INTERNATIONAL

1995 Oil Spill Conference

Achieving and Maintaining Preparedness

ABSTRACTS

USCG API EPA IMO IPIECA

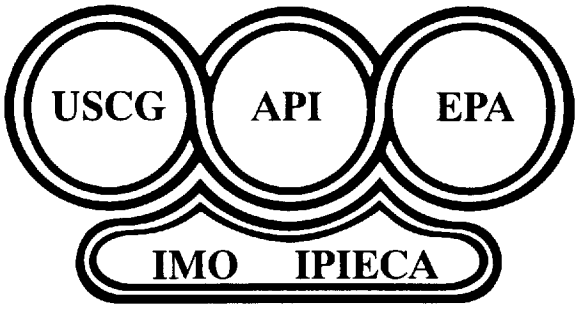
1995 International Oil Spill Conference

Abstracts

1995 International Oil Spill Conference

(Achieving and Maintaining Preparedness)

February 27–March 2, 1995
Long Beach, California



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In Memoriam

Kenneth E. Biglane
1927–1994

The 1995 International Oil Spill Conference Proceedings volume is dedicated to the memory of Kenneth E. Biglane in recognition of his devoted service with the Environmental Protection Agency and valuable contributions to the Biennial International Oil Spill Conferences.

Mr. Biglane was instrumental in pioneering the development of the National Response System in the United States. Early on, he was appointed to head the Emergency Response Office of the Environmental Protection Agency and served as the first Chairman of the National Response Team. It was Mr. Biglane's foresight in working with his government and industry counterparts that identified the need to establish a routine forum for information exchange on oil spill prevention, preparedness, and response that resulted in the first Oil Spill Conference in 1969. Mr. Biglane continued to provide vital guidance and commitment to the Conference through 1993.

1995 International Oil Spill Conference

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Vice Chairman

FOREWORD

This proceedings represents the 14th biennial International Oil Spill Conference (IOSC). Since its inception a quarter of a century ago, the Conference has slowly evolved upward as the political winds of oil spill interest have waxed and waned. Today, this Confernce stands as the premiere international technical conference and trade exposition for the world's oil spill community. In a maturing and more sophisticated industrialized world, nations of all sizes have recognized the importance of international environmental stewardship. Oil spills, though generally of relatively short term, localized influence, are one more environmental perturbation that can be minimized and mitigated by man's active intervention. The goals of this Conference remain much as they were in 1969: "... to delineate the overall dimensions of the oil spills problem, explore the present state of the art of prevention and control of oil spills, and review the relevant research and development efforts of government and private industry, both here and abroad."

The 1995 Conference takes another step forward to maintain its position as the premiere international conference on oil spill issues. To further develop the international cooperation and flow of information, the long time sponsors—the American Petroleum Institute, U.S. Coast Guard, and Environmental Protection Agency—are joined this year by two international organizations. Representing the international regulatory community is the International Maritime Organization (IMO), and representing the international petroleum industry is the International Petroleum Industry Environmental Conservation Association (IPIECA). With this new partnership, the IOSC will greatly enhance its international balance of technical contributions and trade exhibits. More importantly, it will help to communicate the latest in oil spill information to nations of all sizes throughout the world. The long term benefits should include reduced loss of oil to the seas, quicker cleanup, and less environmental impact due to cleanup practices.

During the past half dozen years, new oil spill management regulations have been implemented in the United States and internationally. Although complex and detailed, one primary facet is better preparation and training of response personnel. Unfortunately, the level of interest and involvement in oil spill activities in the world communities is inversely related to the length of time since the last major, newsworthy oil spill event. For that reason, the theme chosen for the 1995 Conference is "Achieving and Maintaining Preparedness." How do we get and stay prepared? The technical papers to be presented, although covering a broad range of topics, were selected with this theme in mind.

What is new for the 1995 Conference? Many changes have been made to continue the process of improving the Conference and to meet the needs of the attendees. This year, one of our goals was to continue the improvement of the technical quality of the papers accepted. A selected group of 45 international reviewers chose 136 papers for this Proceedings and presentation at the Conference. This was from more than 490 submitted. Additionally, 126 poster presentations will be displayed in seven special sessions over a two day period, and are also included in this Proceedings. A new Abstract Book and a day-at-a-glance chart has been developed to assist attendees in selecting the presentations of their choice. Almost 300 vendors of oil spill related goods and services are participating in the associated trade show. Two major west coast spill cooperatives are conducting an on-water demonstration of spill equipment and techniques.

Many other special events are planned. A theme session, highlighted by a keynote luncheon address by the Rt. Honorable Lord Donaldson of Lymington, will feature the *Braer* oil spill in the Shetland Islands. IMO and IPIECA are hosting a special evening session summarizing a recent world-wide seminar series they have sponsored. There also will be a special evening session dealing with Natural Resource Damage Assessment.

Another new feature is the preparation and distribution of three selected topic "white papers." These reviews will cover major topics of interest and will be formatted to provide detailed discussions and information on relevant issues. Corresponding panels of experts have been invited to discuss and debate the issues raised in these white papers.

A sponsors' scholarship program has been instituted to support students and other interested parties who might contribute to and participate in the Oil Spill Conference. Most importantly, this Conference provides a place where the world's experts can meet, visit, and exchange the latest information.

As can be seen, many changes have been made to ensure that the Conference continues to improve to meet the needs of the oil spill community that supports it. In order to continue fulfilling this role, it is most important that attendees provide feedback on the content and quality of this Conference.

The sponsors of the 1995 IOSC would like to thank all of the contributors, reviewers, and others who have made this Proceedings volume possible. I would also like to acknowledge the considerable contribution of time by the various members of sponsoring organizations who have staffed the Steering and Program Committees. They are the heart and soul of the IOSC. Finally, I would like to recognize the professional contributions of Courtesy Associates, and Trade Associates, who have been responsible for the organization and management of this Conference and the trade show. Their considerable expertise brings order out of chaos on a biennial basis.

James P. Ray

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TRACKING BUOYS FOR OIL SPILLS

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The use of tracking buoys in oil spill response, planning, and training and criteria for the selection of these buoys were studied in conjunction with an experiment conducted in the Gulf of Mexico during March 1994 on the relative motions of several oil spill drifter buoys. For the test, wood chips and cottonseed hulls were used to simulate the motion of the oil. Six different types of buoys and three different positioning and tracking systems, in various combinations, were tested. The first day of the program was conducted in Galveston Bay, the second in the Gulf of Mexico off Galveston. Significant differences were noted in the movements of the various buoys. Analysis of the data from these experiments suggests that tracking of the buoys should occur for a longer time period than in the experiments in order to reduce the influence of positioning errors.

AUTHOR: Ron H. Goodman attended the University of Saskatchewan and was graduated with a Bachelor of Arts in Science with specialization in physics. He undertook graduate studies at McMaster University in Hamilton and obtained a PhD. in nuclear physics in 1964. He served as the manager of surveillance and tracking for the *Exxon Valdez* response during 1989. He has been in the oil spill technology business for twenty years, specializing in remote sensing and oil spill models.

AIRBORNE DETECTION, IMAGING AND TELEMETRY OF OIL AND OTHER SPECTRAL FEATURES ON THE OCEAN SURFACE

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A transition is underway in imaging technology for airborne surveillance and reconnaissance operations. Large independent sensor systems carried in dedicated airframes, are being replaced by more economical, compact, and integrated multisensor arrays with a common processor that are portable enough to fit into a variety of small aircraft. Development of such a system was stimulated by a perceived need to enhance marine oil spill response and cleanup, and to better mitigate the environmental and economic impact of such incidents.

The newest of these systems incorporates an aerial platform, a suite of advanced commercial sensors, a six degrees of freedom global positioning system (GPS), advanced database technology to manage spatial data, and image analysis capabilities.

The operational goal of this development is to furnish valuable reconnaissance information in real time to ground users. Such a capability could advance oil spill response and other applications where rapid acquisition, integration, and communication of complex data is essential to decision-making. The ability to conduct day, night, and adverse weather surveillance operations is restricted in current systems and is another benefit this system is designed to provide.

The innovation in the system especially lies in the development of a common processor and image fusion system which integrates, georeferences, and geocorrects multisensor data and transmits it in real time. A graphic interface was designed to provide maps or other projections as a spatial reference system on which to plot data from a surveillance mission. New imaging numerical methods allow processing of composite images, multi-image mosaics, change detection, and other data manipulation, and were tested in field trials of the system.

AUTHORS: Charles P. Giammona has recently become a private consultant, following positions as Director of Physical and Engineering Science for the Marine Spill Response Corporation, and as Associate Dean for Faculty and Research at the City University of New York. His professional experience has included teaching, administration, and research in geoscience, engineering, marine resource assessment, and impact mitigation. His current research emphasis is in remote sensing, dispersant countermeasures, and oil fate and behavior studies.

F. Rainer Engelhardt is Vice President for Research and Development of MSRC. He formerly held executive positions in the Canadian government, responsible for national science and technology programs and petroleum industry regulation, and was a professor in physiology and toxicology in U.S. and Canadian universities. He received his doctorate in environmental physiology in 1973 from the University of Guelph.

OIL THICKNESS DETECTION USING WIDEBAND RADIOMETRY

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A major problem in the cleanup of oil spills on large bodies of water is determining the oil thickness distribution since much of the oil can be contained in a small fraction of the spill area. Knowledge of the location of the thick patches allows one to use cleanup resources more efficiently. To address this problem, we have designed, built and tested a millimeter-wave, frequency-scanning radiometer for remotely determining the thickness of oil films. The work is based on the theory of the frequency-scanning radiometer. Experimental results, obtained in an outdoor laboratory setting, show agreement between our theory and measured data for oil thicknesses ranging from 0 to 10 mm in 1 mm steps. A visible change was obtained for 0.1 mm steps from 0.0 to 1.0 mm of oil. The study also demonstrated that thin oil/water emulsions are detectable.

AUTHOR: Oliver McMahon received his BEE from Manhattan College in 1988 and has been with MIT Lincoln Laboratory ever since. He is a member of IEEE, Eta Kappa Nu, and Tau Beta Pi.

ADVANCED AERIAL SURVEILLANCE SYSTEM FOR DETECTION OF MARINE POLLUTION AND INTERNATIONAL AERIAL SURVEILLANCE COOPERATION IN THE NORTH AND BALTIC SEAS

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Marine pollution of the North and the Baltic Seas caused by accidental and illegal operational discharges has sharpened the awareness of states adjoining these waters. Consequently, the member states of the Bonn Agreement[1] for the North Sea and the Helsinki Convention[2] for the Baltic Sea have agreed to cooperate closely to develop remote-sensing techniques to improve the detection of oil pollution and the identification of polluters, and to develop reliable methods to estimate the total level of oil pollution at sea. In the ministerial declaration of the Third International Conference on the Protection of the North Sea (1990) and according to a recommendation of the Helsinki Commission, the member states are invited to develop and improve the existing remote-sensing techniques for effective evaluation of spills, even at night and under bad weather conditions. With the integration of a laser fluorosensor (LFS) and a microwave radiometer (MWR) in its existing sensor system (SLAR, IR/UV scanner, single frequency MWR), Germany has widened the detection and identification by enabling classification of discharged oil and the detection of released chemicals with fluorescent properties.

Apart from this technical progress, the international cooperation between the North Sea and Baltic Sea states is a further step to deter potential polluters and to improve the prosecution of suspected offenders and to assist oil recovery operations at sea through permanent aerial guidance.

AUTHOR: Capt. Klaus Schroh is head of the Special Federal Unit for Oil Pollution Control, dealing with preventive and actual spill response at sea and within the coastal waters of Germany.

COSTS ASSOCIATED WITH THE CLEANUP OF MARINE OIL SPILLS

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The cost of offshore and coastal cleanup of spilled oil varies greatly from spill to spill but is of high interest in risk assessments, because cost is often used as the basis of comparison. We present data on the costs associated with mechanical offshore cleanup, shoreline cleanup, and offshore burning. A review of eight offshore recovery operations in North America indicates a mean offshore, on-water cleanup cost of approximately $2,500/bbl, with a range of $10 to $6,000/bbl. Smaller spills (1,000 to 2,000 bbl) have a higher per-unit recovery cost than large spills (≥10,000 bbl)—at about two to three times the cost. Review of ten shoreline cleanup operations indicates a mean cleanup cost of approximately $8,000 to $9,000/bbl, an average of 2.5 to 4 times higher than the cost of offshore recovery. Variability in shoreline cleanup costs is high, and costs are highly dependent on both the size of the spill and the remoteness of the spill location; small, widely dispersed spills, such as the *Nestucca* (British Columbia and Washington coasts), involve cleanup costs of more than $20,000/bbl. Although there are few spills where offshore *in situ* burning has been used as a response option, preliminary estimates indicate comparable unit "elimination" costs of about $500/bbl, five times less expensive than offshore on-water recovery and more than an order of magnitude less than mean shoreline cleanup costs.

AUTHOR: John Harper is the President of Coastal & Ocean Resources, Inc., and specializes in coastal studies, especially regarding oil spill impacts, coastal mapping, scientific monitoring, and experimental research. He has been involved with scientific monitoring studies of the *Exxon Valdez* spill from 1989 to 1994.

FULL SCALE OIL CONTAINMENT BOOM TESTING AT SEA

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In May 1994 the Marine Spill Response Corporation, U.S. Coast Guard, U.S. Navy, and Minerals Management Service conducted a joint test of oil containment booms in Lower New York Bay and in the Atlantic Ocean east of Sandy Hook New Jersey. These tests allowed the collection of quantitative data on boom performance, including tow forces, skirt draft, and boom freeboard, as a function of tow speed and environmental forces due to currents, wind, and waves. Four booms were chosen for testing based on their different physical characteristics: The 3M Fire Boom, the Barrier Boom, the USCG/Oil Stop inflatable boom, and the U.S. Navy USS-42 boom. Use of these booms allowed data acquisition over a range of buoyancy to weight ratios from 5:1 up to 52:1, nominal skirt drafts from 61 cm up to 150 cm, and freeboards from 37 cm up to 119 cm.

The data collected allows a comparison between methods for calculating boom loads and measured loads. Existing calculation methods predict towing loads below the mean loads experienced by a boom when used at sea. Further research will be required to develop an encompassing dimensionless empirical formula, based on hydrodynamic theory and the dynamics of vessel motions, to more closely predict oil containment boom tow loads.

TEXAS MARSH BURN: REMOVING OIL FROM A SALT MARSH USING IN-SITU BURNING

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Frequently coastal marsh is burned to enhance regrowth; but rarely is it burned to remove spilled oil. On January 7, 1992, a 40.64 cm crude oil pipeline ruptured causing a spill in a salt marsh. Four days later, in an unprecedented cleanup coordinated by Exxon Pipeline Company and the Texas General Land Office, 1,150 barrels of South Texas crude was ignited and removed, minimizing environmental damage to Copano Bay, Chiltipin Creek, and the surrounding wetlands.

This cleanup had been made difficult by inclement weather and heavy rainfall that saturated the marsh. Ingress and egress had damaged the marsh and was discontinued. Conventional mechanical cleanup techniques had been used with minimal success. Alternative methods like bioremediation, low pressure flooding, and peat moss applications were considered, but proved unfeasible. The unified command system then made an application for a permit to burn and gained approval. Seventy-six hours into the event, a successful test burn was conducted; one day later, the majority of the oil was ignited. It maintained a full burn for 21 hours, self-extinguished, and later was re-ignited for further removal.

Emerging technologies such as in-situ burning are additional implements in the oil spill responder's toolbox. In Texas, burning helped save a marsh.

AUTHOR: Manuel F. Gonzalez is the Director of Field Operations of the Oil Spill Prevention and Response Division of the Texas General Land Office. He is a member of the governor's Environmental Task Force and is on the F-20 committee of ASTM. He is a geologist, and graduated from Texas A & I University, Kingsville.

EVALUATION AND LIMITS OF PROTECTIVE BOOM PLANS FOR HIGH TIDAL RANGE AND STRONG CURRENT AREAS

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The French organization of onshore oil spill response is defined by specific intervention plans (Polmar plans), established for every coastal department. One of the main elements of these plans consists of detailed plans for deploying booms to protect sensitive areas.

The Ministry of the Sea, with assistance from CEDRE, carries out exercises every year in different coastal locations to test the feasibility and efficiency of the boom deployment plans and also to train local personnel in handling antipollution equipment. Lessons learned from these exercises enable the improvement of deployment plans and help define new research areas. Within this framework, CEDRE has undertaken a feasibility study for the installation of booms in high tidal range and strong current areas.

This experimental study involved a 15-day period, during the autumn of 1993, of on-site observations on the behavior of booms installed in one of the most difficult sites on the Atlantic shoreline. The main parameters observed were resistance, containment efficiency, and mechanical behavior of booms during the tide cycle, particularly when booms are stranded at low tide. In spite of successful boom installation, the experiment encountered difficulties due to meteorological and instrumentation problems.

Nevertheless, important lessons have been learned.

- Static boom protection seems to be difficult for such sites, which leads us to question the validity of numerous Polmar plans. We should test alternative response techniques such as dynamic recovery systems set up at the openings to sensitive areas, which will necessitate good coordination between at-sea and on-shore response authorities.
- Mooring systems design and installation are jobs for specialists and should be prepared in advance.
- Various local means, such as fishing vessels or oyster farm barges, can be used for deploying protective booms.

A MULTICOMPONENT OIL SPILL MODEL FOR DISSOLVED AROMATIC CONCENTRATIONS

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When considering the consequences of an oil spill accident, not all oil components are equally harmful to marine life. Some components are more harmful than others, especially the aromatic components. The polyaromatic hydrocarbons (the PAHs) may be accumulated in food chains, while the monoaromatics dissolve much faster into the water than other components.

A model was therefore developed that separates the behaviors of different components of hydrocarbon release. The oil is divided into 20 different classes with increasing carbon number within the range C_4 to C_{55}. Within each class, the hydrocarbons are divided further into 5 subsets (*n*-alkanes, cycloalkanes, aromatics, naphthenes, and resins). The model then keeps track of the fate of each of the components (loss by evaporation, dissolution, or as droplets; or remaining in the slick) during an actual spill event.

After calculating the amount of aromatics dissolved into the water, the actual concentrations are then computed by numerically solving a diffusion-advection equation. Vertical and horizontal turbulence in the water mass are included, as well as effects from variations in the vertical velocity profile.

The paper outlines the approach chosen, and provides examples of some results.

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THE USE OF KNOWLEDGE-BASED SOFTWARE TO IDENTIFY SHORELINE TREATMENT OPTIONS

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A PC-based software package has recently been completed that provides decision makers with support for developing shoreline cleanup strategies. Using data obtained from systematic surveys of shore-zone conditions, or from training or drill scenarios, an artificial intelligence approach builds on existing published manuals and on field experience to develop response options and recommendations for planners and managers.

The system has four basic output components that include:

- the synthesis of the physical shore-zone character and oiling conditions,
- an evaluation of stranded oil persistence,
- a ranking of response priorities, and
- recommended shoreline treatment and/or cleanup methods in a four-layer mode that includes surface or subsurface and heavy/moderate or light/very light oiling conditions. The assessment of shoreline oiling conditions includes evaluation of oil volume, oil type (including weathered oils), and surface and subsurface conditions. The primary functions of the software include storing and sorting data on shoreline character and oiling conditions, simulating spill conditions for training and drills, and providing real-time recommendations in a spill event.

The paper describes the general design as well as the format, input parameters, output data formats, and applications of the software. The project has been a joint government-industry effort supported by Environment Canada and Industry Canada.

AUTHOR: Alain Lamarche is a researcher at CITI, one of Industry Canada's research centers. His main research interests include performance support in general, and environmental decision support in particular. He has practical experience in the design of environmental management systems, including geographical information systems.

A THREE-DIMENSIONAL OIL AND CHEMICAL SPILL MODEL FOR ENVIRONMENTAL IMPACT ASSESSMENT

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A comprehensive model of the dynamic, three-dimensional physical fates of contaminants in the marine environment has been developed. For oil spills, dissolution of aromatics from surface slicks and entrained oil droplets are the source of potential effects for biota in the water column. Oil on the surface and along shorelines provides the basis for evaluation of impacts on birds, marine mammals, and recreational activities. A graphical user interface couples the model to a variety of environmental databases and tools to facilitate specific applications and viewing of simulation results.

STATE-OF-THE-ART TECHNIQUES IN OIL SPILL MODELING

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The status and possible research directions of oil spill modeling are presented here. The physical and chemical processes that take place in oil spills are explained as is their role in the design of an ideal oil spill model. An ideal oil spill model for forecasting must support rapid response, contingency planning, and training. Accurate, full-dimension, real-time prediction of hydrodynamic calculations and oil movements require intensive computations and computing power. Presently the most promising computational platform appears to be a vector supercomputer that has been given essential geographical, bathymetric, and tidal data before the spill. Parallel processing machines could be used in the same way; but present codes, written for sequential machines, must be changed substantially to take advantage of the parallel architecture. Super minicomputer technology is advancing rapidly and should soon be able to run the numerically intensive hydrodynamic codes, bringing the advantages of portability and low cost. Since the present personal computer oil spill models are not able to make accurate hydrodynamic current predictions, they cannot match the accuracy of more computationally intensive models.

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AN INTEGRATED PROGRAM FOR SENSITIVE ENVIRONMENT MAPPING

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The objective of the National Oceanic and Atmospheric Administration's (NOAA) national sensitive environment mapping program is to publish a comprehensive series of standard maps and databases for coastal areas that provide the basis for sensitive environment plans.

Sensitive environment maps have been an integral component of oil spill contingency planning and response since 1979, when the first maps were prepared in advance of oil arriving from the Ixtoc I well blowout. Since then, NOAA has undertaken a nationwide sensitive environment mapping effort that covers most U.S. coastlines, including Alaska, Hawaii, and the Great Lakes.

As part of cooperative efforts with federal agencies, states, and industry, NOAA is now undertaking a program to achieve three goals: map new areas and update existing maps, provide means for broadly distributing sensitive environment data in paper and electronic forms, and extend sensitivity mapping methods to new environments.

In 1994, sensitive environment maps were jointly produced with the states of Texas, California, and Alaska. The Great Lakes materials were completed as part of a cooperative project between the U.S. Coast Guard and Environment Canada. With cooperation from the Marine Spill Response Corporation, NOAA is embarking on a program to format sensitive environment maps for computer-based information systems that help implement requirements of the 1990 Oil Pollution Act (OPA 90). NOAA, the U.S. Fish and Wildlife Service, and the Office of Pipeline Safety are cooperating to extend sensitive environment mapping approaches to inland waters and terrestrial habitats.

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SENSITIVITY MAPPING WORLDWIDE: HARMONIZATION AND THE NEEDS OF DIFFERENT USER GROUPS

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Prospective user groups of sensitivity maps for oil spill response have a variety of needs related to different categories of oil spill, ranging from localized tier 1 spills at fixed installations (such as oil terminals) to catastrophic tier 3 spills. The latter may affect large areas and possibly more than one country. Uses of maps range from planning practical site-specific shore cleanup to strategic planning on a regional scale for "passing ship" scenarios in remote areas. The paper discusses different map types, map scales, categories of information to be included, and symbology, bearing in mind the requirements of different users. Reference is made to international examples. A considerable degree of harmonization of approach for sensitivity maps worldwide can be achieved. However, given that resources can vary tremendously from one region to another, it seems better to promote a broad consistency with respect to symbology rather than an exhaustively detailed scheme to cover every possible resource worldwide.

AUTHOR: Jenifer Baker is a consultant specializing in coastal ecology. She has 25 years experience with oil pollution problems and has worked in many parts of the world.

GEOGRAPHIC INFORMATION SYSTEM (GIS) FOR IMPACT ASSESSMENT, ECOLOGICALLY SOUND MEASURES, AND DOCUMENTATION OF OIL SPILLS

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The geographic information system (GIS) is an objective and standardized oil spill impact assessment tool. In addition to the impact assessment, the GIS provides a helpful tool for judging the size of the impact, choosing environmentally sound cleanup techniques, and planning resources utilization. All information put into a GIS, including daily activity reports, will constitute the essential base for claims from the International Oil Pollution Compensation Fund (IOPC Fund).

Impact assessment. Before cleanup activities start, an impact assessment is made. The impacted area is geographically defined in the field with the detailed geographic position system (dGPS) and maps. Type of coastline, spill volume, and type of oil are documented for each impacted area. If necessary, photos and other information concerning the impacted area are included in the GIS.

Determination of cleanup method. Documented information from the impact assessment is analyzed together with databases containing ecological sensitivity maps, cleanup methods, and experience. The analysis made using the GIS will suggest what cleanup method/s should be used and how best to use resources. The cleanup method(s) chosen by use of the GIS is presented in digital maps and tables of resources needed.

Daily activity reports. All daily activities are documented in the GIS. These include time spent, costs, site, amount of oil cleaned up and method used for cleanup, transfer of oil, and waste disposal. Total and specific cost for each impacted area is calculated daily.

Commanders report. The GIS provides the commander with a total report of all actions taken during the cleanup operation. The report contains total costs, claims, experience, geographical location, date and time, and an impact assessment.

Advantages of the GIS. The GIS provides a standardized and objective impact assessment for each contaminated area and at the same time suggests what cleanup method to use. The system can present daily reports of information and activities undertaken, and easily specify the cost for each activity. The GIS also can present a final report immediately upon completion of the work.

OIL SPILL BIOREMEDIATION AGENTS— CANADIAN EFFICACY TEST PROTOCOLS

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Thirteen commercial oil spill bioremediation agents (OSBAs) were tested over a two-year period during the development of a screening protocol designed to evaluate the hydrocarbon degradation efficacy of OSBAs under warm freshwater or cold marine water conditions. The OSBAs were added at the rate specified, to shaker flasks containing a standard test oil, nutrients if requested, and a defined medium. Standardized freshwater or marine microbial inocula were developed to act as internal controls for the screening protocol, that is, to ensure that conditions were suitable for oil biodegradation to occur in each test performed. After the incubation period, the oil was extracted and analyzed using gas chromatography/mass spectrometry (GC/MS) and gas chromatography with a flame ionization detector (GC/FID). The warm freshwater efficacy method exhibited good reproducibility but the cold marine test requires further refinement. The minimum acceptance standard for products tested under standard warm freshwater conditions is currently based on the product achieving GC-detectable total petroleum hydrocarbon (GCD-TPH), aliphatic, and aromatic reductions of 35, 30, and 10 percent, respectively, when compared with the weathered Alberta Sweet Mixed Blend (ASMB) source oil. These values may be adjusted with further experimental testing. Products with acceptable efficacy and toxicity results will be assumed to have good potential application in spill cleanup and will be identified as such to the spill response community.

THE DEVELOPMENT OF BIOREMEDIATION FOR OIL SPILL CLEANUP IN COASTAL WETLANDS: PRODUCT IMPACTS AND BIOREMEDIATION POTENTIAL

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Although bioremediation for oil spill cleanup has received considerable attention in recent years, its satisfactory use in the cleanup of oil spills in the wetland environment is still questionable and generally untested. We have initiated a multidisciplinary experimental program to evaluate the use of both microbial seeding and fertilizer as means of enhancing oil biodegradation in coastal salt marshes. We are utilizing controlled greenhouse experiments as well as field trials to test the efficacy and ecological safety of these enhanced biodegradation methodologies. This paper summarizes the overall scope of the study and presents some preliminary findings concerning marsh plant response to the bioremediation agents. We shall report on the results of the first year of this three-year investigation.

Sods of marsh (soil and vegetation intact), approximately 30 cm in diameter and 25 cm deep, collected from the inland zone of a *Spartina alterniflora* dominated salt marsh in south Louisiana were used in a greenhouse experiment to identify the effects on plant and soil responses of the following treatments, with and without oil: seeding product, fertilizer product, and control (no product). Mesocosms were sampled for petroleum hydrocarbon chemistry to identify and quantify the degree of oil biodegradation, soil microbial response to determine the effect of the bioremediation products on the microbial communities that are performing the oil biodegradation, soil chemistry to determine the effect of the bioremediation products (such as nutrients, soil reducing conditions, and soil toxins) on those factors that limit the growth of microbes and plants, and plant response to evaluate the effects of the oil and products on plant vigor and growth. This paper presents selected plant responses that demonstrated that the bioremediation products tested had no adverse impact on plant growth. Additionally, soil respiration was increased by fertilizer, but not microbial, application.

DISPERSION AND BIODEGRADATION OF OIL SPILLS ON WATER

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Published literature indicates that oil spill dispersion by chemical dispersants will enhance biodegradation because of the increase in interfacial area. However, some of the literature is contradictory concerning whether the use of surfactants will enhance or temporarily inhibit biodegradation, suggesting that more than one mechanism is at work.

We set out to study the correlation between the area of dispersed oil droplets and the rate and extent of microbial oil degradation using sorbitan surfactants. We varied the surfactant blend hydrophile-lipophile balance (HLB) and treat level in a statistically designed experiment. Both dispersed area and percent oil degraded at a given time were shown to depend on surfactant HLB and treat level, but to different degrees. The difference was accounted for by demonstrating that percent oil degraded depended on both dispersed area and percent sorbitan in the dispersant treat. The quantitative finding that both dispersed area and surfactant chemistry control microbial growth and oil biodegradation explains the apparent contradiction that some good dispersants enhance, while others temporarily inhibit, degradation. Corexit 9500 dispersant was observed to have a positive influence on biodegradation of oil on water.

AUTHOR: Presenter Ramesh Varadaraj obtained his Ph.D. from the Indian Institute of Science, Bangalore, India in 1984 and his post-doctoral training at Georgetown University, Washington, D.C., and at Temple University, Philadelphia, Pennsylvania. He joined Exxon's Corporate Research in 1988 and is currently the program leader for oil spill remediation in Exxon Corporate Research's Environmental Science Section. His expertise is in colloid and interfacial phenomena with emphasis on surfactants and water soluble polymers.

BIOREMEDIATION OF OILED BEACH SEDIMENTS: ASSESSMENT OF INORGANIC AND ORGANIC FERTILIZERS

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The effects of inorganic (ammonium nitrate and triple superphosphate) and organic (fish bone-meal) fertilizers on the biodegradation rates of Venture condensate within a sand-beach environment were assessed over 333 days. Field results showed that the organic fertilizer stimulated microbial growth and metabolic activity to the greatest extent. However, based on chemical analysis of residual oil concentrations and composition, the application of inorganic fertilizers was the superior bioremediation strategy. This paradox between microbiological and chemical results was attributed to the selective growth of different bacterial populations, the preferential use of components within the organic fertilizer over oil by the indigenous microflora, and the production of toxic metabolic by-products from the degradation of the organic fertilizer.

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STUDIES OF IN-SITU BURNING OF EMULSIONS IN NORWAY

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An experimental program, spanning four years, was initiated in 1990 to study the in-situ burning of emulsions. Its main objectives were to study the in-situ burning of emulsions in dynamic conditions (wind, waves, currents, and ice); to define the limitations and effectiveness of in-situ burning in terms of water content, evaporation, and film thickness of crude oils and emulsions; and to determine the physical processes involved in burning water-in-oil emulsions. Field experiments were conducted in basins cut into sea ice ranging in size from 4 m^2 to 300 m^2. Small-scale pan burns and emulsion-heating experiments were conducted in the laboratory. The results show that evaporated water-free oil can be easily ignited and burned with a high efficiency, even in the presence of swells and slush ice. When water contents exceeded 25 percent, the emulsions were difficult to ignite using gelled gasoline, and could not be ignited in the presence of moderate swells. However; ignition could be improved by using alternative igniters. Some postulated processes on the burning of stable emulsions have been confirmed: water must be removed from the emulsion surface before ignition can occur, water is released mainly through evaporation, and the temperature in the emulsion slick does not seem to exceed the boiling point of water.

THE NEWFOUNDLAND OFFSHORE BURN EXPERIMENT—NOBE

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A group of 25 agencies from Canada and the United States conducted a major offshore burn experiment near Newfoundland, Canada. Two lots of oil, about 50 cubic meters (50 tons) each, were released into a fireproof boom. Each burn lasted over an hour and was monitored for emissions and physical parameters. Over 200 sensors or samplers were employed to yield data on over 2000 parameters or substances. The operation was extensive; more than 20 vessels, 7 aircraft and 230 people were involved in the operation at sea.

The quantitative analytical data show that the emissions from this in-situ oil fire were less than expected. All compounds and parameters measured more than about 150 meters from the fire were below occupational health exposure levels; very little was detected beyond 500 meters. Pollutants were found to be at lower values in the Newfoundland offshore burn than they were in previous pan tests.

