Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET)/Coastal Response Research Center (CRRC) National Oceanic Atmospheric Administration (NOAA) Office of Response and Restoration (OR&R)

PROGRESS REPORT FOR THE PERIOD 6/1/2004 THROUGH 10/31/2004

Project Title: Development of Oil Spill Response Cost-Effectiveness Analytical Tool
Contract: Cooperative Agreement No. NA17OZ2607 (CFDA No. 11.419)
Subcontract: No. 03-689

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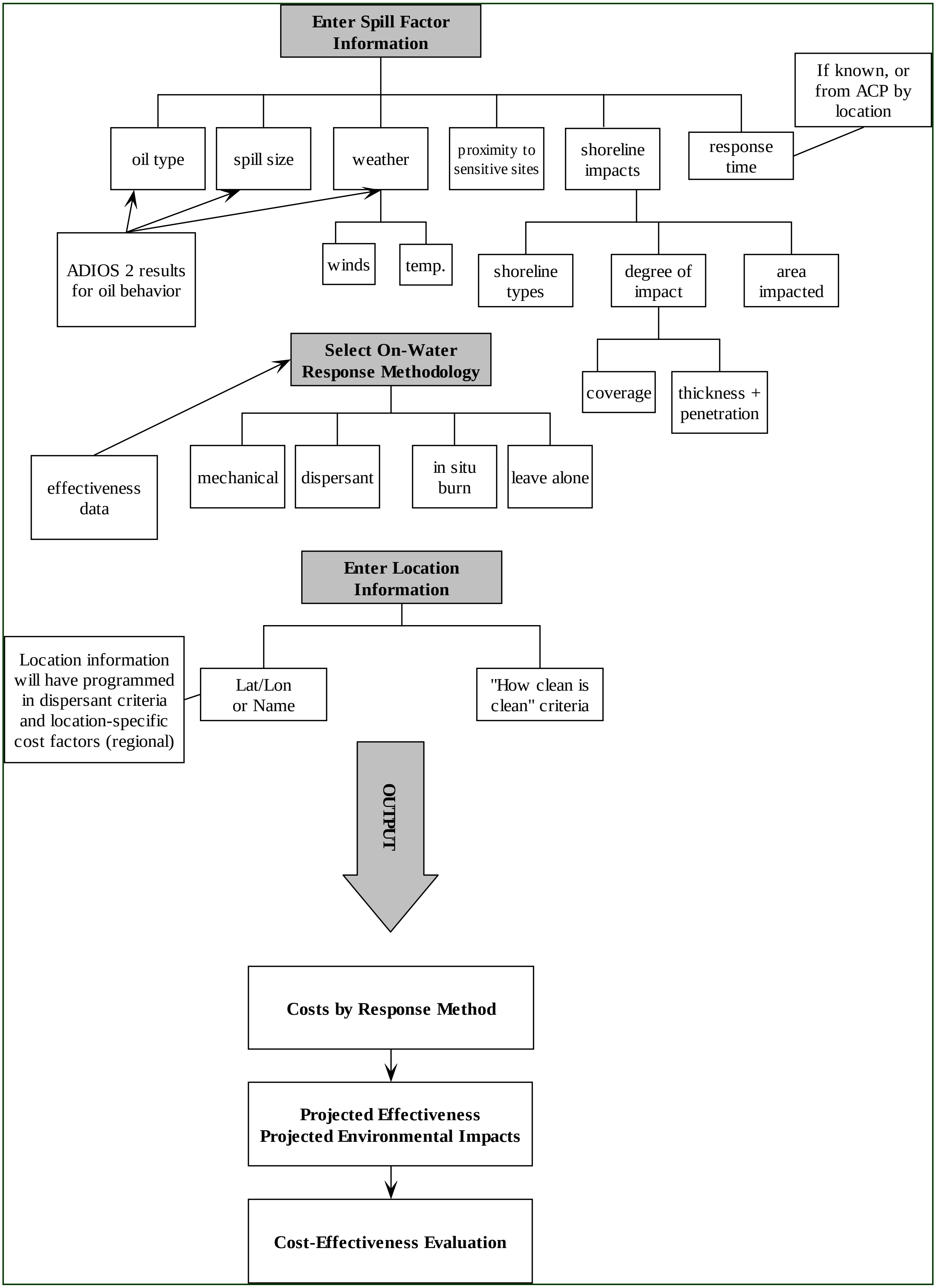
Project Description (From Original Proposal)

Decision-making during oil spill response operations or contingency planning requires balancing the need to remove as much oil as possible from the environment with the desire to minimize impact of the response operations on the environment they are intending to protect. Additionally, there are often limited financial resources from which officials need to fund both oil removal and the ultimate restoration of the oil-impacted *and response-impacted* environment. In the aftermath of an oil spill, officials, trustees, and the responsible party have a concurrent concern for deriving the largest *net gain* of environmental restoration from both the response *and* restoration operations, often while operating within one overall budget.

Questions of cost-effectiveness of various response options (*e.g.,* mechanical recovery, dispersant application, *in situ* burning, natural recovery, wetland vegetation removal) as well as where to "draw the line" between response and restoration are issues that have plagued both response (*e.g.,* USCG and EPA) and restoration (*e.g.,* NOAA) officials. Reliable information on response costs and the effectiveness of various response options have been difficult to come by in the past. With the implementation of pre-authorization of dispersants and even in situ burning in many locations in the US, the choices for oil spill response have increased dramatically. This fact, coupled with greater expectations on the part of officials and the public for effective oil removal and restoration of impacted environments, has created a great need for better information for response and restoration decision-making.

The decision-making tools that this project proposes to develop would help incorporate factors of *cost-effectiveness* of response/restoration operations into net environmental benefit analysis (NEBA). By providing incident-specific (or hypothetical scenario-specific) information on response costs (by methodology), response effectiveness, environmental impacts, and cost-effectiveness, the tools would help response and restoration officials make well-informed choices during actual response and restoration operations. The tools would also help in the evaluation of various response and restoration options for contingency planning or strategizing by understanding the potential costs involved for various response options and the potential effectiveness of those response strategies.

