Interagency Coordinating Committee on Oil Pollution Research

Biennial Report for Fiscal Years 2008 and 2009

December 2009

Homeland Security

United States Coast Guard

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Message from the U.S. Coast Guard Chief, Office of Incident Management and Preparedness

Section 7001 of Title VII of the 1990 Oil Pollution Act (OPA 90) requires the Chairman of the Interagency Coordinating Committee on Oil Pollution Research to submit biennial reports on the Interagency Committee's activities. The United States Coast Guard chairs the Interagency Committee, and has done so since its inception. The Interagency Committee first reported to Congress in 1994 and this report responds to the latest Congressional requirement. It discusses the activities carried out (and ongoing) in fiscal years 2008 and 2009, as well as activities proposed for fiscal years 2010 and 2011. The Interagency Committee continues to serve as an information exchange forum amongst its chartered members, and actively pursues new national and international research and development opportunities.

This report is provided for:

The Honorable John D. Rockefeller, IV
Chairman, Senate Commerce, Science & Transportation Committee

The Honorable Kay Bailey Hutchison
Ranking Member, Senate Commerce, Science & Transportation Committee

The Honorable James Oberstar
Chairman, House Transportation and Infrastructure Committee

The Honorable John L. Mica
Ranking Member, House Transportation and Infrastructure Committee

I am happy to answer any further questions that you may have, and your staff may contact my House Liaison Office at (202) 224-4775.

Sincerely,

A. S. Lloyd
Captain, U.S. Coast Guard
Chairman, Interagency Coordinating Committee
on Oil Pollution Research

Executive Summary

Title VII of the Oil Pollution Act of 1990 established the thirteen-member Interagency Coordinating Committee on Oil Pollution Research (referred to as the Interagency Committee in this report) to "coordinate a comprehensive program of oil pollution research, technology development, and demonstration among the Federal agencies, in cooperation and coordination with industry, universities, research institutions, State governments, and other nations, as appropriate, and shall foster cost-effective research mechanisms, including the joint funding of research." The Chairman of the Interagency Committee, represented by the Coast Guard, is required to submit a biennial report on activities carried out under Section 7001 in the preceding two fiscal years and on activities proposed to be carried out under this section in the current two fiscal year period.

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I. List of Acronyms

ADIOS	Automated Data Inquiring for Oil Spills
ANS	Alaska North Star
BFT	Baffled Flask Test
BIO	Bedford Institute of Oceanography
CDOG	Clarkson Deepwater Oil and Gas
CEWAF	Chemical Enhanced Water Accommodated Fractions
CICEET	Cooperative Institute for Coastal and Estuarine Experimental Technology
CEDRE	Center of Documentation, Research and Experimentation on Accidental Water Pollution
CCG	Canadian Coast Guard
CODAR	COastal raDAR
CPM	Cycles Per Minute
CROSERF	Chemical Response to Oil Spills Ecological Research Forum
CRRC	Coastal Response Research Center
CRREL	Cold Regions Research and Engineering Laboratory
CTD	Conductivity-Temperature-Depth profiler
DE	Dispersant Effectiveness
DMAC-SC	Data Management and Communications Steering Committee
DMP	Dispersant Mission Planner
DOMP	Dispersed Oil Monitoring Plan
DOR	Dispersant-to-Oil Ratio
EDAC	Effective Daily Application Capability
ELA	Experimental Lakes Area
EPA	Environmental Protection Agency
ERD	Environmental Research Division
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HAZMAT	Hazardous Materials
HF	High Frequency
JAT	Joint Assessment Team
LISST	Laser In-Situ Scattering Transmissometry
MCOSA	Monte Carlo model for OSA
MMS	Minerals Management Service
NCP	National Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRMRL	National Risk Management Research Laboratory
OCS	Outer Continental Shelf
OMA	Oil-Mineral Aggregate
OPeNDAP	Open-source Project for a Network Data Access Protocol
ORD	Office of Research and Development
OR&R	Office of Response and Restoration
OSA	Oil Suspended particulate matter Aggregate
OSPR	Office of Spill Prevention and Response

OSRL	Oil Spill Response Limited
OSSM	On-Scene Spill Model
PAH	Polycyclic Aromatic Hydrocarbons
PERF	Petroleum Environmental Research Forum
POPEIE	Probe for Oil Pollution Evidence in the Environment
RFP	Request for Proposal
SCAT	Shoreline Cleanup Assessment Technique
SIO	Scripps Institution of Oceanography
SMART	Special Monitoring of Applied Response Technologies
SOR	Surface washing agent Oil Ratio
SPM	Suspended Particulate Matter
SWA	Surface Washing Agent
SWT	Swirling Flask Test
TDLS	Tunable Diode Laser Spectrometer
USCG	United States Coast Guard
WAF	Water Accommodated Fractions

II. Legislative Requirement

This document responds to the reporting requirements set forth in Section 7001(e) of the Oil Pollution Act of 1990 (P.L. 101-380), which states:

"The Chairman of the Interagency Committee shall submit to Congress every two years on October 30 a report on the activities carried out under this section in the preceding two fiscal years, and on activities proposed to be carried out under this section in the current two fiscal year period."

III. Background

Purpose of the Interagency Committee

Section 7001(a) of the Oil Pollution Act of 1990 (OPA 90) established the Interagency Coordinating Committee on Oil Pollution Research. The purpose of the Interagency Committee is twofold: (1) to prepare a comprehensive, coordinated Federal oil pollution research and development (R&D) plan; and (2) to promote cooperation with industry, universities, research institutions, state governments, and other nations through information sharing, coordinated planning, and joint funding of projects.

Membership

The Interagency Committee was commissioned with 13 members and is chaired by the Coast Guard. Membership includes:

Department of Commerce (DOC)
- National Oceanic and Atmospheric Administration (NOAA)
- National Institute of Standards and Technology (NIST)

Department of Energy (DOE)

Department of Interior (DOI)
- Minerals Management Service (MMS)
- United States Fish and Wildlife Service (USFWS)

Department of Transportation (DOT)
- Maritime Administration (MARAD)
- Pipeline and Hazardous Materials Safety Administration (PHMSA)

Department of Defense (DoD)
- United States Army Corps of Engineers (USACE)
- United States Navy (USN)

Environmental Protection Agency (EPA)

National Aeronautics and Space Administration (NASA)

Department of Homeland Security (DHS)
- United States Coast Guard (USCG)
- Federal Emergency Management Agency (FEMA) - United States Fire Administration (USFA)

Oil Pollution Research and Development Technology Plan

Section 7001(b) of the Oil Pollution Act of 1990 required the Interagency Committee to prepare an Oil Pollution Research and Technology Plan. The Interagency Committee prepared the original Oil Pollution Research and Development (R&D) Technology Plan to define the roles of each federal agency involved in oil spill research and development. The plan was submitted to Congress in April 1992 and later reviewed by the National Research Council's Committee on Oil Spill Research and Development under the auspices of the Marine Board. Using input from the Marine Board, the Committee revised the plan in May 1993 to address spill prevention, human factors, and the field testing/demonstration of developed response technologies. The current version of the plan, still based on Marine Board recommendations, is dated April 1997. The Interagency Committee is coordinating an update of the Technology Plan during the next two fiscal years.

Oil Pollution Research and Development Program

Guided by Section 7001(c), the Interagency Committee coordinates and monitors a variety of oil pollution research and development initiatives with industry, universities, research institutions, state governments, and other entities. Many of these projects were completed in the early years of the Interagency Committee, while others continue to evolve through the current reporting period. Descriptions of the key initiatives under this section as well as their statutes include:

1) *Oil pollution effects and response technology research* – The cornerstone of the Interagency Committee's role and activities is the research conducted and coordinated by its members. Oil pollution research has covered a broad range of topics and continues through the present day. Chapter IV and attachments (1) and (2) in this report describe the key research projects and publications overseen by the Interagency Committee for fiscal years 2007 through 2012.

2) *Demonstration projects* - Section 7001(c)(6) directed that Port Oil Pollution Minimization Demonstration Projects be conducted in New York, New Orleans and Los Angeles/Long Beach. The Great Lakes Oil Pollution Research and Development Act of 1990 amended OPA 90 to include a fourth demonstration in ports in the Great Lakes. Demonstration projects were held in New Orleans (December 1994) and New York (October 1995). After the first two projects were completed, the Coast Guard determined they were not cost effective, and the Interagency Committee agreed that the objectives for the Demonstration projects could be met through other means.[1] Since 1995, the objectives have been addressed through interagency participation in regularly scheduled domestic and international oil spill conferences. The International Oil Spill Conference (triennial), the Clean Pacific and Gulf Conferences (biennial and annual), the Fresh Water Spill Symposium (biennial), and the Inland Spills Conference (biennial), provide expansive forums for the display of the latest spill cleanup and removal technologies.

[1] Interagency Committee Biennial Report to Congress for FY 2001 & 2002

3) *Regional Research Grant Program* - Under Section 7001(c)(8), the Interagency Committee was tasked with establishing a Regional Research Program. The objective was to "coordinate a program of competitive grants to universities or other research institutions, or groups of universities or research institutions, for the purposes of conducting a coordinated research program related to the regional aspects of oil pollution, such as prevention, removal, mitigation, and the effects of discharged oil on regional environments." Funding for the program was authorized for each of the fiscal years from 1991 through 1995. The last reports prepared by the universities and institutions selected under this program were delivered in FY 1996.[2]

Simulated Environmental Testing

The Minerals Management Service (Department of the Interior) has responsibility for the operation and maintenance of Ohmsett – The National Oil Spill Response Test Facility, located at the U.S. Naval Weapons Station Earle in Leonardo, NJ. This responsibility was formalized in 1992 with the publication of the Interagency Oil Spill Research and Technology Plan, mandated by Section 7001(b).

Ohmsett is used for two primary and essential functions related to national oil spill response planning:

1) *Full scale equipment testing* - An estimated 95% of the quantitative performance data on mechanical equipment used by the USCG, EPA, USN and private industry (both domestic and international) is obtained through Ohmsett.

2) *Responder training* - Ohmsett is one of the few facilities in the world where oil spill responders can be trained under various controlled environmental conditions using real oil. Training provided at Ohmsett ensures new responders are educated about oil pollution operations in advance of an incident.

The continued operation and maintenance of the Ohmsett facility is crucial to the MMS Oil Spill Response Research Program. Ohmsett has experienced a 150 percent increase in its use over the past five years. Consequently, the vital equipment necessary to operate the 35-year old facility needed a thorough overhaul. The continued safe and effective operation of Ohmsett required completion of long deferred major repairs as well as replacement of critical facility equipment and control systems. Ohmsett successfully completed a five-year major refurbishment and repair program during this reporting period. A description of these new upgrades and a strategic overview of the facility are provided in attachment (3).

[2] U.S. Coast Guard 1995 Oil Pollution Research Grant Publications: Parts 1 & 2. Final Report. John A. Volpe National Transportation Systems Center, Cambridge, MA, August 1997.

IV. Interagency Committee Activities during Reporting Period

Research and Development Initiatives

The Interagency Committee operates without appropriated funding. The oil pollution research initiatives coordinated and monitored by the Interagency Committee are funded solely by its member agencies or departments.

A number of ongoing and new research projects were managed by the Interagency Committee's components during the fiscal year 2008-09 reporting period: 66 research projects are summarized in attachment (1), and 50 peer-reviewed publications are listed in attachment (2). Oil pollution research initiated or completed during the reporting period covered a variety of topics, including: spilled oil fate and behavior modeling, alternative response technologies, spill toxicity and biological effect, and dispersant use.

Interagency Committee Meetings

As Chair of the Interagency Committee, the Coast Guard encourages interaction amongst member agencies to participate in workshops and the domestic and international oil spill conferences, including:

- Annual Clean Gulf Conference
- Biennial Fresh Water Spills Symposium
- Annual Inland Spills Conference
- Biennial Clean Pacific Conference (inaugural conference held in September 2007)
- Triennial International Oil Spill Conferences (Spillcon 2007 in Perth, Australia; International Oil Spill Conference (IOSC) 2008 in Savannah, GA; Interspill 2009 in Marseilles, France)

At these conferences, federal, state, and non-government officials from around the world display state-of-the-art oil spill response equipment and products. They also exchange information on the latest advances in spill prevention, preparedness, response, and restoration. Interagency Committee members also exchange information at biennial Spill Advisory Group meetings, National Response Team General Committee meetings, and National Response Team Science and Technology Committee meetings.

During fiscal years 2010 and 2011, the Interagency Committee will continue to meet and participate through its member agencies in both national and international research and development forums. The Interagency Committee is developing a quarterly schedule of formal meetings for fiscal years 2010 thru 2012. The Committee met during the November 2009 Clean Gulf Conference in New Orleans, LA. The Coast Guard will also coordinate an interim Interagency Committee meeting in Anchorage, AK, to explore future directions and roles for Arctic related oil pollution research.

Interagency Committee Member Workshop and Conference Participation

Interagency Committee members sponsor or participate in a variety of conferences and workshops related to oil pollution research. Table 1 lists the conferences and workshops attended during fiscal years 2007-2009.

Table 1 – Workshop and Conference Participation – Fiscal Year 2008 (October 1, 2007) thru Fiscal Year 2009 (September 30, 2009)

Venue	Location	Sponsorship	Date(s)
International Oil & Ice Workshop	Anchorage, AK	Alaska Clean Seas, Alaska Department of Environmental Conservation Cook Inlet Spill Response Inc., Oil Spill Recovery Institute, USCG, MMS	October 10-11, 2007
Applied Research for the Spill Response Community	Tampa, FL	NOAA/CRRC/Louisiana Applied and Educational Oil Spill Research and Development Program	November 14, 2007
Habitat Equivalency Metrics Workshop	Durham, NH	NOAA/CRRC	December 4-7, 2007
EPA OSC Readiness Training	San Diego, CA	EPA	February 4-7, 2008
International Maritime Organization (IMO)-International Convention of Oil Pollution Preparedness, Response and Co-operation-Hazardous and Noxious Substances Technical Group 6 Meeting	London, United Kingdom	IMO	March and October 2008
Opening the Arctic Seas: Envisioning Disasters and Framing Solutions	Durham, NH	NOAA/CRRC/US Arctic Commission	March 18-20, 2008
2008 International Oil Spill Conference	Savannah, GA	IMO, NOAA, EPA, USCG, MMS, American Petroleum Institute (API), International Petroleum Industry Environmental Conservation Association (IPIECA)	May 4-8, 2008
In Situ Burn Practitioners' Forum	Durham, NH	NOAA/CRRC/American Petroleum Institute (API)	May 2008
2008 Arctic and Marine Oil Spill Program	Calgary, Alberta Canada	Environment Canada	June 3-5, 2008
AMOP	Calgary, Alberta Canada	Environment Canada	June 3-5, 2008
HF Radar/Integrated Ocean Observing Systems for Spill Response	Durham, NH	NOAA/CRRC	September 2008
Clean Gulf 2008	San Antonio, TX	Industry and governmental	October 28-

		agencies	30, 2008
Dispersant Working Group Meeting at Clean Gulf	San Antonio, TX	NOAA/CRRC	October 29, 2008
Submerged Oil Meeting at Clean Gulf	San Antonio, TX	NOAA/CRRC	October 30, 2008
Reducing Environmental Risks and Impacts in Arctic Coastal and offshore Oil and Gas Exploration	Barrow, AK	NOAA/CRRC	November 12-14, 2008
In Situ Burning of Inland Oil Spills Workshop	Houston, TX	API, BP	December 9-11, 2008
EPA OSC Readiness Training	San Diego, CA	EPA	February, 9-12, 2009
Research & Development Priorities: Oil Spill Workshop	Durham, NH	NOAA/CRRC	March 17 – 19, 2009
Dispersant Workshop	Houston, TX	BP	March 2009
EPA's Freshwater Spills Symposium	St. Louis, MO	EPA	April 27-30, 2009
Interspill 2009	Marseilles, France	IMO, IPIECA	May 2009
2009 Arctic and Marine Oil Spill Program	Vancouver, British Columbia, Canada	Environment Canada	June 2009
2009 "Wrecks of the World: Hidden Risks of the Deep" Conference	Linthicum. MD	American Salvage Association	September 9, 2009
2009 Clean Pacific Conference	Portland, OR	Industry and governmental agencies	September 14-16, 2009

V. Future Activities

During this reporting period, specific research subjects and initiatives rose in prominence and will likely be Interagency Committee priorities for several years. For example, as a result of the decrease in Arctic ice cover, this region will likely experience increased maritime traffic and resource exploration. Consequently, the risk of oil spills in the Arctic could increase.[3] Oil spills in these waters are complex responses due to several factors, such as: 1) the unique biota present; 2) the paucity of available response resources; and 3) temperature effects on the chemical/physical behavior of spilled oil, and the resulting cleanup strategies. Recognizing these complex issues, the Interagency Committee will continue to coordinate and remain cognizant of cold-water response research and development studies. While several Arctic related studies were completed in the past five years, new studies are underway. Studies completed include: a Svalbard, Norway experimental oil spill to study spill detection and oil behavior in ice (reported by MMS); detection of oil on/under ice (reported by MMS), and cold climate research (reported by USCG). These and additional completed and ongoing Arctic research projects from MMS, NOAA, Coastal Response Research Center (CRRC), and the USCG are described in attachment (1).