Polyaromatic hydrocarbons (PAHs) were found to be lower in the soot than in the starting oil and were consumed by the fire to a large degree. Particulates in the air were measured by several means and found to be of concern only up to 150 meters downwind at sea level. Combustion gases including carbon dioxide, sulphur dioxide, and carbon monoxide did not reach levels of concern. Volatile organic compounds (VOCs) were abundant, however their concentrations were less than emitted from the nonburning spill. Over 50 compounds were quantified, several at levels of concern up to 150 meters downwind. Water under the burns was analyzed; no compounds of concern could be found at the detection level of the methods employed. Toxicity tests performed on this water did not show any adverse effect. The burn residue was analyzed for the same compounds as the air samples. Overall, indications from these burn trials are that 150 meters or farther from the burn source emissions from in-situ burning are lower than health criteria levels.

ENVIRONMENTAL IMPACT AND RECOVERY OF A HIGH MARSH PIPELINE OIL SPILL AND BURN SITE, UPPER COPANO BAY, TEXAS

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On January 7, 1992, a rupture in an underground oil transfer pipeline resulted in a spill of about 2,950 bbl (469 m^3) of crude oil into a high marsh community near Chiltipin Creek, San Patricio County, Texas. Authorization for burning the oil, as a cleanup method, was given by the Texas General Land Office (the designated state on-scene coordinator). The environmental impact of the spill and ensuing burn on this high marsh has been assessed by monitoring changes in the total petroleum hydrocarbon (TPH) content of the associated floral community and soil over time. Ultimately 6.5 ha of oil and vegetation of the 15.5 ha surrounded by sorbent booms were burned, causing them to become barren. These bare patches produced by the burn were rapidly colonized by grasses, mainly *Distichlis spicata*. Secondary succession by perennial climax species is slow, resulting in significantly lower species diversity and biomass in the oiled and burned area even after 30 months. Significant changes within, and interactions between, impacted and control areas were determined using repeated measures MANOVA. TPH measurements made in December 1992 and repeated in July 1993 show consistent decreases. The obvious disadvantages of burning as a cleanup method in this high marsh area are the substantial initial damage to plants and the high residual hydrocarbon levels in the sediment.

IN-SITU BURNING OF ALASKA NORTH SLOPE EMULSIONS

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The onset of water-in-oil emulsion formation in an oil slick often signals the closing of the window of opportunity for in-situ burning as a countermeasure. Water contents in excess of 25 percent in a stable emulsion generally preclude ignition of the slick. A study of in-situ burning of water-in-oil emulsions formed by weathered Alaska North Slope (ANS) crude oil has recently been completed by Alaska Clean Seas. The study consisted of three phases: laboratory-scale burns in Ottawa in a 0.13 m^2 burn ring, small-scale burns in Prudhoe Bay in 1.2 m^2 and 3.3 m^2 pans, and meso-scale burns in a 69 m^2 circle of 3M Fire Boom in a water-filled pit at Prudhoe Bay. The laboratory-scale tests showed that stable, weathered ANS crude emulsions could be ignited in-situ using conventional gelled fuel igniters only up to a water content of 25 percent. The combination of adding an oilfield emulsion breaker, Petrolite EXO 0894, and the use of gelled crude oil as an alternate igniter fuel, permitted ignition and efficient combustion of weathered ANS emulsions with water contents of 65 percent, the maximum achievable. The small-scale pan tests conducted in Prudhoe Bay proved the same: that normally unignitable emulsions of weathered ANS crude, up to 65 percent water content, could be successfully ignited and efficiently burned outdoors at 0° to 5° C in winds up to 32 km/h with the application of EXO 0894 one hour prior to ignition. Tests with the Helitorch igniter system suspended from a crane showed that a mixture of gelled gasoline and crude oil was the most effective ignition fuel for the emulsions. Attempts were made to ignite emulsion slicks with gelled igniter fuels containing the emulsion breaker; but this technique did not prove as effective as pre-mixing the breaker into the slick. These tests also indicated that the emulsion burns produced a lighter smoke than that from crude oil. Three meso-scale experimental burns were carried out: one involved approximately 13 m^3 (80 bbl) of fresh ANS crude as a baseline; one used about 8 m^3 (50 bbl) of a stable 50 percent water-in-weathered crude emulsion; and, the final burn was done with 17 m^3 (105 bbl) of stable 60 percent water content emulsion. The oil removal efficiency for the fresh crude oil burn was approximately 98 percent. The oil removal efficiencies for the 50 and 60 percent water emulsions were 97 and 96 percent respectively.

DISPERSANT EFFECTIVENESS AT SEA

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Information from five incidents in U.K. waters since 1980 in which dispersants have been used in responses, and two experimental spills using dispersants in 1993, shed light on the questions of whether dispersion of oil can reduce the overall environmental impact at a spill, whether we can demonstrate that dispersants enhance the rate of natural dispersion, and whether we can quantify how effective dispersants are.

WEATHERING AND CHEMICAL DISPERSION OF OIL AT SEA

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Small-scale laboratory methods were used to simulate the weathering processes that occur when crude oil is spilled at sea. Changes caused by evaporation and water-in-oil (w/o) emulsification were studied separately. W/o emulsions were assessed for chemical dispersibility using the Institut Français du Petrole (IFP) and Mackay-Nadeau-Steelman (MNS) methods.

Larger scale experiments were performed in a meso-scale flume. Crude oil was weathered for three days and then sprayed with dispersant. The results show that emulsion breaking is an important part of the mechanism of chemical dispersion. IFP, MNS, and Warren Spring Laboratory (WSL) tests, conducted on w/o emulsions recovered from the flume, produced much lower levels of dispersion than did treatment in the flume. The standard test procedures do not permit emulsion breaking to proceed to the extent observed in the flume.

A sea trial also was conducted. Preliminary evaluation of the results shows that dispersant application partially broke the w/o emulsion that had rapidly formed. Dispersion proceeded at a slow rate but the treated slick was removed from the surface more rapidly than the control slick. The degree of dispersion was difficult to quantify by visual observation due to the weather conditions. A combination of remote sensing, surface sampling, and subsurface fluorometry provided a more reliable estimate.

IMPROVED LABORATORY DEMULSIFICATION TESTS FOR OIL SPILL RESPONSE

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A critical need currently exists for standard laboratory procedures for evaluating demulsifiers over the range of applications encountered in oil spill response. The procedures should be flexible enough to generate emulsions that are representative of those encountered at various times during a spill situation, and the applications should cover emulsion inhibition, breaking emulsion slicks at sea, and breaking recovered emulsions. Two laboratory test procedures are proposed. The procedures have different mixing energy and treating conditions, but each has the desirable feature of utilizing the same apparatus to generate the emulsion and to test the demulsifier. One procedure, called the wrist-action shaker emulsion test (WRASET), utilizes a standard laboratory apparatus, and is applicable for emulsion inhibition and for simulating at-sea applications of demulsifiers. A second procedure, called the rotating flask emulsion test (ROFLET), can also be used for a range of applications and is applicable for treating emulsions during oil recovery operations. Data from each of the two laboratory emulsion tests are used to demonstrate their features and to provide guidance on their use. An important implication of this work is that laboratory tests currently used to evaluate the effectiveness of dispersants to break up emulsions at sea need to be modified to provide time for the emulsions to be first broken by the dispersant.

A NEW CLEANING PRODUCT FOR OILED BIRDS AND AN INTEGRATED AUTOMATED PROCESS

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A new product for cleaning oiled birds was tested. A laboratory test was made in which several duck feathers, polluted with aged oil, were cleaned in 40° C water with the new product, then rinsed with cold water. Under these conditions, 90 percent of the oil was removed using the new product, versus 30 percent removal in control tests. Standard toxicity testing procedures were used to show the nontoxicity of the product. The new product was then tested using Sintef-Unimed techniques and metabolic activity tests on six mallard ducks. The cleaning process was easy and quick; birds recovered normal metabolic rate and thermal insulation one day after cleaning. Similar results were obtained on site in a rehabilitation center, where birds were also efficiently cleaned. The recovery rate for wild birds was about 60 percent after two weeks, with much higher hydrophobicity recovery rate when using the new product than when using the reference product. This new product for cleaning oiled birds appeared very efficient and nontoxic.

A new technique to wash the birds also was tested on site. Accidently oiled wild birds were cleaned in an automated process, which included washing with the new product and efficient rinsing. The cleaning time was about 10 minutes for one bird. This technique was tested in one of the largest French rehabilitation centers. It appears very promising, considering the decrease in stress to the birds and the reduction in cleaning time.

BIOLOGICAL EFFECTS MONITORING DURING AN OPERATIONAL APPLICATION OF COREXIT 9580

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Following the grounding of the barge *Morris J. Berman* on the northern coast of Puerto Rico in January 1994, conditional approval for the use of the shoreline cleaner Corexit 9580 was granted. One requirement was the inclusion of biological effects monitoring, particularly during the first operational application. This was intended to safeguard against unforeseen ecological consequences from the treatment—to answer the question, does the use of Corexit 9580 result in adverse biological impact beyond that caused by the oil itself? The monitoring was designed to provide immediate operational feedback (Should the application continue?) but also addressed other questions of interest for future incidents and for further research.

Study sites were surveyed before, immediately following, and one day after treatment with Corexit 9580. No significant nearshore effects were observed, and the monitoring team recommended that operations proceed. Followup studies of organisms transplanted into the treatment area also showed few exposure-related effects. Measurable concentrations of both Corexit and oil were found in water samples collected in the treated area, and low levels of hydrocarbons were also found in sea urchins exposed to treatment runoff water. The toxicological significance of the exposure and the tissue residues were beyond the scope of this monitoring effort, but the lack of mortalities in both resident and transplanted organisms suggested a relatively minor short-term biological effect on exposed communities.

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FAST SOURCE-FINGERPRINTING ANALYSIS FOR OIL SPILL RESPONSE

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Source identification of spilled petroleum during incidents is a crucial piece of information required for response activities. The need for rapid, accurate assessment is essential at the onset of a spill to determine the extent and impacts of the incident. This necessity for speed becomes less important as cleanup progresses. Current fingerprinting methods utilize gas chromatography/mass spectroscopy (GC/MS) and have become an important analytical tool because of high selectivity and compound specificity. Disadvantages include time requirements for sample preparation and analysis in addition to the use of soon-to-be-banned chlorinated solvents. Sample analyses may require up to eight hours a sample when using standard techniques. We are currently developing methods to reduce the turnaround time by alternate sample preparation and rapid analysis; primarily through use of thermal extraction and short, narrow-bore capillary columns. This technique can greatly reduce analysis time without sacrificing important chromatographic information. Samples from recent oil spills were compared by standard GC/MS fingerprinting to the fast chromatographic method developed in our laboratory. The identification clarity capability of the faster method is shown by the inclusion of various characteristic biomarkers—such as the more resistant, yet toxic, polycyclic aromatic hydrocarbons, geological biomarker triterpanes and steranes, as well as compounds indicative of weathering and degradation stages.

EFFECT OF STOKES' LAW SETTLING ON MEASURING OIL DISPERSION EFFECTIVENESS

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Industry laboratory tests to measure dispersion effectiveness for oil spills on water measure only the volume percentage of oil dispersed and not the dispersed particle size. The effect of particle size on settling behavior is particularly pronounced in tests that use long settling times to superimpose a dispersion stability criterion on the effectiveness rating.

The authors have studied the effect of settling time on the volume cumulative particle size distribution measured by the Coulter Multisizer II. Using Stokes' law settling to analyze the results, we have demonstrated the effects of settling flask geometry and sample volume on measured effectiveness. These arbitrary test variables control the settling path height and vary markedly from test to test. The intrinsic variables that control settling vs time—initial particle size distribution, aqueous viscosity, and aqueous and oil densities—are functions of aqueous, oil, and dispersant compositions; temperature; and dispersion energy.

The author's analysis shows that the effect of settling variables is to cut off the initial cumulative particle size distribution above a certain particle size, thereby fixing measured effectiveness. Stokes' law provides a measure of this cutoff size. Experimental data have been developed to support this theoretical analysis. This analysis points to the variables that must be considered with different laboratory tests to rank dispersants when settling is part of the test procedure. Even with a single test, ranking may change with settling time given an initially large fraction of large particles and a sufficiently large difference between the densities of water and oil.

AUTHOR: Max L. Robbins was born in Brooklyn, New York in 1927. He graduated from the High School of Music and Art in New York January 1944, as a music major (violin). He served in the U.S. Naval Reserve from May 1945 to December 1946. He graduated from Columbia College in June 1955 (A.B. summa cum laude, with distinction in chemistry). Columbia University awarded him a Ph.D. in Physical Chemistry (interfaces) in 1959. From March 1959 to December 1982 he worked for Exxon Research and Engineering Company, retiring as a Research Associate. He is employed as a consultant today. Dr. Robbins holds 25 patents on applications of microemulsions and oil colloids, including oil spill dispersants and beach cleaners. He has published eight papers on the theory and applications of microemulsions. His outside interests include professional freelancing as a chamber musician (violin).

TESTING AND USE OF SHORELINE CLEANING AGENTS DURING THE *MORRIS J. BERMAN* OIL SPILL

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No. 6 fuel oil from the *Morris J. Berman* spill in January 1994 coated natural beach rock and man-made structures in areas of high visibility and recreational use in San Juan, Puerto Rico. Chemical shoreline cleaning agents were tested to determine if they increased the amount of oil removed from these hard substrates to the degree needed for such high-use areas. Using laboratory effectiveness screening results, two products were selected for testing: Corexit 9580 and PES-51. Also, Corexit 7664 was tested as an after-cleaning flushing agent. Field tests were conducted on both beach rock and riprap, comparing the chemical products with high-pressure, hot-water washing. The objective was to determine the temperature and pressure needed to remove the oil. On beach rock, water alone was not effective below 175° F and 1,000 psi, the pressure at which friable rock began to chip. On riprap, water up to 1,200 psi and 175° F was effective on smooth surfaces but not on rougher pieces. Both chemical products were more effective than water alone. The Corexit 9580 plots appeared to be cleaner, but the differences were not large. There was no dispersion of the oil treated with PES-51, whereas water flushed from the Corexit 9580 plots contained muddy, brown water, indicating some dispersion at the high water pressures used. The Corexit 7664 flush provided no added oil removal. The regional response team approved the use of Corexit 9580 based on relative effectiveness and toxicity.

AUTHOR: Jacqueline Michel is the Director of the Environmental Technology Division of Research Planning, Inc. She has been part of NOAA's Scientific Support Team since 1978, providing expertise in oil spill fate and effects, resources at risk, sensitivity mapping, and shoreline countermeasures.

REMOVING OIL AND SAVING OILED MARSH GRASS USING A SHORELINE CLEANER

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A new shoreline cleaner, which was specially developed during the cleanup of the *Valdez* spill in Alaska, was tested to determine its effectiveness in removing oil from Louisiana Gulf Coast marsh grass thus minimizing the oil impact. Intact plugs of *Spartina alterniflora* containing living plants, roots, and soil microbial communities were collected from salt marshes and transferred to a greenhouse. Plant photosynthesis, respiration, and stomatal conductance were monitored following various oiling and cleaning scenarios. The treatments included: oiled, oiled and cleaned after one day, oiled and cleaned after two days, cleaner only, and control. Plant recovery depended upon the degree of oiling and the type of oil used. Fouling with bunker C oil caused almost total plant mortality unless the plants were cleaned with the shoreline cleaner. South Louisiana crude oil was less toxic but cleaning accelerated recovery as was evident by photosynthetic activity and other plant functions such as regeneration of new shoots. Collectively, these studies demonstrate the potential for saving an oiled *Spartina alterniflora* marsh by use of this shoreline cleaner in a real oil spill.

CHEMICAL TREATING AGENTS: RESPONSE NICHES AND RESEARCH AND DEVELOPMENT NEEDS

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Chemical oil spill treating agents—here meant to exclude chemical oil spill dispersants, burning agents, and bioremediation agents—are one type of countermeasure used to control the release and/or spread of spilled oil. They are infrequently used in the United States, in part because they have been inadequately tested and demonstrated for efficacy and environmental effects. A study planned and sponsored by the Marine Spill Response Corporation examined the potential utility of chemical treating agents during marine oil spills. Through an extensive literature search and market survey process, this study defined specific product classes and evaluated these classes in terms of operational use, efficacy, and environmental fate and effects. Individual products within each class were also evaluated in terms of these study parameters, and a resultant compendium of available products worldwide was produced. Based on the evaluation, as well as results from a workshop held in conjunction with this project, specific response niches (for example, the application for which the countermeasure is best suited) for chemical treating agent classes were proposed. The niches were determined partially by evaluating the classes' relative effectiveness according to oil type and degree of weathering. The study also recommended research and development needs.

AUTHOR: Ann Hayward Walker is president and founder of Scientific and Environmental Associates, Inc., an environmental consulting firm that specializes in oil spill and emergency response planning, training, and related environmental matters. She has 15 years experience in the field and recently has focused her efforts on chemical treating agents.

SHORELINE CLEANSING BY INTERACTIONS BETWEEN OIL AND FINE MINERAL PARTICLES

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Interactions of fine mineral particles with oil stranded on shorelines following spills has been shown to be an important natural cleansing process, capable of accelerating oil removal in most environments, and particularly in low energy environments where wave action and abrasion are negligible. This process involves formation of solids-stabilized oil-in-water emulsions by flocculation of micron-sized mineral fines with oil droplets in the presence of water containing ions (such as sea water). Once flocculated, the oil droplets do not coalesce, and the oil no longer adheres strongly to shoreline sediments, facilitating its removal and dispersion by waves and tidal currents.

The importance of the flocculation process to the rate of oil removal from sediments, the conditions needed for the process to occur, and the properties of the resulting floc have been studied in detail for the *Exxon Valdez* spill. Its potential role in shoreline cleansing also has been studied for other recent spills: *Metula* (1974, Chile), *Arrow* (1970, Nova Scotia), BIOS test spill (1981, Cape Hatt, Northwest Territories), Nosac Forest (1993, Tacoma, Washington), and *Fred Bouchard* (1993, Tampa, Florida). This paper summarizes the various laboratory and field studies and discusses the findings within the contexts of natural shoreline cleansing, and the use of certain treatment techniques.

Section II

MARINE TRANSPORTATION

Session M1B: Salvage

Chairman: Oleg Khalimonov
International Maritime Organization

Session T1A: Financial Liabilities

Chairman: Sidney A. Wallace
Dyer, Ellis, Joseph & Mills

Session W1B: Tanker Routing

Chairman: Steven A. McCall
Maritime Overseas Corporation

Session W2B: Inspection and Maintenance

Chairman: Charles Huber
Mobil Oil Corporation

Session W4B: Prevention

Chairman: Klaus Schroh
Special Unit for Marine Pollution Control
Germany

LIGHTERING AND SALVAGE OF THE TANK BARGE *OCEAN 255* IN AFTERMATH OF A COLLISION, EXPLOSION, AND FIRE IN TAMPA BAY, FLORIDA, AUGUST 1993

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In the early morning hours of August 10, 1993, the 14,000 gross ton tank barge *Ocean 255,* loaded with over 200,000 barrels of aviation fuel, premium and regular gasolines, and diesel fuel collided with the M/V *Balsa 37* west of the Sunshine Skyway Bridge in Tampa Bay, Florida. The energy of the collision resulted in an explosion and fire that completely enveloped the 546 foot barge. The fire burned intensely for over 18 hours while the barge lay grounded north of the main ship channel leading into the Port of Tampa. After the fire was extinguished, the transfer of the remaining cargo, to remove the very prominent threat from explosion and pollution, fell to the U.S. Coast Guard's National Strike Force. The *Ocean 255*'s cargo containment, transfer, venting, and safety systems were completely destroyed, and its stability and hull integrity were in question. The operation was faced with uncertain weather including the possibility of a hurricane developing, frequent strong afternoon thunderstorms and squalls, strong currents, and a vessel that was a virtual time bomb. The entire amount of remaining cargo was transferred in eight days of around-the-clock pumping operations. The damage assessment after the explosion complicated the plans for lightering and salvage operations. However, action and site safety plans, and the formation of integrated teams developed by Maritrans LP (owners of the barge and the responsible party) and the National Strike Force, resulted in a successful and safe removal of the remaining 180,000 barrels of highly flammable cargo without further pollution of the waters of Tampa Bay and the State of Florida.

AUTHOR: Cdr. Jerzy J. Kichner is the Executive Officer of the National Strike Force Coordination Center in Elizabeth City, North Carolina. At the time of this incident he was the Commanding Officer of the Gulf Strike Team and led the National Strike Force response in support of the FOSC Tampa. He holds a BS degree in chemistry from the U.S. Coast Guard Academy and an MS in chemical engineering from the University of Maryland. Cdr. Kichner is a registered Professional Engineer.

RESPONDER IMMUNITY AND SALVAGE

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Marine salvage protects not only vessel and cargo, but also the marine environment. International conventions and federal and some state oil pollution legislation provide legal protection for responders to actual or threatened pollution events. Many of these responder immunity provisions, however, fall short in protecting salvors. As a result, salvors risk incurring liability in their operations. This paper examines responder immunity provisions in the context of the protection they afford the salvor. The paper offers a model responder immunity provision for persons engaged in salvage of a casualty threatening pollution.

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ENHANCING THE CAPABILITIES OF SALVAGE-BASED POLLUTION DEFENSE

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Given the inherent difficulties of oil spill cleanup, salvage-based pollution defense has come to the fore in political and regulatory circles. This is partially a response to public concern over large spills and agrees with the logic of the International Salvage Union's position that preventing a spill is more important, and easier, than cleaning up after one. The report of the Donaldson Inquiry—set up after the grounding of the *Braer* in 1993—focused on defense against pollution rather than cleanup. The report advocated, among other things, franchises of salvage companies paid for by potential polluters. Members of the International Salvage Union can be active partners in this type of defense against oil spills. Some international agreements are needed to make their efforts more effective.

AUTHOR: John Arnold Witte, Sr., is Chief Executive Officer and President of Donjon Marine Co., Inc., USA. He is also Vice-President of the International Salvage Union and a member of the ISU's Executive Committee. In addition, he is a member of the U.S. National Research Council's Committee on Marine Salvage Issues.

The author's career began in 1963, as an admiralty lawyer with the New York firm of Dow and Stonebridge. He left the practice of admiralty in 1967 to form Donjon Marine, a company that initially specialized in salvage and wreck removal. Today, the Donjon group of companies provides a wide spectrum of marine and land-based emergency services, including salvage, pollution/environmental remediation, and hazardous waste disposal.

CERTIFICATES OF FINANCIAL RESPONSIBILITY: CAN THE TRAIN WRECK BE AVERTED?

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Certificates of Financial Responsibility (COFRs) have become one of the major issues facing the international shipping industry. This paper reviews the origins of the COFR impasse, assesses the alternatives presented to date, and outlines the characteristics of a possible new solution. Implications for shipowners are drawn as well.

LIABILITY INCENTIVES FOR REDUCING THE COSTS OF OIL SPILLS

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This paper briefly reviews the economics of liability law related to oil pollution and analyzes selected federal statutes and court cases to assess how liability law has evolved over time in terms of creating incentives for potential spillers to reduce the societal cost of oil spills. Based on a review of statutes and judge-made law, it appears that prior to the Oil Pollution Act of 1990 (OPA 90), the liability provisions of statutes and judge-made law may have failed to provide spillers with sufficient incentives to invest in spill prevention and minimize the societal cost of spills. The OPA liability provisions and judge-made law related to federal government natural resource damage assessment procedures have strengthened the incentive structure by making potential spillers liable for the range of costs of oil spills. However, a sufficient body of judge-made law is not yet available to draw any definitive conclusions about the extent to which the new liability regime created in part by OPA 90 will lead to significantly different outcomes and therefore compel industry to adjust behavior accordingly.

VESSEL LIABILITY AND FINANCIAL RESPONSIBILITY IN THE U.S. COASTAL STATES

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Vessel owners and operators doing business in the United States know by now that simply complying with federal laws and regulations is not enough. Though some states have enacted legislation similar to the federal Oil Pollution Act of 1990, others have their own approach to environmental protection. This paper reviews the patchwork of U.S. coastal state requirements with regard to vessel liability and financial responsibility.

OPA 90 AND THE INTERNATIONAL REGIMES CONCERNING OIL POLLUTION LIABILITY AND COMPENSATION: ARE THEY SO FAR APART, MUST THEY REMAIN SO?

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The Oil Pollution Act of 1990 (OPA 90) set a new course for the United States with respect to oil spill liability and compensation. For 15 years preceding the passage of OPA 90, the United States sought to become party to the international regimes. A 1984 international conference was held at the request of the United States, to modify provisions of existing conventions. Passage of OPA 90 rejected those efforts and implemented a more comprehensive and farther reaching regime. Structurally, the regimes are similar, yet they are far apart with respect to key issues of levels of liability, ease with which those limits may be broken, and scope and extent of compensable damages. The issue examined is whether they must remain so far apart and whether there is a mechanism to bring them back together.

APPLICATION OF OIL SPILL SIMULATIONS TO TANKER ROUTING OFF THE U.S. COAST

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Enactment of the Oil Pollution Act of 1990 has resulted in increased efforts by the U.S. Coast Guard to identify and evaluate existing tanker routing schemes that may pose a threat to sensitive marine resources. The Minerals Management Service is assisting in these efforts through stochastic applications of its oil spill trajectory models. Restricting tanker routes or establishing tanker-free zones would constrain the potential sites of future tanker spills. This restriction would maximize the available response time for containment, recovery, or natural dispersion of tanker spills. Two analyses are described.

In the first analysis, multiple trajectories were simulated from tanker routes off the U.S. west coast. (Similar analyses are planned for the east coast and the Gulf of Mexico.) Contacts with environmental resources, which were assigned sensitivity index values, were plotted as seasonal oil spill contact risk contours. The contours were used to define alternative boundaries of potential tanker-free zones. These alternative boundaries, in turn, may provide specified levels of protection for sensitive marine areas.

The second application of oil spill simulations is in the Gulf of Mexico, where the U.S. Coast Guard is evaluating the potential impact of establishing tanker lightering zones. These lightering zones would concentrate traffic in certain areas where large vessels would offload petroleum cargo into smaller tankers for transport ashore. Results of the oil spill trajectory model characterize the risks from these zones.

AUTHOR: Since 1980, Robert LaBelle and Charles Marshall have worked in oil spill modeling and its application to environmental risk assessment for the U.S. Department of the Interior.

TANKER ROUTING, A PRIVATE COMPANY'S PERSPECTIVE

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This paper addresses the concerns that led a private company to consider voluntary tanker routing, and the reasoning that encouraged them to approach the Coast Guard with their suggestions for that agency's consideration and action. It includes a description of the alternatives studied by the company prior to their proposal to the Coast Guard, and will summarize the events that followed. The paper concludes with the author's concerns regarding future endeavors by industry to try to resolve these types of problems independently.

AUTHOR: Gary Reiter has been involved exclusively in pollution response activities for more than 20 years. He is a retired Coast Guard officer and has worked in the petroleum and pollution response consulting industry for the past four years. He graduated from the University of Southern Colorado and has a Masters in Marine Affairs from the University of Rhode Island.

TUG USAGE FOR ESCORT AND RESCUE TOWING IN PRINCE WILLIAM SOUND, ALASKA

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The second part of the Prince William Sound Disabled Tanker Towing Study was undertaken to evaluate, using computer simulations, the capability of existing escort vessels in Prince William Sound, Alaska, and to examine alternatives that could enhance escort and rescue towing capabilities. The study was undertaken by The Glosten Associates, Inc., the Maritime Simulation Centre the Netherlands, and the Maritime Research Institute Netherlands on behalf of the Disabled Tanker Towing Study Group. A brief discussion of the project background, methodology, and results is contained herein.

WORLD-CLASS OIL SPILL PREVENTION AND RESPONSE FOR THE ALASKAN TRANS-ALASKA PIPELINE SYSTEM TANKER TRADE

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Alyeska Pipeline Service Company, Ship Escort Response Vessel System (SERVS) is the primary response action contractor for Trans-Alaska Pipeline System (TAPS) laden tankers within Prince William Sound and an oil spill removal organization for the Gulf of Alaska. During the past five years, SERVS has implemented a world-class spill prevention and response organization for this region.

The activities of the SERVS prevention and response organization include escort prevention service, spill prevention activities, response equipment, contingency planning, nearshore response, community involvement, fishing vessels program, citizen oversight, and training. Plans have been made for dispersant use, in-situ burning, waste management, coastal resource and sensitive environment inventory, wildlife protection and rehabilitation, and other response strategies. Response equipment and strategy updates are closely coordinated with ship operators/charters (planholders), agencies, and the public, including the Prince William Sound Regional Citizen Advisory Council.

USING INTERNAL ENVIRONMENTAL AUDITING PROGRAMS TO HELP PREVENT SPILL INCIDENTS

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Texaco, Inc. has been performing environmental audits since 1980. Early audits focused on such major facilities as refineries and chemical plants, which often include waterfront transfer facilities. Prior to the *Exxon Valdez* accident, Texaco realized the importance of a strong internal environmental auditing program. Groundwork was laid and, in the summer of 1989, a full-fledged corporate environmental compliance auditing program was in place. Audits are now performed, on a cyclical basis, of all Texaco-owned and/or -operated facilities worldwide.

Texaco's environmental auditing procedures are based on an Environmental Auditing Protocol, which includes a document review, describes the audit process, and provides for quality assurance and auditor training. Emphasis is placed on pollution prevention and pollution response, and on how the auditing program can help make the company better prepared both to prevent and to respond to a spill. An important element in this is having a full corporate commitment to the environmental auditing program, from senior level management on down.

AUTHOR: David A. Davidson is a 1977 graduate of the U.S. Coast Guard Academy, and has an M.S. in Public Administration from Central Michigan University. He spent 12 years on active duty with the U.S. Coast Guard. In 1989, he became Assistant On-Scene Coordinator, Washington State Department of Ecology, and in 1990, Environmental Engineer, Texaco, International Oil Spill Response, Beacon, New York. He is currently assigned as an environmental auditor.

EVALUATION OF THE U.S. COAST GUARD'S TANKER INSPECTION PROGRAM: TANKER INSPECTION IMPACTS

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A study mandated by the Oil Pollution Act of 1990 assessed the effectiveness and adequacy of the U.S. Coast Guard's inspection program for oil tankers. The inspection standards study was conducted in two parts. The first part surveyed the range of inspection programs of the Coast Guard, International Maritime Organization, classification societies, and industry to identify significant gaps and/or duplicate requirements among these programs. The second part analyzed a number of issues related to the effectiveness of the Coast Guard's program. The study was intended to help the Coast Guard determine whether overlap exists in inspection requirements affecting tank vessels and whether increasing, decreasing, or targeting Coast Guard inspection resources would have a measurable impact on the occurrence of marine casualties. The recommendations and conclusions will be presented during the 1995 Oil Spill Conference and are intended to help the Coast Guard improve its marine inspection program's effectiveness.

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PORT STATE CONTROL IN LATIN AMERICA

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A meeting of Latin American maritime authorities held in Santiago, Chile, in 1983, and sponsored by the International Maritime Organization (IMO), the Economic Commission for Latin America and the Caribbean (ECLAC), and the Chilean Maritime Authority, established the Regional Operative Network for Cooperation among Latin American Maritime Authorities (ROCRAM).

A strategy for the region was approved in 1989, which included inspection of ships as a tool to prevent pollution. After an overview study, carried out in 1991 to identify ship inspection capability in Latin America, technical meetings were held in 1991 and 1992. The General Assembly of ROCRAM, held in Viña del Mar in November 1992, approved a Latin American Agreement for Port State Control known as "Acuerdo de Viña del Mar."

Latin América became the second region of the world to implement compulsory port state control as a tool to deal with safety of life at sea and the protection of the marine environment. A one-month training course for inspectors was held at Rio de Janeiro in 1993.

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SAFETY MANAGEMENT FOR THE MARITIME INDUSTRY: THE INTERNATIONAL SAFETY MANAGEMENT CODE

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It is widely accepted that more than 80 percent of all high-consequence marine disasters have been the result of human error (for example, the *Exxon Valdez*, *Amoco Cadiz*, and *Braer* incidents). In the wake of such accidents, it has become apparent that many of these human errors are the result of problems rooted in organizational errors. Though historically it has been a requirement that ship crews be properly certificated before going to sea, owners and operators have not been subject to regulatory requirements that certify their ability to safely manage the operations of their ships. The International Maritime Organization (IMO) has developed and recently adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the International Safety Management Code, or ISM Code), as a mandatory requirement under Chapter IX of the Safety of Life at Sea Convention (SOLAS). The ISM Code is the result of the IMO's commitment to addressing the human element in all aspects of the maritime industry. This paper discusses the safety management system concept behind the ISM Code and what it will mean for the marine industry. The safety management concept includes a number of new and challenging roles and responsibilities for owners, operators, regulators, insurance underwriters, and ship classification societies.

