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Beliefs, Values, and Technical Assessment in Environmental Management: Contaminated Sediments in Puget Sound

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Principles of risk assessment and risk management are rapidly making their way into environmental policy making. Yet risk assessment has proved problematic in use, since focusing on risks can serve to highlight uncertainties in scientific information or to delineate the differences between risk assessment as a technical procedure and the cultural, social, and institutional dimensions of risk that people also expect to influence risk management decisions. This article examines the use of principles of risk assessment in Washington State's development of management standards for contaminated sediments in Puget Sound. It asks whether and how the use of a mixed quantitative-qualitative hazard assessment approach for contaminated-site ranking, coupled with a strategy of separating technical assessment from consideration of social and economic factors in management decisions on a site-by-site basis, helped foster accord on the management approach selected by the Washington Department of Ecology. The Advocacy Coalition Framework (ACF) was utilized in the design and analysis of a survey of policy elites that serves as the principal data collection vehicle for this study. ACF attempts to understand the dynamics of policy formation through examination of the beliefs that opposing advocacy coalitions bring to policy disputes, focusing on whether cross-coalition learning occurs

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in analytical debate over policy. Results show that distinct pro-environment and pro-development advocacy coalitions exist for Puget Sound's contaminated sediments problem. Relatively little disagreement exists across contending coalitions on the ways principles of risk assessment should be applied in ranking contaminated sites for remedial attention, however, suggesting that risk-based management is an area in which cross-coalition learning has occurred. On the other hand, considerable disagreement exists at the policy level, over both the extent to which consideration of risk should drive decisions and the extent to which legal liability should be used to force remedial action. Nevertheless, these diverse actors have proved willing to accept the Department of Ecology's overall approach, suggesting that framing the problem in the language of risk and separating scientific and technical judgments from sociopolitical considerations has had value in moving potential conflict into a realm where a consensus approach can prevail. Difficult political and economic choices remain for the region as the state's sediment management policy continues to evolve. Agreeing to allow major decision points to be framed as problems in risk reduction through parallel but separate processes of risk assessment and risk management has seemingly added resilience to the policy regime developed through the state's rule-making process. ACF emerges in this study as a robust framework for examining the impact of scientific and technical assessment on environmental policy development.

Keywords Advocacy Coalition Framework, contaminated sediment management, environmental risk, Puget Sound, risk assessment and management

Introduction

The U.S. Environmental Protection Agency (EPA) estimates that approximately 10% of the sediments underlying U.S. waters are contaminated with toxic pollutants to a degree that poses potential risks to fish and other marine living resources and to the humans who consume them (U.S. EPA, 1997, 1998). Although this problem can be thought of as an aspect of water quality, no single overarching federal regulatory vehicle like the Clean Water Act exists for contaminated sediments. In the absence of clear federal direction, some states, including the state of Washington, have gone their own ways in developing approaches for dealing with contaminated sediments within their waters. EPA released its national strategy for contaminated sediment management in 1998, but in lieu of a major new federal effort in this area the strategy emphasizes standardizing and improving sediment assessment techniques, continued dredged materials management and contaminated site remediation under existing federal and state authority, source control to prevent additional contamination, and research and outreach (U.S. EPA, 1998).

In 1991 Washington State became the first state to adopt standards for the assessment and management of contaminated marine sediments. These standards were developed by the state's Department of Ecology (hereinafter Ecology) as the culmination of federal, state, and local efforts that began nearly a decade earlier, at a time when Tacoma's Commencement Bay was being investigated for inclusion on the National Priorities List (NPL) for cleanup under the then-new Superfund law.

Unlike water quality management, where supporting technical tools and assessment procedures have evolved through decades of use, sediment management places numerous novel demands upon its supporting technical infrastructure. Sites that are so contaminated that they require remediation must be identified and distinguished from those that are not. Cleanup standards are needed and discharge limits must be established that are protective of sediment quality as well as water quality. For various technical reasons, existing water quality assessment procedures cannot easily be modified to accomplish these ends. Thus an important component of the sediment management regime that emerged in Washington State was a detailed set of technical assessment procedures and rules for their use, developed in parallel with but separate from the management standards that were adopted in 1991.

The developers of Washington's sediment management standards took a risk-based management approach, one increasingly prevalent in the assessment and management of environmental hazards both at the federal level and in many states. Developing a regulatory regime with distinct and separate assessment and management components has generally been viewed within the risk management establishment as an important aspect of such an approach (National Research Council [NRC], 1983). At the same time, an open rule-making process with high levels of participation by a spectrum of outside interests was utilized, a feature increasingly considered key to promoting public accord over the way environmental risks are characterized and managed (NRC, 1996; Commission on Risk Assessment and Risk Management, 1996).

Despite the emphasis the NRC and others have placed on adopting risk-based approaches to managing environmental hazards, whether and how the risk-based approach can improve the management of such hazards remains problematic (NRC, 1994a, 1994b; Kinney & Leschine, 2002). Thus an assessment of how the approach utilized in the development of Washington State's sediment management standards fared in promoting accord in this new area of environmental management can also provide insights into the prospects for risk-based management to achieve similar ends in other arenas. In the section that follows we describe briefly the emergence of risk-based approaches to the management of environmental hazards. A subsequent section introduces the Advocacy Coalition Framework (ACF; Sabatier & Jenkins-Smith, 1993) that was used to frame this study of Washington State's contaminated sediment management standards-setting effort. ACF is well suited for examining the translation of "risk" as a conceptual paradigm into a practical basis for environmental management, we believe. The results of our survey of elite interests involved in this rule-making process are presented next, interpreted through the lens of ACF.