The project's objective is to develop a set of *decision-making tools* for determining the *cost-effectiveness of various oil spill cleanup response options* in order better facilitate short-term and long-term environmental recovery of oil-impacted areas. The tools will be comprised of algorithms and analytical methodologies that are incorporated into a user-friendly computer software program and a pencil-paper-and- calculator protocol that can be used on site or during off-site response or restoration planning. The project addresses CICEET's and OR&R's mission of *minimizing the environmental impact from oil spills and response actions* by improving decision-making during net environmental benefit analyses thereby improving the ultimate outcome of response and restoration operations. As such, the project addresses to some extent *all* of the priority areas for oil spill research and development in CICEET's OR&R program, particularly: *Resolving uncertainties about the long-term fate and effects of dispersing oil* and *Understanding "How Clean is Clean Enough?"*.


Enter Spill Factor Information
If known, or from ACP by location
oil type
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Select On-Water Response Methodology
coverage
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mechanical
dispersant
in situ burn
leave alone
Enter Location Information
Location information will have programmed in dispersant criteria and location-specific cost factors (regional)
Lat/Lon or Name
"How clean is clean" criteria
OUTPUT
Costs by Response Method
Projected Effectiveness
Projected Environmental Impacts
Cost-Effectiveness Evaluation

I. Accomplishments

A. Scheduled Tasks

Original Estimated Timeline and Milestones for Development of Oil Spill Response Cost-Effectiveness Analytical Tool Project		
Phase/Milestone	**Task Objectives**	**Approx. Time To Complete**
Data Collection On Response Actions Phase	Collect additional data on detailed spill response activities (equipment, personnel, time involved, response outcome, oil recovery rates) from incident action plans, USCG/NRT/EPA/NOAA records, responsible party records, spill management team records, hypothetical spill scenarios in Area Contingency Plans, spill drills (PREP), journal articles and reports. (Also collect any concurrent cost data.)	3 months *3 months* concurrent phases
Data Collection On Environmental Impact Phase	Collect additional data and information on environmental impacts of oil and response operations from journal articles, reports, NOAA restoration and damage assessment documents, and other sources. (Also collect any concurrent damage cost data.)	
Data Collection Milestone	**Data collection finished**	**3 months**
Cost Calculations Phase	Calculate costs of spill responses and damages based on actual spill cost data collected in the data collection phase or based on cost estimation methods previously employed in previous studies (Etkin 1998*a*, 1999, 2000*a*, 2001*a*, 2001*b*, 2003; Etkin, *et al.* 2002; Etkin and Pond 2003; Etkin and French-McCay 2003; French-McCay, *et al.* 2002, 2003; Tebeau and Etkin 2003).	2 months *5 months*
Cost Calculations Milestone	**Cost calculations finished**	**5 months**
Database Development	Reconfigure existing databases to accommodate all data fields on response actions, response outcomes, environmental impacts, and costs for use in statistical analyses and algorithm development.	2 months *7 months*
Database Development Milestone	**Database development completed**	**7 months**
Statistical Analyses	Perform statistical analyses of data in reconfigured databases to determine relationships (*e.g.*, correlations, multiple regressions) between different spill factors and costs, and between response strategy and effectiveness of oil removal and environmental recovery.	2 months *9 months*
Statistical Analyses Milestone	**Statistical analyses completed**	**9 months**

Original Estimated Timeline and Milestones for Development of Oil Spill Response Cost-Effectiveness Analytical Tool Project *(continued)*		
Phase/Milestone	**Task Objectives**	**Approx. Time To Complete**
Development Of Algorithms and Decision-Trees	Perform analysis of statistical relationships between spill factors, response measures, response effectiveness, costs, and environmental restoration outcomes to develop mathematical formulae and algorithms to describe relationships between variables. Develop probabilistic (and cost and effectiveness) decision trees for choices in response.	2 months *11 months*
Algorithm Decision-Tree Milestone	**Algorithms and decision-trees completed**	**11 months**
Peer Review of Analyses and Results	**Preparation of report with results of analyses to send to CICEET as well as colleagues and parties potentially interested in project outcome and development of tool**	**12 months**
Modifications to Model Phase	Incorporate any valid and necessary recommended changes from peer review process into algorithms and decision trees.	1 month *13 months*
Incorporation Of Algorithms and Decision-Trees Into Paper/Pencil Tool	Incorporate algorithms and decision trees into simple, user-friendly paper-pencil-and-calculator analysis tool.	2 months *15 months*
Peer Review of Paper/Pencil Tool	Send report and analysis tool methodology to CICEET and reviewers for testing and evaluation.	**16 months**
Modifications to Paper/Pencil Tool Phase	Incorporate valid recommended changes into tool to produced modified tool.	1 month *17 months*
Paper/Pencil Tool Milestone	**Paper-pencil-and-calculator tool completed.**	**17 months**
Incorporation Of Algorithms And Decision-Trees Into Software Tool	Work with computer programmer to incorporate algorithms and decision trees into computer program (software).	4 months *21 months*
Peer Review of Software Tool	**Send report and software tool prototype to CICEET and other colleagues for testing and evaluation.**	**22 months**
Modifications to Software Tool	Incorporate valid recommended changes into tool to produced modified tool.	1 month *23 months*
Software Tool Milestone	**Software tool completed.**	**23 months**
Preparation of Final Report	Final report on project prepared and sent to CICEET and presented at conferences and other appropriate forums.	1 month *24 months*
Final Report and Tools Completed	**Final documentation, pencil-paper-and-calculator tool, and software tool completed.**	**24 months**
Dissemination of Final Product	Final product prepared for dissemination through website and other channels.	Indefinite

