Natural Resource Damage Assessment Emergency Guidance Manual

May, 1996
Version 3.0

Damage Assessment Center
Office of Ocean Resources Conservation and Assessment
National Ocean Service
National Oceanic and Atmospheric Administration
1305 East West Highway, Room 10218
Silver Spring MD. 20910

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INTRODUCTION

The information contained in this manual has been developed to provide guidance to a natural resource damage assessment (NRDA) responder in an oil or hazardous substance release, particularly during the pre-assessment phase of a NRDA effort. The guidance is subject to modification and supplementation as useful information becomes available. The reader should keep in mind that these guidelines are not comprehensive and are designed to serve as a starting point for conducting an NRDA, with emphasis on response to oil spills. When significant injuries to natural resources are suspected, the responder should consult with experts on the natural resources and services of concern. The procedural guidance provided in this manual is also intended to be dynamic. It may be appropriate to alter the procedural steps taken during an incident to more accurately address the particular circumstances of an incident. Thus, incident specific procedural changes relative to those set forth in this manual should not be construed as diminishing the validity of the assessment process.

This manual is not intended to assist in the decision-making process as to which type of NRDA is best suited for each incident. It assumes a basic knowledge of NRDA issues. In some cases, general information is discussed in the text while more detailed guidelines are included as appendices.

The topics covered within this manual are presented in the following order:

1) Definition of the NRDA process and protocols.

2) Roles of the NRDA team.

3) The initial NRDA response.

4) General preassessment strategies and approaches.

5) Preassessment methods for specific natural resources and services.

This manual also includes 15 appendices that provides additional information relevant to NRDA

FEDERAL NATURAL RESOURCE DAMAGE ASSESSMENT

TRUSTEESHIP

The National Oceanic and Atmospheric Administration (NOAA) is one of several Federal agencies designated as a natural resource trustee under legislation enacted in response to the problems caused by releases of oil and hazardous substances into the environment. Other Federal Trustees include the Department of the Interior (DOI), the Department of Agriculture (USDA), the Department of Energy (DOE), and the Department of Defense (DOD)[1]. States and Native American tribes also have trustee responsibilities. A list of State and Federal trustee contacts is included in Appendix 1.

As the principal Federal trustee for the living and non-living resources in the marine environment, NOAA's trustee responsibilities include: all life stages, wherever they occur, of fishery resources of the exclusive economic zone and continental shelf; anadromous and catadromous species throughout their ranges; endangered and threatened species and marine mammals for which NOAA is responsible; tidal wetlands and other habitats supporting these living marine resources; and resources of National Marine Sanctuaries and Estuarine Research Reserves. A list of National Marine Sanctuaries and Estuarine Research Reserves is included in Appendix 2.

FEDERAL REGULATORY FRAMEWORK

The Clean Water Act (CWA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) together provide the fundamental legal basis for natural resource damage claims against spillers. The National Marine Sanctuary Act (NMSA) and the Oil Pollution Act of 1990 (OPA) also have provisions for assessment of natural resource damages; NOAA has developed NRDA regulations specifically for incidents under OPA.

Under Section 311(f) of CWA, trustees are given the authority to recover damages for the costs of restoring or replacing natural resources injured as a result of discharges of oil into the navigable waters of the United States and adjoining shorelines. Under CERCLA, natural resources are broadly defined to include non-living resources, such

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[1] Other Federal land management agencies may also act as trustees. Under OPA, foreign governments may also acts as trustees.

as air, land, and water, as well as living resources. Both CERCLA and OPA require the designation of federal and state officials to act as trustees to protect the public interests in these natural resources by filing claims against potentially responsible parties to recover damages. Trustees are legally designated agencies that are responsible for assessing damages to, and restoring, public resources. Recovered damages must be used to restore injured natural resources or replace services that have been lost as a result of the spill.

CERCLA mandated the issuance of federal regulations to establish procedures for assessment of natural resource damages. In 1986, the DOI issued the "Type B" regulations; in 1987, they issued the "Type A" regulations. Both regulations are published in 43 CFR Part 11. The NRDA process is outlined in schematic form in Figure 1. The DOI regulations were challenged, primarily because of a clause that requires compensation to be the "lesser of" either the diminution of use values or the cost of restoration or replacement. State trustees wanted to be able to select the most appropriate valuation method, regardless of the relative costs of either method. This case, referred to as the Ohio decision, ruled that the "lesser of" rule was not consistent with the intent of Congress. In the Ohio case, the court ruled that there was a distinct preference for restoration over compensation for the lost value of the resource, unless restoration is technically infeasible or if restoration costs are "grossly disproportionate" to the value of services foregone. Therefore, NRDA activities need to be structured so that the need and cost of restoration, as well as the value of lost services during the period of recovery, can be determined. DOI was ordered to rewrite the NRDA regulations to include costs of restoration along with compensation for lost services. NOAA has incorporated this concept into the OPA regulations as well.

The use of the regulations is optional. Therefore, this document describes the existing regulations under CERCLA and OPA as approaches to consider. If, for some reason, the trustees determine that the regulations are not appropriate, the trustees may formulate their own assessment strategy. In fact, most states have regulations and procedures that may be more appropriate for use in pursuing natural resource damages.

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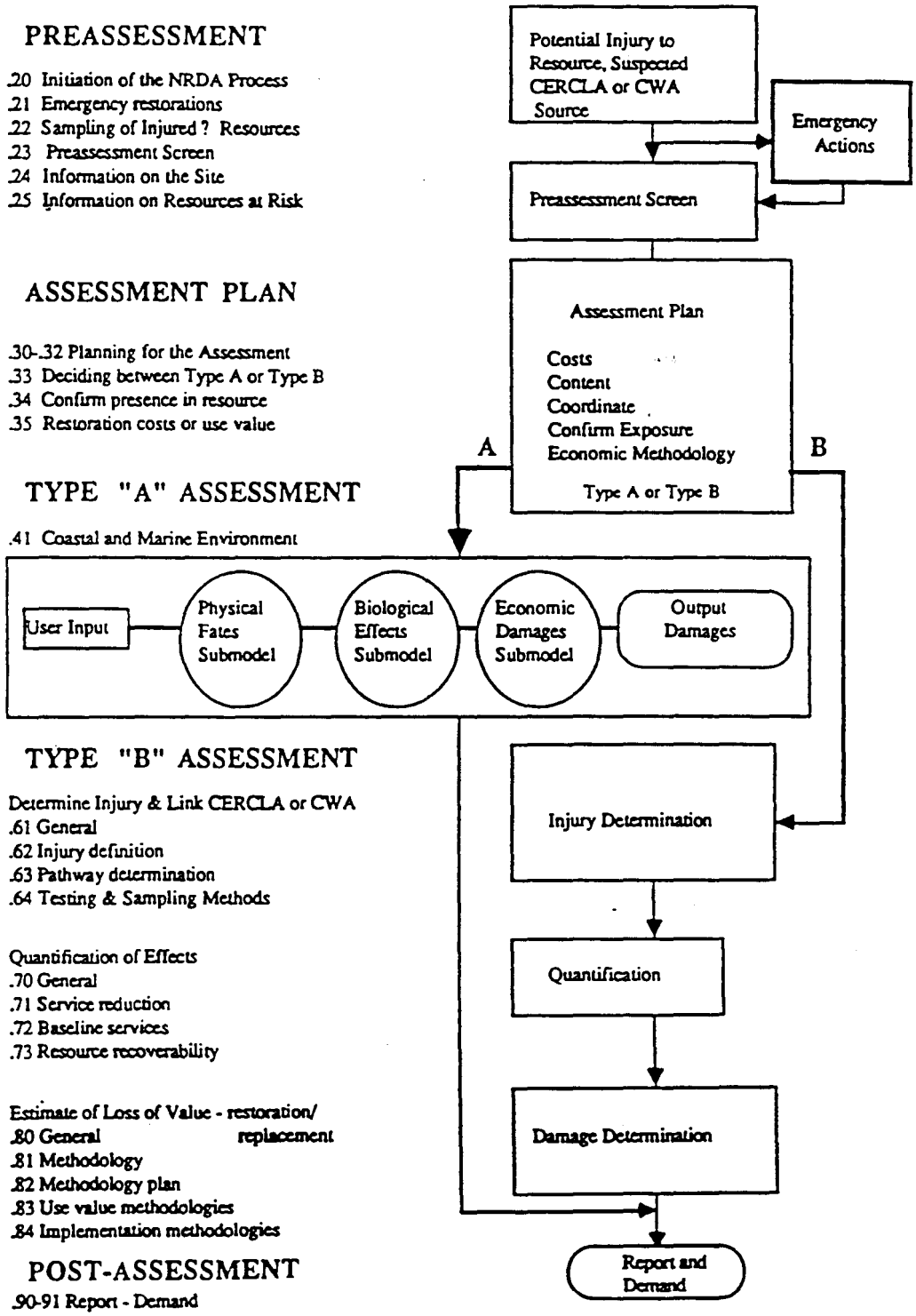

FIGURE 1. An outline of the CERCLA federal natural resource damage assessment process (modified from 51 FR 27677 and 51 FR 16636).

NRDA PROCESS UNDER CERCLA

The first step in the NRDA process under CERCLA is the preassessment screen, during which pathways of exposure, the natural resources potentially at risk, and available data to support an assessment of damages are identified. The purpose of the preassessment screen is to make a determination of the need or justification for conducting a NRDA. The next decision is whether to conduct a Type A or B assessment, as discussed below.

Type A Assessments

CERCLA called for the development of a simplified NRDA method for small incidents, based on unit of discharge or affected area, and requiring minimal fieldwork. In response to this requirement, the DOI developed a computer-based assessment model, the Natural Resource Damage Assessment Model for Coastal and Marine Environments, or NRDAM/CME (DOI, 1987). The computer model for coastal and marine environments is being revised; a similar model for the Great Lakes Environments (NRDAM/GLE). has also been developed. The final rule for the revised CME and new GLE model is scheduled for publication in early 1996. Figure 2 is an overview of the Type A model for coastal and marine environments as it has been proposed.

Overview of the Type A Model

The Type A regulations allow for the assessment of small spills where extensive scientific documentation is either not cost-effective or impossible to carry out. The data necessary to run the model are generally obtainable in published literature, reports generated during the emergency response, and from other natural resourcemanagement agencies.

The NRDAM[2] is composed of four submodels that predict the physical fate of the spilled substance, the biological effects, restoration costs, and the economic damages caused by the spill.

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[2] The NRDAM/CME is described here. The GLE has a similar structure.

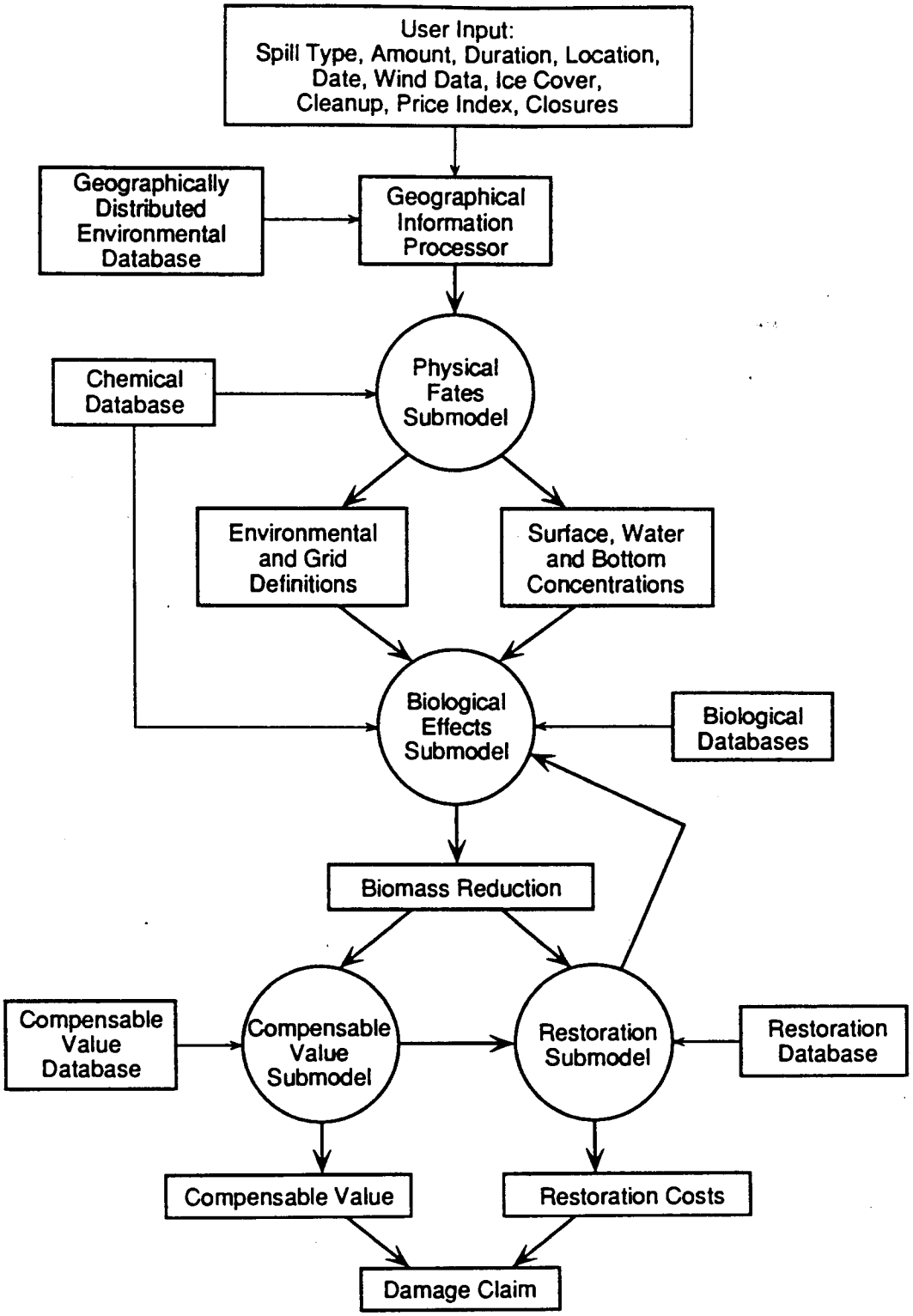

FIGURE 2. **Overview of the CERCLA revised Type A natural resource damage assessment model (Version 2.2) for coastal and marine environments (DOI, 1994).**

The NRDAM/CME is supported by a geographical information system (GIS) which supplies spatially gridded environmental and biotic information to the physical fates, biological fates, and restoration submodels. The user is required to supply the following information to the models:

1) identification number of spilled substance,
2) amount spilled,
3) date and time of the release,
4) duration of release,
5) latitude and longitude of release point,
6) a wind time series,
7) background and tidal currents (including tidal patterns, tidal range, and time of last high tide),
8) cleanup volumes and locations,
9) the GNP price index for the date of the release, and
10) information on closures to fishing, hunting, shoreline recreation, and boating.

A detailed checklist of data requirements is provided in Appendix 3.

The user must supply a wind time series data file. Upon reaching the end of this user-supplied file, the model uses stochastic winds based on the climatological values contained in the database.

Currents are entered as two components. Background currents are assumed constant in time, but may vary spatially as a series of vectors at different latitude-longitude points. The user enters flood tide vectors in a similar manner. The model calculates one or two tidal cycles per day, as chosen by the user.

The physical fates submodel computes the dynamic distribution of the spilled substance in the environment. Computations continue until all environmental exposure levels are below acute toxicity thresholds. The physical fates submodel creates a time series file of surface slick coverage and concentrations of the spilled substance, in the water column, on the bottom, and along the shoreline. When the physical fates submodel computations cease, this time series file is used as input to the biological effects and restoration submodels.

The biological effects submodel computes: (1) direct lethal effects on eggs, larvae, juvenile and adult fish and shellfish, birds, mammals, reptiles, and lower trophic level biota; (2) indirect and long-term effects involving the eventual loss of fish and shellfish as a result of lost eggs, larvae and juveniles, and wildlife (birds, mammals, reptiles) as a result of lost broods; and (3) indirect effects of lost lower trophic level biota and other species without direct use values through the food web. These effects are computed by dynamic juxtaposition of biotic distributions with the distributions of the spilled substance on the water surface, in the water column, in the sediments, and along the shoreline.

In the NRDAM/CME, the biological effects submodel quantifies the injury to natural resources in terms of lost or disrupted services. Then the restoration submodel determines alternative restoration or replacement actions. The choice of actions is based on whether the action is technically feasible and the ability of the natural resourceto recover. For the purposes of the NRDAM/CME, a restoration action is considered technically feasible if it can be performed in such a way as to reduce the injury to resources, and thus the compensable value portion of damages.

The biological effects submodel quantifies the injury to natural resources with and without the performance of various restoration and replacement actions. The most technically feasible restoration alternative is then chosen and the costs of restoration are computed by the restoration submodel. The compensable value submodel calculates damages associated with injuries based on lost use values. Compensable values and restoration costs are then summed to produce a final measure of damages in U.S. dollars.

While the NRDAM/CME is a complex model with large supporting database, it must be emphasized that the model and databases are very much a simplification of reality. It should be remembered that the entire model and databases must be contained and run on a 386 or 486 PC. Simplifications had to be made at many levels to make this possible. For example, the model must work for all coastal and marine environments of the U.S. on any of approximately 470 chemicals and oil which might be spilled. Thus, geographical, environmental, biological, physical-chemical, and toxicological characteristics in the databases and algorithms had to be generalized. Unique site-specific and chemical-specific behaviors could not be included as exceptions to generalized rules.

Injuries Not Included in the Model

There are many categories of injuries that are not considered by the Type A model and additional studies may therefore be necessary. Some of the injuries not addressed by the model include:

- Injury caused by cleanup.
- Injury to terrestrial and atmospheric resources.
- Chronic or sublethal effects, such as reduced reproductive success.
- Endangered species are included, but there are no special values.
- Recreational boating.
- Losses from cooling water or industrial water uses closures.

Type B Assessments

Type B assessments may be conducted for incidents involving complex situations or releases that occur over time. They rely upon site-specific field studies that can be conducted over extended periods and are likely to be costly in comparison to the Type A assessments. CERCLA stated that "Such regulations shall identify the best available procedures to determine such damages, including both direct and indirect injury, destruction, or loss and shall take into consideration factors including, but not limited to, replacement value, use value, and ability of the ecosystem or natural resourceto recover." For biological injuries, the regulations provide some discussion of the types of studies that would be appropriate for Type B assessments, but the rule states that the assessment should be conducted with techniques that have been tested previously for the kind of situation being examined and that have been documented in the technical literature.

The DOI rule requires the development of a restoration or replacement plan. This plan describes the management actions that agencies will take to restore, rehabilitate, replace, or acquire the equivalent resources, that will return the lost or diminished services.

OPA DAMAGE ASSESSMENT REGULATIONS

Focus on Restoration

The goal of the Oil Pollution Act of 1990 (OPA) is to make the environment and public whole for injuries to natural resources and natural resource services resulting from an incident involving a discharge or substantial threat of a discharge of oil. This goal is achieved through returning injured natural resources and services to baseline and compensating for interim losses of such natural resources and services through the restoration, rehabilitation, replacement, or acquisition of equivalent natural resources and/or services. The purpose of this rule is to provide a framework for conducting sound natural resource damage assessments that achieve restoration under OPA.

Under the rule, restoration plans developed with input from the public and responsible parties form the basis of a claim for natural resource damages. Final restoration plans are presented to responsible parties for funding. In addition, the rule allows responsible parties to implement trustee-approved and monitored restoration plans. Because assessments will be conducted in the open, and responsible parties and the public will have opportunities to be involved in the planning process, it is expected that restoration will be achieved more quickly, transaction costs will decrease, and litigation will be avoided.

The rule provides for the use of a range of appropriate and cost-effective procedures for an assessment. Procedures to be used within the rule must meet certain standards: they must be capable of providing information of use in determining the type and scale of restoration appropriate for a particular injury; the additional cost of a more complex procedure must be reasonably related to the expected increase in the quality and/or quantity of information provided by the more complex procedure; and they must be reliable and valid for the particular incident. Trustees must select the most cost-effective of two or more equally appropriate assessment procedures. The natural resource damage assessment process in the rule includes three phases as outlined below: 1) preassessment; 2) restoration planning; and 3) restoration implementation.

Preassessment Phase

When notified by response agencies of an incident involving oil, trustees must first determine threshold criteria that provide their authority to begin the natural resource damage assessment,

such as applicability of OPA and risks to natural resources under their trusteeship. Based on early available information, trustees make a preliminary determination whether natural resources or services have been injured. Through coordination with response agencies, trustees next determine whether response actions will eliminate the threat of ongoing injury. If injuries are expected to continue, and feasible restoration alternatives exist to address such injuries, trustees may proceed with the assessment.

Restoration Planning Phase

The purpose of the Restoration Planning Phase is to evaluate potential injuries to natural resources and services, and use that information to determine the need for and scale of restoration actions. The Restoration Planning Phase provides the link between injury and restoration. The Restoration Planning Phase has two basic components: injury assessment and restoration selection.

Injury Assessment

The goal of injury assessment is to determine the nature and extent of injuries to natural resources and services, thus providing a technical basis for evaluating the need for, type of, and scale of restoration actions. Under the rule, injury is defined as an observable or measurable adverse change in a natural resource or impairment of a natural resource service. Trustees must determine that there is: 1) exposure, a pathway, and an adverse change to a natural resource or service as a result of an actual discharge; or 2) an injury to a natural resource or impairment of a natural resource service as a result of response actions or a substantial threat of a discharge. Trustees must also quantify the degree, and spatial and temporal extent of injuries. Injuries are quantified by comparing the condition of the injured natural resources or services to baseline, where necessary.

Restoration Selection

Once injury assessment is complete, trustees must develop a plan for restoring the injured natural resources and services. Under the rule, trustees must identify a reasonable range of restoration alternatives, evaluate and select the preferred alternative(s), and develop a Draft and Final Restoration Plan. Acceptable restoration actions include any of the actions

authorized under OPA (restoration, rehabilitation, replacement, or acquisition of the equivalent), or some combination of those actions.

Restoration actions under the rule are either primary or compensatory. Each restoration alternative considered will contain primary and/or compensatory restoration actions that address one or more specific injuries associated with the incident. Primary restoration refers to actions taken to return the injured natural resources and services to baseline on an accelerated time frame. Natural recovery also must be considered under primary restoration, in which no human intervention is taken to directly restore injured natural resources and/or services to baseline. Compensatory restoration includes actions to compensate for interim losses of natural resources and/or services pending recovery. The type and scale of compensatory restoration may depend on the nature of the primary restoration action, and the level and rate of recovery of the injured natural resources and/or services given the primary restoration action.

When identifying the compensatory restoration components of the restoration alternatives, trustees must first consider compensatory restoration actions that provide services of the same type and quality, and of comparable value as those lost. If compensatory actions of the same type and quality and comparable value cannot provide a reasonable range of alternatives, trustees may consider other compensatory restoration actions that will provide services of at least comparable type and quality as those lost.

To ensure that a restoration action appropriately addresses the injuries resulting from an incident, trustees must scale the action. The approaches that may be used to determine the appropriate scale of a restoration action include the resource-to-resource or service-to-service approach, and the valuation approach.

Under the resource-to-resource or service-to-service approach to scaling, trustees determine the appropriate quantity of replacement natural resources and/or services to compensate for the amount of injured natural resources or services. Trustees must consider using the resource-to-resource or service-to-service approach for actions that provide natural resources and/or services of the same type, quality, and value as those lost.

In situations where trustees must consider actions that provide natural resources and/or services that are of a different type, quality, or value than the injured natural resources and/or services, or where use of resource-to-resource or service-to-service scaling is inappropriate, trustees may use the valuation approach to scaling. To evaluate actions that provide services of a different type or quality, trustees need a common measure to compare services lost and

services provided, such as the value per unit of service. Trustees first calculate the value of the lost services and then determine the value gained from different scales of the restoration action. Trustees then select the scale of the restoration action under consideration that would provide value equal to the value lost. Responsible parties are liable for the cost of implementing the restoration action that would generate the equivalent value, not for the calculated interim loss in value.

Selection of a Preferred Alternative

The identified restoration alternatives are evaluated based on a number of factors that include: (1) cost to carry out the alternative; (2) extent to which each alternative is expected to meet the trustees' goals and objectives in returning the injured natural resources and services to baseline and/or compensate for interim losses; (3) likelihood of success of each alternative; (4) extent to which each alternative will prevent future injury as a result of the incident, and avoid collateral injury as a result of implementing the alternative; (5) extent to which each alternative benefits more than one natural resource and/or service; and (6) effect of each alternative on public health and safety. Trustees must select the most cost-effective of two or more equally preferable alternatives.

A Draft Restoration Plan will be made available for review and comment by the public, including appropriate members of the scientific community where possible. The Draft Restoration Plan will describe the trustees' preassessment activities, as well as injury assessment activities and results, evaluate restoration alternatives, and identify the preferred restoration alternative(s). After reviewing public comments on the Draft Restoration Plan, trustees must develop a Final Restoration Plan. The Final Restoration Plan will become the basis of a claim for damages.

Restoration Implementation Phase

The Final Restoration Plan is presented to the responsible parties to implement or to fund the trustees' costs of implementing the plan, thus providing the opportunity for settlement of damages claims without litigation. Should responsible parties decline to settle a claim, OPA authorizes trustees to bring a civil action for damages in federal court or seek an appropriation from the Oil Spill Liability Trust Fund for such damages.

ACCESS TO THE OIL SPILL LIABILITY TRUST FUND

Under the Oil Pollution Act of 1990, the Congress created the Oil Spill Liability Trust Fund (OSLTF). This fund provides certain Federal agencies (Interior, Commerce, Agriculture, Defense, and Energy) with moneys for the removal of spilled oil and the initiation of NRDAs. The United States Coast Guard National Pollution Funds Center (NPFC) was delegated the responsibility for management of OSLTF. The NPFC provides the include the following guidance:

- Use of the Fund is limited to oil spills.
- Only the Federal Lead Administrative Trustee (FLAT) can request funds from the OSLTF.
- The FLAT needs to prepare a consolidated request for funding on behalf of all involved trustees. The FLAT must ensure that all affected trustees are allowed to participate. The request should include a brief summary of the proposed activities and basis for the cost estimates.
- When possible, the trustees should first seek funding from the RP.
- The FLAT must ensure that detailed cost documentation is maintained by all trustees that receive moneys from the OSLTF.
- The fund is only available for the "initiation" of NRDAs.
- Although no specific time limits exist, the NPFC has suggested that the request for funds should be made within two weeks of the incident, and initiation activities should be completed within 2 months.
- If the initial ceiling established by the NPFC becomes inadequate, the trustees must request an increase prior to incurring additional expenses.
- The OSLTF will be available for the initiation of oil spill NRDAs regardless whether the assessment is performed in accordance with the Federal NRDA regulations, but the Fund Center strongly encourages the trustees to follow the Federal NRDA regulations.
- Property purchased using the Fund must be surplused at the close of the initiation period.

Initiation Activities

The NPFC defines the scope of "initiation" as those activities that generally coincide with the preassessment screen activities described in the NRDA regulations for CERCLA, or in the natural resource regulations for OPA. The following categories of initiation costs are listed on the NPFC initiation request form:

- Notifications in accordance with the NCP and coordination
- Characterization of discharge and environmental setting
- Determination of potential exposure
- Determination of potential injury
- Characterize potential risk to natural resources and services
- Estimation of extent of injury to natural resources and services
- Estimation of Damages
- Damage assessment determination
- Data collection and analysis
- Report preparation

Contact addresses and phone numbers for the NPFC and an example initiation request to the OSLTF can be found in Appendix 10.

THE NRDA PROCESS

INTRODUCTION

The first activities of a spill response—the identification of the resources at risk from the release—is similar to the first steps in the NRDA response. Based on knowledge of the life stage and populations of organisms present, habitat types, spill size, and the physical and chemical behavior of the spilled material, a preliminary analysis of the extent and magnitude of the impact should be determined. This preliminary analysis is very important because it drives the nature of the short-term data collection. For example, there is usually no need to initiate sediment sampling for an offshore spill of gasoline, because of the rapid, nearly total evaporation of the product from the water surface.

The physical and chemical properties of the spilled material determine which resources may be exposed to injury. For chemical spills, the range in possible types of spills is very large, requiring a spill-specific analysis of the spilled material fate and effect. For the initial phase of assessment, oil spills can be divided into six broad categories, based on the predicted short-term behavior and likely impacts to natural resources. Pertinent properties of each oil type are summarized in Figure 3.

There are several models that can be used to predict the fate of an oil spill. The Type A physical fates submodel reports an updated mass balance for several time periods during each day of the spill, which can be very useful in analysis of pathways of exposure. The SAIC oil weathering model (Payne *et al.*, 1983) can also be used for a wide range of oil types if the boiling point fractions are known. NOAA's Modeling and Stimulation Studies Branch (MASS) developed ADIOS, which is an oil fate model designed to estimate evaporation rates, emulsification, physical properties, etc., for hundreds of specific oils.

Once the potential impacts are identified, the next immediate step is to document exposure. During the early stages of the spill, time-sensitive (perishable) information should be identified and obtained. There needs to be a deliberate effort to conduct a preliminary analysis of the potentially injured resources and to update this analysis as spill conditions change. Even if it is likely or known that a Type A assessment is to be conducted, some limited collection of field data is often useful to support, validate, or augment the model results.

Type 1 Very Light Oils (Gasoline)

- Highly volatile
- Should all evaporate within 1-2 days
- Highly soluble

Type 2 Light Oils (Jet Fuels, Diesel, No. 2 Fuel Oil, Light Crudes)

- Moderately volatile
- Will leave residue (up to one-third of spill amount) after a few days
- Moderately soluble, especially distilled products

Type 3 Medium Oils (Most Crude Oils)

- About one-third will evaporate within 24 hours
- Typical water-soluble fraction 10-100 ppm
- May penetrate substrate and persist
- May be significant clean-up related impacts

Type 4 Heavy Oil (Heavy Crudes, No. 6 Fuel Oil, Bunker C)

- Heavy oils with little/no evaporation or dissolution
- Water-soluble fraction typically less than 10 ppm
- Heavy surface contamination likely
- Highly persistent, long-term contamination possible
- Weathers very slowly; May form tarballs
- May sink depending on product density and water density
- May be significant clean-up related impacts

Type 5 Low API Fuel Oils (Heavy Industrial Fuel Oils)

- Neutrally buoyant or may sink depending on salinity and temperature
- Weathers slowly; sunken oil has little potential for evaporation
- May accumulate on bottom under calm conditions and smother subtidal resources
- Sunken oil may be resuspended during storm events, providing a chronic source of shoreline oiling
- Highly variable and often blended with oils
- Blends may be unstable and the oil may separate when spilled

Type 6 Animal and Plant Oils (Fish Oils, Vegetable Oil)

- Shipped in smaller quantities than petroleum oils, but may be stored in large quantities
- Physical properties are highly variable
- Have a high biological oxygen demand (BOD) which could result in oxygen deprivation in confined water bodies

FIGURE 3. **General oil properties.**

ROLES ON THE EARLY SAMPLING NRDA TEAM

The composition and size of the NRDA team will vary according to the complexity of the spill. For a "typical" spill requiring NRDA field studies (less than one million gallons of oil, shoreline impacts of less than 200 kilometers, emergency response lasts weeks to a few months), the following roles are essential:

NOAA/DAC Coordinator: This person must have the authority to represent NOAA as federal trustee, and can only be a NOAA employee. Responsibilities include the following activities:

- Attend trustee meetings.
- Represent NOAA's trustee interest at meetings[3].
- Determine the potential for impacts to NOAA trustee resources.
- Develop the overall NRDA Strategy
- Initiate trustee meetings and trustee involvement when lacking.
- Evaluate the adequacy of current NRDA activities.
- Recommend activation of additional team members.
- Prepare and submit initiation requests to the USCG Fund Center, or FLAT if NOAA is not lead.

Technical Support Team: Responsibilities for this person (or persons) include the following:

- Evaluate the chemical fate and effects of the spilled material.
- Collect information on natural resources at risk.
- Collect and evaluate perishable economic data.[4]
- Identify data gaps in current NRDA activities.

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[3] Note that the NOAA Regional Response Team (RRT) member also represents NOAA's trustee interest. The RRT member will focus primarily on response issues, while the DAC representative will focus on NRDA issues.

[4] Preassessment economic considerations are included in Appendix 8.

- Assist in developing a consensus among trustees on resources at risk and objectives of early sampling plans.
- Assist with the preparation of the initiation request.
- Assist in preparation of early sampling plans.
- Implement early sampling plan (in coordination with trustees).
- Determine need for specialized or local experts.
- Guide work of specialized experts along NRDA requirements.

Information Manager: Responsibilities for this person include the following:

- Collect reports, minutes of meetings, and technical and response data in an organized manner with full documentation.
- Make sure that all NRDA meetings have minutes taken.
- Develop a simple database on NRDA sampling efforts (who, what, where).
- Prepare a Daily Activities Log for the record and submittal to DAC.
- Prepare and deliver to DAC a complete file on the spill, with an electronic index or reference list.

Legal Counsel: Responsibilities for this person include the following:

- Coordination with co-trustees and Potentially Responsible Party.
- Negotiation of agreements.
- Coordination with the USCG on access OSLTF for initiation.
- Assist in the development of the early NRDA strategy.
- Identification of the Responsible Parties and determination if any exclusions to their liability exist.

Experts: Depending upon the size and potential impacts of the spill, specialized technical experts may be needed on the NRDA team very early during the spill event. They can contribute to the early effort of the team remotely by telecommunications and provide recommendations on several guidelines, detailed methodologies, etc., or go on-scene and direct the activities themselves.

One person may take on multiple roles, depending on the scale and phase of the spill response. Initially, at least two team members are needed to go on-scene, to collect and evaluate the information needed to determine the level of response, and prepare a preliminary sampling strategy. Other team members and experts can be mobilized as needed.

Emergency response is different from planned field surveys in that other schedules must be juggled without proper planning or preparation. Other business and personal commitments must put on hold. The stress of long field days, late meetings, planning for the next day, and emergency conditions are also hard on staff. Thus, team members should be rotated out of emergency response roles after a period of time, usually no longer than 2-3 weeks with an overlap period of 1-2 days for replacement staff.

PREASSESSMENT NRDA STEPS

Oil and chemical spills, by their very nature, create a sense of urgency and chaos with respect to the collection of field data. Thus, a disciplined and systematic approach to evaluating the spill and initiating damage assessment work is needed. Cooperation between clean-up responders and NRDA personnel should be maximized, but the operational response cannot be compromised by NRDA activities. Exchanging information between groups will result in the best response to a spill emergency.

After notification of an incident, there are several steps that an NRDA responder should take. These steps include:

1) Accessing the NOAA Hotline and U.S. Coast Guard (USCG) Pollution Reports (POLREPs) for historical and current information on the spill site, amount spilled, natural resources at risk, status of cleanup, etc.

2) Gathering data regarding natural resources and habitats in the impacted or expected to be impacted area.

3) Collecting information on impaired resource services.

4) Having other in-house personnel continue information searches and identify possible local experts for consultation/assistance.

5) Documenting areas of impact through site surveys and sample collection.

Each of these initial NRDA response steps is detailed below.

ACCESSING SPILL RESPONSE INFORMATION

Immediately following an incident of significant size or potential impact, an incident notification report is entered into the NOAA Hotline Report (Hotline), part of the FirstClass computer network provided by the Hazardous Materials Response and Assessment Division (HMRAD) in Seattle, Washington. Hotline keeps all agencies informed of response activities being conducted throughout an incident and serves primarily as an update or memo board for involved personnel. The accuracy of the Hotline is not guaranteed as early reports may not be updated when additional information becomes available. The USCG also generates POLREPs for each spill on a daily or more frequent basis. POLREPs focus on USCG operational issues, whereas Hotline reports include more information on natural resourceissues being handled by the NOAA Scientific Support Coordinator (SSC). Appendix 11 includes a glossary of terms commonly used during oil spill responses and in the NOAA Hotline reports.

Typical information contained within the daily Hotline reports includes the volume and location of the spill/incident, on-scene personnel, resources at risk, and trajectories. This information is essential to a timely NRDA response. As a spill progresses, additional information becomes available regarding the status of the incident, natural resourceprotection issues, weather forecasts, tidal predictions, and cleanup progress. If an SSC is on-scene, a daily evening report is usually entered into the Hotline.

COLLECTING INFORMATION ABOUT THE SPILL

Although Hotline and POLREPs supply a good background on the spill, a rapid collection and study of available literature, chemcial databases, and maps will allow the NRDA responder to be better prepared and more knowledgeable about the area and the potential impacts. Information to collect can include:

- Geomorphology and physical processes of the area.
- Maps (U.S. Geological Survey topographic maps, NOAA charts).
- Habitat types likely to be encountered.

- Species present.
- General characteristics and behavior of the spilled material

Much of this information is available at the Command Post for operations established by the USCG, U.S. Environmental Protection Agency (USEPA), or State On-scene Coordinator (SOSC). Resources such as Environmental Sensitivity Index atlases (ESI), navigation charts, etc., are usually available at the Command Post. Recently, a great deal of information has been made available in digital formats, including via the internet. However, whenever possible, the NRDA responders should bring their own charts and other general reference and background materials to the spill site, as access to the Command Post resources, and to telephone lines may be difficult.

Onscene, the NRDA responder should request the Federal On-scene Coordinator's (FOSC) permission for timely access to response information as it is generated; this request should be coordinated through the SSC, if present. However, the NRDA responder must understand that the Command Post is the center for clean-up operations during the spill; the objective is for containment, clean-up, and recovery of impacted resources. The NRDA response team must follow all rules and regulations regarding Command Post procedures and protocol. The NRDA responder's requests and activities cannot interfere with containment and cleanup operations.

IDENTIFYING EXPERTS

As the spill conditions are defined, experts may be needed to provide information and evaluate specific natural resourceimpacts. Usually local experts are identified fairly quickly during the preassessment phase of a response operation. This information may be available from the spill Command Post. In addition, non-responder NRDA personnel should identify local and national experts who have a first-hand knowledge of the habitats and resources impacted.

The local and national experts may be consulted regarding sampling and long-term monitoring as they have familiarity with the resources and past survey methods in the area, as well as strategies for injury quantification. As is often the case, the NRDA responders will collect the time-sensitive or "perishable" data immediately prior to, or following, a spill, but experts are usually consulted to develop and conduct longer-term

monitoring programs for injury assessment. Expert input regarding historical sampling methodologies will increase the value of preassessment sampling and analysis procedures. During a response, historical and on-going sampling protocols should be used as much as possible to allow comparative analyses between pre-spill and post-spill conditions and variables. If different sampling methodologies are used, comparative analyses may be different or infeasible.

DOCUMENTING AREAS OF IMPACT

Once arriving on-scene, the NRDA responder's first objective is to survey and evaluate the potential extent of injury to natural resources and identify areas that may be affected in the future. There are several tasks that need to be completed for the preassessment phase. These tasks include:

1) Collection and assessment of readily available information on the type, amount, characteristics, location, and predicted trajectory of the spill.
2) Development of a brief early sampling plan for the NRDA response.
3) Conducting reconnaissance surveys and on-site inspections of exposed areas or areas soon to be exposed.
4) Development and implementation of a more detailed plan for early sampling for determination of the pathways of exposure and injuries.
5) Calculation of a mass balance for the spill (see Appendix 13).
6) Development and implementation of an information management strategy, such that initial information is properly documented and organized.

The NRDA responders need to be aware of the complex number of tasks to be completed during a response. They play many roles: observer, scientist, data manager, and coordinator. They will be involved in numerous meetings with state and federal natural resourcetrustees while simultaneously being responsible for collecting perishable data and documenting the pathways and extent of exposure. The NRDA responders need to remain organized and consistent for the duration of the response.

Figure 4 includes a checklist for the NRDA responder to refer to before leaving the office and during the first few days of the on-scene response. This checklist is not all-inclusive, but should be used as a guide for the types of issues that should be

considered during preassessment activities. Safety of NRDA team members should be a high priority and appendix 14 contains information on safety issues, including a generic site safety plan and a glossary of safety terms.

Checklist for NRDA response: Before Leaving Office

- ☐ Collect initial information on the spill, including the responsible party, the amount released, potential amount, material spilled, location, etc.
- ☐ Ensure that other NOAA elements have been notified (DAC Headquarters, RC, OGC, Sanctuaries, etc.). Keep DARP informed on a routine basis.
- ☐ Begin keeping logbook of activities. Establish a basic filing system and begin filing all relevant documents.
- ☐ Check FirstClass for spill reports. Call the SSC, CRC, or other on-scene personnel for the most recent briefing on spill events and resources at risk.
- ☐ Determine need for any special equipment, personnel, or experts and forward request to DAC headquarters ASAP.
- ☐ Get OSC Command Post phone numbers and location. Maintain a phone and address list for response agencies, trustees, RPs, and contractors.
- ☐ Obtain copies of NOAA charts, ESI maps, and topographic maps. Make letter-sized copies for overflights and ground surveys.
- ☐ Collect information on weather, sea conditions, tide schedules, including wind speed, currents, temperatures.
- ☐ Check contents of kits and select necessary equipment. Check camera. Bring fresh batteries and extra film. Check contents of personal safety kits.
- ☐ Get a supply of Federal Express labels, envelopes, and boxes. Make sure that you have the office credit card.
- ☐ Check laptop computer, portable printer, and software. Check that you have telephone and 3-prong plug adapters. Bring extra disks and paper.
- ☐ Bring extra forms and documents that may be useful, including this manual. Make extra copies of forms.
- ☐ Begin tracking time. Inform DAC headquarters of the need to establish accounting codes for the case.
- ☐ Determine co-trustee concerns and activities. Decide whether to appoint FLAT. Consider whether to appraise USCG Fund Center of potential request

FIGURE 4. **Checklist of early assessment activities for the NRDA responder.**

Checklist for NRDA response: On Scene Issues:

- ☐ Locate the command post and establish a NRDA work area for the trustees. If possible, order a separate phone line. Rent cellular phones if necessary.
- ☐ Evaluate the site safety issues. Obtain a copy of the site safety plan, if available, or develop your own. Make sure that all team members have read and signed the plan.
- ☐ Obtain a briefing on the incident status from the OSC or SSC, including salvage status, response activities, spill trajectory, and weather. Brief the OSC and SSC on expected NRDA activities and logistical needs.
- ☐ Obtain a briefing on the resources at risk, wildlife impacts to-date, and names of contacts for the natural resourceagencies involved in the response.
- ☐ Get on an overflight as soon as possible. Bring charts, camera and/or video camera, and necessary safety equipment. Keep a detailed photo log.
- ☐ Locate and call a meeting of all on-scene natural resource trustee representatives. List trustee concerns and outline next steps in the NRDA process. Identify the resources and services likely to be impacted. Establish a regular meeting schedule.
- ☐ Plan to collect critical samples such as samples of the oil from the source. Evaluate the need for finger-printing and other samples.
- ☐ Develop a daily schedule, including team meetings, covering OSC briefings, and routine contact with DAC headquarters.
- ☐ Document oiled areas using aerial photography and video cameras. Repeat observations over time. Document clean-up actions and appearances of "cleaned" areas.
- ☐ Develop a plan to collect perishable data, collecting data on lost services as well as biological data. Keep track of shoreline, waterway closures, and seafood safety advisories.
- ☐ Coordinate with wildlife rehabilitation groups to make sure that detailed documentation on number, species, and fate of animals is being kept.
- ☐ Formulate a USCG initiation request.

FIGURE 4. (Continued) Checklist of early assessment activities for the NRDA responder.

Checklist for NRDA response: On Scene Issues:

- ☐ Obtain copies of any and all reports, maps, press releases, cleanup plans, and trajectory information from the Command Post and file them.
- ☐ Determine need for additional DAC headquarters or contractor support. Make sure everyone on the teams has appropriate safety gear and training.
- ☐ Determine whether on-scene supplies are adequate. Consider shipping in extra supplies and equipment, including desktop computers and printers.
- ☐ Determine what sampling and NRDA activities are on-going by response agencies, co-trustees, and contractors for the Responsible Party.
- ☐ Make sure that exposure data and information showing the distribution of the oil is being generated and maintained in a systematic manner.
- ☐ Make sure that there are protocols for field data collection are documented and that all NRDA team members understand them. All team members should be keeping detailed notes and photo logs.
- ☐ Make sure to keep tracking time and costs. Coordinate with DAC headquarters to makes sure that financial tracking system is in place. Make sure that field crews assign their time to the correct account numbers.
- ☐ Evaluate the need for experts and identify potential experts, as needed for spill conditions. Refer emergency contracting issues to DAC.
- ☐ Review USCG funding status and consider the need for a supplemental request. Ensure that all co-trustees are keeping adequate records.
- ☐ Implement documentation procedures by distributing forms for field observations, chain-of-custody, photo logs, daily activities reports, etc.
- ☐ Identify types and source of baseline and historical data for the resources and services likely to be impacted.
- ☐ Prepare to meet with the RP. Work with co-trustees to determine if a cooperative assessment is a possibility.
- ☐ Begin to develop overall assessment strategies and begin to draft the preassessment screen and NRDA strategy document.

FIGURE 4. (Continued) Checklist of early assessment activities for the NRDA responder.

Development of a Preassessment Sampling Plan

During a spill response, the NRDA responder should develop a preassessment study plan for collecting critical data on the natural resources and services that have been or are likely to be affected. This plan will help the trustees to coordinate and focus their preassessment efforts. This plan should clearly state: the objectives of the study; what resources are to be studied; the type of samples that are to be collected; the frequency of sampling; and the type of analysis anticipated. Each study plan will be unique for the current spill conditions and must have the flexibility to incorporate new objectives as the on-going spill conditions change.

Typical study plans will incorporate a combination of the following components:

1) On-scene assessment of the incident, both aerial reconnaissance and ground surveys, to map the distribution of the spilled material on the water, in the intertidal zone, and in subtidal habitats.

2) Documentation of natural resourceinjuries through collection of:

   - samples of the source material;
   - environmental samples (slick, sediment, and other) for source confirmation and weathering patterns;
   - water and sediment samples for verification of levels of exposure;
   - tissue samples, to document exposure and uptake;
   - sediment samples for grain-size analysis.

3) Biological surveys for early documentation of injuries to:

   - birds;
   - marine mammals;
   - terrestrial mammals;
   - fish;
   - shellfish;
   - reptiles;
   - intertidal communities.

4) Collection of other documentation regarding habitat and wildlife impacts and/or injuries.

5) Documentation of lost uses (e.g., closures of beaches, waterways, water sources) due to the spill.

The plan should be revised whenever spill conditions change, or when observations/ results indicate impacts are different from the original assumption. The plan should be written, even if only in outline form at first, and distributed to the co-trustees for their review and participation.

On-scene Assessment of the Situation

The early identification of areas impacted or potentially impacted is usually conducted via aerial reconnaissance. During overflights, the extent of the spill should be documented in order to guide the establishment of monitoring stations and reference (unoiled) sites. This information may be collected by the response team, but the trustees need to ensure that the information collected is of the scale, frequency, or detail required for NRDA.

The assessment of areas likely to be impacted can be guided by the oil trajectories provided by the MASS Branch of HMRAD or other response team members. The general techniques for aerial reconnaissance surveys are detailed below.

Aerial Reconnaissance Studies. An overflight of the entire area is conducted during low tide to observe maximum exposure of the intertidal area. An aerial survey allows for an extremely rapid assessment of the entire spill site and is especially useful in determining the relationship between local geomorphology and contaminant distribution, as well as the areal extent of impacts (e.g., heavy accumulations of oil in east-facing pocket beaches, little oil along exposed rocky headlands). Aerial surveys are also useful for observing impacts to wildlife, and censusing wildlife potentially at risk.

Inflight observations are recorded both verbally on tape and photographically with a hand-held 35-mm camera, or a video camera (preferably both). Appendix 4 provides some recommendations for field photography. The best altitude for observations is between 500 and 1,500 feet, although higher or lower altitudes can be used if desired and local flight regulations permit it. Either a helicopter or fixed-wing (high-wing) aircraft may be used.

Primarily, the NRDA responder conducts an overflight to determine the extent of contamination or areas likely to be contaminated,

Important guidelines for conducting a safe and productive overflight are summarized in Figure 5 as an overflight equipment and procedures checklist, and outlined below:

1) Learn the communications protocol in the aircraft, i.e., when not to talk, who is directing the pilot, and how to communicate your wishes.

2) Go over the flight plan with the pilot; have a map of the flight plan sketched out, if possible.

3) Always have your own maps and know the area to be surveyed.

4) Constantly keep track of where you are, and track your elevation.

5) Plot your flight path on your map, noting the time every 30 minutes or when you change direction.

6) Make detailed observations of affected animals or the proximity of animals (birds, mammals, schools of fish) and commercial and recreational fishing, boating, etc. to the pollutant.

7) When mapping contaminants onshore, carefully locate yourself with land features. Use detailed descriptors for contaminant type, coverage, dimensions, behavior (sheening, refloating, or lack thereof). Draw directly onto your map. Note the presence of clean-up workers, position and estimates of number of birds, by species, and observations on position of the contaminant relative to natural resources. For oil spills, use a pre-determined code for describing oil type (mousse, black oil, rainbow sheen, etc.) and coverage, as shown in Appendix 15.

8) Immediately after returning to the Command Post or base of operations, transfer your observations to a worksheet and a clean copy of a map while the information is still fresh in your mind.

9) If photos are taken, identify the location of all photos on the map as they are taken to create an accurate record of the overflight. Check your photo log and make sure it is completed.

During spill emergencies, all available aircraft may be committed to the response operations. Therefore, NRDA overflights may be combined with other operations. The NRDA responder needs to review the flight plan, as the reconnaissance efforts may not be focused in areas of high priority to the NRDA responder. However, there are often multiple overflights conducted per day, and even if an aircraft is made available, NRDA overflight priorities can usually be addressed within this operational framework. The response organizations may be concerned that NRDA activities will

compete for scarce logistics during a spill. The NRDA team needs to be cognizant of, and avoid, potential conflicts.

Equipment:

- ☐ Map or chart for recording overflight information.
- ☐ Tape recorder with cassettes (two long-playing).
- ☐ 35-mm camera with polarizing lenses.
- ☐ Three (3) rolls of 36-exposure Kodachrome or Fujichrome (ASA 64 or 100) film.
- ☐ Video camera with new tape (optional).
- ☐ Plastic, box-type clipboard that contains:
  - ☐ extra lead pencils with erasers;
  - ☐ magic markers;
  - ☐ rubber bands to hold map in place;
  - ☐ oil types descriptions/percent cover definitions.

Do's and Don'ts

- ☐ Do take off loose hats/caps prior to approaching a helicopter, so it won't blow off and get sucked into the engine.
- ☐ Do use a knee board or clipboard to keep maps handy.
- ☐ Do make sure you get a full safety briefing and know how to use the radio in the event of an emergency.
- ☐ Do wear a flotation device if flying over water.
- ☐ Do discuss communications protocol during the flight.
- ☐ Do review flight plan with pilot (have maps of flight plan sketched out, if possible).
- ☐ Do plot flight path (approximately every 30 minutes or when-ever change in direction occurs).
- ☐ Don't have loose papers that can be blown out when the doors are opened.

FIGURE 5. **Overflight equipment and procedures checklist.**

Ground Reconnaissance Studies. Following the overflight, the responder usually visits selected areas for groundtruthing and sampling. These ground surveys should be conducted with the realization that future monitoring studies may be established in some of these areas, so detailed records should be made of all observations.

When physically visiting exposed sites or potentially affected areas, the responder should record the degree of impact (spill distribution, percent coverage, zone of coverage), create visual records of the sites (photographs, video records, field sketches, oral descriptions on tape, etc.), collect samples as needed, and identify areas that may serve as likely reference sites. As time is often the most limiting factor during the early response, this data collection should be carried out as quickly as possible while still maintaining good records of all observations. Guidelines for conducting more detailed surveys of impacted areas by habitat are provided in later sections.

GENERAL PREASSESSMENT STRATEGIES AND APPROACHES

INTRODUCTION

Information regarding the collection of perishable data has been divided into two sections: chemical analyses and biological resources. Accepted methodologies for collection of perishable data from the spill source and water/sediment contamination are presented in the first section, while quantifying the impacts to wildlife and habitats are detailed in the next section.

Prior to collecting samples, the NRDA responder must have knowledge of the proper procedures required for collecting high-quality data. These require ments include:

1) Developing Sample Collection Strategies
   - Clearly stated objectives
   - Hypotheses
   - Endpoints
   - Sample design
   - Controls
   - Number of samples
2) Documentation and Reporting Requirements
   - Quality assurance protocols
   - Sampling equipment and sample containers "clean" requirements
   - Sample identification and labeling
   - Record keeping

These topics are discussed in detail in the following section. The NRDA responder should become intimately familiar with these topics as they define the very structure of the NRDA response.

DEVELOPING SAMPLE COLLECTION STRATEGIES

During a NRDA response, sample collection strategies and procedures should be thoroughly defined and documented. Scientific methodologies that require careful

documentation include outlining the pre-study conditions for analysis. The *a priori* development of formal objectives, hypotheses, analyses, and endpoints is needed to adequately outline the course of study.

Objectives

Stating a clear objective often seems so obvious that it is not explicitly mentioned by people considering sampling projects. The early sampling strategy should include a clear statement of the objectives, which will help to define how samples should be collected. For example, if the objective for collecting a source sample is to have a reference sample for finger-printing purposes, a smaller sample will be needed than if the objective is to collect source oil for later bioassay experiments. During an NRDA response, the objectives are best defined by asking the following questions:

1) What are the potential or suspected injuries?
2) What information and data are needed to evaluate the suspected injuries?
3) What is the priority information (e.g., critical and/or perishable)?

Often, the first priority of an NRDA response is to survey the extent of contamination and then to determine the potential for injury to natural resources and their services.

The early NRDA data will ultimately be used to estimate injuries and loss of services and to focus the later assessment activities. Thus, it is important that the NRDA responder develop and follow clearly stated objectives in order to accurately assess the extent of injury during a spill incident.

Hypotheses

A hypothesis is merely a restatement of the objective in statistical language that can later be subjected to a statistical test, where the hypothesis will be rejected or not rejected, depending on the data results. Experiments having several components may have several different hypotheses.

The development of a formal sampling procedure should also include the development of a null hypothesis. Daniel (1983) defined a null hypothesis as follows:

> "In general, the null hypothesis is set up for the express purpose of being discredited. Consequently, the complement of the conclusion that the researcher is seeking to reach becomes the statement of the null hypothesis. In the testing process, the null hypothesis either is rejected or is not rejected. If the null hypothesis is not rejected, we will say that the data on which the test is based do not provide sufficient evidence to cause rejection. If the testing procedure leads to the rejection of the null hypothesis, we will conclude that the data at hand are not compatible with the null hypothesis, but are supportive of an alternative hypothesis. When we fail to reject a null hypothesis, we do not say that it is true, but that it may be true. When we accept a null hypothesis, we do not say that it is true, just that the evidence supports this hypothesis."

Formulating an explicit hypothesis will also necessitate selecting the endpoint to be used for determining whether the hypothesis is accepted or rejected.

Endpoints

Endpoints are specific measures of the objectives of the experiment, and they determine how parameters such as effectiveness, toxicity, or similarity will be measured. Ideally, endpoints should be a measurable quantity, such as, "the concentration of PAH in tissue, measured as dry weight," or, "the abundance of selected species counted in intertidal quadrats." Endpoints may include qualitative data, but the type of data and the way they will be used should be specified as closely as possible. As part of establishing endpoints, proper sampling procedures should be followed and documented to ensure that the samples are collected and handled appropriately.

Two major problems may result from the failure to select an endpoint for an experiment:

1) The data collected may not have been handled appropriately for the analyses that are needed; and

2) The type of data or the way they were collected may not be appropriate to answer the original objective.

Specific selection of endpoints is also very important when several groups are involved in an experiment, as is frequently the case with NRDA studies. At the conclusion of the project, it may be found that the data collected do not answer the question posed. Or, when several different kinds of data are collected, disagreement may ensue among the

different groups involved over what constitutes the "real" endpoint, and thus the "real" result.

Sampling Design

A sample design includes consideration of reference sites, the number of samples to be collected, the locations where samples will be collected, the timing of sampling, and sample handling and analysis. For monitoring or sampling projects other than very simple ones, the best procedure will be to consult with a statistician while still in the planning stage. More detailed habitat and resource-specific sampling design guidelines are developed in later sections.

Reference Sites. A crucial part of most experiments is the reference site. Most objectives will involve detecting differences, or making comparisons, and thus require a baseline, or reference from which to measure change. In the absence of some sort of reference, interpreting the data will be difficult. In theory, reference sites should be replicates of the tested or experimental site, which are the same in every way, except for the treatment applied.

In practice, reference sites in field studies are never completely identical to the test sites. Usually, one must settle for a "representative control" that is as similar or as representative as is feasible. Other options include the use of experimental units placed in the environment, such as sediment boxes. This technique was used by Berge (1990) to study colonization of biota to sediments impacted by oil, compared with unoiled sediments.

One way to establish reference sites to differentiate or quantify the effects of the cleanup is by the use of "set-asides" (areas that are affected by a spill that are set aside, and left untreated for experimental purposes). NOAA arranged for such "set asides" after the *Exxon Valdez* spill. Having these sites made it possible to conduct the long-term study of treatment effects in Prince William Sound that is still ongoing (Houghton *et al.*, 1991a; 1992). For NRDAs, however, there is seldom the need for separating out oil and cleanup injuries; both are resulting from the spill and both may be included in the injury determination.

Number of Samples. The number of samples to be collected will depend on:

- The hypothesis being tested;
- Data analysis methods (including the statistical certainty desired); and
- Practical considerations (area available, access, personnel, cost, etc.).

A larger number of samples often allows greater power for statistical analysis, but will be more costly. If the parameter being measured is highly variable, such as the distribution of oil in sediments, a large number of samples will be needed to increase the power necessary to conduct statistical testing. A small number of samples will provide an indication of the processes occurring, but may not be representative of the entire study area or adequate to statistically differentiate among sites. One strategy is to collect a large number of samples in the field and then analyze only a subset of the samples collected, based on the early results. However, it is more useful to take fewer carefully thought out samples than to take numerous samples without proper planning.

The number of replicate samples to be collected often depends upon the information expected to be gained from the samples. During the early sampling effort, more replicate samples may be needed because of large variations and patchiness in distribution of the contaminants in the environment. Sample preservation and holding times must also be considered. Guidelines on how to define the sampling strategy and determine the necessary number of samples for chemical and biological sample collection schemes are included in later sections.

QUALITY ASSURANCE PROTOCOLS

To produce data that will stand up in a court room, it is necessary, at a minimum, to be able to characterize the quality of the data. If time permits, it is desirable to specify data quality objectives (DQOs) that meet the needs of the project, and to establish a quality assurance strategy for meeting the DQOs (see, for example, Preparing Perfect Project Plans, USEPA, 1989). The following section provides basic instructions and ideas for meeting only the most fundamental quality assurance needs during a spill response situation. The responder should understand these instructions, and apply them to each specific spill and study.

Perhaps the most basic and important guidance is to ensure that all members of the NRDA team have appropriate training. Take the time to go over methods as a group before splitting up into teams. If possible, go into the field as a group and practice the techniques. Agree upon terminology to be used, and calibrate the various individuals who will be making those observations. Otherwise, one person may describe a site as heavily oiled, while another may describe the same site as partially oiled, etc..

If the basic considerations outlined below cannot be addressed for any given observation, survey, or study, the NRDA responder should seriously consider whether the data generated will have any value at all for a NRDA.

Data Quality

EPA recognizes five measures of data quality:

1) Accuracy or bias—the difference between a measured value and the true or expected value.

2) Precision—the degree of mutual agreement among repeated measurements of the same value or parameter.

3) Representativeness—the degree to which data accurately and precisely represent the characteristic of a population parameter, variation of a property, a process characteristic, or an operational condition.

4) Completeness—a measure of the amount of data collected from a measurement process compared to the amount expected to be obtained under the conditions of measurement.

5) Comparability—the confidence with which one data set can be compared to another.

Under emergency conditions, when time and resources are short, it is recommended that the responder focus on determining and documenting accuracy and precision. Listed below are representative types of data and observations that may be needed in a spill event, with some recommendations on how to control and document data accuracy and precision.

Counts—It may be necessary to count carcasses, to determine densities of live organisms, or to quantify other parameters through counting.

Accuracy can be checked in some cases by verifying counts with a more reliable methodology. For example, an aerial photograph could be closely examined to determine whether aerial counting techniques or ground observations were accurate. Another technique for checking accuracy might be to mark the objects counted by one person using a routine survey technique, and then to check the same area with a second more intense counting technique to determine whether all objects have been counted and marked. It is recommended that 10 percent of counts be checked for accuracy. Decide ahead of time what steps should be taken if the counts don't agree- For example, data may be flagged in the log book, or steps may be taken to recount, etc.

Precision can be checked by counting the same objects in the same area using the same technique. It is recommended that precision be checked by a second counter for 10 percent of the counts. Again, the team will need to decide what steps should be taken if the counts don't agree.

Characterizations—A variety of characterizations may be encountered during a spill damage assessment. A characterization occurs when an observer places a situation or observation into a category. Examples of characterizations include mapping the degree of oiling on a beach, taxonomic identifications, and naming a histopathological condition.

Accuracy may be determined by archiving a standard representation of the category and submitting the standard representation for independent evaluation. For example, the standard representation could be a picture or schematic used for determining level of oiling, or voucher specimens for species identifications and histological conditions. Each standard or voucher specimen should be evaluated or identified by an independent expert to determine whether the characterization was correct.

Precision may be evaluated by conducting replicate characterizations by the same observer and/or different observers. The degree of agreement among replicate characterizations would represent the level of precision associated with the data. It is recommended that 10 percent of the characterizations be checked for precision.

Measurements—A number of parameters might be measured during a spill damage assessment. Typically, measurements use equipment to generate a numerical characterization. For example, the weight or size of an organism, or chemical concentrations might need to be measured.

Physical Measurements–

Accuracy may be determined by regular calibration of the measurement equipment using standards (e.g., standard weights). All calibration measurements should be recorded in the field log. The frequency of calibration depends on the type of equipment; it is better to do too many calibration checks than not enough.

Precision may be determined by repeating the same measurement more than once. It is recommended that 10 percent of the measurements be replicated to allow evaluation of precision.

Chemical Measurements–

Laboratories with demonstrated capabilities and recent successful experience with identical or similar analyses and sample matrices should be used. Analytical laboratories should be willing to provide their Quality Assurance Plan and related documentation. This information should be collected prior to sending samples for analysis.

Accuracy may be checked using various calibration standards, reference materials, laboratory spikes, and blanks. It is recommended that a minimum of one reference material and/or other standard be run with each batch of analyses. It is generally recommended that one of the standards employ the same matrix as that being analyzed for the study.

Precision may be evaluated using replicated analyses of the same sample (assuming that it is homogeneous). One sample per analytical batch should be split and run as a laboratory duplicate. Field duplicates show variations that result from the combined effects of both the sampling and analytical procedures.

Both accuracy and precision deteriorate as the method detection limit is approached. The responder should know the method of detection limit to ensure that the analytical technique is appropriate to the study.

Duplicate counts, calibrations, laboratory replicates, verification by independent experts, and other types of data that allow an evaluation of data quality should be included in field notes and data tables so that an independent evaluation of the data quality may be performed. Therefore, the responder should take appropriate steps to ensure that such data are recorded and reported.

Record keeping and Documentation

Standard operating procedures for all sampling procedures must be written in detailed, clear, simple, and easy-to-follow language. All team members must be trained and experienced in the prescribed procedures. Any changes in procedures, including the justification for the changes, must be recorded in detail in spill-specific logbooks. These logbooks should be sturdy, bound books with sequentially numbered pages. Waterproof paper is preferred for field logbooks.

All information pertinent to field activities should be recorded in the field logbook. The information should be accurate, objective, and complete. The descriptions should be complete enough to allow anyone reading the entries to reconstruct the sampling situation. Additional information may be provided by field data sheets and photographs, both of which should be referred to in entries in the field logbook. Sample tags are NOT appropriate forms for recording important field data unless the information written on each label is transferred to data sheets or the logbook at the end of each day. There is no guarantee that the information recorded on the sample tag will be recorded by the laboratory or made available to the sample collector.

The entries for each day should be closed out with a horizontal line, dated, and initialed. Errors in entries should be corrected by drawing a single line through the error, entering the correct information, and signing and dating the correction. No entry should be erased. Completed logbooks and field data sheets should be kept under chain-of-custody procedures until the trustees release them.

As the logbook accompanies the responder in the field and may be lost or damaged, photocopies of all entries and forms should be made on a daily basis during the

response. The copies should be retained in a secure place, well removed from the scene (e.g., hotel room) in order to prevent the loss of information.

"Clean" Requirements for Sampling Equipment and Sample Containers

Because of the trace levels of contaminants in environmental samples, it is very easy to contaminate a sample unless stringent precautions are taken. Cross-contamination of samples at spills is of particular concern because of the wide range in contamination levels—for example, sampling below oil slicks to collect water samples at parts per billion (ppb) levels. Furthermore, detailed chemical characterization of the sample may be needed to identify the source of the contamination, and even minute amounts of other petroleum products can invalidate the results.

For sample containers:

1) All sample containers must be either organic-free (solvent-rinsed) glass or organic-free (solvent-rinsed) aluminum foil.
2) Lids for glass containers must be lined with either Teflon or solvent-rinsed aluminum foil.

In most cases, certified-clean sample containers will be available in sampling kits for use during spill responses. However, in the event that containers or sampling equipment have to be cleaned in the field, the following procedures should be followed:

FIRST RINSE:	Wash with soap and hot water, rinse with plenty of warm, distilled water.
SECOND RINSE:	Rinse with methylene chloride or acetone (solvents)*.
THIRD RINSE:	(if acetone is used) Pentane or hexane*.

New Glass Jars or Unused Aluminum Foil:

- Do not require first soap and water rinse.
- Require solvent-rinsing.
- Dull side of aluminum foil are solvent-rinsed and stored with clean sides folded together.
- Aluminum foil can also be heated at 450 C for over one hour.

- Glass jars are stored tightly capped with either solvent-rinsed aluminum foil or Teflon-lined caps.

Glass Jars:

- May be cleaned by heating to 450 C for a minimum of one hour.
- Glass jars are stored tightly capped with either solvent-rinsed aluminum foil or Teflon-lined caps.

Sample Collection Equipment:

- Requires solvent-rinsing before collecting each sample.
- Steam-cleaning or a soap wash and hot water rinse is required at the end of each day or between sampling locations.

Waste solvents used in the field must be collected (in a waste solvent jar) and disposed of properly. One alternative is to arrange for sending the waste solvent to the analytical laboratory with the sample shipment, for proper disposal.

* *All solvents (methylene chloride, acetone, pentane, and hexane) used for cleaning MUST be of appropriate quality for trace organic residue analysis and be stored in glass or Teflon containers, NOT plastic. Proper solvent collection and disposal after use is required.*

Sample Identification and Labeling

Sample identification and labeling is extremely important, since many other researchers may be relying upon samples collected during the early phases for a wide range of purposes. Also, only a subset of the samples from a site may be analyzed initially, so many samples may be stored for later study. If multiple teams are collecting samples or establishing stations, it is extremely important that a numerical coding scheme is planned ahead of time. Each sample and station must have a unique identification number.

Recording detailed information, such as the sample location, sampling equipment used, and other conditions is not essential for sample tags, but must be recorded in the field logs. Sample containers are discarded at the analytical laboratories, therefore, the information recorded on sample containers is not always retrievable. However, for samples that are held over long periods, sample details on the sample tag may be helpful to identify a sample or provide a source of missing data.

Maintenance of Chain-of-Custody

All collected samples must be maintained under the custody of one specified person at all times. Each person who accepts custody of a sample is responsible for maintaining the integrity of that sample. Maintaining custody requires that:

- the sample be in one's actual physical possession or view;
- the sample is retained in a secured place (under lock) with restricted access, or;
- the sample is placed in a container and secured with an official seal(s) such that the sample cannot be reached without breaking the seal.

The field sampler is personally responsible for the care and custody of the samples until they are transferred to another person under chain-of-custody. When samples are transferred from one individual's custody to another's, the individuals relinquishing and receiving the samples need to sign and date the chain-of-custody form. The original form remains with the samples; copies may be kept by each custodian, as desired. During shipping, the original chain-of-custody form is included in the shipment; a copy is retained by the shipper.

TYPES OF SAMPLES TO COLLECT

Spill Source

Samples of the known source should be collected in large volumes, one gallon or more, if possible. Usually the USCG or spiller's representative can provide a source sample. But, be aware that a source sample could have been collected from floating slicks, recovery vessels, storage tanks, etc., and may have been contaminated or changed by weathering. It is very important to confirm the origin and handling of samples of the "source material" so it's appropriateness for use can be evaluated. Temporary storage facilities usually have not been cleaned prior to use, so they most likely are contaminated with other materials. Get written documentation of the sample collection and storage history—copies of chain-of-custody forms or signed statements from the collector and custodian. The source sample can be evidence vital to the claim, and it is imperative to have complete and valid documentation of the validity of the sample.

Source samples must be properly stored and turned over to a laboratory as soon as possible. Table 1 lists sample volume and storage requirements for different types of samples.

NOAA's Damage Assessment Center (DAC) has prepared a source sampling kit. Table 2 lists the contents of the kit and a list of emergency alternative components that can be purchased locally during a spill event.

Environmental Samples for Fingerprinting

Samples for fingerprinting are collected to answer the question "Is this the same material that was spilled?", thus they do not have to be quantified, or related to a measured amount of sample. When collecting oil samples for fingerprinting, thick surface slicks are scooped up away from any other petroleum sources, and quickly transferred into the pre-cleaned glass containers and labeled. Thin sheens can be collected with a special sheen sampler composed of Teflon strips on a line which is pulled through the sheens, then stored in a glass jar. Samples for fingerprinting can also include tarballs, oiled sediments, oiled animal parts (feathers preferably), and oiled vegetation. Approximately 100 ml of the oil is needed for accurate fingerprinting analyses. All samples should be kept cold (not frozen), even in transit, until delivered to the analytical lab.

TABLE 1. Requirements for volume and storage of oil spill samples.

Oil Analysis	Quantity	Storage	Other Conditions
Fingerprinting slick or tarball samples	> 100 ml	Pre-cleaned glass jars	Kept cool, dark, and tightly capped until delivered to lab
Fingerprinting source samples	~ 1 gallon	Pre-cleaned glass containers	Kept cool, dark, and tightly capped until delivered to lab
Water Samples	1 gallon	Super-clean glass containers	Kept cold and dark for less than 8 hours. Preservation of sample may be done—contact analytical lab for preservation requirements.
Sediment Samples, Finger-printing	100 gm	Pre-cleaned glass jars	Extreme care should betaken to prevent sample contamination. Kept cold or frozen until delivered to the lab.
Sediment Samples, Total Petroleum Hydrocarbons	100 gm	Pre-cleaned glass jars	Composite subsamples, 10-15 samples from site. Kept cold or frozen until delivered to the lab
Sediment Samples, Grain Size Analysis	50-100 gm	Ziploc or whirl-pak bags	Do not freeze

TABLE 2. Proposed sampling kit contents.

Kit Component	Standard Kit	Emergency Kit
Sampling device	Teflon or PVC bailer	Plastic industrial pail
Cleaning materials (for sampling device)	Liquid soap, scrub brush	Liquid soap, scrub brush
Funnel	Nalgene (8" diam.)	Paper or plastic funnels
Sampling cord	3/16" polyester rope (50 foot length)	3/16" polyester rope (50 foot length)
Sample container	4L amber jugs and labels	4L amber jugs and labels
Cooler	50-100 qt. plastic coolers	50-100 qt. plastic coolers
Shipping materials	See "HAZMAT packing and shipping kit"	See "HAZMAT packing and shipping kit"
Rubber gloves	Neoprene or PVC coated/oil resistant	Neoprene or PVC coated/oil resistant
Personal cleanup materials	Hand cleaner and shop towels	Hand cleaner and shop towels
Disposal materials	Large garbage bags	Large garbage bags

Water Samples

Water samples are very difficult to collect, especially where surface oil slicks are present. When sampling in areas covered by a surface slick, extreme care is needed to "knock" the surface slick aside so that the sampling device can be lowered into the water without becoming contaminated. The depth at which the sample is taken should be recorded and should be consistent among samples. If there is concern that the pollutant may be stratified, samples should be taken at several depth intervals. This is especially important in areas with salinity or temperature gradients.

At oil spills, water samples should be collected directly in the sample container, since oil droplets readily adhere to the inside of samplers. Ideally, water samples should be stored no longer than eight hours. Background contamination samples should be collected well away from any oiled areas, being careful not to sample along the vessel path or near any boat or aircraft engines, to reduce the chance of contamination. As petroleum products and other organic chemicals will readily adhere to glass, several preservatives (methylene chloride, freon 116) may be added to the sample to begin the extraction process. Contact the analytical laboratory to confirm that this preservation technique can be accommodated by their analytical capabilities.

Sediment Samples

Sediment samples are collected differently for different analyses. The responder must understand why the sample is required and the analysis to be conducted. In particular, the responder should determine whether quantitative or qualitative information is necessary. Routine scrape samples collected for fingerprinting, for example, may provide the responder with information on the type and degree of weathering of the oil, but generally will not provide an estimate of the concentration of the contaminant in sample matrix. In order to obtain estimates of concentration, the sampling objectives need to be carefully defined, and the volume of the sample need to be documented.

There are at least three types of sediment samples that may be collected for a NRDA, including: samples for fingerprinting; samples for determining hydrocarbon contamination levels; and samples necessary to describe the sediments and interpret the analytical results (e.g., grain-size, organic carbon). For all sediment sample needs, approximately 100-200 grams (approximately one cup) of oiled sediment samples of surface and/or subsurface oil contamination are usually collected. In gravel areas,

surface samples may be individual clasts placed into the sample jars for analysis, usually for weathering characterization. In non-gravel areas, the surface samples usually come from the top 2 cm of sediment (generally the layer of sediment most likely to be exposed) unless a specific sampling need warrants deeper samples. Subsurface samples from the intertidal zone are collected from discrete, well-defined intervals, usually from the sides of trenches dug into the beach. Core samples can also be used, where the core sample is divided into discrete layers and subsampled by layer to determine concentrations by depth. Detailed record-keeping on the depth and volume of the sample is necessary if the goal of the sampling is to determine contaminant concentration.

Subtidal sediments are usually collected from a larger box corer. The sampling interval should be specified in the sampling plan. All sediment samples should be photographed prior to collection from the trench or sediment core. All samples should be numbered uniquely; it is important to have pre-assigned numbering series when multiple teams are in the field collecting samples. Samples can be collected with clean metal utensils or wooden tongue depressors and placed in pre-cleaned glass jars with Teflon-lined caps, taking care to prevent contamination with other sources of petroleum. For sediment samples used for fingerprinting or hydrocarbon concentration, all samples should be kept cold or frozen, even during transit, until delivered to the analytical lab. The samples collected for grain-size analysis require no special handling/storage conditions.

Shipping guidelines for samples and other chemicals are provided in Appendix 5. The U.S. Department of Transportation has new requirements for shipping of hazardous materials that must be followed.

PREASSESSMENT SAMPLING METHODS FOR EVALUATION OF INJURY TO NATURAL RESOURCES

This section provides the NRDA responder with guidelines for conducting early assessments on natural resources and services. The NRDA responder is not expected to be an "expert" in the identification and analysis of all natural resources and services that may be impacted during a spill. However, the NRDA responder may be required to coordinate and direct field assessment efforts and should be knowledgeable of the study designs and methods used during these studies to assure that the studies are conducted in a manner that will meet the overall NRDA objectives.

This section outlines the type of information needed and early survey methods for a variety of natural resources that may be impacted as a result of spills. Some alteration of the methodologies will likely be necessary for each specific spill. It should be noted that as part of pre-planning activities for NRDA, some trustees and potential spillers are establishing protocols for sampling and survey methods. If such protocols are available, they should be considered for use. Whatever methods are used, it is important that they be documented.

Guidelines for twelve natural resources are presented here. Studies of past spills have indicated that these resources are susceptible to spills, and may therefore be of concern during future spills. The reader should keep in mind that these guidelines are not comprehensive and are designed only to be a starting point for the NRDA. If injuries are suspected to these categories of natural resources, the responder should consult with experts on the specific resources. The resources addressed in this manual include:

1. Non-vegetated Shorelines
2. Marshes
3. Mangroves
4. Seagrasses
5. Corals
6. Rocky Intertidal Communities
7. Fish
8. Shellfish
9. Turtles and Other Reptiles
10. Birds
11. Marine Mammals
12. Terrestrial Mammals

For each resource, the known impacts from historical spills are summarized, and potential methods for documenting impacts or injuries are outlined.

PREASSESSMENT EVALUATION OF INJURY TO NON-VEGETATED SHORELINES

Beaches

A beach is an accumulation of unconsolidated sediment that is transported and molded into characteristic forms by wave-generated water motion. Beaches will form virtually anywhere sediment is available and there is a site for sediment accumulation. Inherent to beaches is change, over time scales ranging from seconds to years. Knowing the patterns of change allows prediction of the behavior of oil spills and the persistence of oiled sediments.

Coastal sediments are classified according to the dominant size of the individual clasts into three general categories: mud (silt and clay), sand, and gravel (from granule to boulder). The variation between the different beach classifications is related to the grain size of the sediments composing the beach. Wentworth (1922) developed the following classification system:

Size Description	Size Range
clay	0.0002-0.004 mm
silt	0.004-0.0625 mm
fine-grained sand	0.0625-0.25 mm
coarse-grained sand	0.25 - 2 mm
granule	2 - 4 mm
pebble	4 - 64 mm
cobble	64 - 256 mm
boulder	> 256 mm

There is a general relationship between the sediment size and the slope of the beachface—the coarser the grain size, the steeper the beachface. The beach slope is also controlled by wave activity in that eroding beaches tend to flatten and accreting beach steepen. Knowledge of the sediment transport patterns for beaches (sand in particular) is important for understanding how oil behaves on them.

Summary of Known Impacts from Oil Spills

From the perspective of oil behavior on beaches, there are two basic factors:

1) The depth of oil penetration into the sediments, and
2) The potential for burial of oiled layers by clean sediments.

The behavior of oil on beach type (fine- and coarse-grained sand beaches, gravel beaches, and mixed sand and gravel beaches) is summarized below.

EXPOSED BEACHES, FINE-GRAINED SAND

- During small spills, oil will concentrate in a band along the high-tide line.
- Under heavy accumulations, oil can cover the entire intertidal area, although the oil will be lifted off the lower part of the beach with the rising tide.
- Oil penetration into fine-grained sand will be less than 10 cm.
- Burial of oiled layers by clean sand within the first few weeks after the spill will be limited usually to less than 30 cm along the upper beachface.
- Deeper burial is possible if the oil is deposited at the beginning of an accretionary period.
- Much of the oil will be removed during the next storm.
- Biological impacts include temporary declines in infaunal populations, which can also affect feeding shorebirds.
- The usually hard, compact sediments will support pedestrian and vehicular traffic.

EXPOSED BEACHES, COARSE-GRAINED SAND

- During small spills, oil will concentrate in a band along the high-tide line.
- Under heavy accumulations, oil can cover the entire intertidal zone, although the oil will be lifted off the lower part of the beach with the rising tide.
- Large amounts of oil can accumulate in the berm runnel where it is unable to drain off the beach at low tide.
- Oil penetration into coarse-grained sand can reach 25 cm.
- Burial of oiled layers by clean sand within the first few weeks after the spill can be rapid.

- Burial over 1 m is possible if the oil is deposited at the beginning of an accretionary period.
- Persistence of deeply buried oil could be long, depending upon the season of year and beach cycle.
- Biological impacts include temporary declines in infaunal populations, which can also affect feeding shorebirds.
- The sediment can be very soft, making vehicular access difficult.

SHELTERED BEACHES, BOTH FINE- AND COARSE-GRAINED SAND

- Oil penetration will be less where the sediments are finer and more poorly sorted.
- Depending on the degree of exposure to any waves, oil persistence can increase to months or years.
- Burial by clean sand is still significant but less than exposed beaches.
- Asphalt pavements can form under heavy accumulations; pavements will change the nature and stability of the substrate and thus its biological utilization.

EXPOSED BEACHES, MIXED SAND AND GRAVEL

- During small spills, oil will be deposited along and above the high-tide swash.
- Large spills will spread across the entire intertidal area.
- Oil penetration into the beach sediments may be up to 50 cm.
- Burial of oil may be deep at and above the high-tide berm, where oil tends to persist.
- Oil can be stranded on low-tide terraces composed of gravel, particularly if the oil is weathered or emulsified.

SHELTERED BEACHES, MIXED SAND AND GRAVEL

- Pavements are likely to form wherever heavy accumulations of oil can fill the voids between the sediments.
- Once formed, these pavements are very stable and can persist for years.

- Any oil stranded above the high-tide line will be highly persistent.

Methods for Assessment of Impact to Shorelines

Preassessment surveys of oil impacts to shorelines should focus on documentation of the degree of oiling and impacts from cleanup on the shoreline. Often the response effort generates shoreline oiling data, as part of the SCAT (Shoreline Cleanup Assessment Team) process. If the shoreline oiling documentation is incomplete or too generalized for NRDA needs, then a more comprehensive assessment may be conducted by NRDA staff. Detailed methods for mapping the degree and extent on shorelines are provided by Owens and Sergy (1994), using standardized terminology and methods. Appendix 6 contains field forms, terminology and code sheets, and field estimation guides for use in shoreline surveys.

NRDA teams may need to make specific observations on the extent and degree of cleanup-related impacts to shoreline habitats. Cleanup-related impacts include:

- Physical removal of oiled sediments: Track volumes and locations of sediments removed from beaches and wetlands.
- Physical removal of oiled vegetation: Track areal extent of cut vegetation or vegetation removed during sediment removal in wetlands.
- Changes in sediment distribution patterns, from sediment reworking, moderate- to high-pressure flushing, or berm relocation: Track areal extent of changes in grain-size distribution.
- Physical disruption and trampling of soft substrates from both foot and vehicular traffic: Track areal extent and degree of disruption, and collect samples to document mixing of oil into substrate from trampling. Document vegetation impacts from disruption.

PREASSESSMENT EVALUATION OF INJURY TO MARSHES

Summary of Known Impacts from Oil Spills

Most information regarding the impact of oil on marshes comes from study of spills affecting vegetation under tidal influence in coastal estuaries. Most of the studies have been of marshes dominated by *Spartina alterniflora*. Based on the available data, there are significant differences among species assemblages. Although every spill is a unique combination of events, there are several factors which affect the behavior and impact of the oil on the marsh ecosystem, as discussed below.

Impacts by Oil Type. It has been shown that light refined products have the greatest acute toxicity to marsh vegetation, when compared to other types of oil. In contrast, observations of spills of crude oils and heavy refined products show mostly short-term impacts, and recovery within 1-3 years (Baker, 1971; Baca *et al.*, 1983; Bender *et al.*, 1980; Michel, 1989). There are even studies which show that an increase in standing crop of the marsh grass occurs following some spills (Hershner and Moore, 1977). Crude oils contain nitrogen, and when nitrogen is limiting, there can be growth simulation under some conditions. However, these benefits appear to be short-lived and the net impact are generally negative.

Extent of Vegetation Contamination. The extent of vegetation contamination is another very important factor. Many plants can survive partial oiling; few survive when all or most of the above-ground vegetation is coated.

Degree of Sediment Contamination. The degree of contamination of sediments is another consideration which can prolong impacts to marsh ecosystems for many years, compared with the early loss of oiled vegetation. Slower recolonization rates are frequently related to hydrocarbon levels in the sediments, though the composition of the oil is as important as the total petroleum content. That is, fresher oil and refined products have higher percentages of the more toxic fractions in oil, whereas heavy oils have lower initial and long-term toxicities.

Exposure. The physical setting of the oiled marsh, relative to exposure to waves and currents, is one of the most important factors controlling the persistence of oiled vegetation and overall rate of recovery. Exposure can work to speed recovery, but, in some cases, it can also work to increase erosion after plant roots die and before new growth can occur.

Seasonal Effects. The timing of an oil spill, relative to the plant's growing season, can affect the nature and duration of the spill impact. In general, oiling during the dormant winter season has the lowest impact, whereas oiling of vegetation during the growing season will likely have longer effects. Mechanisms responsible for the slower recoveries from a spill during the growing season have not been adequately studied, but probably are related to plant stress at a time when the plant's resources are being fully expended. Although salt marsh restoration often has been unsuccessful, better restoration strategies for marshes are being improved (Zedler, 1992).

Methods for Assessment of Impacts to Marshes

NRDA methods mostly concentrate on injury to the marsh vegetation because it is the basis for a highly productive ecosystem. The objective is to quantify the injury in terms of reductions in measures of marsh productivity and function. The areal extent and duration of the injury are determined as well. These reductions can be translated into lost services and functions for valuable species.

For some of the study parameters, it is important to find unoiled reference sites that are similar in every manner except for oil. However, it may be extremely difficult to find appropriate reference sites, especially when spills affect estuarine systems with varying salinities, exposure to physical processes, and species zonations. Where possible, valid statistical designs should be used, so that inferences can be related to larger areas rather than just to the study sites. Measurement parameters that should be considered when evaluating oil effects on salt marshes are listed in Table 3 and discussed below.

Extent and Degree of Oil Contamination. The initial surveys of marshes or wetlands should focus on documenting the areal extent of contamination and distribution of the various types of oiled wetlands using both aerial mapping and ground-survey methods. Initial aerial surveys are conducted to determine the extent of visible contamination. Overflights should be conducted within a two-hour window around low tide, using 7.5 minute topographic quadrangles or aerial photographs as base maps. Observations should include estimates of the width and degree of contamination along each shoreline segment, penetration into channels, wetland zonations, and preliminary selection of stations for groundtruthing. Extensive photodocumentation is important during aerial surveys.

TABLE 3. Parameters for evaluation of oil spill effects on salt marshes.

Extent and degree of oil contamination (on vegetation and sediments)
Degree of trampling (by cleanup activities)
Percent live and dead cover
Quantitative measurements of species composition
Reproductive status or reproductive potential
Above-ground biomass
Observations of effects on marsh fauna

Once the maximum extent of contamination has been determined, vertical infrared aerial photography of the oiled areas should be taken. Vertical photographs can be valuable for developing base maps at the appropriate scale, mapping vegetation zones, and detecting lethal and sublethal responses to oiling. Vertical photographs should be taken shortly after the spill to document the current vegetation health, since plant mortality and/or stress usually does not occur until weeks or months after contamination. Vertical photographs for preparation of detailed maps of vegetation and oiling zones should be taken at scales of 1:2,000 to 1:6,000, depending on the site conditions.

Ground surveys provide the most detail for verifying interpretations of aerial photography and documenting impacts. Ground stations should be established at intervals appropriate to the length of shoreline impacted (every 0.1 to 1.0 kilometer) at locations representative of the zones mapped from aerial photography. Permanent markers should be installed at each station. Transects through oiled marshes should be run to measure actual widths and degrees of oil contamination. At selected transects, a topographic profile should be measured, within a two-hour window around low tide. Topographic profiles are important because both salt marsh and oiling characteristics have strong topographic controls. Usually plant species distribution, degree of flushing and thus natural oil removal rates, and degree of oil contamination are zoned according to elevation relative to sea level. The profile intervals should be short enough to adequately represent the topography of the site and changes in the distribution of

plants and contamination, but no longer than three meters apart so that the topography is accurately recorded. The information recorded at each profile interval can include:

- Horizontal distance;
- Change in elevation;
- Percentage oil coverage in the interval;
- Oil thickness on the sediment surface;
- Depth of oil penetration into sediments;
- Height and thickness of oil on the vegetation;
- Vegetation types;
- Biological resources present;
- Extent of biological resource oiling/contamination;
- Comments on the effects of clean-up activities;
- Location of sediment samples collected; and
- Photographs taken (roll and exposure numbers).

The survey results provide the ground-truth data for quantitative estimates of the acreage of wetlands impacted and the degree of these impacts. If classes of vegetation contamination are used, i.e., light, moderate, and heavy, these classes should be carefully defined (e.g., light contamination is less than 15 percent oil coverage on the vegetation). Field charts to guide estimates of percentage cover reduce variations among field personnel (see percentage estimation chart in Appendix 6). The degree of contamination of vegetation and sediments can be used to predict injury, estimate the duration of recovery, and thus predict damages and lost use, or to justify restoration.

Topographic transects can be used to monitor shoreline erosion as a result of vegetation die-off or clean-up activities. In these cases, profiles are run at regular periods to determine the amount of erosion over time. For assessments of shoreline erosion, the profile is "closed" so that measured changes can be shown to be a result of erosion and not measurement errors. Closure of a profile entails running the profile back up the transect to the original starting point, and calculating of the measurement error in the elevation readings. On most shoreline types, the error should not exceed 10 cm in elevation or 50 centimeters in horizontal distance if the intent is to quantify erosional loss.

Detailed photography is very important to further document oil impacts and changes over time. Photographs should be taken of the various oiling classes, so that visual records are kept.

Degree of Trampling. Where cleanup activities involved entry of workers into marshes to remove pooled oil, oiled debris, or oiled vegetation, there is likely to be additional injury from trampling of vegetation and substrate. Standard terms to describe the degree of vegetation and substrate disturbance should be used. For example, a cleanup index proposed by Winfield and Mendelssohn (1994) is:

0 = No apparent cleanup conducted.

1 = Vegetation not cut at ground surface, but minor (<50 percent) trampling apparent.

2 = Vegetation not cut at ground surface, but major (>50 percent) trampling apparent.

3 = Extensive cleanup impact, with all plants cut at ground level, but little trampling apparent.

4 = Extensive cleanup impact, with all plants cut at ground level and heavy trampling.

These indices are provided only as an example. The NRDA team should develop indices appropriate to the cleanup conditions at the spill.

Percent Live and Dead Cover. To further quantify vegetation injury, estimates of the percentage live and dead cover can be made at frequent intervals along transects, or using randomly located quadrats in each category of oiling based on aerial mapping results. Transects are often preferred because they provide topographic control. One strategy is to establish fixed quadrats at known intervals along selected transects. Using fixed transects and quadrats allows better control for long-term monitoring of changes in cover. An alternative strategy is to locate study plots in each category of oiling degree and measure cover at ten or more randomly located quadrats within each plot. One method for assessment of cover using quadrats is the use of contacts with the vertical projection downwards by eye of a cross-wire intersection (Dalby, 1987). However, quadrats are difficult to handle in tall vegetation. If field counts can't be conducted, the quadrats can be photographed. Abundance counts of the surficial vegetation can be made from the projected slides. A series of photographs should be taken of each quadrat, showing a close-up of the quadrat, the location of the quadrat

with respect to the immediate surroundings, and a shot illustrating the location of the quadrat with the surrounding marsh. These views can be valuable in later interpretation, including assessing how well the quadrat represents the overall study area.

Quantitative Measurements of Species Composition. Using the methods described above, abundance is recorded at the species level so that temporal changes in species composition can be monitored. Such studies are important when there is a potential for recolonization of oiled areas by adventitious species, which might not be detected by simple live/dead cover or biomass assessment methods.

Reproductive Status or Reproductive Potential. At selected sampling sites along transects or in quadrats, quantitative measurements on the reproductive status of the plants can be recorded for comparison of oiled versus reference sites. Note that interpretation of changes in reproduction will require a detailed understanding of the biology of the affected species. For example, seed production can be a indication of health, or of stress. Before implementing such field surveys, experts should be consulted to help design appropriate studies.

Above-ground Biomass. Using the methods of Morris and Haskins (1990), the net aboveground effect on production is conducted by counting the number and measuring the height of all stems within permanent quadrats. Estimates of individual stem biomass can be accomplished by harvesting the vegetation from selected quadrats within the marsh. Biomass can be a valuable measure of injury because of the importance of export of vegetative detritus to coastal food webs.

Effects on Marsh Fauna. During studies of the marsh vegetation, it is important to make systematic observations on obvious effects on dominant marsh fauna. Observations include: presence/absence of organisms; qualitative estimates of relative abundance (e.g., dominant, abundant, frequent, occasional, rare); visual extent of oil contamination; and behavioral observations. Observations need not be limited to animals, but should also be made for burrows, fecal mounds, tracks, etc. If more rigorous assessment of effects to marsh fauna is appropriate, the methods described for intertidal communities and mangroves should be considered.

Following the initial surveys, repeated surveys and aerial photography can be conducted at appropriate intervals as necessary to monitor for oil persistence and vegetative response to oiling.

Application to Injury Quantification

In general, the preassessment studies results should be able to generate data on: 1) severity of injury, in terms of a percentage reduction in function and services; 2) total acreage of injured marshes by degree of oiling; and 3) duration of the injury by degree of oiling categories. As with other injury categories, understanding of how the data may ultimately be used will help focus the preassessment studies. Specific injury quantification procedures, such as the Habitat Equivalency Analysis, or marsh productivity models, may benefit from the collection of additional parameters.

PREASSESSMENT EVALUATION OF INJURY TO MANGROVES

Mangrove forests are one of the dominant estuarine and coastal communities in tropical and subtropical regions. They are closely linked to other nearshore marine communities such as seagrass beds, reef flats, and subtidal reefs. Like temperate-zone salt marshes, mangroves are highly productive, serve as nursery habitat, and may support a great diversity and abundance of animal and plant species. Mangroves root in soft sediments; their trunks and prop roots serve as hard substrate for the attachment and growth of sessile plants and animals. Mangrove forests also serve as buffers for storm waves, limiting erosion and protecting upland communities.

Red, black, and white mangroves are the major species comprising intertidal forests of the southeastern United States, Gulf of Mexico, and Caribbean Sea. Field identification of these species is summarized below.

a) Red mangroves (*Rhizophora mangle*) are recognized by the maze of curved, intertwined prop roots leading from one or more trunks to the sediment surface. The bark is reddish to gray and may have numerous patches of lichens and abscission scars from dead branches. Leaves are dark green with a paler green, speckled underside and are long and pointed. Flowers (if present) are on stalks, whitish-yellow, and ~1 cm in length. Propagules ("seeds", if present) are dark green, curved, cigar-shaped, and up to 30 cm in length. Trees can grow to 20 m, but are 3-8 m tall in areas prone to hurricane damage. Dwarf forests (<2 m) occur in dry or hypersaline environments.

b) Black mangroves (*Avicennia germinans*) are recognized by the array of narrow, finger-like pneumatophores projecting above the sediment surface from subsurface cable roots running outward from the trunk. Pneumatophores are part of the tree's gas exchange system (see below). The bark is dark gray and scaly. Leaves are long and narrow, dark green but whitish underneath. Flowers are stalked, white to yellow, and ~0.5 cm in length. Propagules are pale green, lima bean-shaped, and ~1 cm in length. Trees can grow to 20 m height, but are shrub-like in freeze-prone, dry, or hypersaline areas.

c) White mangroves (*Laguncularia racemosa*) are easily recognized by the broad, paired leaves. The leaves are dull light green and have paired bumps (salt glands) on the stem below the leaf. The bark is reddish, shaggy, or striated in appearance. Flowers are greenish white and arranged in clustered spikes. Propagules are light green, strongly ribbed, oblong-triangular in shape, and <1 cm in length. Trees can be > 15 m, but shrub-like trees are also common.

The three species tend to be distributed differently along intertidal gradients. Red mangroves are most common seaward, with black mangroves landward of red

mangroves, and white mangroves the most landward. However, single-species stands are common, mixed distribution patterns occur in many areas, and species distribution can differ in disturbed or marginal habitats (e.g., drainage ditches, freeze-prone areas).

Mangroves characteristically occur in anaerobic soils. Most oxygen is obtained from the atmosphere via specialized pores (lenticels) primarily located on intertidal surfaces of trees. Lenticels occur on prop roots and lower trunks of red mangroves, on the lower trunks of white mangroves, and on pneumatophores of black mangroves. For all three species, lenticels are points of potential injury when blocked by oil.

Mangrove forests develop only in salt and brackish water environments, having physiological adaptations to salt in water and soil. Red mangroves filter salt from water at the surface of the prop root. Both black and white mangroves have limited salt exclusion at the root surface and excrete excess salt through specialized glands on leaf surfaces. For all three species, subsurface roots absorb water and take in nutrients and are potentially vulnerable to disruption by oil.

Summary of known impacts from oil spills

The nature and degree of oil spill impact are related to many variables: the type and amount of oil, the mangrove life stage, topographic elevation, sediment type, and exposure to physical processes (waves and tidal currents).

Exposure to oil can affect mangroves via different mechanisms. Impacts on mangrove trees from oil spills can result from direct toxicity through absorption of hydrocarbons, disruption of water uptake, and physical blockage of gas exchange pores by oil coating the roots. Seedlings and saplings are especially vulnerable because actively growing surfaces may be directly exposed to floating oil. Floating or stranded propagules are likely to be coated with oil. Effects on all growth stages can become chronic if oil permeates soft, anaerobic sediments and is subsequently released. Oil weathers slowly in anaerobic sediments, retaining more toxic volatile components longer than in aerobic sediments (Burns *et al.*, 1993).

Oiling can also affect organisms living on or among mangroves. Injury may range from reduced growth or partial mortality to losses of species. Oil may affect plants and animals attached to mangroves (the epibiota), associated intertidal species (e.g., oyster beds), and mobile species who utilize mangrove habitats.

Effects of oiling can be immediate (occurring within days), short-term (weeks to months), or long-term (months to years after a spill). Since many effects reported in the literature are poorly documented, the following list of likely impacts should be regarded only as a rough guide.

Immediate impacts may include:

- Oiling and subsequent mortality of algae and marine invertebrates (the epibiota) growing on prop roots, trunks, and pneumatophores.
- Abandonment by or mortality of mobile species that live in or around mangrove forests.
- Defoliation of seedlings and saplings.
- Clearance or expansion of gas exchange pores.

Short-term impacts may include:

- Sloughing-off of dead epibiota from prop roots, trunks, and pneumatophores.
- Leaf droop and chlorosis.
- Partial or total defoliation of adult and juvenile mangroves.
- Mortality of juvenile mangroves.
- Reduced establishment, survival, and growth of propagules.
- Tissue damage to prop roots and pneumatophores.
- Production of adventitious pneumatophores or prop roots.

Long-term impacts may include:

- Death of adult and juvenile mangroves.
- Partial to complete defoliation of adult and juvenile plants.
- Reduced leaf size and increased leaf deformity in surviving plants.
- Decreased growth of surviving plants, including production of fewer leaves, flowers, or propagules.
- Decreased propagule size, increased propagule deformity, and abortion of seeds.

- Rot and loss of limbs, prop roots, and pneumatophores.
- Reduction in size of trees.
- Reduction in density of leaves in the canopy, especially of the upper canopy.
- Secondary mortality of attached organisms due to release of hydrocarbons from sediments or decay and loss of dead mangroves.
- Loss of suitable shoreline habitat, due to death of fringing mangroves.

The type of oil greatly affects the potential for the nature and degree of impacts to mangrove forests. In general, lighter, more refined petroleum products (e.g., jet fuels, gasolines) are more acutely toxic at lower concentrations than are crude oils and heavy, refined products. Crude oils and heavier products persist longer in the environment and may vary greatly in toxicity. Mechanical effects (e.g., smothering, coating of living surfaces by oil) will be greater with more viscous or weathered oils. Although more laboratory and field studies are needed, the following observations can be made.

Light Oils (gasoline, jet fuel, No. 2 fuel oil)

- Fresh oils can have acute toxic impacts to trees, juvenile plants, and associated intertidal biota.
- Sunny, windy conditions will speed evaporation and lessen impacts.
- These light, low viscosity oils form thin sheens which can penetrate deeply into the forest.
- Little oil will adhere to mangrove surfaces.
- Persistence of oil in sediments should be short, unless there has been physical mixing of oil into the substrate by waves or cleanup efforts.

Crude Oils and Heavy Refined Products

- Toxicity will vary depending upon formulation and weathering prior to landfall.
- Fresh oils can have acute, immediate impacts on juvenile plants and associated intertidal biota due to both smothering and to toxic effects.
- Weathered oils do not tend to penetrate deeply into the forest, instead the oil is trapped in the outer fringe.

- Oil can pool into sediment surfaces and accumulate in detrital material such as seagrass wrack. The wrack can absorb the oil, limiting impacts on the forest if the oiled wrack is quickly removed.

- Impacts may be due both to initial heavy coatings/toxicity of oil and chronic contamination where sediments are contaminated.

Effects of Forest Type and Structure on Oil Impacts

Effects of oiling in different forests are determined chiefly by the presence or absence of a berm or high-tide shoreline and whether mangroves grow behind the berm or high-tide shoreline.

1. No berm or high-tide shoreline present.

Mangrove keys located within shallow bays (e.g., Florida Bay), clumps of mangroves on reef flats, along the channels of tidal creeks and rivers, or the leading edges of forests on peninsulas often have no berm or high-tide shoreline. These forests tend to be monospecific or dominated by red mangroves; high tides regularly inundate and overwash the entire forest.

- Oil can wash through mangroves if oil comes ashore at high tide.

- Medium to heavy oils may be trapped by thickets of prop roots.

- Oil may be concentrated in a relatively narrow band if tide is low when oil comes ashore.

- Little sediment oiling is likely, as subsequent tides will tend to lift oil off sediments.

- Juvenile mangrove injury may occur throughout forest if floating slicks contact leaves or meristems.

- Trees will be lightly oiled unless reoiling occurs or oil continues to wash through mangroves as tides rise and fall.

- Injury to associated species will vary with the height of the tide when oil washes ashore.

2. **Berm or shoreline above mean high water (MHW) present.**

(A) FORESTS SEAWARD OF BERM.

Mangrove forests which fringe the shoreline can terminate in an elevated berm or shore. They can occur both in wave-exposed locales, often fronted by a reef flat (as along much of the Atlantic shore of the upper Florida Keys) and in more sheltered areas like along tidal creeks. The outer edge of the mangrove fringe often overhangs water deeper than mean low water (MLW). The topography may slope upwards gradually or steeply, so the mangrove forest may range from a narrow band to a wide intertidal region.

- Oil can penetrate to the berm if the tide is high when oil washes ashore.
- Stranded or detrital material will concentrate oil.
- The maximum accumulation of oil will be at water's edge.
- Sediment oiling is likely, often in a band at the highest water level when oil washed ashore.
- Oiling of prop roots, trunks and pneumatophores usually occurs.
- Juvenile mangrove injury is likely, except to any plants completely submerged when oil comes ashore.
- Trees partially or wholly rooted in deeper water (below water level when oil comes ashore) are often less affected than those in shallower water or where oil strands.
- Reoiling from resuspended or released oil residues may cause additional injury over time.
- Persistence of oil will be lower in wave-exposed or sandy sediments relative to sheltered, muddy, silty, or peaty sediments.

(B) FORESTS LANDWARD OF BERM OR SHORELINE.

Generally called basin forests, species composition may be mixed or monospecific. All are characterized by minimal water movement, with flushing on relatively few tides per month, or with water seepage up through sediments rather than from seaward. Many grow in hypersaline soils.

- Oil may be trapped in the basin if oil overwashes the berm or if the input is from a landward source.
- Oil can spread throughout basin forest.
- Injury to adults and juveniles may be severe, since many basin forests are often physiologically stressed by high soil salinity.
- Persistence of oil and sediment contamination may be high.
- Chronic effects are likely where sediments are contaminated.

Methods for Assessment of Impact to Mangroves

Major goals of an initial assessment in order of priority are documentation of: (1) extent of oiling; (2) baseline condition the mangroves; and (3) measurement of immediate impacts, including any resulting from cleanup activities. The initial assessment should be as quantitative as time and resources permit, since it may have to stand alone. Ideally, it will serve as the baseline for follow-up work. Comparable unoiled sites should be located and sampled similarly where possible. Oil impacts are likely to be immediate for small plants, sessile organisms, and associated mobile species, but will usually not be apparent at the tree or forest level for weeks to months. Field notes, collections, and photographs taken soon after a spill may be invaluable in assessing injury to the former group, since evidence will be quickly lost as organisms move or die and disappear. Measurement parameters that should be considered when evaluating oil effects on mangroves are listed in Table 4 and discussed below.

Extent and Degree of Oiling of Vegetation. If there is extensive oiling of mangroves, overflights may be necessary to determine the distribution of oil along the shore. However, the degree of contamination and extent of oil penetration into mangrove forests cannot be determined by overflights and extensive ground surveys will be needed to determine the areal extent of oil contamination.

Ground stations should be established at regular intervals appropriate to the length of oiled shoreline (e.g., every 0.1 to 1.0 km) or at locations representative of the degree of oiling/physical setting zones observed during overflights. The physical setting may control the rate of recovery, particularly in terms of detoxification of contaminated substrate and recolonization by seedlings. A shoreline segment of 100-150 m length is generally adequate for each site.

TABLE 4. Parameters for evaluation of oil spill effects on mangroves.

Extent and degree of oiling of vegetation
Sediment contamination
Tree defoliation
Tree mortality
Seedling density and condition
Mangrove root mortality
Observation of mangrove fauna
Stress indicators
Planted seedling survival and growth

Still photographs and video should be taken along all transect lines. If time is very limited, the teams can rely more heavily on photography and videos for the initial documentation of oiling conditions, but dimensions (width of penetration) and relative oiling degrees should be measured in the field for representative areas.

For a given oiled site, three factors should be considered: (a) the length of shoreline oiled; (b) the degree of penetration inward from the fringe and the amount of oil coating mangrove surfaces; and (c) verification of the oil source. There are two approaches that are commonly used to survey mangrove forests: the transect method and the station-plot method. For the transect method, each station consists of a topographic transect of the intertidal zone. The topographic profile along the transect should be measured because species distribution, degree of flushing and thus natural oil removal rates, and degree of oil contamination are zoned accordingly to elevation relative to sea level. The profile intervals should be short enough to adequately represent the topography of the site and changes in the distribution of plants and contamination, but no longer than three meters apart so that the topography is accurately recorded. The station-plot method consists of fixed plots of variable size (up to 10 x 10 m^2) established at selected locations representative of areas with similar degrees of contamination, position in the intertidal zone, species composition, etc. At these plots, all the trees and seedlings are measured and marked, so that repeated surveys can be made of the same population.

Regardless of the method used, the following information is recorded for each transect interval or quadrat:

1) Vegetation oiling. The extent of oiling on all vegetation is estimated, using standard terms such as: heavy (51-100 percent oil coverage); moderate (21-50 percent coverage); light (1-20 percent oil coverage); trance (<1 percent); and no oil observed. Type of oil should be recorded, using standard descriptors (see Appendix 6).

2) Height of oiling of the truck, prop roots, and leaves. If there are multiple bands of oiling, the coverage and height of each are recorded.

Sediment Contamination. Mangrove sediments can vary widely in composition and grain size. Where the sediments have a high organic detrital content, they can absorb oil and high concentrations can persist for long periods, such as the five years to-date monitored at the Panama oil spill (Burns *et al.*, 1993), and the nearly 20 years of contamination of the tidal flats oiled in 1977 during the *Zoe Colocotronis* spill Puerto Rico (Corredor *et al.*, 1990). Oil penetration can be assessed rapidly using bamboo skewers inserted into the sediments. Sediment samples are collected to document the source and degree of oil contamination. Composite samples, collected from 5-10 locations within the plot, will best represent the degree of substrate contamination. Subsamples from each core should be combined for each interval being sampled. Commonly 0-5 cm is collected as a surface sample; sampling intervals with depth will be study-specific. Sediment samples should be taken with clean aluminum cores, which are then sectioned and placed in clean glass jars. For oils that evaporate quickly, but which are highly toxic (i.e., jet fuel), oil samples taken soon after the spill may be critical evidence for the NRDA.

Baseline Condition of the Mangroves. The distribution and abundance of tree species, size data, and physical parameters (including sediment types and the presence or absence of existing injuries) should be recorded in as much detail as possible. If time is limited, photographs, videos, and quick field notes should be taken along transect lines, including scans of the canopy, tree trunks, prop roots, and juvenile plants. Photographs should be taken every 5-10 m along the line, and/or locations of photos should be flagged and labeled. Checks at each sample point should be made of the condition of pneumatophores. In the outer fringe, a haphazard sample of 100 prop roots should be made while walking along the edge. The number of live and dead prop roots should be recorded.

If more detailed surveys are possible, they should include the following measurements along transects or quadrats.

1) Tree mortality. The percentage of dead trees at each measuring point along the transect is estimated, either in a band of a defined width or a circle of a defined circumference. Mortality is most likely to be observed weeks to months after the spill. Mortality for each species is also measured.

2) Tree defoliation. The change in percent of ambient light reaching the forest floor due to defoliation is determined by averaging three light measurements with a luxmeter at each interval. Percent open canopy can also be measured using a spherical densitometer, a hand-held device that uses a convex mirror over which a grid pattern is etched. The amount of open space in the tree canopy observed on the mirror survey is then converted to percent open canopy.

3) Basal area measurements. To determine the stand development in terms of tree size and density, adult trees are measured as to their height and diameter at breast height (DBH) at 1.3 m and converted to basal area per hectare.

4) Seedling density and condition. At randomly selected 0.5 x 0.5 m^2 quadrats, seedling density and condition (live, dead, stressed) are recorded.

5) Black mangrove root mortality. At each measuring point, five locations are randomly selected, and ten subsamples of black mangrove roots are collected from 0.5 x 0.5 m2 plots and examined for living tissue.

6) Monitoring of mangrove biota. Epibiota on prop roots can be censused by measuring cover as a percentage of space between mean high water and the longest root tip occupied by individual species, mixed species groups, oil, or bare space. Observations of mobile biota, such as crabs and snails, are recorded, noting the presence of contamination, behavior, distribution relative to the oil, and percent mortality estimates.

7) Other indicators of stress. Observations on bark fissuring, epithelial scarring, lenticel expansion, leaf deformities and chlorosis, and propagule stunting or bending are noted at each interval. These are all indicators of stress, which may eventually result in mortality.

Planted Seedling Survival and Growth. At selected study plots, propagules can be planted to measure seedling survival and growth rates in zones defined by degree or type of substrate contamination. The number of degree-of-contamination categories and number of replicates per category will depend on the spill conditions and study design. The density of the canopy in oiled and unoiled sites should be similar because

dense canopies block sunlight and shade out the understory. Propagules are collected from adjacent clean areas and planted by pushing them into the natural soil to a depth of one quarter of their length at 10 cm intervals. At selected intervals (1-6 months), live and dead seedlings are counted, and measurements of seedling height, number of leaves, number of branches, and number of prop roots are recorded.

More detailed methodologies for mangrove-assessment studies are provided in Getter *et al.* (1981), Getter and Ballou (1985), RPI (1987b), Levings *et al.* (in press), and Garrity *et al.* (in press).

PREASSESSMENT EVALUATION OF INJURY TO SEAGRASS ECOSYSTEMS

Seagrasses and their associated animal communities are often a concern during spills because of the susceptibility of these resources to oiling, the general decline of seagrasses (Thayer *et al.*, 1975) and the important functions that seagrasses provide in nearshore and intertidal marine environments (Marshall, 1991).

Eelgrass (*Zostera spp.*) is the most common seagrass taxon in temperate regions of North America (Thom, 1990), ranging from Alaska to Mexico on the Pacific coast, and extending from Greenland to North Carolina on the Atlantic coast (Thayer *et al.*, 1975). The dominant species in southern waters include turtle-grass (*Thalassia testudinum*), manatee-grass (*Syringodium filiforme*) and shoal-grass (*Halodule wrightii*). Seagrass beds occur both intertidally and subtidally. Subtidal beds are generally less sensitive to oil spills, since they usually do not come into direct contact with the oil, while intertidal plants are at greater risk of oiling (HMRAD, 1992). Some of the services provided by seagrasses include:

- Sediment stabilization.
- Detritus production that provides a major basis of food chains, although the bulk of the biomass is in the sediments (in the rhizomes);
- Substrate for a highly productive invertebrate and epiphytic community, with a total biomass which often approaches or exceeds that of the plants themselves;
- A directly used food source for a few organisms, namely green turtles and manatees, which graze on seagrasses;
- Habitat which is utilized by fish and shellfish as a spawning substrate and as nursery areas; and
- Key role in nutrient cycling, including nitrogen, phosphorus, and sulfur.

Summary of Known Impacts from Oil Spills

Oil effects on tropical, subtropical, and temperate seagrass ecosystems were discussed in Zieman *et al.* (1984) and are summarized below:

- Greatest impacts occur on seagrasses that are intertidal, where the oil comes in direct contact with exposed blades;

- Oil readily adheres to exposed blades, particularly when the oil is heavy or weathered;

- Unless the sediments are also oiled, oiled blades are quickly defoliated and the plants have the capacity to grow new leaves (the leaves grow from a relatively protected meristem). Recovery can occur within 6-12 months;

- Plant mortality has been observed at spills when the sediments were contaminated by oil, although such incidents have been rare.;

- The most sensitive components of the seagrass ecosystem are the epiphytic community and juvenile organisms using the grass beds as a nursery. These species and life stages can be highly sensitive to both the water-soluble and insoluble fractions of oil; and

- The plants can uptake hydrocarbons from the water column and sediments, potentially lowering their tolerances to other stresses.

- Mortality to seagrasses can lead to loss of sediments, prolonging or preventing the re-establishment of the seagrass meadows (Marshall, 1991).

- Oil retained in adjacent mangrove beds and shorelines can result in chronic exposure to seagrass beds, leading to loss of fringing edges of seagrass meadows (Marshall, 1991).

- In certain instances, the main impacts to seagrass beds may be physical injury related to response activities. In particular, shallow seagrass beds may be disturbed by outboard motors, and other equipment (HMRAD, 1992). Shoreline washing may also move oil into subtidal areas, potentially impacted seagrass beds (Houghton *et al.*, 1991b).

Methods for Assessment of Impact to Seagrass Systems

Parameters that should be considered when evaluating oil effects on seagrass systems are listed in Table 5. These measures mostly concentrate on injury to the seagrass bed itself because it is the basis for a highly productive ecosystem. The objective is to quantify the injury in terms of reductions in the key measures of seagrass productivity and function. The areal extent and duration of the injury are to be determined as well. These reductions can be translated into lost services and functions for valuable species. Although seagrass restoration often has been unsuccessful, restoration strategies for seagrass systems are being improved (Fonseca, 1992).

TABLE 5. Parameters for evaluation of oil spill effects on seagrass systems.

Biomass
Species abundance and density
Growth rates
Morphological measures
Physiological measures

Biomass. Measurements of biomass can have extremely high variability, thus many replicates (at least 5-8) per site are needed to support statistical analysis. Although the standing crop of leaves is significant, the majority of the biomass is in the rhizomes and roots. To measure both above- and below-ground biomass requires coring and separating out the various plant components for weighing. Above-ground biomass can be measured by repeated clipping of the leaves (Kenworthy *et al.*, 1993).

Species Abundance and Density. Seagrasses often follow standard successional sequences (Zieman, 1982) into beds dominated by single plant species. There may be one climax species but frequently the succession steps are "reset" by perturbations or environmental conditions such that the climax is not reached. Thus, relative species abundance is generally not useful in detecting oil effects. Instead, they are used to characterize the seagrass habitat in general. Relative abundance and density most frequently are measured using standard quadrat counting methods at randomly located sites.

Growth Rates. Sublethal effects of oil exposure can result in reduced productivity and growth rates. There are various methods to measure productivity in terms of specific growth rates: 1) Short-term growth of leaves can be measured by perforation with a needle at the base of shoots in quadrats and measuring growth over a time period usually of days to weeks (Thom, 1990). Eventually the leaves can be harvested to measure growth in terms of leaf area and dry weight. 2) Long-term growth can be measured by tagging rhizomes at the base of the most recent shoot, then returning months later to collect the tagged segments and measure any new growth (Houghton *et al.*, 1992).

Morphological Measures. Leaf area index, the ratio of leaf area to substrate surface area, provides an estimate of secondary surface area available for epibiota, habitat complexity, and photosynthetic potential. Short-shoot and leaf-pair densities may be a better indicator of biomass where there are large seasonal fluctuations in standard biomass measurements (Kenworthy, 1992).

Physiological Measures. Acute, sub-lethal effects of oil on seagrasses can be measured by changes in the photosynthesis and respiration rates of exposed plants. Durako *et al.* (1993) used photosynthesis versus irradiance responses of leaf tissues exposed to oil to assess oil toxicity to seagrasses. Such laboratory experiments may be needed to link the injury to exposure of the water-accommodated fraction for the specific oil type and seagrass species.

Application to Injury Quantification

All of these methods are directly applicable for injury quantification. Special cases that may require additional studies include spills where impacts are likely from chronic oiling or where a significant amount of the spilled oil was transported into the seagrass bed.

Where there are inadequate pre-spill data, injury can be measured through comparison of oiled versus unoiled, reference sites. Care should be taken in site selection, to document that oiled and reference sites have similar physical settings (in terms of currents and wave energy) and substrate. In some cases, it may be necessary to demonstrate similarity of oiled and reference sites by continuing the evaluation of injury over time until natural recovery has progressed and the parameters converge. The high degree of natural variability in these parameters for seagrasses is an extremely important consideration in the sample design. Various statistical analyses should be used to describe the data and evaluate the significance of differences observed between categories. The results of the assessment should be able to generate data on: 1) severity of injury, in terms of a percent reduction in function and services; 2) total acreage of injured seagrasses; and 3) duration of the injury. If there are two or more degrees of exposure, such as heavily and lightly oiled seagrasses, then these measures of injury can be determined for each exposure category.

PREASSESSMENT EVALUATION OF INJURY TO TROPICAL REEF SYSTEMS

Coral reefs, like mangroves, are one of the dominant intertidal and subtidal communities in tropical and some subtropical environments. Like the salt marshes of the temperate zones, coral reefs serve as nursery habitats and have a high diversity and density of animal and plant species.

Because coral reef systems are mostly subtidal in nature, they are seldom directly impacted by floating pollutants. Since coral reefs are complex ecosystems, assessment of impacts from spills should be conducted only by experts in the field. If impacts to reefs are suspected, then reef experts should be notified and special teams brought in to assess potential impacts. Conditions which might result in reef impacts include:

- Reefs were in direct contact with the oil, because they are intertidal or the spill occurred during unusually low water levels.
- There is likelihood that oil stranded on adjacent shorelines will be a chronic source of sheens.
- Large amounts of oil on the adjacent shoreline were eroded and deposited on the nearshore subtidal habitats.
- Light products were spilled or transported directly in shallow reef waters.

Methods for Assessment of Impact to Tropical Reef Systems

The assessment methods discussed in this section are on the reef-building community, the structural basis for the reef ecosystem. Brown and Howard (1985) review methods for assessing the effects of stress on coral reefs, many of which are applicable to injury assessment. For oil spills, short-term mortality is most expected from physical destruction from grounding or direct contact with the oil. Thus, the emphasis is on measures of sublethal effects that are used to estimate the degree, areal extent, and duration of injury. The key parameters are listed in Table 6. It is very important to document the degree and frequency of oil exposure in the spill area and stratify sampling sites according to degree/type of exposure.

Percent Cover. Quantitative methods for assessing cover can be conducted using the line-transect (point) method or the quadrat method. The transect method is more efficient in that more area can be covered per unit time.

TABLE 6. Parameters for evaluation of oil spill effects on tropical reef systems.

Percent cover
Tissue injury rates
Growth rate
Expulsion of zooxanthellae
Reproduction/recruitment rates
Physical injury

If pre-spill data are available, preference should be given to methods used in previous surveys to improve the strength of before-after comparisons, assumming, of course, that the methods are applicable to the objectives of the study. If the program is monitoring fixed stations, the fixed station quadrat method is the preferred method. Alternatives include photo- and videogrammetry, which will work well if the surface is relatively flat and there is no multi-canopy of surface.

Fixed transects/quadrats are recommended over random ones, so that repeat surveys can confidently identify shifts in zonation. When using the point method, it is important to record what is directly under (and over, such as for branching corals) the point. Reference sites are very important because of the potential for natural and other man-made sources of stress affecting coral reefs. They should be in similar depths and habitats as the oiled sites.

Within the coral reef ecosystem, organisms other than the reef-building corals may be more abundant as well as at greater risk to oil-spill impacts, such as sponges. Cover and abundance measures for these organisms should be included.