The results of this study suggest that the strategy Ecology pursued had positive benefits for the process of putting the contaminated sediment management regime into place. They suggest also that development of the key, risk-based technical assessment tools that undergird the regulatory approach adopted by Ecology, in particular a risk-based site screening model called SEDRANK, may have provided an especially valuable vehicle for facilitating consensus across the diverse parties to this rule making. A concluding section cautions, however, that the consensus achieved in the early 1990s, in part by deemphasizing potentially important elements of the risk-based approach, has more recently proved to be somewhat fragile. As a result, Ecology's efforts in the late 1990s to amend its rule, in order to upgrade the consideration given to human health risks posed by contaminated marine sediments to a level akin to the emphasis currently placed on ecological risks, were shelved late in 1999.

Risk Assessment in Environmental Decision Making

The concept of *risk* is increasingly finding application in environmental management. *Risk assessment*, an activity with a predominantly scientific-technical character, is the process of characterizing the potential adverse human health and environmental consequences of exposure to environmental hazards. *Risk management* is the political process of deciding what to do about risk once it has been determined to exist, taking social, political, economic, and other considerations into account (Ruckelshaus, 1983). Following the release in the early 1980s of a study by the NRC on the use of risk assessment in health and safety regulation (NRC, 1983), the U.S. EPA embarked upon a major effort to place greater reliance on risk assessment as a guide to agency actions (Ruckelshaus, 1983).

The NRC study focused on public policy decisions regarding hazards to human health that result from exposure to toxic substances. It concluded that, properly utilized by regulatory agencies, risk assessment can bridge the gap between science and decision making that it saw as a principal weakness of the public discourse over the management of environmental hazards. Produced to promote more and better use of risk assessment in government decision making, the NRC report dealt extensively with the problems that had hampered the use of risk assessment in environmental regulation in the past. Among other things, it highlighted the inherent subjectivity in the inferences that technical specialists make as they develop risk assessment studies. It pointed with equal concern, however, to the potential pitfalls of allowing scientific judgments to merge with the broader social, economic, and technical considerations that it saw as the province of the policy makers who ultimately decide how to manage risk (NRC, 1983).

The report argued for careful attention to the institutional arrangements under which risk assessments are conducted and utilized. Implicit in its recommendation that organizational separation be maintained between risk assessment and risk management activities is the belief that separating questions of science from broader questions of social preference will result in risk management decisions that show a higher degree of accord across contending factions.

Since that time, risk assessment and allied technocratic approaches have come into wide use in environmental management decisions regarding the cleanup of hazardous wastes. A major regulatory driver is CERCLA, the "Superfund" law (Comprehensive Environmental Response, Compensation and Liability Act of 1981), which emphasizes a risk-based approach in its supporting regulations. Risk assessment has clearly not been a panacea for removing social conflict from public policy decisions on what to do about environmental hazards, however. Focusing on risk can serve to delineate more sharply the differences between risk assessment as a technical enterprise and the cultural, institutional, and social dimensions of risk (Nelkin, 1988; Freudenberg, 1988; Jasanoff, 1993). Or, it can trigger debate about the value content of the science intended to inform public policy decisions (Clark & Majone 1985; Weinberg 1977).

Experience with risk assessment in regulatory decision making has revealed liabilities when experts who develop risk assessments are allowed to become too isolated from the concerns of those who perceive themselves to bear the risks in question. Current thinking is that the best way for experts to avoid "missing" important risk concerns of the affected public is to involve those most affected by risk management decisions in the earliest stages of the analysis, when the risk problem's basic formulation occurs (NRC, 1994b; Commission on Risk Assessment and Risk Management, 1996).

The ACF as a Tool for the Study of Environmental Problem Solving

The ACF (Sabatier & Jenkins-Smith, 1993) flows from a conceptual model of governance in which relatively small policy subsystems, consisting of legislative committees, government agencies, and interest groups, engage in policy debate in individual problem domains over long periods of time, largely out of the public eye (Lee, 1993; Sabatier & Jenkins-Smith, 1993). A key precept of ACF is that the individuals in a policy subsystem can be arrayed into two or more distinct "advocacy coalitions," or relatively stable groupings defined not by institutional affiliation but by the beliefs that members share across a broad spectrum of ideas, termed the coalition's belief system (Sabatier &

Jenkins-Smith, 1993). "Deep core" beliefs refer to fundamental normative and ontological orientations, adding up to whether a person is a liberal or a conservative, for example. Deep core beliefs are very difficult to change. At the "policy core" are the basic policy positions and strategies for achieving core values within a particular subsystem. Such beliefs are more amenable to change, but change may require experiencing serious anomalies to one's worldview. "Secondary beliefs" refer to instrumental decisions—essentially the means appropriate to achieving desired ends—and to the types of information regarded as relevant to implementing the policy core. The decisions to employ a risk-based approach, or to rely on certain types of data and inferences about the key determinants of risk, one focus of this article, are examples of secondary aspects of belief systems. Secondary aspects are more amenable still to change.

