work on O_2 uptake and CO_2 fluxes in excised pneumatophores indicated that oil viscosity was the principal factor in gas exchange; the heavier oils reduced exchange to a greater extent than lighter oils.

Further in this regard, since heavy oiling of roots, pneumatophores, tree trunks and sediment can cause direct mortality (or be highly damaging, see 1994 article by Levings, Garrity and Burns), an experiment was conducted on the effects of crude oil (Prudhoe Bay) dispersants in Panama in December 1984 (Ballou *et al.* 1987). In that TROPICS (Tropical Oil Pollution Investigations) field experiment, coastal sites with contiguous mangroves, seagrass and corals were acutely exposed to untreated crude oil and chemically dispersed crude oil. After 2.5 years of monitoring, the authors concluded that untreated crude oil had severe, long-term effects on the intertidal mangroves and associated fauna, but only minimal effect on the subtidal seagrasses and corals. In contrast, the chemically dispersed oil minimized damage to intertidal mangroves but caused "relatively severe, long-term effects on the coral and seagrass environments". In a subsequent study ten years later (Dodge *et al.* 1996), effects the crude oil on mangroves were still event in terms of a lower than expected increase in the mean trunk diameter of affected trees, a reduced canopy density and increased canopy light transmission, increased leaf thickness, and patterns of new leaf production and senescent leaf loss.

More recently, Teas *et al.* 1993) tested one of the newer, less toxic, non-dispersing shoreline "cleaners" (Corexit 9580) on experimentally oiled (Bunker C fuel oil) red mangroves (*R. mangle*). They concluded that it was effective in minimizing morbidity and mortality but only if used within a few days of an oiling event. However, in a more recent field study, Quilici *et al.* (1995) concluded that shoreline cleaners negatively affected the productivity of *R. mangle* leaves on the treated trees, suggesting a sublethal effect not observed in acute mortality studies. Since there are now a number of non-dispersing cleaners on the market, research is needed to evaluate both their efficacy and sublethal chronic effects on other mangrove species, and subtidal organisms, such as seagrass and coral communities.

One acute and severe consequence of the mass mortality of mangroves following a spill event is the death and decomposition of the underground root mass. Since the root mass in the *Rhizophora* and the *Avicennia* represents 40 to 60 percent of the total forest biomass (Snedaker 1995: Snedaker *et al.* 1994), its loss results in significant erosion and subsidence. Nine years following the TROPICS oiling experiment, the forest destruction and the ground surface elevation loss (approximately 8 cm) were so great that the affected site exhibited the appearance of having been subjected to an "explosion" (Bart Baca, pers. comm.), an observation confirmed during the ten-year follow-up study (S. Snedaker, unpublished data).

Secondary consequences

Mangrove mortality and the expression of stress symptoms may be delayed for one to several years period following an oil spill for reasons that may be related to: (1) the persistence of toxic petrogenic compounds in the sediment, and (2) the weakened state of the trees that makes them susceptible to other stressors. For example, following the M/V Howard Star spill in October, 1978, in Tampa, Bay, Florida (Lewis 1979; Getter, Snedaker and Brown 1980), 25 heavily oiled mangrove trees were tagged for long-term monitoring. However, only three of the identified trees exhibited a response (one died and two exhibited stress symptoms), whereas others, not originally identified as heavily oiled, died in mass (Lewis 1980). This author (SCS) also observed a number of non-tagged dead trees at the same spill site following a severe freeze three years later in January of 1981.

In the earlier M/V Zoe Colocotroni spill in Puerto Rico, observers reported mangrove recruitment at the spill site, and presumed that it was evidence of recovery that later proved to be incorrect. In that instance, mangrove propagules from unaffected or surviving trees colonized the area and developed to the point where their cotyledonous reserves were exhausted; they then perished in mass (Ariel Lugo, pers. comm.). Also, in the subsequent Colocotroni spill litigation, confusion surrounded the question of the exact cause of mortality since the affected area was also subject to natural hypersalinity (Commonwealth of Puerto Rico 1973, 1978; Lugo, Cintron and Geonaga 1981). These examples suggest that otherwise healthy-appearing mangroves that are exposed to other stressors have a significantly higher probability of morbidity and mortality following exposure to oil (see supporting review and citations in Lugo, Cintron and Goenaga 1981).

Although the majority of the oil spill literature documents the adverse effects of oil on mangroves, some workers have documented an apparent "stimulating" effect (cf. Page *et al.* 1979; Thomas 1987). In M.S. thesis research, Thomas (1987) recorded an apparent stimulation in 28 experimental treatments versus inhibitory responses in 75 experimental treatments. Notwithstanding the finding of some positive effects, Thomas argued that any deviation from the "normal" condition is an indication that the oil interfered with normal growth processes and development patterns (see also Getter 1983). To date no one appears to have addressed any of the ecophysiological questions that explicitly pertain to how oil interacts with the physiology of mangroves over the longer term.

