International Journal of Mass Emergencies and Disasters
August 1990, Vol. 8, No. 2, pp. 137-150

FEEDBACK FROM THE FIELD

CONTINGENCY PLANNING: BUILDING THE INFRASTRUCTURE FOR CRISIS DECISION MAKING*

John R. Harrald
Department of Engineering Administration
School of Engineering and Applied Sciences
The George Washington University
Washington, D.C. 20052

The March 24, 1989 grounding of the EXXON VALDEZ on Bligh Reef and the subsequent release of over 240,000 bbls of crude oil into Prince William Sound has once again focused public attention on the process of contingency planning for maritime catastrophic events. The National Response Team Report to the President (May 1989), the preliminary National Transportation Safety Board investigation, congressional hearings, and the public press have all stated that contingency planning performed by Alyeska, Exxon and the federal and state governments was inadequate. Two questions have been asked in all of these preliminary reports and investigations:

- Why did the contingency plans fail to ensure a state of preparedness?
- How do we establish **workable** contingency plans?

*Adapted from a presentation to the Spring Meeting of the Marine Board, National Research Council, National Academy of Sciences, June 15, 1989.

The observation that pre-planning for major oil spill incidents is inadequate is not new. In an article reviewing the progress of oil spill cleanup in the ten years since the Torrey Canyon incident, White, Nichols and Garnett (1979) state that "little progress has been made over the past decade to reduce the impact of oil spills to the extent that available technology should allow" (p. 247). In a *Management Science* article written six years before the EXXON VALDEZ incident, the author and colleagues pointed out that, "the problem of providing an immediate response to areas where major environmental damage may be caused in less than 6-12 hours has not been solved or extensively studied. In these areas, the national strategy fails" (Belardo et al. 1984a).

The objective of this article is to outline some of the problems inherent in planning for the response to a catastrophic oil spill and to show how research completed in the fields of crisis and natural disaster management can be used by those who must solve these problems. Researchers in disciplines as diverse as sociology and operations research have examined organizations which have had to respond to catastrophic natural disasters. Three distinct perspectives emerge from this research which appear to be relevant to the oil spill contingency planning problem:

(1) an organizational perspective describing the evolution and development of organizations in response to crises,

(2) a decision perspective analyzing the decision making processes of crisis organizations, and

(3) an information management perspective developing methods of managing information and providing decision support for crisis managers.

This article will attempt to bring together elements from these research areas to show what must be done for contingency planning to become a method for developing the infrastructure necessary for crisis decision making.

The difficulty in contingency planning for oil spills stems from the fact that these are extremely rare events with impacts far greater than those experienced during more routine emergencies. Society does not deal easily with low probability high consequence

events, particularly when the risk is due to a technological hazard. Wenk (1986) notes that the catastrophic event is qualitatively different from less severe accidents; an observation that is particularly true when applied to oil spills. Charnes, Karwan and coauthors (1979) point out, for example, that, "a large spill response strategy involves preparing for spills over 625,000 times larger than the median spill or over 4,400 times the average spill" (p. 266). Psaraftis et al. (1985) state that "strategic oil spill response decisions typically involve planning horizons of considerable duration; e.g. 5-15 years" (p. 203).

Many observers focus on the low probability of the event and assure themselves that the high consequence event will never happen and that untested response plans will be adequate if it does. A 1977 *EXXON USA* article stated, for example, that "while exercising every precaution to prevent an oil spill [in Prince William Sound] Alyeska has detailed plans to clean up a spill should one occur" (p. 20).

Others see only the consequence of a catastrophic event and insist the activity should not be allowed no matter how small the risk (e.g., the reaction to the nuclear power industry after the Three Mile Island incident). This position gains adherents immediately after a major incident when public interest in the risk and consequences of a catastrophic event is intensely shown for a brief period. If, however, the event does not reoccur, interest diminishes rapidly over time. The public response to the risk of a major oil spill follows this pattern, identified by Wenk (1986) as, "the politics of risk": neglect until some event dramatizes an old and hidden but significant danger and then overreaction. We deal routinely with the accidents of limited consequence, but cannot deal rationally with the catastrophic event. The fact that the very technology which is intended to reduce risk is also a source of risk is, according to Wenk, a fundamental paradox of our technological society.