In addition to expanded Arctic research, the Interagency Committee is considering other new activities for the 2009-2010 reporting period. Three of these new projects include:

1) *Oil Exploration, Production, Refining, and Distribution, Study.* When Congress created the Interagency Committee, it required a study to identify the entire "life cycle" of oil exploration, production, refining, transportation and distribution. The purpose of the study was to permit a focus for research and development in each of the stages of the oil handling process. The study was completed and accepted by Congress in the early 1990's. It has not been updated and specifically lacks focus on newly-evolving issues like: platform spills, floating production-storage-offloading vessel spills, Arctic resource exploration and production, and new technologies for oil spill recovery (e.g., chemical herds, gelling agents, solidifiers, in situ burning, dispersants, emulsion breakers, mechanical recovery all in open water and ice infested waters). The Interagency Committee will explore these and other related topics and their necessary funding options to propose a new study.

2) *Website for Research and Development.* The Committee will establish a formal site for the integration and listing of research and development initiatives by the member agencies. This site will also post research reports and results. These efforts will be coordinated with communication outreach activities similar to those practiced by the National Response Team's Science and Technology Committee.

3) *Oil Pollution Research and Technology Plan* – As stated in Chapter III, the Interagency Committee will review the 1997 plan for revision. The continued evolution of oil exploration technology, handling processes, and the potential problems associated in the Arctic and deep oceans may present new subjects not accounted for in the existing plan.

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[3] Opening the Arctic Seas. Envisioning Disasters and Framing Solutions. Coastal Response Research Center. Final Report. January 2009.

VI. Conclusion

The Interagency Committee continues to serve as a forum for its federal members to coordinate and maintain awareness of ongoing oil pollution research activities. The member components and agencies have successfully completed and shared valuable information about a variety of projects during the current reporting period. They will continue to interact in a number of venues. These include conferences, workshops, meetings of the National Response Team Science and Technology Subcommittee, and through formal meetings. Interagency Committee formal meetings are normally scheduled on an annual or semi-annual basis. Under the leadership of the Coast Guard, the Interagency Committee anticipates extensive interaction with states, industry, and the international research and development community during the next reporting period. This interaction will be especially important supporting new research priorities under consideration by the Interagency Committee.

VII. Appendices

Attachment (1) FY2007-2012 Interagency Coordinating Committee on Oil Pollution Research Initiatives

Attachment (2) FY2007-2009 Publications on Pollution Research

Attachment (3) Overview of Ohmsett National Oil Spill Response Test Tank Facility

FY 2007 – 2010 Interagency Coordinating Committee on Oil Pollution Research Initiatives

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The following summaries are abstracts of research projects provided by sponsoring agencies:

ALTERNATIVE TECHNOLOGIES:

Mitigating Oil Spills from Offshore Oil and Gas Activities by Enhancement of Oil-Mineral Aggregate Formation
Contracting Agency: MMS
Completed: April 30, 2009
To assess the feasibility of a marine oil spill countermeasure strategy based on the stimulation of oil-mineral aggregate (OMA) formation. Experiments will be conducted on both laboratory and wave tank systems under controlled conditions to evaluate its potential effectiveness for the treatment of oil spills from ships, facilities or pipelines. Conceptual mathematical models will be developed from the data to identify the fundamental processes affecting operational effectiveness as a means to provide guidance for field operations. http://www.mms.gov/tarprojects/585.htm. This project is co-funded with the Department of Fisheries and Oceans – Center for Offshore Oil and Gas Environmental Research (COOGER).

Use of Natural Oil Seeps for Evaluation of Dispersant Application and Monitoring Techniques
Contracting Agency: NOAA/CRRC
Completed: 2008
Utilizing the natural seeps of Santa Barbara, California, this project has three primary objectives: 1) to demonstrate the NEAT SWEEP boom and dispersant application technology under full-scale field conditions as a follow-up to its successful OHMSETT trails, 2) to continuously monitor dispersant effectiveness in real-time using NOAA SMART Protocols, and 3) for the first time, to calibrate the SMART Protocol results with discrete large volume sampling of dissolved and dispersed oil-droplet phase hydrocarbons. The resulting data can enhance oil spill response decisions, through improved and validated monitoring methods and more efficient dispersant application techniques. This project is a cooperative effort between two private consulting firms (PECI and Spiltec), the developers of the NEAT SWEEP technology (Elastec American Marine), the Clean Seas Santa Barbara Oil-Spill Response Cooperative, and So Cal Ship Services. Personnel from the UCSB Natural Hydrocarbon Seep Project, the USCG, NOAA, CA Fish and Game OSPR, and other state and federal agencies have also been invited to participate. As such, this project fulfills several of the main operating principles of both CICEET and OR&R to "foster collaboration between academia, government, and the private sector" through commitment to interdisciplinary work." All parties agree that this project represents an advance in dispersant technology and a unique opportunity to intercalibrate monitoring procedures. Completed report available on website www.crrc.unh.edu

Biodegradability of Dispersed Crude Oil at Different Temperatures.
Contracting Agency: EPA/NRMRL
Completed: 2007
Laboratory experiments were initiated to study the biodegradability of oil after dispersants were applied. Two experiments were conducted, one at 20 °C and the other at 5 °C. In both experiments, only the dispersed oil fraction was investigated. Each experiment required treatment flasks containing 3.5% artificial seawater and crude oil previously dispersed by either

Corexit 9500 or JD2000 at a dispersant-to-oil ratio of 1:25. Two different concentrations of dispersed oil were prepared, the dispersed oil then transferred to shake flasks, which were inoculated with a bacterial culture and shaken on a rotary shaker at 200 rpm for several weeks. Periodically, triplicate flasks were removed and sacrificed to determine the residual oil concentration remaining at that time. Oil compositional analysis was performed by gas chromatography/mass spectrometry (GC/MS) to quantify the biodegradability. Dispersed oil biodegraded rapidly at 20 °C and less rapidly at 5 °C, in line with the hypothesis that the ultimate fate of dispersed oil in the sea is rapid loss by biodegradation.

Optimization of Nutrient Application for Oil Bioremediation on Beaches
Contracting Agency: EPA/NRMRL
Completed: 2007
Biostimulation by nutrient application is a viable technology for restoring oil-contaminated beaches. Maximizing the nutrient residence time is essential for achieving a rapid, cost-effective cleanup. The nutrient injection strategy through a perforated pipe at the high tide line was considered, and beach hydraulics were simulated numerically. This enabled estimation of the optimal injection flow rate of nutrient solution. Results indicated that the optimal application is one that starts following the falling high tide and lasts for a half tidal cycle. The saturated wet-front of the nutrient solution on the beach surface would move seaward with the same speed of the falling tide keeping a constant distance with the tide line. The numerical results were generalized to beaches of wide ranges of hydraulic and tidal properties using a novel dimensionless formulation for water flow and solute transport in porous media. Nomographs were presented to provide the flow rate based on four parameters: beach slope, hydraulic conductivity, tidal amplitude, and tidal period.

Transport of Biofuels in Inland Waters
Contracting Agency: EPA/NRMRL
(Ongoing) Estimated Completion: 2011
Because of increased production and transportation of ethanol, a number of spills have occurred to the land surface or to inland waterways. Fuel ethanol itself is composed of mainly ethanol but also some byproducts (usually called fusel oil). To this is added a denaturant, which is usually gasoline or gasoline range hydrocarbons. When this liquid comes into contact with water, the ethanol and gasoline can separate and form two separate phases. The properties and composition of fuel ethanol, denatured fuel ethanol and consumer ethanol fuels have been studied and an EPA report prepared for use by consultants, state agencies, and federal response officials. This information forms part of the knowledge basis for modeling transport of these liquids in inland waterways. The purpose of modeling is for response planning. Given effects of releases of these fuels in water: phase separation, volatilization of gasoline, aerobic biodegradation of ethanol, depletion of oxygen leading to fish kills, the modeling is intended to provide a tool for estimating the ability of booms to recover gasoline and bubblers to reoxygenate impacted waterways. A journal article is in preparation on an expanded dataset of ethanol compositions and development of the model is in progress. A journal paper on the model is planned for late calendar year 2009.

COMMAND, CONTROL, AND COMMUNICATIONS:

Comparing stakeholders' objectives for oil spill response: A Q study of four regions
Contracting Agency: NOAA/CRRC
Completed: August 2008
This report describes the results of a study about the relative importance of spill response objectives to stakeholders, from varied organizations and government agencies. In this study the population of interest includes spill planners, managers, and responders. We did not attempt to ascertain the viewpoints salient among community members in the four regions (i.e., general public). We investigated the views of people involved in response planning and in spill responses in Buzzards Bay, Delaware Bay, San Francisco Bay, and Washington State regions. We begin this paper with a discussion of the research method used in the study, Q method. Then, the results from the four regions are discussed separately. In Buzzards Bay, Delaware Bay, and San Francisco Bay three perspectives were identified in each case. In Washington State two perspectives were identified. We then turn to a discussion of four archetype perspectives that underlay the set of case-specific perspectives. These four perspectives are compared on several themes, including the emphasis they place on mitigating economic impacts, protecting health and safety, mitigating ecological impacts, implementing a coordinated and timely response, addressing needs and concerns of the affected public/communities, gaining public support for the response, mitigating cultural impacts, and mitigating social nuisance impacts.
Final Report: http://www.crrc.unh.edu/final/tulerfinal09/index.html

FATE AND BEHAVIOR MODELING AND ANALYSIS:

Oil Spill Training and Response (STAR) Calculator Program
Contracting Agency: MMS, Shell International Exploration and Production, Inc. and the American Petroleum Institute.
Estimated Completion: August 2009
The purpose of this project is to improve the industry's ability to respond to oil spills. Specifically, the project will develop a software-based tool that can be used to guide in the selection and assessment of response countermeasures during spill events and exercises. The objectives of this project are to standardize the existing software packages; to enhance their utility, user-interface and output; and, to integrate all three response options (mechanical, burning & dispersants) using improved algorithms for their efficient use under a variety of spill scenarios. The project will standardize and unify the three NOAA Spill Tools and combine them with weathering algorithms to better estimate oil recovery/treatment during exercises and actual oil spill events. The STAR Calculator will be in the public domain; all of the algorithms used will be documented and will be freely available with the software. Information on this project can be found at http://www.mms.gov/tarprojects/625.htm
<http://www.mms.gov/tarprojects/625.htm>.

Environmental Response Management Application (ERMA)
Contracting Agency: NOAA/CRRC
Estimated Completion: October 2009

ERMA is an open source web-based GIS tool designed for decision-makers during spills and other hazards. It was created by scientists and practitioners from NOAA's Office of Response and Restoration and the University of New Hampshire under the auspices of the Coastal Response Research Center (CRRC). ERMA integrates and synthesizes various real time and static datasets into a single interactive map, thus providing easy and fast visualization of the area under consideration, improving communication and coordination among stakeholders. ERMA captures base data and incorporates high resolution data relevant to site-specific decision-making. These data can include real time weather and ocean observations, restoration projects, multi-jurisdictionally managed areas and priorities defined by local stakeholders. ERMA allows users to interact directly to upload/download relevant data on the fly. ERMA allows users with diverse abilities to create graphic overlays, special labels, and areas of interest. ERMA can link to documents and plans and to temporal queries to ESI data. All data layers and tool functionalities meet open source compatibility standards enabling users to leverage ERMA data in Google Earth or ArcGIS. ERMA was developed for Portsmouth Harbor, NH as a prototype and is being expanded to support SONS 2010. The second generation of ERMA was developed for the US Caribbean and will be operational Oct 1, 2009.

Effect of Particle Size, Oil Contamination, and Water Table Level on the Effectiveness of Sorbents in Wicking Oil from the Subsurface
Contracting Agency: EPA/NRMRL
Completed: 2008
In this study, use of a cellulose-based sorbent was investigated as a remediation strategy for crude oil contaminated intertidal wetlands. Effectiveness of sorbent as a wicking agent was evaluated in microcosms under simulated intertidal wetlands conditions. Microcosms were designed to impose 3 different oil penetration depths (0.25, 0.5 and 1.0 cm), 2 different tidal amplitudes (5 cm and 10 cm above and below the oil contaminated surface) and 2 different types of sorbents (raw bagasse and hydrophobic treated bagasse). Each microcosm was composed of a clean sand layer, an oil penetrated layer, and an overlain sorbent layer. Oil wicking experiments were performed in airtight microcosms with semidiurnal tide for 6 weeks. At the end of the experiments, each layer of the microcosm was separated and samples were taken. Samples were extracted with dichloromethane and quantified by GC-MS. Effectiveness was calculated as the amount of biomarker recovered in the sorbent layer after 6 weeks normalized to the initial amount of biomarker.

The results indicated that the use of sorbent was beneficial not only in removing oil but also in preventing further contamination. 30~40% of added oil contaminated the underlying clean sand layer in the absence of the sorbent (control) while less than 12% (for untreated sorbent) and 8% (for treated sorbent) in the presence of the sorbent. Effectiveness of the raw bagasse was 68~80% and that of treated bagasse was 74~83%. Oil penetration depth and tidal amplitude both turned out to negatively affect the effectiveness of the sorbent. Effectiveness of the hydrophobic treated sorbent was always higher than the untreated one at any oil penetration depth and a tidal amplitude. Furthermore, the difference in effectiveness between untreated and treated sorbent increased as the level of the variable increased. Thus, hydrophobic treatment was useful to

increase effectiveness of the sorbent. The results suggested that this technique has a potential to stimulate biodegradation by wicking oil out of contaminated intertidal wetlands subsurface to the aerobic zone. Journal articles are in various phases of writing and completion.

Development of a Predictive Bayesian Data-Derived Multi-Modal Gaussian Maximum-Likelihood Model of Sunken Oil Mass
Contracting Agency: NOAA/CRRC
Estimated Completion: August 2010
The problem addressed in this research is the need for cost-effective tracking of sunken oil following a spill, to target cleanup activities and to support cleanup termination decisions. The objectives of this two-year project are to (1) compile and summarize data on the occurrence of sunken oil, directed by the project team including end users and NOAA liaison; (2) develop one or more superimposed, multi-modal predictive Bayesian Gaussian maximum-likelihood models of sunken oil locations across a bay that will accept spatial field data on sunken oil mass and hydrodynamic information from rapidly-deployable models of bottom and subsurface currents, to project assessments of sunken oil locations in time; and (3) verify the model versus sunken oil data, as possible, and simulated datasets. The approach is organized into three overlapping tasks: (1) "Development of conceptual model and data base," including a team kickoff meeting to identify data sources and define model capability, (2) "Model development," including the development of new genetic and other search algorithms for maximum-likelihood calibration of the model with field data, and (3) "Model verification, optimization, and dissemination," including active maintenance of a project website for information dissemination and model download and training activities as appropriate.
Project Page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=27

Dispersion and submergence as extremes of a theoretical continuum: development of numerical algorithms to compute interaction of surface oil with breaking waves
Contracting Agency: NOAA/CRRC
Completed: January 2009
The goal of this project is to develop algorithms for modeling the natural dispersion of oil released at sea. In this work, the processes of natural dispersion and submergence will be approached as two extremes of the interaction between surface oil, whose characteristics constantly change during weathering processes, and a turbulent hydrodynamic environment. Coupling these extremes of behavior into a continuous functional algorithm is the main innovation of this research. This project will build on the work of Delvigne and Sweeney (1988, 1993, 1994), but will also incorporate other processes- emulsification, interfacial tension and rheological characteristics, viscosity, and turbulent energy- into the equations. Special focus will be given to heavier oils and petroleum products, for which there is a dearth of data behind existing algorithms. This work will result in published algorithms that can be used in numerical models of oil dispersion, sediment interactions, and sinking oil into oil spill simulation models in the future.
Project Page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=26

Field Verification of SIMAP Oil Spill Fate and Transport Modeling and Linking CODAR Observation Systems Data with SIMAP Predictions.
Contracting Agency: NOAA/CRRC
Completed: March 2007
This project fills several research needs identified in the National Research Council's 2005 report, including: developing protocols and equipment for dispersed oil tracking, measuring near surface horizontal and vertical diffusivities, and quantifying dissolved and oil-droplet phases in the water column to determine exposure of water column organisms. This project uses the release and surface vessel/aircraft tracking of fluorescein dye and subsurface drogues to measure small-scale transport processes and develop/validate oil spill model algorithms simulating these processes for applications in subsurface dispersion modeling of naturally-entrained and chemically-dispersed oil.
Final Report: http://www.crrc.unh.edu/final/payne2007final/

Measurements and Modeling of Size Distributions, Settling and Dispersions Rates of Oil Droplets in Turbulent Flows
Contracting Agency: NOAA/CRRC
Completed: January 2009
The objective of this research was to measure and parameterize the effects of turbulence and oil properties on the mean settling velocity, dispersion (turbulent diffusion) rate, and characteristic size distributions of oil droplets in sea water.
Project page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=24

Characteristics, Behavior and Response Effectiveness of Spilled Dielectric Insulating Oil in the Marine Environment
Contracting Agency: MMS
Completed: December 31, 2009
Planned wind projects on the U.S. Outer Continental Shelf could consist of wind turbine generators connected to a centralized electrical service platform (ESP). The ESP could contain approximately 40,000 gallons of dielectric insulating oil and approximately 2,000 gallons of assorted oil-based fluids (diesel fuel, lubricating oils, etc.) stored on site for facility maintenance. In addition, each wind turbines could have several hundred gallons of lubricating fluid. The dielectric insulating fluid used in the ESP is typically a mineral oil, but vegetable based oils (soybean oil) may also be used. Several concerns have been raised by regulatory agency and environmental conservancy groups as to the environmental effects of a possible oil spill due to accidental vessel collision or natural catastrophe. The two main concerns addressed were probability of oiling and the minimum transit time of the oil to area and resources at risk.