Chronic consequences

As stated earlier, the majority of the research on oil spills focuses on the immediate post-spill acute effects usually because of impending litigation. With the exception of the published research years after the large oil spill at Bahia las Minas, Panama, in 1986 (cf. Duke and Pinzon 1993; Garrity, Levings and Burns 1994; Burns *et al.* 1994; Levings, Garrity and Burns 1994), almost nothing is documented concerning the long-term impact of oil spills in magnrove-dominated habitats. In that context, one has to wonder how legal damage levies (based on acute impact) would be altered if the chronic effects were also taken into account.

In addition to the above citations, the persistence of oil in sediments at oil spill sites years to decades after the spill event has been noted by a number of authors and observers (Mackin 1950; Corredor *et al.* 1990; Teal *et al.* 1992; Burns *et al.* 1994). Disturbance of the oil impregnated sediments, for example, by tidal action, storm pounding, decomposition of the organic substrate, or walking on the sediment (Teas *et al.* 1989), causes the release of oil in the form of a surface sheen or slick that was termed "bleedwater" by Mackin (1950). Whereas this phenomenon appears to be common in coastal marshes and mangroves, no one appears to have made a determination of the composition of the refugee bleedwater or speculated on the consequences for intertidal and nearshore marine life. Notwithstanding, oil in the form of bleedwater slicks has the ability to scavenge and concentrate organochlorine pesticides and other polar toxic water-insoluble compounds including chellated metals (Seba and Corcoran 1969; Hartung and Klingler 1970; Harvey *et al.* 1972; Hardy *et al.* 1987; von Westernhagen *et al.* 1987).

This chemical scavenging and concentrating process could presumably cause the refugee oil bleedwater to become increasingly more toxic over time.

With regard to the heavy metal components in oil, particularly in crude, no one appears to have examined this factor notwithstanding that mangroves can take up and concentrate metals in leaf tissue at concentrations significantly above background (cf. Carter *et al.* 1973; Tripp and Harriss 1975, Peterson *et al.* 1979; Walsh, Ainsworth and Rigby 1979; Snedaker and Brown 1981, Thomas and Ong 1981, Harbison 1986). Snedaker and Brown (1981), for example, reported the following metal concentration factors (relative to ambient concentrations) for leaves of mature mangroves in southeast Florida: chromium 5-6x, copper 1-2x, iron 2-3x, lead 4-5x, manganese 3-4x, nickel 4-5x, and zinc 1-2x. Although mangroves are relatively resistant to metal toxicity (Walsh, Ainsworth and Rigby 1979), leaves enriched in metals could represent a source of metals entering detrital based marine food webs.

Similar to the metals, the uptake and accumulation of the aromatic fractions in spilled oil might also represent a subtle contamination of the leaf detritus food resource. In an experimental study, Thomas (1987) found that *R. mangle* synthesizes a range of biogenic aliphatic hydrocarbons from C14 to C29 dominated by odd-number compounds with the highest concentrations occurring among C23, C25 and C27-29 compounds. In contrast, the natural presence of aromatic compounds was found to be low. In the experimental dosing study, Thomas found a number of aromatic compounds in leaf tissues and that they closely matched the aromatic composition of the treatment oil. It was also reported that tissue concentrations were inversely proportional to the molecular weight of individual aromatic compounds.

SUMMARY

The principal conclusions that can be drawn from published articles and reports of post-spill evaluations and damage assessments are summarized as follows:

• Light weight refined oils and the volatile components of the heavier oils, including crude oil, are the most toxic, but are also the most susceptible to rapid dissipation, mainly by vaporization.

• Refugee oil that enters and leaves the mangrove habitat on the surface of tidal waters, "paints" the vegetation above the substrate but causes minimal ecological damage.

• Refugee oil that is stranded by wind or current within the mangrove habitat over successive tidal cycles comes in direct contact with the sediment and surface litter where it becomes trapped. Over time, the oil moves downward into the sediment by gravity and tide-driven hydraulic draw down where it may persist for decades.

• Oil impregnated sediments continually release small quantities of oil in the form of bleedwater, the ecological consequences of which are unknown.

• The removal of oil impregnated sediments to mitigate against acute and chronic damage is considered to necessarily be more damaging to the habitat than taking no action. Likewise the use of the new shoreline cleaners, once thought to be a viable option, has recently been questioned.

• The most visible and damaging ecological effect of stranded oil is the acute mortality of juvenile and adult mangrove trees and the associated fauna, within a period of several days.

• Juvenile and adult mangrove trees that survive an oiling event may experience morbidity and mortality if exposed to an unrelated stressor such as severe cold temperatures or draught.

• Sublethal effects of an oil stranding event are still detectable and measurable in a mangrove forest habitat for years to over a decade later even when the forest visually appears to have fully and completely recovered.

• Results from experiments and field assessments consistently indicate that under certain circumstances, albeit poorly defined, petrogenic compounds can have a significant stimulating effect on mangrove growth and development.

• Because of the long-term ecological consequences, actions, such as booming and skimming, to prevent oil stranding within the mangrove habitat is the preferred counter measure to be taken in the event of an oil spill.

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