B. Progress on Tasks

1. APRIL 2003 UPDATE

Cost Data Collection and Database Development

A large amount of data on response costs for actual oil spills has been collected and is continuing. Since each spill is a unique event with costs and impacts dependent on a host of factors, including oil type, location, amount of oil, and random events (weather, oil trajectory, rapidity of response, early response decisions), we have decided that it will be necessary to collect more data on costs than originally anticipated. In addition to data on response costs from actual events, we have also collected an unexpectedly large amount of data on rates and costs for specific equipment types, worker categories, chemicals, and disposables (*e.g.,* sorbents) for both government operations and commercial operations. More of this data has become available than originally anticipated. Having a wealth of this type of data on hand will allow for more accurate estimation of costs for hypothetical situations. Another type of data that continues to be collected is the labor required to clean up different types of shoreline. A preliminary report on the analysis of this type of data is presented in the attached paper, "Estimation of Shoreline Response Cost Factors," to be presented at the 2003 International Oil Spill Conference in April 2003.

As data has been collected, the original models for the database have been modified to accommodate the additional information that has become available. Data collection on all categories of data types will continue for a few more months, *concurrent* with the database development.

Environmental Impact Data Collection and Database Development

Data on the impacts of oil spills, based on historical case studies, has been collected concurrently with the cost data described above. Additional data still needs to be collected. In addition, different approaches to *classifying* and *quantifying* environmental impacts of oil spills *and oil spill response* are being researched in a literature review and in consultation with colleagues. The development of a reasonably efficient method to quantifying and describing spill impacts will be an important part of this project as it will be used to link together with cost information to ascertain the cost-effectiveness of response methods both in terms of oil removal and the impacts of the spilled oil and oil spill response operations.

A basic model for estimating oil spill response costs, and environmental and socioeconomic damages was developed (see attached). The model, entitled "Basic Oil Spill Cost Estimation Model" or "BOSCEM," represents the basic structure of estimating costs in the three categories.

Development of Algorithms for Cost-Effectiveness Model Development

The preliminary algorithms and values for the major variables in the Basic Oil Spill Cost Estimation Model (BOSCEM) were developed. The structure of the cost estimation model allows for simple updating of the variables as more supporting data is collected. Additional refinement of the model will continue after presentation of "Estimation of Shoreline Response Cost Factors," as well as the papers on the cost-benefit analysis of the oil spill response research program US Coast Guard and associated agencies and the financial implications of oil spills in a particular location, San Francisco Bay at the upcoming 2003 International Oil Spill Conference

(6-10 April). Feedback on these papers will be incorporated into future work on the cost estimation model and integration of the that model with measures of response effectiveness in terms of reducing environmental damages.

2. OCTOBER 2003 UPDATE

Cost Data Collection and Database Development

- The cost databases are increasing in size with the addition of considerably more data from a variety of sources.

- The algorithms used for estimating response cost were further refined based on new data obtained to increase accuracy, especially for smaller spills. The difference in costs between government-funded and responsible party-funded response operations based on government versus commercial rates of response contractors is also being investigated based on new data obtained.

Environmental Impact Data Collection and Database Development

- Research is being continuing on existing methodologies for determining environmental sensitivities of different habitats, evaluating effectiveness of response measures for oil removal, criteria for "how clean is clean," net environmental benefit analysis methodologies, and measurements of impacts of response activities for integration into the cost-effectiveness modeling.

- Attendance at a dispersants workshop in Portland, Maine, sponsored by the Maine-New Hampshire Area Committee, including a presentation ERC gave on the impacts of dispersant application and dispersant-based response strategies gave greater insight into the unanswered issues remaining with dispersant use. Public resistance to dispersant use, regardless of potential net *benefits* when from in a net environmental benefit analysis (NEBA), must be considered in the model. The possibility of including more information in the use interface of the model, drawn from previous work conducted by NOAA and others, is being considered to allow decision-makers to inform themselves and the relevant stakeholders of potential impacts and benefits of various response strategies and response measures during the decision-making or pre-spill response planning process.

- The scarcity of reliable information on oil spill costs and the need for this type of information at all levels is very evident. Requests for information on oil spill costs and response cost-effectiveness are becoming more frequent. It is hoped that the information and decision-making guidance inherent in this model will fill an important niche when it is completed.

Development of Algorithms for Cost-Effectiveness Model Development

- A significant part of the shoreline cleanup cost estimation part of the larger model was presented at the April 2003 International Oil Spill Conference in Vancouver, BC, Canada, after having gone through a peer review process (Etkin, D.S. 2003. Estimation of shoreline response cost factors. *Proceedings of the 2003 International Oil Spill Conference.)* The formal presentation and discussions with colleagues at the conference allowed for additional review. Also, additional sources of cost data and shoreline cleanup data were located in these discussions.

- Presentation of two other cost-related papers (Etkin, D.S., D. French McCay, J. Jennings, N. Whittier, S. Subbayya, W. Saunders, and C. Dalton. 2003. Financial implications of hypothetical San Francisco bay oil spill scenarios: Response, socioeconomic, and natural resource damage costs. *Proceedings of the 2003 International Oil Spill Conference,* and Etkin, D.S. and P. Tebeau, P. 2003. Assessing progress and benefits of oil spill response technology development since Exxon Valdez. *Proceedings of the 2003 International Oil Spill Conference)* at the same conference allowed for more peer review of these papers that are also part of the larger cost-effectiveness model and the Basic Cost Oil Spill Cost Estimation Model (BOSCEM) that forms part of the larger model.

- The Basic Cost Oil Spill Cost Estimation Model (BOSCEM) that will form part of the larger cost-effectiveness tool for this project has been turned into a software program. The software is designed so that the user can enter information about a particular spill – volume, oil type, location criteria (habitat type, freshwater vulnerability, state, medium type impacted, socioeconomic value, location use), response methodology, and response effectiveness – in a simple interface and get an estimate of the cleanup response costs, environmental damage costs, and socioeconomic damage costs. User testing will start soon.