Public acceptance of oil transport and exploration in environmentally sensitive areas has been shaken by the EXXON VALDEZ casualty (and by the subsequent tanker incidents of 23-25 June in Narraganset and Delaware Bay). The government and the industry are being challenged to demonstrate an ability to plan for and to manage a major response effort. Significant legislative and regulatory decisions will be made on the basis of this difficult demonstration.

Since catastrophic spills occur very infrequently, and have historically been geographically distributed throughout the world, government and industry must be ready to deliver hundreds of millions of dollars worth of clean-up services anywhere in the world within hours of an incident. This means more than flooding the affected area with people and equipment. It means creating a functional organization, capable of making and implementing decisions and operating according to doctrine.

In most crisis situations, organizations are not capable of making the required decisions or of adhering to their published procedures. Smart and Vertinsky (1977) state that preparedness can be measured in the terms of decision capability and that crisis conditions require the precise and quick implementation of decisions. Dynes and Aguirre (1979) have shown that it is very difficult for organizations to operate according to prearranged doctrine, that during a crisis situation organizations evolve according to feedback rather than coordinating according to plan.

ORGANIZING FOR CRISIS MANAGEMENT

During any disaster response operation, a large complex organization is created. This organization is expected to function immediately and under exceptionally difficult circumstances. Within 20 days of the EXXON VALDEZ incident, there were almost 2,000 Exxon personnel, 500 federal personnel and hundreds of state employees attempting to function as a coherent organization (National Response Team, 1989). The coordination of this response evolved into a two level organization: a three member executive committee comprised of Exxon, Federal and State leaders and a steering committee which represented a wide range of organizations. A significant amount of time passed before a smoothly functioning organization was in place.

Sociologists have examined how organizations evolve during crises. Dynes and Quarantelli (1968) derived a typology of emerging and expanding organizations in order to describe this evolution. Figure 1, taken from Dynes and Aguirre (1979), shows that the type of organizational evolution during a disaster can be defined by type of tasks undertaken by the organization and by the structure of the organization. The tasks may be routine and familiar to an organization, or they may be unusual and unfamiliar. The

organization itself is either the same as the pre-disaster organization or a new crisis-developed structure. This typology leads to four distinct disaster response organizations:

Type I organizations are normal emergency organizations such as the police, fire and rescue units. They are performing familiar, albeit emergency, tasks within an organizational structure which existed before the event.

Type II organizations, called **expanding** organizations by Dynes and Quarantelli (1968), consist of new people in an expanded organization performing familiar tasks. The American Red Cross creates a Type II organization when it expands/replaces local organizations with trained, organized volunteers and reservists in order to deliver relief services after a natural disaster. The expanded operation operates under predetermined doctrine and performs its tasks in a routine manner. The U.S. Forest Service fights major forest fires with a Type II organization defined through the use of the incident command system.

Type III organizations are **extended** organizations. An existing organization undertakes new and unfamiliar tasks, but retains its organizational structure and composition. Police forces have been called upon to operate shelters during a disaster, the Coast Guard was required to care for large numbers of refugees during the Cuban boat lift.

Type IV or **emergent** organizations require new people to perform new tasks while working within an unfamiliar organizational structure. Leadership and structure emerge in ad hoc response to external events.

Type I organizations function well during the "normal" emergency events for which they were designed. For short periods of time, they can perform effectively as extended organizations when emergencies force them into an unfamiliar task environment. Disasters are typically beyond the capabilities of existing organizations, however, and either Type II or Type IV organizations are created. As stated above, the Type II organization requires a reservoir of trained, available personnel and familiar, workable organizational structure and procedures which can be immediately implemented. If these conditions are not met, a Type IV organization will result. The problems with Type IV organizations have been well documented in the sociological literature. Organizations

accept new tasks and new personnel reluctantly since both create unwelcome diversity. In a Type IV organization this process happens in an ad hoc manner in response to external events and internal needs rather than according to plan. Often organizations will tend to accept only those demands which are within their present capabilities rather than increase their capabilities to meet the demand. Drabek (1989) observes that organizations will continue to misapply approaches based upon routine and stable conditions which have minimal relevance during disaster events. Smart and Vertinsky (1977) state that the intensity of a crisis depends on the degree of change required in the organization in order to function successfully.