Tissue Injury Rates. At each study site, transect quadrats measurements of tissue injury should be recorded for all sessile organisms on the reef. There is a high background occurrence of tissue injury on reefs which must be defined. Injury categories must be very objective and standardized among observers, a particular problem for long-term monitoring programs. Typical types of tissue injury for corals and sponges include lesions, necrosis, morbidity, and mortality. Tissue injury can also be determined through histological analysis, although this approach requires physical destruction of the reef for sampling.

Growth Rate. Change in growth rate results from a variety of physiological processes, thus it can be an indicator of oil-induced stress. However, growth rates are inherently variable, among species and within a single species within reef zones, and thus they require a large number of samples. For sparse reefs, collecting samples for analysis can cause extensive damage to the reef. To link reduction in growth rates to health of the reef, it may be necessary to monitor for direct physiological measures of injury, such as reproduction rates. Corals grow at rates of 0.5-12 cm per year, thus monitoring must be conducted considerably post-event, limiting its use. Gladfelter *et al.* (1978) describe methods for measurement growth rates in the field using x-radiography for massive corals or stain markings on branching corals; other methods include field measurements, radioisotope, and weighing specimens.

Expulsion of Zooxanthellae. Several studies have documented the expulsion of zooxanthellae (or bleaching) following exposure to oil, both in the laboratory and following spills. Documentation of bleaching following a spill may be evidence of short-term exposure and response. Bleaching can be readily observed and estimated during surveys, although it requires an experienced observer.

Reproduction/Recruitment Rates. Only recently has information about the reproduction of reef corals increased to the point where studies on oil-spill effects can be designed. Guzmán and Holst (1993) were able to detect reductions in gonad size at oiled versus unoiled reefs five years after the Panama (1986) oil spill. They suggest that size measurement of female gonads (eggs) can be the easiest method to determine changes in reproduction rates for gonochoric coral species. However, sampling efforts are themselves destructive to the reef, and sample preparation and analysis is very time-consuming and thus expensive.

Another approach would be to measure recruitment on settling plates or natural surfaces in oiled and non-oiled areas in similar habitats and time periods. Other physiological and histopathological parameters known as stress responses include mucous production, algal invasions, bacterial infections, other diseases, and reductions in metabolism, but there is little baseline information by species, and they have high natural variability (Brown and Howard, 1985). Furthermore, corals exhibit these responses for a wide range of stresses which are not well understood.

Physical Injury

Although coral reef communities may be injured by the release of contaminants into the water column, reefs may also suffer from direct physical injury as a result of vessel groundings, salvage efforts, and potentially from response operations. Because of the slow growth rates of corals, physical injury to reef structures may persist for decades. Vessel debris and coral rubble may also result in significant secondary injury. Removal of this debris is often the first priority in reef restoration work.

The NOAA Sanctuaries and Reserves Division (SRD) has conducted numerous assessments of vessel groundings in the Florida Keys National Marine Sanctuary and SRD staff should be consulted whenever there is a potential for physical injury to reefs. Assessment approaches will depend upon the type of reef and the nature and extent of the injury, but the goals are to delineate the geographic extent of the grounding site and the debris field, and to identify undamaged areas on the same reef in order to assess the pre-grounding condition of the affected area. These surveys will typically involve underwater high-resolution video and still photography of the affected and unaffected areas. Stainless steel marking stakes may be used to establish permanent reference points for aerial photography and long-term monitoring of reef recovery. High-visibility underwater targets may be deployed at key locations for scale and identification of the affected areas in the aerial photographs.

Application to Injury Quantification

Coral reef system injury can be quantified in terms of the extent and magnitude of the changes in coral reef system condition and function, above those of natural causes. The duration of recovery to pre-spill conditions and function may be estimated from the degree of injury and regional studies on reef ecology.

PREASSESSMENT EVALUATION OF INJURY TO ROCKY INTERTIDAL COMMUNITIES

Rocky coasts encompass many types and sizes of substrates. Included in this general class are:

- Vertical bedrock cliffs, such as along fjords.
- Wide, rocky ledges which may be strewn with boulders.
- Rocky, rubble slopes which are formed by passive accumulation of sand to boulder-sized talus on bedrock slopes.

There can be wide variations in the width of the intertidal zone and the degree of "permeability" of the rocky substrate. Since oil seldom strands on exposed rocky shorelines, emphasis is placed on sheltered intertidal rocky habitats. Because of the low wave energy, there is little sorting of sediments, and there can be a jumbled mix of grain sizes, from boulders to clay overlying the bedrock. This poorly sorted mixture usually does not allow deep penetration of oil into the subsurface. However, determination of the "surface" on a shoreline with boulder- and cobble-sized rubble layer overlying an irregular bedrock platform with patches of muddy sand and granules is complex. Detailed information regarding the effect of oil on the three types of sheltered rocky coasts is summarized below.

Summary of Known Impacts from Oil Spills

VERTICAL ROCKY SHORES

- Oil will adhere readily to the rough rocky surface, particularly along the high tide line, forming a distinct oil band.
- The lower half of the rock face usually stays wet enough to prevent oil from adhering and remaining.
- Heavy oils and weathered oils can coat the upper zone with little impacts to the rich biological communities of the lower zone.
- Fresh oil and light refined products have high acute toxicities which can affect attached organisms after even short exposures.

ROCKY LEDGES

- Oil can adhere readily to the rough rocky surface, particularly along the high tide line, forming distinct oil bands.

- If a beach is present, the oil will penetrate the sediments, with long-term persistence very likely.
- Fractures in the bedrock surface are sites of oil pooling and persistence.
- Even for wide ledges, the lower intertidal zone usually stays wet enough to prevent oil from adhering to the rock surface.
- Heavy oils and weathered oils can persist on the lower intertidal zone by penetrating surficial sediments.
- Fresh oil and light refined products have high acute toxicities which can affect attached organisms after even short exposures.

RUBBLE SLOPES

- Oil can adhere readily to the rough rocky surface, particularly along the high tide line, forming distinct oil bands.
- Oil will penetrate into the crevices formed by the surface rubble and pool at the contact of the rubble and the surface.
- Oil can form pools and eventually pavements under heavy oiling.
- Oil can penetrate deeply into loosely packed rubble, causing long-term contamination of the subsurface sediments.

Methods for Assessment of Impact to Rocky Intertidal Communities

Successful programs require considerable rigor and thought in development of the sampling design. Study sites have to be stratified by degree of oiling, habitat type including degree of exposure to physical processes, and tidal elevation. There should be a minimum of three true replicate sites per unique combination of conditions, including reference (unoiled) sites. Only randomly selected sites will allow inference of the results to other oiled sites, thus the sampling design should include randomized but rejectable site selection within each strata.

Once the sites have been selected, observations are recorded within each site along transects or at quadrats. Lees and Houghton (1995) recommend 5-20 replicate quadrats per tidal elevation, with more quadrats at hererogeneous sites and fewer at homogenous sites. These horizontal transects are centered at the level of maximum development for dominant biological assemblages at each tidal level. Each sample location along the transect is usually a 0.25 square meter quadrat which is initially randomly located then permanently marked, to allow repeated sampling of the same

TABLE 7. Parameters for quantification of oil spill effects on rocky intertidal communities.

Species abundance and density
Percent cover by dominant species
Percent live cover, by species
Percent dead cover, by species
Percent bare ground
Reproductive condition

marked location in subsequent surveys (to reduce variability). Within each quadrat, counts or estimates are made of the parameters listed in Table 7. Methods for collecting these data are described in Baker and Wolff (1987), Moore and McLaughlin (1978), and Zeh *et al.* (1981). Photographs of each quadrat should be taken, for documentation and backup in case additional measurements are needed.

Application to Injury Quantification

Most intertidal communities provide service flows to other natural resources, in terms of habitat and food, as well as recreational and educational value to humans. In some areas, they also provide food for humans. Thus, injury should be measured in terms of a reduction from baseline in the quantity, quality, and composition of the dominant and key communities at the affected sites. In addition, the time to recovery for each strata should be estimated.

PREASSESSMENT EVALUATION OF INJURY TO FISH

Summary of Likely Impacts from Oil Spills

The probability of adverse impacts to marine fishes from spilled oil is influenced by the inherent sensitivity of each species. Sensitivity and susceptibility are functions of life-history, stage and, in turn, habitat preference, behavior, diet, and other factors. Each stage has characteristics that directly control the likelihood and degree of impact during an oil spill.

The sensitivity of fish eggs is high, but reduced somewhat in comparison to larval fish due to the presence of protective membranes that may reduce exposure. Susceptibility of eggs is highly variable. Benthic eggs released in deep water are unlikely to be exposed to oil during a spill. Benthic eggs released in shallow waters are vulnerable to exposure to light oils having a significant water-soluble fraction, but usually the impacts are very localized. Benthic eggs spawned on intertidal or very shallow subtidal substrates are highly vulnerable to direct mortality from contact with floating slicks and from contamination of nearshore, subtidal sediments.

The larval stages of most marine fish are planktonic; their large-scale movements are controlled by water currents because they have limited swimming capabilities. Planktonic larvae use an attached yolk sac during the first few days or weeks, then feed on phytoplankton and zooplankton, which are concentrated in the upper water column. However, dilution of oil under a slick is rapid, and there is a low probability of acute toxic effects on significant percentages of a larval population during an oil spill. However, large spills of light types of oil or those which occur in restricted areas with low flushing rates may produce significant mortalities.

Later life stages of marine fish (juvenile and adult) are considered to be the least sensitive to oil spill impacts. They are very mobile and better able to detect and avoid spills. Acute toxicity is likely to occur only when light, refined products are spilled in lakes, small streams, and rivers. However, there may be concern for long-term, sublethal impacts when sediments in nursery areas have been contaminated.

Field Methods for Fisheries Assessments

Documentation of exposure of fish to petroleum hydrocarbons can be complicated. Direct measurement of petroleum hydrocarbons in fish tissue is not an appropriate indicator of exposure because of the high rate of metabolism of petroleum by most species of fish (Varanasi *et al.*, 1989). Instead, methods have been developed to detect exposure to petroleum hydrocarbons by measurement of their metabolites which are excreted through the bile (Krahn *et al.*, 1993) or by increases in hepatic cytochrome P4501A (Payne *et al.*, 1986). Because petroleum hydrocarbons are ubiquitous in the marine environment, background levels in each species of concern must be included in the monitoring program. Only a few laboratories currently have the capability to measure metabolites or enzymes, although use of these methods is growing.

There are four ways to detect and quantify injury to fish populations: 1) direct body counts of the number of fish killed; 2) comparisons of the population size and composition for pre-spill and post-spill surveys; 3) comparisons of the population size and composition for oiled and reference sites; and 4) toxicity/population modeling (Hilborn, 1993). Each approach has limitations, and more than one approach may be used to provide a more complete assessment of the total injuries for different species assemblages or life stages.

Fish-kill Surveys. Fish-kill surveys estimate the number of adult fish killed immediately after the spill. The American Fisheries Society (AFS, 1992) and USFWS (Meyer and Barclay, 1990) recently updated their publications on fish-kill methods. However, this method often greatly underestimates the total injuries from the spill because it only estimates the number of dead adult fish. Fish-kill investigations are more appropriate in streams and small rivers where the entire water surface along the sampling transect can be surveyed, and the dead fish tend to accumulate within a reasonable distance from their original habitat. The method can be augmented with snorkeling surveys to detect and count dead fish that sank.

Both AFS and USFWS provide guidance on determining the cause of death of dead fish, to rule out other causes of mortality. Oxygen depletion, toxic algal blooms, gas supersaturation, bacterial infections, and natural toxic substances, among others, can result in fish kills. Oil spills may increase the sensitivity of fish populations to these factors.

It is important to note that fish-kill surveys do not provide any evidence of population-level impacts. To provide a quantitative assessment at the population level, it will be necessary to relate the body count to abundance of these impacted species, recruitment rates, etc., generally using population dynamics models.

Pre- versus Post-spill Comparisons. A second method is to conduct post-spill fisheries surveys to detect population or species composition changes compared with similar pre-spill survey data. The value of pre- versus post-spill population surveys in quantifying oil-spill injuries will depend on the natural variability in the measured parameters, the reliability of the data-collection methods, and the degree of injury caused by the spill. For many species, the year-to-year variability is so large that only severe impacts could be measured at statistically significant levels. Prior to developing NRDA study plans for quantification of population-level injuries using this method, the statistical power of such comparisons should be evaluated for each species or

assemblage, to make sure that the detectable changes are within those expected to have resulted from the spill. That is, the degree of change that would have to occur in order to be statistically differentiated comparing data from stations sampled pre- and post-spill should estimated and determined if it is reasonable to expect that amount of change. Also, recent natural events (e.g., cold snaps, hurricanes) should be evaluated as to their potential effects which could complicate correlations of changes to a spill.

Oiled versus Reference Comparisons. This method attempts to detect differences between sub-populations that have been stratified into oiled and reference categories. There can be more than one degree-of-oiling category, if appropriate. This method would be used when there are no pre-spill data available for the species of concern in the impacted area. This method has the same limitations and concerns discussed above for pre- versus post-spill comparisons, with the added difficulty of finding truly representative reference sites in estuarine settings. The sampling plan would have to include analysis of the likely variability in the data and to determine the number of replicates needed to increase the statistical power of the comparisons to the level needed to detect a minimum change.

Toxicity/Population Modeling. Where population-level changes are difficult to measure directly, another approach is to use a biological effects model in conjunction with a population model. Biological effects are derived from exposures estimated from a physical fates or water quality model for the spill conditions and toxicity test data (either from the literature or using local communities and the spilled material). Exposure concentrations and conditions are used to calculate mortality rates and sublethal effects. These effects are then applied to data on species abundance and structure to quantify impacts. The Type A model uses this approach to calculate the mortality and lost weight of both adult and larval fish resulting from exposure to toxic fractions of the oil during a spill, as well as reduced recruitment and lost productivity.

Other injury studies could include histopathological analysis of fish tissues collected from oiled and unoiled areas (discussed in the section on biomarkers). Sublethal effects which can lead to reduced growth, fecundity, and survival can be measured with either field sampling in oiled/reference sites, or controlled laboratory experiments using exposure pathways and concentrations appropriate to the spill conditions. Most of these sublethal effects are associated with chronic exposures to oiled sediments or oil being released from contaminated areas over time. The incidence of histological injury in fish from oiled areas should be compared with fish from similar, but unoiled habitats. Indicators of exposure to petroleum hydrocarbons should also be measured,

to provide a link between the histological changes and the oil spill. These descriptive and qualitative data could be supplemented by modeling the bioaccumulation and sublethal effects to estimate the rate of occurrence and quantify injury. Field data to support the modeling efforts would be valuable.

It may be important to document the pathway of exposure and bioavailability of petroleum hydrocarbons in the habitat through sampling of water, sediments, or filter-feeding organisms such as bivalves. However, it should be noted that there are limited experimental data documenting histological changes in tropical and sub-tropical fish species as a result of exposure and ingestion of petroleum hydrocarbons. It may be necessary to conduct laboratory studies to demonstrate that the injury measured for the species of concern in the impacted area and resource was elicited by exposure to the spilled material.

Application to Injury Quantification

The overall objective of injury quantification for fish is to determine the change in the population resulting from the spill and the rate of recovery, for each targeted species. Depending on the approach and population model, the results would be reported as a percent reduction in a fishery, lost biomass, lost productivity, or numbers of fish not available for commercial or recreational fishing. The approach should consider both immediate losses and future losses as the population recovers to pre-spill conditions.

PREASSESSMENT EVALUATION OF INJURY TO SHELLFISH

Summary of Likely Impacts from Oil Spills

The primary shellfish of concern in coastal U.S. waters are shrimp, molluscs, and crabs, because of their importance to both commercial and recreational users. Shrimp are highly sensitive to the toxic effects of oil in the water column; they usually have the lowest LC_{50} of all shellfish. The eggs of shrimp are the most sensitive life-stage, but not always the one at greatest risk, depending upon the species. For example, brown shrimp eggs are present in deep water where there is little possibility of oil exposure. The larval shrimp also remain mostly offshore in pelagic habitats, moving into estuaries as postlarvae. Thus, juvenile and adult brown shrimp are most susceptible because of their estuarine and shallow coastal distribution. White shrimp, on the other hand, can spawn in shallow water and near the surface, so all life stages could be vulnerable. The probability of impacts to shrimp from spilled oil is influenced by the inherent sensitivity and susceptibility of the species and is a function of their life-history, stage, habitat preference, behavior, diet, etc. Each stage has characteristics that directly control the likelihood and degree of impact during an oil spill.

Impacts to crab species are also dependent upon their life stage, habitat preferences, behavior, etc. Female blue crabs are most susceptible to the toxic effects of oil when the female is carrying eggs. Depending on the species, the spawning period may occur year round, often with a peak spawning period during one portion of the year. Crabs can be exposed to heavy oil spills which sink or are transported along the bottom in brackish water environments. There is also a possibility of crab species scavenging dead, oiled wildlife that are transported into their preferred habitats. The effects of the consumption of petroleum hydrocarbons has not been fully documented in crab species.

Molluscs (primarily clams, mussels, and oysters) often exhibit a wide diversity of impacts when exposed to spilled oil. The extent of impact is most often controlled by life stage and habitat preference. Most molluscan larvae are planktonic and are found in estuaries and nearshore waters with the notable exception of the deep water species. Thus, they are susceptible to acute toxic effects during the early period of a spill. Many of the dominant molluscan species—oysters, clams, and mussels—because of their intertidal, sessile distribution, are very likely to be exposed to contaminants spilled in nearshore areas. Seldom are mollusks killed outright by oil, except when smothered by heavy slicks. Usually, the biggest concerns are uptake and sublethal effects, such as

decreased or abnormal growth, increased mucous production, and decreased respiration rates. Uptake of petroleum hydrocarbons takes place at all levels of water concentrations and can occur for weeks to years following a spill, causing concern about the safety of shellfish consumption. Contaminated shellfish can also provide a pathway for exposure of other resources which feed heavily on intertidal shellfish, such as oystercatchers, harlequin ducks, and sea otters. Once the source of exposure is removed, depuration can occur within a few days to weeks. Therefore, shellfish are an excellent indicator of the bioavailability of oil in the environment.

Field Methods for Population/Behavioral Changes

Crustaceans. When impacts to shrimp are likely to be primarily acute toxicity from direct exposure of animals to the water-accommodated fraction (which includes dissolved and dispersed oil mixed in the water column), use of an exposure model, as described previously for fish, may be appropriate. Field surveys of distribution and abundance, conducted pre- and post-spill, or oiled versus unoiled, may not be effective at detecting even local population changes because of the high degree of spatial variability. However, if sublethal effects are likely, such as exposure via a food web pathway, site-specific studies of the affected populations may be appropriate. Shrimp are algal and detrital scavengers as well as predators, thus they could take up oil if estuarine sediments and/or detritus were contaminated. Shrimp do accumulate petroleum hydrocarbons in their tissues, with whole animal bioconcentration factors for uptake from water of 100-6400 and from food of 20-30 (Scott *et al.*, 1984). Analysis of tissue samples for petroleum hydrocarbons would detect the presence and relative magnitude of uptake and exposure. The results could be used to determine whether there was a need for further assessment of biological injury as well as indicate public health risks due to contaminated seafood.

Quantitative assessment techniques for juvenile and adult blue crabs are limited. Surveys of crab pots in the spill-affected region can be used to indicate: 1) if any whole oil reached benthic habitats, because oil tends to adhere to and become trapped in the pots (based on observations at previous spills); and 2) if crabs themselves have been oiled by inspecting their mouth parts.

Using Bivalves as Exposure Indicators. Bivalves, such as clams, mussels, and oysters, can be used as indicators of exposure and bioeffects. They provide integrated information about the bioavailability and effects of oil which cannot be defined by

chemical analysis of discrete water samples. This capability is particularly important in monitoring oil spills where exposure can be highly variable. The uptake of the spilled oil by bivalves can be used to establish a pathway from the discharge to injured resources. Bivalve collection procedures are relatively easy, and the methods for chemical analysis of tissues have been standardized as part of the National Status and Trends Program (NOAA, 1989). Either resident or transplanted animals can be used. The main advantage in using transplanted mussels or oysters over monitoring resident populations is the experimental control over sampling sites, sampling intervals, and test animals. Bivalves can be strategically transplanted along physical and chemical gradients and in assessment areas where they might normally settle to provide a surrogate monitoring population. The exposure period is controlled by measuring the caged animals at selected intervals. Mehl and Kocan (1993) have developed methods to estimate the exposure concentration of the seawater soluble fraction of crude oil from the tissue concentrations in caged mussels deployed after spills. Thus, caged mussels could be used to confirm the water-column loadings used in models.

Measuring bioaccumulation and growth in transplanted bivalves is a potentially powerful tool in the NRDA process for injury determination, establishing pathways, and restoration monitoring. Biological measurements of bivalve weights and lengths can be used to estimate injuries to biological resources. Juveniles should be used for growth measurements because they grow faster and adults for bioaccumulation because they provide more tissue for chemical analysis.

Salazar (1992) provided the following guidelines for using transplanted bivalves (based on work only with mussels) in NRDA:

- To discriminate differences of exposure and response among assessment sites, a 12-week exposure period is recommended;
- Size sorting of individual organisms is important because juvenile mussels grow faster and appear to accumulate higher concentrations of contaminants in their tissues than adults. Minimizing the size range reduces variability in the test;
- To increase survival rates during deployment, large clusters of mussels should be separated by hand, not machine; and
- If determination of sublethal effects, such as growth rates, is an objective, it is important to have adequate replication and measurement of each live animal at the beginning and end of the exposure.

Resident oyster/mussel populations can be used as exposure indicators if the area affected by the spill has sites which are part of long-term monitoring programs, such as Mussel Watch and National Status and Trends (Brooks *et al.*, 1991).

Monitoring studies to determine the uptake and subsequent depuration of the spilled material should consist of oiled and unoiled site comparisons, to account for the often widespread background levels of petroleum contamination in coastal systems. Samples should be collected on a regular basis, such as monthly, until levels drop to background levels. After the *Apex* barge spill in Galveston in 1990, hydrocarbon levels in shellfish decreased to background levels within five months (Brooks *et al.*, 1991). In comparison, at the *Exxon Valdez* oil spill, elevated levels of PAHs have been found in intertidal mussel beds for over 3.5 years, because of the long-term persistence of subsurface oil in the underlying gravel beaches (Houghton *et al.*, 1992). Figure 6 outlines protocols for sampling bivalve molluscs for chemical analysis of petroleum hydrocarbons.

The physiological indicators of stress in shellfish, especially molluscs, have been well documented (Scott *et al.*, 1984). Histological samples of shellfish should be collected only by experienced or trained staff. The general method for sample collection is as follows:

1) New, clean, sharp scalpels are used for tissue collection for each animal.
2) Forceps should be cleaned prior to each tissue collection.
3) Sample size should be about the size of a small walnut.
4) All samples from the same animal can go into a single Ziploc bag.
6) In addition to outside labeling, internal container labels are required.
7) Samples should be fixed for eight hours with a buffered ten percent formalin solution. This solution can be prepared by mixing nine parts sea water and one part 37 percent formaldehyde.
8) After eight hours, the formalin solution should be completely replaced.
9) Formalin should be replaced every 24 hours for several days.

SAMPLE COLLECTION

- Identify oiled and unoiled sites for comparison.
- Clean areas should be sampled first to minimize the potential for cross contamination.
- Tissue samples (**minimum** of three grams; 30+ grams is better) from each area should be composited into triplicate samples.
- Collect only live animals (shells are tightly closed; must be pried open with a knife).
- With a clean scalpel, cut the tissue from the shell and place in a clean jar.
- Extreme care should be taken when collecting samples in oiled areas not to contaminate the tissue with oil from the shell or sediments. If tissue removal is to be conducted by the laboratory, the whole organism, shell and all, is wrapped in aluminum foil and iced immediately.

ADDITIONAL DOCUMENTATION REQUIREMENTS

- Description of the sampling location (lat/long, water depth, sediments, degree of exposure to tidal flushing).
- Description of visual oiling conditions of the site.
- Photography of intertidal sampling sites, including:
  - overall views to document the location and sediment type;
  - close-up shots of clusters prior to sampling.
- Species identification (if known) for all types collected.
- Water quality measurements (salinity, temperature, dissolved oxygen)
- Collection date and time; collector name; collection methods used.

SAMPLE PRESERVATION AND ANALYSIS

- Samples are kept cold until frozen and are shipped frozen to the laboratory for analysis.
- Only GC or GC/MS analyses should be conducted, so that the source of the contamination can be confirmed.

FIGURE 6. **Methods for assessing oil exposure to molluscs.**

Application to Injury Quantification

Injury to shellfish should be quantified in terms of: a percent reduction in a fishery, lost biomass, lost productivity, or numbers of shellfish not available for commercial or recreational fishing; and the areal extent and duration of shellfish beds with petroleum hydrocarbon concentrations exceeding health standards.

PREASSESSMENT EVALUATION OF INJURY TO SEA TURTLES

Five species of sea turtles regularly spend part of their lives in United States coastal waters of the Atlantic Ocean and Gulf of Mexico: Kemp's ridley, loggerhead, green turtle, hawksbill, and leather back. Sea turtles were widely used by humans in earlier times for food, ornaments, and leather, and they are still used in these ways by many cultures. They are now endangered or threatened and thus protected under the Endangered Species Act (National Research Council, 1990). Many human activities jeopardize to these endangered or threatened sea turtle populations including: beach lighting, beach use and manipulation, incidental capture in shrimp trawls and fishing gear, entanglement in marine debris, collision with boats, oiling and oil rig removal.

While many efforts have reduced threats to sea turtles, the risk of spills from oil production and transportation still persists, including direct oiling of sea turtle habitats, and potential additional impacts resulting from spill cleanup.

Summary of Likely Impacts from Oil Spills

The direct and indirect impacts of oil on sea turtles can be divided into three general categories based on the life stage and habitat: 1) direct oiling of eggs and hatchlings on nesting beaches; 2) direct oiling of hatchlings, juvenile, and adult turtles at sea; and 3) indirect impacts to turtle habitats both in the water and on the beach. Each of these categories are summarized below.

Direct Impacts on Eggs and Hatchlings by Stranded Oil

Oil that contaminates turtle nesting beaches outside the nesting season will generally be weathered to a non-toxic state by the time the nesting turtles arrive. However, a spill resulting in the deposition of oil on eggs or on top of a nest already constructed is likely to increase mortality and affect hatchling morphology. The major conclusions on the physiological and behavioral effects of oil on eggs and hatchlings from laboratory studies (Fritts and McGehee, 1981; Vargo *et al.*, 1986; Lutz and Lutcavage, 1989) are summarized below:

- The number of unhatched eggs in a nest was much higher when fresh crude oil was on the surface of the sand during the last half or quarter of incubation. This effect was thought to be due to displacement of oxygen by

the lighter oil fractions when the rate of oxygen consumption in the nest is at its peak.

- Weathered crude oil was less toxic to turtle eggs than fresh crude oil.
- Hatchling morphology was affected by the amount and time of oiling. Hatchling weights were lower and sizes were smaller when the eggs were exposed to a light dosage of oil mixed in the sand.

Direct Impacts of Oil on Juvenile/Adult Turtles at Sea

Turtles can not only be directly impacted while on nesting beaches but can be directly impacted at sea as well. Juvenile and adult turtles are likely to contact oil slicks during the early stages of a spill and tarballs as the oil weathers. Although there have been many oil spills in areas populated by turtles, large numbers of turtles have rarely been observed to be directly impacted by an oil spill. However, it is difficult to document the number of turtles affected by a spill and many of the affected turtles are likely to never be documented. High-risk areas include migratory routes, foraging areas, and areas offshore of heavily utilized nesting beaches (Michel *et al.*, 1994).

The direct physiological effects of oil on sea turtles include the following (Bossart *et al.*, 1995; Frazier, 1980; Lutz and Lutcavage, 1989; Vargo *et al.*, 1986):

- Sloughing, reddening, accelerated cell division of skin. Increased potential for parasites and infection through damaged skin tissue.
- Reduced diffusion activity and decreased oxygen consumption which result in decreased dive time.
- Decreased digestive efficiency.
- Internal effects: hematological responses; salt gland disruption; immune response (increase in white blood cell counts).
- Tissue damage to nares and eyelids.
- Disruption of olfactory cues (disrupting navigation and orientation).

In addition to direct oiling effects, there is the potential for indirect effects such as increased susceptibility to disease and predation (Vargo *et al.*, 1986).

As the oil weathers to form tar balls, it losses much of its acutely toxic fractions; however, pelagic tar has its own set of effects on sea turtles (Witham, 1978; 1983; Vargo *et al.*, 1986). Turtles feed on objects floating at the water surface; therefore, they are

susceptible to ingestion of tar balls. Tar ball ingestion can block the oral cavity and digestive tract. Floating tar can also coat the flippers which is then ingested as the turtle attempts to clean its flippers. Finally, large quantities of tar have been observed to immobilize smaller turtles.

Indirect Impacts as a Result of Impacts to Turtle Habitats

Besides the effects on turtles at sea, oil also indirectly affects sea turtles through its impacts on their habitat. Degradation of nesting, foraging, resting, or critical turtle habitat may have long-term effects on turtle populations. While individual turtles may not be oiled directly, the oiling and subsequent effects on their habitat may reduce their ability to find sufficient food items or suitable nesting areas. As a result, oiling of their habitat and its indirect effects may actually impact larger numbers of sea turtles than direct contact with spilled oil.

In addition to the impacts from oiling itself, oil cleanup can have deleterious effects as well. Some of the potential threats from cleanup are listed below:

Activity	Impact
Artificial lighting from night operations	Interrupted nesting behavior and hatchling disorientation
Machine and human activity	Crushed nests
	Deter nesting behavior
Equipment on beaches and in intertidal areas	Prevents or slows hatchling from reaching the ocean, resulting in: Increased mortality Increase predation
Marked nests (to prevent cleanup impacts)	Increased poaching
Sand removal and cleaning	Changed beach profile and sediment composition

Methods for Assessment of Injury to Sea Turtles

Injuries to sea turtles can be divided into two categories: injuries to turtle habitat and injuries to turtles directly. Some potential data collection methods are discussed below.

Injury to Turtle Habitat. When spills have occurred in habitats known to be highly utilized by sea turtles for foraging or resting, studies of intertidal and subtidal habitats should be conducted to determine whether the extent (areal dimension) and degree (amount present) of impact to the habitat might affect the services it provides to sea turtles. Conditions when such impacts might occur include: heavy oil that eventually sinks thus contaminating benthic habitats; light, refined products that result in acute mortality to preferred food items that are sensitive to oil, such as sponges; or, high-wave energy conditions which naturally disperse light crude oil or refined products in shallow waters, causing mortality and oil accumulation in benthic invertebrates and sediment contamination (Michel *et al.*, 1994).

One of the most important turtle habitats is nesting beaches. To determine injury to nesting beaches, the first step should be to measure the extent and degree of oil contamination on known nesting beaches. Oil contamination should be mapped by both air and ground surveys. Both surface and buried oil should be surveyed, especially oil above the high-tide line where turtle nests are located. Even oil that does not reach high enough on the beach to cover nests may be a problem for hatchlings crawling to the water. During the nesting season, oiled turtle-nesting beaches should have high priority for oil removal efforts and other activities to minimize exposure of eggs and hatchlings to oil.

Direct Injuries to Sea Turtles. Direct injuries to turtles should also be examined. When the spill conditions are such that direct oiling of juvenile or adult turtles is likely (large spills of heavy oils in areas where turtles are known to concentrate), surveys and recovery of oiled turtles on beaches and at sea may be appropriate. Depending on the magnitude and direction of winds and currents, dead turtles may take weeks to wash ashore. Predators, such as sharks, will feed on turtle carcasses; therefore, an absence of stranded turtles is not conclusive evidence that turtles were not injured. Dead or moribund turtles on beaches should be documented and reported to stranding networks. The species and size of each dead turtle should be recorded. Finally, if possible, it is important to determine the cause of death.

If the spill occurs during the nesting season, each nest should be marked, if possible, so that it will not be disturbed during cleanup activities as well as to document the extent and degree of oiling in the immediate vicinity of the nest. Emergency restoration activities may be needed, such as capturing hatchlings before they attempt to crawl over oiled beaches and into oiled waters. Removal of eggs can only be conducted under proper permitted authority and supervision as the eggs are extremely sensitive to movement at certain developmental stages. Removal of eggs should only be considered as a last resort.

The potential for lethal and sublethal impacts to adults, eggs, and hatchlings from residual oil contamination of sediments, once cleanup efforts have terminated, should be evaluated. Usually the cleanup requirements for public use of beaches will be adequate to protect turtle nesting, but these requirements may be different for remote beaches or where beach erosion concerns limit the amount of sediment removal allowed. In such cases, detailed surveys should needed to document the presence, duration, and chemical composition of the residual oil.

Lastly, oiled nests should be monitored and compared to clean reference nests to evaluate hatching success and emergence success with the degree and nature of oil contamination. Maps of oiled nesting beaches and nest counts can be used to extrapolate the total impact on nesting success. Selected samples of addled eggs and dead hatchlings should be analyzed to determine cause of mortality, if possible (Michel *et al.*, 1994).

While the evaluation of injuries to sea turtle on beaches presents challenges, the quantification of the number of oiled turtles at sea is more difficult. Oil contamination of individual animals will be hard to observe from aircraft, and juvenile and adult sea turtles are difficult to capture or evaluate with boat surveys. However, aerial surveys can be used to determine the number and species of sea turtles present in the area affected by oil. Surveys of impacts to adult turtles may need to continue after response activities have been terminated, since impacts may occur long after the time of the initial release (e.g., ingestion of residual tar balls).

Application to Injury Quantification

Each injury identification study undertaken, such as those listed above, should be considered in light of the next step in the assessment process—quantification.

Quantification activities to consider when developing surveys and sampling plans include (Michel *et al.*, 1994):

- Determining the extent and magnitude of the change in nest success resulting from the spill through statistical comparisons among oiled and reference nests and extrapolation to all oiled nesting beaches;
- Tallying the number of dead juvenile and adult turtles attributable to the spill;
- Quantifying the degradation of important habitats in terms of the area affected, the percent reduction in services provided to sea turtles by the habitat injured by the spill, and the recovery rate of these services.

PREASSESSMENT EVALUATION OF INJURY TO BIRDS

Summary of Known Impacts From Oil Spills

Seabirds, diving birds, and waterfowl are extremely vulnerable to the direct effects of spilled oil. Many exposed birds die after contact, due to the inability to fly and forage after their plumage becomes oil soaked and waterlogged. Thermo-regulatory demands increase when the insulative and waterproofing effects of feathers are reduced, and the oiled bird can quickly die from hypothermia. Birds will ingest oil during preening, and the oil can cause massive damage to internal organs. Lightly exposed birds may survive, but birds exposed immediately before or during the breeding season will be highly stressed and will probably cease breeding after oil exposure.

During cleanup, disturbance to individual birds, to breeding colonies, and to roosting areas may increase damage to birds. Disruption of breeding can result in significant losses. Aircraft and boat traffic associated with cleanup activities will disturb waterbird colonies and raptor nesting. The magnitude of disruption should be factored into any NRDA, as the clean-up disturbance is oil-related and would not have occurred if the oil had not been spilled.

It is important to note that the success of bird cleanup and rehabilitation efforts can vary widely, depending on the condition of the birds before oiling, the type of oil, and the species affected. Even if the birds survive cleanup and are released, they will likely suffer a much greater risk of mortality. Furthermore, there is some evidence to suggest that released birds often do not reproduce, or suffer reduced reproductive success. If large numbers of birds are cleaned and released, it may be worthwhile to track the survival and reproduction of rehabbed birds.

Sublethally oiled birds may experience stress and breeding disruption. Birds which are exposed to as little as 0.1 milliliter of crude oil may abandon the breeding season, with loss of production for the year (Fry *et al.*, 1986; 1987). Those birds remaining in the colony may have reduced egg or chick survival through several mechanisms: 1) direct exposure of eggs to oil, which is toxic at very low amounts (Hoffman, 1990); 2) reduced incubation attentiveness resulting in lowered hatch-ability of eggs (Fry *et al.*, 1987); 3) reduced survival of chicks because of reduced feeding rates by oil-exposed adults (Trivelpiece *et al.*, 1984); and 4) reduced growth of chicks fed oiled foods by adults (Peakall *et al.*, 1982).

Oil spills can impact birds indirectly through habitat degradation, as documented in a study of wading bird colonies in New York Harbor following a 560,000 gallon spill of

diesel. Parsons (1990; 1991) was able to show that wading birds dependent on tidal habitats (snowy egrets and glossy ibis) experienced significant reductions in hatchling survival for two years after the spill, compared to generalist and upland foragers (cattle egret and black-crowned night heron). Most losses were attributed to starvation as a result of tidal habitat degradation and diminished prey populations, especially for those species unable to shift to alternative foraging sites. There were also changes in colony-site use. This study was highly unusual in that the spill affected nesting colonies which had been part of a five-year study on the nesting and foraging ecology of urban wading bird colonies. Thus, there were excellent baseline data as well as unoiled reference sites for post-spill and reference comparisons.

Methods for Assessment of Impact to Birds

Table 8 lists the key parameters for assessing injuries to birds. Each are summarized below.

TABLE 8. Parameters for evaluation of oil spill effects on birds.

Mortalities
Frequency of oiling
Species abundance
Reproductive success (number of nests, eggs, hatchlings, fledglings; growth rates)
Habitat degradation (colony abandonment, foraging rates)

Mortalities and Frequency of Oiling. A team of trained observers should walk shorelines specifically to count oiled carcasses and document live oiled birds. Photographic or video documentation is useful for providing evidence of species and numbers of lightly and moderately exposed birds that could not be captured. A detailed methodology for assessing the numbers and species composition of dead birds that come ashore as a result of an offshore oil spill is included in Appendix 7. This

methodology was developed as part of the Central California Oil Spill Contingency Plan for the Gulf of the Farallones National Marine Sanctuary.

Scavenging of carcasses may occur rapidly, and many birds may be lost if gulls, raccoons, opossums, foxes, or even dogs and cats frequent the shoreline. Because oiled birds are vulnerable to predation, they often will hide to avoid being discovered by predators, including man. Some oiled carcasses will sink, be scavenged, or will drift offshore and never be found. Loss rates can be extremely variable, and are difficult to estimate without experiments using radiotelemetry of carcasses.

Because the number of bird carcasses recovered after an oil spill is often only 5-25 percent of the actual number oiled (Burger, 1993), it is very important to make as good an estimate as possible for the number of birds at risk of exposure from the beginning of a spill. Fixed-wing aircraft or helicopter surveys of bird populations in the vicinity of a spill are the best method to enumerate most species at risk, such as waterfowl, wading birds, raptors, and seabirds. Aerial surveys are not very useful for marsh birds and other secretive birds which cannot be seen from the air. The NRDA team should be prepared to record observations of the numbers of birds in the vicinity of the spill by species or species groups, early in the spill. Sometimes, these early observations are the only available data for estimating the number of birds potentially exposed. Nesting colonies and roosting and loafing areas within a 15 kilometer radius of the oiled area should be monitored by boat and/or foot to observe the frequency and degree of oiling of birds.

Simple extrapolations can be used to estimate total mortality from the carcass counts. There are also computer models that use currents, wind, bird distributions, beached bird counts, etc. during the actual spill to estimate total number of deal birds (ECI, 1991). High natural variability in bird distributions, both spatially and seasonally, makes it difficult to estimate the total and exposed population actually present during a spill incident.

If there are other likely causes of mortality for the species of concern, it may be necessary to determine the cause of death in a representative number of animals, as well as document exposure to the spilled oil. Other causes of mortality could include winter kill or disease. Methods include: collection of samples of oiled plumage and gut contents to fingerprint oil; blood and tissue analysis for oil residues; and histological analysis of tissues to determine cause of death of dead/dying birds and to rule out other, non-spill related, causes of death (Leighton, 1995).

Species Abundances. During an emergency it becomes very difficult to plan and conduct a complete and timely survey to inventory all the birds at risk within the anticipated path of the spilled oil. It is therefore important to have baseline information on numbers of birds and species present by season, so that surveys of critical areas of high bird concentrations can be made in advance of the spill to confirm the bird numbers and current timing of such factors as migration, breeding, and colony use. It is highly desirable for any bird resource inventory to have data on the following factors.

Breeding Colony Data:

1) Location of known colonies of wading birds, waterfowl, seabirds, diving birds, gull and terns, and shorebirds.

2) The species composition and numbers of birds using each of the colonies, and estimates of the annual variation in breeding populations.

3) The feeding areas used by birds from each colony, and locations where high numbers of birds will be found during the day.

4) The variability in location of each colony from year to year. Some colonial waders may change the location of their colony each year, while others will use the same trees and nests for many years. Terns and gulls may use barrier islands with changing beaches and dune patterns, resulting in different annual locations.

The numbers of birds breeding in any given year may depend on many variables, such as food availability, seasonal storm conditions, water temperature, rainfall patterns, and local water conditions. Since any of these may change in a given year, prior knowledge of the annual variation in timing of breeding is particularly useful in anticipating bird species at risk at the beginning of a spill.

Non-breeding Season Data:

1) Locations and numbers of overwintering birds.

2) Migrating species and important stopover sites.

3) Timing of migration by vulnerable species.

Reproductive Success. There are many measures of the reproductive success of nesting birds that can be used to assess injury resulting from exposure to oil. They include egg-laying dates, percent of the colony attempting nesting, hatch dates, clutch

size, ratio of eggs hatched per clutch, young surviving to species-specific number of days, young fledged, growth rates, and total chick days per nest, among others. Where there are limited baseline data for oiled colonies or nest sites, impacts may be detected using oiled and representative control comparisons. Such studies should be carefully designed with adequate replication, representative controls, and careful consideration of other potential sources of contamination or stress.

Habitat Degradation. Because of the importance of mangroves islands and marshes as nesting habitat for birds, when these habitats are oiled, there will most likely be direct impacts to birds. Direct impacts can occur from abandonment of historical nesting or roosting sites in oiled vegetation, avoidance of oiled areas, or, in some cases, total loss of foraging habitat.

Intertidal foraging areas in the oiled area may have reduced abundances of prey, forcing the birds to travel to more distant sites or resulting in reduced nesting attempts and hatchling survival because of starvation. Detecting changes in foraging patterns will only be possible where there are recent baseline data for specific colonies. However, for spill conditions where a significant reduction in the prey base or prey contamination is of concern, it may be possible to compare reproductive success in oiled versus reference colonies. Reduced nesting attempts, chick starvation, or reduced growth rates may indicate a reduction in prey. Lower clutch size, smaller eggs, lower growth rates, high chick mortalities, and presence of petroleum and/or its metabolites in the organs of nesting birds may indicate contaminated prey.

Application to Injury Quantification

The results of the assessment studies should be used to estimate: 1) the total number of birds killed as a result of exposure to the oil spill; 2) future reductions in bird populations from lost reproductive capacity of the dead birds, lost reproductive capacity of oiled birds that survived, losses from reductions in reproductive success of nesting colonies and sites and entire abandonment of colonies; 3) losses in services provided to bird populations by the habitats injured by the spill; 4) the baseline conditions of bird population resources; and 5) the time needed for recovery of bird populations.

PREASSESSMENT EVALUATION OF INJURY TO MARINE MAMMALS

Summary of Known Impacts from Oil Spills

One of the most important adaptations of marine mammals in relation to oil spill response is the various mechanisms used to control body temperature. The ability to maintain normal body temperatures when immersed in relatively cool water is the greatest single factor affecting the survival of individual mammals. Whales and dolphins are believed to be relatively insensitive to spilled oil, because they rely entirely on blubber and skin for thermoinsulation, and the insulative properties of blubber and skin are not affected by exposure to oil. However, the furred mammals such as otters, fur seals, and polar bears are much more vulnerable to oil because they depend on clean fur for thermal insulation.

To review the known impacts of oil spill on marine mammals, the information must be separated into the three marine mammal groups. Although there are some general similarities relative to oiling, the impacts vary between mammal groups. These groups are:

- Cetaceans (whales, dolphins, and porpoises)
- Pinnipeds (seals, sea lions, and walruses)
- Sea otters
- Polar bears

There are three anticipated interactions that may occur for marine mammals when exposed to oil. These include:

1) direct surface fouling;
2) ingestion; and
3) inhalation of the toxic vapors.

Cetaceans. In general, whales, dolphins, and porpoises are considered to have the ability to detect and avoid oil and other petroleum hydrocarbons. The extent and effects of ingestion of oil by dolphins are unknown. There is evidence of oil accumulation by toothed and baleen whales, but there are no data on any lethal or sublethal effects of either ingestion or accumulation in tissues. There are also few data on the effects of direct contact of oil on sensitive tissues. Direct long-term exposure of

gasoline on dolphin skin produces mild, transient damage; effects on eye or nasal membranes are unknown. During the early stages of large spills, there could be general anesthetic effects of volatile hydrocarbons on breathing in marine mammals (Geraci, 1990). After the *Exxon Valdez* oil spill in Prince William Sound, thirteen members of a very stable pod of killer whales disappeared. It has been postulated that the whales could have been killed by exposure to the volatile hydrocarbons during the early days of the 10.8 million gallon spill (Dahlheim and Matkin, 1993).

Observations during spills have documented few direct impacts of oil spills on dolphins. It is thought that dolphins tend to avoid large slicks; captive dolphins are known to actively avoid floating oil. During the June 1990 *Mega Borg* oil spill, surveys of the distribution and behavior of dolphins during the spill were conducted by NOAA scientists (Mullin *et al.*, 1992; Sumltea and Würsig, 1992). They found that dolphins did not appear to detect oil slicks, though they were able to detect and avoid areas covered with emulsified oil. There were no observed marine mammal mortalities. For more information on the impacts of oil spills on marine mammals, refer to Geraci and St. Aubin (1990) and RPI (1987a).

Pinnipeds. The ability of walrus, seal, and sea lion species to detect and avoid oil and other petroleum hydrocarbons is unknown. However, in the wild, there have been many incidents where seals, sea lions, and fur seals have entered into oiled areas, not seeming to notice the oil slicks. Numerous deaths have been related to direct and indirect exposure of seals and sea lions to petroleum hydrocarbons (St. Aubin, 1990).

Most pinniped species rely on thick layers of blubber to protect them from the cold water they live in and to retain their core temperatures. Surface oiling, as with cetaceans, does not present a thermoregulatory problem. Direct surface contact for most pinnipeds is suspected to result in local irritation of a temporary nature. However, several furred pinniped species, such as the northern fur seals, are susceptible to surface oiling. With the reduced insulative properties of their fur, hypothermia often results (St. Aubin, 1990).

Little information is available regarding the effects or impacts from pinnipeds inhaling the volatile, toxic fractions of petroleum hydrocarbons. As with cetaceans, there could be general anesthetic effects of volatile hydrocarbons on breathing in pinnipeds during the early stages of large spills. The consumption of petroleum hydrocarbons has been implicated in numerous seal and sea lion deaths. Experimental results have revealed a wide variety of effects that may result from oil ingestion by different species.

Symptoms related to oil ingestion range from organ diseases to permanent damage or death (St. Aubin, 1990).

Sea Otters. Sea otters are the smallest marine mammals and also the most susceptible to the impacts from an oil spill. Numerous deaths have been related to direct and indirect exposure of sea otters to petroleum hydrocarbons. Sea otters have no subcutaneous blubber layers and depend entirely on their fur pelage for insulation. If their coats become even partially oiled, they usually succumb to hypothermia (Geraci and Williams, 1990).

Inhalation of hydrocarbon vapors results in a wide variety of effects ranging from mild irritation of mucous membranes to permanent damage or even death. Ingestion of petroleum hydrocarbons also results in organ diseases to permanent damage and death. There are many behaviors and habits which predispose sea otters to exposure (Geraci and Williams, 1990).

Polar Bears. Polar bears occur in low densities as solitary animals or family groups associated with pack ice. They must maintain a clean pelt for thermoregulation, thus they would likely ingest oil during grooming (Stirling, 1990). However, little is known about actual effects of oil ingestion.

Field Methods for Population/Behavioral Changes

Field methods for assessing injuries to marine mammals as a result of an oil spill will be a function of the size and type of spill, the spill trajectory, and the seasonal distribution of the animals. Expert marine mammalogists will certainly be involved and use existing studies as a basis for conducting impact assessments. The following list of key parameters to measure oil effects on marine mammals are provided in Table 9 and discussed below.

TABLE 9. Parameters for evaluation of oil spill effects on marine mammals.

Acute effects including mortality
Determination of cause of death
Reduced reproduction
Habitat degradation

Acute Effects Including Mortality. When marine mammals are at risk, aerial, boat, and foot surveys should be designed to identify and count dead organisms. These surveys should also looked for live, oiled animals (noting the degree of oiling), moribund animals, and any behavioral abnormalities. These surveys should be conducted frequently, as early reporting of carcasses is very important because the tissues break down rapidly. Because of their large size, most stranded marine mammals (except sea otters) are readily sighted, so the greatest loss of dead animals is likely to be due to sinking. Only certain persons are allowed to collect marine mammals, thus all carcasses should be reported to the Marine Mammal Stranding Network[3]. Trained mammalogists will respond to collect the necessary data, photography, and samples for necropsy to confirm cause of death and chemical samples for fingerprinting.

A second approach is to compare post-spill counts with data from pre-spill data, using the same or similar survey methods to strengthen the validity of the comparisons. High interannual variations and incomplete pre-spill coverage for the impacted area/populations can be serious limitations. This approach is best used for stable, well-studied populations.

A third approach is to develop computer models to simulate oil movement, the distribution and abundance of animals, and the likelihood of intersection between the

[3] Note that section 109 (h) of the Marine Mammal Protection Act authorizes designated officials (such as NOAA DAC personnel) to take marine mammals if such a taking is for the protection of the health and welfare of the animal, or the protection of public health and welfare.

two. An intersection model was developed to estimate sea otter mortality following the *Exxon Valdez* spill (Bodkin and Udevitz, 1993).

Determination of Cause of Death of Dead Animals. If there are other likely causes of mortality for the species of concern, it may be necessary to determine the cause of death in a representative number of animals. Other possible causes could include a large winter kill or areas with high incidence of disease. Dead animals from the oiled area may be collected for necropsy and histopathological analysis, for comparison with animals collected from outside the oiled areas.

Reduced Reproduction. Reproductive impacts are determined by monitoring for the number and survival of young. Most marine mammals nurture their young for at least one month (but up to two years), thus it is possible to observe and count parents and young over time to determine survival rates. Photo-identification techniques have been used to identify and track individual whales in stable pods according to their unique markings (Bigg *et al.*, 1986). However, there is often a lack of baseline data on life history (birth rates, survival rates for juveniles and adults, etc.) for many species and sub-populations.

Using aerial survey methods, data can be obtained on marine mammal populations and distribution patterns during and following the spill for comparison with pre-spill survey data to quantify the potential extent of injury. The displacement of local populations from known habitats needs to be monitored

Habitat Degradation. When habitats known to be highly utilized by marine mammals are exposed to oil, great care should be taken to avoid assessment activities that may result in disturbance or displacement of the animals. All assessment efforts should be coordinated with the scientists and managers responsible for the management of those species. When marine mammal habitat degredation is an issue, those concerns should be made known to the scientists conducting intertidal and subtidal habitat surveys and studies. In addition to collecting information that may be helpful in evaluating impairment to marine mammal habitats, this coordination should help minimize disturbance of the animals.

Application of Injury Quantification

The results of the assessment studies should be able to support generation of estimates of: 1) the total number of animals killed as a result of exposure to the oil spill; 2) changes in mammal abundance and other population parameters in the oiled-affected areas; 3) losses in services provided to mammal populations by the habitat injured by the spill; 4) the baseline conditions of mammal population resources; and/or 5) the time needed for recovery of mammal population resources.

PREASSESSMENT EVALUATION OF INJURY TO TERRESTRIAL MAMMALS

Summary of Known Impacts from Oil Spills

Many terrestrial mammals forage in intertidal areas or otherwise utilize aquatic habitats, and are therefore at risk from water-bourne spills. Anecdotal information and reports exist on injury to these resources, but very little is known about the impacts of oil spills on terrestrial mammals. The most likely impacts would be the acute effects from contamination of fur and ingestion of oil during preening and chronic effects from ingestion of contaminated food. In oiled/reference study area comparisons of river otters in *Exxon Valdez* studies, researchers found a less diverse diet, lower body mass, larger home ranges, avoidance of preferred habitat, and elevation of blood parameters in animals from oiled areas one year after the spill (Bowyer *et al.*, 1993). Efforts were made to determine differences in populations for oiled/control study areas, but the confidence limits for the population estimates overlapped for most surveys.

Field studies were also conducted to determine effects of the *Exxon Valdez* spill on Sitka black-tailed deer which concentrate on beaches during late winter and early spring to forage on intertidal marine vegetation. Study plans included comparisons of the number of dead deer on oiled versus reference islands and the hydrocarbon levels in tissues and rumen contents. The complete results have not been published but the available information indicates that no differences between oiled and reference areas were found.

Field Surveys for Population/Behavioral Changes

Parameters for assessing injuries to terrestrial mammals as a result of an oil spill are listed in Table 10. These methods assess direct and indirect impacts to the animals themselves. Changes in habitat value may be reflected in shifts in diet or habitat use by animals using oiled areas.

Acute Mortality Counts. Initial activities should focus on estimates of total mortality for each species, so that an assessment of the potential for population-level changes can be made. Experts in terrestrial mammal behavior will be involved and use existing study methods as a basis for censusing the number of dead animals. Surveys of the affected areas to count the number of animals killed (body count) by the spill typically

TABLE 10. Parameters for evaluation of oil spill effects on terrestrial mammals.

Acute mortality counts
Determination of cause of death of dead animals
Changes in reproductive success
Estimates of population-level changes
Habitat degradation

includes a systematic survey using transects or quadrats to count/collect dead or oiled animals (Anderson *et al.*, 1976). The total number of animals killed would be extrapolated from the sampled data, using actual mortality rates for the known survey area modified with correction factors to account for differences between the surveyed area and the entire spill impact zone. Small mammals, such as oiled beach mice, are likely to be quickly scavenged by predators or return to their burrows thereby avoiding discovery by survey teams. Thus, these counts are always an underestimate of the actual number of animals killed. However, field surveys are important in documenting that exposure and mortality have occurred to each species of concern.

Determination of Cause of Death of Dead Animals. If there are other likely causes of mortality for the species of concern, it may be necessary to determine the cause of death in a representative number of animals. Other possible causes could include a large winter kill or areas with high incidence of disease. Dead animals from the oiled area may be collected for necropsy and histopathological analysis, for comparison with animals collected from outside the oiled areas.

Changes in Reproductive Success. For most spill conditions, it will be extremely difficult to directly measure reproductive success in wild populations of small mammals. Instead, injury can be assessed by investigation of the reproductive potential through study of physiological effects on the reproductive organs. Such studies could include comparisons of the histology of the gonads of males and females in the oiled and control populations; or the size, development, and contents of the uterus of mature females to determine if long-standing gonadal failure is evident.

Alternatively, it may be preferable to conduct controlled laboratory studies to assess the influence of oil on reproduction. If sublethal effects on reproduction are thought to be significant for a species, laboratory experiments may be needed to demonstrate a direct cause and effect relationship between exposure and changes in reproduction, in support of field observations of such changes. Otherwise, because of the limited data on the effects of oil on reproductive performance in terrestrial mammals, it may be difficult to prove that the oil exposure was the cause of the observed changes. In development of the laboratory experiments, it is important that the oil used in the experiments is the same product that was spilled and is similar in degree of weathering as the oil to which wild animals have been exposed.

Estimates of Population-level Changes. For species with very limited populations, it may be possible to estimate changes in population based on the estimated mortality. Otherwise, it will be necessary to compare population densities between oiled and control study areas. Generally, there are insufficient historical data to conduct a pre- versus post-spill comparison. The actual field methods for detecting population density changes should be selected based on the behavioral characteristics of each species and availability of historical population distribution data. High natural variability may be factored out by using experimental data or observations from other incidents to assume type and frequency of impact. Measurement of significant differences between impacted and reference sub-populations, particularly for larger animals with low densities and long lifetimes, is extremely difficult, although there are standard methods in use for data collection and analysis (e.g., Davis and Winstead, 1980; Seber, 1982; Shirley *et al.*, 1988; Chao, 1989; Pollock *et al.*, 1989).

Habitat Degradation. There are various biological indicators of habitat degradation appropriate to assessment of impacts to terrestrial mammals. Two possible indicators include changes in food habits and habitat use. Changes in food habits can result from both contamination or localized reductions in preferred food items. Food habits can be described from prey remains in feces, or examination of the stomach contents of collected animals. Habitat-use studies are more complex, consisting of descriptions of activity patterns (e.g., percent time spent foraging and resting), distances traveled to foraging areas or home range size, and other factors appropriate to the species. Methods to assess these indicators include time- and area-constrained observations during which records of the percent time spent on various activities are recorded.

Application to Injury Quantification

The results of the assessment studies should support estimates of: 1) the total number of animals killed as a result of exposure to the oil spill; 2) changes in mammal abundance and other population parameters in the oiled-affected areas; 3) losses in services provided to mammal populations by the habitat injured by the spill; 4) the baseline conditions of mammal population resources; and 5) the time needed for recovery of mammal population resources.

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APPENDIX 1

List of Contacts for:

National Oceanic and Atmospheric Administration

United States Coast Guard

U.S. Department of the Interior

Army Corps of Engineers

EPA Regional Offices

U.S. Forest Service Regional Offices

State Trustees

DAMAGE ASSESSMENT CENTER

BUSINESS ADDRESSES/TELEPHONE NUMBERS

Name	Position	Telephone	Business Address
Headquarters			
Bill Conner	Division Chief	(301) 713-3038 x 190	1305 East West Hwy Silver Spring Metro Center Bldg. # 4, Room 10218 Silver Spring, MD 20910 Fax: (301) 713-4387
Ann Berger	Program Coordinator	(301) 713-3038 x 192	
Paul Chinn	Computer Systems Analyst	(301) 713-3038 x 184	
John Tokar	Chief of DAC Operations	(301) 713-3038 x 175	
Michele McQuillan	Funds Management	(301) 713-3038 x 177	
Robert Ransom	Contracting Officer	(301) 713-3038 x 191	
Darlene Finch	Policy Coordinator	(301) 713-3038 x 207	
Terri Lewis	Secretary	(301) 713-3038 x 176	
Resource Valuation Branch			
Carol Jones	Branch Chief	(301) 713-3038 x 189	
Norman Meade	Senior Economist	(301) 713-3038 x 201	
Brian Julius	Senior Economist	(301) 713-3038 x 199	
Donna Lawson	Economist	(301) 713-3038 x 198	
David Chapman	Economist	(301) 713-3038 x 200	
Injury Assessment Branch			
Carol Ann Manen	Branch Chief	(301) 713-3038 x 196	
Maura Newell	Ecologist	(301) 713-3038 x 195	
Eli Reinharz	Ecologist	(301) 713-3038 x 193	

Regional Damage Assessment Offices:

Name	Position	Telephone	Business Address
Southeast			
Jim Jeansonne	SE Injury Assessment Coordinator	Tel: (813) 570-5391 Fax: (813) 570-5390 1-800-skypage 8625706	NOAA DAC-SE 9721 Executive Center Drive Suite 134 St. Petersburg, FL 33702
John Kern	Ecologist	1-800-sky-8888 5704957	
Delores Toscano	Secretary		
Southwest			
John Cubit	SW Injury Assessment Coordinator	Tel: (310) 980-4081 Fax: (310) 980-4084 1-800-skypage 8625707	Long Beach Federal Bldg. 501 West Ocean Boulevard Long Beach, CA 90802
Northeast			
Frank Csulak	NE Injury Assessment Coordinator	Tel: (908) 872-3005 Fax: (908) 872-3088 1-800-skypage 8625705	c/o NOAA/NMFS Sandy Hook Laboratory 74 McGruder Road Highlands, NJ 07732
Northwest			
Rob Wolotira	NW Injury Assessment Coordinator	Tel: (206) 526-4360 Fax: (206) 526-6665 1-800-skypage 8625704	NOAA Damage Assessment 7600 Sand Point Way NE Seattle, WA 98115-0070
Douglas Helton	Spill Coordinator	1-800-skypage 8625708	

Supporting DAC Offices:

Name	Position	Telephone	Business Address
Oregon			
Nick Iadanza	Fishery Biologist	Tel: (503) 230-5428 -5420 Fax: (503) 230-5435	NMFS 525 NE Oregon St. Room 500 Portland, Or. 97232
Alaska			
Brad Smith	Fishery Biologist	Tel: (907) 271-5006 Fax: (907) 271-3030	National Marine Fisheries Service 222 West 7th Ave Box 43 Anchorage, AK 99513

DAMAGE ASSESSMENT AND RESTORATION PROGRAM ADDRESSES

Office of General Counsel- Natural Resources (GCNR)		
Headquarters		
Craig O'Connor		1315 East-West Hwy, Room 15132
Kirsten Erickson		Silver Spring, MD 20910
Sharon Shutler		
Linda Burlington		Tel: (301) 713-1217
Nancy Briscoe		Fax: (301) 713-1229
GCNR-Northeast		
Anton Giedt		1 Blackburn Drive
Marguerite Matera		Gloucester, MA 01930
Nancy Gailitis		Tel: (508) 281-9211 Fax: (508) 281-9389
		1-800-skypage 8953390 (Anton)
Jack Moakley		116 Water Street
		Woods Hole, MA 02543
		Tel: (508) 540-0269 Fax (508) 548-5124
GCNR Northwest		
Robert Taylor	(206) 526-4565	7600 Sand Point Way NE,
Maryann Nickerson	(206) 526-4567	Seattle, WA 98115-0070
Gail Siani	(206) 526-4566	
Dave Neander	(206) 526-4564	Tel: (206) 526-6604 Fax: (206) 526-6665 (main line)
GCNR Southeast		
Stephanie Fluke		NOAA Office of General Counsel
Cheryl Scannell		9721 Executive Center Drive, Suite 137
		St. Petersburg, FL 33702
		Tel: (813) 570-5362 (Stephanie)
		5365 (Cheryl)
		Fax: (813) 570-5376
Southwest		
Kathe Pease		Long Beach Federal Building
Paula Lindenmuth		501 West Ocean Boulevard, Suite 4470
Jennifer Peacock		Long Beach, CA 90802
		Tel: (310) 980-4080 Fax: (310) 980-4084

NOAA Restoration Center Regional Contacts

Name/ Region	Business Address	Telephone
Jim Burgess Acting Director Office of Habitat Conservation	Silver Spring Metro Center Bldg. 3 1315 East-West Highway Room 12716 Silver Spring, MD 20910	Tel: (301) 713-2325 Fax: (301) 713-1043
Garry Mayer Director Restoration Center	Silver Spring Metro Center Bldg. 3 1335 East-West Highway Silver Spring, MD 20910	Tel: (301) 713-0174 Fax: (301) 713-0184
Gordon Thayer Southeast	NOAA/NMFS/Beaufort Laboratory 101 Pivers Island Road Beaufort, NC 28516	Tel: (919) 728-3595 Fax: (919) 728-8784
John Catena Northeast	NMFS Habitat Conservation Branch One Blackburn Drive Gloucester, MA 01930	Tel: (508) 281-9251 Fax: (508) 281-9301
Jim Thomas Mid-Atlantic	Silver Spring Metro Center Bldg. #1 1335 East-West Highway Silver Spring, MD 20910	Tel: (301) 713-0174 Fax: (301) 713-0184
Mark Helvey Southwest	NOAA/NMFS/SWR Long Beach Federal Building, Suite 4200 501 West Ocean Boulevard Long Beach, CA 90802	Tel: (310) 980-4079 Fax: (310) 980-4084
Robert Clark Northwest and Alaska	NOAA/NMFS Restoration Center NW 7600 Sand Point Way, NE Seattle, WA98115-0070	Tel: (206) 526-4338 Fax: (206) 526-6665

NOAA SANCTUARIES AND RESERVES DIVISION (SRD)

(See appendix two for individual sanctuary contacts)

Name	Business Address	Telephone
Jim Lawless Chief, SRD (Acting)	NOAA SRD 1305 East West Hwy, 12th Floor Silver Spring, MD 20910	Tel: (301) 713-3155 x 194 Fax: (301) 713-0404
Charlie Wahle Chief, Technical Projects Branch	NOAA SRD 1305 East West Hwy, 12th Floor Silver Spring, MD 20910	Tel: (301) 713-3128 x 156 Fax: (301) 713-0404 Pager: 1-800-sky 8888 3471047
Janice Sessing NRDA Coordinator	NOAA SRD 1305 East West Hwy, 12th Floor Silver Spring, MD 20910	Tel: (301) 713-3128 x 147 Fax: (301) 713-0404

NOAA DAC CONTRACTORS

Name	Business Address	Telephone
Deborah French	Applied Science Associates, Inc. (ASA) 70 Dean Knauss Drive Narragansett, RI 02882	Tel: (401) 789-6224 Fax: (401) 789-1932
Mike Huguenin	2067 Massachusetts Avenue Cambridge, MA 02140	Tel: (617) 354-0074 Fax: (617) 354-0463
Jacqueline Michel	Research Planning, Inc. 1200 Park Street Box 328 Columbia, SC 29202	Tel: (803) 256-7322 Fax: (803) 254-6445
Ann Bailey	EcoChem, Inc. 1401 Norton Building 801 Second Avenue Seattle, WA 98104	Tel: (206) 233-9332 Fax: (206) 233-0114

NOAA HAZARDOUS MATERIALS RESPONSE AND ASSESSMENT DIVISION (HMRAD)

(SSC and CRC contacts are listed separately)

Name	Business Address	Telephone
David Kennedy Division Chief	HMRAD N/ORCA-3 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206) 526-6464 Fax: (206) 526-6329 1-800-sky-page # 5798801
Jean Snider USCG Liason CDR Gerry Wheaton	c/o Commandant (G-MER) United States Coast Guard, Rm 2104 2100 2nd Street SW Washington, DC 20593	Tel: (202) 267-0418 (202) 267-6120 Fax: (202) 267-4825 1-800-sky-page # 5798802
Bob Pavia Branch Chief SSC Branch	HMRAD N/ORCA-31 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206) 526-6319 Fax: (206) 526-6329 1-800-sky-page # 5798817
Gary Petrae Chief SSC	HMRAD N/ORCA-31 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206) 526-6949 Fax: (206) 526-6329 1-800-sky-page # 5798803
Alyce Fritz Branch Chief CRC Branch	HMRAD N/ORCA-32 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206) 526-6305 Fax: (206) 526-6941 1-800-sky-page # 5798811
John Lindsay Chief CRC	HMRAD N/ORCA-32 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206)526-6939 Fax: (206) 526-6941 1-800-sky-page # 2380985
Nir Barnea Safety Officer	HMRAD N/ORCA-32 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206) 526-6943 Fax: (206) 526-6329 1-800-sky-page # 5172565
Alan Mearns BAT Team	HMRAD N/ORCA-32 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206) 526-6336 Fax: (206) 526-6941 1-800-sky-page # 5798806
HAZMAT Duty Officer		206-669-1820
HAZMAT Answering Service		206-726-2148

SCIENTIFIC SUPPORT COORDINATORS (SSC)

Name/ District	Business Address	Telephone
Stephen Lehman CG District 1 CT, MA, ME, NH, NJ, NY, RI, VT	NOAA SSC HAZMAT 1st Coast Guard District (mer) 408 Atlantic Avenue Boston, MA 02110	(617) 223-8016 Fax: (617) 439-0468 1-800-sky-page # 5798814
Gary Ott CG District 5 DE, MD, NC, NJ, PA, VA	NOAA SSC HAZMAT 5th Coast Guard District USCG RTC Yorktown (t-mer) Yorktown, VA 23690	(804) 877-8307 898-2755 Fax: (804) 898-2394 1-800-sky-page # 5798816 Answering Service: (804) 875-2964
Edward Levine New York Steve Meador (assistant SSC)	NOAA SSC HAZMAT Building 110, Box 2, Room 122 Governor's Island New York, NY 10004	(212) 668-6428 Fax: (212) 668-6370 1-800-sky-page # 5798815 Meador # 3470988
Ken Barton CG Districts 2 & 9 IL, IN, MI, MN, NY, OH, PA, WI	NOAA SSC HAZMAT 1240 East 9th, Room 2147 Cleveland, OH 44199	(216) 522-7760 Fax: (216) 522-7759 1-800-sky-page# 5798813
Brad Benggio CG District 7 FL, GA, SC	NOAA SSC HAZMAT Miami Federal Building 51 SW First Avenue, Room 119 P.O. Box 83 Miami, FL 33130	(305) 530-7931 Fax: (305) 530-7932 1-800-sky-page # 5798823
CDR Ilene Byron CG District 8 AL, FL, GA, LA, MS, NM, TX James Illg, Assistant SSC	NOAA SSC HAZMAT 8th Coast Guard District (m-ssc) Hale Boggs Federal Building 500 Camp Street New Orleans, LA 70130-3396	(504) 589-6901 Fax: (504) 589-4999 1-800-sky-page # 5798819
CDR Jim Morris CG District 11 AZ, CA, NV, UT	NOAA SSC HAZMAT 11th Coast Guard District (m) US Federal Office Bldg., Rm 5110 501 West Ocean Boulevard Long Beach, CA. 90802	(310) 980-4107 Fax: (310) 980-4109 1-800-sky-page # 5798818
Sharon Christopherson CG Districts 13 & 14 ID, MT, OR, WA, HI, and Pacific Territories	NOAA SSC HAZMAT HMRAD N/ORCA31 BIN C15700 7600 Sand Point Way NE Seattle, WA 98115	(206) 526-6829 Fax: (206) 526-6329 1-800-sky-page # 5798807
John Whitney CG District 17 AK	NOAA SSC HAZMAT Grace Hall, Suite 300 4230 University Drive Anchorage, AK 99508	(907) 271-3593 Fax: (907) 271-3139 Page: (907) 275-3134

COASTAL RESOURCE COORDINATORS (CRCs) and COMMERCE REGIONAL RESPONSE TEAM MEMBERS

Name/ District	Business Address	Telephone
Ken Finkelstein EPA Region 1 (CT, MA, ME, NH, VT)	EPA Region 1 90 Canal Street - HSS7 Boston, MA 02203-2211	Tel: (617) 223-5537 Fax: (617) 573-9662 1-800-sky-page # 1854096
Diane Wehner EPA Region 2 (NJ, NY, Puerto Rico)	NOAA c/o EPA 290 Broadway, 18th floor New York, NY 10007	Tel: (212) 637-3259 Fax: (212) 637-3253
Peter Knight EPA Region 3 (DE, MD, PA, VA, WV)	EPA Region 3 Superfund Branch 841 Chestnut Building Philadelphia, PA 19107	Tel: (215) 597-3636 Fax: (215) 597-9890
Denise Klimas (RRT for Puerto Rico) EPA Regions 4 (AL, FL, GA, KY, MS, NC, PR, TN, SC, VI)	NOAA HAZMAT c/o EPA Waste Division 345 Courtland Street NE Atlanta, GA 30308	Tel: (404) 347-5231 Fax: (404) 347-0076
Ron Gouguet EPA Region 6 (AR, LA, NM, OK, TX)	EPA Region 6 Superfund Management Branch 1445 Ross Avenue, 10th Floor Dallas, TX 75202	Tel: (214) 655-2232 Fax: (214) 655-6460
Laurie Sullivan Helen Hillman EPA Region 9 (CA, HI, AZ, NV, Guam, American Somoa)	EPA Region 9 75 Hawthorne Street H-1-2, 9th Floor San Francisco, CA 94105	Tel: (415) 744-3126 Fax: (415) 744-3123
LT Chris Beaverson EPA Region 10 (ID, OR, WA)	EPA Region 10 1200 6th Avenue (HW-113) Seattle, WA 98101	Tel: (206) 553-2101 Fax: (206) 399-0124
Mark Miller RRT for Alaska	NOAA HMRAD 7600 Sand Point Way NE Seattle, WA 98115	Tel: (206) 526-6945 Fax: (206) 526-6329

USCG FUND CENTER (NPFC)

Name	Business Address	Regions	Telephone
Daniel F. Sheehan Director, NPFC	USCG NPFC 4200 Wilson Blvd Suite 1000 Arlington, VA 22203	Headquarters	Phone: (703) 235-4756 Fax: (703) 235-4837
CDR Liston Jackson Regional Manager	USCG NPFC 4200 Wilson Blvd Suite 1000 Arlington, VA 22203	Team I: (Alabama, Arkansas, Iowa, Kansas, Louisiana, Mississippi, Nebraska, New Mexico, Oklahoma, Texas)	Phone: (703) 235-4770 Fax: (703) 235-4837
CDR Bob Smith Regional Manager	USCG NPFC 4200 Wilson Blvd Suite 1000 Arlington, VA 22203	Team II: (Delaware, Florida, Georgia, Kentucky, Maryland, North Carolina, Pennsylvania, Puerto Rico, South Carolina, Tennessee, Virgin Island, Virginia, District of Columbia, West Virginia)	Phone: (703) 235-4771 Fax: (703) 235-4837
CDR Ron Gan Regional Manager	USCG NPFC 4200 Wilson Blvd Suite 1000 Arlington, VA 22203	Team III: (Alaska, American Samoa, Arizona, California, Colorado, Guam, Hawaii, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming)	Phone: (703) 235-4765 Fax: (703) 235-4837
CDR Tim Cummings, Regional Manager	USCG NPFC 4200 Wilson Blvd Suite 1000 Arlington, VA 22203	Team IV: (Connecticut, Illinois, Indiana, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Rhode Island, Vermont, Wisconsin)	Phone: (703) 235-4579 Fax: (703) 235-4837

USCG MARINE SAFETY OFFICES (MSO)

(Note that many MSOs cover more than one port or state - Contact the closest MSO for information)

ALASKA		
MSO Anchorage	Commanding Officer, USCG MSO Federal Building & US Courthouse 510 "L" Street, Suite 100 Anchorage, AK 99501-1946	Tel: (907) 271-6700 Fax: (907) 271-6751
MSO Juneau	Commanding Officer, USCG MSO 2760 Sherwood Lane Suite 2A Juneau, AK 99801-8545	Tel: (907) 463-2450 Fax: (907) 463-2445
MSO Valdez	Commanding Officer, USCG MSO P.O. Box 486 Valdez, AK 99686-0486	Tel: (907) 835-4791 Fax: (907) 835-5153

ALABAMA		
MSO Mobile	Commanding Officer, USCG MSO 150 North Royal Street P.O. Box 2924 Mobile, AL 36652-2924	Tel: (205) 441-5201 Fax: (205) 441-6169

CALIFORNIA		
MSO San Francisco	Commanding Officer, USCG MSO Building 14 Coast Guard Island Alameda, CA 94501-5100	Tel: (510) 437-3134 Fax: (510) 437-3072
MSO Los Angeles/Long Beach	Commander, 11th CG District (mer) 501 West Ocean Boulevard Long Beach, CA 90822-5399	Tel: (310) 980-4300 Fax: (310) 980-4381
MSO San Diego	Commanding Officer, USCG MSO 2710 North Harbor Drive San Diego, CA 92101-1064	Tel: (619) 557-5860 Fax: (619) 557-6769

CONNECTICUT		
COTP Long Island Sound	COTP Long Island Sound 120 Woodward Ave New Haven, CT. 06512	Tel: (203) 468-4407

FLORIDA		
MSO Jacksonville	Commanding Officer, USCG MSO 2831 Talleyrand Avenue, Rm 213 Jacksonville, FL 32206-3497	Tel: (904) 232-2640 Fax: (904) 232-2664
MSO Miami	Commanding Officer, USCG MSO 51 SW 1st Avenue, 5th Floor Miami, FL 33130-1609	Tel: (305) 536-5691 Fax: (305) 536-7005
MSO Tampa	Commanding Officer, USCG MSO 155 Columbia Drive Tampa, FL 33606-3598	Tel: (813) 228-2191 Fax: (813) 228-2399
GEORGIA		
MSO Savannah	Commanding Officer, USCG MSO P.O. Box 8191 Savannah, GA 31412-8191	Tel: (912) 652-4353 Fax: (912) 652-4052
GUAM		
MSO Guam	Commanding Officer, USCG MSO, Guam Box 176 PSC 455 FPO AP 96540-1056	Tel: 8-011-671-550-7340 International Fax: 8-011-671-339-6210
HAWAII		
MSO Honolulu	Commanding Officer, USCG MSO 433 Ala Moana Boulevard, Room 1 Honolulu, HI 96813-4909	Tel: (808) 541-2068 Fax: (808) 541-3136
ILLINOIS		
MSO Chicago	Commanding Officer, USCG MSO 215 West 83rd Street Ste. D Burr Ridge, IL 60521-7059	Tel: (708) 789-5830 Fax: (708) 789-5843
KENTUCKY		
MSO Louisville	Commanding Officer, USCG MSO 600 Martin Luther King Place, Rm 413 Louisville, KY 40202-2230	Tel: (502) 582-5194 Fax: (502) 582-6825
MSO Paducah	Commanding Officer, USCG MSO 225 Tully St Paducah, KY 42003	Tel: (502) 442-1621 fax: (502) 442-1633

LOUISIANA		
MSO Morgan City	Commanding Officer, USCG MSO 800 David Drive, Room 232 Morgan City, LA 70380-1304	Tel: (504) 384-2406 ext. 161 Fax: (504) 589-6793
MSO New Orleans	Commanding Officer, USCG MSO 1440 Canal Street Tidewater Building New Orleans, LA 70112-2711	Tel: (504) 589-6196 Fax: (504) 589-6218
MASSACHUSETTS		
MSO Boston	Commanding Officer, USCG MSO 445 Commercial Street Boston, MA 02109-1045	Tel: (617) 223-8444 -3025 Fax: (617) 223-3032
MARYLAND		
MSO Baltimore	Commanding Officer, USCG MSO Customhouse 40 Gay Street Baltimore, MD 21202-4022	Tel: (410) 962-5121 -5105 Fax: (410) 962-0930
MAINE		
MSO Portland	Commanding Officer, USCG MSO P.O. Box 108 Downtown Station Portland, ME 04112-1096	Tel: (207) 780-3251 Fax: (207) 780-3567
MICHIGAN		
MSO Detroit	Commanding Officer, USCG MSO 110 Mt. Elliot Avenue Detroit, MI 48207-4380	Tel: (313) 568-9580 Fax: (313) 568-9581
MSO Sault Ste. Marie	Commanding Officer, USCG MSO c/o USCG Group, Sault Ste. Marie 337 Water Street Sault Ste. Marie, MI 49783-9501	Tel: (906) 635-3210 Fax: (906) 635-3238
MINNESOTA		
MSO Duluth	Commanding Officer, USCG MSO Canal Park 660 South Lake Street Duluth, MN 55802-2352	Tel: (218) 720-5274 -5286 Fax: (218) 720-5258

MISSOURI		
MSO St. Louis	Commanding Officer, USCG MSO 1222 Spruce Street St. Louis, MO 63103-2832	Tel: (314) 539-2655 -3091 Fax: (314) 539-2649
NORTH CAROLINA		
MSO Wilmington	Commanding Officer, USCG MSO 272 North Front Street Suite 500 Wilmington, NC 28401-3907	Tel: (919) 343-4882 -4881 Fax: (919) 343-4423
NEW YORK		
MSO Buffalo	Commanding Officer, USCG MSO Federal Building, Room 1111 111 West Huron Street Buffalo, NY 14202-2395	Tel: (716) 846-4168 Fax: (716) 846-4171
MSO New York	COTP, New York c/o USCG Group Governor's Island Building 108 New York, NY 10004-5000	Tel: (212) 668-7917 7810 Fax: (212) 668-7759
OHIO		
MSO Cleveland	Commanding Officer, USCG MSO 1055 East 9th Street Cleveland, OH 44114-1092	Tel: (216) 522-4405 Fax: (216) 522-3290
MSO Toledo	Commanding Officer, USCG MSO Federal Building, Room 501 234 Summit Street Toledo, OH 43604-1590	Tel: (419) 259-6398 -6372 Fax: (419)259-6374
OREGON		
MSO Portland	Commanding Officer, USCG MSO 6767 North Basin Avenue Portland, OR 97217-3929	Tel: (503) 240-9355 -9301 Fax: (503) 240-9302
PENNSYLVANIA		
MSO Philadelphia	Comanding Officer, USCG MSO 1 Washington Avenue Philadephia, PA 19147-4395	Tel: (215) 271-4803 -4800 Fax: (215) 271-4833

PUERTO RICO		
MSO San Juan	Commanding Officer, USCG MSO P.O. Box 3666 San Juan, PR 00902-3666	Tel: (809) 729-6800 x300 Fax: (809) 722-2697
RHODE ISLAND		
MSO Providence	Commanding Officer, USCG MSO 20 Risho Avenue East Providence, RI 02914-1215	Tel: (401) 528-5335 Fax: (401) 528-5202
SOUTH CAROLINA		
MSO Charleston	Commanding Officer, USCG MSO 196 Tradd Street Charleston, SC 29401-1899	Tel: (803) 724-7683 Fax: (803) 724-7705
TEXAS		
MSO Corpus Christi	Commanding Officer, USCG MSO P.O. Box 1621 Corpus Christi, TX 78403-1621	Tel: (512) 888-3192 -3162 Fax: (512) 888-3115
MSO Houston	Commanding Officer, USCG MSO 9640 Clinton Drive Houston, TX 77029	Tel: (713) 672-6639 Fax: (713) 671-5177
MSO Galveston	Commanding Officer, USCG MSO Post Office Building 601 Rosenburg St. rm 301 Galveston TX, 77550	Tel: (409) 766-3687 Fax: (409) 766-3689
MSO Port Arthur	Commanding Officer, USCG MSO Federal Building 2875 75th Street & Hwy 69 Port Arthur, TX 77640-2099	Tel: (409) 723-6513 -6500 Fax: (409) 723-6534
VIRGINIA		
MSO Hampton Roads	Commanding Officer, USCG MSO Norfolk Federal Building 200 Granby Street Norfolk, VA 23510-1888	Tel: (804) 441-3302 -3307 Fax: (804) 441-3262
VIRGIN ISLANDS		
MSO St. Thomas	Commanding Officer, USCG MSO P.O. Box 818 St. Thomas USVI 00804	Tel: (809) 776-3497 Fax: (809) 774-1687

WASHINGTON MSO Seattle	Commanding Officer, USCG MSO 1519 Alaskan Way South Pier 36, Building 1 Seattle, WA 98134-1192	Tel: (206) 286-5550 Fax: (206) 286-5544

WISCONSIN MSO Milwaukee	Commanding Officer, USCG MSO 2420 South Lincoln Memorial Drive Milwaukee, WI 53207-1997	Tel: (414) 747-7156 -7155 Fax: (414) 747-7108

WEST VIRGINIA MSO Huntington	Commanding Officer, USCG MSO 1415 6th Ave Huntington, WV 25701	Tel: (304) 529-5524 Fax: (304) 522-9457

DEPARTMENT OF THE INTERIOR
OFFICE OF ENVIRONMENTAL POLICY & COMPLIANCE

REGIONAL ENVIRONMENTAL OFFICERS (REO), ASSISTANTS (REA), AND SECRETARIES

Region	REO/REA/Secretary	Business Address	Telephone
Boston CY, MS, ME, NH, NY, RI, VT, NJ	Andy Raddant	408 Atlantic Avenue, Rm 142 Boston, MA 02210	(617) 223-8565 Fax: (617) 223-8569
Philadelphia DC, DE, MD, PA, VA, WV, IL, IN, MI, MN, OH, WI	Donald R. Henne Michael Chezik Carol D. Beall	Custom House, Room 217 200 Chestnut Street Philadelphia, PA 19106	(215) 597-5378 Fax: (215) 597-9845
Atlanta AL, FL, GA, KY, MS, NC, PR, TN, SC, VI	James H. Lee Gregory L. Hogue Carolyn Hendricks	Russell Federal Bldg., Suite 1320 75 Spring Street, SW Atlanta, GA 30303	(404) 331-4524 Fax: (404) 331-1736
Albuquerque AR, LA, NM, OK, TX	Glenn B. Sekavec Steve Spencer Sandra S. Gay	625 Silver Avenue S.W. Suite 190 Albuquerque, NM 87103	(505) 766-3565 Fax: (505) 766-1059
San Francisco AS, AZ, CA, CM, GU, HI, NV	Patricia S. Port Chip Demarest Twyla K. Dyck	600 Harrison Street, Suite 515 San Francisco, CA 94107	(415) 744-4090 Fax: (415) 744-4121
Portland ID, OR, WA	Charles S. Polltyka Preston A. Sleeger Kay Kler-Haggenjos	500 NE Multnomah, Suite 600 Portland, OR 97232-2036	(503) 231-6157 Fax: (503) 231-2361
Anchorage AK	Paul D. Gates Pamela A. Bergman Mary S. McCormick	1689 C Street, Room 119 Anchorage, AK 99501-5126	(907) 271-5011 Fax: (907) 271-4102
Denver CO, KS, MT, NE, ND, SD, UT, WY, IA, MO	Robert F. Stewart Barbara M. Schmalz LaVonia M. Watkins	P.O. Box 25007 (D-108) Denver Federal Building (Building 56, Room 1018) Denver, CO 80225-0007	(303) 236-6900 Fax: (303) 236-4093

U.S. FISH AND WILDLIFE SERVICE
ENVIRONMENTAL CONTAMINANTS PERSONNEL

Name	Position	Telephone	Business Address
Headquarters			
Frand De Luise	Chief	(703) 358-2148 Fax: (703) 358-1800	4401 North Fairfax Drive #330 Arlington, VA 22203
Branch of Damage Assessment & Response			
Pam Matthes	Branch Chief		
Robin Nims Elliott	Fish & Wildlife Biologist		
Pete Escherich	Fish & Wildlife Biologist		
Jeff Underwood	Fish & Wildlife Biologist		
Karen Waldvogel	Environmental Scientist		
Branch of Contaminant Prevention, Investigations, and Biomonitoring			
Tim Kubiak	Branch Chief		
Charlie Chandler	Fish & Wildlife Biologist		
Geoffrey Ekechukwu	Fish & Wildlife Biologist		
Bob Fletcher	Fish & Wildlife Biologist		
Tim Hall	Fish & Wildlife Biologist		
Linda Lyon	Fish & Wildlife Biologist		
Dan Olson	Fish & Wildlife Biologist		
Steve Smith	Fish & Wildlife Biologist		
Sean Furniss	Refuges Coordinator	(703) 358-2043 Fax: (703) 358-1826	4401 North Fairfax Drive 670 Arlington Square Arlington, VA 22203
National Biological Survey/ BEST			
Wayne Willford		(202) 482-3880 Fax: (202) 273-3279	1849 C Street, NW Room 2242 Washington, DC 20240
NBS/ Patuxent Analytical Control Facility			
John Moore Pattie McDonald		(301) 497-5680 Fax: (301) 497-0515	Patuxent Wildlife Research Center Patuxent Analytical Control Facility Route 197 & Powder Mill Road Laurel, MD 20708

U.S. FISH AND WILDLIFE SERVICE
REGIONAL OFFICES

Name	Telephone	Business Address
REGION 1		
Marvin Plenart, Regional Director	(503) 231-6118	Eastside Federal Complex
Don Steffeck, Chief (DEC)	(503) 231-6223	911 NE 11th Avenue
Tom O'Brien	(503) 231-6223	Portland, OR 97232-4181
Roger Helm (NRDA)	(03) 231-6223	
	Fax: (503) 231-6243	
REGION 2		
John Rogers, Jr., Regional Director	(505) 766-2321	500 Gold Avenue, SW
Charlie Sanchez, Jr., Chief (DEC)	(505) 766-2914	P.O. Box 1306
Paul Fore (NRDA)	(505) 766-2914	Albuquerque, NM 87103
	Fax: (505) 766-8063	
REGION 4		
James Pulliam, Regional Director	(404) 679-4000	1875 Century Boulevard
Jerry O'Neal	(404) 679-7127	Atlanta, GA 30345
Rick Dawson (NRDA)	(404) 679-7137	
	Fax: (404) 679-7081	
REGION 5		
Ronald Lambertson, Regional Director	(413) 253-8300	300 Westgate Center Drive
Tim Fannin	(413) 253-8646	Hadley, MA 01035-9589
Dolores Savignano (NRDA)	(413) 253-8613	
	Fax: (413) 253-8482	
REGION 7		
Walter Stieglitz, Regional Director	(907) 786-3542	1011 East Tudor Road
Everett Robinson-Wilson	(907) 786-3493	Anchorage, AK 99503
Ron Britton (NRDA)	(907) 786-3483	
	Fax: (907) 786-3350	

U.S. FISH AND WILDLIFE SERVICE
FIELD OFFICES

Location	Personnel	Telephone	Business Address
REGION 1:			
Boise, Idaho	Charles Lobdell, Field Supervisor William Mullins	(208) 334-1931 Fax: (208) 334-9493	4696 Overland Road Room 576 Boise, ID 83705
Carlsbad, California	Gail Kobetich, Field Supervisor Mickey Rivera	(619) 431-9440 Fax: (619) 431-9618	2730 Locker Avenue, W Carlsbad, CA 92008
Honolulu, Hawaii	Robert P. Smith, Field Supervisor Chip Demarest Jon Hale	(808) 541-2749 Fax: (808) 541-2756	300 Ala Moana Blvd. Room 6307 P.O. Box 50167 Honolulu, HI 96813
Olympia, Washington	Dave Frederick, Field Supervisor Kate Benkert Jeff Momot	(206) 753-9440 Fax: (206) 753-9008	3704 Griffin Lane, SE Suite 102 Olympia, WA 98501-2192
Portland, Oregon	Russell Peterson, Field Supervisor Carol Schuler Colleen Henson	(503) 231-6179 Fax: (503) 231-6195	2600 SE 98th Avenue Suite 100 Portland, OR 97266
Reno, Nevada	Dave Harlow, Field Supervisor Stanley Wiemeyer Pete Tuttle	(702) 784-5227 Fax: (702) 784-5870	4600 Kietzke Lane Building C, Room 125 Reno, NV 89502
Sacramento, California	Wayne White, Field Supervisor Steve Schwarzbach Tom Maurer	(916) 978-5603 Fax: (916) 978-5056	2800 Cottage Way Room E-1803 Sacramento, CA 95825
Ventura, California	Craig Faanes, Field Supervisor Barrie Todd Toni Abaijian	(805) 644-1766 Fax: (805) 904-6288	2493 Portola Road Suite A Ventura, CA 93003

REGION 2:			
Albuquerque, New Mexico	Jennifer Fowler-Propst, Field Supervisor Mark Wilson Mary Orms (T) Matt Custer (T)	(505) 883-7877 Fax: (505) 883-7876	3530 Pan American Hwy NE Suite D Albuquerque, NM 87107
Arlington, Texas	Robert Short, Field Supervisor Denise Baker Joel Lusk	(817) 885-7830 Fax: (817) 885-7835	711 Stadium Drive East Suite 252 Arlington, TX 76011
Austin, Texas	Sam Hamilton, State Administrator Elizabeth Materna	(512) 482-5454 Fax: (512) 482-5442	611 East 6th Street 4th Floor Austin, TX 78701
Clear Lake/ Houston, Texas	Dave Hankla, Field Supervisor Brian Cain Dede Albe	(713) 286-8282 Fax: (713) 488-5882	17629 El Camino Real Suite 211 Houston, TX 77058
Corpus Christi, Texas	Rogelio Perez, Field Supervisor Tom Schultz Steve Robertson David Potter	(512) 994-9005 Fax: (512) 994-8262	c/o Corpus Christi State Univ. Campus Box 338 6300 Ocean Drive Corpus Christi, TX 78412
Phoenix, Arizona	Sam Spiller, Field Supervisor Kirke King Cynthia Martinez	(602) 379-4720 Fax: (602) 379-6629	3616 West Thomas Suite 6 Phoenix, AZ 85019
Tulsa, Oklahoma	Jerry Brabander, Field Supervisor Dan Martin Todd Adornato	(918) 581-7458 Fax: (918) 581-7467	222 South Houston Suite A Tulsa, OK 74127

REGION 4:			
Boqueron, Puerto Rico	Jim Orland, Field Supervisor Felix Lopez	(809) 851-7297 Fax: (809) 851-7440	P.O. Box 491 Boqueron, PR 00622
Brunswick, Georgia	Phillip Laumeyer, Field Supervisor Greg Masson	(912) 265-9336 Fax: (912) 265-1061	801 Gloucester Street Room 334 Brunswick, GA 31520
Charleston, South Carolina	Roger Banks, Field Supervisor Diane Duncan	(803) 727-4707 Fax: (803) 727-4218	P.O. Box 12559 217 Fort Johnson Road Charleston, SC 29422-2559
Daphne, Alabama	Larry Goldman, Field Supervisor Pete Douglas Sharon Delchamps	(205) 441-5181 Fax: (205) 441-6222	2001 Highway 98 Suite A Daphne, AL 36526

Lafayette, Louisiana	Dave Fruge, Field Supervisor Paul Conzelmann Gerald Bodin Jane Ledwin	(318) 262-6630 Fax: (318) 262-6663	825 Kaliste Saloom Brandywine II, Suite 102 Lafayette, LA 70508
Panama City, Florida	Gail Carmody, Field Supervisor Mike Brim Diane Bateman	(904) 769-0552 Fax: (904) 763-2177	1612 June Avenue Panama City, FL 32405-3721
Raleigh, North Carolina	Linda (Mike) Gantt, Field Supervisor Tom Augspurger Kate Looney	(919) 856-4520 Fax: (919) 856-4556	551 Pylon Drive P.O. Box 33726 Raleigh, NC 27636-3726
Vero Beach, Florida	Dave Ferrell, Field Supervisor Doug Morrison Nancy Morse	(407) 562-3909 Fax: (407) 562-4288	1360 US Hwy 1 Suite 5 Vero Beach, FL 32960
Vicksburg, Mississippi	Allen Mueller, Field Supervisor Lloyd Inmon	(601) 634-5995 Fax: (601) 634-7750	Thomas Building Room 235 900 Clay Street Vicksburg, MS 39180

REGION 5: Annapolis, Maryland	John Wolflin, Field Supervisor Robert Foley	(410) 269-5448 Fax: (410) 269-0832	1825-B Virginia Street Annapolis, MD 21401
Charlestown, Rhode Island	Tim Prior, Assistant Field Supervisor	(401) 364-9124 Fax: (401) 364-0170	P.O. Box 307, Rt. 1A Shoreline Plaza Charlestown, RI 02813
Concord, New Hampshire	Gordon Beckett, Field Supervisor Ken Carr Ken Munney Laura Eaton Drew Major	(603) 225-1411 Fax: (603) 225-1467	22 Bridge Street Suite 400 Concord, NH 03301-4901
Cortland, New York	Dave Stilwell, Acting Field Supervisor John Hickey Ken Karwowski Kathryn Jahn	(607) 753-9334 Fax: (607) 753-9699	3817 Luker Road Cortland, NY 13045
Long Island, New York	Nancy Schlotter, Assistant Field Supervisor Chuck Merckel	(516) 581-2941 Fax: (516) 581-2972	P.O. Box 608 Islip, NY 11751
Old Town, Maine	Gordon Russell, Assistant Field Supervisor Steve Mierzykowski	(207) 827-5938 Fax: (207) 827-6099	1033 South Main Street Old Town, ME 04468

Pleasantville, New Jersey	Cliff Day, Field Supervisor Craig Moore Mark Roberts Robert Frakes Katie Zeeman	(609) 646-0620 Fax: (609) 646-0352	927 North Main Street Building D1 Pleasantville, NJ 08232
White Marsh, Virginia	Karen Mayne, Assistant Field Supervisor Stephen Zylstra Mike Drummond	(804) 693-6694 Fax: (804) 693-9032	P.O. Box 480 Mid-County Center Route #17 White Marsh, VA 23183
REGION 7:			
Anchorage, Alaska	Ann Rappoport, Field Supervisor Sonce de Vries	(907) 271-2781 Fax: (907) 271-2786	605 West 4th Avenue Room 62 Anchorage, AK 99501
Fairbanks, Alaska	Pat Sousa, Field Supervisor Elaine Snyder-Conn Keith Mueller	(907) 456-0323 Fax: (907) 456-0346	101 12th Avenue Box 19, Room 232 Fairbanks, AK 99701
Juneau, Alaska	Nevin Holmberg, Field Supervisor Deborah Rudis	(907) 586-7240 Fax: (907) 586-7154	3000 Vintage Blvd. Suite 201 Juneau, AK 99801

NATIONAL PARK SERVICE CONTACTS: NRDA PROGRAM AND REGIONAL OFFICES

NRDA Program	Business Address	Telephone
Daniel Hamson, Chief Environmental Response, Planning, and Assessment Division	National Park Service Environmental Quality Division 1849 C St. N.W. Rm 1210 Washington, DC 20240	Tel: (202) 208-7504 Fax: (202) 208-4260 Pager: 1-800-skytalk # 4190091
Ernie Ralston		Skytalk # 4190092

Regional Park Offices	Business Address	Telephone
North Atlantic	15 State Street Boston, MA 02109	(617) 223-5200
Mid-Atlantic	143 South 3rd Street Philadelphia, PA 19106	(215) 597-7013
Southeast	75 Spring Street Atlanta, GA 30303	(404) 331-4998
Midwest	1709 Jackson Street Omaha, NE 68102	(402) 221-3471
Rocky Mountain	P.O. Box 25287 Denver, CO 80225	(303) 969-2107
Southwest	P.O. Box 728 Santa Fe, NM 87504-0728	(505) 988-6012
Western	600 Harrison Street, Suite 600 San Francisco, CA 94107	(415) 745-3955
Pacific Northwest	83 South King Street, Suite 212 Seattle, WA 98104	(206) 553-5565
Alaska	2525 Gamble Street Anchorage, AK 99503	(907) 257-2687

U.S. BUREAU OF LAND MANAGEMENT STATE OFFICES

State	Business Address	Telephone
Alaska	222 West 7th Avenue #13 Anchorage, AK 99513-7599	(907) 271-5076
Arizona	3707 North 7th Street P.O. Box 16563 Phoenix, AZ 85011	(602) 650-0206
California	Federal Building 2800 Cottage Way Sacramento, CA 95825	(916) 978-4743
Colorado	2850 Youngfield Street Lakewood, CO 80215	(303) 239-3700
Eastern States Office	7450 Boston Boulevard Springfield, VA 22153	(703) 440-1700
Idaho	3380 Americana Terrace Boise, ID 83706	(208) 384-3001
Montana	Granite Towers 222 North 32nd Street P.O. Box 36800 Billings, MT 59107	(406) 255-2904
Nevada	Federal Building 850 Harvard Way P.O. Box 12000 Reno, NV 89520	(702) 785-6590
New Mexico	1474 Rodeo Road P.O. Box 27115 Santa Fe, NM 87502-7115	(505) 438-7501
Oregon	1300 NE 44th Avenue P.O. Box 2965 Portland, OR 97208	(503) 280-7026
Utah	324 South State Street Suite 301 Salt Lake City, UT 84111-2303	(801) 539-4010
Wyoming	2515 Warren Avenue P.O. Box 1828 Cheyenne, WY 82003	(307) 775-6001

U.S. ARMY CORPS OF ENGINEERS DIVISION OFFICES

Division	Business Address	Telephone
Huntsville	P.O. Box 1600 Huntsville, AL 35807-4301	(205) 955-5460
Lower Mississippi Valley (Regulatory Branch)	P.O. Box 80 Vicksbury, MS 39181-0080	(601) 634-5818
Missouri River (Planning Branch)	12565 West Center Road Omaha, NE 68144-3869	(402) 221-7267
New England (Operations Branch)	424 Trapelo Road Waltham, MA 02254-9149	(617) 647-8321
North Atlantic (Regulatory Branch)	90 Church Street New York, NY 10007-2979	(212) 264-3996
North Central	111 North Canal Street Chicago, IL 60606-7205	(312) 353-6310
North Pacific (Planning/ Engineering Branch)	P.O. Box 2870 Portland, OR 97208-2870	(503) 326-3780
Ohio River (Construction/ Operations Branch)	P.O. Box 1159 Cincinnati, OH 45201-1159	(513) 684-6811
Pacific Ocean (Construction/ Operations Branch)	Building 230 Ft. Shafter, HI 96858-5440	(808) 438-9293
South Atlantic (Construction/ Operations Branch)	77 Forsyth Street SW Room 313 Atlanta, GA 30335-6801	(404) 331-6740
Transatlantic (Construction/ Operations Branch)	P.O. Box 2250 Winchester, VA 22601-1450	(703) 665-3629
South Pacific (Construction/ Operations Branch)	630 Sansome Street Room 720 San Francisco, CA 94111-2206	(415) 705-1226
Southwestern (Construction/ Operations Branch)	1114 Commerce Street Dallas, TX 75242-0216	(214) 767-2436

U.S. EPA REGIONAL OFFICES

Region	Business Address	Telephone
Region 1, Emergency Response Section	60 Westview Street Lexington, MA 02173 Attn: Response Planning Coordinator	(617) 860-4361
Region 2, RPB Removal & Emergency Preparedness Programs (MS-211)	2890 Woodbridge Avenue Edison, NJ 08837	(908) 321-6656
Region 3, Title III Section (3HW34)	841 Chestnut Street 9th Floor Philadelphia, PA 19107	(215) 597-5998/1357
Region 4, Emergency Response & Removal Branch	345 Courtland Street NE 1st Floor Atlanta, GA 30365	(404) 347-3931
Region 5, EERB (HSE-5)	77 West Jackson Boulevard 5th Floor Chicago, IL 60604-3507	(312) 886-6236
Region 6, Contingency Planning Section (62-EP)	First Interstate Bank Tower 1445 Ross Avenue Dallas, TX 75202-2733	(214) 655-2270
Region 7, EPPB (ENSV)	25 Funston Road 2nd Floor Kansas City, KS 66115	(913) 551-5000
Region 8, Prevention Section (HWM-ER)	One Denver Place 999 18th Street, Suite 500 Denver, CO 80202-2405	(303) 293-1603
Region 9, ERS (H83)	75 Hawthorne Street San Francisco, CA 94105	(415) 744-1500
Region 10, SRIS (HW114)	1200 Sixth Avenue 11th Floor Seattle, WA 98101	(206) 553-1090

U.S. DEPARTMENT OF AGRICULTURE NRDA CONTACTS:

Name	Business Address	Telephone
Bill Opfer, Harry Kringler, George Sundstrom,	USDA 14th and Independance Ave Room 240-W Admin Building Washington, D.C. 20250-1300 Fax: (202) 205-0861	(202) 205-0906 (202) 260-6565 (202) 260-6556
Terry Harwood Evironmental Health Engineer	US Forest Service 201 14th St. S.W. Washington, D.C. 20250	(202) 205-1156

U.S. FOREST SERVICE REGIONAL OFFICES

Region	Business Address	Telephone
North	Federal Building P.O. Box 7669 Missoula, MT 59807	(406) 329-3092
Rocky Mountain	740 Simms Street Lakewood, CO 80401	(303) 275-5041
Southwest	Federal Building 517 Gold Avenue SW Albuquerque, NM 87102	(505) 842-3291
Intermountain	Federal Building 324 25th Street Ogden, UT 84401	(801) 625-5352
Pacific Southwest	630 Sansome Street San Francisco, CA 94111	(415) 705-2874
Pacific Northwest	333 SW 1st Avenue P.O. Box 3623 Portland, OR 97208	(503) 326-4154
South	1720 Peachtree Road NW Atlanta, GA 30367	(404) 347-7229
East	310 West Wisconsin Avenue Milwaukee, WI 53203	(414) 297-3620
Alaska	Federal Office Building, P.O. Box 21628 Juneau, AK 99802	(907) 586-8806

STATE NATURAL RESOURCE TRUSTEE CONTACTS

ALABAMA
James Martin
Commissioner
Department of Conservation & Natural Resources
P.O. Box 301450
Montgomery AL 36130-1450
Tel: (334) 242-3486 Fax: (334) 242-3167

James Warr
Department of Environmental Management
Montgomery AL 36109
Tel: (334) 271-7700 Fax: (334) 271-7950

ALASKA
Mark Broderson
Alaska Department of Environmental Conservation
410 Willoughby Ave., Suite 105
Juneau AK 99801-1798
Tel: (907) 465-5323

Harry Noah
Commissioner
Alaska Department of Natural Resources
400 Willoughby Ave.
Juneau AK 99801-1724
Tel: (907) 465-2400 Fax: (907) 465-3886

Kristina O'Connor
Alaska Department of Natural Resources
3601 C St. #1380
Anchorage AK 99503
Tel: (907) 762-2580 Fax: (907) 563-0415

Ernest Piper
Program Manager, Damage Assessment & Restoration
Alaska Dept. of Environmental Conservation
555 Cordova Street Anchorage AK 99501

Frank Rue
Commissioner
Alaska Department of Fish and Game
P.O. Box 25526
Juneau AK 99802-5526
Tel: (907) 465-4100 Fax: (907) 465-2332

John Sandor
Commissioner
Alaska Department of Environmental Conservation
410 Willoughby Ave. Suite 105
Juneau AK 99801-1795
Tel: (907) 465-5050 Fax: (907) 465-5070

Claudia Slater
Alaska Department of Fish & Game
333 Raspberry Rd.
Anchorage AK 99502
Tel: (907) 267-2336 Fax: (907) 349-1723

Alex Swiderski
Assistant Attorney General
Alaska Department of Law
1031 W. 4th Ave. Suite 2000
Anchorage AK 99501
Tel: (907) 269-5274 Fax: (907) 278-7022

AMERICAN SAMOA
Ray Tulafono
Director
Office of Marine Wildlife
P.O. Box 3730
Pago Pago AS 96799
Tel: (684) 633-4456 Fax: (684) 633-5044

CALIFORNIA
Pierre DuVair
Economist
CA Dept of Fish & Game
P. O. Box 944209 1700 K St., Suite 250
Sacramento CA 94244-2090
Tel: (916) 327-0911 Fax: (916) 324-8829

Paul Kelly
Resource Assessment Coordinator
CA Dept. Fish and Game / OSPR
1700 K Street P.O. Box 944209
Sacramento CA 94244-2090
Tel: (916) 323-4335 Fax: (916) 323-4407

Don Lollock
Chief, Scientific Program
CDF&G Office of Oil Spill Prev. & Response
OSPR,
California Dept. of Fish & Game
1700 K Street, Suite 250
Sacramento CA 95814
Tel: (916) 445-8285 Fax: (415) 324-8829

Michael Martin
Staff Toxicologist
CA Dept. of Fish and Game
20 Lower Ragsdale Drive #100
Monterey CA 93940

Michael Neville
Deputy Attorney General
California Attorney's General Office
50 Fremont Street Suite 300
San Francisco CA 94105-2239
Tel: (415) 356-6364 Fax: (415) 356-6257

Robert Ricker
Staff Toxicologist
Office of Oil Spill Prevention & Response
1700 K Street Suite 250
Sacramento CA 95814

Sara Russell
Deputy Attorney General
Office of the Attorney General
2101 Webster St. 12th Floor
Oakland CA 94612-3049
Tel: (510) 286-0845 Fax: (510) 286-4020

Katherine Verrue-Slater
Staff Counsel
CDFG - Oil Spill Office
1700 K Street Suite 250
Sacramento CA 95814

CONNECTICUT
Sydney Holbrook, Commissioner
CT Department of Environmental Protection
79 Elm Street
Hartford CT 06106
Tel: (203) 424-3001 Fax: (203) 566-7932

Scott Deshefy
CT. DEP
Enforcement Program, Waste Division
79 Elm Street
Hartford, CT 0616
Tel (203) 424-3374

DISTRICT OF COLUMBIA
Ferial Bishop
Administrator
D.C. Department of Consumer & Regulatory Affairs
Environmental Regulations Administration
2100 Martin Luther King Jr. Ave., SE
Washington DC 20020
Tel: (202) 404-1136 Fax: (202) 404-1141

DELAWARE
Rob Allen
Environmental Scientist
Dept of Natural Resources & Env. Conservation
Div. of Air and Waste Mgmt/Superfund Branch
715 Grantham Lane
Newcastle DE 19720
Tel: (302) 323-4540 Fax: (302) 323-4561

Ben Anderson
DNREC
Watershed Assessment Branch
P.O. Box 1401
Dover, DE, 19903
Tel: (302) 739-4590

Jeanne Langdon
Deputy Attorney General
Office of the Attorney General
89 Kings Highway P.O. Box 1401
Dover DE 19903
Tel: (302) 739-4636

Christopher Tulou
Secretary
Dept of Natural Resources & Environmental Conservation
89 Kings Highway P.O. Box 1401
Dover DE 19903
Tel: (302) 739-4403 Fax: (302) 739-6242

FLORIDA
Patricia Kingcade
Office of General Counsel
Florida Dept. of Environmental Protection
M. Stoneman Douglas Bldg. 3900
Commonwealth Blvd.
Tallahassee FL 32399
Tel: (904) 921-9702

Debbie Preble
Chief
Office of Coastal Protection
Department of Environmental Protection
3900 Commonwealth Blvd., Mail Sta. 59
Tallahassee FL 32399
Tel: (904) 488-2974 Fax: (904) 488-5957

GEORGIA
Lonice Barrett
Commissioner
Georgia Department of Natural Resources
205 Butler St., Suite 1252
Atlanta GA 30334
Tel: (404) 656-3500 Fax: (404) 656-0770

Robert Bomar
Senior Assistant Attorney General
Office of the Attorney General
40 Capitol Square, SW Atlanta GA 30334-1300
Tel: (404) 656-7273 Fax: (404) 651-6341

GUAM
Micheal Ham
Administrator
Guam Coastal Management Program
Bureau of Planning P.O. Box 2950
Agana GU 96910
Tel: (671) 472-4201 Fax: (671) 477-1812

Rufo Legion
Chief
Division of Aquatic & Wildlife Resources
Department of Agriculture
P.O. Box 2950 Agana GU 96910
Tel: (671) 734-3944 Fax: (671) 734-6570

HAWAII
Keith Ahue
Chairperson
Hawaii Board of Land & Natural Resources
1151 Punchbowl St.
Honolulu HI 96813
Tel: (808) 587-0400 Fax: (808) 587-0390

Laurence Lau
Deputy Attorney General
Office of the Attorney General
465 South King St. Room 200
Honolulu HI 96813
Tel: (808) 587-3050 Fax: (808) 587-3077

John Lewin, M.D.
Hawaii Director of Health
1250 Punchbowl St.
Honolulu HI 96813
Tel: (808) 586-4410 Fax: (808) 586-4444

LOUISIANA
Daniel Duhon
Deputy Coordinator
Louisiana Oil Spill Coordinator's Office
Office of the Governor 1885 Wooddale Blvd,
12th Floor
Baton Rouge LA 70806

Dale Givens
Assistant Secretary
Office of Water Resources
Department of Environmental Quality
P.O. Box 82215
Baton Rouge LA 70884-2215
Tel: (504) 765-0634 Fax: (504) 765-0635

William Goodell
Assistant Attorney General
Office of the Attorney General
P.O. Box 94095
Baton Rouge LA 70804-4095
Tel: (504) 342-7900 Fax: (504) 342-7901

Roland Guidry
Louisiana Oil Spill Coordinator
Office of the Governor
1885 Wooddale Blvd. 12th Floor
Baton Rouge LA 70806

Ivor van Herden
Assistant Secretary
Office of Coastal Resource Management
Department of Natural Resource
P.O. Box 44487
Baton Rouge LA 70804-4487
Tel: (504) 342-1375 Fax: (504) 342-1377

Corky Perrett
Marine Fisheries Division
Department of Wildlife and Fisheries
P.O. Box 98000
Baton Rouge LA 70898-9000
Tel: (504) 765-2801 Fax: (504) 765-2489

Micheal Smith
Assistant Attorney General
Attorney General's Office
P.O. Box 94095 301 Maine St.
Baton Rouge LA 70801
Tel: (504) 342-7900 Fax: (504) 342-7901

MASSACHUSETTS
Trudy Coxe
Commissioner
Massachusetts Department of Environmental Protection.
One Winter St.
Boston MA 02108
Tel: (617) 292-5500 Fax: (617) 556-1049

Karen McGuire
Assistant Attorney General
Office of the Attorney General
200 Portland Street
Boston MA 02114
Tel: (617) 727-2200 Fax: (617) 727-3251

Dale Young
Section Chief
DEP/Bureau of Waste site Cleanup
1 Winter Street, 5th Floor
Boston MA 02108
Tel: (617) 292-5785 Fax: (617) 556-1049

MARYLAND
John Chlada
Emergency Management Coordinator
Maryland Department of the Environment
2500 Broening Highway
Baltimore MD 21224
Tel: (410) 631-3305 Fax: (410) 631-3888

Denise Ferguson-Southard
Dept. of the Environment
Office of the Attorney General
2500 Broening Hwy.
Baltimore MD 21224
Tel: (410) 631-3053 Fax: (410) 631-3943

Anthony Gorski
Assistant Attorney General
Office of the Attorney General
2500 Broening Hwy
Baltimore MD 21224
Tel: (410) 631-3502 Fax: (410) 631-3943

John Griffin
Secretary
Maryland Department of Natural Resources
Tawes State Office Bldg. 580 Taylor Ave.
Annapolis MD 21401-2397
Tel: (410) 974-3041 Fax: (410) 974-5206

Mike Hare
Administrator
Emergency Response Operations
Maryland Department of the Environment
2103 Annapolis Rd.
Baltimore MD 21230
Tel: (410) 333-2950 Fax: (410) 333-3728

Jane Nishida
Secretary
Maryland Department of the Environment
2500 Broening Highway
Baltimore MD 21224
Tel: (410) 631-3084 Fax: (410) 631-3888

MAINE
William Brenan
Commissioner
Department of Marine Resources
State House Station #21
Augusta ME 04333
Tel: (207) 287-6550 Fax: (207) 287-6024

Dennis Harnish
Assistant Attorney General
Office of the Attorney General
Station 6
Augusta ME 04333
Tel: (207) 626-8800 Fax: (207) 626-8828

Ronald Lovaglio
Commissioner
Department of Conservation
State House Station #22
Augusta ME 04333
Tel: (207) 287-4900 Fax: (207) 287-2400

Bucky Owen
Commissioner
Department of Inland Fisheries & Wildlife
State House Station #41
Augusta ME 04333
Tel: (207) 287-5202 Fax: (207) 287-6395

Edward Sullivan
Commissioner
Department of Environmental Protection
State House Station # 17
Augusta ME 04333
Tel: (207) 287-7688 Fax: (207) 287-7826

MISSISSIPPI
J.I. Palmer
Executive Director
Mississippi Department of Environmental Quality
P.O. Box 2035
Jackson MS 39289-1305
Tel: (601) 961-5000 Fax: (601) 354-6965

NORTH CAROLINA
Jonathan Howes
Secretary
Dept of Environment, Health & Natural Resources
P.O. Box 27687
Raleigh NC 27611-7687
Tel: (919) 715-4101 Fax: (919) 715-3060

NEW HAMPSHIRE
James DiStefano
Executive Director
Fish & Game Department
2 Hazen Drive
Concord NH 03301
Tel: (603) 271-3421 Fax: (603) 271-1438

NEW JERSEY
Richard Engel
Deputy Attorney General
Office of the Attorney General
25 Market St. CN-093
Trenton NJ 08625
Tel: (609) 984-4863 Fax: (609) 984-9315

Marty McHugh
Chief, Office of NRDA
New Jersey Dept. of Environmental Protection
CN-404
Trenton NJ 08625
Tel: (609) 292-3541 Fax: (609) 984-0836

Robert Shinn, Jr.
Commissioner
N.J. Department of Environ. Protection & Energy CN 402
401 East State St., Floor 7
East Trenton NJ 08625-0402
Tel: (609) 292-0432 Fax: (609) 292-7695

NEW YORK
Steve Stanford
Chief
Dept. of Environmental Conservation
Natural Resource Damage Unit
50 Wolf Road Room 459
Albany NY 12233-1090
Tel: (518) 457-7765 Fax: (518) 485-8424

Sharon Brooks
Dept. of Environmental Conservation
Natural Resource Damage Unit
50 Wolf Road Room 459
Albany NY 12233-1090
Tel: (518) 457-7765 Fax: (518) 485-8424

Gordon Johnson
Deputy Chief
Office of the Attorney General
120 Broadway 26th Floor, Room 108
New York NY 10271
Tel: (212) 416-8448 Fax: (212) 416-6007

Marc Matsil
Chief
City of Parks and Recreation
1234 Fifth Ave.
New York NY 10029
Tel: (202) 360-1417 Fax: (212) 360-1426

Pat Primi
State of New York
Department of Law
Environmental Protection Bureau
120 Broadway, 26 Fl.
New York, NY. 10271
Tel (212) 416-8481 Fax (212) 416-6007

Micheal Zagata
Commissioner
New York State Dept. of Environmental Conservation
50 Wolf Rd., Room 604
Albany NY 12233-1010
Tel: (518) 457-1162 Fax: (518) 457-6996

OREGON

Cheryl Coon
Assistant Attorney General
Office of the Attorney General
1515 SW Fifth Ave. Suite 410
Portland OR 97201
Tel: (503) 229-5725 Fax: (503) 229-5120

Langdon Marsh
Director
Oregon Dept of Environmental Quality
811 Southwest, 6th Ave.
Portland OR 97204-1390
Tel: (503) 229-5300 Fax: (503) 229-6124

Gregory Robart
Oregon Dept of Fish & Wildlife
Habitat Conservation Division
2501 S.W. First Ave., P.O. Box 59
Portland OR 97207
Tel: (503) 229-6967 Fax: (503) 229-5969

PENNSYLVANIA

John Arway
Chief, Environmental Services
PA Fish and Boat Commission
450 Robinson Lane
Bellefonte PA 16823
Tel (814) 359-5147

Don Brown
DEP/Office of Chief Counsel
400 Market Street, 9th Floor P.O. Box 8464
Harrisburg PA 17105-8464
Tel: (717) 787-9368 Fax: (717) 783-7911

Peter Colangelo
Executive Director
Pennsylvania Fish & Boat Commission
3532 Walnut St. P.O Box 67000
Harrisburg PA 17106-7000
Tel: (717) 657-4515 Fax: (717) 657-4033

Donald Madl
Executive Director
Pennsylvania Game Commission
2001 Elmerton Ave.
Harrisburg PA
17110-9797
Tel: (717) 787-3633 Fax: (717) 772-0502

James Seif
Secretary
Pennsylvania Department of Environmental Protection
16th Floor, Market St., State Office Bldg. P.O. Box 2063
Harrisburg PA 17105-2063
Tel: (717) 787-2814 Fax: (717) 783-8926

Wm. Stanley Sneath
Office of Chief Counsel, SW Region
PA DEP
Lee Park, Suite 6015
555 North Lane
Conshohocken, PA 19428-2233
Tel (610) 832-6300 Fax (610)-832-6321

PUERTO RICO

Pedro Gelabert
Secretary
Department of Natural and Environmental Resources
P.O. Box 5887, Pta de Tierra Sta.
San Juan PR 00906
Tel: (809) 723-3045 Fax: (809) 722-2785

Hector Russe
Chairman,
Environmental Quality Board
P.O. Box 11488
Santurce, PR 00910

PALAU

Noah Idechong
Chief
Division of Marine Resources
Bureau of Resources & Development
P.O. Box 100
Koror PW 96940
Tel: (680) 488-2266 Fax: (680) 488-1662

Demei Otodeb
Director
Division of Conservation & Entomology
P.O. Box 117
Koror PW 96940
Tel: (680) 488-2487 Fax: (680) 488-1662

RHODE ISLAND
Timothy Keeney
Director
Department of Environmental Management
9 Hayes St.
Providence RI 02908
Tel: (401) 277-2771 Fax: (401) 277-6802

Micheal Rubin
Assistant Attorney General
Office of the Attorney General
72 Pine St.
Providence RI 02903
Tel: (401) 274-4400 Fax: (401) 277-1331

SOUTH CAROLINA
Ed Duncan
Environmental Coordinator
S.C. Wildlife & Marine Resources Dept.
Marine Resources Center
P.O. Box 12559
Charleston SC 29422-2559
Tel: (803) 762-5014 Fax: (803) 762-5007

Ron Kinney
Director
Waste Assessment & Emergency Response
S.C. Dept of Health & Environmental Control
2600 Bull St.
Columbia SC 29201
Tel: (803) 734-5235 Fax: (803) 734-5216

Keith Lindler
Director
Division of Site Engineering & Screening
S.C. Department of Health & Environmental Control
2600 Bull St. Columbia SC 29201
Tel: (803) 896-4052 Fax: (803) 896-4001

Elizabeth Partlow
Director
Environmental Affairs
P.O. Box 11369
Columbia SC 29211
Tel: (803) 734-0543 Fax: (803) 734-0356

TEXAS
Ingrid Hansen
Texas General Lands Office, Legal Division
1700 North Congress Ave
Austin TX 78701-1495
Tel: (512) 475-1395 Fax: (512) 463-5098

Diane Hyatt
Natural Resource Damage Assessment
Texas General Land Office
1700 North Congress Avenue
Austin TX 78701
Tel (512) 475-1395 fax 463-5367

Don Pitts
Texas Parks and Wildlife
4200 Smith School Road
Austin, TX 78744
Tel (512) 389-4726 fax (512) 389-4394

Richard Seiler
Texas Natural Resource Conservation Commission
MC142
P.O. Box 13087
Austin TX 78711-3087
tel: (512) 239-2523 fax (512) 239-2527

VIRGINIA
Carl Josephson
Assistant Attorney General
Office of the Attorney General
900 East Maine Street
Richmond VA 23219
Tel: (804) 786-2452 Tel: (804) 786-0034

Becky Norton-Dunlop
Secretary of Natural Resources
P.O. Box 1475
Richmond VA 23212
Fax: (804) 786-0044 Tel: (804) 371-8333

VIRGIN ISLANDS
Roy Adams
Commissioner
U.S.V.I. Dept of Planning & Natural Resources
Suite 231, Nisky Center
St. Thomas VI 00802
Tel: (809) 774-3320 Fax: (809) 774-5416

Paul Gimenez
Solicitor General
Office of the Attorney General
48B-50C Kronprinsdens Gade
St. Thomas VI 00802
Tel: (809) 774-5666 Fax: (829) 774-9710

WASHINGTON

Dick Logan
Oil Spill Resource Damage Assessment Coordinator
Washington State Dept. of Ecology
P.O. Box 47600
Lacey, WA 98503
Tel: (360) 407-6971 Fax: (360) 407-6902

Jay Manning
Office of the Attorney General
P.O. Box 40117
Olympia WA 98504-0117
Tel: (360) 459-6158 Fax: (360) 438-7743

Mary McCrea
Assistant Attorney General
Office of the Attorney General
629 Woodland Square Loop P.O. Box 40117
Olympia WA 98504-0117
Tel: (360) 459-6155 Fax: (360) 438-7743

Greg Sorlie
Program Manager
Washington Department of Ecology
M/S PV-11
Olympia WA 98574-8711
Tel: (360) 459-6037 Fax: (360) 407-6902

APPENDIX 2

NOAA Sanctuaries and Reserves Division

Site Descriptions and Contacts

for National Marine Sanctuaries and National Estuarine Research Reserves:

Alabama

American Samoa

California

Delaware

Florida

Georgia

Hawaii

Maine

Maryland

Massachusetts

Michigan

New Hampshire

New Jersey

New York

North Carolina

Ohio

Oregon

Puerto Rico

Rhode Island

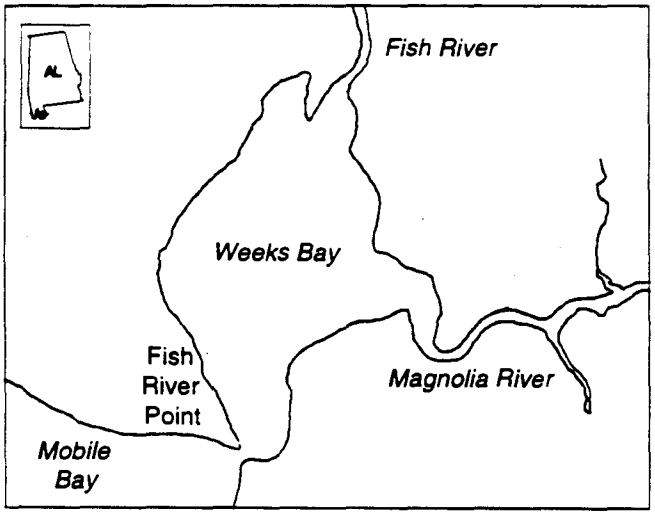
South Carolina

Texas

Virginia

Washington

ALABAMA
Weeks Bay National Estuarine Research Reserve



Size: 3,028 acres Province: Louisianian

Significant Resources

Weeks Bay NERR contains forested uplands, wetlands and swamps, salt marsh, tidal flats, seagrass beds, and open water. These habitats provide support for a variety of organisms, including critical nursery grounds for fish and shellfish. Endangered species, including the Alabama Red-Bellied Turtle and Black Pine Snake, can be found here. Over 330 species of birds have been identified within the Reserve, including nearly 100 resident species, 125 wintering species, and 85 spring and fall migrants. More than 50 mammal, 70 reptile, 40 amphibian, and 180 fish species can be found in the waters and surrounding lands of the Reserve.