Scientific and technical information influences decision making through what Sabatier and colleagues call "analytical debate," a process by which information enters the policy arena in point–counterpoint fashion, brought there by members of one or another advocacy coalition. Its purpose is to defend (or refute) the importance of a particular problem or situation in specific locales or contexts, to demonstrate (or refute) particular causal linkages associated with the problem, or to demonstrate (or refute) the efficacy of proposed solutions. Two other key ideas of ACF relevant to this study are that policy adoption is likely to require some degree of cross-coalition learning in relation to the problem (called "policy-oriented learning" by ACF researchers) and that adopted policies will embody the belief system of the governing coalition.

The recent history of risk assessment in environmental management highlights a number of issues that have long been of interest to ACF researchers and raises questions that the ACF approach is well suited to address. First, if scientists and technical experts in fact share the belief and value sets of the broader coalitions with which they identify, as ACF research suggests (Sabatier & Zafonte, 1994), then separating subjective scientific inferences from the broader social values that are supposed to inform risk management decisions may be more difficult and less beneficial than risk assessment practitioners assume. Related to this, the ability of agency officials to achieve consensus on what to do about risk through the considered balancing of social, economic, and political factors may be degraded if they too identify with particular advocacy coalitions (Sabatier & Zafonte, 1994).

Another area of great interest to ACF researchers concerns the risk assessment community's investment in the notion that the nature of the forums in which risk information is developed, communicated, and applied can strongly influence the results obtained. For example, the NRC's idea of an "analytic-deliberative process" for developing environmental risk assessments in a way broadly inclusive of the affected public has received considerable attention (NRC, 1996; Commission on Risk Assessment and Risk Management, 1996; Kinney & Leschine, 2002). ACF research in areas of environmental policy has come to similar conclusions, albeit in a less prescriptive way than in the commission work cited (Sabatier & Jenkins-Smith 1993; Sabatier & Zafonte, 1997).

Lastly, the risk-based approach is supposed to promote efficiency in governmental responses to risk, in the sense that both under- and overprotection of the public from risks are avoided. Risk assessment specialists like to argue that the information risk assessment provides about the "true" character of risk promotes compromise among the contending ideologies that often drive environmental disputes. In principle, those who believe that economic development should not be hobbled in the name of environmental protection and those who believe the environment must not be sacrificed in the name of economic development should both find something to like in the risk-based approach. This too is a proposition that has expression in the language of ACF. Can contending factions that disagree on policy core issues (e.g., the proper scope of remediation programs) still find agreement on important secondary aspects of their belief systems (e.g., the approach to be used in deciding whether areas of contamination constitute "problems" worthy of remedial action)? To the extent that such agreement exists, does it also promote agreement about other aspects of policy?

In this article we address these questions through examination of the development and use of risk-based technical decision tools in the process of defining sediment management standards for Puget Sound, under Washington State's Model Toxics Control Act (MTCA; Revised Code of Washington 70.105D et seq.). Marine sediment contamination has been a focus of scientific research and regulatory attention in the region for more than a decade, and a highly technocratic process for defining and evaluating management options for problems of sediment contamination has evolved. The state rule-making effort that led to adoption of the sediment management standards relied upon a technical approach for classifying sediment contamination that had been under development for nearly a decade, originating in the effort to remediate highly contaminated marine sediments in Tacoma's Commencement Bay under Superfund.

The state's sediment management standards' rule-making process involved many of the same participants as earlier regulatory efforts to address problems created by the presence of sediment contamination. It evolved into a highly participatory environmental decision-making forum in which a number of the principles of risk-based management outlined above were utilized. The broad question we pursue concerns whether the use of decision strategies based on maintaining a conceptual distinction between technical assessment and management activities and framed in the vocabulary of risk can indeed promote cross-coalition learning and accord over policy approaches, despite underlying differences between coalitions in "deep" and "policy" core beliefs. The relatively long history of sediment contamination as a problem for regulatory attention in the region makes it ripe for assessment via ACF.

In the next section we introduce the problem of sediment contamination and discuss the role technical assessment has played in sediment management for Puget Sound. In subsequent sections we report on the results of a survey we did of participants in the Washington Department of Ecology's rule-making process and others affected by the development of sediment management standards for Puget Sound.

One purpose of the survey was to determine whether distinct advocacy coalitions exist for Puget Sound's sediment contamination problem, particularly as defined by economic development and environmental protection interests. The presence of highly contaminated marine sediments in harbors and waterways has been one of the most contentious marine pollution problems of the past decade and a half. It is frequently characterized as conflict between interests who see the expansion of seaborne commerce as vital to the maintenance of both local economies and global competitiveness and those who regard the dredging and re-disposal into marine waters of contaminated sediments as posing unacceptable risks to marine environmental resources (Kagan, 1991). A second purpose of the survey, emphasized in this article, is to examine the extent to which scientific and technical information and assessments promote the kind of cross-coalition policy-oriented learning that can lead to policy change (Sabatier, 1988).