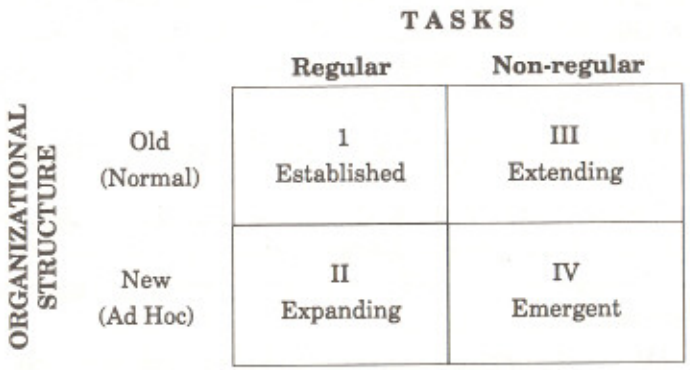

Figure 1. Disaster Organization Typology.

Since the resource demands created by a catastrophic pollution event are beyond the capabilities of existing organizations, Type I and Type III organizations are irrelevant to contingency planning for such events. The size and capability of a Type II organization are constrained by the resources which are acquired, developed and allocated before an event occurs. The viability of the American Red Cross' resource base of trained disaster personnel was, for example, severely tested by the almost simultaneous occurrence of Hurricane Hugo and the Loma Prieta earthquake and the subsequent mobilization of over 3,000 relief workers.

Type IV organizations have evolved in the aftermath of all major oil spills. Immediately after the AMOCO CADIZ oil spill, for example, Bellier and Massart (1979) observed that the French had

to evolve a large scale organization for beach cleaning operations which relied heavily on the Army. The need for an organization led to early rejection of the pre-planned organization which relied upon regional emergency services. The preliminary record of the EXXON VALDEZ response shows a similar evolution of ad hoc organizational structures.

Planners are faced with a difficult choice: they must either find methods and resources to ensure the creation of an adequate Type II organization or create ways to manage an emerging Type IV organization. If a Type III organization is the goal, human resources management policies and procedures must be developed which provide for training, staffing, and mobilization. The levels of funding required to ensure the constant state of readiness required for the response to major pollution incidents will be significant. Bellantoni et al. (1979) developed a baseline cost of $100 million for pollution response equipment required by U.S. Coast Guard in the continental United States, and their estimate excluded maintenance, support, and personnel costs. The cost of developing and supporting an organization capable of deploying this equipment will undoubtedly exceed the costs of hardware. Drabek (1989) states that the degree to which response tasks have been accepted as routine is an important predictor of success. It may be logical to assume that, in spite of all preparations and planning, a Type IV organization will evolve in the aftermath of any catastrophic event. If we accept this premise, we must focus our attention on the difficult command, control and communications problems it implies.

THE ANALYSIS OF CRISIS DECISION MAKING

Once a catastrophic event occurs, responsible disaster managers must create an organization appropriate to the demands of the crisis. In order to do this, the disaster and the decisions which have to be made in its wake must be anticipated. Contingency planning, in other words, must be scenario based and decision oriented. The generation of realistic scenarios is critical and non trivial. Alyeska based their contingency plan on two scenarios, a routine spill and a worst case spill. The worst case scenario envisioned a 200,000 bbl release from a tanker in a 10-hour period under ideal weather conditions. The EXXON VALDEZ lost 240,000 bbls in approximately 2-3 hours. Scenario generation is a creative, challenging

task requiring adequate time and expert participants. We must be able to use the fragmented and diverse knowledge of experts to create new, consistent, and integrated scenario based knowledge. This will require experts to "bootstrap" their knowledge through group processes. Scenario generation for rare events is not the description of existing knowledge, it is the generation of currently unknown information through the guided interaction of experts.

War planners have invested extensive resources generating scenarios on which to base national strategy and tactics. The National Academy of Sciences' Marine Board (1979) produced a study of the nation's capability of responding to a maritime hazardous materials incident based upon a set of skillfully created scenarios. Nunamaker, Weber and Chen (1989) have used the University of Arizona decision support room to facilitate the development of crisis scenarios by senior executives of major industries. Contingency planners must have clear understanding of the type of events which may occur and the relative probability of these events. They must develop methods which move beyond simple, descriptive scenarios to examine environmental conditions and constraints, response options, strategic tactical problems, and critical political and organizational concerns.