Staff and Facilities

Five permanent employees and three contract employees staff the Reserve. A volunteer force of approximately fifty people assist in various programs of the Reserve. A 4,000 square foot interpretive center, two miles of nature trails, a classroom, office space, an observation deck, research lab, and specimen display area are some of the facilities present on-site. Easy water access and publicly-owned boat launching sites increase the opportunities for public use.

History and Location

Weeks Bay, a small estuarine embayment of Mobile Bay, Alabama, was designated as a Reserve in 1986.

Uses and Programs

Ongoing research programs include assessment and abatement of non-point source pollution, hydrodynamic modelling, and inventories of fauna and flora. Education programs including guided boat tours of the Reserve, nature walks, information brochures, a guest lecture series, slide presentations, and an extensive, hands-on specimen collection are designed to educate the public about the resources of Weeks Bay. The Reserve conducts a teacher training program that allows the teachers to bring students for site visits. An extensive volunteer program enhances public involvement in coastal resource protection and helps support Reserve programs.

Site Accomplishments and Goals

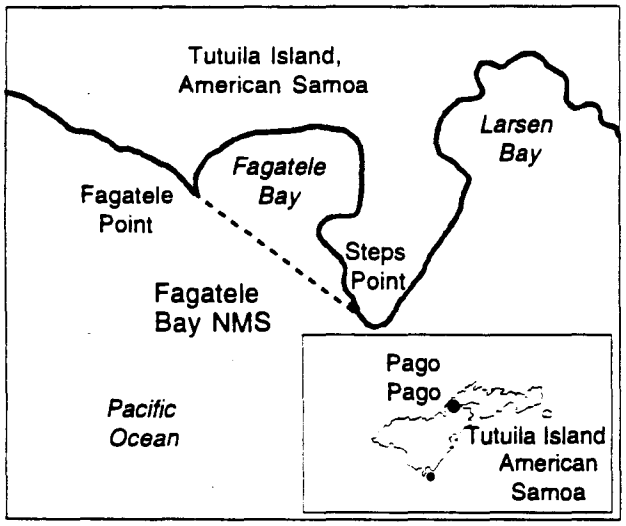
Weeks Bay was designated an Outstanding National Resource Water in 1992. A carnivorous plant bog is being restored, and a display area for living specimens is under construction. The extensive collection of plant and animal specimens, cultural and archaeological artifacts, and published literature about the area continues to grow. Planning has begun for the addition of a facility to house visiting researchers.

For more information, please contact:

Brenda Spivey, Research Manager
Weeks Bay National Estuarine Research Reserve
11300 U.S. Highway 98
Fairhope, Alabama 36532

Phone Number: (205) 928-9792
Fax Number: (205) 928-1792

AMERICAN SAMOA
Fagatele Bay National Marine Sanctuary



Size: 0.28 nmi²; American Samoa territorial waters

Significant Resources

Fagatele Bay NMS protects a fringing coral reef ecosystem contained within an eroded volcanic crater on the island of Tutuila in American Samoa. This smallest and most remote of all the sanctuaries is the only true tropical reef in the National Marine Sanctuary Program.

Nearly 200 species of coral in Fagatele Bay are slowly recovering from a devastating attack by the crown-of-thorns starfish in the late 1970s. The starfish destroyed over 90 percent of the living corals.

Since that time, new growth has been compromised by two hurricanes, several tropical storms, and this past year, a severe coral reef bleaching event. This cycle of growth and destruction is typical of tropical marine ecosystems. Signs are everywhere that the rich diversity of the reef is being replenished anew.

Coral provides the backdrop to a vibrant marine environment fueled by the tropical sun and enriched by nutrients from the eroding island. Gliding among the recovering corals in the Bay are schools of surgeonfish, parrotfish, damselfish, and brightly colored butterfly fish. Lobsters, crabs, octopus, squid, sharks and an occasional sea turtle also live in, or frequent, the bay.

From June to September, the bay may be visited by humpback whales and their newborn calves, as well as courting males who sing whalesongs during their stay. Several species of dolphin also include Fagatele Bay in their range.

Human Use and Values

The main human use of Fagatele Bay is subsistence fishing, although sport fishing does occur. Some levels of non-consumptive recreational uses exist and are expected to increase. The site may contain cultural resources reflecting the 3000+-year residency by native Samoans.

Site Designation and Regulations

Fagatele Bay was placed on the List of Recommended Areas in 1982 and made an Active Candidate later the same year. It was designated as a National Marine Sanctuary in April 1986. Within the inner bay, only traditional fishing methods are permitted and taking invertebrates is prohibited. Historical and cultural artifacts found in the bay are fully protected.

Staff and Facilities

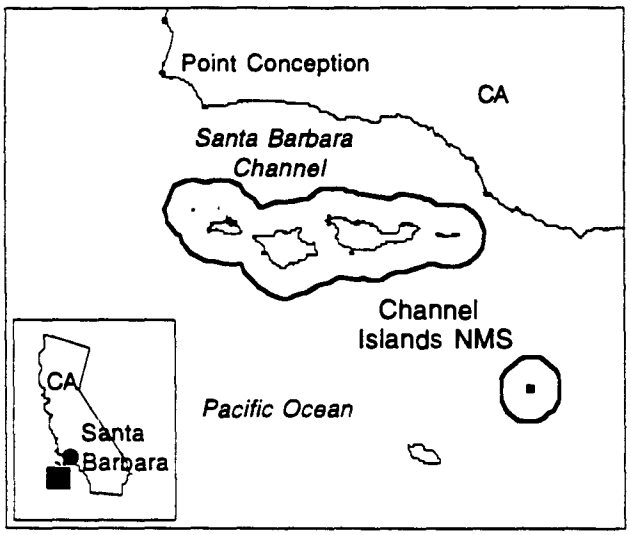
Fagatele Bay NMS has been staffed by an on-site coordinator for the past seven years. An education coordinator was hired early last year to conduct outreach and public awareness programs for the site. Staff members are American Samoa Government (ASG) employees based in Pago Pago and operate through a cooperative agreement between NOAA and ASG's Economic and Development Planning Office. The Sanctuary Office is leased from the Department of Marine Wildlife Resources (DMWR). Enforcement is a cooperative effort between the Sanctuary, the National Marine Fisheries Service and the American Samoa Department of Marine and Wildlife Resources.

For more information, please contact:

Nancy Daschbach, Sanctuary Coordinator
Fagatele Bay National Marine Sanctuary
P.O. Box 4318
Pago Pago, AS 96799

Phone Number: 011-684-633-7354
Fax Number: 011-684-633-7355

CALIFORNIA
Channel Islands National Marine Sanctuary



Size: 1,252 nmi²; CA state and federal waters

Significant Resources

The Channel Islands National Marine Sanctuary, located approximately 25 miles off the coast of Santa Barbara, California, encompasses the waters surrounding San Miguel, Santa Rosa, Santa Cruz, Anacapa and Santa Barbara Islands from mean high tide to 6 nautical miles offshore, and completely surrounds the Channel Islands National Park. The Channel Islands are in a transition zone due to the convergence of warm and cool ocean currents. Extensive beds of giant, southern palm, and feather boa kelp and rocky intertidal areas support invertebrate populations of sponges, crabs, abalone, lobster, sea stars, sea urchins, octopi, and squid. Over sixty species of birds breed in the Sanctuary. Twenty-seven species of whales and dolphins visit or inhabit Sanctuary waters. The Channel Islands support one of the largest and most diverse populations of pinnipeds in the world, providing feeding and nursery areas for five resident and one transitory species of seals and sea lions. The secluded, relatively undisturbed waters of the Sanctuary provide a full or part-time home for several endangered species, including blue, humpback and sei whales, southern sea otters, Guadeloupe fur seals, the Brown Pelican, and the California least tern. Lining the ocean floor in this region are a wealth of prehistoric artifacts from the Chumash Indians as well as the remains of over 100 historic shipwrecks.

Human Use and Values

Although relatively remote from the heavily urbanized mainland, a high level of recreational activities are supported by access through regular boat trips, and by charter boats and planes. The site supports commercial fisheries such as sea urchin, mackerel, halibut, abalone, anchovy, rockfish, crab, and lobster. Military activities occur in parts of the Sanctuary, and oil extraction and shipping lanes lie in the vicinity. Extensive scientific research also occurs in and around the Sanctuary.

Site Designation and Regulations

In 1977 the Channel Islands was one of three California sites chosen for further study as a National Marine Sanctuary (others were Monterey Bay and Point Reyes-Farallon Islands). In September 1980, the site was designated as a Sanctuary. Regulations prohibit the deposition or discharge of substances or materials; hydrocarbon activities; alteration of the seabed; removing or damaging cultural resources; disturbing marine mammals and birds by operating motorized aircraft at less than 1000 feet over the Sanctuary; and operating commercial transport vessels within one nmi around an island.

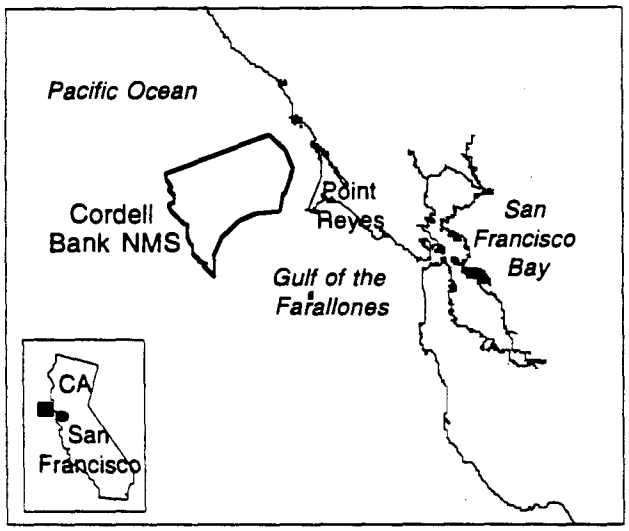
Staff and Facilities

A Manager and Education Coordinator are responsible for the daily operation of the Sanctuary. Surveillance and enforcement are provided by National Park Service rangers through an interagency agreement with the Channel Islands National Park. The Sanctuary has a cooperative agreement with the Santa Barbara Museum of Natural History, to provide a wide range of educational programs including the Sea Center, an aquarium and education facility, and Los Marineros, a marine education program for children.

For more information, please contact:

LCDR John Miller, Sanctuary Manager
(LCDR Edward Casano, as of 1/96)
Channel Islands National Marine Sanctuary
113 Harbor Way
Santa Barbara, CA 93109
Phone Number: (805) 966-7107
Fax Number: (805) 568-1582

CALIFORNIA
Cordell Bank National Marine Sanctuary



Size: 397 nmi²; federal waters off California

Significant Resources

Cordell Bank, the northernmost seamount on the California continental shelf, is a granitic formation submerged between depths from 50 to 100 meters. The 9.5-mile Bank is roughly elliptical in shape, covering an area of 18 square nautical miles. Upwelling of nutrient rich waters, deep light penetration, and wide depth ranges provide productive habitat for an unusual assortment of marine species. Several of the species were previously undescribed in these waters at such depths, such as purple hydrocoral. On the Bank, rich communities of invertebrates such as sponges and anemones flourish. The area is a paradise for fishermen and advanced divers. Many species of fish have been recorded, though the Bank is dominated by rockfish in both variety and abundance. Many of the marine mammals found here are endangered or threatened: right, blue, fin, sei, humpback and sperm whales, and Steller sea lions. Fifty species of seabirds, including the endangered brown pelican, use the Bank as a feeding area. Four species of sea turtles (green, leatherback, Pacific ridley, and loggerhead), all endangered or threatened species, are also found in the Sanctuary.

Human Use and Values

The abundance of rockfish populations supports a valuable commercial and recreational fishery over and near Cordell Bank. Divers also use the Sanctuary. Shipping lanes for traffic from the ports of San Francisco Bay pass the Bank. Regular naval operations occur in the vicinity. Cultural and historical resources may be present. The Sanctuary has increasing numbers of marine mammal and seabird enthusiasts visiting the Bank.

Site Designation and Regulations

Cordell Bank was placed on the List of Recommended Areas in 1981, and was named as an Active Candidate in 1983. The Sanctuary was designated in May 1989. Regulations prohibit disturbance of the seabed; depositing or discharging substances or materials; removing or injuring Sanctuary resources, and hydrocarbon activities.

Staff and Facilities

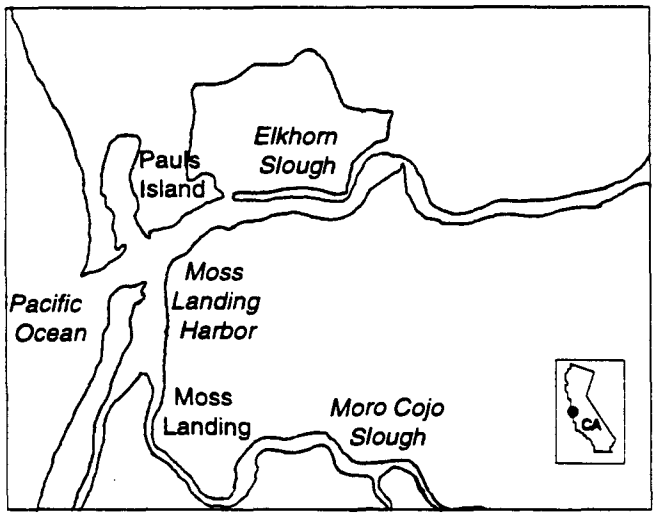
Cordell Bank NMS is administered by the staff of the Gulf of the Farallones NMS, which includes a Manager, Assistant Manager, Research Coordinator and Secretary based in Fort Mason in San Francisco. Programs for the Cordell Bank Sanctuary are linked to those for the Gulf of the Farallones NMS for research, education, and management. Cordell Bank is expected to benefit from the development of the Pier One Learning Center in San Francisco, which involves the conversion of a warehouse through a Federal, State, and community partnership into a marine learning center. A volunteer program has been developed to survey the Sanctuary populations of marine mammals and seabirds.

For more information, please contact:

Edward Ueber, Sanctuary Manager
Cordell Bank National Marine Sanctuary
Fort Mason, Building #201
San Francisco, CA 94123

Phone Number: (415) 556-3509
Fax Number: (415) 556-1419

CALIFORNIA
Elkhorn Slough National Estuarine Research Reserve



Size: 1,385 acres Province: Californian

Significant Resources

Elkhorn Slough contains not only the second largest salt marsh in California, but also grasslands, woodlands, maritime chaparral, mud flats, freshwater ponds, and open water. These natural communities provide nursery areas for fish and are a critical stop along the Pacific flyway for migratory birds. Marine mammals resident in the Reserve are harbor seals, sea lions, and sea otters. Bird populations are composed of primarily migratory, water-associated species, with population peaks in fall and spring; endangered birds that use the Reserve include the California brown pelican, and peregrine falcon. The Reserve provides nursery grounds for many fish species, including the Pacific herring, starry flounder, and several species of shark. The site contains Indian middens.

Staff and Facilities

The site recently completed and moved its staff into a new administrative building. The 2,500 square foot visitor's center is the central interpretive facility of the Reserve. Additional facilities include a library, small lab, five miles of hiking trails, and weather station. One hundred volunteers work with six full-time and four part-time staff members in the daily operation of the site. Volunteers provide such support as interpretive services, assistance in research projects, and maintenance of trails.

History and Location

Elkhorn Slough NERR received final designation in 1980. The Reserve is located 3.5 miles east of Moss Landing in central California.

Uses and Programs

Teacher training programs, special events and workshops, brochures, outreach at local community and science fairs, and interpretive nature walks are some of the features of the Reserve's education program. Research activities have been funded and conducted by various public and private groups. Monitoring tracks mussel tissue (conducted by the state), water quality (conducted by volunteers), and the weather. Habitat restoration is an ongoing project. Moss Landing Marine Laboratory is located nearby. Surrounded by areas dominated by agricultural and heavy industrial uses, the Reserve offers opportunities for hiking, birding, nature study and photography.

Site Accomplishments and Goals

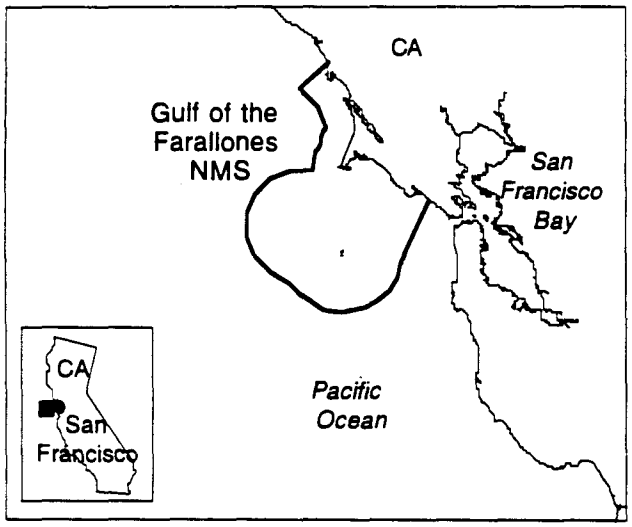
The Reserve has trained over 1,200 teachers to utilize Reserve facilities and enhance their environmental education programs. Over 10,000 students visited the Reserve on field trips last year alone. Substantial strides are being made regarding the removal of exotic vegetation on the Reserve with the elimination of fifteen acres of eucalyptus trees and the planting of thousands of oaks in their stead. The Reserve has been instrumental in the modest beginnings of a geographic information system (GIS) that will include the Reserve and vicinity. Tidal erosion and nonpoint source pollution are the focus of much needed research and study.

For more information, please contact:

Steve Kimple, Reserve Manager
Elkhorn Slough National Estuarine
Research Reserve
1700 Elkhorn Road
Watsonville, California 95076

Phone Number: (408) 728-0506
Fax Number: (406) 728-1056

CALIFORNIA
Gulf of the Farallones National Marine Sanctuary



Size: 948 nmi²; California state and federal waters

Significant Resources

In the Gulf of the Farallones National Marine Sanctuary, gusting winds, ocean currents and the rotation of the earth combine each spring and summer to produce an explosion of marine life. The Sanctuary contains a complete spectrum of marine habitats, from the extensive wetlands of Tomales Bay and Bolinas Lagoon to subtidal reefs at Duxbury Reef to pelagic and deep ocean waters up to 46 nmi offshore. These productive natural communities support a complex array of species including bull and giant kelp, eelgrass, coralline algae; and invertebrates such as brittle stars and anemones also flourish in this area. Organisms including clams, snails, crabs, and a diverse population of fish species vary widely over season and habitat type. Within the Sanctuary are nurseries and spawning grounds for commercially valuable species such as Dungeness crab, Pacific herring, sole, and rockfish. Marine mammals include six species of pinnipeds, and 26 species of cetaceans, including -- the endangered blue whale. California's largest breeding population of harbor seals lives there along with California sea lions and elephant seals. Nesting seabird populations are significant resources of the site; the Sanctuary has the largest concentration of breeding seabirds in the continental United States.

Human Use and Values

The Sanctuary experiences a high volume of recreational uses including sport fishing and whale and bird-watching. Over 9,000,000 people visited the Sanctuary in 1994. Highly productive commercial fisheries and private mariculture operations occur within the boundaries. Shipping lanes converge in the Sanctuary. Military maneuvers occur on a regular basis. The Sanctuary contains numerous shipwrecks including the *San Agustin*, a Spanish galleon sunk in 1595. Prehistoric resources are also present.

Site Designation and Regulations

In 1977 the Point Reyes-Farallon Islands site was selected to be studied for its potential to become a National Marine Sanctuary, along with Monterey Bay and the Channel Islands. The Gulf of the Farallones NMS received final designation in January 1981. Regulations prohibit discharging of substances; altering the seabed; hydrocarbon activities; operating a commercial transport vessel within two nautical miles of and flying motorized aircraft under 1000 ft within one nmi of areas of special biological significance; and removing or damaging any historical or cultural resources.

Staff and Facilities

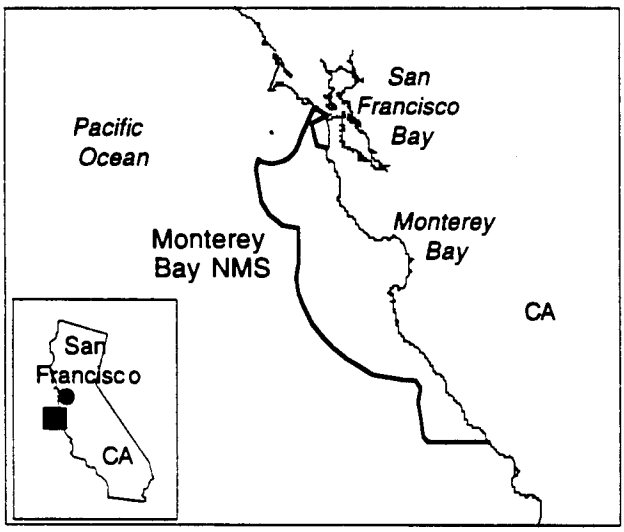
A Sanctuary Manager, Research Coordinator, and Secretary are based in Fort Mason in San Francisco. The staff also manages Cordell Bank NMS, and shares education, research, and management programs with the sister Sanctuary. The staff has developed volunteer programs to monitor the shorelines, including photo documentary and organism identification. The Sanctuary is also participating in the development of the Pier One Learning Center in San Francisco through a Federal, State, and community partnership.

For more information, please contact:

Edward Ueber, Sanctuary Manager
Gulf of the Farallones National Marine Sanctuary
Fort Mason, Building #201
San Francisco, CA 94123

Phone Number: (415) 556-3509
Fax Number: (415) 556-1419

CALIFORNIA
Monterey Bay National Marine Sanctuary



Size: 4,024 nmi²; CA state and federal waters

Significant Resources

Monterey Bay NMS is located in a broad transition zone between the Oregonian biogeographic province to the north and the Californian province to the south. The Sanctuary's most significant feature is the Monterey Canyon, the deepest and largest submarine canyon incising the continental shelf of North America. The nutrient-rich currents that nourish the area make possible the highly productive and diverse habitats and marine life. The mosaic of soft and hard bottoms, submarine canyon, rocky and sandy intertidal areas, and kelp forests of giant and bull kelp support a rich and abundant population of marine flora and fauna. The species-rich invertebrate population includes soft coral, sponges, clams, snails, crab, shrimp, abalone, sea urchins, mussels, and sea anemones. Over 345 species of fish are found in the Sanctuary and include pelagic, demersal, and benthic species. About 94 species of birds have been identified as utilizing the bay; the site is important to seabirds as a migratory stopover and as wintering grounds. The threatened marbled murrelet breeds in the Sanctuary area. Four species of sea turtles (leatherback, green, loggerhead, and Pacific ridley), all of whom are threatened or endangered, occur within the waters of the Sanctuary. Breeding, feeding, and migration areas are provided for over 26 species of marine mammals including several endangered species such as the southern sea otter and the grey whale. Over 300 shipwrecks may occur within the boundaries and significant prehistoric cultural sites exist throughout the site and coastal area.

Human Use and Values

The Sanctuary is accessible and hosts a high level of recreational use. Commercial fisheries such as salmon, rockfish, swordfish, tuna, squid, and anchovy are important to the regional economy, as is tourism. Oil and gas extraction, sand mining, and designation of ocean dump sites are prohibited within the Sanctuary. Major shipping lanes and military activity occur in portions of the site. Numerous education and research programs are conducted throughout the Sanctuary.

Site Designation and Regulations

In September 1992, Monterey Bay received final designation and became the largest Sanctuary in the national system. Regulations prohibit hydrocarbon activities; depositing or discharging substances or materials; taking or damaging Sanctuary resources; altering the seabed; and operating motorized aircraft at less than 1000 feet over specified biologically sensitive areas.

Staff and Facilities

The Sanctuary staff is based in Monterey and includes a Manager, Assistant Manager, Education Coordinator, Water Quality Specialist, two Program Specialists, the Water Quality Protection Program Director, NMFS Enforcement Agent, and Administrative Assistant. The staff has permanent office quarters that include a small publications display area. Fort Ord, a local military base, is being turned over to civilian authorities; the Sanctuary staff is working closely with the authorities to develop any appropriate additional facilities that might benefit the Sanctuary. A small boat, used for educational purposes, is maintained at the Monterey Harbor near the U.S. Coast Guard pier. The Sanctuary also has developed an agreement with the California Department of Fish and Game to operate the large enforcement vessel *Bluefin.*

For more information, please contact:

CDR Terry Jackson, Sanctuary Manager
Monterey Bay National Marine Sanctuary
299 Foam Street, Suite D
Monterey, CA 93940

Phone Number: (408) 647-4201
Fax Number: (408) 647-4250

CALIFORNIA
San Francisco Bay Proposed National Estuarine Research Reserve

On May 21, 1993, Governor Pete Wilson of the State of California formally nominated sites within the San Francisco Bay to be included in the National Estuarine Research Reserve System. The nomination package for the San Francisco Bay National Estuarine Research Reserve (SFBNERR) proposes a multi-component Reserve, consisting of six salt and tidal brackish marshes.

The SFBNERR is proposed to be managed by the San Francisco State University. The University is currently home to a number of internationally-known scholars in the fields of aquatic and conservation biology, geochemistry and geographic information systems. The University also operates the Romberg Tiburon Center for Environmental Studies, a field center for research on San Francisco Bay and its environs.

On December 6, 1993, Under Secretary Dr. James Baker approved the following sites as components for inclusion in the proposed SFBNERR, and therefore eligible to proceed with the next steps towards designation:

South Bay: Bair Island Ecological Reserve
Central Bay: Corte Madera Marsh
San Pablo Bay: China Camp State Park
Petaluma River: Petaluma Marsh
Suisum Bay: Rush Ranch

Because a site in the Delta area was not selected, Dr. Baker's letter requested additional information regarding the ecological characters of the two proposed Delta sites, Lower Sherman Island and Browns Island.

SRD received a response from Governor Pete Wilson, that included the necessary information needed to make a decision regarding the site in the Delta. His letter asked that the Suisum Bay Component include Peytonia Ecological Reserve and Hill Slough Wildlife Area.

A cooperative agreement totalling $75,000 has been awarded to SFSU, to begin collection of information on the approved sites, hold public meeting and prepare a draft management plan and environmental impact statement.

On March 22, 1994, Dr. Baker responded positively to Governor Wilson's request. Accordingly, the following additions were made to the prior approval:

Detta Component Browns Island
Suisum Bay Component: Rush Ranch
Peytonia Ecological Reserve and Hill Slough Wildlife Area

For More Information, please contact:

Mike Vasey, Acting Reserve Manager
San Francisco Bay
National Estuarine Research Reserve (proposed)
San Francisco State University
Department of Biology
San Francisco, CA 94132

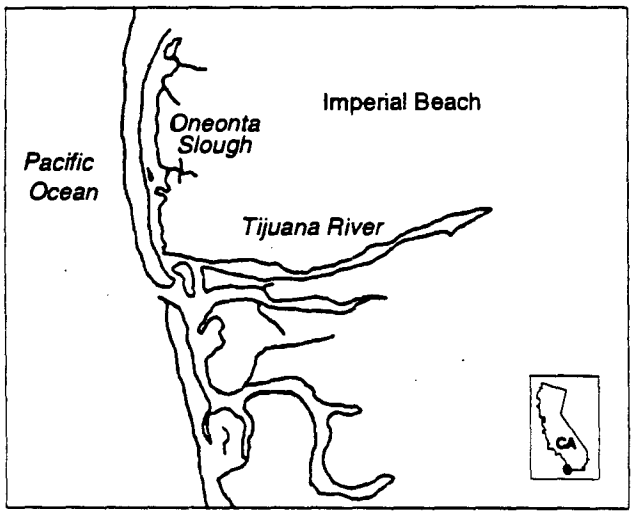
Phone Number: (415) 338-1957
Fax Number: (415) 338-2295

Sanctuaries and Reserves Division
1305 East West Highway, SSMC4-12
Silver Spring, Maryland 20910

Phone Number: (301) 713-3132
Fax Number: (301) 713-0404

NERR Branch Chief: Randy Schneider

CALIFORNIA
Tijuana River National Estuarine Research Reserve



Size: 2,513 acres Province: Californian

Significant Resources

The ecosystem of the Tijuana River NERR, the southernmost estuary in the United States, contains riparian and upland habitats, agricultural land, beaches, barrier dune systems, mud flats, salt marsh, coastal sage, and open water. The salt marsh-dominated habitat is characterized by extremely variable streamflow, with extended periods of drought interrupted by heavy floods during wet years. Over 370 species of birds including several threatened or endangered species such as California brown pelican, Belding's savannah sparrow, light-footed clapper rail, California least tern, snowy plover, and least Bell's vireo occur here. Approximately 36 prehistoric sites have been identified in the uplands adjacent to the Reserve. Historic sites, including World War II defense installations, are also within the Reserve.

Staff and Facilities

Five permanent and three temporary employees staff the Reserve. Over fifty volunteers assist in various facets of the Reserve's operation. A 6,500 square foot visitors center houses exhibits, student lab, library, theater/meeting room. Additional buildings include offices and a garage/shop. Other facilities include four miles of walking trails, four miles of equestrian trails, and three miles of public beach. Research facilities include a two-acre field tidal laboratory.

History and Location

Tijuana River NERR received its designation in 1982. Land management is conducted by the California Dept. of Parks and Recreation and the U. S. Fish and Wildlife Service. The Tijuana River NERR is an intertidal coastal estuary on the border between California and Mexico, with three-quarters of its watershed in Mexico.

Uses and Programs

The principle education programs are the MARSH curriculum for primary grades, and the three-week, field-based programs for 5th grade students from the local district. Materials are produced in both English and Spanish and are distributed through workshops at the Reserve and in Mexico. Other programs include interpretive walks for the public, theme days such as "Estuary Day," participation in community events, and public presentations. New activities include watershed study and volunteer water quality monitoring. Research projects have included watershed management techniques for wastewater discharges and the nature of artificial wetlands as a mitigation tool.

Site Accomplishments and Goals

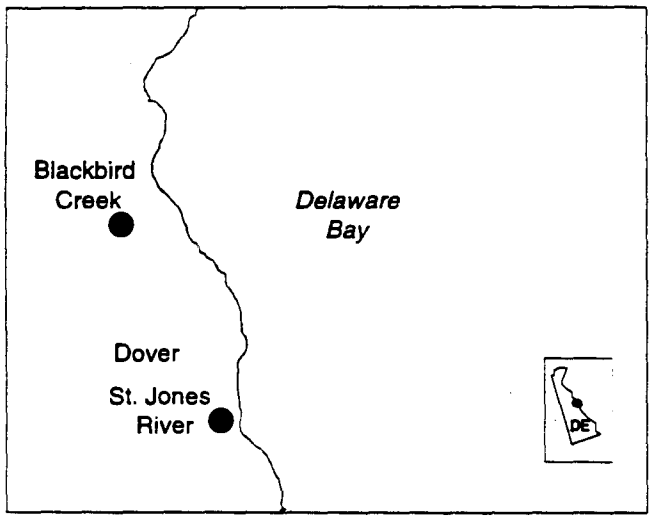
The Reserve lists among its accomplishments the visitors center, with its interpretive exhibits; a 500-acre restoration plan; the Pacific Estuarine Research Laboratory; bilingual education programs; a nationally significant body of published estuarine research; a fifteen-year data set of biological monitoring; an award-winning native plant garden; and completion of an ecological profile of the estuary. The site is becoming increasingly involved with research and planning efforts throughout the watershed, especially in Mexico. This has been facilitated by NOAA's funding of the development of a watershed based Geographic Information System.

For more information, please contact:

Joanne Kerbavaz, Reserve Manager
Tijuana River National Estuarine Research Reserve
California Department of Parks and Recreation
301 Caspian Way
Imperial Beach, California 91932

Phone Number: (619) 575-3613
Fax Number: (619) 575-6913

DELAWARE
Delaware National Estuarine Research Reserve



Size: 8,600 acres Province: Virginian

Significant Resources

The Delaware NERR features full range tidal wetlands dominated by saltmarsh cordgrass and salt hay, open water of creek, river, and bay areas, and buffered by freshwater wooded fringe, farmlands, and meadows. The Reserve is endowed with a rich pre-history and a historic 18th century plantation setting. The Reserve is adjacent to the Delaware Bay and contains, in conjunction with the neighboring Ted Harvey Conservation Area, nearly 100 species of birds; this important portion of Delaware's shoreline has been designated as part of the Western Hemisphere Migratory Shorebird Reserve Network. The cultural and historic resources of the component have been intensively surveyed, resulting in an identification of 32 archaeological sites in the St. Jones component and 73 prehistoric sites of the Blackbird Creek Component.

Staff and Facilities

Reserve operations and programs are overseen by a staff of five. A volunteer corps is being developed to assist the staff in monitoring, education, and trail maintenance. Current facilities available to the Reserve include a visitors center that focuses on the historical and cultural aspects of the region, fishing pier, 1300 ft. boardwalk, two miles of trails, dock, and boat ramp.

History and Location

The Delaware NERR received its designation in June 1993. The Reserve, the newest in the system, is located along the shores of the Delaware Bay with the main St. Jones River component located 6 miles southeast from the Capitol complex of Dover and a satellite complex located 24 miles north along the Blackbird Creek.

Uses and Programs

Education services are being developed to facilitate the information exchange between estuarine researchers and the coastal users and decision makers. Activities are being scheduled that will further develop children through adults' awareness of human uses, misuses, conservation, and protection of estuarine resources. Research concentrates on the resource of the Reserve for establishing a baseline for long-term monitoring and inventory of plant and animal species, as well as cultural and historical resources within the Reserve, including the monitoring of water resources and contributing watershed of the Reserve. Research studies will be developed to determine resource response to induced activities in the controlled environment of the Reserve.

Site Accomplishments and Goals

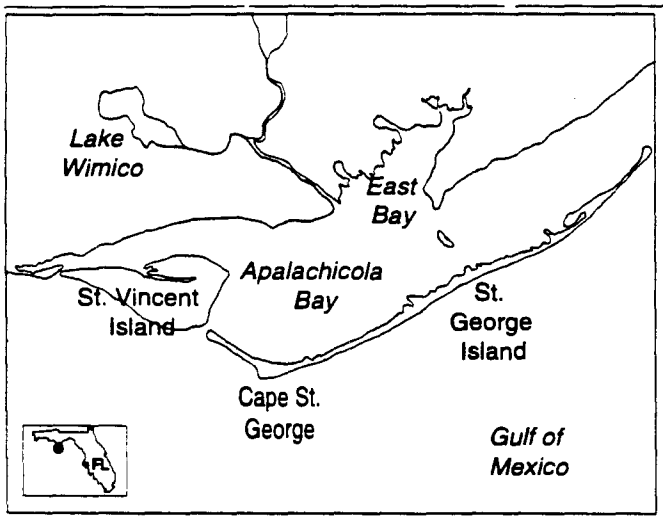
The most significant accomplishment of the Reserve has been the acquisition of 910 acres of formerly privately owned lands and wetlands for protection as the key lands for long-term research and education. The next important goal is to introduce the general public to the Reserve and its purposes and to provide programs that will instill an environmental/cultural ethic for future beneficial human interactions with estuarine resources.

For more information, please contact:

Sarah W. Cooksey, Reserve Manager
Delaware National Estuarine Research Reserve
Delaware Department of Natural Resources and Environmental Control
P.O. Box 1401
Dover, Delaware 19903

Phone Number: (302) 739-3451
Fax Number: (302) 739-2048

FLORIDA
Apalachicola National Estuarine Research Reserve



Size: 193,758 acres Province: Louisianian

Significant Resources

The Apalachicola National Estuarine Research Reserve is composed of a mosaic of habitats, including forested flood plains, salt and freshwater marsh, barrier islands, and open water. These natural communities support a variety of species. Over 1,100 species of vascular plants include 36 that are endangered or threatened. The Bay is considered one of the most important avian habitats in the southeastern United States; 315 species, of which 25 are endangered or threatened, are found here. Freshwater, estuarine, and marine species (180) form the fish population. Fifty-seven species of mammals make their home here. The highest species diversity of amphibians and reptiles in North America north of Mexico has been listed from the Apalachicola Bay basin.

Staff and Facilities

The Reserve has thirteen permanent staff members and a volunteer program, all based in Apalachicola. The facilities of the Reserve include an interpretive center (3,300 square feet), classrooms, research lab, and library. Three to five miles of trails provide public access to the resources of the Reserve.

History and Location

Apalachicola NERR received its designation in 1979. The Reserve, currently the largest in the NERR system, is located in the Panhandle region of Florida, approximately 55 miles southeast of Panama City.

Uses and Programs

Educational efforts include on-site and outreach education programs, classroom curricula, natural history field trips, and interpretive displays for the general public. Research concentrates on the resources of the Reserve in such efforts as long-term monitoring of chemical, physical, and biological parameters important to estuarine productivity, protection and monitoring of sea turtle and migratory bird populations, and marsh restoration. On-site assistance is provided for regional research projects. The Reserve encourages recreational boaters and fishermen to utilize the bountiful natural resources found within the Reserve, but to utilize them in a manner which will preserve the pristine nature of the resources.

Site Accomplishments and Goals

Reserve research staff have been involved in projects covering a vast array of subjects including fresh water needs, geology, botany, endangered species, shoreline stabilization, point and non-point pollution, oyster populations, and habitat restoration. The education section has opened a live exhibit estuarine simulation exhibit with tremendous involvement from local school systems. In addition, approximately five hundred walk-in tourists enjoy the exhibit each month. The Reserve plans to build new laboratory and office facilities while converting existing facilities into an environmental education facility.

For more information, please contact:

Woody Miley, Reserve Manager
Apalachicola Bay National Estuarine
Research Reserve
261 7th Street
Apalachicola, Florida 32320

Phone Number: (904) 653-8063
Fax Number: (904) 653-2297

FLORIDA
East Coast Florida Proposed National Estuarine Research Reserve

The Florida Department of Environmental Protection's Bureau of Coastal and Aquatic Managed Areas, received a site selection award from NOAA for the purpose of investigating areas along the east coast of Florida suitable for designation as a National Estuarine Research Reserve. A site selection committee was established which included representatives from the Florida Department of Education, the Governor's office, the Florida State University Marine Lab, the Rookery Bay and Apalachicola Research Reserves, the State Coastal Zone Management Office, and the Bureau as well as SRD. Staff collected data, visited sites and conducted numerous public meetings in the areas which were considered - Indian River Lagoon; Guana, Tolomato, and Matanzas Rivers (GTM); Mosquito Lagoon; and Banana River.

On March 8, 1994, the Governor and Cabinet of Florida approved Phase I of the East Coast Florida NERR site, which includes the Matanzas River portion of the proposed Reserve. In September 1994, the State of Florida approved Phase II, which includes the Guana and Tolomato Rivers, located North of the City of St. Augustine. A nomination package has been sent to NOAA for review and approval. The next step is to set up a 28 member advisory committee that will provide opportunities for representatives of all interested parties concerned with the development of the Reserve to participate in development of the EIS and Management Plan. Extensive public participation will also be provided during the development of the management plan.

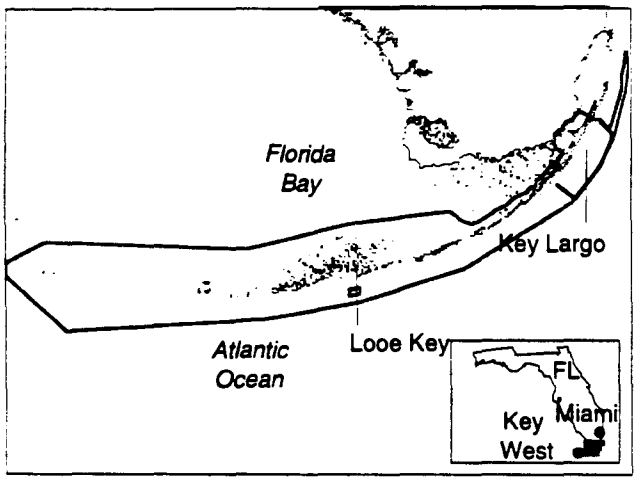
For More Information, please contact:

Sanctuaries and Reserves Division
1305 East West Highway, SSMC4-12
Silver Spring, Maryland 20910

Phone Number: (301) 713-3132 x 126
Fax Number: (301) 713-0404

NERR Branch Chief: Randy Schneider

FLORIDA
Florida Keys National Marine Sanctuary
including Key Largo and Looe Key National Marine Sanctuaries



Size: 2,800 nmi²; Florida state and federal waters

Significant Resources

The Florida Keys NMS, the largest marine Sanctuary on the East Coast, contains North America's most extensive living coral reef, one of the largest bank reef systems in the world. Interdependent and interconnected habitats including patch and bank reefs, seagrass meadows, soft and hard bottom, and coastal mangroves, support a rich diversity of marine life. Octocorals and stony corals are the predominant invertebrate, and the fish population is abundant and diverse, including tropical and temperate species. Three species of sea turtles (green, hawksbill, and loggerhead) are found throughout the Keys, and use various habitats for nesting, feeding, and shelter. A variety of coastal and marine birds use the Florida Keys, including several species that are found nowhere else in the country. The endangered West Indian manatee is found throughout the Keys.

Human Use and Values

The Florida Keys are subject to an intense level of human use due to their proximity to the Miami metropolitan area and their popularity as a vacation spot. Tourism, recreational uses ranging from fishing to diving to boating, commercial fishing and shellfishing, military activities, research, and treasure salvaging compete for natural resources that are reduced in both quantity and quality as the population increases. The Keys have an unusually large concentration of shipwrecks that represent 500 years of European presence in the Americas.

Site Designation and Regulations

Inspired by a series of ship groundings in 1989 coupled with the growing threats of coral diseases and increased water quality problems, the Florida Keys NMS was designated by the Florida Keys National Marine Sanctuary and Protection Act in November 1990. Key Largo, designated as a NMS in December 1975, and Looe Key, designated as a NMS in January 1981, are now incorporated within the Florida Keys NMS. Regulations still in place for Looe Key and Key Largo portions of the Florida Keys NMS prohibit removing or damaging natural or historical resources or marine life; discharging substances; and using wire fish traps, trawls, explosives, spear guns, or dangerous weapons. Sanctuary wide regulations are defined in the Comprehensive Management Plan. A required Water Quality Protection Program, developed by the Environmental Protection Agency and the State, has been integrated into the Plan. As mandated by the Keys Act, NOAA considered water use zoning as a mangement tool. A Citizens Advisory Council has contributed significantly to Plan development, including recommending a zoning proposal to NOAA for inclusion. The draft plan was released in April 1995.

Staff and Facilities

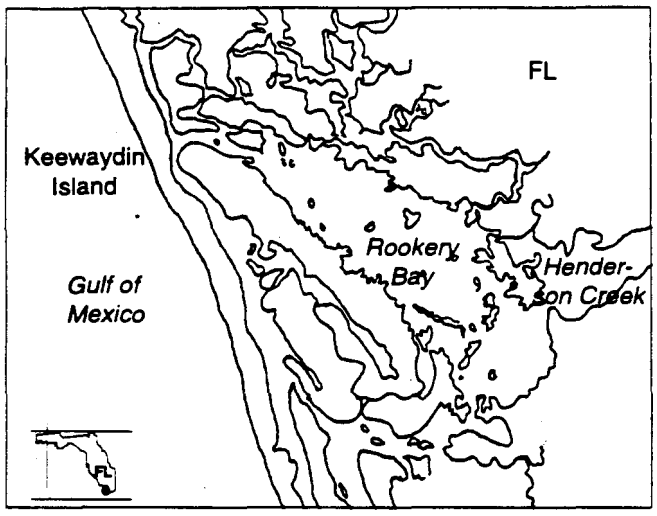
The Sanctuary Superintendent and an administrative staff of six are located in Marathon, Florida, a central location for the populated portion of the Keys. In addition, two regional offices are located in Key Largo, Upper Keys Region, and in Looe Key, Lower Keys Region. The staff based in Key Largo includes a Manager, Assistant Manager, Regional Biologist, Education Coordinator, and eleven other staff members. The staff based in Looe Key includes a Manager, Assistant Manager, Education Coordinator, and eight other staff members. Through a cooperative agreement with the State, surveillance and enforcement are provided by Florida Department of Environmental Protection Sanctuary Enforcement Officers who are located at the two Regional offices.

For more Information, please contact:

Billy Causey, Sanctuary Superintendent
Florida Keys National Marine Sanctuary
P.O. Box 500368
5550 Overseas Highway - Main House
Marathon, FL 33050

Phone Number: (305) 743-2437
Fax Number: (305) 743-2357

FLORIDA
Rookery Bay National Estuarine Research Reserve



Size: 9,400 acres Province: West Indian

Significant Resources

Pristine mangrove forests of black, red, and white species, coastal scrub, pine flatwoods, hardwood hammocks, barrier beaches, open water, and seagrass and oyster beds form the ecosystem of the Rookery Bay NERR. Over 150 species of birds including the bald eagle and roseate spoonbill are found here. A rookery supporting 500 wading bird nests is located within the Reserve. Over 120 species of fish including snook, sea trout, tarpon, and mullet inhabit the water. The endangered West Indian manatee is a common resident; other protected species include Florida panther, bald eagle, piping plover, scrub jay, gopher tortoise, indigo snake, scrub rosemary, bromeliads, and orchids.

Staff and Facilities

Seventeen full-time staff are based at the Reserve. The staff are responsible for administration of the programs and operation of the marine research lab, classroom, and fleet of eight boats (including three 26' custom-designed vessels used in the education program). The Reserve has a geographic information system (GIS) and remote sensing system. The Briggs Nature Center, operated by The Conservancy, Inc., employs two full-time naturalists and up to four interns, and serves as the interpretive center for the Reserve. The National Audubon Society employs a part-time warden/biologist who monitors wading and shore bird populations.

History and Location

The Rookery Bay NERR is located in Southwest Florida, five miles south of Naples. The Reserve received designation status in 1978.

Uses and Programs

Primary research efforts of the Reserve focus on water quality monitoring, mangrove restoration, and habitat mapping. Visiting investigator and internship programs are in place. Long-term monitoring dates back to 1955. Education programs include field studies, boat trips, outreach efforts, and workshops for teachers and environmental professionals. The Department of Natural Resources and The Conservancy, Inc. have a cooperative education agreement. The Conservancy, Inc. operates an interpretive center with displays that leads to a boardwalk. A non-profit group, The Friends of Rookery Bay, Inc., supports the Reserve's education, research, and resource management programs through volunteer efforts and fund raising.

Site Accomplishments and Goals

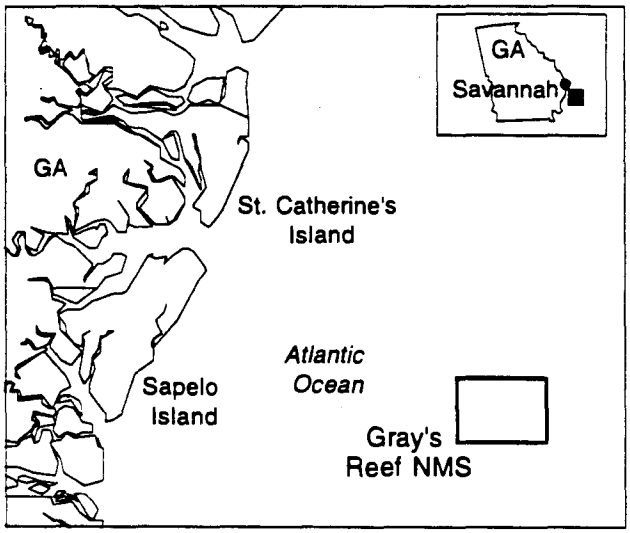
The Reserve has established a successful education program reaching over 23,000 people a year with on-site and outreach programs. The research program, established in 1991, has grown to a staff of six with funding in excess of $500,000. The Reserve has been approved as a regional site for injured marine mammal response and recovery. Rookery Bay NERR has received funding from other agencies such as the Environmental Protection Agency, U.S. Fish and Wildlife Service, and National Science Foundation. Future goals include establishment of facilities for overnight accommodations and increased office, classroom, and lab space.

For more information, please contact:

Gary Lytton, Reserve Manager
Rookery Bay National Estuarine
Research Reserve
10 Shell Island Road
Naples, Florida 33942

Phone Number: (813) 775-8845
Fax Number: (813) 775-7606

GEORGIA
Gray's Reef National Marine Sanctuary



Size: 17 nmi²; federal waters off Georgia

Significant Resources

Gray's Reef is a submerged hard bottom (limestone) area that, as compared to surrounding areas, contains extensive but discontinuous rock outcropping of moderate (6 to 10 feet) height with sandy, flat-bottomed troughs between. The series of rock ledges and sand expanses has produced a complex habitat of caves, burrows, troughs, and overhangs that provide a solid base for the abundant sessile invertebrates to attach and grow. This rocky platform with its carpet of attached organisms is known locally as a "live bottom habitat". This topography supports an unusual assemblage of temperate and tropical marine flora and fauna. Algae and invertebrates grow on the exposed rock surfaces; dominant invertebrates include sponges, barnacles, sea fans, hard coral, starfish, crabs, lobsters, snails, and shrimp. The reef attracts numerous species of benthic and pelagic fish, including black sea bass, snapper, grouper and mackerel. Since Gray's Reef lies in a transition area between temperate and tropical waters, reef fish population composition changes seasonally. Loggerhead sea turtles, a threatened species, use Gray's Reef year-round for foraging and resting and the reef is part of the only known winter calving ground for the highly endangered northern right whale. Fossil bivalves and gastropods, and mastodon bones located in the area indicate that the reef was once a shallow coastal environment and an exposed landform as recently as 10,000 years BP. As a terrestrial environment there may exist at Gray's Reef extant prehistoric cultural resources.

Human Use and Values

Gray's Reef is one of the most popular recreational fishing and sport diving destinations along the Georgia coast. Sportfishing occurs year-round but at different levels of intensity. Commercial fishing is restricted, as are military, mineral extraction, and ocean dumping activities. Little commercial shipping occurs near Gray's Reef. The site has supported a variety of scientific studies. It currently supports reef fish and invertebrate monitoring programs. A resource characterization is in progress.

Site Designation and Regulations

Gray's Reef was made an Active Candidate in 1979. Final designation as a National Marine Sanctuary came in January 1981. The Sanctuary was named in recognition of Milton B. Gray, who studied the area in the 1960's as a biological collector and curator at the University of Georgia Marine Institute on Sapelo Island. Regulations prohibit alteration of the seabed; use of wire fish traps, bottom trawls, and explosives; damage to or removal of bottom formations and other natural or cultural resources; and discharge of substances or materials.

Staff and Facilities

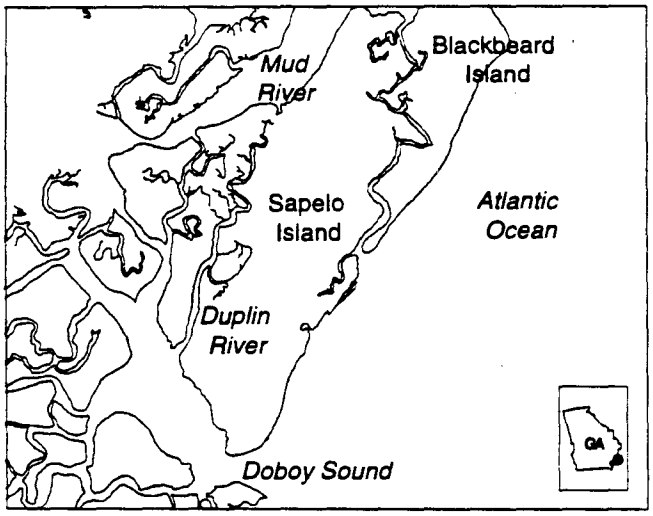
A Manager, Assistant Manager, and Education Coordinator are responsible for the daily operation of the Sanctuary. The headquarters and interpretive center are located at the Georgia Marine Science Center on Skidaway Island near Savannah, GA. A variety of exhibits and a reef tank depict the Sanctuary environment at the Aquarium on Skidaway. Other major exhibits of the Sanctuary are located at the Fernback Museum of Natural History in Atlanta and the Tybee Island Marine Science Center. The Sanctuary has produced educational posters, workbooks, and field guides that support the Sanctuary's education program.

For more information, please contact:

Reed Bohne, Sanctuary Manager
Gray's Reef National Marine Sanctuary
30 Ocean Science Circle
Savannah, GA 31411

Phone Number: (912) 598-2345
Fax Number: (912) 598-2367

GEORGIA
Sapelo Island National Estuarine Research Reserve



Size: 6,111 acres Province: Carolinian

Significant Resources

Sapelo Island is the fourth largest barrier island on Georgia's coast and is one of the most pristine. The Reserve boundaries enclose marsh, hardwood hammock, dune systems, and beaches. The 4,000-acre Duplin River estuary serves as home to a wide variety of marine life. The habitats provide nursery areas for shrimp and juvenile forms of menhaden, sea trout, blue crab, and sea bass. Bald eagles and loggerhead sea turtles are also found in the Reserve. A number of cultural and historic sites are contained in the Reserve boundaries.

Staff and Facilities

The Reserve office is located in a restored oyster tabby sugar mill built in 1809. Within the Reserve boundaries the University of Georgia operates the forty-year old Marine Institute, which pioneered research in the marsh and estuary, and provided the example for the National Estuarine Research Reserve System. The Marine Institute has offices, labs, a dormitory, library, conference center, and computer facilities. Two research vessels are also provided by the Marine Institute. A public passenger ferry provides access to the islands. Five permanent staff members oversee the daily operations of the Reserve.

History and Location

Sapelo Island NERR is located 7.5 miles northeast of Darien, Georgia. The Reserve was officially designated in 1976. The Reserve abuts natural areas owned and managed by Georgia Department of Natural Resources.

Uses and Programs

Guided tours and school field trips are given two to three times a week all year round; in 1994, over 6,000 people were taken on a four-hour boat and land tour of the Reserve's marshes, forests, and beaches. The Reserve has also become part of the Kids Network. Research is conducted with various other agencies. The University of Georgia Marine Institute, located at the lab, is a partner in the development of a remote sensing and weather monitoring system. An ongoing monitoring program is conducted at four sites on the Reserve with measurements regularly taken from a number of biotic and abiotic paramenters. Other factors such as turbidity are continuously monitored.

Site Accomplishments and Goals

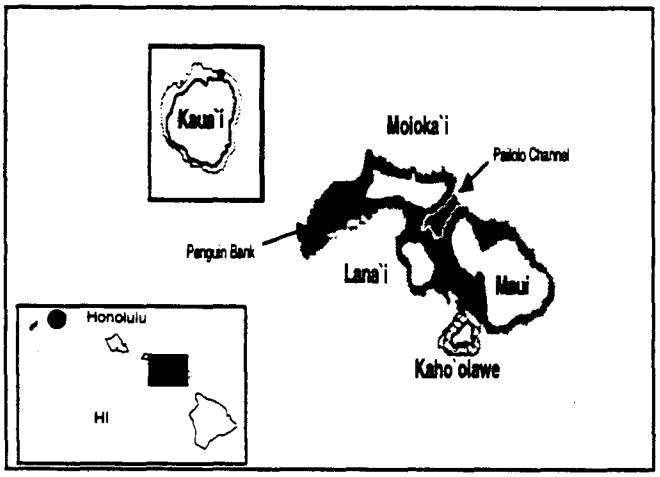
Two new ecological brochures and a Reserve newsletter were published in 1994. A new 3,000 square foot visitor interpretive center for the Reserve and Sapelo Island in general is now under construction and is scheduled for completion in the fall of 1995. A new interpretive nature trail is currently being built. Ten new interpretive and directional signs for the Reserve and Gray's Reef NMS have been designed and constructed; additional signs are necessary to interpret the various habitats of the region. A new state passenger ferry has been purchased and a 206-acre lighthouse tract has been obtained. The Reserve and surrounding island are being placed on a geographic information system (GIS) using NOAA research funding.

For more information, please contact:

Buddy Sullivan, Reserve Manager
Sapelo Island National Estuarine
Research Reserve
Georgia Department of Natural Resources
P.O. Box 15
Sapelo Island, Georgia 31327

Phone Number: (912) 485-2251
Fax Number: (912) 262-3143

HAWAII
Hawaiian Islands Humpback Whale National Marine Sanctuary



Size: 1300 nmi²; Hawaii state and federal waters

Significant Resources

The warm, shallow waters surrounding the main Hawaiian Islands constitute one of the world's most important humpback whale habitats. Scientists estimate that two-thirds of the entire North Pacific humpback whale population (approx. 2500 - 3000 whales) migrate to Hawaiian waters to engage in breeding, calving and nursing activities. The continued protection of humpback whales and their habitat is crucial to the long-term recovery of this endangered species. Hawaii also contains many other spectacular marine and coastal resources, including: 24 species of whales and dolphins; the highly endangered Hawaiian monk seal; sea turtles; sea birds; coral reef ecosystems; sandy beaches and rocky, volcanic intertidal areas.

Human Use and Values

Hawaii's coastal and marine resources fuel a variety of recreational, commercial and subsistence activities, which in turn, play a critical role in the Hawaiian economy. Examples of such uses include: commercial, recreational and subsistence fishing, shipping and barging, surfing, swimming, kayaking, canoeing, diving, boating, whale watching, research, and military activities. Native Hawaiians also use the Sanctuary for traditional, cultural, subsistence and religious purposes. Numerous archeological and historical sites that document native Hawaiian uses and past eras in Hawaii can be found throughout the islands.

Site Designation and Regulations

Congress designated the Hawaiian Islands Humpback Whale National Marine Sanctuary as part of the Oceans Act of 1992. The designated boundary includes the area from the highwater mark to the 100-fathom (600 feet) isobath around Maui, Molokai, Lanai; Penguin Bank; and a small portion off the Kilauea Point National Wildlife Refuge, Kauai. The purposes of the Sanctuary are: (1) to protect humpback whales and their habitat; (2) to educate and interpret for the public the relationship of humpback whales to the Hawaiian Islands marine environment; (3) to manage selected uses of the sanctuary; and (4) to provide for the identification of marine resources and ecosystems of national significance for possible inclusion in the Sanctuary. The Act also provides for the inclusion of the waters around Kahoolawe Island in the Sanctuary on January 1, 1996, unless the Secretary of Commerce finds the area not suitable following an examination and assessment of the resources and uses of the area.

The development of the Sanctuary Management Plan is a joint effort between the public, NOAA's Sanctuaries and Reserves Division (SRD) and the State of Hawaii. The Office of State Planning (OSP) is the lead state agency and has established a 50-member Sanctuary Working Group which is designed to offer advice and recommendations to both OSP and SRD in the preparation of the Environmental Impact Statement and Management Plan (EIS/MP). SRD and OSP are currently working to complete the document and release it for public review and comment.

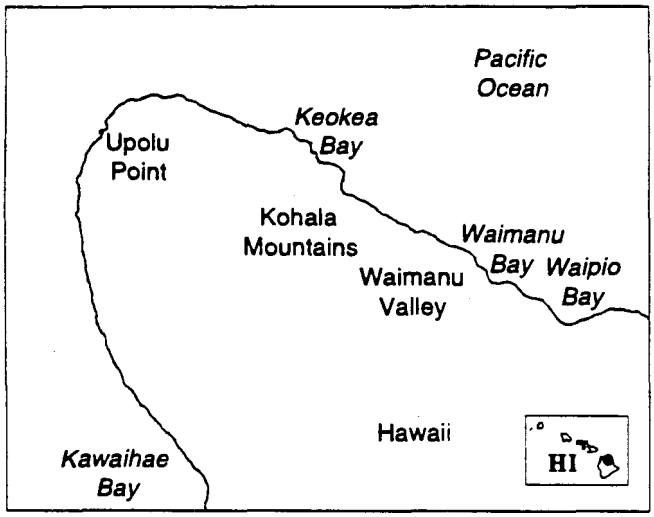
Staff and Facilities

The Hawaii Sanctuary has one on-site program specialist located at the Sanctuary office in Kihei, Maui. Two additional persons have been contracted to conduct outreach efforts in Oahu and Kauai. The Sanctuary has one office in the Federal Building in Honolulu and another office in Kihei, Maui.

For more information, please contact:

Allen Tom, On-Site Program Specialist
Hawaiian Islands Humpback Whale NMS
726 South Kihei Rd.
Kihei, HI 96753
Phone: (808) 879-2818; Fax (808) 874-3815

HAWAII
Waimanu Valley National Estuarine Research Reserve



Size: 3,400 acres Province: Insular

Significant Resources

Waimanu Valley NERR and the adjacent Puu O Umi Natural Area Reserve encompass a diverse watershed typical for remote valleys on the windward (wet) side of the big island of Hawaii. Watershed components include an embayment, estuary, wetland, streams, tributaries, waterfalls, and springs. Aside from past native Hawaiian subsistence uses, the water resources of the valley are among the few in the state that have not been permanently diverted and developed for human use. Native and non-native plant species can both be found in the valley. Native fauna in the valley include: the endangered Hawaiian hoary bat (the only land mammal native to the Hawaiian Islands); five fish species; black- crowned night heron; Newell's shear-water; and the golden plover. Numerous significant archaeological sites are preserved in the valley.

Staff and Facilities

The Reserve is managed by the Hawaii Department of Land and Natural Resources Natural Areas Reserves System (DLNRNARS). Staffing consists of two part-time DLNRNARS employees assisted by trail and site maintenance crews as needed. Waimanu Valley is a roadless wilderness reserve. Facilities are limited to back country campsites with composting toilets and an interpretive display at the start of the seven mile Muliwai Trail to the Reserve.

History and Location

Waimanu Valley is located in a remote area of the windward side (northeast coast) of the Big Island. In the early 1800's, Waimanu was inhabited by about 200 people. They cultivated taro and fruits and raised fish in a loko i'a (water enclosure). By 1914, only three families remained in the valley, perhaps because of changing life-styles and economic reasons. The last occupants left the valley soon after the devastating tsunami of April 1, 1946.

Uses and Programs

The remote location of Waimanu Valley NERR has limited the education and research programs available at the site. Research projects have included stream studies, hydrologic monitoring, wildlife monitoring, and archaeological surveys. Education projects have included a site brochure, and the production of a video that includes former inhabitants of the valley. Waimanu Valley is popular among wilderness hikers and campers. DLNR issues a limited number of camping permits on the stone berm at the valley mouth.

Site Accomplishments and Goals

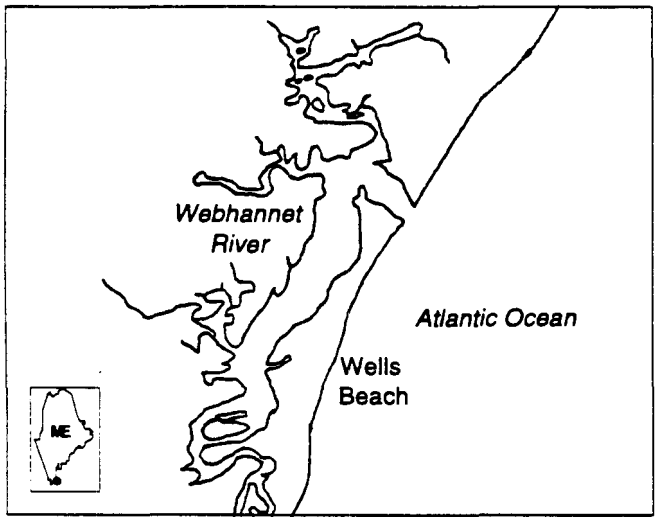
Waimanu Valley NERR is clarifying its role within the NERR System before further developing facilities or programs. NOAA and DLNR are currently discussing potential management alternatives.

For more information, please contact:

Peter Schuyler, Reserve Manager
Waimanu Valley National Estuarine
Research Reserve
Department of Land and Natural Resources
Division of Forestry and Wildlife
1151 Punchbowl Street
Honolulu, Hawaii 96813

Phone Number: (808) 587-0054
Fax Number: (808) 548-0160

MAINE
Wells National Estuarine Research Reserve



Size: 1,600 acres Province: Acadian

Significant Resources

Wells NERR, Maine, is part of the Webhannet and Little Rivers estuarine system. The Reserve contains an extensive array of natural communities including upland fields and forest, swamp and dune forest, salt marsh, beach, and tidal river. While the Reserve does not support large finfish populations, it does provide important breeding areas for invertebrates such as the soft-shell clam. The Wells NERR also supports populations of whitetail deer, piping plovers, snowy egrets, and bald eagles. A historic salt water farm is also contained within the Reserve.

Staff and Facilities

The Greek Revival-style mansion of the Laudholm Farm site provides 2,260 square feet of office, interpretive, and research space. The building is undergoing major renovation. Seven miles of trails provide access to the Reserve environment. A professional and support staff of ten are aided by an active volunteer staff of more than 250, who serve as docents and receptionists, and provide maintenance.

History and Location

Designated in 1986, Wells NERR is located along the southern coast of Maine, in the York County town of Wells, midway between Portland, Maine and Portsmouth, New Hampshire. Land portions of the Reserve are owned by the federal government (including parts of the Rachel Carson National Wildlife Refuge), the State of Maine, and the town of Wells.

Uses and Programs

Education programs include those geared toward children (estuarine ecology curriculum for K-8, "Junior Researcher" summer program) and adults (workshop series, guided subject tours). Monitoring and inventory of Reserve resources are ongoing. Research projects focus on marsh habitats as sources of food and the influence of sea level rise on formation of marshes and beaches. Techniques for control of exotic plants and animals are also developed.

Site Accomplishments and Goals

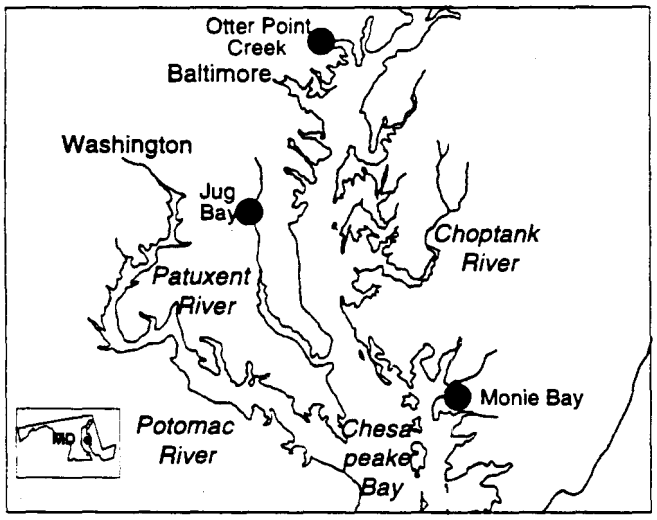
Wells NERR's programs have grown at a rapid pace. The education program offers a variety of on-site and off-site programs to elementary students and teachers, including an estuary based K-8 curriculum, a summer ecology day camp, and a summer science teachers academy. The research program supports numerous ongoing research projects focused on sea level rise, estuarine water quality, fishery habitat requirements, and salt marsh restoration. Expansion of auditorium, classroom, office, and laboratory space are currently being discussed to address growing program needs.

For more information, please contact:

Jim List, Reserve Manager
Wells National Estuarine Research Reserve
RR#2, Box 806
Wells, Maine 04090

Phone Number: (207) 646-1555
Fax Number: (207) 646-2930

MARYLAND
Chesapeake Bay (MD) National Estuarine Research Reserve



Size: 4,820 acres Province: Virginian

Significant Resources

The Chesapeake Bay NERR in Maryland is formed by three distinctly different components (Monie Bay, Jug Bay, and Otter Point Creek). Monie Bay contains salt marsh, forested and shrub wetlands, coastal grasslands, forested uplands, and open water. Jug Bay contains upland forest and fields, forested and shrub wetlands, and freshwater marsh. Otter Point Creek encompasses forested uplands and wetlands, freshwater marsh, and open water. Six prehistoric archaeological sites are located at the Monie Bay Component, while Otter Point Creek contains one and Jug Bay has five in or near its boundaries. The Reserve is a haven for resident and migratory birds, including the endangered peregrine falcon and bald eagle.

Staff and Facilities

A Reserve staff of three full-time employees and one half-time employee coordinates the Chesapeake NERR-Maryland among the state, county, and local participants. The Monie Bay Component, located in the lower Bay, is ideal for researchers to work undisturbed; it has no trails or facilities. The Otter Point Component, the northern main Bay site, has developed and developing trail networks. There are no facilities, although a Reserve visitors center is under development. A western shore tributary site, the Jug Bay Component has a visitors center, boardwalk and earthen trails, observation decks and towers, and outdoor interpretive signs.

History and Location

Chesapeake Bay NERR-MD is a multi-component Reserve. The three components which comprise the Reserve represent three different estuarine ecosystems found in the Bay: salt marsh, tidal freshwater riverine, and tidal freshwater Chesapeake Bay mainstem. The Monie Bay Component was designated in 1985. Both the Jug Bay and Otter Creek Components were designated into the Reserve in 1990.

Uses and Programs

General outreach and education activities occur at all three components, including "Estuary Talks" and the development of an education curriculum. Research is also conducted at all three components, with such activities as waterfowl censusing, water quality monitoring, and development of site profiles. Some of the components are limited use whereas other components do allow recreational and commercial fishing, boating, and some hunting.

Site Accomplishments and Goals

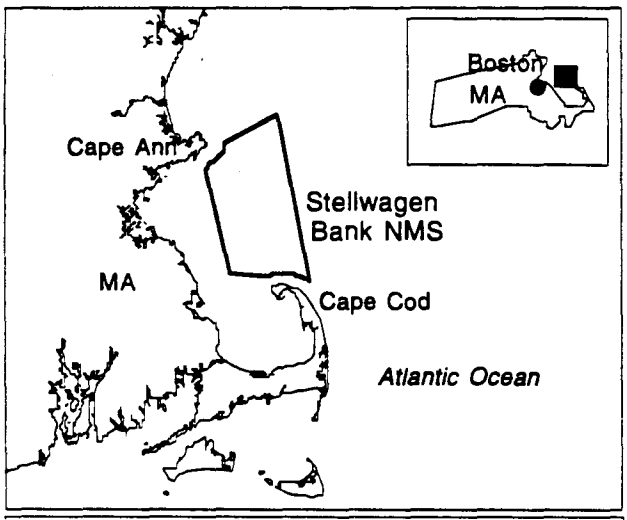
An annex to the visitors center at the Jug Bay Component was completed and formally dedicated in October 1993. Plans for a visitors center at the Otter Point Creek Component are being finalized and it is anticipated that construction will begin by 1995. This center will be the focal point for the Reserve with programming that features all three components. Education staff at the Reserve are finalizing an estuarine curriculum guide for teachers. Upon completion of the guide, workshops will be planned to help train teachers.

For more information, please contact:

Mary Ellen Dore, Reserve Manager
Chesapeake Bay National Estuarine Research Reserve in Maryland
Department of Natural Resources
Tawes State Office Building, B-3
580 Taylor Avenue
Annapolis, Maryland 21401

Phone Number: (410) 974-3382
Fax Number: (410) 974-2833

MASSACHUSETTS
Stellwagen Bank National Marine Sanctuary



Size: 638 nmi²; federal waters off Massachusetts

Significant Resources

The Sanctuary surrounds the entire Stellwagen Bank, a glacially deposited topographic feature lying in depths of around 65 feet in the shallowest areas with other areas in the upper plateau in the 100 foot range. The seaward side of the Bank drops off rapidly to over 600 feet. Stellwagen Bank is the most prominent submarine feature in Massachusetts Bay, stretching for nearly 20 miles between northern Cape Cod and Cape Ann, Massachusetts.

Two distinct peak productivity periods produce a complex system of midwater and benthic habitats. These habitats support benthic and pelagic species by providing cover and anchoring locations for invertebrates; they also provide feeding and nursery grounds for more than a dozen cetacean species including the endangered humpback, northern right, sei, and fin whales. The area supports foraging activity by diverse seabird species, dominated by loons, fulmars, shearwaters, storm petrels, cormorants, phalaropes, alcids, gulls, jaegers, and terns. Fish and invertebrate populations subject to seasonal and migration shifts include both demersal and pelagic species, such as bluefin tuna, herring, cod, flounders, lobster, and scallops. Leatherback and Atlantic ridley sea turtles (endangered species) use the area for feeding. Historic data strongly suggest the presence of several shipwreck sites within the Sanctuary, including the recently discovered and historically significant wreck of the steamship Portland which sank in 1898.

Human Use and Values

Commercial fishing has historically been the most economically important activity on the Bank, although whalewatching has grown steadily since 1976 due to the relative proximity of the Bank to the metropolitan Boston area and significant concentration of whales and dolphins that visit the Bank each year. It is currently estimated that around half a million people visit the Bank each year on whale watch vessels. Recreational fishing and boating, research, and commercial shipping are other important human uses. At least seven historic shipwrecks have been identified within or adjacent to the Sanctuary, but more will likely be discovered when the planned cultural resource inventory has been completed. Heavily-used shipping-lanes that cross the sanctuary transport more than 2700 commercial vessels principally carrying refined petroleum products, in and out of the Port of Boston annually.

Site Designation and Regulations

Stellwagen Bank was designated as a Sanctuary in November 1992 during reauthorization of the Marine Protection, Research, and Sanctuaries Act of 1972. It appeared on the Site Evaluation List in August 1983, and was made an Active Candidate in 1989. Final Sanctuary regulations, which became effective March 20, 1994, include prohibitions on most discharges; the disposal of dredged or other materials; mining for sand and gravel; injuring marine mammals, seabirds, and sea turtles; and contructing on or disturbing the seabed.

Staff and Facilities

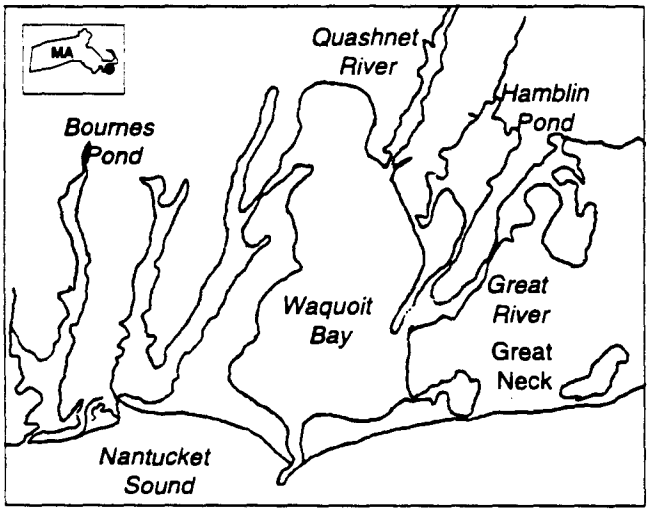
Stellwagen Bank National Marine Sanctuary is currently staffed by a Sanctuary Manager, an Education Coordinator, and a Secretary. The Sanctuary office is located in Plymouth, Massachusetts, and is exploring various alteratives for opening a visitors center in the region. SBNMS has a 30' vessel capable of supporting enforcement patrols and certain limited research activities. A state-of-the-art conductivity, temperature and depth recorder, which also measures dissolved oxygen and clorophyla concentrations, was acquired recently and will be used to conduct environmental monitoring activities in the Sanctuary.

For more information, please contact:

Brad Barr, Sanctuary Manager
Stellwagen Bank National Marine Sanctuary
14 Union Street
Plymouth, MA 02360

Phone Number: (508) 747-1691; Fax Number: (508) 747-1949

MASSACHUSETTS
Waquoit Bay National Estuarine Research Reserve



Size: 2,250 acres Province: Virginian

Significant Resources

Waquoit Bay NERR contains salt ponds, salt marsh, forest, barrier beaches and dune systems, and open water. The wide array of physical environments and chemical conditions support diverse and abundant floral and faunal species. Rare and endangered species include the piping plover and the plant Sandplain Gerardia. The Reserve contains areas of intense, moderate, and low human impact, and includes South Cape Beach State Park, a recreation area. Waquoit Bay contains some areas of historic and cultural interest, including several historic structures and was used as an encampment by Native Americans.

Staff and Facilities

The former Swift Estate, is the site of the Reserve Headquarters and Visitors Center. Research labs, classrooms, library, dormitory, five miles of trails, boardwalks, and outdoor signage are other amenities of the Reserve. Six employees and several interns are assisted by a volunteer force of about 100 people.

History and Location

Waquoit Bay NERR is located on the south shore of Cape Cod, Massachusetts, straddling Falmouth and Mashpee. The Reserve was designated in 1988.

Uses and Programs

Education programs include evening programs such as "Evenings on the Bluff," a summer series of environmental entertainments, as well as interpretive walks, watershed awareness training, open houses, and a science camp. Much of the outreach effort is aimed at coastal managers and addresses non-point source pollution issues. Reserve research programs include the effects of docks and piers, barrier beach dynamics, water quality monitoring and endangered species studies. NSF, EPA, and NOAA fund the Land Margin Ecosystem Research (LMER) Project which examines the coupling of watersheds to receiving waters, specifically as anthropogenic inputs of nitrogen affecting the Bay.

Site Accomplishments and Goals

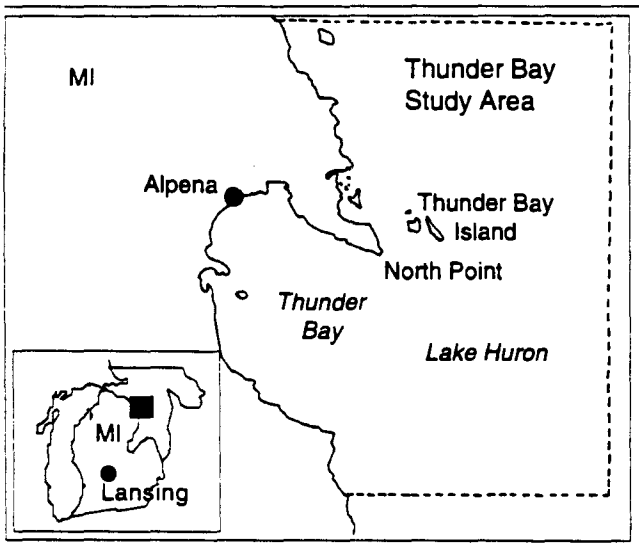
Waquoit Bay NERR sponsored a conference called "Nitrogen Removal On-Site Wastewater Treatment Systems: Technologies and Regulatory Strategies" in February 1992. Because of this conference, and the ensuing published proceedings, workshops, and meetings, Waquoit Bay has been designated as one of eight sites in the National On-site Demonstration Project. In addition, Waquoit is working with local, regional, state, and federal officials to establish a National Wildlife Refuge adjacent to the Reserve as part of the ongoing effort to reduce nitrogen loading to the Bay. The Waguoit Bay NERR staff co-chairs an EPA Ecological Risk Assesment Project focusing on the Waquoit Watershed.

For more information, please contact:

Christine Gault, Reserve Manager
Waquoit Bay National Estuarine Research Reserve
Department of Environmental Management
P.O. Box 3092
Waquoit, Massachusetts 02536

Phone Number: (508) 457-0495
Fax Number: (617) 727-5537

MICHIGAN
Thunder Bay National Marine Sanctuary (proposed)



Michigan state waters

Significant Resources

Thunder Bay's combination of historical resources grant this site unique national significance. Over one hundred shipwrecks have been identified in the Thunder Bay area, including wooden-hulled schooners, steamers, barges, tugboats, and freighters. This concentration of shipwrecks attracts numerous recreational divers and has led the State to declare Thunder Bay a Michigan Bottomland Preserve. In addition to these cultural aspects, there are important natural features. The highly sculptured bottom forms a complex system of geologic features. Misery Bay Sinkhole, North Point Reef, and the Thunder Bay Island Rock Wall are three of the more outstanding bottom features. Also included are several threatened or endangered species such as the Bald Eagle, Common Loon, Caspian Tern, Common Tern, Dwarf Lake Iris, Lake Sturgeon, Deepwater Cisco, Shortjaw Cisco, and the Kiyi. Within the Sanctuary study area, Scarecrow's Island and Thunder Bay Island form part of the Michigan Islands National Wildlife Refuge (U.S. Fish and Wildlife Service), home to many species of colonial nesting birds and waterfowl.

Human Use and Values

The site's collection of underwater cultural resources and proximity to the Michigan Islands National Wildlife Refuge, has made the site an important recreational resource for many visitors to the region. Michigan Department of Natural Resources seasonally stocks Thunder Bay with a variety of fish, including brown trout and steelhead.

Status of Site Designation

Thunder Bay was included on the Site Evaluation List (SEL) in 1983 and remained until 1991 when it was made an Active Candidate. An on-site liaison is working with a variety of local, State, Native American, and Federal agencies to prepare a Draft Environmental Impact Statement and Management Plan (DEIS/MP). A Thunder Bay Resource Inventory has been prepared by Michigan Sea Grant to contribute to the implementation of this portion of the designation process. Members of the Thunder Bay Core Group are reviewing and will use portions of this document in development of management alternatives for the DEIS/MP. Thunder Bay is the first active candidate for the National Marine Sanctuary designation located in the Great Lakes, and is the only freshwater site under active consideration within the National Marine Sanctuary Program.

Staff and Facilities

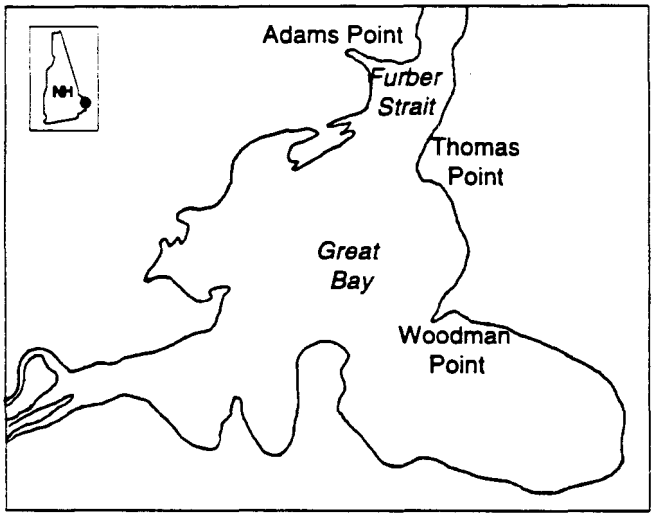
The on-site Liaison is working full-time with the State of Michigan during the designation process. Education and Facilities plans are being developed through cooperative efforts with Michigan State University.

For more information, please contact:

Michele Malarney, On-Site Liaison
Thunder Bay National Marine Sanctuary (proposed)
Department of Parks, Recreation, and
Tourism Resources
Natural Resource Building, Room 141
Michigan State University
East Lansing, MI 48823

Phone Number: (517) 432-3142
Fax Number: (517) 432-3597

NEW HAMPSHIRE
Great Bay National Estuarine Research Reserve



Size: 5,280 acres Province: Acadian

Significant Resources

Salt marsh, tidal creeks, woodlands, open fields, mud flats, rocky intertidal area, eelgrass beds, and open waters form the ecosystem of Great Bay NERR, New Hampshire. The Reserve has eighteen rare or endangered plant species and five rare or endangered fauna (bald eagle, common tern, common loon, eastern hognose snake, and four-toed salamander). Great Bay is a favorite winter perch for the bald eagle. Flora include many species at their northernmost limit.

Staff and Facilities

The Reserve headquarters are located in Durham, adjacent to the University of New Hampshire. The UNH Jackson Estuarine Lab is located on the Reserve itself. The 5,000 square foot Sandy Point Discovery Center houses indoor and outdoor exhibits. Two miles of trails, including boardwalks and observation decks, provide access to Great Bay NERR; the waters of the Reserve are accessible through six boat launching sites. The staff includes a full-time manager and part-time education coordinator.

History and Location

Great Bay NERR is adjacent to the Great Bay National Wildlife Refuge, which is located on the east side of the Bay and includes Thomas Point and Woodman Point. The Reserve received its designation in 1989. There are a variety of land owners within the Reserve, including the State, the federal government, and private citizens.

Uses and Programs

The Reserve features the newly opened Sandy Point Discovery Center with indoor and outdoor exhibits as well as interpretive trails. Education programs for elementary and secondary students are offered at the Center and a curriculum for grades 1-6 will be released in September 1995. Research projects underway include water quality and waterfowl monitoring; eelgrass and salt marsh restoration; and evaluating non-point sources pollution control efforts. The Reserve is also actively involved with oil spill contingency planning. Volunteers participate in both research and education programs.

Site Accomplishments and Goals

The Reserve has completed the second phase of the NERR Three Phase Monitoring Program with the publication of its site characterization, *An Estuarine Profile*. The Reserve's first Technical Report is a study on wintering eagles in the bay. A second Technical Report on wintering waterfowl will be available in September 1995. The Reserve also is in the process of creating a Great Bay Foundation to increase volunteer participation.

For more information, please contact:

Peter Wellenberger, Reserve Manager
Great Bay National Estuarine Research Reserve
New Hampshire Department of Fish and Game
225 Main Street
Durham, New Hampshire 03824

Phone Number: (603) 868-1095
Fax Number: (603) 271-1438

NEW JERSEY
Mullica River Proposed National Estuarine Research Reserve

In July 1993, Governor of New Jersey nominated the Mullica River Great Bay estuary for inclusion in the NERRS Program. The site, located in southern New Jersey, is regarded as one of the least-disturbed settings in the densely populated urban corridor of the northeastern United States. The proposed reserve encompasses 114,047 acres and incorporates a variety of terrestrial, wetland, and aquatic habitats, ranging from protected state forests to barrier islands and a long-term ecosystem observatory on the continental shelf.

The proposed reserve is a major migratory stop and wintering area for many waterfowl, shorebirds and raptors, and supports numerous stocks of finfish and shellfish. This region also holds a great deal of historic interest associated with its early settlement by Native Americans and the use of the Mullica River-Great Bay estuary by privateers who preyed on British ships during the Revolutionary War.

The Governor has assigned administrative responsibilities for the site to the Office of Land and Water Planning of the New Jersey Department of Environmental Protection. Daily management responsibilities will be handled by the Institute of Marine and Coastal Sciences at Rutgers University.

The state has received financial assistance to prepare a draft environmental impact statement and draft management plan (DEIS/DMP). A preliminary DEIS/ DMP draft plan has been prepared with the assistance of a Citizen's Advisory Committee. This group is now preparing a response to SRD's review and comment on the document. Public hearings are expected to be held in Spring 1995, to solicit additional comments on the DEIS/ DMP.

For More Information, please contact:

Michael De.Luca, Project Manager
Mullica River
National Estuarine Research Reserve (proposed)
Institute of Marine and Coastal Sciences
Rutgers University
P.O. Box 231
New Brunswick, NJ 08903

Phone Number: (908) 932-9489 x512
Fax Number: (908) 932-8578

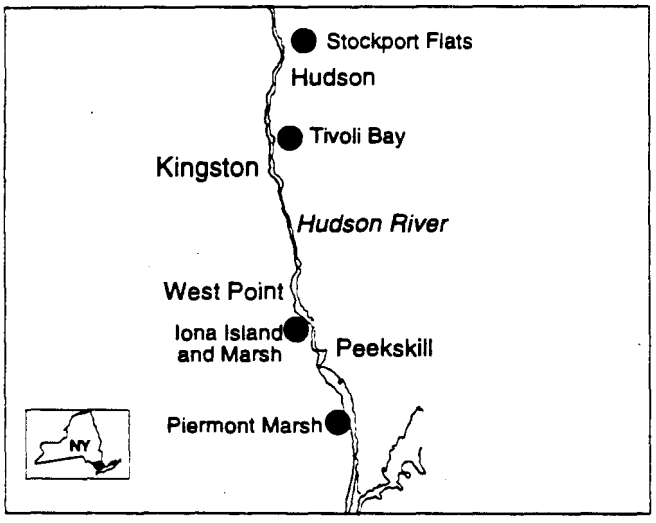
or:

Sanctuaries and Reserves Division
1305 East West Highway, SSMC4-12
Silver Spring, Maryland 20910

Phone Number: (301) 713-3132
Fax Number: (301) 713-0404

NERR Branch Chief: Randy Schneider

NEW YORK
Hudson River National Estuarine Research Reserve



Size: 4,838 acres Province: Virginian

Significant Resources

The Hudson River NERR is composed of four units representing the salinity regime of the Hudson: Piermont Marsh, Iona Island, Tivoli Bay, and Stockport Flats. The natural communities represented in the components include brackish and freshwater tidal marshes, forested uplands, mud flats, and islands. The osprey, bald eagle and a host of other life forms are found in the Reserve. Several historical structures also occur within the Reserve boundaries, including an ice house on the National Register of Historic Places, located in the Stockport Flats component.

Staff and Facilities

The headquarters of Hudson River NERR are located at the Bard College Field Station, which houses offices, laboratories, a library, herbarium, overnight quarters, boats, and field gear. Two regional exhibit halls are being developed associated with the Tivoli Bay and Stockport Flats components. Over ten miles of trails are available to the public. Three full-time and three part-time staff members oversee daily operations.

History and Location

Located in Columbia, Dutchess, and Rockland Counties, New York, the Hudson River NERR was officially designated in 1982.

Uses and Programs

Education programs and facilities include interpretive field programs and classes, workshops for local officials and teachers, and traveling exhibits (an educational resource library). A variety of research efforts are underway, focusing on non-point source pollution studies, community characterizations, studies of ecosystem processes, and investigations of exchanges between wetlands and the Hudson River and the wetlands restoration projects. The Reserve co-sponsors two Fellowship Programs.

Site Accomplishments and Goals

The Reserve has coordinated coastal education, research, and management activities with the Hudson River Estuary Management Program, the New York/ New Jersey Harbor Estuary Program, the New York State Coastal Management Program, and the New York State Greenway. A stream monitoring program linked to a Geographic Information System (GIS) has been used to predict and monitor non-point pollution sources. Hudson River resource centers have been created and professional development workshops for teachers in Hudson River ecology have been held. The Reserve is undertaking wetlands restoration planning for Reserve sites, as well as other Hudson River sites.

For more information, please contact:

Elizabeth Blair, Reserve Manager
Hudson River National Estuarine Research Reserve
C/O Bard College Field Station
Annandale-On-Hudson, New York 12504

Phone Number: (914) 758-5193
Fax Number: (914) 758-8273

NEW YORK
St. Lawrence River
Proposed National Estuarine Research Reserve

The St. Lawrence River is part of the Eastern Great Lakes Basin biogeographic province. It is the connecting waterway between the Great Lakes and the Atlantic Ocean. The area being examined is along a 16-mile stretch of the river (between Waddington and Massena) currently owned by the New York Power Authority (NYPA).

Land and water areas presently targeted for the proposed reserve encompass over 6,000 acres, including freshwater wetlands, riparian uplands and open waters of tributaries as they enter the St. Lawrence River. Proposed within reserve boundaries are three sites designated as "significant coastal fish and wildlife habitats" by the New York State Secretary of State, under New York's Coastal Management Program.

Acreage included within the proposed reserve are, variously, under the managing jurisdictions of NYPA, the New York State Department of Environmental Conservation (as a State Wildlife Management Area), the New York State Office of Parks, Recreation and Historic Preservation (as a State Park), and St. Lawrence Aquarium & Ecological Center, Inc. (proposed site of a major freshwater aquarium & ecological educational and research facility).

The State received a $10,000 site selection award in 1989 to examine potential sites. In 1993 the governor submitted a nomination package that was approved by OCRM. The St. Lawrence-Eastern Ontario Commission (SLEOC) is currently working with an 18-member advisory committee in development of a draft reserve management plan and environmental impact statement for the proposed reserve.

For More Information, please contact:
Dr. Daniel Palm, Project Manager
Thomas Cutter, Technical Manager
St. Lawrence-Eastern Ontario Commission
317 Washington St.
Watertown, NY 13601

Phone Number: (315) 785-2460
Fax Number: (315) 785-2545

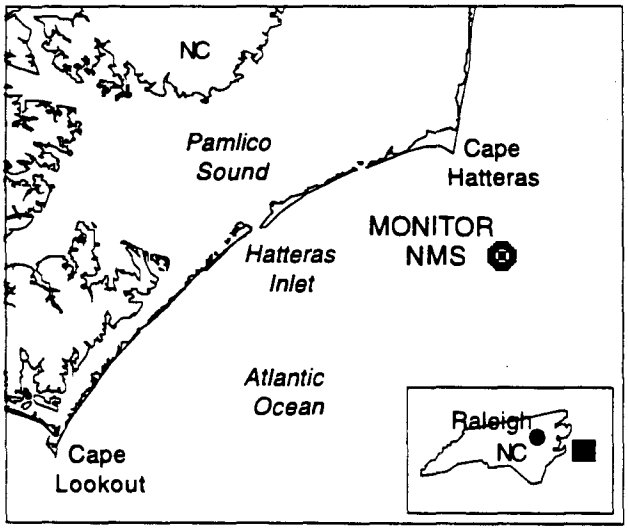
or:

Sanctuaries and Reserves Division
1305 East West Highway, SSMC4-12
Silver Spring, Maryland 20910

Phone Number: (301) 713-3132
Fax Number: (301) 713-0404

NERR Branch Chief: Randy Schneider

NORTH CAROLINA
Monitor National Marine Sanctuary



Size: A circle 1 nmi in diameter; federal waters

Significant Resources

The *Monitor* was the prototype for a class of U.S. Civil War ironclad turreted warships that significantly altered both naval technology and marine architecture in the nineteenth century. Designed by the Swedish engineer John Ericsson, the vessel contained all of the emerging innovations that revolutionized warfare at sea; it was constructed in a mere 110 days. The *Monitor* fought the Confederate ironclad CSS Virginia at Hampton Roads, Virginia in one of the most celebrated naval battles in American history. Sunk during a gale in December 1862, less than a year after her commissioning, the wreck lies upside down and has suffered considerable deterioration and structural damage. In addition to natural deterioration caused by the elements, the wreck also appears to have been damaged by vessel anchoring and possible depth charges dropped during World War II.

The ocean bottom in the vicinity of the *Monitor* is composed of sand, shell hash, and clay. The wreck lies near the northernmost limit of tropical fish, and supports a combination of temperate and tropical species, dominated by red barbier in one survey. Twenty-five species of fish have been observed, as well as a wide variety of encrusting organisms such as corals, sponges, sea squirts, sea anemones, hydroids, barnacles, mussels, and oysters. The wreck appears to function as a productive artificial reef, although cold-water intrusions by the Labrador Current may limit productivity.

Use and Visitation

For over a century, the *Monitor* lay undiscovered in 230 feet of water 16 miles off Cape Hatteras, North Carolina. In August of 1973, scientists aboard Duke University's research vessel *Eastward* located the *Monitor* using sidescan sonar. Since its designation as a Sanctuary, numerous expeditions have visited the *Monitor* gathering scientific data. The anchor, the lantern, and other artifacts have been recovered. Access is generally limited to scientific research conducted under a permit issued by NOAA; however, special-use permits will be issued during 1994 for non-research visits to this historic vessel.

Site Designation and Regulations

The *Monitor* was placed on the National Register of Historic Places in October 1974 as a resource of national significance. The *Monitor* became the first National Marine Sanctuary, designated in January 1975. Regulations prohibit anchoring, stopping, and drifting within the Sanctuary; conducting salvage or recovery operations; using diving, dredging, or wrecking devices; conducting underwater detonation; drilling in the seabed; laying cable; and trawling.

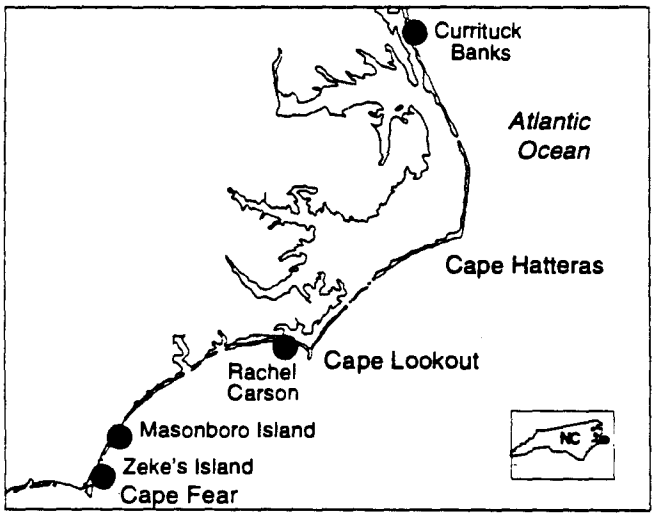
Staff and Facilities

The current staff of the *Monitor* NMS includes a Manager and Education Coordinator, based in Tidewater Virginia. Surveillance of the site is provided by the U.S. Coast Guard. The Mariners Museum in Newport News, Virginia, through a long term cooperative agreement with NOAA, maintains the *Monitor* Collection of artifacts and documents and assists in developing education programs, including permanent and traveling exhibits related to the Sanctuary. Artifacts have also been exhibited at the Edwin Ulrich Museum in Wichita, KS; the Philadelphia Maritime Museum; the Naval Academy in Annapolis, MD; the Washington Navy Yard and Department of Commerce in Washington, DC; and various locations in North Carolina and Virginia.

For more information, please contact:

John Broadwater, Sanctuary Manager
Monitor National Marine Sanctuary
Building 1519
Fort Eustis, VA 23604-5544
Phone Number: (804) 878-2973
Fax Number: (804) 878-4619

NORTH CAROLINA
North Carolina National Estuarine Research Reserve



Size:10,000 acres Province: Virginian/Carolinian

Significant Resources

North Carolina NERR is formed by four components scattered along the Outer Banks. Together, these components contain ocean beaches, dunes, shrub thickets, salt and brackish marshes, tidal flats and creeks, eelgrass beds, and open water. All four components are dedicated State Nature Preserves. Thousands of waterbirds use the protected habitats. Threatened loggerhead sea turtles nest in the Reserve; other threatened and endangered species that occasionally use the components are peregrine falcons, piping plovers, and green sea turtles. Hard clams, blue crabs, and flounder are among the notable aquatic organisms. The Zeke's Island component vicinity has Civil War shipwrecks; the Currituck Banks component contains shell middens and pottery fragments.

Staff and Facilities

Public trails are available at each component. Volunteers assist the staff of three permanent employees. The administrative office of the Reserve is housed within the University of North Carolina at Wilmington (UNCW) at the Center for Marine Science Research. The research office is situated on UNCW property across the intracoastal waterway from Masonboro Island. The Reserve educational office is located in Beaufort.

History and Location

North Carolina NERR is formed by four components that represent different barrier island estuaries: Zeke's Island, Rachel Carson, Currituck Banks, and Masonboro Island. Separate components of the Reserve were officially designated in 1985 and 1991. The non-profit Society for Masonboro Island is assisting the State to acquire the remaining privately-owned tracts on this undeveloped barrier island component.

Uses and Programs

NOAA-funded research has been conducted at all four components, the majority at Rachel Carson and Masonboro Island. Phased monitoring has begun at the Zeke's Island and Masonboro Island components. A field guide and educational curricula are available. A research bibliography is being developed for all four components. Educational outreach is performed by the Reserve education specialist. Field trips are offered by the education specialist and through the North Carolina Aquariums and North Carolina Maritime Museum.

Site Accomplishments and Goals

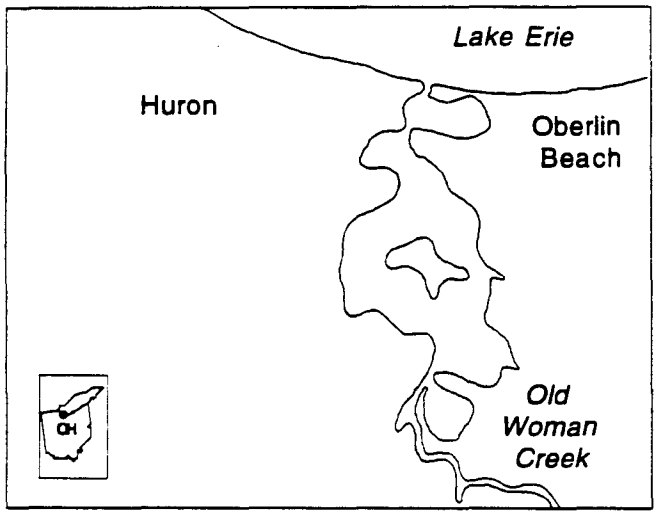
The Reserve Research/Educational Facility was built during 1992-93 using NOAA development funds and construction assistance from UNCW and Cape Fear Community College. The 1,000 square foot structure includes two offices, a laboratory, classroom, and computer room. Proximity to Masonboro Island makes this building an ideal location for research, monitoring, and education activities.

For more information, please contact:

Dr. John Taggart, Reserve Manager
North Carolina National Estuarine Research Reserve
Center for Marine Science Research
University of North Carolina at Wilmington
7205 Wrightsville Avenue
Wilmington, North Carolina 28403

Phone Number: (910) 256-3721
Fax Number: (910) 256-8856

OHIO
Old Woman Creek National Estuarine Research Reserve



Size: 571 acres Province: Great Lakes

Significant Resources

Located on a drowned stream mouth draining into Lake Erie, the Old Woman Creek NERR contains numerous habitat types, including barrier beach, embayment marshes, swamp forests and upland hardwood forests, mud flats, and open water. Nearly three hundred species of birds and more than forty species of fish have been identified within the Reserve boundaries. Several species that are threatened, endangered, or of special concern are found on the Reserve, including the American bald eagle, sharp-shinned hawk, spotted turtle, eastern fox snake, and the Blanding's turtle. Old Woman Creek has a rich history of occupation by Native Americans over the past several thousand years.

Staff and Facilities

The Reserve's administrative offices are located in the 6,100 square foot Ohio Center for Coastal Wetlands Studies, which overlooks the estuary. The Center provides laboratory space, classrooms, a visitors center, and wildlife observation area. The Reserve also has on-site dormitory facilities for researchers and program participants. The Reserve is staffed by four full-time and three temporary employees, and a volunteer force of 25-30 who assist with operations, public programs, and maintenance tasks.

History and Location

Old Woman Creek NERR, located two miles east of Huron, Ohio, is the smallest Reserve in the system and currently the only one in the Great Lakes. The site was officially designated in 1980.

Uses and Programs

The visitors center and natural history exhibits serve as a focal point for the public to learn about coastal wetlands. Estuarine ecology classes are frequently presented, as well as teacher and leader training workshops and seminars for natural resource professionals. Research efforts are directed towards developing a better understanding of freshwater estuarine ecosystems. The Reserve's long-term monitoring program is providing information on chemical, physical, and biological parameters important to estuarine productivity, and has recently been expanded to examine the effectiveness of farming best management practices (BMPs) in the Old Woman Creek Watershed during storm event runoff.

Site Accomplishments and Goals

The Old Woman Creek NERR staff was recently awarded the 1994 NOAA Award For Excellence in Estuarine Research Reserve Management for designing innovative approaches to research, monitoring, education and outreach, and resource management.

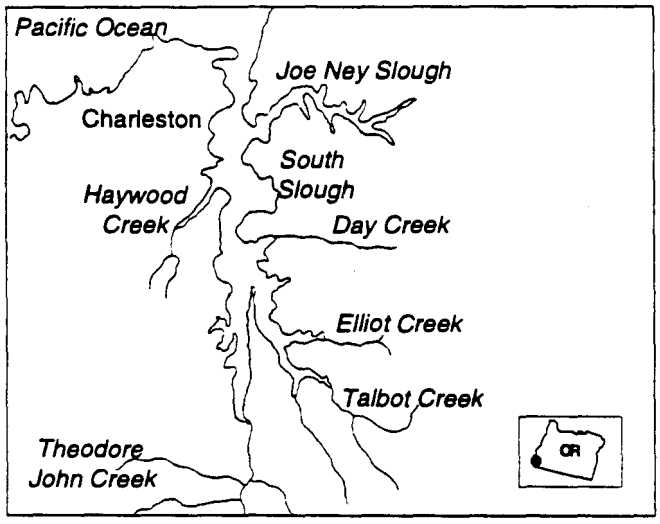
Over the next two years, OWC NERR staff hopes to redesign an exhibit in the visitor center which interprets present day watershed land uses and upgrade another exhibit that explains the foundation of the estuarine food chain; complete phase II of the research dormitory; remodel the boat and equipment storage building; initiate an educational stewardship program for residents and agricultural producers of the watershed; and to make selected "real time" water quality data more accessible to the general public and coastal decision makers of the Lake Erie region.

For more information, please contact:

Eugene Wright, Reserve Manager
Old Woman Creek National Estuarine
Research Reserve
2514 Cleveland Road East
Huron, OH 44839

Phone Number.: (419) 433-4601
Fax Number.: (419) 433-2851

OREGON
South Slough National Estuarine Research Reserve



Size: 4,500 acres Province: Columbian

Significant Resources

The South Slough is one of seven tidal inlets which collectively form the Coos Estuary. South Slough NERR is responsible for stewardship of approximately 25 per cent of the drainage areas of the South Slough Inlet. The Reserve contains upland forest, freshwater and salt marsh, mud flats, eelgrass beds, and open water. A large variety of invertebrates, including clam and shrimp, thirty species of fish, including salmon and trout, and one hundred species of birds, including nesting bald eagles, can be found adjacent to the Reserve. Two sites of archaeological significance have been identified.

Staff and Facilities

The 4,000 square foot Reserve headquarters has a photo gallery and auditorium, and houses the staff of six permanent and one to seven temporary employees. Volunteers assist in the operation of the Reserve. Five miles of trails include information kiosks and a two-level observation deck. There is intern housing and a small field laboratory available.

History and Location

The South Slough, located five miles southwest of Coos Bay, Oregon, is one of seven tidal inlets which collectively form the Coos Estuary. The South Slough NERR, designated in 1974, was the first in the NERR System.

Uses and Programs

Flora and fauna inventories, habitat restoration, and provision of tools and information for estuarine resource managers are some of the research projects undertaken at South Slough NERR. The Reserve collects and maintains summary data on the physical environmental features of the area. Educational efforts have produced formal programs for grades 4-12, and off-site outreach efforts include waterfront signs for local communities. Other educational programs include canoe trips, guided trail walks, and special workshops. The Reserve contains about one hundred acres of commercial oyster culture.

Site Accomplishments and Goals

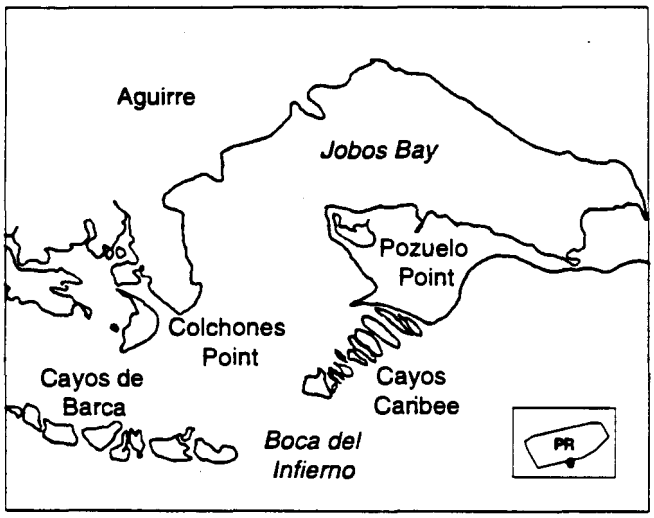
Acquisition of resources defined in the initial management plan for the Reserve has been completed. Future plans for the Reserve involve large scale habitat restoration and a re-evaluation of the Reserve
boundaries.

For more information, please contact:

Mike Graybill, Reserve Manager
South Slough National Estuarine
Research Reserve
P.O. Box 5417
Charleston, Oregon 97420

Phone Number: (503) 888-5558
Fax Number: (503) 888-5559

PUERTO RICO
Jobos Bay National Estuarine Research Reserve



Size: 2,800 acres Province: West Indian

Significant Resources

Jobos Bay NERR, located on the south central coast of Puerto Rico, contains a variety of habitats: subtropical dry forest, fringing and basin mangroves, mud salt flats, chain of seventeen islets, seagrass beds, coral reefs, and open waters. Mangroves are composed of red, black, and white species; coral reefs include fire, finger, elkhorn, and brain coral. The seagrass beds vary in density, both before and behind the reef front. A population of endangered West Indian manatees (approximately 300) found at the site is believed to be the second largest assemblage of this marine mammal in Puerto Rico. The endangered hawksbill sea turtle can also be found in the Reserve.

Staff and Facilities

Five full-time employees oversee the daily operations of the site. Volunteers support the Reserve's programs. Administrative offices, trails, and a rudimentary boardwalk are among the facilities available at the site. A restored historic structure located onsite serves as the visitor center for the Reserve.

History and Location

Jobos Bay NERR, designated in 1981, is located on the south central coast of Puerto Rico.

Uses and Programs

Curriculum materials, field trips, boat trips, interpretive exhibits, and outreach activities are all among the education resources of Jobos Bay NERR. Research focuses on providing technical assistance to scientists working on-site and to students working on local and regional science projects. Water quality monitoring of the Reserve is ongoing.

Site Accomplishments and Goals

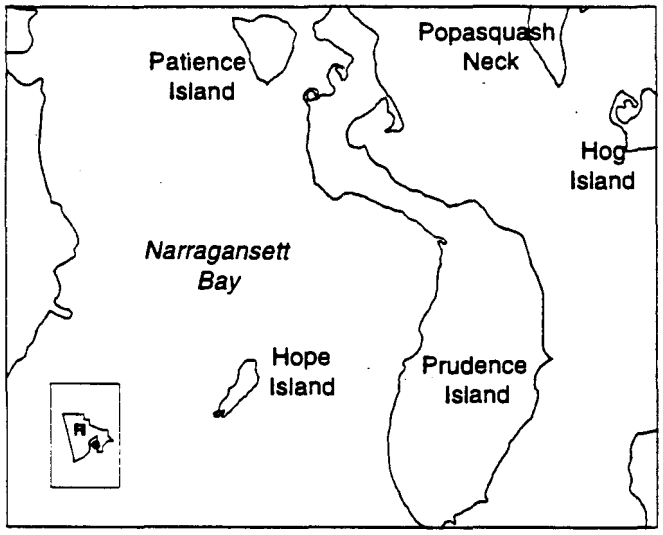
Environmental education advice has been offered to nearly 48,000 students and citizens since the designation of the Reserve. The visitor's center is scheduled for completion early 1994. Our Educational and Outreach programs have reached nearly 48,000 students and citizens since designation of the Reserve. The visitor's center and library facilities have been completed. Our goal is to develop a Resource Protection Program to ensure a stable environment for research, education, and outreach programs.

For more information, please contact:

Carmen Gonzalez, Reserve Manager
Jobos Bay National Estuarine Research Reserve
P.O. Box B
Aguirre, Puerto Rico 00704

Phone Number: (809) 853-4617
Fax Number: (809) 853-4618

RHODE ISLAND
Narragansett Bay National Estuarine Research Reserve



Size: 4,950 acres Province: Virginian

Significant Resources

Narragansett Bay NERR consists of upland fields and forests, freshwater and salt marshes, tidal flats, eel-grass meadows, and open waters among the matrix of habitats. Deer, raccoon, fox, and rabbit are among the land mammals found in the Reserve; bird species include great blue heron, green-backed heron, little blue heron, great egret, snowy egret, black-crowned night heron, and glossy ibis. Soft-shell clams, quahogs, lobster, striped bass, and flounder are found in the Reserve waters. Hope Island is the site of a major wading bird rookery. Harbor seals occasionally use exposed offshore rocks as haulout and rest areas. Prudence Island contains the historic North End farm site and prehistoric Indian shell middens. Patience Island contains the foundations of an 18th century oysterman's house.

Staff and Facilities

The Reserve has three employees and utilizes the services of numerous volunteers from the Prudence Conservancy for scientific monitoring and other specific projects as they arise. The Reserve has the following facilities: deep water dock for large vessels; two floating docks for small boats; dock-side interpretive building; picnic areas; beach; overnight visitors' cottage; four miles of trails with wayside exhibits and accompanying printed hikers' guide.

History and Location

Narragansett Bay NERR received its designation in 1980. The site is located ten miles south of Providence, Rhode Island, and comprises land on Prudence, Patience, and Hope Islands, in addition to the surrounding waters. Land ownership is held mainly by the state, with one parcel owned by the Prudence Conservancy.

Uses and Programs

The Reserve has both on-site and off-site education programs, and works with the Narragansett Bay Project to increase awareness of the Bay's resources. Research is focused on the salt marshes and aquatic habitats and is conducted by regional researchers. The Reserve is also home to a wading bird protection program on Hope Island that has included monitoring of nesting habitat for nearly twenty years. Long-term atmospheric and water quality monitoring programs are in place. Reserve grounds support both commercial and recreational shellfishing.

Site Accomplishments and Goals

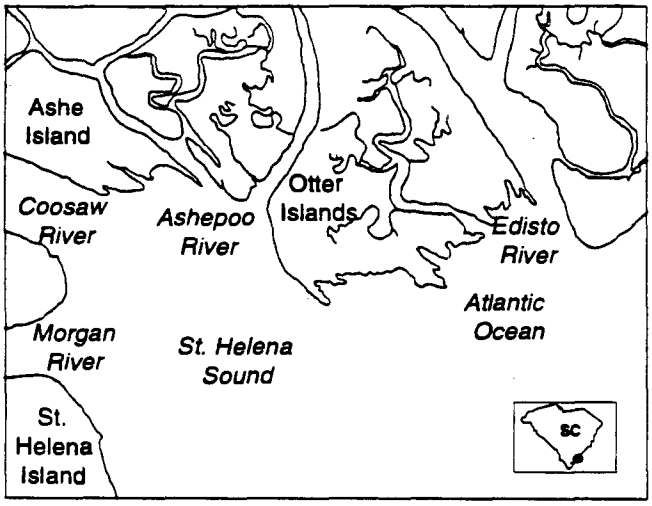
The Reserve is in the process of designing and constructing a facility with a lab, education room, meeting room, and office. As part of this project, the caretaker's cottage and overnight visitors' cottage are also being repaired. Long-term research and monitoring programs are ongoing. The Reserve is developing as close working relationship with the University of Rhode Island's Sea Grant Program. Through a joint project involving the Sea Grant Program, the Narragansett Bay Project, and the Reserve, study was completed analyzing the economic value of Narragansett Bay. Other joint projects among the three programs are currently underway.

For more information, please contact:

Allan Beck, Reserve Manager
Narragansett Bay National Estuarine
Research Reserve
Department of Environmental Management
Box 151
Prudence Island, Rhode Island 02872

Phone Number: (401) 683-5061 (on-site)
(401) 277-2771 (Providence)
Fax Number: (401) 277-6802

SOUTH CAROLINA
ACE Basin National Estuarine Research Reserve



Size: 136,599 acres Province: Carolinian

Significant Resources

The ACE Basin NERR contains islands (Ashe, Beet, Boulder, Big, Otter, and Warren Islands), salt and brackish marsh, dune systems, tidal flats, maritime and upland forest, and open water. More than 500 species of birds, mammals, reptiles, amphibians, and plants occur here. The American alligator, loggerhead sea turtle, shortnose sturgeon, bald eagle, and wood stork are all endangered or threatened species found in the Reserve. About 40% of South Carolina's nesting bald eagles are found in the ACE Basin. The Atlantic bottlenose dolphin is a common marine mammal; occasionally, West Indian manatees and several species of whales are found in nearshore waters. The site requires a comprehensive, scholarly investigation of cultural resources; the Reserve does contain a number of historic structures, some of which are on the National Historic Register.