The Problem of Sediment Contamination

Much of the sediment contamination in Puget Sound and other urban bays and estuaries is the legacy of past industrial practices. Present point source discharges of wastes, airborne emissions, and urban runoff also contribute to the sediment contamination that is found in most urban bays and waterways. Pulp mills, shipyards, and wood processing facilities have been especially significant historical sources of sediment contamination in the Pacific Northwest. Once released, many toxic chemicals tend to concentrate in sediments because they have a propensity to bind to sediment particles and to be relatively insoluble in water. As a result, even pollutant discharges within current water quality guidelines can lead to a buildup of high levels of toxics in surrounding sediments.

Once contaminated, sediments may serve as reservoirs that recontaminate local waters long after the original pollutant source has been eliminated. Such recontamination can occur either as the product of natural resuspension of particulates by bottom currents, or as the result of human activities ranging from incidental vessel prop wash to the deliberate dredging and re-disposal of contaminated sediments in port and waterway maintenance operations.

Sediment contamination is not easily reversed, as many highly toxic substances are also highly persistent. On the other hand, once sources of new contamination are eliminated, natural sedimentation can act to bury contaminants to the point where, if protected from further disturbance, they will remain in isolation from the biotic environment. "Do nothing" is a viable policy option, and the basic policy problem can be viewed as defining the range of circumstances under which "do nothing" is inappropriate.

In their exposed condition, contaminated sediments can pass on their burden of toxics to bottom-dwelling marine organisms that include crabs, shellfish, and flounders and other demersal fish. Thus they may serve as a reservoir of toxic contamination that both adversely affects marine communities and poses risks to humans through food chain transfer. Removal can be very expensive and the act of dredging can itself liberate large volumes of contaminants to the water column. Moreover, re-disposal, whether at sea or at upland sites, may serve to transfer risks from one location to another. To technical experts it is natural to use the vocabulary of risk to elaborate upon the human and environmental problems that contaminated sediments pose.

Washington State enacted its contaminated sediment management standards with a relatively high degree of public support. By contrast, problems of sediment contamination elsewhere in the nation have frequently led to the bogging down of policy making. Both maintenance projects for urban waterways clogged by silt and port expansion projects aimed at capturing a greater share of lucrative international trade have become subject to protracted debate, pitting environmentalists, fishermen, and recreationists against economic development interests over proposals to dredge highly contaminated sediments.

The high-visibility, decade-long standoff that developed over the deepening of channels leading to the Port of Oakland, California, requiring the dredging and disposal of highly contaminated sediments, is indicative of the potential the problem of sediment contamination has to engender protracted political debate. Robert Kagan (1991) characterized the bureaucratic and political standoff that developed over the dredging of Oakland Harbor as "adversarial legalism" fueled by overly fragmented decision-making authority. In New York, New Jersey, and the Great Lakes, proposed dredging projects have similarly foundered over the issue of sediment contamination. In each of these cases, advocacy politics, expressed through litigation and other means, has played a prominent role in determining how the competing interests of environmental protection and economic vitality are to be traded off.

The process that led to successful adoption of sediment management standards for Puget Sound proved to be relatively low-key and low-profile, however, despite the fact that the environmental and economic stakes in the presence of sediment contamination are also high in the Puget Sound region. Among questions raised are: (1) whether distinct economic development and environmental protection coalitions indeed exist in the region; (2) to the extent that they do, what agreement exists on "policy core" and secondary aspects of contending factions' belief systems; and (3) the extent to which principles of risk-based management have infused the scientific and technical debate, and the practical effect this has had on decision outcomes. To the extent that there has been general accord on the direction of Puget Sound's contaminated sediment management policy, can the use of a risk-based approach be said to have contributed, or does the approach taken at least mirror the considerations that the interests to the policy say must be taken into account for a policy to be acceptable to them?

Scientific and Technical Assessment and Sediment Management in Puget Sound

Concern for the effects of contaminated sediments on marine organisms in Puget Sound emerged in the late 1970s and early 1980s as a result of scientific studies conducted by the National Oceanic and Atmospheric Administration (NOAA). The nomination in 1983 of Commencement Bay, Tacoma to the NPL under the then-new Superfund program (created under CERCLA) was among the first major efforts to address the problem of sediment contamination. The designation of Commencement Bay as a Superfund site was motivated by the presence in sediments of high levels of polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), heavy metals, and other toxic contaminants. The levels of some of these contaminants were among the highest ever recorded in marine and estuarine sediments, though subsequent sampling revealed equal or greater contaminant levels in Elliott Bay (at the Seattle waterfront), in Boston Harbor, and in other urban embayments around the United States (U.S. Congress, OTA, 1987).

The suggestion that the presence of contaminated sediments in urban embayments of Puget Sound was the reason why demersal fish living in contact with sediments were showing high incidences of tumor-like lesions was one of the major galvanizing influences that led to the creation in the mid-1980s of the Puget Sound Water Quality Authority (PSWQA, 1987, hereinafter Authority; Leschine, 1990). The issue was actively promoted as a contamination-related problem of major concern by scientific experts in the region, and contaminated sediments and dredging became one of the principal issues upon which the Authority focused as it developed its first Puget Sound Water Quality Management Plan (PSWQA, 1987).