- The algorithms used for estimating response cost were further refined based on new data obtained to increase accuracy, especially for smaller spills. The difference in costs between government-funded and responsible party-funded response operations based on government versus commercial rates of response contractors is also being investigated based on new data obtained.

3. MAY 2004 UPDATE

Cost Data Collection and Database Development

- With the increasingly limited moderate- to large oil spills that have occurred in the last decade (Etkin 2001, 2002, 2003, 2004), it is necessary to derive a good part of the response cost data, as well as impact data, from modeling of various types of hypothetical spills. Data from field studies, tank tests, and spills of opportunity are used to support and validate the modeling results. Cost and impact modeling has been conducted for spills in the following locations:

    - Gulf of Mexico off Galveston Bay, Texas (National Research Council 2001, Etkin 2000, Etkin 2001*b,c,d*)

    - Delaware Bay, Delaware (National Research Council 2001, Etkin 2000, Etkin 2001*b,c,d*)

- Offshore Mid-Coast California (National Research Council 2001, Etkin 2000, Etkin 2001*b,c,d*)
- Suisun Bay, California (National Research Council 2001, Etkin 2000, Etkin 2001*b,c,d*)
- San Francisco Bay (Etkin, *et al.* 2002, 2003; French-McCay, *et al.* 2002, 2004; US Army Corps of Engineers/California State Lands Commission 2003)
- James River, Virginia (Research Planning, Inc., *et al.* 2001)
- Puget Sound, Washington (Etkin, *et al.* 2005, Pilkey-Jarvis, *et al.* 2005)
- Columbia River, Washington (Etkin, *et al.* 2005, Pilkey-Jarvis, *et al.* 2005)
- Off-Coast Washington (Etkin, *et al.* 2005, Pilkey-Jarvis, *et al.* 2005)
- Inland navigable waterways, including Great Lakes (Etkin 2004*a*)

Note: In some cases Applied Science Associates, Inc.'s proprietary SIMAP oil spill impact model system was employed, or is being employed, and in other cases, NOAA's Trajectory Analysis Planner (TAP) was used to model spill trajectories and impacts. For the inland waterway impact analysis, ERC's Basic Oil Spill Cost Estimation Model was employed. Cost and impact data from these modeling projects are being used to further develop the algorithms for costs and impacts for the cost-effectiveness analytical tool.

- Extensive modeling analysis has been conducted on data from two actual spills for which there is considerably detailed data on shoreline cleanup – 1989 Exxon Valdez oil spill in Prince William Sound, Alaska, and 2000 PEPCO Pipeline spill in Chalk Point, Maryland (Etkin 2003*b*).

- ERC Oil Spill Cost Databases have been enhanced with new response cost data on previous spills and additional spills. Data on costs from commercial response contractors, including new information on contracting issues as related to response costs and logistics/per diem costs for personnel, have been upgraded for use in estimating costs for hypothetical scenarios and Area Contingency Plan scenarios.

- New cost data on dispersant application and *in situ* burning have been collected for incorporation into the tool.

- ERC has upgraded its computer equipment and software to accommodate new databases and to create the most up-to-date software.

Environmental Impact Data Collection and Database Development

- New data on environmental/natural resource damages have been and are continuing to be incorporated into ERC Oil Spill Cost Databases. For example, the issue of extensive wetland cleanup operations possibly doing more harm than good is being considered.

- Data on socioeconomic impacts have been and are continuing to be incorporated into ERC Oil Spill Cost Databases as it has been determined that these damages and impacts are important for inclusion in modeling and evaluating the benefits of oil removal/response operations.

- Modeling projects, as described above, are being used in conjunction with actual spill case studies to determine oil impacts.

- Research on oil spill persistence and classification of oils with regard to persistence was conducted in conjunction with EPA (Davis, *et al.* 2004).

Further Research into Efficacy and Potential Environmental Impacts of Oil Spill Response Operations

- The importance of taking into account the potential impacts of the oil spill response itself was realized. This also needs to be included in the analytical tool.

- Dr. Etkin participated in the National Academy of Sciences Committee on Understanding Oil Spill Dispersants: Efficacy and Effects 15 March 2004 meeting in Washington, DC to learn more about recent research and controversies in the use of dispersants as an oil spill response strategy. At this meeting and a subsequent meeting, data on exceptionally high rates of mechanical recovery were also presented as a comparison to dispersant use and as a means to discourage the use of dispersants. The analyses employed were largely based on incorrect data. ERC submitted a comment to the National Academy of Sciences with regard to the conclusions that mechanical recovery rates have been intentionally deflated to discourage the use of mechanical containment and recovery and encourage the use of dispersants. The comments and original report are included on the CD-ROM accompanying this update.)

- ERC is evaluating methods to factor in the impacts of oil spill dispersant chemicals on water column in discussions with EPA, from modeling work conducted on Washington State spills, and from additional data presented at the National Academy of Sciences meetings.

- ERC is evaluating the issue of delays in response using dispersants due to resistance from stakeholders.

- New data that purportedly shows that dispersants are ineffective in cold water are being evaluated.

- ERC is conducting studies of methods for determining outcome of oil removal effectiveness and net environmental benefit.

- ERC is conducting research on modeling the point of "diminishing return" for response, particularly shoreline cleanup.

Development of Algorithms for Cost-Effectiveness Model Development

- Initial algorithms incorporated into the ERC Basic Oil Spill Cost Estimation Model and its simplified derivative EPA Basic Oil Spill Cost Estimation Model have been and are continuing to be revised based on additional data collected. The modified algorithms will be incorporated into the tool.

- The user interfaces for the analytical tool are under development. Changes are being made to accommodate the increased complexity of the data and factors that need to be considered in the tool.