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OPERATIONAL POLLUTION PREVENTION PROGRAMS FOR LOADED TANKERS TRANSITING COASTAL WATERS

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Loaded tankers constitute a high-risk scenario during coastal navigation and inward transit to their destination terminal. An effective pollution prevention program based on prudent operational procedures can be developed on a port- and terminal-specific basis that will effectively reduce this risk and make cleanup and contingency plans largely redundant.

When the high cost and marginal effectiveness of oil spill cleanup is considered, a pollution prevention program appears particularly attractive. This is especially true if the threat of toxic chemical cargoes entering the water column is also borne in mind.

Most marine accidents that result in pollution take place in coastal waters to tankers under 100,000 dwt. The St. Lawrence Gulf and River on Canada's east coast constitute a fragile landlocked marine ecosystem that is potentially vulnerable to the depredations of pollution from vessels in transit to Montreal and the Great Lakes.

Perceptive assessment and strict operational programs have been established to ensure that only low-risk vessels, prudently navigated under approved terminal-specific programs, gain access to ports in the Maritime Provinces and thence to Canada's hinterland waterways.

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SALVAGE OR PREVENTIVE MEASURE? A PRACTICAL PERSPECTIVE

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The Salvage Convention provisions incorporated in the 1990 Lloyd's Standard Form of Salvage Agreement have increased the spill responder's armory. The hitherto accepted "primary purpose" test, used in determining whether an operation is salvage or a preventive measure, is being challenged increasingly. Salvors' operational priorities have changed; in conducting operations under LOF 90 contracts they are much more environmentally aware. Such awareness is closely linked with the special compensation now available, and salvage is increasingly treated by some as a preventive measure. The shipowner, now obliged to fund special compensation, may seek to have salvage services provided under contracts other than LOF 90 if he considers the financial burden too onerous. This reluctance to readily agree to LOF 90 may force authorities with statutory responsibility to use intervention powers more readily.

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PROTECTING THE GREAT BARRIER REEF FROM AN OIL SPILL

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If a large oil spill occurred in the Great Barrier Reef there would be significant environmental damage to an asset worth over $1 billion each year to the Australian economy. Preventing an oil spill from occurring is the best protection for the Great Barrier Reef. To this end the Great Barrier Reef Marine Park Authority has been working closely with other agencies to reduce the risk of a spill. Measures taken to date include development of an oil spill contingency plan for the Great Barrier Reef, having the Reef declared the world's first Particularly Sensitive Area, introducing compulsory pilotage in parts of the reef, undertaking education and awareness campaigns and widely promoting the view that an emphasis on prevention is preferable to cleanup.

Section III

FATE AND EFFECTS IN AQUATIC ENVIRONMENTS

Session M1C: NRDA Implementation Issues

Chairman: Linda Burlington
National Oceanic and Atmospheric Administration

Session T2A: NRDA State Perspectives, Case Studies

Chairman: John Chlada
Maryland Department of the Environment

Session T3C: Fresh Water Concerns, Planning

Chairman: David E. Fritz
Amoco Oil Company

Session Th1A: Fresh Water Fate and Effects

Chairman: Gary Sergy
Environment Canada

Session Th2A: Fate and Effects in Aquatic Environments

Chairman: Gail Thomas
U.S. Environmental Protection Agency

Session Th3D: Fresh Water Cleanup, Case Studies

Chairman: Don Erickson
Bay West, Inc.

A COOPERATIVE APPROACH FOR MEASURING DIRECT-USE DAMAGES: THE 1992 AVILA BEACH (CALIFORNIA) OIL SPILL

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A cooperative approach was used to estimate natural resource damages from the Avila Beach, California, spill. The approach was cooperative because we, on behalf of Union Oil Company of California (UNOCAL), and the economist working for the State of California shared data collection and damage estimation responsibilities. Cooperative assessments have several advantages, including reduced costs and less duplication. Because this case was not settled when this paper was submitted, we provide no damage estimates.

AUTHOR: Richard Dunford is Vice President of Triangle Economic Research. He manages and develops assessments of environmental damages from oil spills and hazardous substance releases. His work has appeared in publications such as Land Economics, the American Journal of Agricultural Economics, and the Journal of Soil and Water Conservation.

NATURAL RESOURCE DAMAGE ASSESSMENT OF THE *PRESIDENTE RIVERA* OIL SPILL, DELAWARE RIVER

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On June 24, 1989, the Uruguayan merchant marine tanker *Presidente Rivera,* loaded with 19 million gallons of No. 6 fuel oil, ran aground in the Delaware River near Marcus Hook, Pennsylvania, spilling between 200,000 and 300,000 gallons of oil. Currents spread the oil over approximately 29 miles of shoreline in New Jersey, Delaware, and Pennsylvania, reaching upstream as far as Little Tinicum Island, a wildlife refuge near Philadelphia, and downstream as far as Reedy Island, south of the Chesapeake and Delaware Canal.

Natural resources under the trusteeship of New Jersey, Delaware, Pennsylvania, the U.S. Department of the Interior, and the National Oceanic and Atmospheric Administration (U.S. Department of Commerce) were affected by the spill, including shoreline parks, fisheries, marshes, birds, and wildlife. Additionally, portions of the river were closed to vessel traffic and nearby creeks were boomed off, preventing access to marinas and boat ramps.

After three years of damage assessment, pretrial discovery, and negotiations, the trustees reached a settlement on natural resource damages with the responsible party. This paper discusses the strategy used by the trustees in developing a natural resource damage claim and highlights some of the lessons learned during the assessment and settlement process.

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COMPUTER MODELS FOR DAMAGE ASSESSMENT: ESTIMATES OF USE AND RESULTS

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Through the process of natural resource damage assessment (NRDA), certain public agencies have the authority to recover monetary damages from parties responsible for injury to natural resources from a discharge of oil or a release of a hazardous substance. Computer simulation models have been developed as simplified procedures for these natural resource trustees to use in calculating damages without undertaking extensive field studies. The revised Natural Resource Damage Assessment Model for Coastal and Marine Environments (NRDAM/CME) and the Natural Resource Damage Assessment Model for the Great Lakes Environments (NRDAM/GLE) are being developed to serve an expanding user community of public natural resource trustees. These tools may enable natural resource managers to expedite settlements and execute environmental restoration.

To estimate the potential use of the NRDA models for oil spills, the authors have developed a set of candidate spill occurrences based on the historical record. Representing an estimated 337 applicable spill events in the subject year, 121 model runs generated damage figures ranging from zero to more than half a million dollars.

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INCIDENT COMMAND SYSTEM AND NATURAL RESOURCE DAMAGE ASSESSMENT: MULTIPLE ROLES FACING NATURAL RESOURCE TRUSTEE AGENCIES

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This paper discusses the continually evolving subjects of emergency response and natural resource damage assessment (NRDA) from the perspective of a state natural resource trustee agency. Following the *Exxon Valdez* and *American Trader* spills, California enacted a law that gave the Department of Fish and Game primary responsibility for management of oil spills in marine waters of the state. There are considerable advantages to placing the lead responsibility for spill response and damage assessment on a single trustee agency which must carry out prespill planning and training, and participate in drills. Trustee agencies potentially face numerous roles in significant spill events; methods have been developed to facilitate the conduct of these activities. In particular, the unified command structure, incident command system, and the trustee NRDA team concept are useful.

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INNOVATIVE PROCEDURES FOR NATURAL RESOURCE DAMAGE ASSESSMENT

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The State of Texas has developed an innovative scheme for resolving contentious issues in assessing natural resource damages from coastal oil spills. The Texas statute and regulations provide for mediation among state natural resource trustees to resolve differences among them when assessing natural resource damages. The state trustees have formally signed a memorandum of agreement to institute mediation whenever they have disputes about any aspect of damage assessment in a case.

The statute and regulations also require the responsible person (the spiller) to mediate any disagreement about the assessment as a prerequisite to the jurisdiction of any court. This provision gives both the trustees and the responsible person an opportunity to reach a negotiated agreement without initiating expensive and lengthy litigation.

The regulations implementing damage assessment procedures and protocols were developed through the use of a negotiated rulemaking process. This process brought together representatives from state trustee agencies, the regulated community, and citizen environmental groups.

The Texas statute and rules require the state natural resource trustees to invite the responsible person to participate in all phases of the damage assessment process. By specifically providing for a negotiated assessment process, this provision encourages cooperation and discourages duplication and withholding of vital information. The regulations are designed to encourage the trustees and the responsible person to coordinate information, studies, and assessment procedures. The goal is to initiate restoration of the injured resources as quickly as possible without a "battle of the experts." The regulations require the state trustees to coordinate their assessment activities in conjunction with federal natural resource trustees. The obvious benefits of the arrangement are to promote intergovernmental cooperation and coordination and to allow the responsible person to deal with a unified trustee response to damage assessment. The benefits to all parties are the swift initiation of restoration actions, efficient use of expended funds, and an open process.

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A COOPERATIVE DAMAGE ASSESSMENT: LESSONS FROM THE GREENHILL SPILL

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Following a September 1992 natural gas and oil well blowout in Timbalier Bay, Louisiana, natural resource trustees took action under the Oil Pollution Act of 1990 (OPA), Clean Water Act (CWA), and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to restore the natural resources injured by the spill. Trustees appointed by the State of Louisiana and the U.S. Government worked cooperatively with the well owner, Greenhill Petroleum Corporation, in a natural resource damage assessment (NRDA). The resolution of the Greenhill NRDA marks an early success for all parties involved. The process was concluded in December 1993, only 14 months after the spill, when Greenhill and the trustees signed a natural resource restoration agreement. The cooperative assessment and innovative approaches used by the trustees and the well owner resulted in the rapid resolution of the case, rapid environmental restoration, and relatively low assessment costs.

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THE GREAT POM-POM CAPER: WASHINGTON'S FIRST COMPENSATION SCHEDULE APPLICATION

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When the Washington State Oil Spill Compensation Schedule was developed as a shortcut to estimating natural resource damages, the concept was applauded. But how has it worked in reality? The first use of the compensation schedule successfully occurred in April 1993, when the *Nosac Forest* spilled an estimated 6,260 gallons of intermediate fuel oil into Commencement Bay in Tacoma during a fuel transfer. Within eight months, the P&I club representing the ship paid in full the $122,696 damage claim calculated by the compensation schedule. Although running the compensation schedule formulas is straightforward, determining the input values offers several challenges. Because the compensation schedule generates a $1–$50/gallon figure, spill volume is a key factor. Limited information about the oil transfer—a common problem—complicated efforts to measure the amount spilled from the *Nosac Forest* and led to much time spent gathering and analyzing recovery data to generate an estimate. Another complication of this case was ranking the toxicity of the product. Good coordination of the unified state Resource Damage Assessment Committee with tribal representatives and the responsible party expedited resolution of the damage claim. Through the *Nosac Forest* experience, the compensation schedule demonstrated its effectiveness in quantifying damages that might otherwise not be addressed, making restoration funds available relatively quickly. This case also taught some helpful lessons regarding data collection needs and ways the regulation can be improved.

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IDENTIFYING AND MAPPING SENSITIVE RESOURCES FOR INLAND AREA PLANNING

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The U.S. Environmental Protection Agency (USEPA) is required to evaluate oil storage facilities to determine (1) which should be defined as those that could cause "significant and substantial harm" to environmentally sensitive areas in the event of a release, and (2) the appropriateness of facility response plans in addressing potential environmental threats. Accordingly, the National Oceanic and Atmospheric Administration (NOAA) has been assisting USEPA in developing guidelines, data structures, and maps for sensitive resource assessment using Geographic Information System (GIS) technology. The recommended approach for developing sensitivity maps and databases include a shoreline-habitat mapping technique used for estuarine, lacustrine, and large river settings. Shoreline type is mapped and ranked on a scale of 1 to 10, from least to most sensitive to oil spill impacts. A watershed approach is used to differentiate among small rivers and streams. Stream reaches are mapped according to a system that relates oil behavior and effects to stream characteristics, such as gradient, discharge, and water turbulence. Data on sensitive biological and human-use resources include both spatial and temporal components. The focus is on water-associated species, riparian vegetation, and all wetland types, not just threatened and endangered species. Standardized formats for hard copy maps and screen presentation will facilitate use by response organizations.

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OIL SPILL CHEMICALS IN FRESHWATER ENVIRONMENTS: TECHNICAL ISSUES

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This summary of current protocols and on-going research for effectiveness and toxicity testing of chemical agents also discusses data interpretation and analyses for these tests. In addition, a decision tree to provide an initial framework for discussing the development of authorization for the use of chemical treating agents is proposed. For the purposes of the study, chemical treating agents include herding agents, emulsion treating agents, elasticity modifiers, solidifiers, shoreline cleaning agents, shoreline pretreatment agents, and dispersants.

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AQUATIC RESOURCE CHARACTERIZATION OF THE UPPER OHIO RIVER BASIN USING A GEOGRAPHIC INFORMATION SYSTEM

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The Commonwealth of Pennsylvania successfully negotiated a $1.75 million settlement with Ashland Oil Company for injuries to aquatic resources and recreational users resulting from the January 1988 oil spill into the lower Monongahela and upper Ohio Rivers. The commonwealth's natural resource trustee agencies reserved these funds for special studies to learn more about the aquatic resources of the impacted rivers.

A project team including commonwealth agencies, consulting experts, and the Ohio River Valley Water Sanitation Commission agreed to use the framework of a geographic information system (GIS) to organize geo-referenced natural resource data spatially. This paper discusses the development of a GIS base map of a river system modified by a series of navigation dams and outlines the ecological basis of the aquatic habitat classification system. This system divides individual navigation pools into component parts along longitudinal, cross-sectional, and vertical axes. These components are then combined to delimit aquatic areas and habitat conditions to define aquatic habitat types. These habitat types will serve as the basis for making an inventory of environmentally sensitive areas; and the completed GIS will have coverages of infrastructural, monitoring/regulatory, recreational, and environmental themes. The GIS will be used by Pennsylvania agencies in the management and protection of the natural resources supported by the Ohio River and its tributaries.

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THE GREAT LAKES SPILL PROTECTION INITIATIVE: A PUBLIC/PRIVATE PARTNERSHIP

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The Great Lakes Spill Protection Initiative (GLSPI) was launched in 1992 by eight Great Lakes governors and the chief executive officers of six oil companies. The major objectives of the initiative are to foster a harmonious regulatory framework to promote spill protection efforts, to assure effective response capacity, and to develop cooperative approaches to spill prevention. The initiative undertook a review of existing state regulations, compiled a database of regional response contractors, and facilitated a dialogue between state agencies and industry representatives. The results of these efforts led to recommendations for reviewing and revising state reporting requirements for consistency with federal requirements, streamlining the notification process by establishing a common number for reporting spills, enacting legislation to exempt responders from spill liability in states that have not already done so, coordinating response exercises among industry and governmental agencies, improving spill data collection for the Great Lakes basin, establishing guiding principles for developing state regulations, developing economic incentives to encourage industry prevention efforts, implementing outreach programs to raise awareness of spill protection principles, and continuing the dialogue between government and industry representatives. The GLSPI demonstrates the benefits of a public/private spill protection partnership that may be applicable to other regions.

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A SCREENING-LEVEL EVALUATION OF IMPACTS TO A MONTANA LOTIC MACROINVERTEBRATE COMMUNITY FROM A FUEL OIL SPILL

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A pipeline rupture during the winter of 1993 released an undetermined amount of refined fuel into a small stream on the Flathead Indian Reservation in Montana. A screening-level bioassessment was performed in conjunction with supporting sediment and water analytical chemistry, to provide a preliminary evaluation of the effects of the spill and subsequent remedial response actions on the benthic community.

A variety of community-level metrics were compared to the habitat scores to evaluate the biological condition of each station sampled relative to the reference, thereby isolating effects related to contaminant release from those due to background habitat conditions. A comparison of taxa richness and Ephemeroptera:Plecoptera: Tricoptera (EPT) Index values from March 1993 to March 1994 indicated partial recovery at the rupture point after intensive soil cleanup and remediation activities. Approximately one year following the spill, the rupture point exhibited 60 and 75 percent recovery respectively in taxa richness and EPT Index. At farther downstream stations, ≤15 and <10 percent recovery in taxa richness and EPT Index respectively were observed.

FATE AND EFFECTS OF CRUDE OIL IN A SOUTHERN CALIFORNIA STREAM DRAINAGE

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On April 6, 1993, a crude oil pipeline ruptured releasing an estimated 6,200 bbl of blended San Joaquin Valley crude oil (27° API gravity) which flowed overland and through interstate freeway stormwater culverts to a small stream in Kern County, southern California. A mixture of crude oil and water flowed 12 km downstream to an emergency containment/underflow dike. Response operations were completed within 21 days resulting in recovery of approximately 3,400 bbl of liquid crude and an additional 1,200 bbl of oil contained in nearly 19,000 yd^3 of excavated soil and streambed sediments (74 percent recovery).

Water quality data collected throughout the stream within 24 hours of the release demonstrated total petroleum hydrocarbon (TPH; method 8015-modified, GC/FID) concentrations ranging from 55 to 120 mg/L with BTEX (total benzene, toluene, ethylbenzene and xylene isomers; method 5030/8020) concentrations less than 145 µg/L. Within 72 hours of the spill, TPH concentrations were less than 8 mg/L and total BTEX concentrations were less than 25 µg/L. Within five weeks of the spill, TPH and most BTEX constituents were below detection limits. Average sediment TPH concentrations in impacted stream segments ranged from <100 to 21,733 mg/kg prior to cleanup while postcleanup samples ranged from <50 to 1325 mg/kg. Average September concentrations ranged from 11 to 299 mg/kg.

Qualitative benthic macroinvertebrate samples collected within a few days of the spill indicated reduced taxonomic diversity and numerical abundance in impacted stream segments. Quantitative macroinvertebrate samples collected five months after the spill, however, identified diverse and abundant benthic macroinvertebrate populations, relative to reference stations, where streamflow volumes were sufficient to maintain such invertebrate communities.

Upstream vegetation was characterized as cottonwood-willow riparian woodland that may have experienced some spill-related stress in the form of leaf drop, which was photographically documented. A transition riparian zone, dominated by mule fat, tamarisk, and red willow, exhibited no symptoms of stress following the spill. Annual grassland dominated by nonnative grasses, forbs (broad leaved, nonwoody plants), and native wildflower species occurred along the lower portions of the creek and was not affected by the spill except for the physical impact of cleanup operations.

Avian surveys conducted in riparian habitat in April and June suggested that bird populations utilizing oiled and unoiled reaches of Grapevine Creek were similar. Lower species richness and abundance in April was attributed to extensive response operations. Avian surveys conducted along downstream, dry wash portions of the creek in June, however, indicated greater species abundance and diversity along these previously oiled reaches of the creek relative to an unoiled reference channel.

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AN OIL SPILL IN AN ILLINOIS LAKE: ENVIRONMENTAL EXPOSURE ASSESSMENT

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On April 27, 1985, an oil pipeline ruptured, releasing 10,775 barrels (452,550 gallons) of a Southern Louisiana crude oil into Newton Lake, a 1,750-acre electric power plant cooling lake in Jasper County, Illinois. The oil, which flowed into the northern part of the 6-mile eastern arm of the V-shaped lake, was restricted by booms to the upper third of the lake. A long-term environmental assessment program was immediately initiated and continued until October 1991.

Shortly after the accident, offshore (benthic) lake sediments nearest the release site contained up to 5,000 μg/g [ppm] total hydrocarbons. A steep gradient of decreasing hydrocarbon concentrations in sediments occurred with distance from the point where the oil entered the lake. By 1989, concentrations of total hydrocarbons in offshore sediments were less than 50 μg/g in all areas (zones) except in an area of the lake within 1 mile of the release where isolated total hydrocarbons concentrations ranged from <50 μg/g to 430 μg/g. Fingerprinting of polycyclic aromatic hydrocarbon (PAH) assemblages six years after the spill revealed that traces of the spilled oil (<400 ng/g total PAHs) remained only in this uppermost part of the lake. PAH assemblages from other sources than the spilled oil were identified in offshore lake sediments as the major contributing PAHs. Low concentrations of residual oil were found in subsurface sediments in the upper 0.4 mile of the lake. Diagenetic perylene was particularly abundant in sediments (up to 2,400 ng/g) especially in the depositional (deepest) areas of the lake. Only trace amounts of a few PAHs (<50 ng/g total PAHs), most from sources other than the released oil, were found in shoreline sediments in any part of the lake. Tissues of fish collected in 1985 shortly after the spill and again in 1991 did not contain detectable levels (<10 ng/g dw) of released oil PAHs.

AUTHOR: Ted Sauer, an organic geochemist and environmental chemist, is Research Leader at Battelle Ocean Sciences. For the past 15 years, he has been involved, as a principal investigator and/or program manager, in aquatic and groundwater assessments of crude and refined oil spills, chemical characterizations of effluents, aquatic pollutant monitoring programs, and analytical methods evaluation projects.

AN OIL SPILL IN AN ILLINOIS LAKE: ECOLOGICAL AND HUMAN HEALTH ASSESSMENT

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Long-term ecological studies were initiated shortly after an April 1985 release of 452,550 gallons of a Southern Louisiana crude oil into a 1750-acre electric power plant cooling lake. Aquatic plants (macrophytes) in the most heavily oiled region of the lake were coated with oil and most had died by late summer 1986. Macrophytes from lightly oiled areas of the lake had nearly recovered by late summer 1986. Macrophytes in other parts of the lake were completely unaffected by the release of oil. A year after the release, diversity and abundance of bottom-living animals decreased in the most heavily oiled parts of the lake and previously dominant insect larvae were replaced by opportunistic oligochaetes. Complete recovery of the most severely affected benthic communities required four years in the deep parts of the lake and five years in shallow areas. There was a small kill of fish (≈200 fish) immediately after the release and a small decrease in the abundance of preferred recreational fish species (largemouth bass and white crappie) during the summer after the release. However, between 1986 and 1991, abundance of recreational fish in the lake was comparable to that before the accident. Fish did not accumulate sufficient PAH in edible tissues to pose a health risk to human consumers.

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OILING OF MANGROVE KEYS IN THE 1993 TAMPA BAY OIL SPILL

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On August 10, 1993, three vessels collided in the channel leading from the Gulf of Mexico into Tampa Bay, Florida. More than 300,000 gallons of No. 6 fuel oil and 30,000 gallons of gasoline, Jet-A fuel, and No. 2 fuel oil were discharged into Tampa Bay. Most oil moved out to sea and weathered until August 14. Onshore winds then moved the slick onto beaches and into Boca Ciega Bay. Four mangrove keys inside Johns Pass were oiled with No. 6 fuel oil. Floating oil washed through two keys, but slicks and oil patty stranded against berms or elevated sections of two others. Oil contacted three species of mangroves: black *(Avicennia germinans)*, red *(Rhizophora mangle)*, and white *(Laguncularia racemosa)*. Nine months after oiling, significantly more juvenile red and black mangroves were dead at three oiled keys than at unoiled sites or a fourth oiled key. Juvenile plants died if leaf shoots were oiled. Where the oil patty was stranded in greatest amounts, adult red mangroves defoliated and died, and surviving red and black mangroves showed significant deterioration of fringing prop roots and pneumatophores.

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MITIGATION STRATEGIES AT AN ESTUARINE MANGROVE AREA AFFECTED BY AN OIL SPILL

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A simulated oil spill was carried out under controlled conditions at an estuarine mangrove forest dominated by *Rhizophora mangle*. Two mitigation strategies were thereafter applied: addition of nutrients to restore sediments C/N and C/P ratios and addition of a commercial shoreline cleaner without further surface washing. Photosynthetic capacity of leaves, soil respiration rate, and litter disappearance rate were measured periodically to evaluate differential responses of these community functional variables to the treatments. Application of shoreline cleaner negatively affected the productive capacity of *R. mangle* leaves. Soil respiration rate was stimulated in all of the oiled experimental plots but to a lesser extent in those where shoreline cleaner was applied—presumably as a result of less retention of hydrocarbon fractions in the sediments. Although litter increased its dry weight by 0.4 percent as a result of hydrocarbon addition, its disappearance rate did not slow down and remained unaltered among the different treatments compared to controls. Results suggest that the studied mangrove community possesses the capability to respond to moderate, medium crude oil spills. Neither the use of a shoreline cleaner nor the addition of nutrients alone is recommended as a mitigation strategy under such conditions.

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WEATHERING EXPERIMENT ON SPILLED CRUDE OILS USING A CIRCULATING WATER CHANNEL

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Crude oil spilled in the sea is mixed with the sea water by the wind and waves resulting in increases in its water content and viscosity as time passes. We have constructed a small, transfer type circulating water channel of an elliptical circuit-track form. Using an attached circulating unit, together with a wind tunnel, artificial waves are generated to enable simulation corresponding to the natural circumstances in the sea. The experiment disclosed the following results.

- *Drastic changes in the properties (water content and viscosity) of the oil depend on the power of waves.*
- *Contrasting processes are observed between heavy and light crude oils during weathering.*
- *Heavy crude oils form a massive water-in-oil emulsion (mousse) with increases in both water content and viscosity.*
- *Light crude oils behave differently at summer sea temperatures, dispersing into the sea water without making a massive mousse, but forming a fragile mousse containing air bubbles at winter sea temperature.*

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DISTRIBUTION AND WEATHERING OF OIL FROM THE IRAQ-KUWAIT CONFLICT OIL SPILL WITHIN INTERTIDAL HABITATS—TWO YEARS LATER

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The heavily oiled coastal bays of Dafi and Musallamiyah on the Saudi Arabian coast were surveyed in 1992 and again in 1993, two years after the Iraq-Kuwait conflict oil spill. All habitat types showed little improvement or recovery from their condition one year earlier. Oil on the exposed outer beaches was beginning to form asphalt pavements, much like the ones still present from the 1983 Nowruz spill. Moderately exposed sand flats with bars showed no change in the distribution of surface oil; but in some areas, the subsurface oil migrated deeper, up to twice the depths in 1992. The heavy surface oil on moderately exposed sand flats was hardening into incipient pavements, which are sealing off the heavy subsurface oil from natural removal and weathering processes. Sheltered habitats showed even less improvement, with contamination likely to remain for decades. Factors contributing to the long-term persistence of oil in these intertidal habitats include the initial, heavy oil loading; deep penetration into porous sand substrates, even on the lower intertidal zone; deep penetration into animal burrows in muddy sediments; and subsequent formation of extensive asphalt pavements, which have sealed the subsurface oil from physical removal processes and slowed chemical weathering.

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RESPONSE TO A MAJOR GASOLINE RELEASE INTO THE MISSISSIPPI RIVER

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On January 18, 1994, unleaded gasoline began entering the Mississippi River through the bank adjacent to an oil distribution/storage facility in St. Louis, Missouri. Reported as a minor, per the National Contingency Plan, it developed into a major discharge. Of the 364,930 gallons lost, 140,000 gallons discharged into the river. The amount of product recovered from all sources was 107,000 gallons. The emergency phase of the response ran from January 18 to 24. Not until January 24 was the cause determined to be a 10.7 ft by 1/4 in fracture near the center of the floor of a two million gallon tank. Secondary containment showed no evidence of the catastrophic release. The extreme cold permitted the initial booming of the gasoline, but recovery was complicated by flowing river ice, ice shelves, temperatures that froze equipment, and access down 45 feet of snow-covered riprap. Elastol, fire-fighting foam, barges, weir and barrel skimmers, and vacuum trucks were utilized for water and land recovery operations. Safety concerns were paramount for the federal, state, and local personnel and yet there was a demonstrated weakness in timely development and enforcement of the comprehensive site safety plan. This unusual spill heightened the awareness of many prevention and response issues.

AUTHOR: Cdr. Jane M. Hartley is Chief of the Second Coast Guard District Response Advisory Team. She facilitates financial, environmental, and logistical support for the federal OSC during, and in preparation for, responses to a release of oil on the western rivers. She has a master degree in Environmental Sciences and Engineering from the University of North Carolina.

SAN JOAQUIN VALLEY CRUDE OIL SPILL INTO A FRESHWATER STREAM: A CASE STUDY

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In April 1993, a pipeline rupture occurred adjacent to a primary California freeway on the north slope of the Tehachapi/San Emigdio Mountains leading into the San Joaquin Valley. An estimated 6,200 barrels of blended San Joaquin Valley crude oil (27° API gravity) sprayed on the freeway, and flowed downslope and into Grapevine Creek. The crude oil flowed 12 kilometers terminating at a containment dike constructed during the initial response. Cleanup activities were completed and approved by the lead regulatory agency within 21 days of the release.

The release occurred at an elevation of 730 meters above sea level, spraying oil on to the northbound lanes of the freeway and closing it for 36 hours. After passing through engineered freeway drainage, the oil entered Grapevine Creek and flowed through 1,525 meters of riparian habitat and 8,500 meters of grassland habitat. Elevation at the terminus was 300 meters. Upper Grapevine Creek supports dense riparian vegetation that may have contributed to significant diurnal flow fluctuations and caused surface flows to retreat 1,500 meters from the terminus during the afternoon and early evening hours during response operations. Typical flow rates in Grapevine Creek during the response operations were less than 0.15 m^3/s (less than 5 ft^3/s).

Cleanup activities included steam cleaning the freeway and engineered drainage system and hand cleanup in the riparian section. Cleanup efforts in the downstream grassland section were complicated by the fluctuating flow rates. A site in Grapevine Creek with continual surface flow was selected for stream-flow diversion. Utilizing portable irrigation equipment, the flow from the creek was used to irrigate 40 acres of adjacent grassland. The system was operated for 21 days and required 24-hour supervision to adjust for stream flow fluctuations.

Approximately 3,400 barrels of crude oil were recovered as a liquid from two primary locations: a permanent concrete containment weir and the terminus containment dike. Recovered liquids were returned to tankage for subsequent processing. An estimated 1,200 barrels of crude oil were collected in 19,000 cubic yards of excavated soil and sediment. Thus, approximately 74 percent (4,600 barrels) of the spilled oil was recovered. The soil was converted into a road-base material and used to pave pipeline system facilities for dust control, at a cost of less than $30 a ton.

Water samples collected during and after cleanup activities combined with surveys of macroinvertebrates, birds, and riparian habitat indicate only short-term and localized impacts. Dissolved hydrocarbons in surface waters declined rapidly. Benthic macroinvertebrate population density and diversity were similar to reference station within five months of the initial release.

AUTHOR: Mark Lowe has been with Four Corners Pipe Line Company for three years, overseeing and managing oil spill response activities, site assessments, remediations, and various operational compliance issues. Prior to this, he was a consulting engineer with Groundwater Technology. He holds a B.S. in geological engineering from the South Dakota School of Mines and Technology.

FOLLOW-UP STUDY ON OILED VEGETATION CUTTING ALONG THE DELAWARE RIVER

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In July 1992, the tank vessel *Canadian Liberty* spilled approximately 50 barrels of heavy Venezuelan crude oil into the Delaware River. Eight miles of New Jersey riverbank were oiled. The product clung to the vegetation, forming a bathtub ring about 20 cm wide at the high-tide mark. Cutting of vegetation was approved for areas with the highest waterfowl concentrations and highest degree of oiling, and in public-use areas. The objective of cutting was to remove impacted vegetation to prevent secondary oiling of waterfowl and to allow use of the public park. Emphasis was placed on limiting habitat degradation by selective manual cutting from boat and shore.

A yearlong study was undertaken to monitor the recovery of the cut vegetation. Comparisons to uncut oiled vegetation and control sites were made. Nine monitoring stations were established in the area affected by the spill. Vegetation surveyed were *Phragmites communis* (common reed grass), *Peltandra virginica* (arrow arum), and *Scripus olneyi* (bulrush). One year after cleanup operations, cut and oiled vegetation appeared to have completely recovered. The distributions, densities, and heights of vegetation oiled and/or cut were not noticeably different from control transects of unimpacted vegetation.

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THE COLONIAL PIPELINE SPILL: A CASE STUDY

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The response to the Colonial Pipeline spill in Fairfax County, Virginia, provided an opportunity to apply the emergency response concepts of the Oil Pollution Act of 1990. Protection of human health and the environment was the paramount goal of the response. This goal was successfully achieved through the establishment of a unified command system to coordinate federal, state, and local interests and activities. The major operational objectives of the response were to secure the source of the spill, limit its migration through the use of containment boom, and recover spilled oil by using skimmers and other mechanical means. For the most part, these operational objectives were achieved in an efficient manner. However, some difficulties were encountered due to the inaccessibility of the major recovery area, debris-clogged skimmers, and insufficient supply of on-scene response resources. Such problems were addressed through the use of additional federal resources and innovative response principles, such as the construction of a temporary pipeline to transport recovered oil. Agencies involved in the response noted strengths and weaknesses in the areas of logistics, notification, communication, resource availability, and response actions and highlighted areas for improvement. The review and future implementation of such lessons learned can enhance the level of preparedness for spills of a similar nature.