Staff and Facilities

Although the ACE Basin NERR does not have an interpretive center at present, plans are in the making for a modern facility in the near future. The Reserve does have a trail system and temporary headquarters for staging educational activities at Bear Island. A staff of six permanent employees are supplemented by a temporary worker and a small volunteer force.

History and Location

The ACE Basin NERR, composed of the drainage basin for the Ashepoo, Combahee, and Edisto river systems, is located 45 miles south of Charleston, South Carolina. It received designation status in 1992.

Uses and Programs

Educational programs include tours and interpretive messages, coastal adventure cruises aboard the Reserve's research vessel, teacher workshops and curriculum development, and special outreach efforts during career day and environmental week events. Research focuses on sustainable resource management and coastal management-oriented studies. Environmental monitoring, site characterization, and assessment of habitat conditions are ongoing projects within the Reserve.

Site Accomplishments and Goals

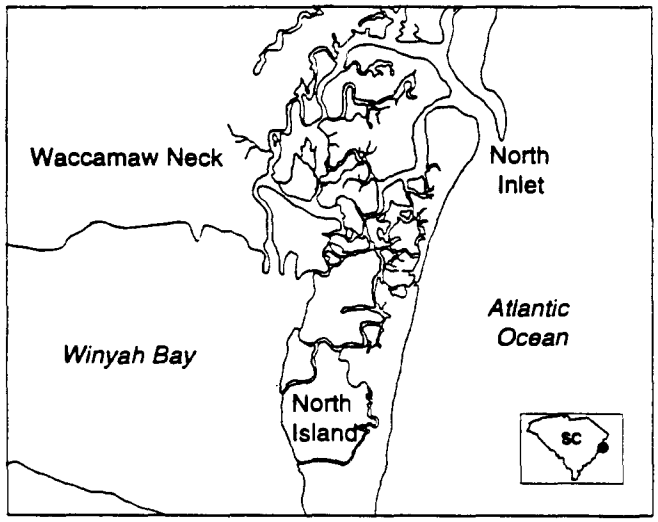
The ACE Basin NERR is part of an unprecedented conservation initiative involving federal, state, local, and private environmental interests working together to preserve some of the most diverse and fragile habitat in coastal America. Approximately one-third of the 350,000 acres identified within the basin has been protected. Future plans include establishment of a facility to serve not only as a focal point for operations and management, but also as an interpretive/education center for visitors and school groups.

For more information, please contact:

Michael McKenzie, Reserve Manager
ACE Basin National Estuarine Research Reserve
South Carolina Department of Natural Resources
P.O. Box 12559
Charleston, South Carolina 29412

Phone Number: (803) 762-5062
Fax Number: (803) 762-5001

SOUTH CAROLINA
North Inlet-Winyah Bay National Estuarine Research Reserve



Size: 9,080 acres Province: Carolinian

Significant Resources

Two estuarine systems are represented within the Reserve boundaries. North Inlet Estuary has been minimally disturbed by human activity, and Winyah Bay Estuary has been substantially altered by activities within the Bay and surrounding watershed. Outstanding water and resource quality in North Inlet Estuary have provided the basis for a widely recognized research program focused on understanding ecological processes in a relatively undisturbed estuary. The Reserve consists of high salinity marshes, tidal creeks, lagoons, old rice fields (formerly impounded brackish marshes), intertidal oyster reefs, mud flats, and sand bars. One of the largest wading bird nesting sites in the southeast, Pumpkinseed Island, is located in the Reserve. Significant cultural and historic resources are also associated with the area.

Staff and Facilities

The Reserve is presently operated by a staff of seven employees including two senior scientists and two full-time research specialists who work closely with an Education Coordinator. Headquarters are located at the Baruch Marine Field Laboratory, a modern research complex operated by the University of South Carolina. Laboratories, classrooms, library, computer facilities, education displays, an interpretive boardwalk, and seawater system are used by the staff. An interpretive center, housing and conference facilities are also available.

History and Location

The North Inlet-Winyah Bay NERR was designated in 1992. A formal designation ceremony was held in 1993 in conjunction with the dedication of the new Baruch Marine Field Laboratory. The Reserve is east of Highway 17 near Georgetown, SC, which is located about 30 miles south of Myrtle Beach and 50 miles north of Charleston.

Uses and Programs

Programs administered by the Reserve provide opportunities to learn about the resources. Evening lectures, forums, and seminars directed toward adult audiences complement family-oriented courses which often include field trips within the Reserve. Teacher training workshops and ecology classes for elementary school children are also sponsored. The research program includes a long-term monitoring component which tracks physical, chemical, and biological information necessary to determine seasonal and annual changes in ecosystem structure, function, and health. Currently, the staff is formulating a site characterization and integrating Reserve monitoring and research programs with University-based and visiting investigators.

Site Accomplishments and Goals

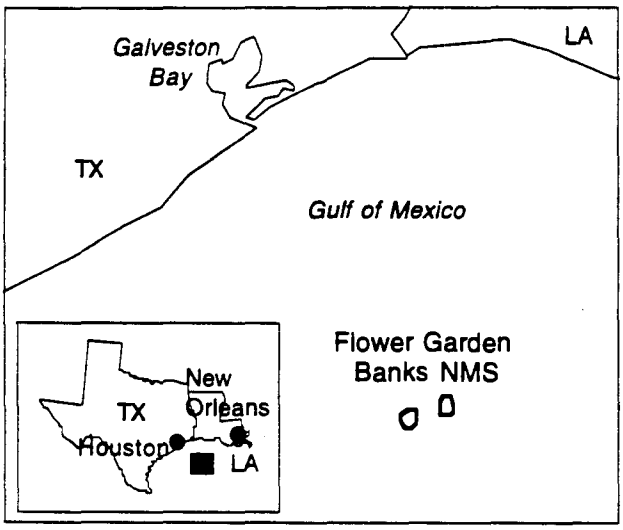
Although the Reserve is comparatively new to the NERR System, significant progress has been made on several fronts. Educational programs, materials, and displays have been seen by thousands of visitors. The research staff has implemented a monitoring program which assesses long and short-term variability in key ecosystem variables. Computer-based data management allows easy access to data and trend analyses. Efforts to increase interactions with the Coastal Zone Management Program are already underway.

For more information, please contact:

Dr. Dennis Allen, Reserve Manager
North Inlet-Winyah Bay National Estuarine Research Reserve
Baruch Marine Field Lab
P.O. Box 1630
Georgetown, South Carolina 29440

Phone Number: (803) 546-3623
Fax Number: (803) 546-1632

TEXAS
Flower Garden Banks National Marine Sanctuary



Size: 42 nmi²; federal waters off Texas/Louisiana

Significant Resources

One hundred miles off the coast of Texas and Louisiana, a pair of underwater gardens emerge from the depths of the Gulf of Mexico like an oasis in a desert. This oasis is the Flower Garden Banks, two separate submerged salt dome features supporting the northernmost coral reefs on the continental shelf of North America. By a sheer twist of nature, the reefs sit at the ultimate edge of existence 50 feet from the surface. Any further north the environmental conditions would not be suitable for coral reef development. One has to travel over 600 miles southeast to the Florida Keys and over 400 miles south to Mexico's Gulf of Campeche to find the nearest coral reef.

Together, the East and West Flower Garden Banks contain about 350 acres of tropical coral reef with approximately 21 species of coral. Among the nearly 250 other invertebrate species are mollusks, brittle stars, sea urchins, and lobsters. The fish population includes 175 resident tropical species as well as resident and migratory pelagic species. The threatened loggerhead sea turtle frequents the banks. Manta rays, whale sharks, and spotted dolphins are also common visitors to Flower Garden Banks. The East Flower Garden Bank is the location of the only known oceanic brine seep in the continental shelf waters of the Gulf of Mexico. The brine seep is anoxic and is populated by bacteria capable of using hydrogen sulfide in chemosynthetic primary production and providing a food source for surrounding bank communities.

Human Use and Values

The principal activities in the vicinity of the Sanctuary are oil and gas extraction, commercial fishing, recreational pursuits, ship traffic, and research. Accessibility for recreation and research is limited to vessels having adequate range and overnight facilities. There has been a history of scientific interest since 1930. There are probably no significant historical or cultural resources, given the distance from shore.

Site Designation and Regulations

In 1979, the site was made an Active Candidate for Sanctuary designation, partly due to escalating oil and gas development and vessel anchoring. With industry threats mostly ameliorated by restrictions from BLM, it was withdrawn in 1982. In 1984, the site was again raised to Active Candidacy after severe anchor damage caused by an industry vessel was documented. Final designation came in January 1992. Regulations prohibit anchoring; oil and gas exploration and development; processing, injuring or taking corals and other marine organisms; use of fishing gear except hook and line gear; discharging or depositing any substances or materials; altering the seabed; building or abandoning structures, using explosives or releasing electrical charges. Major accomplishments at the site have been the installation and maintenance of mooring buoys and the development of a long-term monitoring program.

Staff and Facilities

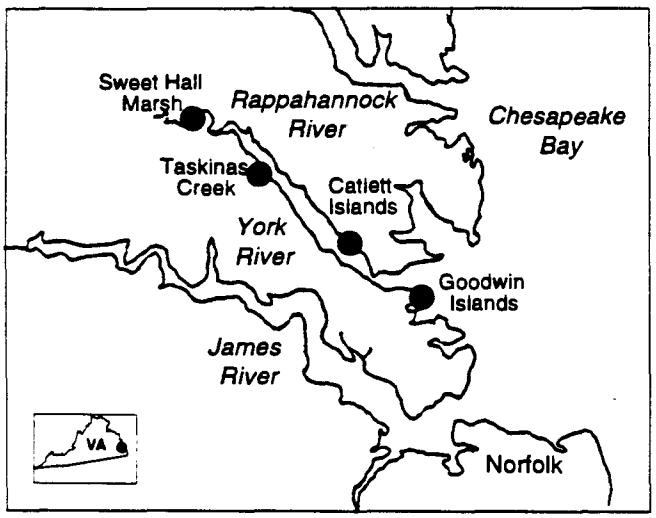
A Manager and Education Coordinator based in Bryan, TX are responsible for the day to day operation of the Sanctuary. Cooperative state, federal, industry, and non-profit partnerships have been established for fundraising, education, research, and monitoring.

For more information, please contact:

Dr. Steve Gittings, Sanctuary Manager
Flower Garden Banks National Marine Sanctuary
1716 Briarcrest Dr., Suite 603
Bryan, TX 77802

Phone Number: (409) 847-9296
Fax Number: (409) 845-7525

VIRGINIA
Chesapeake Bay (VA) National Estuarine Research Reserve



Size: 4,435 acres Province: Virginian

Significant Resources

The Reserve is composed of four sites in the York River basin in Virginia. The Goodwin Islands Component contains forested uplands, Spartina alterniflora dominated wetlands, tidal flats, oyster bottom, submerged aquatic vegetation, and open water; the Catlett Islands Component contains saltmarsh, forested wetlands, forested hammocks, and open water; the Taskinas Creek Component encompasses fresh and brackish water wetlands, upland forest, tidal flats, and open water; the Sweet Hall Marsh Component is characterized by freshwater marsh, forested and shrub wetlands, upland forests, and open water. The components span a salinity gradient of 18-22 ppt. Taskinas Creek and the Catlett Islands Components are rich in prehistoric and early colonial archaeological sites. The other components have not had surveys conducted.

Staff and Facilities

The Reserve headquarters are located in the Brown House at the Virginia Institute of Marine Science (VIMS), College of William and Mary. The staff consists of five full-time employees, two graduate research assistants, and several volunteers. The Reserve also has access to some of the facilities of York River State Park, including a 7,000 square foot visitors center, auditorium, wet lab, and amphitheater. Fourteen miles of trails are available to the public.

History and Location

The Chesapeake Bay NERR-Virginia was designated in 1991. The Reserve is located in the York River, one of the major tributaries to Chesapeake Bay. The Reserve is convenient to the Yorktown-Williamsburg portions of the historic Yorktown, Williamsburg, Jamestown triangle.

Uses and Programs

A wide variety of research occurs in all four components of the Reserve. Major efforts include marsh plant community patterns, avian ecology, submerged aquatic vegetation ecology, patterns of estuarine debris accumulations, and long-term trends in ground and surface water quality. Educational efforts focus on disseminating Reserve-generated research and monitoring data for classroom use and related curriculum development by Virginia teachers. The major vehicle for disseminating this information is educational computer networks accessible to Virginia educators.

Site Accomplishments and Goals

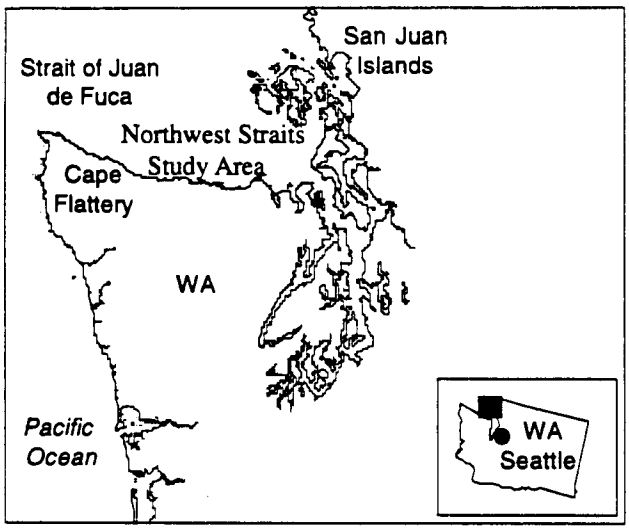
Effective partnerships have been established with several organizations to carry out research and educational programs. Organizations such as the Coast Guard, EarthWatch, Consortium for Interactive Instruction, and the Virginia Living Museum have all participated on Reserve programs, in addition to site volunteers. Projects initiated include monitoring, dissemination of educational materials, and debris accumulation studies. The Reserve staff has completed site evaluation for expansion into the Rappahannock, Potomac, and Plankatank rivers. Planning is underway for an educational center at a York River site that will be the prototype of similar centers to be added as the Reserve expands into other major tributaries.

For more information, please contact:

Dr. Maurice Lynch, Reserve Manager
Chesapeake Bay National Estuarine Research Reserve in Virginia
P.O. Box 1346
Virginia Institute of Marine Science
Greate Road
Gloucester Point, Virginia 23062

Phone Number: (804) 642-7135
Fax Number: (804) 642-7120

WASHINGTON
Northwest Straits National Marine Sanctuary (proposed)



Washington State waters

Significant Resources

Northwest Straits is located north of Puget Sound, and encompasses the waters surrounding the San Juan Islands, north to the Canadian border, U.S. waters west to the entrance of the Strait of Juan de Fuca, the Strait of Georgia, Haro and Rosario Straits. The twelve-foot tidal range has produced a variety of habitats including rocky shores, sand and mud flats, and marshes. The rich diversity of algae and invertebrates form the basis of the food web that supports fish, birds, and marine mammals. Predominant fish species include salmon, halibut, pollock, anchovy, rockfish, lingcod, cabezon, and sculpin. Predominant bird species are auklets, gulls, terns, and oystercatchers. Over 200 bald eagles, the single largest concentration in the continental United States, winter in the area. Marine mammals using Northwest Straits for at least part of the year include minke, gray, killer, and pilot whales; harbor and Dall porpoises; harbor and elephant seals; and Stellar sea lions. Fossil Bay and Protection Island are rich in fossilized clams, snails, and ammonites.

Human Use and Values

The site has multiple uses, including a high level of recreational activity, through boating, fishing, clamming, duck hunting, kayaking, diving, and nature observation. Extensive commercial fishing and marine transportation activities also take place. Intense research activity has occurred since 1904; the University of Washington maintains a marine biology lab at Friday Harbor on San Juan Island.

Status of Site Designation

This site appeared on the Site Evaluation List (SEL) in 1983 as Washington State Nearshore. It was made an Active Candidate under the name of Northern Puget Sound by the 1988 reauthorization of the Marine Protection, Research, and Sanctuary Act of 1972. A Discussion Paper presenting the rationale for a federal Sanctuary in all state waters, a description of some of the threats to the marine resources, and suggestions for ways in which the Sanctuary could address those threats was drafted for public review in 1993. SRD and Washington State Department of Ecology signed a Memorandum of Understanding in 1994. NOAA, in conjunction with the State Department of Ecology, held 26 focus group meetings throughout the study area in March 1995 to ensure accurate information was considered for the Draft Environmental Impact Statement (DEIS) and Management Plan. Three public meetings were held in May. NOAA has not yet determined if a Sanctuary is appropriate for this area. The DEIS/MPis expected to be completed in the Fall of 1995, and available for public review and comment.

Staff and Facilities

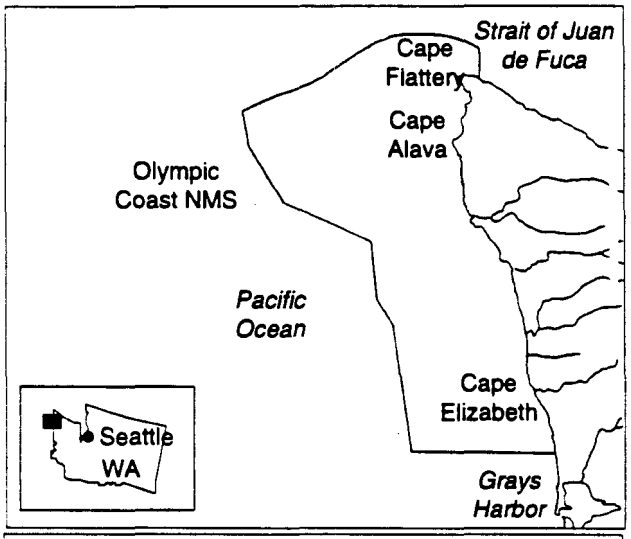
An on-site liaison and a program specialist are working with the State of Washington and other interested parties to complete the designation and decision process for a Sanctuary in Northwest Straits. A regional Sanctuary and Reserves Division office has been established at the NOAA facilities in Seattle.

For more information, please contact:

Pamela James, On-site Liaison
Northwest Straits
National Marine Sanctuary (proposed)
NOAA/SRD (Seattle)
7600 Sand Point Way, NE; Bin C 15700
Seattle, WA 98115

Phone Number: (206) 526-4293
Fax Number: (206) 526-4294

WASHINGTON
Olympic Coast National Marine Sanctuary



Size: 2500 nmi²; Washington state and federal waters

Significant Resources

The Olympic Coast NMS encompasses a variety of habitats, including high energy rocky coasts, tide pools, sand beaches, marshes, kelp beds, sea stacks, and open water over a broad, shallow continental shelf extending seaward from the Strait of Juan de Fuca. Coastal upwelling from submarine canyons adjacent to the broad shelf and several estuarine systems are the cause for the nutrient-rich waters and high productivity of the site. The seabird colonies of Washington's outer coast are among the largest in the continental U.S. The spectrum of natural and diverse communities provide important habitat for waterfowl using the Pacific Flyway. The region also contains one of the largest populations of bald eagles in the continental U.S. The Sanctuary supports a wide variety of fish and invertebrates including 5 species of salmon, steelhead and sea-run cutthroat trout, halibut, pink shrimp, and Dungeness crab among others. Endangered or threatened species that make use of the site include the bald eagle, peregrine falcon, brown pelican, short-tailed albatross, Stellar sea lion, sea otter, and humpback whale. Twenty-nine species of marine mammals are reported to breed, rest within, or migrate through the Olympic Coast region. The northern part of the coast is an important habitat for a reintroduced population of sea otters. Significant historical and cultural resources within and immediately adjacent to the Sanctuary include: Indian village sites, ancient canoe runs, petroglyphs, Indian artifacts, and numerous shipwrecks.

Human Use and Values

The site is valuable for commercial and recreational uses. The relatively pristine Olympic Coast is an important aesthetic resource and its recreational value is enhanced by the presence of the Olympic National Park, the offshore wildlife refuges (which are designated as a Biosphere Reserve and World Heritage Site), and wilderness areas. The cultural flavor of the site is enhanced by the presence of four federally recognized Native American tribes. Commercial shipping consisting of tankers and barges transit the area while approaching and departing Puget Sound. Commercial and recreational fisheries target such species as shellfish, salmon, groundfish, and halibut. The site has been used for field research by the University of Washington for the last twenty-five years.

Status of Site Designation

The site appeared on the Site Evaluation List (SEL) in 1983 as Western Washington Outer Coast. It remained on the SEL until 1988 when it was made an Active Candidate by the reauthorization of the Marine Protection, Research, and Sanctuary Act of 1972. Renamed as Olympic Coast, the Draft Environmental Impact Statement and Management Plan was released in July 1991. The Final Environmental Impact Statement and Management Plan was released in December 1993. Olympic Coast National Marine Sanctuary was formally designated in July 1994.

Staff and Facilities

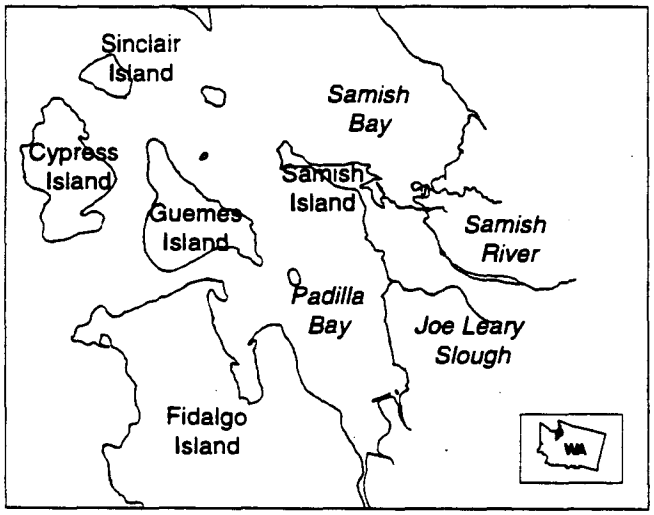
The site is staffed by a Sanctuary Manger, Executive Officer, Research Coordinator, Education Coordinator and Secretary. The main office is located in Port Angeles, WA, with a satellite office in Forks, WA. A research and enforcement vessel, *Tatoosh*, is based in Port Angeles.

For more information, please contact:

Todd Jacobs, Sanctuary Manager
Olympic Coast National Marine Sanctuary
138 W. First St.
Port Angeles, WA 98362-2600

Phone Number: (360) 457-6622
Fax Number: (360) 457-8495

WASHINGTON
Padilla Bay National Estuarine Research Reserve



Size: 10,700 acres Province: Columbian

Significant Resources

The Padilla Bay NERR is characterized by large expanses of intertidal mud flats covered by eelgrass (the largest contiguous seagrass meadow in the Pacific Northwest). Small amounts of salt marsh, bare mud flats, and subtidal habitat are included. Invertebrate species include clams, crabs, and shrimp. About 57 species of fish use the waters, including salmon, smelt, herring, and flounder. The eelgrass beds provide a nursery area for young salmon and crab. Approximately 239 species of birds occur in the area; it is particularly notable for large flocks of dabbling ducks. Black brant use the area for feeding during the spring and fall migrations. Bald eagles nest in the Reserve and harbor seals utilize the shallow tide flats for haulout and pupping. Several archaeological sites have been identified, but none occur directly on the bay.

Staff and Facilities

A 7,000 square foot interpretive center houses exhibits, salt water aquaria, theater, lab, and classroom. Support facilities include overnight lodging, conference room, laboratory, and maintenance areas. Three miles of pedestrian trails, two points of beach access, two observation decks, and a boat launch are available. All spaces are handicap-accessible. Ten full-time and two part-time staff carry out operations and programs, and are assisted by interns and volunteers.

History and Location

The Padilla Bay NERR is located between Burlington and Anacortes in Northern Puget Sound, Washington. The Reserve was officially designated in 1980.

Uses and Programs

Research projects have been directed to the major resources and habitats, and have included characterization projects as well as specific studies. Monitoring efforts have focused on establishing baseline information for water quality parameters. Education programs are provided for all age levels. Three curricula are implemented for grades K-12 and college courses are scheduled throughout the year. Public workshops and lectures are offered on weekends. Exhibits in the Interpretive Center provide passive educational opportunities.

Site Accomplishments and Goals

Since site designation in 1980, the Reserve has provided on-site estuarine education programs for over 60,000 students and teachers. Research projects are identifying the issues and problems associated with non-point source pollution and assisting with recommendations for control. Habitats in the Reserve are potentially threatened by an invading cordgrass species and monitoring and growth studies are being implemented.

For more information, please contact:

Terry Stevens, Reserve Manager
Padilla Bay National Estuarine Research Reserve
1043 Bayview-Edison Road
Mt. Vernon, Washington 98273

Phone Number: (360) 428-1558
Fax Number: (360) 428-1491

APPENDIX 3

Type A Model Inputs

TYPE A MODEL DATA NEEDS CHECKLIST

1. SPILL SITE: Latitude and longitude (deg., min., sec.) _____

2. SPILL DATE AND TIME: Year, month, day, hour _____

3. CHEMICAL OR OIL TYPE SPILLED: Name(s), CAS #

   a. CHEMICALS: need CAS # to ID it; synonyms help in identification _____

   b. OILS: type, oil characteristics to classify it (see table) _____

4. AMOUNT SPILLED: Amount, units (MT, bbl, gal, liters, lbs, kg) _____

   (Note: If is a chemical in solution or a mix, need to know percent composition, and also the amount of THE chemical released.)

5. DURATION OF RELEASE: Hours over which amount is spilled _____

6. SECOND STAGE RELEASE: For oils, may specify two releases (amounts and durations), second immediately following the first _____

7. WIND TIME SERIES: Wind speed (knots) and direction (deg. from). From 24 hours before spill to end of significant contamination on or in the water _____

8. CURRENTS: Vectors (speed in m/sec or kts; direction in deg.) at locations in X-Y space over area of spill effects; mean over time during spill effects; at surface for oils, mean over depth for sinking chemicals _____

   a. Non-tidal background current velocities _____

   b. Tidal current velocities at maximum flood _____

9. TIDE STAGE:

   a. Time of high tide the day of the spill _____

   b. Tide range (meters) the day of the spill _____

10. ICE CONDITIONS: Present or not (for Alaska, select data provided)

11. CLEANUP OF SPILLED CHEMICAL OR OIL, for any number of subareas:

    a. Location, within a range of latitude and longitude _____

    b. Timing, within a range of days and hours since the spill _____

    c. Amount and units for removed mass of chemical or oil; after correction for water, sediment, and other contaminants. Note that water content in an emulsified oil should be subtracted _____

12. AIR TEMPERATURE: (C) (optional, default provided) _____

13. WATER TEMPERATURE: (C) (optional, default provided) _____

14. SUSPENDED SEDIMENT CONCENTRATION (mg/l); _____

    SETTLING VELOCITY (m/day): (optional, default provided)

15. GNP PRICE INDEX = Implicit price deflator for the Gross National Product for the quarter which includes the spill date _____

16. CLOSURE DATA (see attached details):

    a. Harvest: Fisheries, hunting/trapping _____

    b. Recreation: Beaches and boating _____

CLOSURE DATA REQUIREMENTS FOR THE NRDAM

For each biological province affected:

1. HARVEST: FISHERIES and HUNTING/TRAPPING

   Area (km2) and days closed by each category.

   (If multiple closures of differing area and days were made, add up area times days to calculate areas-days closed. Then divide by the days of most closures to obtain an equivalent area and days closed.)

   a. Finfisheries in 3 habitat categories:

      1. Seaward (main water body of the province) open water
      2. Landward (estuaries or inlets off the main water body, or brackish upstream regions) open water
      3. Structured habitats (wetlands, mangroves, seagrass beds, macroalgal beds, coral reefs, mollusk reefs)

   b. Shellfisheries in 3 habitat categories:

      1. Seaward (main water body of the province) open water
      2. Landward (estuaries or inlets off the main water body, or brackish upstream regions) open water
      3. Structured habitats (wetlands, mangroves, seagrass beds, macroalgal beds, coral reefs, mollusk reefs)

   c. Waterfowl hunting

   d. Mammal hunting or trapping

2. BEACHES:

   Length (km) and days closed by each category and by month of the year.

   (If multiple closures of differing length and days were made, add up length times days in a given month to calculate length-days closed for the month. Enter that value of km-days as the equivalent length closed for 1 day that month.)

   a. Federal beaches (national seashores and parks)

   b. State or locally-owned beaches (other public beaches)

3. BOATING:

   Total boating-days.

   (Determine the number of boat-days lost due to closures, i.e., the number of boat trips of one day duration lost.)

APPENDIX 4

Field Photography and Video Techniques

FIELD PHOTOGRAPHY TECHNIQUES

Professional quality photographs are absolutely essential during spill response. Photographs convey ideas and information much more effectively than written words alone. In transmitting data, a photograph should assist—not confuse and irritate—the audience. Video-taping equipment is a necessity for documenting spill occurrence and distribution. Following are some helpful hints to avoid some of the common pitfalls made by scientists photographing an oil spill site.

1) Film is cheap!! Don't be afraid to take pictures. The expenses associated with a scientific oil spill response often run into hundreds of thousands of dollars.

2) Cameras. The field camera must be durable, preferably lightweight, and have a through-the-lens light meter. Many of the new 35-mm, single-lens, reflex compact cameras by Nikon, Minolta, Olympus (etc.) fulfill these requirements.

3) Lens. A 50-mm or 55-mm lens gives the viewer the most realistic picture of the object. A low F-stop (1.4-1.8) is necessary to be able to take pictures under varying light conditions. A UV filter should be used to protect the lens. The use of a polarizing filter during good light conditions eliminates much of the glare coming off the water (used primarily during overflights, unless the sun is extremely bright).

4) Beach Shots. At least three photographs should be taken of the beach: (1) up and (2) down the coast and (3) directly perpendicular to the beach. At zonal stations, additional photographs should include those of the profile line, trenches, and all aspects of oil distribution and biological effects. A person in the photograph is useful for discerning scale and depth of field.

5) A Straight Horizon. One of the most common problems for the beginner coastal photographer in taking pictures is a crooked horizon—make sure it is straight! In order to present a balanced photograph, it should be composed of approximately one-third sky (sometimes less) and two-thirds land.

6) Shutter Speed. The slower the shutter speed, the greater the depth of field. We most often use 1/125 of a second or 1/60 of a second during darker conditions.

7) Film Type. We have found that both Kodachrome-64 and Fujichrome 100 give us good pictures both on the beach and during overflights. They are wide-latitude films capable of absorbing exposure errors, give natural colors, and do not appear grainy. Good quality black-and-white prints can also be made. In

addition to K-64 and Fuji 100, we also take some high-speed Ektachrome (ASA 400) in the field in case of poor light conditions. Seattle Filmworks provides the option of high quality slides and prints from the same film, but it must be mailed off for developing. Film is constantly being upgraded. We recommend that you experiment with other types of film. But, don't use it at a critical spill until you have tried it on a beach somewhere.

8) Bracketing. Take the shots you feel are most important as your light meter reads, and then two others at ±1/2 F-stop. This will be a better guarantee of getting the correct exposure. Always check your light meter against other cameras. Change the battery regularly.

9) Shooting into the Sun. On a bright day (looking toward the sun), your camera will read at a closed aperture. This will result in an underexposure or a dark photograph of the beach. In order to get the correct exposure, take the light reading out of the sun's glare or open up the aperture 1/2 to 1 F-stop.

10) Close-Up Photographs. For determining the biological and geological impact of an oil spill, the close-up photograph is most useful. In all cases, an object of well-known size must be placed in the photograph for scale. Preferably, the scale should be marked in centimeters and placed in the lower right-hand corner of the photograph. The 15-cm scale that you will receive at the course works very well. NEVER place the scale in the center of the photograph. The camera should be held parallel to the surface to be photographed to prevent out-of-focus edges.

11) Aerial Photographs. Shutter speed should be set at 1/250 or faster, if possible. Don't steady the camera by leaning against the plane (vibrations!). Photographs should be taken through an open window or door, if possible; if not, at least make sure the window is clean. Again, be careful to avoid crooked horizons. Also, beware of reflections—wear dark shirts to minimize reflection.

12) Spare Batteries. Always have spare batteries with you for the camera, and know how to change them.

13) Number of Rolls. Carry at least 3 or 4 rolls of 36 exposure film with you. Prepare and label film before starting an overflight—saving valuable air time and minimizing mistakes.

14) Logging Pictures. For logging of pictures, write everything in a spill log book during field work, including the photo and video information. That evening, fill in what you can of a regular photo log. When the slides are developed, immediately put in clear binder sheets with the roll code on each slide. Then finish filling out the log while looking at the slide.

15) Copies of Photo Logs. Make copies of the photo logs for DAC-HQ and the slide binder. Put the originals in the official case file. Put the binder copy in front of each set of slides.

16) Practice with Camera. Remember to use a steady hand, especially with long lenses. Practice with the camera you will be using, bring it home and take family and field pictures, including close-ups, telephoto, and wide. An actual spill is not the ideal time to learn to use the camera.

17) Protect from the Elements. Most spill situations involve hard environments for cameras. Protect them around salt water, even salt spray. Zip-lock freezer bags are very useful, especially inside of the regular nylon or hard camera cases. After a spill, wipe cameras (but not the lens glass itself) with a soft rag that has been sprayed with a silicon spray.

18) From an Aircraft. When photo/video documenting oiling or recreational lost use from an aircraft, try to get the pilot to understand what you are doing and use appropriate flight patterns and altitudes. The pictures need to have sufficient resolution to see people.

19) Images. For oil slicks, use a polarizing filter and spin it to see what gives the image you want to show.

FIELD VIDEO TECHNIQUES

By: Brian Julius, NOAA Damage Assessment Center

- Have at least two video cameras available to be sent to a spill—one primarily for recording information pertaining to lost use (beaches, marinas, etc.) and one for documenting injury. The best arrangement may be to have a video camera for each regional scientist and at least one that is stored at HQ.
- Don't rent video cameras if you can avoid it. They are expensive (~$125/day) and often are not maintained in good working order.
- Video cameras preferably should have color viewfinders, since it is often hard to differentiate between oil, waves, and shoreline when shooting from a helicopter with a black and white viewfinder. Investigate the quality and usefulness of the video camera with the large (~3") color viewscreens.
- Video cameras preferably should have image stabilization capabilities to use during helicopter overflights.
- Make sure all people (both scientists and economists) who may be called to respond to a spill are trained to use the video cameras and have had some time to practice.
- When shooting video (or still photos) from a helicopter, the best arrangement is to remove the doors on the side on which you are shooting, but leave the opposite side doors on to minimize noise and vibration.
- When shooting from a helicopter or fixed-wing aircraft, try to fly with the sun behind you to minimize glare on the water.
- During helicopter overflights, it is very useful to shoot video and still photographs of the same things: a) provides a level of insurance against operator error; and b) still photos may be very useful in "ground truthing" the video for landmarks, distances, etc.
- Try to minimize the use of the zoom capabilities when shooting video from a helicopter. The camera takes a second or so to autofocus and provides a blurry image during that period.
- All video (and still) cameras should be equipped with polarizing filters.

APPENDIX 5

*Shipping Guidelines for Samples and Other Chemicals**

* *For assistance with Federal Express shipping, call 800-238-5355 and ask for the Hazardous Material Desk. The U.S. Department of Transportation also has a hotline for hazardous material packaging and shipping: 202-366-4488*

IATA PACKING AND SHIPPING REQUIREMENTS FOR DANGEROUS GOODS, WITH EMPHASIS ON PETROLEUM AND RELATED SAMPLES

Prepared by:

Scott Zengel

Research Planning, Inc.

1200 Park Street

Columbia, South Carolina 29201

July 1995

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INTRODUCTION

Samples of oil and oiled sediments may often fall under the category of dangerous goods, also known as hazardous materials. Special packing and shipping procedures are required when dangerous goods are being transported. The U.S. Department of Transportation (USDOT) and the International Air Transport Association (IATA) are two major groups that regulate the transportation of dangerous goods. It is assumed that DAC/RAP responders will ship oil-related samples via Federal Express (FedEx). FedEx follows IATA regulations, which are emphasized here. This short summation of IATA regulations and procedures should in no way serve as a substitute for certified dangerous goods training, or for more detailed review of the **Dangerous Goods Regulations** (DGR) published by IATA (1995). Dangerous goods training and/or information is available through FedEx (800-238-5355, Ext. 1666), IATA (800-716-6326), and HAZMATPAC (800-677-3210). This summary of IATA procedures includes the identification, packing, marking and labeling of packages, and the documentation of dangerous goods for shipment. It should be emphasized that these categories of dangerous goods handling and shipping are the responsibility of the **shipper**. Hypothetically, if you are a DAC/RAP responder sending oil-related samples considered dangerous goods to a laboratory via FedEx, you are considered the shipper. Carriers such as FedEx are considered dangerous goods **operators**, not shippers. To aid in the use of previously prepared shipping kits, please see the **Dangerous Goods Packing and Shipping Checklist** (Appendix 1).

IDENTIFYING DANGEROUS GOODS

Regardless of amount, oil related samples (including oiled sediments) are classified as dangerous goods unless the petroleum product's flash point (FP) is greater than 60.5°C (closed cup test) or 65.6°C (open cup test). FP will vary with oil type and degree of weathering. Examples of FPs reported for crude oil and various oil products are given in Table 1. FP values can vary significantly for the same type of oil or product. The responsible party will often have information on the FP of a particular spilled material. Several databases, including ADIOS, also have FP

TABLE 1. Flash points of selected oil types reported by Bobra (1989). Note: methods included various closed cup, open cup, unspecified tests.

OIL TYPE	FP(°C)
No. 2 fuel oil	38, 50, 91
No. 6 fuel oil	60, 66, 110
Marine Diesel Fuel	209
Prudhoe Bay Crude Oil...	
.....0 % weathered	30
.....7 % weathered	71
.....11 % weathered	84

information. Weathered oils generally lose their volatile fractions and many heavily weathered oils will not be classified as dangerous goods. The effect of weathering on FP (Bobra 1989) is described by the equation:

$$FP = FP_O (1 + C(WF))$$

where: FP_O = the FP of fresh oil (°C)
C = a constant related to the oil type
WF = the fraction of weathered oil

If it is determined that the oil under consideration has a flash point greater than the specified criteria, samples will not be considered dangerous goods. These may be packed and shipped using conventional practices and packaging. Materials with FP below the stated criteria are **Class 3** dangerous goods, or **flammable liquids**. Because of the emphasis on oil, Class 3 materials are the principal type of dangerous good considered here. Other Class 3 materials DAC/RAP personnel might ship would include laboratory substances such as solvents (acetone, hexane, pentanes). In addition, methyl chloride-methylene chloride mixtures (Class 2, Division 2.2, non-flammable gases), and acids such as hydrochloric acid (Class 8, corrosives) might also

be shipped by DAC/RAP personnel. Methods for packing and shipping dangerous materials not treated here are detailed in the DGR.

Section 4 of the DGR contains a **List of Dangerous Goods (LDG)**. The LDG alphabetically lists dangerous materials by their **proper shipping names** (see Appendix 2 for copies of selected pages). For each dangerous good, the LDG also lists a **United Nations (UN) identification number**, the dangerous goods **Class** or **Division**, the required **hazard label**(s), the **packing group**, a **packing instructions** code number, and the **maximum net quantity** of the dangerous good allowed per package.

The proper shipping names for oil related samples will generally include: Petroleum Crude Oil; Petroleum Distillates, N.O.S.; Petroleum Products, N.O.S.; or Flammable Liquid, N.O.S. The first three proper shipping names generally apply to samples of source oil. Flammable liquid, N.O.S. applies to sediment samples containing oil. Where N.O.S. (not otherwise specified) is used, a technical description in parentheses should follow the proper shipping name on packages and documentation. For example, a certain sample of oiled sediments should be listed on packages and shipping waybills as "Flammable Liquid, N.O.S. (mixture of sand and diesel fuel)". A distillate oil product such as No. 2 fuel oil should be listed as "Petroleum Distillate, N.O.S. (No. 2 fuel oil)".

Also of importance in identifying dangerous goods, the packing group **(PG)** refers to the degree of hazard or danger a particular material represents. PG is based on flammability for Class 3 dangerous goods (flammable liquids). The PG categories are: I (great danger); II (medium danger); and III (minor danger). Oil related samples fall into PG II or III. Distinction between PG II and III is based on FP. PG II applies if the FP is less than 23°C (c.c.), and PG III applies if the FP is equal to or greater than 23°C, but less than or equal to 60.5°C (c.c.). The PG influences the packing instructions and the maximum net quantity per package.

For small net quantities, a special distinction referred to as **Limited Quantity (LTD. QTY.)** may apply. The packing instruction code for limited quantities is listed just below the regular packing instructions for a particular material in the LDG (Example 1). The limited quantity packing instruction code always begins with a "Y", and both the packing instruction code and the maximum net quantity are printed in italics (e.g., *Y305/1L*). Dangerous goods shipped LTD. QTY have less stringent regulations concerning their packaging.

PACKING DANGEROUS GOODS

The packing instruction codes found in the LDG refer you to the corresponding instructions in Section 5 of the DGR. The packing instructions are basically a list of appropriate packaging (glassware, boxes, jerricans, drums, etc.) and packaging specifications for the dangerous goods under consideration. There are also general packing requirements (i.e., use and specifications concerning absorbent materials, tape, etc.) that apply to all dangerous goods packing.

Glassware is generally appropriate as an inner packaging for most oil related samples considered dangerous goods. The glass sampling jars and bottles commonly in use by DAC/RAP personnel generally meet DGR specifications. The outer packaging of choice are generally fiberboard boxes, especially in combination with an inner cooler or ice-chest since most samples will need to be kept frozen or cold for shipment. Dangerous goods packing requires the use of fiberboard boxes (or other packaging) which have been tested and UN certified. Dangerous goods shipped LTD. QTY. do not require certified packaging, but LTD. QTY. packaging must be able to withstand damage and wear to the same degree as similar certified packaging.

Complete packing kits are available in a variety of models and sizes from HAZMATPAC (1994). All HAZMATPAC packing materials meet DGR requirements and are certified (Wyle Laboratories, 1994). HAZMATPAC packages also have most of the marking and labeling requirements for dangerous goods already printed on the packaging (except for hazard labels). Complete instructions for packing are included with the HAZMATPAC kits. A typical kit contains: fiberboard box, inner cooler, 4 sampling jars and lids, fiberboard container and partitions for jars, plastic liners for jars and cooler, tape to seal jar lids, tape to seal box, and absorbent material.

MARKING AND LABELING PACKAGES

Marking and labeling are detailed in Section 7 of the DGR. For oil related samples, the proper shipping name, the UN identification number of the dangerous good, the name and address of the shipper, the name and address of the **consignee** (the final recipient of the package), and the UN certified packaging code must be marked on the package. The appropriate hazard label (flammable liquid) and two handling labels

for package orientation (2 "up" arrows) are also generally required. Goods shipped LTD. QTY. do not require the UN packaging certification code or hazard labels. However, limited quantity packages must be clearly marked "LTD. QTY.". Certified labels can be purchased from HAZMATPAC and FedEx. The "flammable liquid" hazard label is bright red with white lettering and symbols.

DOCUMENTATION OF DANGEROUS GOODS

Documentation of dangerous goods shipment is treated in Section 8 of the DGR. The original chain-of-custody forms should be sent with the samples. Copies of the chain-of-custody forms should be retained by the shipper and the operator. The consignee should be contacted in advance concerning shipment and the nature of any dangerous goods.

A **declaration of dangerous goods** is required for the shipment of dangerous materials. This form must be completed by the shipper. FedEx uses a Dangerous Goods Waybill, which is a combination of their usual airbill with a declaration of dangerous goods form. These can be ordered from FedEx. When shipping dangerous goods, FedEx charges an additional $10.00 fee per package.

Information generally required on the declaration includes the airport of departure, the airport of destination, whether the shipment is within the safety and quantity limitations for **passenger** or **cargo aircraft** (see LDG), the proper shipping name, the hazard class, the UN dangerous good identification number, the quantity (number of packages X the net quantity of dangerous good) and type of packaging (4G=fiberboard box), the packing instruction code and packing group, and any authorizations. The only authorizations likely to apply for oil-related samples is "LTD. QTY." In addition, U.S. regulations require the listing of an **emergency telephone number.**

REFERENCES

Bobra, M.A., 1989, A catalogue of crude oil and oil product properties: Unpublished report , Environmental Protection Directorate, Environment Canada, Ottawa, Ontario, 420 pp.

HAZMATPAC, 1994, Hazmatpac Certified Packaging Catalogue, HAZMATPAC, Inc., Houston, Texas, 48pp.

IATA, 1995, Dangerous Goods Regulations, 36th edition: IATA, Montreal, Quebec, 646pp.

Wyle Laboratories, 1994, Hazmatpac certification test report No. 43860-13: Wyle Laboratories, Huntsville, Alabama, 8pp.

Appendix 1.

Dangerous Goods Packing and Shipping Checklist

Dangerous Goods Packing and Shipping Checklist[1]

- ☐ UN-1507 (for 4 x 16 oz. or 1 L jars) and/or UN-1527 (9 x 8 oz. jars) HAZMATPAC shipping kits (includes fiberboard box, cooler, liner bags, inner fiberboard container and partitions, tape, absorbent, and instructions). Available from HAZMATPAC (phone: 800/923-9123). Kits for other sizes of sample containers are also available.
- ☐ Pre-cleaned sample jars, 1 case of 1 L glass jars with Teflon-lined lids and sample tags. Available from Eagle-Picher (phone: 800/331-7425).
- ☐ BLUE-ICE packs (Rubbermaid is one manufacturer). Available from Wal-Mart, K-Mart, Tackle Shops, Marine Supply Stores, etc.
- ☐ Hazard Labels for Flammable liquids, Class 3 (FL3). Available from HAZMATPAC in rolls of 500, L-850 (paper) or L-851 (vinyl), or from FedEx (phone: 800/238-5355, ext. 1666 for Dangerous Goods Department).
- ☐ Dangerous Goods Airbills. Available from FedEx.
- ☐ Copy of "IATA Packing and Shipping Requirements...". Available from RPI.
- ☐ Copies of Pages 148 and 189 from the **List of Dangerous Goods,** published in IATA's **1995 Dangerous Goods Regulations**. These pages give information for Petroleum crude oil, Petroleum distillates, N.O.S., Petroleum products, N.O.S., and Flammable liquids, N.O.S., which will be needed to complete the Dangerous Goods Airbill.
- ☐ If you do not have copies of the above two items, if a more recent version of the **Dangerous Goods Regulations** is applicable, or if you are shipping other types of dangerous goods (flammable solvents, corrosive chemicals, etc.) you will need the most recent copy of the **Dangerous Goods Regulations**. These are available from IATA (phone: 800/716-6326) or HAZMATPAC.

[1] This checklist applies for oil-related samples, based on information and regulations available and applicable for 1995. Please see the final item on the checklist first if the above stipulations do not apply.

Appendix 2.

Selections from Pages 148 and 189 of the 1995 List of Dangerous Goods

UN or ID No.	Proper Shipping Name/Description	Class or Division	Subsidiary Risk	Hazard Label(s)	PG	PASSENGER AIRCRAFT Pkg Instr.	PASSENGER AIRCRAFT Max Net Qty/ Pkge	CARGO AIRCRAFT ONLY Pkg Instr	CARGO AIRCRAFT ONLY Max Net Qty/ Pkge	Special Provisions see Subsect. 4.4
A	B	C	D	E	F	G	H	I	J	K
	Flammable gas (small receptacles not fitted with a dispersion device, not refillable), see Receptacles, small, containing gas, etc. (UN 2037)									
1993	**Flammable liquid, n.o.s. ***	3		Flammable liquid	I	302	1 L	303	30 L	A3
				Flammable liquid	II	305	5 L	307	60 L	
				Flammable liquid	II	*Y305*	*1 L*			
				Flammable liquid	III	309	60 L	310	220 L	
				Flammable liquid	III	*Y309*	*10 L*			
2924	**Flammable liquid, corrosive, n.o.s. ***	3	8	Flammable liquid & Corrosive	I	302	0.5 L	303	2.5 L	A3
				Flammable liquid & Corrosive	II	305	1 L	307	5 L	
					II	*Y305*	*0.5 L*			
				Flammable liquid & Corrosive	III	309	5 L	310	60 L	
					III	*Y309*	*1 L*			
	Flammable liquid preparations, n.o.s., see Flammable liquid, n.o.s. (UN 1993)									
△ 1992	**Flammable liquid, toxic, n.o.s. ***	3	6.1	Flammable liquid & Poison	I	Forbidden		303	30 L	A3
				Flammable liquid & Poison	II	305	1 L	307	60 L	
					II	*Y305*	*1 L*			
				Flammable liquid & Poison	III	309	60 L	310	220 L	
					III	*Y309*	*2 L*			
□ 3286	**Flammable liquid, toxic, corrosive, n.o.s. ***	3	6.1 8	Flammable liquid & Poison & Corrosive	I	Forbidden		303	2.5 L	
F				Flammable liquid & Poison & Corrosive	II	305	1 L	307	5 L	
					II	*Y305*	*0.5 L*			
△ 3180	**Flammable solid, corrosive, inorganic, n.o.s. ***	4.1	8	Flammable solid & Corrosive	II	415	15 kg	417	50 kg	A3
					II	*Y415*	*5 kg*			
				Flammable solid & Corrosive	III	419	25 kg	420	100 kg	
					III	*Y419*	*5 kg*			
△ 2925	**Flammable solid, corrosive, organic, n.o.s. ***	4.1	8	Flammable solid & Corrosive	II	415	15 kg	417	50 kg	A3
					II	*Y415*	*5 kg*			
				Flammable solid & Corrosive	III	419	25 kg	420	100 kg	
					III	*Y419*	*5 kg*			
3178	**Flammable solid, inorganic, n.o.s. ***	4.1		Flammable solid	II	415	15 kg	417	50 kg	A3
				Flammable solid	II	*Y415*	*5 kg*			
				Flammable solid	III	419	25 kg	420	100 kg	
				Flammable solid	III	*Y419*	*10 kg*			
1325	**Flammable solid, organic, n.o.s. ***	4.1		Flammable solid	II	415	15 kg	417	50 kg	A3
				Flammable solid	II	*Y415*	*5 kg*			
				Flammable solid	III	419	25 kg	420	100 kg	
				Flammable solid	III	*Y419*	*10 kg*			
3176	**Flammable solid, organic, molten, n.o.s. ***	4.1				Forbidden		Forbidden		A3
3097	**Flammable solid, oxidizing, n.o.s. ***	4.1	5.1			Forbidden		Forbidden		A3
△ 3179	**Flammable solid, toxic, inorganic, n.o.s. ***	4.1	6.1	Flammable solid & Poison	II	415	15 kg	417	50 kg	A3
					II	*Y415*	*1 kg*			
				Flammable solid & Poison	III	419	25 kg	420	100 kg	
					III	*Y419*	*10 kg*			
2926	**Flammable solid, toxic, organic, n.o.s. ***	4.1	6.1	Flammable solid & Poison	II	415	15 kg	417	50 kg	A3
					II	*Y415*	*1 kg*			
				Flammable solid & Poison	III	419	25 kg	420	100 kg	
					III	*Y419*	*10 kg*			
0420	**Flares, aerial †**	1.1G				Forbidden		Forbidden		
0421	**Flares, aerial †**	1.2G				Forbidden		Forbidden		
0093	**Flares, aerial †**	1.3G		Explosive		Forbidden		151	75 kg	
0403	**Flares, aerial †**	1.4G		Explosive 1.4		Forbidden		151	75 kg	
0404	**Flares, aerial †**	1.4S		Explosive 1.4		151	25 kg	151	100 kg	

	UN or ID No.	Proper Shipping Name/Description	Class or Division	Subsidiary Risk	Hazard Label(s)	PG	PASSENGER AIRCRAFT Pkg Instr.	PASSENGER AIRCRAFT Max Net Qty/ Pkge	CARGO AIRCRAFT ONLY Pkg Instr	CARGO AIRCRAFT ONLY Max Net Qty/ Pkge	Special Provisions see Subsect. 4.4
	A	B	C	D	E	F	G	H	I	J	K
□	0411	PETN with not less than 7% wax, by weight	1.1D				Forbidden		Forbidden		
		PETN/TNT, see Pentolite, etc. (UN 0151)					Forbidden		Forbidden		
Δ	1203	Petrol	3		Flammable liquid	II	305	5 L	307	60 L	A100
					Flammable liquid	II	*Y305*	*1 L*			
	1267	Petroleum crude oil	3		Flammable liquid	II	305	5 L	307	60 L	A3
					Flammable liquid	II	*Y305*	*1 L*			
					Flammable liquid	III	309	60 L	310	220 L	
					Flammable liquid	III	*Y309*	*10 L*			
Δ	1268	Petroleum distillates, n.o.s.	3		Flammable liquid	I	302	1 L	303	30 L	A3
					Flammable liquid	II	305	5 L	307	60 L	
					Flammable liquid	II	*Y305*	*1 L*			
					Flammable liquid	III	309	60 L	310	220 L	
					Flammable liquid	III	*Y309*	*10 L*			
Δ		Petroleum ether, see Petroleum distillates, n.o.s. (UN 1268)									
	1075	Petroleum gases, liquefied	2.1		Flammable gas		Forbidden		200	150 kg	A1
Δ		Petroleum naphtha, see Petroleum distillates, n.o.s. (UN 1268)									
Δ		Petroleum oil, see Petroleum products, n.o.s. (UN 1268)									
□	1268	Petroleum products, n.o.s.	3		Flammable liquid	I	302	1 L	303	30 L	A3
					Flammable liquid	II	305	5 L	307	60 L	
					Flammable liquid	II	*Y305*	*1 L*			
					Flammable liquid	III	309	60 L	310	220 L	
					Flammable liquid	III	*Y309*	*10 L*			
		Petroleum raffinate, see Petroleum distillates, n.o.s. (UN 1268)									
Δ		Petroleum spirit, see Petroleum distillates, n.o.s. (UN 1268)									
	2645	Phenacyl bromide	6.1		Poison	II	613	25 kg	615	100 kg	
					Poison	II	*Y613*	*1 kg*			
Δ	2311	Phenetidines	6.1		Poison	III	611	60 L	618	220 L	
					Poison	III	*Y611*	*2 L*			
□	2904	Phenolates, liquid	8		Corrosive	III	818	5 L	820	60 L	
					Corrosive	III	*Y818*	*1 L*			
□	2905	Phenolates, solid	8		Corrosive	III	822	25 kg	823	100 kg	
					Corrosive	III	*Y822*	*5 kg*			
	2312	Phenol, molten	6.1				Forbidden		Forbidden		
	1671	Phenol, solid	6.1		Poison	II	613	25 kg	615	100 kg	
					Poison	II	*Y613*	*1 kg*			
Δ	2821	Phenol solution	6.1		Poison	II	609	5 L	611	60 L	A3
					Poison	II	*Y609*	*1 L*			
					Poison	III	611	60 L	618	220 L	
					Poison	III	*Y611*	*2 L*			
	1803	Phenolsulphonic acid, liquid	8		Corrosive	II	609	1 L	813	30 L	
					Corrosive	II	*Y809*	*0.5 L*			
Δ	2766	Phenoxy pesticide, liquid, flammable, toxic, * flash point less than 23°C	3	6.1	Flammable liquid & Poison	I	Forbidden		303	30 L	
					Flammable liquid & Poison	II	305	1 L	307	60 L	
						II	*Y305*	*1 L*			
Δ	3000	Phenoxy pesticide, liquid, toxic *	6.1		Poison	I	603	1 L	604	30 L	A4
					Poison	II	609	5 L	611	60 L	A6
					Poison	II	*Y609*	*1 L*			
					Poison	III	611	60 L	618	220 L	
					Poison	III	*Y611*	*2 L*			

APPENDIX 6

Field Forms and Codes

Sketch

Trench

Wildlife Observation

Percent Cover Estimator

Shoreline Survey Evaluation Form and Codes

Photo Log

Video Log

Chain-of-Custody

SKETCH MAP

11/05/92

Segment Name_____
Segment No._____
Date_____
Names_____

Checklist

__North Arrow
__Scale
__Oil Distribution
__High-Tide Line
__Low-Tide Line
__Substrate Types
__Trench Locations

Legend

1Δ
Trench Number.
No Subsurface Oil

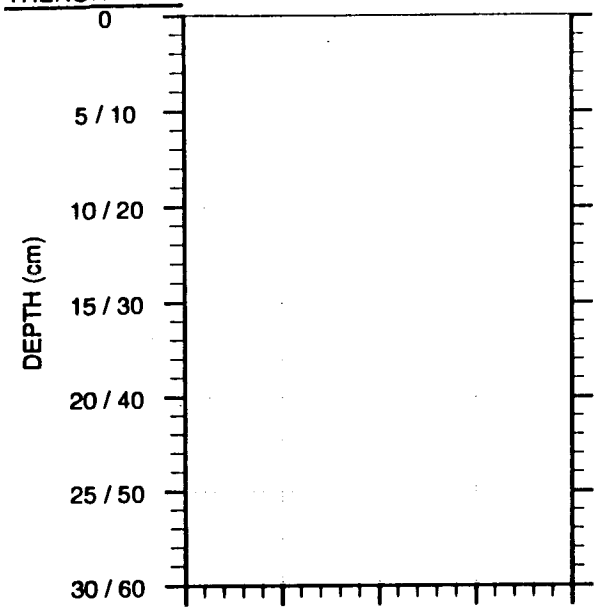
2▲
Trench Number.
Subsurface Oil

TRENCH DESCRIPTION FORM

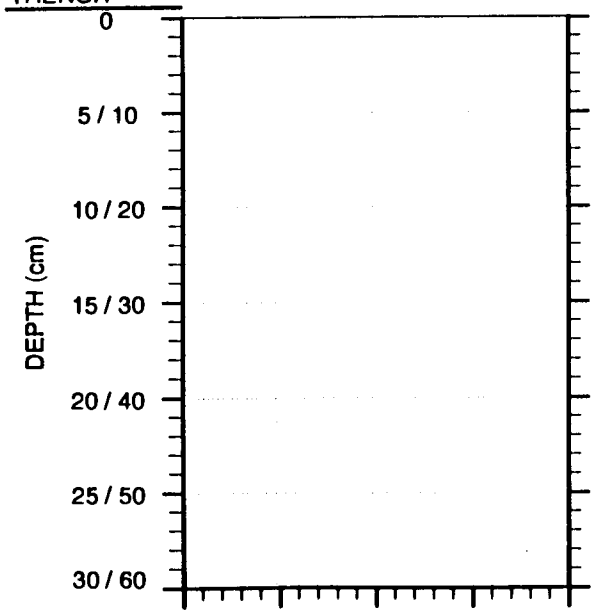
STATION _____ DATE _____ RECORDERS _____

SAMPLES TYPE/ INTERVAL/ NUMBER		PHOTOS	
TR -		TR -	
TR -		TR -	
TR -		TR -	

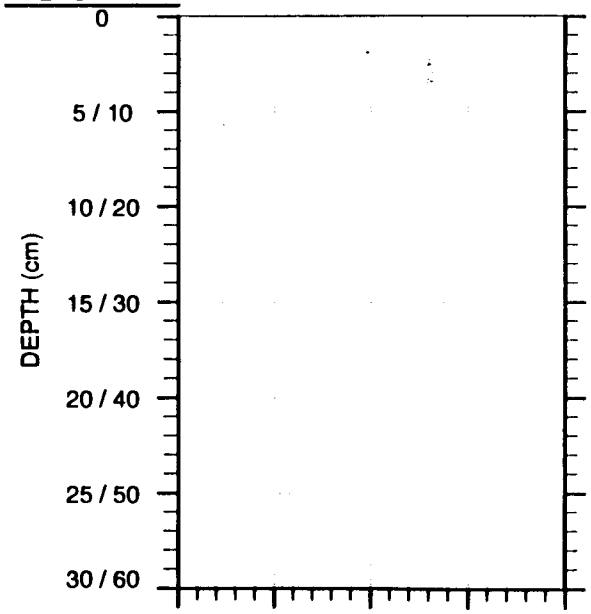
TRENCH - _____ OIL _____ SEDIMENTS (Ø SIZE) _____



TRENCH - _____ OIL _____ SEDIMENTS (Ø SIZE) _____



TRENCH - _____ OIL _____ SEDIMENTS (Ø SIZE) _____



OIL SPILL WILDLIFE OBSERVATION RECORD

DATE: _____ TIME: _____ OBSERVER: _____

AGENCY/ADDRESS: _____

_____

SURVEY MODE: _____ PHONE: _____

WIND DIRECTION, SPEED: _____ WEATHER/VISIBILITY: _____

AREA SURVEYED: _____

_____

TYPE OF DOCUMENTATION: _____

WILDLIFE OBSERVED:	SPECIES 1	SPECIES 2	SPECIES 3
SPECIES:	_____	_____	_____
TOTAL NUMBERS: (count/estimate)	_____	_____	_____
NUMBER OILED: (count/estimate)	_____	_____	_____
DEGREE OILING:	_____	_____	_____
	_____	_____	_____
	_____	_____	_____
NUMBER UNOILED: (count/estimate)	_____	_____	_____
NUMBER COLLECTED:	_____	_____	_____

(USE ADDITIONAL SHEETS FOR MORE SPECIES)

OIL IN AREA: _____ LOCATION OF OIL: _____

AMOUNT OR AREA OF OIL: _____

LOCATION OF WILDLIFE IN RELATION TO OIL: _____

_____

BEHAVIOR OF WILDLIFE _____

_____

_____

OTHER COMMENTS: _____

_____

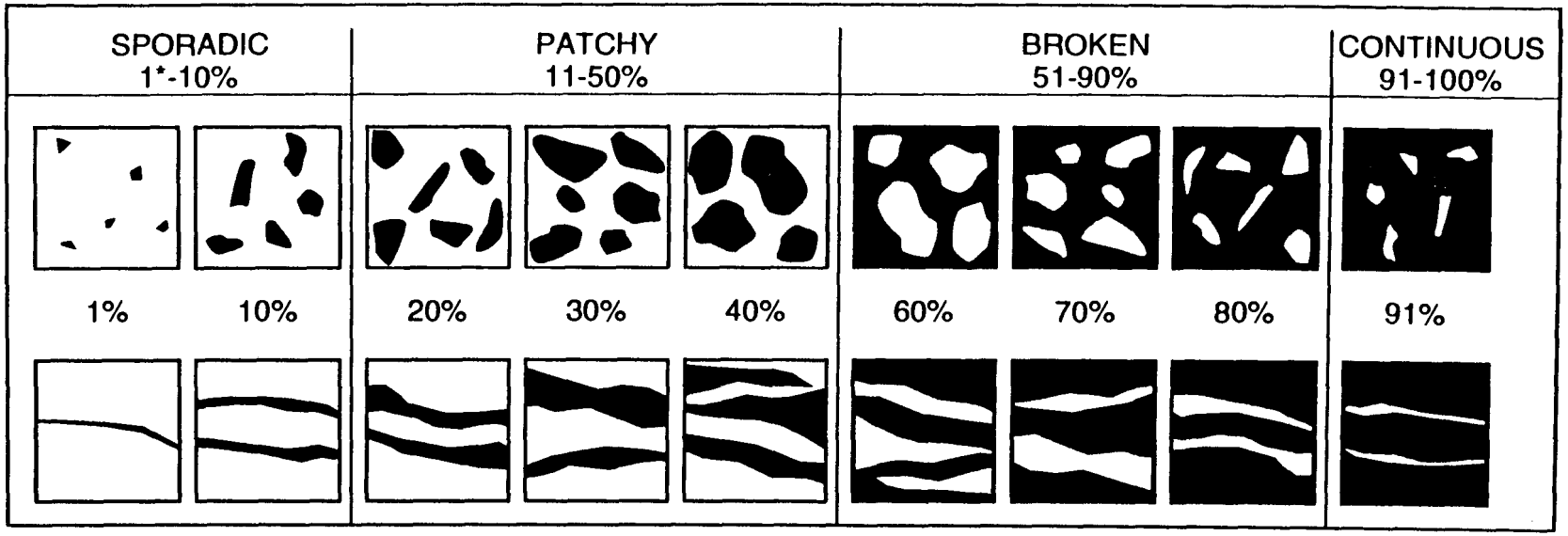
_____

PLEASE RETURN TO: FOR QUESTIONS PLEASE CALL:

_____ _____

_____

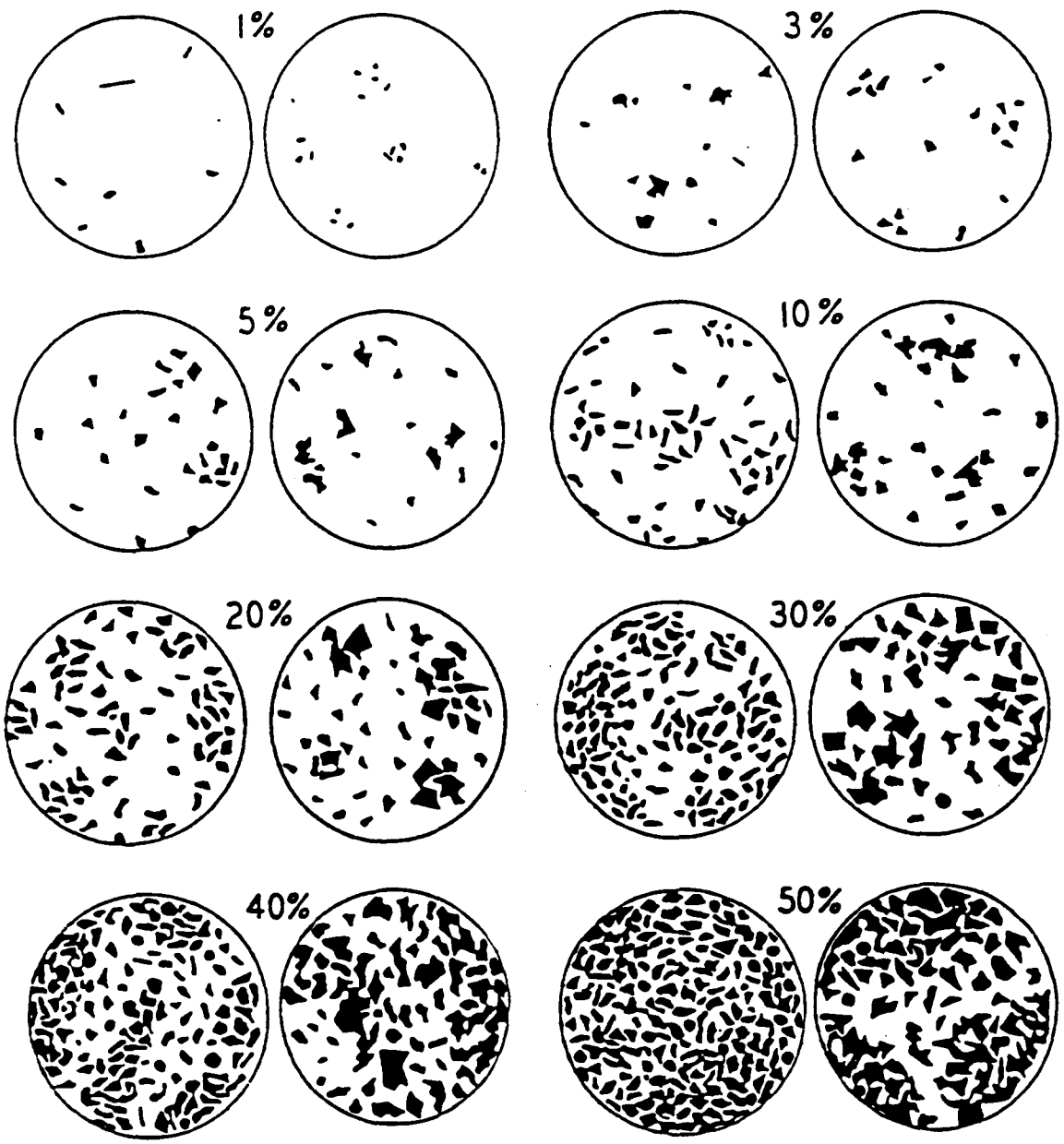
OIL COVER ESTIMATION CHART



*TRACE = <1%

Grain Scales: cont.

Comparison Chart For Visual Percentage Estimation (After Terry and Chilingar, 1955).



SHORELINE SURVEY EVALUATION FORM Page __ of __

1	G	Segment Name:	Date:
	E	Segment ID:	Time: to
	N	Surveyed From: Foot / Boat / Helicopter/Overlook	

2	T	Team No.			
	E	Name:	for:	Name:	for:
	A	Name:	for:	Name:	for:
	M	Name:	for:	Name:	for:

3	L	Shoreline Types:
	A	Sediment Types:
	N	Location Description:
	D	Access Restrictions:

4 **Description of oiling conditions** _ Oil Length _ Width _ Type/Thickness _ Substrate Type

SURFACE OIL: _ Oiled Debris

SUBSURFACE OIL: _ Extent _ Thickness Clean _ Thickness Oiled _ Intertidal Location
_ Sediment Type _ Oil Description _ Burial _ Penetration

5 **Segment-specific considerations for cleanup operations**
_ Environmental _ Cultural _ Degree of Recreational Use

6 **COMMENTS**

SHORELINE OIL TERMINOLOGY/CODES 1/11/94

Oil Distribution

C	Continuous	91 - 100%
B	Broken	51 - 90%
P	Patchy	11 - 50%
S	Sporadic	<1 - 10%
T	Trace	<1%

Surface Oiling Descriptors - Thickness

PO	Pooled Oil (fresh oil or mousse > 1 cm thick)
CV	Cover (oil or mousse from >0.1 cm to <1 cm on any surface)
CT	Coat (visible oil <0.1 cm, which can be scrapped off with fingernail)
ST	Stain (visible oil, which cannot be scrapped off with fingernail)
FL	Film (transparent or iridescent sheen or oily film)

Surface Oiling Descriptors - Type

FR	Fresh oil (unweathered, liquid oil)
MS	Mousse (emulsified oil occurring over broad areas)
TB	Tarballs (discrete accumulations of oil <10 cm in diameter)
PT	Patties (discrete accumulations of oil >10 cm in diameter)
TC	Tar (highly weathered oil, of tarry, nearly solid consistency)
AP	Asphalt Pavements (cohesive, heavily oiled surface sediments)
NO	No Oil

Subsurface Oiling Descriptors

Sand

SL	Single Layer (a layer of oiled sand extending from the surface or buried by a layer of clean sand)
ML	Multiple Layers (multiple layers of clean and oiled sand)
OF	Oil Film (sediments are lightly oiled with an oil film or stain on the sand)

Gravel

OP	Oil-Filled Pores (pore spaces are completely filled with oil, to the extent that the oil flows out of the sediments when disturbed)
OR	Oil Residue (sediments are visibly oiled with black/brown coat or cover on the clasts)
TR	Trace (discontinuous film or spots of oil, or an odor or tackiness)
NO	No Oil (no evidence of any type of oil)

Sediment Types

R	Bedrock outcrops	B	Boulder (>256 mm in diameter)
C	Cobble (64-256 mm	P	Pebble (4-64 mm)
S	Sand (0.06-2 mm)	M	Mud (silt and clay, < 0.06 mm)
RR	Riprap	SW	Seawalls

Degree of Oil Category

H	Heavy	> 10 feet wide continuous band
M	Medium	> 3 feet to ≤ 10 feet continuous or broken band
L	Light	> 1 foot to ≤ 3 feet band of any type; multiple oil swash lines
VL	Very Light	≤ Sporadic tarballs

NOAA DAMAGE ASSESSMENT CENTER
VIDEOTAPE LOG

1305 East West Highway, Silver Spring Md. 20910
For more information contact Doug Helton
301-713-3038 x 197 or fax 301-713-4387

Project_____ **Photographer**_____

Location(s) _____ **Date(s)** _____

Cassette Type_____ **Tape #**_____ **Length (min.)**_____

Description: ***(Including: Primary purpose of video, general description of contents, detailed locations (attach map if possible), important landmarks, time of day, weather conditions, tide stage, corresponding still photographs and notes. If overflight: Aviation company, name of pilot, aircraft type, flight path (attach map if possible), altitude(s) flown, etc.)***

Signature: _____ **Date:**_____

NOAA DAMAGE ASSESSMENT CENTER
PHOTOGRAPHIC LOG

1305 East-West Hwy, Rm 10218 Silver Spring Md. 20910
For more Information contact Doug Helton
301-713-3038 or fax 301-713-4387

Project_____ **Photographer**_____

Film Type_____ **Roll #**_____ **Date Processed**_____

Notes_____

Date	Frame #	Location	Description
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		
	21		
	22		
	23		
	24		

Date	Frame #	Location	Description
	25		
	26		
	27		
	28		
	29		
	30		
	31		
	32		
	33		
	34		
	35		
	36		
	37		
	38		
	39		
	40		

NOAA DAMAGE ASSESSMENT CENTER
CHAIN OF CUSTODY FORM

1305 East-West Hwy, Rm 10218, Silver Spring, MD. 20910
For more information contact Douglas Helton
301-713-3038 x 197 or fax 301-713-4387

Project_____ **Sampler**_____

Sample I.D. #	Date Collected	Location	Sample Type (Tissue, oil, water. Include species name and tissue type)	Comments:

Collected by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

* If shipped, include carrier name and copy of shipping invoice

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

Relinquished by: *(signature)*	Received by: *(signature)*	Condition:	Date/Time

* If shipped, include carrier name and copy of shipping invoice

Chain of Custody Procedures

BACKGROUND

The NOAA Damage Assessment Center (DAC) has established chain of custody procedures for those personnel collecting field data. This document is a record of the methods used to handle samples collected for the damage assessment process, which may become evidence in a court of law. It is important that each member of the field team understands the basic custody requirements- take the time to go over the various labels and forms and make sure that team members understand how to fill them out.

The procedures outlined in this document represent one acceptable method. The failure in any particular instance to follow one or more of the steps listed here does not necessarily render evidence either inadmissible or unusable.

DEFINITION OF CUSTODY

"Chain-of-custody" procedures are followed to "authenticate" a sample from the time it is taken until the results are introduced as evidence into court. A sample is in your "custody" when:

1. It is in your actual physical control and presence.

2. It is in your view.

3. It is not in your physical presence but is secure in a place of storage to which only you have access.

4. It is not in your view or physical presence but is secured in a place of storage to which only you and identified others have access.

SAMPLE COLLECTION

1. As few people as possible should handle the sample from its taking through laboratory analysis.

2. Samples tags should be used to identify each sample. These are filled out in water-proof ink and attached to the sample container at the time the complete sample is collected. The tags should contain the following information: sample ID #, contents, time/date of collection, location, and collector.

3. Field Data Record logbooks with numbered pages should be used to record field measurements and other pertinent information. These notes will be used to refresh the sample collector's memory in the event he/she later testifies regarding his/her actions. Data entered in the logbooks or forms are recorded with ball-point pen or waterproof ink. Each page is signed by the sample collector and any available witness. The preparation

and custody of the logbooks during the survey are the responsibility of the survey coordinator. Once the survey is complete, field data logbooks and data forms are to be retained by the survey coordinator or a designated representative. Any errata in entries should be lined out with a single line and initialed and dated so a later reader can read what was written before the correction.

4. The sample collector is responsible for the care and custody of the samples until they are properly dispatched to the receiving laboratory or turned over to an assigned custodian or courier. The sample collector must assure that each sample is in his/her "custody" so no one can tamper with it.

5. If colored slides, photographs, or other related evidence are obtained to show the impact of the pollutant or substantiate any other conclusions of the investigations, the following documentation should be on the back of the photo, the field data logbook, or photolog form: incident, time, date, site location, description, and the name and signature of the photographer. Film or other materials of this nature which may be used as evidence, should be handled using chain-of-custody procedures.

TRANSFER OF CUSTODY AND SHIPMENT

1. Collected samples must be accompanied by the original chain-of-custody form. A copy of the chain-of-custody form should be kept by the field or project coordinator. When turning over the possession of a part or all of the samples to a field analysis station or to a laboratory, the transferor and transferee should sign and record the time and date on the sheet.

2. Samples are to be packed and sealed for shipment in appropriate containers to avoid damage. A sample seal should be attached across the lid of each shipping container in such a manner that the container cannot be opened without breaking the seal. This lock and/or seal is not to be removed until the shipping container is opened by the laboratory custodian or a designee.

3. If sent by mail, the package is sent via Registered Mail with Return Receipt Requested. If sent by common carrier, all shipping receipts should be retained as part of the permanent chain-of-custody documentation.

4. Couriers picking up samples at the airport, post office, etc., should sign the shipping documents to acknowledge receipt of the samples.

LABORATORY CUSTODY PROCEDURES

The following procedures should be followed regarding the handling and custody of samples in the laboratory. In any given instance, an assistant may perform any item indicated below, but a record should be made of the assistant's participation.

1. A designated custodian should:

a. Accept and receive custody of the shipped samples.

b. Record the physical condition of the shipping container noting any broken seals or indications of any tampering.

c. Open the shipping container (and at his/her option saving or not saving any seals or stickers on that container).

d. Cross-check and verify the information on the chain-of-custody receipt with the tags or other markings on the sample containers.

e. Make appropriate entries in the chain-of-custody receipt making sure the identity of the courier is reflected.

f. Enter or have an assistant enter the information contained on the sample tags and/or markings on the field data sheet and on the analysis requested sheet, into a bound logbook.

g. Place all of the received samples in an appropriate storage area which is capable of being secured against access whether or not the access to the building is secured.

2. A designated person should routinely be in charge of distributing samples to the appropriate analysts, or each analyst should be in charge of collecting his/her samples from the storage area. In any event, the person performing that activity should be identified in the analysis records for each sample.

3. When not needed or being used in the laboratory for analysis, the unused portion of the sample should be returned to its storage area.

4. All identifying tags, seals, or stickers from the sample container should be retained with the analysts notes and other analysts documents.

5. Each analyst is responsible for the care and custody of each sample received by him/her for analysis form the time of receipt until the sample is exhausted or returned to its storage area. Samples should be returned to a storage area by the analyst who analyzed the sample, and the analysts' records for the sample should record any deviation from that practice.

6. The laboratory director should obtain authorization from the project coordinator and case attorney for sample disposal for civil cases. No criminal cases samples are to be disposed of until the case is closed and all appeals have been heard. The prosecuting attorney must be consulted prior to disposal of any evidence for criminal cases.

LABORATORY DOCUMENTATION

The procedures generally recognized by professional chemists and laboratories for documenting their work are acceptable for documentation in laboratories contracted by DAC for damage assessment work.

All sample data, laboratory observations, and calculations will be recorded in logbooks or in bench sheets. Each lab document should, on its first page, reflect the project number, date of composing, names of analysts and assistants participating, and any other information concerning the identity of the sample analyzed. Any document reflecting results of analysis should have similar identifying data on the first page. Charts or printouts from instrumentation, graphs, and similar "display" type documents should have similar identifying information affixed to them. Both draft and smooth copies of any such documents should be retained as part of the lab documentation.

Correspondence, report notes, methods, references, sample inventories, checkout logs, etc. should be part of the permanent lab records.

Any logbook or bench sheet needs to contain (1) clear identification of who made what entries on the same, and (2) information sufficient to enable the entry-maker to recall and describe each step of the analysis performed. The analyst and his/her assistants may be called upon to testify in subsequent legal proceedings about the analysis performed and results obtained. Also, procedures followed if it became necessary for that to be done. Irregularities (if any) observed during the analytical process should be noted. If, in the professional judgment of the analyst, a deviation from a particular analytical method is advisable or used, the deviation should be described and the reasons for that deviation should be recorded.

Logbooks or comparable permanent records must be kept which reflect each instance in which lab instruments or instrumentation are calibrated. Such records are the very foundation of the later analytical work performed, and are critical in any later legal proceeding.

Any continuous monitoring records (e.g. charts showing temperatures of storage cabinets where some samples are stored) should be kept for some years.

Before a final lab report is sent out, the lab personnel will assemble and cross-check information on sample tags, custody records, bench sheets, analysts' logbooks and/or notes, and in any relevant permanent records to ensure that data pertaining to each particular sample is consistent throughout all lab documents.

APPENDIX 7

Central California Oil Spill Contingency Plan - Assessment of Numbers and Species Composition of Dead Beached Birds

NOAA Technical Memorandum

NOS MEMD 25

Central California Oilspill Contingency Plan

Assessment of Numbers and Species Composition of Dead Beached Birds

Harry W. Carter and Gary W. Page

Point Reyes Bird Observatory

4990 Shoreline Highway

Stinson Beach, California 94970

Prepared for:

The Gulf of the Farallones National Marine Sanctuary, San Francisco, CA and the Marine and Estuarine Management Division,Washington, D.C.

March 1989

National Marine Sanctuary Program
Marine and Estuarine Management Division
Office of Ocean and Coastal Resource Management
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

NOTICE

This report has been approved by the National Ocean Service of the National Oceanic and Atmospheric Administration (NOAA) and approved for publication. Such approval does not signify that the contents of this report necessarily represent the official position of NOAA or of the Government of the United States, nor does mention of trade names or commercial products constitute endorsement or recommendation for their use.

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ACKNOWLEDGEMENTS

This report was funded by Contract No. CA 8006-4-0002 with the Marine and Estuarine Management Division of NOAA. N. Stone and M. Croom of the Gulf of the Farallones National Marine Sanctuary were instrumental in the development of this report and have extensively reviewed it. The Point Reyes Bird Observatory provided additional support. We thank L. E. Stenzel for helpful comments on earlier drafts of the manuscript, and E. Tuomi, S. Goldhaber, and M. Simonds for editing and typing. The California State Automobile Association, Erickson Maps, and Compass Maps granted permission for the duplication and use of their maps in this report. This is Contribution No. 384 of the Point Reyes Bird Observatory.

ABSTRACT

A detailed plan for assessing the numbers and species composition of dead birds that come ashore after oil spills in central California is developed by the Point Reyes Bird Observatory for the Gulf of the Farallones National Marine Sanctuary. The plan relies on carefully conducted counts of dead oiled birds on a prescribed set of beach segments to derive reliable estimates of the total number of dead oiled birds along the total shoreline in each of 8 coastal regions between Salmon Creek, Sonoma County, and Point Lobos, Monterey County. Regional plans include descriptions, maps, and access for beach segments plus suggestions for efficient censusing under different oilspill scenarios. The plan could provide reliable data for type B oilspill damage assessments for marine birds in central California under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

INTRODUCTION

Damages to marine bird populations are the most visible and permanent impacts to the marine ecosystem from oil spills. These damages are assessed initially by estimating the numbers of each species that are debilitated or killed. Numbers must be estimated as accurately as possible because: 1) accuracy permits the best evaluation of the impact of the specific mortality incident, in concert with other incidences, on bird populations over time; and 2) settlements awarded for damages are often proportional to the numbers of birds that are debilitated or killed at the time of the oil spill incident.

Point Reyes Bird Observatory (PRBO) has undertaken damage assessments for marine birds during the 1984 **Puerto Rican** and 1986 **Apex Houston** oil spills in central California (PRBO 1985; Page and Carter 1986; Ford et al. 1987) and has conducted a long-term beached bird program throughout California from 1971 to 1985 (Ainley et al. 1980, Page et al. 1982, Stenzel et al. 1988). From this extensive experience, we have established a specific procedure for oilspill damage assessment for seabirds in central California that provides three components to the estimate for numbers of each species impacted. These are:

1. **Live oiled birds recovered from beaches and sent to rehabilitation centers for treatment;**
2. **Dead oiled birds that washed ashore;**
3. **Dead oiled birds that did not wash ashore.**

Numbers of live oiled birds are estimated from tallies of records kept at rehabilitation and/or beach collection centers, provided that adequate records are maintained (see Carter et al. 1987 for suggestions). Numbers of dead oiled birds that did not wash ashore are estimated through the use of a computer model that integrates documented movements of oil slicks at sea with the distribution and abundance of marine birds in affected ocean areas. Numbers of dead oiled birds that washed ashore are estimated from beached bird censuses. This estimate has been the focus of most of PRBO's research efforts and is the theme of this report. Our use of beached bird censuses for damage assessment purposes requires sophisticated, coordinated, and large-scale counts of beached carcasses in order to derive reliable estimates. It is the objective of this contingency plan to provide a reliable and detailed method for estimating the total number of dead beached birds in the event of an oil spill.

The urgent need for this contingency plan already has been demonstrated during the **Puerto Rican** and **Apex Houston** oil spills where initial responses by state agencies were limited solely to the "rescue" of live oiled birds and their transportation to and care at rehabilitation centers. San Francisco Bay is a major oil refining center for crude oil tankered from Alaska and transported to and from southern California. In addition, outer continental shelf (OCS) oil development is proposed for the near future in northern California (Lease Sale 91, February 1989) and central California (Lease Sale 119, 1991). Oil from Californian tracts is proposed to be tankered to San Francisco Bay for refining. Thus, the frequency of oil spills is expected to increase along the central California coast, further emphasizing the urgent need for this contingency plan.

Design and contents of the contingency plan

This contingency plan covers the entire outer coast of central California between Salmon Creek, Sonoma County, and Point Lobos, Monterey County. Most estuaries within this area (i.e., Bodega Harbor, Drake's Estero, Bolinas Lagoon, San Francisco Bay, and Elkhorn Slough) are not included in the plan; only Tomales Bay is included. Most of the shoreline covered in the plan is accessible by road. We have developed the contingency plan on a land-based reconnaissance system involving teams

of beached bird counters that cover a series of pre-defined **beach segments** within eight different **regions** of the coast.

This report is divided into two parts: 1) general information on census procedures and analysis of results; and 2) specific plans for beached bird censuses in eight central California regions. Regional plans include descriptions, maps, and directions for all beach segments in each region, as well as suggestions for efficient censusing under different oilspill scenarios. Depending on the extent of an oil spill and specific areas of the coast where oiled birds are expected to come ashore, one or any combination of the regional plans could be activated.

We have designed this contingency plan in a way that provides for: 1) efficient and detailed data collection; 2) reliable estimates of the numbers of dead oiled birds under different oilspill scenarios; and 3) modification of methods of data analysis as experience dictates. In fact, each spill should be regarded as a learning experience for the refinement of data collection techniques, data analyses, and the precision of final estimates. In particular, we need to learn more about the patterns of carcass deposition on beaches and the persistence of beached carcasses under various environmental conditions. This information will enable us to further evaluate the validity and sensitivity of final estimates to currently unknown sources of bias. Thus, this contingency plan is based on the best available information on the use of beached bird censuses in oilspill damage assessments and, at the same time, acts to investigate and perfect this technique over time.

BACKGROUND INFORMATION

HOW TO CONDUCT A BEACHED BIRD CENSUS

The objective of a beached bird census is to obtain an exact count of all the dead and live injured birds along a beach segment on a specific day. Live birds are usually more conspicuous than carcasses on the beach surface, but they sometimes move to less conspicuous locations just above the beach where they can be overlooked. Since carcasses may be partially covered by sand, kelp, wood or other debris, and may be located anywhere on the beach (above, on, and below the high tide line), a beached bird counter must search carefully, often with much zig-zagging, to avoid missing carcasses. This requires much more time than a simple walk at a leisurely pace. A pair of seven or eight power binoculars can reduce the time needed to cover a beach segment since suspicious-looking objects can be checked from a distance.

The beached bird counter must possess skill in identifying aquatic birds. The ability to identify live aquatic birds is a very helpful aid for identifying dead beached birds. Many dead birds will be decomposed, heavily scavenged, or, in the case of a spill, covered with oil, consequently, they often appear much less familiar than their living representatives. Some of the important clues to carcass identification come from the size and shape of the bill, feet, and body, and the pattern of feathering on the wing. Along the California coast, it is not uncommon to find carcasses of three species of loons, four species of grebes, three species of cormorants, the Brown Pelican, the Sooty Shearwater, the Northern Fulmar, two species of scoters, the Red Phalarope, eight species of gulls and four species of alcids (Table 1). An ability to identify carcasses of these species is a minimum requirement for a beached bird counter. Observers who are not confident of their ability to identify all of these species should carry a standard avian field guide with them.

Minimum data to be recorded for each census are: beach name and location; date; and the name and address of the person(s) making the observation. For each carcass, minimum data are: species; age and sex (when possible); evidence for cause of death (especially the presence of oil on the plumage); the stage of decomposition; and evidence of scavenging. This information is recorded most accurately on a pre-prepared beached bird census form such as the one illustrated in Table 2. It is best to fill out the form in pencil when in the field because pen ink can run and smear if wetted. It is also useful to take several pencils on a census in case of loss or breakage.

Location, date, and observer

The location, date, and observer are usually recorded once at the top of the census form (Table 2). The boundaries of the beach should always be recorded since they more precisely define the length of beach covered than the beach name. The names, addresses, and phone numbers of the observers are valuable for later contact if questions arise about some aspect of the census; observer information should be recorded on the back of the form. Any unusual conditions encountered are also important to note (e.g., oil on beach; a heavy cover of debris on beach possibly causing missed carcasses; possible intervention by people burying or piling up carcasses, etc.).

Species identification

The beached bird counter should never guess at the species' identity of a carcass. Where uncertainty exists between two species, identification can be recorded as being either species (for example, Red-throated/Pacific Loon). Other possible categories for uncertain identifications are gull species or murrelet/auklet species. If this is not possible, record the carcass as "unknown species" and make a brief description on the back of the census form.

Table 1. Common bird species encountered on beached bird censuses in central California (data from Stenzel et al. 1988).

Common Name	Scientific Name	Species Abbreviation
Common Loon	Gavia immer	COLO
Pacific Loon	G. arctica	PALO
Red-throated Loon	G. stellata	RTLO
Horned Grebe	Podiceps auritus	HOGR
Eared Grebe	P. caspicus	EAGR
Western Grebe	Aechmophorus occidentalis	WEGR
Clark's Grebe	A. clarksii	CLGR
Northern Fulmar	Fulmarus glacialis	NOFU
Sooty Shearwater	Puffinus griseus	SOSH
Brown Pelican	Pelecanus occidentalis	BRPE
Double-crested Cormorant	Phalacrocorax auritus	DCCO
Brandt's Cormorant	P. penicillatus	BRCO
Pelagic Cormorant	P. pelagicus	PECO
White-winged Scoter	Melanitta deglandi	WWSC
Surf Scoter	M. perspicillata	SUSC
Red Phalarope	Phalaropus fulicarius	REPH
Glaucous-winged Gull	Larus glaucescens	GWGU
Western Gull	L. occidentalis	WEGU
Herring Gull	L. argentatus	HEGU
California Gull	L. californicus	CAGU
Ring-billed Gull	L. delawarensis	RBGU
Mew Gull	L. canus	MEGU
Heermann's Gull	L. heermanni	HEEG
Black-legged Kittiwake	Rissa tridactyla	BLKI
Common Murre	Uria aalge	COMU
Ancient Murrelet	Synthliboramphus antiquus	ANMU
Cassin's Auklet	Ptychoramphus aleuticus	CAAU
Rhinoceros Auklet	Cerorhinca monocerata	RHAU

Table 2. BEACHED BIRD CENSUS FORM

Page No. of

Date:_____ Beach Segment No:_____ Segment Name:_____

N. Boundary:_____ S. Boundary:_____

General beach condition/weather/census remarks:_____

Toe clip pattern:_____

Observers: 1_____ 2_____

Bird No.	Species Name	Condition	Age	Sex	Oiled?	Oil type	Oil extent	Where oiled	Scav.?	Toes Clipped?	Cause of death
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											

CODES:

Condition: O (alive-active); 1 (alive-unresponsive); 2 (fresh dead); 3 (decomposing); 4 (dried bones/feathers); U (unknown).
Age: HY, AHY, FY, SY, TY, etc. (hatching, after-hatching, first, second, third year, etc.); IM (immature); AD (adult); U (unknown).
Sex: F (female); M (male); U (unknown).
Oiled: Y (yes); N (no); U (unknown).
Oil type: 1 (heavy); 2 (light); 3 (sheen only); 4 (smell only); U (unknown).
Oil extent: 1 (small globules, <2% of body); 2 (2-33% of body); 3 (33-66% of body); 4 (66-100% of body).
Where oiled: 1 (dorsal only); 2 (ventral only); 3 (entire body); 4 (head only); 5 (feet only); 6 (wings only); 7 (other).
Scavenged: Y (yes); N (no); U (unknown).
Other causes of death: 1 (shot); 2 (tangled in fishing line); 3 (tangled in plastic); 4 (other).
Toes Clipped: If the carcass has been found for the first time indicated with N for new; otherwise record which toes have been clipped previously on each foot.

If more than one page is required for a single census, use additional pages numbered 2, 3, etc. and repeat date and beach name at top of each additional page.

Aging and sexing

It is valuable to record the age and sex of carcasses whenever possible because a bias toward a particular sex or age group could affect the degree of impact of mortality on a species. To age and sex seabirds, a knowledge of morphological details is required that most observers must learn beforehand in order to be competent. For example, it is possible to determine the sex of Western and Clark's grebes by bill shape and size, and to determine the age of gulls by differences in plumage. These are only two of the many ways that observers can learn to identify age and sex classes of various species.

Cause of death

Visible evidence for causes of death that should be recorded include: shot; choked on a food (or other) item; tangled in fishing line, fishing nets or plastic six-pack holders; broken wing(s); and oiled. Such causes of death are often easy to detect, but some carcasses do not show a visible cause and must be recorded as "unknown." Any other information that may suggest a cause of death should also be recorded.

Carcass condition

It is important to obtain an idea of how long the bird has been dead. This can be done by recording carcasses as: fresh -- without signs of decomposition; decomposing -- with (any) rotting flesh; or decomposed -- skin, feathers and bones, and without (any) rotting flesh. Scavengers (e.g., Turkey Vultures, Common Ravens, Common Crows, and gulls) may consume parts of carcasses, making them appear more decomposed than others which have not been scavenged. The beached bird counter should look for signs that part of the carcass has been eaten and record this information whenever found. Vultures can reduce a fresh carcass to skin and bones in just one day. A recently-dead bird that has been heavily scavenged looks like just bones and feathers, but small bits of fresh tissue often are attached to bones and the bones retain a reddish-brown color. This can mislead careless counters into thinking that carcasses have been present for a long time and mistakenly recording them as decomposed. Scavenging often can be identified when the bird's feathering as been turned inside out (skin on the outside and the feathers on the inside). The skin and feathers often are pulled over the skull by a scavenger such that the bill is hidden inside the neck feathering.

Marking carcasses

After noting all of the above information, the beached bird counter should mark the carcass in a distinctive manner or remove it from the beach so that it will not be counted on a subsequent census. Normally, it is easiest to clip the tips of the outer primaries of each wing with a pair of scissors, but when plumage is oiled, it is better to clip off a pre-specified toe from one foot (for example, the outer toe on the bird's right foot). We recommend marking the carcass and leaving it on the beach for ease and accuracy. On subsequent censuses, observers must check each carcass to determine whether it has been marked previously.

HOW TO COLLECT DATA ON CARCASS TURNOVER

Typically, beached bird censuses are conducted at bi-weekly or monthly intervals to provide information on average carcass numbers and to identify periods of exceptionally high or low seabird mortality. However, in the case of an oil spill, the objective and frequency of censuses change. Now,

the total number of dead oiled birds beaching along the entire length of coast affected by the spill must be determined. One way to obtain this information would be to count birds daily along the entire length of coastline for the duration of the spill's impact which could extend from several days to a few weeks. Depending on the duration of spill impact, length of affected coastline, and available manpower, such extensive census coverage can be impractical. Thus, it may be necessary to conduct censuses in some areas and to extrapolate estimates for the "uncovered" areas at a later time.

One useful extrapolation method requires estimates of the daily rates of carcass deposition and of carcass persistence for beaches. "Carcass turnover" is the term used to describe the combined effect of these two processes on the number of carcasses on beaches. Data for measuring carcass turnover can be obtained by covering the same beach segment each day and recording the number of marked carcasses remaining from previous censuses and the number of newly-deposited, unmarked carcasses. The toe or combination of toes that are clipped on the carcass identifies the first date found. On finding a carcass, the beached bird counter must check the toes on both feet. If the bird has one or more clipped toes, the counter records which toes have been clipped along with all the other information required on the beached bird census form (Table 2). If no toe has been clipped, the counter uses scissors to cut off the appropriate combination of toes for that day. On the beached bird census form, the counter indicates that the carcass was discovered for the first time on that date and indicates which combination of clipped toes is being used to denote that date, along with the other data that describe the carcass.

METHODS OF ESTIMATING NUMBERS OF BEACHED BIRDS DURING AN OIL SPILL

During an oil spill, live and dead birds come ashore over a period of days. The length of this period and number of birds varies with: the size of the spill; type of oil; distance of the spill from shore; strength and direction of ocean currents and wind; type of shoreline; and the abundance, species composition, and distribution (especially distance) of birds off shore. The number of birds reaching shore builds quickly to a peak and then tapers off more slowly. Usually, people remove live birds from easily accessible beaches but the dead ones generally remain until they are washed back out to sea, scavenged, buried in the sand, or decompose. Consequently, many dead oiled birds remain on the beach for several days, whereas most live ones disappear within a day or two of reaching shore.

Lay persons, who happen to be on the beach, often act on their concern over the welfare of the oiled live birds by taking them from the beach and turning them over to a park employee, rehabilitation worker or other responsible person. This participation of the public, while possibly beneficial to some live birds, tends to be disorganized and overlooks dead birds. In fact, so much attention is placed on rescuing live birds that little information is obtained on the number of dead birds, even though they may outnumber the live ones. The methods we describe are meant to be used for estimating the number of dead birds that come ashore, **not** the number of beached live birds. We assume that the public will remove too many live birds for beached bird censuses to reflect accurately the total number of live birds coming ashore. A tally of the number of live birds must be derived from the records of collection and rehabilitation centers.

There are two extreme circumstances that can be encountered when one confronts the task of estimating the numbers of birds that come ashore during an oil spill. Under ideal circumstances, there is prior warning that oiled birds are likely to come ashore and there are a sufficient number of counters available to cover the entire coastline over which the birds are expected to beach. At the opposite extreme is the situation where oiled birds have been beaching for one or more days before the spill is known to have occurred, and there are not enough counters available to cover the entire coastline. The 1984 **Puerto Rican** oil spill, where a tanker leaked oil after being damaged by an explosion, is an example of the early-warning scenario. In this instance, there were two or three days to prepare for beached bird censuses from the time the tanker began leaking oil to the point when the first oiled birds reached shore. The 1986 **Apex Houston** oil spill exemplified the lack-of-warning scenario. The first

evidence that there had been a spill was the appearance of oiled birds along the coast on a weekend.

In order to count and/or extrapolate the number of carcasses on beaches, we divide the coastline into regions which are distinguished from one another by the general direction the shoreline faces. The regions are subdivided further into beach segments according to beach type and accessibility. Beach segments are classified by one of five beach types, defined by the relative degree to which they accumulate and retain carcasses.

Early-warning scenario unrestricted by availability of counters

Under these ideal circumstances, the number of carcasses on each accessible beach segment in a coastal region impacted by the spill must be counted every day for the duration of the spill. The numbers of carcasses on inaccessible beach segments with deposition zones are extrapolated from actual rates (birds/km) determined on adjacent or nearby segments of the same beach rank. Beach segments without deposition zones are excluded from consideration. The extrapolation is made simply by multiplying the total number of carcasses found on the covered segment during the duration of the spill by the ratio of the length of the uncensused segment to the censused segment or:

$$T_u = T_c\,(L_u/L_c) \qquad \text{[Equation 1]}$$

where:
T_u = the total number of carcasses on the uncensused segment during the spill period,
T_c = the total number of carcasses on the censused segment during the spill period,
L_u = the length (km) of the uncensused segment,
L_c = the length (km) of the censused segment.

The extrapolated carcass totals for all uncensused coastal segments combined are divided among species in exact proportion to the species composition for all censused segments combined. For example, if Common Murres made up 57.1% of the total carcasses on censused segments, it is assumed that they also make up 57.1% of the carcasses extrapolated for the uncensused segments.

Lack-of-warning scenario with too few observers to cover all shoreline

This is the worst case scenario where we are unable to respond to an oil spill until one or more days after birds have started to come ashore. Even then, our response is limited by the number of observers. In this case, we attempt to: 1) conduct carcass turnover counts on every possible day on a sample of beaches in the impacted region; and 2) conduct censuses on all other segments once to obtain a single count per segment. The extrapolation of the number of carcasses washing ashore on a beach segment is derived from the equation:

$$N_t = \frac{O_d}{\sum_{i=1}^{d} S^{d-i} P_i} \qquad \text{[Equation 2]}$$

where:
N_t = the total number of carcasses that actually wash ashore on a beach segment during the t days of the spill extrapolation period,
O_d = the "observed" number of birds found on day d on a single census of a beach segment,
d = the number of days that birds from the spill have deposited on a beach segment up to the time of the single census (i.e., $1 \leq d \leq t$),

P_i = the proportion of the total number of carcasses coming ashore during the spill period that are estimated to have been deposited on day i (based on the daily deposition of live birds in that coastal region derived from tallies at collection and rehabilitation centers), and
i is an index variable for day in the summation.
S = the average daily persistence or "survival" of carcasses is determined from carcass turnover counts in the region as:

$$S = \frac{\sum_{k=1}^{c} \frac{T_k}{T_{k-1} + U_{k-1}}}{C} \qquad \text{[Equation 3]}$$

where:
T_k = the number of carcasses marked from day k=0 through day k-1 that were resighted on day k,
U_k = the number of newly-deposited (unmarked) carcasses that are marked on day k,
k = the day of resighting of previously marked carcasses (i.e., k = 1, 2,...., c),
c = the number of successive days of resightings of carcasses.

Carcasses are marked from day k=0 to day k=c-1 whereas marked carcasses are resighted from day k-1 to day k=c. It is important to point out that in equation 3, "days" refer to days of resighting marked carcasses. In equation 2, "days" refer to days within the spill period. To clarify this, we have used differing notation in these equations.

The derivation of equation 2 can be visualized through the following example:

$$O_1 = n_1$$
$$O_2 = Sn_1 + n_2$$
$$O_3 = S^2n_1 + Sn_2 + n_3$$
$$O_4 = S^3n_1 + S^2n_2 + Sn_3 + n_4$$

where: O_1, O_2, O_3 and O_4 represent the number of carcasses that would be found on a beach on day 1, day 2, day 3, and day 4 of the spill respectively; and n_1, n_2, n_3, and n_4 represent the number of carcasses that actually come ashore on each of these days, respectively. Thus, the number of carcasses observed on a single beach census is related to the total number of carcasses that have washed ashore but is also dependent on how long carcasses visibly remain on the beach.

For example, let us assume that $N_t = 100$ (in other words, an overall total of 100 carcasses washed up on the beach segment during a 4-day spill period). In fact, 25 birds had come ashore on day 1, 35 on each of days 2 and 3, and 5 on day 4. Then $n_1 = 25$, $n_2 = 35$, etc. Carcass persistence from one day to the next (S) is found to average 0.80 from the carcass turnover counts. The number of birds the counter would find on day 3 (O_3) is the sum of the three terms in the example or:

$$O_3 = (0.8)^2 25 + (0.8)35 + 35 = 79$$

Now, let us assume that we do not know n_i but we do know O_3 and can estimate P_i (the proportions of N_t washing in each day determined from live birds). For example, say that 949 live oiled birds from this region were tallied at collection and rehabilitation centers over the 4-day spill period. Of this total, 236 had been recovered from beaches on day 1, 330 on day 2, 335 on day 3, and 48 on day 4. Thus, we estimate P_i as: $P_1 = 0.249$, $P_2 = 0.348$, $P_3 = 0.353$, and $P_4 = 0.051$. N_t can then be estimated from O_3 using equation 2 as follows:

$$N_t = O_3/(S^2P_1 + SP_2 + P_3)$$
$$= 79/(0.8)^2\ 0.249 + (0.8)\ 0.348 + 0.353$$
$$= 100.$$

It is evident from this example that we need three pieces of information to calculate N_t. O_d, the number of carcasses found on a beach on day d, is determined exactly from a carcass count; S is calculated as the average daily rate of carcass persistence on a beach; and P_i, the proportion of N_t that is expected to be deposited on day i, is based on the proportion of the overall number of live birds coming ashore during the spill period that came ashore on day i in the same region. It is assumed that this proportion is similar between live and dead birds. The rehabilitation center's record for each bird interned must include the date the bird was taken from the beach and the location it came from (see Carter et al. 1987).

As in the early-warning scenario, the number of carcasses on uncovered and inaccessible beach segments with deposition zones are extrapolated from actual rates (birds/km) estimated for adjacent or nearby segments of similar beach rank using equation 1 but substituting N_t for T_c. Beach segments without deposition zones are excluded from consideration.

Hybrid Scenarios

The first of the two types of hybrid scenarios occurs when there is early warning of the spill but insufficient numbers of counters to cover all beach segments. Censuses are conducted using the same method as for the lack-of-warning scenario except that coverage for the carcass turnover counts begins the first day that birds come ashore. The several beaches covered in this experiment provide actual values of P_i for the dead birds so that P_i does not need to be derived from data for live birds (although it would be valuable to compare the two methods).

The second hybrid scenario occurs when a sufficient number of counters are available to cover all beach segments, but, because of lack of warning, carcass censuses do not commence until one or more days after the first oiled birds have come ashore. In this case, censuses are conducted using the same method as for the early-warning scenario. We derive values of S from daily counts and P_i values from rehabilitation center records for live birds. The O_d value for each beach segment comes from the first day counts are made. Then, using the data analysis method described under the lack-of-warning scenario, we calculate the number of carcasses that came ashore on the beach but disappeared before the counts began. These are added to the count data for the subsequent period to provide an estimate of the total number of dead oiled birds coming ashore.

GENERAL DESIGN OF REGIONAL PLANS

Overview of regions and beach segments

We divided the entire (404 km) coastline of central California (excluding all estuaries, except Tomales Bay) into eight region as follows:

Region 1: Salmon Creek to Point Reyes
Region 2: Point Reyes to Golden Gate
Region 3: Golden Gate to Pillar Point
Region 4: Pillar Point to Pigeon Point
Region 5: Pigeon Point to Point Santa Cruz
Region 6: Point Santa Cruz to Monterey
Region 7: Monterey to Point Lobos
Region 8: Tomales Bay

These regions differ from each other by the general direction the shoreline faces and general type of shoreline habitat: Region 1 faces W to SW and contains rocky and sandy shorelines; Region 2 faces SW to S and contains rocky and sandy shorelines; Region 3 faces W and contains sandy shorelines; Region 4 faces W and contains sandy shorelines; Region 5 faces SW and contains rocky and sandy shorelines; Region 6 faces SW to W and contains sandy shorelines; Region 7 faces W and contains rocky and sandy shorelines; and Region 8 is somewhat enclosed such that it does not face the open ocean and contains sandy, rocky, and marsh shorelines. The various regions differ with regard to exposure to the open ocean, current and wind regimes; distributions and abundances of birds at sea; proximity to ship/tanker lanes; and likelihood of being impacted by oil spills. Thus, it is not appropriate to extrapolate results between regions. However, we do depend on extrapolations within each region. Therefore, regional plans can be implemented separately from or in conjunction with other regional plans, as necessary.

Within each region, we divided the entire shoreline into beach segments. We assigned a name and number for each segment, moving sequentially from north to south. Other characteristics of beach segments listed are: length, beach type, beach rank, direction facing, and accessibility. The coded beach types and beach ranks are defined in Tables 3 and 4, respectively. In creating segments, we attempted to include only one beach type, to stay within a 1-3 km length range, and to provide for efficient access and censusing. No segments are greater than 6.6 km in length.

While each region is described in more detail in following sections of this report, a summary of the numbers and lengths of beach segments of different beach ranks in each region is provided in Table 5.

APPENDIX 8

Preassessment Economic Considerations

On-scene Collection of Economic Data during Oil Spills

Introduction

Successful damage assessments are not sequential processes with distinct biological and economic analyses. Rather, economic issues must be considered during the early stages of the assessment because: 1) the nature and scope of the injuries studies may need to be tailored to certain economic methodology(s); and 2) certain types of data are perishable and must be collected prior to the formal assessment effort. This document provides a general strategy and checklists for economic data collection.

Economic Considerations during the Preassessment

The first step is to gain a qualitative understanding of the resources affected by the spill. This activity involves not just establishing a list of resources affected by the spill, but gaining an understanding about the nature of these resources. Examples of resource characteristics that should be noted in the initial assessment phases include: any ways in which the resources affected are unique, regionally or nationally; the presence or absence of resources with similar ecological/biological characteristics nearby; and qualitative estimates about the severity of the injury.

Once this basic information about the nature of the resources injured is gathered, the next step is to identify the resource service categories affected, as well as the individual service losses. The most common resource service categories affected by spills are: recreational, commercial, ecological, passive use, subsistence, cultural/historical, and scientific/research services. It is important to note that a spill may severely affect some services within a given category while not affecting others at all. For example, a spill that oils the upper portion of the vegetation within a wetland may significantly affect the ability of that wetland to provide habitat for wildlife, while not adversely affecting the provision of erosion or storm protection services.

A qualitative assessment of the type and extent of resource service losses frequently will guide the choice of economic methodology, and thus provides insight into the types of injury studies required to support the damage determination effort. For example, damages resulting from a spill that severely injures a unique resource and affects primarily passive use values will be quantified using very different

methodologies than those used to quantify damages from a spill causing moderate injuries to beach recreation and commercial fishing. The type and scope of injury studies needed to support these two types of assessments will often be very different. Thus, early attempts to characterize the resources and services affected by a spill will help prevent unnecessary efforts directed towards resources with low or no quantifiable values, and will provide guidance as to the type(s) of scientific and economic studies required in the later stages of the assessment.

Perishable Data Concerns

Certain types of economic data are perishable, i.e. if they are not collected during the initial on-site efforts, they cannot be reconstructed at a later time. Perishable data concerns are most prevalent for spills involving significant recreational and commercial service impacts. Examples of perishable data include in-person, photographic, or videotaped counts of recreational beachgoers before and after oil comes ashore, or vessels queued to enter a closed waterway. Photographs or videos of spill impacts, such as oiled beaches or wildlife, are often also essential for substantiating trustee claims regarding specific resource service losses.

Other types of information, such as formal closure notices for beaches and waterways, notices of fishing restrictions, and certain parameters required by the Type A model are not perishable, but often are much easier to collect at the time of the incident.

Documenting Impacts to Resource Services

Preassessment data on recreational and other potential service impacts are necessary to answer the following questions:

- Which activities been affected?
- What are the likely effects on those activities?

  Have there been official or defacto[1] closures

  Is there a reduction in participation or in user value?
- What is the temporal and geographic scale of the impact?

[1] De facto closures include "non-official" closures due to restrictions on access to the site or limitations on activities at the site as a result of the discharge and response to the discharge.

- Are there substitutes for that activity?
- What types of historical data exist at the affected site?

Categories of activities to consider include

- Beach recreation
- Parks and archeological/historical sites visitation
- Private recreational boating
- Private recreational fishing
- Charter recreation fishing and boating
- Commercial fishing
- Commercial transportation
- Subsistence use
- Hunting and wildlife viewing

Basic Strategy

The following checklists are designed to identify and prioritize relevant economic information that may be available during the preliminary assessment phase of a spill. Data needs are categorized as follows:

Background: Basic information that guides subsequent data collection efforts (e.g., resources at risk, location of recreational activities)

Perishable: Information that can only be collected immediately following the spill (photos of spill effects, changes in recreational-use patterns)

Semi-perishable: Information that is in theory available after the response or preassessment phase is over, but frequently is discarded or very difficult to access later (e.g., closure notices, newspaper articles)

Durable: Information that is available after the response or preassessment phase is over, but may still be useful to collect in the preassessment phase (fishery landings data, POLREPS, 3rd party claims data

RECREATIONAL BEACHES

Background

- ❑ Information on jurisdiction and ownership of beaches, and contacts with management agencies or private parties responsible for maintenance of beaches and issuance of closure notices (contact names, addresses, phone numbers).
- ❑ Physical location and size of beaches.

Perishable

- ❑ Overflight videos and photographs of: 1) areas projected to be oiled; 2) oiled beach area or closed regions; and 3) adjacent, unaffected beaches.
- ❑ Response-related data on beach oiling surveys, including characteristics of the beach, duration of oiling, degree of contamination, barriers to access, level and types of cleanup, and when they were cleaned and available for use.
- ❑ Information on changes in usage patterns resulting from the spill (e.g., number of people transported to alternate sites, including information on the effectiveness of beach closure enforcement.
- ❑ Photo and written documentation of physical barriers to beach access (e.g., signs, tape, cleanup equipment, etc.).
- ❑ Information on events moved, postponed or canceled (e.g., fish tournaments).

Semi-Perishable

- ❑ Formal beach-closure notices issued by management agencies.
- ❑ Information on access patterns (e.g., private vs. public, drive vs. walk, primarily residents vs. tourists from nearby hotels).
- ❑ Newspaper articles related to extent and nature of oiling, beach closures, etc.
- ❑ Hotel, private and public parking receipt data for beaches within walking distance of parking lots/garages.

Durable

- ❑ Beach attendance data collected on a regular basis by management agencies.
- ❑ Post clean-up videos and photographs of affected beach areas.
- ❑ Physical characteristics, access patterns, and use levels for substitute sites.
- ❑ Statistics on tourists entering general area and hotel occupancy rates.
- ❑ Data on the nature and extent of third-party claims.
- ❑ Weather conditions before, during, and after the spill.

PARKS AND ARCHEOLOGICAL/HISTORICAL SITES

Background

- ❒ The type and location of archeological/historical resources at risk or affected.
- ❒ Information on agencies responsible for managing and maintaining these resources (jurisdiction/ownership/trusteeship). Get names of contacts and phone numbers.

Perishable

- ❒ Overflight videos and photographs of: 1) areas projected to be oiled prior to stranding; 2) oiled areas/closure regions during period of oiling/closure; and 3) adjacent, unaffected areas during period of spill.
- ❒ Response-related data which can be used to identify when archeological/historical resources were oiled, how long they remained oiled, the extent and degree of contamination, and when they were cleaned.
- ❒ Information on defacto closures (e.g., boating closure in adjacent waterway may bar access to certain sites).
- ❒ Information on the nature and extent of any archeological contextual losses (contextual information refers to the undisturbed condition and position of archeological artifacts).
- ❒ Information on the effectiveness of park/resource closure enforcement.

Semi-Perishable

- ❒ Formal closure notices issued by management agencies.
- ❒ Information on access patterns (how people get there, who are the users, etc.)
- ❒ Hotel, private and public parking receipt data for resources within walking distance of parking lots/garages.
- ❒ Newspaper articles related to closure or other spill effects on parks and archeological/historical resources.

Durable

- ❒ Baseline resource usage/attendance figures compiled on a regular basis by resource management agencies.
- ❒ Archeological artifact prices available from museums, auction houses, collectors.
- ❒ Resource management reports that reference archeological sites and activities conducted at these sites.
- ❒ Permitting information detailing archeological projects being conducted at the site.

RECREATIONAL BOATING

Background

- ❒ Location of boat ramps and marinas within spill region and in adjacent areas.
- ❒ Management agencies responsible for issuing licenses and dealing with other boating-related issues (contact names, addresses, phone and fax numbers).

Perishable

- ❒ Overflight videos and photographs of marinas and other boat launch areas that are: 1) projected to be affected by the spill; 2) affected by the spill; and 3) in adjacent, unaffected regions. Be sure to capture number of slips available, number of slips filled during period of spill and the types of boats using that area.
- ❒ Photographs, videos, maps, and other documentation of boom placement and cleanup operations resulting in defacto waterway and marina closures, restrictions in access, or delays in vessel movements.
- ❒ Information on the effectiveness of closure enforcement.
- ❒ Interviews with marina operators and boaters on typical usage patterns, and changes in usage due to the spill.

Semi-Perishable

- ❒ Formal waterway closure notices issued by USCG or other agencies, including Pollution Report (POLREPS) and Situation Reports (SitReps).
- ❒ Transcripts of USCG radio broadcasts, including Notices to Mariners regarding closures, safety zones, no passing zones, cleanup operations, etc. Newspaper articles pertaining to waterway closures, oiled boats, etc.
- ❒ Logs from marinas in affected and unaffected areas, documenting daily entry and exit of vessels, percentage occupancy of available slips, types of boats moored, etc.
- ❒ Contacts for boat yards used for vessel cleaning and data on the cost of cleaning.

Durable

- ❒ Recreational boating data collected on a regular basis by management agencies.
- ❒ Overflight videos and photographs of marinas and boat launch areas affected by the spill taken after cleanup is complete and all closures are lifted.
- ❒ Data on number of registered vessels and contact information (for later surveys).
- ❒ Physical characteristics, access patterns, and use levels for substitute sites.
- ❒ Data on the nature and extent of third-party claims.
- ❒ Weather conditions before, during, and after the spill.

RECREATIONAL FISHING

Background

- ❒ Location of site used by recreational anglers and types of fishing done in affected and surrounding areas (pier, shoreline, boat-based, targeted species, etc.).
- ❒ Contact information for resource management agencies responsible for issuing licenses, setting and monitoring catch limits, and dealing with other fishing-related issues (contact names, addresses, phone and fax numbers).

Perishable

- ❒ Overflight videos and photographs of fishing areas that are: 1) projected to be affected by oil; 2) oiled/closed regions during period of impact; and 3) adjacent, unaffected fishing areas during the period of spill. Be sure to capture number anglers of each type (e.g., boat- vs. shore-based).
- ❒ Information pertaining to defacto closures, such as locations of booms, response vessels, etc. that would prevent fishing in a certain area.
- ❒ Information on the effectiveness of park/resource closure enforcement.
- ❒ Interviews with recreational anglers on changes in usage related to the spill and information on fishing success during the period of the spill.
- ❒ Information on special events moved, postponed, or canceled due to the spill (e.g., fishing tournaments).

Semi-Perishable

- ❒ Formal closure notices, detailing the location, nature and duration of the closure(s). (Note that both fishing and waterway closures may prevent fishing.)
- ❒ Newspaper articles pertaining to waterway closures, fishing closures, and other fishing-related issues.

Durable

- ❒ Information on fishing seasons designated by resource management agencies: start and end dates, bag limits, size limits, species types, etc.
- ❒ Baseline data collected by resource management agencies regarding recreational landings, biostatistics, number of anglers, average effort, etc.
- ❒ Data on number of fishing licenses issued and contact information (for later surveys.)
- ❒ Physical characteristics, access patterns, and use levels for substitute sites.
- ❒ Data on the nature and extent of third-party claims.
- ❒ Weather conditions before, during, and after the spill.

RECREATIONAL BOATING/FISHING (CHARTER)

(Note: Much of the data in this category will be captured during the efforts to collect data on private recreational fishing and boating described above. In collecting that data, care should be taken to identify those vessels that are charters vs. those vessels that are owned and operated as private recreational vessels)

Background

- ❒ Management agency responsible for regulating charter operators (contact names, addresses, phone and fax numbers).
- ❒ Berthing locations for charter vessel.

Perishable

- ❒ Interviews with charter operators documenting charter vessel destinations, average number of people per trip, length of trip, frequency of trips, type of trip (fishing or sightseeing), targeted species, and effects of spill/closure.

Semi-Perishable

- ❒ Copies of charter operator logs documenting actual charter trips, including dates and times, number of people aboard, and destination(s).
- ❒ List of charter boat operators working in the area.
- ❒ Commercial brochures from charter boat operators working in the area.

Durable

- ❒ Data on number of charter boat licenses issued, type of license, capacity of vessel, and necessary names and phone numbers of people issued licenses (for survey purposes).
- ❒ Baseline data collected by resource management agencies on levels of recreational fishing in the affected and surrounding areas.
- ❒ Historical gate receipt data from resource management agencies for areas in which recreational anglers are charged to fish.
- ❒ Data on the nature and extent of third-party claims.

COMMERCIAL FISHING

Background

- ❒ Management agencies responsible for regulating and monitoring commercial fishing activities (contact names, addresses, phone and fax numbers).
- ❒ List of commercially important species in the area and where they typically are caught.
- ❒ Types of vessels and gear in use.
- ❒ Current regulatory status of the fishery (open, closed, landing quotas, etc.).

Perishable

- ❒ Information on the effectiveness of commercial fishing closure enforcement.
- ❒ Information on defacto fishery closures caused by restrictions on waterway access, marina closures, cleanup activities, or other spill-related impacts.
- ❒ Interviews with commercial fishermen regarding typical fishing patterns (e.g., times, locations, species, and general techniques) and the effects of the spill on these activities.