Numerous toxicological studies have been performed on mineral and vegetable-based oils over the last decade. Mineral and vegetable-based oils display low direct toxicity because they do not contain the water soluble and multi-ringed poly-nuclear aromatic hydrocarbons typically found in petroleum-based oils. Due to their low toxicity and usage, little research has been performed on the response options available to cleanup a spill of dielectric fluids on the marine environment. In the unlikely event of a spill, how would the dielectric insulating oil be removed from our oceans and shorelines? How persistent are these oils in the marine environment?

To provide a comprehensive analysis of the possible fate and effects of spilled dielectric insulating oil, LSU and MMS will conduct a collaborative one (1) year project to provide a detailed literature review and scientific information on the characteristics, weathering behavior, and window of opportunity for using short-term response options for removal of spilled dielectric fluids in the marine environment. The goals of this project will be achieved through a series of laboratory and field-scale studies conducted at research facilities in Baton Rouge, Louisiana (LSU) and Leonardo, New Jersey (Ohmsett). The results from this project will have a direct effect on the spill response policies and decision-making of federal and state agencies when dealing with accidental releases of dielectric insulating fluids in the marine environment. Results from this study will aide planning and management personnel when designing coastal use permits for future offshore wind generation systems.
http://www.mms.gov/tarprojects/636.htm.

Objectives: The goals of this one (1) year scientific project are to provide detailed literature review and produce valid data and results on the characteristics, weathering behavior, and window of opportunity for using short-term response options for removal of spilled dielectric fluids in the marine environment. The goals of the proposed project will be achieved through a series of six (6) tasks:

1. An intensive literature review of U.S. and European sources.
2. A series of laboratory flask studies to determine weathering characteristic, product dispersibility, and accurate analytical methodology.
3. A field study to accurately determine applicability of in-situ burning as a response tool.
4. A laboratory flask study to measure the affects of long-term weathering and biodegradation on dielectric insulating fluid in the marine environment.
5. A series of field studies to accurately determine capabilities/limitations of conventional response tools for removal of dielectric fluids from the marine environment.
6. Preparation and submittal of a final draft and report to MMS

All tasks, except task No. 5, will be performed at LSU in Baton Rouge, Louisiana. Task No. 5 will be completed at the Ohmsett facility in Leonardo, New Jersey.

A Knowledge-Based Reasoning for the Interpretation of PAH Data
Contracting agency: NOAA/CRRC
Estimated completion: 2009
This project will produce a knowledge-based reasoning model for the interpretation of PAH data. The model will interpret available data to provide an indication of the PAH source type. This knowledge-based model will draw upon and compile information and techniques from numerous peer- reviewed, published papers. This published information will form the foundation for implementing the knowledge-based approximate reasoning model through the procedures of fuzzy logic, a significant new branch of mathematics. Fuzzy logic is concerned with the quantification of membership within a set and associated set operations. Output from the model can be thought of as an expression of an observation's degree of membership in a set (pyrogenic sources, petrogenic sources, and so on).

This model will be accomplished within the *Ecosystem Management Decision Support* (EMDS) application framework which integrates the logic engine of *NetWeaver* (Rules of Thumb, Inc.) and *ArcGIS* (ESRI) to perform spatially relevant evaluations (within Microsoft *Windows*). To conduct an analysis with EMDS, the user would merely provide a data view that includes a GIS theme containing PAH chemical analysis. This provides the input to the knowledge base that describes how to interpret the information provided. Other components of the EMDS application framework will supply valuable ancillary information regarding the evaluation: The *Hotlink Browser* provides an intuitive explanation for the results, while the *Data Acquisition Manager* will assist with determining what missing data would have the largest impact on results.

The *NetWeaver* logic engine evaluates data against a knowledge base that provides a formal specification for the interpretation of data. The logic engine allows partial evaluations based on available information, making it ideal for use in situations where the level of detail in PAH data is often variable and incomplete. A second key feature provided by the logic engine is the ability to evaluate the influence of missing information on the logical completeness of an assessment. The engine, in conjunction with the EMDS Project Environment and the *Data Acquisition Manager*, provides powerful diagnostic tools for determining which missing data may be most valuable, given the available data, and determining how much priority to give to missing data, given other logistical information.

Sophisticated geographic analyses often produce impressive looking maps. However, if the analytical system that produces a map cannot also explain the derivation of analysis results being portrayed in a relatively simple and straightforward way, then the system appears to observers as a black box. The *Hotlink Browser* displays the evaluated results of a knowledge base. Users can navigate the networks of analysis topics to trace the logic of evaluations in an intuitive interface. More importantly, the presentation of results in this graphic format is sufficiently intuitive, so users of the system can use the *Hotlink Browser* as a powerful communication tool that effectively explains the basis of evaluation results to broad audiences.

HAZARDOUS SUBSTANCE RESPONSE:

HAZMAT Program Evaluation
Contracting Agency: USCG
Completed: October 2007
A project was initiated to take a systems approach to evaluate the current state of oil and HAZMAT spill prevention, response capability and preparedness and incident management. This evaluation consisted of a series of workshops throughout the country that engaged all levels of spill responders both inside and outside of the Coast Guard. Using that evaluation as a starting point, a multi-year R&D investment strategy was developed that will help close key performance gaps. The document created is an internal working document.
Report: "Oil and Hazardous Materials Spill Response Technology Development Strategic Plan.," Mark VanHaverbeke, October 2007.

NATURAL RESOURCES INJURY ASSESSMENT AND RESTORATION:

Integrating Physiological and Demographic Parameters into NRDA
Contracting Agency: NOAA/CRRC
Completed: June 2007
The Natural Resource Damage Assessment (NRDA) process strives to estimate the injury to wildlife populations from oil spills and mitigate human responses to assure recovery of ecosystem services. Estimates of animal population sizes have confidence intervals based on measurement error and the natural temporal and spatial variability of the sampled population. Understanding the magnitude and causes of pre-spill (baseline) variability is crucial for interpreting the demographic injury that is estimated following an oil spill. The first objective was to characterize the baseline demographic variability in four populations of seabirds in coastal New England, USA, that are typical of wildlife populations that are at risk from oil spills. We studied: Common Terns (*Sterna hirundo*) breeding at Monomoy National Wildlife Refuge (1970 - 1985) and on Bird Island, Marion, MA (1970 - 2002), Roseate Tern (*Sterna dougallii*) breeding on Bird Island (1970 - 2002) and on Falkner Island, Stewart B. McKinney National Wildlife Refuge (1978 - 2002).
Final Report: http://www.crrc.unh.edu/final/tseng2007final/

Using Benefit Transfer to Evaluate the Effectiveness of Restoration Projects
Contracting Agency: NOAA/CRRC
Completed: January 2009
This project will test a new approach to benefit transfer, which is a method for estimating the economic value of lost interim services. Benefit transfer is more cost-effective than other benefit estimation methods, because it uses existing data to measure economic damages. However, some studies of the benefit transfer method have concluded that the common approaches to benefit transfer may fail validity tests. This proof studied parameter updating approach to benefit transfer using beach recreation data from the Texas Gulf and Mid-Atlantic coasts. The results were compared to those obtained using a random utility model to evaluate the validity of this approach.
Project page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=20

Ecology and Economics for Restoration Scaling
Contracting Agency: NOAA/CRRC
Completed: January 2009
Resource managers rely on a variety of methods to determine the appropriate type and amount of restoration needed following oil spills and other environmental disturbances impacting ecological resources, communities, and habitats. Determining the appropriate level of comensatory restoration is known as "restoration scaling". Methods of restoration scaling draw on a variety of techniques from the fields of ecology and economics including: the development of metrics to quantify ecological services, the use of models to establish equivalence between injured and restored services, and valuation of the use of resources. This research will result in a synthesis of restoration scaling methods previously used in coastal response and restoration. The final product will be a report which will serve as a reference/tool for NOAA scientists, public officials, industry, and members of the public faced with making decisions regarding restoration scaling techniques in the aftermath of an environmental incident.
Project Page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=25

Establishing Performance Metrics for Oil Spill Response, Recovery and Restoration
Contracting Agency: NOAA/CRRC
Completed: January 2007
This project examines spill management metrics from scientific and stakeholder perspectives. The approach uses the New England region as a laboratory for proving a method that could be applicable to other areas. The multi-step approach used will involve experts, stakeholder groups including local government officials, and the public balancing science-driven and values-driven concerns. Examination of recent spills, such as the grounding of a tank barge in Buzzards Bay on April 27, 2003 or the North Cape oil spill in Narragansett Bay on January 19, 1996, will provide an inventory of historically significant metrics employed during response, damage assessment, recovery and restoration and provide a framework for assessing attitudes and opinions regarding the efficacy of these metrics. This research will result in a powerful tool for strategic planning in preparation for spills, tactical decision-making in the event of a spill, and damage assessment, recovery, and restoration efforts after spills. Moreover, the specific inclusion of important public and stakeholder views prior to occurrence of a spill will result in a greater understanding of the conflicts and trade-offs facing spill managers, improved communication between lay and expert groups, and swifter, more satisfying decisions.
Final Report: http://www.crrc.unh.edu/final/tuler2007final/tulerfinalreport2007.htm

Monetary Values and Restoration Equivalents for Lost Recreational Services on the Gulf Coast of Texas Due to Oil Spills and Other Environmental Disruptions
Contracting Agency: NOAA/CRRC
Completed: January 2008
The purpose of this project is to develop a recreational demand model of beach use on the Gulf Coast of Texas to value human use "damages" due to oil spills and other environmental disruptions. The damages will be valued in terms of monetary and non-monetary compensation.
Project Page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=18

OIL TOXICITY AND EFFECT:

Anaerobic Biodegradability and Toxicity of Non-Petroleum Oils
Contracting Agency: EPA
Estimated Completion: 2010
Several factors affecting anaerobic biodegradation kinetics of vegetable oil in freshwater sediments were investigated. An optimum dose of ferric hydroxide (1.0 g Fe(III)/kg sediment) was found to stimulate anaerobic biodegradation of canola oil (18.6 g oil/kg) to the maximum by increasing oil mineralization extent and facilitating the initiation of active oil degradation in microcosms. The effect of iron was shown to maximize methane yield and to minimize the lag time for initiation of active oil degradation. Supply of nutrients (nitrogen and phosphorus) and pH buffer (calcium carbonate) to the sediments significantly enhanced iron reduction rate but did not have a significant effect on methanogenesis from oil biodegradation in microcosms. An integrated sedimentation and biodegradation mesocosm study demonstrated that the canola oil, which became entrained in sediments as oil-mineral aggregates, was biodegradable under anaerobic conditions. Although oil-mineral aggregation at high initial mixing energy (200 rpm) transported significantly less oil from the surface and water column to the sediment phase than

low mixing energy (20 and 40 rpm), this factor did not significantly influence the methane production rate. These laboratory microcosm and mesocosm results provide useful data for future planning of field trials on anaerobic bioremediation of vegetable oil spills in inland aquatic environments.

Aerobic Biodegradability and Toxicity of Non-Petroleum Oils
Contracting Agency: EPA/NRMRL
Estimated Completion: 2010
The overall objective of this project is to quantify the oxygen depletion and aqueous toxicity in oil-impacted water columns that are poorly, moderately, and fully mixed because depletion of oxygen in such water columns and release of toxic intermediates can lead to severe toxic impacts on the receiving water body. This evaluation was performed on canola oil, which is predominantly composed of oleic acid moieties containing one double bond, with and without the presence of butylated hydroxytoluene (BHT), the most commonly used antioxidant in the vegetable oil industry. Future research after completion of the canola oil study will take place with sunflower oil (which has moieties with 2 double bonds) and linseed oil (which has moieties containing 3 double bonds). Biodegradability and Microtox toxicity evaluations will be conducted for each of these oil types. The canola oil study has been completed, and the sunflower oil experiments have been initiated.

The aerobic biodegradation of five triacylglycerols (TAGs), three liquids [triolein (OOO), trilinolein (LLL), and trilinolenin (LnLnLn)], and two solids [tripalmitin (PPP) and tristearin (SSS)] was studied in water. Respirometry tests were designed and conducted to determine the biochemical oxygen demand (BOD) parameters of the compounds. In the case of the solid lipids, the degradation process was limited by their extremely non-polar nature. When added to water, PPP and SSS formed irregular clumps or gumballs, not a fine and uniform suspension required for the lipase activity. After 30 days, appreciable mineralization was not achieved; therefore, first-order biodegradation coefficients could not be determined. The bioavailability of the liquid TAGs was restricted due to the presence of double bonds in the fatty acids (FAs). An autoxidation process occurred in the allylic chains, resulting in the production of hydroperoxides. These compounds polymerized and became non-biodegradable. Nevertheless, the non-oxidized fractions were readily mineralized, and BOD rate constants were estimated by non-linear regression: LLL ($k = 0.0061/h$) and LnLnLn ($k = 0.0071/h$) were degraded more rapidly than OOO ($k = 0.0025/h$). Lipids strongly partitioned to the biomass and, therefore, Microtox toxicity was not observed in the water column. However, EC_{50} values (< 15% sample volume) were measured in the solid phase.

Biodegradability and Toxicity of Biodiesel Blends
Contracting agency: EPA/NRMRL
Estimated completion: 2010
While there are great benefits to using biodiesel as a fuel, its environmental fate and effects need to be evaluated and the risks associated with their use understood. There is a dearth of information on the states and conditions biodiesel and its blends have in the environment, their fate, and their effects on aquatic organisms. The current understanding of the fate and effects of biodiesel and its various blends is inadequate to evaluate environmental risks from its use. Furthermore, unlike petroleum diesel, biodiesel fuels are made from many sources, including soy oil, rapeseed/canola oil, reclaimed restaurant grease, fish oil, and rendered animal fats, each

having different chemical compositions. This wide variability of biodiesel formulations may result in very different toxicological and environmental fates depending on the feedstock. The objective of this work is to determine the biodegradability and biodegradation kinetics of several different biodiesel blends (B100, B80, B60, B40, B20, and B0). The second objective is to quantify the toxicity of the water accommodated fraction of the biodiesel blends as measured by the Microtox assay, which uses the bioluminescent bacterium *Vibrio fischeri* as the test species. Later, similar studies will be conducted with other biodiesel feedstocks. Journal articles will be produced beginning in fiscal year 2010.