Testing of Analytical Tool Algorithms and Assumptions in Practical Applications

- ERC has also used portions of the cost-effectiveness analytical tool to analyze oil spill costs and the relative benefits of oil removal as part of a cost-benefit analysis of oil spill prevention. Use of the tool in actual applications allowed for better evaluation of the issues that would arise in it use and find areas in which improvements or modifications should be made. As part of this effort, ERC has:

    - Submitted comments to the White House Office of Management and Budget (OMB) on OMB's *Draft 2003 Report to Congress on the Costs and Benefits of Federal Regulation* (*Federal Register* Vol. 68, No. 22: pp. 5,492 – 5,527) (on CD-ROM).This project was another application of the cost evaluation tool.
    - Evaluated the benefits of oil spill prevention regulations and initiatives in the EPA Oil Program using cost tools to measure the benefit of "oil not spilled."

- ERC is conducting additional research on the use of oil spill cost tools for evaluating the benefits of various types of oil spill response methods and capabilities (including timing of response) in Washington State oil spill scenarios. (This is described in greater detail under Future Presentations.)

4. OCTOBER 2004 UPDATE

Additional modeling work was conducted for Washington state waters to determine the costs and impacts of 40 different major oil spills scenarios, using different oil spill response methodologies (no response, mechanical containment and recovery only, *in situ* burning in conjunction with mechanical containment and recovery, and dispersant application in conjunction with mechanical containment and recovery). In addition, the impact of different timing of responses (getting equipment there at earlier times) was investigated.

Significant impacts of the timing of responses (when equipment and personnel are brought on scene and deployed) were found. This needs to be factored into the cost analytical tool. In addition, issues involving the modeling of the actual effectiveness of mechanical containment and recovery operations over time were found to be significant in determining the outcome of modeling results. This indicates that it will be important to factor in the continuous reduction in oil removal efficiency based on the spreading of the oil, personnel shift changes, and offloading and storage of recovered oil. The reduction in efficiency over time (based on the work of Gregory, Allen, and Dale 1999) is significant in terms of changing the amount of oil that can reasonably be expected to be removed offshore. (This reduction in removal efficiency is based on an already de-rated effective daily oil recovery capability as a baseline as opposed to the manufacturer's nameplate capacity.) Modeling of actual required spill response capability (tiers of response required under response capability standards of the US Coast Guard or state standards) versus what actually might happen based on errors in judgment, poor strategy, and uncontrollable factors, such as weather changes and logistical complications presents a challenge. The cost analytical tool algorithms need to take into account different levels of efficiency based on how well the response is carried out.

These additional factors are being included in the revised cost analytical tool.

C. Difficulties Encountered

In conducting the research for this project, ERC has encountered a number of obstacles, difficulties, and challenges, including:

- Scarcity of data on oil spill response costs due to decreasing number of moderate- to large-sized spills and a general reluctance on the part of responsible parties to release data on costs due to litigation and privacy concerns.
- Location-specific nature of spills makes the use of trajectory analysis and natural resource damage assessment of some type important in determining impacts of spilled oil – incorporation of this into the algorithms is challenging.
- For most spill responses (and strategies) there are what might be considered "reasonable costs" for response operations that are carried out using general industry practice and standards and "reasonable" behavior and choices by response officials and spill managers, but there are spills for which the *actual* costs exceed these reasonable costs due to ill-conceived response strategies or unanticipated problems related to logistics, weather, and operational issues – incorporation of these factors into the algorithms is challenging.
- The fewer number of actual spills is creating a less-experienced group of spill responders that may in future reduce the effectiveness of spill response despite improvements in spill response equipment and methods – incorporation of these factors into the algorithms is challenging.
- In some cases, the line between natural resource damages and socioeconomic damages (*e.g.*, fishing) becomes somewhat blurred.
- "How clean is clean" criteria differ regionally and in different political climates.
- The drive by local stakeholders to "do something" in spill response operations rather than employ natural recovery methods can be a strong motivating factor in decision-making and response planning even if this potentially increases the impacts of the oil and/or the recovery operations themselves and reduces the long-term recovery of an impacted area.
- Hand calculation methods for determining cost-effectiveness with "look-up" tables, etc., has been determined (through preliminary testing of EPA BOSCEM and other parts of

the cost model) to be difficult for untrained users to apply and will be less accurate than more complicated algorithms using formulae incorporated into software.

- Changes in algorithms proposed due to new information from modeling of spills. Use of modeling necessary due to general lack of data on actual spills, particularly for larger and worst-case discharge scenarios.
- Modeling of the *timing* of response operations (when equipment and personnel are brought on scene and deployed) and differences in state versus federal response standards (*e.g*., for state of Washington) has shown that this component needs to be factored in.
- Modeling of the actual effectiveness of mechanical containment and recovery operations over time requires factoring in of the continuous reduction in oil removal efficiency based on the spreading of the oil, personnel shift changes, and offloading and storage of recovered oil. The reduction in efficiency over time (based on the work of Gregory, Allen, and Dale 1999) is significant in terms of changing the amount of oil that can reasonably be expected to be removed offshore. (This reduction in removal efficiency is based on an already de-rated effective daily oil recovery capability as a baseline as opposed to the manufacturer's nameplate capacity.) Modeling of actual required spill response capability (tiers of response required under response capability standards of the US Coast Guard or state standards) versus what actually might happen based on errors in judgment, poor strategy, and uncontrollable factors, such as weather changes and logistical complications presents a challenge. The modeling needs to take into account different levels of efficiency based on how well the response is carried out.

Additional logistical challenges have caused some delays in completion of the project.

- Part-time schedules of programmers and support personnel due to the small size of ERC creates challenges in meeting deadlines.
- Illness and personal issues requiring days away from work for principal investigator delayed project completion.

Overall, the research process and application of preliminary models and cost tools has shown that the issue is considerably more complex than originally anticipated, creating challenges in meeting the two-year deadline.