Semi-Perishable

- ❒ Formal fishing closures issued by resource management agencies, detailing the location, nature, and duration of the closures.
- ❒ Newspaper articles on the effects of the spill on commercial fishing.

Durable

- ❒ Baseline/historical data collected by resource management agencies on amount and species of commercial landings, biostatistics, and ex-vessel prices.
- ❒ Information on fishing seasons designated by resource management agencies: start and end dates, catch limits (number and size), species types, other restrictions, etc.
- ❒ Data on the nature and extent of third-party claims.

COMMERCIAL TRANSPORTATION/SHIPPING:

(Note: One of the potential services provided by surface water is the provision of navigational access. The loss in access can be quantified by comparing vessel movements predicted to have occurred in the absence of the discharge with the actual vessel traffic patterns during the discharge.)

Background

- ❒ Types of vessels utilizing affected area (e.g., tankers, cargo/bulk, tug and barge, etc.).
- ❒ Whether or not the affected area has a USCG Vessel Traffic Service (VTS).
- ❒ Agencies responsible for monitoring and regulating vessel traffic (contact names, addresses, phone and fax numbers).

Perishable

- ❒ Overflight videos and photographs showing vessels queued up at the entrance to a closure area, or waiting at nearby anchorages to enter the affected waterways.
- ❒ Qualitative or quantitative data regarding the number of vessels unable to enter the affected waterway due to the spill.
- ❒ Information on the effectiveness of waterway closure enforcement.

Semi-Perishable

- ❒ Formal closure notices, Notices to Mariners, USCG Pollution Reports (POLREPS), USCG Situation Reports (SitReps), and other documents related to closures or traffic restrictions (no passing zones, safety zones, no wake zones, etc.).
- ❒ Data from the VTS, Harbor Pilots' Associations or other agencies on the names, types, vessel dimensions, previous and next port-of-call, and dates and times of arrival and departure for a period of comparable vessel traffic patterns outside of the dates in which vessel traffic was affected by the spill.
- ❒ Information on the procedures and protocols by which VTS (or other agency) data are collected, recorded, and archived.
- ❒ Newspaper articles related to waterway closures, delays in vessel traffic, etc.

Durable

- ❒ Maps of the affected waterways showing locations of specific ports, berths, and facilities.
- ❒ Data on hourly vessel costs by vessel type.
- ❒ Aggregate historical data on vessel traffic and shipment amounts to compare relative traffic across years.
- ❒ Data on the nature and extent of third-party claims.

SUBSISTENCE USE

Background

- ❒ Management agencies responsible for regulating, managing, and/or monitoring subsistence use (contact names, addresses, phone and fax numbers).
- ❒ Nature and size of groups that rely on resource for subsistence.
- ❒ Types of subsistence resources.
- ❒ Type of subsistence uses provided by the resource (food, shelter, etc.).

Perishable

- ❒ Nature and extent of spill impacts on subsistence resources and uses, including changing patterns of subsistence uses.
- ❒ Interviews with group members relying on resource for subsistence use.

Semi-Perishable

- ❒ Newspaper articles pertaining to impacts of the spill on subsistence uses.

Durable

- ❒ Baseline data collected by resource management agencies regarding types and levels of subsistence use.
- ❒ Information on restrictions placed by resource management agencies on subsistence use (e.g., no spear fishing).
- ❒ Information on the nature and extent of third-party claims.

HUNTING AND WILDLIFE VIEWING

Background

- ❒ Types of hunting and wildlife viewing done in affected and surrounding areas (species by area).
- ❒ Management agencies responsible for issuing hunting licenses, and setting hunting seasons and limits (contact names, addresses, phone and fax numbers).
- ❒ Locations and access points for hunting/wildlife viewing.

Perishable

- ❒ Information pertaining to defacto closures, including restrictions on waterway access, and location of booms and cleanup operations that would prevent access to hunting/viewing areas.
- ❒ Interviews with hunters/wildlife viewers pertaining to their usage patterns and how their use was affected by the spill.

Semi-Perishable

- ❒ Formal closure notices from management agencies detailing the location, nature, and duration of closures affecting these activities.
- ❒ Newspaper articles pertaining to effects of the spill on hunting and wildlife viewing.

Durable

- ❒ Information on hunting seasons designated by resource management agencies: start and end dates, limits, species types, etc.
- ❒ Baseline data collected by resource management agencies regarding hunting and/or wildlife viewing activities.

ECOLOGICAL SERVICE LOSSES/ HABITAT EQUIVALENCY MODEL INPUTS

Much of the information collected for injury determination is applicable to the Habitat Equivalency Model, and some of this information is listed below for clarity. The emphasis is on resources such as mangroves, seagrasses coral reefs etc. and the services they provide.

Background

- ❒ Physical location/characteristics of resources
- ❒ Information on services provided by the resources at risk.
- ❒ Information (Agency,contact person/number) on jurisdiction of resources.

Perishable

- ❒ Overflight videos and photographs of areas projected to be oiled before the oil actually hits.
- ❒ Documentation of services being provided by resources at risk (Ground truthing videos/photographs).
- ❒ Overflight videos and photographs of oiled resources during period of oiling.
- ❒ Documentation of service level changes resources during the period of oiling. (e.g. changes in service flow, length of time for changes to occurs, duration of changes by ground truthing videos/photographs).
- ❒ Information on changes in service levels as a result of response activities. (e.g. movement of birds/mammals out of breeding areas) Both at spill site and at nearby "unaffected" sites.

Semi-Perishable

- ❒ Documentation on response activities (e.g. bird recovery counts, turtle nest relocation) both official and unofficial.
- ❒ Information/Documentation on migration/breeding interruptions.
- ❒ Media (Newspaper, Television, Radio) reports on impacts to resources and services.
- ❒ Physical characteristics and service flows of reference sites
- ❒ Information on changes in service flows resulting from things other than the spill.

Durable

- ☐ Population data collected on a regular basis by resource management agencies.
- ☐ Documentation/Reports identifying size and location of resources affected by the spill.
- ☐ Documentation/Reports on baseline services provided by the resource in the region
- ☐ Documentation/Reports on baseline service levels provided by the resource in the region

APPENDIX 9

NOAA Preassessment Guidance Document

Prepared For:

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
OFFICE OF GENERAL COUNSEL
DAMAGE ASSESSMENT REGULATIONS TEAM
14th & Constitution Avenue, N.W.
Washington, D.C. 20230

PREASSESSMENT PHASE

GUIDANCE DOCUMENT

Prepared By:

Jacqueline Michel

Research Planning, Inc.
Post Office Box 328
1200 Park Street
Columbia, S.C. 29202

and

Eli Reinharz
National Oceanic and Atmospheric Administration
Office of General Counsel
Damage Assessment Regulations Team
14th & Constitution Avenue, N.W.
Washington, D.C. 20230

January 1994

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LIST OF COMMONLY USED ACRONYMS

ACP - Area Contingency Plan

APHA - American Public Health Association

ASTM - American Society for Testing and Materials

CDA - Comprehensive Damage Assessment

CERCLA - Comprehensive Environmental Response, Comprehension and Liability Act (42 U.S.C. 9601 et seq.)

EDA - Expedited Damage Assessment

LAT - Lead Administrative Trustee

NOAA - National Oceanic and Atmospheric Administration

NRDA - Natural Resource Damage Assessment

OPA - Oil Pollution Act of 1990

OSC - On-Scene Coordinator

QA - Quality Assurance

RP - Responsible Party

SSC - Scientific Support Coordinator

USACE - U.S. Army Corps of Engineers

USCG - U.S. Coast Guard

USEPA - U.S. Environmental Protection Agency

USFWS - U.S. Fish and Wildlife Service

USGS - U.S. Geological Survey

ACKNOWLEDGEMENTS

This project was funded by the NOAA, Office of General Counsel, Damage Assessment Regulations Team. We would like to thank the following NOAA staff who contributed their ideas and critiques to the document: Randall B. Luthi, Linda B. Burlington, Sharon K. Shulter, Robert J. Gutro, and Bill Triplett. William G. Conner and Douglas R. Helton of the NOAA Damage Assessment Center also provided valuable input. There were many other reviewers of the draft who provided insightful comments and suggestions to improve the usefulness of the final document. Deborah P. French of Applied Science Associates, Inc. contributed to the section on selection factors for the compensation formulas and Type A models. Robert T. Stuart of EVS Consultants, Inc. contributed to the sections in Appendix B and E on toxicity testing. Carol Jones and David Chapman of NOAA's Damage Assessment Center contributed to the sections on recreational participation and navigational effects in Appendix B. Debra K. Scholz of Research Planning, Inc. assisted in data collection and review of the document.

PREASSESSMENT PHASE GUIDANCE DOCUMENT

1.0 Introduction

Discharges of oil have the potential to cause significant environmental and economic effects on a wide range of natural resources and services. The extent of such effects depends upon where the discharge occurs, type and volume of the discharge, time of year, and environmental conditions prevailing at the time of the discharge. Prevention of oil discharges is the most logical means of reducing pollution problems. However, prevention is not an absolute fail-safe mechanism. Consequently, measures must be in place to address the effects of oil once it is discharged into the environment.

The Oil Pollution Act of 1990 (OPA) was enacted, in part, to address concerns related to discharges of oil. OPA directed the National Oceanic and Atmospheric Administration (NOAA), in consultation with the U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), and other affected agencies, to promulgate regulations for the assessment of natural resource damages resulting from the discharge of oil. Under this authority, NOAA is formulating damage assessment procedures for natural resource trustees that will apply to all discharges of oil within the navigable waters of the United States and the Exclusive Economic Zone. This guidance document was prepared to provide assistance to natural resource trustees for the planning and implementation of preliminary assessments, referred as the Preassessment Phase, using the Natural Resource Damage Assessment (NRDA) regulations promulgated under OPA.

Assessment of natural resource damages may be facilitated by some aspects of oil discharges. Often, discharges of oil have a known source, well-defined period of occurrence, and responsible parties (RPs). It is usually relatively easy to delineate and map the areal extent of surface contamination, and there are numerous case histories upon which the duration of exposure can be projected for the most commonly oiled habitats. There is an extensive literature on effects resulting from the discharge of oil for certain types of organisms, especially short-term effects. The most difficult feature of oil discharges is that they occur suddenly, without warning. The trustees must prepare to quickly evaluate the conditions of the discharge, make decisions, and dispatch teams to the discharge site who are

able to collect useful data using the proper protocols, where appropriate. Thus, discharges of oil require careful prespill planning on many aspects, from notification requirements, to identification of protocols for early sampling activities, to the application of recovered damages.

Since NRDA activities are highly multidisciplinary, it is important to be familiar with the language of damage assessment. Appendix A is a glossary of terms that will assist the user of this document.

2.0 Prespill Planning

2.1 Purpose

The trustees are strongly encouraged to undertake prespill planning activities at the Regional Response Team (RRT) and Area Planning Committee levels. These plans should identify the responsibilities of the trustees in the case of an oil discharge covered by OPA. Prespill Plans should also allow for the compilation of information needed by the trustees to begin damage assessment activities. The trustees, RPs, and response agencies should identify, in advance, how they should coordinate activities and information during the emergency phase of an oil discharge. Prespill planning and coordination among the principal parties involved are major factors in the success or failure of any oil-related NRDA.

One mechanism for facilitating prespill planning is the use of a Memorandum of Understanding (MOU) between trustees and Memorandum of Agreement (MOA) between trustees and RPs. These agreements ensure the cooperation and coordination of the trustees and RPs in the planning and completion of damage assessment activities, and application of any natural resource damages recovered for restoration. The agreements should provide a framework for the implementation of natural resource damage assessment and associated party responsibilities. Agreements should be prepared during the prespill planning process. If there is no agreement in place, it should be prepared soon after an actual discharge of oil. NOAA has prepared draft language for such agreements.

2.2 Scope

To the extent practicable, the trustees, in conjunction with other willing participants where appropriate, should undertake prespill planning activities, similar to the oil contingency planning activities outlined in section 4202(a) of OPA for Area Planning Committees. The trustees should establish working groups at the regional or local area level to undertake these activities. Suggested prespill planning activities include:

1. Develop a NRDA team.

The NRDA team is responsible for planning and conducting damage assessments in the case of a discharge of oil. The size of the team should be a function of the scope and complexity of the assessment, and may include a trustee agency coordinator, a resource biologist, an environmental (petroleum) chemist, a resource economist, a restoration expert, an information specialist, a Quality Assurance (QA) specialist, a data manager/sample custodian, a statistician, and a resource attorney. Appendix B discusses the roles of these team members. It is not always necessary to have a different person for each role, but experience has shown that each role is a full-time commitment, especially for significant discharges. Each person on the team should have a working knowledge of NRDA regulations and requirements and be ready to begin preassessment activities immediately upon notification of a discharge of oil. The team should not be *ad hoc*; members must be knowledgeable in NRDA issues and have established working relationships with each other, other trustees and response community.

2. Identify outside experts.

Since oil discharges are sudden and episodic, it is not possible to maintain sufficient staff to conduct all NRDA activities. Depending on the conditions of the discharge, the trustees will need different experts on the team to assist in designing and conducting studies for different natural resources and services. The trustees should identify the types of NRDA expertise needed for a discharge in their area, and prepare a list of potential contacts available to provide that expertise. Experts without conflicts of interest should be used as an independent peer review group for potential natural resource damage assessment activities. Where practicable, the trustees may also find that using a blind panel of peer reviewers (i.e.,

not allowing reviewers knowledge of who is undertaking the study so as to minimize personal bias) will provide the most equitable review process. Where appropriate, the trustees should also invite these experts to participate in prespill planning. Experts can be drawn from within federal, state, and local agencies; academic facilities; private organizations; industry; and the public.

3. *Identify special support services.*

Certain support services, such as analytical and testing laboratories capable of performing the specialized hydrocarbon chemistry, toxicity testing, and histopathology needed for an NRDA on oil discharges, should be identified. Backup services should also be identified since the needs of both response and damage assessment activities can exceed even regional capabilities. Support activities conducted at the discharge site or potentially affecting any response activities must be coordinated with the federal OSC or designee. Other types of special support services that may be needed include:

- Field support for reconnaissance surveys by aircraft or vessel;
- Monitoring logistics for sample collection, handling, preservation, storage, and transport;
- Data management support;
- Human health and safety support; and
- NRDA training support.

4. *Collect information on natural resources and services potentially affected by discharges of oil along high risk areas.*

Area Planning Committees are responsible for the identification of sensitive natural resources and services in their areas, and development of protection priorities and approaches for these resources and services. The trustees are encouraged to serve on these committees to ensure incorporation of all special concerns and considerations and ensure consistency with the NRDA Prespill Plans. Examples of issues include seasonality of the natural resources, along with unique questions on protection, the overall effectiveness of cleanup countermeasures, effects versus natural recoveries, etc. These types of response issues are addressed in the Fish and Wildlife and Sensitive Environments Annexes of the Area

Contingency Plans (ACP). Besides having the opportunity to assist in creating and updating the ACPs, the trustees are also given the opportunity to comment when those ACPs are submitted to the Regional response Team for review. Personnel conducting damage assessment should coordinate with those involved with the response on issues affecting natural resources; they should clarify the anticipated activities and roles of each during the discharge and identify the data needs of the trustees that could be implemented through joint activities. Approaches for data sharing among the trustees, response agencies, and possibly the RPs, if they are involved, should be developed. This is particularly important since damage assessment data are often not made immediately available to the public. The trustees are encouraged to participate in training and coordination activities of the response community, such as drills for discharges of oil.

5. *Identify potential trustees and RPs at sites that may be affected by discharges of oil.*

All potential trustees and their trust resources and services for each region should be identified. They should develop criteria for the designation of a Lead Administrative Trustee (LAT) for a discharge, provide a mechanism for notification of the affected trustees, develop approaches for coordination with response agencies during the discharge, and agree on how to make incident-specific decisions. The trustees should identify potential RPs in their area and decide whether the RPs are willing to participate in the prespill planning process. The trustees may establish guidelines for involvement of RPs in the Preassessment Phase.

6. *Identify sources of information for background data.*

The trustees should develop lists or databases on the types of background information currently collected that may be of potential use in a NRDA. Where practicable, the trustees should identify and prioritize the most important information, and encourage or support the collection of such information in a cost-effective manner. Types of information considered potentially important include: petroleum hydrocarbon contamination in indicator organisms and exposure pathways [e.g., Mussel Watch programs conducted by various states; National Status and Trends Program (NS&T) of NOAA; Biological and Environmental Status and Trends Program (BEST) of the USFWS; Environmental Monitoring and Assessment Program

(EMAP) of the USEPA; National Water Quality Assessment Program (NAWQA) of the U.S. Geological Survey (USGS); species census and inventory; baseline data on species populations; recreational use statistics; and economic values for selected natural resources and services. Familiarity with the types of baseline data available will allow the trustees to formulate better data collection approaches. The trustees should also collect information on successful restoration efforts for trust resources and services, and needed restoration efforts in their region.

7. *Design a general approach and develop protocols for a data collection and analysis.*

The trustees may want to develop scenarios for the types of natural resources and services that may be affected by a discharge of oil, and plan for an appropriate study design, including data collection needs and sampling protocols. Where practicable, data collection and analysis protocols should be similar to those used in baseline studies to ensure comparability with the incident-specific assessment. The trustees should prepare standard protocols in a format that allows easy customization for a specific discharge. With prespill planning, initial damage assessment efforts may be better-implemented and generate more useful data. The trustees should prepare field kits for collection of samples and measurements in the early or emergency phase of a discharge. Appendix C lists recommended contents of various types of emergency sampling kits.

8. *Establish a centralized data management system for NRDA data.*

There is a pressing need to have a data management plan in place that provides efficient access to collected data following a discharge. Typical NRDA studies are highly multidisciplinary, involving experts from many different organizations who need access to data collected by various groups. For example, wetlands specialists studying injury to oiled marshes should use the same degree-of-oiling classifications as mapped by shoreline survey teams. The trustees are encouraged to develop a centralized data management system to support NRDA needs. A centralized database for NRDA data can be implemented in a range of formats, from hardcopy to digital spatial databases using Geographic Information System (GIS) software, according to the degree of complexity of the discharge. At a minimum, the

plan should address the type and volume of data, uses of the data, existing data management capabilities, types of analyses conducted, QA needs, reporting requirements, and access to data. Guidance on developing and applying effective data management systems can be found in Michener et al. (1985), Michener (1986), and USEPA (1990). The data management plan should also include provisions for distribution of updates to NRDA team members on a timely basis.

3.0 Overview of the Preassessment Phase

3.1 Purpose

The Preassessment Phase is a very important component in the overall damage assessment process. It is the period during which the trustees collect and evaluate information about an oil discharge so that a decision can be made as to which damage assessment procedure to undertake, if any. As proposed, the Preassessment Phase has a different purpose and duration than the preassessment screen step in the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) rule (1986; 1987). With the completion of the Preassessment Phase, the trustees will have collected and evaluated sufficient information so that they can select a damage assessment approach. In contrast, the preassessment screen under CERCLA is primarily a "desktop" exercise. In fact, the CERCLA preassessment screen is similar to the very first step in the Preassessment Phase under OPA, the *Preassessment Determination*.

3.2 Relationship to Response Activities

It is very probable that the Preassessment Phase will be conducted simultaneous with the OSC response activities. Any activities conducted in the discharge area should be coordinated with the OSC or designee, especially with regards to damage assessment trustees' requests for response operations resources. The trustees at the discharge site are likely to be participating as part of the OSC's response organization and member of the damage assessment team. The response activities are under the jurisdiction of the OSC,

whereas the damage assessment activities are under the jurisdiction of the trustees.

3.3 Scope

The Preassessment Phase provides a decisionmaking framework for the trustees to decide on the nature and extent of preassessment activities. Figure 1 outlines this framework. The process begins with notification when natural resources and services may be injured. Subsequent to notification, the trustees make their first decision on whether preassessment activities are justified, termed here the *Preassessment Determination*. The trustees make this decision with readily available information. This initial determination is a desktop exercise, with a timeline of hours to a few days, similar to the preassessment screen under CERCLA. In *Preassessment Determination*, coordination with the trustees, response agencies, and RPs should begin where appropriate.

The next decision occurs in the *Damage Assessment Determination*. In this step, the trustees decide whether damage assessment is justified. For most discharges of oil, completing this Determination will require limited data collection and analysis conducted during one sampling season.

The steps of the *Damage Assessment Determination* outline the process whereby the trustees build an understanding of the likely extent of injury to natural resources and services. Through characterization of the conditions of the discharge and receiving environment (Step 1), the trustees develop a conceptual model of the likely exposure pathways (i.e., actual or threatened, direct or indirect) to the natural resources or services (Step 2), and the potential injuries (Step 3). Observations or measurements of acute toxicity effects as well as research results from previous discharges or experiments that have reported injuries resulting from the oil are used in this evaluation. The following step requires the trustees to establish a link between the observed or predicted injuries and oil exposure (Step 4) to assess the potential risk to natural resources and services. Next, the trustees must estimate the extent (i.e., spatially and temporally) of the resultant injuries (Step 5) so that an initial estimate of the potential damages can be made (Step 6). On the basis of information collected to date, the trustees decide whether to conduct a damage assessment.

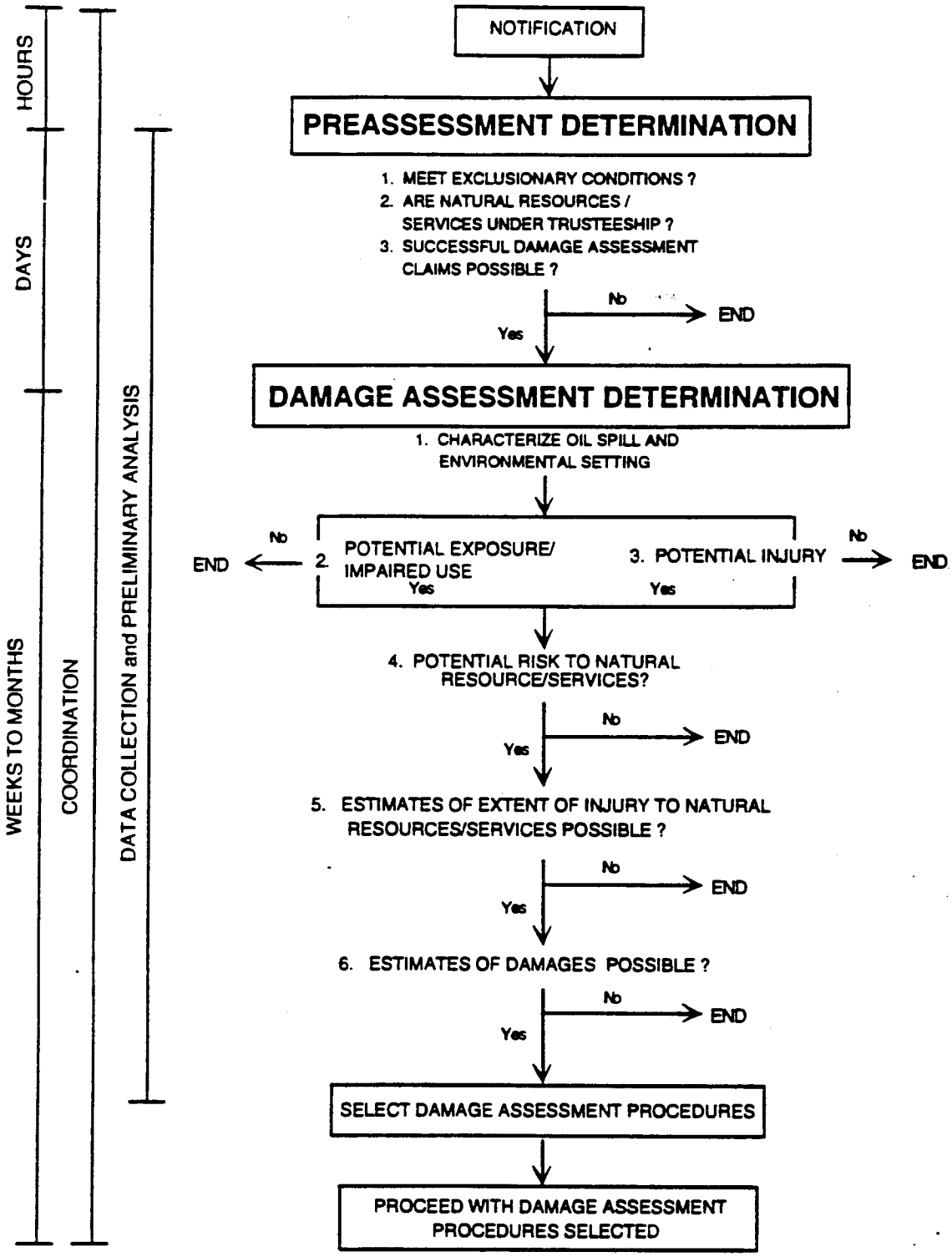

FIGURE 1. Preassessment Phase decisionmaking framework.

The third decision to be made by the trustees is the *Selection of the Damage Assessment Procedures*. Factors are provided to guide the trustees in this selection. However, it is up to the best professional judgment of the trustees to evaluate the conditions of the discharge relative to these factors. Once damage assessment selection is made, the trustees estimate the costs to complete the full damage assessment and evaluate the cost-effectiveness of the procedure. If the damage assessment is not cost-effective, then revisions to the assessment procedure should be made, or an alternative procedure selected.

At the conclusion of the Preassessment Phase, the trustees prepare a Preassessment Phase report, which documents the actions, decisions, and costs incurred by the trustees. If, at the conclusion of the Preassessment Phase, the trustees decide not to proceed, they may recover all appropriate assessment costs to date.

The entire Preassessment Phase should be completed within 6 months. The trustees have the flexibility to modify the timeframes as appropriate to the conditions of the discharge.

4.0 Notification

A NRDA begins with notification of an oil discharge, consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). According to the Plan, the OSC or lead response agency generally provides notification to the trustees. After learning of the discharge, the trustees should then notify all the other known potential trustees of a NRDA.

In practice, it is not clear how the OSC or lead response agency should make this determination. One option is to notify the trustees of every discharge. However, each year thousands of oil discharges are reported to local response agencies and/or the National Response Center. Between the period 1973 and 1990, approximately 105,000 oil discharges were reported and tracked by the U.S. Coast Guard (USCG) (Goodspeed, 1991) through its Marine Pollution Retrieval System, which includes only discharges located in coastal waters and the Great Lakes region. Of these discharges, 74% were less than 50 gallons, and 95% were less than 1,000 gallons. Although there is no fixed relationship between discharge size

and likely damages, very small discharges do not routinely result in significant natural resource damages. Therefore, the trustees should establish some criteria for when they require notification of a discharge. The most simple criterion is discharge size. As part of prespill planning, the trustees should review the oil discharge histories for their areas and natural resources, and develop notification criteria for response agencies.

The trustees should, at a minimum, provide for inclusion in ACPs:

- Updated contact name and phone numbers;
- Criteria for when contacts should be notified;
- Guidance on whether notification should occur on a 24-hour basis or during normal working hours;
- How notification is made during off-hours, if different than above; and
- How the other trustees are notified.

5.0 Coordination

Discharge of oil occur suddenly and go through an emergency phase during which activities focus on command and control of the discharge and mitigation of effects. The response community places great emphasis on prespill planning, coordination, and drills for emergency preparation. The trustees also need to emphasize prespill planning for NRDA activities, particularly for coordination among the trustees and response agencies. Under some circumstances and at the discretion of the trustees, potential RPs could be involved in prespill planning. Involvement of the RPs is dependent on the trustees identifying the RPs, the willingness of the RPs to become involved, and the ability of both the trustees and RPs to conduct preassessment in an effective and efficient manner.

One important coordination issue that needs quick resolution when multiple trustees are conducting a joint assessment is the designation of a Lead Administrative Trustee (LAT). When there are no guidelines for selection of a LAT, a LAT should be selected by consensus early in the Preassessment Phase. Alternatively, the trustees may designate Co-Lead Administrative Trustees. The federal trustees are required to select a LAT under Executive Order 12777, 56 FR 54757 (October 22, 1991). Further, a federal LAT must be designated

for access to the Oil Spill Liability Trust Fund (Fund) if the LAT is a state or Indian Tribe, as only Federal agencies can access the Fund.

Responsibilities of the LAT will vary depending upon trustee capabilities and dynamics, but may include:

- Scheduling meetings of the trustees;
- Preparing agendas and procuring space or other needs for the meetings;
- Acting as a central contact point for the trustee agencies involved in the discharge;
- Liaison with the appropriate OSC or designee;
- Coordinating preassessment data collection and analysis as well as other activities;
- Establishing and maintaining records for the trustees; and
- Contracting with consultants or experts to assist in the NRDA.

Selection of a LAT may be based on factors such as the trustee with the majority of natural resources at risk or one with the ability to provide the necessary administrative support.

During an actual discharge, Preassessment Phase coordination will depend greatly upon the complexity of the discharge and NRDA activities. An oil-specific NRDA team needs to be established with members who can participate throughout the NRDA process. The most complex conditions will require a multi-level structure, such as that which evolved during the EXXON VALDEZ NRDA. When many trustees are involved in a complex NRDA, the overall management of the NRDA may be directed by a Trustee Council. This council may be composed of senior representatives from each trustee entity. The Trustee Council makes the final decisions on the type of damage assessment to be conducted, studies needed to support the claims, and final damage claim. There may be a designated LAT for the Trustee Council. If a trustee must act before a LAT is designated or Council is formed, the trustee should inform the designated LAT of all activities performed in order to facilitate future coordination.

Under the Trustee Council, special committees may be formed to deal with various

aspects of planned injury studies, such as QA, economics, data management, analytical chemistry, legal issues, and restoration. The number of disciplinary study committees depends upon the natural resources affected (e.g., there may be committees for birds, fisheries, oil trajectory and fate, etc.). Members of the committees should include the principal investigator of each study, trustee representatives specializing in the natural resource or service, and experts. Each committee should elect a committee leader who takes responsibility for calling meetings, finalizing the agenda, distributing documents, chairing the meetings, and settling disputes. Legal representatives from each trustee would form a Trustee Legal Committee which would operate at an organizational level immediately below the Trustee Council. Both the Trustee Council and Legal Committee should be involved in determining the final damage claim. During the Preassessment Phase, it is essential that these committees form to minimize duplication of effort. Such coordination is best achieved through prespill planning.

For NRDAs of lesser complexity, the trustees may form a single team with representatives from each trustee agency, technical staff who are conducting the studies (i.e., both scientific and economic), legal staff from each trustee, and also could include peer reviewers, and possibly the RPs. A LAT should be designated with the responsibilities as outlined above. This NRDA team should meet as soon as possible after a discharge. The NRDA team reviews and approves all NRDA activities and assigns specific individuals or agencies as the lead for each activity. *Ad hoc* working groups can form to address special topics, such as data management and QA.

6.0 Preassessment Determination

6.1 Purpose

Preassessment Determination is the threshold by which the trustees determine whether a full Preassessment Phase is justified. This step is somewhat similar to the preassessment screen under CERCLA (1986; 1987).

6.2 Scope

Preassessment Determination is intended to be a desktop exercise, relying only upon readily available information on the discharge and environmental setting. This decision may be made within hours and should not take any longer than 1-2 days after receipt of sufficient information about the discharge (see Figure 1).

To make this decision, the trustees will have to evaluate the natural resources and services potentially at risk from the discharge. Information on the conditions of the discharge and likely resources and services at risk is obtained from the on-scene response agencies. For most large discharges of concern under USCG jurisdiction, the NOAA Scientific Support Coordinator (SSC) will have information on the oil trajectory, short-term fate and behavior of the oil discharged, resources and services at risk, and response actions taken to-date. For discharges under USEPA jurisdiction, the Emergency Response Team (ERT) and/or Technical Assistance Team (TAT) can provide similar information. Federal and state resource managers who are assisting the OSC or designee in the response can provide on-scene information on the resources and services that are present and may be affected. Often at small discharges, the local resource manager or state response representative is the only official to investigate the discharge. The trustees can contact specialists in oil discharge effects to provide their expertise on the likelihood of injury to trust resources and services, given the conditions of the discharge.

Information which the trustees should obtain includes:

1. Circumstances of the discharge.

The circumstances of the discharge to consider include: location of the discharge; source of the discharge; cause of the discharge; time and duration of the discharge; status (i.e., discrete/intermittent/continuous); oil type; quantity discharged (i.e., actual and potential); receiving body (e.g., water, land); extent of contamination and trajectory; other contaminants on-board; and unusual on-scene conditions.

Knowledgeable sources involved in the actual response, or their agency representatives, can provide this information. It is very important to obtain up-to-date information since conditions of the discharge change rapidly.

2. *Characteristics of the oil.*

Factors to consider in characterizing the oil include: physical and chemical variables of the discharged oil; results of weathering models or expert estimates for evaporation rates, dissolution, tendency for formation of emulsions, photo-oxidation rates, and biodegradation potential; and toxicity data.

Physical variables of greatest importance in development of a conceptual model for the behavior and fate of the discharged oil include specific gravity, viscosity, and pour point. The specific gravity will indicate whether the oil is likely to float or sink, relative to the specific gravity of fresh water (1.0) and salt water (1.03). Usually, only very heavy refined products, such as No. 6 fuel oil, sink on their own (i.e., without incorporation of sediments) in salt water. In fresh water, some heavy crude oils and heavy refined products, such as Bunker C and No. 6 fuel oil, can sink immediately after the discharge or after some weathering. Viscosity is used to indicate the potential of oil to spread, whether the oil is dispersible or not, the likely penetration into sediments, and likely ease of removal of oil stranded on the shoreline. The pour point of an oil determines whether it will be a liquid or solid at ambient water temperatures. Most of these physical variables are provided in product documentation available from the shipper or owner of the product.

Chemical variables of greatest importance during the Preassessment Phase include the boiling point fractions and water-soluble fraction. The boiling point fractions are used to estimate or model loss by evaporation within the first hours to days. The water-soluble fraction indicates the potential magnitude of exposure for water-column organisms. These data are more difficult to obtain for specific oils, particularly the Water-soluble fraction, because it is scattered throughout the gray literature. McAuliffe (1987) reported the water-soluble fraction of six crude oils equilibrated with saline water to range between 20 and 40 mg/L. Total aromatics constituted 35-80% of the total dissolved hydrocarbons. The aromatic fraction is of greatest concern because this fraction has the greatest acute toxicity effect. The salinity of the solubility measurement is important since specific hydrocarbon solubilities in seawater are lower than in freshwater, by about 70% (Sutton and Caulder, 1975).

The amount of an oil slick lost to evaporation is also very important since the most volatile aromatic components are the most acutely toxic (e.g., benzene, ethyl benzene, toluene, and xylene). There are several models available to estimate evaporation rates. The SSC can provide the results of the NOAA oil Automated Data Inquiry for Oil Spills model for fate of discharges in water. This computer model contains internal databases of key physical and chemical variables for many common types of oil which are used to estimate evaporation rates, emulsion-forming tendencies, viscosity, and a mass balance for incident-specific conditions within hours to a few days after the discharge. Other models in the public domain include an oil weathering model which calculates amounts of oil lost to evaporation, dispersion, and dissolution over time (Payne et al., 1983), and the Type A model which calculates the amount of oil lost to evaporation as part of the mass balance.

For discharges where most models are not appropriate (i.e., on land or narrow rivers, oil types not in the database, unusual weather or sea conditions, etc.), experts involved in the response usually have developed their best estimates for these properties. Evaporation is usually an important process in the first hours to several days after the discharge. Notable exceptions are for discharges under ice or when the oil immediately penetrates porous soils.

Some of the models address both dissolution and dispersion, although the subroutines for these processes are less well-defined. The Automated Data Inquiry for Oil Spills model predicts the formation of water-in-oil emulsions. Formation of emulsions is of concern because they significantly slow all weathering processes, increase the amount of oil product by a factor of 2-3 because of water content of up to 70%, and greatly reduce the efficacy of oil recovery equipment (i.e., mainly skimmers). Photo-oxidation and biodegradation are important mechanisms for petroleum degradation for periods of weeks to years after the discharge.

Toxicity data for different oil types are available from various sources, although there is no single best source of information. Some oils are well-tested, such as Cook Inlet and Prudhoe Bay crude oils which have toxicity data for a large number of arctic species (Rice et al., 1976; 1979). There have been very few compilations, such as the one by Scott et al. (1984) for marine shellfish. There are many on-line and published databases with chemical

and toxicity data for specific compounds, which may be of value, particularly for refined products. These databases include: AQUatic Toxicity Information REtrieval System (AQUIRE), which is a database of aquatic toxicity test results for 5,500 individual chemical compounds compiled by the USEPA (Pilli et al., 1989); and several databases available through the Chemical Information System (CIS), such as Chemical Hazard Response Information System or CHRIS (1984), originally developed by the USCG, and Oil and Hazardous Materials-Technical Assistance Data System originally developed by the USEPA (1981), among others. Since oil discharges involve complex mixtures, toxicity data for whole oils are more appropriate. Oil in water toxicity data using standard aquatic toxicity methods are widely scattered, with limited data available for early life stages which are most sensitive. There are even less data available on sediment toxicity for indicator organisms. Most of the sediment toxicity data are for individual hydrocarbon compounds which are pyrogenic rather than petrogenic in origin (Long and Morgan, 1990). That is, sediment data are derived from the combustion of fossil fuels which generate a very different suite of compounds with different mechanisms of toxicity. For example, benzo[a]pyrene is a common contaminant in urban watersheds, but it is only present in whole crude oil at the 1-2 parts per million level (National Academy of Sciences, 1985). Where available, however, toxicity data for key organisms of concern can be used to determine the potential for short-term effects to aquatic and intertidal organisms.

3. Nature of receiving environment.

The nature of the receiving media of a discharge can affect the:

- Effectiveness of natural removal processes (i.e., spreading area, degree of exposure to river and tidal currents and wave energy, substrate type, shoreline habitats);
- Potential for water-column exposures (i.e., water depth, dilution potential); and
- Potential for benthic exposures (i.e., erosion, deposition, resuspension).

For aquatic environments, important factors include: water body configuration (i.e., length, width, depth); currents (i.e., direction, velocity); tidal cycle; wave energy;

temperature profiles; and seasonal considerations. For terrestrial environments, important factors include: topography; soil type; ground-water flow regime; degree of development; and seasonal considerations.

All oils are subject to the same weathering and physical transport processes. It is the nature of the receiving environment that determines whether a given discharge may result in significant injury. For example, a 100,000 gallon gasoline discharge in the open ocean will have significantly lower ecological effects than a similar discharge in a tidal channel. In the absence of appropriate computer models, the trustees will have to develop conceptual models on the likely behavior of an oil discharge, its partitioning into different compartments of concern (i.e., surface and bottom water, groundwater, sediment, soil, air, biological organisms), and it's persistence in these compartments. Sheltered environments will have longer-term effects compared to exposed environments because of the persistence of the contaminant (National Academy of Science, 1985). Water-column effects are of concern mostly where water depths and rates of dilution with clean water are low. Discharges of oil seldom result in acute toxicity effects (e.g., observable fish kills), except in rivers and streams where the fish cannot escape and the dilution of the plume is limited. Water-column effects are also more likely to result from the discharge of light, refined products. The potential for bottom water or benthic exposures is higher where the receiving environment is shallow or has high suspended particulate loads, in freshwater settings where heavy oils are more likely to sink, and with heavy oils which are more likely to sink.

4. Natural resources and services characteristics.

Assessment of potential effects requires the trustees to determine the natural resources and services at risk. Assessment of ecological effects includes: habitat types; existing species and life stages, including threatened or endangered species present; species sensitivity to effects of oil; ability of potentially affected resources to recover; and unique ecosystem components. Assessment of services at risk includes utilization of the threatened area for recreational, commercial, or ecological importance, or of special significance; or for its mere existence.

With this information, the trustees should be able to assess the potential risk of injury

to trust resources and services. The trustees are encouraged to interview response members from natural resource agencies who are on scene as well as oil experts who are knowledgeable about the behavior and fate of the discharged oil and for the resources and services potentially at risk. A Preassessment Determination does not generally involve a reconnaissance of the discharge, although NRDA team members may have to go on-scene to obtain the necessary information from the response operations. A Preassessment Determination does not require data collection and analyses.

Since conditions of the discharge may change suddenly either because of an actual variation in the field or laboratory or a correction to early information, the initial assessment of a discharge may be revised. Further, the trustees will be notified about potential discharges for which the trajectory and natural resources and services at risk will be understandably uncertain. When changes in the conditions of the discharge occur, it is important that the information on environmental setting and natural resources and services present is updated.

6.3 Conditions to Proceed

The decision to proceed with a full Preassessment Phase is based on the following conditions:

1. The discharge of oil does not qualify for the exclusionary conditions set forth in Section 1002(c) of OPA; namely any discharge which is:
   a. Permitted by a permit issued under federal, state, or local law;
   b. From a public vessel; or
   c. From an onshore facility which is subject to the Trans-Alaska Pipeline Authorization Act (43 U.S.C. 1651 et seq.);
2. The trustees may assert authority under OPA for natural resources and services that may be adversely affected by the discharge of oil; and
3. There is a reasonable probability that the trustees can make a successful damage claim based on the scientific, economic, and legal merits of the case (i.e., potential for injury resulting from the discharge of oil and successful and

meaningful restoration and/or compensation).

The trustees must be able to obtain enough information to demonstrate that these conditions are met in order to proceed with preassessment activities. Documentation requirements for the decision to proceed with a full preassessment are minimal, and could be satisfied with a report containing the following information:

- The trustees' current understanding of the discharge and environmental conditions;
- A summary of the current understanding of the transport, fate, and effects of the discharged oil;
- A summary of the natural resources and services potentially at risk; and
- Identification of trustees for the natural resources and services potentially at risk.

7.0 Damage Assessment Determination

The objective of Damage Assessment Determination is to collect data sufficient to decide which damage assessment procedure to conduct, if any. Damage assessment is appropriate for those injured natural resources and services that can be restored or for which damages can be estimated.

The trustees should be aware of the limitations in the ability to measure or predict effects resulting from the discharge. Predictions and estimates on such effects should be made based on best professional judgment and the use of available procedures. During the Damage Assessment Determination, a realistic consideration of all potential limitations will allow the trustees to determine the most appropriate assessment procedures to conduct and possible restoration alternatives to consider.

There are six steps to complete this determination, as listed below and discussed in the following sections:

1. Characterize discharge and environmental setting;
2. Determine potential exposure;
3. Determine potential injury;
4. Characterize potential risk to natural resources and services;
5. Estimate extent of injury to natural resources and services; and

6. Estimate damages.

The complexity of the tasks will be a function of the scope and complexity of the discharge and likely injuries.

7.1 Characterize Discharge and Environmental Setting

The first step in Damage Assessment Determination is characterization of the discharge and environmental setting which serves as the basis for the following analyses. This characterization consists of:

- Circumstances of the discharge;
- Characteristics of the oil;
- Nature of the receiving environment; and
- Characteristics of the natural resources and services in the receiving environment.

These activities are similar to those undertaken during the Preassessment Determination, as discussed in Section 6.2, but now they are conducted in greater detail. Additionally, these activities are modified to reflect the information gained during initial data collection and analysis. Therefore, the trustees have a better basis on which a more focused characterization can be made.

7.2 Determine Potential Exposure

In this step, the trustees identify the potential for direct and indirect exposure. Direct exposure may be defined through the use of either a conceptual model based on the available information, or the results from preliminary transport and fate models. If the discharge meets the conditions of use of the Type A model for the estuarine/marine or Great Lakes environments, the trustees may want to run the model with the most current information to provide an estimate of the short-term fate of the discharged oil. Other models can be used as well if they are readily available and applicable. The objective is to develop a general analysis of the transport and fate of oil into the various compartments of: air; water surface or water column; sediments; shorelines or soils; groundwater; and biological organisms. This effort is the first attempt at a realistic mass balance of the discharge. Hopefully, there

are some analytical data or field observations available at this time to confirm the trustees' assumptions on oil behavior, conditions of the discharge, etc., which can be used to determine the potential exposure. The trustees should describe their understanding of the pathway through which the oil may be transported, resulting in exposure to the potentially injured natural resources and services. The response activities used to combat the discharge should also be considered in this pathway analysis, particularly as some approaches will significantly alter the fate of the oil. Some estimation of the magnitude of exposure is needed so that injury determination is possible.

In the absence of direct exposure, the trustees should determine if there is adverse effect on or impaired/diminished use of a natural resource or service. An example of an indirect adverse effect is where exposure to oil has resulted in the reduction or elimination of food chain resources thereby resulting in starvation of a higher trophic level resource (e.g., birds). An example of impaired/diminished use is where a recreational beach is closed in anticipation of oiling.

If there is no potential for exposure or adverse effect on or impaired/diminished use of the natural resource or service, preassessment activities for that resource or service should cease; otherwise, preassessment should continue. For example, oil slick maps and water quality sampling during a discharge of oil may document that the oil is not likely to come in contact with a recreational fishery habitat. Such a finding would allow the trustees to terminate further preassessment for that recreational fishery.

7.3 Determine Potential Injury

The third step, which runs simultaneously with potential exposure step, is the determination of potential injury. Natural resources and services can be considered as potential receptors to the oil discharge. Again, response and cleanup effects on natural resources and services should be included in this analysis. Using the most current data available, the trustees should determine the potential for injury, in terms of types and attributes of habitats and biological resources affected. The potential injury can be determined from direct observations of injury from early field surveys, toxicity data for the

discharged product, case histories and research from previous discharges (i.e., particularly for injuries which are delayed), and preliminary chemical analyses. There should be enough information from early field studies and data collection for the trustees to prepare a realistic analysis of the natural resources and services at greatest risk of injury.

If there is no potential for injury for a particular natural resource or service, preassessment activities for that resource or service should cease; otherwise, preassessment should continue. In the recreational fishery example above, if the fishery was exposed to the discharge resulting in a precautionary closure, preassessment would continue despite the fact that no natural resources were affected (i.e., fish mortalities). The closure represents an injury to a fishing-related service.

7.4 Characterize Potential Risk to Natural Resources and Services

The fourth step in a Damage Assessment Determination allows the trustees to establish likely cause-effect associations between the potential exposure and injury to natural resources and services resulting from the discharge of oil as that term is defined. Potential risk of injury to natural resources as a result of exposure to oil may result if the oil is likely to: (1) exist in a form and concentrations sufficient to cause an adverse effect (i.e., direct or indirect); or (2) come in contact (i.e., actual or perceived) with natural resources or services with which it can interact adversely.

This association can be established during the Preassessment Phase by two main approaches: through direct observations or sampling and analysis. Direct observation includes: maps of the distribution of oil in various habitats; documentation of direct exposure of the resource to the oil; results of census or inventory data on the number of dead/oiled organisms; tabulation of the number of days of closure of recreational sites, etc. Sampling and analysis includes results from: range-finding and short-term toxicity tests; rapid bioassessment surveys which can be used to indicate the relative severity of effects; chemical results that indicate the presence of the oil at levels known to cause injury; bioaccumulation indicators which document exposure and uptake by the natural resource; histopathological evidence of exposure and injury; and other biochemical or physiological

biomarker information.

Establishing exposure and injury associations does not necessitate a formalized risk assessment procedure, but should be based on the weight of evidence of the data collected as well as best professional judgment. The correlation of chemical, toxicity, ecological, and/or biomarker data is the best means of establishing associations between the discharged oil and potential risk of injury. In the absence of such data or with incomplete data, the potential for risk may be determined relative to established standards or criteria, or to scientifically sound thresholds using chemical data alone. It may also be possible to use the results of fate, transport, and effect models to provide evidence of possible associations between the discharged oil and potential injury.

If there is no potential for risk to natural resources or services, preassessment activities should cease; otherwise, preassessment should continue with estimating the extent of injury.

7.5 Estimate Extent of Injury to Natural Resources and Services

The fifth step is to preliminarily estimate the current and future extent (i.e., magnitude and duration) of the injury to both natural resources and services. This determination requires that the trustees define the spatial and temporal boundaries of the discharged oil and its effects on natural resources and their services. The objective is to attempt to generate an initial quantitative measure of the injury. There are two approaches to this task: (1) measure the extent of resource injured and translate to lost services; or (2) measure services injured directly. In the first approach for example, injuries to an oiled marsh are described in terms of the number of acres affected for each degree of oiling and the projected number of years over which recovery is expected to occur. The recovery rate may vary for the different types of services provided by a healthy, fully functioning marsh. The injury could be translated into lost services as lost wetland acre-years for each relevant service flow. In the second approach, closure of a recreational beach will result in lost beach days which is a direct measure of the injured lost services.

If the extent of injury to natural resources or services cannot be determined,

preassessment activities should cease; otherwise, preassessment should continue with estimating damages.

7.6 Estimate Damages

The sixth and final step in Damage Assessment Determination is to generate a preliminary estimate of the monetary value or damages of the injuries to natural resources and their services. Further, included in this calculation is an estimate of the cost of likely restoration actions, and all assessment-related costs. At the Preassessment Phase, such calculations will be understandably rough and subject to change as more information is obtained. One approach is to use ranges of values, rather than have to select a single value.

If an estimate of damages is not possible, preassessment activities should cease; otherwise, preassessment should continue with selecting the most appropriate damage assessment procedures.

8.0 Selection of Damage Assessment Procedures

8.1 Purpose

At this stage, the trustees have completed a preliminary analysis of the types of injury which occurred, identified additional studies needed to verify and quantify injury, and estimated the damages resulting from the injuries. The trustees have also made the decision to proceed with damage assessment activities. The next step is to select a damage assessment procedure. The trustees should use the damage assessment approach that is most appropriate to the discharge. This section describes the general considerations and identifies the specific factors which the trustees may consider in selecting a damage assessment procedure.

8.2 General Considerations

The Preassessment Phase directs the trustees to consider the following general considerations in Damage Assessment Determination:

- The size and nature of the discharge and environmental setting;

- The extent to which the discharge of oil is expected to cause injury to natural resources and services;
- The expected environmental and/or economic values provided by those affected natural resources and services;
- The extent to which response actions carried out or planned will prevent further injury to natural resources and services without further action;
- The extent to which the discharge of oil meets the conditions for using the potential damage assessment procedures;
- The extent to which natural resource and service injuries can be verified with available information and quantification methods;
- The extent to which restoration alternatives can return injured natural resources and services to their baseline or comparable conditions;
- The extent to which damages based on natural resource and service injuries can be verified with available information and quantification methods; and
- Whether anticipated damage assessment procedures are cost-effective.

Another important consideration is the willingness of the RPs to negotiate a natural resource damage claim. If the RPs are willing to negotiate claims on the basis of simplified damage assessment procedures, such as compensation formulas or computer models, these procedures may provide useful methods of assessment. If, however, it is likely that the RPs will contest the damage assessment and require the trustees to litigate their damage claim, more detailed and expensive methods will be required.

8.3 Specific Selection Factors

Based on the results of the Preassessment Phase, selecting a damage assessment procedure requires the best professional judgment of the trustees. Every discharge of oil is a unique combination of conditions which cannot be translated into a simple decision chart. Further, there will be many unknowns and uncertainties in the quantification and valuation of injury at the end of the preassessment. Consequently, the factors have to be carefully evaluated relative to the known and estimated conditions of the discharge and injured natural

resources and services. The specific factors for selecting each of the four damage assessment procedures are discussed in the following subsections. However, these selection factors are not rigid, and the trustees do not need to select a particular procedure for a particular discharge.

8.3.1 Compensation Formulas

Compensation formulas are available for estuarine/marine as well as select inland (freshwater) surface waters of the United States and its protectorates. The compensation formulas were derived from a statistical analysis of a large number of runs of a draft of the revised Type A model. The model runs were based on a series of simplifications which may affect the resulting damages. The model runs were made based on the notions that:

- The discharge was instantaneous;
- The discharge occurred to a water body, at the water surface, and at a single location;
- The oil was categorized as one of five types: heavy crude, light crude, No. 2 fuel oil, diesel, or gasoline;
- The discharge affected a uniform habitat, which means that the model was run assuming only one habitat was present;
- The discharge occurred under average weather conditions and uniform winds;
- Non-tidal currents were not significant, and tidal currents were spatially uniform;
- Special species, such as threatened and endangered species, were not given any special values; however, values are in proportion to rareness; and
- Passive use values were not included.

The compensation formula procedure is based on the following conditions:

1. *Discharge volume is small, and the discharge is of short duration at a single location.*

Small discharges generally do not result in damages large enough to warrant extensive field data collection and analysis to determine natural resource and service injuries. Small

discharges are very common. Discharges less than 50,000 gallons represent 99.8% and discharges less than 10,000 gallons represent 99% of the number of oil discharges reported to the USCG between 1973 and 1990 (Goodspeed, 1991). Compensation formulas may be the only cost-effective option for small discharges of oil.

2. *Conditions of the discharge and receiving waters may be considered typical for the habitat and season of the discharge.*

The model was run for normal (i.e., average) conditions for each season, for both the physical fates and biological effects submodels. Therefore, discharges during extremely unusual storms, floods, or biological cycles may not be adequately represented.

3. *No special species or habitats were significantly injured.*

Special species include those which are threatened, endangered, or otherwise of special value. Special habitats include those critical ecosystems which support special species. The economic submodel did not provide special values for these species and habitats.

4. *Chronic toxicity effects are not expected to be significant.*

Effects are assumed to result from acute toxicity and direct oiling by surface slicks, and not chronic toxicity. All biological resources are believed able to recover within the life span of the species.

5. *Only one or two habitat types were significantly affected, and the volume affecting each type can be estimated.*

The formulas provide damages by volume and habitat type, assuming fresh oil is discharged into that habitat type. Therefore, if many habitats are affected, particularly if some of those are affected only by weathered oil, the compensation formulas may not be appropriate.

The trustees may determine that the use of the compensation formula is appropriate after considering the following factors:

1. The amount of the discharge is between 10 gallons and 50,000 gallons, 24 hours after the discharge begins;
2. The injury and damages resulting from the discharge are appropriate

for calculation using the compensation formulas based on the conditions described above and in French et al. (1993a&b); and

3. The discharge is such that accurate quantification of injury and damages is not cost-effective.

8.3.2 Revised Type A Models

The revised Type A model calculates injury and damages for oil discharges in estuarine/marine and Great Lakes aquatic environments. The model system contains geographical information such as environmental conditions, coastline, bathymetry, and habitat type. Biological and economic information represent regional averages by habitat type. Injuries in multiple habitats are calculated. The user specifies discharge amount, location, time, duration, oil type, environmental conditions (e.g., wind time series, currents), cleanup amounts, and fishing and recreational closures. Damages due to restoration, use, and passive use values are included.

Assumptions and properties of the revised Type A model are summarized below. To the extent that these assumptions are reasonable for the discharge considered, the Type A model may be used. The ultimate test of "reasonableness" is if the major portion of the damages are for injuries adequately addressed by the model. Further, the model may be used for part of the assessment, with certain natural resources addressed separately in another manner as required.

Assumptions for the Type A model include:

1. Winds are uniform spatially, but vary temporally.

The model accepts as input a single wind time series which is assumed invariant in space. For discharges which cover very large areas, traverse great distances, or occur in mountainous areas where topographic effects are important, spatial variability in the wind may have a significant effect. To compensate for this effect, the wind time series can be compiled using the recorded wind speeds and directions corresponding to the geographic area in which the major portion of a discharge is found at any given time during a discharge.

2. *Currents are vertically averaged.*

The currents in the model are two dimensional, vertically averaged values. Three-dimensional complexities such as reverse flows at depth, vertical shear profiles, upwelling, and downwelling are inherently neglected in the Type A model. Thus, both the magnitude and direction of transport vectors in the water column may be inaccurate if these complexities are significant. However, the ultimate effect on economic damages is usually not significant in offshore and other areas where the biological habitats are homogeneous.

3. *Resolution of physical domain is reasonable for the conditions of the discharge.*

The fates submodel resolves the physical domain into discrete rectangular grid cells, with attributes being uniform within a cell. Increasing the resolution (i.e., using a greater number of smaller cells), provides a better representation of the real world as long as reliable data at the finer resolution is available. The Type A model has a resolution of 1 to 10 km, commensurate with available data for bathymetry, habitat type, shoreline type, and currents. Higher resolution is used in nearshore areas, with broader scales offshore.

4. *Resolution of contaminant distributions is reasonable for the conditions of the discharge.*

The model represents the contaminant on the water surface and in the water column by distributions of discrete slicks or particles. The maximum number of slicks and particles allowed by the computational software/hardware affects the ability of the model to resolve these spatial distributions. The model is designed to adequately resolve contaminant releases of up to a few days in duration. Very long term, chronic discharges, which may result in widespread distributions of contaminants, are beyond the scope of the Type A model.

5. *The discharge occurs in geographic regions covered by the model.*

The ecosystems included in the assessment are those aquatic systems in the Great Lakes, and in estuarine and marine environments of the United States, including territories and possessions. The seaward bounds are at or are just beyond the Exclusive Economic Zone boundaries. All regions where salinity is brackish or saline (>0.05%) are included. In some regions (i.e., major estuaries and river mouths), tidal freshwater habitats are also

included. Intertidal portions of shorelines are habitats considered by the model. Upland, groundwater, and atmosphere are not included in the model domain, nor are injuries suffered by biological organisms in these environments.

6. Injuries and damages are for services to the United States public.

Injuries and the resulting damages are quantified only for resource services to U.S. populations (i.e., of people). Thus, injury to a "U.S. fish" (e.g., a fish later caught by a U.S. fisherman) is quantified whether the injury or discharge occurs in U.S. or in nearby international waters. "U.S. fish" are assumed to move freely and randomly in a water body regardless of the border. All injuries to wildlife, because of their mobility and migration through the U.S. for at least a portion of each year, are assumed compensable to the U.S. public to the extent that they provide services to that population. Food-web losses in international habitats within the model domain which result in injury to U.S. fish and wildlife resources are included in the model's calculation of compensable value.

7. Species valued in the model are appropriate for the conditions of the discharge.

Biological resources assessed for injury are fish, wildlife (i.e., other vertebrates), invertebrates, and plants. Those fish, shellfish, and wildlife species having some measurable consumptive, nonconsumptive, or passive use value, and where quantification of their abundance can be documented, are included in direct valuations of injury. These are, for the most part, the larger fish, shellfish, reptiles, and mammals, and all bird species which make primary use of Great Lakes and estuarine/marine aquatic habitats. Plants, invertebrates, and small vertebrates are included as contributors to food webs and habitat value for the individually valued fishery and wildlife species.

8. Abundances are assumed average.

The environment is represented by aerially and seasonally averaged abundances. Incident-specific and short-duration (i.e., weeks or less) concentrations of biological organisms are not specifically modeled, but are included in the overall average.

9. Injury results from acute toxicity.

The injury is quantified based on the acute toxicity of a perturbation in toxic

contaminant concentration. The model is not designed to address long-term, chronic exposure to pollutants. Toxic responses are averaged over species groups.

10. Ecosystem-level interactions are assumed insignificant.

It is assumed that the mortalities and changes in biological productivity are small enough that ecosystem structure is not significantly changed. The model does not address changes in predator-prey or competitive relationships between populations. The direct mortality from the contaminant and loss of food resources are assumed the main effects on the populations. The populations affected are not assumed to respond in any compensatory manner (i.e., natural mortality and reproduction rates after the discharge effects dissipate are assumed the same as before the discharge).

11. Restoration is that which minimizes injury and the resulting damages.

Only technically feasible restoration actions which will reduce biological injury and the resulting damages due to lost services are assumed performed. The reduction in biological injury is measured by the biological-effects submodel, assuming technically feasible restoration actions are performed.

Alternative restoration actions for each habitat type which are documented in the literature as most effective in reducing injury and represent the most cost- effective methodology for doing so are considered possible actions. A restoration action is performed on a habitat over the area where it is possible to reduce the injury.

12. Restocking is one-for-one and in-kind.

After toxic concentrations have dissipated by restoration or natural recovery of the habitat, restocking of fishery species and wildlife is performed if stocks can be provided at the age the lost individuals would be at the time the habitat is recovered and can support restocked individuals.

13. Only on-site and in-kind restoration actions are considered.

On-site restoration actions performed on the habitat affected are considered potentially most able to reduce the total injury and the resulting damages to the public. If on-site restoration is not possible, damage is based on lost services pending recovery.

14. Consumptive use values remain constant.

Consumptive uses included in the model are for fishing and hunting. It is assumed that catchability of the stocks and effort devoted to exploiting the stock are not significantly changed. It is also assumed that the price or value of an individual animal remains unchanged after the discharge.

15. Nonconsumptive or recreational use values per unit resource remain constant.

It is assumed that the level of recreational activity and its geographic distribution are not significantly affected by the discharge.

16. Only fishery and wildlife-related recreational injuries are estimated by the model.

Other recreational injuries are specified by the user as closures. The user may specify closures to fishing, hunting, shoreline use, and boating in terms of area or length closed per unit time. The model assumes 100% loss of use and value over that time and area closed, with no possibility of substitution.

17. Cumulative effects are not addressed.

The model treats each discharge as an isolated event. Previously existing contamination and toxic effects are not accounted. The trustees may determine that the use of the Type A model is appropriate after considering the following factors:

1. The conditions of the discharge substantively meet the assumptions specified above;
2. The compensation formulas are not sufficient alone to estimate injury and damages resulting from the discharge; and
3. There is no other cost-effective procedure available to estimate injury and damages resulting from the discharge.

8.3.3 Expedited Damage Assessment (EDA)

Expedited Damage Assessment (EDA) is an approach which consists of limited, focused studies to document injury, existing oil-effects literature to quantify injury, and existing economic valuation approaches to calculate damages. EDA is a more complex

approach than the compensation formulas or Type A model, and, thus, the factors for selection are more complex and multidimensional. The OPA rule discusses the factors used to determine whether an EDA is the appropriate procedure for a given discharge, and the reader is encouraged to refer to the rule.

The trustees may determine that the use of an EDA is appropriate after considering the following factors:

1. *The use of the compensation formulas or Type A models alone do not sufficiently consider the injury and damages resulting from the discharge.*

Conditions of the discharge which would not be sufficiently considered by either the compensation formulas or Type A model are if:

- The volume of the discharge is not known or readily estimated;
- The discharge occurred over a period greater than a few days;
- Injuries to unique habitats or special species occurred and are readily quantified;
- A complex discharge trajectory that covers very large areas is not readily modeled;
- The distribution and/or abundance of affected biological organisms are known to differ significantly from seasonal averages (e.g., unusually large concentrations of wintering waterfowl were present and affected);
- The ecosystems affected are not addressed by the model (e.g., rivers, small lakes); and
- There are known, readily determined injuries resulting from chronic exposures.

The injury and damages resulting from the discharge may be adequately calculated using a combination of the Type A model, and injury determination/ quantification and compensable values studies. For some discharges, the Type A model may address most of the potential injuries and damages, with a few notable exceptions which can be readily determined from limited data collection efforts. The most cost-effective approach is the use

of components of the Type A model to calculate damages for those natural resources and services that are appropriate, and conduct the limited studies needed to address the remaining injured resources and services. For example, the Type A model may be used to calculate damages to fisheries, assuming the conditions of the discharge generally meet the assumptions in the model. Recreational losses from beach closures may be calculated separately based on incident-specific, baseline data on user days and surveys conducted after the discharge.

2. *There is readily available information on the nature of the discharge and its effect on natural resources and/or services.*

To the extent practicable, the trustee should rely on existing information regarding natural resources and/or services at risk when undertaking an EDA. This is particularly true for information that helps establish a baseline for natural resources and/or services. Such data enable the trustee to: (a) establish background levels and types of hydrocarbons in key exposure pathways prior to the discharge; (b) characterize the physical and chemical parameters prior to the discharge; (c) characterize the status of the biological and habitat resources prior to the discharge; and (d) identify other information sources, such as population surveys or catch statistics that may be useful in quantifying injury and determining lost services. In addition to baseline data, other information useful for an EDA includes literature that documents injuries to similar natural resources and identifies the level and flow of services provided by injured natural resources.

Sources of information include government, academia, and private organizations. Existing federal monitoring programs that may provide the data for environmental parameters include NOAA's National Status and Trends (NS&T), USFWS Biological and Environmental Status and Trends (BEST), USGS National Water Quality Assessment Program (NAWQA), USEPA Environmental Monitoring and Assessment Program (EMAP), and NOAA National Marine Fisheries Service (NMFS) Fisheries of the United States. Abundant baseline information in each of the categories may not always be available to the trustee. Failure to locate relevant information, however, does not preclude the trustee from selecting an EDA. An EDA may still be appropriate provided that the trustee can obtain the necessary data from

limited focused studies.

Selection of an EDA may depend on general categories and characteristics of oil. The physical and chemical properties of oil may help determine the exposure pathway, natural resources likely to be injured, and duration of that injury. The nature and extent of injury to natural resources, in turn, will depend on the type of petroleum hydrocarbons. Many types of oil have been studied extensively and their particular characteristics and effects upon natural resources are often well established in scientific literature. Discharges of such oil are most suitable for an EDA. In circumstances where the trustee determines that the characteristics and effects of the particular discharge are not well known or are uncertain, an EDA may yet be appropriate provided that injury can be established by limited, focused studies.

Petroleum hydrocarbons can generally be organized into the categories of: (1) very light refined products (i.e., gasoline); (2) light oil (i.e., diesel, No. 2 fuel oil, and certain light crudes); (3) medium crude oil; and (4) heavy oil (i.e., No. 6 fuel oil and Bunker C). For each category, some generalizations can be made regarding the volatility, degree of persistence, and toxicity associated with oil. These characteristics should assist the trustee in determining whether an EDA is an appropriate assessment approach.

Size and location are other important factors to be considered in determining whether an EDA is appropriate. Accordingly, the proposed rule encourages the trustee to take both size and location of the discharge into account when selecting the relevant damage assessment procedure.

Discharges smaller than 50,000 gallons in open water generally either disperse, contaminate small areas, or have limited effects. Compensation formulas or the Type A model may adequately address damage assessment needs for these discharges. Discharges larger than 1,000,000 gallons may spread over large areas and lead to extensive contamination and effects to natural resources and/or services. Accordingly, discharges greater than 1,000,000 gallons may require a CDA with greater emphasis on injury determination and quantification. The EDA approach, therefore, may be most appropriate for most discharges between 50,000 and 1,000,000 gallons. These guidelines do not

preclude the trustee from conducting an EDA for discharges below 50,000 or above 1,000,000 gallons. A discharge less than 50,000 gallons that occurs in a unique or sensitive habitat, for example, may lead the trustee to conclude that the Type A model should be supplemented with limited, focused studies. Likewise, injury determination and quantification for a discharge of 1,000,000 gallons in open water may be adequately addressed by an EDA. Accordingly, the trustee will have to assess the size of the discharge in the context of the location of the discharge and natural resources and/or services affected when selecting the appropriate damage assessment procedure.

When discharges occur in unique or sensitive habitats, such as marshes, mangroves, or coral reefs, or where there are synergistic effects, the effects relative to the size of the discharge may be disproportionately large. Under those circumstances, selection of an EDA will be based upon the trustee's determination that the procedure can accurately account for this injury. Where there are studies documenting important aspects of a unique or sensitive habitat, for example, the existence of this data may be relevant in a trustee's decision to select an expedited approach.

Occasionally, a single location may be plagued by consecutive discharges in a relatively short timeframe. Likewise, a discharge may occur in a chronically degraded location where multiple pollutants have been discharged over long periods of time. Under either of these two scenarios, it may be difficult for the trustee to differentiate effects resulting from each discharge with only minimal field data. Designing and implementing a study to differentiate effects pursuant to the CDA procedures, however, is likely to be very costly. Accordingly, where the trustee expects that the costs of a CDA under such circumstances are likely to greatly exceed the estimated damages, the trustee may wish to consider an EDA.

3. *The injury and damages resulting from the discharge can be adequately calculated by conducting limited, focused injury determination/ quantification and compensable values studies.*

These studies are generally limited in two ways. First, the trustee should be able to limit the types of natural resources for which injuries will be sought to those of recreational,

commercial, or ecological importance as well as resources of special significance. Second, the scope of injuries the trustee will examine should be limited to mortality, sublethal effects that can be determined with limited and focused studies, and/or lost services.

Natural resources and/or services of commercial, recreational, or ecological importance, or resources of special significance are most appropriate for an EDA because such resources are often being managed, conserved, or protected. Accordingly, extensive data on life history, population, distribution, abundance, and economic values for services may already exist for these resources. Further, concern regarding the effects of oil on these resources may have stimulated studies that document certain effects. Extensive new data collection requirements to establish injury for these natural resources and/or services, therefore, may not be necessary.

The scope of injuries addressed in an EDA should be more limited than that of a CDA. For an EDA, the trustee should focus primarily on mortality, sublethal effects that are considered significant and can be documented with limited, focused studies, and loss of services provided by natural resources.

4. *Potential restoration actions can be implemented without complex (i.e., multiple habitats/biological resources) or prolonged (i.e., multi-year) injury determination/quantification and compensable value studies.*

One of the main objectives of an EDA approach is to speed the damage assessment process so that restoration is initiated more quickly. Thus, the restoration alternatives for the affected resources and/or services should be technically feasible, have a high probability of success, are cost-effective, and result in a net environ-mental benefit. In addition, the injury determination/quantification and compensable values studies should be cost-effective when compared to the likely level of damages. Where, for example, the costs of a CDA greatly exceed the expected damages, the trustee should consider narrowing the scope of studies and using an EDA. Finally, restoration actions should be derived from the limited, focused injury studies.

8.3.4 Comprehensive Damage Assessment (CDA)

Comprehensive Damage Assessment (CDA), by its nature, is complex, requiring extensive field and/or laboratory studies to document and quantify injury. Such studies usually require scientifically valid sampling designs and statistical analyses so that the resulting data and analyses meet the standards of litigation-quality products.

The trustees may determine that the use of a CDA is appropriate after considering the following factors:

1. *The injury and damages resulting from the discharge can best be determined through a more complex, prolonged process, involving a broad scope of injury determination/quantification and compensable values studies.*

The conditions of the discharge which would not be sufficiently considered by any of the other NRDA approaches, in addition to those listed under the first factor for EDA, include:

- The extent of exposure, injury, and impaired/diminished use is large spatially and temporally (e.g., affecting many habitats and species through multiple pathways which are pervasive and persistent);
- Injury via chronic toxicity is likely to comprise a significant component;
- The conditions of the discharge are likely to result in significant bioaccumulation;
- Community- and ecosystem-level effects are likely; and
- There are no standards or criteria with which to make comparison.

2. *Information concerning the nature of the discharge and its effects on natural resources and/or services is not readily available.*

All of the other approaches only consider injuries that are well-documented or readily determined. There are many conditions of a discharge which are not adequately studied in the past and would require detailed studies to determine natural resource and service injuries and damages, such as:

- Discharges of an unusual oil type for which there were insufficient data on

behavior, fate, and toxicity;

- When the exposure pathway is not clearly identifiable;
- Significant effects are likely to occur to natural resources which were previously studied (e.g., there are little data on the effects of oil on terrestrial mammals, reptiles, or amphibians); and
- Economic valuation techniques are not well developed for the affected natural resources or services.

3. *Potential restoration actions cannot be determined or implemented without substantive injury determination/quantification and compensable values studies.*

Where the distribution and abundance of injured natural resources and the quality and quantity of services are poorly understood or considered unique, more complex and prolonged assessments may be needed as a basis for restoration. Limited injury studies may be insufficient to determine the feasibility, effectiveness/ success, and cost-benefit of various restoration alternatives and options. Information on injury may be critical to recovery monitoring (i.e., especially if more than one generation of a resource is involved) and potential restoration research (i.e., new approaches to restore resources and services not recovered or recovering at lower than expected rates).

8.4 Estimation of Assessment Costs

Once damage assessment approaches are tentatively selected, the trustees should then estimate the costs needed to conduct the assessment. The general scope and duration of proposed efforts must be outlined. Since these efforts have not yet been formulated in detail, such estimates are necessarily rough. Multi-year studies, for instance, are particularly difficult to cost out because of the likelihood of changes in scope once the first year's data are evaluated. Cost estimates should be made by technical staff who are knowledgeable and experienced in the types of studies proposed.

Costs should also be made for the restoration planning components of the damage assessment. In some cases, there will be a need for feasibility studies prior to the completion

of the damage assessment. Thus, the restoration component can be a significant percentage of the overall damage assessment costs.

The steps for cost estimation are to:

1. Identify each study needed to complete the damage assessment. Include scientific, economic, QA, data management, restoration planning, and overall management components;
2. Assign knowledgeable and experienced staff to prepare a 1-2 page summary of the scope and duration of each study, and estimated direct and indirect costs (e.g., labor, fringe benefits, travel, equipment, supplies, sample analysis, data analysis, report preparation, overhead, etc.) with categories for labor, travel, supplies equipment, laboratory analysis, data report preparation, and other direct costs;
3. Have the NRDA team review the study plans and costs to make sure that they are necessary, reasonable, and cost-effective;
4. Revise the scope and costs for studies as appropriate;
5. Be sure that adequate time is allowed for staff to attend NRDA team meetings, assist in preparation of the damage assessment claims, and in preparation for and participation in the public review and comment phases; and
6. Total all costs for the estimated duration of the damage assessment. The costs for the damage assessment should be tabulated by category and year.

8.5 Final Selection

The final selection of damage assessment procedures is based on a qualitative evaluation of the conditions of the discharge, the types of injuries that may occur, the trustees' best estimate of the likely damage value, and the estimated costs to complete the damage assessment and restoration planning using the selected procedure. The only guideline in selection of a damage assessment procedure is that the costs of the assessment and restoration should be reasonable (i.e., not significantly high relative to the expected damage claim). If the damage assessment and restoration costs are not reasonable, then the trustees have two options:

1. They should revise the scope of the proposed studies to make them more cost-effective; or
2. They should select an alternative procedure.

At this stage, there should be enough information about the discharge so that the trustees can select one of the four damage assessment procedures: compensation formulas; Type A models; EDA; or CDA.

9.0 Data Collection and Analysis

9.1 Purpose

Throughout the Preassessment Phase, the trustees may collect data for a range of needs and decisions. Data collection and analysis are driven by the conditions of the discharge and information needs of the trustees, rather than a separate step in the process. The purpose of data collection and analysis in the Preassessment Phase is to ensure that there is sufficient information to evaluate the potential risk to natural resources and services resulting from the discharge of oil.

9.2 Scope

The scope of trustee data collection and analysis should be reasonable in light of the characteristics of the discharge and the natural resources and/or services potentially affected by the discharge. Information collected should provide a connection to natural resources and services injury, or considered relevant to the assessment process, likely restoration alternatives implemented, and/or compensable values. Because of the time frame limitations, data collected for preassessment decisionmaking must be readily available. Preassessment data collection and analysis should be completed in a timely fashion, otherwise such activities probably would not address preassessment needs and should be re-evaluated. Information from other sources, such as response agencies, should be used as much as possible to avoid duplication of efforts.

Types of data collection and analysis likely to be conducted where reasonably

practicable include:

- Data necessary to make a determination to proceed with the Preassessment Phase;
- Ephemeral or perishable data that may be lost if not collected immediately; and
- Necessary data that serves as the basis for the selected damage assessment procedure, the absence of which data would prevent the trustee(s) from proceeding with damage assessment determination (i.e., input into the compensation formulas or Type A models, or the sampling design and statistical analysis for necessary incident-specific injury studies).

9.3 Preassessment Protocols

It is difficult to identify specific data collection and analysis protocols because of the unique conditions of each discharge and wide range in the types of natural resources and services potentially affected. However, there are important guidelines the trustees should follow in the development of data collection protocols.

First, preassessment protocols should be applicable to the discharge and environmental setting. Discharges of oil by their nature have patchy distributions that change rapidly. Many of the potentially affected biological species are very mobile and have patchy distributions as well. The type and number of samples collected over space and time will vary significantly and should reflect the conditions of the discharge.

Second, preassessment protocols should follow accepted, cost-effective scientific methodologies which are verified for the habitats, species, and pathways of concern, where practicable. There are many different protocols which exist for the types of field assessment that may be used during the Preassessment Phase. Standard methods are known for a wide range of chemical and ecological assessment techniques by the American Society for Testing and Materials (ASTM, 1987); USEPA; U.S. Army Corps of Engineers (USACE); American Public Health Association (APHA, 1985); and U.S. Fish and Wildlife Service. For example, USEPA has developed and validated rapid bioassessment protocols for benthic macroinvertebrates and fish in streams and rivers (Plafkin et al., 1989). Rapid bioassessment is based on evaluation of relatively few samples at a site. It was initially developed as an

inexpensive screening tool, but now higher level protocols exist for progressively more rigorous applications and provide more confirmational data on injury and its quantification. The rapid bioassessment protocols are excellent examples of the types of methods which may be used during the Preassessment Phase. Appendix B includes discussions and references for biological and chemical study methods which may be appropriate for the Preassessment Phase of a damage assessment.

The most appropriate protocols for a given discharge may not be standardized or may be the only protocols available at the time. For example, the USEPA- approved methods for analysis of organic contamination of water and sediment samples include 150 target analytes, of which only 19 compounds which are petroleum-type hydrocarbons which might be used in an assessment for an oil discharge (Sauer and Boehm, 1991). Of these, only about half are found in any significant quantities in petroleum hydrocarbons. The use of the USEPA-approved method would therefore not generate data upon which the discharged product could be characterized in terms of its source, toxicity, and weathering fate. Sauer and Boehm (1991) have recommended methods specifically designed to address assessment needs for oil discharges that are much more relevant for use in damage assessment studies.

Third, preassessment protocols should be consistent with existing studies for specific natural resources or sampling/analytical methods if such studies are likely to provide baseline data. Many census techniques are very sensitive to even small differences in method, and thus baseline and incident-specific data collection methods should be as identical as possible. Alternatively, pilot studies could be conducted to calibrate the different methods when a new method is used. It is important to consider that the results, if they may be used for injury determination and quantification, should be able to survive intense scrutiny by other experts. Thus, protocols used should provide data consistent with the data quality requirements.

Factors that should be considered in selecting protocols include, but are not limited to: the nature of the discharge and environmental setting; study design requirements [such as those developed by Green (1979)]; QA and data management requirements; potential human health and safety; and benefits and costs of alternative protocols.

9.4 Types of Preassessment Information

During the Preassessment Phase, the trustees are encouraged to collect and analyze all information that may be connected to the oil discharge, including baseline and historical data, case histories of previous discharges of oil, incident-specific data, and data on reference and control conditions.

9.4.1 Baseline and Historical Data

Baseline data refers to on-site information of conditions prior to the discharge that are compared to incident-specific information of those same conditions subsequent to the discharge. Data on baseline conditions provide quantitative information on natural variability of resources and other (i.e., human-induced) variability, thus serving as a temporal comparison. Such data should be collected from locations and natural resources and services that may be affected by the discharge. When baseline data is lacking, the trustees may need to rely on more qualitative historical data that may serve to identify preexisting trends.

The damage assessment approach is dictated, in part, by the extent and quality of baseline data on potentially affected natural resources and services. In past assessments, baseline data were seldom of sufficient extent and quality to fully satisfy the needs of injury quantification. Very few monitoring programs include appropriate analytical targets useful to assess baseline petroleum hydrocarbon contamination levels and sources. The National Status and Trends Program of NOAA and various state Mussel Watch Programs are possible sources of baseline data and long-term trends on petroleum hydrocarbons in sediment and bivalve shellfish. Baseline data on biological and human-use resources should be carefully reviewed for the quality of data collection and analysis, the absence of intervening events that would affect the resources (e.g., unusual weather, salt-water intrusion, or other discharges), and whether the sampling methods used in the baseline data collection are comparable with the sampling design used in incident-specific studies. Oftentimes, baseline and historical data are valuable during preassessment activities to characterize the environmental setting of the discharge site, identify the potential resources and services at risk, indicate variability in the resources and services, and understand community and ecosystem inter-relationships which

may be affected by the discharge.

9.4.2 Case Histories of Previous Discharges of Oil

A special type of data collected during the Preassessment Phase includes case histories of previous discharges of oil under comparable conditions of the discharge and in similar environmental settings. An understanding of appropriate case histories will allow the trustees to focus their activities on the natural resources and services most likely at risk. Many oil-related discharge effects are well documented by scientific studies of previous discharges of oil or demonstrated from laboratory experiments. The trustees should collect and evaluate the oil literature, with the following objectives:

1. *Provide empirical data on the natural resources and services most likely at risk.*

Although each discharge of oil is a unique combination of conditions, a review of previous discharges of the same or comparable oil type, environmental setting, and physical processes can assist the trustees in identification of the natural resources and services most likely at risk. The trustees should compile a list of resources and services present, and, based on studies of previous discharges and the advice of experts, identify those resources and services that may be affected by the discharge. For example, whales and dolphins often surface in the vicinity of slicks during oil discharges, but very few studies have reported any immediately discernable detrimental effects (Geraci, 1990). In the absence of obvious effects on dolphins during a discharge, the trustees should turn to the oil literature to determine if effects to dolphins were reported for other discharges under comparable conditions.

2. *Develop the conceptual model for pathways of exposure.*

There will only be limited chemical data available during the Preassessment Phase of a discharge which the trustees can use to evaluate the potential extent of exposure. The trustees will have to rely on the literature for the behavior and fate of an oil discharge to develop a conceptual model to determine how the oil is most likely transported in water, sediments, and tissues, and the relative concentrations and composition of the oil as it is transported and weathered. This conceptual model drives the prediction of which habitats

and biological resources may be exposed (i.e., directly or indirectly) or be threatened to be exposed.

3. Identify successful methods for injury determination.

Standard methods for biological assessment can be used for oil damage assessments. However, the trustees may need to enact special refinements to tailor the method to the specific conditions of the discharge. The trustees will especially need to focus on terminology for oiling categories, guidelines for sampling in contaminated environments, and specific analytes for chemical analysis and interpretation.

4. Provide the basis for predicting damages.

An integral part of the preassessment process is estimating the extent of injury so that a rough preliminary damage figure can be calculated. Until the damage assessment is complete, the trustees will have to rely upon the literature and their best professional judgment to predict the extent of effects. For example, recovery rates for oiled marshes can be derived from monitoring studies of previous discharges that were comparable in type and degree of oiling, vegetation type, physical setting, and substrate.

The literature on case histories of and research results on oil discharges is widely scattered, and much of it is gray literature. Since 1969, the American Petroleum Institute, in conjunction with the USCG and USEPA, has sponsored a bi-annual Oil Spill Conference and proceedings. Though the conference covers policy, training, operations, and legal issues as well as scientific studies, the proceedings are an excellent source for identifying case histories, literature, and researchers on many different topics. Environment Canada sponsors an annual Arctic Marine Oil Spill Program conference which also publishes a proceedings, with emphasis on arctic oil discharge issues. The National Research Council (National Academy of Science, 1985) published a summary of oil inputs, fates, and effects in marine ecosystems as an update to a 1975 synthesis.

In addition to peer-reviewed journals, case histories and effects related to discharges of oil are published in a series of special topic books. Citations for these publications are included in Appendix D by topic, though this list is by no means complete. Unfortunately, there is no current, comprehensive synthesis of the oil-effects literature. Further, many

recent, quantitative studies are kept confidential until on-going damage assessments are settled.

9.4.3 Incident-Specific Data

Incident-specific data is usually needed for injury determination and quantification. Incident-specific data collection and analysis are likely to fall into the following three categories:

1. Mapping of oil distribution;
2. Collection of chemical samples; and
3. Documentation of immediate effects.

Each of these categories is discussed in the following sections.

9.4.3.1 Mapping Oil Distribution

One of the most important types of data that needs to be systematically collected during the early stages of a discharge is detailed documentation of the areal extent of the oil contamination: on the water surface; along the shoreline; in sediments; and on land. Time-series maps may be needed, depending on the duration of the discharge. Standard terms for characterizing the amount of oil should be defined and used. Often it is difficult to enforce the use of standard terms among different teams, and particularly over time as the amount of oil diminishes. Photodocumentation by all teams becomes very important as a means to verify and calibrate the actual use of field descriptors. If the data are collected properly, they can be used for stratifying habitats by the degree of oiling to compute a mass balance of the discharge, estimate exposure, and validate computer models. Distribution of oil slicks on the water should be mapped daily until the slicks dissipate. Maps of oil on the shoreline or land should be generated once most of the oil is stranded, and then over time to predict recovery rates or document on-going exposure.

At most larger discharges, the response organization generates information on oil distribution on a daily basis, either as descriptions or maps. The trustees should rely on this source of information when it is available, and not duplicate these efforts. However, the

response organization may not always generate degree-of-oiling data to the scale needed for damage assessment use. The trustees should therefore keep track of the status and scale of oil mapping efforts by the response agencies, and be prepared to supplement mapping efforts or continue making observations as needed, once the response effort is terminated. If supplemental data collection is required, the trustees should collaborate with the federal or state OSC or designee.

9.4.3.2 Collection of Chemical Samples

Samples for chemical analysis during the early stages of a discharge consist of two general types: fingerprinting of the oil and measurement of the concentration of selected contaminants. For fingerprinting, samples of the known source of the discharge must be obtained. There is always a great demand for samples of the source, so a large volume (i.e., one gallon or more) should be collected, where practicable. Characterizing the neat or unweathered oil is critical so as to track the changes in the oil over time as it weathers. It is very important to confirm the origin and handling of the source material so its validity can be evaluated. The OSC or RP can usually provide a source sample. The trustees, however, should be aware that a "source" sample can be collected from floating slicks, recovery vessels, storage tanks, etc., and may be contaminated or weathered. Temporary storage barges or tanks are not regularly cleaned prior to use, so they most likely are contaminated with other materials. As with all samples, chain-of-custody documentation for the source sample should be obtained.

With a valid source oil, environmental samples can be analyzed to determine whether they are contaminated with the same oil, a technique known as fingerprinting. Samples for fingerprinting are collected to answer the question "Is this the same oil as was discharged?" Oiled samples therefore do not have to be quantified, or related to a measured amount. Samples do not have to be representative of the amount of oil present, only the type. Fingerprint samples may be collected from sheens from the water surface where there is concern about multiple sources of floating oil. Tarballs on beaches can be fingerprinted to differentiate the discharged oil from chronic background accumulation. Samples of oiled

feathers from birds or mammals are collected to link the oiled animal to the discharge. Bivalve molluscs, both in-situ as well as caged, can be sampled to measure bioavailability of the oil, assuming that the discharged oil in tissue samples can be fingerprinted and differentiated from background or other sources over time.

Samples for quantitative measurement of a contaminant must be collected in a manner which is representative of the area being sampled. Because of extensive patchiness in the distribution of oil, collection of representative samples can become quite complicated. The trustees should identify sampling objectives, and develop appropriate sampling approaches, including the number of replicate and composite samples. One approach is to collect a larger number of samples or replicates. A subset of those samples can then be selected for preliminary analysis to screen for the magnitude of variability, or concentrations at the sites where maximum contamination is expected. Proper sample preservation methods and holding times should be used.

Representative water samples are very difficult to collect, especially where surface oil slicks are present. Contamination is likely. Surface slicks are also likely to track differently than contaminated plumes of water. Further, evaporation and dilution rapidly decreases concentrations in the water column to very low levels, except where such processes are restricted (i.e., in rivers and streams, isolated water bodies, or very cold climates). In most coastal and marine settings water samples for quantitative analysis of oil concentrations are not a high priority. In riverine and shallow-waterbody settings, with light products such as No. 2 fuel oil and jet fuel and where public water supplies are at risk, water-column sampling is more appropriate.

Other types of collection and measurement that may be appropriate during oil discharge studies include temperature, salinity, and dissolved oxygen, so that the basic water-quality conditions of the site are documented. Detailed descriptions of the sampling location should be recorded, including visual description of the degree of oil contamination of the site, physical setting, elevation or depth, description of the sample (e.g., grain size, nature of contamination, water turbidity, etc.), and type of sample (i.e., grab, composite).

For all data collection and analysis efforts, development of and compliance with QA

plans are essential (refer to Section 9.5). Any deviation from the approved and published plan should be documented, and the potential effect on the validity of the sample determined. Without careful prespill planning, collection of samples during a discharge may result in important data being lost.

9.4.3.3 Documentation of Immediate Effects

Early on-scene surveys of the affected area will be needed to determine short-term effects to natural resources and services that occurs soon after the discharge. Such effects include, but are not limited to, fish kills, dead and oiled birds and mammals, closures of recreational parks, and reduced human use of the oiled areas. Sampling and census of these effects must be conducted during the time of occurrence. Taking census of populations that are actually present in the affected or threatened areas can provide field data or verification for computer models. Natural resources or services which have significant spatial or temporal variations in their distribution or life stage (e.g., migratory waterfowl and spawning streams for anadromous fish) need on-scene documentation relative to their presence and activity at the time of the discharge. Photodocumentation of oiled and affected natural resources and services should be an integral component of all early data collection activities.

9.4.4 Data on Reference and Control Conditions

During the Preassessment Phase it may be necessary to establish reference and/or conditions. Reference and control data refers to off-site information of unaffected conditions that are compared to the similar or same, respectively, on-site conditions affected by the discharge. Establishing such conditions soon after the initial oiling will allow the trustees to document the extent of exposure as well as collect data on the presence and condition of natural resources and services at the time of exposure.

Data on reference and control conditions are needed to provide spatial comparisons. Most study objectives will involve detecting differences or making comparisons, and thus require a reference or control from which to measure change. Reference and control conditions should be selected based on the close resemblance and proximity to the affected

conditions, but remain free from the potential effects resulting from the discharge. Reference or control conditions, however, may not always be available because of the nature or size of the discharge relative to the natural resources and services affected, or the special status of specific resources and services (i.e., unique habitats, sensitive species).

9.5 Quality Assurance (QA) Procedures

Quality Assurance (QA) procedures are essential for the collection of data in a manner which is scientifically acceptable and legally defensible. Since data collected during the Preassessment Phase may form the basis for spatial and temporal comparisons, these data must be collected in a manner which assures their highest quality and validity. Because of the unplanned nature of discharges of oil, development of QA procedures through prespill planning efforts is most efficacious.

One way to assure that data collected during the Preassessment Phase meets these requirements is to follow the USEPA guidelines for preparing quality assurance project plans (USEPA, 1980). There is a pocket guide on Preparing Perfect Project Plans (USEPA, 1989) which outlines and summarizes the process. Additional guidance on QA project plans can be found in Gaskin, (1988), Simes (1991), and USEPA (1984; 1985; 1989; 1992). While the USEPA requirements are not always applicable to a damage assessment, they provide a useful reference for the issues which should be addressed. During the Preassessment Phase in particular, the QA plan may be developed in phases as the need for data collection and analysis evolve. At a minimum, QA procedures should assure that:

1. The sampling, processing and analysis techniques are applied consistently and correctly;
2. The number of lost, damaged, or uncollected samples is minimized;
3. The integrity of the data record is maintained;
4. Data collected are accurate, precise, representative, complete, and comparable with similar data collected elsewhere; and
5. The study results are reproducible (within the constraints of the discharge).

Duplicate counts, calibrations, laboratory replicates, verification by independent

experts, and other types of data that allow an evaluation of data quality should be included in field notes and data tables so that an independent evaluation of the data quality may be performed. Therefore, the trustees should take appropriate steps to ensure that such data are recorded appropriately. From a legal perspective, valid QA procedures must be followed for the data to be admissible as evidence in court and merit the rebuttable presumption where applicable. Appendix E contains example QA protocols for data collection and analysis during Preassessment Phase activities developed by NOAA.

10.0 Preassessment Phase Costs

Costs that the trustees are entitled to recover for activities conducted during the Preassessment Phase include, but are not limited to, costs associated with:

1. Notification;
2. Coordination with other trustees, response agencies, and the RPs;
3. Preassessment Determination;
4. Damage Assessment Determination;
5. Data collection and analysis;
6. Report preparation; and
7. Emergency restoration.

Categories of costs which are recoverable include staff time directly involved in the preassessment activities; necessary travel to collect data and attend meetings; expendable supplies used during the conduct of the above activities, such as film, field notebooks, sampling containers, etc.; rental or leasing of aircraft, boats, large sampling gear, and equipment needed to conduct field surveys and sampling; hiring of contractors to assist in data collection, analysis, consultation, and report preparation; costs of laboratory analysis of samples; rental of facilities for on-scene operations of the NRDA team and associated meetings; and preparation and distribution of reports, announcements, public releases, etc.

Care should be taken not to include trustee costs which are strictly related to response actions. It may be difficult under some conditions to draw a sharp line between response and NRDA activities early in the discharge. However, the trustees need to make this distinction.

Costs which relate to the regular management responsibilities of the trustees unrelated to the discharge of oil are not justified.

Preassessment costs should be fully documented. All personnel should keep detailed records of time and specific activities conducted. Because of the emergency conditions of a discharge, normal procurement procedures oftentimes may need to be bypassed, and extraordinary expenses are incurred. Careful and complete records must be kept. All necessary and reasonable costs incurred during the Preassessment Phase for implementation of the damage assessment are eligible for a claim for immediate funding from the Oil Spill Liability Trust Fund under section 6002(b) of OPA. If the trustee costs are paid by the Fund, the guidelines published by the USCG (1992) should be strictly followed. Key components of these guidelines are:

- Resource documentation should be compiled on a daily basis and fully itemize all expenditures, costs, and activities for which the trustees are requesting reimbursement. These daily reports should be completed on the date of activity;
- It is necessary to substantiate that the NRDA initiation activities were performed as a result of a specific discharge. A unique Federal Project Number should be used on all documentation;
- Original resource documentation is preferred which should not be retyped even if it is handwritten;
- Key individuals need to be identified who can attest to the accuracy of the information, and may be required to testify during cost recovery efforts;
- The trustees are encouraged to use the forms provided by the USCG, though other formats are allowable;
- The federal LAT needs to monitor the cumulative costs to make sure that they do not exceed the ceiling provided by the applicable Request and Authorization for Initiation Funding; and
- Within 30 days of completion of initiation of the NRDA, the federal LAT needs to consolidate all trustee documentation and submit a request for reimbursement.

11.0 Preassessment Phase Report

11.1 Purpose

The Preassessment Phase Report documents all the preassessment activities and decisions undertaken by the trustees. The report should also include the potential damage claim and assessment cost estimates used in making the damage assessment determination decision to proceed, and the selected assessment procedures to conduct. The report will be released for public review and become part of the administrative record of the case. Further, the report should be a concise and accurate summary of the data and factors the trustees rely on to make their decisions.

11.2 Scope

The contents of the Preassessment Phase Report are a function of the scope of the preassessment activities (i.e., complexity of the discharge and data collection efforts) and damage assessment method selected. At a minimum, the report should include:

1. Summary of the discharge.

This section should include information on the circumstances of the discharge, characteristics of the oil, oil trajectory and area affected, nature of the receiving environment, types and effectiveness of response efforts (i.e., containment, cleanup, and protection), activities ordered by the federal OSC or local/state agencies, and wildlife emergency restoration undertaken by the trustees.

2. Summary of trustee activities.

These activities can be listed in chronological order. Topics would include: notification; lists of trustees involved in the damage assessment; coordination among the trustees, response agencies, and RPs, short summaries of the types of data collected and early sampling programs implemented, emergency restoration undertaken, results of meetings, proposed data management systems, and services and experts contracted to support the NRDA activities.

3. Potential exposure.

In cases of direct exposure, the trustees should present a concise summary of the current understanding of: oil type, properties, projected weathering rates and fate, the conceptual model used to assess potential exposure, summary of early chemical results, and a general evaluation of the pathways. Where direct exposure is lacking, impaired/diminished use of, or adverse change in a natural resource should be briefly documented.

4. Potential injury.

This section summarizes the potential injury considered by the trustees. Each natural resource and service potentially affected should be discussed, in terms of their physical, chemical, biological, or other characteristics.

5. Potential risk to natural resources and services.

This section summarizes those natural resources and services that may be at risk as a result of the discharge. A brief discussion should be included on the basis for these natural resources and services being at risk and any available supporting data based on the preponderance of evidence or best professional judgment.

6. Estimated extent of injury to natural resources and services.

This section summarizes the trustees' best estimate of the extent (i.e., magnitude and duration) of the injury.

7. Estimate of damages.

In this section, the trustees describe the methods used to calculate damages and report the range of damages likely to result from the discharge of oil. Appropriate caveats as to the accuracy and precision of the calculations should be included.

8. Recommendations for further damage assessment activities.

The selected damage assessment procedures are identified and types of activities needed to support further damage assessment are outlined. The report does not include a detailed discussion of the Damage Assessment Plan, which is developed after the damage assessment procedures are selected.

12.0 Emergency Restoration

Although emergency restoration is not part of the Preassessment Phase, they are

addressed here because the need for such actions may be raised while the trustees are conducting preassessment activities. The authority for the trustees to undertake emergency restoration for natural resources and services under limited circumstances is provided for in the OPA rule. Further, section 1012(j)(2) of OPA excludes such actions from the standard public review and comment requirements for NRDA restoration plans.

Emergency actions should be considered when:

- Immediate action is required to avoid an irreversible loss to natural resources or services; or
- Immediate action is required to prevent or reduce any continuing damages to natural resources or services; and
- The trustees have authority to take such actions.

The trustees should make every attempt to have emergency restoration approved by the OSC or designee such that it does not interfere with response actions. Additionally, the RPs, if known and cooperative, should be invited to participate in the decision to undertake emergency restoration where practicable. The trustees will have to demonstrate that any emergency restoration undertaken independent of the response agencies under this authority was necessary and, to the extent reasonably practicable, cost-effective. In most cases, emergency restoration would be conducted after the response activities are terminated. Emergency restoration would commence only under the direction of the trustees, rather than the response agency.

Examples of the types of emergency restoration the trustees may undertake include:

- Placement of shore protection structures along a marsh shoreline where the vegetation was killed to minimize erosion of the shoreline during winter storms;
- Closure of a fishery or hunting season to speed recovery through higher recruitment rates; and
- Construction of additional parking at alternative recreational areas.

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APPENDIX A
GLOSSARY

Appendix A

Glossary

Accurate (data): The closeness of a measured value to its true value.

Acute: An effect in which the organism of interest is exposed to the contaminant such as oil for only a small portion of its life cycle (i.e., generally less than 4 days). Typical effects endpoints include mortality or immobility.

Analyte: The specific component measured in a chemical analysis.

Assessment: The determination of environmental conditions through physical, chemical, biological or other conditions.

API Gravity: A scale of specific gravities for petroleum fluids. Based on a simple inverse relationship with specific gravity.

Baseline: The condition of a natural resource and/or service, taking into account natural or other variability, that would have existed had the discharge of oil not occurred. In the absence of reliable data on variability, the baseline is the condition of the natural resource or service of interest immediately prior to the discharge.

Baseline Data: Information which is systematically collected for a natural resource and/or service of interest over a period of time and on a regular basis.

Benthic: Pertaining to the bottom of a body of water.

Binding Proteins: Protein structures in organisms that serve as host biomarkers to potentially toxic substances, resulting in select stress responses.

Bioaccumulation: The process by which a contaminant such as oil is taken up by organisms directly through the physical exposure pathway or through consumption of food containing the contaminated substance. Bioaccumulation incorporates the concepts of bioconcentration and biomagnification.

Bioavailability: The tendency of a contaminant such as oil to partition in a form conducive to uptake by organisms.

Bioconcentration: The process by which a contaminant such as oil is directly taken up (i.e., by absorption only) from water and is accumulated to levels greater than those found in the surrounding water.

Biodegradation: The process of degradation of a contaminant such as oil because of its

use as a food source for certain microorganisms. This process is limited to a great extent by temperature, nutrients and oxygen availability.

Biological Resource: The resource referred to in section 1001(20) of OPA as fish, wildlife and biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame and commercial species; and species listed as endangered or threatened under Federal or State law. Biota encompasses shellfish, terrestrial and aquatic plants and other living organisms not otherwise listed in this definition.

Biomagnification: The increase in tissue concentrations of a bioaccumulated chemical substance such as oil as it passes up through the trophic levels.

Biomarker: A biochemical, physiological, or histological indicator of either exposure to, or effects of, xenobiotic contaminants such as oil at the suborganismal or organismal level.

Blank: A QA sample of a pure substance that is used to measure the contribution of analytes from all laboratory sources external to the sample.

Boiling Point: The temperature at which the vapor pressure of a specified liquid equals the atmospheric pressure.

Brackish: Pertaining to water with a low salt content; usually up to 5 parts per thousand during the period of average annual low flow.

By-product: A substance produced as a result of the transformation of the original product.

Chronic: An effect in which the organism of interest is exposed to the contaminant such as oil for a significant stage of its life cycle or the entire life cycle (i.e., generally weeks to years depending on the reproductive life cycle of the organism). Typical effects endpoints include reproductive, growth or development impairment as well as behavioral changes).

Commercial Service (or Resources of Commercial Importance): Those services that are oriented toward the provision of income or profit for a private party. Examples include: agriculture, shipping, commercial fishing, charter boat operations, water intake for plant operations, mining, and log harvesting.

Community (Biological): An assemblage of populations that live in an environment and interact with one another forming a distinctive living system with its own

composition, structure, environmental relations, development, and function.

Comparable: A measure of confidence in being able to contrast one data set with another.

Compensable Value: The total diminution in value of the injured natural resources and/or services as a result of the discharge, from the onset of the discharge until recovery to baseline or comparable conditions is deemed complete by the trustee(s).

Compensation Formula: One of the simplified damage assessment procedures using a formula developed from computer simulations to calculate damages.

Complete: The amount of valid data obtained (i.e., that met QA acceptance criteria) compared to the planned amount.

Composite: A homogenized collection of distinct samples.

Comprehensive Damage Assessment (CDA): A range of procedures to assess damages to a natural resource and/or service based on complex, prolonged studies.

Consumptive Use: Those uses of a natural resource that involve harvesting of the resource. Examples include hunting and fishing.

Control: The condition where all variables, except the presence of the oil, are the same, and which can be manipulated, measured, and monitored.

Cost-effective: When two or more activities provide the same or comparable level of benefits, the least costly activity providing that level of benefit may be selected.

Damage Assessment Determination: The second stage in the Preassessment Phase which allows the trustees to decide which damage assessment procedure to conduct, if any, once preassessment is justified.

Damages: The amount of money calculated to compensate for injury to, destruction of, loss of or loss of use of a natural resource, including the reasonable cost of assessing or determining the damages, which shall be recoverable by the United States, a state, Indian tribe, or foreign trustee under OPA.

Data: Measures related to the oil discharge and environmental setting.

Data Collection and Analysis: The gathering and evaluation of data relevant to NRDA.

Depuration: A process that results in elimination of a substance from organisms.

Discharge: Any emission of oil (other than natural seepage), intentional or unintentional and includes, but is not limited to, spilling, leaking, pumping, pouring, emptying, or dumping.

Dispersion: A process which results from the incorporation of small particles or

globules of oil (ranging in size from < 0.5 um to several mm) into the water column, and can be maintained by continuous agitation (i.e, storms or turbulent waters).

Dissolution: The process of dissolving oil in the medium of concern, usually water. Dissolution is typically slow due to the slightly soluble hydrocarbons and various mineral salts present in the oil.

Downwelling: The physical process where surface waters sink due to a higher density relative to surrounding waters.

Duplicate: A second analysis made on the same sample or second sample.

Ecological Service (or Resources of Ecological Importance): The physical, chemical, and biological functions that one resource provides for another. Examples include the provision of food, protection from predation, nesting habitat, biodiversity, erosion control, and waste assimilation.

Ecosystem: The biological community and its environment which, together, function as a system of complimentary relationships, with the transfer and circulation of energy and matter.

Effect: The impact on or result of a natural resource and/or service exposed to the discharge of oil.

Emergency Restoration: Actions taken by the trustees to restore natural resources and services in those limited situations where the imminent loss of that resource or service may occur before any assessment of injury and restoration plan could be developed and implemented.

Emulsification: The process whereby oil is incorporated into the medium of concern, usually water, in the form of small droplets. Emulsions in water can either be oil in-water or water-in-oil, formed as a result of wave actions.

Endpoint: Response of a natural resource or service to a contaminant such as oil in the field or laboratory.

Environmental Setting: The total natural background of a site, including its physical, chemical, and biological components.

Ephemeral: The physical or biological components of the environment that are short lived or transitory.

Evaporation: The single most important weathering process for the first several days

of an oil discharge. Results in a loss of the lighter fractions through volatization from petroleum products (e.g., benzenes, naphthalenes).

Exclusive Economic Zone (EEZ): The zone established by Presidential Proclamation Numbered 5030, dated March 10, 1983, including the ocean waters of the areas referred to as "eastern special areas" in Article 3(1) of the Agreement between the United States of America and Union of Soviet Socialist Republics on the Maritime Boundary, signed June 1, 1980.

Existence Service: A service provided indirectly to individuals via knowledge of the direct provision of a service to other resources and/or other individuals and future generations. Such knowledge provides an individual with a greater sense of happiness or well-being.

Expedited Damage Assessment (EDA): A range of procedures to assess damages to a natural resource or service based on limited, focused studies.

Exposed to: Means all or part of a natural resource that may be in contact with oil or with any medium containing the oil.

Exposure: Means that the natural resource was exposed and there is a pathway between the discharge and exposed natural resource.

Extent: Encompasses magnitude and direction of the oil discharge.

Fate: The disposition of a contaminant such as oil in various environmental media as a result of transport, transformation, and degradation.

Fingerprinting: An analytical process of characterizing a contaminant such as oil to determine if an unknown sample in the environment is the same as that from the source.

Grab: A distinct sample.

Habitat: The area which supports a given organism, population or community.

Histopathology: The study of tissue responses to injury.

Historical Data: Data that are collected for a natural resource and/or service that is spatially or temporally discontinuous.

Incident: The occurrence or series of occurrences having the same origin, involving one or more vessels, facilities, or any combination thereof, resulting in the discharge or substantial threat of discharge of oil.

Injury: Any adverse change in a natural resource, or any impairment of a service provided by a resource relative to baseline, reference, or control conditions. Injury incorporates

the definitions of "destruction," "loss," and "loss of use."

Injury Resulting From a Discharge: An injury resulting from (or caused by) a discharge occurs when the trustee(s) has demonstrated that: (1) with direct exposure, (a) the natural resource was exposed; (b) there is a pathway between the discharge and exposed natural resource; and (c) the exposure of oil, its components, or by-products has been shown by rigorous and appropriate scientific methodology to have an adverse effect on the natural resource in laboratory experiments or the field; or (2) in the absence of direct exposure, (a) the adverse effect on or impaired/diminished use of a natural resource has been shown by rigorous and appropriate scientific methodology; and (b) the adverse effect on or impaired/diminished use of the natural resource would not have occurred but for the fact of the discharge or threat of a discharge.

In-Situ: Performed or observed in the environment of concern.

Intertidal: The region between highest and lowest tide lines (i.e., that region covered with water at high tide and exposed at low tide) in a marine, estuarine, or tidal freshwater environment.

Lead Administrative Trustee (LAT): A natural resource trustee who is designated on an incident-by-incident basis for the purpose of preassessment and damage assessment, and chosen by the other trustees whose natural resources are affected by the incident. The LAT facilitates effective and efficient communication between the OSC and other natural resource trustees regarding their activities relating to damage assessment during the response phase. A LAT may also be chosen to coordinate prespill planning for damage assessment.

Lesion: An injury to an organ or tissue of a biota resulting in impairment or loss of function.

Lethal: Causing death by direct action (i.e., cessation of all visible signs of biological activity).

Lipophilic: Having a strong attraction for fats.

Metabolite: A substance produced by or taking part in metabolism.

Natural Resource: Land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and another such resource belonging to, managed by, held in trust by, appertaining to or otherwise controlled by the United States (including the resources of the EEZ), any state and local government, Indian tribe, or foreign

government.

Natural Resource Damage Assessment (NRDA): The process of collecting and analyzing information to determine damages for injuries to a natural resource and/or service.

Navigable Waters: Waters of the United States, including the territorial sea.

Necrotic: Dead or decaying tissue.

Neat Oil: Fresh, unweathered oil.

Neoplasm: An abnormal growth of issue (e.g., tumor).

Nonconsumptive Use: The use of a natural resource that does not involve harvesting of the resource. Examples include bird watching, swimming, and nature photography.

Objectives: The goals established for NRDA and its component studies.

Oil: Oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil, but does not include petroleum, including crude oil or any fraction thereof, which is specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. 9601) and which is the subject to the provisions of that Act.

Oil Spill Liability Trust Fund (or Fund): The Oil Spill Liability Fund of Fund, established by section 9509 of the Internal Revenue Code of 1986 (26 U.S.C. 9509).

Organism: An individual animal or plant having diverse parts that function together as a whole to maintain life and its activities.

Passive Use Value: The value individuals place on a natural resource that is not derived from their own direct use of the resource. Such value may be derived from the knowledge that the resource exists, it provides services to other resources, other individuals are currently able to use the resource, and future generations will be able to use the resource.

Pathway: The course the oil takes from the point of discharge to, between, and among natural resources.

Perishable: The biological substances likely to deteriorate if not collected immediately.

Petrogenic: Oil or petroleum derived.

Photo-oxidation: Transformation of petroleum hydrocarbons through an autocatalytic free-radical chain reaction through the use of natural sunlight.

Population (biological): A group of organisms of the same species, generally occupying a contiguous area, and capable of interbreeding.

Pour Point: The lowest temperature at which oil will flow in the medium of concern, usually water, under specified conditions.

Preassessment Determination: The first stage of the Preassessment Phase which allows the trustees to determine whether preassessment is justified.

Preassessment Phase: The preliminary assessment phase of an oil NRDA.

Precise (data): The degree of agreement between independent measurements as a result of repeated applications of a method under specified conditions (i.e., closeness of replicate measures).

Protocol: A scientific, economic, legal, or regulatory accepted procedure used as guidance to implement an activity.

Pyrogenic: Combustion-derived.

Quadrat: A sampling plot, usually one square meter, used to study organisms.

Quality Assurance (QA): The total integrated program for assuring the reliability of collected data.

Quality Assurance Project Plan: An orderly assemblage of detailed and specific procedures which delineates how data of known and acceptable quality are produced for a specific project or study within the NRDA.

Rebuttable Presumption: The procedural device describing the evidentiary weight that must be given to any determination or assessment of damages in any administrative or judicial proceeding made by a natural resource trustee in accordance with the natural resource damage assessment rules under CERCLA or OPA.

Receptor: A natural resource and/or service or component of that resource and/or service that may be adversely affected by a contaminant such as oil.

Recovery: The process by which the injured natural resource and/or service returns to its baseline or comparable condition within the constraints of natural or other variability.

Recreational Service: The direct use of resources by individuals for purposes of

enjoyment or relaxation. Examples include consumptive uses (i.e., those uses that involve harvesting of the resource) such as fishing and hunting, as well as nonconsumptive uses such as swimming, picnicking, boating, bird watching, nature photography, hiking and camping.

Reference: A natural resource or service that is physically, chemically, and biologically similar to that affected by a discharge.

Replicate: One of a number of independent observations the total of which make up a sample to determine variability.

Representative (data): The degree to which data accurately and precisely reflect the conditions or parameters being sampled.

Resources of Special Significance: A category of natural resource that is afforded statutory or regulatory protection (e.g., threatened or endangered species), or is of cultural or archaeological significance (e.g., religious or native American artifacts).

Responsible Party (RP): A person described or potentially described in one or more of the categories set forth in section 1001(32) of OPA.

Restoration: An action that returns the injured natural resource and/or service to its baseline condition.

Reverse Flows: Subsurface currents which flow in opposing direction to surface currents.

Risk: The determination that adverse effects to a natural resource and/or service may occur.

Sample: A selected segment of a population studied to gain knowledge of the whole.

Sampling: The process of taking observations of a population.

Service: The physical, chemical, biological, aesthetic, and cultural functions performed by the natural resource for other resources or humans.

Significant: A difference, at a specified probability level, between or among two or more sampling distributions.

Solubility: A measure of oil that can be dissolved in a solvent, usually water. The solubility of oil in water is extremely low, generally less than 5 ppm. Solubility is an important measure in relation to the potential toxicity of hydrocarbons to biota.

Specific Gravity: The ratio of the mass of the oil to the mass of an equivalent volume of the water. The specific gravity of an oil is a measure of its density and affects

its ease of dispersion. Since most crude oils and refined petroleum products have specific gravities that are less than the specific gravity of water, these oils generally will float on water initially. The only exceptions are certain heavy crudes and residual fuel oils.

Spreading: The process whereby oil floating on water increases in area over time. Oil of lower viscosity spreads at a faster rate than that of higher viscosity.

Spike: The addition of a known amount of a substance to a sample.

Statistical Analysis: The formal mathematical statements of the specific hypotheses to be tested.

Study Design: The plan that addresses the level of effort required in implementing an assessment.

Sublethal: Below the concentration that directly causes death (i.e., effects on behavior, biochemical or physiological function, and histology of biota).

Subtidal: The region in marine, estuarine, or tidal freshwater environments which is deeper than the lowest tide line, such that it is always submerged at any tidal height.

Success: Achieving the objectives that are established in the NRDA.

Technically Feasible: The technology necessary to implement an element of the damage assessment plan or restoration methodology which has a reasonable chance of success in an acceptable period of time.

Toxicity: The inherent potential of a contaminant such as oil to cause adverse effects to biological resources.

Toxicity Test: The determination of the presence or absence of a specific substance such as oil based on biological response.

Transport: The movement of a contaminant such as oil from one location to another.

Trustee: An official of the federal or state government, an Indian tribe, or a foreign government designated according to section 1006(b) of OPA who may present a claim for and recover damages for injury to, destruction of, loss of, or loss of use of, a natural resource.

Type A Model: One of the simplified damage assessment procedures using a computer model to calculate damages.

Upwelling: The physical process where bottom waters rise due to a lower density

relative to surrounding waters.

Uncertainty: The total variability in data collection and analysis, including systematic (human bias) and random errors.

Variable: A measurement or observation of an attribute characteristic of a natural resource or service of interest.

Variability: The difference between replicate measurements or observations (i.e., within sample variability) or between sample statistics (i.e., between sample variability).

Vertical Shear Profiles: The physical condition where current velocities (i.e., both speed and direction) vary with depth. A plot of current velocity as a function of depth is a vertical shear profile.

Viscosity: The measure of the flow resistance of the oil. Viscosity is important in terms of its environmental fate and effects. Viscosity of oil decreases rapidly with an increase in temperature. Viscosity increases as oil weathers since low molecular weight, volatile fractions are lost most rapidly.

Volatility: The degree to which fractions of oil evaporate. Volatility is measured by vapor pressure.

Wave Energy: Turbulent mixing caused by waves.

Weathering: The alteration of the physical and chemical properties of discharged oil through a series of natural processes which begin when the discharge occurs and continue until the oil is removed. Major processes which contribute to weathering include: evaporation, dissolution, photo-oxidation, emulsification and biodegradation.

Xenobiotic: A foreign chemical or substance, such as discharges of oil, not produced in nature nor normally considered a constitutive component of a specified biological system.

APPENDIX B

GUIDELINES FOR PREASSESSMENT DATA COLLECTION

Appendix B

Guidelines for Preassessment Data Collection and Analysis

B.1 Early Sampling Team

The composition and size of the team involved in data collection during the Preassessment Phase will vary according to the complexity of the discharge of oil (see Section 2.2 of text). For discharges where a moderate to large effort is required for preassessment activities, the following specific core team members are usually needed, either on-scene or as support staff to the field team:

- Trustee Agency Coordinator (from all of the trustees)
- Resource Biologist (for each of the major resources/habitats affected by the discharge)
- Environmental (Petroleum) Chemist
- Resource Economist
- Restoration Expert
- Information Specialist
- QA Specialist
- Data Manager/Sample Custodian
- Statistician
- Resource Attorney

The responsibilities of each core team member are discussed below.

Trustee Agency Coordinator: The trustee coordinator must be an agency employee which has the authority to represent the trustees. Responsibilitie include:

- Attend trustee meetings;
- Represent trustee responsibilities at meetings;
- Determine the potential for effects to trust resources and services;
- Organize trustee meetings and involvement when lacking;
- Evaluate the adequacy of current NRDA activities; and
- Recommend activation of additional team members.

Resource Biologist: Responsibilities include:

- Develop familiarity with the local habitats and biological resources;

- Determine the natural resources potentially at risk;
- Assist in developing consensus among trustees on natural resources and services at risk, and objectives of data collection plans;
- Design and implement necessary and relevant data collection activities, and implement sampling and testing programs;
- Identify data gaps in current NRDA activities; and
- Determine need for specialized or local experts, and guide work of experts along NRDA requirements.

Environmental (Petroleum) Chemist: Responsibilities include:

- Evaluate the chemical fate and effects of the discharged substance, and use this information in the development of appropriate data collection plans;
- Review and update plans for collection and processing of chemical samples; and
- Evaluate or specify the proposed analytical protocols, reviewing the protocols of the selected laboratory to determine their ability to meet the data quality requirements.

Resource Economist: Responsibilities include:

- Assist in developing consensus among trustees on resource services at risk, and objective of related data collection plans;
- Provide expertise on the NRDA regulations and past cases;
- Conduct the economic components of the damage assessment; and
- Work closely with the core team members to determine the appropriate assessment method, and assure that the assessment is addressing the issues of greatest importance to the damage assessment.

Restoration Expert: Responsibilities include:

- Collect information on restoration alternatives;
- Identify the types of studies needed to support selection of restoration alternatives;
- Initiate the development of the restoration plan; and
- Develop monitoring plans and project activities related to restoration planning and implementation.

Information Specialist: The information specialist is a incident-specific on-site role rather than a member of the planning team. Responsibilities include:

- Collect reports, write minutes of meetings, and file technical and response data in an organized manner with full documentation;
- Make sure that all NRDA meetings have prepared minutes; and
- Prepare a Daily Activities Log for the record.

QA Specialist: Responsibilities include:

- Review/update QA protocols for all data collection activities; and
- Make sure that sampling activities follow QA protocols.

Data Manager/Sample Custodian: Although many of the tasks conducted by the data manager are part of QA, at discharges, an on-site person should be assigned these operational responsibilities, which include:

- Develop a consistent database on NRDA sampling efforts (i.e., who, what, where);
- Track sample chain-of-custody forms;
- Review and approve data forms;
- Responsibility for receiving, properly storing, and shipping samples; and
- Prepare and deliver a complete file on the discharge to the trustees, with an electronic index or reference list.

Statistician: Responsibilities include:

- Be familiar with all types of environmental data analyses including parametric and nonparametric statistics, and multi-variate techniques;
- Have a practical understanding of field sampling methods and issues;
- Design statistically sound sampling strategies; and
- Monitor implementation of the sampling strategy and suggest changes when needed.

Resource Attorney: Responsibilities include:

- Provide analysis of legal considerations in the NRDA;
- Play a key role in representing trustees to the RPs;
- Draft agreements among the trustees and between the trustees and RPs; and
- Provide legal advice to the trustees throughout the NRDA process.

Depending on the discharge conditions, specialized technical experts may be needed on the NRDA team at the very beginning. These technical experts can contribute to the early effort of the team remotely by telecommunications and provide recommendations (e.g., methodologies, etc.), or go on-scene and direct the activities themselves.

One person can take on multiple roles, depending on the scale and phase of the response. Initially, at least two team members are needed to go on-scene to evaluate the discharge conditions, collect the information needed to determine the level of response, and prepare a preliminary sampling strategy. One of these members should include the information specialist. Other team members and experts can be mobilized as needed.

B.2 On-Scene Assessment

In order to conduct the Damage Assessment Determination for most discharges, the trustees may need to go on-scene to collect pertinent data. The presence of the trustees is necessary because so much information is generated and exchanged verbally on-scene among responders or is incompletely documented.

B.2.a Data Collection Activities

Once the trustees arrive on-scene, the first objective is to survey and document the nature and extent of injury to natural resources and services, and identify those resources and services that may be affected in the future. There are several tasks that need to be completed as part of preassessment. These tasks include:

1. Collection and assessment of readily available information on the type, amount, characteristics, location, and predicted trajectory of the discharged substance;
2. Development of an abbreviated data collection plan for the NRDA response;
3. On-scene assessments of the incident, through reconnaissance surveys and on-site inspections of areas that may be affected;

4. Development and implementation of a more detailed data collection plan for early sampling to determine the potential exposure and injuries of natural resources and services; and
5. Documentation and reporting requirements.