Studies Using Aquatic Turtles (the Diamondback Terrapin and Snapping Turtle) to Assess the Potential Long-term Effects of Oiling of Nests During Early Embryonic Development

Contracting agency: NOAA/CRRC
Completed: March 2008
This study examined the long term effects on embryonic and hatchling turtles following embryonic exposure to WAF and CEWAF under exposure conditions simulating those that may exist in natural nests. Prior to percolation through the substrate column, total PAH ("tPAH") in WAF solutions were similar (High, 43; Low 67 ppm). Following percolation, tPAH was also similar in physically-dispersed fractions (High, 14; Low 24 ppm). Addition of dispersant (CEWAF solutions) increased tPAH prior to percolation in the High treatment (300 ppm) relative to Low (13 ppm), but percolation resulted in nearly equal concentrations in both treatments (High, 30; Low, 22 ppm) due to physical trapping of dispersed oil by the nest substrate. In both WAF and CEWAF treatments, percolation reduced low molecular weight (MW) compounds such that embryos were exposed to primarily mid- to high MW compounds. Total PAH in eggs differed 15-fold between the CEWAF High and WAF High treatments (560 and 36 ppb respectively), the former characterized by higher MW compounds than the latter. Alteration of PAH profiles during percolation to egg depth demonstrates that the composition of PAHs in water that arrives on a beach following a spill do not reflect the suite of compounds to which embryos are exposed.
Final Report: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=13

Acute and Chronic Effects of Crude and Dispersed Oil on Chinook Salmon Smolts (Onchorhynchus tshawytscha)

Contracting Agency: NOAA/CRRC
Completed: August 2007
Due to the large maritime transport of crude oil from Alaska to California, there is significant potential for catastrophic spills that could seriously impact salmon populations during key periods of their migration. This study examined the toxic actions of the water-accommodated fraction (WAF) and chemically-dispersed fraction (CEWAF) of Prudhoe Bay Crude Oil (PBCO) on the smolts of Chinook salmon (*Onchorhyncus tshawytscha*). A closed, flow-through test system for exposing salmon smolts to declining concentrations of WAF or CEWAF (using the dispersant Corexit 9500) of PBCO was developed. The WAF and CEWAF were fully characterized for hydrocarbons by gas chromatography-flame ionization detection. After exposure to various concentrations of oil or dispersed oil for 96 hours, the LC50 of the WAF tests was approximately 20 fold lower than that of the CEWAF tests. The mortality results

suggest that application of oil dispersants decreased the toxicity of oil. The Final Report: http://www.crrc.unh.edu/final/tjeerdemafinal/

Survival time models quantitatively can predict lethal effects of pulsed and different duration exposures to water accommodated fraction PAH from spilt oil

Contracting Agency: NOAA/CRRC
Completed: August 2007
Toxicity data derived from conventional concentration-effect test designs predict effect at a single exposure time. A few test durations might be used in some tests to coarsely predict how mortality changes with exposure time. Even in tests employing several exposure times, the selected concentration treatments generate optimal data for only one of the exposure durations. Predictions of effect at different durations are unavoidably gross because mortality information was not collected optimally during the entire exposure. Also, the conventional concentration-effect approach does not quantify mortality that potentially could occur after exposure stops. Such post-exposure mortality can be quite high. These shortcomings can be avoided by noting mortality in test treatments through time including post-exposure mortality, and applying survival time modeling to the resulting data. Survival time models allow inclusion of covariates such as exposure concentration, resulting in models that include both exposure concentration and duration.

We parameterized survival time models with data generated for six representative polycyclic aromatic hydrocarbons (PAH) associated with the water-accommodated fraction of oil. Survival models incorporating exposure concentration and duration were produced for the grass shrimp, *Palaemonetes pugio*, a common test species and an ecologically important one in salt marshes and other coastal environments. The absence of post-exposure mortality allowed use of models based only on mortality during the actual exposure. The results were then used to demonstrate a QSAR approach to predicting survival time model parameters for untested PAH.
Final Report: http://www.crrc.unh.edu/final/newman2007final/

Impacts of Low Levels of Residual Oils on Toxicity Assessment of Oil Spills using the Target Lipid Model

Contracting agency: NOAA/CRRC
Completed: February 2007
A method is presented for developing scientifically defensible numeric guidelines for oil-related constituents, specifically monocyclic aromatic hydrocarbons (MAH) and polycyclic aromatic hydrocarbons (PAHs), in the water column and sediment. The guidelines are equivalent to a HC5, a hazard concentration value that protects 95 percent of the test species. The model of toxicity used in this evaluation is the target lipid model (TLM) that was developed for assessing the toxicity of Type I narcotic chemicals (Di Toro et al. 2000).
Final Report: http://www.crrc.unh.edu/final/mcgrath2007/

Acute and Chronic Effects of Oil, Dispersant and Dispersed Oil to Symbiotic Cnidarian Species

Contracting agency: NOAA/CRRC
Completed: January 2007
Cnidarian-algal symbioses exist as a sensitive balance between the two partners (cnidarian-host and symbiont algae). Chemical contaminants can disrupt this balance resulting in symbiosis

breakdown and loss of algae from the host cnidarian. This phenomenon, known as bleaching, can result in the death of the species and is particularly important in tropical regions where corals form the trophic and structural foundation of the ecosystem. Similarly, in temperate coastal communities symbiotic anemones, such as *Anthopleura elegantissima*, are important members of the rocky intertidal community and are also at risk for chemical contaminant driven bleaching events. Currently, there is little data regarding the effects (particularly chronic, sub-lethal effects) of oil, dispersants and dispersed oil on these sensitive cnidarian-algal species using realistic exposure regimes in combination with extensive chemical characterization of the exposure media and bioaccumulated fractions in these organisms. The project will address this data gap. In addition, this study will support predictive models and will aid in the decision-making on dispersant use in areas with coral reefs and in temperate rocky intertidal zones.
Final Report: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=6

REMOTE SENSING AND AERIAL OBSERVATION:

Svalbard, Norway Experimental Oil Spill to Study Spill Detection and Oil Behavior in Ice
Contracting agency: MMS, Alaska Department of Environmental Conservation, Alaska Clean Seas, ConocoPhillips, ExxonMobil, Shell Technology Norway, and Statoil ASA
Completed: January 30, 2007
This project designed and implementation a field spill in Svalbard, Norway in March 2006, where several remote sensing systems were tested in both surface and airborne modes to detect oil in and under sea ice. Experiment were conducted over solid land fast sea ice representative of the type of ice found in many near shore Arctic regions of the world including the Alaskan North Slope. In late March 2006, 3,400 liters of fresh Stratfjord crude oil were injected under the ice. All of the oil was completely contained within the skirt.

From March 27-31, 2006, the ground penetrating radar successfully detected and mapped the oil from the surface, showing a clear difference in signature between clean and oiled ice. We were not able to "see" the ice/oil/water interface from the helicopter but did come back with a very clear profile of the snow and ice top surface from the airborne trials. It appears that with the current "off the shelf" radar technology we can provide a useful operational tool to quickly map oil under ice from the surface (a major improvement over drilling holes) and potentially to map oil buried under snow on top of the ice from a helicopter at low level. We are still analyzing ice samples for gas concentrations to assess the future potential of ethane sensors. The acoustics system provided mixed results and the data requires more analysis to assess future prospects in this area.

More than sixteen scientists and observers from the funding agencies participated. Fate and behavior experiments were conducted throughout the field program. Following the conclusion of field activities, the site was monitored until the crude oil migrated to the surface. On May 30, 2006, a successful in situ burn was conducted culminating in a highly efficient (96%+) oil burn in ice (no surprise on the high efficiency). This was after the oil was in and under ice for 2-months.

A report was sent to the Governor of Svalbard documenting the field work, in situ burn activities and the status of the spill site. All aspects and requirements of the spill permit were completed and the site was returned to its natural state. This research project left a positive impression with

the Norwegian government for complying with all aspects of the spill permit requirements. This is extremely important for obtaining spill permits in the future. This project is complete. The final reports are available at http://www.mms.gov/tarprojects/569.htm.

Reports: Summary Field Report, DF Dickens Associates Ltd., SINTEF, The University Centre at Svalbard, and Boise State University, April 12, 2006.
Field Report on In Situ Burn Activities at Svea, Svalbard, May 2006, DF Dickens Associates Ltd, SINTEF, June 9, 2006.
2006 Svalbard Experimental Spill to Study Spill Detection and Oil Behavior in Ice, Final Technical Report, DF Dickins Associated Ltd., SINTEF, The University Center in Svalbard, Boise State University, 55 pp., December 15, 2006.

Detection of Oil on and Under Ice - Phase 3
Contracting Agency: MMS, Alaska Clean Seas and the Alaska Department of Environmental Conservation
Completed: July 25, 2008
This research project undertook a series of tasks to assess the technical feasibility and cost of developing and incorporating airborne oil detection systems in future field trials with oil and ice. Tasks include:

- Airborne Oil under Ice Hardware Evaluation
- Airborne Oil under Ice Development Plan
- Surface Oil under Snow Modeling
- Airborne Oil under Ice Computer Modeling
- Software Update and Training for Prudhoe Bay, AK Operations
- Preparation and Planning for Prudhoe Bay, AK Workshop
- Conduct a 2-DayTraining Class and Workshop in Prudhoe Bay, AK

This project is complete. The final reports are available at http://www.mms.gov/tarprojects/588.htm.

Final Reports: Evaluation of Higher-Powered Airborne Radar Systems to Detect Oil Under Ice and Snow – Scenario Descriptions, D. Dickins and J. Bradford, DF Dickins and Associates and Boise State University, 8 pp., August 17, 2007.
Summary of Search results on Airborne Radar Systems with an Operating Frequency Range of 500MHz to 1GHz, D. Dickins and J. Bradford, DF Dickins and Associates and Boise State University, September 14, 2007.
Detection of Oil on and Under Ice: Phase III - Evaluation of Airborne Radar System Capabilities in Selected Arctic Spill Scenarios, D. Dickins, DF Dickins and Associates and Dr. J. Bradford, Boise State University, 55 pp. July 2008.

Development of a Portable Multispectral Aerial Sensor for Real-time Oil Spill Thickness Mapping in Coastal and Offshore Waters
Contracting agency: MMS and California Department of Fish and Game
Completed: April 30, 2009
This research project developed a portable, easy-to-operate, aerial sensor to detect and accurately map the thickness and distribution of an oil slick in coastal and offshore waters in real-time. The project included five separate over-flights of the Santa Barbara Channel and the Ohmsett facility

for sensor and algorithm verification and ground-truthing. The thickness sensor system was successfully flight tested in day/night operations over the Ohmsett facility from June 16-20, 2008. The thickness sensor system was also successfully flight tested over the Coal Oil Point, CA natural oil seeps on November 13, 2008 to verify total system integration. The thickness sensor system was operational used to respond to the Oil Spill from Platform A, Santa Barbara, CA on December 8-10, 2008. This project is complete. The final report is available at http://www.mms.gov/tarprojects/594.htm.
Final Report: Development of a Portable Aerial Sensor for Real-time Oil Spill Thickness Mapping in Coastal and Offshore Waters, Dr. Jan Svejkovsky, Ocean Imaging Corporation, Solano Beach, CA , 33. pp., May 14, 2009.

Delivery and Quality Assurance of Short-Term Trajectory Forecasts from HF Radar Observations
Contracting agency: NOAA/CRRC
Completed: January 2009
The project is proposing to develop, assess, and document the use of real-time ocean surface current maps from high frequency (HF) radar installations. Specifically, we will evaluate the use of these data in support of oil spill response activities. An extensive test of these capabilities was conducted in connection with the NOAA Safe Seas 2006 oil spill exercise offshore San Francisco in August, 2006. We intend to conduct a systematic post-exercise evaluation and to document lessons learned. We also intend to quantitatively assess the performance of the short-term (24-hour) surface current prediction methodology that was developed for the Safe Seas 2006 exercise by comparing observed and predicted currents under a wide range of environmental conditions. To aid that assessment, we will conduct a multi-day, multi-deployment field experiment using an array of GPS-tracked surface drifters. Finally, we intend to document our results in the form of a package of recommendations and procedures for the integration of HF radar-derived products into real-time spill response protocols
Project Page: **http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=23**

HUMAN DIMENSIONS:

Social Disruption from Oil Spills and Spill Response: Characterizing Effects, Vulnerabilities, and the Adequacy of Existing Data to Inform Decision-Making
Contracting agency: NOAA/CRRC
Estimated completion: May 2010
This research project investigates what is involved in bringing a systematic assessment of socioeconomic vulnerability considerations into area-based oil spill contingency planning. While this project has one eye on the ultimate goal of producing practical decision-support or social impact assessment tools, it presupposes that several types of information need to be collected, evaluated, and synthesized before such tools can be constructed. Specifically: (1) human dimensions endpoints threatened by oil spills need to be systematically identified; (2) the relationships between these endpoints, effects, and planning and management actions should be evaluated; (3) the sufficiency of existing data and data-analysis tools to characterize and anticipate these causal relations must be assessed
Project Page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=30

SUBMERGED, SUNKEN AND HEAVY OILS:

Heavy Oil Recovery
Contracting agency: USCG
(Ongoing) Estimated completion: 2012
This project will develop a blueprint for method(s) within the oil response industry to recover heavy oil located on the bottom. The first objective was to develop 3 to 5 proofs of concept for heavy oil detection technologies and then select 1-3 for prototype development. Testing of the prototypes was completed in February, 2009 and the final detection report was issued. The next objective is to develop proofs of concept, then prototype devices for the recovery of heavy oil starting in 2009. A Broad Agency Announcement will be released and again conceptual designs will be sought with a few prototypes being developed by 2012.
Interim Report: "Heavy Oil Detection (Prototypes) Final Report", Kurt A. Hansen; Michele Fitzpatrick; Penny R. Herring; Mark VanHaverbeke, June 2009

Investigation of Physical and Chemical Causes of Heavy Oil Submergence
Contracting agency: NOAA/CRRC
Estimated completion: March 2010
The objectives of this research are i) to examine the causes and effects of density changes in heavy petroleum oils that cause just-buoyant oils to become overwashed and sink at sea and in fresh water, and ii) to examine the physical and chemical causes for refloatation of heavy oils. The proposed work includes both simulation of spills at the bench-scale and examination of real samples of submerged oil from spills of opportunity. The factors affecting oil submergence to be considered include: temperature, solid-phase uptake, water uptake (and emulsification), evaporation and photo-oxidation. This work will lead to a better understanding of the micro-changes in oils and their environments that lead to submergence of oils. This is expected to benefit both the spill modelling and spill response communities.
Project Page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=29

SHORELINE ASSESSMENT:

A System for Integrated SCAT Data Collection and Management: eSCAT, SCATdb, and Photologger
Contracting agency: NOAA/CRRC
Estimated completion: Ongoing.
During response, oiled shorelines must be surveyed to guide cleanup operations. The Shoreline Cleanup and Assessment Technique (SCAT) is a standard method for conducting these surveys. Multiple field teams often conduct SCAT. SCAT surveys quickly produce a large and complex dataset comprised of SCAT observations, GPS positions, and photographs. In order to guide response decision-making, SCAT field data must be processed and analyzed in a timely manner. Until recently, SCAT and GPS data were collected on standardized paper worksheets, transcribed to electronic form, and then incorporated into maps and other decision-making products. Photographs were not tightly managed alongside SCAT data. Today, with the emergence of robust handheld computing technology, the deficiencies inherent in paper data collection are no longer necessary or acceptable. Paper data collection can be slow, error prone,

and lacking quality control and integration with GPS technology. Digital options are available to address all these challenges. To exploit these potential advantages, the Office of Response and Restoration is developing a field data collection and management system for SCAT data and photographs which is comprised of: (1) specialized software for efficient SCAT data collection with GPS-integrated handheld devices, (2) a relational SCAT database which expedites the synthesis of field data into decision making products, promotes community standards, and supports standard paper worksheet data collection methods, and (3) an image database which allows for the processing, documenting, and sharing of large quantities of digital photographs. For this project, commonly used, readily available, and open-source computing resources were chosen so that end-users could easily test, adopt, and improve this system.

OIL-IN-ICE AND COLD WEATHER RESPONSE:

Oil Recovery with Novel Skimmer Surfaces under Cold Climate Conditions
Contracting agency: MMS and Prince William Sound Oil Spill Recovery Institute
Completed: August 2007
The research project conducted a comprehensive analysis of the adhesion processes between oil or ice-in-oil mixtures and various surface patterns and materials that are being used or proposed for use in oil skimmers, under cold climate conditions. This knowledge was used to develop mechanical response equipment that can be efficiently used under these conditions. The work included bench scale studies in our laboratory as well as field testing. Following the laboratory tests materials and surface patterns were selected that performed best under cold climate conditions. Full scale oil spill recovery testing was conducted at the U.S Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, in Hanover, NH. This provided valuable information regarding the correlation between the laboratory tests and full scale experiments, as well as demonstrates the potential of the proposed skimmer modifications under conditions similar to response operations.