The previous inability to meet the deadline of the grant period is of great concern. But, given the additional time, ERC believes that we will be able to deliver a product that has broad application and will be of great interest to the spectrum of oil spill response officials, policy makers, and planners. ERC would like to do its best effort to incorporate the great amount of data and new information gathered over the last several months into the final product.

D. Anticipated Success in Meeting Project Objectives in Scheduled Project Period

Due to the extension of this project beyond the original contract time period, the project must be completed by 31 January 2005.

E. Preliminary data (incorporate in text or attach)

(Relevant papers have been included in the accompanying CD-ROM.)

F. Manuscripts, Reports, Presentations

(Relevant papers, reports, and presentations have been included in the accompanying CD-ROM.)

II. Tasks and Activities for Next Reporting Period

A. Tasks for the Next Reporting Period

Dr. Etkin met via teleconference with CRRC Co-Director Dr. Nancy Kinner to discuss the "no-cost extension" of this contract and a plan for completion of the project. The following schedule and methods for dissemination of the project results were agreed upon:

Preparation of project update: 29 October 2004
Completion of draft report: 31 January 2005
Presentation to CRRC/CICEET Committee (Silver Spring, MD): 22 March 2005

Dissemination of project results (analytical tool)

Distribution of the project results includes providing a report describing the development and use of the cost analytical tool, as well as providing a description of the pencil and calculator algorithms and look-up table methodology, and the software tool that allows for entry of spill criteria to calculate cost-effectiveness by response method. Dissemination of the project report and the tools will be through the following venues:

- CRRC/CICEET website (http://www.crrc.unh.edu)
- ERC website (http://www.environmental-research.com)
- Presentation at Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Calgary, Alberta, Canada (7 – 9 June 2005)
- CRRC/CICEET Exhibit at 2005 International Oil Spill Conference, Miami, Florida (15 – 19 May 2005)
- Presentations at Regional Response Team/Area Committee Meetings
- Direct distribution to federal agencies (US Coast Guard, NOAA, EPA, MMS)
- Direct distribution to oil-spill related state agencies
- Direct distribution to industry (through American Petroleum Institute and associated organizations)

B. Future Presentations:

ERC will be presenting the following papers (as platform presentations) directly or tangentially-related to this project at the 2005 International Oil Spill Conference (15 – 19 May 2005, Miami, FL) pending approval by the IOSC Review Committee:

***Modeling the Impacts of Response Method and Capability on Oil Spill Costs and Damages for Washington State Spill Scenarios* [Dagmar Etkin (ERC), Deborah French-McCay, Jill Rowe, Nicole Whittier, and Sankar Sankaranarayanan (all of Applied Science Associates, Inc.), and Linda Pilkey-Jarvis (Washington Department of Ecology)] [Draft attached on CD-ROM]**

Abstract

The issues and results of modeling a major crude oil spill scenarios in outer coast and sound locations in the state of Washington, USA, to determine relative costs and impacts are explored. Oil spill trajectory and fate and effects modeling were coupled with modeling of response operation strategies (conventional mechanical containment and recovery operations; dispersant application with concurrent mechanical containment and recovery; and in-situ burning with concurrent mechanical containment and recovery) to estimate oil spill response costs and socioeconomic and environmental impacts. The complex issues in modeling the impact of response capability and timing of initial response operations were also examined, comparing the US Coast Guard (USCG) federal response capability standards, proposed Washington State standards, and potential theoretical higher response capability standards.

Results of initial modeling showed little difference in costs and impacts between on-water response options and capability levels, with the exception of being significantly lower than the "no response" option, in which only protective shoreline response, but no on-water removal, were employed. The extremely high level of theoretical oil recovery (50 to 70%) that occurred in the modeling was adjusted in a second analysis to account for increasing inefficiencies in recovery capability with time, demonstrating that oil recovery under Washington State's earlier and more aggressive response standard was three times as high as under the federal response standard. Greater differences in costs and impacts were then realized. Increasing on-water oil removal through more efficient oil slick surveillance, training in strategic response, and more timely response can all contribute to reducing spill impacts and costs.

Note: This study is providing additional modeled costs and impacts (environmental and natural resource damages, socioeconomic impacts) of various spill scenarios under different response strategies. The trajectory modeling and response modeling employed are the most sophisticated yet employed and is providing valuable data. The comparison of impacts based on different response strategies and response capabilities is part of an effort to evaluate response capability and contingency planning standards for state legislation using cost-benefit analyses (see also next paper).

Applying a Modeling Cost/Benefit Analysis of Oil Spill Preparedness to a State's Contingency Plan Rule Process **[Linda Pilkey-Jarvis, Elin Storey, Rebecca Post (all of Washington Department of Ecology), Dagmar Etkin (ERC), Deborah French-McCay, Jill Rowe, Nicole Whittier, and Sankar Sankaranarayanan (all of Applied Science Associates, Inc.)]**
Abstract
Two oil spill preparedness regulations developed in the early 1990's by the Washington State Department of Ecology were opened for revision and consolidation. The regulations mandate tank and cargo vessel-, facility- and pipeline contingency planning, drill participation, and approval of response contractors. The regulations cover plan holders located throughout Washington State, operating on both marine and inland waters. An advisory committee was formed to guide the agency through the rule development. The revision and consolidation was needed for many reasons. After ten years, the regulations lacked recognition of important improvements in regional planning, incorporation of lessons learned from drills and spills, and the inclusion of measurable standards to determine whether plan holders are prepared for worst case spills. Key portions of the state's ten-year-old regulatory program were written as companion guidance documents, and needed to be moved into the regulation to comply with a

Washington State Supreme Court decision mandating that agencies use rulemaking processes with public comment to set standards, rather than rely on guidance to industry.