Figure B.1 includes a checklist for NRDA trustees to refer to during the first few days of the on-scene data collection activities. This checklist is not all-inclusive, but should be used as a guide for the types of issues addressed. Further, NOAA has prepared an Emergency Procedures Manual (Research Planning, Inc., 1993) which provides guidance to NRDA teams on early sampling activities during discharges of oil.

The trustees should develop an early study plan for collecting necessary and relevant data on the natural resources and services that may be affected. This plan will be used in the Preassessment Phase to select the type of damage assessment to conduct. The plan should clearly state: the objectives of the study; which natural resources and services are to be studied; the type of samples that are to be collected; the frequency of sampling; and the type of analysis anticipated. Each study plan will be unique for the current discharge conditions and must have the flexibility to incorporate new objectives as the on-going discharge conditions change. The plan should be written and distributed to the other trustees for their approval and participation.

B.2.b Aerial Reconnaissance

The initial identification of areas potentially affected is usually conducted through aerial reconnaissance. During reconnaissance, documentation of the extent of the discharge is very important for establishing monitoring stations, and baseline and reference sites. This information is not always routinely collected by the response team at the scale, frequency, or detail required for later analysis under NRDA.

Aerial surveys allow an extremely rapid assessment of the entire discharge site and are especially useful in determining the relationship between local geomorphology and contaminant distribution as well as the areal extent of effects (e.g., heavy accumulations of oil in east-facing pocket beaches, oil sheens in backwater lakes along a river). Inflight observations are recorded both orally on

- ☐ Obtain a briefing on the discharge status from the OSC or SSC at the Command Post. Be sure to get updated information on the discharge and potential discharge amount, response activities, trajectory of the discharge, weather conditions which might affect discharge conditions, etc. as the discharge progresses.

- ☐ Evaluate the site safety issues. Obtain a copy of the site safety plan, if available.

- ☐ Establish a filing system and begin filing all documents.

- ☐ Obtain copies of local charts and topographic maps of the discharge area. Make photocopies of the discharge site for recording information during overflights and ground surveys.

- ☐ Obtain copies of any and all reports (e.g., pollution reports, Hotline, operational summaries), maps, and trajectories on the discharge from the Command Post, newspaper articles, press releases, response plans, etc.

- ☐ Obtain a briefing on the natural resources and services at risk, reports on effects to-date, and names of contacts for the resource agencies involved in the response. Identify all response activities by resources agencies.

- ☐ Get on an overflight as soon as possible. Bring maps or charts, camera and/or videocamera, overflight checklist, and necessary safety equipment. Take sufficient photographs; keep a detailed photolog.

- ☐ Ship in supplies and response kits that may be needed.

- ☐ Check contents of kits and determine need for supplemental equipment and supplies (e.g., film, batteries, videotapes, more sampling jars, cleaning and preservation chemicals, etc.).

- ☐ Get tide schedules.

- ☐ Develop an initial data collection plan, including samples from the source.

- ☐ Determine schedule of daily meetings so that the appropriate people attend.

- ☐ Establish a NRDA work area. Rent cellular phones. Distribute names/phone contacts for the team.

- ☐ Determine need for contractor support.

FIGURE B.1 Checklist of early assessment activities for NRDA trustees.

- ☐ Develop an early data collection plan to collect data on oil effects to natural resources and services, making sure to coordinate with response activities. Identify baseline/reference conditions.
- ☐ Form NRDA teams to implement the sampling plans. Make sure everyone on the teams has appropriate safety gear and training.
- ☐ Make sure that maps showing the distribution of the discharge over the area and time are generated in a systematic manner.
- ☐ Make sure that there are written QA protocols for data collection and that these protocols are understood by all NRDA team members.
- ☐ Distribute copies of reports on natural resources and services at risk and sampling plans to home offices.
- ☐ Evaluate the need for experts and identify potential experts as needed for discharge conditions.
- ☐ Brief SSC and other operational responders on NRDA activities.
- ☐ Generate lists of names, phone contacts, and activities for all persons involved with data collection.
- ☐ Review OPA Fund procedures.
- ☐ Consider emergency restoration actions.
- ☐ Implement documentation procedures by distributing forms for field observations, chain-of-custody, photologs, daily activities reports, etc.
- ☐ Coordinate with biological rescue and rehabilitation groups to make sure that detailed documentation of number, species, and fate of animals is kept.
- ☐ Keep track of shoreline, waterway closures, and seafood safety advisories.
- ☐ Consider damage assessment options.

FIGURE B.1 Continued.

audio tape, and photographically with a hand-held 35 mm camera or a videocamera; preferably both. The best altitude for observations is between 500 and 1,500 feet. Either a helicopter or fixed-wing (i.e., high-wing) aircraft may be used.

Primarily, the overflights are conducted to determine the extent of contamination or habitats that may be contaminated, and observe biological resources and services highly susceptible to future effects.

Some important guidelines for conducting a safe and productive overflight are outlined below:

1. Learn the communications protocol in the aircraft (i.e., when not to talk, who is directing the pilot, and how to communicate your objectives and plans);
2. Go over the flight plan with the pilot. Have a map of the flight plan sketched out, if possible;
3. Always have your own maps and know the area surveyed;
4. Keep track of your location and elevation;
5. Plot your flight path on your map, noting the time every 30 minutes or when you change direction;
6. Make detailed observations of affected resources or the proximity of resources (e.g., vegetation, fish, birds, mammals, etc.) and services (i.e., recreational, commercial, ecological, and special significance) relative to the oil discharge;
7. When mapping oil onshore, carefully locate yourself with land features. Use detailed descriptors for contaminant type, coverage, dimensions, behavior (e.g., sheening, refloating, or lack thereof). Draw directly onto the map. Note the presence of response workers, locations and estimates of number of biota by species, and observations on position of the oil relative to natural resources and services. Use a pre-determined code for describing oil type (e.g., mousse, black oil, rainbow sheen, etc.) and coverage. Figure B.2 contains recommended terminology for oil descriptions and terms;
8. Immediately after returning to the Command Post or base of operations, transfer your observations to a worksheet and a clean copy of a map while the information is still fresh; and

9. If photographs are taken, check your photo log and make sure it is completed. Identify the location of all photos on the map as they are taken to create an accurate record of the overflight.

B.2.c Ground Reconnaissance Studies

Once the overflight is complete, ground surveys are needed to groundtruth the aerial observations and collect samples. These ground surveys are conducted with the realization that future monitoring studies may be established in some of these areas, so detailed records should be made of all observations.

When physically visiting exposed sites or potentially affected areas, the trustees should record the extent of effects (i.e., discharge distribution, percent coverage, zone of coverage, etc.), create visual records of the sites (i.e., photographs, video records, field sketches, oral descriptions on tape, etc.), collect samples as needed, and identify areas that may serve as likely baseline and reference sites. Systematic documentation of observations is extremely important. Figure B.2 includes recommended terminology and codes for use in shoreline surveys. Detailed methods for systematic shoreline surveys are also described in Owens (1991) and Debusschere et al. (1992).

Hand-held Global Positioning System (GPS) units make sample location easy to determine and record. GPS is a satellite positional and navigation network which allows determination of a position fix within tens of meters.

B.3 Chemical Sampling

B.3.a Objectives

Stating a clear objective often seems so obvious that it is not explicitly mentioned by investigators considering sampling projects. However, it is frequently the case that objectives are not well formulated, resulting in inconclusive results. With clearly stated objectives, the trustees can be confident in the design and implementation of data collection plans. During preassessment activities at a discharge of oil, chemical samples are collected primarily to answer the following basic questions:

1. Is this oil the same as the oil which was discharged?;

Shoreline Slope

Low	Less than 30 degrees
Medium	Between 31 and 60 degrees
High	Between 61 and 90 degrees
Vertical	Vertical or near vertical

Shoreline Zone

SU	Supratidal (above normal spring high tide levels)
UI	Upper Intertidal
MI	Middle Intertidal
LI	Lower Intertidal

Oil Category Width

W	Wide	> 6 m wide
M	Medium	> 3 m to ≤ 6 m
N	Narrow	> 0.5 m to ≤ 3 m
V	Very Narrow	≤ 0.5 m

Sediment Types

R	Bedrock outcrops
B	Boulder (>256 mm in diameter)
C	Cobble (64-256 mm)
P	Pebble (4-64 mm)
G	Granule (2-4 mm)
S	Sand (0.06-2 mm)
M	Mud (silt and clay, < 0.06 mm)
RR	Riprap (man-made permeable rubble)
SW	Seawalls (impermeable)

Oil Distribution

C	Continuous	91 - 100%
B	Broken	51 - 90%
P	Patchy	11 - 50%
S	Sporadic	1 - 10%
T	Trace	<1%

Surface Oiling Descriptors - Thickness

PO	Pooled Oil (fresh oil or mousse > 1 cm thick)
CV	Cover (oil or mousse from >0.1 cm to <1 cm on any surface)
CT	Coat (visible oil <0.1 cm, which can be scrapped off with fingernail)
ST	Stain (visible oil, which cannot be scraped off with fingernail)
FL	Film (transparent or iridescent sheen or oily film)

Surface Oiling Descriptors - Type

FR	Fresh Oil (unweathered, liquid oil)
MS	Mousse (emulsified oil occurring over broad areas)
TB	Tarballs (discrete accumulations of oil <10 cm in diameter)
PT	Patties (discrete accumulations of oil >10 cm in diameter)
TC	Tar (highly weathered oil, of tarry, nearly solid consistency)
SR	Surface Oil Residue (non-cohesive, heavily oiled surface sediments, characterized as soft, incipient asphalt pavements)
AP	Asphalt Pavements (cohesive, heavily oiled surface sediments)
NO	No Oil
DB	Debris; logs, vegetation, rubbish, garbage, response items such as booms, etc.

Subsurface Oiling Descriptors

SAP	Subsurface asphalt pavement (cohesive)
OP	Oil-Filled Pores (pore spaces are completely filled with oil, to the extent that the oil flows out of the sediments when disturbed). May also consist of weathered oil such as a buried lens of asphalt pavement
PP	Partially Filled Pores (pore spaces partially filled with oil, but the oil does not flow out of the sediments when disturbed)
OR	Oil Residue (sediments are visibly oiled with black/brown coat or cover on the clasts, but little or no accumulation of oil within the pore spaces)
OF	Oil Film (sediments are lightly oiled with an oil film, or stain on the clasts)
TR	Trace (discontinuous film or spots of oil, or an odor or tackiness)
NO	No Oil (no evidence of any type of oil)

Sheen Color

B	Brown
R	Rainbow
S	Silver
N	None

FIGURE B.2 Shoreline oil terminology/codes.

2. What is the concentration of the oil in the media being sampled?; and
3. What is the composition of the oil in the media being sampled?

The quality of the results obtained from the sample analysis is directly related to:

- Collecting representative samples;
- Using appropriate sampling techniques; and
- Properly preserving the samples until they are analyzed.

B.3.b Chemical Sampling Methods

B.3.b.1 Environmental Samples for Fingerprint Analysis

Samples for fingerprint analysis are collected to answer the question "Is this oil the same as the oil which was discharged?" Consequently, such samples do not have to be quantified, or related to a measured amount of sample. Fingerprint samples are grab samples, not composites. They are compared with a "source" sample, preferably one carefully collected directly from the original container (i.e., vessel, pipeline, tank), and not from floating slicks or stranded oil.

The following techniques are used to collect thin sheens: for offshore, a special sheen sampler composed of teflon strips on a line is pulled through the sheens; for nearshore, pre-cleaned teflon filter papers are used to pick up small sheens (Henry, 1993). In all cases, special care is taken to prevent contamination with sheens from the exhaust of boat motors or washing off the sides of the sampling platform. Samples for fingerprinting can also include tarballs, oiled sediments, oiled animal parts (i.e., preferably fur/feathers), and oiled vegetation. Biological samples are collected in clean, glass jars or cleaned aluminum foil and kept frozen until analysis. Sample containers, sample volumes, and holding times are listed in Table B.1. All lids should be cleaned aluminum- or teflon-lined, not plastic.

B.3.b.2 Collection of Water Samples

Water samples are very difficult to collect where surface oil slicks are present. When sampling in areas covered by a surface slick, extreme care is needed to "knock" the surface slick aside so that the sampling device can be lowered into the water without becoming contaminated. Water samples should be collected directly in the sample container since oil droplets readily adhere to the inside of most samplers. For shallow water samples, it is necessary to wade into the water or lean over from a platform to collect the sample. The container is opened, allowed to fill, and closed at the desired water depth. Deeper water samples have to be collected by lowering the

TABLE B.1 Sample requirements for discharges of oil.

Oil Analysis	Quantity	Storage	Other Conditions
Fingerprinting slick or tarball samples.	> 100 ml	Precleaned glass jars or aluminum foil	Kept cold or frozen until delivered to the lab.
Fingerprinting source samples	~ 1 gallon	Precleaned glass containers	Kept cold or frozen until delivered to the lab.
Weathering source samples	~ 1 liter	Precleaned glass jars	Kept cold or frozen until delivered to the lab.
Water Samples	~ 1 gallon	Super-clean glass containers	Kept cold and dark for less than 8 hours. Preservation of sample may be done — check with analytical lab.
Sediment Samples, Fingerprinting	100 grams	Precleaned glass jars or aluminum foil	Extreme care should be taken to prevent sample contamination. Kept cold or frozen until delivered to the lab.
Sediment Samples, Total Petroleum Hydrocarbons	100 grams	Precleaned glass jars or aluminum foil	Composite subsamples, 10-15 samples from site. Kept cold or frozen until delivered to the lab.
Sediment Samples, Grain Size	50-100 grams	Ziploc or whirl-pak bags	No special conditions required.

sampling container to the desired depth and remotely opening and closing the container at that depth. Under most conditions, concentrations in the water will be very low, and the potential for contamination is high. Additionally, surface slicks and the water-accommodated fraction track differently. Therefore, the presence of oil on the water surface is not always an appropriate criteria for collection of water-column samples.

Depending on the analytical method used, minimum sample volumes range from one liter to one gallon. With replication, the volume of water shipped to the laboratory can be significant. Ideally, water samples should be stored no longer than eight hours, although, if they are kept cold (4°C) and dark, water samples may be

stored for as long as five days. Background samples should be collected well away from any oiled areas, being careful not to sample along the vessel path or near any boat or aircraft engines, to reduce the chance of contamination.

B.3.b.3 Collection of Sediment Samples

Sediment samples are collected from two general settings: surface sediments (i.e., terrestrial soils and intertidal sediments) which are readily visible and collected by hand; and subtidal sediments which are usually sampled with a remote sampling device. Intertidal surface sediments and soils are relatively easy to sample since variability in the sediment type and degree of contamination can be readily discerned and described. Two of the most difficult issues in sediment sampling at oil discharges are:

1. Collection of a representative sample where there is extreme variability in the amount of oil. On an oiled marsh, the contamination will range from oil pooled on the surface to patches adjacent to visibly clean sediments. This problem is even more difficult where the sediments are coarse (i.e., in the range of pebbles to cobbles) and where the natural variability is compounded by the size of the clasts compared to the sampling container. One approach is to composite sub-samples, but this approach does not facilitate statistical analysis of the variability at a site.
2. Prevention of cross contamination when moving between heavily contaminated sites and clean sites. Keeping sampling equipment and supplies clean between sites at an oil discharge is very difficult. The only guarantee against cross contamination is to use new, clean utensils at every sampling site. On-site cleaning of utensils or corers is not recommended. Blanks are extremely important to collect, particularly at the cleaner sites.

Detailed descriptions and photographs of the samples and site are needed. Photoscales are always used when photographing sediment sampling sites. Documentation includes both overview and close-up photographs. To determine oil penetration with depth, trenches are dug, described, and photographed. Grain-size estimators (i.e., field guides that visually show grain-size classes) are used to describe sediment textural parameters. Standard oil descriptors are used to characterize the

type and degree of contamination. Sampling site locations are shown on detailed field sketches or maps.

Subtidal or bottom sediment samples pose a different set of problems mainly because they require use of sampling devices deployed from a boat, or diver-held corers. Samplers which take box cores with minimal disturbance of the surface are the preferred device because most of the contamination in the first few weeks is likely to be on the sediment surface. Box corers also allow ready collection of replicates or composites at a site. Cleaning of the sampling device is a second problem, especially when the sediment contamination levels are high. Soap and water, scrub brushes, large volumes of clean water, and solvent rinses are needed to clean the sampling device between stations. Collection of the waste solvent for disposal must also be addressed.

It is important to record water depth, time of collection (i.e., so depth can be corrected to mean sea level in tidal waters), sediment description, visible oiling conditions, depth of bioturbation, presence of oxidized and reduced zones, and presence and relative density of invertebrates. The sediment surface should be photographed prior to collection from the corer.

Samples of approximately 100-200 grams (i.e., approximately one cup) are usually sufficient. The data collection plan should specify the sample intervals and depths. All samples should be numbered uniquely. It is important to have preassigned numbering series for samples when multiple teams are in the field collecting samples. Samples are collected with clean metal utensils or wooden tongue depressors and placed in precleaned glass jars with teflon-lined caps.

B.4 Toxicity Testing

B.4.a Objectives

Toxicity tests are used to determine whether discharged oil and its degradation by-products have measurable effects on the biota potentially exposed during a discharge of oil. When combined with field surveys documenting direct effects in the field, toxicity data establish the link between the discharge and ecological responses (Parkhurst et al., 1989). The objectives of toxicity tests are to: correlate an adverse ecological response with exposure to the discharged oil, and determine the

concentrations at which response occurs for the species of concern. Toxicity test results can be used in preassessment as a screening tool to indicate potential biological effects and whether further bioassessment studies are needed.

There are two approaches to determine toxicity of a substance: the *toxicity-based approach* which directly measures the biological effect resulting from exposure to the contaminated pathway from the discharge site; and the *chemistry-based approach* which uses chemical analyses and laboratory-generated criteria (e.g., LC50 values) to estimate toxicity (Parkhurst et al., 1989). Both of these approaches are complementary and may be used for quantifying toxicity of water and sediments contaminated by a discharge of oil.

B.4.b Methods

The following toxicity tests are examples of those suitable for use in preassessment. There are many more which may be appropriate for specific discharge conditions. While the most commonly measured endpoint is death or immobility of the organisms, other endpoints frequently measured include changes in reproduction, growth, development, and behavior.

The toxicity tests listed in Table B.2 are representative of commonly used types of standardized tests. As long as accepted protocols are followed, there is the potential for establishing local or regional test protocols with endemic species or species of local and regional concern.

TABLE B.2 Freshwater, and marine and estuarine toxicity tests.

Test	Endpoint	Duration	Reference
Freshwater			
Water Column			
Acute Toxicity Tests LC_{50}, EC_{50}, or IC_{50}			
Fish			
- Rainbow trout (*Oncorhynchus mykiss*)	survival	2 to 8 days	APHA, 1989; ASTM, 1992
- Coho salmon (*O. kisutch*)			USEPA, 1985
- Brook trout (*Salvelinus fontinalis*)			ASTM, 1992
- Fathead minnow (*Pimephales promelas*)			ASTM, 1992
- Bluegill (*Lepomis macrochirus*)			ASTM, 1992; USEPA, 1985
- Goldfish (*Carassius auratus*)			ASTM, 1992; USEPA, 1985
- Channel catfish (*Ictalurus punctatus*)			ASTM, 1992
- Green sunfish (*Lepomis cyanellus*)			ASTM, 1992
Invertebrates	immobilization and/or survival	2 to 8 days	ASTM, 1992; USEPA, 1985
- Daphnids (*Daphnia* sp.)			
- Water flea (*Ceriodaphnia dubia*)			
- Amphipods (*Gammarus* sp.)			
- Crayfish (*Orconectes* sp., *Cambarus* sp., *Procambrus* sp., *Pacifastacus leniusculus*)			
- Mayflies (*Hexagenia* sp.)			
- Midges (*Chironomus* sp.)			
- Snails (*Physa* sp. and *Amnicola limosa*)			

APHA = American Public Health Association

ASTM = American Society for Testing and Materials

PSEP = Puget Sound Estuary Program

USEPA = U.S. Environmental Protection Agency

Freshwater (continued) Chronic Toxicity Tests Early Life Stage Toxicity Tests Fish - Salmonids - Fathead minnow - White sucker (*Catostomus commersoni*) - Channel catfish - Bluegill - Striped bass (*Morone saxatilis*)	survival/ abnormal development survival/growth survival/growth survival/growth survival/growth survival/growth	30 days post swim-up 32 days 32 days 32 days 32 days 45 days	ASTM, 1992
Life-Cycle Tests Invertebrates - *Ceriodaphnia dubia* partial-life cycle test - *Daphnia magna* life-cycle test	survival/ reproduction	7 days 21 days	USEPA, 1989 USEPA, 1989
Algal Growth Test - *Selenastrum capricomumtum*	growth	96 hours	USEPA, 1985
Sediment (*Sediment Elutriate*) Invertebrates - Amphipod (*Hyalella azteca*) - Midge (*Chironomus* sp.)	survival/growth survival/growth	10 days 10 days	ASTM, 1992
Marine and Estuarine *Water Column* Acute Toxicity Tests LC_{50}, EC_{50}, or IC_{50} Fish - Sheepshead minnow (*Cyprinodon variegatus*) - Mummichog (*Fundulus heteroclitus*) - Longnose killfish (*Fundulus sirnilis*) - Silversides (*Menidia* sp.) - Threespine stickleback (*Gasterosteus aculeatus*) - Pinfish (*Lagodon rhomboides*) - Spot (*Leiostomus xanthurus*)	survival	2 to 8 days	ASTM, 1992

Marine and Estuarine (continued) Fish (continued) - Shiner perch (*Cymatogaster aggregata*) - Tidepool sculpin (*Oligocottus maculosus*) - Sanddab (*Citharichthys stigmaeus*) - Flounder (*Paralichthys dentatus, P. lethostigma*) - Starry flounder (*Platichthys stellatus*) - English sole (*Parophrys vetulus*) - Herring (*Clupea harengus*)	survival	2 to 8 days	ASTM, 1992
Invertebrates - Copepods (*Acartia* sp.) - Shrimp (*Penaeus* sp., *Pandalus* sp.) - Grass shrimp (*Palaemonetes* sp.) - Sand shrimp (*Crangon septemspinosa*) - Mysid (*Mysidopsis* sp.) - Blue crab (*Callinectes sapidus*) - Shore crab (*Hemigrapsus* sp., *Pachygrapsus* sp.) - Green crab (*Carcinus meanas*) - Fiddler crab (*Uca* sp.) - Oyster (*Crassostrea* sp.) - Blue mussel (*Mytilus edulis*) - Hard clam (*Mercenaria mercenaria*) - Polychaete (*Capitella capitata*)	immobilization and/or survival	2 to 8 days	ASTM, 1992
Chronic Toxicity Tests Early Life-Stage Toxicity Tests Fish - Gulf toadfish (*Opsanus beta*) - Sheepshead minnow - Atlantic silversides (*Menidia menidia*) - Inland silversides larval test (*M. berylina*)	survival/growth	42 days 28 days 28 days 7 days	ASTM, 1992

Invertebrates Echinoderm sperm cell fertilization test - Sea urchin (*Strongylocentrotus droebachienses*) - Sand dollar (*Dendraster excentricus*)	fertilization	200 minutes	Dinnel et al., 1987
Bacteria - *Photobaterium phosphoreum* (Microtox®)	biolumin-escence	15 minutes	PSEP, 1991
Sediments			
Fish Anaphase abberation test (rainbow trout gonad cells)	genotoxicity/ cytotoxicity	48 hours	PSEP, 1991
Invertebrates Amphipods - *Phepoxynius abronius* - *Eohaustorius estuarius* - *Ampelisca abdita* - *Grandidierella japonica*	survival/ avoidance	10 days	ASTM, 1992
Polychaete (*Neanthes* sp.)	survival/growth	20 days	PSEP, 1991
Bacteria - *Photobaterium phosphoreum* (Microtox®)	biolumin-escence	15 minutes	PSEP, 1991

B.4.c Advantages and Disadvantages of Toxicity Tests

Toxicity tests are oftentimes an appropriate and powerful bioassessment technique for discharges of oil. However, the advantages and disadvantages (MacDonald et al., 1992) should be considered prior to their use at a specific discharge site.

Advantages

- Provide quantifiable information on the potential for biological effects at a discharge site;
- Are indirect indicators of bioavailability of the contaminant;

- Responses are not restricted by a predetermined list of contaminants;
- Indicate potential effects of sensitive species or to species of particular concern;
- Are performed under controlled test conditions which minimize natural variability;
- Not dependent on the presence of any particular in-situ population;
- Spatial resolution of toxicity test results is better than for most other assessment approaches;
- Many have well-developed and widely accepted protocols; and
- Are quick and relatively inexpensive.

Disadvantages

- Are not designed to mimic natural exposure, so may be difficult to relate directly to actual exposures at a discharge which change rapidly over time;
- Responses are not necessarily directly related to a specific contaminant;
- The tests are difficult to perform correctly by inexperienced laboratories;
- Are not surrogates for determining population changes;
- Not appropriate for exposures that cause subtle effects over long periods, or when the major concern is bioaccumulation; and
- May observe toxicity in "clean" sites due to unknown or unquantified factors.

B.5 Biomarkers

Biomarkers are direct biological measurements used to quantify the degree of exposure or response to the contaminant (Hunsaker and Carpenter, 1990). More specifically, biomarkers are "...biochemical, physiological, or histological indicators of either exposure to, or effects of, xenobiotic chemicals at the suborganismal or organismal level" (Huggett et al., 1992). There are two types of biological indicators: exposure and response indicators. Exposure indicators establish that organisms were subjected to a potentially deleterious stressor and quantify the extent of that exposure. However, exposure indicators cannot be used to detect deleterious effects. In contrast, response indicators demonstrate that deleterious effects are occurring, although often it is difficult to link the cause of the effect to exposure to the

discharged oil. Thus, in most instances, both response and exposure indicators are needed to establish that effects are occurring and link the cause of those effects to oil exposure. Biomarker tests currently applied to specific groups of organisms are listed below (MacDonald et al., 1992):

Mollusks	Mixed function oxygenase (MFO) enzymes (weak) Binding proteins Neoplasms Lesions and other histopathological disorders Growth reduction
Fish	Mixed function oxygenase (MFO) enzymes Binding proteins Lesions and other histopathological disorders Deoxyribonucleic acid (DNA) adducts Skeletal defects Polyaromatic hydrocarbon (PAH) metabolites in bile Reproductive measures
Birds/Marine Mammals	Mixed function oxygenase (MFO) enzymes Reproductive measures Lesions and other histopathological disorders

B.5.a Exposure Indicators

The most appropriate biochemical endpoints to measure exposure to oil and its by-products include: bioaccumulation in tissues and presence of hydrocarbon metabolites in bile. Bioaccumulation in tissues is a direct measure of exposure and applicable to oil discharge conditions. Petroleum hydrocarbons are highly lipophilic and known to have high bioconcentration factors for many organisms, particularly shellfish (Scott et al., 1984). There are numerous studies on bioconcentration factors, uptake, and depuration-rate kinetics for different species and biological organs.

One commonly used technique for bioaccumulation studies is the deployment of mussels collected from resident natural populations in the affected area to measure both bioavailability and degree of exposure (Salazar, 1992). Mussel collection procedures are relatively easy and chemical analyses of tissues are standardized (NOAA, 1989). Salazar (1992) provides the following guidelines for using mussels in support of natural resource damage assessment studies:

- To discriminate differences of exposure and response among assessment sites, a 12-week exposure period is recommended;
- Adults appear more sensitive and have lower survival rates than juvenile mussels;
- Size sorting of individual organisms is important because juvenile mussels grow faster and appear to accumulate higher concentrations of contaminants in their tissues than adults;
- To increase survival rates during deployment, large clusters should be separated by hand, not machine; and
- If determination of sublethal effects, such as growth rates, is an objective, it is important to have adequate replication and measurement of each live animal at the beginning and end of the exposure.

Resident mussel populations can be used for monitoring if the area affected by the discharge includes stations with an historical record of levels of contaminants as suggested by Brooks et al. (1991).

A second category of exposure indicators are those which indirectly measure exposure by detecting a biochemical response to the exposure. This approach is used: where the hydrocarbons do not readily bioaccumulate, such as for fish which rapidly metabolize the oil (Varanasi et al., 1989); when direct measurement of the contaminant is difficult; or when the contaminant was depurated from the organism. Appropriate measurements for oil discharge studies include metabolites in the bile of fish (Varanasi et al., 1989) and hepatic MFO enzyme activity in fish and molluscs (Payne et al., 1986; Collier and Varanasi, 1991). The measurement in fish of reactions catalyzed by the hepatic cytochrome P4501A may prove useful in monitoring oil discharge effects. However, much more work is required to translate exposure and sublethal stress, as detected by monitoring of biomarkers, into biological effects at the population, community, or ecosystem level.

B.5.b Response Indicators

Response indicators are used to demonstrate that effects occurred as a result of exposure to the discharged oil. Although work was completed on response indicators at all levels of ecological organization, from the individual to the

community (Hellawell, 1986; Hunsaker and Carpenter, 1990), the most timely indicators are survival and histopathology at the individual organism level for preassessment data collection.

Reduction in survival is a biological response that integrates exposure to environmental concentrations of contaminants. It is one of the least sensitive endpoints because mortality is an all-or-nothing response. However, important information can be gained from monitoring survival of selected organisms, especially where toxicity responses are well documented. Histopathology, the study of tissue responses to injury or disease, can be an important tool during preassessment to determine whether the cause of death of an organism could be related to exposure to the oil discharge, and as an early indication of biological effects resulting from sublethal exposure. Most research on histopathological biomarkers have focused on the liver of higher organisms such as fish, where neoplasms (i.e., cancerous tumors), areas of excessive growth, and specific degenerative or necrotic lesions are reported (Myers et al., 1990). Some of these responses are from long-term, chronic exposures. More appropriate during preassessment might be indicators of acute exposures, such as injuries to the gills, lesions on the skin, eyes, and lips of fish. Histopathological studies of dead birds and mammals are often used to determine the cause of death.

Most of the time, histopathological analyses are conducted by federal or state laboratories, the agencies which manage the affected resource. These agencies have the expertise needed to properly collect organisms, prepare the tissue sections, and examine and interpret the data.

B.5.c. Advantages and Disadvantages of Biomarkers

During preassessment activities, biomarkers can be used to indicate that organisms are exposed to oil, and may indicate that adverse effects are occurring. Biomarkers can also be used to determine the extent and duration of contamination through the measurement of biological responses. However, the advantages and disadvantages of using biomarkers should be understood prior to their use during preassessment. MacDonald et al. (1992) discuss the advantages and disadvantages of biomarkers for bioassessment studies at hazardous waste sites as well as guidelines for selecting a test. This information is modified here for discharges of oil.

Advantages

- Measure actual biological responses to contaminants;
- May integrate patchy temporal exposures, which are of great concern during discharges of oil;
- Demonstrate effects on endemic organisms;
- Assess a variety of severity levels;
- Measure more sensitive responses than other bioassessment methods;
- Able to be selective for a particular contaminant or class of contaminants;
- Can be selective for a particular species of concern;
- May be less expensive than higher-level ecological studies; and
- Some tests yield quick results, and may be useful in pilot and scoping studies.

Disadvantages

- No existing USEPA or other accepted protocols;
- No absolute measure of unacceptable response;
- Responses may be caused by natural factors or background contaminants;
- Require experienced expert investigators to design studies and interpret results;
- Not always a known relationship between response and significant ecological effects;
- Not yet feasible for all groups of organisms or contaminants; and
- Few commercial laboratories can perform the tests.

B.6 Ecological Sampling

The wide range of biological systems potentially affected by a discharge of oil makes it extremely difficult to identify specific ecological sampling protocols appropriate for preassessment activities. For a specific resource, experts knowledgeable in quantitative field methods and data analysis should be consulted to assist in the design of data collection plans. The types of ecological sampling that may be conducted during preassessment include census surveys of populations, number of acutely affected organisms, number of dead organisms, various types of reproductive failure, and collection of samples for chemical and histopathological analysis.

Rapid bioassessment techniques are useful as quick, screening tools to determine if there is a need for more detailed, quantitative surveys. For example, the USEPA has published rapid bioassessment protocols for use in streams and rivers for benthic macroinvertebrates and fish (Plafkin et al., 1989). Both the USFWS and American Fisheries Society have published methods for investigation of fish kills that are appropriate for discharges of oil in riverine and estuarine settings (Meyer and Barclay, 1990; American Fisheries Society, 1992). The American Society for Testing and Materials (1992) has published standard methods for many different types of ecological surveys. Wildlife surveys commonly use transect, quadrat, and trap counts to estimate the total population present within the study area (Anderson et al., 1976; Davis and Winstead, 1980). Assessments of intertidal communities are discussed by Gonor and Kemp (1978) and Moore and McLaughlin (1978). Many of the papers listed in Appendix C include field methods for bioassessments.

B.7 Data Collection on Recreational Participation

B.7.a Objectives

Recreation participation sampling is used to determine whether discharged oil and its degradation by-products have measurable effects on the quantity and/or quality of recreation activities. During preassessment activities at an oil discharge, data on recreational participation are collected primarily to answer the following basic questions:

1. Are there recreation activities in the discharge location which might be affected?
2. What are the likely effects of the oil discharge on these recreational activities?
3. Are there other locations where people may recreate instead of the discharge area?
4. What types of data have been previously collected for each activity at each site?

Categories of recreation activities to consider include (but are not limited to):

Beach Recreation

Fishing:

- Shore/Jetty
- Pier
- Private Boat
- Charter/Party Boat

Boating:

- Motor boating
- Sailing

Nature Viewing:

- Photography
- Specimen Collecting

Specialized Activities:

- SCUBA Diving
- Kayaking/Canoeing
- Small water craft use
- Wind surfing

B.7.b Methods

During preassessment activities, tasks should include the determination of official or de facto closures, identification of uses by activity and location for the affected and potentially affected areas, assessment of the availability of use level data, and initial evaluation of potential levels of injury.

B.7.b.1 Determination of Closures

Official or de facto closures of recreation sites should be determined. De facto closures include "non-official" closures due to restrictions on access to the site or limitations on activities at the site as a result of the discharge and response to the discharge. These closures may be imposed by local municipalities, USCG, or other official agencies as a result of health concerns, response activities, or other reasons. Determination of official closures should be made from those officials issuing the closure notice. Determination of de facto closures should be made from local officials and/or response personnel.

B.7.b.2 Determination of Locations of Recreational Activity

The location of activities, likely substitutes for potential injured (or closed) sites, and probable effect from the discharge, can be determined through interviews with knowledgeable local officials, and/or current users. Possible interview questions should determine the types or recreation that occur at sites most likely affected by the discharge, recreation patterns (i.e., peak times of day, week, season), possible substitute locations, characteristics of substitute sites relative to the primary site, and likely levels of activities.

B.7.b.3 Availability of Use Level Data

The availability of use level data for those activities potentially affected by the discharge should be made during the Preassessment Phase. Possible data sources could include:

Local knowledgeable officials
Revenue generating agencies
Enforcement officials
Local recreation businesses
Available databases on recreation activities

B.7.b.4 Assessment on Potential Injury Levels

Determination of the potential injury levels should be made during the Preassessment Phase. This determination can be made by combining the information gathered from the previous three steps of data collection. If the extent of injury, or resultant effects, cannot be determined, preassessment for these activities should cease; otherwise preassessment should continue to calculate preliminary estimates of damages.

B.8 Data Collection to Assess Navigational Effects

B.8.a Objectives

One of the potential services provided by surface water is the provision of navigational access. Preassessment of navigation patterns is conducted to determine whether the discharged oil and its degradation by-products have measurable effects

on the loss of surface water for navigation. Injury to surface water resources can be measured, in part, through the loss of navigational access. This loss of access can be measured by comparing vessel movements predicted to have occurred in the absence of the discharge with the actual vessel traffic patterns during the discharge. Preassessment activities should include the determination of port closures and potential levels of shipping activity.

B.8.b Methods

During the preassessment activities, tasks should include the determination of access closures and of typical navigation access levels. Information regarding closures of navigation access can be obtained from the USCG "Captain of the Port Notices." Closures typically vary by time of day and location during a discharge and thus daily if not hourly closures should be documented. Information regarding typical shipping patterns may be obtained through either of two primary sources, depending on the amount of shipping activity. In the case that a Vessel Traffic Service (VTS) is present in the port, information relevant to this preassessment activity can be obtained from this system. Information available from the VTS includes: date and time of entry into the VTS reporting area; vessel name; next and previous port of call; vessel length; vessel draft; vessel beam; vessel type (e.g. tanker, container ship, etc.). In addition, information regarding the location and time of vessels anchored outside the port, as a result of the closure, should be obtained.

In the event that no VTS is present in the port, the information necessary for surface water effects through lost navigational access can be obtained from vessel logs. Vessel logs are available from the shipping agents of the various vessels. The local Harbor Pilots Association can list those ships requiring a harbor pilot to enter the port and thus can identify the appropriate shipping agent. Information to be obtained from the vessel logs is similar to that obtained from the VTS reports.

Preassessment activities should include the determination of port closures and potential levels of shipping activity. If the extent of navigation access effects cannot be determined, preassessment for this activity should cease; otherwise preassessment should continue with estimating damages.

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APPENDIX C

EMERGENCY FIELD KITS FOR NATURAL RESOURCE DAMAGE ASSESSMENTS

Appendix C

Emergency Field Kits

C.1 Introduction

Because of the unplanned nature of discharges of oil, it is extremely important that the trustees have emergency field kits ready for use at all times. These kits should contain the equipment and supplies needed to implement damage assessment activities. The kits should contain the minimum items needed to document effects and implement data collection plans. There may be different versions of emergency field kits for the different types of natural resources and receiving environments that may be encountered.

C.2 Standard Emergency Field Kit

The standard kit contains the equipment and supplies most likely needed for NRDA activities at most discharges. At the time of the discharge, nautical charts, topographic maps, and road maps for the discharge site are added.

- ☐ 92-quart cooler with side handles (can be used as carrying case for the kit)
- ☐ Day pack
- ☐ Box-type plastic clipboards
- ☐ Waterproof logbooks with numbered pages
- ☐ Expanding file folders, containing the following paper/forms
  - Original and copies of field forms to be used
  - Waterproof paper for copying field forms
  - Chain-of-custody forms
  - Activities checklist
  - Organization phone lists
  - QA protocols for selected sampling methods
  - Sample tags and labels
  - Field estimator guides for percent cover, grain size, etc.
- ☐ Camera: 35-mm, SLR with 50-mm lens, UV and polarizing filters, carrying case
- ☐ Film: five rolls each of ASA 64, 100, and 400 slide film; color print film
- ☐ Photoscales: 15 cm and 30 cm

- ☐ Mechanical pencils with replacement lead and erasers
- ☐ Waterproof ink markers
- ☐ Color pencil and marker sets
- ☐ Pads of paper
- ☐ Ruler and dividers
- ☐ Large, heavy rubber bands
- ☐ Various types of tape: masking, cellophane, strapping, electrical, and duct tape
- ☐ Plastic bags: various sizes of Ziploc bags; whirl-pak bags; large trash bags
- ☐ Calculator
- ☐ Micro-cassette tape recorder, with extra tapes and batteries
- ☐ Hand lens
- ☐ Tally meter
- ☐ Flashlight with extra batteries
- ☐ Binoculars
- ☐ Compass
- ☐ Refractometer
- ☐ Thermometer
- ☐ Rubber gloves, both surgical and heavy-duty vinyl
- ☐ Ear plugs
- ☐ Tar-off towelettes
- ☐ First-aid kit
- ☐ Field pocket knife
- ☐ Folding shovel
- ☐ Wooden tongue depressors in small packs
- ☐ Roll of paper towels
- ☐ Disposable plastic scoops and stainless steel spatulas
- ☐ Precleaned aluminum foil and extra rolls
- ☐ Evidence tape
- ☐ Sample jars: precleaned glass jars with teflon lids
  - 100-ml: box of 24
  - 500-ml: box of 12
  - 1,000-ml: box of 12

- 1-gallon bottles: box of 4, with shipping containers

- ☐ Prepaid overnight carrier shipping forms
- ☐ Field guide books (birds, fish, invertebrates, mammals, plants, macroalgae, etc.)

C.3 Optional Equipment for Standard Kits

In addition to the items listed above, there are larger and more expensive pieces of equipment which can be extremely valuable on-scene. It is usually possible to lease these from local vendors at the discharge site or ship them on-scene once the need arises. These include:

- ☐ Pager for each team member, assuming that there is coverage for the discharge site
- ☐ Portable cellular phone, assuming that there is coverage for the discharge site
- ☐ All-weather video camera, with extra batteries, extra tapes, and cigarette lighter recharger option
- ☐ Portable computer with FAX modem and extra disks
- ☐ Portable printer
- ☐ Global Positioning System (GPS) hand-held unit

C.4 Specialized Survey Kits

In addition to the items listed above, special kits can be developed for the following types of surveys:

C.4.a Shoreline Survey Kit

- ☐ Profile rod set
- ☐ 50-m fiberglass tape measure
- ☐ Hand level
- ☐ Flagging tape
- ☐ Cement trowel for scraping the surface of trenches
- ☐ Precleaned aluminum core barrels
- ☐ Grain-size estimators
- ☐ 0.25 m^2 and 1.0 m^2 quadrats

C.4.b Water Sampling Kit

Water samples need to be kept cold and dark immediately after collection to minimize sample degradation. Samples should be collected directly in the sample jar rather than transferred from the collecting bottle into the sample jar.

- ☐ Water-sample holder to collect water samples directly in the sampling jar
- ☐ Additional boxes of precleaned glass jars (1,000-ml and 1-gallon)
- ☐ Teflon squeeze bottle for rinsing solvents
- ☐ Rinsing solvents for cleaning sample holder
- ☐ Preserving chemicals, if needed
- ☐ Solvent waste container
- ☐ Alconox cleaner soap
- ☐ Scrubbing brush
- ☐ Collapsible containers
- ☐ Salinity, temperature, and conductivity meter

C.4.c Aquatic Biological Sampling Kit

If the kit is to be shipped by a commercial carrier, the need for special packages or volume limits for fixatives and preservatives should be determined.

- ☐ Small dip net
- ☐ Small grab or dredge (e.g., Ponar grab, Ekman dredge)
- ☐ Small beach seine
- ☐ Kick net
- ☐ Small plankton net with several replacement nets and collecting bottles
- ☐ Sieve bucket
- ☐ Wash bottle and graduated cylinder
- ☐ Collapsible plastic containers
- ☐ Fish measuring board
- ☐ Nalgene sample bottles, various sizes
- ☐ Identification keys (e.g., invertebrates, fish)
- ☐ Field balance
- ☐ Fixatives
- ☐ Preservatives

- ☐ Sorting pans with white bottoms
- ☐ Field forms
- ☐ Meter sticks
- ☐ Photoscales
- ☐ 0.25 m^2 and 1.0 m^2 quadrats
- ☐ Sample vials, various sizes
- ☐ Sample labels
- ☐ Permanent markers
- ☐ Random number table
- ☐ Magnifier

APPENDIX D

OIL SPILL EFFECTS REFERENCE LIST

Appendix D

Reference List

D.1. Introduction

The literature on effects resulting from discharges of oil is extensive and highly multidisciplinary. Much of the literature is "gray" in that it is published in conference proceedings, agency reports, and company documents. One major source of information is the Proceedings of the International Oil Spill Conferences. These conferences have been held biennually since 1969, and the Proceedings published by the American Petroleum Institute in Washington, D.C. Peer-reviewed articles are published in a very wide range of journals. Literature searches are complicated by an even more extensive literature on chronic contamination by petroleum hydrocarbons which may not always be applicable to oil discharges. In February 1993, the ban on publication of the results of the NRDA studies of the EXXON VALDEZ oil discharge was lifted. Therefore, these previously unavailable studies should be published in the next few years, providing much new information on the effects of oil on sub-arctic marine resources.

In this appendix, selected references on the effects of the discharge of oil are listed by resource type. This list is by no means inclusive in terms of the literature or topics. The references listed below are intended to give the reader an overview of the available literature for the types of natural resources of concern for the discharge of oil.

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APPENDIX E

QUALITY ASSURANCE

Appendix E

Quality Assurance

E.1 Introduction

Quality assurance (QA) procedures are necessary to ensure that data are collected in a scientifically valid and legally defensible manner. This section describes many of the more general QA procedures that should be considered when collecting and analyzing environmental samples as part of data collection during the Preassessment Phase of a NRDA involving the discharge of oil. These procedures are general in nature because they pertain to samples collected for most kinds of environmental variables. They include procedures that should be followed when samples are collected in the field and shipped to laboratories (Puget Sound Estuary Program, 1991).

The USEPA has developed four QA approaches in its QA program (USEPA, 1991). Category I projects (i.e., major discharges of oil) involve the most rigorous and detailed approach, while Category IV projects involves the least stringent approach. The trustees should use the approach, or some version of it, that most accurately reflects the intended use of the data and the type of work being conducted.

E.2 Sampling Preparation

All members of the field team should thoroughly review the field survey plan, including QA criteria, before each sampling excursion. The plan should be checked for completeness and clarity of objectives. A complete plan should contain the following major elements:

- Identification of the scientific party and responsibilities of each member;
- Statement and prioritization of study objectives;
- Description of survey area, including background information and station locations;
- Identification of variables measured, and required containers and preservatives;
- Identification of all sample splits or performance samples submitted with the survey samples;
- Brief description of sampling methods, including station positioning

technique, sampling devices, replication, and any special considerations;

- Detailed sampling schedule, including time, date, and location of embarkation and debarkation;
- Storage and shipping procedures;
- Identification of laboratories to which samples should be shipped after completion of sample collection;
- Survey logistics requirements (e.g., on vessels should include laboratory and sample storage needs); and
- All special equipment needed for the survey (e.g., GPS unit, video camera, communication devices).

Study objectives and their prioritization should be understood by all members of the sampling team. This will ensure that if modifications of the survey plan become necessary in the field, their effect on the overall goals of the survey can be evaluated adequately. After the sampling plan is reviewed, contingency plans should be outlined. These plans should include potential problems and their solutions. To ensure that all required sampling equipment and supplies are available at the time of sampling, an equipment checklist should be constructed. Spare parts and backup supplies should be included in the inventory.

E.3 Documentation

It is important throughout any sampling and analysis program to maintain integrity of the sample from the time of collection to the point of data reporting. Proper chain-of-custody procedures allow the possession and handling of samples traced from collection to final disposition. Documents needed to maintain proper chain-of-custody include:

- Field Logbook - All pertinent information on field activities and sampling efforts should be recorded in a bound logbook. The field supervisor should be responsible for ensuring that sufficient detail is recorded in the logbook. The logbook should enable someone else to completely reconstruct the field activity without relying on the memory of the field crew. All entries should be made in indelible ink, with each page signed and dated by the author, and a line drawn through the remainder of any page. All corrections should consist of permanent line-out deletions that are initialed.

At a minimum, entries in a logbook should include:

- Date and time of starting work;
- Names of field supervisor and team members;
- Purpose of proposed sampling effort;
- Description of sampling site, including information on any photographs or video that may be taken;
- Location of sampling site;
- Details of actual sampling effort, particularly deviations from standard operating procedures;
- Field observations;
- Field measurements made (e.g., pH, temperature, flow);
- Field laboratory analytical results;
- Sample identification;
- Type and number of sample bottles collected; and
- Sample handling, packaging, labeling, and shipping information (including destination).

- Sample Labels - Labels must be waterproof and securely attached to the outside and/or placed inside each sample container (i.e., depending on the kind of sample) to prevent misidentification of samples. Labels must contain at least the sample number, preservation technique, date and time of collection, location of collection, and signature of the collector. Labels should be marked with indelible ink. Abbreviated labels may also be placed on the cap of each jar to facilitate sample identification.
- Chain-of-Custody - A chain-of-custody record must accompany every sample set. Each person who has custody of the samples must sign the form and ensure that the samples and records are not left unattended unless secured properly.
- Custody Seals - Custody seals are used to detect unauthorized tampering with the samples. Sampling personnel should attach seals to all shipping containers sent to the laboratory by common carrier. Gummed paper seals or custody tape should be used so that the seal must be broken when the container holding the samples is opened.

E.4 Collection of Water Samples

Water samples should be collected through deployment of water samplers to the desired depth of sampling, rather than using pumps and tubing. With pumps and tubing, there is always the risk that oil droplets will adhere to the inside wall of the tubing and be released randomly, making collection of a representative water sample difficult. The most commonly used samplers are the Kemmerer, Van Dorn, Niskin, and Nansen samplers. Samplers should be teflon-lined or composed of stainless steel. Multiple water samplers can be fixed on a rosette frame so that several depths can be sampled during one cast or replicate samples can be taken at the same depth.

When collecting water samples, the best technique is to collect the sample directly in the sample container, rather than having to transfer the water from the sampler to the container. This technique will minimize the potential for loss of sample integrity due to adherence of oil droplets to the inside surfaces of the sampler. The sample container is attached to a weighted holder which has a spring-mounted teflon stopper which can be opened once the container has reached the selected depth. Some types of sample bottles are designed for deployment with the stoppers closed. For example, Go-Flo bottles have a pressure sensor which triggers the opening of the stoppers when the sample bottle reaches a depth of about 10 meters. When it is necessary to collect water samples where surface slicks are present, use of a close/open/close type of bottle is required.

When sampling in clean areas, standard water samplers can be used. Prior to deployment, the stoppers of water samplers are cocked open. At this step, it is critical that the stoppers and the interior of the sampler remain free from contamination. All members of the sampling team should avoid touching the stoppers and the insides of the sampler.

Once the sampler reaches the desired depth, it should be allowed to equilibrate with ambient conditions for 2-3 minutes before it is closed. It is recommended that at least two samplers be used simultaneously for each depth. A second sampler provides a backup to the primary sampler in case of malfunction. A second sampler also increases the volume of sample available for subsampling and rinsing. To ensure that all subsamples at a particular depth are collected from the same water parcel, it is essential that they all be taken from a single cast, such as through use of a rosette sampler. Multiple casts using a single water sampler cannot meet this objective.

Once the water sampler is brought on board the sampling vessel, the stoppers should

be checked immediately for integrity of the seals. If a stopper is not properly sealed, water from the sampled depth may have leaked out during retrieval and been replaced by water from shallower depths. In such cases, the entire water sample should be rejected.

Because a visual inspection might not detect all leaks, an additional check on sampler function may be conducted when sampling in marine settings. This check involves comparing the salinity of the water sample with ambient salinity determined with a CTD (Conductivity-Temperature-Depth probe) deployed with the sampler. A significant difference between ambient salinity and the salinity of a sample or an inconsistency between the salinity of a sample and the salinity profile determined from water in the other samplers from the same cast are indications that a particular sample is invalid. Water samples for chemical analysis and toxicity testing may consist of a single grab sample or a composite collected over a specific period. Containers must be made of non-toxic materials such as Nalgene, high density polyethylene, or polypropylene, and should be new and thoroughly cleaned before use. In the field, containers should be rinsed with sample water at least three times before collecting the actual sample. Each container should be filled completely to exclude any air and sealed appropriately. All containers should be placed on ice as soon as possible. They should be kept cold (4°C) and dark, never frozen. If the sample is collected directly in the container, care should be taken to assure integrity of the sample label.

E.5 Collection of Subtidal Surficial Sediments

This section describes the procedures required to collect an acceptable subtidal surficial sediment sample for chemical analysis and/or toxicity testing. In the past, sampling crews were given relatively wide latitude in deciding how to collect samples. However, because sample collection procedures influence the results of all subsequent laboratory and data analyses, it is critical that samples be collected using acceptable and standardized techniques. Detailed methods are provided here because few groups routinely collect subtidal samples.

E.5.a Design and Operation of Sediment Samplers

The primary criterion for an adequate sampler is that it consistently collects undisturbed samples to the required depth below the sediment surface without contaminating them. An additional criterion is that the sampler can be handled properly onboard the survey

vessel. An otherwise acceptable sampler may yield inadequate sediment samples if it is too large, heavy, or awkward to be handled properly. A common sampling device for subtidal surficial sediments is the modified van Veen bottom grab. However, various coring devices (e.g., box corer, Kasten corer) are also used.

Collection of undisturbed sediment requires that the sampler:

- Creates a minimal bow wake when descending;
- Closes to form a leak proof seal after the sediment sample is taken;
- Prevents sediment washout and excessive sample disturbance when ascending; and
- Allows easy access to the sample surface.

Most modified van Veen grabs have open upper faces that are fitted with rubber flaps. Upon descent the flaps are forced open to minimize the bow wake, whereas upon ascent the flaps are forced closed to prevent sample washout. Some box corers have solid flaps that are clipped open upon descent and snap shut after the corer is triggered. Although most samplers seal adequately when new, the wear and tear of repeated field use eventually reduces this sealing ability (i.e., through chipped or improperly aligned jaws). A sampler should therefore be properly maintained and monitored constantly for proper operation and minimal sample leakage. If unacceptable leakage occurs or the sampler malfunctions in any manner, the sampler should be repaired or replaced. If a sampler is borrowed or leased for a project, its operation and sealing ability should be evaluated prior to sampling. Further, it is prudent to have a backup sampler onboard the survey vessel if the primary sampler begins leaking during a cruise.

The required penetration depth below the sediment surface is a function of the desired sample depth. Generally, it is better to penetrate below the desired sample depth to minimize sample disturbance when the sampling device closes. Penetration depth of most sampling devices varies with the sediment character; it is greatest in fine-grained sediments and least in coarse-grained sediments. In both cases, penetration depth can be modified by adding or removing weights from the samplers. Thus, it is optimal to use a sampler that has a means of weight adjustment. If a sampler cannot consistently achieve the desired penetration depth, an alternate device should be used.

The sampler should be brought aboard the vessel with a minimum amount of swinging to minimize sample disturbance. Once the sampler is secured onboard the survey vessel, it is

essential that the surface of the sample be made accessible without substantially disturbing the sample. Most samplers have hinged flaps on their upper face for this purpose. The openings in the upper face of the sampler should be large enough to allow convenient subsampling of the sediment surface. If an opening is too small, the sample may be unduly disturbed during subsampling.

The sampling device should be attached to the hydrowire of the vessel boom using a ball-bearing swivel. The swivel will minimize the twisting forces on the sampler during deployment and ensure that proper contact is made with the bottom. For safety, the hydrowire, swivel, and all shackles should have a load capacity at least 3 times greater than the weight of a full sampler. In addition, screw-pin shackles should have wire through the eye and around one side of the shackle to prevent the pin from rotating.

The sampler should be lowered through the water and retrieved at a controlled speed of approximately 1 foot per second. Under no circumstances should the sampler be allowed to "free fall" to the bottom, as this may result in premature triggering, an excessive bow wake, or improper orientation upon contact with the bottom. The sampler should contact the bottom gently, and only its weight or piston mechanism should be used to force it into the sediment.

E.5.b Sediment Sampling Interval

The upper 2 cm of sediment is recommended for analysis because that is the sediment horizon in which most infaunal organisms reside and the horizon that is contacted most frequently by epifaunal organisms. When collecting the upper 2 cm of sediment, it is recommended that a minimum penetration depth of 4-5 cm be achieved for each acceptable sample. The portion of sample below the upper 2 cm of sediment can be discarded after the surficial sediment is collected (unless the study design specifies otherwise).

Although the 2-cm specification is arbitrary, it will ensure that:

- Relatively recent sediments are sampled;
- Adequate volumes of sediment can readily be obtained to satisfy the needs of most study objectives; and
- Data from different studies (historical or ongoing) can be compared validly.

Sampling depths other than the upper 2 cm may be appropriate for specific purposes, or when baseline data are available for a different interval.

E.5.c Sediment Sample Acceptability Criteria

The sediment in the sampler should be inspected to determine if the sample satisfied the following acceptability criteria:

- The sampler is not overfilled with sample such that the sediment surface is pressed against the top of the sampler;
- Overlying water is present, indicating minimal leakage;
- The overlying water is not excessively turbid, indicating minimal sample disturbance;
- The sediment surface appears relatively undisturbed, indicating lack of channeling or sample washout; and
- The desired penetration depth is achieved (i.e., 4-5 cm for a 2-cm-deep surficial sample).

If a sample does not meet all of these criteria, it should be rejected and discarded away from the sampling station.

E.5.d Sediment Sample Collection

After a sample is judged acceptable, the following observations should be entered on the field log sheet:

- Date and time;
- Station location at the time of bottom contact;
- Station depth;
- Gross characteristics of the surficial sediment
  - Texture
  - Color
  - Biological structures (e.g., shells, tubes, macrophytes)
  - Presence of debris (e.g., wood chips, wood fibers, human artifacts)
  - Presence of oily sheen
  - Obvious odor (e.g., hydrogen sulfide, oil, creosote);
- Gross characteristics of the vertical profile determined after the surficial sediments

are collected

- Vertical changes in sediment characteristics
- Presence and depth of any apparent redox potential discontinuity layer; and

- Penetration depth.

Before subsamples of the surficial sediments are taken, the overlying water must be removed. The preferred method of removing this water is by slowly siphoning it off near one side of the sampler. Methods such as decanting the water or slightly opening the sampler to let the water flow out are not recommended since they may result in unacceptable disturbance or loss of fine-grained surficial sediment and organic matter.

Once the overlying water is removed, the surficial sediment can be subsampled. Only sediments not in contact with the sides of the sampling device should be subsampled. It is recommended that subsamples be taken using a flat scoop. This device will allow a relatively large subsample to be taken accurately to a depth of 2 cm. Coring devices are not recommended because they usually collect inadequate amounts of surficial sediment, and therefore require repeated extractions to obtain a sufficient volume of material for analysis of conventional sediment variables. A curved scoop is not recommended because it does not sample a uniform depth or volume with depth. Because accurate and consistent subsampling requires practice, it is advisable that an experienced person perform this task. Finally, sample contamination during collection must be avoided. All sampling equipment (e.g., scoops, containers) should be made of noncontaminating material, and should be cleaned appropriately before use. It is recommended that all objects coming in contact with the sample be made of glass, stainless steel, or PTFE (e.g., polytetrafluoroethylene such as teflon). To avoid contamination, all sampling equipment should be cleaned in sequence with site water, pesticide-grade acetone, and pesticide-grade methylene chloride prior to initial use and between use for each station. Methylene chloride should be allowed to evaporate prior to using the equipment.

E.5.e Sediment Sample Homogenization

Sediment from single samples or composites of multiple samples should be homogenized prior to collecting subsamples. Compositing and homogenization can be accomplished by transferring sediment to a clean glass or stainless steel bowl and thoroughly

homogenizing by stirring with stainless steel spoons or spatulas until textural and color homogeneity are achieved. The contents of the bowl should be continuously homogenized as subsamples are taken to prevent potential settlement of larger particles. In addition, unrepresentative material (e.g., stones, wood chips, seagrass) should be removed at the discretion of the chief scientist and noted in the field logbook. The bowl and all utensils should be cleaned in sequence with site water, pesticide-grade acetone, and pesticide-grade methylene chloride between composites, and kept covered with aluminum foil to prevent airborne or other contamination. The methylene chloride should be allowed to evaporate prior to using the bowl and utensils.

All samples should be preserved according to the test requirements. In most cases, the samples are packed in ice and kept cold (4°C) and dark. Samples for toxicity testing should not be frozen.

E.5.f Collection of Sediment Chemistry Samples

If sediment chemistry samples are being collected concurrently with sediment toxicity test samples, they should be collected from the same homogenized sediment sample to ensure that the toxicity and chemical results are related as closely as possible. Sample homogenization and removal of bioassay aliquots should be conducted so that chemical aliquots are not contaminated in the process. Recommended sample size for chemical analysis is about 100 grams (i.e., about one cup), and samples should be placed into clean glass jars with teflon or aluminum cap liners. Sediment samples for chemical analysis can and should be frozen as soon as possible.

E.5.g Replication of Samples for Toxicity Testing

Replicate analyses are conducted on toxicity test subsamples to assess the variability encountered in laboratory testing, rather than the variability of sediment toxicity that exists in the field. To assess field variability, an alternate sampling design could be specified that requires each test replicate to be run on a separate replicate grab sample from each station. The primary drawback to this technique is that the single set of chemical concentrations usually measured at each station would not relate directly to the sediment toxicity measured in each replicate grab sample. This lack of direct relationship between toxicity test and chemical results can sometimes make data interpretation difficult for individual replicate

samples. However, the mean toxicity test response could be compared directly with the chemical concentrations if the chemical measurements are made on a composite of equal amounts of sediment subsampled from each of the replicate samples used for toxicity test analysis.

E.6 Collection of Intertidal Sediments and Soils

Collection of intertidal sediments and soil samples is relatively straightforward because the samples do not have to rely on a remote sampling device. Detailed methods for sampling are provided in USEPA (1984; 1989). Many of the components of sediment and soil sampling are similar to those discussed in the previous section. Key differences include:

- Sampling interval - usually the top 5 cm of sediment are collected, or visual observations are used to select intervals;
- Grain size variations can be very large, from clay to boulders, making the sample more heterogeneous and requiring more replicates or composites;
- The level of contamination can be very high, so extreme care must be taken to avoid cross contamination. New core tubes or sampling utensils should be used for each sample; and
- Sites should be photographed prior to the collection of samples.

E.7 Tissue Sampling

Tissue samples are collected for either chemical or histological analysis. Organisms analyzed for petroleum hydrocarbons should be freshly killed. Decomposed organisms are rarely of any value for analysis. Field documentation should include detailed descriptions of the oiling conditions of the site, location, elevation, etc. Each organism should be photographed prior to sampling. For example, when collecting molluscs, overview photographs to document the exact location and substrate and close-up shots of clusters prior to sampling are valuable.

All instruments used in handling samples must be made of a non-contaminating material (e.g., stainless steel, glass, teflon, aluminum). Whole small organisms may be stored in clean glass jars. Large or irregularly shaped organisms may be wrapped in solvent-rinsed aluminum foil, placing the organism against the dull side. Tissue sections may be taken either on site from freshly killed organisms or in the laboratory from carefully

collected and preserved samples. New, clean, sharp scalpels are used for tissue collection from each animal. The stomach and intestinal tract should be collected last to minimize contamination. Recommended sample size is 10-15 grams. Samples for chemical analysis should be kept at 4°C.

Samples for histological analysis should be about the size of a walnut and kept cold or preserved in the field. All samples from the same organism can go into a single bag. Preserved samples should be fixed for eight hours with an appropriate preservative solution. After the first eight hours and then every 24-hours, the preservative solution should be completely replaced.

E.8 Sample Shipment

All preserved samples should be shipped immediately after completion of sampling to minimize the number of people handling the samples and to protect sample quality and security. Samples should be shipped by priority overnight air freight. As samples are prepared for shipping, the following considerations should be kept in mind.

- Shipping containers should be in good shape and capable of withstanding rough treatment during shipping (e.g., rigid plastic ice chests).
- Samples should be packed tightly:
  - Dividers must separate all glass containers; and
  - Empty space within shipping boxes should be filled so that jars are held securely.
- All containers must be leak proof. If a container is not leakproof by design, the interior should be lined with two heavy-duty plastic bags and the tops of bags should be tied once samples are inside. Adequate absorbent material should be placed in the container in a quantity sufficient to absorb all of the liquid. Drain spouts on ice chests should be taped shut.
- All samples should be accompanied by a sample analysis request. Variables analyzed by the laboratory, and total number and kind of samples shipped for analysis should be listed on the request sheet. The laboratory should acknowledge receipt of shipment by signing and dating the form, and returning a copy to the designated QA coordinator.
- A chain-of-custody record for each shipping container should be filled out

completely and signed.

- The original chain-of-custody record and analysis request should be protected and placed inside the shipping box. A copy of each record should be retained by the shipping party.
- The custody seal should be attached so that the shipping box cannot be opened without breaking the seal.
- For shipping containers carrying liquid samples:
  - A "This End Up" label should be attached to each side to ensure that jars are transported in an upright position; and
  - A "Fragile-Glass" label should be attached to the top of box to minimize agitation of samples.
- Shipping containers should be sent by a carrier that will provide a delivery receipt. This will confirm that the contract laboratory received the samples and serve as a backup to the chain-of-custody record.
- All shipping charges should be prepaid by the sender to avoid confusion and possible rejection of the sample package by the laboratory.
- Notify the laboratory that samples were shipped. Supply the laboratory with the following information:
  - Date and time of shipment;
  - Name of carrier and way bill number(s);
  - Number of samples shipped; and
  - Information on changes, delays, etc.

E.9 References Cited

Puget Sound Estuary Program, 1991, Puget Sound protocols: U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, WA.

U.S. Environmental Protection Agency, 1984, Sediment sampling quality assurance user's guide: Environmental Monitoring Support Laboratory, Las Vegas, NV.

U.S. Environmental Protection Agency, 1989, Soil sampling quality assurance user's guide, Review Draft: Environmental Monitoring Support Laboratory, Las Vegas, NV.

U.S. Environmental Protection Agency, 1991, Preparation aids for the development of

Category IV Quality Assurance Project Plans: EPA/600/8-91/005, Office of Research and Development, Washington, DC, 57 pp.

APPENDIX 10

USCG Initiation Guidance:

USCG Fund Center Contacts

Hypothetical Initiation Request

Request and Authorization for Obligation of Funds from Oil Spill Liability Trust Fund to INITIATE the ASSESSMENT of NATURAL RESOURCE DAMAGES

I. As the Lead Federal Administrative Trustee (Lead Trustee), Department of _____ requests the obligation of funds to initiate the Assessment of Natural Resource Damages for the following oil spill incident:

_____

_____

_____

_____

II. **Potential Trustee Notifications:**

	Participating Yes / No
Department of Agriculture (USDA)	____/____
Department of Defense (DOD)	____/____
Department of Energy (DOE)	____/____
Department of the Interior (DOI)	____/____
Department of Commerce (DOC)	____/____

III. **Request for Funds:**

Initial Request - Amount $_____

Supplemental Request -

Previous Amount $_____

Current Amount $_____

IV. **Use:**

These funds are to be used only for discharge detection and identification; trustee identification and notification; and those activities described in 43 CFR 11.22, 11.24, and 11.25, as they relate to oil. Uses shall be consistent with the National Contingency Plan (NCP).

Estimated costs and completion dates:

	Cost	Est. Date (Month/Year)
Site Characterization	$_____	_____/_____
Early Sampling, Data Collection & Evaluation	$_____	_____/_____
Identification Of Pathways	$_____	_____/_____
Identification Of Exposed Areas	$_____	_____/_____
Exposed Water Estimates	$_____	_____/_____
Estimates Of Concentrations	$_____	_____/_____
Identification Of Potentially Affected Resources	$_____	_____/_____
_____	$_____	_____/_____
Requested Amount	$_____	

The computation or other basis of each of these estimates, including personnel [(# persons)x(# days)x($/day)], equipment [(# days)x($/day)], and contractor estimates are to be provided on separate sheet.

V. **Lead Trustee's Allocation Of Funds:**

USDA	$_____
DOD	$_____
DOE	$_____
DOI	$_____
DOC	$_____
(State)_____	$_____
_____	$_____
Total (all of above)	$_____

VI. **Documentation and Payment:**

The Lead Trustee shall provide documentation of all expenditures, costs and activities for which reimbursement is sought. This documentation shall itemize costs incurred to initiate the assessment of natural resource damages, including: daily expenditures by individual, giving name, title or position, activity performed, time on task, salary or hourly rate, travel cost, per diem, out of pocket or extradinary expenses; equipment purchased or rented, with the daily or hourly rate; and materials and consulting fees. All documentation will be compiled on a daily basis.

Each participating trustee will certify that costs are not currently being recovered or obtained from any other source and include details of any payments received by the trustee from the responsible party, guarantor, a third party source or express appropriation. Within 30 days of completion of the actions to initiate the assessment of natural resource damages, the Lead Trustee will provide a written invoice to the National Pollution Funds Center (NPFC) using form SF-1080, Voucher for Transfer Between Appropriations, accompanied by the documentation described above. The Lead Trustee will certify on the SF-1080 that all costs for which reimbursement is requested are within the scope of this agreement and that all activities performed are consistent with the NCP. Transfer instructions will be provided on the SF-1080.

VII. **Cost Recovery:**

The Lead Trustee shall ensure that all trustees involved in this incident agree to assign cost recovery actions arising from this incident to the OSLTF, to the extent they represent costs reimbursed pursuant to this agreement. In addition, the Lead Trustee agrees to cooperate fully with the NPFC in any claim or action by the OSLTF against the responsible party, guarantor, or other persons to recover costs from this incident. The Lead Trustee shall notify the NPFC of any negotiations to execute an agreement between any natural resource trustee and any responsible party/guarantor which address funding or liability associated with costs covered in this agreement.

VIII. **Certification And Assignment Of Contact Person:**

I certify that Department of_____is the Federal Lead Administrative Trustee and that I am authorized to sign this document on behalf of the Department of _____.

_____
(Signature of Official and Title)

For the Department of _____

_____
(Date)

Lead Trustee Contact Person: _____
Address: _____
_____
Phone: _____
Fax: _____

IX. **Authorization:**

The NPFC authorizes the obligation of funds to the Department of _____ to initiate assessment of natural resource damages for the incident and activities described in their request dated _____. Total amount of funds reimbursable under this agreement shall not exceed $_____. The Federal Project Number _____, must be referenced on daily cost documentation, and the Document Control Number _____, must be included on all requests for reimbursement from the OSLTF.

X. **Supplemental Requests:**

Nothing in this authorization prohibits the Lead Trustee from requesting supplemental funds on the same incident.

XI. **Deobligation:**

This agreement will be closed one year from the date of authorization. Any amounts for which reimbursement and documentation have not been submitted will be deobligated, after written notice to the Lead Trustee has been sent and a 90-day period has elapsed.

_____
Case Officer

_____
Date

NPFC Contact Person: _____
Address: _____
_____
Telephone: (703) 235-_____
Fax: (703) 235-4837

Case Management Teams

Case Management Recepionist (general info.) 703-235-4756
Case Management Fax 703-235-4837

TEAM I - responsible for Alabama, Arkansas, Iowa, Kansas, Louisiana, Mississippi, Missouri, Nebraska, New Mexico, Oklahoma, and Texas.

CDR Craig Leisy, REGIONAL MANAGER 703-235-4770
BMC Freddie Thompson 703-235-4778

Includes Coast Guard Districts 2 and 8, and EPA Regions IV (Mississippi and Alabama only), VI, and VII.

TEAM II - responsible for Delaware, Florida, Georgia, Kentucky, Maryland, North Carolina, Pennsylvania, South Carolina, Tennessee, Virgin Islands, Virginia, Washington D.C., and West Virginia.

CDR Bob Smith, REGIONAL MANAGER 703-235-4771
LT Mary Sohlberg 703-235-4766
SKC Carlos Maxwell 703-235-4779

Includes Coast Guard Districts 5 and 7, and EPA Regions II (Virgin Islands), III, and IV (excluding Mississippi and Alabama).

TEAM III - responsible for Alaska, American Samoa, Arizona, California, Colorado, Guam, Hawaii, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming.

CDR Carl Crampton, REGIONAL MANAGER 703-235-4765
CWO2 Dan Hess 703-235-4767
MSTC Pat Glenn 703-235-4768

Includes Coast Guard Districts 2 (Colorado, North Dakota, South Dakota, and Wyoming) 11, 13, 14, 17, and EPA Regions VII, IX, and X.

TEAM IV - responsible for Connecticut, Illinois, Indiana, Maine, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Rhode Island, Vermont, and Wisconsin.

CDR Wayne Hamilton, REGIONAL MANAGER 703-235-4769
LCDR Jim Cumming 703-235-4758
CWO2 Lloyd Wiggins 703-235-4777

Includes Coast Guard Districts 1 and 9 , and EPA Regions I, II, and V.

Hypothetical Oil Spill[1]:

Basis For Estimates:

Objective:

This document supports the trustees request for obligation of funds from the Oil Spill Liability Trust Fund for the Initiation of the Assessment of Natural Resource Damages. These funds will be used for the preliminary assessment of the extent to which natural resources have been injured by the hypothetical oil spill.

At this stage of the oil spill it is critically important to collect data that (a) are essential to determine the impact of the spill on natural resources, and (b) will disappear and be lost if not recorded immediately. This initial assessment will be the foundation for a longer-term natural resource damage assessment. Examples of the data to be collected include documentation of oiling patterns in ecosystems, documentation of immediate effects on coastal biota, and information characterizing lost recreational and commercial use. Because oil contamination is dynamic, dead organisms disappear rapidly, and human use patterns change daily, data regarding such factors must be collected immediately or they will be lost. This work is being performed in a coordinated effort by the State and Federal Trustee agencies.

The Federal Lead Administrative Trustee will coordinate to ensure that all the trustee agencies participating in this request are aware of the OSLTF record-keeping requirements.

In this initiation request, the trustees propose four main activities: 1) Site Characterization, 2) Early Sampling and Data Collection, 3) Identification of Pathways and estimates of concentrations, and 4) Identification of Potentially Affected Resources. Each of these activities may have one or more sub-tasks associated with them. These categories of initiation activities are consistent with the USCG OSLTF request and Obligation Form. A description of each task and a total estimated budget for all projects is attached. If you have any questions, please contact the the Lead Trustee's technical representative on-scene at the spill.

---

[1] This document would be appended to the "Request and Authorization for Obligation of Funds" form, pages 51-55 of the USCG Technical Operating Procedures Guidance Manual, found earlier in this Appendix.

Activities:

I. Site characterization

Purpose: To travel to the spill site, determine the types of shorelines impacted by the oil spill, and coordinate with the co-trustees and responsible party.

In this activity we will travel to the spill site and begin assessing the major types of habitats and species present in the vicinity of the oil spill, with special attention to the species and habitats known to be most sensitive to oil. This activity will be performed jointly by personnel from all the trustee agencies, relying heavily on the expertise of biologists having prior experience on this coast and with similar oil spills. Affected areas will be surveyed on foot, from boat, and by helicopter.

This category will also include the costs of travel to the spill site and initial coordination costs among the Trustees and with the Responsible Party.

II. Early sampling and data collection

Purpose: To determine current and potential geographic extent of injuries, types of habitats and species affected, types of injuries and their potential severity, and to collect data necessary to later determine the potential for lost use of those resources. We have broken these tasks into four sub-categories: 1) Reconnaissance, 2) Potential Extent and Severity, 3) Collection of perishable lost use data, and 4) Information management and report preparation.

1) Reconnaissance: In this activity we will determine locations of oiling, types of habitats oiled, and initial impacts on coastal resources. Methods will include reconnaissance by helicopter, surveys on foot, by boat, and by diving. We will record species affected and geographic extent of effects. Samples will be taken and preserved for documentation. Information will be compiled, processed and analyzed for a preliminary report. The data will be used to design surveys for the quantification phase of the natural resources damage assessment.

2) Potential Extent and Severity: Based on information from the reconnaissance activity, surveys will be designed to quantify the areal extent and severity of injury to natural resources, including, but limited to marshes, birds, marine mammals, fish, shellfish, sea grasses, algae, and other intertidal/subtidal species. Priority will be given to species of greatest economic and ecological importance, including rare and endangered species. Methods will include

established techniques most appropriate and cost-effective for each situation, such as quadrat counts and point-intercept transect surveys. Specific methods will be determined by the project scientists based on their expert judgment and information from the reconnaissance surveys. Preliminary quantification may also include use of assessment models.

3) Collection of perishable lost use data: In this activity we will be collecting perishable data that may later be needed to measure the economic value of lost recreational and commercial use of coastal resources. Relevant resources affected may include beaches, parks, marinas, waterways, fisheries, wildlife viewing areas, and other aquatic recreation areas. Data collected will include counts of recreational users, patterns of use at substitute sites, and formal closure notices. Methods will include helicopter over flights, interviews with sources such as the Chamber of Commerce, hotel managers, resource management agencies, marina owners, fishermen, and environmental groups.

4) Information management and report preparation: Volumes of information relevant to impacts on natural resources are currently being generated by the trustees, the response agencies, the Responsible Party, university researchers, spill clean-up contractors, salvage contractors, environmental groups, etc. Much of this information is difficult or impossible to collect at a later date. This information will be systematically collected and maintained and later synthesized and summarized into an incident report.

III. Identification of pathways and estimates of concentrations.

Purpose: To relate observed natural resource injuries to effects of oil from the vessel, as opposed to effects of other factors unrelated to the spill.

In this activity we will determine movements, patterns of oiling, and sources of oil in coastal habitats. Oil observations will be made daily. Oil will be collected from these habitats for chemical analysis, which will be used for purposes such as measurements of weathering, toxicity, and identification of source. Methods will include aerial surveys by helicopter, and ground-level surveys on foot and by boat. Oil will be collected following established QA/QC procedures to maintain integrity of such samples. These procedures include use of specially prepared, chemically clean containers, sealed with evidence tape, and accompanied by chain of custody forms.

Computers may be used to model the potential pathways and help to determine the potential concentrations of oil to which natural resources may be exposed.

IV. Potentially affected resources

Identification of Potential Affected Resources: The following is a partial list of natural resources of primary concern in the vicinity of the oil spill that could be potentially impacted by the spilled oil:

Salt Marshes
Sand beaches
Sea grass beds
Coastal populations of fish and shellfish, and other commercially important species
Marine Mammals
Seabird populations and roosting areas
Rocky intertidal ledges supporting high biomasses of biota such as seaweeds, shellfish and other marine species.
Tourist and recreation areas

The trustees will continue to identify resources at risk and determine whether these resources have been, or are expected to be exposed to the oil released from the vessel.

Labor Categories:	Costs	Travel Costs	Cost	Per Diem	Cost
Federal Trustee #1 (On-scene):					
4 biologists x $550 per day x 10 days	$22,000	4 person x $650	$2,600	4 person x $192 per day x 10 days	$7,680
2 contractors x $600 per day x 10 days	$12,000	2 person x $600	$1,200	2 person x $192 per day x 10 days	$3,840
2 scientific divers x $800 per day x 10 days	$16,000	2 divers x $600	$1,200	2 divers x $192 per day x 10 days	$3,840
Federal Trustee #2		Mileage			
1 biologist x $550 per day x 2 days	$1,100	$25 per day x 2 days	$50	1 person x $192 per day x 2 days	$384
2 biologists x $550 per day x 10 days	$11,000	$25 per day x 10 days	$250	2 person x $192 per day x 10 days	$3,840
2 envir. specialists x $500 per day x 10 days	$10,000	$25 per day x 10 days	$250	2 person x $192 per day x 10 days	$3,840
State Trustee #1		Mileage			
16 tech staff x $250 per day x 10 days	$40,000	16 person x $25 per day x 10 days	$4,000	Local (N/A)	$0
2 biologists x $400 per day x 10 days	$8,000	NA		NA	
1 contractor x $400 per day x 10 days	$4,000	NA		NA	
State Trustee # 2					
4 tech staff x $250 per day x 10 days	$10,000	4 person x $25 per day x 10 days	$1,000	Local (N/A)	$0
	$134,100		$10,550		$23,424

Equipment (Lead to purchase or rent)	Costs	Transportation Rental	Costs
Video Camera (Rental w/ accessories)	$150	Boat Charters (Bird Surveys)	
Video Camera (Purchase w/ accessories)	$1,200	5 inshore trips x $500 per trip	$2,500
Sampling Equipment		Boat Charters (Diver Surveys)	
(Pre-cleaned bottles, scoops, coolers, blue ice, Tyvek suits/booties, film/processing, etc.)	$800	5 offshore trips x $500 per trip	$2,500
Cellular phone rental (including calls)			
(3 phones x @ $100 per day x 10 days)	$3,000	Overflights	
Diving Gear (replacement due to oiling)		9 trips x 1.5 hrs x 600/hr	$8,100
(Four sets each of : BC's, wet suits, masks, snorkels, fins, hoses)	$2,550		
	$7,700		$13,100

Laboratory Support		
50 samples x $500 each for analysis	$25,000	Screen for total hydrocarbons, total aromatics, and individual aromatics from standard protocols)

Subtotal Personnel	$168,074
Subtotal Other	$20,800
Subtotal Laboratory	$25,000
GRAND TOTAL	$213,874

APPENDIX 11

Glossary of Abbreviations
and Definitions for
Marine Oil Spill Response

GLOSSARY OF ABBREVIATIONS AND DEFINITIONS

FOR

MARINE OIL SPILL RESPONSE

Contents

Glossary of Abbreviations and Definitions for:

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Compiled by:
National Oceanic and Atmospheric Administration
Hazardous Materials Response and Assessment Division
Scientific Support Coordination Branch

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TITLE I—OIL POLLUTION, LIABILITY, AND COMPENSATION

SEC. 1001. DEFINITIONS.

For the purposes of this Act, the term—

"act of God"
means an unanticipated grave natural disaster or other natural phenomenon of an exceptional, inevitable, and irresistible character the effects of which could not have been prevented or avoided by the exercise of due care or foresight;

"barrel"
means 42 United States gallons at 60 degrees Fahrenheit;

"claim"
means a request, made in writing for a sum certain, for compensation for damages or removal costs resulting from an incident;

"claimant"
means any person or government who presents a claim for compensation under this title;

"damages"
means damages specified in section 1002(b) of the Act, and includes the cost of assessing these damages;

"deepwater port"
is a facility licensed under the Deepwater Port Act of 1974 (33 U.S.C. 1501-1524);

"discharge"
means any emission (other than natural seepage), intentional or unintentional, and includes, but is not limited to, spilling, leaking, pumping, pouring, emitting, emptying, or dumping;

"exclusive economic zone"
(EEZ) the zone established by Presidential Proclamation Numbered 5030, dated March 10, 1983, including the ocean waters of the areas referred to as eastern special areas in Article 3(1) of the Agreement between the United States of America and the Union of Soviet Socialist Republics on the Maritime Boundary, signed June 1, 1990;

"facility"
means any structure, group of structures, equipment, or device (other than a vessel) that is used for one or more of the following purposes: exploring for, drilling for, producing, storing, handling, transferring, processing, or transporting oil. This term

includes any motor vehicle, rolling stock, or pipeline used for one or more of these purposes;

"foreign offshore unit"
means a facility that is located, in whole or in part, in the territorial sea or on the continental shelf of a foreign country and that is or was used for one or more of the following purposes: exploring for, drilling for, producing, storing, handling, transferring, processing, or transporting oil produced from the seabed beneath the foreign country's territorial sea or from the foreign country's continental shelf;

"Fund "
means the Oil Spill Liability Trust Fund, established by section 9509 of the Internal Revenue Code of 1986 (26 U.S.C. 9509);

"gross ton"
has the meaning given that term by the Secretary under part J of title 46, United States Code;

"guarantor"
means any person, other than the responsible party, who provides evidence of financial responsibility for a responsible party under this Act;

"incident"
means any occurrence or series of occurrences having the same origin, involving one or more vessels, facilities, or any combination thereof, resulting in the discharge or substantial threat of discharge of oil;

"Indian tribe"
means any Indian tribe, band, nation, or other organized group or community, but not including any Alaska Native regional or village corporation, which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians and has governmental authority over lands belonging to or controlled by the tribe;

"lessee"
means a person holding a leasehold interest in an oil or gas lease on lands beneath navigable waters (as that term is defined in section 2(a) of the Submerged Lands Act (43 U.S.C. 1301(a))) or on submerged lands of the Outer Continental Shelf, granted or maintained under applicable State law or the Outer Continental Shelf Lands Act (43 U.S.C. 1331 et seq.);

"liable or liability"
shall be construed to be the standard of liability which obtains under section 311 of the Federal Water Pollution Control Act (33 U.S.C. 1321);

"mobile offshore drilling unit"
means a vessel (other than a self-elevating lift vessel) capable of use as an offshore facility;

"National Contingency Plan"
means the National Contingency Plan prepared and published under section 311(d) of the Federal Water Pollution Control Act, as amended by this Act, or revised under section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. 9605);

"natural resources"
includes land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the exclusive economic zone), any State or local government or Indian tribe, or any foreign government;

"navigable waters "
means the waters of the United States, including the territorial sea;

"offshore facility"
means any facility of any kind located in, on, or under any of the navigable waters of the United States, and any facility of any kind which is subject to the jurisdiction of the United States and is located in, on, or under any other waters, other than a vessel or a public vessel;

"oil"
means oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil, but does not include petroleum, including crude oil or any fraction thereof, which is specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (42 U.S.C. 9601) and which is subject to the provisions of that Act;

"onshore facility"
means any facility (including, but not limited to, motor vehicles and rolling stock) of any kind located in, on, or under, any land within the United States other than submerged land; the term Outer Continental Shelf facility means an offshore facility which is located, in whole or in part, on the Outer Continental Shelf and is or was used for one or more of the following purposes: exploring for, drilling for, producing, storing, handling, transferring, processing, or transporting oil produced from the Outer Continental Shelf;

"owner or operator"
means (A) in the case of a vessel, any person owning, operating, or chartering by demise, the vessel, and (B) in the case of an onshore facility and an offshore facility, any person owning or operating such onshore facility or offshore facility, and (C) in the case of any abandoned offshore facility, the person who owned or operated such facility immediately prior to such abandonment;

"permittee"
means a person holding an authorization, license, or permit for geological exploration issued under section 11 of the Outer Continental Shelf Lands Act (43 U.S.C. 1340) or applicable State law;

"person"
means an individual, corporation, partnership, association, State, municipality, commission, or political subdivision of a State, or any interstate body;

"public vessel"
means a vessel owned or bareboat chartered and operated by the United States, or by a State or political subdivision thereof, or by a foreign nation, except when the vessel is engaged in commerce;

"remove or removal"
means containment and removal of oil or a hazardous substance from water and shorelines or the taking of other actions as may be necessary to minimize or mitigate damage to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, and public and private property, shorelines, and beaches;

"removal costs"
means the costs of removal that are incurred after a discharge of oil has occurred or, in any case in which there is a substantial threat of a discharge of oil, the costs to prevent, minimize, or mitigate oil pollution from such an incident;

"responsible party"
means the following:

(A) VESSELS—In the case of a vessel, any person owning, operating, or demise chartering the vessel.

(B) ONSHORE FACILITIES—In the case of an onshore facility (other than a pipeline), any person owning or operating the facility, except a Federal agency, State, municipality, commission, or political subdivision of a State, or any interstate body, that as the owner transfers possession and right to use the property to another person by lease, assignment, or permit.

(C) OFFSHORE FACILITIES—In the case of an offshore facility (other than a pipeline or a deepwater port licensed under the Deepwater Port Act of 1974 (33 U.S.C. 1501 et seq.)), the lessee or permittee of the area in which the facility is located or the holder of a right of use and easement granted under applicable State law or the Outer Continental Shelf Lands Act (43 U.S.C. 1301-1356) for the area in which the facility is located (if the holder is a different person than the lessee or permittee), except a Federal agency, State, municipality, commission, or political subdivision of a State, or any interstate body, that as owner transfers possession and right to use the property to another person by lease, assignment, or permit.

(D) DEEPWATER PORTS—In the case of a deepwater port licensed under the Deepwater Port Act of 1974 (33 U.S.C. 1501-1524), the licensee.

(E) PIPELINES—In the case of a pipeline, any person owning or operating the pipeline.

(F) ABANDONMENT—In the case of an abandoned vessel, onshore facility, deepwater port, pipeline, or offshore facility, the persons who would have been responsible parties immediately prior to the abandonment of the vessel or facility.

"Secretary"
means the Secretary of the department in which the Coast Guard is operating;

"tank vessel"
means a vessel that is constructed or adapted to carry, or that carries, oil or hazardous material in bulk as cargo or cargo residue, and that—

(A) is a vessel of the United States;

(B) operates on the navigable waters; or

(C) transfers oil or hazardous material in a place subject to the jurisdiction of the United States;

"territorial seas"
means the belt of the seas measured from the line of ordinary low water along that portion of the coast which is in direct contact with the open sea and the line marking the seaward limit of inland waters, and extending seaward a distance of 3 miles;

"United States and State"
mean the several states of the United States, the District of Columbia, the Commonwealth of Puerto Rico, Guam, American Samoa, the United States Virgin Islands, the Commonwealth of the Northern Marianas, and any other territory or possession of the United States; and

"vessel"
means every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water, other than a public vessel.

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Selected National Contingency Plan Definitions

§ 300.4 Abbreviations.

(a) Department and Agency Title Abbreviations:

ATSDR	—	Agency for Toxic Substances and Disease Registry
DOC	—	Department of Commerce
DOD	—	Department of Defense
DOE	—	Department of Energy
DOI	—	Department of the Interior
DOJ	—	Department of Justice
DOL	—	Department of Labor
DOS	—	Department of State
DOT	—	Department of Transportation
EPA	—	Environmental Protection Agency
FEMA	—	Federal Emergency Management Agency
HHS	—	Department of Health and Human Services
NIOSH	—	National Institute for Occupational Safety and Health
NOAA	—	National Oceanic and Atmospheric Administration
RSPA	—	Research and Special Programs Administration
USCG	—	United States Coast Guard
USDA	—	United States Department of Agriculture

(Note: Reference is made in the NCP to both the Nuclear Regulatory Commission and the National Response Center. In order to avoid confusion, the NCP will spell out Nuclear Regulatory Commission and use the abbreviation NRC only with respect to the National Response Center.)

(b) Operational Abbreviations:

ARARs	—	Applicable or Relevant and Appropriate Requirements
CERCLIS	—	CERCLA Information System
CRC	—	Community Relations Coordinator
CRP	—	Community Relations Plan
ERT	—	Environmental Response Team
FCO	—	Federal Coordinating Officer
FS	—	Feasibility Study
HRS	—	Hazard Ranking System
LEPC	—	Local Emergency Planning Committee
NCP	—	National Contingency Plan
NPL	—	National Priorities List
NR	—	National Response Center

NRT	—	National Response Team
NSF	—	National Strike Force
O&M	—	Operation and Maintenance
OSC	—	On-Scene Coordinator
PA	—	Preliminary Assessment
PIAT	—	Public Information Assist Team
RA	—	Remedial Action
RAT	—	Radiological Assistance Team
RCP	—	Regional Contingency Plan
RD	—	Remedial Design
RI	—	Remedial Investigation
ROD	—	Record of Decision
RPM	—	Remedial Project Manager
RRC	—	Regional Response Center
RRT	—	Regional Response Team
SAC	—	Support Agency Coordinator
SERC	—	State Emergency Response Commission
SI	—	Site Inspection
SMOA	—	Superfund Memorandum of Agreement
SSC	—	Scientific Support Coordinator

§ 300.5 Definitions.

Terms not defined in this section have the meaning given by CERCLA or the CWA.

activation
means notification by telephone or other expeditious manner or, when required, the assembly of some or all appropriate members of the RRT or NRT.

alternative water supplies
as defined by section 101(34) of CERCLA, includes, but is not limited to, drinking water and household water supplies.

applicable requirements
means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility citing laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

bioremediation agents
microbiological cultures, enzyme additives, or nutrient additives that are deliberately introduced into an oil discharge and that will significantly increase the rate of biodegradation to mitigate the effects of the discharge.

burning agents
means those additives that, through physical or chemical means, improve the combustibility of the materials to which they are applied.

CERCLA
is the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986.

CERCLIS
is the abbreviation of the CERCLA Information System, EPA's comprehensive data base and management system that inventories and tracks releases addressed or needing to be addressed by the Superfund program. CERCLIS contains the official inventory of CERCLA sites and supports EPA's site planning and tracking functions. Sites that EPA decides do not warrant moving further in the site evaluation process are given a No Further Response Action Planned (NFRAP) designation in CERCLIS. This means that no additional federal steps under CERCLA will be taken at the site unless future information so warrants. Sites are not removed from the data base after completion of evaluations in order to document that these evaluations took place and to preclude the possibility that they be needlessly repeated. Inclusion of a specific site or area in the CERCLIS data base does not represent a determination of any party's liability, nor does it represent a finding that any response action is necessary. Sites that are deleted from the NPL are not designated NFRAP sites. Deleted sites are listed in a separate category in the CERCLIS data base.

chemical agents
means those elements, compounds, or mixtures that coagulate, disperse, dissolve, emulsify, foam, neutralize, precipitate, reduce, solubilize, oxidize, concentrate, congeal, entrap, fix, make the pollutant mass more rigid or viscous, or otherwise facilitate the mitigation of deleterious effects or the removal of the pollutant from the water.

claim
as defined by section 101(4) of CERCLA, means a demand in writing for a sum certain.

claimant
see OPA definitions

coastal waters
for the purposes of classifying the size of discharges, means the waters of the coastal zone except for the Great Lakes and specified ports and harbors on inland rivers.

coastal zone
as defined for the purpose of the NCP, means all United States waters subject to the tide, United States waters of the Great Lakes, specified ports and harbors on inland rivers, waters of the contiguous zone, other waters of the high seas subject to the NCP, and the land surface or land substrata, ground waters, and ambient air proximal to those waters. The term coastal zone delineates an area of federal responsibility for response action. Precise boundaries are determined by EPA/USCG agreements and identified in federal regional contingency plans.

community relations
means EPA's program to inform and encourage public participation in the Superfund process and to respond to community concerns. The term public includes citizens directly affected by the site, other interested citizens or parties, organized groups, elected officials, and potentially responsible parties.

community relations coordinator
means lead agency staff who work with the OSC/RPM to involve and inform the public about the Superfund process and response actions in accordance with the interactive community relations requirements set forth in the NCP.

contiguous zone
means the zone of the high seas, established by the United States under Article 24 of the Convention on the Territorial Sea and Contiguous Zone, which is contiguous to the territorial sea and which extends nine miles seaward from the outer limit of the territorial sea.

cooperative agreement
is a legal instrument EPA uses to transfer money, property, services, or anything of value to a recipient to accomplish a public purpose in which substantial EPA involvement is anticipated during the performance of the project.

damages
see OPA definitions

discharge
as defined by section 311(a)(2) of the CWA, includes, but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying, or dumping of oil, but excludes discharges in compliance with a permit under section 402 of the CWA, discharges resulting from circumstances identified and reviewed and made a part of the public record with respect to a permit issued or modified under section 402 of the CWA, and

subject to a condition in such permit, or continuous or anticipated intermittent discharges from a point source, identified in a permit or permit application under section 402 of the CWA, that are caused by events occurring within the scope of relevant operating or treatment systems. For purposes of the NCP, discharge also means threat of discharge.

dispersants
means those chemical agents that emulsify, disperse, or solubilize oil into the water column or promote the surface spreading of oil slicks to facilitate dispersal of the oil into the water column.

drinking water supply
as defined by section 101(7) of CERCLA, means any raw or finished water source that is or may be used by a public water system (as defined in the Safe Drinking Water Act) or as drinking water by one or more individuals.

environment
as defined by section 101(8) of CERCLA, means the navigable waters, the waters of the contiguous zone, and the ocean waters of which the natural resources are under the exclusive management authority of the United States under the Magnuson Fishery Conservation and Management Act; and any other surface water, ground water, drinking water supply, land surface or subsurface strata, or ambient air within the United States or under the jurisdiction of the United States.

Exclusive Economic Zone (EEZ)
see OPA definitions

facility
as defined by section 101(9) of CERCLA, means any building, structure, installation, equipment, pipe or pipeline (including any pipe into a sewer or publicly owned treatment works), well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, or aircraft, or any site or area, where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located; but does not include any consumer product in consumer use or any vessel.

feasibility study
(FS) means a study undertaken by the lead agency to develop and evaluate options for remedial action. The FS emphasizes data analysis and is generally performed concurrently and in an interactive fashion with the remedial investigation (RI), using data gathered during the RI. The RI data are used to define the objectives of the response action, to develop remedial action alternatives, and to undertake an initial screening and detailed analysis of the alternatives. The term also refers to a report that describes the results of the study.

first federal official
means the first federal representative of a participating agency of the National Response Team to arrive at the scene of a discharge or a release. This official coordinates activities under the NCP and may initiate, in consultation with the OSC, any necessary actions until the arrival of the predesignated OSC. A state with primary jurisdiction over a site covered by a cooperative agreement will act in the stead of the first federal official for any incident at the site.

fund or trust fund
means the Hazardous Substance Superfund established by section 9507 of the Internal Revenue Code of 1986.

ground water
as defined by section 101(12) of CERCLA, means water in a saturated zone or stratum beneath the surface of land or water.

Hazard Ranking System
(HRS) means the method used by EPA to evaluate the relative potential of hazardous substance releases to cause health or safety problems, or ecological or environmental damage.

hazardous substance
as defined by section 101(14) of CERCLA, means: Any substance designated pursuant to section 311(b)(2)(A) of the CWA; any element, compound, mixture, solution, or substance designated pursuant to section 102 of CERCLA; any hazardous waste having the characteristics identified under or listed pursuant to section 3001 of the Solid Waste Disposal Act (but not including any waste the regulation of which under the Solid Waste Disposal Act has been suspended by Act of Congress); any toxic pollutant listed under section 307(a) of the CWA; any hazardous air pollutant listed under section 112 of the Clean Air Act; and any imminently hazardous chemical substance or mixture with respect to which the EPA Administrator has taken action pursuant to section 7 of the Toxic Substances Control Act. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance in the first sentence of this paragraph, and the term does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas).

Indian tribe
as defined by section 101(36) of CERCLA, means any Indian tribe, band, nation, or other organized group or community, including any Alaska Native village but not including any Alaska Native regional or village corporation, which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians.

inland waters
for the purposes of classifying the size of discharges, means those waters of the United States in the inland zone, waters of the Great Lakes, and specified ports and harbors on inland rivers.

inland zone
means the environment inland of the coastal zone excluding the Great Lakes and specified ports and harbors on inland rivers. The term inland zone delineates an area of federal responsibility for response action. Precise boundaries are determined by EPA/USCG agreements and identified in federal regional contingency plans.

lead administrative trustee
a natural resource trustee who is designated on an incident-by-incident basis for the purpose of preassessment and damage assessment and chosen by the other trustees whose natural resources are affected by the incident. The lead administrative trustee facilitates effective and efficient communication during response operations between the OSC and the other natural resource trustees conducting activities associated with damage assessment, and is responsible for applying to the OSC for access to response operations resources on behalf of all trustees for initiation of a damage assessment.

lead agency
means the agency that provides the OSC/RPM to plan and implement response action under the NCP. EPA, the USCG, another federal agency, or a state (or political subdivision of a state) operating pursuant to a contract or cooperative agreement executed pursuant to section 104(d)(1) of CERCLA, or designated pursuant to a Superfund Memorandum of Agreement (SMOA) entered into pursuant to Subpart F of the NCP or other agreements may be the lead agency for a response action. In the case of a release of a hazardous substance, pollutant, or contaminant, where the release is on, or the sole source of the release is from, any facility or vessel under the jurisdiction, custody, or control of Department of Defense (DOD) or Department of Energy (DOE), then DOD or DOE will be the lead agency. Where the release is on, or the sole source of the release is from, any facility or vessel under the jurisdiction, custody, or control of a federal agency other than EPA, the USCG, DOD, or DOE, then that agency will be the lead agency for remedial actions and removal actions other than emergencies. The federal agency maintains its lead agency responsibilities whether the remedy is selected by the federal agency for non-NPL sites or by EPA and the federal agency or by EPA alone under CERCLA section 120. The lead agency will consult with the support agency, if one exists, throughout the response process.

management of migration
means actions that are taken to minimize and mitigate the migration of hazardous substances or pollutants or contaminants and the effects of such migration. Measures may include, but are not limited to, management of a plume of contamination, restoration of a drinking water aquifer, or surface water restoration.

miscellaneous oil spill control agent
is any product, other than a dispersant, sinking agent, surface collecting agent, biological additive, or burning agent, that can be used to enhance oil spill cleanup, removal, treatment, or mitigation.

National Pollution Funds Center
(NPFC) the entity established by the Secretary of Transportation whose function is the administration of the Oil Spill Liability Trust Fund(OSLTF). Among the NPFC's duties are: providing appropriate access to the OSLTF for federal agencies and states for removal actions and for federal trustees to initiate the assessment of natural resource damages; providing appropriate access to the OSLTF for claims; and coordinating cost recovery efforts.

National Priorities List
(NPL) the list, compiled by EPA pursuant to CERCLA section 105, of uncontrolled hazardous substance releases in the United States that are priorities for long-term remedial evaluation and response.

National Response System
(NRS) the mechanism for coordinating response actions by all levels of government in support of the OSC/RPM. The NRS is composed of the NRT, RRTs, OSC/RPM, Area Committees, Special Teams, and related support entities. The NRS is capable of expanding or contracting to accommodate the response effort required by the size or complexity of the discharge or release.

National Strike Force
(NSF) a special team established by the USCG, including the three USCG Strike Teams, the Public Information Assist Team (PIAT), and the National Strike Force Coordination Center. The NSF is available to assist OSCs/RPMs in their preparedness and response duties.

National Strike Force Coordination Center
(NSFCC) is authorized as the National Response Unit by CWA sections 311(a)(23) and(j)(2), means the entity established by the Secretary of the department in which the USCG is operating at Elizabeth City, North Carolina with responsibilities that include administration of the USCG Strike Teams, maintenance of response equipment inventories and logistic networks, and conducting a national exercise program.

natural resources
means land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the exclusive economic zone defined by the Magnuson Fishery Conservation and Management Act of 1976), any state or local government, any foreign government, any Indian tribe, or, if

such resources are subject to a trust restriction on alienation, any member of an Indian tribe.

navigable waters
as defined by 40 CFR § 110.1, means the waters of the United States, including the territorial seas. The term includes:

(1) All waters that are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters that are subject to the ebb and flow of the tide;

(2) Interstate waters, including interstate wetlands;

(3) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, and wetlands, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:

    (i) That are or could be used by interstate or foreign travelers for recreational or other purposes;

    (ii) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce;

    (iii) That are used or could be used for industrial purposes by industries in interstate commerce;

(4) All impoundments of waters otherwise defined as navigable waters under this section;

(5) Tributaries of waters identified in paragraphs (1) through (4) of this definition, including adjacent wetlands; and

(6) Wetlands adjacent to waters identified in paragraphs (1) through (5) of this definition: Provided, that waste treatment systems (other than cooling ponds meeting the criteria of this paragraph) are not waters of the United States.

(7) Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with EPA.

offshore facility
as defined by section 101(17) of CERCLA and section 311(a)(11) of the CWA, means any facility of any kind located in, on, or under any of the navigable waters of the United States and any facility of any kind which is subject to the jurisdiction of the United States and is located in, on, or under any other waters, other than a vessel or a public vessel.

oil
as defined by section 311(a)(1) of the CWA, means oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil.

Oil Spill Liability Trust Fund (OSLTF)
the fund established under section 9509 of the Internal Revenue Code of 1986(26 U.S.C. 9509).

on-scene coordinator
(OSC) means the federal official predesignated by EPA or the USCG to coordinate and direct responses under Subpart D, or the government official designated by the lead agency to coordinate and direct removal actions under Subpart E of the NCP.

onshore facility
as defined by section 101(18) of CERCLA, means any facility (including, but not limited to, motor vehicles and rolling stock) of any kind located in, on, or under any land or non-navigable waters within the United States; and, as defined by section 311(a)(10) of the CWA, means any facility (including, but not limited to, motor vehicles and rolling stock) of any kind located in, on, or under any land within the United States other than submerged land.

on-site
means the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action.

operable unit
means a discrete action that comprises an incremental step toward comprehensively addressing site problems. This discrete portion of a remedial response manages migration, or eliminates or mitigates a release, threat of a release, or pathway of exposure. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site. Operable units may address geographical portions of a site, specific site problems, or initial phases of an action, or may consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site.

operation and maintenance
(O&M) means measures required to maintain the effectiveness of response actions.

person
as defined by section 101(21) of CERCLA, means an individual, firm, corporation, association, partnership, consortium, joint venture, commercial entity, United States government, state, municipality, commission, political subdivision of a state, or any interstate body.

pollutant or contaminant
as defined by section 101(33) of CERCLA, shall include, but not be limited to, any element, substance, compound, or mixture, including disease-causing agents, which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations, in such organisms or their offspring. The term does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance under section 101(14)(A) through (F) of CERCLA, nor does it include natural gas, liquefied natural gas, or synthetic gas of pipeline quality (or mixtures of natural gas and such synthetic gas). For purposes of the NCP, the term pollutant or contaminant means any pollutant or contaminant that may present an imminent and substantial danger to public health or welfare.

post-removal site control
means those activities that are necessary to sustain the integrity of a Fund-financed removal action following its conclusion. Post-removal site control may be a removal or remedial action under CERCLA. The term includes, without being limited to, activities such as relighting gas flares, replacing filters, and collecting leachate.

preliminary assessment
(PA) means review of existing information and an off-site reconnaissance, if appropriate, to determine if a release may require additional investigation or action. A PA may include an on-site reconnaissance, if appropriate.

public participation
see the definition for community relations.

public vessel
as defined by section 311(a)(4) of the CWA, means a vessel owned or bareboat-chartered and operated by the United States, or by a state or political subdivision thereof, or by a foreign nation, except when such vessel is engaged in commerce.

quality assurance project plan
(QAPP) is a written document, associated with all remedial site sampling activities, which presents in specific terms the organization (where applicable), objectives, functional activities, and specific quality assurance (QA) and quality control (QC) activities designed to achieve the data quality objectives of a specific project(s) or continuing operation(s). The QAPP is prepared for each specific project or continuing operation (or group of similar projects or continuing operations). The QAPP will be prepared by the responsible program office, regional office, laboratory, contractor, recipient of an assistance agreement, or other organization. For an enforcement action, potentially responsible parties may prepare a QAPP subject to lead agency approval.

release
as defined by section 101(22) of CERCLA, means any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment (including the abandonment or discarding of barrels, containers, and other closed receptacles containing any hazardous substance or pollutant or contaminant), but excludes: Any release which results in exposure to persons solely within a workplace, with respect to a claim which such persons may assert against the employer of such persons; emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft, vessel, or pipeline pumping station engine; release of source, byproduct, or special nuclear material from a nuclear incident, as those terms are defined in the Atomic Energy Act of 1954, if such release is subject to requirements with respect to financial protection established by the Nuclear Regulatory Commission under section 170 of such Act, or, for the purposes of section 104 of CERCLA or any other response action, any release of source, byproduct, or special nuclear material from any processing site designated under section 102(a)(1) or 302(a) of the Uranium Mill Tailings Radiation Control Act of 1978; and the normal application of fertilizer. For purposes of the NCP, release also means threat of release.

relevant and appropriate requirements
means those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

remedial design
(RD) means the technical analysis and procedures which follow the selection of remedy for a site and result in a detailed set of plans and specifications for implementation of the remedial action.

remedial investigation
(RI) is a process undertaken by the lead agency to determine the nature and extent of the problem presented by the release. The RI emphasizes data collection and site characterization, and is generally performed concurrently and in an interactive fashion with the feasibility study. The RI includes sampling and monitoring, as necessary, and includes the gathering of sufficient information to determine the necessity for remedial action and to support the evaluation of remedial alternatives.

remedial project manager
(RPM) the official designated by the lead agency to coordinate, monitor, or direct remedial or other response actions under Subpart E of the NCP.

remedy or remedial action
(RA) those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment. The term includes, but is not limited to, such actions at the location of the release as storage, confinement, perimeter protection using dikes, trenches, or ditches, clay cover, neutralization, cleanup of released hazardous substances and associated contaminated materials, recycling or reuse, diversion, destruction, segregation of reactive wastes, dredging or excavations, repair or replacement of leaking containers, collection of leachate and runoff, on-site treatment or incineration, provision of alternative water supplies, any monitoring reasonably required to assure that such actions protect the public health and welfare and the environment and, where appropriate, post-removal site control activities. The term includes the costs of permanent relocation of residents and businesses and community facilities (including the cost of providing alternative land of equivalent value to an Indian tribe pursuant to CERCLA section 126(b)) where EPA determines that, alone or in combination with other measures, such relocation is more cost-effective than, and environmentally preferable to, the transportation, storage, treatment, destruction, or secure disposition off-site of such hazardous substances, or may otherwise be necessary to protect the public health or welfare; the term includes off-site transport and off-site storage, treatment, destruction, or secure disposition of hazardous substances and associated contaminated materials. For the purpose of the NCP, the term also includes enforcement activities related thereto.

remove or removal
as defined by section 311(a)(8) of the CWA, refers to removal of oil or hazardous substances from the water and shorelines or the taking of such other actions as may be necessary to minimize or mitigate damage to the public health or welfare or to the environment. As defined by section 101(23) of CERCLA, remove or removal means the cleanup or removal of released hazardous substances from the environment; such actions as may be necessary taken in the event of the threat of release of hazardous

substances into the environment; such actions as may be necessary to monitor, assess, and evaluate the release or threat of release of hazardous substances; the disposal of removed material; or the taking of such other actions as may be necessary to prevent, minimize, or mitigate damage to the public health or welfare or to the environment, which may otherwise result from a release or threat of release. The term includes, in addition, without being limited to, security fencing or other measures to limit access, provision of alternative water supplies, temporary evacuation and housing of threatened individuals not otherwise provided for, action taken under section 104(b) of CERCLA, post-removal site control, where appropriate, and any emergency assistance which may be provided under the Disaster Relief Act of 1974. For the purpose of the NCP, the term also includes enforcement activities related thereto.

removal costs
see OPA definitions

respond or response
as defined by section 101(25) of CERCLA, means remove, removal, remedy, or remedial action, including enforcement activities related thereto.

Responsible Party
see OPA definitions

SARA
is the Superfund Amendments and Reauthorization Act of 1986. In addition to certain free-standing provisions of law, it includes amendments to CERCLA, the Solid Waste Disposal Act, and the Internal Revenue Code. Among the free-standing provisions of law is Title III of SARA, also known as the Emergency Planning and Community Right-to-Know Act of 1986 and Title IV of SARA, also known as the Radon Gas and Indoor Air Quality Research Act of 1986. Title V of SARA amending the Internal Revenue Code is also known as the Superfund Revenue Act of 1986.

sinking agents
means those additives applied to oil discharges to sink floating pollutants below the water surface.

site inspection
(SI) means an on-site investigation to determine whether there is a release or potential release and the nature of the associated threats. The purpose is to augment the data collected in the preliminary assessment and to generate, if necessary, sampling and other field data to determine if further action or investigation is appropriate.

size classes of discharges
refers to the following size classes of oil discharges which are provided as guidance to the OSC and serve as the criteria for the actions delineated in Subpart D. They are not

meant to imply associated degrees of hazard to public health or welfare, nor are they a measure of environmental injury. Any oil discharge that poses a substantial threat to public health or welfare or the environment or results in significant public concern shall be classified as a major discharge regardless of the following quantitative measures:

(1) minor discharge
means a discharge to the inland waters of less than 1,000 gallons of oil or a discharge to the coastal waters of less than 10,000 gallons of oil.

(2) medium discharge
means a discharge of 1,000 to 10,000 gallons of oil to the inland waters or a discharge of 10,000 to 100,000 gallons of oil to the coastal waters.

(3) major discharge;
means a discharge of more than 10,000 gallons of oil to the inland waters or more than 100,000 gallons of oil to the coastal waters.

Size classes of releases
refers to the following size classifications which are provided as guidance to the OSC for meeting pollution reporting requirements in Subpart B. The final determination of the appropriate classification of a release will be made by the OSC based on consideration of the particular release (e.g., size, location, impact, etc.):

(1) minor release
means a release of a quantity of hazardous substance(s), pollutant(s), or contaminant(s) that poses minimal threat to public health or welfare or the environment.

(2) medium release
means a release not meeting the criteria for classification as a minor or major release.

(3) major release
means a release of any quantity of hazardous substance(s), pollutant(s), or contaminant(s) that poses a substantial threat to public health or welfare or the environment or results in significant public concern.

sorbents
essentially inert and insoluble materials that are used to remove oil and hazardous substances from water through adsorption, in which the oil or hazardous substance is attracted to the sorbent surface and then adheres to it; absorption, in which the oil or

hazardous substance penetrates the pores of the sorbent material; or a combination of the two. Sorbents are generally manufactured in particulate form for spreading over an oil slick or as sheets, rolls, pillows, or booms. The sorbent material may consist of, but is not limited to, the following materials:

source control action
is the construction or installation and start-up of those actions necessary to prevent the continued release of hazardous substances or pollutants or contaminants (primarily from a source on top of or within the ground, or in buildings or other structures) into the environment.

source control maintenance measures
are those measures intended to maintain the effectiveness of source control actions once such actions are operating and functioning properly, such as the maintenance of landfill caps and leachate collection systems.

specified ports and harbors
means those ports and harbor areas on inland rivers, and land areas immediately adjacent to those waters, where the USCG acts as predesignated on-scene coordinator. Precise locations are determined by EPA/USCG regional agreements and identified in federal regional contingency plans.

spill of national significance
(SONS) a spill that due to its severity, size, location, actual or potential impact on the public health and welfare or the environment, or the necessary response effort, is so complex that it requires extraordinary coordination of federal, state, local, and responsible party resources to contain and clean up the discharge.

state
means the several states of the United States, the District of Columbia, the Commonwealth of Puerto Rico, Guam, American Samoa, the Virgin Islands, the Commonwealth of Northern Marianas, and any other territory or possession over which the United States has jurisdiction. For purposes of the NCP, the term includes Indian tribes as defined in the NCP except where specifically noted. Section 126 of CERCLA provides that the governing body of an Indian tribe shall be afforded substantially the same treatment as a state with respect to certain provisions of CERCLA. Section 300.515(b) of the NCP describes the requirements pertaining to Indian tribes that wish to be treated as states.

Superfund Memorandum of Agreement
(SMOA) means a nonbinding, written document executed by an EPA Regional Administrator and the head of a state agency that may establish the nature and extent of EPA and state interaction during the removal, pre-remedial, remedial, and/or enforcement response process. The SMOA is not a site-specific document although

attachments may address specific sites. The SMOA generally defines the role and responsibilities of both the lead and the support agencies.

Superfund state contract
is a joint, legally binding agreement between EPA and a state to obtain the necessary assurances before a federal-lead remedial action can begin at a site. In the case of a political subdivision-lead remedial response, a three-party Superfund state contract among EPA, the state, and political subdivision thereof, is required before a political subdivision takes the lead for any phase of remedial response to ensure state involvement pursuant to section 121(f)(1) of CERCLA. The Superfund state contract may be amended to provide the state's CERCLA section 104 assurances before a political subdivision can take the lead for remedial action.

support agency
means the agency or agencies that provide the support agency coordinator to furnish necessary data to the lead agency, review response data and documents, and provide other assistance as requested by the OSC or RPM. EPA, the USCG, another federal agency, or a state may be support agencies for a response action if operating pursuant to a contract executed under section 104(d)(1) of CERCLA or designated pursuant to a Superfund Memorandum of Agreement entered into pursuant to Subpart F of the NCP or other agreement. The support agency may also concur on decision documents.

support agency coordinator
(SAC) the official designated by the support agency, as appropriate, to interact and coordinate with the lead agency in response actions under Subpart E of this Part.

surface collecting agents
means those chemical agents that form a surface film to control the layer thickness of oil.

surface washing agent
is any product that removes oil from solid surfaces, such as beaches and rocks, through a detergency mechanism and does not involve dispersing or solubilizing the oil into the water column. Tank vessel as defined by section 1001 of the OPA means a vessel that is constructed or adapted to carry, or that carries oil or hazardous material in bulk as cargo or cargo residue, and that:

(1) is a vessel of the United States;

(2) operates on the navigable waters; or

(3) transfers oil or hazardous material in a place subject to the jurisdiction of the United States.

threat of discharge or release
see definitions for discharge and release.

tank vessel
see OPA definitions

threat of release
see definition for release

treatment technology
means any unit operation or series of unit operations that alters the composition of a hazardous substance or pollutant or contaminant through chemical, biological, or physical means so as to reduce toxicity, mobility, or volume of the contaminated materials being treated. Treatment technologies are an alternative to land disposal of hazardous wastes without treatment.

trustee
means an official of a federal natural resources management agency designated in Subpart G of the NCP or a designated state official or Indian tribe who may pursue claims for damages under section 107(f) of CERCLA.

United States
when used in relation to section 311(a)(5) of the CWA, means the states, the District of Columbia, the Commonwealth of Puerto Rico, the Northern Mariana Islands, Guam, American Samoa, the United States Virgin Islands, and the Pacific Island Governments. United States, when used in relation to section 101(27) of CERCLA, includes the several states of the United States, the District of Columbia, the Commonwealth of Puerto Rico, Guam, American Samoa, the United States Virgin Islands, the Commonwealth of the Northern Marianas, and any other territory or possession over which the United States has jurisdiction.

vessel
as defined by section 101(28) of CERCLA, means every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water; and, as defined by section 311(a)(3) of the CWA, means every description of watercraft or other artificial contrivance used, or capable of being used, as a means of transportation on water other than a public vessel.

volunteer
means any individual accepted to perform services by the lead agency which has authority to accept volunteer services (examples: See 16 U.S.C. 742f(c)). A volunteer is subject to the provisions of the authorizing statute and the NCP.

worst-case discharge
as defined by section 311(a)(24) of the CWA, means, in the case of a vessel, a discharge in adverse weather conditions of its entire cargo, and, in the case of an offshore facility or onshore facility, the largest foreseeable discharge in adverse weather conditions.

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General Oil Spill Response
(source: *Shoreline Countermeasures Manual*: HAZMAT, NOAA)

absorption
The take up of a substance into another substance.

acute
Having a sudden onset, lasting a short time, of a stimulus severe enough to induce a response rapidly. Can be used to define either the exposure or the response to an exposure (effect). The duration of an acute aquatic toxicity test is generally 4 days or less and mortality is the response measured.

aerobic
Able to live or grow only where free oxygen is present.

anaerobic
Able to live and grow where there is no air or free oxygen.

annual
A plant that lives only one year or season.

API gravity - **(see specific gravity)**
A unitless measure of relative density based on specific gravity. Defined by the equation: API Gravity = 141.5 - 131.5 Sp. Gr. (60°/60°F)

aqueous solubility
The percentage of a material (by weight) that will dissolve in water at ambient temperature.

aromatic
Organic compounds containing any of a series of benzene ring compounds. They are unsaturated organic ring compounds with low boiling points and are generally toxic to aquatic life.

benthos
The plants and animals that live in and on the bottom of a water body.

berm
A wedge-shaped sediment mass built up along the shoreline by wave action. Sand berms typically have a relatively steep seaward face (beach face) and a gently sloping surface (berm top). A sharp crest (berm crest) usually separates the two oppositely sloping planar surfaces on top of the berm. Berms on sand beaches are eroded away during storms, thus a berm may not be present if the beach is visited shortly after a

storm. On gravel beaches, however, steep and high storm berms are activated and refurbished during storms.

biota
Animal and plant life characterizing a given region. Flora and fauna, collectively.

booms
Both containment and absorbent booms are used for the collection, deflection, and containment of spreading oil. Containment booms are somewhat rigid structures extending both above and below the water acting as barriers to surface oil. Primary containment booms are usually deployed close to oiled shorelines to trap oil being flushed from beaches before it is collected. Secondary containment booms are deployed farther out to trap oil that leaks past primary booms. Absorbent boom is used along the shore-water interface to collect oil dislodged during treatment operations. It is important that absorbent boom be changed once the sorbent capacity is reached. Great care should be taken to seal the shore ends of booms so that no oil can get past. This is particularly difficult at rocky shorelines, or areas strewn with boulders and cobbles. The use of absorbent pads or other materials, such as pom poms, can be effective sealants.

brackish
Intermediate in salinity (0.50 to 17.00 parts per thousand) between sea water and fresh water.

chronic
Involving a stimulus that is lingering; often signifies periods from several weeks to years, depending on the reproductive life cycle of the aquatic species. Can be used to define either the exposure or the responses to an exposure (effect). Chronic exposure typically induces a biological response of relatively slow progress and long continuance.

clam shell
A mechanical device mounted at the end of a crane that picks up soil or mud with a pincer-like movement.

coagulating agent
Chemical additives applied to oil to form a more cohesive mass.

contact period
The time required to maximize the efficiency of the sorbent or chemical agent or the time before plant or animal damage occurs.

density - **(see also specific gravity)**
The ratio of weight to volume of a substance, usually expressed as grams per cubic centimeter. Density water = 1.0 g/cm2

dispersant
Chemical agent used to disperse and suspend oil in water leading to enhanced biodegradation.

dissolution
The process of oil dissolving into the water column. The extent of dissolution is dependent on the oil's aqueous solubility.

distillate
A refined hydrocarbon obtained by collection and condensation of a known vapor fraction of the crude oil.

drag line
A mechanical device that excavates or transports soil, using a container pulled over earth by cables or chains.

dredge
A device used to remove sediment from the bottom of a water body.