Oil adhesion experiments to novel skimmer surfaces under cold climate conditions were conducted at the University of California, Santa Barbara to examine surface geometry and materials tailored to conditions present in cold climates. A series of full-scale oil spill recovery experiments were conducted February 26-March 9, 2007 at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL) in Lebanon, NH. The goal of the experiments was to provide actual data as to the effects of oil adhesion on different drums on oil skimmers under varying conditions (oil types, ice/no ice, drum rotation speed, etc.). This project is complete. The final report is available at http://www.mms.gov/tarprojects/573.htm.
Reports: Oil Recovery with Novel Skimmer Surfaces under Cold Climate Conditions, A. Keller, K. Clark, Bren School of Environmental Science and Management, University of California, Santa Barbara, CA, 51 pp., August 1, 2007.

Planning Support for an Experimental Oil Spill in Pack Ice
Contracting agency: MMS
Completed: January 2008
The MMS partnered with the Department of Fisheries and Oceans Canada - Center for Offshore Oil and Gas Environmental Research (COOGER) in planning an experimental oil spill in pack

ice offshore Eastern Canadian in 2007/2008. The initial experimental oil spill was to be conducted by the Department of Fisheries and Oceans (DFO) Canada offshore Eastern Canada in March 2007. The Canadian Coast Guard (CCG) was committed to supplying an ice breaker and helicopter as support vessels for one week as services in kind to the project. There was a storm off Canada that blew in the pack ice and trapped over 200 fishing vessels and between 400-500 fishermen. All available CCG ships and helicopters were mobilized to assist the fisherman. The project did not receive the promised vessels from the CCG, and the oil in ice experiment did not take place. The oil in ice experiment was rescheduled and conducted in January 2008 by DFO Canada and the CCG. This project is complete and information on this project can be found at http://www.mms.gov/tarprojects/586.htm.

International Oil in Ice Workshop 2007

Contracting agency: MMS, Alaska Clean Seas, Alaska Department of Environmental Conservation, Cook Inlet Spill Prevention and Response, Prince William Sound Oil Spill Recovery Institute and the U.S. Coast Guard.
Completed: December 2007
This research project organized and conducted an international workshop on recent advances in cleanup of oil spills in ice and cold climates. The Oil in Ice Workshop was conducted October 10-12, 2007 at the Marriott hotel in Anchorage, AK. The workshop objective was to provide an international forum for presentation and discussion of key research, operational and logistical issues associated with the response to accidental spills from exploration and development projects in ice-affected environments. This project is complete. Information on this project can be found at http://www.mms.gov/tarprojects/587.htm.
Reports: To access the conference proceedings, click on the highlighted Oil in Ice Workshop in the project description. When the proceedings come up, click on the large Oil in Ice Workshop 2007 symbol in the center of the screen. This will take you to the Proceedings Home Page.

Effect of Protistan Predation on Biodegradation of Oil in Arctic Sea Ice

Contracting agency: NOAA/CRRC
Completed: December 2009
Protistan predation has previously been shown to negatively impact biodegradation in subsurface environments through top-down pressure on the bacterial community. It is likely that similar predator-prey relationships exist in Arctic sea ice. Due to the difficulty of cleaning and recovery of oil in sea ice, bioremediation has been proposed as a cost-effective means to degrade oil within the extensive network of brine channels that often form. In order to understand the potential for bioremediation to occur, the predator-prey dynamics that occur within the ice needs to be understood in order to evaluate the usefulness of biodegradation in Arctic sea ice. This research is examining the effect protistan predation has upon the bacterial community, as well as the potential for complete degradation of crude oil.

Oil-in-Ice: Transport, Fate, and Potential Exposure

Contracting agency: NOAA/CRRC
Estimated completion: 2010
Oil spilled in the arctic marine environment can be rapidly frozen into the ice sheet. The oil will in this way be to some extent preserved, in the sense that evaporation, dissolution, and degradation are expected to be reduced. This implies that the oil will retain much of its potential

toxicity upon release from the ice, either via transport in brines channels and/or eventual breakup and melting of the ice sheet. Being able to estimate the pathways, release rates, and chemical characteristics of the remaining oil will provide the basis for eventual environmental risk and impact assessments. The purpose of this project is to provide a basis and methodology for estimating routes and magnitudes of potential environmental exposures and concentrations of oil components migrating through the ice regime as the oil is subjected to a freezing-thawing cycle.

A transport/exposure laboratory study is suggested to determine how ice growth conditions affect the transport and fate of entrapped oil in ice. Quantitative data on the partitioning of oil (dissolved, particulate oil) components (bioavailable fractions) into brine inclusions and channels, and rates of vertical transport, will be collected. Since biodegradation of petroleum hydrocarbons at subzero temperatures has not yet been shown, it will be essential to determine *if* crude oil biodegradation takes place in marine sea ice within a defined span of time and to what extent. If so, the contribution of biodegradation to the depletion of hydrocarbons in comparison to other depletion processes will be quantified.
The study directly addresses the need for exposure and injury assessment tools for oil spills in cold climates. The use of passive samplers is a fast and cheap method to detect polycyclic aromatic hydrocarbons (PAHs), the most toxic group of all the compounds present in oil. In this proposal, we suggest advancing the use of two different passive samplers as a tool to detect PAHs from oil spills in ice cores. The two types of passives samplers being considered are polyethylene (PE), and solid-phase micro-extraction (SPME) fibers. They will be used to detect the transport and fate of oil-derived PAHs in ice cores.

In a combination of laboratory and field studies, performance reference compounds will be included in the polyethylene matrix to enable their use as kinetic samplers and shorten deployment time in the field. In flow-through exposures using Narragansett Bay water, deployment will be undertaken to verify the use of the passives samplers to reflect dissolved concentrations as either equilibrium or kinetic samplers. Finally, in simulated oil spills in ice cores in the laboratory, dissolved concentrations of oil components will be detected using the passive samplers. The developed passive samplers will enable the oil spill community to deploy passive samplers to measure baseline conditions before a spill, as kinetic samplers during a spill and during the recovery phase of the natural ecosystem.

The findings from the laboratory experiments will be used in the development of an oil-in-ice sub-model. In contrast to most other recent and on-going work at the macro-scale, this project will start at the micro- and meso-scale (roughly mm to cm and cm to m or greater, respectively), to build up an understanding and a dynamic model from basic principles, to the maximum extent possible. Other experimental and model development work at this scale will contribute to the technical basis for the proposed model development.

The development of the numerical model associated with this project will integrate knowledge, understanding, and data derived from other tasks within this project and from earlier work by other investigators, into an internally consistent and relatively comprehensive numerical framework. The goal is to produce a dynamic module focused on micro- and macro- physical scales, built up as much as possible from first principles, to serve as a building block in an eventual large scale model of ice dynamics. The available level of funding is insufficient to

complete the modeling work, in addition to all the necessary laboratory work. We therefore propose to produce a prototype model at the end of the first year, and seek additional funding to complete the model calibration, testing and documentation during the second year.

CHEMICAL TREATING AGENTS AND DISPERSANTS:

Investigation of the Ability to Effectively Recover Oil Following Dispersant Application
Contracting agency: MMS
Completed: December 31, 2007
The research project resolved the question as whether the application of dispersants to an oil slick reduces the ability to subsequently recover oil with conventional skimming systems. The objectives were met through a series of bench scale laboratory tests and full scale tank experiments conducted at Ohmsett - The National Oil Spill Response Test Facility in June 2007. This project is complete. The final report and four video clips are available at http://www.mms.gov/tarprojects/589.htm.
Reports: Investigation of the Ability to Effectively Recover Oil Following Dispersant Application – Final Report, SL Ross Environmental Research Ltd., 21 pp., December 2007.

Mid-Scale Test Tank Research on Using Oil Herding Surfactants to Thicken Oil Slicks In Broken Ice
Contracting agency: MMS, ExxonMobil Upstream Research Company and its Petroleum Environmental Research Forum partners Agip Kashagan North Caspian Operating Company, Sakhalin Energy Investment Company (Shell) and Statoil ASA
Completed: March 2007
The Minerals Management Service (MMS) and ExxonMobil have jointly funding research on the use of chemical herding agents to thicken oil spills in broken ice to allow them to be effectively ignited and burned in situ. Laboratory and small scale wave tank research is complete and the (results are very promising). Five field experiments were successfully completed:

- November 14-December 2, 2005 - Conduct a series of research experiments on the efficacy of herders to thicken oil slicks among broken ice at sub-zero temperatures at the scale of 100 m2 in the Ice Engineering Research Facility Test Basin at the US Army Cold Regions Research and Engineering Laboratory (CRREL), located in Hanover New Hampshire.
- January-February 2006 - Conduct a series of research experiments on the efficacy of herders to thicken oil slicks among broken ice at sub-zero temperatures. Tests will be conducted at the scale of 1000 m2 at Ohmsett – The National Oil Spill Response Test Facility. The Ohmsett experiments will be conducted in conjunction with the MMS Alaska Environmental Studies Program oil spreading and emulsification experiments in broken ice already scheduled for the winter 2006.
- October 2006 – Conduct a series of in situ burn experiments on the scale of 50 m2 with chemical herders and crude oil at the Fire Training Grounds, Prudhoe Bay, AK. The burns would be conducted in a specially prepared pit containing broken sea ice.
- February 13-17, 2006 - Five full scale research experiments on the efficacy of herders to thicken oil slicks among broken ice at sub-zero temperatures were successfully conducted at the scale of 1000 m2 at Ohmsett – The National Oil Spill Response Test Facility.

- November 2-7, 2006 a series of in situ burn experiments were successfully conducted on the scale of 50 m2 with chemical herders and crude oil at the Fire Training Grounds, Prudhoe Bay, AK. The burns were conducted in a specially prepared pit containing broken sea ice. This is a permitted activity and all necessary permits have been secured. All planned experiments in the test matrix were completed.

This project is complete. The final report can be found at http://www.mms.gov/tarprojects/554.htm.
Reports: Mid-Scale Test Tank Research on Using Oil Herding Surfactants to Thicken Oil Slicks in Broken Ice, S.L. Ross Environmental Research Ltd., Ottawa, ON, Canada, 66pp., March 7, 2007.

Understanding the Effects of Time and Energy on the Effectiveness of Dispersants
Contracting agency: MMS, ExxonMobil, Total, Statoil, Oil Spill Response Limited, Alaska Clean Seas, Sakhalin Energy Investment Company (Shell operated), and Department of Fisheries and Oceans Canada
Completed: December 31, 2007
This international joint research project was designed to gather data to support decision makers in the process of determining whether dispersants should be used in low energy environments. This information is useful for dispersant decision making in ice cover (an ice field reduces wave motion) or other calm conditions. Questions addressed were:

- Will the dispersant stay with the oil until there is enough energy to disperse the slick?
- How much energy is needed to disperse the slick after dispersants are applied?
- If energy is provided to facilitate dispersion, will the droplets stay in the water column after mixing or will they resurface?

This project is complete. The final report can be found at http://www.mms.gov/tarprojects/563.htm.
Report: Effects of Time on the Effectiveness of Dispersants – Final Report, Resby, J.L., Brandvik, P.J., Daling, P.S., Guyomarch, J., Eide, I., SINTEF, CEDRE, Statoil, 116 pp., December15, 2007.

Research at Ohmsett on the Effectiveness of Chemical Dispersants on Alaskan Oils in Cold Water
Contracting agency: MMS
Completed: May 2007
The U.S. Minerals Management Service funded and conducted two series of large-scale dispersant experiments in very cold water at Ohmsett – The National Oil Spill Response Test Facility, located in Leonardo, New Jersey in February-March 2006 and January-March 2007. Alaska North Slope, Endicott, Northstar and Pt. McIntyre crude oils and Corexit 9500 and Corexit 9527 dispersants were used in the two test series. The crude oils were tested fresh, weathered by removal of light ends using air sparging and weathered by placing the oils on water in both breaking wave and non-breaking wave conditions.

In February-March 2006, a total of twenty-five large-scale DE experiments were successfully completed at the Ohmsett facility. Ten control experiments (no dispersant) and fifteen Corexit 9527 dispersant application experiments were completed in the test program.

The total quantity of crude oil used in the 2006 test program was approximately 1,600 liters and between 65 and 80 liters of oil were used in each experiment. In a few cases where a limited amount of oil was available, smaller volumes were discharged. The estimated average oil thickness for the oil slicks was 1 to 4 mm depending on the experiment being conducted. The total quantity of dispersant used in the 2006 test program was approximately 150 liters and between 4 and 16 liters of dispersant (including overspray) was used in each experiment.

In January-March 2007, a total of twenty-one large-scale DE experiments were successfully completed at the Ohmsett facility. Nine control (no dispersant applied), ten Corexit 9500 dispersant applied experiments and two Corexit 9527 dispersant applied experiments were completed in the test program. Thirteen of the experiments were conducted between January 30 and February 6 and the remaining eight experiments were completed between March 13 and March 15, 2007. The air temperature at the end of the first week of testing dropped dramatically and the tank surface water froze. The ice was broken up using wave action but a layer of frazil ice built up in the tank and the main test program had to be suspended until the onset of warmer weather. One test (No.13) was completed in the frazil ice conditions to investigate the use of dispersants in these conditions while the opportunity presented itself.

The total quantity of oil used in the 2007 test program was approximately 1,560 liters and between 70 and 85 liters of oil were used in each experiment. The estimated average oil thickness for the slicks was 1-2 mm depending on the experiment being conducted. The total quantity of dispersant used in the 2007 test program was approximately 90 liters and between 7 and 12 liters of dispersant was used in each experiment (including overspray). This project is complete. The final reports and film clips can be found at http://www.mms.gov/tarprojects/568.htm.
Reports: Dispersant Effectiveness Testing in Cold Water on Four Alaskan Crude Oils. SL Ross Environmental Research and MAR, Inc., 59 pp. July 2006. Twenty-six film clips are available with this final report.
Corexit 9500 Dispersant Effectiveness Testing in Cold Water on Four Alaskan Crude Oils. SL Ross Environmental Research and MAR, Inc., 35 pp. May 2007. Twenty-one film clips are available with this final report.

Changes with Dispersant Effectiveness with Extended Exposure in Calm Seas
Contracting agency: MMS
Completed: January 31, 2008
research project investigated the conditions that might lead to the loss of surfactants from dispersant-treated oil, so that subsequent application of breaking waves will not result in dispersion. A one-week test series was conducted at Ohmsett - The National Oil Spill Response Test Facility in June 2007. Long-term exposures of "topped" Oseberg crude oil pre-mixed with Corexit 9500 dispersant on the Ohmsett tank surface were completed. This project is complete. The final report and two film clips can be found at http://www.mms.gov/tarprojects/590.htm.
Reports: Changes in Dispersant Effectiveness with Extended Exposure in Calm Seas – Final Report, SL Ross Environmental Research Ltd., A. Lewis Oil Spill Consultancy, MAR, Inc., 27 pp., December 2007.

Upgrade of SMART Dispersant Effectiveness Monitoring Protocol
Contracting agency: MMS and USCG
Completed: September 16, 2008
The objectives of this research project were three-fold:

- To conduct an analysis of monitoring data (visual and instrumental monitoring) collected during Ohmsett dispersant experiments completed between 2003 through 2007, for the purposes of verifying the reliability of existing SMART effectiveness monitoring protocols and recommending changes to improve monitoring methods;
- Obtain input from end-users of the SMART protocol regarding past experience with the protocol and instrumentation, as well as their needs for upgrading the effectiveness and operational utility of the protocol; and
- To review the commercially available off-the-shelf instruments that might fit the needs of the USCG Strike Teams for monitoring the effectiveness of oil spill dispersant operations.

This project is complete. The final reports can be found at http://www.mms.gov/tarprojects/598.htm.
Reports: Update SMART Protocol for Monitoring Efficacy of Oil Spill Dispersant Operations: Proceedings of the Stakeholders Workshop, S.L. Ross Environmental Research Ltd., Ottawa, ON Canada, 21 pp., August 2008.
Updating the SMART Dispersant Monitoring Protocol: Review of Commercial off the Shelf Instruments, S.L. Ross Environmental Research Ltd., Ottawa, ON, Canada, 19 pp., August 2008.
Updating the SMART Dispersant Monitoring Protocol: Review of Ohmsett Results from 2001-2007, S.L. Ross Environmental Research Ltd., Ottawa, ON, Canada, 45 pp., August 2008.

Development of a Training Package on the Use of Chemical Dispersants for Ohmsett - The National Oil Spill Response Test Facility
Contracting agency: MMS
Completed: February 28, 2009
This research project fill's an existing gap in oil spill response in the United States by providing hands on training in chemical dispersants for first responders, planners and government agencies by utilizing the unique capabilities of Ohmsett - The National Oil Spill Response Test Facility. This project developed a chemical dispersant training course to be conducted at Ohmsett that includes practical hands-on experience with handling, safety, application, monitoring, efficacy and recovery in breaking wave environments.
This project is complete and information can be found at http://www.mms.gov/tarprojects/613.htm.