AUTHOR: Kevin Koob serves as a master federal on-scene coordinator in Region III responding to oil spills and HAZMAT incidents. Prior to coming to EPA in 1989, the author served as a USCG Marine Safety Officer in the Port of Philadelphia. He remains active in the USCG Reserve currently assigned as the executive officer of the USCG Reserve Unit Philadelphia.

Section IV

SPILL MANAGEMENT/MITIGATION

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U.S. Environmental Protection Agency

Session T1B: Preparedness Planning I

Chairman: Stacey Gerard
U.S. Department of Transportation

Session T3A: Training/Exercises I

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EARL, Singapore

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Canadian Coast Guard

Session W1A: Low API Gravity Oils, Response to Oils That Sink

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Shell Oil Company

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Session W3D: The 1993 Tampa Bay Oil Spill

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Shell International Shipping Limited

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Mercer Management Consulting

Session Th3B: The Morris J. Berman *Spill*

Chairman: Mark Miller
National Response Corporation

AN INTEGRATED APPROACH TO CORPORATE PREPAREDNESS

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Many companies in the oil, chemical, petrochemical, and/or energy businesses are faced with the challenges of providing for and then assuring appropriate emergency planning and response capabilities for all of their operations. Most of the efforts devoted to this subject have been aimed at individual facilities within a company. And while preparedness at the local level is certainly an essential ingredient to corporate preparedness, there is also a need to take a holistic approach to a company's response readiness, recognizing that extremely large or extended emergencies may exceed the response capabilities of small facilities. Therefore, in most cases, there is a need for a companywide emergency preparedness and response program to coordinate effectively a crisis that exceeds the capabilities of an individual facility or business unit.

Unocal, a fully integrated oil company, has developed and is implementing such a corporate emergency preparedness and crisis management program. To establish this program, the following conclusions were reached and elements were established in the program to address each of them.

- Corporate policy, direction, and planning is essential for effective companywide preparedness and response to a crisis.
- A method is needed to assure the preparedness of all facilities, which is the foundation of any emergency response, including responses by corporate teams.
- Corporate notification of major emergencies within the company is necessary for a rapid assessment and response by those outside the facility.
- A chain of command and divisions of responsibilities, from the emergency responders to the senior executives, must be clearly established and communicated.

CONFIRMING RESPONSE EFFECTIVENESS: AN OVERVIEW AND GUIDE TO OPERATIONAL MONITORING

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Monitoring is a common, if generally implicit, part of spill response. However, there are no general guidelines for designing and carrying out spill response monitoring. With a few notable exceptions, as in shoreline assessments, monitoring rules are made up as the response progresses. Important rules of monitoring, such as those concerning adequate controls, are often left out or remain ill-defined, leading to unjustified product claims. As a result, there is often considerable debate and confusion about the effectiveness of protection and cleanup actions as well as the need to move on or terminate the response.

A framework has been developed to help make monitoring an explicit process in spill response management. This framework forces (1) clear identification of the objectives of prevention and cleanup strategies, (2) selection of meaningful and useful end points, to quickly document effectiveness, (3) an appropriate strategy (statistical or otherwise) for collecting and reporting needed feedback information, (4) an often-overlooked quality assurance/quality control plan, (5) a data or information management plan, and (6) confirmation that a decision was (or was not) made based on monitoring results. The most important aspect of an explicit monitoring plan is that it forces not only clear definition of "how clean is clean enough," but also how this measure will be operationally documented. Elements of this process are indeed covered in many past responses and in some recent documents. Nevertheless, there is a critical need to develop additional rapid response tools for chemistry, biology, and toxicology and for a more thorough operational monitoring guide for spill response.

NORTHRIDGE EARTHQUAKE PIPELINE RUPTURE INTO THE SANTA CLARA RIVER

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On January 17, 1994, an oil spill of more than 3,500 barrels occurred on the Santa Clara River as a result of a pipeline rupture during the Northridge earthquake. A unified command was formed by ARCO, the State of California, and the U.S. Government to respond to this spill into the habitat of two endangered species. Logistics difficulties caused by the earthquake were overcome, including problems caused by misinformation on concurrent events. The spill occurred in a shallow, rapid-flowing waterway that was at serious risk for flash floods, requiring use of tactics typically used in inland spills. Actions were taken based on the need for quick removal due to predicted rain, and unique problems encountered with the oiled vegetation. The case highlighted potential problems with older pipelines constructed using acetylene welds.

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CHALLENGES OF CONTINGENCY PLANNING IN A SMALL ISLAND DEVELOPING STATE—TRINIDAD AND TOBAGO

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The oil industry is the engine of the economy of Trinidad and Tobago, with a production of around 125,000 barrels of oil a day, of which 55,000 come from offshore on the east coast and 31,000 from the west coast of Trinidad. Two refineries with total capacity of 230,000 barrels a day are located along the west coast of Trinidad.

For these local oil operations an average of 50 and 800 tankers, annually, visit ports on the east and west coast, respectively. The daily crude tonnage of tankers passing through the south Caribbean now exceeds 2 million metric tons (t). Tanker traffic, therefore, creates a major risk for oil spills and complicates contingency planning in Trinidad and Tobago, and the southern Caribbean.

Small island states with serious deficiencies in financing their contingency plans can utilize tiered emergency response schemes to offset the obvious weaknesses in their response capabilities; but unless multilateral funding is available, the benefits of tiered response would be limited. Assistance to small island states to help ratify the IMO conventions and protocols remains the best form of insurance against all oil spill perils.

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CONTINGENCY PLANNING IN CHILE

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While Chile had experienced various major oil spills (including the 1974 *Metula* spill of 52,500 tons, the 1978 *Cabo Tamar* spill of 12,500 tons, and the 1987 *Cabo Pilar* spill of 7,500 tons), contingency planning for oil spills had been carried out on a voluntary basis. The Chilean maritime authority had assumed the responsibility for oil spill control in terms of equipment and trained personnel.

Since November 1992, a new regulation is in force. Responsibility for oil and chemical spills control is assumed by the industry. According to the new regulations, every oil and chemical terminal must have contingency plans to deal with spills, proper equipment, and trained personnel. Vessels, Chilean or foreign flag, must have approved contingency plans in line with Regulation 26 of Annex I of the International Convention on Prevention of Pollution from Ships, MARPOL 73/78. Even though Chile is not party to MARPOL 73/78, Annexes I, IV, and V of the convention were incorporated as national regulations by Decree No. 1, 1992. Maritime authorities will continue to have their own equipment and will act only if needed. Almost all oil terminals and refineries have implemented their contingency plans and are in the process of purchasing equipment and training personnel.

AUTHOR: Capt. Francisco Pizarro is a Master Mariner with 14 years at sea and 16 years as a Nautical Surveyor with the Chilean Coast Guard. He received training in oil and chemical spills at Texas A&M and Corpus Christi Universities. Since 1984, he has been an independent consultant/surveyor acting for IMO, P&I clubs, shipping, and the oil and chemical industry. He has been involved in the preparation and revision of many contingency plans in Chile.

INDUSTRY, GOVERNMENT, AND REGIONAL EFFORTS IN OIL SPILL CONTINGENCY PLANNING: MALAYSIA'S PERSPECTIVES

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The increasing incidence of oil spills in the Strait of Malacca and the South China Sea has resulted in growing concern about Malaysia's capability to respond to oil spills in its waters. This concern is compounded by the ever-growing number of oil tankers plying the Strait of Malacca and the South China Sea, as well as the intensifying exploration and development of offshore petroleum resources.

Various measures were taken by the government to deal with the problem, including a review of its National Oil Spill Contingency Plan (NOSCP) and incorporating a coordinated and a cost-effective response mechanism among the various government agencies. The incorporation of the Petroleum Industry of Malaysia Mutual Aid Group (PIMMAG), which enables the oil industry to pool its oil spill response resources, reflects the industry's commitment to strengthen the NOSCP. Since the mid 1970s, a number of regional plans have been instituted including the Traffic Separation Scheme for the Strait of Malacca, the Strait of Malacca and Singapore Revolving Fund, the Lombok-Macassar Oil Spill Contingency Plan, the Brunei Bay Oil Spill Contingency Plan, the ASEAN Oil Spill Response Plan, and the proposed ASCOPE Oil Spill Contingency Plan.

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EXERCISES AS ASSESSMENT OPPORTUNITIES: A FOCUS ON THE FIX

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Exercises are a means to an end, not an end in themselves. They provide the opportunities for repetition and practice that make them such an invaluable tool for operational effectiveness through training. Clearly, there need to be opportunities to practice and perfect response and response management skills, where mistakes are permissible and learning is the objective. Nonetheless, well-planned exercises that incorporate an equally well-planned evaluation are critical. These greatly assist management in determining the level of preparedness of the organization to respond to a spill. What are our strengths we want to build on? What are our weak points we have to shore up? What are our priority issues now?

An exercise can be designed to maximize assessment opportunities, and to address the following specific issues.

- Exercise objectives and assessment objectives: how may they differ?
- Expectations of "success:" planning factors versus performance standards
- What are the components of an effective readiness assessment—such as selection of the optimum exercise event, composition of control and evaluation teams, or evaluator training?
- Documentation of results: data collection, reduction, and analysis
- The payoff—assessment findings and reports, a management followup process to "focus on the fix"

NATIONAL DRILL OF THE VENEZUELAN OIL SPILL CONTINGENCY PLAN

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In November 1993, the first drill of the Venezuelan national oil spill contingency plan (VNCP) was carried out to evaluate both the response capability of the plan to cope with an emergency and the effectiveness of the regional response organization to manage the given scenario.

During four days of intensive work, 800 participants, evaluators, and controllers of the drill made decisions and took actions to mobilize resources and pollution countermeasure equipment for cleanup operations.

To measure the effectiveness of the response actions, 23 oil spill response processes were evaluated based on flow charts or decision trees designed for each process.

In summary, the drill covered all areas related to response actions in the case of an oil spill (alert, notification, evaluation, decision-making, mobilization, field response, and postmortem), evaluating the ability of the VNCP to cope with a major emergency and identifying weaknesses in order to improve the response capability.

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SHIP ESCORT RESPONSE VESSEL SYSTEM (SERVS) FISHING VESSEL OIL SPILL RESPONSE TRAINING

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During the *Exxon Valdez* oil spill cleanup it became obvious that fishing vessels were a valuable asset. Their value was recognized by the Ship Escort Response Vessel System (SERVS), and they have become an integral part of the SERVS response capability. SERVS is a world leader in oil spill prevention and response and is charged with meeting the requirements of the Prince William Sound Tanker Oil Discharge Prevention and Response Plan. The Prince William Sound response plan and the Nearshore Response Plan both require a trained group of oil spill technicians to operate a fleet of small boats. Fishing vessels and their crews are in an ideal position to fulfill this function. SERVS and Prince William Sound Community College (PWSCC) are in the third year of a fishing vessel crew training program. Prince William Sound Community College, as part of the University of Alaska system, has developed a partnership with SERVS that included the codevelopment of a fishing vessel training program. The three major goals of this training are to teach vessel crews to safely operate the equipment they will employ to contain and clean up a spill, to provide general health and safety training, and to give participants an insight into their responsibilities within the SERVS oil spill response organization. The first year provides basic instruction. Each subsequent year reviews the first year and presents new material on equipment operation. The classes are structured to include both classroom and on-water training utilizing the fishing vessels.

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CANADA'S DEVELOPMENT OF A NATIONAL EXERCISE PROGRAM

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Canada has established a response community exercise program, with the use of four tools that were developed through extensive consultation with response community members in each region of Canada. The tools developed are: a Program Guide that describes an approach toward coordinating response community exercises, a Planning & Evaluation Guide that provides a framework and project management approach toward conducting exercises, an exercise information system to support the sharing of learning from exercises, and a training course for exercise managers. These tools can be used to guide any response community in the establishment of a coordinated and consistent program of exercises.

AUTHOR: Alec Attfield is the Coast Guard officer responsible for the development and implementation of the National Exercise Program. Prior to work with the Coast Guard, he worked as a high school mathematics teacher and then as a management consultant specializing in program evaluations, organizational studies, and comprehensive audits.

DEVELOPMENT AND TRAINING OF A FACILITY OIL RESPONSE TEAM

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Over the course of fifteen years, Tosco's Avon Refinery has developed a highly successful oil spill response organization. Three approaches were evaluated: use of management personnel without in-house training, use of management personnel with in-house training, and all-volunteer personnel with in-house training. The all-volunteer approach has been the most effective, based on continuing evaluations. This approach has been flexible and has been upgraded to meet the needs of changing response criteria.

Benefits of the all-volunteer approach include a high rate of participation and consistency, rapid response, familiarity with the facility, knowledge of local sensitive resources, and training in local conditions. Difficulties associated with the approach include conflicts with normal duties, ongoing training costs, and training for shift workers.

Costs associated with the approach include equipment purchase, equipment maintenance, supplies, training and drills, and management costs. Equipment was carefully selected to meet the specific characteristics of the environment surrounding the refinery.

Performance standards were developed to provide training criteria in specific areas (such as boat operations, boom deployment, and navigation). Completion of all performance standards leads to personnel certification and response status.

AUTHOR: Stephen M. Collins is the Tosco Refinery Oil Spill Prevention and Response Supervisor. A graduate of St. Mary's College, he has been employed by Tosco for 20 years. His current duties include the formation and implementation of the Avon Oil Response Team, procurement of equipment, and documentation and regulation management for oil spill response.

DELIVERING OIL SPILL HEALTH AND SAFETY TRAINING FOR BEACH CLEANUP: INNOVATIVE ENVIRONMENTAL EDUCATION AT WORK

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The California Conservation Corps provides trained workers for oil spill cleanup. Delivering effective training that exceeds the requirements of applicable regulations and meets the educational needs of the students has necessitated minimizing the traditional classroom component and introducing nontraditional educational methodologies into the curriculum.

AUTHOR: Paul Penn is currently the Oil Spill Response Program Manager for the California Conservation Corps. He is directly responsible for all aspects of the program. Previously, he was the SARA-Title III Program Manager for the State of California and the author of the California Hazardous Material Incident Contingency Plan. He holds an MS degree in environmental management from the University of San Francisco.

LESSONS LEARNED FROM THE NATIONAL PREPAREDNESS FOR RESPONSE EXERCISE PROGRAM

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The National Preparedness for Response Exercise Program (PREP) was developed to meet the intent of the Oil Pollution Act of 1990 (OPA 90). PREP is a unified federal effort and incorporates the exercise requirements of the Coast Guard; Environmental Protection Agency (EPA); Research and Special Programs Administration (RSPA), Office of Pipeline Safety; and the Minerals Management Service. (MMS).

Each year 20 PREP area exercises are held: six led by the federal government and 14 led by the industry. Five of the six government-led exercises are conducted in coastal areas where the Coast Guard is designated as the federal on-scene coordinator (FOSC). One is held in an inland region where the EPA is the FOSC.

Each government-led pollution simulation typically involves more than 40 agencies and more than 400 participants. The PREP simulations focus on a geographical community response to a pollution incident with a unified command structure. The unified command is supported by the four basic elements of an incident command system: planning, operations, logistics, and finance.

Area PREP exercises create realistic situations focusing on specific objectives. Emphasis is placed on the realism and decision-making process throughout the entire 30 weeks it takes to prepare an exercise. The National Strike Force Coordination Center collects data from critiques and other aspects of the exercise to help create and develop a standard for exercise evaluation. Data collected and lessons learned at each exercise are disseminated throughout the oil spill industry.

SWEDISH COAST GUARD RESPONSE TRAINING PROGRAM

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The efficiency of an oil spill response operation depends very much on the response commander's knowledge, experience, and possibilities of analyzing and reviewing the situation. Decisions must be made quickly and under great pressure.

All officers in the Swedish Coast Guard (CG) have the same basic training in response preparedness. During service they will utilize their knowledge on board in real operations and in exercises (local, regional, national, and international). Through different senior courses, some of them will be authorized to be on-scene commanders and finally response commanders. The possibilities for training response commanders under "real" conditions are limited. Weak points in the organization, decision procedures, command centers, and such are usually found during actual operations, however. The Swedish Coast Guard has decided on a strategy to train the response commander and his staff in their normal workplaces, with their normal tools, and with the people they are used to working with. To accomplish this, the Coast Guard has developed a portable computerized exercise support system providing the command with necessary data and images to run an exercise.

AUTHOR: Cdr. Dan Thorell has been Deputy Head of Response Operations at Swedish Coast Guard Headquarters since 1988. He is 39 years old and has served in the the Coast Guard since 1975. He began his service aboard CG cutters, moved to response vessels, and, in 1984, to a regional headquarters—where he remained until his current assignment.

RECOVERY OF SUBMERGED OIL AT SAN JUAN, PUERTO RICO 1994

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The January 1994 grounding and discharge of over 800,000 gallons (3,028,000 liters/3,028 m^3) of low API gravity No. 6 oil from the tank barge *Morris J. Berman* at San Juan, Puerto Rico was one of those infrequent but typically major events that set in motion a massive skimming and shoreline cleanup operation. As these actions proceeded effectively along the northern coast of Puerto Rico, it quickly became apparent that significant quantities of oil from the *Berman* had submerged and continued to recontaminate economic, historic, and environmentally sensitive coastal areas after the leaking barge and floating oil had been removed. Recognizing the unique nature of the problem and general lack of Coast Guard or industry-wide experience in the emerging field of submerged oil recovery, the federal on-scene coordinator (FOSC) formed a group within the overall organization to respond to the situation. The methods implemented by this group recovered approximately 145,000 gallons of oil from the seabed at an estimated cost of $8 million.

GROUP V FUEL OILS: SOURCE, BEHAVIOR, AND RESPONSE ISSUES

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Electric utilities have been increasing their use of Group V fuel oils (known in the industry as low-API gravity fuel oils or LAPIO), because of their relatively low cost and high btu values. Group V fuel oils are defined as having an API gravity less than 10 at 60° F (thus a specific gravity ≤ 1.00 g/cm^3). These oils have a wide range of densities and properties and thus cannot be characterized as a single product with a given set of properties and behavior. Group V fuel oils can float, be neutrally buoyant, sink, or all three, depending on their composition and the physical nature of the receiving waters (salinity, temperature, suspended sediment content). They can physically separate into fractions with different behavior. Three models are proposed for predicting the behavior of Group V fuel oil spills, based on observations at previous spills. If spilled directly into the water, heavier-than-water oil will form into drops and remain in suspension if there is any current. In no-current areas, sinking oil can accumulate on the bottom and be recovered. When mixed in the surf zone, the oil tends to pick up sand and sink, without ever stranding on shore. Special problems are associated with locating, containing, and recovering oil that is neutrally buoyant or on the bottom.

HEAVY OIL SPILLS: OUT OF SIGHT, OUT OF MIND

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Heavy oils include those low API gravity (LAPIO) petroleum hydrocarbons that will sink below the water surface, either to the bottom or to some level in the water column. While there is a tendency to ignore spilled oil that is no longer visible at the surface, submerged oil may resurface or be transported onto shorelines where it can present unexpected and reoccurring cleanup problems.

Factors influencing sinking and movement of sunken oil must be considered to guide heavy-oil spill contingency planning and response. Procedures that have been used successfully or show potential application for the location, mapping, and recovery of submerged oil should be included in planning. Decision diagrams are useful in the identification of appropriate procedures and technologies for varying oil characteristics and environmental situations. These decision diagrams include consideration of sunken oil assessment procedures, possible containment technology, and candidate recovery technologies.

CONDITIONS UNDER WHICH FLOATING SLICKS CAN SINK IN MARINE SETTINGS

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Ten spills were identified in which the oil initially floated, but eventually sank. In all cases, the oils were heavy residual products (such as No. 6 fuel oil) or heavy crudes. In seven of the cases, oil sank only after mixing with sand, by either stranding on the beach or mixing in the offshore surf zone. In two of the cases, oil sank after being heated during fires. In only one case was loss by evaporation proposed us the cause of the oil's not floating. Because incorporation of sediment (primarily sand) into the oil makes the oil-sediment mixture dense, the oil can separate from the mixture and refloat. It seems likely that the separation or settling out of the sand from the sand-oil mixture depends on the viscosity of the mix, and thus may depend on temperature.

BURIAL AND BREAKDOWN OF OIL IN COASTAL DUNE SYSTEMS

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In 1992 and 1994, sites where oiled beach material, resulting from tanker spills at sea, had been buried in sand dunes in 1978 were located. Analysis of samples from one site (Hemsby, Norfolk) was inconclusive but samples from Pendine in south Wales contained small quantities of hydrocarbon residues and bacterial populations capable of metabolizing catechol. Gas sampling also showed elevated concentrations of volatile hydrocarbons and carbon dioxide within the deposit compared with controls in adjacent sand dunes. Following the beaching of heavy fuel oil at Pendine in January 1994, oiled sand from the beach was deposited in the nearby dune system and a monitoring experiment was set up. Evidence of hydrocarbon degradation was found soon after deposition and was especially rapid close to the previous deposit. Progress of the oil decomposition is being monitored by collection and analysis (chemical and microbiological) of core samples and in-situ measurements of gaseous emissions. Because of problems of sand being moved by the wind and consequent concentration of oil residues on the surface, alternative methods of surface stabilization by vegetation are also being tested.

AUTHOR: Roger Daniels is a plant ecologist who has worked for the Institute of Terrestrial Ecology for 21 years. For the past 10 years he has taken a special interest in the impacts of the oil industry on plant and animal communities.

RESPONSE OPERATIONS TO THE *AEGEAN SEA* ACCIDENT

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The Greek flag ship *Aegean Sea* loaded with 79,094 tons of Brent blend, the light crude oil from the North Sea fields, coming from Sullom Voe terminal in the Shetland Islands, stranded at 4:50 a.m., December 3, 1992, when she was approaching the port of La Coruña on the northwest coast of Spain. The accident was followed by explosion, fire, and an oil spill UN — UN which precipitated a difficult, complex, and expensive response operation to control and mitigate the effects of oil pollution. Weather conditions did not allow the containment and recovery of oil at sea; therefore the response operations concentrated mainly on protecting sensitive areas, collecting oil in estuaries and harbors, shoreline cleanup, and recovery of crude oil and bunker remaining onboard the damaged ship.

The enormous pressure from the media and public opinion groups, the number of experts and observers wanting to come on scene, and the persistence of the commercial firms offering all kinds of equipment and products, in particular chemical dispersants and bioremediation techniques further complicated the situation. Compensation claims for expenses and damage caused by the oil spill is another important chapter of this incident. Intense claims activity went on during the operations and an agreement was signed in respect to claims handling.

This paper describes the above-mentioned operations and comments on other aspects of the crisis management.

AUTHOR: Since 1992, Fernando Pardo has been head of Maritime Transport of Dangerous Goods, the General Directorate of Merchant Marine, Spain. He had previously served as head of their Maritime Pollution Division, and has headed the Ministry of Public Works' Ports Safety Division. Among other assignments, he was a member of the EEC Advisory Committee for the Control and Reduction of Pollution Caused by the Spillage at Sea of Hydrocarbons and Other Harmful Substances, and a National Expert on Maritime Pollution with the General Directorate of Environment, Nuclear Safety and Civil Protection, the Commission of European Communities in Brussels.

HANDLING AND DISPOSAL OF OILY WASTE FROM OIL SPILLS AT SEA

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Disposal of recovered oil and debris following an oil spill at sea can present a real challenge to the spill response team: many technical issues and options are involved. The mainly oil component should be kept separate from the mainly debris component of the waste as far as possible. This not only reduces handling problems, but also provides a better opportunity to wash or aerate the debris to allow it to be classified as nonhazardous. Nonhazardous waste landfill remains a potentially cheap option where regulations allow it. Solidification or stabilization techniques may be useful in the future to convert waste oil and debris to a suitable form for landfill. Reclamation of recovered oil is attractive in principle, particularly for large spills; but the presence of contaminants makes it difficult, in practice, for the oil to be recovered. Incineration is technically feasible and mobile/transportable systems are potentially attractive, provided permits can be obtained. A number of biological methods including land farming appear to have promise. Further development work is needed to determine possible techniques for this application.

SCIENTIFIC CRITERIA TO OPTIMIZE OIL SPILL CLEANUP

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Aberdeen University Research and Industrial Services (AURIS) undertook a joint industry pilot investigation on "Scientific Criteria for Optimizing Oil Spill Cleanup Operations and Effort" from October 1993 to March 1994. This project examined the worldwide scientific literature on the effects of oil spills, and experimental and natural clearances, on both rocky shores and salt marshes, to ascertain whether defensible scientific criteria could be used to establish the appropriate end point for oil spill cleanup operations. After exhaustive screening of the literature, the investigation found that ecological recovery of shore biota usually follows natural time scales of up to three years for rocky shores and five years for salt marshes, regardless of cleanup. Cleanup has a negative or marginal influence on these time scales, so there is little *scientific* justification for shore treatment. It may be justified, however, by socioeconomic factors relating to recreation, tourism, fisheries, aquaculture, visual amenity, or birds and mammals. In exceptional cases, where oil has formed heavy smothering deposits or toxic subsurface deposits, there are grounds for treatment to promote ecological recovery of the shore biota within the expected time scales.

AUTHOR: David Sell is Projects Manager of the Aquatic Sciences Section of AURIS, Ltd., a consultancy owned by Aberdeen University. His interests are marine fouling of oil platforms and effects of oil-related developments on the marine environment. He holds a Ph.D. from Aberdeen University.

NET ENVIRONMENTAL BENEFIT ANALYSIS FOR OIL SPILL RESPONSE

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This paper discusses Net Environmental Benefit Analysis (NEBA) from an ecological point of view, that is, the weighing of advantages and disadvantages of various spill responses with regard to flora and fauna and their habitats, compared with no response. Particular attention is paid to nearshore dispersant spraying and shore cleanup; and the scientific case history and experimental evidence that can be brought to bear on these responses is reviewed. For shoreline cleanup, consideration is given both to the shore itself and to potentially interacting systems that could be affected in various ways depending on the spill response (e.g., a bird colony or nearshore aquaculture facilities). For some scenarios, nearshore dispersant spraying can offer a net environmental benefit. For most cases of shore oiling, there is little ecological justification for any form of cleanup if only the shore itself is considered, but moderate cleanup carried out for the sake of interacting systems is acceptable. Aggressive cleanup often delays recovery.

AUTHOR: Jenifer Baker is a consultant specializing in coastal ecology. She has 25 years of experience with oil pollution problems and has worked in many parts of the world.

EVALUATING OIL SPILL CONTINGENCY AND PREVENTION PLANS USING MEASURES OF QUALITY, NOT QUANTITY

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The Oil Pollution Act of 1990 has led to a dramatic increase in the number and volume of formal plans intended to mitigate the impacts of spilled oil. The U.S. Coast Guard and state regulatory offices have not developed evaluation methodologies that will ensure that contingency planners capture essential information rather than simply mass-producing documentation for bureaucratic review. This paper reports on a methodology for evaluating contingency and prevention plans based on a structured representation of the plan and assignment of relative importance weights by experts using a commercially available decision support aid. The methodology is tested using two examples: a comparison of the plans used during the *Exxon Valdez* response, and the development of a prevention plan evaluation tool for the State of Washington. The evaluations show that the elements of a plan are typically of very unequal importance. The elements evaluated as least important by the experts, however, are typically the easiest to provide. The evaluation methodology proposed will help focus reviewers and planners on those elements critical to pollution prevention and response.

TAMPA BAY SPILL: COMMAND AND CONTROL ISSUES

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A three-vessel collision in the Tampa Bay entrance channel on August 10, 1993, caused a huge explosion and fire, major damage to all vessels, and spills of 330,000 gallons of No. 6 oil and 32,000 gallons of a mixture of light petroleum products. A dynamic team was forged to respond to a complex series of problems. Functional command centers and forward command posts were established, a unified command system was implemented, and federal, state, and local governments and the multiple responsible parties coordinated efficiently. The unified command dealt effectively with considerations such as vessel control, fire fighting, lightering, salvage, pollution cleanup, and impacted wildlife. An active approach to the media resulted in critical information being relayed to the public and the response effort being portrayed accurately. The development of trust with multiple local governments enabled the response team to meet local needs while gaining their support. The unified command dealt with difficulties such as communicating effectively with the field and ensuring safety for large number of responders involved in a variety of hazardous activities.

AUTHOR: Capt. Richard W. Harbert is Commanding Officer, U.S. Coast Guard Marine Safety Office, Tampa. He was the federal on-scene coordinator for the August 10, 1993, Tampa Bay spill. He holds a bachelor of science degree from the University of Washington and a master of science degree from the University of Michigan.

BEACH CLEANING AND THE ROLE OF TECHNICAL SUPPORT IN THE 1993 TAMPA BAY SPILL

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This paper reports on the decision-making process and shoreline cleanup methods used following the oiling of 23 km (14 mi) of ocean-front sand beaches in the St. Petersburg, Florida, area in August 1993. Although cleanup of sand beaches usually is relatively straightforward, in this instance the high recreational use of the beaches during the traditional Labor Day weekend in early September created pressure to deal with the shoreline oiling in a rapid and efficient manner. Achieving this goal required a coordinated effort by all participants in the response operation. Key points include the following:

- The importance and value of consensus among state, federal, and responsible party representatives
- Use of systematic beach survey measurements and data to determine the extent and type of surface and subsurface oiling and to define the scope of the problem
- Field testing, evaluation, and final development of recommendations for cleanup
- Use of heavy equipment and the development of cost estimates for alternative methods in the context of timing and tradeoffs.

The consensus reached by the technical support group for the cleanup operations involved a combination of manual removal, mechanical removal, surf-washing, and tilling. The possible effects of sediment removal were evaluated through use of beach profile and sand budget information from a long-term monitoring program. This spill response emphasized the role and importance of technical support and the interaction with field supervisors and operators, to develop appropriate and successful cleanup strategies and techniques.

AUTHOR: Edward Owens is a coastal geologist who since 1970 has been concerned with oil spills in a range of temperate, tropical, and arctic environments. He has been involved with numerous response operations and has presented shoreline response training courses worldwide. During the Tampa Bay spill he was contracted by Maritrans to provide technical support for their cleanup operations.

RESPONSE TO OILED WILDLIFE IN TAMPA BAY

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Tri-State Bird Rescue & Research, contracted by one of the responsible parties (Maritrans), managed the wildlife response following the three-vessel collision and oil spill in Tampa Bay on August 10, 1993.

Four hundred sixty-one animals (461) were delivered during the response; 370 of the animals were oiled. Species included brown pelicans, cormorant, tern, egret and heron sp., and two reptiles, the loggerhead sea turtle and the gopher tortoise. The most common taxon was brown pelicans (291). Of the oiled animals received, 80 percent were successfully treated and returned to the wild. Of the brown pelicans received, 90 percent were successfully treated and released.

This paper discusses the care provided for the oiled animals and addresses the special aspects of this wildlife response, including a team-work approach, involving training and use of local rehabilitators, veterinarians, and concerned citizens; agency coordination in treating endangered species; and the challenges of operating a wildlife hospital outdoors.

OIL SPILL CAPABILITY ASSESSMENT PROGRAM FOR FIXED FACILITIES

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Mobil's oil spill capability assessment program is used to determine improvements needed in oil spill prevention and response in Mobil's worldwide terminals, blend plants, and offshore facilities. The rationale for this program and its development, including the protocol and methodology used during the assessments, are presented here.

The assessment process includes two to five days to conduct the survey, depending on the size of the facility, and three to five days of preparation and follow-up work. A detailed checklist, personnel interviews, records review, and walk-around surveys of the facility and its equipment and local cooperatives are used in conducting an assessment. To date, 163 assessments have been completed—the majority outside the United States, with most, 85, conducted in Asia and the Pacific Rim.

The process of conducting an assessment and the general types of findings and recommendations is discussed. Recommendations are divided into five categories: facility, equipment, procedures, training, and other (including issues, such as local cooperatives and contractors, environmental sensitivity, and national contingency plans).

AUTHOR: Jeff James has been with Mobil for 23 years and has had assignments in terminals and refineries. He has hands-on experience with numerous emergencies, including oil spills. For the past four years, he has been concerned specifically with oil spills and crisis preparedness. He has conducted 40 oil spill response capability assessments in more than 20 countries.

JUST MAKE IT HAPPEN: LOGISTICS CONCEPTS, PROCESSES, AND INFRASTRUCTURE IN MAJOR OIL SPILL RESPONSE

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A comprehensive examination of the major logistics elements of a large-scale oil spill removal organization (OSRO) has been completed, focusing on the contingency support aspects of the organization—the development of oil spill logistics concepts, processes, and infrastructure. The key principles associated with command and control, contingency planning, and resource management were considered in the context of the most recent major response—the barge *Morris J. Berman* spill at San Juan, Puerto Rico. The manner in which sound logistics support strategies quickly injected organization into response processes, shaped available options, and influenced the success of a major oil spill cleanup operation was observed and examined.

