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NETWORK COHESIVENESS AMONG OIL SPILL RESPONDERS IN THE DELAWARE BAY: A MULTI-DIMENSIONAL SCALING ANALYSIS

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I. INTRODUCTION

The growing significance of organizations as actors in modern urban communities is by now a well known fact. As Turk (1970) suggests, modern society can be viewed as an aggregate of organizations which appear, disappear, change, merge, and form networks of relations with each other. This perspective provides a useful tool for understanding how society responds to, and deals with, environmental issues such as marine oil spills. Indeed, mass responses to a broader setting are both formulated and enacted by organizations. Agencies, however, do not always coordinate and communicate to the extent necessary for the successful completion of their responsibilities. Unfortunately, it often takes a catastrophic event to call this issue into question. For example, on March 24, 1989 the Exxon Valdez ran aground on Bligh Reef spilling eleven million gallons of oil into Alaska's Prince William Sound. Because of this event, the nation's concern for oil spills has dramatically increased. One manifestation of this increased awareness was the creation of the Oil Pollution Act of 1990 (OPA'90). A component of this legislation includes the augmentation of oil spill contingency planning in the nation. By mandating a more comprehensive state of planning, it is hoped that responders will be more effective in their response to oil spills.

The simple compilation of plans, however, is not enough to ensure effective response. Good planning depends on a variety of factors. For example, Quarantelli (1987) suggests that good disaster planning must be, among other things, integrated rather than fragmented. Thus, an entire community focus is the best approach for the planning process.

A variety of groups and organizations must take part in an integrated effort. This is true to the extent that disasters affect entire communities, not single individuals or organizations. Many organizations and groups find themselves having to cope with the effects of a disaster when one occurs. If only one agency is involved in the planning process (including not just compiling plans, but also engaging in response exercises, training programs, memorandums of understanding, and the like), the community in general will be ill equipped to respond to a disaster. Drabek (1986) argues that the single most critical variable affecting the quality of community response is interorganizational relations.

One factor that affects interorganizational relations is the extent to which planning fosters coordination among organizations. There should exist a mutually agreed upon linking of activities between two or more groups instead of a planning response based on a centralized, top-down control system. This "command and control" model (adopted from the military) is inappropriate for disasters although it is often implemented (Dynes, 1990). Quarantelli (1987) instead advocates an emergent resource coordination effort which takes into account the abilities of each organization.

Planning can also affect interorganizational networks by seeking to create a central communications network (Scanlon, 1981; 1982). During a disaster, for example, agency officials often find themselves having to communicate with numerous other organizations. In many instances the officials working in these organizations are unknown to each other. As a result, information flow between those responders who are unfamiliar with each other will be difficult to initiate and maintain (Quarantelli, 1988).

This paper examines the extent to which interorganizational communication exists for agencies that are responsible for oil spill clean-up response in the Delaware Bay and River. Many organizations (public, private and non-profit) are responsible for oil spill response and planning in this region. These organizations generally form a heterogeneous group, i.e., each has a different mission and varies in size, jurisdictional level, and source of funds. Consequently, in order for this diverse group of organizations to successfully respond to oil spills, they must maintain contact with each other. As Galaskiewicz and Marsden (1978) point out, communication between actors is a necessary condition for any collective action. Moreover, without some form of contact (either formal or informal), further relations of any type among organizations is impossible. Thus, an information network constitutes a basis for interorganizational resource transfers (e.g.,cooperation, exchange, coordination, resource sharing) by reducing the level of uncertainty for actors. It follows that if the agencies charged with responsibilities for oil spill management are not familiar with each other, oil spill response and planning will be disorganized, lethargic, and subsequently ineffective.

II. METHODOLOGY

Seventeen organizations were selected for this study as the primary actors for oil spill management in the Delaware estuary. Nine of these were federal agencies, six were state government agencies, and two were non-profit organizations. These agencies were chosen for two reasons. First, each organization is a member of the Multi-Agency Local Response Team (MALRT). Second, each has some role outlined in the various oil spill contingency plans for this area, including the Local Contingency Plan and the Regional Contingency Plan. Thus, the organizations selected constitute the set of agencies that would be expected to respond in the event of an oil spill in the estuary. These organizations may be conceptualized as an "action-set" which is typically defined as "a group of organizations formed into a temporary alliance for a limited purpose" (Aldrich, 1979:280). Data on interorganizational contact were collected via face-to-face, in-depth interviews. Respondents were primarily those people who are ultimately responsible for policy decision-making within their organization (as opposed to those in charge of operations).