Chemical Dispersant Research at Ohmsett
Contracting agency: MMS
Completed: February 28, 2009
This research project contained three distinct tasks.
Task 1: Calm Seas Application and Dispersant Wash-Out
The Petroleum Environmental Research Forum (PERF) funded a research project conducted by SINTEF in Norway and CEDRE in France that has looked at the same issue of dispersant wash out but at laboratory bench scale. The Oseberg crude oil used in the PERF study was shipped to Ohmsett and was used in the 2007 study (TAR Project 563). To date no comparison of the

findings from these two studies has been made. The first item addressed in Task 1 was to complete such a comparison to determine what can be learned from the different test methods and scales. In the testing phase of Task 1 multiple test rings were deployed across in the Ohmsett test tank so a range of slick thickness and/or oil types can be monitored in one test sequence. Dispersant wash out rates were monitored throughout the test period by sampling the surface oil and testing dispersant effectiveness (DE) using a bench-scale test such as the WSL rotating flask method as by measuring the interfacial tension of the sampled oil with fresh sea-water. A two-week testing program was conducted May 19-30, 2008 at Ohmsett to test oil thickness and oil type effects on dispersant wash-out.

Task 2: Surface Wave Energy Characterization for the Ohmsett Test Tank
This research project measured the surface turbulence at Ohmsett under various wave configurations and compared these energies to those encountered in the field at specific sea-states. There are three basic mixing energies of primary significance in the dispersion process. These include the process that mixes dispersant into the oil, the energy that breaks the treated oil into small droplets and the larger scale energy that mixes the droplets of oil down into the water column. This work focused on the quantification of the surface turbulence available to break the treated slick into a fine-drop, oil-in-water dispersion. Because of the shallow depth of the Ohmsett tank the third mixing process could not be fully simulated. The mixing of applied dispersant into the oil versus water is an important short-term process but it is not the critical component except where viscous oils or emulsions are involved. A two-week testing program was conducted August 18-29, 2008 at Ohmsett.

Task 3: Dispersant Effectiveness on Heavy California Oils
Dispersant effectiveness (DE) experiments were conducted on six viscous Californian Outer Continental Shelf (OCS) crude oils in April of 2005 at Ohmsett to gather data on this subject. (TAR Project No. 514). The crude oils tested with viscosities lower than 6,500 cP were dispersible to a significant degree whereas the oils with viscosities of 33,000 cP and greater were not. Oils with similar viscosities yielded similar DE results suggesting that viscosity alone was a good measure of likely DE, at least in this test series. Unfortunately oils with viscosities between 6500 and 33,000 cP were not available for testing during the 2005 study. This research project obtained California OCS crude oils with viscosities between 6,500 and 25,000 cSt and conducted large-scale experiments at Ohmsett to determine the DE of dispersants in this viscosity range to fill in the knowledge gap. A one-week testing program will be conducted June 2-6, 2008 at Ohmsett. This project is complete. The final reports and film clips can be found at http://www.mms.gov/tarprojects/554.htm.

Reports: Dispersant Effectiveness Testing on Viscous U.S. Outer Continental Shelf Crude Oils: Phase 2, S. L. Ross Environmental Research Ltd., Ottawa, ON, Canada, 21 pp., November 2008. Thirteen film clips are also available to support the final report.

Calm Seas Application and Dispersant Wash Out" S. L. Ross Environmental Research Ltd. and A. Lewis Oil Spill Consultancy, Ottawa, ON, Canada, 67 pp., December 2008.

Surface Turbulence Measurements at Ohmsett, Febrice Veron, Newark, D. E. and S.L. Ross Environmental Research Ltd., Ottawa, ON, Canada 40 pp., April 2009.

Validation of the Two Models Developed to Predict the Window of Opportunity for Dispersant Use in the Gulf of Mexico
Contracting agency: MMS
Estimated completion: December 2009
In a previous MMS-funded research project entitled: Identification of Window of Opportunity for Chemical Dispersants on Gulf of Mexico Crude Oils http://www.mms.gov/tarprojects/595.htm, two correlation models were developed to predict the window of opportunity (or time-window) for successful chemical dispersant use in the Gulf of Mexico (GOM). The models consist of correlation relationships established using best-fit correlation between readily available fresh oil properties and the window of opportunity for successful chemical dispersant use estimated using data from GOM crude oils and spill volumes of 1,000 and 10,000 barrels. The study demonstrated that combination of Sulfur, Saturate and Wax contents of the fresh oils correlated best with the time-window for dispersant use.

This project aims to validate and improve the two correlation models using a well know oil spill model OILMAP, adding crude oils from outside the GOM for which physical and chemical properties are available, introducing ten new crude oils from the GOM for which physical and chemical properties will be measured in this study, considering existing data from large tank tests and field trials/spills, and using data from new small tank tests. The project also aims to evaluate the sensitivity of the models to water temperature, wind speed and the oil viscosity with the aim to include effects of these parameters into the models. The goals of the research project will be achieved by a series of seven tasks:

1. To validate the time-window predicted by SL Ross for the 24 crude oils selected from the Environment Canada's oil propriety database and using the SLROSM oil spill model.
2. To validate and to improve the two correlation models proposed by SL Ross using 24 or more additional crude oils outside the GOM for whish physical and chemical properties are available in the Environment Canada's oil property database or provided by the MMS;
3. To validate and to improve the two correlations models using ten new crude oils from the GOM. Physical and chemical properties of these new oils will be measure in this study;
4. To perform sensitivity analysis of the correlation models to show how the time-window varies with temperature, wind speed, viscosity cutoff (threshold) and the spill volume;
5. To validate and to improve the correlation models using existing data from large tank tests and field spills;
6. To validate and to improve the correlation models using new experimental data from small tank tests. The new dispersion experiments will be conducted in this project.
7. Data Analysis and Final Report Preparation.

Information on this project can be found at http://www.mms.gov/tarprojects/637.htm.

Employing Chemical Herders to Improve Oil Spill Response Operations
Contracting agency: MMS
Estimated completion: March 2010
The objective of this research program is to extend the research on herders in pack ice conditions, in open water and in salt marshes. This proposed project is a continuation of TAR

Project 554 "Mid-Scale Test Tank Research on Using Oil Herding Surfactants to Thicken Oil Slicks in Broken Ice". There are three tasks in this project.

Task 1: Using Herders to Enhance Mechanical Recovery of Oil in Pack Ice

Field deployment tests of booms and skimmers in broken ice conditions in the Alaskan Beaufort Sea highlighted the severe limitations of conventional containment and recovery equipment in even trace ice. The main problem is that booms, deployed to collect and concentrate oil for effective skimming, also collect and concentrate ice pieces that quickly render the skimmers ineffective. The research on using herding agents to thicken slicks for in situ burning has shown that they can significantly contract and thicken oil among ice, without concentrating the surrounding ice. This could be beneficial to mechanical recovery. In fact, as a skimmer removes oil from the center of a herded slick, the action of the herding agent may cause the slick to continuously contract towards the skimmer, eliminating the need to move the skimmer around to contact all the oil. However, it has been observed that the active ingredient in herding agents (the surfactant) renders sorbent pads less hydrophobic and their water retention increases considerably. This could be a significant detriment to oleophilic skimmers such as drums, discs and rope mops whose recovery surfaces contact herding agent. This should not be an issue with other skimmers types such as weirs and vacuums. Experiments will be conducted in the laboratory and at Ohmsett – The National Oil Spill Response Test facility to explore the capabilities and limitations of using herding agents to thicken oil in loose pack ice for recovery by skimmers.

Task 2: Using Herders to Clear Oil Slicks in Salt Marshes

A parallel to the situation in pack ice exists in salt marsh environments: access for mechanical recovery equipment is almost non-existent due to concerns over damaging the marsh substrate. This task will involve preliminary laboratory experiments in small-scale simulated marshes to determine if chemical herders might play a role in clearing spilled oil from the marsh. The existing contract has been modified to include the following task.

Task 3: Herders to Improve Operational Efficiency of Dispersant Operations

The application of a herding agent around the periphery of a slick just prior to it being treated with dispersant would cause the slick to contract into much thicker oil, covering a much smaller area with a more uniform, and predictable, thickness. This would allow more precise application of dispersant to a smaller area of oil at a more predictable dosage. Herders will contract free-spreading oils with thicknesses ranging from <1 μm to 1+ mm into slicks of ~1 to 4 mm thickness, eliminating the sheen overdosing problem and greatly aiding the thick slick under-dosing problem. This offers the possibility of significantly improving dispersant targeting. Slicks that have spread to «1 mm thickness could be shrunk and thickened with a chemical herder applied with a helicopter-slung bucket delivery systems, or vessel-based delivery systems, then treated with dispersant from ships or aircraft. Another possibility is the application of herding agents around slicks in calm seas to prevent them from spreading until the wind picks up and breaking waves (necessary for effective chemical dispersion) appear. Experiments will be conducted in the laboratory and at Ohmsett – The National Oil Spill Response Test facility to explore the capabilities and limitations of using herding agents to improve the operational efficiency of dispersant operations. Information on this project can be found at http://www.mms.gov/tarprojects/617.htm.

Chemical Dispersant Research at Ohmsett: Phase 2
Contracting agency: MMS
Estimated completion: December 31, 2009
Two tasks will be addressed in this research project.

Task 1. Evaluation of Dispersant Effectiveness in Low-Dose, Repeat Applications
Conventional wisdom and usual practice for the application of dispersant to large oil spills is through large, fixed-wing aircraft spraying. However, the spray from a single pass from such spray systems can treat a slick of only about 0.15 mm thick at the normal design application ratio of one part dispersant to 20 parts of oil. Thick oil patches accounting for 80 to 90 % of the total oil volume can easily be 10 to 100 times thicker than this. The application rate of dispersant from an aircraft application hitting the thick oil could be in the range of 1:200 to 1:2000 under such conditions. The question to be answered in this project is: Does dispersant applied in very low doses (1:1000 to 1:200) disperse a small fraction of an otherwise dispersible oil or is it simply ineffective until a minimum threshold concentration of dispersant in the oil is achieved, possibly through repeated spray passes?

The answer to this question has significant ramifications with respect to operational decisions in dispersant application on thick oil slicks. For example, if a test spray were completed on a thick oil slick and no dispersion was observed the dispersant might be considered to be in-effective, whereas multiple applications of the dispersant might be necessary to achieve a dosage sufficient to generate dispersion. This work will be completed at two test scales. Initial work will be completed at a laboratory test tank scale to assess the effect of low-dose application on a number of oils. Once trends have been determined in the laboratory testing will be completed at Ohmsett to verify similar behavior at full-scale. Three tasks will be accomplished.

1. Small Scale Tests
2. Large Scale Ohmsett testing
3. Data Analysis and Technical Report

Task 2. Validation of Small-Scale Laboratory Test Dispersant Effectiveness Ranking
Bench scale dispersant effectiveness tests are routinely used around the world to rank the potential effectiveness of a dispersant product on standard oils or to study the effect of oil and dispersant type and environmental parameters on dispersant effectiveness. In the United States oils must achieve a measured effectiveness of 45% or greater in the swirling flask to be placed on EPA's NCP Product Schedule as an approved dispersant. But, what do the effectiveness values recorded in these laboratory tests mean with respect to likely effectiveness in the field and do the bench scale tests fairly evaluate dispersant products? Attempts have been made to correlate the results of bench scale tests to one another with mixed success thus suggesting that few, if any, of the tests are representative of real-world situations.

Very limited field data is available to allow the comparison of bench scale test results to field success and so this has also not been adequately done. It is proposed that the Ohmsett test facility be used as a surrogate to the field to provide "field" effectiveness estimates on a select number of oils for a select number of dispersants. Bench-scale tests would be conducted using the same dispersant and oil combinations and the results compared to establish if the bench-scale test results can be used to provide reasonable estimates of field performance. The EPA Baffled

Flask Test (BFT) and the WSL Laboratory test (WSL) will be the bench-scale test methods used in the study. The BFT is being proposed as the new EPA standard and the WSL test has been shown to be more representative of field. Three tasks will be accomplished.

1. Large Scale Ohmsett Testing
2. Bench Scale DE Testing
3. Data Analysis and Technical Report

Information on this project can be found at http://www.mms.gov/tarprojects/638.htm.

Dispersion of Crude Oil and Petroleum Products in Freshwater

Contracting agency: EPA/NRMRL
Completed: 2007

The effects of surfactant composition on the ability of chemical dispersants to disperse crude oil in fresh water were investigated. The objective of this research was to determine whether effective freshwater dispersants can be designed in case this technology is ever considered for use in freshwater environments. Previous studies on the chemical dispersion of crude oil in fresh water neither identified the dispersants that were investigated nor described the chemistry of the surfactants used. This information is necessary for developing a more fundamental understanding of chemical dispersion of crude oil at low salinity. Therefore, the relationship between surfactant chemistry and dispersion effectiveness was investigated in this study. It was found that dispersants can be designed to drive an oil slick into the freshwater column with the same efficiency as in salt water as long as the hydrophilic-lipophilic balance is optimum.

Development of a Protocol for Testing the Efficacy of Surface Washing Agents in Removing Oil Contaminating the Surfaces of Shorelines

Contracting agency: EPA/NRMRL
Completed: 2008

The U. S. Environmental Protection Agency (EPA) has developed a laboratory testing protocol to evaluate the effectiveness of surface washing agents (SWAs) to remove crude oil from a solid substrate. Variables were tested to determine their effect on SWA performance. The protocol was most sensitive to SWA:oil ratio (SOR) and rotational speed of mixing; it was not greatly affected by contact time, mixing time, or SWA concentration when total applied mass is constant. Interfacial tension and contact angle were measured for Prudhoe Bay Crude (PBC) oil in the presence of 6 SWAs. SWAs were ranked based on 1) efficiency under the developed protocol, 2) ability to reduce interfacial tension and 3) ability to increase oil-substrate contact angle. In order for oil displacement to be thermodynamically favored, a SWA must have a lower interfacial tension with the substrate than does the oil. Using Young's equation, the difference between the two solid-liquid interfacial tensions was calculated from the three phase contact angle and the interfacial tension between the two liquids. SWAs were ranked based on each of these criteria, and data were correlated with effectiveness under the protocol. Work is continuing on refinement of the protocol for use on larger surfaces.

Identification of Window of Opportunity for Chemical Dispersants on Gulf of Mexico Crude Oils

Contracting agency: MMS
Completed: November 27, 2007

This research project developed a best-fit correlation between readily available fresh oil properties and the window of opportunity for successful chemical dispersant use on Gulf of Mexico crude oils. This project is complete. The final report is available at http://www.mms.gov/tarprojects/595.htm.
Reports: Identification of Window of Opportunity for Chemical Dispersants on Gulf of Mexico Crude Oils, November 2007, By Randy Belore, S.L. Ross Environmental Research Ltd., Ottawa, ON, Canada

Literature Review on Chemical Treating Agents in Fresh and Brackish Water
Contracting agency: MMS
Estimated completion: December 2009
The objective of this research project is to conduct a comprehensive literature review and technical evaluation on the use of on chemical treating agents in fresh and brackish water. Chemical treating agents and chemical dispersants are designed to work effectively in salt water (35ppt salinity). Near shore environments are seasonally influenced by significant freshwater outfalls (i.e. Mississippi River) and northern marine areas where melting sea ice poses unique situations where the use of dispersants might be used. The water in these areas will be fresh (0% salinity) and brackish (10-15% salinity) and this may alter the effectiveness of chemical treating agents and dispersants and thus alter the treating agents and dispersant use decision. Information is required to assist in making science based regulatory decisions on the use of chemical treating agents under these conditions. This research information will be useful to the to the oil spill planning and response community and will assist those making dispersant use decisions in variable seasonal conditions. Information on this project can be found at http://www.mms.gov/tarprojects/635.htm.

Dispersant Effectiveness as a Function of Energy Dissipation Rate and Particle Size Distribution
Contracting agency: EPA/NRMRL
Estimated completion: 2010
The overall goal of this research is to conduct scientific studies addressing the following objectives: (1) to quantify the natural rates of dispersion for multiple crude oils over a range of sea states (wave energies); (2) to quantify the effectiveness of multiple representative oil dispersant formulations on different types of reference crude oils; (3) to define the sea states (wave energies) over which current commercial dispersant formulations are most effective by quantifying the degree of dispersion expected under varying wave energies; and (4) to conduct toxicological analyses of exposed organisms to determine if dispersed oil provides a toxic exposure to the test species. All of these studies have been or are being done under both batch and continuous flow conditions to accommodate sea currents that further dilute the dispersed oil over time. To achieve the stated objectives, pilot-scale wave studies are conducted in a fabricated wave tank that simulates different wave conditions including periodic breaking waves amid regular, non-breaking waves. The wave tank measures 32 m long, 0.6 m wide, and 2.0 m deep. The tank is equipped with a flap-type wavemaker that generates waves with periods varying from about 0.5 to 3 seconds. To date, significant findings have been reported in several journal articles (listed at the end of this document). Wave energy is key to effective dispersant treatment. Toxicity studies are still on-going, and results will not be available until FY 2010.