EC50
Median effective concentration; the concentration of material in water to which test organisms are exposed that is estimated to be effective in producing some sublethal response in 50 percent of the test organisms. See also, LC50.

emulsification
The process by which oil is mixed with water.

emulsion
A permanent suspension or dispersion of water in oil. Water-in-oil emulsions may contain 20% - 80% water.

endless rope
A continuous rope-like oil sorbent device that is pulled across the surface of the water to pick up oil.

erosion
The wearing away by action of water or wind of unprotected or exposed earth.

estuary
Classic definition A drowned river valley that has a significant influx of fresh water and is affected by the tides. Most of the coastal water bodies in the mid-Atlantic region are estuaries (e.g., Chesapeake Bay, Delaware Bay).

evaporation
The conversion of a fluid—including hydrocarbons—to a gaseous state.

fast ice
Any sea ice that forms along and remains attached to the coast, or that forms between grounded ice bergs, or is attached to the bottom in shallow waters. May form in situ from seawater or by freezing of pack ice to the shore. It may extend a few meters to several hundred kilometers from the shore.

fertilizer
A substance or agent that helps promote plant or seed growth.

flash point
The lowest temperature at which vapors from a volatile liquid (e.g., oil) will ignite.

flushing
Use of a water stream to make oil flow to a desired location or recovery device.

fouling
Accumulation of oil or other materials, such as debris, that makes a device inoperative.

free oil
See mobile oil.

gelling agent
See coagulating agents.

habitat
The chemical, physical, and biological setting in which a plant or animal lives.

herding agent
Chemical agent that confines or controls the spread of a floating oil film.

intertidal
The part of the shoreline that lies between high-tide and low-tide water levels.

kinematic viscosity **(see viscosity)**
A measure of viscosity in stokes. Can be related to Viscosity by taking the viscosity of a liquid in poise divided by its density, expressed in stokes. Kinematic Viscosity water =

1.0 centistokes. Kinematic Viscosity milk = 1.64 centistokes. Kinematic Viscosity olive oil = 91.30 centistokes

lagoon
A shallow, linear, and usually oblong water body, located parallel with and connected to a larger water body by one or more inlet channels.

landfill
A dump that has progressive layers of waste matter and earth.

LC50
Median lethal concentration; the concentration of material in water to which test organisms are exposed that is estimated to be lethal to 50 percent of the test organisms. See also EC50.

lower explosive limit
The lowest concentration (lowest percentage of the substance in air) that will produce a flash of fire when an ignition source is present.

marsh fringe
The edge of the marsh adjacent to the water.

migration
Seasonal movement of a group of animals from one location to another.

mobile oil
Oil that can refloat when water is applied (as in high tide).

mobilization
Movement of oil caused by physical forces, such as gravity, tides, or wind. Mobility of oil is limited by its viscosity.

mousse
A type of oil/water emulsion.

non-persistent
Decomposed rapidly by environmental action.

oil/water separator
A device for separating oil from water.

oleophilic
A material that has affinity for oil.

paraffin
The waxy saturated component of crude oil, having relatively high boiling point and low volatility. Any member of the methane series having the general formula C_nH_{2n+2}.

penetration
Downward motion of oil into sediments from the surface driven by gravitational forces.

perennial
Vegetation that continues to grow for several years.

permeability
The degree to which fluids can flow through a substance. Measured in Darcys. Permeability is not equal to porosity. High porosity of a material does not insure high permeability. However, a substance cannot be permeable without having some degree of porosity.

physiography
General term for the shape of the earth's surface.

pooled oil
Oil thickness exceeds one centimeter. This need not be uniform.

porosity
The volume of void spaces in a sediment mass, measured in percent.

pour point
The lowest temperature at which a substance will flow by gravity from a specified container under standard conditions.

ppb
Parts per billion, unit of concentration. One ppb can be approximated by one teaspoon in 1,300,000 gallons.

ppm
Parts per million, unit of concentration. One ppm can be approximated by one teaspoon in 1,300 gallons.

private wetlands
Lands bordering on state tidal wetlands, below the mean tide line subject to the effects of the regular rise and fall of tide. Lands able to support growth of wetland vegetation.

recontamination
Contamination by oil of an area that was previously cleaned.

rhizome
A root-like stem under or along the ground, ordinarily in a horizontal position, which usually sends out roots from its lower surface and leafy shoots from its upper surface.

riprap

(a) A layer of large, durable fragments of broken rock, specially selected and graded, and thrown together irregularly or fitted together. Its purpose is to prevent erosion by waves or currents and thereby preserve the shape of a surface, slope, or underlying structure. It is used for irrigation channels, river-improvement works, spillways at dams, and revetments for shore protection.

(b) The stone used for riprap.

salt pan
A pool above high tide, drained only by evaporation so that salt is accumulated and concentrated.

seine
A fish net that can be used to collect sorbent or debris.

sheen
Thin layer of floating oil. May appear as silver (0.00007mm), rainbow (0.00015mm), or gray (0.001mm), depending on thickness.(3)

sinking agent
Additive applied to floating oil to facilitate its sinking to the bottom. Sinking agents are prohibited under 40 CFR.

skimmer
A mechanical device that removes an oil film from the water surface. Oil skimmers collect oil spilled on, or released to, the water's surface. They come in a wide range of shapes and sizes. Skimmers generally have a higher recovery rate than sorbents, providing enough oil is present to justify the costs for its use. Skimmers are usually equipped with storage space for collected oil. Oil is herded to a collection point along a containment boom located close to shore yet in water of sufficient depth for the skimmer to function. Two types of skimmers currently in use are described below. Other types of skimmers are being tested for possible use at a later date.

Band skimmers, or Rope skimmers use an oleophilic material such as polypropylene. Oil is collected by a floating, continuous rotating band or rope drawn through an oil slick or along the water's edge of a contaminated area. Adhered oil is wrung from the band by a squeeze roller and collected in an oil sump. These bands are used in either static (stationary) or dynamic (towed)

modes. Bands can be torn by solids or skimmed debris. Efficiency is high in calm waters, poor in choppy waters and waves.

Belt skimmers use an oleophilic belt mounted on the front of a small vessel. The oleophilic belt pushes the floating oil below the waterline. Oil not adsorbed by the belt is collected into a holding area located behind the belt. Oil carried up the belt is recovered at the top of the system by a squeeze belt or scraper blade. It is then pumped into a storage container. These skimmers can not operate in shallow waters or tight areas.

slurry
A suspension of particles in water.

solubility
The amount or fraction of a substance (e.g., oil) that dissolves into the water column, measured in ppm.

solvent
A chemical agent that will dissolve oil.

sorbent
All sorbent materials work on the same principles—oil adheres to the outside of the material or sorbs into the material by capillary action. There are three basic types of sorbent materials: mineral based, natural organic, and synthetic organic. Currently, only synthetic organic sorbents are being used in the field in the form of booms, pads, and mops. Peat is currently in the testing and demonstration phase.

specific gravity
The measure of the density of a substance such as oil or sea water, usually determined at 20°C, compared to the density of pure water at 4°C. Thus, specific gravity varies slightly with temperature.

stain
Oil that is visibly present but cannot be scraped off with a fingernail.

sublethal
Below the concentration that directly causes death. Exposure to sublethal concentrations of a material may produce less obvious effects on behavior, biochemical, or physiological functions and histology of organisms.

substrate
The substance, base, or nutrient on which, or the medium in which, an organism lives and grows, or the surface to which a fixed organism is attached; e.g., soil, rocks, and water.

substrate penetration
Vertical distance from surface to where oil has percolated into the substrate.

subtidal
That part of the coastal zone that lies below the lowest low-tide level so that it is always underwater.

sump
A pit or reservoir that serves as a drain from which oil can be collected.

supratidal
Above the normal high-tide line.

suspended particulate matter (SPM)
Particulate matter, usually sediments, which are in suspension in the water column. Suspended particulate matter may adhere to oil and increase its specific gravity.

tank barge
A barge for transporting liquids.

tarballs
Lumps of oil (<10 cm in diameter) weathered to a high density semisolid state.

tidal variation or range
The vertical distance between high and low tides.

toxicity
The inherent potential or capacity of a material (e.g., oil) to cause adverse effects in a living organism (Rand and Petrocelli, 1985).

upper explosive limit
The highest concentration (highest percentage of the substance in air) that will produce a flash of fire when an ignition source is present.

vacuum systems
Used to recover oil collected behind containment booms along the beach face and in the water during shoreline flushing operations. Where equipment access allows, vacuums can be used to remove pools of oil directly from shorelines and surfaces of heavily oiled rocks. Two vacuum systems currently in use are described below.

> The first system is classified as a vacuum device but requires a high-velocity air stream, (150 mph) to draw oil, water, and debris into the unit's collection chamber. Due to the 6- to 12-inch diameter of the inlet hose, it rarely becomes clogged by debris. The inlet nozzle should

always be placed slightly above (never below) the fluid's surface. The distance at which it is held above the fluid is critical to limit the amount of water intake. This system is suitable for picking up weathered oil, tarballs, and mousse from water or shorelines, and to vacuum oil from skimming vessels, boomed areas, or debris-laden sites. The primary advantage is its ability to pick up oil of any viscosity and, where necessary, lift fluid more than 30 feet. The system can pick up and decant simultaneously. The main disadvantages are that it usually picks up a high water/oil ratio and can be difficult to repair in the field.

The second system, barge-mounted vacuum trucks, use high-suction pumps and a cylindrical chamber capable of sustaining very low internal pressure, i.e., minus 12 psi. Vacuum is created in the chamber,and a 3- to 4-inch diameter hose is usually placed slightly below the surface of a floating oil slick thus allowing a mixture of water and oil to enter the collection chamber. The position of the open end of the vacuum hose is critical. If it is placed too far down into the oil slick, recovered fluid will be mostly water; if not deep enough, air will be sucked into the system and much of the vacuum will be lost. The primary advantages of the vacuum truck system are: it can recover fluid of nearly any viscosity; it has a rapid pickup rate of thick oil layers; and it can recover a wide variety of small debris. Primary disadvantages are its limited lift, no more than 20 to 30 feet, and the length of time required to re-establish a vacuum if air enters the hose. As with the other vacuum, this one also picks up a high water/oil ratio.

vapor
The gaseous phase of a substance which is normally a liquid.

viscosity
Flow resistance; referring to internal friction of a substance (e.g., oil) that is a function of the oil type and temperature.

volatility
The tendency for a liquid to vaporize.

water soluble fraction
That portion of an oil which will dissolve in water.

weathering
Natural influences such as temperature, wind, and bacteria that alter the physical and chemical properties of oil.

weir
A vertical barrier placed just below the surface of the water so that a floating oil slick can flow over the top.

wetlands
lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, and is at least periodically saturated with or covered by water (Cowardin et al. 1979).

wrack
Accumulations of plant debris that is deposited at or above the high-tide line (e.g., *Spartina* or kelp debris).

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VESSEL NOMENCLATURE

(Source: USCG Marine Safety School, Reserve Training Center; Yorktown, VA)

after peak
Aftermost tank or compartment of a ship abaft the aftermost watertight bulkhead.

after perpendicular
A vertical line measured to the base line intersecting the after edge of the rudder post and the summer load waterline.

amidship
The mid or center transverse plane of a vessel located midway between the forward and after perpendiculars

angle bar
A bar of angle-shaped steel used in ship's construction.

athwartships
Across the ship at right angles to the centerline.

base line
Horizontal reference line, usually at the lowest boundary.

(1) For vessels with a flat keel plate the base line is the upper surface of the flat plate keel, or the thickness of the garboard strake, above that level, for vessels having lap seam construction.

(2) For vessels with a hanging bar keel, the base line is usually at the lower contour of the molded surface.

(3) For vessels with a designed trim or drag, the base line is at the lowest point.

beam
(1) The width of a vessel.

(2) A transverse horizontal member stiffening and supporting a portion of a deck or flat.

bilge keel
A longitudinal fin or plate fitted to the outside of the shell on the bilge strake installed to reduce rolling of the ship.

bilge strake
The strake of curved shell plates at the bilge.

bottom/bottom shell
Portion of hull or plating below the bilge strake.

bracket/knee plate
A steel plate, usually of triangular shape and commonly with a reinforcing flange, used to stiffen or tie the beam angles to bulkheads, frames to longitudinals, or any two structural parts which meet at an angle, in order to strengthen the joint against flexing. A bracket differs from a gusset in that it meets at least one of the surfaces to which it is attached, angularly, being secured thereto by a riveted flange or welded.

breast hook
A triangular-shaped plate bracket joining port and starboard side stringers at the stem.

bulkhead
A term applied to the vertical partition walls which subdivide the interior of the vessel into compartments or spaces. The various types of bulkheads are distinguished by their location, use, type of material, or method of fabrication. Bulkheads which contribute to the strength of the vessel are referred as strength bulkheads, those which are essential to watertight subdivision are watertight or oil tight bulkheads, and gastight bulkheads serve to prevent the passage of gas or fumes.

bulkhead deck
The uppermost deck to which watertight bulkheads are carried.

bulwark
The fore-and-aft vertical plating immediately above the upper edge of the stringer strake.

butts
The end joint between two plates or members which meet end to end and run transversely across the vessel and/or vertically up the side shell.

camber
The transverse curvature of a deck, athwartships.

center vertical reel (CVR)
The vertical, centerline web of the keel.

centerline
The fore-and-aft line at the middle of the ship, extending from the stem to the stern at any level.

chain locker
Space or compartment in which hawsers and chains are stored.

clip
Short length of plate or angle, used to attach and connect the various members of the ship structure.

coaming

(1) The plates and shapes making up the raised boundaries of a hatch, skylight, or opening in a deck or a bulkhead for the purpose of stiffening the edges of the opening and resisting the ingress of water

(2) The piece between the deck and the lower sill of a doorway.

cofferdam
The narrow void space between two bulkheads, decks, or floors used to isolate the spaces from each other and prevent leakage between the adjoining compartments.

collar
Filler plate used around a shape where it passes through plating to maintain watertightness.

collision bulkhead
The foremost watertight transverse bulkhead aft of the bow of the vessel. It extends from the innerbottom of the vessel up to the freeboard deck and is designed to keep water from advancing throughout the remainder of the vessel.

dead weight
Dead weight refers to the carrying capacity of a vessel at any draft and water density. It includes the weight of the cargo, fuel, lubricating oil, fresh water, passengers, and baggage and the crew and their personnel effects.

deadrise
The transverse angular rise of a vessel's bottom from the keel to the bilge.

deck beam
An athwartships horizontal structural member that supports a deck and/or platform.

deep side transverses (deep webs)
A build-up frame installed to provide additional strength, consisting of a flanged web plate or other stiffener on its edge.

depth
The vertical measurement amidships from the main deck, at the side of the vessel, to the molded baseline.

displacement:
The displacement of the vessel when it is afloat. It is equal to the weight of water in long tons that a floating ship displaces.

double bottom
The space between the inner bottom and the shell plating of a vessel normally used for the storage of liquids.

doubler plate
A plate fitted outside or inside another plate, but not welded to the vessel's framing, for the purpose of providing additional strength or stiffness to that area.

draft
The depth of the vessel below the waterline measured vertically to the lowest part of the hull, propellers, or other reference points.

drop strake
A strake that is terminated before it reached the bow or the stern of the vessel. The number of strakes dropped depends on the reduction of the girth between the midship section and the ends of the vessel.

duct keel
A tunnel-like structure within the double bottom tanks utilized to run the fore-and-aft system piping.

flange
That part of the plate or shape bent at right angles to the remainder of the plate or shape to form an angle to provide strength to the member.

flare
Curvature of the forward frames or shell plating, outward.

flat reel
The principal fore-and-aft component of the vessel's framing, located at the centerline of the bottom plating and run from stem to stern.

floor
A vertical plate between the inner bottom and shell, extending from side shell to side shell of the vessel.

fore peak
A large watertight compartment at the extreme forward end of the vessel, usually below the forecastle, utilized for trimming the vessel.

forecastle
A superstructure located at the extreme forward end of the main deck of the vessel.

forward perpendicular
A line perpendicular to the base line and intersecting the forward side of the stem at the summer load waterline.

frames/framing
Built up rib-like structural members that act as stiffeners for the side shell and maintain the transverse form of the vessel.

frame spacing
The fore-and-aft distance measured between adjacent transverse frames.

freeboard
The vertical distance from waterline to top of freeboard deck measured at the side of the vessel.

freeboard deck
The uppermost continuous deck having permanent means of closing all weather openings.

garboard strake
The A strake or strake of shell plating located adjacent to the keel plate.

girder
A fore-and-aft continuous strength member, usually found in the bottom of the vessel or under a deck. Girders provide longitudinal strength and support the deck plating and the beams.

gusset
A triangular or square bracket plate lying in a horizontal or slightly inclined plane that connects members or supports.

hatch
An opening in the deck used for access to the ship's hold and through which cargo is loaded and unloaded.

hawse pipe
A tube or pipe through the side shell of the vessel and through which the anchor chain is led overboard from the anchor windlass.

hogging
Deformation of the ship when the middle portion of the vessel is higher than the bow and stern.

hold
Interior compartment of a ship, primarily used for the stowage of cargo.

hull
The structural body of a ship, including shell plating, framings, decks, etc.

intercostal
Separate structural members located between frames, floors, beams, etc.

length between perpendiculars
The length of the vessel between the forward and the after perpendicular.

length overall
The extreme length of the vessel measured from the foremost point of the stem to the aftermost point of the stern.

lightening holes
Holes cut in structural member to reduce their weight and to provide access to other structural components within a compartment or void.

limber hole
A small hole or slot cut in a frame or plate for the purpose of preventing oil or water from collecting. A drain hole.

longitudinal
The fore-and-aft structural shape or member utilized for stiffening and attached to the underside of decks, platforms, inner bottoms, or located on the inboard side of the shell plating.

main deck
The uppermost continuous strength deck running from the bow to the stern.

midship
Midway between fore-and-aft perpendiculars.

midship section
A cross section of the hull and superstructure at or near amidships giving the scantlings of the principal structural members.

molded line
A datum line from which can be determined the exact location of the various parts of a ship. These lines also define the geometry of the hull as a surface without any thickness.

nomenclature
Nomenclature is defined as the act, process, or instance of naming and describing the various structural components of a vessel.

orlop deck
A partial deck in the cargo hold of a freight vessel.

rider plate
A continuous flat plate attached to top of the vertical keel.

sagging
Deformation of the ship when the middle portion is lower than the bow and stern.

scantlings
The dimensions, sizes, and thicknesses of the various structural components of the vessel.

seam
The fore-and-aft joint of the shell, deck, and tank top plating, or the lengthwise edge joint of any plating running in the longitudinal direction.

section modulus
The section modulus is defined in the Load Line Regulations and basically consists of calculations to determine the strength of the various hull girder components of the vessel as related to the stresses and movements that the vessel will be able to withstand in a seaway.

shaft alley
A watertight structure fitted around the entire shaft between the engine room and the shaft stuffing box(es) at the stern. This space provides protection for the shaft(s), access to the shaft(s) and bearings, and protects the engine room and possibly the after holds from flooding should a leak develop within this space.

sheer
The longitudinal curve of the vessel's decks in a vertical plane.

sheer strake
The uppermost continuous strake of side shell plating connected at the strength deck edge.

shell plating
The plates forming the outer side and bottom side of the hull.

shelter deck
A continuous deck from stem to stern on the vessel fitted with at least one tonnage opening.

skeg
(1) The continuation of the keel which supports the heel of the rudder.

(2) In barges skegs are attachments to the after hull that act as a sort of stationary rudder to stabilize the movement of the barge through the water when towed. These barge skegs may be adjustable.

stanchion/pillar
A vertical column used to support decks, platforms, girders, etc.

stealer plate
A plate that is butt-connected and made extra wide to fit in place of two narrower plates near the ends of the ship where the girth of the vessel is decreased.

stem
The bow frame forming the apex of the intersection of the forward sides of the vessel. It is rigidly connected at the lower end to the keel and it may be fabricated from a forging, casting, or structural steel plating. It extends to the uppermost deck.

stern frame
A large, heavy casting, forging or weldment attached to the keel and forming the after end of the ship's structure. It supports the rudder and it serves as a frame for connecting the shell plating to the end of the vessel.

stern tube
The watertight tube enclosing and supporting the tail shaft. It consists of a cast iron or cast steel cylinder fitted with a bearing surface within which the tailshaft, enclosed in a liner, rotates.

stiffener
An angle, T-bar, channel, flatbar, etc., used to stiffen and form a support for plating of a bulkhead, web frame, etc.

strake
A course or row of deck, bulkhead, bottom or side shell, or any other plating, running longitudinally.

stringer strake
A strake of deck plating that runs along the outboard edge of the main strength deck.

swash bulkhead
A longitudinal or transverse non-tight bulkhead fitted in a tank to decrease the swashing action of the liquid contents as the vessel rolls and pitches in a seaway.

transverse
The distance across at a right angle to the fore-and-aft centerline.

'tween deck
A partial deck between any two adjacent decks.

web frames
Large transverse frames in longitudinally framed vessels located between bulkheads to support shell longitudinals and decks. In transversely framed vessels they are installed where additional strength is required.

wind and water strake
A strake located at the longitudinal waterline and exposed to the wind and water(sea) while the vessel is at anchor or underway.

DRAFT

RAP MANUAL INSERT: PRELIMINARY ASSESSMENT OF CHEMICAL SPILLS

by

Deborah P. French and Henry Rines
Applied Science Associates
70 Dean Knauss Drive
Narragansett, RI 02882
401-789-6224

prepared for

National Oceanic and Atmospheric Administration
Damage Assessment Center
Silver Spring, MD

Contract 50-DGNC-1-00007
Task 100

ASA 95-001

July 31, 1995

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1. INTRODUCTION

The purpose of this document is to (1) summarize the potential fates and effects of chemical spills into aquatic (surface water) environments, (2) provide example scenarios and sensitivity analysis using the type A Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME) which illuminate fates and effects, (3) outline a strategy for responding to chemical spills in preparation for Natural Resource Damage Assessment (NRDA), i.e., in the Preassessment Phase of the NRDA process, and (4) provide suggested approaches for injury identification and quantification in Expedited and Comprehensive Damage Assessments.

Historically, most attention for spill response and NRDA has been paid to oil spills. Since oil floats, is relatively insoluble, is visually observable, and fouls shorelines which are often easily accessable, responding to oil spills can center on visual methods. However, most chemicals are denser than water and/or are not visually obvious. This makes injury identification and quantification more difficult. Chemical sampling methods for mapping fates are required in most cases. Thus, a good understanding of the potential fates and effects is needed for a field response to a spill to provide useful information to a NRDA. Otherwise, tremendous effort may be expended for little return of useful data.

The NRDAM/CME provides a useful tool to trustees in performing NRDAs on chemical spills. It is designed as a stand-alone tool for smaller spills, providing a bottom line injury and damage quantification based on a minimum of user inputs. It quantifies in three stages physical fates, biological effects, and economic damages. Graphical display of the fates submodel output shows where the spilled material is expected to go in time and space, as well as its concentrations. Biological effects submodel output quantifies estimated injuries by species group. Thus, the NRDAM/CME may be used as a preassessment tool to plan an NRDA or it may be used as part of a larger NRDA, i.e., as part of an Expedited or Comprehensive Damage Assessment (EDA or CDA), to quantify fates and acute effects, for example.

The example cases below illuminate important aspects of the fates and effects of chemical spills as a function of the chemical's properties and toxicity. These examples show where effort should be placed in responding to a chemical spill as part of an NRDA. Potential sampling strategies and priorities are outlined based on knowledge gained from the examples.

2. FATES AND EFFECTS OF CHEMICAL SPILLS

The fate of a spilled chemical is determined by a number of physical, chemical, and biological processes. These may be categorized as part of *transport* or *reactions*. The basic equation for modeling physical fate of a chemical, as a concentration at a given point (x,y,z), is summarized as follows:

rate of change of concentration = local source loading
+ transport
+ reactions

In the case of a spill event, the local source loading is the rate of release of chemical. The rate of release may vary over time, from an instantaneous spill to a chronic discharge.

Transport includes carriage by currents induced by tides, winds, waves, freshwater discharge, density gradients, and other forces. Transport occurs on a continuous range of scales, from large scale oceanographic currents to less than 1 meter resolution. Transport on larger scales which is resolved by an analysis or model is termed advection. Small scale motion not resolved by a model is quantified as randomized mixing or diffusion. It is important to determine what scale is important to the fate and effects of a spill. For example, in the open ocean, only larger scale currents may be important, the smaller scales being only contributors to randomized dispersion of a plume being carried by the large scale currents. In coastal areas and estuaries, smaller scale motions may be important forcing functions to the fate of the chemical. Smaller scale motions may determine which specific habitats are affected. Since habitats vary on smaller spatial scales in coastal areas, the smaller scale physical motions are significant. Thus, in quantifying fates, transport on all significant scales must be quantified.

Transport may also include chemical and biological processes. Reactions may change the character or association of the chemical, and so affect movement of the chemical in the environment.

Reactions include:

(1) evaporation from the air-water interface,

(2) volatilization from the water column to the atmosphere,

(3) dissolution from solid state,

(4) adsorption to particulate matter,

(5) desorption from particulate matter,

(6) chemical complexation, transformation and degradation,

(7) biological transformation and degradation,

(8) biological uptake and ingestion,

(9) excretion and depuration from biota.

Transport affected by these reactions include:

(1) sinking or floating of the chemical caused by a density difference with the water,

(2) evaporation and volatilization to the atmosphere,

(3) sinking or floatation of particulate matter with associated chemical,

(4) settling and resuspension of sediments,

(5) transport in organisms or their wastes.

A physical fates model quantifies loading, transport, and reactions of a spilled chemical. Loadings are spelled out as model inputs. Initially, the density of the spilled material determines vertical transport, either floating or sinking. Floating chemicals form slicks until dispersed. Sinking chemicals entrain water into the plume, slowing their descent. If the density of the plume becomes similar to that of the surrounding water, the sinking process stops and other transport mechanisms govern fate.

Transport at scales important to the event must be quantified. The sub-scale transport is treated as a randomized motion of a specified magnitude.

Each of the reactions should be quantified. Physical-chemical properties of the chemical are used to quantify the reactions and chemical transport processes. Biological uptake and depuration may also be modeled based on physical-chemical properties (e.g., octonol-water partitioning coefficient which measures affinity for water versus nonpolar compounds). Typically, reactions included in points (6) through (9) are treated as a single constant decay rate in a fates model.

For examples and reviews of physical fates modeling of chemicals, see the following references: Burns et al. (1982), Ambrose (1983), Connally and Thomann (1985), Reed, 1989, Gobas and McCorquodale (1992), Lyman et al. (1982), Mackay et al. (1992a,b, 1993, 1995), Schnoor (1992), French et al. (1994a,b),

Biological effects of chemical spills include acute and chronic impacts. Effects to consider include lethal and sublethal.

The acute effect of chemicals on aquatic biota is traditionally modeled using the LC50 or EC50. The model is that percent mortality, or percent reduction in some other measured endpoint, is a log-normal function of concentration. The LC50 is that concentration lethal to 50% of bioassay test organisms. The EC50 is the concentration which reduces the measured rate (e.g., growth rate) to 50% of normal. It is well recognized that LC50s vary by chemical, species, life stage, time of exposure, test conditions and animal condition. Standardized techniques have been developed for bioassays to control these variables.

French (1991) and French et al. (1994a, i.e., for the NRDAM/CME) developed a toxicity model which relates LC50 to time of exposure and temperature. The model evaluates exposure time for affected biota. Losses are integrated over space and time to estimate a total loss. See these references for more details.

The basic toxicological model for chronic effects is that chemical may be taken up directly from the water through the skin, gills, and other membranes, or it may be ingested in food. Chemical enters the bloodstream and moves throughout the body. The chemical may be transformed internally and excreted. Depuration is the term used to include all elimination and cleansing processes. The balance of uptake plus ingestion with depuration determines the concentration of chemical within the body. Toxic effects are related to body burden, the most serious toxic effect being lethality.

Chemicals with higher partitioning between lipids and water tend to accumulate in organisms to greater extent (bioaccumulation). For these chemicals, this effect increases higher in the food chain because ingestion is the dominant route of exposure (biomagnification).

There is a very large literature addressing the biological effects of chemicals in aquatic environments. For examples and reviews of modeling the biological effects of chemicals, see the following references: Burns et al. (1982), Ambrose (1983), Connally and Thomann (1985), French and French, 1989, French (1991), Peterle (1991), Gobas and McCorquodale (1992), Schnoor (1992), Calabrese and Baldwin (1993), Suter et al. (1993), French et al. (1994a,b,c).

3. EXAMPLE SCENARIOS USING THE NRDAM/CME

The NRDAM/CME was run for a number of hypothetical spill scenarios to illustrate potential fates and effects of chemical spills. Sensitivity to input parameters was investigated.

Representative chemicals were selected based on a review of chemical supply volume, reported spill frequency, historical spill volumes, and relative toxicity by Fingas et al (1991) using Canadian data. Fingas et al developed a priority list based on equal weighing of these factors. The top 70 chemicals in their list are in Table 2.1. No analagous list appears available for U.S. statistics. It is likely that the U.S. list would be similar.

The NRDAM/CME database contains most of the top 70 chemicals. Those used in the present sensitivity study using the model are listed in Table 2.2. The chemicals were classified as an oil (including petroleum products), organic, or inorganic. They were also classified according to physical-chemical properties and toxicity data taken from the NRDAM/CME database (Table 2.2). The classifications are:

(1) Volatile Floaters:
- density < 1.0
- vapor pressure > 0.0001 atm

(2) Nonvolatile Floaters:
- density < 1.0
- vapor pressure < 0.0001 atm

(3) Soluble sinkers, Low Partitioning, Low toxicity:
- density > 1.0
- solubility > 200 mg/l
- partition coefficient (KOC) < 100
- 96 hour LC50 (@25 C) > 10 ppm (dissolved concentration)

(4) Soluble sinkers, Low Partitioning, High toxicity:
- density > 1.0
- solubility > 200 mg/l
- partition coefficient (KOC) < 100
- 96 hour LC50 (@25 C) < 10 ppm (dissolved concentration)

(5) Soluble sinkers, Medium Partitioning, Low toxicity:
- density > 1.0
- solubility > 200 mg/l
- 100 < partition coefficient (KOC) < 2000
- 96 hour LC50 (@25 C) > 10 ppm (dissolved concentration)

(6) Soluble sinkers, Medium Partitioning, High toxicity:
- density > 1.0
- solubility > 200 mg/l
- 100 < partition coefficient (KOC) < 2000
- 96 hour LC50 (@25 C) < 10 ppm (dissolved concentration)

(7) Insoluble sinkers, Medium Partitioning, High toxicity:
- density > 1.0
- solubility < 200 mg/l
- 100 < partition coefficient (KOC) < 2000
- 96 hour LC50 (@25 C) < 10 ppm (dissolved concentration)

(8) Insoluble sinkers, High Partitioning, High toxicity:
- density > 1.0
- solubility < 200 mg/l
- partition coefficient (KOC) > 2000
- 96 hour LC50 (@25 C) < 10 ppm (dissolved concentration)

These classifications characterize the fates and effects of spills of the chemicals in the class.

Floating chemicals form slicks when spilled (at or near the water surface). If the floating chemical is volatile, it evaporates rapidly. Little material gets into the water column, regardless of the other properties, since most of it evaporates.

Sinking chemicals descend in the water column as a plume at a rate proportional to the difference in density relative to the water. Typically, the plume will reach the bottom. From the bottom, soluble chemicals rapidly are dispersed in the water column. Insoluble chemicals are dispersed more slowly. The water column plume is carried down current. The partitioning coefficient is the ratio of adsorbed to dissolved chemical. Higher partitioning results in more chemical adsorbed to particulate matter and settling to the bottom. Chemicals with higher partitioning coefficients also are retained by sediments to a greater extent. Insoluble chemicals with high partitioning coefficients remain in the sediments at the spill site for extended periods of time.

The required inputs for the NRDAM/CME are summarized in Table 2.3.
Clearly, spill location, date, amount and chemical type (i.e., chemical properties and toxicity) have a large effect on injuries and damages calculated by the model. Duration of release can be important in that it is in effect a dispersal process.

Wind speed and direction has much less influence on results for sinking chemicals than for floaters including oils. Slicks are transported by wind. For material in the water column, wind forcing affects wind-driven surface currents and waves.

As will be borne out by model results, and has been observed in actual spills, currents have a very large influence on fates and effects. Current shears (currents which vary in space) are important dispersion mechanisms.

Cleanup is more difficult for chemicals, especially sinking chemicals, than for oils. It is not usually performed in spill response. The effect of cleanup on fates and effects was not investigated with the model in the present analysis.

Scenarios were run for the chemicals in Table 2.2 in 4 locations, two seasons, and varying currents. Table 2.4 summarizes the inputs to the model. No ice data, cleanup, or closures were used in any scenarios. Default data for environmental conditions were used (air and water temperature as in Table 2.4, suspended sediment concentration at 10 mg/l, and suspended sediment settling velocity of 3 m/day). Some scenarios with other temperatures were run to examine sensitivity to this parameter.

The scenarios on the west Florida shelf were set up so that currents would take the material away from land. The background currents were uniformly constant over the region, directed toward the south. Winds were 5 kts from the northeast, generating a small wind-driven surface current toward the southwest. Figures 2.1 to 2.23 illustrate fates processes as a function of chemical class (Table 2.2) for these scenarios.

Figures 2.1 to 2.16 show pentachlorophenol concentrations at intervals after an instantaneous spill of 100 metric tons (MT) and for varying background current speeds. The plume is drawn out because this insoluble chemical with high partitioning remains at the spill site in the sediments for an extended time period. The material slowly disperses into the water column and is carried down current. The rate of movement is, of course, driven by current velocity. The relative effect of the wind-driven flow is higher for scenarios with lower background currents, since movement is the vector sum of each current component. Higher currents also disperse the chemical to below toxic (and graphical) threshold concentrations faster.

Figures 2.17 to 2.19 show sodium cyanide concentrations at intervals after an instantaneous spill of 100 MT and for 10 cm/sec background currents. The plume is circular because, although the chemical is heavy and sinks to the bottom initially, it is so soluble that it all returns to the water column in a pulse and is carried down current. Since there is no current shear (variation of currents in space) in this example, the plume remains intact and circular. With more current the plume moves more rapidly and disperses to non-toxic concentrations faster.

Figure 2.20 shows sodium hydroxide concentrations at 7 days after an instantaneous spill of 100 MT and for 10 cm/sec background currents. The plume is circular for the same reasons as for sodium cyanide, since it has similar physical-chemical properties (Table 2.2). However, since sodium cyanide is more toxic than sodium hydroxide, the plume of concentration above toxic threshold is more intense in the graphic at 7 days for cyanide (Figure 2.19 versus Figure 2.20).

Figures 2.21 to 2.23 show tetraethyl lead concentrations at three intervals after an instantaneous spill of 100 MT and for 10 cm/sec background currents. This chemical is representative of the insoluble sinkers with medium partitioning. The partitioning retains some chemical on the bottom at the spill site, drawing out the plume to some degree, but not as much as for the high partitioning insoluble chemicals (e.g., pentachlorophenol).

Figures 2.24 and 2.25 show snapshots of sodium hydroxide spills in Delaware River and Galveston Bay, respectively. The plumes for spills off of Cape May look similar to those off the west Florida

shelf. Plumes at the Mega Borg site on the Texas shelf appear circular and stationary, because of very low current speeds assumed in these scenarios.

Tables 2.5 to 2.16 summarize injuries and damages to fisheries and wildlife assessed by the model. The chemicals are indicated by their abbreviation listed in Table 2.2. Adult stock losses are kg killed. Young-of-the-year (YOY, i.e., eggs, larvae and juveniles less than 1 year old) losses are numbers of individuals missing at age 1 year, accounting for mortality during the first year of life. Wildlife losses are in numbers killed or missing.

The majority of the injuries assessed by the model for chemical spills are to fish and shellfish. The model estimates acute lethality to fish, shellfish, and their eggs and larvae based on dissolved chemical concentrations in the water column and sediments. Lethal and sublethal effects on lower trophic level production are also estimated. Losses up the food chain are assumed proportional to lower trophic level losses. The wildlife losses assessed by the model are via the food web and via oiling by slicks. Thus, these are low or insignificant for most scenarios summarized in the tables (except for oil spills).

For all volatile floating chemicals, injuries and damages are very low for all the scenarios investigated. This is because the spilled material forms a slick and evaporates rapidly. High toxicity is not influential because of this fate. Where water column effects might be significant is where discharge is under water and the chemical is very soluble. In this case, toxicity would determine effects. (The NRDAM/CME is not configured to handle sub-surface releases.)

If a floating chemical is not volatile, as is nonyl phenol, it will eventually enter the water column and cause effects to aquatic biota.

For sinking chemicals, and for non-volatile floaters, the single most influential parameter on effects (injuries) and damages is toxicity. Figures 2.26 to 2.45 clearly show a strong correlation between fish kills, shellfish kills, young-of-the-year (YOY) losses, lost catch weight (kg) and lost catch value ($) and the appropriate LC50. Figures 2.26 through 2.39 are for shelf spills, and so include few injuries to habitats other than open water. The relationship to toxicity is stronger for these than for the estuarine spills (Figures 2.40 to 2.45), although all are significant. Correlation coefficients range from 0.6 to 0.7 generally, with some correlations above 0.9.

The relationship of injuries and damages to solubility is not significant (see Figures 2.46 to 2.49, correlation coefficients all less than 0.25). There is similarly no correlation with density or with any of the other physical parameters listed in Table 2.2.

Currents disperse spilled chemicals, such that injuries and damages generally decrease with increasing current speed, all else being equal (i.e., habitats affected are the same, etc.). Tables 2.15 and 2.16, and Figures 2.50-2.51, show this effect for sample chemicals. However, at very low current speeds, losses may be less than for slightly higher currents, because the contamination is confined to a small area where exposure is lessened.

Toxicity increases with temperature, and so, all other things constant, injuries and damages are higher at higher temperatures. Tables 2.17 and 2.18 show results for a scenario off Cape May (100 MT of sodium hydroxide with 10 cm/sec background current) using a summer spill date and biological abundances but run at three different temperatures. The losses increase at higher temperatures.

Clearly, increasing volume spilled will cause increasing damages. This was shown in the compensation formula runs (French et al., 1993). However, the relationship is not linear across all spill volumes. As spill size increases, injuries do not necessarily increase proportionately because of effects thresholds being exceeded at the lower ranges and because there are limits to the kills (i.e., they are all dead and further injury must await immigration).

4. STRATEGY FOR RESPONDING TO CHEMICAL SPILLS

It is clear from Figures 2.1 to 2.25 that, in most cases and for all but insoluble chemicals with high partition coefficients, direct sampling of the chemical in the water column will be difficult and must be performed immediately after the spill. Locating the plume will be increasingly difficult over time. A drogue or tracer (such as rhodamine dye) could be used to locate the plume and follow it. Sampling could be performed in a grid focused on the plume. Without such guidance, it is likely that the plume will be missed.

In situ measurements of the chemical (or pH, for acids and bases) would be the most efficient method. Some chemicals may be turbid or colored, providing a signal. However, most would require bottle samples and laboratory measurement. Suitable bottle preparation and sample preservation need to be performed. Also, many of these chemicals are hazardous and toxic to people as well. Appropriate precautions should be taken.

Accurate and synoptic measurement of currents is the single most valuable data type for estimating the fate of the spilled chemical. Attention should be focused on the areas likely to be affected. Sinking chemicals will be found preferentially in the lower water column near the spill site and currents at depth may differ from those at the surface, especially in an estuary or riverine system. Under calm conditions, a current meter may be hand-deployed from a boat to obtain localized data on currents. Drogues or drifters, if available, also are useful tools. Tidal current charts and tables for the area should be consulted to find out what data are available, what currents to expect, and where additional data may be required.

Since most of the injuries are expected to be to fish, shellfish and young-of-the-year, these resources should be focused on to the extent possible. Injuries to structural habitats such as wetlands, seagrasses, coral reefs, oyster reefs, mangroves, and macroalgal beds can also be significant.

The American Fisheries Society (1992, 1993) has published methods for fish kill investigations which would be very useful for planning and injury assessment in the field. However, finding dead fish in large water bodies is much more difficult than in streams and confined areas.

Eggs and larvae disintigrate rapidly after death, and so it is not feasible to count "dead bodies" for these stages. Measurement of a difference between egg and larval populations in plume waters versus clean waters is also not likely to succeed, given the large natural patchiness and variability in abundances.

Injured structural habitats can be observed more readily and over a long period of time, since these habitats have long recovery times. Methods would be similar to those used for oil spill injuries.

Injuries to benthic habitats and biota may be significant for all sinking chemicals if toxic thresholds are exceeded. Most of the injury will be at or near the spill site. However, partitioning chemicals can be sedimented long distances from the spill site, particularly in areas where a water column plume encounters shallow water and intertidal areas. Again, accurate assessment of the transport of the plume will elucidate where benthic assessments should be focused.

5. APPROACHES FOR INJURY IDENTIFICATION AND QUANTIFICATION

The most significant parameters in determining injuries and damages resulting from chemical spills into a given environment are density, solubility, toxicity, volume spilled and dispersion by currents. The following points outline likely injuries and general approach to quantification.

(1) Volatile floating chemicals are not likely to enter the water column or cause significant injury. Use of simplified procedures (NRDAM/CME or Compensation Formulae) for these spills (of all volumes) would usually be justifiable.

(2) For other chemicals, the combination of volume, toxity, and dispersion by currents determines the degree of exposure and injury. The higher the volume, the higher the toxicity and the lower the dispersion, the more likely the injuries will be significant enough to warrent substantial field sampling of chemical concentrations and injuries.

(3) For all spills to be assessed with the NRDAM/CME, any other model, or with site-specific studies, accurate measurement or estimation of currents is needed. It is very difficult or impossible to measure an entire current field after a spill event. Field measurements of currents can be used to calibrate and verify a hydrodynamic model, which will fill in the current field while obeying the laws of physics.

(4) The NRDAM/CME can be run as a screening tool to evaluate where injuries are likely to occur and where and when to sample. Again, accurate current fields are needed to make reasonable predictions with (any) model. The model may be used to determine whether injuries are expected to be significant enough to warrent significant field effort.

(5) In Expedited and Comprehensive Damage Assessments, a model will usually provide the only estimate of acute injuries to eggs and larvae, and may be the best estimate for all water column acute injuries. For chemical spills where most of the acute injuries are to water column organisms, modeling may be the best approach. Sediment exposure and injuries may be directly measurable and integrated by a model.

(6) For chronic effects, both direct sampling and modeling are fruitful approaches. Modeling of chronic effects of chemicals is well developed in the ecological risk assessment literature.

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Table 2.1 Top 70 ranked chemicals on the priority list developed by Fingas et al. (1991).

Table 2.2 Priority chemicals and their properties as assumed in the NRDAM/CME, Version 2.2, sorted by chemical class. (RANK = rank in Fingus et al., 1991; ID = chemical abbrieviation used in this report; CLASS = classification used in this report; IN = inorganic; ORG = organic; LC50 = 96 hour LC50 at 25 C).

RANK	CHEMICAL	ID	CAS #	CLASS	DENSITY (g/cm3)	SOLUBILITY (mg/l)	VAPOR PRES. (atm)	PARTITION COEF. (KOC)	LC50 LARVAE (ppb)	LC50 FISH (ppb)
Volatile Floaters:										
0	FUEL OIL, NO. 6	No6	0	0 2 OIL 1	.964	15.30	.34E-03	1402.0	196.6	284.7
0	CRUDE OIL, LIGHT	LtC	0	0 7 OIL 1	.780	16.00	.50E-02	860.2	748.1	1079.0
1	AMMONIA	NH3	7664	41 7 IN 1	.680	346000.00	.10E+02	2.0	18420.0	294200.0
4	STYRENE	STY	100	42 5 ORG 1	.906	300.00	.99E-02	794.3	18090.0	289000.0
14	TOLUENE	TOL	108	88 3 ORG 1	.867	379.30	.36E-01	724.4	1112.0	54010.0
22	BENZENE	BEN	71	43 2 ORG 1	.877	820.00	.13E+00	316.2	4978.0	118400.0
23	XYLENE, MIXTURE	XYL	1330	20 7 ORG 1	.870	115.50	.13E-01	1622.0	2252.0	35960.0
27	METHYL ALCOHOL	MEAL	67	56 1 ORG 1	.791	1000000.00	.17E+00	8.3	646200.0	736600.0
38	ETHYLBENZENE	ETHB	100	41 4 ORG 1	.865	140.00	.13E-01	1380.0	1686.0	101400.0
43	VINYL ACETATE	VAC	108	5 4 ORG 1	.932	20000.00	.14E+00	52.5	20470.0	327000.0
53	ETHYL ALCOHOL	ETHA	64	17 5 ORG 1	.789	437100.00	.53E-01	16.2	1337000.0	220800.0
63	ACRYLONITRILE	ACR	107	13 1 ORG 1	.810	70000.00	.13E+00	28.8	5044.0	33910.0
67	ISOPROPYL ALCOHOL	ISOA	67	63 0 ORG 1	.785	249800.00	.57E-01	24.0	586500.0	9368000.0
Nonvolatile Floaters:										
37	NONYL PHENOL	NPHE	25154	52 3 ORG 2	.950	1.00	.11E-07	1514000.0	38.3	611.9
Soluble sinkers, Low Partitioning, Low Toxicity:										
17	CALCIUM CHLORIDE	CACL	10043	52 4 IN 3	2.152	298300.00	.00E+00	90.2	167200.0	2670000.0
25	FORMALDEHYDE	FORM	50	0 0 ORG 3	1.080	1000000.00	.60E-01	2.0	22690.0	362400.0
26	ACETIC ACID	ACA	64	19 7 ORG 3	1.050	568500.00	.15E-01	16.2	23640.0	40540.0
32	SODIUM CARBONATE	NABC	497	19 8 IN 3	2.533	71000.00	.00E+00	9.6	24060.0	46710.0
Soluble sinkers, Low Partitioning, High Toxicity:										
2	CHLORINE	CL	7782	50 5 IN 4	1.468	7247.00	.75E+01	2.0	51.1	816.2
6	SULFURIC ACID	HSO4	7664	93 9 IN 4	1.840	1000000.00	.13E-05	2.0	504.0	8050.0
7	SODIUM CYANIDE	NACN	143	33 9 IN 4	1.610	1000000.00	.00E+00	2.0	138.0	2204.0
8	HYDROCHLORIC ACID	HCL	7647	1 0 IN 4	1.160	1000000.00	.32E-01	2.0	3384.0	54050.0
18	SODIUM HYDROXIDE	NAOH	1310	73 2 IN 4	2.130	521500.00	.00E+00	3.1	1681.0	26850.0

39 ETHYLENE GLYCOL EGLY 107 21 1 ORG 4 1.140 1000000.00 .10E-03 3.9
2104.0 2535000.0
45 NITRIC ACID NAC 7697 37 2 IN 4 1.503 1000000.00 .75E-01 2.0
6847.0 62250.0
48 PHOSPHORIC ACID PO4 7664 38 2 IN 4 1.864 1000000.00 .38E-04 2.0
6162.0 56020.0
49 FERRIC CHLORIDE FECL 7705 8 0 IN 4 2.900 530600.00 .00E+00 2.4
6053.0 10970.0
51 HYDROFLUORIC ACID HFL 7664 39 3 IN 4 1.220 1000000.00 .20E+00 2.0
2895.0 26320.0
56 CALCIUM OXIDE CAO 1305 78 8 IN 4 3.370 1199.00 .00E+00 2.0
6625.0 60220.0
60 HYDRAZINE HYD 302 1 2 IN 4 1.010 1000000.00 .19E-01 2.0
33.7 538.3
69 POTASSIUM CYANIDE KCN 151 50 8 IN 4 1.526 1000000.00 .00E+00 2.0
43.3 692.0
70 POTASSIUM PERMANGANATE KPM 7722 64 7 IN 4 2.700 80000.00 .00E+00 9.0
448.0 7155.0

Soluble sinkers, Medium Partitioning, Low Toxicity:
29 ETHYLENE DICHLORIDE EDC 107 6 2 ORG 5 1.250 8500.00 .11E+00 134.9
145600.0 243600.0
42 CARBON TETRACHLORIDE CTC 56 23 5 ORG 5 1.594 800.00 .12E+00 794.3
43240.0 690600.0
64 TRICHLOROETHANE TCE 25323 89 1 ORG 5 1.339 4400.00 .13E+00 292.2
20140.0 62730.0

Soluble sinkers, Medium Partitioning, High Toxicity:
11 PHENOL PHE 108 95 2 ORG 6 1.132 82000.00 .60E-03 138.0
4122.0 5426.0
12 ZINC SULFATE ZNSO 7733 2 0 IN 6 3.740 349800.00 .00E+00 121.5
1507.0 2581.0
36 CALCIUM HYDROXIDE CAOH 1305 62 0 IN 6 2.240 1697.00 .00E+00 322.1
3770.0 60220.0
352 CHLOROBENZENE CLB 108 90 7 ORG 6 1.107 488.00 .15E-01 776.2
762.3 2832.0

Table 2.2 (continued)

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0 NITROCHLOROBENZENE, O- NCB 88 73 3 ORG 6 1.305 1410.00 .41E-05 398.1
148.8 2377.0
0 1,1,1,2-TETRACHLOROETHANE TTCE 630 20 6 ORG 6 1.553 2850.00 .18E-01 977.2
4189.0 66910.0

Insoluble sinkers; Medium Partitioning, High Toxicity:
3 TETRAETHYL LEAD TEPB 78 0 2 ORG 7 1.659 2.00 .36E-03 942.1
8.7 16.3
55 PARATHION PARA 56 38 2 ORG 7 1.260 20.00 .50E-07 1197.0
2.7 267.7
61 MALATHION MAL 121 75 5 ORG 7 1.230 145.00 .53E-06 371.9
130.8 494.3

Insoluble sinkers; High Partitioning, High Toxicity:
5 PCB-1254 PCB 11097 69 1 ORG 8 1.500 .06 .13E-06 36370.0
4.3 68.7
10 PENTACHLOROPHENOL PCP 87 86 5 ORG 8 1.978 80.00 .14E-06 12300.0
478.2 268.3
40 FENITROTHION FENI 122 14 5 ORG 8 1.320 20.00 .79E-08 7959.0
.1 2.3
68 CHLORDANE CHL 57 74 9 ORG 8 1.670 1.85 .13E-07 9997.0
4.9 10.4
299 HEXACHLOROBENZENE HCB 118 74 1 ORG 8 2.044 .01 .25E-07 67610.0
4074.0 2.5

Table 2.3 Required inputs for the NRDAM/CME, version 2.2.

Data Type	Input Data	Units
Spill location	Latitude	deg., min., sec.
	Longitude	deg., min., sec.
Spill date	Year, month, day	#
Starting time	Time spill starts	hours (0-23)
Chemical name	Select from database	text
CAS #	Chemical Abstract Service Registry Number	#-#-#
Amount spilled	Volume or mass spilled (or pure chemical or oil)	as selected by user
Units for amount spilled	Select from MT, kg, gal., bbl, liters, pounds	as selected by user
Duration of release	Time over which spill occurs	hours
Amount second release (oils only)	Volume or mass of second phase of release immediately following first release	as selected by user
Duration of second release	Time over which secondary release occurs	hours
Wind data	Wind time series of speed and direction	speed in knots, direction in degrees (from)
Background currents	Current vectors in 2-D space (x,y) for mean background current assumed constant	m/sec or kts for each of E-W and N-S components
Tidal currents	Current vectors in 2-D space (x,y) for maximum flood current on day of spill	m/sec or kts for each of E-W and N-S components
Number of tidal cycles per day	Select one (K1) or two (M2) high tides per day	# (1 or 2)
Time of high tide	Time of high tide nearest to the time of the spill	hours (0-23)
Tide range	Tide range (height) on the day of the spill	meters
Ice conditions	In Alaska, select default ice grid	select ice "on" or "off" for ice or no ice

Data Type	Input Data	Units
Cleanup	Specifiy mass of pure chemical or oil removed, time window, spatial window, and shoreline vs. water surface for each removed batch	Mass or volume units, hours since spill, latitude and longitude bounds
Air temperature	Air temperature on day of the spill	C
Water temperature	Surface water temperature on the day of the spill	C
Suspended sediment concentration	Total suspended solids	mg/l
Settling velocity	Settling velocity for suspended sediments	m/day
Price Index	GNP Price Index for the base year 1987 (= 117.2 for second quarter 1991 $, used in the economic database)	#
Closure data	Closure areas and timing for fisheries, hunting, beaches and boating	areas or lengths, days closed

Table 2.4 Summary of input data for chemical spill scenarios.

Input Data	**Off Cape May in Summer**	**Off Cape May in Winter**	**Delaware River (Pres. Rivera)**	**Texas Shelf (Mega Borg)**	**Galveston Bay shallowwater near wetland**	**West Florida Shelf (vary currents)**
Year	1995	1995	1989	1990	1991	1995
Month	July	Feb.	June	June	June	July
Day	3	3	24	9	1	4
Hour	0	0	5	0	0	0
Lati-tude (deg.N)	38.84	38.84	39.75	28.55	29.541	29.931
Longi-tude (deg.W)	74.475	74.475	75.472	94.133	94.558	84.124
Release dura-tion (hours)	0	0	2	2	1	0
Amount spilled (MT)	100	100	930	100	100	100
Wind	from NE @ 5 kts	from NE @ 5 kts	as Pres-idente Rivera spill (NOAA buoy 44009)	as Mega Borg spill (buoy SW of spill site)	from SW @ 5-7 kts	from NE @ 5 kts
Back-ground current (cm/sec toward)	10 to SW	10 to SW	12 down-river (as Pres. Rivera)	as Mega Borg spill (fresh-water outflow from estu-aries)	0	10, 25, 50, 75, or 100 to S
Tidal current (cm/sec maximum flood)	10 to NW	10 to NW	In general 20 cm/ sec, based on ASA hydro-dynamic model	0	10 towards up-estuary	0
# high tides per day	2	2	2	1	1	1
Time (hrs) of high tide	6	6	5	7	12	0
Tidal range (m)	1.0	1.0	2.0	0.6	0.6	1.0
Air temper-ature (C)	23	4	21	27	27	29

Input Data	**Off Cape May in Summer**	**Off Cape May in Winter**	**Delaware River (Pres. Rivera)**	**Texas Shelf (Mega Borg)**	**Galveston Bay shallowwat er near wetland**	**West Florida Shelf (vary currents)**
Water temper- ature (c)	23	7	118	23	23	29
Price Index	117.2	117.2	108.1	112.7	117.2	117.2

Table 2.5 Fisheries losses for scenarios off Cape May in summer.

Chemical	Adult Stock Finfish	Adult Stock Shellfish	YOY at Age 1 yr. Finfish	YOY at Age 1 yr. Shellfish	Catch kg	Catch $
NH3	0.	0.	1.	1.	0.	1.
STY	0.	0.	9.	13.	4.	7.
TOL	0.	0.	977.	1410.	411.	744.
BEN	0.	0.	68.	98.	28.	52.
XYL	0.	0.	28.	41.	12.	21.
MEAL	0.	0.	98.	142.	41.	75.
ETHB	0.	0.	76.	109.	32.	58.
VAC	0.	0.	138.	199.	58.	105.
ETHA	15.	0.	66.	95.	51.	73.
ACR	2.	0.	3464.	4996.	1460.	2644.
ISOA	0.	0.	1.	2.	0.	1.
NPHE	1639.	45.	280537.	491869.	120978.	221709.
CACL	0.	0.	1.	17.	11.	14.
FORM	1.	11.	3.	154598.	5363.	5092.
ACA	178.	1001.	15.	2775.	1689.	2844.
CL	15234.	22498.	430537.	3467090.	288022.	489056.
HSO4	1577.	10349.	2599.	3178634.	129610.	136763.
NACN	16843.	37443.	773348.	14691370.	738581.	1058050.
HCL	41.	1034.	413.	834823.	30592.	30250.
NAOH	441.	1985.	5262.	389428.	14109.	18860.
EGLY	3.	877.	268.	961361.	34702.	33754.
NAC	9.	1407.	56.	487652.	18525.	18610.
PO4	29.	10.	50.	66289.	2819.	3031.
FECL	665.	7316.	114.	10677580.	368649.	290020.
HFL	239.	30695.	746.	20688800.	734426.	579776.
CAO	35.	9596.	155.	10649810.	370002.	290664.
HYD	178314.	490919.	15060670.	147829800.	6896300.	13492400.
KCN	34644.	1533804.	51980.	170189000.	7728340.	10868100.
KPM	1231.	1532.	354.	175204.	12074.	16475.
EDC	11.	91.	4.	54.	158.	258.
CTC	0.	0.	0.	0.	0.	0.
TCE	91.	109.	18.	116.	330.	671.
PHE	1745.	1874.	43.	2094.	5214.	10679.
ZNSO	29587.	191252.	6281.	16268280.	349583.	750397.
CAOH	49.	182.	149.	26829.	1583.	1922.
TEPB	3202543.	1492778.	4509816.	64911700.	8085850.	12810800.
PARA	262518.	177436.	24219680.	64306100.	8629760.	12780300.
MAL	18189.	24812.	2866.	2578139.	154085.	199172.
PCB	610881.	550607.	30069560.	5186542.	4163750.	6068730.
PCP	191817.	71797.	2563.	6834.	375469.	584559.
FENI	5939803.	3390001.	932934700.	335809000.	100796000.	380577000.
CHL	3269241.	1314827.	40007260.	7147730.	10065600.	28837700.

Table 2.6 Wildlife losses for scenarios off Cape May in summer.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
NH3	.0	.1	.0	.2	.3
STY	.0	.1	.0	.2	.3
TOL	.0	.1	.0	.2	.3
BEN	.0	.1	.0	.2	.3
XYL	.0	.1	.0	.2	.3
MEAL	.0	.1	.0	.2	.3
ETHB	.0	.1	.0	.2	.3
VAC	.0	.1	.0	.2	.3
ETHA	.0	.1	.0	.2	.3
ACR	.0	.1	.0	.2	.3
ISOA	.0	.1	.0	.2	.3
NPHE	.0	28.6	.0	12.6	41.3
CACL	.0	.1	.0	.2	.3
FORM	.0	.5	.0	.7	1.2
ACA	.0	.1	.0	.2	.4
CL	.0	.3	.0	.5	.7
HSO4	.1	.9	.0	1.1	2.1
NACN	.3	.9	.0	1.1	2.4
HCL	.0	.8	.0	1.1	2.0
NAOH	.0	.7	.0	.9	1.6
EGLY	.0	.7	.0	.9	1.6
NAC	.0	.7	.0	.9	1.6
PO4	.0	.3	.0	.5	.7
FECL	.5	5.4	.0	14.5	13.1
HFL	.5	5.4	.0	14.5	13.1
CAO	.5	5.4	.0	14.5	13.1
HYD	.4	1.2	.0	1.6	3.2
KCN	1.7	5.4	.2	14.5	14.5
KPM	.0	.3	.0	.5	.7
EDC	.0	.1	.0	.2	.3
CTC	.0	.1	.0	.2	.3
TCE	.0	.1	.0	.2	.3
PHE	.0	.3	.0	.5	.7
ZNSO	1.7	5.4	.3	28.9	14.6
CAOH	.4	4.2	.0	11.3	10.3
TEPB	1.7	5.4	.2	14.5	14.5
PARA	.8	2.4	.1	6.3	6.6
MAL	.5	5.4	.0	14.5	13.1
PCB	.5	5.4	.0	14.5	13.1
PCP	1.3	4.2	.1	11.3	11.4
FENI	1.7	335.6	.3	14.5	364.1
CHL	1.7	335.6	.2	14.5	364.1

Table 2.7 Fisheries losses for scenarios off Cape May in winter.

	Adult Stock		YOY at Age 1 yr.			
Chemical	Finfish	Shellfish	Finfish	Shellfish	Catch kg	Catch $
NH3	0.	0.	0.	0.	0.	0.
STY	0.	0.	4.	0.	0.	1.
TOL	0.	0.	24.	0.	2.	9.
BEN	0.	0.	6.	0.	0.	2.
XYL	0.	0.	0.	0.	0.	0.
MEAL	0.	0.	0.	0.	0.	0.
ETHB	4.	0.	19.	0.	7.	22.
VAC	0.	0.	4.	0.	0.	1.
ETHA	1.	0.	0.	0.	0.	1.
ACR	7.	0.	1607.	0.	119.	568.
ISOA	0.	0.	0.	0.	0.	0.
NPHE	575.	0.	113063.	0.	8453.	40124.
CACL	0.	0.	0.	0.	0.	0.
FORM	0.	0.	7.	8910.	298.	294.
ACA	330.	572.	25.	0.	941.	2297.
HSO4	7040.	9254.	30887.	8280790.	146543.	161241.
NACN	36139.	41157.	445505.	49084580.	380675.	559356.
HCL	37.	637.	1135.	2909628.	33821.	34127.
NAOH	285.	1335.	3525.	4768640.	52162.	53463.
EGLY	0.	183.	5097.	4023095.	24603.	25758.
NAC	2.	403.	30.	2120724.	11620.	11715.
PO4	72.	11.	78.	30679.	1063.	1110.
FECL	2858.	2540.	4434.	74128040.	224173.	192231.
HFL	469.	27509.	798.	95316400.	673193.	549710.
CAO	25.	2416.	1338.	92093910.	233578.	195457.
HYD	249225.	264199.	13263920.	193188400.	2657950.	6952140.
KCN	231972.	1866894.	1966973.	1798363000.	11325800.	10274700.
KPM	2655.	421.	1562.	196856.	8251.	10801.
EDC	0.	0.	0.	0.	0.	0.
CTC	0.	0.	0.	0.	0.	0.
TCE	0.	0.	0.	0.	0.	0.
PHE	7959.	2778.	19.	0.	5938.	14073.
ZNSO	16875.	609967.	8239.	7336270.	985010.	978655.
CAOH	20.	0.	302.	28.	43.	157.
CLB	22015.	13409.	2811.	1353.	25368.	61346.
TEPB	5131709.	1454445.	12478670.	155506700.	8951210.	18842600.
PARA	111701.	25777.	25210520.	191687700.	9344370.	18238600.
MAL	48913.	11767.	7662237.	6493914.	618283.	2787400.
PCB	294755.	100556.	1472659.	6851360.	626530.	1432360.
PCP	102055.	25606.	13902.	235.	68120.	165993.
FENI	8209720.	1987260.	9090250000.	9023374000.	3739050000.	5497580000.
CHL	3922640.	1026941.	3152402.	6590580.	3254020.	7977910.

Table 2.8 Wildlife losses for scenarios off Cape May in winter.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
NH3	.0	.1	.0	.0	.1
STY	.5	.5	.0	.0	1.0
TOL	.0	.1	.0	.0	.1
BEN	.0	.1	.0	.0	.1
XYL	.5	.5	.0	.0	1.0
MEAL	.0	.1	.0	.0	.1
ETHB	.5	.5	.0	.0	1.0
VAC	.0	.1	.0	.0	.1
ETHA	.0	.1	.0	.0	.1
ACR	.0	.1	.0	.0	.1
ISOA	.0	.1	.0	.0	.1
NPHE	31.3	25.2	.0	.0	56.5
CACL	.0	.1	.0	.0	.1
FORM	.0	.1	.0	.0	.1
ACA	.0	.1	.0	.0	.1
HSO4	.1	.7	.0	.9	1.7
NACN	.3	.7	.0	.9	2.0
HCL	.1	.6	.0	.7	1.4
NAOH	.1	.6	.0	.7	1.4
EGLY	.0	.5	.0	.7	1.2
NAC	.0	.5	.0	.7	1.2
PO4	.0	.1	.0	.0	.1
FECL	.5	5.6	.0	14.9	13.6
HFL	.5	5.6	.0	14.9	13.6
CAO	.5	5.6	.0	14.9	13.6
HYD	.5	1.1	.0	1.4	3.0
KCN	.5	5.6	.0	14.9	13.6
KPM	.0	.2	.0	.2	.5
EDC	.0	.1	.0	.0	.1
CTC	.0	.1	.0	.0	.1
TCE	.0	.1	.0	.0	.1
PHE	.0	.1	.0	.0	.1
ZNSO	.5	5.6	.0	14.9	13.6
CAOH	.0	.1	.0	.0	.1
CLB	.0	.1	.0	.0	.1
TEPB	.4	4.6	.0	12.2	11.1
PARA	.5	1.5	.1	2.0	4.1
MAL	.0	.2	.0	.2	.5
PCB	.5	5.6	.0	14.9	13.6
PCP	.7	2.1	.1	5.4	5.5
FENI	.5	5.6	.0	14.9	13.6
CHL	1.3	3.7	.2	9.5	9.9

Table 2.9 Fisheries losses for scenarios in the Delaware River.

	Adult Stock		YOY at Age 1 yr.			
Chemical	Finfish	Shellfish	Finfish	Shellfish	Catch kg	Catch $
No6	9.	169.	169.	23.	433.	716.
LtC	3.	104.	110.	14.	262.	417.
NH3	7.	0.	4.	1.	11.	79.
STY	3.	0.	0.	0.	5.	35.
TOL	15.	0.	18.	0.	27.	186.
BEN	11.	0.	5.	0.	18.	123.
XYL	23.	0.	11.	0.	35.	251.
MEAL	120.	17.	4.	253.	356.	1403.
ETHB	5.	0.	20.	0.	13.	86.
ETHA	499.	103.	1.	81.	991.	5050.
ACRY	121.	6.	51.	461.	457.	1614.
ISOA	2.	0.	4.	181.	110.	146.
NPHE	6819.	388.	36614.	2295370.	1362620.	1624030.
CL	14491.	11659.	155870.	15799400.	8814200.	10240600.
HSO4	104486.	8311.	121510.	4702590.	358877.	961035.
NACN	254371.	13656.	221175.	19235700.	6246140.	8430590.
HCL	9967.	2089.	17600.	761731.	113626.	201026.
NAOH	42496.	4117.	55521.	1963820.	376980.	671080.
EGLY	24.	114.	48620.	1658770.	209882.	305573.
KCN	1617597.	309229.	318566700.	1003572000.	179673000.	300077000.
EDC	424.	485.	221.	23598.	15574.	20498.
CTC	97.	134.	253.	27249.	15962.	18879.
PHE	39718.	8448.	75684.	1946980.	1241350.	1695480.
CLB	10784.	8376.	2493.	245184.	170380.	271119.
TEPB	425073.	784669.	966222.	62785000.	32680800.	43223400.
PCB	396878.	375332.	1240382.	43475200.	21466900.	27232700.
HCB	31677.	13675.	57740.	2290280.	1100720.	1535160.

Table 2.10 Wildlife losses for scenarios in the Delaware River.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
No6	234.2	9.4	148.5	.0	392.1
LtC	204.0	8.1	140.2	.0	352.3
NH3	.0	.0	.0	.0	.0
STY	4.6	.1	.0	.0	4.7
TOL	4.2	.1	.0	.0	4.3
BEN	.0	.0	.0	.0	.0
XYL	4.3	.1	.0	.0	4.4
MEAL	.0	.0	.0	.0	.0
ETHB	4.7	.1	.0	.0	4.9
ETHA	.3	.0	.0	.0	.4
ACRY	.1	.0	.0	.0	.1
ISOA	.3	.0	.0	.0	.4
NPHE	284.2	7.7	47.9	.0	339.8
CL	.0	.0	.0	.0	.0
HSO4	.1	.0	.0	.0	.1
NACN	.1	.0	.0	.0	.1
HCL	.1	.0	.0	.0	.1
NAOH	.1	.0	.0	.0	.1
EGLY	.1	.0	.0	.0	.1
KCN	1.0	5.1	.0	20.2	12.9
EDC	.0	.0	.0	.0	.0
CTC	.1	.0	.0	.0	.1
PHE	.0	.0	.0	.0	.0
CLB	.0	.0	.0	.0	.1
TEPB	.5	.1	.0	.0	.6
PCB	.9	5.1	.0	20.2	12.7
HCB	.4	.1	.0	.0	.4

Table 2.11 Fisheries losses for scenarios on the Texas shelf.

	Adult Stock		YOY at Age 1 yr.			
Chemical	Finfish	Shellfish	Finfish	Shellfish	Catch kg	Catch $
No6	0.	0.	0.	0.	0.	0.
LtC	0.	0.	0.	0.	0.	0.
NH3	1.	0.	47.	1.	2.	5.
STY	0.	0.	59.	1.	1.	4.
TOL	0.	0.	368.	6.	5.	23.
BEN	0.	0.	114.	2.	2.	7.
XYL	0.	0.	244.	4.	4.	15.
MEAL	1.	0.	4.	0.	2.	5.
ETHB	0.	0.	322.	5.	5.	20.
VAC	2.	0.	81.	1.	4.	12.
ETHA	920.	0.	1.	0.	1219.	2096.
ACR	29.	0.	489.	8.	42.	128.
ISOA	0.	0.	4.	0.	0.	0.
NPHE	12600.	0.	555606.	9957.	22995.	81726.
CACL	0.	0.	16.	6.	2.	6.
FORM	0.	0.	287.	11.	5.	21.
ACA	5754.	0.	187.	3.	7145.	17424.
CL	573117.	2072.	11146.	12661.	1047090.	4922300.
HSO4	160568.	562.	10607.	14622.	292141.	1352770.
NACN	515517.	1934.	32963.	36288.	941141.	4477970.
HCL	10145.	3.	1630.	2577.	12808.	45703.
NAOH	25684.	90.	2225.	3524.	46751.	220601.
EGLY	56.	0.	264.	64.	119.	578.
NAC	3699.	9.	488.	780.	6016.	27490.
PO4	7189.	23.	4472.	7641.	14334.	65476.
FECL	66270.	223.	168.	283.	117396.	549844.
HFL	227298.	641.	47169.	48663.	411589.	1710010.
CAO	19570.	53.	5390.	6131.	35609.	149773.
HYD	1992822.	17556.	1549205.	74900.	2573070.	8573290.
KCN	7460830.	324474.	102026000.	1013801000.	25635600.	95123800.
KPM	38594.	128.	1829.	2353.	69350.	313642.
EDC	0.	0.	0.	0.	0.	0.
CTC	0.	0.	0.	0.	0.	0.
TCE	1344.	2.	0.	0.	2075.	7818.
PHE	18635.	0.	6696.	261.	22747.	61896.
ZNSO	1245471.	73654.	156387.	196196.	2251960.	8919420.
CAOH	3524.	13.	6486.	11097.	9351.	41375.
CLB	580120.	322.	271232.	40506.	771432.	2676010.
NCB	455610.	1767.	721784.	127597.	876613.	4149580.
TTCE	480.	1.	130.	218.	860.	3570.
TEPB	55007080.	114930.	32829720.	3511931.	90954800.	390919000.
PARA	4412578.	13240.	51390590.	7867970.	10743700.	45999900.
MAL	4277650.	14101.	879949.	182418.	7353170.	34259200.
PCB	1527685.	4225.	923348.	253470.	2710410.	12081500.
PCP	1298216.	5391.	1777.	2212.	2392590.	11702500.
FENI	36541540.	77316.	148849100.	17778100.	69026500.	290287000.
HCB	983244.	3793.	490817.	122012.	1801360.	8684480.

Table 2.12 Wildlife losses for scenarios on the Texas shelf.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
No6	450.7	70.3	725.2	.0	1256.0
LtC	179.1	28.5	.1	.0	210.0
NH3	3.3	1.3	.1	.0	6.1
STY	3.3	1.3	.1	.0	6.1
TOL	3.3	1.3	.1	.0	6.1
BEN	3.3	1.3	.1	.0	6.1
XYL	3.3	1.3	.1	.0	6.1
MEAL	3.3	1.3	.1	.0	6.1
ETHB	3.3	1.3	.1	.0	6.1
VAC	3.3	1.3	.1	.0	6.1
ETHA	3.3	1.3	.1	.0	6.1
ACR	3.3	1.3	.1	.0	6.1
ISOA	3.3	1.3	.1	.0	6.1
NPHE	122.0	21.0	.1	.0	146.7
CACL	1.8	.7	.0	.0	3.3
FORM	1.8	1.5	.0	.0	4.9
ACA	1.8	.7	.0	.0	3.3
CL	9.5	4.0	.2	.0	18.0
SO4	23.5	14.4	.4	.0	47.1
NACN	26.8	14.9	.3	.0	50.3
HCL	23.5	13.1	.3	.0	44.2
NAOH	23.5	14.4	.4	.0	47.1
EGLY	23.5	13.1	.3	.0	44.2
NAC	20.2	11.7	.3	.0	38.1
PO4	3.3	2.7	.1	.0	9.0
FECL	211.7	121.4	2.8	.3	398.8
HFL	116.0	66.9	.0	.1	217.6
CAO	211.7	121.4	2.8	.3	398.8
HYD	59.6	30.5	2.6	.0	106.6
KCN	294.4	144.8	13.9	.6	572.7
KPM	9.5	4.0	.2	.0	18.0
EDC	1.8	.7	.0	.0	3.3
CTC	1.8	.7	.0	.0	3.3
TCE	1.8	.7	.0	.0	3.3
PHE	1.8	1.5	.0	.0	4.9
ZNSO	384.2	195.9	30.4	.7	752.3
CAOH	1.8	1.5	.0	.0	4.9
CLB	9.5	4.0	.2	.0	18.0
NCB	142.2	83.5	1.7	.2	270.2
TTCE	1.8	1.5	.0	.0	4.9
TEPB	310.6	158.1	13.9	.3	605.8
PARA	115.9	67.0	1.5	.1	217.4
MAL	225.6	125.2	14.2	.3	464.2
PCB	211.7	121.4	2.8	.3	398.8
PCP	101.1	58.7	1.3	.1	190.4
FENI	241.5	138.6	2.9	.3	453.9
HCB	70.2	39.2	1.0	.1	149.0

Table 2.13 Fisheries losses for scenarios in Galveston Bay.

Chemical	Adult Stock Finfish	Adult Stock Shellfish	YOY at Age 1 yr. Finfish	YOY at Age 1 yr. Shellfish	Catch kg	Catch $
No6	363.	0.	88051.	7315.	2806.	9182.
LtC	0.	0.	0.	0.	0.	0.
NH3	7.	0.	2516.	240.	26.	16.
TOL	649.	1.	54425.	3963.	3153.	10583.
NPHE	17358.	907.	21950080.	1890094.	504604.	1677530.
HSO4	53501.	11179.	1595113.	9920760.	341332.	1122800.
NAOH	38294.	7049.	1248069.	1249115.	120639.	340707.
EGLY	165.	6980.	1240062.	2091850.	60199.	236755.
KCN	78370.	1583061.	22598320.	1612593000.	15675500.	45448500.
EDC	234.	116.	5211.	191.	1250.	4082.
CTC	50.	0.	12023.	690.	949.	3988.
TCE	911.	59.	112478.	8646.	5471.	18436.
PHE	48689.	4154.	4109716.	193096.	184610.	534454.
CLB	8373.	931.	5433913.	1734614.	193099.	721931.
NCB	499737.	17005.	1885878000.	138262600.	42994800.	157192000.
PCB	29494.	5866.	10671830.	7199045.	571204.	2207940.
PCP	215885.	79631.	264629400.	1095713.	2430750.	3286950.
HCB	25445.	2150.	2053550.	815624.	91993.	256898.

Table 2.14 Wildlife losses for scenarios in Galveston Bay.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
No6	1096.1	235.0	313.5	.0	1644.6
LtC	1129.1	252.8	320.6	.0	1702.6
NH3	.0	.0	.0	.0	.0
TOL	.0	.0	.0	.0	.0
NPHE	235.4	89.2	61.3	.0	385.9
HSO4	5.9	3.3	.1	.0	10.8
NAOH	3.5	2.0	.1	.0	6.7
EGLY	3.5	2.0	.1	.0	6.7
KCN	146.8	84.2	.4	.3	274.3
EDC	.0	.0	.0	.0	.0
CTC	.0	.0	.0	.0	.0
TCE	.0	.0	.0	.0	.0
PHE	.0	.0	.0	.0	.1
CLB	.0	.0	.0	.0	.1
NCB	166.0	96.9	2.3	.2	314.7
PCB	30.9	17.2	.4	.1	56.7
PCP	242.6	138.7	3.3	.3	455.5
HCB	8.8	5.0	.1	.0	16.2

Table 2.15 Fisheries losses for scenarios off the west coast of Florida.

Chem-ical	cm/sec	Adult Stock Finfish	Adult Stock Shellfish	YOY at Age 1 yr. Finfish	YOY at Age 1 yr. Shellfish	Catch kg	Catch $
NAOH	10	41092.	295.	4390750.	1017602.	121076.	359480.
NAOH	25	27637.	237.	2017102.	490407.	65647.	175371.
NAOH	50	1881.	0.	201644.	210981.	5473.	13307.
NAOH	75	3807.	0.	26721.	189456.	6360.	10734.
NAOH	100	55.	0.	27624.	189381.	1474.	5447.
NACN	10	380614.	127036.	16655760.	24115200.	986887.	2963480.
NACN	25	177400.	489465.	7092085.	78642650.	1245810.	4386060.
NACN	50	63096.	488725.	4069298.	78280980.	1057740.	4016390.
NACN	75	1739.	123029.	677699.	22141020.	260069.	1067400.
NACN	100	7619.	123029.	705094.	22146800.	268098.	1065740.
TEPB	10	2912874.	389067.	39465700.	65548190.	5161130.	12444600.
TEPB	25	1106052.	374295.	12769840.	59160270.	2318500.	6080890.
TEPB	50	411261.	367695.	4986054.	57787420.	1242380.	3608880.
TEPB	75	357944.	369471.	4300210.	57661020.	1194700.	3838070.
TEPB	100	363374.	1807516.	9084639.	276789900.	3912170.	13448000.
PCP	10	1258827.	9428.	18750250.	2280249.	1930910.	3900820.
PCP	25	601352.	5464.	7235393.	879720.	925066.	2114770.
PCP	50	508040.	3827.	5207963.	4671289.	903409.	2315360.
PCP	75	337042.	2466.	2351073.	282467.	490126.	1053130.
PCP	100	211566.	1603.	1048641.	130798.	302865.	627558.

Table 2.16 Wildlife losses for scenarios off the west coast of Florida.

Chemical	cm/ sec	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
NAOH	10	.0	.0	.0	3.1	3.1
NAOH	25	.0	.0	.0	3.1	3.1
NAOH	50	.0	.0	.0	.0	.0
NAOH	75	.0	.0	.0	.0	.0
NAOH	100	.0	.0	.0	.0	.0
NACN	10	.0	.0	7.8	5.1	12.9
NACN	25	.1	.2	30.9	20.4	51.6
NACN	50	.1	.2	30.9	20.4	51.6
NACN	75	.0	.0	7.8	.0	7.8
NACN	100	.0	.0	7.8	.0	7.8
TEPB	10	3.2	2.1	23.2	20.0	48.6
TEPB	25	.1	.2	23.2	18.7	42.1
TEPB	50	.1	.2	23.2	18.7	42.1
TEPB	75	.1	.2	23.2	18.7	42.1
TEPB	100	72.1	27.2	114.7	112.8	326.7
PCP	10	.1	.2	.1	24.9	25.2
PCP	25	.1	.2	.0	24.9	25.2
PCP	50	.0	.0	.0	5.1	5.1
PCP	75	.1	.2	.0	24.9	25.2
PCP	100	.1	.2	.0	24.9	25.2

Table 2.17 Effect of varying temperature on fishery injuries from a 100 MT sodium hydroxide spill off Cape May in summer.

Temper-ature	Adult Stock Finfish	Adult Stock Shellfish	YOY at Age 1 yr. Finfish	YOY at Age 1 yr. Shellfish	Catch kg	Catch $
2	3546.	16735.	16224.	3147851.	150754.	173055.
10	7139.	47849.	8322.	6504908.	312686.	356552.
23	16843.	37443.	773348.	14691370.	738581.	1058050.

Table 2.18 Effect of varying temperature on wildlife injuries from a 100 MT sodium hydroxide spill off Cape May in summer.

Temperature	Waterfowl	Seabirds	Other bird	Mam-turt	Total
2 C	.0	.7	.0	.9	1.6
10 C	.1	.9	.0	1.1	2.1
23 C	.3	.9	.0	1.1	2.4

Table 2.2 Priority chemicals and their properties as assumed in the NRDAM/CME, Version 2.2, sorted by chemical class. (RANK = rank in Fingus et al., 1991; ID = chemical abbrieviation used in this report; CLASS = classification used in this report; IN = inorganic; ORG = organic; LC50 = 96 hour LC50 at 25 C).

RANK	CHEMICAL	ID	CAS #			CLASS		DENS-ITY (g/cm3)	SOLU-BILITY (mg/l)	VAPOR PRES. (atm)	PARTITION COEF. (KOC)	LC50 LARVAE (ppb)	LC50 FISH (ppb)
Volatile Floaters:													
0	FUEL OIL, NO. 6	No6	0	0	2	OIL	1	.964	15.30	.34E-03	1402.0	196.6	284.7
0	CRUDE OIL, LIGHT	LtC	0	0	7	OIL	1	.780	16.00	.50E-02	860.2	748.1	1079.0
1	AMMONIA	NH3	7664	41	7	IN	1	.680	346000.00	.10E+02	2.0	18420.0	294200.0
4	STYRENE	STY	100	42	5	ORG	1	.906	300.00	.99E-02	794.3	18090.0	289000.0
14	TOLUENE	TOL	108	88	3	ORG	1	.867	379.30	.36E-01	724.4	1112.0	54010.0
22	BENZENE	BEN	71	43	2	ORG	1	.877	820.00	.13E+00	316.2	4978.0	118400.0
23	XYLENE, MIXTURE	XYL	1330	20	7	ORG	1	.870	115.50	.13E-01	1622.0	2252.0	35960.0
27	METHYL ALCOHOL	MEAL	67	56	1	ORG	1	.791	1000000.00	.17E+00	8.3	646200.0	736600.0
38	ETHYLBENZENE	ETHB	100	41	4	ORG	1	.865	140.00	.13E-01	1380.0	1686.0	101400.0
43	VINYL ACETATE	VAC	108	5	4	ORG	1	.932	20000.00	.14E+00	52.5	20470.0	327000.0
53	ETHYL ALCOHOL	ETHA	64	17	5	ORG	1	.789	437100.00	.53E-01	16.2	1337000.0	220800.0
63	ACRYLONITRILE	ACR	107	13	1	ORG	1	.810	70000.00	.13E+00	28.8	5044.0	33910.0
67	ISOPROPYL ALCOHOL	ISOA	67	63	0	ORG	1	.785	249800.00	.57E-01	24.0	586500.0	9368000.0
Nonvolatile Floaters:													
37	NONYL PHENOL	NPHE	25154	52	3	ORG	2	.950	1.00	.11E-07	1514000.0	38.3	611.9
Soluble sinkers, Low Partitioning, Low Toxicity:													
17	CALCIUM CHLORIDE	CACL	10043	52	4	IN	3	2.152	298300.00	.00E+00	90.2	167200.0	2670000.0
25	FORMALDEHYDE	FORM	50	0	0	ORG	3	1.080	1000000.00	.60E-01	2.0	22690.0	362400.0
26	ACETIC ACID	ACA	64	19	7	ORG	3	1.050	568500.00	.15E-01	16.2	23640.0	40540.0
32	SODIUM CARBONATE	NABC	497	19	8	IN	3	2.533	71000.00	.00E+00	9.6	24060.0	46710.0
Soluble sinkers, Low Partitioning, High Toxicity:													
2	CHLORINE	CL	7782	50	5	IN	4	1.468	7247.00	.75E+01	2.0	51.1	816.2
6	SULFURIC ACID	HSO4	7664	93	9	IN	4	1.840	1000000.00	.13E-05	2.0	504.0	8050.0
7	SODIUM CYANIDE	NACN	143	33	9	IN	4	1.610	1000000.00	.00E+00	2.0	138.0	2204.0
8	HYDROCHLORIC ACID	HCL	7647	1	0	IN	4	1.160	1000000.00	.32E-01	2.0	3384.0	54050.0
18	SODIUM HYDROXIDE	NAOH	1310	73	2	IN	4	2.130	521500.00	.00E+00	3.1	1681.0	26850.0

39	ETHYLENE GLYCOL	EGLY	107	21	1	ORG	4	1.140	1000000.00	.10E-03	3.9	2104.0	2535000.0
45	NITRIC ACID	NAC	7697	37	2	IN	4	1.503	1000000.00	.75E-01	2.0	6847.0	62250.0
48	PHOSPHORIC ACID	PO4	7664	38	2	IN	4	1.864	1000000.00	.38E-04	2.0	6162.0	56020.0
49	FERRIC CHLORIDE	FECL	7705	8	0	IN	4	2.900	530600.00	.00E+00	2.4	6053.0	10970.0
51	HYDROFLUORIC ACID	HFL	7664	39	3	IN	4	1.220	1000000.00	.20E+00	2.0	2895.0	26320.0
56	CALCIUM OXIDE	CAO	1305	78	8	IN	4	3.370	1199.00	.00E+00	2.0	6625.0	60220.0
60	HYDRAZINE	HYD	302	1	2	IN	4	1.010	1000000.00	.19E-01	2.0	33.7	538.3
69	POTASSIUM CYANIDE	KCN	151	50	8	IN	4	1.526	1000000.00	.00E+00	2.0	43.3	692.0
70	POTASSIUM PERMANGANATE	KPM	7722	64	7	IN	4	2.700	80000.00	.00E+00	9.0	448.0	7155.0
Soluble sinkers, Medium Partitioning, Low Toxicity:													
29	ETHYLENE DICHLORIDE	EDC	107	6	2	ORG	5	1.250	8500.00	.11E+00	134.9	145600.0	243600.0
42	CARBON TETRACHLORIDE	CTC	56	23	5	ORG	5	1.594	800.00	.12E+00	794.3	43240.0	690600.0
64	TRICHLOROETHANE	TCE	25323	89	1	ORG	5	1.339	4400.00	.13E+00	292.2	20140.0	62730.0
Soluble sinkers, Medium Partitioning, High Toxicity:													
11	PHENOL	PHE	108	95	2	ORG	6	1.132	82000.00	.60E-03	138.0	4122.0	5426.0
12	ZINC SULFATE	ZNSO	7733	2	0	IN	6	3.740	349800.00	.00E+00	121.5	1507.0	2581.0
36	CALCIUM HYDROXIDE	CAOH	1305	62	0	IN	6	2.240	1697.00	.00E+00	322.1	3770.0	60220.0
352	CHLOROBENZENE	CLB	108	90	7	ORG	6	1.107	488.00	.15E-01	776.2	762.3	2832.0

Table 2.2 (continued)

0	NITROCHLOROBENZENE, O-	NCB	88	73	3	ORG	6	1.305	1410.00	.41E-05	398.1	148.8	2377.0
0	1,1,1,2-TETRACHLOROETHANE	TTCE	630	20	6	ORG	6	1.553	2850.00	.18E-01	977.2	4189.0	66910.0
Insoluble sinkers; Medium Partitioning, High Toxicity:													
3	TETRAETHYL LEAD	TEPB	78	0	2	ORG	7	1.659	2.00	.36E-03	942.1	8.7	16.3
55	PARATHION	PARA	56	38	2	ORG	7	1.260	20.00	.50E-07	1197.0	2.7	267.7
61	MALATHION	MAL	121	75	5	ORG	7	1.230	145.00	.53E-06	371.9	130.8	494.3
Insoluble sinkers; High Partitioning, High Toxicity:													
5	PCB-1254	PCB	11097	69	1	ORG	8	1.500	.06	.13E-06	36370.0	4.3	68.7
10	PENTACHLOROPHENOL	PCP	87	86	5	ORG	8	1.978	80.00	.14E-06	12300.0	478.2	268.3
40	FENITROTHION	FENI	122	14	5	ORG	8	1.320	20.00	.79E-08	7959.0	.1	2.3
68	CHLORDANE	CHL	57	74	9	ORG	8	1.670	1.85	.13E-07	9997.0	4.9	10.4
299	HEXACHLOROBENZENE	HCB	118	74	1	ORG	8	2.044	.01	.25E-07	67610.0	4074.0	2.5

Table 2.3 Required inputs for the NRDAM/CME, version 2.2.

Data Type	Input Data	Units
Spill location	Latitude	deg., min., sec.
	Longitude	deg., min., sec.
Spill date	Year, month, day	#
Starting time	Time spill starts	hours (0-23)
Chemical name	Select from database	text
CAS #	Chemical Abstract Service Registry Number	#-#-#
Amount spilled	Volume or mass spilled (or pure chemical or oil)	as selected by user
Units for amount spilled	Select from MT, kg, gal., bbl, liters, pounds	as selected by user
Duration of release	Time over which spill occurs	hours
Amount second release (oils only)	Volume or mass of second phase of release immediately following first release	as selected by user
Duration of second release	Time over which secondary release occurs	hours
Wind data	Wind time series of speed and direction	speed in knots, direction in degrees (from)
Background currents	Current vectors in 2-D space (x,y) for mean background current assumed constant	m/sec or kts for each of E-W and N-S components
Tidal currents	Current vectors in 2-D space (x,y) for maximum flood current on day of spill	m/sec or kts for each of E-W and N-S components
Number of tidal cycles per day	Select one (K1) or two (M2) high tides per day	# (1 or 2)
Time of high tide	Time of high tide nearest to the time of the spill	hours (0-23)
Tide range	Tide range (height) on the day of the spill	meters
Ice conditions	In Alaska, select default ice grid	select ice "on" or "off" for ice or no ice

Data Type	Input Data	Units
Cleanup	Specifiy mass of pure chemical or oil removed, time window, spatial window, and shoreline vs. water surface for each removed batch	Mass or volume units, hours since spill, latitude and longitude bounds
Air temperature	Air temperature on day of the spill	C
Water temperature	Surface water temperature on the day of the spill	C
Suspended sediment concentration	Total suspended solids	mg/l
Settling velocity	Settling velocity for suspended sediments	m/day
Price Index	GNP Price Index for the base year 1987 (= 117.2 for second quarter 1991 $, used in the economic database)	#
Closure data	Closure areas and timing for fisheries, hunting, beaches and boating	areas or lengths, days closed

Table 2.4 Summary of input data for chemical spill scenarios.

Input Data	**Off Cape May in Summer**	**Off Cape May in Winter**	**Delaware River (Pres. Rivera)**	**Texas Shelf (Mega Borg)**	**Galveston Bay shallowwater near wetland**	**West Florida Shelf (vary currents)**
Year	1995	1995	1989	1990	1991	1995
Month	July	Feb.	June	June	June	July
Day	3	3	24	9	1	4
Hour	0	0	5	0	0	0
Lati-tude (deg.N)	38.84	38.84	39.75	28.55	29.541	29.931
Longi-tude (deg.W)	74.475	74.475	75.472	94.133	94.558	84.124
Release dura-tion (hours)	0	0	2	2	1	0
Amount spilled (MT)	100	100	930	100	100	100
Wind	from NE @ 5 kts	from NE @ 5 kts	as Pres-idente Rivera spill (NOAA buoy 44009)	as Mega Borg spill (buoy SW of spill site)	from SW @ 5-7 kts	from NE @ 5 kts
Back-ground current (cm/sec toward)	10 to SW	10 to SW	12 down-river (as Pres. Rivera)	as Mega Borg spill (fresh-water outflow from estu-aries)	0	10, 25, 50, 75, or 100 to S
Tidal current (cm/sec maximum flood)	10 to NW	10 to NW	In general 20 cm/ sec, based on ASA hydro-dynamic model	0	10 towards up-estuary	0
# high tides per day	2	2	2	1	1	1
Time (hrs) of high tide	6	6	5	7	12	0
Tidal range (m)	1.0	1.0	2.0	0.6	0.6	1.0

Input Data	**Off Cape May in Summer**	**Off Cape May in Winter**	**Delaware River (Pres. Rivera)**	**Texas Shelf (Mega Borg)**	**Galveston Bay shallowwater near wetland**	**West Florida Shelf (vary currents)**
Air temper-ature (C)	23	4	21	27	27	29
Water temper-ature (c)	23	7	118	23	23	29
Price Index	117.2	117.2	108.1	112.7	117.2	117.2

Table 2.5 Fisheries losses for scenarios off Cape May in summer.

Stock	YOY at Age 1 yr.		Adult			
Chemical	Finfish	Shellfish	Finfish	Shellfish	Catch kg	Catch $
NH3	0.	0.	1.	1.	0.	1.
STY	0.	0.	9.	13.	4.	7.
TOL	0.	0.	977.	1410.	411.	744.
BEN	0.	0.	68.	98.	28.	52.
XYL	0.	0.	28.	41.	12.	21.
MEAL	0.	0.	98.	142.	41.	75.
ETHB	0.	0.	76.	109.	32.	58.
VAC	0.	0.	138.	199.	58.	105.
ETHA	15.	0.	66.	95.	51.	73.
ACR	2.	0.	3464.	4996.	1460.	2644.
ISOA	0.	0.	1.	2.	0.	1.
NPHE	1639.	45.	280537.	491869.	120978.	221709.
CACL	0.	0.	1.	17.	11.	14.
FORM	1.	11.	3.	154598.	5363.	5092.
ACA	178.	1001.	15.	2775.	1689.	2844.
CL	15234.	22498.	430537.	3467090.	288022.	489056.
HSO4	1577.	10349.	2599.	3178634.	129610.	136763.
NACN	16843.	37443.	773348.	14691370.	738581.	1058050.
HCL	41.	1034.	413.	834823.	30592.	30250.
NAOH	441.	1985.	5262.	389428.	14109.	18860.
EGLY	3.	877.	268.	961361.	34702.	33754.
NAC	9.	1407.	56.	487652.	18525.	18610.
PO4	29.	10.	50.	66289.	2819.	3031.
FECL	665.	7316.	114.	10677580.	368649.	290020.
HFL	239.	30695.	746.	20688800.	734426.	579776.
CAO	35.	9596.	155.	10649810.	370002.	290664.
HYD	178314.	490919.	15060670.	147829800.	6896300.	13492400.
KCN	34644.	1533804.	51980.	170189000.	7728340.	10868100.
KPM	1231.	1532.	354.	175204.	12074.	16475.
EDC	11.	91.	4.	54.	158.	258.
CTC	0.	0.	0.	0.	0.	0.
TCE	91.	109.	18.	116.	330.	671.
PHE	1745.	1874.	43.	2094.	5214.	10679.
ZNSO	29587.	191252.	6281.	16268280.	349583.	750397.
CAOH	49.	182.	149.	26829.	1583.	1922.
TEPB	3202543.	1492778.	4509816.	64911700.	8085850.	12810800.
PARA	262518.	177436.	24219680.	64306100.	8629760.	12780300.
MAL	18189.	24812.	2866.	2578139.	154085.	199172.
PCB	610881.	550607.	30069560.	5186542.	4163750.	6068730.

PCP	191817.	71797.	2563.	6834.	375469.	584559.
FENI	5939803.	3390001.	932934700.	335809000.	100796000.	380577000.
CHL	3269241.	1314827.	40007260.	7147730.	10065600.	28837700.

Table 2.6 Wildlife losses for scenarios off Cape May in summer.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
NH3	.0	.1	.0	.2	.3
STY	.0	.1	.0	.2	.3
TOL	.0	.1	.0	.2	.3
BEN	.0	.1	.0	.2	.3
XYL	.0	.1	.0	.2	.3
MEAL	.0	.1	.0	.2	.3
ETHB	.0	.1	.0	.2	.3
VAC	.0	.1	.0	.2	.3
ETHA	.0	.1	.0	.2	.3
ACR	.0	.1	.0	.2	.3
ISOA	.0	.1	.0	.2	.3
NPHE	.0	28.6	.0	12.6	41.3
CACL	.0	.1	.0	.2	.3
FORM	.0	.5	.0	.7	1.2
ACA	.0	.1	.0	.2	.4
CL	.0	.3	.0	.5	.7
HSO4	.1	.9	.0	1.1	2.1
NACN	.3	.9	.0	1.1	2.4
HCL	.0	.8	.0	1.1	2.0
NAOH	.0	.7	.0	.9	1.6
EGLY	.0	.7	.0	.9	1.6
NAC	.0	.7	.0	.9	1.6
PO4	.0	.3	.0	.5	.7
FECL	.5	5.4	.0	14.5	13.1
HFL	.5	5.4	.0	14.5	13.1
CAO	.5	5.4	.0	14.5	13.1
HYD	.4	1.2	.0	1.6	3.2
KCN	1.7	5.4	.2	14.5	14.5
KPM	.0	.3	.0	.5	.7
EDC	.0	.1	.0	.2	.3
CTC	.0	.1	.0	.2	.3
TCE	.0	.1	.0	.2	.3
PHE	.0	.3	.0	.5	.7
ZNSO	1.7	5.4	.3	28.9	14.6
CAOH	.4	4.2	.0	11.3	10.3
TEPB	1.7	5.4	.2	14.5	14.5
PARA	.8	2.4	.1	6.3	6.6
MAL	.5	5.4	.0	14.5	13.1
PCB	.5	5.4	.0	14.5	13.1
PCP	1.3	4.2	.1	11.3	11.4
FENI	1.7	335.6	.3	14.5	364.1
CHL	1.7	335.6	.2	14.5	364.1

Table 2.7 Fisheries losses for scenarios off Cape May in winter.

	Adult Stock		YOY at Age 1 yr.			
Chemical	Finfish	Shellfish	Finfish	Shellfish	Catch kg	Catch $
NH3	0.	0.	0.	0.	0.	0.
STY	0.	0.	4.	0.	0.	1.
TOL	0.	0.	24.	0.	2.	9.
BEN	0.	0.	6.	0.	0.	2.
XYL	0.	0.	0.	0.	0.	0.
MEAL	0.	0.	0.	0.	0.	0.
ETHB	4.	0.	19.	0.	7.	22.
VAC	0.	0.	4.	0.	0.	1.
ETHA	1.	0.	0.	0.	0.	1.
ACR	7.	0.	1607.	0.	119.	568.
ISOA	0.	0.	0.	0.	0.	0.
NPHE	575.	0.	113063.	0.	8453.	40124.
CACL	0.	0.	0.	0.	0.	0.
FORM	0.	0.	7.	8910.	298.	294.
ACA	330.	572.	25.	0.	941.	2297.
HSO4	7040.	9254.	30887.	8280790.	146543.	161241.
NACN	36139.	41157.	445505.	49084580.	380675.	559356.
HCL	37.	637.	1135.	2909628.	33821.	34127.
NAOH	285.	1335.	3525.	4768640.	52162.	53463.
EGLY	0.	183.	5097.	4023095.	24603.	25758.
NAC	2.	403.	30.	2120724.	11620.	11715.
PO4	72.	11.	78.	30679.	1063.	1110.
FECL	2858.	2540.	4434.	74128040.	224173.	192231.
HFL	469.	27509.	798.	95316400.	673193.	549710.
CAO	25.	2416.	1338.	92093910.	233578.	195457.
HYD	249225.	264199.	13263920.	193188400.	2657950.	6952140.
KCN	231972.	1866894.	1966973.	1798363000.	11325800.	10274700.
KPM	2655.	421.	1562.	196856.	8251.	10801.
EDC	0.	0.	0.	0.	0.	0.
CTC	0.	0.	0.	0.	0.	0.
TCE	0.	0.	0.	0.	0.	0.
PHE	7959.	2778.	19.	0.	5938.	14073.
ZNSO	16875.	609967.	8239.	7336270.	985010.	978655.
CAOH	20.	0.	302.	28.	43.	157.
CLB	22015.	13409.	2811.	1353.	25368.	61346.
TEPB	5131709.	1454445.	12478670.	155506700.	8951210.	18842600.
PARA	111701.	25777.	25210520.	191687700.	9344370.	18238600.
MAL	48913.	11767.	7662237.	6493914.	618283.	2787400.
PCB	294755.	100556.	1472659.	6851360.	626530.	1432360.
PCP	102055.	25606.	13902.	235.	68120.	165993.
FENI	8209720.	1987260.	9090250000.	9023374000.	3739050000.	5497580000.
CHL	3922640.	1026941.	3152402.	6590580.	3254020.	7977910.

Table 2.8 Wildlife losses for scenarios off Cape May in winter.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
NH3	.0	.1	.0	.0	.1
STY	.5	.5	.0	.0	1.0
TOL	.0	.1	.0	.0	.1
BEN	.0	.1	.0	.0	.1
XYL	.5	.5	.0	.0	1.0
MEAL	.0	.1	.0	.0	.1
ETHB	.5	.5	.0	.0	1.0
VAC	.0	.1	.0	.0	.1
ETHA	.0	.1	.0	.0	.1
ACR	.0	.1	.0	.0	.1
ISOA	.0	.1	.0	.0	.1
NPHE	31.3	25.2	.0	.0	56.5
CACL	.0	.1	.0	.0	.1
FORM	.0	.1	.0	.0	.1
ACA	.0	.1	.0	.0	.1
HSO4	.1	.7	.0	.9	1.7
NACN	.3	.7	.0	.9	2.0
HCL	.1	.6	.0	.7	1.4
NAOH	.1	.6	.0	.7	1.4
EGLY	.0	.5	.0	.7	1.2
NAC	.0	.5	.0	.7	1.2
PO4	.0	.1	.0	.0	.1
FECL	.5	5.6	.0	14.9	13.6
HFL	.5	5.6	.0	14.9	13.6
CAO	.5	5.6	.0	14.9	13.6
HYD	.5	1.1	.0	1.4	3.0
KCN	.5	5.6	.0	14.9	13.6
KPM	.0	.2	.0	.2	.5
EDC	.0	.1	.0	.0	.1
CTC	.0	.1	.0	.0	.1
TCE	.0	.1	.0	.0	.1
PHE	.0	.1	.0	.0	.1
ZNSO	.5	5.6	.0	14.9	13.6
CAOH	.0	.1	.0	.0	.1
CLB	.0	.1	.0	.0	.1
TEPB	.4	4.6	.0	12.2	11.1
PARA	.5	1.5	.1	2.0	4.1
MAL	.0	.2	.0	.2	.5
PCB	.5	5.6	.0	14.9	13.6
PCP	.7	2.1	.1	5.4	5.5
FENI	.5	5.6	.0	14.9	13.6
CHL	1.3	3.7	.2	9.5	9.9

Table 2.9 Fisheries losses for scenarios in the Delaware River.

	Adult Stock		YOY at Age 1 yr.			
Chemical	Finfish	Shellfish	Finfish	Shellfish	Catch kg	Catch $
No6	9.	169.	169.	23.	433.	716.
LtC	3.	104.	110.	14.	262.	417.
NH3	7.	0.	4.	1.	11.	79.
STY	3.	0.	0.	0.	5.	35.
TOL	15.	0.	18.	0.	27.	186.
BEN	11.	0.	5.	0.	18.	123.
XYL	23.	0.	11.	0.	35.	251.
MEAL	120.	17.	4.	253.	356.	1403.
ETHB	5.	0.	20.	0.	13.	86.
ETHA	499.	103.	1.	81.	991.	5050.
ACRY	121.	6.	51.	461.	457.	1614.
ISOA	2.	0.	4.	181.	110.	146.
NPHE	6819.	388.	36614.	2295370.	1362620.	1624030.
CL	14491.	11659.	155870.	15799400.	8814200.	10240600.
HSO4	104486.	8311.	121510.	4702590.	358877.	961035.
NACN	254371.	13656.	221175.	19235700.	6246140.	8430590.
HCL	9967.	2089.	17600.	761731.	113626.	201026.
NAOH	42496.	4117.	55521.	1963820.	376980.	671080.
EGLY	24.	114.	48620.	1658770.	209882.	305573.
KCN	1617597.	309229.	318566700.	1003572000.	179673000.	300077000.
EDC	424.	485.	221.	23598.	15574.	20498.
CTC	97.	134.	253.	27249.	15962.	18879.
PHE	39718.	8448.	75684.	1946980.	1241350.	1695480.
CLB	10784.	8376.	2493.	245184.	170380.	271119.
TEPB	425073.	784669.	966222.	62785000.	32680800.	43223400.
PCB	396878.	375332.	1240382.	43475200.	21466900.	27232700.
HCB	31677.	13675.	57740.	2290280.	1100720.	1535160.

Table 2.10 Wildlife losses for scenarios in the Delaware River.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
No6	234.2	9.4	148.5	.0	392.1
LtC	204.0	8.1	140.2	.0	352.3
NH3	.0	.0	.0	.0	.0
STY	4.6	.1	.0	.0	4.7
TOL	4.2	.1	.0	.0	4.3
BEN	.0	.0	.0	.0	.0
XYL	4.3	.1	.0	.0	4.4
MEAL	.0	.0	.0	.0	.0
ETHB	4.7	.1	.0	.0	4.9
ETHA	.3	.0	.0	.0	.4
ACRY	.1	.0	.0	.0	.1
ISOA	.3	.0	.0	.0	.4
NPHE	284.2	7.7	47.9	.0	339.8
CL	.0	.0	.0	.0	.0
HSO4	.1	.0	.0	.0	.1
NACN	.1	.0	.0	.0	.1
HCL	.1	.0	.0	.0	.1
NAOH	.1	.0	.0	.0	.1
EGLY	.1	.0	.0	.0	.1
KCN	1.0	5.1	.0	20.2	12.9
EDC	.0	.0	.0	.0	.0
CTC	.1	.0	.0	.0	.1
PHE	.0	.0	.0	.0	.0
CLB	.0	.0	.0	.0	.1
TEPB	.5	.1	.0	.0	.6
PCB	.9	5.1	.0	20.2	12.7
HCB	.4	.1	.0	.0	.4

Table 2.11 Fisheries losses for scenarios on the Texas shelf.

	Adult Stock		YOY at Age 1 yr.			
Chemical	Finfish	Shellfish	Finfish	Shellfish	Catch kg	Catch $
No6	0.	0.	0.	0.	0.	0.
LtC	0.	0.	0.	0.	0.	0.
NH3	1.	0.	47.	1.	2.	5.
STY	0.	0.	59.	1.	1.	4.
TOL	0.	0.	368.	6.	5.	23.
BEN	0.	0.	114.	2.	2.	7.
XYL	0.	0.	244.	4.	4.	15.
MEAL	1.	0.	4.	0.	2.	5.
ETHB	0.	0.	322.	5.	5.	20.
VAC	2.	0.	81.	1.	4.	12.
ETHA	920.	0.	1.	0.	1219.	2096.
ACR	29.	0.	489.	8.	42.	128.
ISOA	0.	0.	4.	0.	0.	0.
NPHE	12600.	0.	555606.	9957.	22995.	81726.
CACL	0.	0.	16.	6.	2.	6.
FORM	0.	0.	287.	11.	5.	21.
ACA	5754.	0.	187.	3.	7145.	17424.
CL	573117.	2072.	11146.	12661.	1047090.	4922300.
HSO4	160568.	562.	10607.	14622.	292141.	1352770.
NACN	515517.	1934.	32963.	36288.	941141.	4477970.
HCL	10145.	3.	1630.	2577.	12808.	45703.
NAOH	25684.	90.	2225.	3524.	46751.	220601.
EGLY	56.	0.	264.	64.	119.	578.
NAC	3699.	9.	488.	780.	6016.	27490.
PO4	7189.	23.	4472.	7641.	14334.	65476.
FECL	66270.	223.	168.	283.	117396.	549844.
HFL	227298.	641.	47169.	48663.	411589.	1710010.
CAO	19570.	53.	5390.	6131.	35609.	149773.
HYD	1992822.	17556.	1549205.	74900.	2573070.	8573290.
KCN	7460830.	324474.	102026000.	1013801000.	25635600.	95123800.
KPM	38594.	128.	1829.	2353.	69350.	313642.
EDC	0.	0.	0.	0.	0.	0.
CTC	0.	0.	0.	0.	0.	0.
TCE	1344.	2.	0.	0.	2075.	7818.
PHE	18635.	0.	6696.	261.	22747.	61896.
ZNSO	1245471.	73654.	156387.	196196.	2251960.	8919420.
CAOH	3524.	13.	6486.	11097.	9351.	41375.
CLB	580120.	322.	271232.	40506.	771432.	2676010.
NCB	455610.	1767.	721784.	127597.	876613.	4149580.
TTCE	480.	1.	130.	218.	860.	3570.
TEPB	55007080.	114930.	32829720.	3511931.	90954800.	390919000.
PARA	4412578.	13240.	51390590.	7867970.	10743700.	45999900.
MAL	4277650.	14101.	879949.	182418.	7353170.	34259200.
PCB	1527685.	4225.	923348.	253470.	2710410.	12081500.
PCP	1298216.	5391.	1777.	2212.	2392590.	11702500.
FENI	36541540.	77316.	148849100.	17778100.	69026500.	290287000.
HCB	983244.	3793.	490817.	122012.	1801360.	8684480.

Table 2.12 Wildlife losses for scenarios on the Texas shelf.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
No6	450.7	70.3	725.2	.0	1256.0
LtC	179.1	28.5	.1	.0	210.0
NH3	3.3	1.3	.1	.0	6.1
STY	3.3	1.3	.1	.0	6.1
TOL	3.3	1.3	.1	.0	6.1
BEN	3.3	1.3	.1	.0	6.1
XYL	3.3	1.3	.1	.0	6.1
MEAL	3.3	1.3	.1	.0	6.1
ETHB	3.3	1.3	.1	.0	6.1
VAC	3.3	1.3	.1	.0	6.1
ETHA	3.3	1.3	.1	.0	6.1
ACR	3.3	1.3	.1	.0	6.1
ISOA	3.3	1.3	.1	.0	6.1
NPHE	122.0	21.0	.1	.0	146.7
CACL	1.8	.7	.0	.0	3.3
FORM	1.8	1.5	.0	.0	4.9
ACA	1.8	.7	.0	.0	3.3
CL	9.5	4.0	.2	.0	18.0
SO4	23.5	14.4	.4	.0	47.1
NACN	26.8	14.9	.3	.0	50.3
HCL	23.5	13.1	.3	.0	44.2
NAOH	23.5	14.4	.4	.0	47.1
EGLY	23.5	13.1	.3	.0	44.2
NAC	20.2	11.7	.3	.0	38.1
PO4	3.3	2.7	.1	.0	9.0
FECL	211.7	121.4	2.8	.3	398.8
HFL	116.0	66.9	.0	.1	217.6
CAO	211.7	121.4	2.8	.3	398.8
HYD	59.6	30.5	2.6	.0	106.6
KCN	294.4	144.8	13.9	.6	572.7
KPM	9.5	4.0	.2	.0	18.0
EDC	1.8	.7	.0	.0	3.3
CTC	1.8	.7	.0	.0	3.3
TCE	1.8	.7	.0	.0	3.3
PHE	1.8	1.5	.0	.0	4.9
ZNSO	384.2	195.9	30.4	.7	752.3
CAOH	1.8	1.5	.0	.0	4.9
CLB	9.5	4.0	.2	.0	18.0
NCB	142.2	83.5	1.7	.2	270.2
TTCE	1.8	1.5	.0	.0	4.9
TEPB	310.6	158.1	13.9	.3	605.8
PARA	115.9	67.0	1.5	.1	217.4
MAL	225.6	125.2	14.2	.3	464.2
PCB	211.7	121.4	2.8	.3	398.8
PCP	101.1	58.7	1.3	.1	190.4
FENI	241.5	138.6	2.9	.3	453.9
HCB	70.2	39.2	1.0	.1	149.0

Table 2.13 Fisheries losses for scenarios in Galveston Bay.

Chemical	Adult Stock Finfish	Adult Stock Shellfish	YOY at Age 1 yr. Finfish	YOY at Age 1 yr. Shellfish	Catch kg	Catch $
No6	363.	0.	88051.	7315.	2806.	9182.
LtC	0.	0.	0.	0.	0.	0.
NH3	7.	0.	2516.	240.	26.	16.
TOL	649.	1.	54425.	3963.	3153.	10583.
NPHE	17358.	907.	21950080.	1890094.	504604.	1677530.
HSO4	53501.	11179.	1595113.	9920760.	341332.	1122800.
NAOH	38294.	7049.	1248069.	1249115.	120639.	340707.
EGLY	165.	6980.	1240062.	2091850.	60199.	236755.
KCN	78370.	1583061.	22598320.	1612593000.	15675500.	45448500.
EDC	234.	116.	5211.	191.	1250.	4082.
CTC	50.	0.	12023.	690.	949.	3988.
TCE	911.	59.	112478.	8646.	5471.	18436.
PHE	48689.	4154.	4109716.	193096.	184610.	534454.
CLB	8373.	931.	5433913.	1734614.	193099.	721931.
NCB	499737.	17005.	1885878000.	138262600.	42994800.	157192000.
PCB	29494.	5866.	10671830.	7199045.	571204.	2207940.
PCP	215885.	79631.	264629400.	1095713.	2430750.	3286950.
HCB	25445.	2150.	2053550.	815624.	91993.	256898.

Table 2.14 Wildlife losses for scenarios in Galveston Bay.

Chemical	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
No6	1096.1	235.0	313.5	.0	1644.6
LtC	1129.1	252.8	320.6	.0	1702.6
NH3	.0	.0	.0	.0	.0
TOL	.0	.0	.0	.0	.0
NPHE	235.4	89.2	61.3	.0	385.9
HSO4	5.9	3.3	.1	.0	10.8
NAOH	3.5	2.0	.1	.0	6.7
EGLY	3.5	2.0	.1	.0	6.7
KCN	146.8	84.2	.4	.3	274.3
EDC	.0	.0	.0	.0	.0
CTC	.0	.0	.0	.0	.0
TCE	.0	.0	.0	.0	.0
PHE	.0	.0	.0	.0	.1
CLB	.0	.0	.0	.0	.1
NCB	166.0	96.9	2.3	.2	314.7
PCB	30.9	17.2	.4	.1	56.7
PCP	242.6	138.7	3.3	.3	455.5
HCB	8.8	5.0	.1	.0	16.2

Table 2.15 Fisheries losses for scenarios off the west coast of Florida.

Chem-ical	cm/sec	Adult Stock Finfish	Adult Stock Shellfish	YOY at Age 1 yr. Finfish	YOY at Age 1 yr. Shellfish	Catch kg	Catch $
NAOH	10	41092.	295.	4390750.	1017602.	121076.	359480.
NAOH	25	27637.	237.	2017102.	490407.	65647.	175371.
NAOH	50	1881.	0.	201644.	210981.	5473.	13307.
NAOH	75	3807.	0.	26721.	189456.	6360.	10734.
NAOH	100	55.	0.	27624.	189381.	1474.	5447.
NACN	10	380614.	127036.	16655760.	24115200.	986887.	2963480.
NACN	25	177400.	489465.	7092085.	78642650.	1245810.	4386060.
NACN	50	63096.	488725.	4069298.	78280980.	1057740.	4016390.
NACN	75	1739.	123029.	677699.	22141020.	260069.	1067400.
NACN	100	7619.	123029.	705094.	22146800.	268098.	1065740.
TEPB	10	2912874.	389067.	39465700.	65548190.	5161130.	12444600.
TEPB	25	1106052.	374295.	12769840.	59160270.	2318500.	6080890.
TEPB	50	411261.	367695.	4986054.	57787420.	1242380.	3608880.
TEPB	75	357944.	369471.	4300210.	57661020.	1194700.	3838070.
TEPB	100	363374.	1807516.	9084639.	276789900.	3912170.	13448000.
PCP	10	1258827.	9428.	18750250.	2280249.	1930910.	3900820.
PCP	25	601352.	5464.	7235393.	879720.	925066.	2114770.
PCP	50	508040.	3827.	5207963.	4671289.	903409.	2315360.
PCP	75	337042.	2466.	2351073.	282467.	490126.	1053130.
PCP	100	211566.	1603.	1048641.	130798.	302865.	627558.

Table 2.16 Wildlife losses for scenarios off the west coast of Florida.

Chemical	cm/ sec	Waterfowl	Seabirds	Other birds	Mammals & turtles	Total
NAOH	10	.0	.0	.0	3.1	3.1
NAOH	25	.0	.0	.0	3.1	3.1
NAOH	50	.0	.0	.0	.0	.0
NAOH	75	.0	.0	.0	.0	.0
NAOH	100	.0	.0	.0	.0	.0
NACN	10	.0	.0	7.8	5.1	12.9
NACN	25	.1	.2	30.9	20.4	51.6
NACN	50	.1	.2	30.9	20.4	51.6
NACN	75	.0	.0	7.8	.0	7.8
NACN	100	.0	.0	7.8	.0	7.8
TEPB	10	3.2	2.1	23.2	20.0	48.6
TEPB	25	.1	.2	23.2	18.7	42.1
TEPB	50	.1	.2	23.2	18.7	42.1
TEPB	75	.1	.2	23.2	18.7	42.1
TEPB	100	72.1	27.2	114.7	112.8	326.7
PCP	10	.1	.2	.1	24.9	25.2
PCP	25	.1	.2	.0	24.9	25.2
PCP	50	.0	.0	.0	5.1	5.1
PCP	75	.1	.2	.0	24.9	25.2
PCP	100	.1	.2	.0	24.9	25.2

Table 2.17 Effect of varying temperature on fishery injuries from a 100 MT sodium hydroxide spill off Cape May in summer.

Temper-ature	Adult Stock Finfish	Adult Stock Shellfish	YOY at Age 1 yr. Finfish	YOY at Age 1 yr. Shellfish	Catch kg	Catch $
2	3546.	16735.	16224.	3147851.	150754.	173055.
10	7139.	47849.	8322.	6504908.	312686.	356552.
23	16843.	37443.	773348.	14691370.	738581.	1058050.

Table 2.18 Effect of varying temperature on wildlife injuries from a 100 MT sodium hydroxide spill off Cape May in summer.