The Water Quality Authority operated primarily as a problem identification and intergovernmental coordination agency, and in that role participated in or promoted a number of management initiatives that dealt with contaminated sediments. The federal government entered the Puget Sound water quality management arena through creation of the Puget Sound Estuary Program (PSEP), begun in 1984 under EPA Region Ten's (Seattle-based) Office of Puget Sound. PSEP focused on the environmental problems of Puget Sound's urban bays through Urban Bay Action Teams, multiagency task forces.

In 1985 PSEP, Ecology, the Washington Department of Natural Resources (DNR), and the U.S. Army Corps of Engineers Seattle District (Army Corps) formed a cooperative program called the Puget Sound Dredge Disposal Analysis (PSDDA), dedicated to addressing disposal options for dredged material, which had become a contentious issue. PSDDA emphasized a sound-wide view of the problem of dredging and dredged material disposal, the use of scientifically and technically defensible criteria in examining disposal options, and public acceptability of the management options identified. Its approach was highly compatible with the philosophy of the Authority, which actively supported its work (Leschine, 1990). PSDDA developed numerous technical approaches for evaluating sediment contamination, including the technical basis for selection of a series of open water disposal sites (for sediments with low levels of contamination) now in regular use throughout Puget Sound.

Technical assessment has long been central to management efforts to deal with contaminated sediments. There is, however, considerably less agreement among technical experts about the appropriate technical basis for sediment management decisions than for water quality standards. A proliferation of technical approaches to sediment assessment has been the result (Lind, 1994). Central to the Puget Sound program was a novel assessment approach, developed originally to guide the Superfund investigation in Commencement Bay, the so-called AET, or Acceptable Effects Threshold.[1] The great advantage of the AET approach from a technical point of view was that it reflected well the types of data on sediment chemistry and biology that were most readily available for Puget Sound.

That the AET approach came to be widely accepted for use in the region, becoming the primary basis for classifying sediments under the state's Sediment Management Standards, may also be testimony to the extensive networking among agency technical staff and academic and professional consultants that has occurred through PSDDA and other technical support programs as sediment management issues have been dealt with. Bish (1982) studied water quality governance in the Puget Sound region during the period in which many of the basic management programs that are central today were being put into place. He characterized the governance system as highly open and highly dependent upon extensive and ongoing interaction among a multiplicity of single-purpose agencies whose cooperation is generally required for policy change. He found this system to be generally conducive to a problem-solving process that has operated with a high degree of consensus in most instances.

Development of the Sediment Management Standards

The development of sediment management standards for Puget Sound ultimately became a two-pronged effort, aimed at both defining standards for discharges that affected sediment quality and the identification, ranking, and ultimate cleanup of sites where contamination was already present. This comprehensive approach grew out of the recommendations of a broad-based advisory group in reaction to Ecology's announced intention to pursue a much narrower effort aimed primarily at developing classification criteria (Lind, 1994).

The Authority, whose primary mission was to develop and revise biennially the Puget Sound Water Quality Management Plan (hereinafter Plan), provided the first public forum for the discussion of sediment issues. It convened a sediment advisory committee in 1986 with membership from state, federal, and local governments and representatives from industry, environmental groups, and the tribes. This served to acquaint advocacy groups with sediment issues and provided impetus to Ecology to move forward with its own rule-making effort.

Ecology's efforts to draft rules began in 1987, following the emergence of the 1987 Plan. Ecology retained the advisory committee structure developed by the Authority, and representation was enlarged (Lind, 1994). As the sediment quality standards initiative moved forward, the private sector was represented by both traditional polluting industries and technical consultants who would stand to profit from remediation and other control efforts. Agency representation included both regulatory agencies like Ecology, EPA, and the Washington Department of Fisheries (WDF; now the Department of Fish and Wildlife), and potentially regulated agencies like the region's public ports, public dischargers (e.g., King County Metro, as it was then known, the agency with responsibility for municipal sewage treatment), and DNR, the trustee agency for the state's tidelands.

In 1991, Ecology formally adopted its sediment management standards (Washington Administrative Code Chapt. 173-204-100). The goal was "the reduction and ultimate elimination of adverse effects on biological resources and significant health threats to humans from surface sediment contamination." The rules that emerged were quite elaborate in structure, including separate consideration of criteria for human and ecological health protection (with emphasis on the latter), highly detailed assessment procedures, and explicitly differentiated assessment and management spheres. Criteria developed using the AETs from the Commencement Bay Superfund program and PSDDA distinguished "no" and "minor" adverse effects levels for sediment contamination on the basis of both chemical and biological evidence.

The standards that emerged utilize a number of different technical assessment procedures within a single overarching regulatory framework. The AETs are applied to classify sediments with respect to the "no" or "minor" adverse effects criteria. While the overall approach stops short of full-blown quantitative risk assessment (e.g., no effort is made to develop probabilities or likelihood of occurrence), it does, in its use of a range of biological effects that stand as surrogates for population effects, constitute a hazard, or qualitative risk assessment.