Once a set of scenarios is generated, the decision process which will create and implement the response capability must be analyzed. This decision process is, in its simplest terms, one of pattern matching. The disaster has dimensions of location, duration, intensity, and impact. The response will have the dimensions of people, skills, equipment, money, and time. Fraser (1979), for example, discusses how realistic scenarios are critical for the selection and sizing of response equipment. Garry (1981) shows how scenarios can be used to estimate resource requirements for a state response plan. Bellantoni et al. (1979) used a set of scenarios to determine recommended deployment requirements for U.S. Coast Guard pollution response equipment. Matching the resources to the problem will require a series of decisions which must be anticipated and analyzed during the contingency planning process. What decisions must be made? What information should be available to the decision maker when these decisions are made? What are the relationships between variables and outcomes? How are the decisions constrained by available resources?

The output of this decision analysis is an identification of information requirements, identification of resource requirements and constraints, and the development of training scenarios for decision makers. The decision analysis will also predict the results of optimal response efforts and has, therefore, implications for prevention strategies. If, for example, oil spill containment and vessel salvage operations would be impossible under certain weather conditions, more stringent vessel movement control may be justified.

The author and colleagues have used decision analysis techniques to model the decision sequence which occurs during Red Cross disaster relief operations (Harrald et al. 1989) and for maritime casualties (Harrald and Wallace 1989, Harrald et al. 1989). The decision analysis identifies the relationships between stochastic and deterministic variables, decisions and objectives. Information which reduces the uncertainty in variables critical to decision making must be made readily available to the crisis decision maker.

DECISION SUPPORT AND INFORMATION MANAGEMENT

Identifying the decisions which will be required and the information required to support these decisions is only an intermediate step. The information handling and decision support infrastructure must be built which will enable decision makers to operate under extreme conditions. Dynes and Quarantelli (1977) point out that during a crisis both the rate of decision making and the absolute number of decisions made increase and that organizational resources are committed quickly, often to tasks outside of the organization's previous domain of competence. External frustration with decision process often causes an organization to lose autonomy during a crisis situation, and results in it coming under the umbrella of new coordinating arrangement.

Figure 2, adapted from Smart and Vertinsky (1977) shows that the quality of decisions is adversely impacted by the poor quality of information, inadequate information processing and the decrease of cognitive ability induced by stress. Decision support and information processing capabilities must be built into the contingency planning process. Primitive information management tools such as logs, status boards, oil spill tracking systems are in com-

mon use. Integrated, multi user decision support systems and comprehensive data base systems are routinely used in major corporations and government agencies in support of routine activities, but they are not usually available to disaster managers. Chartrand (1989) terms this use of technology as," building the infrastructure for decision making" (p. 14) . However, each time a disaster occurs, managers once again discover what Jacques Vallee noted, that: "all of our equipment and software tends to be organized around rational decisions. Crises by their very nature are irrational processes" (Quoted in Chartrand and Punaro, 1985, p. 15).

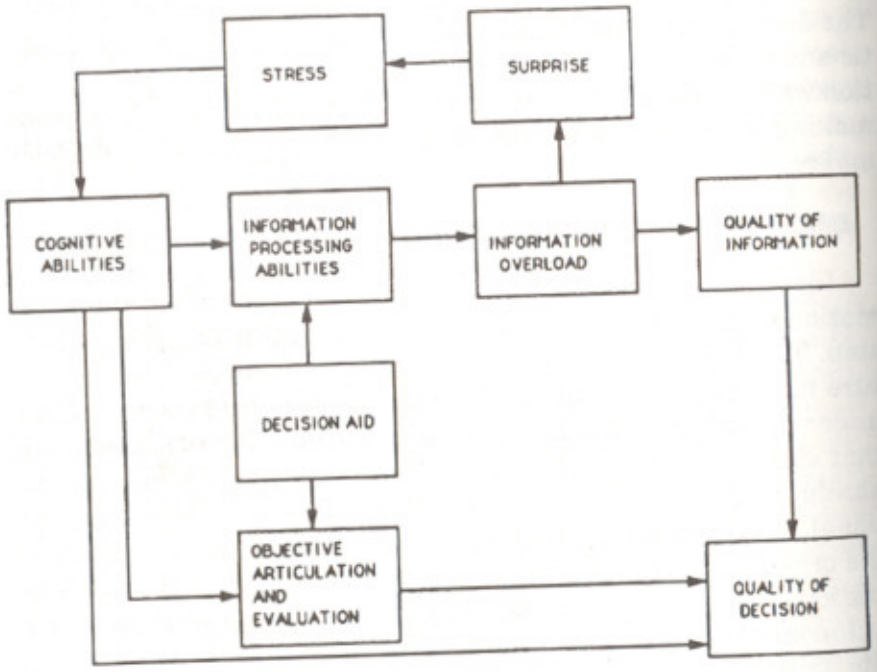

Figure 2. A Conceptual Model of the Role of a Decision Aid in a Crisis Decision Process.