AUTHOR: John R. Ives is the Director of Logistics for the National Response Corporation. A former U.S. Air Force logistics officer, he served as the Chief of Air Force Contingency Logistics for the Central/South American theater and Logistics Squadron Commander at Dhahran Air Base, Saudi Arabia, during Desert Storm. An author published in various professional journals, he possesses a Master of Science degree in management from Embry Riddle Aeronautical University.

DYNAMIC CONTINGENCY PLANNING WITHIN A COMMAND AND CONTROL FRAMEWORK

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In the development of the area contingency plan, the federal on-scene coordinator (FOSC) received a vast array of response expertise from the membership of each area committee. This expertise provided a wealth of response knowledge vital in contingency planning. Additionally, each agency in the area committee could be involved in the response command structure. These agencies, each with very different policies and procedures, offer a unique challenge to the FOSC in implementing that area contingency plan.

Another challenge faced by the FOSC is ensuring that the operational expertise contained in the area contingency plan is available to each member of a diverse response organization, including personnel mobilized from agencies in areas outside the FOSC area of responsibility, who may be unfamiliar with both the contingency planning process and the command and control (C & C) structure they are augmenting.

The solution to both these challenges lies in arranging the area contingency plan in a format outline directly representing the C & C response structure determined by the FOSC and the area committee. This paper discusses the steps in the Savannah Area Contingency Plan and the evolution of its format; the operational and training advantages of this format; and the potential for this format to incorporate improvements.

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TO IMPROVE THE RESPONSE TIME: A COMMUNITY DECISION

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The effectiveness of a good contingency plan requires trained personnel and specialized equipment and can only be improved through sound predetermined operational strategies, to which all impacted communities contribute. To achieve such a plan depends on the willingness of potential on-scene commanders to recognize the competency of all stakeholders within a community.

This conclusion was derived from many informational and training sessions held in small and large communities following the amendments to the Canada Shipping Act. This legislation requires any response organization wishing to obtain accreditation to have specific action plans to protect and clean up designated sensitive areas.

The results of these sessions defined both the sensitive areas and the most appropriate strategies for mitigating the impact of an oil spill. The sessions approach was used in Montreal, Quebec City, and Sept-Iles to plan for the protection of the St. Lawrence ecosystem which is made up of river, estuary, and ocean-type environments.

EFFECTIVELY MANAGING LEVEL OF EFFORT IN OIL SPILL CLEANUP: RESOLVING THE "HOW CLEAN IS CLEAN" ISSUE

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Successful oil spill response requires effectively managing the level of effort devoted to response operations. This includes choosing appropriate technologies and implementing them to achieve optimal environmental benefit, while controlling costs. At the end of the response, effective management requires resolving the "how clean is clean" issue to ensure a smooth termination of the response effort. Various approaches to making these management decisions are reviewed, based on experience in the *Exxon Valdez, American Trader,* and *Morris J. Berman* spills. The advantages and constraints of these approaches are summarized, along with suggestions about how the process might be facilitated.

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THE PRECAUTIONARY APPROACH AND THE IMO

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The International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) is developing guidelines on the implementation of the "precautionary approach" in the work of IMO, as set out in Principle 15 of the Rio Declaration and Agenda 21. This paper provides an introduction to the precautionary approach as it has been developed in international law. Second, proposals before MEPC to apply the precautionary approach are discussed, including a framework for decision making within IMO. An example is provided of how such a framework would be applied in practice to an actual issue before the IMO.

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PREVENTION OF POLLUTION FROM SHIPS IN ARGENTINA: GOVERNMENT-INDUSTRY COOPERATION

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The Argentine Coast Guard is a security force acting as police coast guard and providing within its broad scope other outstanding services related to navigation safety and environmental protection. It is an institution with a deep historical background, which finds its roots in the colonial office of Captain of the Port, established by Spain January 8, 1756. This office was regulated by the Spanish Colonial Code until March 8, 1793, when King Charles V enacted the General Ordinances which outlined the main principles that rule the institution today.

Those regulations have covered water pollution since 1937, but only in 1977 did the institution start work on the principles laid down by the International Maritime Organization, through the efforts of the Marine Environmental Protection Committee. The first principle is prevention. The second is that anyone who causes pollution is required to pay. In 1979, by Maritime Ordinance 4/79, vessels were allowed a 10-year period (1981–1991) to adjust to these new rules. These developments took place in accordance with MARPOL 73/78, an agreement endorsed by Argentina in 1993. This information was disseminated in Latin America through free courses and technical advisory services.

AUTHOR: Senior Officer (Prefecto Mayor) José Manuel Rolón joined the Argentine Coast Guard February 24, 1960. He studied for three years at the School of Officers and graduated as Junior Officer. He attended several specialized training courses in the country and abroad. Since 1977 his duties have been directly related to environmental protection.

THE M/C *HAVEN* OIL SPILL: ENVIRONMENTAL ASSESSMENT OF EXPOSURE PATHWAYS AND RESOURCE INJURY

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On April 11, 1991, an explosion on the M/C *Haven* resulted in a fire and the release of approximately 145,500 metric tons (t) of heavy Iranian crude oil near Genoa, Italy, in the industrialized coastal region of the northern Ligurian Sea. Approximately 30,000 t of cargo oil was released to the sea, of which only one-tenth reached the shoreline beaches along the Italian Riviera. An environmental assessment of the affected region indicated injury from the spilled oil to subtidal *Posidonia/Cymodocea* (seagrass) beds and the deep-sea benthic community and associated commercial fisheries. This was one of the first oil spills in which it was documented that oiled, shallow subtidal sediments (<10 m) were efficiently cleaned and large amounts of residual oil reached the deep sea bottom (100 to 400 m) as a result of burning cargo.

SPILL RESPONSE MANAGEMENT AND THE *MORRIS J. BERMAN* SPILL: THE FOSC'S PERSPECTIVE

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The grounding of the tank barge *Morris J. Berman* triggered a massive response effort. Fifteen U.S. Government and Commonwealth of Puerto Rico agencies and more than 30 contractors joined forces to clean up the spill. An ICS-style unified command system was successfully, if not perfectly, implemented in this incident. The response organization evolved as the operational situation changed, and the flexibility of the ICS approach was crucial to this ability to adapt. The decision-making process used in this response also ensured that timely and correct decisions were reached with the views of all involved entities, government and nongovernment, fully considered.

However, the lack of coordinated planning and dialogue among various sectors of the response community before the incident continues to hamper the collective ability of responders to come together quickly and effectively in emergency situations. It is time for the response community to develop a consensus standard that provides at least the nucleus of a common approach to spill response management.

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MANAGING HERITAGE RESOURCE PROTECTION: A CASE STUDY FROM THE *BERMAN* SPILL RESPONSE

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Heritage resources were a significant concern during the *Morris J. Berman* oil spill response, which began on January 7, 1994, in Puerto Rico. Numerous pre-Columbian artifacts and archeological sites, along with some of the oldest historic structures under U.S. jurisdiction were at risk from the spreading oil and subsequent response activities. A group of interagency professionals quickly formed into what was soon known as the Heritage Resources Management Team to deal with the myriad evolving issues involving heritage resources. Discovering success in a team approach, this core team became an integral, high-performing part of the larger response organization. Although this paper presents a case study of how heritage resources were tackled during the *Morris J. Berman* oil spill response, the decision-making and problem-solving methods described are applicable to any response effort. Incorporating heritage resource protection strategies in response planning and organization is crucial for mitigating future threats to these priceless remains of our history.

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THE *MORRIS J. BERMAN* SPILL— MSRC's OFFSHORE OPERATIONS

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The January 1994 spill off the coast of Puerto Rico may best be known for the oil it deposited on beaches of a prime resort area of this beautiful island during a peak tourism period. But we at the Marine Spill Response Corp. saw the spill as the first true field test, under real-life conditions, of one of our 16 specially designed, 208-foot oil spill recovery vessels.

While deemed successful, the operations in the offshore environment—an area little covered by oil recovery manuals—highlighted a number of important considerations, which may be grouped into three areas: impact of physical factors, both human and natural; flexibility in execution of procedures to suit the specific situation; and issues involved in the decontamination process.[2]

Being aware that the enhancement of policies and procedures is a continuing effort, we can apply knowledge gained during the *Morris J. Berman* spill to recommend—and, where appropriate, implement—measures to make operations still more efficient and effective in response to future spills.

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OPERATIONAL CONSIDERATIONS— TANK BARGE *MORRIS J. BERMAN* SPILL

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The tank barge *Morris J. Berman* grounded on January 7, 1994, spilling at least 750,000 gallons of low API fuel oil onto the most heavily used beaches of San Juan, Puerto Rico, at the height of tourist season. The vessel's condition deteriorated rapidly due to heavy ocean swells. Most of the discharged oil was blown directly ashore into three natural containment basins. The rest beached in varying quantities along 65 kilometers of shoreline on the north coast from Loiza to Punta Borinquen. On January 8, lightering and salvage operations commenced, the barge was removed from strand on January 15, towed offshore, and scuttled approximately 28 kilometers north of San Juan in 1,000 fathoms of water. Response operations were complicated by the large quantities of oil that sank while retaining its original viscosity and remaining highly mobile. This required a technically, logistically, and financially demanding cleanup operation involving diving, dredging, sand removal, sand washing, sand replacement, and biodegradation.

Section V

SUSTAINABLE GLOBAL PREPAREDNESS

Session T2B: International Conventions on Funding and Intervention

Chairman: Daniel Sheehan
U.S. Coast Guard

Session T3D: Industry/Government Cooperation in Planning and Response I

Chairman: Edmond P. Thompson
U.S. Coast Guard

Session T4D: Industry/Government Cooperation in Planning and Response II

Chairman: Richard Bavister
Exxon Company International

Session W3A: International Legal Framework

Chairman: Mark Weller
Texaco, Inc.

Session Th3A: Bilateral Regional Agreements

Chairman: David Edwards
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OIL POLLUTION ACT OF 1990: CURE, CATALYST, OR CATASTROPHE

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Congress departed from the international community to unilaterally enact comprehensive oil spill legislation, the Oil Pollution Act of 1990 (OPA). OPA legislates in several areas not covered by the international liability scheme for oil spills, including requirements for double-hull vessels, manning standards for foreign vessels, vessel response plans, and detailed and extensive provisions for liability for natural resource damages. Thus, it clearly provides better protection for the U.S. marine environment than would the international liability scheme. While OPA has encouraged the international community to take certain steps to provide greater protection, significant differences remain between OPA and the applicable international rules and standards. Protection of the marine environment on a global scale would be increased if the United States and the international community could bridge these differences.

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FRANCE AND THE RIGHT OF INTERVENTION ON THE HIGH SEAS

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Over 20 years, France has developed a system for making the best use of the right to intervene in case of a pollution threat established in accordance with international law. A single authority—the Préfet Maritime—has been established for each of the three coasts of France. Once it has been recognized that a ship may pose a pollution threat to the shoreline, even if the ship is on the high seas, the Préfet may act to either persuade the captain or shipowner to take necessary measures (such as arranging for a tow) to prevent an accident, or to take direct action himself as required. So far, persuasion, sometimes through a ship's flag state embassy, has proved to be sufficient in every case.

THE *BRAER*: LEGAL ASPECTS OF A MAJOR OIL SPILL

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The International Oil Pollution Compensation Fund (IOPC Fund), an intergovernmental organization with 58 member states, has recently been involved in a major oil spill of great interest both legally and technically, namely, the *Braer* incident, which occurred in January 1993 in the United Kingdom. The *Braer* was laden with approximately 84,000 metric tons (t) of crude oil when it grounded off the Shetland Islands. The ship broke up and the entire cargo escaped into the sea. The United Kingdom Government and Shetland Islands Council incurred expenses for cleanup operations, but these costs were fairly limited, estimated at not greater than US$6 million. The incident resulted in a very large number of claims from small businesses and individuals who suffered economic losses. A local claims office was set up on Shetland to handle these claims. So far, over 1,000 claims have been settled and paid for, representing a total of almost US$45 million. These claims cover losses suffered by fishermen, salmon farmers, crofters, and owners of houses that became polluted by wind-blown oil spray. Many of these claims have given rise to difficult legal problems regarding the admissibility of claims for compensation, in particular those concerning so-called pure economic losses. This paper addresses the practical problems that have arisen in handling the claims and analyzes some of the legal problems encountered.

RESEARCH ON MARINE POLLUTION, PREVENTION, AND RESPONSE IN SHENZHEN, CHINA

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Shenzhen is situated near Hong Kong. About ten years ago, two harbors, Shekou and Yantian, located in the west and east of Shenzhen respectively, were under construction. Harbors and facilities have been planned by industries, while environmental concerns have been more or less neglected. A "Report of Research on the Feasibility of a Marine Pollution Prevention System for Seaports in Shenzhen" was discussed in May 1993 in Shenzhen. This paper describes the main elements of that program, including an oil spill monitoring and control system, contingency planning for oil spill response, and cooperation among industries and government in dealing with marine pollution. The aim of this paper is to demonstrate how concern for the environment should be established from the beginning in constructing a seaport. Finally, the end of this paper presents lessons learned, concerning the financial support of oil pollution response facilities, management problems and their countermeasures, implementation of international conventions on marine pollution prevention, and the importance of port state control. These lessons may be helpful for developing countries in planning their seaports to achieve better environmental protection.

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NORWEGIAN POLLUTION CONTROL AUTHORITY WORK ON SHIPWRECKS

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Work on shipwrecks is one of the Norwegian Pollution Control Authority's (NPCA) priority areas. The basis for the "Wreck Program" was the desire to have a complete compilation of shipwrecks lying along the Norwegian coast. The project was defined in three phases: registration, priority ranking, and required action stages. A database consisting of 2,100 entries was built up from the study of archives in Norway and abroad. The search was limited to ships of over 100 tons gross weight that had gone down in Norwegian territorial waters after 1914. Wrecks were considered to be one of three types: of high pollution, possible pollution, or no pollution potential. In 1993, the NPCA commissioned the physical inspection of 15 wrecks using divers and remotely operated vehicles (ROVs). Findings were compiled in reports that indicate the condition of the wrecks varies greatly. Corrosion has set in, and the quantity of oil involved is greater than anticipated. This paper covers the registration work, cooperation in planning activities, 1993 inspection reports, and further NPCA plans for Norwegian work on shipwrecks. Experiences relating to emptying wrecks are also noted.

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PREPAREDNESS PLANS VERSUS ACTUAL RESPONSE: THE INCIDENT SPECIFIC PREPAREDNESS REVIEW OF THE T/B *MORRIS J. BERMAN* MAJOR OIL SPILL

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The Incident Specific Preparedness Review (ISPR) of the T/B *Morris J. Berman* oil spill response was the first convened by Commandant (G-M). It developed procedures and methodologies in examining oil spill responses that compared the planned implementation of the Area Contingency Plan with the actual response. The ISPR yielded numerous lessons learned that should lead to improvements in response planning.

AUTHOR: Captain Richard C. Vlaun is a 1969 graduate of the U.S. Coast Guard Academy. Much of his career has been in the fields of marine safety and marine environmental protection. He is currently the Chief, Marine Safety Division, Fifth Coast Guard District.

PARTNERSHIPS IN SPILL RESPONSE: A POLICY ALTERNATIVE—THE CANADIAN EXPERIENCE

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This paper reviews the main conclusions and recommendations of Canada's 1990 Public Review Panel Report on Tanker Safety and Marine Spills Response Capability concerning oil spill response, as well as the subsequent assessment of various policy options leading to the selection of a government/industry partnership. The framework for marine spill response in Canada was established by legislation in amendments to the Canada Shipping Act. A variety of issues have been raised during consultations in relation to the areas of risk, the equipment needs for responding in a tiered fashion to a 10,000 metric ton spill, the personnel requirements and their training and exercise requirements, the management structure, the fee structures and the role of the advisory councils.

MAJOR OIL SPILL RESPONSE PROGRAM OF THE PETROLEUM ASSOCIATION OF JAPAN

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The Petroleum Association of Japan (PAJ) has been implementing a major oil spill response program since 1991, supported and subsidized by the Ministry of International Trade and Industry (MITI), from the viewpoint of contributing to a secure, stable oil supply for Japan. PAJ's program consists of the stockpiling and lending of oil spill response equipment, and research and development related to oil spills and response techniques. In the event of major oil spill incidents, PAJ will lend the equipment stockpiled at the base, free of charge, to government agencies or parties concerned upon their request, in order to minimize damages. Those parties who borrow the equipment bear the expense of transportation, deployment, cleanup, and repair. PAJ's purpose is to support initial response operations by supplying additional equipment.

To stockpile and to release it, PAJ so far has four domestic and three overseas bases, with domestic bases in Chiba, Mizushima, Yokkaichi, and Niigata, and overseas bases in Julong East, Singapore; Port-Klang, Malaysia; and Al-Khafji, Saudi Arabia. The equipment installed includes oil skimmers (36 units), foamed flotation booms (16,000 m), inflatable booms (7,000 m) and portable tanks (56 units).

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ESTABLISHING OPTIMAL RESPONSE STRATEGIES USING REAL-TIME CURRENT OBSERVATIONS: A LOCAL, COOPERATIVE APPROACH

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With the mandates of the Oil Pollution Act of 1990 requiring stockpiles of mechanical recovery equipment, an effective baseline response strategy was needed for the U.S. Coast Guard Houston/Galveston Captain of the Port Zone. A small group of federal, state, and industry volunteers established a study team to set baseline response and equipment deployment strategies based on local tide and current data. Procedures consisted of strategically positioning a series of buoys within a known area of concern and tracking the buoys with a handheld global positioning system unit. Patterns and trends were established, tested in a field deployment exercise, and shared with members of the oil spill response community. The study resulted in the following observations:

- Federal-state-industry cooperation in response planning is essential.
- A pragmatic methodology is best suited for determining tidal and current trends and the potential effect on response equipment deployment strategies.

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TO BOLDLY GO WHERE NO STATE HAS GONE BEFORE

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The Marine Safety Division of the 11th Coast Guard District and the California Office of Oil Spill Prevention and Response are pursuing new avenues to assure that federal, state, and local efforts in California achieve the goals of the Oil Pollution Act of 1990 and the Lempert-Keene-Seastrand Oil Spill Prevention and Response Act of 1990. Coordination of the seven California area committees, publishing detailed area contingency plans, and the implemention of a memorandum of agreement on oil spill prevention and response highlight recent cooperative successes. In 1994 a joint Coast Guard/state/industry incident command system task force drafted an ICS field operations guide and incident action plan forms that meet National Interagency Incident Management System and fire scope ICS requirements.

OIL SPILL RESPONSE PLANNING IN EASTERN EUROPE: A BULGARIAN CASE STUDY

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The opening of Eastern Europe to western companies has created a need for international cooperation between these companies and Eastern European governments. This new relationship presents a particular challenge for the oil industry as well as an opportunity for emerging governments to benefit from western companies' experience. In 1993, Texaco Offshore Bulgaria submitted the first western oil spill response plan for the Bulgarian Black Sea. This paper presents a case study based on Dames & Moore's preparation of this plan. The plan was prepared in cooperation with the Bulgarian government, and included public discussions. It joined the country's existing response resources with Texaco's existing international response strategy. The result was a plan combining local knowledge and support and western capability and experience. This paper outlines the issues addressed in the plan. One critical point discussed below is that of protecting tourist beaches, which are an essential part of the Bulgarian economy. The paper concludes with a discussion of how cooperation between western industry and Eastern European government can result in successful oil spill response planning and help identify key factors for both attaining and maintaining preparedness in the face of the new challenges.

INTERNATIONAL CONVENTION ON OIL POLLUTION PREPAREDNESS, RESPONSE AND COOPERATION—AN OVERVIEW

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The casualties of *Torrey Canyon* in 1967 and the *Amoco Cadiz* in 1977 gave rise to the Civil Liability Convention 1969, the Fund Convention 1971, and the Salvage Convention 1989. The *Exxon Valdez* casualty in 1989 gave rise to the Oil Pollution Act 1990. It also gave rise to a new Convention known as the Oil Pollution Preparedness, Response and Co-operation Convention 1990. This convention is likely to receive greater approval from the shipping industry as it concentrates on mitigating loss and damage resulting from oil pollution through preparedness and early response and on preventing pollution by encouraging salvage.

The basic operative provisions of the convention are oil pollution emergency plans and reporting procedures, action on receiving an oil pollution report, national and regional response systems, international cooperation in pollution response, research and development, technical cooperation, bilateral and multilateral cooperation, institutional arrangements, and reimbursement of cost of assistance.

While not imposing any legal liabilities, the convention will undoubtedly motivate the shipping industry and all maritime states to prepare adequately for disasters and accidents. This will ultimately benefit the environment, and is a welcome start to be built upon.

AUTHOR: Capt. Ashok Mahapatra was born in November 1955, and he first took command of a foreign-going ship in April 1983. In June 1986, he joined the Directorate General of Shipping as a Nautical Surveyor. He completed a dissertation on Human Factors Affecting Marine Collisions in 1991 for an extra masters degree; he has presented papers at various international seminars and conferences.

IMO-OPRC INFORMATION SYSTEM

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To facilitate response activities of the International Maritime Organization (IMO) and its member states with respect to oil pollution in the Persian Gulf, the IMO Oil Pollution Co-ordination Centre (OPCC) was established in February 1991. During such operations and other relevant activities, it was recognized that databases on national contact points and the type of assistance member states could offer would be valuable and should be developed. In addition, the OPCC has developed other databases and utilized them when the OPCC responds to oil pollution emergencies and provides general advice concerning oil pollution preparedness and response to member states. These activities are related to some of the requirements assigned to IMO under the International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990 (the OPRC Convention). The convention will enter into force on May 13, 1995.

AUTHOR: Since May 1991, Kiyoshi Ohne has been on secondment from the Maritime Safety Agency of Japan to the Marine Environment Division of IMO. He acts as Information Officer in the Oil Pollution Co-ordination Centre to assist in the implementation of the OPRC Convention.

DEVELOPMENT OF EFFECTIVE NATIONAL RESPONSE SYSTEMS

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A commonsense approach is proposed for the provision of guidance to developing countries engaged in the formulation of national oil spill response systems. Key to the concept is the development of the system by the country's own professionals with the help of an international assistance team (IAT). The membership of the IAT is custom designed to suit the culture and technical needs of each country.

The international assistance team provides the training necessary to the professionals from the receiving country who will draft the national response policy and oversee the drafting of the national contingency plan. The IAT then enters into a partnership with this core group to complete the remaining response system development. The involvement of the IAT decreases as the program progresses towards self-sufficiency.

The program's goal is to develop a sustainable response system. The planning process will follow already established, internationally accepted practices such as risk assessment and identification of sensitive areas to protect. In cases where the identified risks and sensitive areas necessitate a larger system than the country can sustain, bilateral and regional agreements will be sought to guarantee rapid assistance in the event of a spill. The program is compatible with the concept of "twinning," where a developed country enters into partnership with a developing country, thereby increasing the sustainable level of response.

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IMO'S STRATEGY FOR THE IMPLEMENTATION OF THE OPRC CONVENTION

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The International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) will enter into force May 13, 1995, less than five years after its adoption by a global diplomatic conference convened by the International Maritime Organization in December 1990. However, since then IMO has actively pursued a strategy for implementing the OPRC Convention in close cooperation with interested governments and industry. The primary objective of this strategy is to enhance the capacity of countries to effectively carry out the requirements of the convention and strengthen IMO's ability to assist countries in this process. The strategy is realized by action taken by IMO's OPRC standing working group, in which government and industry experts participate, and by IMO staff, experts, and consultants as part of a technical cooperation program for the protection of the marine environment.

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OIL SPILL REGULATORY SYSTEMS IN MEXICO AND THE UNITED STATES

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Mexico and the United States are at a critical point in the process of redefining their trade relationships and integrating their economies. As the North American Free Trade Agreement increases trade, there is likely to be a corresponding rise in oil production, transportation, storage, and use, and with this a greater potential for oil related spill incidents. As a result, there will be a need for regulatory reform and new policy development in oil spill prevention, planning, and response. Both the U.S. and Mexico have established, although somewhat different, regulatory systems that address oil spills, as well as a history of efforts to standardize and coordinate oil spill related activities. However, recent events have underscored the need to evaluate existing systems and look for new ways to develop integrated oil spill control mechanisms. These mechanisms are already evolving; and with the continuing effort to reform regulatory systems and increase coordination, there seems to be considerable promise for the common future of Mexico and the United States on this issue.

AUTHOR: David Lopez is Chief of the Western Operation Section of the Emergency Response Division of the U.S. EPA in Washington, D.C. From May until October 1994, he was assigned to the U.S. Embassy in Mexico City to provide technical assistance in the area of hazardous waste.

TRANSBOUNDARY RESPONSE OPERATIONS: A LOOK TO THE NORTH

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The prospect of conducting pollution response operations in the waters of another country is or should be daunting to American oil spill response organizations (OSROs), especially those capable of large-scale deployment of forces across national borders. Problems raised by transboundary operations are very complex, require solutions to be developed by governments, but with OSROs at the negotiating table, and should be addressed well before the pollution incident occurs. One of the most difficult impediments is a legal one, the OSRO's liability when operating in a foreign jurisdiction, but other barriers exist as well, such as customs and immigration requirements, labor laws, tax and insurance issues, and disposal of waste.

This paper addresses these problems, focusing chiefly on the liability question, using Canada and existing Canadian law to illustrate the difficulties faced by transboundary response operations. It cannot be taken for granted that close cooperation in responding to a transboundary spill will automatically occur, even where adjoining nations are good friends and have similar legal systems. The paper explains why this is so, and illustrates the kinds of impediments that should be removed in advance, if an effective response is to be launched when a spill happens in a transboundary setting.

AUTHOR: Laurie L. Crick, an associate with the Washington, D.C. law firm of Dyer, Ellis, Joseph & Mills, specializes in maritime and environmental law. She received her bachelor's degree in business from the University of Kentucky in 1986 and her juris doctor from the University of Virginia School of Law in 1989.

IMPEDIMENTS TO CROSS-BOUNDARY OIL SPILL RESPONSE ALONG UNITED STATES BORDERS

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The Oil Pollution Act of 1990 (OPA 90) promoted a coordinated industry and government enhancement of response resources to combat oil spills effectively in the United States. However, the United States remains vulnerable to oil spills near the borders it shares with Canada, Mexico, and various nations in the Caribbean due to legal and administrative impediments associated with cross-boundary spill response activities.

This paper explores cross-boundary related issues that could hinder a response and the relationship and roles of industry and government with regard to such issues, and provides recommendations to enhance improved cooperation between government and industry to facilitate response activities. The international structure that currently exists—globally, regionally, and bilaterally—provides a basic framework that promotes cooperation between nations to respond harmoniously to spills threatening the shores of neighboring countries. However, the existing agreements and understandings only provide a basic umbrella. They require planning and implementation of details and commitment to take the specific actions required to implement these agreements and understandings fully. As a result, the enhanced private response capability that now exists in the United States may not be available in a spill involving cross-boundary operations. Neighboring nations must take action to facilitate cross-boundary activities by responders by providing responder-immunity protection similar to that provided under OPA 90 and by removing potential impediments to response activities: laws and other requirements relating to matters such as customs, immigration, and safety training.

AUTHOR: Jonathan K. Waldron is Senior Regional Counsel with the Marine Spill Response Corporation. Prior to coming to MSRC in 1991 he served with the U.S. Coast Guard for 20 years in operational and legal assignments involving environmental, maritime, and international matters. He received his undergraduate degree from the U.S. Coast Guard Academy and his Juris Doctor from the University of Miami, Florida, in 1981.

MODERNIZING THE COPENHAGEN AGREEMENT

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The Copenhagen agreement concerning Cooperation in Measures to Deal with Pollution of the Sea by Oil came into force in October 1971. The new Copenhagen agreement, signed on March 29, 1993, encompasses cooperation regarding measures to deal with pollution of the sea by oil as well as other harmful substances. This will be done through cooperation in contingency planning, research and development, response actions, and aerial surveillance. The agreement extends the parties' internal water, territorial water, and other areas at sea to the limits of the continental shelf, fishery zone, and economic zone.

During the past three years great efforts have been made to cooperate more closely, for example, in areas with joint borders of territorial waters, in aerial surveillance, technical development, research and development, and education.

AUTHOR: Cdr. Dan Thorell has been Deputy Head of Response Operations at Swedish Coast Guard Headquarters since 1988. He is 39 years old and has served in the Coast Guard since 1975. He began his service aboard CG cutters, moved to response vessels, and, in 1984, to a regional headquarters—where he remained until his current assignment.

Section VI

THE *BRAER* INCIDENT

Session T3B: Part I

Chairman: Joseph A. Nichols
International Tanker Owners Pollution Federation, Ltd.

Session T4B: Part II

Chairman: Oleg Khalimonov
International Maritime Organization

THE *BRAER* INCIDENT: SHETLAND ISLANDS, JANUARY 1993

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On Tuesday, January 5, 1993, the tanker *Braer* laden with 84,700 metric tons of Norwegian Gullfaks crude oil drifted aground at Garths Ness, Shetland Islands. Over the next eight days, the vessel's total cargo of crude oil was spilled.

The Marine Pollution Control Unit immediately activated the Marine Emergencies Information Room in London and deployed staff to Shetland. It was agreed with Shetland Islands Council to establish a joint response center at Sumburgh Airport to coordinate and control the shoreline cleanup.

The incident affected an area of international environmental importance and also threatened the local economy. Because of the lightness of Gullfaks crude and the severe weather, the bulk of the oil dispersed naturally and very little came ashore. The land beyond the shoreline was polluted by airborne oil spray carried on the storm force winds.

Aerial spraying of dispersant on oil on the sea took place on three days. Some environmentally sensitive areas were protected by booms and dams. Of the 39 sites considered at risk, only 9 beaches and other sites merited cleaning.

AUTHOR: Chris Harris is Chief Executive of the Coastguard Agency, United Kingdom, and as Director of Marine Emergency Operations was the government's overall commander of the counter-pollution response to the *Braer* incident.

THE DONALDSON REPORT: IMPLICATIONS FOR THE SHIPPING INDUSTRY

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Following the grounding of the *Braer* off the coast of Shetland in January 1993 the British Government ordered an inquiry into the prevention of pollution from merchant shipping. The inquiry, chaired by Lord Donaldson, published its report on May 17, 1994, as Safer Ships, Cleaner Seas. The report contains 103 recommendations, many of them of potential significance to the international shipping industry.

This paper analyzes some of the most important recommendations, offers a preliminary industry reaction to them, and concludes that the report will make a major contribution to the debate on ship safety and environmental protection.

AUTHOR: Since 1978, Chris Horrocks has been Secretary General of the International Chamber of Shipping (ICS), which coordinates the trade association interests of the international shipping industry. In 1990 he also became Director of the International Shipping Federation (ISF), representing the interests of maritime employers' associations.

Section VII

POSTER PRESENTATIONS

Session T2

Chairman: Lawrence J. Hannon
U.S. Minerals Management Service

Session T3

Chairman: Joyce M. Perdek
U.S. Environmental Protection Agency

Session T4

Chairman: Joyce M. Perdek
U.S. Environmental Protection Agency

Session W1

Chairman: John S. Farlow
U.S. Environmental Protection Agency

Session W2

Chairman: John S. Farlow
U.S. Environmental Protection Agency

Session W3

Chairman: Daniel A. Sullivan
U.S. Environmental Protection Agency

Session W4

Chairman: Daniel A. Sullivan
U.S. Environmental Protection Agency

TECHNICAL CORRECTION OF THE PAINT FILTER LIQUIDS TEST

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On April 30, 1985, the U.S. Environmental Protection Agency (EPA) issued a final rule requiring the use of the Paint Filter Liquids Test (PET), Method 9095, to determine the presence of free liquids in either bulk or containerized waste. From the summer of 1993 to January 1994, the validity of the Paint Filter Test was challenged. Through extensive research, it was concluded to contain testing procedures which produced inaccurate evaluations of a sorbent's performance. Although the EPA plans to make modifications, the new proposal is not set for discussion until several years from now to clarify all existing problematic issues.

AUTHOR: Ed Schrader, an international consultant and researcher specializing in hydrocarbon sorbents and oil spill mitigation and remediation, is chairman of the Millsaps Geology Department and Director of the Sorbent Laboratory of Millsaps College. He is a member of several international standards committees and advisor to federal and state agencies on environmental affairs.

WATER-IN-OIL EMULSIONS: HOW THEY ARE FORMED AND BROKEN

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Studies on the formation of emulsions were summarized, and analytical methods used to determine the final results of the emulsion breaking process were evaluated. These include visual appearance, viscosity, zero-shear-rate viscosity, elasticity, water content, and conductivity. All but the latter two are useful for determining the stability of an emulsion.

The development of four new tests was reviewed. These test the effectiveness of emulsion breakers in open and closed systems and emulsion preventers in open and closed systems. Results of testing on commercial products are presented.