The rulemaking approach included an analysis of the costs and benefits of oil spill preparedness. This was developed using oil spill trajectory, cost, and impact modeling, as well as by compiling the results of an extensive written survey of contractor and plan holder preparedness costs. The impacts of potential spills in Washington's outer coast, sound, and river environments were modeled varying the response options and operational timing in order to understand how timing and response action may reduce damages from spills. It was a critical point to the state that the assumptions built into the models and the limitations of the approach were clearly communicated to the advisory committee participants. This paper will identify key differences between the federal and state legislative authorities that inevitably result in some variations between the federal and state requirements that companies in Washington must follow. The suitability of this analytical approach to develop measurable planning standards for rulemaking will be discussed.

2005 International Oil Spill Conference Issue Paper (White Paper): Potentially-Polluting Wrecks **[Jacqueline Michel (Research Planning, Inc.), Dagmar Etkin (ERC), Robert Urban (PCCI), Jon Waldron (Blank Rome LLP), and Trevor Gilbert (Australian Maritime Safety Authority)]**

Abstract
Recent catastrophic losses of several vessels, including the Prestige, Erika, Tricolor, and Evoli Sun have produced tremendous pressure on vessel owners and governments to engage in extraordinary efforts to remove all pollutants from these submerged wrecks and at times remove the wreck itself.

Removal is particularly an issue where the wreck is causing ongoing physical impacts to the surrounding habitat, either from the fuel, cargo or the vessel itself. Similarly, a number of vessels *(e.g.,* Jacob Luckenbach, Castillo De Salas, and Mississinewa, among others), which sank long ago, have begun releasing oil, fouling sensitive environmental habitats, stimulating criticism of the insufficient depollution undertaken (if any) and generating adamant demand for removal of all pollutants from those wrecks, and at times removal of the wreck remains.

These events and the potential for large numbers of similar incidents over the next several years, demand that we (government and industry together) begin planning now for how best and most effectively to respond to future and potential future events. The "do nothing" option often preferred in the past (*e.g.*, Nadhodka) has become now hardly acceptable in new incidents. Public demand for depollution of old wrecks, including war casualties or other historic vessels, is expected to continue growing.

This paper proposes to begin that best response planning process by:

- Outlining the scope of the problem of potentially polluting wrecks through a worldwide review of what is known of such wrecks and the analysis of examples of particular interest, to be proposed by the author and the workgroup.
- Recommending national and international actions to implement detailed risk assessments and action plans aimed at implementing rational, practicable response to future events, including:
    - Defining/describing technological challenges to pollutant removal.

- Describing/defining the relevant factors that must be addressed in assessing the environmental, social, political, and funding consideration.

Note: In this project, ERC will employ portions of the cost-effectiveness analytical tool to evaluate the cost-effectiveness of salvage and response operations in reducing the potential impacts of oil releases from submerged wrecks. This is a unique application of this tool for the purpose of evaluating policy.

The following presentation will be made at the 2005 Arctic and Marine Oilspill Program Technical Seminar (7 – 9 June 2005):

Development of an Oil Spill Response Cost-Effectiveness Analytical Tool (Dagmar Etkin, ERC) *Abstract*

Decision-making during oil spill response operations or contingency planning requires balancing the need to remove as much oil as possible from the environment while also minimizing the impact of the response operations on the environment they are intending to protect. Additionally, there are often limited financial resources from which officials need to fund both oil removal and the ultimate restoration of the oil-impacted *and response-impacted* environment. In the aftermath of an oil spill, officials, trustees, and the responsible party have a concurrent concern for deriving the largest *net gain* of environmental restoration from both the response *and* restoration operations, often while operating within one overall budget.

This paper describes the development and use of decision-making tools that incorporate factors of *cost-effectiveness* of response/restoration operations into net environmental benefit analysis (NEBA). The project's objective was to develop a set of *decision-making tools* for determining the *cost-effectiveness of various oil spill cleanup response options* in order better facilitate short-term and long-term environmental recovery of oil-impacted areas. By providing incident-specific (or hypothetical scenario-specific) information on response costs (by methodology), response effectiveness, environmental impacts, and cost-effectiveness, the tools can help response and restoration officials make well-informed choices during actual response and restoration operations. The tools can also help in the evaluation of various response and restoration options for contingency planning or strategizing by understanding the potential costs involved for various response options and the potential effectiveness of those response strategies.

B. Work Plan To Accomplish Tasks

Future Tasks

The outstanding tasks that need to be accomplished by 31 January 2005 include:

- Completion and modification of algorithms for on-water response costs using mechanical containment and recovery methods, chemical dispersants, and *in situ* burning for different oil types and conditions;
- Completion and modification of algorithms for shoreline response operations for different shore types based on amount of oiling, proximity of sensitive resources, and "how clean is clean" criteria.
- Modification of algorithms to measure the "success" of response operations in reducing short- and long-term environmental impacts and socioeconomic impacts.

- Incorporation of the algorithms into a user-friendly user interface for software and possible hand calculation method.
- Preparation of a draft report for presentation and review.

III. Expenditures

All additional work in the next period will be conducted on a no-cost basis.

References

Davis, B., D.S. Etkin, M. Landry, and K. Watts. 2004. Determination of oil persistence: A historical perspective. *Proceedings of the Fifth Biennial Freshwater Spills Symposium:* in press.

Etkin, D.S. 2000. *Shoreline Cleanup Cost Modeling for Tanker Casualty Oil Spill Scenarios Specified by the National Research Council Transportation Research Board Committee on Evaluating Alternative Tanker Designs.* Environmental Research Consulting, Winchester, MA. 9 June 2000. 41 pp.

Etkin, D.S. 2001*a*. Analysis of oil spill trends in the US and worldwide. *Proceedings of the 2001 International Oil Spill Conference:* pp. 1,291 – 1,300.

Etkin, D.S. 2001*b*. Comparative methodologies for estimating on-water response costs for marine oil spills. *Proceedings of the 2001 International Oil Spill Conference:* pp. 1,281 – 1,289.