Hazard assessment focuses on the pathways by which sources of potential hazard can reach such receptors of concern as humans or valued ecological resources. Hazard management then focuses on measures which can block or decrease the probability of hazards reaching these receptors or which can mitigate the consequences if they do. Under the sediment management standards, source control is the primary management mechanism. Through the device of "sediment impact zones" (SIZs), economic factors are taken into account on a case-by-case basis to permit discharges which, following the adopted criteria, cause impacts at the "minor" adverse effects level. This concession was instrumental to winning the support of public and industrial dischargers (Lind, 1994). While computer models are used to predict whether effluent discharges will stay within the "minor" effects category of the regulations within the designated SIZ, the thrust of the approach is to emphasize that the designation of an SIZ is a management decision and not the product of technical analysis (Lind, 1994).

The Role of Hazard Assessment in Site Ranking: The SEDRANK Model

Ecology has compiled an extensive database on contaminant concentrations in sediments from throughout Puget Sound that it uses for initial identification and screening of sites that could become candidates for cleanup. Adjacent sampling stations with levels of contamination that are high enough in comparison to cleanup screening levels (CSLs) become a "station cluster of potential concern." The CSLs are defined by calculating AETs against the database. A hazard assessment is then conducted to see whether such clusters rate designation as a cleanup site, a step with legal implications for the site's owners, who stand to become potentially responsible parties (PRPs) under MTCA, the state's hazardous waste site cleanup statute.

The hazard assessment approach Ecology uses is embodied in the site-ranking model SEDRANK, which was developed by consultants for Ecology as a tool for implementing the sediment management standards (PTI, 1990). A multiagency review panel oversaw development of SEDRANK, but the model was not subject to the same level of public scrutiny as the standards themselves. The model could thus reflect beliefs and values of agency technical personnel over those of others with a stake in the outcomes of its use (Lind, 1994).

SEDRANK is the clearest articulation of the hazard assessment approach in the multistage process that Ecology adopted for identifying those sites that ultimately warrant cleanup under the regulations. It combines disparate quantitative and qualitative information into separate assessments of the ecological and human health hazards posed by a site (Figure 1; the human health hazard evaluation is conceptually similar to the

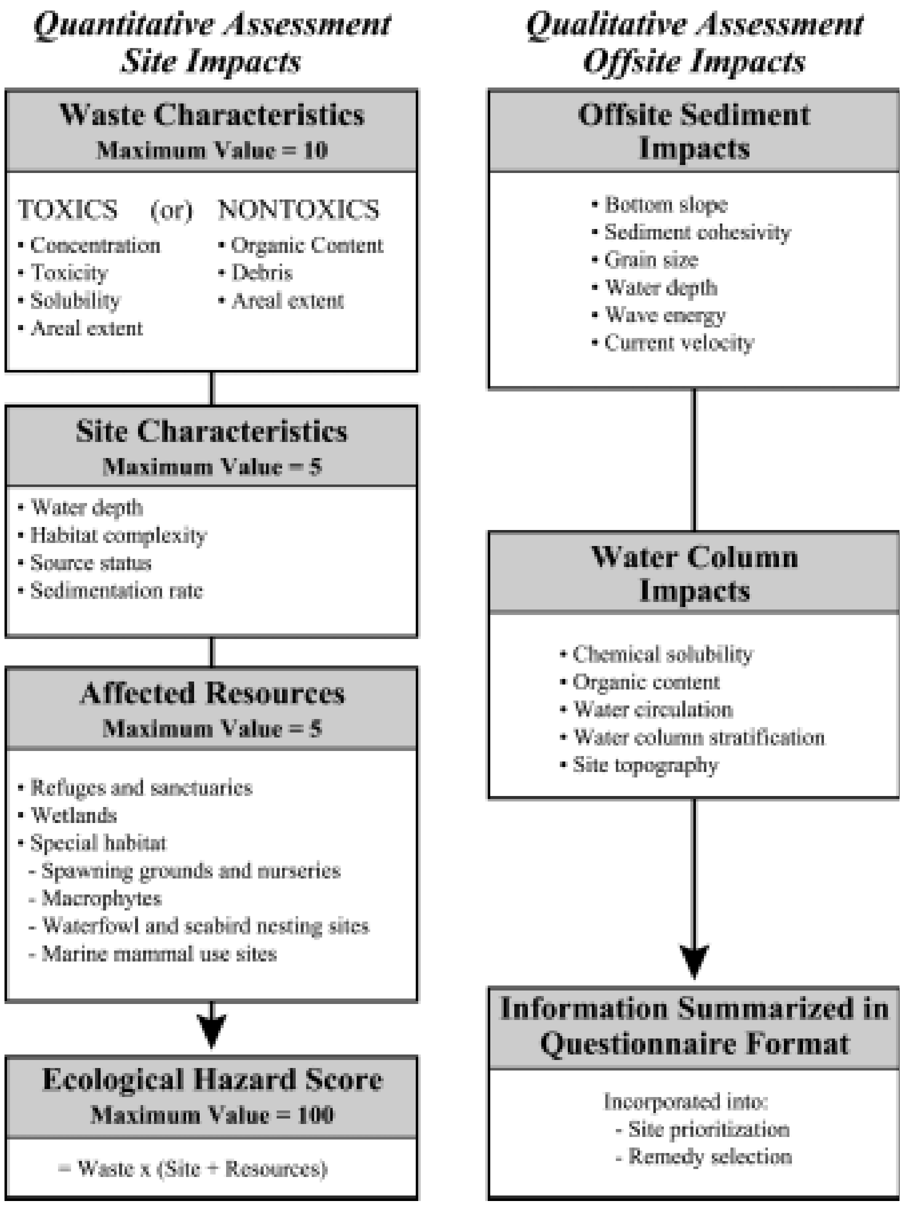

Figure 1. Schematic of SEDRANK's approach to environmental hazard evaluation (adapted from PTI, 1990).