AUTHOR: Merv Fingas in the chief of the Emergencies Science Division of Environment Canada. He has worked on oil spill research over the past 20 years and specializes in spill behavior, dynamics, and analysis. He has bachelor degrees in arts and chemistry and masters degrees in business, mathematics, and chemistry.

EVALUATION OF DISPERSANT TOXICITY USING A STANDARDIZED MODELED-EXPOSURE APPROACH

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A spiked-exposure toxicity test procedure has been developed, in which initial dispersant concentrations are diluted at a standardized rate to provide a simple model of exposure experienced in the field. Traditionally, acute dispersant toxicity has been described using constant-concentration exposures of 24 to 96 hours. Constant concentrations are unrealistic in the field because of the dilution effects of wind and wave conditions required for dispersant application. The spiked-exposure procedure has been adopted in California as a standardized tool for comparing dispersant toxicity. Five dispersants have been tested using four Californian species. Tests using oil and dispersant-oil mixtures are being developed.

AUTHOR: Lisa Weetman has been a researcher at the University of California at Santa Cruz for two years with the Oil Spill Dispersant Project. She is currently a graduate student at Moss Landing Marine Laboratories.

ENVIRONMENTAL SENSITIVITY AND PROTECTION FOR THE NORTHEAST CASPIAN SEA

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An environmental sensitivity and impact analysis was performed for the largest ever two-dimensional marine geophysical survey to be conducted in the Kazakhstan sector of the Caspian Sea. A total of 35,000 km of seismic lines are to be shot covering an offshore area of 100,000 km^2. The purpose of the environmental studies is to identify critical environmental sensitivities and to develop operating rules for the seismic work to protect the environment.

AUTHOR: Bernhard Metzger is an environmental planner and manager of the Arthur D. Little environmental impact and risk assessment consulting practice.

MAKING SENSE OF MULTIPLE RESPONSE PLANNING REQUIREMENTS

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Federal agencies with responsibility for developing response plan regulations mandated by the Oil Pollution Act of 1990 met regularly throughout the rulemaking development process to coordinate their efforts and ensure a consistent regulatory approach across the various regulations. A key aspect of this coordination was to facilitate the regulated community's efforts to implement multiple response planning requirements without generating multiple response plans. This resulted in significant cost savings to owners or operators of facilities required to submit response plans.

AUTHOR: Bobbie Lively-Diebold works for the oil program at EPA headquarters in Washington, D.C. She works as a project manager to develop regulations to implement OPA 90 response plan requirements for EPA-regulated facilities, and coordinates with other agencies to develop and implement OPA 90 requirements, including drills.

TRACE METALS AND BIOMARKERS IN OIL: A TOOL FOR IDENTIFICATION OF SPILLS

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The western offshore oil activities contribute significantly to India's hydrocarbon requirements. Oil spills in the sea cause serious problems to marine ecology and oil installations. Since weathering effects interfere with most of the matching methods now in use, a crude fingerprinting method is needed to identify the sources of oil spilled on the west coast. The ratios of n-alkanes and isoprenoids, along with trace elements, apparently are independent of weathering effects and thus could be especially useful in the matching of oil to its source.

AUTHOR: Ranu Gadi holds a doctorate in environmental chemistry and has 8 years of research experience. Presently, she is working in the area of oil spills.

THE EFFECTS OF IN-SITU BURNING OF OIL ON FIRE BOOM

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In situ burning of oil is an efficient way to get rid of spilled oil at sea. Recent tests have proven that the benefits associated with in situ burning of oil far outweigh the potential health hazards of the smoke from the oil fire. Fire-resistant materials are available for use in the construction of fireproof oil booms. The effects of oil fires on these booms were studied: more than a dozen tests were carried out on fire booms to evaluate the effectiveness of the booms for use with in situ burning of oil.

AUTHOR: Richard J. Lazes has been involved with the oilfield industry for more than 12 years. Lazes founded Oil Stop, Inc., a company dedicated to developing and manufacturing a patented oil containment boom called the Auto Boom and other new technology employed to mitigate oil and chemical spills from tankers.

JOINT CHINA-NOAA PORT AREA CONTINGENCY PLANNING PROJECT

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As part of a World Bank-funded Ship Waste Disposal Project, the China Academy of Transportation Sciences (CATS) developed a model for port oil spill emergency plans. The National Oceanic and Atmospheric Administration was asked to participate in three stages of the model's development: 1. a review of information collected from four major ports and identification of additional data needed to develop the plan, 2. work to finalize the plan's format and develop a prototype plan for Guangzhou, and 3. in-country training and a test of the prototype plan. After these efforts, CATS will revise the model and develop plans for Ningbo, Shanghai, Dalian, Tianjin, and Xiamen.

AUTHOR: Edwin A. Levine serves as NOAA's Scientific Support Coordinator for the U.S. Coast Guard from Connecticut through Delaware. He provides scientific support in the areas of oceanography, biology, geology, and chemistry to federal on-scene coordinators during, and in preparation for, responses involving the release of oil or hazardous substances.

TEXAS GENERAL LAND OFFICE OIL SPILL GIS AND TRAJECTORY MODELING

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The Texas General Land Office (GLO) has developed elements of an oil spill decision support system that integrate a trajectory model, a real-time environmental monitoring network, and a customized geographic information system (GIS) application. Through applied research, the GLO is striving to improve the reliability of oil spill trajectory modeling by improving the quality and timeliness of the environmental inputs. A GLO-developed GIS user interface facilitates the quick and efficient production of high-quality maps, to provide spill response managers with timely environmental and other spill-related information.

AUTHOR: Robert D. Martin is the state scientific support coordinator for the GLO's Oil Spill Prevention and Response Program and the chief of research for the GLO's Information Systems Program. He provides on-scene technical and scientific support to the GLO's oil spill response activities, leads the GLO trajectory team, and manages several oil spill GIS and remote sensing research projects.

MECHANICAL PROTECTION GUIDELINES

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The recently published Mechanical Protection Guidelines will:

- provide guidelines for identifying and prioritizing areas of economic, environmental, and cultural sensitivity, including formats for mapping sensitive areas;
- describe the types of shoreline protection measures available, with emphasis on limits and requirements of each protection measure;
- provide guidance on developing site-specific protection strategies, including equipment and logistics needed, operational constraints, and physical conditions of the site (charts and tables are included as tools for development of the most feasible and successful strategies); and
- provide continuity among area plans, to facilitate exchange of information and use by regional and national response teams.

AUTHOR: Cdr. Frank Whipple, chief of the Operations and Compliance Branch of the 11th Coast Guard District, previously commanded the Atlantic Strike Team and was the executive officer of the Marine Safety Office, Galveston, Texas. His marine safety tours have included assignments at Marine Inspection Office Los Angeles/Long Beach, California; supervisor of the Marine Safety Detachment Ponce, Puerto Rico; Marine Safety Office San Francisco, California; and the Marine Safety Programs, Planning and Special Projects Staff, Coast Guard Headquarters. Cdr. Whipple spent a year of postgraduate management training with Crowley Maritime Corporation.

TRENDS IN OIL SPILL RATES FOR FOUR HIGH-TRAFFIC AREAS

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A paper presented at the 1981 International Oil Spill Conference analyzed spill data in four regions of the United States that carry heavy oil traffic and focused on spills of more than 10,000 gallons in the years 1974 through 1977, to determine what differences, if any, exist in the spill rates. The findings of that earlier study are compared with more recent (1990–1993) data from the Emergency Response Notification System and the Oil Spill Intelligence Report to show how the patterns have changed.

AUTHOR: Gail Thomas is employed by the U.S. Environmental Protection Agency. She is a member of the Emergency Response Division, Oil Pollution Response and Abatement Branch, and oversees EPA's National Contingency Plan Subpart J Chemical Countermeasures program.

MSRC SHUTTLE BARGE SYSTEM FOR SHALLOW-WATER OIL SPILL CLEANUP

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When the U.S. Coast Guard stipulated that 20 percent of oil spill response requirement had to be capable of use in shallow water, MSRC began the design of a new system. To meet the recovery capacity requirements, early decisions mandated that the system be operable in two feet of water with a swift current, capable of beaching without damage, road transportable without permits, and comply with all Coast Guard rules for documentation and inspection. The resulting shuttle barge systems are stored, on trailers, at 15 coastal U.S. sites, and in Hawaii and the U.S. Virgin Islands.

AUTHOR: Capt. George W. Dowell III, U.S. Navy, ret., graduated from the U.S. Naval Academy in 1960 and earned a MSEE in 1967. Captain Dowell specialized in engineering, ship design, shipbuilding, and repair of vessels ranging from nuclear aircraft carriers to small craft. After leaving the Navy in 1991, he joined the Marine Spill Response Corporation as vessel manager.

OBTAINING THE FEDERAL RESPONDER IMMUNITY STANDARD IN THE UNITED STATES

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Limited liability for oil spill responders encourages aggressive actions that can maximize response efforts. The Marine Spill Response Corporation (MSRC), the world's largest oil spill response corporation, launched a nationwide campaign in 1991 to encourage the passage of responder immunity as contained in the Oil Pollution Act of 1990 in the coastal states and jurisdictions of the United States. As a national and not-for-profit organization, MSRC was a viable catalyst for successfully advocating the adoption of responder immunity. By the end of 1992, the 25 states/jurisdictions in MSRC's primary operating area had adopted responder immunity.

AUTHOR: David N. Lakin has been the Director of Government Affairs at the Marine Spill Response Corporation (MSRC) since 1990. Before joining MSRC, he served in various government affairs capacities with Exxon. He has more than 20 years experience in public and private sector government/public affairs.

SIMULATION-BASED OIL SPILL RESPONSE MANAGEMENT TRAINING

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Since June 1993, the Center for Marine Environmental Protection and Safety has operated (and integrated into its industry-oriented training programs for the Oil Pollution Act of 1990) a NorControl Oil Spill Management Simulator.

AUTHOR: David C. Barry is Assistant Director of the Center for Marine Environmental Protection and Safety at the Massachusetts Maritime Academy. He holds degrees in chemical and civil engineering. He has participated in the management of responses to marine oil spills including those of the B.T. Nautilus, Sarah Frank, Knock Ardy, Diamond Star, Borsec, and Atlantic Star.

EMERGENCY RESPONSE ACTIVITIES AT CEDRE

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French response capabilities in case of accidental water pollution are based on CEDRE's expertise in mitigation of both oil and chemical spills in marine and inland waters. As an association under the Ministry of the Environment, CEDRE acts for national organizations (such as the French Navy or Civil Security) or for private companies (oil and shipping companies). Its help can be provided from a distance (by phone/fax) or on the scene of the operation.

AUTHOR: Roger Kantin, was appointed head of the Emergency Response Service of CEDRE, the French accidental water pollution center, in 1990. Michel Albrecht, Joseph Blanc, and Claudine Le Mut-Tiercelin belong to the Emergency Response Service. The four people are in charge of CEDRE's around-the-clock operational advisory capabilities.

MMS GULF REGION GIS DATABASE FOR OIL SPILL CONTINGENCY PLANNING

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The Minerals Management Service (MMS) established the Coastal Marine Institute (CMI) at Louisiana State University as part of the Center for Coastal, Energy, and Environmental Resources to promote environmental research related to the oil, gas, and mining industries. One of the primary initiatives of CMI is to create an environmental information program to support government and industry oil spill contingency planning needs to fulfill the requirements of the Oil Pollution Act of 1990 and MMS compliance regulations. The MMS Gulf Region geographical information system (GIS) database will contain critical information about the location and character of environmental resources, infrastructure, and administrative boundaries that occur within the coastal region of the U.S. Northern Gulf of Mexico. Information needed to support the program will be collected from state and federal resource agencies, industry, and other data providers.

AUTHOR: Shea Penland is an Associate Research Professor at the Coastal Studies Institute and is the Director of the Oil Spill Contingency Planning Program at Louisiana State University. Prof. Penland has more than 15 years of experience in coastal geoscience research and services related to coastal land loss, oil spill planning, and response and framework geology studies.

PROTECTION OF NATURAL RESOURCES AGAINST OIL SPILLS BY BOOM ARRANGEMENTS

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An experiment and a computational approach were used to study flow fields around boom arrangements. A volume analysis was performed to quantify the effectiveness of the boom arrangements. The open-channel experiment showed that the booms were most effective when placed at 60° to the shoreline with cylinders placed along the center line. The results of the numerical algorithm were compared with the experimental results, which showed the influence of the cylinders and the recirculation formed between the walls to corral the oil.

AUTHOR: Kau-Fui Vincent Wong graduated from the University of Malaya in 1973 and obtained an M.S. degree in 1975 and a Ph.D. in 1977 from Case Western Reserve University. He has been with the University of Miami since 1979. He received the ASME Curriculum Innovation Award, 1990. He has published over a hundred publications, principally concerning the environment.

ELECTRONIC DESKTOP MAPPING: ENVIRONMENTAL SENSITIVITY ATLASES OF THE GREAT LAKES

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Environmental sensitivity atlases of the Canadian shorelines of Lake Superior, Lake Ontario, and Lake Huron have been completed in digital (desktop geographic information system) and paper formats for use in responses to spills of oil and other hazardous materials. These atlases allow responders to work from a common basis to rapidly identify the resources at risk during a spill and their relative priorities for protection and cleanup.

AUTHOR: Philip Baker manages response, preparedness, and prevention for the Environmental Emergencies Section of Environment Canada's Ontario Region office. He has a chemical engineering degree and a masters degree in business administration. Prior to Environment Canada, he worked with Esso Canada and Petro-Canada, and in science education.

A NEW TOOL FOR LARGE-SCALE OIL COMBAT

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Trailing suction hopper dredges maintain ports and their entrance channels around the world. Several of these dredges have already operated as oil spill cleanup vessels as a secondary assignment. Different types of available oil spill response systems were applied.

Recent developments allow these dredges to use their own dredge pumps, making these vessels by far the largest capacity oil spill cleanup vessels available in the world. The add-on system requires no modifications of the vessel and a relatively low investment. Tests have documented very good performance.

AUTHOR: M. Ruud Ouwerkerk is President of Dredge Technology Corporation, the U.S. subsidiary of IHC Holland N.V. IHC has been active for almost two decades in the application of hopper dredges for cleanup of marine spills. Mr. Ouwerkerk has presented several papers on this subject during the past five years.

EXPERIMENTAL DESIGN TO QUANTIFY CHEMICALLY DISPERSED CRUDE BIOAVAILABILITY TO PHYTOPLANKTON

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A method for quantifying the influence of dispersants on petroleum bioavailability to primary producers in marine food chains has been developed, using the common marine alga *Isochrysis galbana* as the primary producer. Considerations pertinent to exposure media preparation, exposure chamber apparatus, and quantification strategies are presented.

AUTHOR: Christopher O. Younghans-Haug has devoted the past 10 years of his life to studying the fate and distribution of contaminants throughout the environment. His current interests address how emerging countermeasures influence the fate of oil spills at sea with particular emphasis on petroleum behavior within marine food chains.

SEABIRD RESTORATION: A REVIEW OF NEEDS AND OPTIONS

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Seabird restoration plans require reliable estimates of the birds directly affected by a spill and the impact of that mortality on populations. They also require restoration techniques known to increase the rate of natural recovery. Unfortunately, restoration proposals have been hindered by damage assessments based on outdated and/or inappropriate data, exaggerated estimates of damages, and a lack of proven restoration techniques. Regular monitoring of seabird resources, knowledge of natural and anthropogenic factors influencing populations, and recognition of the typically limited role humans can play in seabird restoration will lead to the development of more realistic restoration plans.

AUTHOR: George J. Divoky has studied sea birds for 30 years, primarily in arctic Alaska, where he has conducted studies of pelagic birds, and continues a 20-year study of black guillemots breeding in man-made structures.

WILDLIFE RESPONSE: COLONIAL PIPELINE SPILL

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Tri-State Bird Rescue and Research was contracted to manage the wildlife response following a discharge of 340,000 gallons of No. 2 diesel fuel into Sugarland Creek in Fairfax County, Virginia, on March 28, 1993. A wildlife stabilization team was sent to Virginia to establish an on-site medical stabilization facility for affected animals, which were then transferred to Tri-State's oil spill rehabilitation facility in Delaware.

Treating some of the less-frequently (nonavian) oiled wild animals, including turtles and beavers, presented challenges. Colleague participation and interagency coordination were both important.

AUTHOR: Lynne Frink, director of Tri-State Bird Rescue and Research Inc., has edited or authored numerous works on the effects of oil on wildlife. She responds to spills throughout the world, and led the U.N.-sponsored wildlife training and response team in the Middle East following the Gulf War.

BEACH RESTORATION PROCEDURES

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A variety of procedures have been applied to the restoration of sandy beaches impacted by oil spills. These procedures have met with varying degrees of success, depending on factors including the nature of the oil, beach characteristics, and environmental conditions. Based on the assumption that no universal procedure exists for beach restoration, determination of appropriate procedures requires evaluation of incident-specific conditions. A series of decision guides has been developed to assist in this process. These decision guides, suitable for development of spill contingency response plans and during actual emergency responses, have been developed to aid in the selection of the most appropriate techniques.

AUTHOR: Robert W. Castle is a marine geologist who specializes in oil spill response and planning. He has developed manuals of practice on various aspects of spill response and has investigated the effectiveness and impacts of response techniques at scores of sites including the *Exxon Valdez*, Tampa Bay, and *Berman* spills.

BIOAVAILABILITY OF SEDIMENT OIL RESIDUES FOUR YEARS FOLLOWING THE MARTINEZ SPILL

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Transplanted bivalves were used as sentinel organisms to assess bioavailability of San Joaquin Valley (SJV) crude oil residues in impacted sediments four years following the 1988 Shell Martinez Refinery spill in Suisun Bay, California. Sediments, bivalves exposed for three months, and control (unexposed) bivalves were analyzed by gas chromatography/mass spectrometry (GC/MS) for polynuclear aromatic hydrocarbons (PAHs). The study documented a range of weathering stages, and a range of mixtures of SJV crude oil with another petrogenic source, pyrogenic PAHs, and diagenic alkyl PAHs in Peyton Slough intertidal sediments four years following the spill. Less-weathered SJV oil residues remaining in the estuarine sediments were more bioavailable than the intermediate or advanced weathered residues, and more bioavailable than the pyrogenic PAHs that comprise the background PAHs in the Suisun Bay sediments.

AUTHOR: Paul D. Boehm, vice president and managing director at Arthur D. Little, has led investigations of the fate of oil in spills ranging from the *Amoco Cadiz* to the *Exxon Valdez*.

RESOLVING THE TOW SPEED THAT CAUSES BOOM OIL LOSS

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Oil loss boom testing at the Ohmsett test facility obtained first loss tow speeds that averaged 0.75 knots. These results supported flume testing and became a rule of thumb. About 1980 the OITC identified the fact that basin side wall and bottom clearances affected first loss performance. Investigations defined a relation between boom skirt depth and basin clearances. Evolution of test methods demonstrated 30 percent higher relative tow speeds. A protocol was developed, and recent testing has resulted in first loss tow speeds as high as 1.5 knots. First loss testing has progressed steadily at Ohmsett and current efforts focus on understanding hydrodynamic effects.

AUTHOR: David DeVitis is a mechanical engineer who has participated in boom testing at Ohmsett since 1992.

REGIONAL RESPONSE TEAM PREAPPROVAL OF IN-SITU BURNING FOR OPERATIONAL USE

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On January 7, 1994, Regional Response Team VI that covers the Gulf coast approved a plan that allows the federal on-scene coordinator to approve the use of burning three miles or farther off the coasts of Louisiana or Texas. This landmark action is the first preapproval for in-situ burning in the continental U.S. The plan was presented to the response team by the Marine Spill Response Corporation on behalf of the response industry and its clients.

AUTHOR: Gus Stacy is the Environmental Advisor for the Marine Spill Response Corporation's Gulf Region headquartered in Lake Charles, Louisiana. Prior to joining MSRC in June 1991, he held numerous wildlife and environmental positions with the State of Louisiana.

INFORMATION TECHNOLOGY: KEY TO ACHIEVING AND MAINTAINING OIL SPILL PREPAREDNESS

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Recent developments in oil spill information systems have extended the accessibility of information to users in operational and planning environments through the integration of databases, predictive models, expert systems and advanced user interfaces. Such systems now represent the gateway to full "command and control" systems for oil spill preparedness and response.

AUTHOR: Andrew Tyler is currently head of BMT's Marine Information Systems group. He has been responsible for oil spill information system developments in the group for four years.

DEVELOPMENT OF AN OPTIMAL OIL BOOM IN WAVES

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The performance of an air-inflated oil boom, recently developed by the authors, is investigated for the purpose of designing an optimal shape. Well-designed oil booms should be able to follow the water surface closely and also maintain a vertical position in waves. A numerical method based on a linear potential theory is developed to predict the motion characteristics of oil boom in waves; the optimal configuration of the boom is determined based on numerical studies. Hamilton's principle is employed to derive the equations of motion of the float and the skirt. The equations of motion are formulated for the case in which the float and the skirt are connected by a hinge. The computational method is limited to a two-dimensional approximation. Through the parameter study of physical properties (draft, shape of boom, weight of chain, water plane area), we can decide the optimal shape of oil boom to produce minimum relative heave response in waves.

AUTHOR: Il-Hyoung Cho earned M.S.E. and Ph.D. degrees at Seoul National University. He now works at the Korea Research Institute of Ships and Ocean Engineering.

EMERGENCY WEATHER STATION SYSTEM SUPPORT TO OIL SPILL RESPONSE

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An emergency weather station (EWS) system has been developed by Environment Canada to meet the demand for specialized services during disasters. This portable system is designed to gather and analyze field data effectively and to provide dedicated and timely briefings directly to emergency responders at their field sites. Atmospheric, ice, and sea-state data are collected and integrated in real time on spatial and temporal scales improved from that of the existing networks. These mesoscale observations and analyses of both surface and upper-air parameters are invaluable in data-sparse coastal areas and over the open water.

AUTHOR: Ev Wilson, meteorologist, B.Sc., is a program specialist for the Environmental Emergency Response (EER) Division, Canadian Meteorological Centre of Environment Canada. This division deals with atmospheric, ice, and sea-state aspects of natural and technology-based hazards—from oil spills, chemical releases, and nuclear accidents to severe weather, volcanic eruptions, earthquakes, and forest fires.

INTEGRATED OIL CONTAINMENT AND RECOVERY SYSTEM

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The primary goal of oil spill response crews is to prevent oil from going ashore. Thus, the measure of an oil spill recovery system's performance becomes the volume of spilled oil recovered per unit time. Throughout the 1980s and into the '90s, developments have been made which increase both the encounter and recovery rates of oil on water. The thesis of this paper is that the role of a recovery system is first to contain spilled oil and then to concentrate the oil such that skimmers may operate at their maximum rated capacity.

AUTHOR: Jan Allers is President of AllMaritim and has been involved in the development of oil spill recovery systems for 15 years. He resides in Bergen, Norway and travels the world.

THE *BRAER* OIL SPILL

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The *Braer* oil spill caused little lasting damage to the environment. The reasons for this were the dispersability of the oil and the severe weather at the time of the spill. The bird population was relatively unscathed, and the principal economic effect was on the salmon farms in the affected area. Dispersants were used. This decision was a correct one, for, although the oil dispersed naturally, this was not known at the time. Lord Donaldson's report supported their use as the first line of defense in the UK. The command arrangements worked well, with good cooperation among all the agencies involved. Although media pressure was intense, it was generally handled very well.

AUTHOR: Robin Perry joined the oil industry after 16 years in the Royal Navy, working for Shell, and later BNOC, Britoil and BP. In 1980 he became responsible for spill response in the Beatrice Field, the UK's first nearshore field, becoming Chairman of the Oilspill Workgroup of the UK Offshore Operators Association. After other management appointments, he was General Manager of the Oil Spill Service Centre, Southampton (OSSC) from 1989 to 1994. He formed his own consultancy at the beginning of 1995.

PROTOCOL DEVELOPMENT FOR SORBENT CONTAINMENT BOOMS

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The Emergencies Engineering Division (EED) of Environment Canada, the Marine Spill Response Corporation, the Canadian Coast Guard, the United States Coast Guard, and the United States Minerals Management Service funded a project that resulted in the development of a new standard performance testing protocol for oil spill sorbents. As a continuation of this project, work is being performed to develop a protocol for testing sorbent booms in a containment configuration at the EED test tank facility in Ottawa. The protocol includes elements to test the behavior of sorbent booms using various currents, oil loading rates, and oil viscosities. The protocol will be proposed as a Canadian test standard and eventually as an international standard.

AUTHOR: For the past few years, David Cooper has been with Environment Canada's Emergencies Engineering Division developing protocols for the testing of sorbent materials for use in oil spills. He sits as vice-chair of the Canadian General Standards Board sorbent committee and participates in the ASTM F20 Committee on Hazardous Substances and Oil Spill Response.

NEW TECHNIQUE FOR OIL RECOVERY ALONG SHORES (FLOATING AND GROUNDED)

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Experience has shown that the coastal zone is best for efficient oil spill recovery, because of the natural thickening of the oil layer. This zone includes large areas with very shallow waters, as well as beach areas, which present particular recovery problems. The new PBAS (paddle belt amphibious skimmer) system improves the performances of paddle belt skimming heads on choppy seas, and allows them to operate in very shallow waters and even on ground, with optimal efficiency because of its light-weight and easily transported special amphibious support vessel.

AUTHOR: Jean Bronnec is a graduate engineer with 40 years' experience in the industry. He designed the Egmopol oil spill recovery equipment, and has participated in many major oil spill cleanup operations, including the *Amoco Cadiz* and the *Exxon Valdez*. He is now a consulting engineer and spill cleanup expert with J.B. Consult.

EFFECT OF WAVES ON CONTAINMENT BOOM RESPONSE

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A series of generic model booms were developed, built, and tested in the Stevens towing tank. Precise measurements were made of heave response to waves for catenary tows. Drag force was also measured. Test variables included model size, buoyancy/weight ratio, speed, wave size and gap/length ratio.

AUTHOR: R. L. Van Dyck has been with Stevens for 43 years. In addition to bydrodynamic design, development and model testing of marine vehicles, he has worked in the building technology research fields of water conservation and solar energy flow through shaded window systems.

TEFLON NETS: A NOVEL APPROACH TO THIN FILM OIL SAMPLING

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Thin film oil sampling has presented a significant problem because of the limited volume of oil typically obtained via the traditional sampling techniques, decanting and TFE fluorocarbon (Teflon) strip adsorption, described in ASTM-D4489, the consensus standard governing waterborne oil sampling. A novel approach to thin film oil sampling, using prototype Teflon mesh nets, was examined in this study. Benchtop experiments were designed to examine material type and mesh size considerations relative to the International Maritime Organization's oil thickness/appearance scale. The results of field experiments using the prototype Teflon nets indicate that the performance of the Teflon nets is far superior to either of the decanting or Teflon strip sampling methods in thin film oil sampling applications.

AUTHOR: Dean Greimann is a marine science technician in the U.S. Coast Guard. His duty stations have included the USCGC *Polar Star*, USCG International Ice Patrol, USCG Academy, and, most recently, USCG Marine Safety Laboratories. He enjoys laboratory work and, in his spare time, designing new methods for enhancing the oil pollution prevention and enforcement efforts of the Coast Guard.

COAST GUARD VOSS/NOFI/FIOCS/SEA SLUG AT-SEA EVALUATION

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At-sea evaluations of the Coast Guard Vessel of Opportunity Skimming System (CGVOSS), the Norwegian NOFI VEE Sweep and the Fully Integrated Oil Collection System (FIOCS) oil-recovery systems were conducted to determine their seaworthiness and handling and towing characteristics. Tests were conducted off the coast of Groton, Connecticut. Dynamic data were collected for information on the stability and performance of each system. The Canflex Sea Slug storage device was also tested to determine the performance of an expandable containment vessel under tow. The data shows that the CGVOSS performed well in low sea states and low speeds, the NOFI and FIOCS systems perform well in low and high sea states, and the Sea Slug is stable at low towing speeds.

AUTHOR: Deborah Furey has been at CDNSWC for nine years and with the Towed Systems branch for seven years. She received her bachelors degree in aerospace engineering and her masters degree in engineering mechanics at Virginia Polytechnic Institute. She is currently enrolled in graduate studies at the University of Maryland.

THE NATIONAL CONTINGENCY PLAN PRODUCT SCHEDULE DATABASE

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The U.S. Environmental Protection Agency's Emergency Response Division maintains the National Contingency Plan Product Schedule Database that allows users to view and compare product data quickly and efficiently. The current word processing format of the NCP Product Schedule Notebook does not allow for the rapid and efficient searching of toxicity and effectiveness data. Rapid access to NCP product data is vital to on-scene coordinators during the early stages of spills. The NCP Product Schedule Database provides the user with a mechanism to quickly view and/or print product data, comparison reports, and product lists.

AUTHOR: Gail Thomas is employed by the U.S. Environmental Protection Agency. She is a member of the Emergency Response Division, Oil Pollution Response and Abatement Branch, and oversees EPA's National Contingency Plan Subpart J Chemical Countermeasures program.

BIOREMEDIATION STUDY OF SPILLED CRUDE OIL ON FOWLER BEACH, DELAWARE

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A statistical approach was used to determine whether nutrient and/or microbial inoculation enhances the loss of crude oil experimentally released onto plots on the shoreline of Delaware Bay. Five replicates of three treatments were examined (nutrients alone, nutrients plus an inoculum of indigenous bacteria from the site, and an unamended control). An unoiled control served as a baseline for microbiological and toxicological studies. Preliminary results suggested that, although microbial growth was similar on all oiled plots, alkanes degraded faster on the nutrient plots than on the unamended plots by week 2.

AUTHOR: Albert D. Venosa is a research microbiologist with the U.S. Environmental Protection Agency. He has worked for EPA since 1968 and has served as Program Manager of the Oil Spill Bioremediation Research Program for the Risk Reduction Engineering Laboratory, Cincinnati, Ohio, for the past four years.

BIOTREATMENT OF PETROLEUM CONTAMINATION IN OPEN SYSTEMS

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A new technology overcomes one of the major problems in applying biological based methods to oil spills in open systems, supplying nutrients in a form that remains associated with the oil for significant periods. The technology, System ET 20, uses specific bacterial strains that adhere to hydrocarbons and a unique oleophilic, controlled-release nitrogen and phosphorous source. Tests using crude oil indicate that System ET 20 can significantly degrade the aliphatic and aromatic fractions of crude oil. There is also some indication of significant attack on the polar components of the oil, although this fraction is difficult to monitor analytically.

AUTHOR: Eugene Rosenberg is professor of microbiology and director of the Biotechnology Institute, Tel-Aviv University, and scholar-in-residence at the Fogarty International Center for Advanced Study, N.I.H., Bethesda, Maryland. His research fields are oil-degrading bacteria, bioemulsifiers, drag-reducing biopolymers, biobleaching of wood pulp, and development of adhesive antibiotic T.A.

UNIFIED COMMAND: THE MECHANISM FOR ENSURING A COMPREHENSIVE, COORDINATED RESPONSE

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When an oil spill incident occurs, it should be viewed as a single problem, requiring a single, highly focused response effort. Constructing such an effort can be difficult when multiple organizations exist with the authority to launch simultaneous, potentially divergent response operations. The unified command concept is designed to address this problem and specify, for example, the primary responsibilities of the unified commanders. The concept also addresses the relationship between a unified command structure and a responsible party's management team, and describes how the two are integrated during response operations.

AUTHOR: Thomas G. McCloskey is President of The McCloskey Group, Inc. Since forming the company in 1980, he has created and presented numerous training programs, including one on the effective management of oil spill response operations. In addition, he has prepared more than 50 response plans for more than 30 companies, and has been directly involved in field response efforts during the following oil spill incidents: Tampa Bay (for Maritrans), *Mega Borg*, *American Trader*, and *Exxon Valdez*.

NUMERICAL SIMULATION OF THE *AEGEAN SEA* OIL SPILL

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A numerical study of the trajectory of the *Aegean Sea* oil slick was made, using the Météo-France oil spill model. The model, configured for operation on a workstation, predicts the drift, spread, dispersion, and shoreline interaction of the spilled oil. Its main component is a hydrodynamic ocean model, forced by the wind fields of the European Centre for Medium Range Weather Forecasts atmospheric model. Model predictions were compared with results of aircraft and beach surveys.

AUTHOR: Pierre Daniel has been with Météo-France for 10 years. He is rapporteur on marine transport modeling within the World Meteorological Organization.

NUTRIENT RETENTION IN THE BIOREMEDIATION ZONE OF A SANDY BEACH

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A tracer study was conducted on a low-energy beach in Delaware Bay to determine how the nutrient washout rate is affected by the tidal cycle. When tracer was applied during spring tide, it was reduced to background levels following a single high tide; but when it was applied during neap tide, tracer persisted in the bioremediation zone for a much longer time. The washout rate was found to be related to the extent of water coverage during high tide.