Aldrich (1979) argues that it is a fundamental fact of organizations that they can not internally generate all the resources they need to function. Hence, organizations find themselves in relationships with other organizations out of necessity. The form of interaction, however, varies from voluntary to mandated interaction (Hall et.al., 1977). Organizations with oil spill management responsibilities form relationships which involve laws and regulations (i.e., OPA'90) specifying areas of domain.

This study explores inter-agency contact among oil-spill responders in the Delaware Bay. Respondents from each organization were first asked if they have contact (formal or informal) with each of the other agencies for general, non-specific reasons. Each respondent was then asked if they maintain contact with each of the other agencies in the action-set on terms that specifically deal with oil spill issues. A five-point ordinal scale was developed by combining scores on the two types of inter-agency contact.[1]

A multidimensional scaling (MDS) technique was undertaken in order to assess the relationships and networks that exist between the organizations that have primary responsibility for oil spill

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[1] The five-point ordinal scale was coded 1 through 5; where 1 indicates that both organizations report maintaining both types of communication with each other, 2 indicates that both organizations report maintaining at least one type of contact with each other while one reports maintaining both types of communication with the other, 3 indicates that either both organizations report maintaining one type of communication with each other or one organization reports maintaining both types of contact with the other, 4 indicates that one organization reports maintaining one type of communication with the other, and 5 indicates that neither organization maintains any type of contact with each other. The more communication links an agency has, the more likely that agency will score 1's. Thus the cumulative score for that agency will be relatively low. Conversely, those agencies that are not actively involved in the network will tend to score 4's and 5's, making their overall score relatively high.

response and planning in the Delaware estuary. The MDS technique allowed us to pinpoint the most centrally located organizations which presumably have access to more information and thus may be more effective responders.

A centrality score is one measure of an agency's embeddedness in an information network. Specifically, agencies central to networks generally have better access to all others in the system, while those peripherally positioned must depend on them for continued flow of resources (Galaskiewicz, 1979). A central position in a network allows an agency to perform its duties more easily. Moreover, organizations in the center of networks are structurally dominant. Boje and Whetten (1981) argue that network centrality enhances an organization's power because the ability to control resources (including information) increases as a function of proximity to the core of a system of transactions. Similarly, Galaskiewicz (1979) finds that centrality predicts an organization's level of influence to a greater degree than the size of the organization's resource base. This is true to the extent that network members assume that central actors have a greater potential for mobilizing resources controlled by others.

In this analysis, centrality scores are obtained by adding the absolute value of the two dimensional coordinates and dividing them by two. Further, MDS takes the two dimensional coordinates and plots them in a euclidian space which permits a graphic presentation of complex structures. This method locates the centroid of the space and computes Euclidean distance from each point in the two dimensional solution to the centroid. Hence, the closer to the center an organization lies on the plot, the more central that organization is in terms of the general network between all agencies. Moreover, the plot also reveals specific sub-networks between agencies. The agencies that lie close together on the plot exhibit more cohesive relationships. Hence, sub-networks may emerge as important relationships and indicate which agencies have more contact with each other and are subsequently more salient actors in oil spill management activities.

MDS obtains its final solution through an iterative process. In other words, solutions are tried until they no longer produce a better fit for the overall model. The final model, then, is determined by "Kruskal's stress" and the R^2 value, two goodness-of-fit measures. Stress-test values approaching zero and R^2 values approaching one indicate a better fitting model.

The following section is an analysis of the centrality measures and the plots for the communication measures.