environmental hazard evaluation depicted in the figure). The quantitative assessments that are done result in scores on 0–100 scales that permit the ranking of sites according to the potential ecological or human health hazard each poses. By taking such characteristics as water depth, resource sensitivity, and site proximity to sensitive resources into account, SEDRANK takes the broader approach to defining the scope of environmental cleanup that is espoused by the risk assessment community. This approach implicitly rejects the narrower alternative of many other pollution management regimes in which levels of toxic chemicals alone become the primary basis for regulatory decisions, with the results of laboratory studies or other indirect evidence defining the rationale for the actions taken. At the same time, the approach is limited enough in scope to leave significant questions of social and economic values in the hands of managers to resolve by other means. This, too, is in accord with the principles of risk assessment laid out in the second section above.

SEDRANK scores do not by themselves define whether a site will emerge as a high-priority site targeted for cleanup. The sediment management standards allow for Ecology to apply "best professional judgment on a case by case basis" in taking other factors into account in deciding the priority for cleanup. These include public perceptions, the financial status of dischargers or landowners, their compliance history, current or pending actions that affect them under other regulatory programs, and the "size of the cleanup action proposed or determined necessary" (WAC 173-204-550). Thus a separation of broader social and economic considerations from the technical factors which guide the assessment phase of site ranking is achieved, in a manner consistent with the general guidance now coming out of the environmental risk management literature.

The purpose of site ranking via SEDRANK is "to estimate, based on technical information compiled during the hazard assessment procedures . . . the relative potential risk posed by the site to human health and the environment" (WAC 173-204-540). The approach used to effect these rankings embodies judgments which, though technical in character, have potentially significant implications for the broader community of interests affected by sediment management decisions (but whose role in the development of the model and its supporting technical tools was fairly limited). A question that arises, therefore, is whether according broad discretion to Ecology to take social and economic values into account in deciding the ultimate priority of sites serves as sufficient counterbalance to the biases that could arise if application of SEDRANK alone were to make these determinations. Put another way, if differences among advocacy groups are defined within the broader underlying debate over values and beliefs in the sediment management policy arena, then do similar differences appear in preferences with respect to the risk assessment concepts that, through application of SEDRANK, define the effective reach of the contaminated sediment remediation program? This and other questions were explored by means of the survey described in the next section.

The Sediment Management Survey

A mail survey was conducted in the spring of 1994 by means of a questionnaire developed to examine the beliefs and values of participants in the Puget Sound contaminated sediment management program (Lind, 1994). The questionnaire was modeled after surveys conducted by Sabatier and his colleagues in investigations of environmental management issues in Lake Tahoe and the San Francisco Bay Delta (Sabatier, Hunters, & McLaughlin, 1987; Sabatier, 1989). Survey categories were developed to identify

- factors respondents perceived to be important to the ecological health of Puget Sound and to "quality of life" in the Puget Sound region;
- beliefs about the relative importance of potential sources of sediment contamination and beliefs regarding the effects and significance of contamination in Puget Sound;
- perceived importance of the factors taken into account when areas of contamination are rank-ordered for cleanup attention via Ecology's site-ranking model;
- perceived quality of supporting scientific information for the sediment management program and beliefs concerning the efficacy of various approaches to taking scientific information into account in decisions;
- extent of agreement with specific policy proposals that address sediment contamination; and
- beliefs regarding the appropriate scope of sediment management, appropriateness of roles played by various governmental and other organizational entities in it, and extent to which other actors' positions and actions are perceived to be in accord with one's own views.

The survey was designed to ascertain whether distinct advocacy coalitions exist for the sediment management problem and to examine the influence of scientific and technical assessments on the nature of the emerging sediment management program. One hypothesis behind the survey was that there will be less conflict over scientific and technical issues associated with the use of hazard assessment in the management regime than over the broader socioeconomic and political considerations that Ecology's procedural rules consign to separate management consideration. (The former involve secondary aspects of belief systems while the latter chiefly concern policy core beliefs.)

A corollary hypothesis is that the separation of assessment and management in the sediment management regime has facilitated its implementation with relatively little social conflict, despite underlying differences in "deep" and "policy" core beliefs. Specifically, we hypothesize that the adoption of a hazard assessment approach for contaminated site screening, coupled with formal delineation of the scope of considerations to be left to the discretion of managers in deciding the ultimate disposition of sites, represented an instrumental choice about which there was broad, cross-coalition accord.

The survey was directed at "policy elites" defined via formal position in organizations, participation in public forums regarding sediment management, or reputation. Ninety-two survey forms were distributed to individuals who were first contacted by phone to determine their willingness to participate. Sixty-two surveys were returned, of which 60 were utilized in the analysis. Individuals were selected on the basis of their membership in one of seven subgroups with some role to play in development of the sediment management standards (Table 1).