Temperature	Waterfowl	Seabirds	Other bird	Mam-turt	Total
2 C	.0	.7	.0	.9	1.6
10 C	.1	.9	.0	1.1	2.1
23 C	.3	.9	.0	1.1	2.4

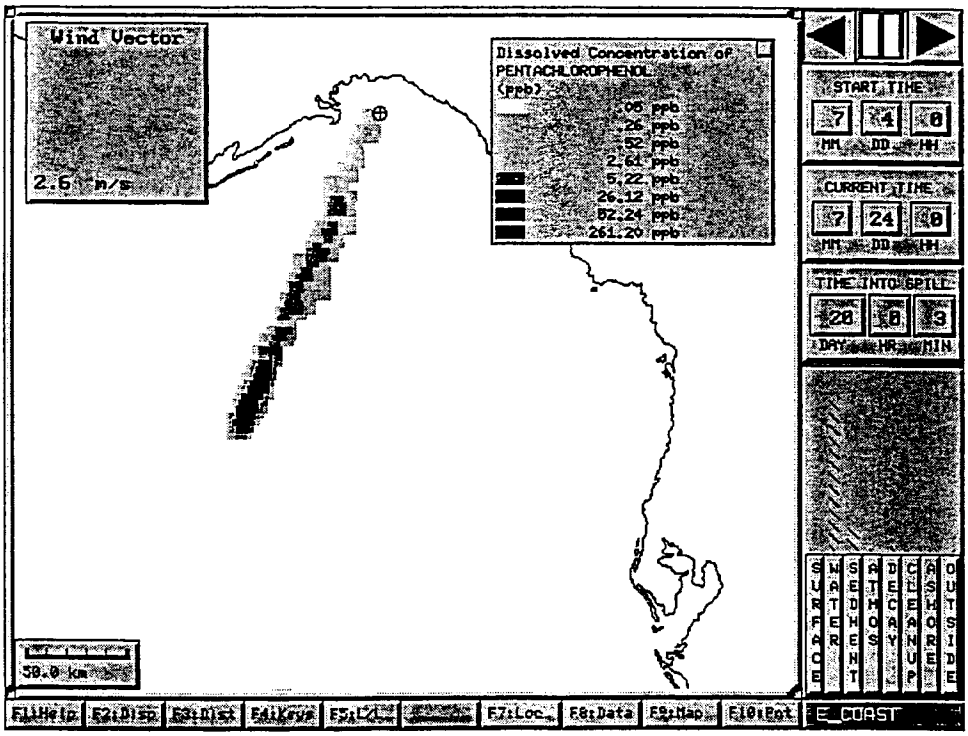
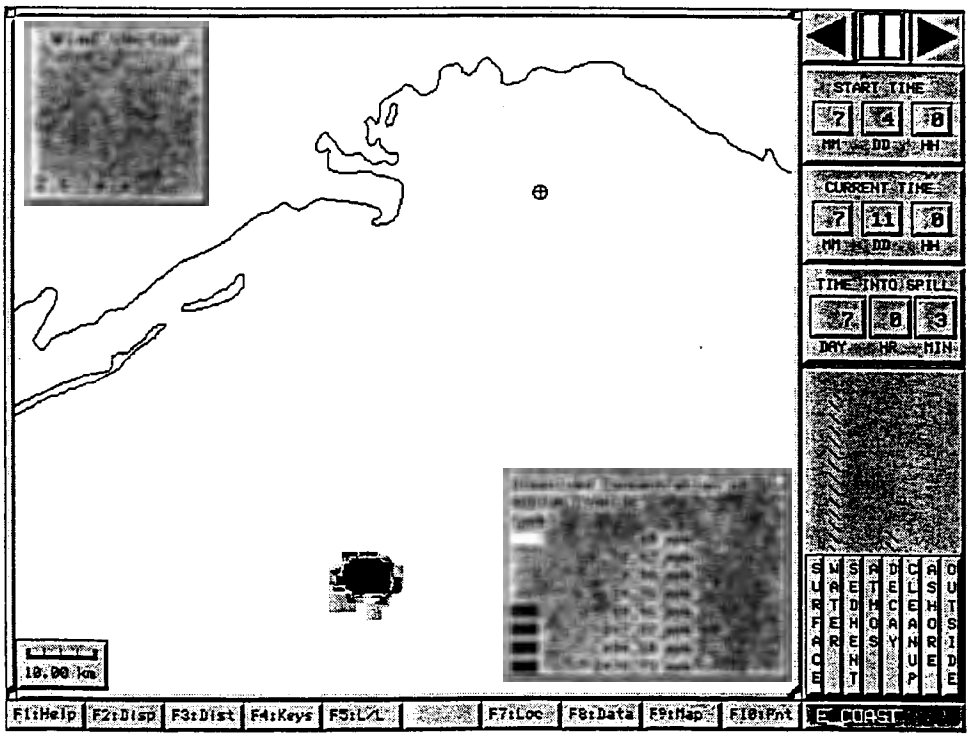


Figure 2.1 Dissolved concentrations in the water column for a 100 MT spill on the west Florida shelf of pentachlorophenol assuming 10 cm/sec background currents: at 20 days after the spill.



Background current: 10 cm/sec

Figure 2.2 Dissolved concentrations in the water column for a 100 MT spill on the west Florida shelf of sodium cyanide assuming 10 cm/sec background currents: at 7 days after the spill.

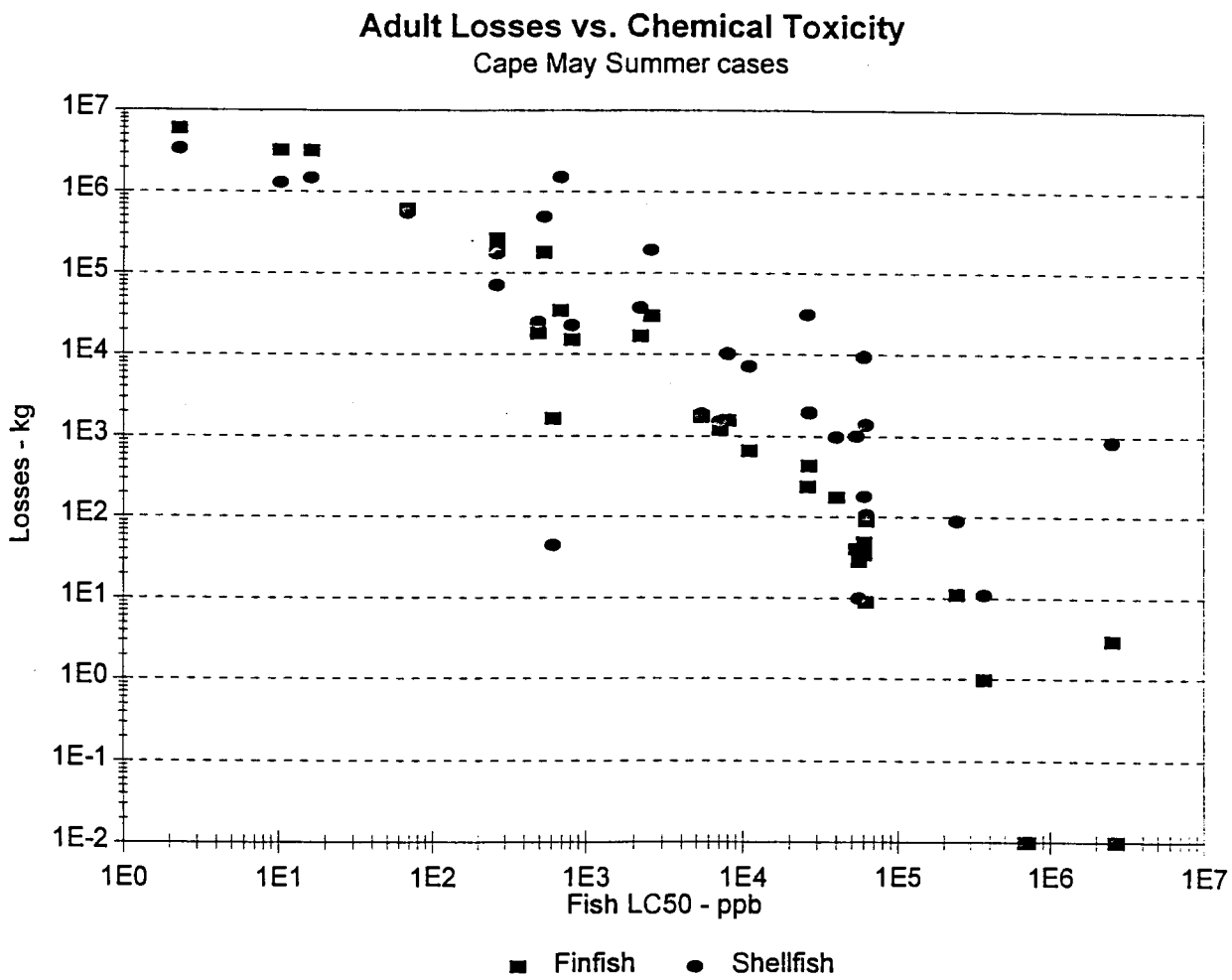


Figure 2.3 Adult fishery kills versus 96 hour LC50 for fish on a log-log plot, 100 MT spill off Cape May in summer.

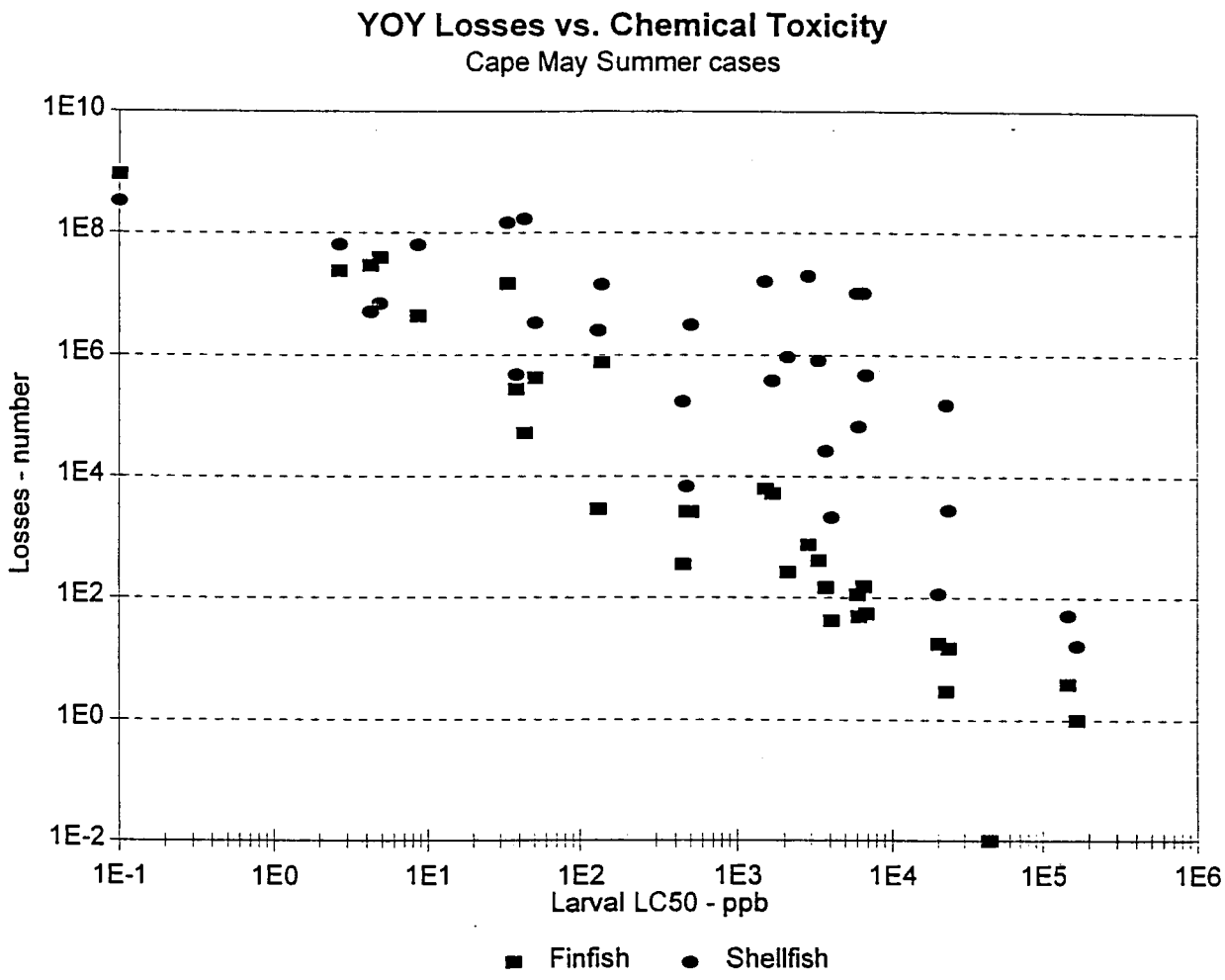


Figure 2.4 Young-of-the-year kills versus 96 hour LC50 for larvae on a log-log plot, 100 MT spill off Cape May in summer.

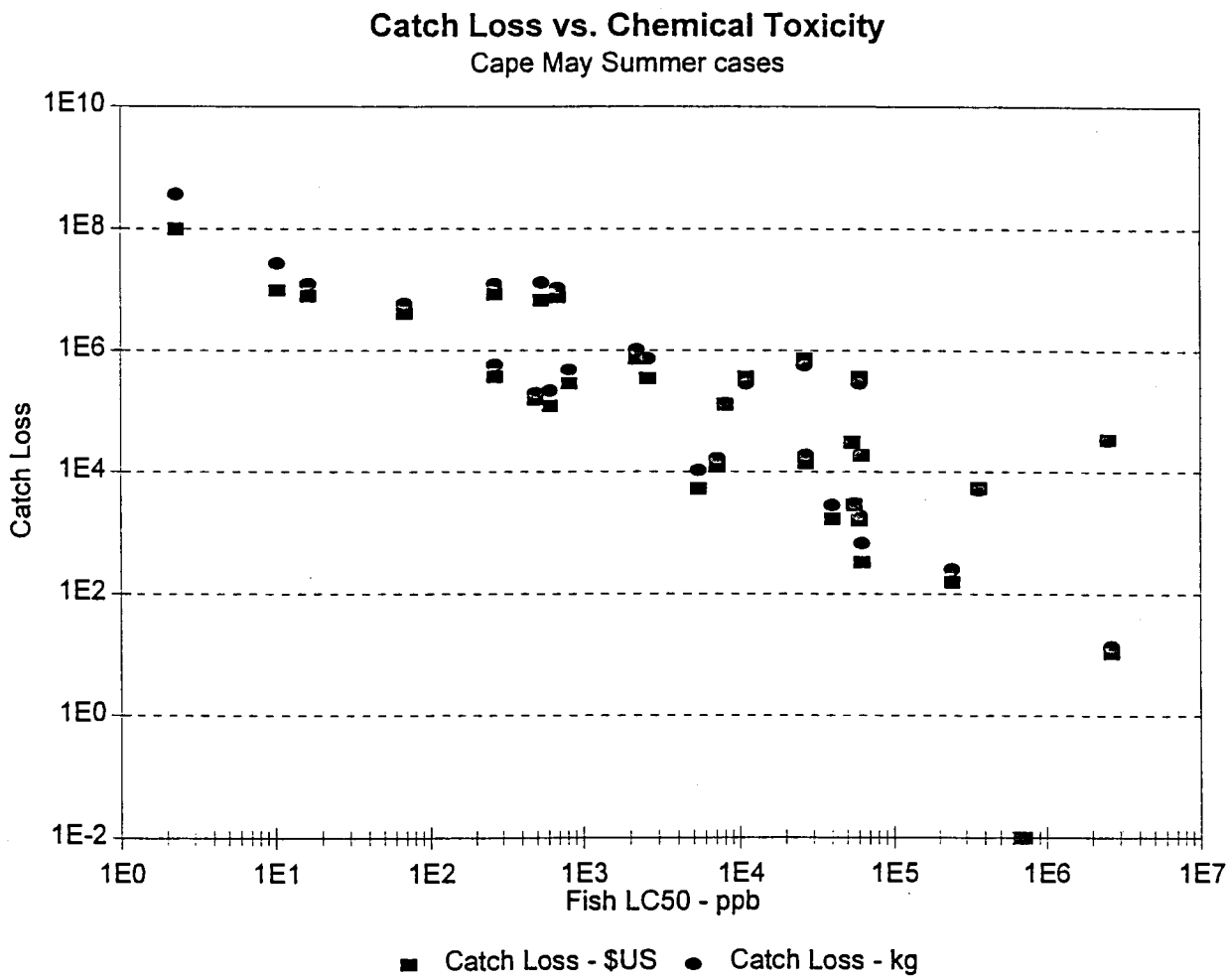


Figure 2.5 Catch loss in weight and value versus 96 hour LC50 for fish on a log-log plot, 100 MT spill off Cape May in summer.

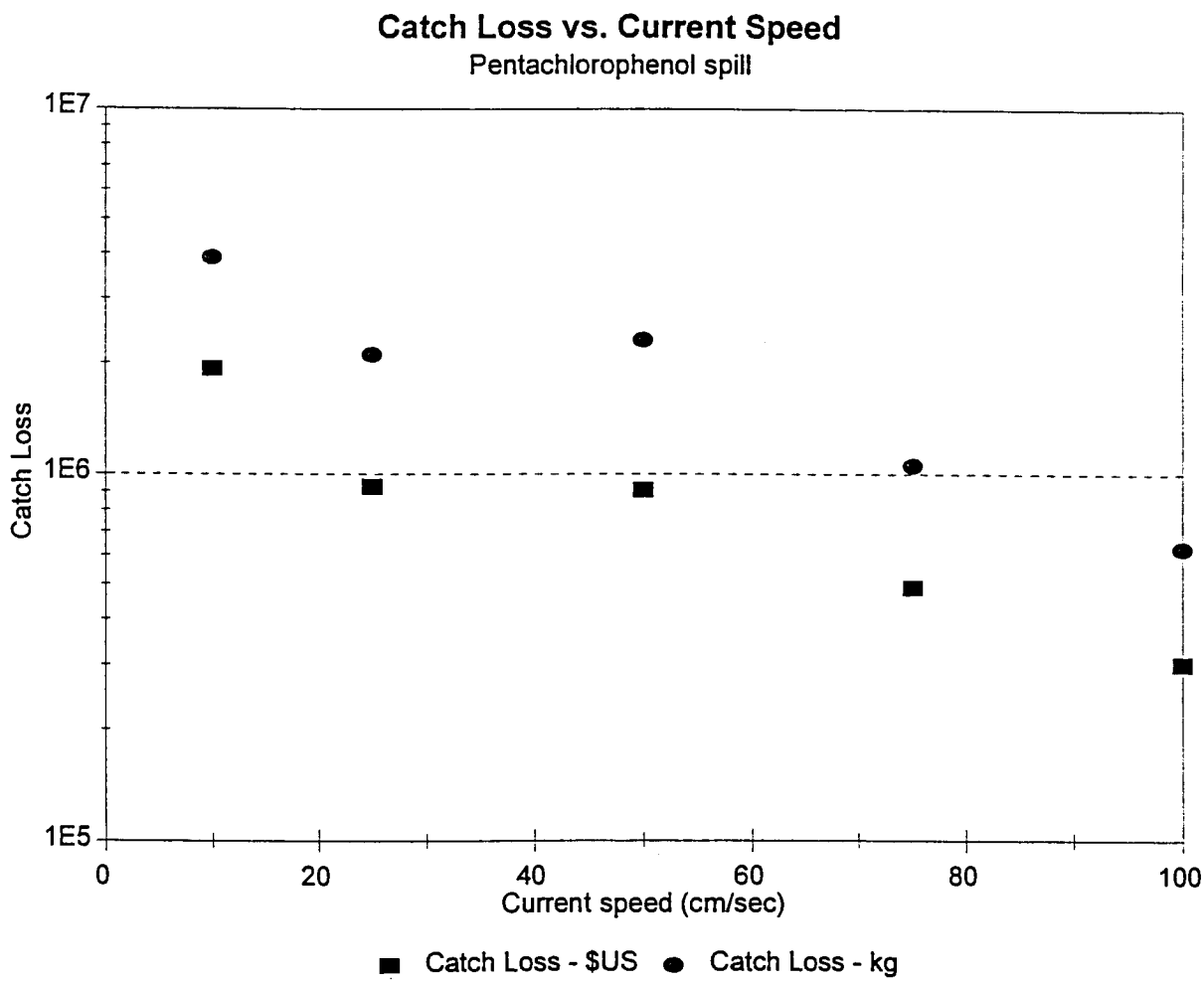


Figure 2.6 Catch loss in weight and value versus current speed for 100 MT pentachlorophenol spills on the west Florida shelf.

CONSIDERATIONS AND METHODS FOR PERFORMING MASS BALANCE CALCULATIONS FOR OIL SPILLS

prepared by:

Deborah P. French
Applied Science Associates
70 Dean Knauss Drive
Narragansett, RI 02882

prepared for:

National Oceanic and Atmospheric Administration
Damage Assessment Center
Silver Spring, MD

Contract 50-DDNC-1-00007
Task Order 100

ASA 95-01

August 31, 1995

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1. INTRODUCTION

When conducting a preliminary assessment or NRDA for an oil spill, it is often helpful to account for all of the oil fates. This information may be useful in identifying, characterizing, and quantifying exposure to biota and other natural resources. One way to synthesize the overall fates from a discharge, including cleanup and weathering, is through the development of a mass balance. The exercise of estimating a mass balance forces consideration of all the fates of the spilled oil, not just the most visible portions. Estimation of a mass balance of oil can strengthen an assessment by showing where additional studies or analysis may be required for certain resources.

Although a detailed mass balance, such as the one developed Wolfe et al., (1994) for the EXXON VALDEZ, may take several years to reconstruct, a preliminary mass balance may be feasible during the preassessment phase of a spill. Consideration of the potential fates of the oil will assist trustees in estimating the loading of oil into certain habitats, which may be useful in identifying and scaling injury studies in certain areas. For example, Scholz and Michel (1992) conducted a mass balance on the T/V MEGA BORG spill in Texas to determine what the fraction of the oil burned in the fire and the other fates. This information was used in determining the potential for oil exposure to shrimp (Nance, 1992).

A mass balance may be useful in evaluating the success of the response operations and to provide a check on the total amount spilled. A mass balance approach was used to check divergent estimates of a fuel oil spill into the Cape Fear river, N.C. (Baca et al., 1983). These estimates may be necessary if the trustees decide to use a model or compensation table, as these methods generally require an estimate of both the amount spilled and the amount recovered.

In many incidents, the USCG, NOAA HAZMAT, or other responders may generate a mass balance and the NRDA team should evaluate and determine whether the existing fates information is adequate for their purposes. This document summarizes the various considerations, methods and difficulties in estimating a mass balance, and highlights the information necessary to independently evaluate and/or calculate a mass balance. In addition, the reader is referred to the pertinent literature on oil fates and modeling.

2. GENERAL DESCRIPTION OF OIL SPILL FATES

Once oil is spilled on water, a number of physical, chemical, and biological processes begin to occur. The relative importance of these processes will depend on the type of oil and the ambient environmental conditions. These processes include:

1) spreading on the water surface
2) evaporation of volatile components to the atmosphere
3) combustion of hydrocarbons (accidentally or as part of response efforts)
4) emulsification to form oil-in-water emulsions (mousse)

5) entrainment of whole oil droplets into the water column (natural dispersion)
6) chemical dispersion of oil droplets into the water column
7) dissolution of soluble components from surface slicks and entrained droplets into the water column
8) adsorption to and absorption of particulate matter onto oil
9) floatation of buoyant oil droplets and oil-particulate complexes
10) transport of water surface and water column oil by currents
11) settling of particulate oil
12) adherence of oil to sediments and surfaces
13) resuspension of sedimented oil
14) beaching and refloatation off shorelines
15) wave and other shoreline cleansing processes
16) mechanical cleanup from water surfaces and shorelines
17) degradation (photolysis, chemical, biological)

These various fates can be integrated into 8 main compartments :

1) water surface:
2) atmosphere
3) burned
4) water column
5) sediments
6) shorelines (with loadings for each habitat)
7) recovered in mechanical cleanup
8) degraded

3. GENERAL APPROACHES TO ESTIMATION OF A MASS BALANCE

The estimation of mass balance of a spill generally requires combining field observations and measurements with the development and application of some sort of oil fate model, whether back-of-the-envelope or involving differential equations. Given the availability of oil fate models, and particularly the publicly-available NOAA ADIOS oil weathering model, the NOAA HAZMAT oil trajectory models, and the CERCLA type A NRDA Model for Coastal and Marine Environments (NRDAM/CME, French et al., 1994a,b), mass balance estimates may be readily generated. The critical step is in obtaining the necessary information to input to the models. The literature on fate modeling should be consulted for description and quantification of the processes. Reviews of this literature include Stolzenbach et al (1977), Jordan and Payne (1980), Huang and Monastero (1982), Murray (1982), Huang (1983), Spaulding (1988), Coon and Knoke (1990), Reed (1992), ASCE (1995), and Spaulding (1995).

4. OBTAINING NECESSARY DATA FOR MASS BALANCE CALCULATIONS

The data needed for estimation of a mass balance are the same as those needed as input to an oil spill fate model. The following is a discussion of potential sources of information and considerations for these data needs. Table 1 summarizes the considerations and strategies.

Table 1. Primary data needs for calculation of a mass balance.

Data Type	Difficulties	Solutions
Amount spilled	Often estimated by amount missing, but volume remaining often includes water and other contaminants	Measure water (and other contaminant) content of volume remaining
Location of spill	Inaccuracy	Distance relative to shore, landmarks, and resources of concern
Timing of oil release	Inaccurately known or reported	Locate observer
Oil characteristics (as spilled)	Incomplete or approximate information	Consult literature or perform necessary laboratory analyses
Environmental Conditions: Winds, temperature, cloud cover, ice cover	Weather data usually available from local airport and NOAA weather buoys but location may not be representative of spill site	Deploy temporary meteorological station at or near spill site
Current data	No compiled sources, not usually monitored	Consult existing sources, deploy current meters
Amount skimmed from water surface at discrete intervals in time	Reported volumes include water in mixture and/or as part of a mousse; time history not always reported	Separate oil from water, measuring oil volume; measure degree of emulsification of the separated oil (mousse)
Amount recovered from shorelines	Oil is mixed with sediment and debris	Measure oil content in solid wastes
Amount of submerged oil removed	Oil contains water and sediments	Measure water and sediment content
Amount chemically dispersed	Dispersant efficiencies are not well measured in past events	Estimate dispersant effectiveness in sample locations
Amount burned	No direct measurement possible	Obtain data on location, timing and conditions so can be estimated

Amount Spilled:

The starting point for a mass balance is usually the amount spilled. However, the amount of oil spilled in an incident is almost always disputed. In principle, the determination of the amount spilled is a simple calculation: the amount on the vessel prior to the incident minus the amount remaining on the vessel after the incident is the amount spilled. This is usually calculated twice: first onboard the vessel, using ullage measurements (the height of the cargo

relative to the top of the tank) and correcting for water bottom (water will leak into the tank, and being heavier than oil, will sit on the tank bottom, displacing the oil). Second, the remaining cargo in the damaged tanks is either lightered to smaller vessels, or directly unloaded at a shoreside facility. Tank reading from the lightering vessels, tank readings from a shoreside terminal, pumping rate information, or a combination of approaches may be used to develop a final loss report. The actual calculations, however, are complicated by the number of tanks on the vessel, damage to the vessel, type of oil (especially whether it needs to be heated), residue left in the tanks, contamination of the cargo with water, and number of lightering vessels. In some cases, the uncertainties associated with these various factors may exceed the volume spilled. The bottom line is that the spill volume data may need to be carefully evaluated by a cargo surveyor.

Spill Location:

Accurate information on the spill location is important to a mass balance calculation because the relative distance to shore, depth, and local oceanographic conditions will be important starting conditions to a fates models. In most cases, accurate location information will be readily available from the USCG or other responders. In a few cases, such as mystery spills, spills that are discovered after the fact, or spills that occur while a vessel is underway (e.g., APEX HOUSTON), identifying the precise location data may be difficult.

Timing and Duration of the Release:

The timing and duration of the release will affect the behavior of the oil (e.g., did it happen on a flood or ebb tide, etc,) and thus accurate information is necessary to establish initial conditions for evaluation of fates and modeling. The NRDA responder should collect information on the beginning time of the incident, the duration of the release, and the amount released per time period. As with spill location, this information is often readily available, but in some circumstances may need to be reconstructed from on-site observers or other sources.

Oil Characteristics:

Oil fates will vary significantly, depending on the physical and chemical behavior of the spilled oil. Important oil characteristics needed for estimating fate are:

1) density
2) viscosity
3) volatile content (operationally, hydrocarbons with boiling points <340°C, see Appendix A)
4) surface tension
5) emulsion (mousse) water content
6) distillation curve data (percent boiled off at temperature intervals)

These parameters may be obtained from the USCG, NOAA HAZMAT, or the vessel or cargo owner. More general information on oil types can be obtained from Environment Canada's Oil

Property Catalog (Bobra and Gallaghan, 1992; Whiticar et al., 1992 and more recent editions), NOAA HAZMAT's ADIOS database, and the NRDAM/CME oil fates model database. In some cases, laboratory analysis of oil samples may be necessary to get the necessary information.

Surface Oiling:

Overflights and ground observations of the extent of oiling should be collated into maps of slick areas and shoreline contamination as a function of time since the spill. Thickness of slicks can be estimated by color and continuity of the oil, and so this information should be recorded. Thickness and volume coverage of oil on shorelines should also be mapped.

Wind and other Environmental Data:

The fate of the spilled oil will depend, in part, on the ambient environmental conditions. Specific data needs include:

1) Wind Speed and direction
2) Air Temperature
3) Water Temperature
4) Cloud Cover
5) Ice Cover
6) Wave Heights

These parameters may be obtained from several sources. Wind, air temperature and cloud cover data are normally available from the local airport or National Weather Service Station. There are also offshore meteorological buoys maintained by NOAA (National Climatic Data Center, Ashville, NC) which can provide such information after the fact. Ice cover should be observed at the time of the spill, as it is not normally recorded by government agencies.

In some cases, available meteorological stations will not be representative of conditions at the spill site, e.g., if the airport is inland, the winds may be quite different than offshore. In these cases, a meteorological station can be set up with an anemometer and temperature recorder.

Current Data:

Current data should ideally be measured at the time of the spill. If this is not feasible, existing data sources may be used. Even if current measurements are made, existing data should be compared to confirm that the current measurements are reasonable. Existing data can complete the description of a measured current field, as well.

Current data is not often available in a single document, but must be compiled from several sources. There are a number of types and sources of current data for the coasts of North America. The largest source of tidal current information, also with the widest coverage, is the National Ocean Service Branch (NOS) of the National Oceanic and Atmospheric Administration (NOAA). The NOS standard publications include tide and tidal current tables and tidal current charts and diagrams. A brief description of each is given below and in Table 2. This information may also be found in the Catalog of Charts and Publications distributed free by NOAA.

In some of the more heavily travelled coastal areas local tide and pilot books may be available. These often have detailed tidal current information for select locations, but may or may not be verified. In addition a great number of numerical modelling studies have been performed on coastal embayments and estuaries around the U.S., often in conjunction with current measurement programs. Model predicted tidal and other currents based on these applications are often available through the literature but may be difficult to track down. Similarly, analyses based on current meter data can provide invaluable information concerning circulation patterns and current speeds in any body of water. For the latter examples, coastal state universities and oceanographically-oriented technological institutions such as Woods Hole Oceanographic Institute, Scripps Institution of Physical Oceanography, U.S Geological Survey, CERC U.S. Army Corp of Engineers etc. are responsible for the publication of this and related work.

Large scale coastal circulation information (usable for background currents) is also available from NOAA in the Strategic Assessment Branch publications titled "Coastal and Ocean Zones Strategic Assessment: Data Atlas". These atlases contain different types of circulation information for each of the US offshore areas including tidal, geostrophic and long term means. On a larger scale still, the Defense Mapping Agency publishes an Atlas of Pilot Charts for the North Atlantic including the Gulf of Mexico and for the North Pacific with (background) current patterns derived from ship drift data.

NOAA's Strategic Assessment Branch has also reviewed physical and hydrologic characteristics for each of the major estuaries of the east, Gulf of Mexico and west coasts of the U.S. their "National Estuarine Inventory Data Atlas, Volume 1: Physical and Hydrologic Characteristics" (November 1985) contains long-term mean river inflows (as volume per time). These may be used to infer river velocities in some cases (i.e., where one river is the main freshwater inflow).

Table 2. Sources of Current Data.

COASTAL TIDE AND CURRENT DATA SOURCES FOR NORTH AMERICA
National Oceanic and Atmospheric Administration (NOAA)
National Ocean Service (NOS)

Distribution Branch, (N/CG33)
National Ocean Service
Riverdale, Maryland 20737-1199
Tel. (301) 436-6990 Fax. (301) 436-6829

Tide Tables:

1. East Coast of North and South America
2. West Coast of North and South America
3. Alaskan Supplement.

Tidal Current Tables:

1. Atlantic Coast of North America.
2. Pacific Coast of North America and Asia.

Tidal Current Charts:

1. Boston Harbor.
2. Charleston Harbor, S.C.
3. Long Island Sound and Block Island Sound.
4. Narragansett Bay.
5. Narragansett Bay to Nantucket Sound.
6. New York Harbor.
7. Puget Sound, Northern Part.
8. Puget Sound, Southern Part.
9. San Francisco Bay.
10. Upper Chesapeake Bay.
11. Tampa Bay.

Regional Tide and Tide Current Tables
New York Harbor to Chesapeake Bay

Tidal Circulation and Water Level Forecast Atlas
Delaware River and Bay

Tidal Current Diagrams

1. Long Island Sound and Block Island Sound
2. Boston Harbor

Coastal and Ocean Zones Strategic Assessment: Data Atlas, Strategic Assessment Branch, National Ocean Service, NOAA:

1. East Coast
2. Gulf of Mexico
3. Bering,Chukchi and Beaufort Seas
4. Gulf of Alaska
5. West Coast

National Estuarine Inventory Data Atlas, Strategic Assessment Branch, National Ocean Service, NOAA:

1. Volume 1: Physical and Hydrologic Characteristics (East and West Coast estuaries; mean river flow)

Defense Mapping Agency (DMA)
Also available through the NOAA Distribution Branch

Atlas Of Pilot Charts
1. North Atlantic Ocean
2. North Pacific Ocean

Other Sources

1. Local Tide and Pilot Books

Example:
Eldridge Tide and Pilot Book
Robert Eldridge White, Publisher
34 Commercial Wharf
Boston, Mass. 02110
Tel. (617) 742-3045
Contains:
Tide and current data for Gulf of Maine to Florida
Current Charts for:
Buzzards Bay
Vineyard and Nantucket Sounds
Long Island and Block Island Sounds
New York Harbor
Current Diagrams for:
Boston Harbor
Narragansett Bay
Chesapeake Bay

2. Hydrodynamic Modeling Studies

Water Contamination and Emulsification:

One of the difficulties in calculating a mass balance is the fact that recovery estimates often include water as well as oil. Recovery estimates may be confounded by 1) water accidentally picked up with the oil; and 2) water-in-oil emulsion (mousse), which is a stable emulsion of small droplets of water incorporated in oil. The formation of mousse depends on oil composition and sea state. Emulsified oil can contain as much as 80% water (Wheeler, 1978; Daling and Brandvik, 1988). In some cases, recovered oil is decanted, removing the free water. However, the decanting process is never 100% efficient and does not generally break down emulsions, so even the decanted oil overestimates the "true" recovery.

Amount Recovered

Cleanup information may be obtained from the U.S. Coast Guard (USCG), by other Federal and State response organizations, the Responsible Party, and their cleanup contractors. Disposal records may also be a source of information. In some instances, daily information may be available for each cleanup activity and operational area (e.g, amount recovered by skimming in a specific area). The quality of cleanup estimates varies widely, depending on whether the estimates are corrected for water contamination and debris, and other biases. Recovery estimates are often highly optimistic, and it is not uncommon to find reports that conclude that more oil was recovered than was spilled.

The cleanup data should be collected at the most detailed level possible, i.e., by location and by time interval. Because weathering and other factors change the oil characteristics rapidly, detailed cleanup data will facilitate calculation of an accurate mass balance.

Amount Dispersed

The amount of oil dispersed naturally and by chemical dispersant application cannot be readily measured in the field. Data needed to estimate natural dispersion are the oil characteristics and environmental conditions noted above.

For chemical dispersants, data should be collected on amount applied, and the location and timing of the application. The responders' observations on effectiveness of the application should be recorded. Also, the condition of the oil, i.e., weather it is emulsified to a mousse and its viscosity, should be noted, as both of these conditions greatly affect the effectiveness of dispersant application (e.g., Daling and Brandvik, 1988).

Amount Burned

Data which will help quantify the amount of oil burned include:

1) location and dimensions of burn footprint
2) timing and duration of burn
3) degree of confinement of oil by booms, etc.
4) quantities and timing of water and fire fighting chemicals applied.

Amount Degraded

Direct measurement of oil degradation in the field is difficult because rates are typically slower than the rates of other processes affecting the fate of the oil. A large number of measurements in space and time would be needed to quantify a degradation rate. Quantification of other confounding processes must also be performed and corrections made.

Since degradation rates are small relative to other processes, this effort is usually not a priority. Alternatively, estimation methods may be used after the fact.

5. ESTIMATION OF MASS BALANCE AND FATE

Water Surface:

Oil volume on water may be estimated from accurate maps of slick areas and their colors. Table 3 contains conversion factors from areas to volumes. Note that if the slick is mousse, correction needs to be made for water content.

Table 3 Conversion factors for calculating volume of oil in slicks based on color (from RPI, 1992, after International Tanker Owners Pollution Federation, 1981).

Oil Type	Oil Appearance (Color)	Approximate Oil Thickness (mm)	Conversion Factor (m3/km2)
Oil sheen	silver	>0.0001	0.1
Oil sheen	iridescent	>0.0003	0.3
Crude and fuel oils	black or dark brown	>0.1	100.0
Water-in-oil emulsions (mousse)	brown or orange	>1.0	1000.0

Atmosphere:

Percent evaporated of spilled oil will approach the percent volatile content of the parent oil after a few days exposure to air. Model algorithms and data for estimating evaporation rates over the first few days are available from Stiver and Mackay (1984), Payne et al. (1983, 1984), Bobra (1992), the NRDAM/CME and the NOAA ADIOS model. The NRDAM/CME uses the Stiver and Mackay algorithm. For back-of-the-envelope calculations, the percent volatile content will suffice.

Burned:

Burning, either intentionally or as a result of an accident, is an additional complication to the mass balance problem. The amount of oil consumed in a ship or barge fire may be difficult to estimate and this uncertainty may be compounded by the contamination of the cargo remaining on-board with water and fire fighting chemicals. Because of the complexity of direct measurement or estimation, the amount lost to burning may be determined by subtracting all other known fates and assuming that the remainder was lost to burning.

However, a rough estimate of the amount lost to burning may be calculated directly, using various assumptions about burn rates and the size and duration of the fire. In controlled studies of floating oil, burn velocities (the rate at which a fire burns downward) of 2-4 mm/minute/m^2 have been observed[1]. However, burning velocity will vary depending on the type of oil, the thickness of the oil, whether the oil is contained in a tank, or floating; and the degree of weathering.

The total amount of oil lost to burning will be a function of the burn rate, the footprint of the fire, and duration of the fire. Determining the appropriate burn rate will likely require specialized expertise, but the NRDA responder may be able to collect the other information from response reports. An example of an estimation of burned mass is in RPI (1992).

Water Column:

It is usually not possible to adequately sample the water column to measure oil content and mass in the water. A more fruitful approach is to use an oil fate model for this calculation. Mass in the water will increase from a very small percentage of the spill under calm conditions or when mousse is present, to high percentages at high wind speeds with large waves (for example, as occurred after the *Braer* spill).

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[1] In: Fire Hazard Calculations for Large Open Hydrocarbon Fires; Building and Fire Research Laboratory, National Institute of Standards and Trends.

Sediments:

Sediment contamination may occur through a variety of processes, including adsorption to particulate matter, and for very dense oils, direct sinking. Heavily contaminated sediments may be detected visually (e.g., divers, underwater video), or using remote sensing (certain types of sonar). Chemical methods may be used to document lower levels of contamination. However, unless large amounts of have sunk to the bottom in nearshore areas, detection and quantification of oil in sediments will often require a considerable sampling effort. As with burning, the amount lost to sedimentation is often calculated through determination of all other fates and subtracting. Alternatively, sediment contamination may be estimated using models. Critical input parameters would include suspended sediment loads and sediment settling velocities (the NRDAM/CME has default values for these parameters).

Shorelines:

Oil on shorelines should be mapped areally and vertically within the sediments. A mass balance can be calculated from volume contaminated and percentage oil estimates. Examples of this type of calculation are in Baca et al. (1983) and Finkelstein and Gundlach (1981).

If such data are not available, and oil came ashore completely covering a shoreline segment, mass on the shore could be estimated using the COZOIL model (Reed and Gundlach, 1989a,b). This model is based on the following. The fate of spilled oil that reaches the shoreline depends on characteristics of the oil, the type of shoreline, and the energy environment. Once beached, oil will continue to weather. However, several additional processes become important: reflotation, penetration into the substrate, and retention/transport in the beach-groundwater system. Erosion of oiled substrate from the beach to offshore sediments may also occur.

CSE/ASA/BAT (1986), Gundlach (1987), Reed and Gundlach (1989a,b) and Reed et al., 1989 have shown that shoreline oil holding capacity varies by oil and shoreline type. Tables 4 and 5 show the maximum oil thickness on the shore as a function of three oil viscosity ranges, average oil penetration, average oil content, and removal time constants for ten shore types. Each shoreline segment has an oil holding capacity based on oil type, shore type, beach slope, beach width (Table 6) and shoreline grid length.

In the model by Reed and Gundlach (1989a), deposition occurs when oil intersects the shore surface. Deposition ceases when the holding capacity for the shore surface is reached. Subsequent oil deposited is not allowed to remain on the shore surface. The shoreline oil is then removed exponentially with time. The removed oil is returned to the water column on a rising tide (sufficiently high to wet the oiled surface) and offshore winds.

Table 4 Maximum surface oil thicknesses for various beach types as a function of oil viscosity (CSE/ASA/BAT, 1986). Volume of oil per area of shore in m^3/m^2 is equivalent to mm thickness divided by 1000.

	Oil Thickness (mm) by Oil Type[1]		
Shore Type	Light (<30 cSt)	Medium (30-2000 cSt)	Heavy (>2000 cSt)
1. Exposed rocky	0.5	2	2
2. Wave cut platform	0.5	2	2
3. Fine sand	4	17	25
4. Coarse sand	4	17	25
5. Mixed sand/gravel	2	9	15
6. Gravel/cobble	2	9	15
7. Exposed tidal flats	3	6	10
8. Sheltered rocky	1	5	10
9. Sheltered tidal flat[2]	6	30	40
10. Sheltered marsh	6	30	40
11. Glacier	2	4	6

Notes:

1. Example oil types are:

Light - Kerosene, gasoline, diesel fuel
Medium - medium to light crude oils and light bunkers
Heavy - heavy bunker oils, heavy and weathered crude

2. It is assumed that sheltered tidal flats have the same oil thickness as sheltered marshes.

Table 5 Oil removal time constants for various oil types (CSE/ASA/BAT, 1986).

Shore Type	Average Oil Penetration Depths (cm)	Average Oil Content (%)	Removal Time Constant (days)
1. Exposed rocky	NA[1]	NA	1
2. Wave cut platform	NA	NA	1
3. Fine sand	4.8	9	1.67-10 (~5)
4. Coarse sand	4.8	9	1.67-10 (~5)
5. Mixed sand/gravel	17.8	9	2-20 (~10)
6. Gravel/cobble	17.8	9	2-20 (~10)
7. Exposed tidal flats	NA	NA	1
8. Sheltered rocky	NA	NA	20-100 (~50)
9. Sheltered tidal flats	NA	NA	100-1000 (~500)
10. Sheltered marsh	NA	NA	100-1000 (~500)
11. Glacier	NA	NA	1

Note: NA - Not Available

Table 6 Typical beach slope and widths by shore type (CSE/ASA/BAT, 1986; CERC, 1984).

Shore Type	Mean Beach Slope (m/m)	Mean Beach Width (m)				
		East Coast	Gulf of Mexico	Californ ia	Pacific NW	Gulf of Alas-ka
1. Exposed rocky	5.7	2	1	2	3	3
2. Wave cut platform	5.7	2	1	2	3	3
3. Fine sand	0.15	10	5-15	10	15	20
4. Coarse sand	0.15	10	5	10	15	20
5. Mixed sand/gravel	0.89	5	5	5	7	10
6. Gravel/cobble	0.89	3	2	3	4	6
7. Exposed tidal flats	0.15	10	10	10	15	20
8. Sheltered rocky	5.7	2	1	2	3	3
9. Sheltered tidal flats	0.01	140	20	120	210	300
10. Sheltered marsh	0.01	140	50	120	210	300
11. Glacier edge	5.7	-	-	-	-	3

Recovered in Cleanup:

Cleanup reports should be carefully evaluated to determine whether adjustments have been made for water contamination. Measurements and adjustments may be necessary. Storage and handling procedures for the skimmed wastes need to be identified. The oil may also have weathered, such that volatiles have evaporated, after recovery and this evaporation should be corrected for.

For solid wastes recovered from shorelines and cleanup operations, the estimation of oil volume is extremely difficult and tedious. If the total volume of wastes is relatively small, it might be safely ignored. Otherwise sampling and measurements need to be made.

Dispersed:

Estimation of oil dispersed naturally will require an oil fate modeling approach. Measurement in situ is not practical given rapid dispersion and sampling difficulties. (Fates modeling literature is cited above in Section 3.)

Degraded:

Oil degradation rates are available in the literature, but they vary substantially by oil type, weathering state, and local conditions. Temperature, nutrient supply and aeration are important factors to consider. For mass balance purposes, however, the amount degraded may be estimated by difference after accounting for other processes, or even ignored, since it is a small percentage of the total spill.

6. EXAMPLE CASES

An example of the difficulties which arise in estimating spilled volume and cleanup is provided by the *Morris J. Berman* case. Table 7 summarizes estimates of oil recovery by skimmers. Note that the three sources of information do not always agree. In addition, 41,300 gal. of submerged oil, after correction for water content of the waste, was recovered. All the fluid wastes were place in a large barge. No measurement of the water content of the waste barge was made, but rough estimations were available.

Table 8 outlines an overall mass balance of the spill based on the available data. If the rough estimate of 35% water in the liquid waste barge is assumed, skimming recovered 84% of the spilled oil. Assuming all the volatiles evaporated (20%), more oil was estimated skimmed than was available on the water surface! Clearly the 35% figure is too low, or perhaps the spill amount was inaccurate. Measurement of the water content of the wastes would help resolve this issue.

Data for the *Morris J. Berman* spill were used as inputs to the NRDAM/CME for the calculation of fates and mass balance. The NRDAM/CME has been used for several other spills in this manner, and is available to trustees for such purposes.

Back-of-the-envelope and manual calculations of mass balance have been performed on a number of spills based on field observational data. The reader is referred to Baca et al. (1983), Finkelstein and Gundlach (1981), and RPI (1992) for details.

Oil weathering models, such as ADIOS (prepared by NOAA HAZMAT), are very useful for quick estimation of mass balance. ADIOS contains oil property data for numerous oils and products. ADIOS calculates a simple mass balance based on generally-accepted evaporation, emulsification, spreading and entrainment algorithms. Inputs are amount spilled and timing, wind and wave conditions, temperature, water density, and, if desired, certain oil parameters.

Outputs include estimated oil density, viscosity, water content, percent evaporated, percent dispersed, and percent remaining on the water surface as a function of time since the spill.

Tables 9 to 20 provide some examples of ADIOS outputs which illustrate how fate and mass balance vary by oil type and conditions. The most important oil parameters are viscosity and percent volatiles. The most important environmental conditions are wind speed and wave height. These parameters were varied in producing the tables.

Lighter products and crudes contain high volatile content, and so much of the material evaporates rapidly. Evaporation is slower and involves a smaller percentage of oil for heavy oils. Evaporation rate increases with wind speed and temperature (Tables 9-20).

Dispersion into the water column increases with wind speed and wave height. However, emulsification can also occur (if the oil emulsifies) increasing with wind speed and wave height. Emulsification increases oil viscosity, which in turn slows dispersion. At a certain threshold, an oil is too viscus to entrain into the water column, and so dispersion is low. Daling and Brandvick (1988) have measured these thresholds for several oils.

Table 21 provides an example mass balance for the *Mega Borg* spill prepared by RPI (1992). For this spill, the total amount of oil lost was based on oil missing from the cargo. A major portion of the lost oil burned. However, the amount burned could not be directly estimated with confidence. Instead, it was estimated by difference, after estimating the amounts in the water, on the shorelines and recovered in cleanup operations, which was assumed to be the amount discharged (rather than burned).

Oil recovery estimates were based on volume of oil/water mixture skimmed, corrected for water content and for evaporation based on the time skimmed and the weathering model by Payne et al (1991b). Shoreline oil was estimated from shoreline surveys and corrected for evaporation using the same weathering model and assuming exposure to evaporation over the average time it took for the oil to reach shore.

Oil volumes in surface slicks and sheens were estimated using overflight observations and the conversion factors in Table 3. In the ultimate mass balance, the final observed sheen distribution was used (Table 21).

Oil volumes dispersed into the water column were estimated using field samples of hydrocarbon concentrations under the slicks. The area of the slick times a depth of 3 m times the concentration measured in the upper 3 m gave an estimated mass in the water column. Clearly this is a rough estimate of oil dispersed into the water column, but it provides a field estimate of dispersion as a percentage of slick volume, for both naturally and chemically dispersed slicks.

The sum of recovered oil, oil in sheens, and oil in the water column was subtracted from the missing cargo volume to estimate oil burned. The mass balance (Table 21) was then used to evaluate potential for injuries to water column biota (e.g., shrimp).

Wolfe et al (1994) evaluated the mass balance of the *Exxon Valdez* (Table 22 and Figures 1-3). Figures 1-3 (from Wolfe et al, 1994) give a time history of the mass balance, with Figure 3 being the simplest presentation. Table 22 presents the ultimate fate. The distribution of floating oil and amount beached were estimated using the NOAA On Scene Spill Model (OSSM) with corrections made by comparison to overflights.

In the first 10 days following the March 24 spill, most of the oil was floating. By 10 days 40% was evaporated, dispersed or beached (~2%), with 60% remaining floating. However, the floating oil quickly beached and further evaporated so that by May 1, 46% of the oil was beached while only 4% remained floating. NOAA's Oil Weathering Model (OWM) (developed by Payne et al, 1991a) was used to estimate rates and amounts of oil evaporated and dispersed based on composition of the oil, area and thickness of the slick, temperature and wind speed.

Oil skimmed was emulsified. Thus, measurement of water content was used to correct the mousse volume skimmed to actual oil recovered. Oily solid wastes were found to be about 4.5% oil.

Water column degradation (photolysis and biodegradation) was estimated using literature decay rates. Shoreline degradation and transport to subtidal sediments was estimated from shoreline oil content measurements over time and from sediment traps near oiled beaches.

7. CONCLUSIONS

Calculation of an oil mass balance facilitates full accounting of all oil spilled and potential exposure to natural resources. It points out data needs which are critical and perishable. Table 1 summarizes the data needs which are perishable (if no other agency or entity is collecting such information).

The *Mega Borg* and *Exxon Valdez* mass balance estimations discussed above demonstrate:

(1) the physical-chemical processes and fates of oils which are significant to injury determination

(2) the considerable data needs and difficulty in performing a field sample-based estimate of mass balance

Thus, use of oil fate models to estimate a mass balance is highly recommended. Field sampling and observations can then serve to correct, strengthen and validate the model estimates.

The running of ADIOS on scene will help determine where spilled oil has gone in the environment. Running of the NRDAM/CME will provide spatially-explicit information on fates and mass balance. These tools are very useful for designing a sampling plan and NRDA strategy.

Table 7. Oil-water mix (bbl.) recovered (cleaned up) by date based on three sources of information.

NRC values are volumes estimated to be in the barge, from M. Noel, NRC, 1/26/94; NOAA HAZMAT estimates are amounts (bbl.) in the barge including solids; Daily Fact Sheets are USCG estimates of the amounts of oil-water mix skimmed. Fact Sheet values began on January 14 with a cummulative recovery volume of 15570 bbl. The table values assume that the recovery amount was equal each day up to Jan. 14.

Date	NRC Values			HAZMAT	Daily
Jan.	morning	night	daily tot.	estim.	Fact Sheets
9	2011.83	1422.16	3433.99	3900.0	2595.0
10	1746.37	1599.91	3346.28	1500.0	2595.0
11	2439.95	673.71	3113.66	2500.0	2595.0
12	861.94	722.6	1584.54	3600.0	2595.0
13	1068.61	852.65	1921.21	1900.0	2595.0
14	1170.34	1278.82	2449.16	2400.0	2595.0
15	325.03	316.63	641.66	800.0	2021.0
16	753.13	676.66	1429.79	1400.0	2615.0
17	833.71	832.79	1666.5	1000.0	2177.0
18	527.5	475.11	1002.61	900.0	799.0
19	221.72	264.42	486.14	500.0	308.0
20	8.63	267.8	276.43	500.0	241.0
21	11.53	0.	11.53	300.0	572.0
22				600.0	
23				400.0	
24				700.0	
25				300.0	
26				600.0	
27				400.0	
28				300.0	
29				300.0	
30				200.0	
31				600.0	

Table 8. Mass balance of the Morris J. Berman oil spill, January 7, 1994 based on HAZMAT information obtained by Feb. 9, 1994.

---

(1) Amount on barge initially: 35,000 bbl.

(2) Removed by Lightering:

21,700 bbl. of oil-water mix lightered off,
estimated 30% water by soundings in barge
15,190 bbl. of oil lightered off

(3) Amount Spilled:

19,810 bbl. of oil spilled (or sank with barge)
by subtraction of (1) - (2):
17,000 bbl. of oil believed spilled at grounding time (1/2 cargo)
2,810 bbl. of oil spilled/sank following days, assuming above

(4) Recovered in Cleanup:

25,600 bbl. of oil-water mix recovered mostly by skimming,
estimated 35% water

16,640 bbl. of oil estimated cleaned up Jan. 9-31
= 84% of amount spilled

10,270 bbl. of oil cleaned up Jan. 9-14
6,370 bbl. of oil cleaned up Jan. 15-31

(5) Evaporation:

20% of amount spilled
(HAZMAT estimate based on volatile content)
= 3,962 bbl. of oil if cargo was 35,000 bbl.

(6) Unaccounted for:

remaining in environment plus that cleaned from beaches
= -792 bbl. of oil

Suggesting all oil not evaporated was recovered!

(7) Solid Wastes:

6,000 yd3 from decon operations
600 yd3 of oiled sand from beach cleanup

Table 9. Sample mass balance for spill of No. 6 fuel oil, wind 5 kts.

Oil Budget Table

Oil Name: FUEL OIL NO.6
API: 11.8 Pour Point: between -4.0 C and 15.0 C
Mousse Const: 18% evaporated
Wind Speed: Constant at: 5 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	0	0	100
6	100	0	0	100
9	100	0	0	100
12	100	0	0	100
15	100	1	0	99
18	100	1	0	99
21	100	1	0	99
24	100	2	0	98
30	100	3	0	97
36	100	4	0	96
42	100	6	0	94
48	100	7	0	93
60	100	10	0	90
72	100	12	0	88
84	100	13	0	87
96	100	15	0	85
108	100	16	0	84
120	100	17	0	83

Table 10. Sample mass balance for spill of No. 6 fuel oil, wind 12 kts.

Oil Name: FUEL OIL NO.6
API: 11.8
Mousse Const: 18% evaporated
Wind Speed: Constant at: 12 kn

Pour Point: between -4.0 C and 15.0 C

Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	0	0	100
6	100	0	0	100
9	100	1	0	99
12	100	2	0	98
15	100	3	0	97
18	100	4	0	96
21	100	5	0	95
24	100	7	0	93
30	100	9	0	91
36	100	11	0	89
42	100	13	0	87
48	100	14	0	86
60	100	17	0	83
72	100	19	1	80
84	100	20	1	79
96	100	21	1	78
108	100	22	1	77
120	100	23	1	76

Table 11. Sample mass balance for spill of No. 6 fuel oil, wind 20 kts.

Oil Name: FUEL OIL NO.6
API: 11.8 Pour Point: between -4.0 C and 15.0 C
Mousse Const: 18% evaporated
Wind Speed: Constant at: 20 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	0	0	100
6	100	1	0	99
9	100	2	0	98
12	100	4	0	96
15	100	6	0	94
18	100	8	0	92
21	100	10	0	90
24	100	11	1	88
30	100	13	1	86
36	100	15	1	84
42	100	17	2	81
48	100	18	2	80
60	100	20	2	78
72	100	22	3	75
84	100	23	4	73
96	100	24	4	72
108	100	25	5	70
120	100	26	5	69

Table 12. Sample mass balance for spill of No. 2 fuel oil, wind 5 kts.

Oil Name: FUEL OIL NO.2
API: 31.6 Pour Point: between -27.0 C and -6.0 C
Mousse Const: No mousse formation is expected.
Wind Speed: Constant at: 5 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	5	0	95
6	100	13	0	87
9	100	20	1	79
12	100	27	1	72
15	100	32	2	66
18	100	37	3	60
21	100	41	4	55
24	100	44	5	51
30	100	50	6	44
36	100	54	8	38
42	100	57	10	33
48	100	60	11	29
60	100	64	14	22
72	100	66	16	18
84	100	68	18	14
96	100	69	19	12
108	100	70	20	10

Table 13 Sample mass balance for spill of No. 2 fuel oil, wind 12 kts.

ADIOS(TM) 1.1

Oil Name: FUEL OIL NO.2
API: 31.6 Pour Point: between -27.0 C and -6.0 C
Mousse Const: No mousse formation is expected.
Wind Speed: Constant at: 12 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	13	2	85
6	100	26	8	66
9	100	34	15	51
12	100	40	22	38
15	100	44	28	28
18	100	47	33	20
21	100	48	37	15
24	100	49	40	11

Table 14 Sample mass balance for spill of No. 2 fuel oil, wind 20 kts.

ADIOS(TM) 1.1

Oil Name: FUEL OIL NO.2
API: 31.6 Pour Point: between -27.0 C and -6.0 C
Mousse Const: No mousse formation is expected.
Wind Speed: Constant at: 20 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
1	100	5	2	93
2	100	13	6	81
3	100	19	12	69
4	100	25	18	57
5	100	29	24	47
6	100	32	31	37
7	100	34	36	30
8	100	36	41	23
9	100	37	45	18
10	100	38	49	13
11	100	39	52	9

Table 15 Sample mass balance for spill of Alaskan North Slope crude, wind 5 kts.

Oil Name: ALASKA NORTH SLOPE
API: 26.4 Pour Point: -18.0 C
Mousse Const: 0% evaporated
Wind Speed: Constant at: 5 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient distillation emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	11	0	89
6	100	16	0	84
9	100	18	0	82
12	100	20	0	80
15	100	22	0	78
18	100	23	0	77
21	100	24	0	76
24	100	25	0	75
30	100	26	0	74
36	100	27	0	73
42	100	28	0	72
48	100	29	0	71
60	100	30	0	70
72	100	31	0	69
84	100	32	0	68
96	100	32	0	68
108	100	33	0	67
120	100	33	0	67

Table 16 Sample mass balance for spill of Alaskan North Slope crude, wind 12 kts.

Oil Name: ALASKA NORTH SLOPE
API: 26.4 Pour Point: -18.0 C
Mousse Const: 0% evaporated
Wind Speed: Constant at: 12 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient distillation emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	14	0	86
6	100	18	0	82
9	100	20	0	80
12	100	22	0	78
15	100	23	0	77
18	100	24	0	76
21	100	25	0	75
24	100	26	0	74
30	100	28	0	72
36	100	29	0	71
42	100	30	0	70
48	100	31	0	69
60	100	32	0	68
72	100	33	0	67
84	100	34	1	65
96	100	35	1	64
108	100	35	1	64
120	100	36	1	63

Table 17. Sample mass balance for spill of Alaskan North Slope crude, wind 20 kts.

Oil Name: ALASKA NORTH SLOPE
API: 26.4 Pour Point: -18.0 C
Mousse Const: 0% evaporated
Wind Speed: Constant at: 20 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient distillation emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	16	0	84
6	100	19	0	81
9	100	21	0	79
12	100	23	0	77
15	100	25	0	75
18	100	26	0	74
21	100	27	0	73
24	100	28	0	72
30	100	30	1	69
36	100	31	1	68
42	100	32	1	67
48	100	33	1	66
60	100	34	2	64
72	100	35	2	63
84	100	36	3	61
96	100	36	3	61
108	100	37	4	59
120	100	37	4	59

Table 19. Sample mass balance for spill of ARAMCO Arabian Light crude, wind 12 kts.

Oil Name: ARABIAN LIGHT, ARAMCO
API: 33.5 Pour Point: -15.0 C
Mousse Const: 14% evaporated
Wind Speed: Constant at: 12 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	24	0	76
6	100	29	1	70
9	100	31	1	68
12	100	33	1	66
15	100	34	1	65
18	100	36	1	63
21	100	37	1	62
24	100	38	1	61
30	100	40	1	59
36	100	41	1	58
42	100	42	1	57
48	100	43	1	56
60	100	45	1	54
72	100	46	2	52
84	100	47	2	51
96	100	47	2	51
108	100	48	2	50
120	100	49	2	49

Table 20. Sample mass balance for spill of ARAMCO Arabian Light crude, wind 20 kts.

Oil Name: ARABIAN LIGHT, ARAMCO
API: 33.5 Pour Point: -15.0 C
Mousse Const: 14% evaporated
Wind Speed: Constant at: 20 kn Wave Height: Default values

Water Temperature: 10 C
Instantaneous release of 100 m ton
*Insufficient emulsification data, answers may be inaccurate.

Time hours	Total Released metric tons	Evaporated percent	Dispersed percent	Floating percent
0	100	0	0	100
3	100	26	1	73
6	100	30	1	69
9	100	32	2	66
12	100	35	2	63
15	100	36	2	62
18	100	38	2	60
21	100	39	2	59
24	100	40	2	58
30	100	42	2	56
36	100	43	2	55
42	100	44	3	53
48	100	45	3	52
60	100	47	3	50
72	100	48	4	48
84	100	48	4	48
96	100	49	4	47
108	100	50	5	45
120	100	50	5	45

Table 21. Mass balance for the Mega Borg spill of 8-29 June 1990 (from RPI, 1992).

Oil Source	Total bbls Recovered/ Estimated	Estimated bbls Evaporated	Estimation of Initial bbls Required
Volume Un-Accounted for	——	——	121,561
Sinking	——	——	——
Skimming	5,405	5,405	10,810
Beach Deposition	3	9	12
Sheens	18,671	27,867	46,538
Totals	24,079	33,281	57,360
Estimated Loss due to:			
Natural Dispersion in Water Column			2,024
Chemical Dispersion in Water Column			432
Total Dispersion Loss			2,456
Estimated Total Product Discharged	57,360 + 2,456 =		59,816
Estimated Total Product Loss due to Incineration (calculated by difference)	121,561 - 59,816 =		61,745

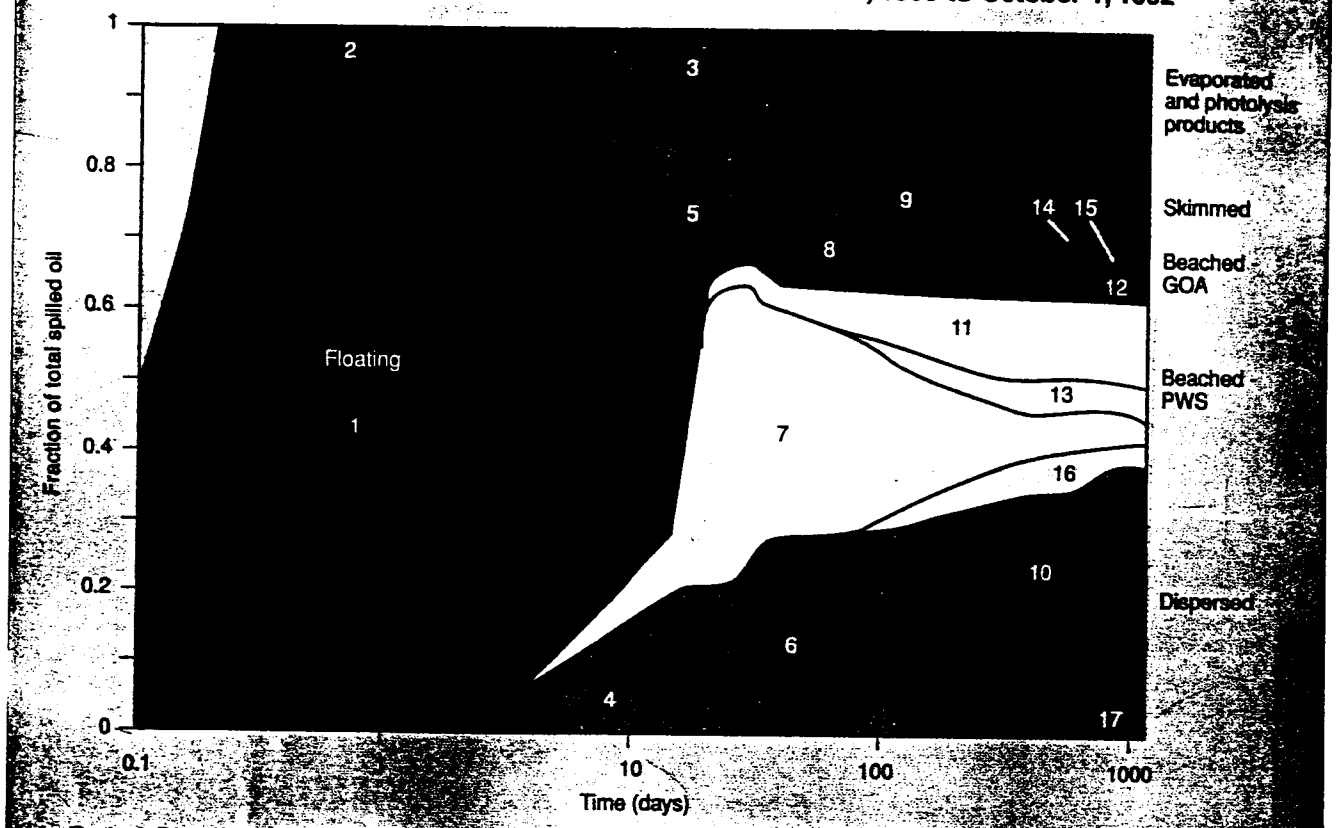
Table 22 Provisional summary mass balance (as of fall 1992) (from Wolfe et al., 1994).

Compartment	Estimate	Minimum	Maximum
Subtidal sediments[a]	0.13	0.08	0.16
Floating	0.00	0.000	0.0
Beached[a]	0.02	0.001	0.04
Recovered/disposed	0.14	0.12	0.18
Dispersed[a]	<0.01	0	0.01
Aqueous biodegradation and photolysis products	0.50	0.4	0.6
Atmospheric photolysis products	0.20	0.18	0.25

[a]Primarily as refractory oil residuals (>60% in nearshore subtidal and beached; >90% in offhosre sediments and dispersed).

FIGURE 1

The fate of *Exxon Valdez* oil: Overall mass balance from March 24, 1989 to October 1, 1992



1 = Floating in Prince William Sound (PWS); 2 = evaporated hydrocarbons; 3 = atmospheric photolysis products; 4 = dispersed in PWS; 5 = floating in Gulf of Alaska (GOA); 6 = dispersed in GOA; 7 = beached in PWS; 8 = beached in GOA; 9 = retrieved by skimmers; 10 = biodegraded in water; 11 = biodegraded on PWS beaches; 12 = biodegraded on GOA beaches; 13 = retrieved (cleaned up) from PWS beaches; 14 = retrieved from GOA beaches; 15 = eroded and dispersed from GOA beaches; 16 = eroded from PWS beaches to shallow subtidal zone; 17 = oil residuals to offshore sediments. Greater detail is provided for the "Beached-PWS" section of this mass balance in Figure 2.

FIGURE 2
Fate of *Exxon Valdez* oil beached inside Prince William Sound, exclusive of oil dispersed through the action of winter storms and cleanup activities

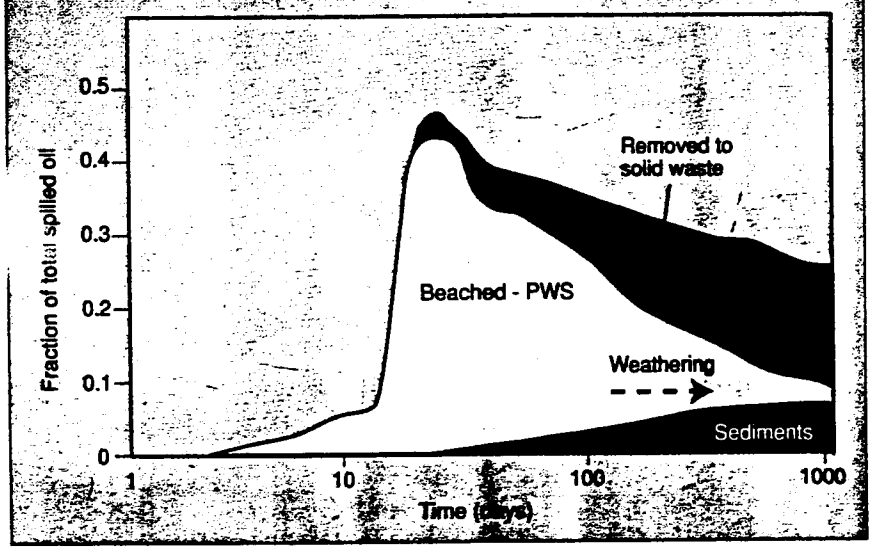
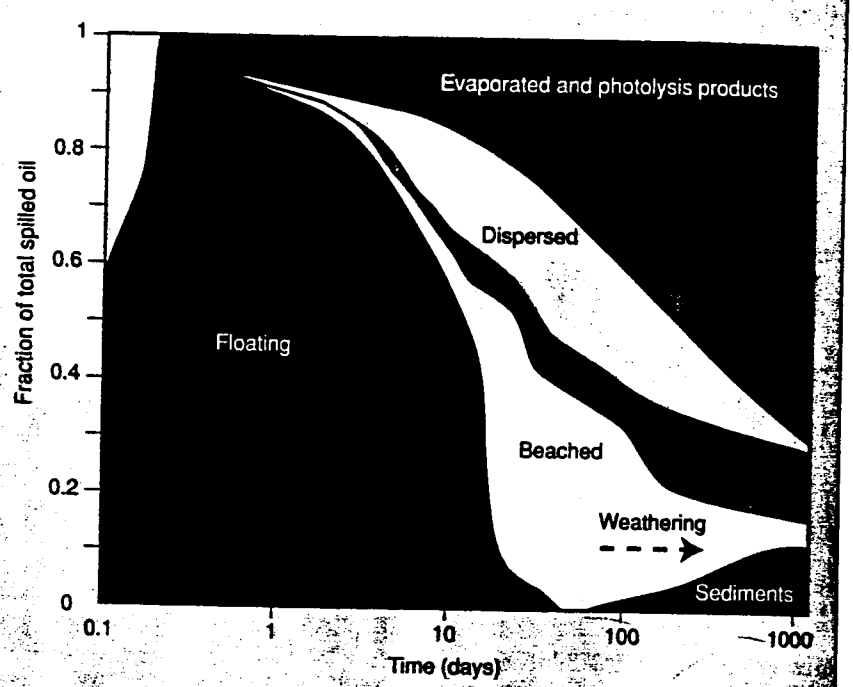


FIGURE 3

Overall fate of *Exxon Valdez* oil, recombining and summarizing compartments illustrated in Figures 1 and 2



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Appendix A. Volatile Aromatics in Oils (340°C = 644°F is the assumed boiling point limit for volatiles).

Aromatic (Synonyms)	Formula	Molecular Weight	Boiling Point (°C)
AR#1: Aromatics < 100 mol. wt:			
Benzene	C^6H^6	78	80
Toluene (methylbenzene)	$C^5H^5CH^3$	92	110.6
Phenol (hydroxybenzene)	$C^6H^5NO^2$	94	182
AR#2: Aromatics > 100 mol. wt:			
Xylenes (dimethylbenzenes)	$C^6H^4(CH^3)^2$	106	138-144
Ethylbenzene	C^8H^{10}	106	136
Styrene (ethenylbenzene)	$C^6H^5CH{=}CH^2$	104	146
Cumene (isopropylbenzene)	C^9H^{12}	120	152
Chlorobenzene	C^6H^5Cl	112.56	132
Nitrobenzene	C^6H^5NO2	123	211
Diethylbenzene	$C^{10}H^{14}$	134	183
Biphenyl	$C^{12}H^{10}$	154	256
Naphthalene	$C^{10}H^8$	148	218
Tetralin (tetrahydronaphthalene)		132	208
Naphthalenes (substituted, in general)		-	≤340
Anthracene	$C^{14}H^{10}$	178	340
Anthracenese (substituted, in general)		--	≤340
Phenanthrene	$C^{14}H^{10}$	178	340
Phenanthrenes (substituted, in general)		--	≤340

APPENDIX 14

Safety Guidelines:

Introduction

OSHA Training Requirements

Medical Surveillance

Generic Site Safety Plan for Oil Spill Activities

Safety Guidelines and Checklists

- *General Safety Gear Checklist*
- *Safety Acronyms List*
- *Checklist of Exposure Recommendations and Symptons of Oil Over-Exposure*
- *Extreme Temperature Environments Safety Checklist*
- *Small Boat Safety Checklist*
- *Aircraft Safety Checklist*
- *Airboat Safety Checklist*
- *Snorkeling Safety and Gear Checklist*
- *Safety Concerns During In-Situ Burning*

INTRODUCTION

The early damage assessment response to an oil or chemical spill may require that DAC and contractor personnel work in areas that pose a threat to health and safety. Each incident will pose special problems, and on-scene personnel must take the time to identify, evaluate, and take steps to avoid or minimize risks. This evaluation should be updated periodically as information is collected and as conditions and circumstances change. Health and safety risks include exposure to hazardous chemicals, but in most situations, physical hazards related to field work in remote areas may be much more likely. These hazards include aircraft crashes, slipping, falling, being struck by moving equipment, heat and cold stress, drowning, dangerous plants or animals, etc. This section summarizes the basic safety requirements and provides information and checklists that highlight safety considerations.

OSHA TRAINING REQUIREMENTS[1]

I. INITIAL TRAINING

The **Code of Federal Regulations**, Section 29, Subsection 1910.120, Paragraph E [29 CFR 1910.120(e)] states that all employees working on sites containing hazardous wastes shall receive training in health and safety issues and procedures before going on-site. Damage Assessment Center (DAC) Rapid Assessment Program (RAP) personnel generally fall under the category of workers who are on-site occasionally for specific limited tasks such as monitoring or general surveying, who are not likely to be exposed to hazardous wastes over permissible or published exposure limits. These personnel are required to receive a minimum of 24 hours of training offsite and one day of field experience under a trained, knowledgeable supervisor. The 24-hour requirement is generally referred to as the 24-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training. These courses are taught by trained and qualified instructors and organizations, and cover specific topics specified in Regulation **29 CFR 1910.120(e)**. OSHA furthermore requires that HAZWOPER instructors provide training certification for employees who complete the 24-hour training program.

II. REFRESHER TRAINING

OSHA also requires eight hours of annual refresher training for employees who are required to receive initial HAZWOPER training. The eight hours of refresher training includes review of topics covered under the initial HAZWOPER course, critiques of incidents occurring in the past year, and any other relevant health and safety topics. Refresher training does not necessarily require formal training and does not require certification. However, to document refresher training, a documentation form has been developed for DAC RAP personnel to record the hours and topics to be applied to the refresher requirements. A blank form and an example of a completed form a provided on the following pages.

[1] This brief summation of OSHA training requirements should in no way serve as a substitute for more detailed review of Regulation **29 CFR 1910.120(e)**.

DOCUMENTATION OF TRAINING HOURS APPLIED TO OSHA 8-HOUR REFRESHER REQUIREMENT

NAME: _____

AFFILIATION: _____

NUMBER OF HOURS: _____

TRAINING: _____

LOCATION: _____

DATE: _____

SUMMARY OF APPLICABLE ACTIVITIES:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(Signature)

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
Office of Ocean Resources Conservation and Assessment
Silver Spring, Maryland 20910

NOV 14 1994

DOCUMENTATION OF TRAINING HOURS APPLIED TO OSHA 8-HOUR REFRESHER REQUIREMENT

Name: Scott Zengel

Affiliation: Research Planning, Inc.

Number of hours: 2.5

Training: NOAA DAC Rapid Assessment Program (RAP) Annual Training

Location: Narragansett, Rhode Island

Date: September 12-16, 1994

Summary of Applicable Activities:

Readings, presentations, demonstrations, and discussion of various safety topics of importance to DAC/RAP personnel. Topics included:

- site safety plans
- dealing with heat stress
- hypothermia and cold water survival
- small boat safety
- helicopter safety
- fixed-wing aircraft safety
- diving/snorkeling in contaminated waters
- packing and shipping hazardous materials.

Doug Helton

Doug Helton, NOAA Damage Assessment Center, DAC-RAP 1994 training course

MEDICAL SURVEILLANCE [2]

I. MEDICAL SURVEILLANCE REQUIREMENTS

Regulation **29 CFR 1910.120(f)** states that certain employees working on sites containing hazardous wastes shall be enrolled in a medical surveillance program. For DAC RAP personnel, medical surveillance would only be required for employees who may have been exposed to hazardous materials above permissible or published exposure levels for 30 days or more a year, and/or employees who are injured, become ill, or develop symptoms due to possible overexposure to hazardous substances or health hazards. Based on current RAP activities and levels of response, medical surveillance may not be required, but may be initiated at the request of the individual.

II. EXPOSURE SURVEY

In order to monitor exposure, each RAP team member should complete an exposure survey following each spill response and on a yearly basis. A copy of these forms should be provided to DAC headquarters. The survey provides a record of the employee's exposure history. An exposure survey typically includes a list of the spills/sites visited during the past year, the specific hazards present at each site, any protective gear that was used, the work tasks (overflights, beach surveys, etc.) performed, the physical effort and duration of the work, and a master list of the particular types and amounts of chemicals/substances the employee may have been exposed to. An exposure survey template is provided below.

[2] This brief summation OSHA Medical Surveillance and Record Keeping Requirements should in no way serve as a substitute for more detailed review of Regulation **29 CFR 1910.120(f)** and **29 CFR 1910.20(d)**.

NOAA DAC RAP EXPOSURE SURVEY

Name and date: _____

Job title: _____

Affiliation: _____

Work address: _____

Work phone: _____

Date of birth: _____

Sex: _____

All the following questions refer to employment experiences while a member of the DAC RAP Team. This form should be completed after each response event. This form can also be used as an annual exposure survey. The intent of this survey is to record employee exposures and potential exposures to hazardous substances and conditions. If there are any concerns regarding exposure or potential exposure, or if any medical treatment is required, the employee should contact their supervisor immediately.

1) List the major site(s) or spill(s) for which you have gone on-scene. Include dates, specific hazards, etc.

2) List the on-scene activities performed (overflights, shoreline surveys, snorkel surveys, oil sampling, etc.), and the number of days performing each.

3) List any protective gear you used while on-scene (respirator, chemical protective clothing, etc.). Include the duration of use and the work effort (light, moderate, heavy, maximal).

4) List all hazardous chemicals, substances, etc. you may have been exposed to (acids, caustics, pesticides, metals, dusts/particles, solvents, other chemicals, physical hazards, biological hazards, etc.). Be as specific as possible; include the frequency and duration of possible exposure.

5) Describe in detail any symptoms you have experienced that might be the result of exposure to hazardous materials while on-scene. Include the duration of the symptoms and any medical attention or treatment received.

SITE SAFETY PLANS[3]

Regulation **29 CFR 1910.120(b)** requires that a site-specific safety and health plan be developed and kept on-site to address the safety and health hazards of each phase of site operation. Furthermore, the site safety plan should include the requirements and procedures for employee protection. The elements of a site safety plan should address at least the following topics: 1) the safety and health risk or hazard analysis for each site task and operation; 2) employee training assignments; 3) personal protective equipment (PPE) to be used by employees for each site task and operation; 4) medical surveillance requirements; 5) frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques, instrumentation, and equipment to be used; 6) site control measures; 7) decontamination procedures; 8) the emergency response plan; 9) confined space entry procedures; and 10) the spill containment program. Specific requirements for several of the elements listed above are described in greater detail in Regulation **29 CFR 1910.120**, paragraphs d, e, f, g, j, k, l.

In addition to the elements listed above, the site safety plan should also provide for pre-entry briefings to be held prior to initiating any site activity, and anytime thereafter as necessary, to ensure that employees are aware of the site safety plan and are following it. In addition, inspections should be conducted by a designated site safety and health supervisor to determine the effectiveness of the site safety plan. Any deficiencies in the plan must be corrected by the employer. As an example, a generic site safety plan is provided on the following pages.

[3] This brief summation site safety plan requirements should in no way serve as a substitute for more detailed review of Regulation **29 CFR 1910.120(b)**, and related paragraphs and subsections.

GENERIC SITE SAFETY PLAN FOR OIL SPILL ACTIVITIES
NOAA DAMAGE ASSESSMENT CENTER

This site safety plan should provide the necessary information to NOAA/DAC personnel and contractors working on an oil spill site, per OSHA and NCP requirements. After reading and understanding it, sign your name at the sign-up sheet on the last page.

A. SITE DESCRIPTION

Location:

Hazards: Oil Type: _____
Treatment Chemicals: _____
General Safety Hazards: _____

Weather Related Hazards: __ heat stress __ hypothermia __ frostbite __ severe storms __ fog
other: _____

Surrounding Population: __ industrial __ residential __ rural __ unpopulated
other: _____

Topography: __ rocky __ sand/gravel beach __ docks __ marshes __ tidal flats
other: _____

B. SITE ORGANIZATION

Function and Name	Phone Number
FOSC:	
Scientific Support Coordinator:	
DAC Team Leader	
Site Safety and Health Officer:	
Responsible Party:	
State Trustee Representative:	
Other Federal/State/Local Reps:	

C. ON-SITE ACTIVITIES

___ site surveys by foot
___ overflights
___ sampling (water, sediment, biota)
___ OTHER activities
_____

___ collection of oiled/dead wildlife
___ boat surveys
___ diving

Activity plans are to be developed daily, and all persons involved in these activities must receive a safety briefing.

D. SITE CONTROL

1. ***Reporting***: Anyone entering or departing a work area, or associated control zones, shall report to the site supervisor.

2. ***Site Safety Plan***: No person shall enter a site without subscribing to this or another approved Site Safety and Health plan.

3. ***Training***: No person shall enter a site without adequate training in hazardous waste operations safety and health; based on work assignment and applicable hazardous conditions.

4. ***Site Boundaries***: The following control boundaries have been established, and should be marked as follows:

   A. Exclusion (Hot) Zone(s): Orange, red, or black and yellow
   B. Contamination Reduction (Warm) Zone(s): Yellow
   C. Support (Cold) Zone(s): Green

The above zones shall be marked as needed to control traffic and enforce decontamination procedures. Appropriate placards, barricades, traffic cones, and/or boundary tape shall be used for this purpose. The Site Safety Officer shall periodically inspect work areas to ensure the effectiveness of boundaries.

5. ***Site Map***: The site safety map is attached and shall be modified as necessary for each sector by the site safety supervisor when any of the following are modified:

   A. Exclusion Zone Boundaries.

   B. Contamination Reduction Zone: Boundaries, decontamination layout, equipment storage, temporary waste storage areas, washing, and toilets and hygiene facilities.

   C. Support Zone: Boundaries, first aid stations, emergency fire fighting equipment, command posts/office spaces, new equipment staging/storage, eating/rest areas, and bird/mammal cleaning and rehabilitation.

   D. Location of Unidentified Hazards: Underground cables, overhead cables, pits, trenches, open holes/hatches, wasted deck plate, hearing protection areas, hard hat areas, suspected locations of poisonous plants, insects, or animals, high pressure wash areas, bioremediation application areas, and dispersant application areas.

E. HAZARD EVALUATION

CHEMICAL HAZARDS (check appropriate category of oil, or attach MSDS if available).

___ ***Oils Containing Benzene***: including crude, gasoline, military JP4, commercial JET B, aviation gasoline, gas oils, and feed stocks.

Composition: Composed of an indefinite petroleum distillate mixture. May contain benzene, toluene, xylene, and polynuclear aromatic hydrocarbons (PAHs) in concentrations that may vary widely depending on the source of the oil, weathering, and aging.

Hazard Description: May cause dermatitis by skin contact; nausea by inhalation; and eye irritation. Benzene is a hematological toxin (it affects the blood and blood forming organs), and is a carcinogen. The most important potential benzene, toluene, or xylene hazard is in poorly ventilated areas (such as pits or under docks), or around freshly spilled oil. Benzo(a)pyrene is a skin contact hazard and potentially may cause skin cancer with chronic skin contact. As oil weathers and ages, benzo(a)pyrene becomes more concentrated because it evaporates much slower than other chemicals in the mixture.

Basic Precaution: Stay away from, or upwind of, fresh oil spills; wear chemical resistant clothing as necessary to protect against skin or eye contact; periodically change protective clothing that has oil on it; immediately change clothing that is showing evidence of oil penetrating to your skin; and wash skin with soap and water when changing into street clothing, before eating/drinking, or when exiting to a contamination reduction zone. Flush eyes with water if oil gets in them. If ingested, do not induce vomiting—contact a physician. Urine phenol should be tested as soon as possible (and not later than 72 hours after exposure) if there is a suspected overexposure to benzene. Urine specific gravity should be corrected to 1.024 for this test. If urine phenol values exceed 75 mg per liter, further testing in accordance with Regulation 29 CFR 1910.1028(i)(4) may be needed, and individuals must be removed from areas of potential benzene exposure until values return to normal levels.

___ ***Oil Not Containing Benzene***: including kerosene, diesels, military JP5, and commercial JET A.

Composition: Composed of an indefinite petroleum distillate content typically including polynuclear aromatic hydrocarbons (PAHs). The concentration of these products will vary widely depending on the source of the oil, weathering, and aging.

Hazard Description: May cause dermatitis by skin contact; nausea by inhalation; and eye irritation by contact. Benzo(a)pyrene is a skin contact hazard and potentially may cause skin cancer with chronic skin contact.

Basic Precaution: Wear chemical resistant clothing as necessary to protect against skin or eye contact; periodically change protective clothing that has oil on it; immediately change clothing that is showing evidence of oil penetrating to your skin; and wash skin with soap and water when changing into street clothing, before eating/drinking, or when exiting to a contamination reduction zone. Flush eyes with water if oil gets in them. If ingested, do not induce vomiting—contact a physician.

___ ***Bioremediation Application***: See attached Material Safety Data Sheet (MSDS) when these products are in use.

___ ***Dispersant Applications***: See attached Material Safety Data Sheet (MSDS)when these products are in use.

___ ***Hydrogen Sulfide (H_2S)***: H_2S is a clear, foul smelling gas that smells like rotten eggs. Although the smell may be detected at very low concentrations, it is not a good warning property because exposure to dangerous concentrations deadens the sense of smell. Hydrogen sulfide is found in certain crude oils ("sour" crudes), and is also generated by decaying organic materials.

Hazard Description: H_2S is very irritating to the eyes, even at low concentration. At higher concentrations, it is irritating to mucus membranes. Concentrations resulting in respiratory irritation may cause pulmonary edema. It is also a chemical asphyxiant, which causes asphyxiation in a manner similar to cyanide. Other effects include headache, dizziness, excitement, staggering gait, diarrhea, fatigue, and insomnia. H_2S is a central nervous system depressant, and high concentrations may cause paralysis of the respiratory system. H_2S is also a flammable gas.

- OSHA PEL: 10 ppm
- IDLH: 300 ppm
- OSHA STEL: 15 ppm
- Flammable Range: 4.0 to 44%

Basic Precaution: Avoid areas above exposure limits. Use colorimetric or electronic concentration meters or dosimeters to monitor exposures. For concentrations above exposure limits, positive pressure supplied air or self-contained breathing apparatus must be used. For very high concentrations in confined spaces, monitor for explosive atmospheres.

First aid for exposures includes flushing the eyes with water and support respiration as needed. MEDICAL TREATMENT MUST BE GIVEN FOR SUSPECTED OVEREXPOSURE!

ENVIRONMENTAL MONITORING FOR CHEMICAL HAZARDS: The following monitoring shall be conducted. Monitoring equipment shall be calibrated and maintained in accordance with the manufacturer's instructions (electronic equipment shall be calibrated before each day's use).

INSTRUMENT	FREQUENCY
__ Combustible gas	___continuous, ___hourly, ___ daily, other:
__ Oxygen	___continuous, ___hourly, ___ daily, other:
__ HNU	___continuous, ___hourly, ___ daily, other:
__ OVA	___continuous, ___hourly, ___ daily, other:
__ WBGT/heat stress	___continuous, ___hourly, ___ daily, other:
__ Noise	___continuous, ___hourly, ___ daily, other:
__ H_2S Monitor	___continuous, ___hourly, ___ daily, other:
__ other chemical specific monitors (colorimetric/electronic):	
1.	___continuous, ___hourly, ___ daily, other:
2.	___continuous, ___hourly, ___ daily, other:

Additional hazards may be encountered on site and shall be marked on the attached maps (along with any other applicable hazards found during the site survey).

F. GENERAL SITE SAFETY AND HEALTH PROCEDURES

The following controls shall be observed on site (check appropriate).

___ ***Buddy System***: Personnel must work within sight of a partner at all times in the exclusion and decontamination zones. A partner shall be assigned by the site safety supervisor as personnel check in.

___ ***Occupational Medical Monitoring***: Personnel entering an exclusion zone shall be enrolled in an occupational medical monitoring program in accordance with Regulation 29 CFR 1910.120.

___ ***Fires***: Each restriction zone and associated contamination reduction zone shall have at least one of each of the following:

- A fully charged Class A fire extinguisher for ordinary fires
- A fully charged Class B fire extinguisher for liquid fires
- Hand held fog horn to alert personnel

The above items shall be maintained in a readily accessible location, clearly labeled in red, and with the location noted on the project map.

___ ***Slippery Rocks and Surfaces***: All personnel in the work area shall wear rubber safety boots with steel toe/shank and textured bottoms. Boat survey teams may substitute clean deck shoes with textured soles kept free of oil on cloth/leather uppers.

___ ***Mud***: Dangerous mud flats posing a trap hazard shall be designated on the site safety map as areas off limits to personnel. Mark these locations with banner tape, barricades, or other marking equipment.

___ ***Lighting***: Fixed or portable lighting shall be maintained for dark areas or work after sunset. Sufficient illumination shall be provided at a minimum to meet the requirements of table H-120.1 (Minimum Illumination Intensities) of Regulation 29 CFR 1910.120(m).

___ ***Work Near Water***: All personnel working in boats, on docks, or generally within 10 feet of water deeper than 3 feet shall wear Coast Guard approved personal flotation devices (PFDs).

___ ***Heat Stress***: The site safety officer shall make heat stress determinations throughout the day. If it is determined that a heat stress hazard exists, an alert shall be passed to all teams to implement mandatory rest periods. The Site Safety Officer shall generally be guided by the ACGIH guidelines in determining work/rest periods. Fluids shall be available at all times and encouraged during rest periods (see attached information sheet on heat related health effects).

___ ***Cold Stress***: Workers shall be provided with adequate warm clothing. The Site Safety Officer shall make cold stress determinations throughout the day when temperatures fall below 50° F.

- If a cold stress hazard exists, an alert shall be passed to all teams to implement mandatory rest/warm-up periods. The Site Safety Officer shall generally be guided by ACGIH guidelines in determining rest/warm-up periods.
- For prolonged cold weather operations, warming shelters shall be provided for rest periods. Warm and/or sweat fluids (such as soups, cocoa, cider, or sweetened—low caffeine—hot teas) shall also be available during rest periods. Drinking coffee should not be encouraged.
- For prolonged water temperatures below 59° F, or a combined water and air temperature less than 100° F, exposure suits shall be worn by personnel in small boats or aircraft over water.

___ ***High Noise Level***: Hearing protection shall be used in high noise areas (exceeding 84 dBA, or as designated by the Site Safety Officer). Locations likely to exceed this level

include: the vicinity of vac-trucks and heavy equipment; bird-hazing stations; and generally where noise levels require personnel to raise their voices to be heard.

___ ***Confined Spaces***: In general, confined spaces shall not be entered by DAC personnel during oil spill response activities. If confined space entry is required, a special procedure shall be developed for this purpose using specially trained personnel for testing/evaluation of those spaces, and for entry in accordance with the unit safety and health manual.

___ ***Poisonous/Infectious Insects***: All personnel shall be provided with long sleeved clothing and insect repellent in designated areas.

___ ***Poisonous Snakes***: All personnel working in designated areas shall wear snake proof leggings or hip high rubber boots. Snake bite kits shall be kept with first aid kits in these areas.

___ ***Poisonous Plants***: Long sleeved clothing shall be worn in areas designated to contain these plants.

___ ***Electrical Hazards***: Electrical power lines (buried or overhead) shall be marked on applicable project maps and physically marked in the field, as necessary.

___ ***Trap Hazards***: Open manholes, pits, trenches, or similar hazards shall be noted on project maps and marked with placarded barricades. The Site Safety Supervisor shall ensure that these locations are periodically checked during the day; and additionally in the event that entering personnel are not accounted for at the end of a shift.

___ ***Carbon Monoxide***: Equipment operators shall ensure that personnel do not linger or work near exhaust pipes.

___ ***Falling Objects***: Hard hat areas determined by site survey shall be noted on project maps.

___ ***UV Light Exposure***: Sunscreens of protection factor 15 (or greater) and UV tinted safety glasses shall be made available for response personnel as needed.

___ ***Helicopter Operations***: Pilots shall provide safety briefings for all passengers.

___ ***Small-boat Operations***: Boat captains shall provide safety briefings for all passengers.

___ ***All Terrain Vehicles*** (ATVs): Drivers shall maintain a safe speed at all times and shall not be allowed to operate vehicles in a reckless manner. ATV drivers shall not operate ATVs outside of areas and lanes specified by the Site Safety Supervisor.

G. PERSONAL PROTECTIVE EQUIPMENT (PPE) Refer to attachment _____.

H. DECONTAMINATION PROCEDURES

Contaminated personnel and personnel entering contaminated areas shall be decontaminated in accordance with the current work plan or attached decon layout.

I. SANITATION AND PERSONAL HYGIENE

Potable water, non-potable water, toilets, and personal hygiene facilities shall be readily available. For further information see Regulation 29 CFR 1910.120(n).

J. EMERGENCY PROCEDURES

1. Emergency Medical Procedures:

- Contact designated Emergency Medical Technician (EMT) (posted organization/work plan).
- DO NOT attempt to move seriously injured personnel—call for an ambulance to come to the injured person.
- The closest hospital for regular emergencies is:

  _____ Phone: _____
- Closest hospital for chemical exposure emergencies:

  _____ Phone: _____
- Contact Agency for Toxic Substance and Disease Registry (ATSDR) at (404) 639-0615 (24 hours).

2. Emergency Fire Procedures:

- DO NOT attempt to fight fires other than small fires. A small fire is generally considered to be a fire in the early stages of development which can be readily extinguished with personnel and equipment in the immediate area in a few minutes time.
- DO NOT take extraordinary measures to fight fires.
- YOU MUST sound the appropriate fire signal if the fire cannot be put out quickly.
- Alert nearby personnel to call fire department.
- Notify supervisor.

- When the fire alarm is sounded, personnel shall IMMEDIATELY leave the work area WITH THEIR ASSIGNED BUDDY, to the entry/exit point, as designated by the evacuation route.
- The Site Supervisor OR the Fire Department shall ensure that the fire is extinguished and a temporary fire watch has been posted BEFORE restarting work.

3. ***Evacuation Routes***:

Primary Evacuation Route: _____

_____

_____

Secondary Evacuation Route: _____

_____

_____

Assembly Point:_____

_____

_____

K. COMMUNICATION

1. ***Hand Signals***:

THUMBS UP: I'm OK/I agree
THUMBS DOWN: Don't agree
HANDS ACROSS THROAT: Out of air/trouble breathing
GRAB HAND/ARM: Come with me
HANDS ON HEAD: I need assistance
Repeated short blasts from a hand held fog horn shall be used to indicate a fire emergency.

2. ***Radio Communication***:

Working:
freq:_____, chnl:_____ (__VHF __UHF __CB _____OTHER)

Emergency:

freq:_____, chnl:_____ (__VHF __UHF __CB _____OTHER)

freq:_____, chnl:_____ (__VHF __UHF __CB _____OTHER)

3. ***Phone Communication***:

On-Scene Coordinator:

(_____)_____ (__voice __fax __cellular __pager __home)

(_____)_____ (__voice __fax __cellular __pager __home)

Site Safety and Health Officer:

(_____)_____ (__voice __fax __cellular __pager __home)

(_____)_____ (__voice __fax __cellular __pager __home)

Agency for Toxic Substance and Disease Registry (ATSDR)

(404) 639-0615 (24 hours) (voice); (404) 639-0655 (FAX)

Case Officer: _____

ATSDR can provide emergency medical and toxicological information, assist in determining procedures for potential chemical overexposures, and can provide on-scene assistance for certain chemical emergencies.

Police:

(_____)_____ (__voice __fax __cellular __pager __home)

(_____)_____ (__voice __fax __cellular __pager __home)

Fire:

(_____)_____ (__voice __fax __cellular __pager __home)

(_____)_____ (__voice __fax __cellular __pager __home)

Ambulance/EMT/Hospital:

(_____)_____ (__voice __fax __cellular __pager __home)

(_____)_____ (__voice __fax __cellular __pager __home)

(_____)_____ (__voice __fax __cellular __pager __home)

OTHER NUMBERS:

_____

(_____)_____ (__voice __fax __cellular __pager __home)

OTHER NUMBERS:

_____

(_____)_____ (__voice __fax __cellular __pager __home)

_____

(_____)_____ (__voice __fax __cellular __pager __home)

_____

(_____)_____ (__voice __fax __cellular __pager __home)

Sign Up Sheet

Team Member (Print Name)	Contact Number (Phone, Pager)	Signature	Date

References:

(a) Regulation 29 CFR 1910.120; OSHA regulations for Hazardous Waste Sites

(b) Regulation 40 CFR 311; Worker Protection

(c) NIOSH/OSHA/USCG/EPA Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (NIOSH 85-115)

(d) Site Safety Program for Oil Spill Response

SAFETY GUIDELINES AND CHECKLISTS

Safety guidelines and checklists for specific conditions and damage assessment activities are listed below. Checklists are provided for: general safety gear; safety acronyms; oil exposure recommendations and symptoms of oil over-exposure; extreme temperature environments; small boat safety; aircraft safety; airboat safety; snorkeling safety and gear; and safety concerns during in-situ burning. Much of the material included in this section was provided by Nir Barnea, NOAA HAZMAT.

GENERAL SAFETY GEAR CHECKLIST

- ❑ Coveralls
- ❑ Rubber boots
- ❑ Neoprene gloves
- ❑ Hard hat
- ❑ Tyvec coveralls (2 pair) and boots (3 pair)
- ❑ Chemical resistant boot/shoe covers
- ❑ Personal flotation device (PFD)
- ❑ Rain gear (jacket, hood, overalls)
- ❑ Leather gloves

SAFETY ACRONYMS LIST

- ❑ **IDLH**: Immediately Dangerous to Life and Health (worker must be able to escape such conditions within 30 minutes without suffering permanent damage, and without experiencing conditions or symptoms that would interfere or impair escape).

- ❑ **TLV**: Threshold Limit Value (an exposure standard, set by the American Conference of Governmental Industrial Hygienists (ACGIH), these are recommended exposure limits which should not be exceeded; however, these are not legal limits).

- ❑ **REL**: Recommended Exposure Limits (an exposure standard set by the National Institute for Occupational Safety and Health (NIOSH), these are also recommended exposure limits, and are generally more conservative than TLVs).

- ❑ **PEL**: Permissible Exposure Limits (the legal exposure limits set by OSHA, when these are exceeded, workers may be legally considered over-exposed and various steps and actions must be taken; PELs are published in 29 CFR 1910.1000).

- ❑ **TWA**: Time-Weighted Average (measured concentrations of contaminants, usually averaged over an 8-hour time-period, the various standards and limits are usually applied as TWAs).

- ❑ **STEL**: Short Term Exposure Limits (a 15-minute TWA which cannot be exceeded, regardless of whether an 8-hour standard is met. STELs are legal standards set by OSHA).

- ❑ **Ceiling**: A contaminant concentration that should not be exceeded at any time, regardless of whether TWA limits or standards (PEL, STEL) are met.

CHECKLIST OF EXPOSURE RECOMMENDATIONS AND SYMPTOMS OF OIL OVER-EXPOSURE

SKIN/EYE CONTACT

- ❑ Avoid skin contact with oil; oil-resistant gloves, boots, and coveralls are useful
- ❑ Wash coveralls and other gear frequently; immediately remove any oil-soaked garments
- ❑ If skin contact occurs, remove oiled clothing and wash with soap and plenty of water, baby oil, and industrial strength hand cleaners (GOOP, GO-JO are also appropriate). Do not use gasoline, diesel, etc., or chemicals used to decontaminate equipment, to wash the skin
- ❑ If eye contact occurs, wash with water for at least 15 minutes; be sure to wash under the eyelids
- ❑ Note that skin exposure at depth (under pressure) while diving can result in skin burns not usually observed after exposure on land

SIGNS OF OVER-EXPOSURE

- ❑ Skin irritation
- ❑ Eye irritation
- ❑ Rashes
- ❑ Burns
- ❑ Any form of contact dermatitis

INHALATION OF PETROLEUM FUMES/VAPORS

- ❑ When possible, stay upwind from spill and vapors
- ❑ Avoid oil-contaminated areas with poor ventilation (such areas are also explosive hazards)
- ❑ If air concentrations are extremely high, use of a full-face respirator with organic vapor cartridges or even self-contained breathing apparatus (SCBA) may be warranted or required
- ❑ If inhalation over-exposure occurs, move person to well-ventilated area with fresh air, support respiration, and seek medical attention

SIGNS OF OVER-EXPOSURE

- ❑ Respiratory tract irritation
- ❑ Eye irritation
- ❑ Nausea
- ❑ Dizziness
- ❑ Giddiness
- ❑ Vomiting
- ❑ Headache

ASPIRATION (intake of liquid oil or oil in water droplets into the lungs)

- ❑ Aspiration of oil is very dangerous and may result in severe illness or death
- ❑ Do not SCUBA dive or snorkel in oil-contaminated waters
- ❑ Avoid or stay upwind of areas where water mists or spray are generated concurrent with oil-contamination (i.e., shoreline areas with large surf, waterfalls, hydro-electric dams, industrial cooling towers)
- ❑ If aspiration occurs, seek medical attention

SIGNS OF OVER-EXPOSURE

- ❑ Symptoms could include many of those listed above, as well as:
  - ❑ severe pneumonitis (severe inflammation of the lungs)
  - ❑ pulmonary edema (effusion of fluid into the lungs)

INGESTION

- ❑ Do not SCUBA dive or snorkel in oil-contaminated waters
- ❑ While working in the field, thoroughly wash hands and face before eating or drinking
- ❑ Keep all foods, drinks, containers, and utensils free of oil-contamination
- ❑ Label all liquid containers used in the field, including those containing drinking water or other drinks
- ❑ If ingestion occurs, give milk or water and seek medical attention. DO NOT induce vomiting, as this may result in aspiration

SIGNS OF OVER-EXPOSURE

- ❑ Nausea
- ❑ Vomiting
- ❑ Dizziness
- ❑ Gastro-intestinal tract irritation
- ❑ Diarrhea
- ❑ Giddiness

EXTREME TEMPERATURE ENVIRONMENTS SAFETY CHECKLISTS

HOT ENVIRONMENTS:

- ❑ Sun block (at least SPF 15)
- ❑ Drinking water (up to 1 quart/hour/person)
- ❑ Sunglasses
- ❑ Hat
- ❑ Light colored, lightweight, loose fitting clothing
- ❑ Long sleeved shirts and long pants (to reduce sun exposure)
- ❑ Schedule regular breaks; take breaks in shaded areas
- ❑ No alcohol
- ❑ Limit coffee, tea, and soft-drink intake (if not water, drink sports drinks such as Gatorade™ or Powerade™)

COLD-WATER ENVIRONMENTS:

- ❑ Close fitting foam-type PFD provides better insulation
- ❑ Float coats are even better
- ❑ Survival suits are best
- ❑ Insulated clothing and warm hats (e.g., "Thinsulate" materials)
- ❑ Neoprene (wet suit) hood and gloves. Note that oil can degrade wetsuit material
- ❑ No alcohol

SMALL BOAT SAFETY CHECKLIST

- ❑ Check marine forecast
- ❑ Float plan (notify the OSC, SSC, or DAC/RAP leader as to where you are going, when you are going, what you will be doing, when you expect to return, and who will be with you)
- ❑ Marine/nautical charts
- ❑ Drain plug (make sure it is in, also good to have a spare)
- ❑ Sufficient fuel/oil (use rule of thirds)
- ❑ Personal floatation devices for all crew members
- ❑ Survival suits (for cold water environments)
- ❑ Foul-weather gear
- ❑ Life-ring or float cushions
- ❑ Fire extinguisher (check location, charge, and directions for use)
- ❑ Distress flares (hand-held red flare, orange smoke flare, rocket flares, water tight container)
- ❑ Freon air horn and/or whistle
- ❑ VHF-FM radio or handheld VHF radio (CH16 for distress calls)
- ❑ Bailing bucket and/or hand bilge pump
- ❑ Paddle or oar
- ❑ Boat hook
- ❑ Anchor and sufficient line (at least 7 times maximum depth)
- ❑ Painter line (attached to bow of boat)
- ❑ First-aid kit
- ❑ NO SMOKING

ESPECIALLY NEEDED FOR ISOLATED OR REMOTE LOCATIONS:

- ❑ Manual crank cord (for electric-start outboard engines)
- ❑ Extra set of spark plugs
- ❑ Extra cotter keys, shear pin, and prop
- ❑ Tool set (pliers, channel locks, phillips and regular screwdrivers, crescent wrench, sharp knife, and duct tape at minimum)
- ❑ Emergency locator device (e.g., EPRB, etc.)

NEEDED IF BOAT OPERATOR WILL BE OPERATING THE BOAT WHILE ALONE:

- ❑ Automatic engine cut-off (usually a trip wire attached to boat operator and the engine or an ignition switch)

AIRCRAFT SAFETY CHECKLIST

NOAA AIRCRAFT OPERATIONS CENTER (AOC) REGULATIONS:

- ❑ Consult with NOAA AOC or DAC HQ before arranging charter to ensure compliance with NOAA guidelines
- ❑ Do not use single engine aircraft for over-water flights where aircraft will be more than gliding distance from the shoreline
- ❑ Survival equipment must be available for each person and must be applicable for the operating environment, including PFDs and survival suits

AIRCRAFT IN GENERAL:

- ❑ Flight plan (OSC, SSC, or DAC/RAP leader must be notified of flight purpose, destination, estimated time of return, and personnel involved)
- ❑ Mission plan (pilot and crew should be briefed on mission purpose, objectives, sites, routes, number of people, gear, etc.)
- ❑ Appropriate charts (pilot/crew and scientific personnel)
- ❑ Safety briefing (pilot or crew should brief mission personnel concerning aircraft safety procedures, safety gear, and radio operations)
- ❑ Personal floatation devices (when flying over or near water)
- ❑ Survival suits (for cold-water environments)
- ❑ Emergency locator device (e.g., EPRB, at least present on the aircraft)
- ❑ Safety belts
- ❑ Loose items should be well secured prior to entering aircraft
- ❑ Keep track of aircraft location at all times
- ❑ NO SMOKING

HELICOPTERS:

- ❑ Approach helicopter from the front or a forward side angle so the pilot (right side) or crew can see you
- ❑ Approach helicopter from the down-hill side if on a slope
- ❑ Do not board helicopter until pilot or a crew member signals it is OK for you to do so
- ❑ Eye protection (especially when approaching the aircraft)
- ❑ Hearing protection
- ❑ Safety belts or gunner's belt
- ❑ Loose items secured (including small items such as hats, film canisters, data sheets, etc.)

AIRBOAT SAFETY CHECKLIST

- ❑ Only use airboats in protected waters without wave-chop, where conventional boats cannot operate because of shallow depth
- ❑ Float plan (notify the OSC, SSC, or DAC/RAP leader as to where you are going, when you are going, what you will be doing, when you expect to return, and who will be with you)
- ❑ Discuss float plan and objectives with airboat operator
- ❑ Personal floatation devices for all crew members
- ❑ Fire extinguisher (check location, charge, and directions for use)
- ❑ Distress flares (hand-held red flare, orange smoke flare, rocket flares, water tight container). Note: Flares may be dangerous if you are stuck in a marsh where the aboveground vegetation is dry
- ❑ Freon air horn and/or whistle
- ❑ VHF-FM radio or handheld VHF radio
- ❑ Bailing bucket and/or hand bilge pump
- ❑ Paddle, push pole, boat hook
- ❑ NO SMOKING

SPECIAL CONSIDERATIONS FOR AIRBOATS:

- ❑ Hearing protection
- ❑ Eye protection
- ❑ Secure all loose materials which could be sucked into the propeller
- ❑ Check for any loose bolts, rivets, screws, etc. on the boat (deadly projectiles)
- ❑ Keep all body parts and equipment away from prop cage
- ❑ Never stand behind or approach the rear section of an airboat (prop blades and small projectiles are deadly)
- ❑ Request the airboat pilot check the bolts which secure the prop to the drive shaft (vibrations regularly loosen these bolts) and tighten them if loose. If the prop comes off the drive shaft it will splinter against the cage and send deadly projectiles in all directions (disconnect battery during inspection)
- ❑ Ask if prop bolts are safety wired (related to the above)
- ❑ Inspect the propeller blade (disconnect battery) for any cracks or fractures; these could lead to stress failure (see the above description). Prop blades should be waxed at least 2-3 times per year to maintain proper condition
- ❑ Sit down at all times when the airboat is in motion
- ❑ If sudden power loss occurs, shift your body toward the bow of the airboat to allow the following wake to pass under the boat, rather than swamping it

SNORKELING SAFETY AND GEAR CHECKLIST

- ❑ Permission must be obtained from the branch chief to undertake any diving activities
- ❑ To skin dive or snorkel, personnel must be NOAA certified skin divers or get pre-approval from the NOAA dive master
- ❑ For information or assistance, contact Cliff Newell or David Kruth, NOAA Diving Office in Seattle. PHONE: 206/526-6196 (FAX: 206/526-6506).
- ❑ Do not enter the water if oil or an oil sheen is present on the water surface or is likely to occur during the dive
- ❑ Be aware that oil contact at depth (under water pressure) can result in skin burns not usually observed after contact with oil on land. Additionally, inhalation (aspiration) of water droplets containing oil can result in pneumonitis and pulmonary edema, potentially resulting in death in severe cases
- ❑ Do not enter any confined spaces while skin diving or snorkeling
- ❑ Become familiar with the surroundings and any special conditions (e.g., tides waves, currents, depths, submerged obstructions, water clarity, water temperature, dangerous organisms) prior to making a dive plan or entering the water. Consult with local divers or at least local people familiar with the area
- ❑ Dive buddy (ALWAYS use the buddy system—both snorkelers should understand and agree on the dive plan. If one buddy is uncomfortable or a disagreement arises, both buddies should leave the water together)
- ❑ Arrange for a surface observer to keep track of your location and notify authorities in case of emergency (this is a person who stays on the boat or watches from the shoreline, depending on your entry). If water depths are too deep to stand, a rescue boat and personnel are required. Observers and divers should be trained in CPR/First aid
- ❑ Dive plan (notify the OSC, SSC, or DAC/RAP leader concerning your activities, objectives, location, expected return time, and personnel involved)
- ❑ Dive flags (should be on the boat and/or towed on a float and line by the snorkelers)
- ❑ Mask, snorkel, and fins
- ❑ Anti-fog solution for mask
- ❑ Foot protection (closed-toe dive boots or aqua socks preferred)
- ❑ Gloves

SNORKELING SAFETY AND GEAR CHECKLIST (continued)

- ❑ Weight belt (quick release buckle)
- ❑ Wet suit or dive skin (provides warmth, skin protection, and buoyancy). Note that oil can degrade some wetsuit materials.
- ❑ Buoyancy vest with mouth inflater
- ❑ Dive knife or tool (in case of entanglement)
- ❑ Whistle (for distress signal, locator, or to alert boats, etc.)
- ❑ Sun block
- ❑ Immediately wash yourself after diving, and avoid touching any objects you are unfamiliar with while under water

SAFETY CONCERNS DURING IN-SITU BURNING (ISB)

RAP team members will not be directly involved with ISB operations, and therefore should not be at great danger during such activities. However, for general safety purposes, RAP team members should be aware of the types of dangers associated with ISB techniques.

- ❑ Be aware of ISB operations (and all other response and cleanup activities) being undertaken during a spill. Brief the FOSC or the SSC of your whereabouts and operations while on-scene. Avoid areas in the vicinity of burning and the resultant smoke plume. Be aware of changing wind conditions, especially if they differ from predicted forecasts.
- ❑ Toxic and irritating gases (SO2, NO2, CO), PAHs, and fine particulates are produced during ISB. These substances are highest in concentration in the smoke plume. If in the vicinity of the smoke plume, especially if it is near ground level, leave the area immediately. Inhalation of fine particulate matter is generally the greatest health concern associated with the smoke plume.
- ❑ Be aware of flame and ignition hazards during ISB. If flames appear to be approaching your work area, leave the area immediately.
- ❑ If using small boats, be aware of the heightened vessel traffic which may be associated with ISB operations. Be aware that vessel operators involved in the ISB are concentrating on their operations, not on your position. Also, low visibility may be associated with smoke from the ISB, increasing the potential for vessel accidents.
- ❑ Due to the very high temperatures produced during an ISB, heat stress may also be a factor.

Safety Short # 2
3/30/92
Nir Barnea

Industrial Hygiene Acronym Soup

IDLH: Immediately Dangerous to life and health. Defined as conditions that pose immediate danger to life or health, or conditions that pose a threat of severe exposure. Two factors were considered when establishing the IDLH limits:

1. Workers must be able to escape such environment within 30 minutes without suffering permanent health damage.
2. Workers must be able to escape without severe eye or respiratory tract irritation or other conditions that might impair their escape.

IDLH values were determined based on animal and human data. They may be found in the NIOSH Pocket Manual and other references.

TWA: Time-Weighted Average. Unless otherwise mentioned, it is the concentration of contaminants over an 8 hour period. It is determined by sampling the breathing zone of the worker for 8 hours. Mathematically it is expressed as follows:

TWA=_ (Ci x _ti)/_ _ti

Where	Ci	is the average concentration over time period _ti
	_ti	is the period of time during which one sample is taken.

To determine the level of exposure, the TWA reading is compared to a standard such as the threshold limit value(TLV) or permissible exposure limits (PEL). If the reading exceeds the standard, overexposure occurred.

STEL: Short Time Exposure Limits: A 15 minute TWA concentration that may not be exceeded, even if the 8-hour TWA is within the standards. TWA-STEL are given for contaminants for which short-term hazards are known. For the rest, an excursion factor of 3 has been used: STEL should not exceed 3 times the TWA limit.

Ceiling: A concentration that should not be exceeded at any time. Note that both TWA and STEL permit limited excursion if, in the end, the average is below the exposure limit. The ceiling value, however, may not be exceeded. The following graph may help exemplify those terms. Note that excursions above the TWA line are compensated by periods of low exposure. The ceiling value is not exceeded.

LIST OF ACRONYMS IN SPILL RESPONSE

ADIOS - Automated Data Inquiry for Oil Spills. The new oil weathering model being developed by MASS. It has an extensive oil properties database.

Aireye - The oil surveillance system operated by the USCG which can be used to map oil slicks.

BAT - The BioAssessment Team. A special team within HMRAD which deals with biological risk information. They conduct longer term research on spill topics.

CAMEO - Computer-Aided Management of Emergency Operations. A computer system developed by NOAA which contains chemical fact sheets for over 2000 chemicals, a synonym search routine, the ALOHA episodic air model, format for managing Tier II data, and a computer mapping application.

CERCLA - The Comprehensive Environmental Response, Compensation, and Liability Act.

COIL - Chemical Oil Identification Laboratory. USCG lab in Groton, Conn. which specializes in fingerprinting analysis of oil spills. They compare various suspect oil for a match with the spilled oil.

COTP - Captain of the Port. The senior ranking USCG official at the MSO. This person is also the FOSC.

DARP - NOAA's Damage Assessment and Restoration Program, including the Damage Assessment Center (DAC), the Restoration Center (RC) and General Counsel's Office (GC).

DRAT - District Response Assessment Team. Civilians who will provide technical support to the USCG for spill planning and response. There will be four per district.

ESI - Environmental Sensitivity Index maps, which show the distribution and seasonality of oil-sensitive habitats and wildlife.

FOSC - Federal On-Scene Coordinator.

HMRAD - Hazardous Materials Response and Assessment Division of NOAA.

HOTLINE - The HMRAD real-time spill reporting system, which is set up for most spills where HMRAD staff are on-scene and accessible through E-mail.

ITOPF - International Tanker Owners Pollution Federation.

LSU - Louisiana State University; the contractor used by HMRAD for chemical support during spills. They usually run chemical analyses for fingerprinting oil spills.

MARPLOT - The computer mapping program being developed by HMRAD for use in both CAMEO and in support of spill response. It will run on both PC and Macs.

MASS - Modeling and Simulation Studies Branch of NOAA.

MSO - Marine Safety Office. USCG offices which are responsible for designating coastal and river areas.

MSRC - Marine Spill Response Corporation.

NCP- The National Contingency Plan

NRDA- Natural Resource Damage Assessment

NRDAMCME- a damage assessment computer model developed by the Department of the Interior

NRT- The National Response Team composed of all Federal agencies that are involved in response to oil and hazardous substance spills.

NST - National Strike Team of the U.S. Coast Guard. There are now three regional teams: Atlantic Strike Team (AST) which has been newly re-established; Gulf Strike Team (GST); and the Pacific Strike Team (PST or PAC Team).

OPA- The Oil Pollution Act of 1990

OHMSETT - Oil and Hazardous Materials Simulated Environmental Testing Tank. Facility in Leonardo, NJ recently reopened as part of OPA for testing of oil spill response equipment and chemical treating agents.

OSPR - California's Dept. of Fish and Game's Office of Spill Prevention and Response.

OSSM - Oil Spill Simulation Model; the current oil trajectory model MASS uses for spills.

P&I Club - The Protection and Indemnity Club-underwriters for tanker insurance.

PIAT - Public Information Assistance Team, of the U.S. Coast Guard, as a special team sent to bigger spills to assist the OSC deal with the media and public.

POLREP - The Pollution Report of the USCG, the reporting mechanism for spills.

PRIME - The computer system which supports HMRAD's E-mail system

RAR - Resources at Risk.

RAP - NOAA Damage Assessment Center's Rapid Assessment Program

REO- The Department of the Interior's Regional Environmental Officers

RRT - Regional Response Team.

SCAT - Shoreline Cleanup Assessment Team. There is a SCAT manual which defines the methods and terminology for collection of information on shoreline oiling to support cleanup decision-making.

SOS - Spill Operations System. The computer system being developed my MSRC to support their entire response operations. It will include a module for resources at risk, which is based, in part, on ESI maps.

SSC - NOAA's Scientific Support Coordinators.

SSC CAMEO - A version of CAMEO for SSCs, with emphasis on data management support needed during spills, and some spill tools and databases.

TARMAC - Trajectory and Areal Routines for Management and Control. The NOAA oil spill trajectory model which will run on the Macintosh.

TAT - Technical Assistance Team, which provides technical support to EPA for inland spills.

TOVALOP - Tanker Owners Voluntary Agreement concerning Liability for Oil Pollution.

APPENDIX 15

Floating Oil Descriptions

Standardized Descriptions for Floating Oil*

	Approx. Layer-Thickness		Approx. Volume/area	
	mm	in.	liters/km^2	gallons/mile^2
barely visible	0.00004	0.000001	50	50
silver sheen	0.0007	0.00000	100	75
first color trace	0.0001	0.000006	200	150
bright colors	0.0003	0.00001	400	300
dull colors	0.001	0.00004	1200	1000
dark colors	0.003	0.0001	3600	3000

* Reproduced from the "Oil Spill Slide Rule", ©1985, Government Publishing Office, The Hague/The Netherlands

General Glossary of Terms Used on NOAA Oil Spill Maps

Spill characteristics appear differently under low light conditions and under strong wind conditions. Observations in an up-sun direction are typically difficult to interpret. New observers should be "calibrated" with experienced observers in order to make the proper distinctions between oil types and to properly identify natural phenomenona.

Light sheen	A light, almost transparent layer of oil. Sometimes confused with windrows and natural sheen resulting from biological processes.
Silver sheen	A slightly thicker layer of oil that appears silvery or shimmery.
Rainbow sheen	Sheen that reflects colors.
Brown oil	Typically a 0.1mm - 1.0mm thick layer of water-in-oil emulsion. (Thickness can vary widely depending on wind and current conditions.)
Mousse	Water-in-oil emulsion often formed as oil weathers; colors can range from orange or tan to dark brown.
Black oil	Area of black colored oil sometime appearing with a latex texture. Often confused with kelp beds and other natural phenomenona.
Mousse streaks	Dark colored oil with obvious textured appearance oriented in lines or streaks. Brown oil and mousse can be easily confused with algae scum collecting in convergent lines, algae patches, or mats of kelp or fucus.
Tarballs	Weathered oil that has formed a pliable ball. Size may vary from pinhead to about 30 cm. Sheen may or may not be present.
Tar mats	Non-floating mats of oily debris (usually sediment and/or plant matter) that are found on beaches or just offshore.
Pancakes	An isolated patch of oil shaped in a mostly circular fashion, pancakes can range in size from a few meters across to hundreds of meters in diameter. Sheen may or may not be present.