The first steps toward supporting crisis decision capabilities are to reduce the irrationality of crisis management by managing the creation of a crisis organization, analyzing the decisions which this organization will be called upon to make, and effectively using

information technology to support the organizational decision making. Several authors have reported the development of conceptual models or prototype crisis management systems (Mick and Wallace 1986; Belardo et al. 1984b; Harrald and Conway 1981; Wallace and de Balogh 1985; and Everson 1986a). Everson (1986b) reports that Emergency Preparedness Canada has developed a relational data base structure for its disaster management information requirements. The author has worked with the American Red Cross to develop decision support systems and data base systems for their disaster relief managers (Harrald, Boukari, and Sapp 1989). The Coast Guard and private industry have developed data bases which track pollution equipment availability throughout the world (Imbrie and Karwan 1979). Computer based data based systems, knowledge based decision support systems and expert systems are realistic technologies to apply to the difficult problems of disaster management.

CONCLUSION

Contingency planning is more than producing a document for the approval of the appropriate government regulators. The result of the process must be a set of procedures which will ensure the creation of an organization capable of responding to the target incidents. It must define ways to manage the transition state as the organization evolves from a Type I to Type II organization. It must define the training and mobilization procedures required to ensure that a Type IV organization is avoided or must create the capability of controlling and supporting the emerging organization. It must contain the results of a creative scenario generation process and detailed decision analysis. Most importantly, the plan must be more than paper and procedures. It must result in the allocation of resources (including personnel) identified as critical to the plan and must create the information processing and decision support tools necessary for its implementation. Contingency planning is one of the critical tasks of our technological society. A key to its success may be the adaptation technology to meet the demands of crisis management.

REFERENCES

Belardo, Salvatore, John R. Harrald, William A. Wallace, and James E. Ward. 1984a. "A Partial Covering Approach to Siting Response Resources for Major Maritime Oil Spills." *Management Science* 30: 1184-1196.

Belardo, Salvatore, Kirk R. Karwan, and William A. Wallace. 1984b. "Managing the Response to Disasters Using Microcomputers." *Interfaces* 143, No. 2: 29-39.

Bellantoni, J., J. Garlitz. R. Kodis, A. O'Brien, and A. Passara. 1979. *Deployment Requirements for U.S. Coast Guard Pollution Response Equipment: Volume I: Analysis*. Cambridge, Massachusetts: U.S. Department of Transportation, Transportation Systems Center.

Bellier, P. and G. Massart. 1979. "The AMOCO CADIZ Oil Spill Cleanup Operations: An Overview of the Organization, Control and Evaluation of the Cleanup Techniques Used." *Proceedings: 1979 Oil Spill Conference*. Washington, D.C.: American Petroleum Institute: 141-146.

Charnes, Abraham, William W. Cooper, Kirk R. Karwan, and William A. Wallace. 1979. "A Chance Constrained Goal Programming Model to Evaluate Response Resources for Marine Pollution Disasters." *Journal of Environmental Economics and Management* 6: 244-274.

Chartrand, Robert L. 1989. Remarks made to June 7, 1989 meeting of the Washington Operations Research/Management Science Council. Washington, D.C. (unpublished).

Chartrand, Robert L. and Trudie A. Punaro. 1985. *Information Technology Utilization in Emergency Management*. Report 85-745, Congressional Research Service, Library of Congress. Washington D.C.: U.S. Government Printing Office.

Drabek, Thomas E. 1989. "Disasters as Nonroutine Social Problems." Paper presented at the 27th Joint National Meeting of the Canadian Operations Research Society, The Institute of Management Sciences and the Operations Research Society of America, Vancouver, British Columbia, Canada.

Dynes, Russell R. and B.E. Aguirre. 1979. "Organizational Adaptation to Crises: Mechanisms of Coordination and Structural Change." *Disasters* 3: 71-79.