III. INTER-AGENCY CONTACT ANALYSIS

Although it would have been fruitful to analyze two separate communication networks based on the type of contact (oil-specific and general), the three-point ordinal scales used to measure each type of contact were too limited for analysis. MDS plots of linear and non-linear fit, as well as plots of transformation for each communication network, suggested degenerate data transformations therefore decreasing the reliability of the results (see Kruskal and Wish, 1978). Thus, the decision was made to combine the two types of contact into one five-point ordinal measure of inter-agency contact. Although not error-free, the subsequent analysis produced smoother linear, non-linear, and transformation plots, suggesting a more continuous, nondegenerate transformation. Thus, more faith is placed in the results of the single communication network.

Interestingly, however, the two-dimensional plot of the single communications network produces somewhat similar results as the plots of oil-specific and general contact. And for the most part, a few core organizations remain central and a few remain on the periphery of all three networks. (See Appendix A for a complete discussion.)

The following section reports the results of the MDS two-dimensional solution for the inter-agency communication network. The Kruskal stress score of .264 and the R^2 of .607 indicate a moderate fit of the squared distance scores to the transformed data. A three-dimensional solution was sought, but the results showed no substantial increase in the fit of the model. A better fitting model could have been obtained with more precise measures of inter-agency communication.

The centrality scores for contact among the 17 organizations shows which organizations are structurally dominant (see table 1). The United States Coast Guard (USCG) has the lowest score (.1886), making this the most embedded agency in the information network

Table 1. Centrality Scores for Responders

Agency	Centrality Score
U.S. Coast Guard (USCG)	.1886
Environmental Protection Agency, Region III (EPAIII)	.3937
National Oceanic and Atmospheric Administration (NOAA)	.4251
New Jersey Office of Emergency Management (NJOEM)	.4586
Delaware Emergency Planning and Operations (DEPO)	.6426
New Jersey Department of Environmental Protection (NJDEP)	.6877
U.S. Army Corps of Engineers (USACE)	.7458
Department of Interior (DOI)	.7500
Pennsylvania Department of Environmental Resources (PADER)	.8127
Delaware Natural Resources and Environmental Control (DNREC)	.8273
Tri-State Bird Research and Rescue (TRIST)	.8443
Delaware Bay and River Cooperative (DBRC)	.9493
Pennsylvania Emergency Management Agency (PEMA)	1.0028
Environmental Protection Agency, Region II (EPAII)	1.0310
Occupational Safety and Health Administration (OSHA)	1.0649
Federal Emergency Management Agency, Region III (FEMAIII)	1.2445
Federal Emergency Management Agency, Region II (FEMAII)	1.8806

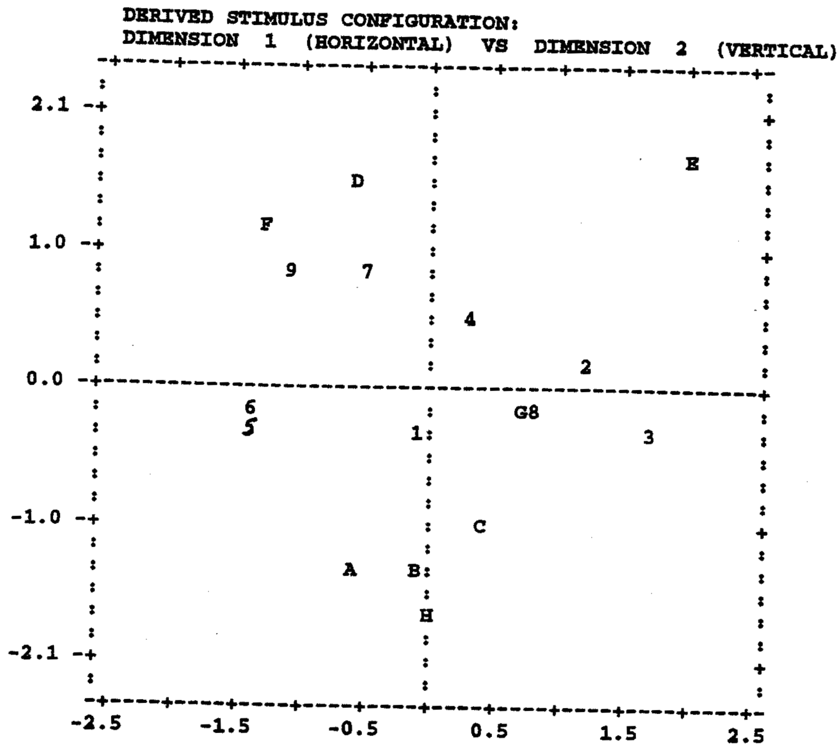

Figure 1. MDS Plot of Contact Among Organizations*

*Key:

1=USCG	A=DBRC
2=NJDEP	B=USACE
3=EPAII	C=DOI
4=EPAIII	D=OSHA
5=PADER	E=FEMAII
6=DNREC	F=FEMAIII
7=DEPO	G=NOAA
8=NJOEM	H=TRIST
9=PEMA	

that exists among these organizations. This result was expected since the USCG is tasked with providing a designated On-Scene Coordinator (OSC) for any oil spill. The OSC is meant to be the linchpin of any clean-up operation and coordinates the activities of all other response organizations. Moreover, the USCG is responsible for maintaining the Local Contingency Plan, officially entitled "The Philadelphia Subregional Oil and Hazardous Substance Pollution Contingency Plan" (1990). This plan is followed by any agency that responds to oil spills in the Delaware Estuary. The USCG, then, is clearly meant to be the lead agency for coordinating planning and response to marine oil spills in the Delaware Bay and River.

While the USCG is clearly the most central actor in this network, there are other organizations with low scores. These include the Environmental Protection Agency, region III (.3937), the National Oceanic and Atmospheric Administration (.4251), and the New Jersey Office of Emergency Management (.4586). These agencies seem to be the most central in the interorganizational network. What is interesting to note about this finding is that the New Jersey Office of Emergency Management is the only state level agency in this group. However, the data does not allow us to speculate about how and why these relationships emerge.

In terms of the organizations with the highest centrality scores (i.e., those with the lowest amount of centrality in the network) the Federal Emergency Management Agency, region II shows the highest score (1.8806). Other agencies with high centrality scores include the Federal Emergency Management Agency, region III (1.2445), the Occupational Safety and Health Administration (1.0649), the Environmental Protection Agency, region II (1.0310), and the Pennsylvania Emergency Management Agency (1.0028). Thus, their access to all other organizations in the network is relatively limited.

The two dimensional plot reveals a pattern which is similar to the centrality scores. One interpretation of this plot (see figure 1) suggests that no overall cohesive network exists between agencies. Moreover, there is minimal clustering of agencies indicating no substantial sub-networks of communication. In several instances some agencies seem to form links with each other. For example, the National Oceanic and Atmospheric Administration and the New Jersey Office of Emergency Management cluster together as do the Pennsylvania Department of Environmental Resources and the Delaware Department of Natural Resources and Environmental Control. However, the clustering together of only two agencies does not necessarily indicate a substantial sub-network.

IV. CONCLUSION

One overall conclusion might suggest that a tight interorganizational network between all agencies who have nationally mandated oil spill management responsibilities for the Delaware Estuary does not exist. This finding may have implications for the ability of these organizations to work together during a disaster response. As pointed out earlier, interorganizational communication is a central variable for collective action to take place. Communication reduces the level of uncertainty for agencies who suddenly find themselves engaged in an oil spill response with a variety of other organizations. If responders are familiar with each other, information can flow easily between these organizations, and the overall response to the event should be better. If, on the other hand, responders are unfamiliar with each other, as they appear to be on the basis of this analysis, the flow of information will be hindered which may prove detrimental to the disaster response.

These conclusions, however, are restricted by certain limitations. First, local industry officials are also part of planning and response. Unfortunately, data from the area oil companies was unavailable; as a result, we have no knowledge as to how these companies fit into this response network. Second, distinctions between oil-specific and general contact were blurred in this analysis in order that a larger ordinal scale of inter-agency communication could be used. And finally, future analyses of this communication network should rely on multiple measures of the frequency and type of communication between organizations.