Development of a Laboratory Protocol Testing the Effectiveness of Commercial Solidifiers in Cleaning Up Oil Spills on Water
Contracting agency: EPA/NRMRL
(Ongoing) Estimated completion: 2011
The objectives of this work are: (1) to develop a protocol for testing the effectiveness of solidifiers used for treating oil on water, (2) to evaluate the recovery of oil from solidified product, (3) to determine the mechanism of solidification, and (4) to quantify the effects of environmental conditions (temperature, salinity, mixing energy, degree of oil weathering, etc.) on the solidification process. These objectives will lead to a better scientific understanding of the solidification process so that interpretation of results of testing is facilitated. Work began in FY 2008, and an interim article will be written by the end of 2009.

Environmental Conditions Affecting Dispersant Effectiveness
Contracting agency: EPA/NRMRL
Estimated completion: 2009
This work has used the EPA laboratory testing procedure, "The Baffled Flask Test" to evaluate dispersant effectiveness under differing conditions of temperature, salinity, oil weathering, oil type and energy input. The baffled flask test is proposed for usage in EPA's listing of products for oil spill response and provides a more consistent and well-mixed test than was previously available. The data from this study will provide guidance on conditions that are favorable for dispersal and have been used in a statistical analysis to produce a set of correlation functions. The current work has led to several journal and conference presentations since its inception. The project was completed in 2008 by a concluding investigation of the ability to predict dispersability from a component analysis of the crude oil and a compilation and statistical evaluation of data produced to date. The results are being used by EPA in modeling of oil spill and dispersed oil transport. Two papers are in draft form for submission to journals in fall 2009.

Impact of Wave Motion on Dispersed Oil Droplets
Contracting agency: EPA/NRMRL
Estimated completion: 2009
Evaluation and modeling of the effects of irregular wave trains on oil spill dispersal and transport of dispersed oil. These effects control the dispersal of oil in many situations and are intended for eventual incorporation into large-scale oil spill models. The work was based on development of modeling approaches that simulate transport under wave trains. The velocity of water varies in regular waves in a classically-known pattern of elongated ellipses. These patterns of flow then are interacting with dispersed oil droplets, which are additionally influenced by droplet size and buoyancy. Taken together these phenomena determine the depth to which various particles are dispersed into the water column. The situation is more complex for irregular wave trains, which in one sense are sets of waves of varying wavelength superimposed upon each other. Statistical distributions of waves are needed in the numerical simulation in these cases. Two articles have been completed, one each on regular and irregular waves.

Guidance for Dispersant Decision Making: Potential for Impacts on Aquatic Biota
Contracting agency: NOAA/CRRC
Estimated completion: October 2009
This project will provide responders with a quick guide allowing them to determine the likely water volume adversely affected by naturally- or chemically-dispersed oil and dissolved hydrocarbons, as well as the surface area impacted by floating oil, with which they can evaluate tradeoffs of dispersant use and plan monitoring activities, including for natural resource damage assessment. The Oil Spill Impact Guide (OSIG) will be based on a matrix of 240 model runs using ASA's SIMAP physical fates, exposure and oil toxicity models, where key variables determining impact are varied: oil type, weathering state, oil volume, environmental (e.g., wind speed, temperature) conditions, dispersant use, and toxicity to aquatic biota. The research and lessons learned from this effort will contribute to national efforts aimed at developing decision-making tools and supporting information related to spill response, and specifically with respect to dispersant use. The results of the research will be presented and explained to the spill response community during or adjunct to a spill-response related meeting or conference. The presentation will be part of a focused half-day workshop on dispersant decision-making, where discussion of the results and implications will be solicited. The seminar will include presentation of the Oil Spill Impact Field Guide and calculator. The Oil Spill Impact Guide will be freely available on the web.

The Relationship Between Acute and Population Level Effects of Exposure to Dispersed Oil, and the Influence of Exposure Conditions Using Multiple Life History Stages of an Estuarine Copepod, Eurytemora affinis, as a Model Planktonic Organism
Contracting agency: NOAA/CRRC
Estimated completion: October 2008
This study examines the relationship between sublethal exposure and population level effects of the estuarine copepod, *Eurytemora affinis*, to short-term dispersant, water-accommodated fractions (WAF) and chemically enhanced water accommodated fractions (CE-WAF) of weathered oil under normal and UV light conditions. In this study, static constant acute toxicity experiments determined 24 and 48 h LC50 concentrations for nauplii, copepodites and adults using dispersant Exxon Corexit 9500 and weathered Alaskan North Slope crude oil. The most sensitive life stage, nauplii, was exposed to dispersant, WAF and CE-WAF at previously determined LC50 concentrations. Under either ambient laboratory or UV light conditions, nauplii that survived toxicant exposure were followed for approximately three generations in order to develop life history tables and population profiles. E. affinis is a relatively sensitive species (based on acute toxicity) to dispersant alone, WAF or CE-WAF. However, for organisms surviving an initial exposure approximating the 24-hour LC50 value for a 24-hour period, there was no evidence of any change in fecundity or overall population growth in culture over approximately three generations, with or without exposure to UV light after exposure to the WAF. Final Report: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=15

Effects of Dispersants on Oil-SPM Aggregation and Fate in US Coastal Waters
Contracting agency: NOAA/CRRC
Estimated completion: March 2008
This project studied OSA formation in the laboratory using bench scale testing and natural sediments from five different US coastal waters so that factors controlling formation and fate of

both physically- and chemically-dispersed oil droplets in coastal environments can be better understood and modeled, especially oil sedimentation. Parameters that were varied are oil type, sediment type and concentration, dispersant type and dispersant-to-oil ratio (DOR). Project results showed that OSAs do form readily with chemically dispersed oil and most of the natural sediments used in this project. The hypothesis of enhancement of oil sedimentation is valid. Enhancement of oil sedimentation due to application of chemical dispersant was obtained in most of the experiments conducted in this study.
Final Report: http://www.crrc.unh.edu/final/khelifafinal2008/

Dispersant Effectiveness as a Function of Energy Dissipation Rate and Particle Size Distribution
Contracting agency: NOAA/CRRC
Completion: January 2008
The 2005 dispersants report by the National Research Council concluded that studies on chemical oil dispersant effectiveness are constrained by a lack of quantitative data on energy dissipation rate and particle size distribution. To address this challenge, a wave tank was constructed at the Bedford Institute of Oceanography in collaboration with the U.S. EPA for the purpose of conducting controlled oil dispersion studies. Waves in this tank are generated using a flap-type wave-maker that is capable of generating breaking waves using dispersive focusing technique.
Project Page: http://rfp.crrc.unh.edu/projects/viewProject.php?PROJECT_ID=17

IN-SITU BURNING:

Research on Improving Methods for Recovering Residues from In Situ Burning of Marine Oil Spills
Contracting agency: MMS
Estimated completion: July 31, 2010
The objective of the proposed research program is to develop methods for (1) recovering potentially non-buoyant ISB residues through innovative surface and sub-surface collection means; and (2) recovering buoyant residues, including those attached to sorbent agents that were intentionally added to the residue to prevent subsequent residue sinking. The goals of the program are to:

1. Refine and develop ideas for preventing ISB residues from sinking and for collecting both buoyant and non-buoyant ISB residues, based on earlier studies.
2. Test the ideas experimentally by conducting a laboratory study involving small-scale residue recovery experiments.
3. Design an experimental program to test the concepts at Ohmsett using real residues.
4. Conduct experiments at Ohmsett to evaluate the collection/recovery techniques.
5. Make recommendations on the best techniques to consider for further evaluation at future burns.

The goals will be accomplished by conducting experiments at the SL Ross laboratory in Ottawa, ON, at the Fire Training Facility at Prudhoe Bay, AK and at the Ohmsett facility. Information on this project can be found at http://www.mms.gov/tarprojects/647.htm.

FY 2007 – 2009 Publications on Pollution Research
Contributed by Interagency Committee Member Agencies

Bejarano, A.C., G.T. Chandler, L. He, T.L. Cary, and J.L. Ferry. 2006. Risk Assessment of the NIST Petroleum Crude Oil Standard Water Accommodated Fraction (WAF): Further Application of a Copepod-Based Full Life-Cycle Bioassay. *Environmental Toxicology and Chemistry*. 25: 1953-1960.

Bejarano, A.C., G.T. Chandler, L. He, and B.C. Coull. 2006. Individual to Population Level Effects of South Louisiana Crude Oil Water Accommodated Hydrocarbon Fraction (WAF) on a Marine Meiobenthic Copepod. *Journal of Experimental Marine Biology and Ecology*. 332(1): 49-59.

Botrus, D., M.C. Boufadel, E. Wickley-Olsen, J.W. Weaver, R. Weggel, K. Lee and A.D. Venosa. 2008. Wave tank to simulate the movement of oil under breaking waves. *Proceedings of the 31st Arctic and Marine Oil Spill Program (AMOP) Technical Seminar on Environmental Contamination and Response.* Edmonton Alberta, Canada, June 2-5, 2008. pp. 53-68.

Boufadel, M.C., E. Wickley-Olsen, T. King, T., Z. Li, K. Lee and A.D. Venosa. 2008. Theoretical foundation for predicting dispersion effectiveness due to waves. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 509-514.

Boufadel, M.C., K. Du, V. Kaku, and J. Weaver. 2007, Lagrangian simulation of oil droplets transport due to regular waves. *Environmental Modeling and Software*. 22(7): 978-986.

Boufadel, M.C., H.L. Li, M.T. Suidan, and A.D. Venosa. 2007. Tracer studies in a laboratory beach subjected to waves. *Journal of Environmental Engineering-ASCE*. 133(7): 722-732.

Bugden, J. B., C.W. Yeung, P.E. Kepkay, and K. Lee. 2008. Application of Ultraviolet Fluorometry and Excitation-Emission Matrix Spectroscopy (EEMS) to Fingerprint Oil and Chemically Dispersed Oil in Seawater. *Marine Pollution Bulletin*. 56(4): 677-85.

Campo-Moreno, P, Y. Zhao, M.T. Suidan, and A.D. Venosa. 2007. Biodegradation kinetics and toxicity of vegetable oil triacylglycerols under aerobic conditions. *Chemosphere* 68(11): 2054-2062.

Chen, F.H. and P.D. Yapa. 2007. Estimating the Oil Droplet Size Distributions in Deepwater Oil Spills. *Journal of Hydraulic Engineering*. 133(2): 197-207.

Chung, S., J. Gandee, M.T. Suidan, and A.D. Venosa. 2008. Effect of sand particle size, oil contamination, and water table level on the effectiveness of sorbents in wicking oil from contaminated wetland. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 537-540.

Coastal Response Research Center. 2006. Submerged Oil – State of the Practice and Research Needs - December 12-13, 2006.

Cole, M. G., T. L. King, and K. Lee. 2007. Analytical Technique for Extracting Hydrocarbons from Water Using Sample Container as Extraction Vessel in Combination with a Roller Apparatus. *Can. Tech. Rep. Fish. Aquat. Sci.* 2733: vi + 12p.

DiToro, D.M., J.A. McGrath, and W.A. Stubblefield. 2007. Predicting the Toxicity of Neat and Weathered Crude Oil: Toxic Potential and the Toxicity of Saturated Mixtures. *Environmental Toxicology and Chemistry*. 26(1): 24-36.

Gopalan, B., E. Malkiel, and J. Katz. 2008. Experimental Investigation of Turbulent Diffusion of Slightly Buoyant Droplets in Locally Isotropic Turbulence. *Physics of Fluids*, September 2008. Copyright 2008, American Institute of Physics.

Hansen, K. A, and Job Bello, Susan Clauson, R. Camilli, B Bingham, Mette T. Eriksen, Eric Maillard, John Morris, Pamela J. Luey. Preliminary Results for Oil on the Bottom Detection Technologies. *Proceedings of the Thirty-First Arctic and Marine Oilspill Program,* Environment Canada, Ottawa, ON, pp. 713-740, 2008

Kaku, V. J., M. C. Boufadel, and J. W. Weaver, Scaling exponents of structure functions in an eccentrically rotating flask. *Advances in Theoretical and Applied Mechanics*, in press.

Kepkay, P.E., C.W. Yeung, J.B.C. Bugden, Z. Li and K. Lee. Ultraviolet Fluorescence Spectroscopy (UVFS): A new means of determining the effect of chemical dispersants on oil spills. *Proceedings of the 2008 International Oil Spill Conference, Savannah, Georgia, USA,* May 4-8, 2008. pp. 639-644.

Khelifa, A., B. Fieldhouse, Z. Wang, C. Yang, M. Landriault, M.F. Fingas, C.E. Brown, and L. Gamble. 2007. A Laboratory Study on Formation of Oil-SPM Aggregates using the NIST Standard Reference Material 1941b. *Proceedings of the Thirtieth Arctic and Marine Oil Spill Program Technical Seminar*, Environment Canada, Ottawa, Ontario, pp. 35-48.

Khelifa, A., M.F. Fingas, B.P. Hollebone, and C.E. Brown. 2007. Effects of Chemical Dispersants on Oil Physical Properties and Dispersion. *Proceedings of* the *Thirtieth Arctic and Marine Oil Spill Program Technical Seminar*, Environment Canada, Ottawa, Ontario, pp. 105-116.

Khelifa, A., B. Fieldhouse, Z. Wang, C. Yang, M. Landriault, C.E. Brown, and M.F. Fingas. 2008. Effects of Chemical Dispersant on Oil Sedimentation Due to Oil-SPM Flocculation: Experiments with the NIST Standard Reference Material 1941b. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, pp. 627-631.

Khelifa, A., M. Chun, J.L.E. Eubank, and C.E. Brown. 2008. Physical Properties of Oil-SPM Aggregates: Experiments with the NIST Standard Reference Material 1941b. *Proceedings of the Thirty-first Arctic and Marine Oil Spill Program Technical Seminar*, Environment Canada, Ottawa, Ontario, Vol. 1, pp. 35-51.

Koran, K.M., A.D. Venosa, and C. Luedeker. 2008. Evaluation of detergency, interfacial tension and contact angle for five surface washing agents. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 785-790.

Lee, K., Z. Li, P. Kepkay, M.C. Boufadel and A.D. Venosa. 2008. Effects of chemical dispersants on oil-mineral-aggregation in a wave tank. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 633-638.

Lee, K., Z. Li, P. Kepkay, M.C. Boufadel and A.D. Venosa. 2008. Wave tank studies on formation and transport of OMA from the chemically dispersed oil. In: *Oil Spill Response: A Global Perspective*, Davidson, W.F., K. Lee and A. Cogswell, A. (eds), NATO Science for Peace and Security Series – C: Environmental Security, Springer Publishing Company. pp. 159-177.

Li, H., Z. Qinghong, M. Boufadel, and A. Venosa. 2007. A universal nutrient application strategy for the bioremediation of oil-polluted beaches. *Marine Pollution Bulletin* 54: 1146–1161.

Li, Z., P. Kepkay, M.C. Boufadel, A.D. Venosa and K. Lee. 2008. Oil droplet size distribution as a function of energy dissipation rate in an experimental wavetank. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 621-626.

Li, Z., P. Kepkay, K. Lee, T. King, M.C. Boufadel, and A.D. Venosa. 2007. Effects of chemical dispersants and mineral fines on crude oil dispersion in a wave tank under breaking waves." *Marine Poll. Bulletin.* 54: 983-993.

Li, Z., K. Lee, T. King, M.C. Boufadel, and A.D. Venosa. 2008. Assessment of chemical dispersant effectiveness in a wave tank under regular non-breaking and breaking wave conditions. *Marine Poll. Bulletin.* 56: 903-912.

Li, Z., Lee, K., Kepkay, P., Boufadel, M.C., and Venosa, A.D. 2008. Chemical dispersant effectiveness: droplet size distribution as a function of energy dissipation rate. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 777-784.

Li, Z., K. Lee, P. Kepkay, T. King, W. Yeung, M.C. Boufadel and A.D. Venosa. 2008. Wave tank studies on chemical dispersant effectiveness: Dispersed oil droplet size distribution. In: *Oil Spill Response: A Global Perspective, Davidson*, W.F., K. Lee and A. Cogswell, A. (eds), NATO Science for Peace and Security Series – C: Environmental Security, Springer Publishing Company. pp. 143-157.