Dynes, Russell R. and E.L. Quarantelli. 1968. "Organizational Communications and Decision Making in Crises." Newark, Delaware: Disaster Research Center, University of Delaware.

Dynes, Russell R. and E.L. Quarantelli. 1977. "Disaster Types of Organization in Disaster Response and Their Operational Problems." Newark, Delaware: Disaster Research Center, University of Delaware.

Everson, Peter R. 1986a. "Emergency Planning Decision Support Systems." Pp. 11-28 in *Terminal Disasters*, edited by Sallie A. Marston. Boulder, Colorado: Institute of Behavioral Sciences, University of Colorado.

Everson, Peter R. 1986b. "A Selective Review of Information Technology and Its Application Emergency Planning and Response." Ottawa, Canada: Emergency Preparedness Canada Report No. 87.03.07.

EXXON. 1977. "Protecting Prince William Sound: Impressive Protective Measures Safeguard and Impressive Body of Water which Tankers must Traverse with Cargoes of Alaskan Oil." *EXXON USA* 16, No. 3:16-21.

Fraser, J.P. 1979. "Oil Spill Countermeasures--A Rational System for Selection and Sizing of Equipment." *Proceedings: 1979 Oil Spill Conference*. Washington, D.C.: American Petroleum Institute: 253-255.

Garry, B.J. 1981. "The Massachusetts Oil Spill Contingency Planning Model." *Proceedings: 1981 Oil Spill Conference*. Washington, D.C.: American Petroleum Institute: 87-92.

Harrald, John R., Djamel Boukari, and Fred R. Sapp. 1989. "The Design of a Disaster Management Decision Support System for the American Red Cross." Washington, D.C.: George Washington University Working Paper. (unpublished)

Harrald, John R. and Steven M. Conway. 1981. "The Use of Decision Support Aids in the Development of an Action Oriented Contingency Plan." *Proceedings: 1981 Oil Spill Conference*. Washington, D.C.: American Petroleum Institute: 509-512.

Harrald, John R., Henry S. Marcus and William A. Wallace. 1989. "The Management of a Maritime Crisis: The Integration of Planning, Prevention, and Response." *Interfaces*. (forthcoming)

Harrald, John R. and William A. Wallace. 1989. "An Analytic Approach to Planning the Response to Technological Disasters." *Industrial Crisis Quarterly* 2: 257-270.

Imbrie, Robert J. and Kirk R. Karwan. 1979. "Computer Searching for Pollution Cleanup Equipment." *Proceedings: 1979 Oil Spill Conference*. Washington, D.C.: American Petroleum Institute: 257-260.

Marine Board, Assembly of Engineering, National Research Council. 1979. "Responding to Casualties of Ships Bearing Hazardous Cargoes." Washington, D.C.: National Academy of Sciences.

Mick, Stephen and William A. Wallace. 1986. "Expert Systems as Decision Aids to Disaster Management." Pp. 195- 204 in *Terminal Disasters: Computer Applications in Emergency Management*, edited by Sallie A. Marston. Boulder, Colorado: Institute of Behavioral Sciences, University of Colorado.

National Response Team. 1989. *The EXXON VALDEZ Oil Spill: A Report to the President*. Washington, D.C.

Nunamaker, J.F., Jr., E. Sue Weber, M. Chen. 1989. "Organizational Crisis Management Systems: Planning for Intelligent Action." *Journal of Management Information Systems*. (forthcoming)

Psaraftis, Harilaos N., Geverghese G. Tharakan, Avishai Ceder. 1986. *Optimal Response to Oil Spills: The Strategic Decision Case*. Operations Research 34, No. 2: 203-217.

Smart, Carolyne and Ilan Vertinsky. 1977. "Designs for Crisis Decision Units." *Administrative Sciences Quarterly* 22: 640-657.

Wallace, William A. and Frank De Balogh. 1985. "Decision Support Systems for Disaster Management." *Public Administration Review* 45: 134-146.

Wenk, Edward, Jr. 1986. *Tradeoffs: Imperatives of Choice in a High-Tech World.* Baltimore, Maryland: The Johns Hopkins University Press.

White, I.C., J.A. Nichols, and M.J. Garnett. 1979. "Ten Year Overview of Oil Spill Clean-Up at Sea." *Proceedings: 1979 Oil Spill Conference*. Washington, D.C.: American Petroleum Institute: 247-251.