APPENDIX A

As shown in Tables 2 and 3, there are differences in centrality scores and clustering of organizations between the oil-specific and general plots. For example, the National Oceanic and Atmospheric Administration (NOAA) is the most central of all organizations when focusing on general contact, but is not at all central in the oil-specific network. Similarly, organizations such as the Delaware Bay and River Cooperative and Delaware Department of Natural Resources and Environmental Control are more centrally embedded in the oil-specific network than in the general communications network. Thus, the type of communication is important for some organizations when discussing network embeddedness. However, a few core organizations such as the U.S. Coast Guard, Environmental Protection Agency, Region III, and the New Jersey Office of Emergency Management are centrally embedded in all three networks (oil-specific, general, and combined). Similarly, the Environmental Protection Agency, Region II, and the Region II and III offices of FEMA remain on the periphery of all three networks (see Tables 1, 2, and 3).

Further, all three network plots display a similar diffuseness of communication, with the oil-specific plot showing more clustering among organizations (see Figures 2 and 3 as well as Figure 1). Although combining oil-specific and general contact measures blurred any distinctions and comparisons that could be made between the two types of networks, the overall conclusions remain the same. Further, the combined measure of inter-organizational contact provided more reliable results.

Table 2. Centrality Scores for Responders (Oil Specific Contact)

Agency	Centrality Score
Environmental Protection Agency, Region III (EPAIII)	.3714
New Jersey Office of Emergency Management (NJOEM)	.4160
U.S. Coast Guard (USCG)	.4562
Delaware Natural Resources and Environmental Control (DNREC)	.4581
Tri-State Bird Research and Rescue (TRIST)	.5576
Delaware Bay and River Cooperative (DBRC)	.6302
U.S. Army Corps of Engineers (USACE)	.7060
Delaware Emergency Planning and Operations (DEPO)	.7320
Department of Interior (DOI)	.7491
Pennsylvania Department of Environmental Resources (PADER)	.7523
National Oceanic and Atmospheric Administration (NOAA)	.7878
New Jersey Department of Environmental Protection (NJDEP)	.7946
Environmental Protection Agency, Region II (EPAII)	.8723
Federal Emergency Management Agency, Region III (FEMAIII)	1.0050
Pennsylvania Emergency Management Agency (PEMA)	1.2064
Federal Emergency Management Agency, Region II (FEMAII)	1.4743
Occupational Safety and Health Administration (OSHA)	1.4996

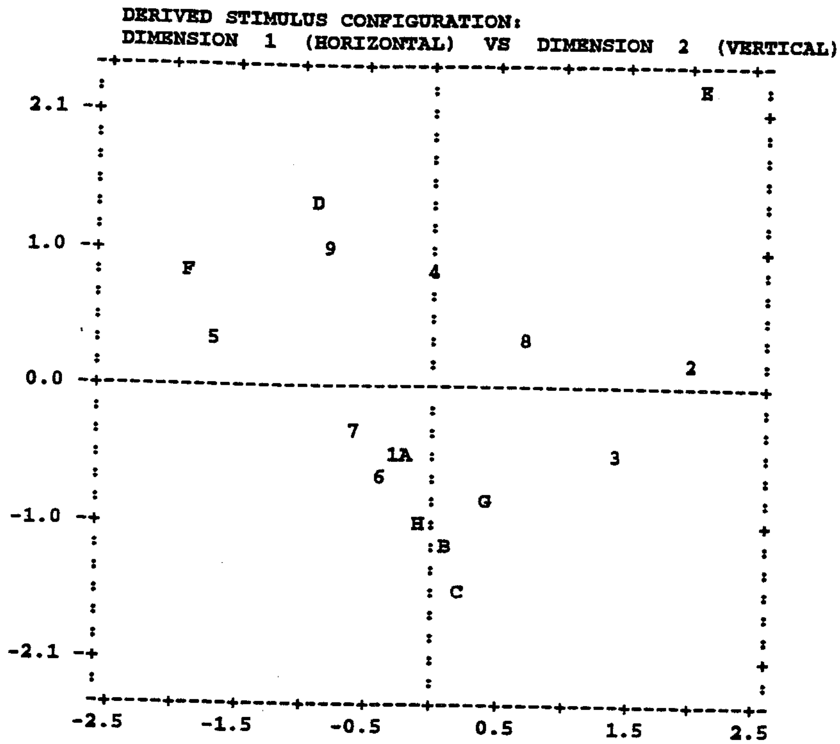

Figure 2. MDS Plot of Oil Contact Among Organizations*

*Key:

1=USCG	A=DBRC
2=NJDEP	B=USACE
3=EPAII	C=DOI
4=EPAIII	D=OSHA
5=PADER	E=FEMAII
6=DNREC	F=FEMAIII
7=DEPO	G=NOAA
8=NJOEM	H=TRIST
9=PEMA	

Table 3. Centrality Scores for Responders (General Contact)

Agency	Centrality Score
National Oceanic and Atmospheric Administration (NOAA)	.3734
U.S. Coast Guard (USCG)	.3828
New Jersey Department of Environmental Protection (NJDEP)	.4478
Environmental Protection Agency, Region III (EPAIII)	.4945
New Jersey Office of Emergency Management (NJOEM)	.5633
Department of Interior (DOI)	.6887
Delaware Emergency Planning and Operations (DEPO)	.6948
Pennsylvania Department of Environmental Resources (PADER)	.7347
Occupational Safety and Health Administration (OSHA)	.7560
Pennsylvania Emergency Management Agency (PEMA)	.8117
U.S. Army Corps of Engineers (USACE)	.8294
Federal Emergency Management Agency, Region III (FEMAIII)	1.0179
Delaware Bay and River Cooperative (DBRC)	1.0265
Environmental Protection Agency, Region II (EPAII)	1.0839
Tri-State Bird Research and Rescue (TRIST)	1.2585
Federal Emergency Management Agency, Region II (FEMAII)	1.3796
Delaware Natural Resources and Environmental Control (DNREC)	1.4177

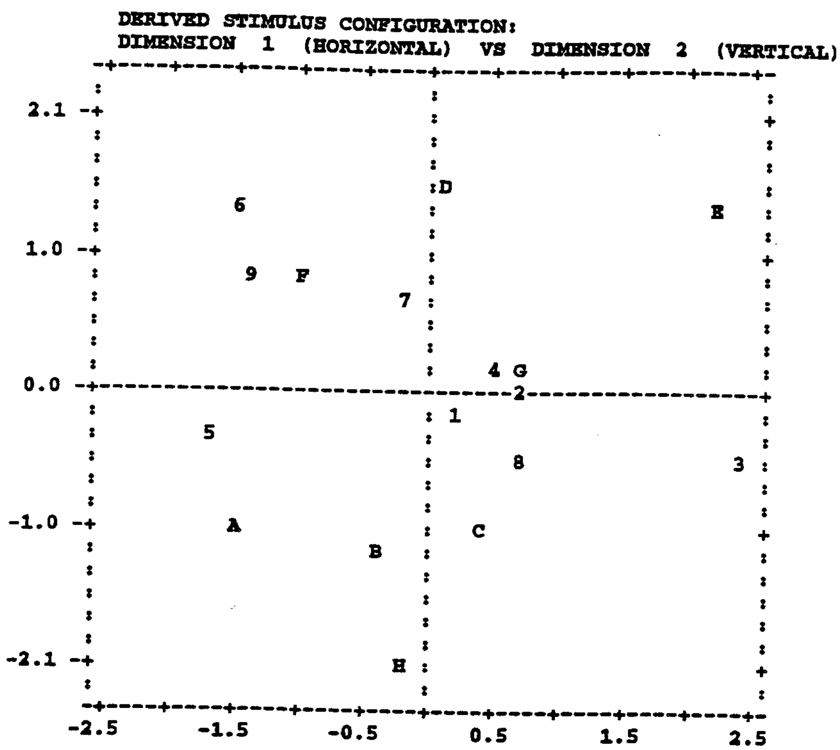

Figure 3. MDS Plot of General Contact Among Organizations*

*Key:

1=USCG	A=DBRC
2=NJDEP	B=USACE
3=EPAII	C=DOI
4=EPAIII	D=OSHA
5=PADER	E=FEMAII
6=DNREC	F=FEMAIII
7=DEPO	G=NOAA
8=NJOEM	H=TRIST
9=PEMA	

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