AUTHOR: Brian Wrenn is a postdoctoral assistant at the University of Cincinnati, where he conducts research on the microbiology of oil spill bioremediation and crude oil biodegradation.

SENSITIVITY ANALYSIS IN OIL SPILL MODELS: CASE STUDY USING ADIOS

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The Hazardous Material Response and Assessment Division (HAZMAT) at the National Oceanic and Atmospheric Administration uses the oil weathering software package named Automated Data Inquiry for Oil Spills (ADIOS) to investigate the oil weathering process. This model combines a database of physical and chemical properties of oils with a simulation model computing mass losses, density, viscosity, and water content of an oil spill due to evaporation, dispersion, and emulsification.

A first-order sensitivity analysis of the ADIOS evaporation algorithm indicates that it might be possible to provide a taxonomy of oils with respect to the reliability of results generated by the model.

AUTHOR: Roy Overstreet is a physical oceanographer in the Modeling and Simulation Studies Branch of the National Oceanic and Atmospheric Administration in Seattle, Washington. He received a B.A. in physics from the University of California in 1958 and an M.Sc. in physical oceanography from the University of Washington in 1965.

A PROTOCOL FOR EXPERIMENTAL ASSESSMENTS OF BIOREMEDIATION STRATEGIES ON SHORELINES

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An experimental protocol has been developed for assessing the efficacy of bioremediation strategies for the treatment of petroleum contaminated shoreline sediments. It is a framework for the design of experimental field trials that enables independent organizations to compare the results of experiments conducted in different environments. Coordinated studies of this nature are needed to formulate operational guidelines for the application of bioremediation agents during oil spill response situations.

AUTHOR: Kenneth Lee is a research scientist within the Department of Fisheries and Oceans, Canada. He is responsible for research programs in chemical oceanography dealing with microbial transformation of contaminants in estuarine and coastal environments.

USCG RESPONSE EQUIPMENT INTEGRATED LOGISTICS SYSTEM

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The United States Coast Guard procured specialized oil spill containment and removal equipment to support the goals of the Oil Pollution Act of 1990. To manage the equipment inventories, an integrated logistics maintenance and tracking system (ILS) was implemented. The ILS provides a systematic means for documenting and controlling the configuration of system components so that life-cycle costs, operational performance/use, and equipment readiness can be regulated, tracked, and documented.

AUTHOR: Christine Burk is assigned to the National Strike Force Coordination Center located in Elizabeth City, North Carolina, as the Logistics and Equipment Division branch chief. She is responsible for managing and coordinating the USCG National Maintenance Contract for pre-positioned oil spill response equipment, which includes the ILS.

CASE STUDIES OF STANDARDIZED TECHNIQUES TO DOCUMENT SHORELINE OILING CONDITIONS

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The concept of standard terms and definitions, forms or checklists, and sketches is intended as the foundation for a variety of field programs or surveys designed and tailored to meet specific goals. The idea of standardized assessment procedures has developed over recent years to meet the requirements of spill response managers and planners prior to shoreline cleanup or treatment. The approach has been adopted by Environment Canada and the U.S. National Oceanic and Atmospheric Administration as a primary technical support tool for oil spill response. This paper presents eight case studies that illustrate a range of applications.

AUTHOR: Edward H. Owens is a coastal geologist who has been involved with oil spills since 1970 in a range of temperate, tropical, and Arctic environments. He has been involved with numerous response operations and has been active in the development of standardized procedures for spill response technical support.

OIL SPILL DECISION SUPPORT SYSTEM FOR THE VENEZUELAN OIL INDUSTRY

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In 1991, the Venezuelan oil industry, through INTEVEP, its research and development subsidiary, started a project to implement an oil spill decision support system (DEPET 4.0) for the Venezuelan national oil spill contingency plan. For this primary tool for taking spill response actions in operational drills and real emergencies, the industry developed a database of possible scenarios in predetermined sites and for natural resource damage assessment.

The system covers the entire Venezuelan coastline, with each of five management zones serviced by a separate base map and data.

AUTHOR: Carlos Villoria joined INTEVEP, S.A., the R&D subsidiary of Petróleos de Venezuela (PDVSA), in 1980 as a research engineer in the offshore department. He currently acts as environmental manager of a joint venture between Lagoven, S.A. (operating subsidiary of PDVSA), Shell, Exxon, and Mitsubishi, for development of an LNG project offshore of eastern Venezuela.

A GENERAL MIGRATION MODEL FOR BIOLOGICAL IMPACT ASSESSMENT

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To develop a tool to quantify the potential biological impacts of oil spills in the Barents Sea marginal ice zone, a generalized migration model, driven by biological field data, was made to reproduce detailed movement patterns of individuals within a population. This model (MIGMOD) has been coupled to the natural resource impact model system to provide a complete set of working tools for environmental impact assessment.

AUTHOR: Keith Downing holds a B.A. in mathematics from Bucknell University (1983) and a Ph.D. in computer science/artificial intelligence from The University of Oregon (1990). His professional interests include biological impact assessment, ecosystem modeling, object-oriented programming, and emergent biological computation.

ROLE OF ENVIRONMENT CANADA EMERGENCY OFFICERS IN OIL SPILL RESPONSE MANAGEMENT

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Environment Canada has established standard operating procedures (SOPs) for their emergency response officers so that they can respond to environmental emergencies with a uniform and professional approach. The SOPs cover a wide range of issues due to the complexity and intricacy of spills and related emergency situations. The focus here is on procedures for responding to oil spills. These include, but are not limited to, conducting a preliminary assessment of the spill, determining lead government agency responsibility, assessing and addressing response and protection needs, ensuring appropriate information is documented and distributed to concerned groups, dealing with the media, obtaining legal evidence and support, arranging finances, and using and obtaining approval for implementing certain response technologies.

AUTHOR: Caroline Ladanowski developed these procedures while on assignment with the Preparedness Division to work on plans, procedures, and policies for environmental emergencies on behalf of Environment Canada. She has now returned to her position with the Emergencies Engineering Division where she handles a number of international initiatives related to the environmental assessment and remediation of abandoned missile sites in former Soviet states.

IN SITU BIOREMEDIATION OF PETROLEUM HYDROCARBON CONTAMINATED SOIL AND GROUND WATER

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OHM designed and installed an in situ bioremediation system with an above ground water treatment system at a petroleum hydrocarbon distribution and fuel facility. The remediation system consists of an infiltration trench system to deliver treated, amended ground water to the upper silty lens, and an injection well system to deliver water to the lower sand and gravel lens. A French drain is located downgradient of the groundwater injection systems to provide hydraulic control of the site. Recovered ground water is pumped to an on-site treatment system prior to re-injection.

AUTHOR: Douglas Jerger, OHM's technical director of bioremediation, has more than 20 years experience in applied microbiology. He designs and implements programs for laboratory, pilot, and field projects, and provides technical management for ongoing projects. He has a B.S. in biology, M.S. in microbiology, and a Ph.D. in environmental engineering.

IMMOBILIZATION TECHNIQUE FOR IN SITU BIODEGRADATION OF CRUDE OIL

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An immobilization technique was developed and standardized for seeding oil spills with specific oil degrading microorganisms, fertilizing them with nitrogen- and phosphorus-containing salts and controlling the further spread of the oil spill. Thermocol was used as a carrier molecule on which nutrients as well as microbial cells were adsorbed.

Studies were carried out to correlate the amount of biodegradation to that of release of nitrogen and phosphorus adsorbed on the carrier molecule. The release of nutrients from the carrier molecule was slow: 76 percent of the crude oil was degraded in 3 days at nitrogen and phosphorus concentrations of 36.19 mg and 8.15 mg respectively as revealed by gas liquid chromatographic analysis. Without addition of nutrients, 62 percent of the crude oil was degraded in 9 days.

AUTHOR: Asha Juwarkar has worked on various aspects of environmental microbiology and biotechnology in the National Environmental Engineering Research Institute for 12 years. She is Assistant Director of the Environmental Biotechnology Division.

INTEGRATED HYDRODYNAMIC-OIL SPILL MODELING IN COASTAL WATERWAYS USING SPILLSIM

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In estuaries and coastal waterways oil spill models must be coupled with hydrodynamic models to give accurate slick predictions. Two case studies show how the UNIX-based SPILLSIM model can be used to advantage with either two-dimensional finite-element current models (Galveston Bay) or three-dimensional current models (Juan de Fuca-Strait of Georgia waterway).

AUTHOR: Donald Hodgins is the president of Seaconsult and has directed the company's research activities in emergency response systems for oil spills and maritime search and rescue, and innovative remote-sensing systems such as the SeaSonde radar for ocean currents and the SEACAST system for satellite image-model data fusion.

BIOREMEDIATION: RESULTS OF THE FIELD TRIALS OF LANDEVENNEC (FRANCE)

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Results of studies performed all around the world on bioremediation techniques are not often comparable because they have been performed through different methodologies. To address this problem, several organizations have combined their efforts to define a common methodology to assess bioremediation techniques' efficiency through field experiments.

To confirm the validity of this protocol, a 9 month experiment was performed on oiled plots on a sheltered estuarine beach in France. In this experiment, biodegradation efficiency was assessed though multiple analyses (chemical and microbiogical) including changes in chemical composition of the residual oil.

AUTHOR: Gradually in chemistry and experienced in oil drilling, François-Xavier Merlin joined CEDRE in 1979. He is in charge of the studies and development dealing with treatment products to be used on oil spills. He has published various publications and handbooks on this subject.

DECONTAMINATION FOR THE T/B *MORRIS J. BERMAN* INCIDENT

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When the tank barge *Morris J. Berman* went aground near San Juan, Puerto Rico, the ensuing cleanup created the need for a major decontamination effort. A main decontamination site was established, with supplemental operations at six satellite sites. Mobile decontamination teams were dispatched as needed to a number of remote sites. In all, more than 100 personnel participated in the decontamination effort.

AUTHOR: Joseph B. H. Smith, special projects manager for Foss Environmental Services Company, has worked in the spill response industry for 20 years.

A COOPERATIVE APPROACH TO OIL SPILL PLANNING

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California's oil spill cooperatives joined forces to prepare a regional resource manual. The manual provided cooperative members detailed information on sensitive marine resources, response strategies, spill envelopes, response resources, navigation hazards, and other topics for incorporation into individual facility or vessel response plans being prepared for compliance with the stringent requirements of California's Oil Spill Prevention and Response Act. Detailed maps of sensitive resources, response strategies, and spill envelopes were prepared using a geographic information system (GIS) for ease of presentation and revision. Maps were supported by detailed tables on the facing page, producing a maximally user-friendly document.

AUTHOR: William Gorham earned a Ph.D. in biology from the University of Southern California. After eight years teaching as a biology professor in California and the Virgin Islands, he joined ENSR. As a senior scientist, he has prepared numerous environmental assessments and ecological surveys and more than 30 OSCPs.

THE U.S. EPA 1994 NATIONAL SURVEY OF OIL STORAGE FACILITIES

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In an effort to better characterize the facilities regulated by the agency's oil pollution prevention regulations, the U.S. Environmental Protection Agency is conducting a national survey of oil storage facilities that are potentially subject to 40 CFR Part 112 (the 1994 SPCC Facilities Study).

AUTHOR: Janet LaFiandra Weiner is the attorney/advisor for EPA's Emergency Response Division. She is a graduate of Columbia Law School, where she was editor-in-chief of the *Columbia Journal of Environmental Law*. She also holds a masters degree in government administration from the University of Pennsylvania.

CALIFORNIA'S AREA CONTINGENCY PLANS: A SUCCESSFUL STATE/FEDERAL PARTNERSHIP

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The area planning effort that took place in California in 1993 was unique in its level of coordination between state, local, and federal offices, as well as in its strict organizational format to get the job done. The completed documents stand as models for the rest of the nation to follow, and the methods used to accomplish this goal highlight a useful approach to complex programmatic tasks.

AUTHOR: Adam Sutkus holds a B.A. in environmental science from the University of California, Los Angeles, and a masters in public administration from the University of Southern California. He has worked at the federal EPA, the U.S. Senate, and for local and state governments. He now heads the state's area planning efforts at the California Oil Spill Prevention and Response Office.

VESSEL RESPONSE PLANS: A TILE IN THE MOSAIC OF THE NATIONAL RESPONSE SYSTEM

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With the implementation of the Oil Pollution Act of 1990 came the requirement for vessels to develop plans for responding to oil spills from their vessels. While some companies had such plans in the past, the National Response System did not formally recognize their existence. Individual vessel response plans must now be viewed as an integral part of the National Response System. All of the parties that could be involved in an oil spill response must begin to view themselves as one tile of many that make up the mosaic known as the National Response System.

AUTHOR: Lt. Cdr. Smith has held numerous positions in the field of marine safety, including serving as an on-scene coordinator's representative at major oil spills. He is currently assigned to U.S. Coast Guard Headquarters, where he is involved in the implementation of the vessel and facility response plan requirements of OPA 90.

CONSENSUS-BASED, CONSOLIDATED CONTINGENCY PLAN

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The authors of the Oil Pollution Act of 1990 (OPA 90) viewed the key to effective response to be a contingency plan developed by all stakeholders. OPA 90 laid the groundwork for developing true consensus-based contingency plans. Northwest U.S. state and federal agencies have combined the plans of two U.S. Coast Guard Captain of the Port zones, one Environmental Protection Agency (EPA) region, and three states into one document that addresses general operational and administrative spill response issues. Operational issues that differ among the participants are covered in comprehensive geographic response plans (GRPs).

AUTHOR: Roger Mowery (Capt., USCG, ret.) is an executive assistant/incident commander with the Washington State Maritime Commission (a state oil spill organization). He served 30 years with the U.S. Coast Guard, having completed his last assignment as Commanding Officer of Marine Safety Office, Puget Sound.

PRINCIPLES OF WAR APPLIED TO OIL SPILL INCIDENT MANAGEMENT

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The principles of war provide both nomenclature and insight into incident management. Understanding the National Response System infrastructure and organizational environment, together with the principles of war, allows rigorous study of historical lessons and their application to future spill incidents.

AUTHOR: John Giesen has been an instructor with the TEEX Service for over three years, specializing in incident and prevention management systems. He serves in the United States Marine Corps Reserve.

CISPRI TECHNICAL MANUAL—A DIFFERENT APPROACH

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Cook Inlet Spill Prevention & Response, Inc. (CISPRI) is an oil industry sponsored oil spill response cooperative with headquarters in Nikiski, Alaska. CISPRI presently provides a variety of spill response services in support of member company petroleum operations in the Cook Inlet region of Alaska.

Currently, each of CISPRI's 12 member companies has one or more contingency plans (one company has seven). By utilizing a single agency-approved CISPRI Technical Manual, each member is allowed to include in their C-Plan, by reference, all common response information that is included in the CISPRI Technical Manual.

AUTHOR: Victoria Askin has been with CISPRI since its inception in 1991. For the past two years she has been responsible for compiling, writing, and periodic updates of the CISPRI Technical Manual.

CLEAN COASTAL WATERS COST PARTICIPATION FORMULA

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Clean Coastal Waters, Inc.'s (CCW) cost participation formula (COSTPART™) is a computerized formula which calculates the cost allocation of CCW operations and equipment purchases to member companies. Costs are allocated on the basis of oil volumes handled during specific oil-handling activities such as terminal transfers, production operations, and pipeline operations. The formula accounts for the relative risks of spill occurrence for the various activities, using a relative risk analysis of historical spills resulting from activities similar to those performed by CCW members. COSTPART is statistically based and has been adapted for use on IBM-compatible personal computers.

AUTHOR: J. Michael Sartor, P.E., is Woodward-Clyde's Western Region practice leader for oil spill contingency and Spill Prevention, Control, and Countermeasures (SPCC) planning services. He is responsible for overseeing and supporting all projects involving oil spill and SPCC planning. He has managed the preparation of contingency plans, spill risk assessments, and early response estimates.

GETTING A "GRP:" THE GEOGRAPHIC RESPONSE PLANNING EFFORT IN WASHINGTON STATE

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Geographic response plans (GRPs) lay out oil spill booming and collection strategies in priority order, as well as identify natural and logistical resources within a certain region. Nine draft GRPs currently exist for Washington's marine waters; another series is under development for the Columbia/Snake River system. Each GRP evolved from a workshop where a diverse set of participants designed protection strategies and priorities, based on information about sensitive natural resources and local currents and tides. Draft plans are now being refined through field verification and public review. Recent spills have confirmed the value of GRPs in enabling rapid resource protection.

AUTHOR: Paul Heimowitz has been an environmental planner with the Washington State Department of Ecology since 1990. A member of the Spill Prevention & Planning Unit, the author works on oil spill damage assessments and helps develop regional spill response and restoration plans. He has a bachelor's degree in ecology, and a master's in marine resource management.

MAJOR OIL SPILL INCIDENTS: LESSONS FOR RESPONSE PLANNING

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It is abundantly clear that we have a great deal to gain by preventing damaging oil spills. But what defines such spills? What are their sources, sizes, and the most appropriate response measures? To understand better what factors may help to minimize the amount of damage caused by oil spills, the authors examined case histories of major spills as reported in the *Proceedings of the International Oil Spill Conferences*. Data on factors related to the facility or vessel, environment, and response efforts for these spills were reviewed to identify important influences on environmental damage.

AUTHOR: Dana Stalcup is currently team leader for Oil Pollution Response Policy and Guidance in the Emergency Response Division of EPA headquarters. He has worked in the development of oil pollution prevention and response regulations for several years, including managing the Emergency Response Notification System database.

DECISION SUPPORT FOR OIL SPILL RESPONSE CONFIGURATION PLANNING

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We have developed a prototype oil spill response configuration system to help U.S. Coast Guard (USCG) planners determine the appropriate response equipment and personnel for major spills. Advanced artificial intelligence planning techniques, as well as other software tools, have been applied to spill trajectory modeling, plan evaluation, and map display. We have successfully demonstrated the initial prototype system to various USCG personnel at the regional and national levels on a specific major spill scenario from the San Francisco Bay area.

AUTHOR: Roberto Desimone is a senior computer scientist within SRI's applied artificial intelligence technology program. He has a Ph.D. in artificial intelligence from the University of Edinburgh, Scotland. He can be reached at SRI by phone on (415) 859-4038 or by e-mail to roberto@erg.sri.com.

SPILL RESPONSE PLANNING FOR SEASONAL VARIABILITY OF RIVER CURRENTS

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Response plans for the lower Columbia River will have to be amended to allow for the dramatic change in river currents resulting from winter precipitation and spring runoff and the presence of four major dams. Earlier response plans accounted for the seasonal variability of sensitive species as well as daily tidal fluctuations, but ignored the seasonal variability of river discharges. In the future, the Columbia River response community needs to be armed with strategies for both high- and low-flow river conditions.

AUTHOR: Paul Slyman is a spill prevention and response specialist with the Oregon Department of Environmental Quality.

ESTIMATING THE VOLUME OF OIL LEAKING FROM ABOVEGROUND STORAGE TANKS

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An order-of-magnitude estimate of the volume of oil potentially leaking from aboveground storage tanks (ASTs) has two primary components: estimating a relationship between AST age and the probability of failure due to corrosion; and determining thresholds, based on current technologies and/or methods, below which oil leaking from ASTs would not be detected. A distribution of ASTs by five storage capacities (50,000, 200,000, 876,000, 1,000,000 and 4,000,000 gallons) and five age categories (0–10 years old, 11–20 years old, 21–30 years old, 31–40 years old, and 40 years old or older) was used to demonstrate the relationship between tank capacity, tank age, and volume of oil leaked.

AUTHOR: Kevin Mould is an environmental engineer for EPA's Emergency Response Division. He holds a master's degree in engineering from Virginia Tech. Prior to government service, he worked with a Long Beach, California, structural design firm.

DEVELOPMENT OF CULTURAL RESOURCES PROTECTION GUIDELINES FOR ALASKA'S ON-SCENE COORDINATORS

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In recognition that oil spills and hazardous substance releases typically require response actions within the first 24 hours, the Alaska Regional Response Team (RRT) has developed draft Cultural Resources Protection Guidelines for Alaska to establish an emergency procedure for taking cultural resources into account during responses and to ensure that response actions comply with the National Historic Preservation Act. The draft guidelines were developed in consultation with the Alaska State Historic Preservation Officer and the Advisory Council on Historic Preservation. The mechanism for formally establishing the guidelines' emergency procedures is a programmatic agreement, which will be signed by appropriate federal and state agencies' historic preservation officials.

AUTHOR: Pamela Bergmann has undertaken planning and response activities for oil spills since 1987. She is an active participant in the Alaska Regional Response Team and was involved in response and environmental restoration after the T/V *Exxon Valdez* spill.

COSS: A MESOSCALE TEST BED FOR NEARSHORE SPILL RESEARCH

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A large wave tank prototype known as the Coastal Oilspill Simulation System was designed, constructed, and tested, yielding a basic facility that accurately models nearshore physical conditions. This tank design has direct application in testing chemical and biological oil spill treating agents.

AUTHOR: Tim Reilly is the environmental health analyst for the Marine Spill Response Corporation.

AREA CONTINGENCY PLANS: THE GOOD, THE BAD, AND THE EVER-EVOLVING

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The existence of area contingency plans, at least in draft form, for coastal and inland areas, combined with the National Contingency Plan's emphasis on and deferral to area committees, presents a timely opportunity for area committees to address vital response issues. By drawing upon each others' plans, area committees can enhance their own plans and assist the development of a comprehensive and consistent system for oil spill response. This presentation identifies specific area committee responsibilities imposed under the National Contingency Plan. Materials to be available at the conference will suggest key issues for inclusion in plan revisions and offer helpful samples from existing plans.

AUTHORS: Carolyn White is a regional attorney for the Marine Spill Response Corporation, with primary responsibility for the Northeast and Gulf Regions.

Patricia Donahue is the environmental advisor for the Northeast Region of Marine Spill Response Corporation.

WORKER SAFETY AND TRAINING REQUIREMENTS IN THE MARINE ENVIRONMENT

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The current worker safety requirements focus primarily on land-based hazardous waste disposal sites and emergency operations at land sites. It is often difficult to interpret the application of these requirements in the context of marine-related oil spill response operations. Overlapping governmental jurisdictions can cause problems associated with worker safety activities and suggestions relating to the application of safety requirements to persons who may become involved with a response effort are offered.

AUTHOR: Jonathan K. Waldron is senior regional counsel with the Marine Spill Response Corporation. Prior to coming to MSRC in 1991 he served with the U.S. Coast Guard for 20 years in operational and legal assignments involving environmental, maritime, and international matters. He received his undergraduate degree from the U.S. Coast Guard Academy and his juris doctor from the University of Miami, Florida, in 1981.

ON-SCENE COORDINATOR AREA RESPONSE SYSTEM

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The U.S. Environmental Protection Agency Region VI utilizes a field deployable geographic information system (GIS) known as OSCARS (on-scene coordinator area response system) to improve its spill management capabilities. The following fields are found in OSCARS: sensitive ecosystems, watersheds, population centers, response organizations, disposal facilities, operational/logistical support functions, facilities/pipelines information, and ortho-digital photography. The system is deployed on a laptop computer with expandable hard drives.

AUTHOR: Donald P. Smith has been the senior on-scene coordinator for the U.S. Environmental Protection Agency Region VI since 1984. He received a Bachelor of Arts degree in political science from the University of Texas at Arlington, specializing in environmental studies.

CALIFORNIA OFFICE OF OIL SPILL PREVENTION AND RESPONSE

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The Office of Oil Spill Prevention and Response (OSPR), the Department of Fish and Game, is the lead state agency charged with oil spill prevention and response in the marine environment of the state of California. The OSPR was established pursuant to the California Oil Spill Prevention and Response Act of 1990. The legislation provides the OSPR Administrator with substantial authority to direct spill response, cleanup, and natural resource damage assessment activities.

AUTHOR: Mark B. Garcia is the Chief of External Affairs and Prevention Education programs at the California Department of Fish and Game's Office of Oil Spill Prevention and Response. His programs include governmental coordination, public outreach (response assistance and individual prevention practices), small craft refueling dock self-compliance, and volunteer coordination.

SAFETY SYSTEMS INTEGRATION IN A LARGE OIL SPILL RESPONSE ORGANIZATION

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Improvements in oil spill and hazardous materials response organizations are designed to increase the effectiveness of response efforts. Parallel improvements in employee safety and health can be made by integrating some of the same organizational and technological systems developed to support the primary mission of response (for example, oil collection or site remediation). Examples can be seen in two safety programs developed by a large marine oil spill response organization: a vessel-based level-B site assessment and characterization system, and a computer-based spill operating system that integrates site-specific site safety plan (SSP) templates.

AUTHOR: Steve Magasis is the safety supervisor for MSRC's Northwest Region. He is a certified industrial hygienist, and has 15 years of experience in the environmental health and safety field.

FISHING INDUSTRY AND COMMUNITY SUPPORT

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Alyeska Pipeline Service Company, acting as the response action contractor for Trans-Alaska Pipeline System laden tankers within Prince William Sound, recognizes that a successful, rapid response to a major oil spill requires significant support from local communities and fishing vessels.

AUTHOR: Richard C. Long holds a United States Coast Guard 500 ton Master's License and has more than 20 years experience in the marine industry. He began his career with Alyeska's Ship Escort and Response Vessel System (SERVS) as a duty officer in 1989, and became the fishing vessel coordinator in 1991.

OIL SPILL CONTINGENCY PLANNING CRITERIA FOR INTERNATIONAL RIVER BASINS

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Many issues must be taken into account during the development and implementation of bilateral oil spill contingency plans for rivers and river basins shared by two or more countries. Such bilateral plans between Ecopetrol Colombia and PDVSA Venezuela respond to the need for well-designed tools for response to spills in international river basins that are near or within areas where petroleum exploration, production, and transportation activities are being carried out. Information collected during the last six years helped in the development of this bilateral oil spill contingency plan.

AUTHOR: Elia Gómez is a geographer, who has been working for 10 years on the National Contingency Plan for PDVSA. She also worked on the design and implementation of the Catatumbo and Arauca International Rivers Contingency Plans.

THE *BRAER* SPILL: OIL FATE GOVERNED BY DISPERSION

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The fate of 86,000 metric tons (t) of Gullfaks crude oil at the *Braer* incident was governed by the process of natural dispersion. The overall impact of the spill was minimal in time and extent indicating that dispersing oil spilled at sea can reduce the impact of oil spills. Experimental work in the North Sea has shown that the characteristics of the oil played a critical role in promoting the dispersion process. The *Braer* incident provides support for the use of dispersants to reduce the environmental impact of a spill in cases where the oil type is less amenable to natural dispersion.

AUTHOR: For five years, Tim Lunel has worked at the National Environmental Technology Centre (formerly Warren Spring Laboratory) on dispersant use as a response method for oil spilled at sea. He was called in to assist the U.K.'s Marine Pollution Control Unit (MPCU) during the *Braer* incident.

NEW OIL SPILL ENVIRONMENT PROTECTION AND CONTINGENCY PLAN REQUIREMENTS—ARGENTINA

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As part of a concurrent wave of environmental awareness and restructuring of the oil industry in Argentina, the Secretariat of Energy, building upon an initial study by the Argentine Petroleum Institute, has developed several new regulations and guidelines designed to protect the environment. Exploration, development, and production of oil fields are now subject to new environment controls and the format and content of environment impact analyses, and oil spill contingency plans are defined. Offshore regulations are expected in 1994/95.

AUTHOR: Erich Gundlach has provided scientific support during major oil spills and developed response plans for over 18 years, both in the United States and internationally. For the last three years, he has conducted environmental assessments and contingency plan studies in Latin America, and particularly in Argentina.

REMEDIATION OF OIL-CONTAMINATED DEBRIS USING A ROTARY KILN COMBUSTOR

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The Emergencies Engineering Division (EED) of Environment Canada's Environmental Technology Centre has been investigating the use of combustion to remediate oil-contaminated debris resulting from marine oil spills. Rotary kiln technology was determined to be suitable for such wastes, and offers an environmentally safe solution to this problem. The debris used for these tests were oil-contaminated gravel and sorbents.

The rotary kiln tests were conducted at the Energy Research Laboratory, CANMET, Natural Resources Canada between January and February 1994. The system consists of the rotary kiln combustor, feed systems, afterburner, and packed bed spray tower, induced draft fan, and stack.

AUTHOR: Laura Ouellette has been working in the environmental and combustion fields in the private and public sectors for eight years. She has prepared and presented combustion and environmental remediation papers at seminars and conferences in Canada. She received her masters in applied science (chemical engineering) in combustion modeling from the University of Ottawa in 1988.

MEXUSPAC: MEXICO/U.S. PACIFIC REGIONAL RESPONSE COORDINATION TEAM

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The Agreement of Cooperation Between the United States of America and the United Mexican States Regarding Pollution of the Marine Environment by Discharges of Hydrocarbons and other Hazardous Substances, signed in Mexico City in 1980, provides a framework for cooperation in response to pollution incidents that pose a threat to the waters of both countries. Under this agreement, MEXUSPAC organizes Mexican and U.S. response agencies to plan for and respond to pollution emergencies in the marine environment. The MEXUSPAC contingency plan designates the commandant of the Mexican Second Naval Zone and the chief of the U.S. Coast Guard 11th District Marine Safety Division as the MEXUSPAC Cochairmen, and defines on-scene commanders, joint operations centers, and communications protocols that would be needed to coordinate the response to pollution incidents affecting both countries.

AUTHOR: Lt. Cdr. Daniel Whiting serves as chief of the 11th USCG District Response Advisory Team. He graduated in 1978 from the Coast Guard Academy and has served as navigator aboard USCGC *Sagebrush* (WLB 299), commanding officer of LORAN-C Station Kure Island, Marine Science Technician School chief, and port operations officer at MSO San Juan, Puerto Rico.

FREQUENCY OF OIL SPILLS COMPARED TO EVERYDAY HAZARDS

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Comparing the frequency of oil spills with other common hazards, many subjective values appear to lead the public to perceive oil spills and other environmental risks with greater concern than would seem to be warranted by the relative risk numbers.

AUTHOR: George Lowden is a vice president of the environmental consulting firm of ICF Incorporated, located in Fairfax, Virginia. For 12 years, he has provided support to the U.S. Environmental Protection Agency and, more recently, the U.S. Department of Transportation, in the development and implementation of regulations dealing with oil and hazardous chemicals.

OIL SPILL CONTINGENCY PLANNING IN THE LATIN AMERICAN PETROLEUM INDUSTRY

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A questionnaire was circulated between ARPEL (Asistencia Recíproca Petrolera Empresarial Latinoamericana) member companies in which their capacity to confront an oil spill contingency on their shores, separately and collectively, is determined. The results show that a need exists for preparing sensitivity maps to be utilized in the contingency plans. It can be concluded from this study that the Latin American petroleum industry centered in ARPEL should orient itself toward regional cooperation that would strengthen institutional capacity and maximize the effectiveness of government-industry collaboration in handling emergency situations.

AUTHOR: Juan Miguel Moyano is a chemical engineer with a graduate degree in marine pollution chemistry from studies in England. He has worked for the Uruguayan Navy's Oceanographic Service for seven years; has been an adjunct professor at the University of Uruguay since 1981; and an environmental advisor for ARPEL since 1991.

PRIVATE SECTOR/GOVERNMENT COOPERATION DURING A BAHRAIN SPILL RESPONSE OPERATION

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On November 23, 1993 a barge struck one of the undersea crude oil lines from Saudi Arabia to Bahrain. The resultant spill released approximately 4,000 bbl of crude into the sea and sensitive adjacent beach areas.

The BAPCO oil spills contingency plan contains procedures for cooperation with appropriate private sector and government agencies and these were set in motion at once, coincident with company response. The Response Command Centre, immediately initiated a GAOCMAO (Gulf Area Oil Companies Mutual Aid Organization) alert.

The Contribution of all these resources resulted in the cleanup being completed 10 days after the spill.

AUTHOR: Derek Brown holds a B.Sc. honours degree in mechanical engineering from Imperial College London, and is a chartered engineer. He has held environmental affairs responsibilities with the Bahrain Petroleum Company from 1970 through 1994. He is currently adviser, special projects and has been chairman of the regional oil spill Cooperative, GAOCMAO, three times.

INFORMATION TO MINIMIZE IMPACTS FROM FRESHWATER OIL SPILLS

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The American Petroleum Institute (API) has the only program in the United States dedicated to freshwater oil spill research. In existence since 1990, the API Inland Spills Work Group consists of representatives from industry and government. Projects have included a manual prepared with NOAA that evaluates cleanup techniques in order to minimize environmental impacts of spills in freshwater habitats, a literature review and annotated bibliography of environmental and human health effects of freshwater oil spills, a study of chemical treating agents for use in freshwater applications, and an evaluation of in situ burning of oil spilled in marshes.