Etkin, D.S. 2001*c*. *Mechanical Containment and Recovery Cost Models For Tanker Casualty Oil Spill Scenarios Specified by the National Research Council Transportation Research Board Committee on Evaluating Alternative Tanker Designs.* Environmental Research Consulting, Winchester, MA. 21 February 2001. 127 pp.

Etkin, D.S. 2001*d*. Methodologies for estimating shoreline cleanup costs. *Proceedings of the 24th Arctic and Marine Oilspill Program Technical Seminar*: pp. 647 – 670.

Etkin, D.S. 2002. Analysis of past marine oil spill rates and trends for future contingency planning. *Proceedings of the 25th Arctic and Marine Oilspill Program Technical Seminar*: pp. 227 – 252.

Etkin, D.S. 2003*a*. Analysis of US oil spill trends to develop scenarios for contingency planning. *Proceedings of the 2003 International Oil Spill Conference:* in press.

Etkin, D.S. 2003*b*. Estimation of shoreline response cost factors. *Proceedings of the 2003 International Oil Spill Conference:* pp. 1,243 – 1,253.

Etkin, D.S. 2003*c*. *Final Report: Bio-economic Modeling for Oil Spills from Tanker/ Freighter Groundings on Rock Pinnacles in San Francisco Bay: Volume III of VII. Spill Response Report – Shag Rock.* US Army Corps of Engineers, Sacramento District. Contract No. Oil Spill Analysis and Modeling DACW07-01-C-0018. Subcontract No.: 2001-038-01. May 2003. 167 pp.

Etkin, D.S. 2003*d*. *Final Report: Bio-economic Modeling for Oil Spills from Tanker/ Freighter Groundings on Rock Pinnacles in San Francisco Bay: Volume IV of VII. Spill Response Report – Blossom Rock.* US Army Corps of Engineers, Sacramento District. Contract No. Oil Spill Analysis and Modeling DACW07-01-C-0018. Subcontract No.: 2001-038-01. May 2003. 153 pp.

Etkin, D.S. *2004a. Analysis* of benefits of EPA oil program. . *Proceedings of the Fifth Biennial Freshwater Spills Symposium:* in press.

Etkin, D.S. 2004*b*. Modeling oil spill response and damage costs. *Proceedings of the Fifth Biennial Freshwater Spills Symposium:* in press.
Etkin, D.S. 2004*c*.. Twenty-year trend analysis of oil spills in EPA jurisdiction. *Proceedings of the Fifth Biennial Freshwater Spills Symposium:* in press.
Etkin, D.S. 2005. Development of an oil spill response cost-effectiveness analytical tool. *Proceedings of the 2005 International Oil Spill Conference:* in preparation.
Etkin, D.S. 2005. Quantifying benefits of developments in oil spill prevention, preparedness, and response. *Proceedings of the 2005 International Oil Spill Conference:* in preparation.
Etkin, D.S., D. French McCay, J. Jennings, N. Whittier, S. Subbayya, W. Saunders, and C. Dalton. 2003. Financial implications of hypothetical San Francisco bay oil spill scenarios: Response, socioeconomic, and natural resource damage costs. *Proceedings of the 2003 International Oil Spill Conference:* pp. 1,317 –1,325.
Etkin, D.S., D. French-McCay, J. Rowe, N. Whittier, and S.Sankaranarayanan, and L Pilkey-Jarvis. 2005.Development Impacts of response method and capability on oil spill costs and damages for Washington State spill scenarios *Proceedings of the 2005 International Oil Spill Conference:* in preparation.
Etkin, D.S., D. French-McCay, N.Whittier, S. Subbayya,, and J. Jennings 2002. Modeling of response, socioeconomic, and natural resource damage costs for hypothetical oil spill scenarios in San Francisco Bay. *Proceedings of the 25th Arctic and Marine Oilspill Program Technical Seminar*: pp. 1,075 – 1,102.
French-McCay, D. J.J. Rowe, N.Whittier, S. Sankaranarayanan, and D.S.Etkin. 2004. Estimation of potential impacts and natural resource damages of oil. *Journal of Hazardous Materials* Vol. 107 (2004): pp. 11–25.
French-McCay, D., N.Whittier, S. Subbayya, J. Jennings, and D.S. Etkin. 2002. Modeling fates and impacts for bio-economic analysis of hypothetical oil spill scenarios in San Francisco Bay. *Proceedings of the 25th Arctic and Marine Oilspill Program Technical Seminar*: pp. 1,051 – 1,074.
Gregory, C.L., A.A. Allen, and D.H. Dale. 1999. Assessment of potential oil spill recovery capabilities. *Proceedings of the 1999 International Oil Spill Conference:* pp. 527 – 534.
National Research Council Transportation Research Board/Marine Board Committee on Evaluating Alternative Tanker Designs. 2001. *Special Environmental Performance of Tanker Designs in Collision and Grounding: Method for Comparison (Report 259)*. National Academy of Sciences, Washington, DC. 146 pp.
Pilkey-Jarvis, L. E. Storey, R. Post, D.S. Etkin, D. French-McCay, J. Rowe, N. Whittier, and S. Sankaranarayanan. 2005. Applying a modeling cost/benefit analysis of oil spill preparedness to a state's contingency plan rule process. *Proceedings of the 2005 International Oil Spill Conference:* in preparation.
Research Planning, Inc., Applied Science Associates, Inc., and Environmental Research Consulting. 2001. *Final Report: Assessment of the Potential Impacts of Oil Spills from the National Defense Reserve Fleet (NDRF*). Prepared for Maritime Administration, South Atlantic Region, Department of Transportation, Norfolk, Virginia. October 2001. 75 pp.
US Army Corps of Engineers San Francisco District and California State Lands Commission. 2003. *San Francisco Central Bay Rock Removal Project: Feasibility Study Reference Report.* November 2003. 78 pp.