Li, Z., Lee, K., King, T., Boufadel, M.C., and Venosa, A.D. 2008. Assessment of chemical dispersant effectiveness in a wave tank under regular non-breaking and breaking wave conditions. *Marine Pollution Bulletin.* 56, 903-912.

Li, Z., Lee, K., King, T., Boufadel, M. C., and Venosa, A. D. (In press). Evaluating crude oil chemical dispersion efficacy in a flow-through wave tank under regular non-breaking wave and breaking wave conditions. *Marine Pollution Bulletin.*

Li, Z., Lee, K., King, T., Boufadel, M.C., Venosa, A.D. (Submitted). Evaluating oil spill chemical dispersant efficacy in an experimental wave tank: 2, Significant factors determining *in-situ* droplet size distributions. *Environmental Engineering Science.*

Li, Z., Lee, K., King, T., Kepkay, P.E., Boufadel, M.C., Venosa, A.D. (Accepted with minor revision). Evaluating oil spill chemical dispersant efficacy in an experimental wave tank: 1, Dispersant effectiveness as a function of energy dissipation rate. *Environmental Engineering Science.*

Lin, C-Y., H. Wu, R.S. Tjeerdema, and M.R. Viant. 2007. Evaluation of Metabolite Extraction Strategies from Tissue Samples Using NMR Metabolomics. *Metabolomics*. 3(1): 55-67.

Luedeker, C., K.M. Koran, and A.D. Venosa. 2008. Effect of variables on performance of surface washing agents under a newly developed testing protocol. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 843-846.

Ma, X., A. Cogswell, K. Lee, Z. Li. 2008. Particle size analysis of dispersed oil and oil-mineral aggregates with an automated epi-fluorescence microscopy system. *Environmental Technology*. 29: 737-748.

Pillapakam, S., D. Botrus, R. Bechtel, J. W. Weaver, M. C. Boufadel. 2009. Transport of passive tracers in irregular seas. *Applied Mathematical Modeling*. Submitted for review.

Seager, T., S. Tuler, R. Kay, K. Satterstrom, and I. Linkov. 2007. Typological Review of Environmental Performance Metrics with Application to Oil Spill Response. *Integrated Environmental Assessment and Management*. 3(3): 310-321.

Srinivasan, R., Q. Lu, G.A. Sorial, A.D. Venosa, and J. Mullin. 2007. Dispersant effectiveness of heavy fuel oils using the baffled flask test. *Environmental Engineering Sci,* 24(9): 1307-1320.

Tebeau, Peter A., Kurt. A. Hansen, Joshua W Fant and Meaghann M Terrien, Assessing the Long-Term Implementation Costs versus Benefits Associated with Laser Flurorosensor Spill Response Technology. *Proceedings of the Thirtieth Arctic and Marine Oil spill Program*, Environment Canada, Ottawa, ON, pp. 451-468, 2007.

Tebeau, Peter A., Dagmar S. Etkin and Deborah P. French-McCay . Using Analytical Models to Assess the Benefits of Oil Spill Response Technology. *Proceedings of the Thirtieth Arctic and Marine Oil spill Program*, Environment Canada, Ottawa, ON, pp. 657-680, 2007.

Tuler, S.P., F.K. Satterstrom, R. Kay, and I. Linkov. 2006. The *Bouchard-120* and Chalk Point Spill Responses: Objectives and Performance Metrics," In: *Environmental Security in Harbors and Coastal Areas: Management Using Comparative Risk Assessment and Multi-Criteria Decision Analysis*, eds. I. Linkov, G. Kiker, and R. Wenning. (Amsterdam: Springer).

Unger, M.A., M.C. Newman, and G.G. Vadas. 2007. Predicting Survival of Grass Shrimp (*Palaemonetes pugio*) During Ethylnaphthalene, Dimethylnaphthalene, and Phenanthrene Exposures Differing in Concentration and Duration. *Environmental Toxicology and Chemistry*, 26(3): 528-534.

Venosa, A.D. and E.L. Holder. 2007. Biodegradability of dispersed crude oil at two different temperatures. *Marine Poll. Bulletin.* 54: 545-553.

Venosa, A.D., K. Lee, M.C. Boufadel and Z. Li. 2008. Dispersant effectiveness as a function of energy dissipation rate in a wave tank. *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, USA, May 4-8, 2008. pp. 777-784.

Wickley-Olsen, E., M.C. Boufadel, T. King, Z. Li, K. Lee, and A.D. Venosa. 2007. Regular and breaking waves in wave tank for dispersion effectiveness testing. *Proceedings of: the 30th Arctic and Marine Oilspill Programs (AMOP) Technical Seminar*, Edmonton, AB, Canada, 161-187.

Wickley-Olsen, E., M.C. Boufadel, T. King, Z. Li, K. Lee and A.D. Venosa. 2008. Regular and breaking waves in wave tank for dispersion effectiveness testing. *Proceedings of the 2008 International Oil Spill Conference,* Savannah, Georgia, USA, May 4-8, 2008. pp. 479-508.

Wrenn, B.A., Virkus, A., Mukherjee, and A.D. Venosa. 2009. Dispersibility of crude oil in fresh water. *Environmental Pollution.* 157: 1807-1814.

Wrenn, B.A., R.J. Downer, and A.D. Venosa. 2008. Effects of mixing energy on the sedimentation of vegetable oil spills by clay. *Env. Toxicol.* 29: 1-9.

Ohmsett - The National Oil Spill Response Test Tank Facility

Background

Title VII of the Oil Pollution Act of 1990 (OPA-90) mandated the reactivation of Ohmsett - The National Oil Spill Response Test Tank Facility, located in New Jersey for oil pollution technology testing and evaluations under Department of the Interior, Minerals Management Service (MMS) administration. This responsibility was formalized in 1992 with publication of the Interagency Oil Spill Research and Technology Plan.

Ohmsett is the only facility where full-scale oil spill response equipment testing, training and research can be conducted in a marine environment with oil under controlled environmental conditions (waves, temperature, oil types). The facility provides an environmentally safe place to conduct objective testing and to develop devices and techniques for the control of oil and hazardous material spills. Ohmsett's mission is to increase oil spill response capability through independent and objective performance testing of equipment, providing realistic training to response personnel, and improving technologies through research and development. Public and private sector entities use Ohmsett as a research center to test oil spill containment/clean-up equipment and techniques, to test new designs in response equipment, and to conduct training with actual oil spill response technologies. To date twenty-four countries have utilized the facility.

The facility is located on the waterfront complex of Naval Weapons Station Earle in Leonardo, New Jersey, an hour south of New York City and is maintained and operated by MMS through a contract with MAR, Incorporated of Rockville, Maryland. The primary feature of Ohmsett is a large, above ground, concrete test tank measuring 667 feet long, 65 feet wide and 11 feet deep. The tank is filled to a depth of 8 feet with 2.6 million gallons of crystal clear salt water. The facility provides an environmentally safe place to conduct objective, independent testing of oil spill response equipment as well as training responders. Information on Ohmsett can be found at the website http://www.ohmsett.com/.

Testing

The Ohmsett facility represents a necessary intermediate step between small scale "laboratory testing" and open water testing of equipment. In the past, Ohmsett was used almost exclusively to test and evaluate oil spill skimmers and containment booms. However, new types of research are being conducted at Ohmsett to increase facility utilization. MMS has expanded the capabilities of Ohmsett to test all types of oil spill response equipment, techniques and methodologies. In the past five years, the scope of testing activities at Ohmsett has substantially broadened. To respond to the challenges of testing and evaluating the equipment required to respond to oil spills in ice infested waters MMS has upgraded the testing capabilities at Ohmsett to provide a controlled environment for cold water testing and training (with or without ice). The facility is now able to simulate realistic broken ice conditions. These upgrades enable the Ohmsett facility to remain open year round and to host cold water testing and training during the winter months. Ohmsett now has the ability to test and evaluate fire resistant containment booms using an air-injected propane burner system that realistically simulates in situ burning at sea.

The capability to conduct effectiveness testing on a variety of chemical treating agents, dispersants and emulsion breakers and sorbent products has also been added. The use of chemical dispersants in the United States is on the verge of achieving a similar acceptance status to that of mechanical containment and recovery countermeasures. The Ohmsett facility is rapidly becoming a world leader in realistic dispersant effectiveness testing through the design and development of a calibrated, referenced and realistic test protocol and subsequent testing under cold and temperate conditions using fresh and weathered crude and fuel oils. The National Research Council strongly supported the use of wave tank testing in their recent review of chemical dispersants. Ohmsett is the world's largest wave-tank complex presently conducting such research and is the logical venue for bridging the gap between laboratory and field testing.

The Ohmsett facility allows for testing and evaluation of remote sensing instruments under a wide range of conditions. Sensors can be mounted on the Ohmsett bridge or on the tower above the tank. The tank is also large enough that aircraft and helicopters can fly over a test oil slick to evaluate sensor performance.

Ohmsett is essential in fulfilling the MMS's regulatory responsibilities under the OPA 90 and to the MMS's mission of ensuring safe and environmentally sound oil and gas development on the OCS. The MMS uses Ohmsett as a test bed for spill response technology development. Ohmsett is not only a vital component of the MMS's oil spill research program, it is a national asset that provides testing, research, and training opportunities to government, industry, academia, and private organizations. Information gathered at Ohmsett plays an essential role in the development of new technology and in the creation of more effective procedures for responding to future oil spills. The facility directly supports the MMS goal of ensuring that the best and safest oil spill detection, containment and removal technologies are available to protect the United States coastal and oceanic environments. Without Ohmsett the research and testing and evaluation of oil spill response equipment systems and methodologies with real oil as well as responder training would have to be conducted during actual spills where conditions cannot be repeated and would interfere with response operations. Types of research and development on oil spill response equipment that have been tested at the Ohmsett facility include:

- Fate and behavior of crude oil and oil products research
- Aerial remote sensing equipment and systems
- Above and underwater oil detection systems
- Oil collection booms (inland, fast-water and ocean)
- Fire resistant booms (passive and active)
- Stationary skimmers (drum, disk, rope, belt, weir, etc), high speed skimmers, and in ice skimmers
- Temporary oil storage devices
- Offload and transfer pumps and centrifuges
- Viscous oil pumping systems
- Autonomous marine booster pump
- Sorbents and sorbent booms
- Chemical treating agents and dispersants
- Ship to shore oil transfer line quick disconnect couplings

- Steam lances (to heat oils to be able to pump)
- Remote underwater pipeline leak repair and collection system

Ohmsett uses American Society of Testing and Materials (ASTM) standards for all oil spill equipment evaluations. ASTM standards exist for equipment testing such as booms and skimmers, for the selection of appropriate equipment for spill response, for oil spill terminology and for related laboratory procedures. These protocols define a series of test methods to determine the oil containment and recovery efficiencies of spill response equipment, such as booms and skimmers, when they are subjected to a variety of towing and wave conditions. In addition to oil containment evaluations, numerous other performance characteristics are quantitatively and qualitatively identified and determined. The tests provide standardized procedures for any system tested. Additionally, the tests provide evaluation of the system's capabilities in different environmental conditions and the ability to compare test results of a particular equipment type with others having undergone these standard tests.

Members of the Ohmsett staff belong to the ASTM F20 Committee on Hazardous Substances and Oil Spill Response. The F20 Committee was formed in 1975 to develop and update documents relevant to hazardous substances and oil spill response. The committee, with current membership of approximately 120, now has jurisdiction of over 55 standards, published in the Annual Book of ASTM Standards. Ohmsett has been used as a test bed to test and develop new ASTM standards. The ASTM subcommittee on skimmers recently adopted a standard methodology for measuring the nameplate capacity for a given skimmer system. The test method employed was based on a final draft version of ASTM's F-2709, Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems (ASTM 2008a). This protocol, which has recently been balloted and adopted, was developed in conjunction with the U.S. Coast Guard National Strike Force (NSF), and complies with the test criteria found in ASTM F-631, Standard Guide for Collecting Skimmer Performance Data in Controlled Environments (ASTM, 2008b). A complete listing of all tests conducted at Ohmsett can be found at http://www.ohmsett.com/Summary_of_Activities.html

Training

Ohmset is the premier hands-on training site from state and federal government agencies, private industry and foreign countries. Ohmsett has been selected by the U.S. Coast Guard (USCG) as its designated training facility for personnel newly assigned to oil spill response duties and for personnel attached to the National Strike Force Coordination Center. The USCG currently conducts up to six, week long training classes a year at Ohmsett. Other government agencies such as the U.S. Environmental Protection Agency and the U.S. Navy use the facility to train their emergency response personnel. Ohmsett is also the premier training site for private industry. Many domestic and international of oil companies and private spill response organizations send their response personnel to Ohmsett training classes to practice with the same equipment they have in their inventory. This allows students the opportunity of containing and collecting different types of oils during changing sea conditions from calm to open ocean.

The training facility includes a 25 seat classroom with state-of-the-art audio-visual equipment. Following classroom instruction, students get hands-on training in the tank where they practice

recovering oil, using real equipment under conditions that simulate an actual oil spill. Training advantages include: increase proficiency using actual oil spill recovery equipment, practice is conducted with oil under realistic oil spill conditions with waves and currents, and performance is analyzed by collecting and measuring recovered oil. Students can review their oil recovery efficiencies and critique their videotaped performances. Training sessions can be configured to meet specific needs. Classes have included:

- Texas A&M University National Spill Control School Training - Oil Spill Strategies and Techniques Training
- USCG Boot Camp/Lightering, Oil Spill Responder Training (OSRT), and National Strike Force Training
- 40-Hour HAZWOPER
- 8-Hour HAZWOPER Refresher
- Confined Space Entry certification training
- First Responder and Management training for Alaska Clean Seas, Chevron/Texaco, ConocoPhillips,
- Incident Command System training for MMS

Recent Refurbishment and Facility Upgrades

Ohmsett has experienced a 150 percent increase in its use over the past five years; and vital equipment, necessary to the operation of the 35-year old facility, was beginning to break down. The continued safe and effective operation of Ohmsett had to be ensured through the completion of long deferred major repairs as well as replacement of necessary facility equipment and systems. Ohmsett has completed a five-year major refurbishment and repair program that entailed:

- Replacement of electric drive motors that are used to tow a movable bridge the length of the tank and the replacement of mechanical components of the tow cable system
- Installation of a 1,500 lb. capacity hydraulic crane with a 40 foot reach on the Ohmsett deck for equipment deployment and retrieval in the tank
- Installation of a 1,000 lb capacity crane with a 20 foot reach on the Ohmsett bridge
- Resurfacing and repainting of the tank and exposed metal work
- Design and construction of a new oil containment area
- Replacement and upgrade of the storage tank piping
- Repair or replacement of the wave generator motor and drive system
- Installation of an electrical substation to operate testing equipment
- Replacement of the existing chemistry laboratory trailer with a permanent, renovated laboratory building and new analytical equipment
- Rebuilding of the oil-water separator and processing system
- Acquisition of pumps and related items for draining the test tank
- Renovation of the equipment storage building
- Replacement of major electrical and communication cables
- Six underwater viewing windows were also removed, cleaned, and reinstalled;
- Construction of a dedicated oil storage containment building

Current upgrades include replacement of the wave generator and absorbing beaches and replacement of the Ohmsett Auxiliary Bridge.

New Capabilities

New capabilities for testing and training that were implemented in 2007-2008 include:

- Development and implementation of a Spanish language first responder training class. The class is offered each August.
- Development and implementation of a "Hands-On" chemical dispersant training class.
- Development and implementation of a Fast Water oil spill response training
- Complete upgrade of the piping for the Ohmsett oil recovery system from 2-inch diameter to 6-inch diameter to accommodate testing of a high volume skimmer for Tesoro
- Installation of a new chemistry laboratory and new analytical equipment for oil site analyses.
- Purchase of new monitoring equipment chemical dispersant testing: LISST particle size analyzer and Turner C3 solid state fluorometer.

Summary

Ohmsett's mission is to increase oil spill response capabilities through independent and objective performance testing of equipment, providing realistic training to response personnel, and improving response technologies through research and development. The continued safe and effective operation of the Ohmsett facility is crucial to the MMS mission of ensuring safe and environmentally sound Outer Continental Shelf mineral development. Many of today's commercially available oil spill cleanup products and services have been tested at Ohmsett either as off-the-shelf commercially available equipment, or as equipment or technology still under development. In North America, a large portion of existing independent performance data and information on containment booms and skimmers have been obtained through testing at Ohmsett. Ohmsett will continue to provide testing, research, and training opportunities to government, industry, academia, and private organizations. The facility plays a critical role in the ability of all of these institutions and stakeholders to fulfill their goals, mandates, and regulatory requirements towards maintaining an environmentally clean record while providing energy for the American people.