AUTHOR: David E. Fritz is a Senior Research Engineer in Amoco Oil Company's Research and Development Department specializing in oil spill science and technology. He is chairman of the API Inland Spills Work Group. He has masters degrees in environmental and chemical engineering.

RISK MANAGEMENT IN OIL PIPELINES AND GAS PIPELINES

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Several methods have been developed by Dutos e Terminais do Centro-Oeste e São Paulo, a subdivision of Petrobrás's Transportation Department, to guarantee the mitigation of identified risks in pipeline installations, using a managerial approach rather than the traditional technical approach.

AUTHOR: Luiz de Lima Buzelin, a mechanical engineer, has worked at Petrobrás since 1968. Currently, he is in charge of management of Dutos e Terminais do Centro-Oeste e São Paulo.

ADVANCED CHEMICAL FINGERPRINTING FOR OIL SPILL IDENTIFICATION AND NATURAL RESOURCE DAMAGE ASSESSMENTS

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For petroleum fingerprinting in support of natural resource damage assessments (NRDA) and other regulatory and litigation-driven scientific studies, the state of the art now focuses on polycyclic aromatic hydrocarbons (PAH) and saturated biomarker analyses, coupled with ratio and/or principal component analysis techniques, for advanced chemical fingerprinting (ACF) and allocation of petroleum mixtures to multiple sources. This strategy is being applied to oil spills, in-ground petroleum releases, and coal tar-petroleum source differentiation scenarios. The National Oceanic and Atmospheric Administration's (NOAA) draft injury guidance on NRDA recommends the application of ACF to oil spill assessments under the Oil Pollution Act of 1990.

AUTHOR: Paul D. Boehm, Vice President and Managing Director of Arthur D. Little's Environmental, Health, and Safety Consulting operations, has conducted oil spill assessments and has pioneered fingerprinting methods for oil spills from the *Amoco Cadiz* to the *Exxon Valdez*.

THE VULNERABILITY ANALYSIS: EVALUATING EFFECTS OF OIL DISCHARGES ON THE ENVIRONMENT

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Various components make up a vulnerability analysis of the potential effects of an oil discharge or a release of a hazardous substance on the environment. Although the process used in the oil spill vulnerability analysis would be appropriate for other planning purposes, this particular analysis is an element of the OPA 90 response plan that the owner or operator of a "substantial harm" facility must prepare and submit to the U.S. Environmental Protection Agency.

AUTHOR: Bobbie Lively-Diebold works for the oil program in EPA headquarters in Washington, D.C. She is a project manager developing regulations to implement OPA response plan requirements for EPA-regulated facilities and she coordinates with other agencies to develop and implement OPA requirements, including drills.

SHORELINE OIL FROM *EXXON VALDEZ*: CHANGE FROM 1991 TO 1993

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During summer of 1993, the Alaska Department of Environmental Conservation surveyed 45 sites in Prince William Sound that were oiled by the March 1989 *Exxon Valdez* oil spill. The data describe the oil's visual properties and extent. Comparisons provide estimates of oil reduction since 1991.

From 1991 to 1993, an estimated 50 percent reduction in the amount of asphalt, surface oil residue, and mousse was largely caused by manual removal and raking. Subsurface oil reduced by about 65 percent. Sites mechanically tilled or from which oiled sediment was removed improved the most, but natural reduction was still greater than 50 percent.

AUTHOR: James Gibeaut is a coastal geologist who has conducted shoreline oiling surveys in Prince William Sound since 1989. He is currently a research associate at the University of Texas at Austin.

EVALUATION OF HISTORIC SPILL SITES FOR LONG-TERM RECOVERY STUDIES

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Reports on over 300 oil spill incidents were reviewed for the potential value of conducting followup surveys to obtain new or additional information related to the long-term effects of the spill or cleanup operation. A three-stage screening process enabled focusing on marine spills where impacts to the coastal zone were well documented, where spill size was over 1,200 barrels (50,200 gallons), and had occurred prior to 1987. A total of 36 candidate sites were put on the shortlist, of which 25 were rated as low priority, 9 as moderate priority, and 2 (*Amoco Cadiz* and *Metula*) as high priority for future study. This study hopes to elicit feedback concerning additional sites that have been overlooked or have additional merits for followup investigation.

AUTHOR: Erich Gundlach has studied oil spills for over 18 years, and participated in the scientific evaluation of many of the largest spills to date. He has also developed many spill-related review studies, contingency plans, and environmental impact analyses, both in the United States and internationally.

OIL BOOM LINEAR HAULER LAUNCH AND RECOVERY SYSTEM

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The oil boom linear hauler launch and recovery system promotes technical advances in launching, recovering and storing large lengths of oil boom. This launch and recovery system is capable of handling differing types and varying lengths of boom from ships of opportunity while deploying or storing to and from pallets or ISO open top containers versus multiple storage reels.

AUTHOR: Steve Koepenick performs business and product development, representing small businesses in marketing, planning and merger and acquisition activities. His prior experience includes sea test system development for various Navy ocean engineering programs. His formal education is in mechanical engineering from the University of California, Santa Barbara, and management from the Naval Postgraduate School, Monterey.

NOAA'S *EXXON VALDEZ* LONG-TERM SHORELINE ECOSYSTEM MONITORING PROGRAM—1990–1994 TRENDS

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Halfway through a 10-year monitoring program, NOAA continues to track biological, chemical, and shoreline profile recovery at nearly three dozen sites in Prince William Sound, Alaska. By simple measures (percent visible oil, percent plant cover) all but three or four sites recovered in two to three years. However, by a more integrated biological, chemical, and physical profile, most previously oiled and treated sites are still recovering.

AUTHOR: Alan Mearns (Ph.D., fisheries, University of Washington) leads the HMRAD Biological Assessment Team and has 25 years' experience (15 with NOAA) monitoring recovery of coastal ecosystems and reporting on effects of pollution. His team is the recipient of a 1992 Department of Commerce Silver Medal. He wishes to thank all the participating scientists, technicians, and sponsors.

RECOVERY OF SAUDI ARABIAN SHORE BIOTA FOLLOWING THE GULF WAR

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Five months after the impact of oil on the shores of Dawhat ad Dafi and Dawhat al Musallamiya, long-term biological monitoring was initiated on permanent transects (PTL) on representative habitats and similar but uncontaminated control habitats outside the area. Upper shore biota was virtually eliminated on all oiled shores, while lower shores showed a 60 to 90 percent mortality, depending on the substrate type. By September 1994, species diversity comparable to that of controls was present on the mid and lower regions of impacted shores. Abundances are still generally lower for most species on affected shores, and abnormal population density fluctuations for some species are still apparent.

AUTHOR: David Jones, Ph.D., Reader in University of Wales, is author of the Seashore Guide to Kuwait and Arabian Gulf (1986).

A COMPREHENSIVE APPROACH TO OIL SPILL AND HURRICANE IMPACTS

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The effects of a 1992 oil spill and hurricane on salt marsh recovery on a Louisiana barrier island was evaluated through a combination of landscape- and community-scale analyses. Landscape-scale analyses indicated that the hurricane had a profound effect on island land cover and morphology. The analyses indicated that the oil spill had minimal effect on island vegetation. The landscape analysis detected changes in vegetative cover in areas where oiling occurred in 1992. Field surveys identified additional small areas where oil had a negative effect on land cover. The community-scale analysis detected fine-scale vegetative responses to the spill.

AUTHOR: Karolien Debusschere is a project scientist at Coastal Environments, Inc., and conducts research in a variety of oil spill and geomorphology related issues, including oil spill response, fate, and effects monitoring; natural resource damage assessment; and bioremediation.

VISUAL INFORMATION SYSTEMS AND GIS IN CRISIS MANAGEMENT

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In an emergency, visual information is the most rapid and powerful means of communication available. Emerging computer-based technologies such as user-friendly geographic information systems (GIS), live-link monitoring, video CDs, and 3-D visualization have already proven effective in communications and decision support when appropriately applied to oil and gas operations.

AUTHOR: Stephen Sheppard, Ph.D., is an Associate at Dames & Moore and a senior specialist in visual assessment and communications. He has more than 18 years of experience in the fields of environmental and computer-aided planning.

EFFECTIVENESS OF OIL SPILL RECOVERY SYSTEMS

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The measure of the effectiveness of an oil spill recovery system is the ability of the system to recover the most oil in the least time. Because of the rapid spreading and thinning of spilled oil, it is essential that oil recovery equipment be tested and rated using realistic oil encounter rates and spilled oil thicknesses. ASTM standards F631 and F808 define encounter rate (ER), throughput efficiency (TE), and oil recovery efficiency (ORE). Using these definitions and testing using realistic slick thicknesses, encounter rates, and environmental conditions makes ranking the effectiveness of oil spill recovery devices possible.

AUTHOR: Robert Watkins is a naval architect in private practice in Blue Hill, Maine. He has had over 10 years' experience in the design, testing, and construction of oil recovery vessels, barges, and VOSSes.

HARDSHELLED CLAM RECOVERY FROM *EXXON VALDEZ* OILING AND SHORELINE TREATMENT

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Native littleneck clams (*Protothaca staminea*) from Prince William Sound were sampled to evaluate recovery from the March 1982 *Exxon Valdez* oil spill. Hydraulic washing flushed quantities of material from upper elevations, often burying the lower beaches in sediment with few fines and little organic carbon. Sampling at stations representing several degrees of oiling and treatment disturbance showed that hydraulically washed beaches had significantly lower clam densities in 1990. Recruitment has been very limited on washed beaches; as a result, clam densities remained very depressed through 1992 compared with those on unoiled beaches and on beaches that were oiled but not washed.

AUTHOR: Jonathan P. Houghton (A.B. Harvard, Ph.D. University of Washington) has been active in intertidal and nearshore research along the coastlines of Washington and Alaska since 1969. He monitored the immediate effects of the 1989 *Exxon Valdez* oil spill and various beach treatment approaches on the intertidal assemblages and continues to monitor their recovery.

OPTIONS FOR MINIMIZING ENVIRONMENTAL IMPACTS OF FRESHWATER SPILL RESPONSE

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Selecting appropriate protection, response, and cleanup techniques is a critical element affecting the ultimate environmental impact and cost resulting from a spill. The American Petroleum Institute and National Oceanic and Atmospheric Administration jointly developed a guide as a tool for contingency planners and field responders to identify techniques that in themselves have minimal intrinsic ecological impact and minimize the impact of the oil. The guide provides information on 29 response methods and classifies their relative environmental impacts for four oil types and 12 freshwater environments and habitats. Spill topics of special concern in freshwater settings are also discussed, including public health, conditions under which oil might sink, oil behavior in ice conditions, permafrost, and use of fire-fighting foams.

AUTHOR: Lt. Cdr. Kenneth Barton is the NOAA Scientific Support Coordinator for the Great Lakes and inland rivers. He works with the U.S. Coast Guard and Environmental Protection Agency in providing scientific support for spill contingency planning and response.

MANGROVE RESTORATION: CARTAGENA, COLOMBIA, COASTAL OIL SPILL CASE STUDY

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On June 26, 1990, an accidental oil spill occured at a refinery located in Cartagena, Colombia, affecting a 2.5 ha coastal mangrove area and killing all its associated fauna. A special manual cleanup program made it possible to restore part of the polluted soil without harming most of the mangrove plants nor affecting water exchange conditions in the site. Further comparative monitoring programs showed that the ecosystem was totally restored and has grown to a 10 ha forest which is now being used for coastal remediation research.

AUTHOR: Mauricio Ibáñez has a B.Sc. degree in biology from Universidat Javeriana, Colombia, and has had post-graduate training in marine sciences, limnology and oil spill response and planning in Sweden. He has worked for Aquaculture Enterprises, Inc., and the Colombian state oil company Ecopetrol. He is currently the National Contingency Planning Coordinator for Colombia.

IS GROUND WATER PROTECTED AGAINST RELEASES FROM ABOVEGROUND STORAGE FACILITIES?

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Growing concern about the threat to our nation's ground water from leaking above-ground oil storage facilities has prompted a reevaluation of regulatory and nonregulatory programs to prevent such contamination. Government and industry have begun efforts to address this concern.

AUTHOR: Kevin Mould works for the oil program at EPA headquarters in Washington, D.C., focusing on issues related to the regulation of oil storage facilities.

IDENTIFYING AND INCORPORATING SENSITIVE ENVIRONMENT CONSIDERATIONS FOR INLAND RESPONSE/CONTINGENCY PLANNING

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The Oil Pollution Act of 1990 (OPA 90) requires the Environmental Protection Agency to have oil storage facilities develop response and contingency plans. One of the purposes of the plans is avoidance and minimization of risk and injury to sensitive environments from a potential discharge of oil at the facility. The U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) are collaborating with the Environmental Protection Agency to adopt and modify NOAA's coastal identification and mapping of sensitive environments protocol for inland areas. This will encourage identification and mapping consistency between the two areas and can be applied to other OPA 90 mandated plans.

AUTHOR: Jeffrey L. Underwood is national spill response coordinator for the U.S. Fish and Wildlife Service in Arlington, Virginia. He coauthored, with NOAA, the Fish and Wild and Sensitive Environments Plan (in the NCP), authored the FWS's Spill Response Contingency Plan, and is an instructor for the FWS's Natural Resource Damage Assessment Training Course.

PROTECTION OF COASTAL SHORELINES FROM OIL SPILLS USING NATURAL AGENTS

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Some products have been proposed which will reduce the adhesion of oil to rocks, and thus diminish the impact of oil spills on shorelines. The products are natural, biodegradable materials (polysaccharides). Experiments conducted in a simulated tidal zone resulted in a 20% to 30% decrease in the adhesion of oil compared with control tests. The products retained their effectiveness for six days after application. In situ tests also showed significant results.

VENEZUELAN OIL SPILL NATIONAL CONTINGENCY PLAN: DISPERSANT LABORATORY PROGRAM

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The Venezuelan Ministry of Environment has set strict regulatory measures forbidding the use of oil dispersants, based on the lack of information about the effects of those products on native or tropical biological species. As a result, INTEVEP has conducted research using commercial dispersant products, aimed at providing information on the feasibility of their use according to effectiveness and toxicity data necessary for the appropriate approval from the ministry authorities. Studies were carried out with five different commercial dispersants. Overall analysis indicates that Corexit 9527 gave best results: its effectiveness is among the highest and its toxicity could be regarded as moderate, an adequate combination not found in the other products tested.

AUTHOR: Jorge Rodríguez-Grau, an environmental toxicologist, at present is head of the Ecology Section of the General Management of Ecology and Environment at INTEVEP. He joined INTEVEP in 1989 after he had earned a B.S. from Texas A&M and a Ph.D. from the University of North Texas (1989).

COST EFFECTIVE OIL SEEP REMEDIATION: SORBENT WASTE MINIMIZATION PILOT PROJECT

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Site evaluation resulted in the replacement of a passive sorbent system by floating oil stabilization with skimming to remove seeping petroleum products from navigable waterways.

After one year, the following changes had occurred.

- Hazardous waste dropped from 135,000 to zero pounds per year.
- Two to three barrels per week of recycled oil containing less than 3 percent water were being produced.
- Long term liability inherent in landfill disposal of hazardous waste was eliminated.
- Remediation cost was reduced by 50 to 60 percent.

The success of this open-water project shows a high degree of applicability for thin-layer oil recovery in settling ponds, gravity separators, and stormwater processing.

AUTHOR: John P. Scambos, a founder of ERR, Inc., which specializes in oil/water separation technologies, has received recognition for his innovative, cost-effective approach to difficult remediation projects.

TEXSONDE '94—RADAR MEASUREMENT OF SURFACE CURRENTS FOR OIL SPILL MODELING

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The SeaSonde 12.5 MHz radar was used to measure surface currents offshore Galveston for a one month period (March 1994). The radar generally performed well when sited with open beach exposure; however, data return was found to vary with wind direction, which led to occasional reductions in the total coverage area. Although useful for input directly to oil spill models, the utility of the radar current data could be improved through assimilation into hydrodynamic flow models.

AUTHOR: Donald Hodgins is the president of Seaconsult and has directed the company's research activities in emergency response systems for oil spills and maritime search and rescue, and innovative remote-sensing systems such as the SeaSonde radar for ocean currents and the SEACAST system for satellite image-model data fusion.

COMPARING CRUDE OIL TOXICITY UNDER STANDARD AND ENVIRONMENTALLY REALISTIC EXPOSURES

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Standard aquatic toxicity tests do not address real-world, spiked exposure scenarios that occur during oil spills. We evaluated differences in toxicity of physically and chemically dispersed Kuwait crude oil to mysids (*Mysidopsis bahia*) under continuous and spiked (half-life of 2 hours) exposure conditions. The 96-hr LC50s for physically dispersed oil were 0.78 mg/L (continuous) and >2.9 mg/L (spiked), measured as total petroleum hydrocarbons (TPH). Values for chemically dispersed oil were 0.98 mg/L (continuous) and 17.7 mg/L (spiked) TPH. Continuous-exposure tests may overestimate the potential for toxic effects under real-world conditions by a factor of 18 or more.

AUTHOR: Charles Pace is currently a senior environmental scientist at Exxon Biomedical Sciences, Inc.

CHEMICAL ANALYSIS METHODS FOR CRUDE OIL

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Using an oil chemical analysis method developed in our laboratory, more than 280 compounds in the Alberta Sweet Mixed Blend (ASMB) oil have been positively identified. The distribution of selected target compounds offers unique and sensitive fingerprints for matching the source of spilled oil and tracing the weathering process of oil in the environment. The pattern recognition plots involving more than 100 oil-specific individual components and component groupings permit deduction of a best set of values for oil exposure to weathering. Using data from different samples including crude oil, weathered oil, and 22-year-old spilled oil as examples, the distinct advantages of the described method over the current methods are examined.

AUTHOR: Zhendi Wang is a senior research scientist working in oil spill research and development. His specialties and research interests include fate and behavior of oil in the environment, identification and characterization of oil components, development of analytical protocols for various spill-related samples, and spill-treating agent studies and analysis of dispersants and surfactants.

OIL SPILL INTELLIGENCE REPORT INTERNATIONAL OIL SPILL DATABASE: RECENT TRENDS

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Several major oil spills toward the end of 1994 may make the early 1990s begin to mirror the pattern of oil spills from the late 1970s and early 1980s, based on data maintained by the staff of the Oil Spill Intelligence Report newsletter.

AUTHOR: Jeff Welch heads database development projects at the Cutter Information Corporation, an independent publisher and information services provider headquartered in Arlington, Massachusetts. He has been gathering and maintaining data on oil spills worldwide for more than five years.

TRAINING AND DOCUMENTATION

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This presentation will visually demonstrate information on oil spill response training and documentation for compliance with current requirements, with a link to the response training and documentation requirements of international, federal, state, and local agencies. Administrative support and a computer-generated tracking system are used to assist in compliance with these regulatory requirements.

AUTHOR: Michael Cain has worked in oil spill response for nine years and is currently Director of Training and Safety for Clean Seas, an oil spill cooperative based in Carpinteria, California.

THE DEVELOPMENT OF POTENTIAL PROTECTION STRATEGIES FOR TIDAL INLETS

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Protection of coastal environments on the landward sides of tidal inlets requires effective systems of booms within the inlets. Protection strategies have been developed for more than 200 inlets on the coasts of California and Florida. They call for the use of deflection booming to divert oil to low-current zones, where it can be collected with skimmers, or to catchment areas along the shore, where it can be cleaned up. The strategies are based on an understanding of the hydrodynamics and geomorphology of the tidal inlets.

AUTHOR: Miles O. Hayes is a geomorphologist with 30 years experience in basic and applied research on coastal processes and tidal inlets. He is President of Research Planning, Inc., a science and technology firm specializing in oil spill research and response.

REVIEW OF U.K. POLICY ON RESPONSE TO OIL AT SEA

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The review carried out by NETCEN on the most appropriate response methods for oil spilled in U.K. waters concludes that aerial application of dispersants remains the most effective primary response. Modifications to operational procedures, in particular increased monitoring of the effectiveness of the dispersant response, is suggested. Research is ongoing on dispersant efficiency and toxicity, and changes in operational procedures should be dependent on these research programs.

AUTHOR: For five years Tim Lunel has worked at the National Environmental Technology Centre (formerly Warren Spring Laboratory) on response methods for oil spilled at sea. The *Braer* incident catalyzed the review of U.K. policy, and he was present at that spill to provide technical assistance.

LESSONS LEARNED: THE METHODOLOGY OF CONDUCTING OIL SPILL RESPONSE TRAINING

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Achieving and maintaining preparedness for oil spill response is similar to other emergency services in that constant training is required to achieve success. Careful consideration of what training is required must be conducted through systematic task and training needs analysis. Only then can the methods and suppliers of such training be selected. Once initiated, the training must be maintained, reinforced, and updated through exercises or other schemes. This paper looks at some lessons learned from conducting oil spill training and concludes that emergency response training for oil spills can be financially justifiable.

AUTHOR: Bernard Bennett is currently the Training School Manager for Oil Spill Response, Ltd. This international school trains 600 to 700 persons per year in all spill response disciplines. Bennett has been fully involved in oil spill response since 1981, when he started employment at the Oil Spill Service Centre, Southampton, England.

JIN SHIANG FA CASE STUDY: WHAT COULD HAVE BEEN DONE?

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On October 14, 1993, the fishing vessel *Jin Shiang Fa* grounded at Rose Atoll with 100,000 gallons of fuel on board. Rose Atoll is one of the most pristine atolls in the world. Due to its extreme remoteness, responders had very limited options and were unable to recover any fuel. Six weeks after the grounding, a salvage vessel arrived on scene and found the *Jin Shiang Fa* completely destroyed by a storm, and a third of the reef dead. No response expense was spared. Yet no fuel was ever recovered. When traditional response methods are not feasible, alternative options should be considered.

AUTHOR: William Capune is a 1990 graduate of the U.S. Coast Guard Academy with a bachelors degree in applied science. He responded to the *Jin Shiang Fa* grounding while he was assigned as the Marine Environmental Protection Branch Chief at Marine Safety Office Honolulu.

DEVELOPING THE STATE ON-SCENE COORDINATORS' COURSE FOR ALASKA

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Before the development of the state on-scene coordinators' course, spill response training available to the Alaska Department of Environmental Conservation focused on technical aspects, safety, and the incident command system. To function in a unified command and carry out legislatively mandated tasks, a program was needed to instruct responders in the department's duties. As the course evolved, a synergistic relationship developed, which is redefining the response program.

AUTHOR: Harry Young is an environmental specialist with the Alaska Department of Environmental Conservation. He has also served as a spill response coordinator for ARCO, and program coordinator of the Texas A&M Oil Spill School, as well as with Texas A&M's Environmental Engineering Division, and as a Coast Guard officer.

EVALUATION OF VARIOUS SURFACE OIL DETECTORS APPLIED TO HAZARDOUS ZONES

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Handling hydrocarbons at terminals or refineries leads to many opportunities for oil spills. In a search of the quickest response to this type of spill, the French Direction of Civil Protection funded a study aimed at achieving state of the art detection of oil spills at terminals. CEDRE evaluated four types of oil detectors: ultraviolet, infrared, visible, and a membrane one. The evaluation consisted of measuring the response to various thicknesses and several oils.

AUTHOR: François Cabioc'h, 42, is a chemical engineer who has been involved in the oil field industry for 11 years. He joined CEDRE in 1989 as a member of the research and development team. His main fields of activity include oil removal techniques at sea (burning and recovery) and contingency planning.

DEPLOYMENT TEST FOR ALYESKA, GPS-POSITIONED DRIFTER BUOY

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The field test of a free-floating buoy system (the Oil Tracker) was conducted for the Alyeska Pipeline Service Company on November 15–17, 1994. During those three days, several buoy deployments were conducted in varying weather conditions. The Oil Tracker buoys transmitted their positions to both the response vessel and the command center in Valdez in real time.

AUTHOR: Michael Hefer is president of Western Data Systems, which he founded in 1981. Since 1990 his activities have been in the Global Positioning System (GPS) field. His work in conjunction with the Amoco Oil Company led to the development of a system for tracking spilled oil in real time.

THE PERFORMANCE OF BOOMS IN AN OFFSHORE ENVIRONMENT

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The Marine Spill Response Corporation, Southwest Region, conducted offshore oil spill training exercises and boom tests between May 22, 1991, and August 2, 1991. Test documents and still and video pictures document the operations and evaluation of each of the nine booms used. The tests determined operational performance in the following areas: boom handling, loading, securing, deploying, retrieving, seagoing performance, response to waves, and tow force.

AUTHOR: James Nash is President of Chapman, Inc., Atlantic Highlands, New Jersey. He has performed test and evaluation work for 25 years. Since 1980 he has concentrated on spill remediation and operations projects.

TRAINING FOR SUCCESS: A FUNCTIONAL MANAGEMENT TRAINING SYSTEM FOR RESPONSE ORGANIZATIONS

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The U.S. Coast Guard and other organizations have adopted the unified command system (UCS) as "the" management system for pollution response. However, people in these organizations have little experience working within the UCS. This training gives participants an alternative way to think during pollution response by raising their experience level so that they will be able to predict what to do during a response and will know how to do it. Experiencing this alternative way of thinking will improve their chances for success by helping them plan their missions, determine goals, and assemble cohesive staffs capable of coordinating successful responses.

AUTHOR: Lt. David Stalfort is a course designer and trainer currently assigned to the Marine Safety Branch, U.S. Coast Guard Reserve Training Center, Yorktown, Virginia. He has more than 10 years of experience working in the marine environmental response field.

QUALITY AND THE UNIFIED COMMAND: THE REINVENTION OF SPILL RESPONSE

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Area contingency planning guidance advocates a unified command support mechanism. Marine Safety Office (MSO) Hampton Roads used total quality management to improve the unified command processes. Following participation in an industry-sponsored spill management team exercise in October 1993, MSO Hampton Roads chartered a quality action team (QAT) to prepare for its December 1993 area exercise.

Before this exercise, the Hampton Roads unified command had the opportunity to try out several quality-based innovations during an actual response. They were further refined by the QAT and effectively executed during the exercise. The enhancements were operationally validated during a March 1994 spill.

AUTHOR: Capt. Gary Thornton, a 27-year U.S. Coast Guard veteran, has held a variety of assignments in operations and in marine safety. He served as commanding officer of the Marine Safety Office, Hampton Roads, from 1990 to 1994. He is currently chief of the Boating Safety Division of the Eighth Coast Guard District.

EVALUATION AND CORRECTION: KEYS TO RESPONSE PREPAREDNESS

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Preparedness for oil spill response requires having trained people and relevant equipment. It must also include a disciplined and logical approach to define and implement clear policies, reasonable and coordinated plans, complementary operational and support procedures, and focused training. Preparedness relies on evaluation of team performance in simulated and actual response operations, objectively critiquing the results, and improving proficiency through a formal remedial action program to build better response capabilities.

AUTHOR: Roger Mickelson is director of the Operations and Crisis Management Division, Systems Research and Applications Corporation. He served as assistant emergency coordinator for the Department of Defense and as a response manager. His team has developed over 60 oil spill response exercises focusing on the evaluation of industry capabilities and needed improvements.

ENVIRONMENTAL TRAINING FOR OIL SPILL RESPONSE

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A training needs analysis study undertaken for Environment Canada's emergency responders discovered that a wide range of knowledge, from scientific to interpersonal relations and communications, is required to do their jobs effectively.

AUTHOR: Maureen Moffatt has been in the environmental emergencies field for 14 years, both in the Canadian Coast Guard and Environment Canada, specializing in preparedness issues. Internationally, she worked extensively with Caribbean countries and on the development of training courses and implementation strategy for the International Maritime Organization.

SANTA MONICA BAY PREP 94: MAJOR SPILL EXERCISE PLANNING/EXECUTION

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The largest simulated response conducted under the most realistic conditions since the grounding of the *Exxon Valdez* has been captured on video. It shows the production and execution of the Preparedness for Response Exercise Program oil spill exercise held in September 1994 in Santa Monica Bay. The exercise involved over 500 people from more than 60 organizations. Chevron played the role of responsible party in this simulation of a spill of about 10,000 barrels of crude oil. The video focuses on the incident command system and the people for whom prevention and preparedness is a daily business.

AUTHOR: Lt.(j.g.) Kara M. Satra is assigned to the U.S. Coast Guard 11th District Marine Safety Division and was the project officer for the 1994 Santa Monica Bay PREP exercise.

AIR CURTAIN INCINERATION FOR EMERGENCY DISPOSAL OF OIL SPILL DEBRIS

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Disposal of oiled waste materials following a spill provides a significant challenge in Canada's northern boreal forests. Voluminous amounts of waste, composed of a mixture of oil and water as well as organic and mineral matter, must be dealt with following cleanup in muskeg or bog ecosystems. The Prairie Oil Spill Containment and Recovery Advisory Committee (PROSCARAC) has developed a portable air curtain incinerator to provide an acceptable waste disposal method. The environmental acceptability of the incinerator is shown by the results of a test burn.

AUTHOR: Alan Kennedy has a Ph.D. in environmental science from the University of Calgary. He is currently a senior environmental advisor for Imperial Oil Resources and chairman of the PROSCARAC Research and Development Committee.

ON-SCENE COORDINATOR TRAINING: THE CHALLENGE AND THE SOLUTION

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Providing training and actual experience for on-scene coordinators can be accomplished by OSC meetings, tabletop exercises, and an annual training week involving classroom instruction and field exercises.

The training part is easy; it's getting the students to the training that's hard.

AUTHOR: Gordon Goff is the emergency preparedness coordinator in the Emergency Response and Removal Branch, EPA Region IV, Atlanta. He has been with EPA Headquarters, Regions X and IV since 1977.

ALASKA NEARSHORE DEMONSTRATION PROJECTS

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The Alaska Department of Environmental Conservation (ADEC) was appropriated $1.2 million to design and conduct nearshore demonstration (NSD) projects in the Gulf of Alaska and southeast Alaska. The objective of these projects was to demonstrate response equipment positioned in coastal communities using local resources and local vessels of opportunity to contain and recover oil from orphan spills or spills that have escaped primary containment efforts. Depending on the coastal communities involved, the vessels of opportunity may be seiners, trollers, gill-netters, crabbers, or tenders. The NSD project successfully served as a prototype for the development of a statewide nearshore coastal oil spill response capability.

AUTHOR: Larry Dietrick has over 20 years' experience in spill response, prevention, and planning.

DRILLING FOR REALITY

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ARCO Marine, Inc. (AMI) has been holding regular oil spill drills for its spill team members since the mid-1970s. Over the years the drills have gotten more elaborate and more costly, employing equipment and testing initial response and transition management. By the 1993 drill, it was found, the drills were losing their educational benefits and for the most part had become well-rehearsed stage plays, with spill team members and other participants as actors and equipment as props. The drills were not providing the education necessary to develop team members for their roles as response managers. AMI rethought the drill process and, with the concurrence of the U.S. Coast Guard, the Alaska Department of Environmental Conservation, and the Ship Escort and Response Vessel System, decided that it was time to "drill for reality."

AUTHOR: Since graduating from the University of Michigan, Robert Levine has had duties including energy conservation, inert gas and crude oil washing system engineering, plan approval, vapor emissions control, oil spill response, engineering design, and representing AMI in Alaska. His accomplishments include construction of five tankers, supervision of a major oil spill cleanup, numerous engineering projects, and five patents.

ON SCENE COORDINATOR/COTP EMPLOYMENT OF AN INFRARED SENSOR

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Infrared sensors have proven invaluable in the detection of and response to oil and chemical spills in the Gulf of Mexico and Mississippi River, and in other Coast Guard mission areas.

AUTHOR: Lt. Cdr. William R. Marhoffer has served in the Marine Safety Program for 12 years and is currently the senior investigating officer at Marine Safety Office New Orleans, Louisiana. In addition to B.S. and M.Eng. degrees in electrical engineering, he holds a merchant marine officer's license as a second assistant engineer.

Poster received too late to include in Session W1

U.S. COAST GUARD SPILL PLANNING, EXERCISE, AND RESPONSE SYSTEM (SPEARS)

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The confluence of managing risk, achieving preparedness, partnership, and effective pollution response actions is a "sine qua non" for minimizing water pollution and damage to the environment and natural resources. To succeed, the U.S. Coast Guard is implementing a new computer-based tool called SPEARS for use by Coast Guard on scene coordinators for incidents involving hazardous chemical or oil pollution. Highly capable, versatile, and user friendly, SPEARS uses state of the art technology, databases, mathematical models, and digital maps to manage information and support decision making for risk management, planning, exercises, and pollution response.

AUTHOR: Lt. Cdr. Shane Ishiki is a policy analyst assigned to the Pollution Response Branch of U.S. Coast Guard Headquarters, and is the project officer for the development and implementation of SPEARS. He is a graduate of the U.S. Coast Guard Academy and holds a Masters Degree from Harvard University.