Survey Results

A series of principal components factor analyses with varimax rotation were performed on groupings of survey items selected to establish the basic advocacy coalition structure and to permit examination of responses over a range of items concerning particulars of the sediment management system. In addition, t-tests were performed to test differences in group means on constructed scales suggested by the factor analysis.

A factor analysis of thirteen perceived threats to quality of life in the Puget Sound region (presented in the original survey in the form of a 100-point thermometer scale with 0 = not a problem at all and 100 = extremely serious threat) led to the extraction of four factors (with eigenvalues > 1). The four taken together explain 70% of the total variance in the 13 items. Just two of the factors explain 50% of the variance and lead to two attitudinal scales that we label the *Marine Ecosystem Problems* and *Social and Economic Problems* scales. The Marine Ecosystem Problems scale is comprised of four items that relate to marine environmental concerns and the loss of critical habitat: water quality in Puget Sound (r = .84), aquatic sediment contamination (r = .79), declining salmon/steelhead runs (r = .76), and loss of wetlands and other critical habitat (r = .75). (The r values in parentheses are the factor loadings for the rotated scales, similar to correlation coefficients.) The Social and Economic Problems scale is developed from four "quality of life" and business opportunity items: crime (r = .87), air pollution (r = .74), poor public schools (r = .74), and excessive environmental regulation (r = .56).[2]

A second factor analysis concerns respondents' evaluations of 10 threats to the ecological health of Puget Sound, likewise presented on 100-point thermometer scales in the survey. Two factors were extracted, explaining 58% of the total variance in the 10 items. The first scale, *Habitat Loss/Development Threats*, consists of the items shoreline development (residential and industrial) (r = .81), nonpoint source pollution (r = .75), loss of wetlands and other fish and wildlife habitat (r = .74), and logging in stream headwaters (r = .69). Declining salmon and steelhead runs and sediment contamination

Table 1
Survey response rates by advocacy group

Advocacy group membership	Surveys mailed	Surveys returned	Return rate
Regulatory and resource agencies; these are primarily agency staff from state and federal agencies with regulatory roles over sediments (e.g., EPA, NOAA, Ecology, USFWS).	28	19	68%
Regulated and potentially liable public agencies; these are the staff of public dischargers and other potentially liable or regulated public agencies (e.g., cities, METRO, ports, DNR, Navy, Corps).[a]	18	10	55%
Environmental groups; these are board members or staff of environmental groups that have been actively involved in contaminated sediment policy.	11	7	64%
University scientists; these are university scientists who are conducting research on sediment-related issues. This groups includes researchers in fisheries, oceanography, environmental engineering, public health, and chemistry.	8	7	88%
Industry; these are owners or environmental managers of point source discharging or waterfront industries. This group also includes lobbyists and attorneys who represent industries.	13	8	73%
Environmental consultants; these are primarily engineers, chemists, and biologists who work in sediment monitoring or sediment remediation.	7	6	86%
Tribal representatives; these are tribal environmental staff with familiarity in sediment issues. This group did not include any tribal members.	7	4	57%
Total	92	60	65%

[a]In cases where a particular agency serves a dual role of regulator and regulated party (e.g., DNR, Corps) the individual was categorized according to his or her particular duties.

received loadings of r = .54 and r = .56, respectively, on this factor. The second scale, termed *Threats from Discharges and Spills*, consisted of the threat of major oil spills (r = .86), routine and accidental oil discharges (r = .83), municipal point source discharges (r = .72), and contaminated sediments (r = .57). The first factor alone explained 45% of the total variance in responses to the 10 survey items. The contaminated sediments item has about the same loading on both factors, reflecting its dual significance both as degraded habitat and as a source of marine pollution.

A third factor analysis was applied to a series of eight survey items concerning perceived threats to human health in the Puget Sound region. Two factors, explaining 71% of the total variance across the eight items, were extracted. The first, explaining 56% of the total variance and labeled the *Air and Terrestrial Pollution* Scale, consisted of drinking water contamination (r = .90), air pollution (r = .80), and toxic waste sites on land (r = .55). The second scale, labeled *Marine and Aquatic Pollution*, consisted of four items: contaminated runoff from urban or agricultural areas (r = .90), contaminated sediments (r = .88), industrial point source discharges to Puget Sound (r = .88), and treated or untreated sewage discharges to Puget Sound (r = .82). Toxic waste sites on land had a loading on this second factor (r = .57) comparable to its loading on the air and terrestrial pollution scale.

The six scales described above lead to grouping of the interests listed in Table 1 into distinct environmental protection and economic development coalitions (Lind, 1994). All but the Social and Economics Problems scales represent environmental attributes associated with quality of life, ecosystem health in Puget Sound, or human health in the Puget Sound region. Those we have grouped into the pro-environment coalition consistently attach more importance to the issues depicted on the five scales representing environmental attributes than do those assigned to the pro-development coalition (Figure 2).[3] As might be expected, the reverse occurs for the scale relating to social and economic problems, combining as it does factors related to the state of the economy and the stability of the

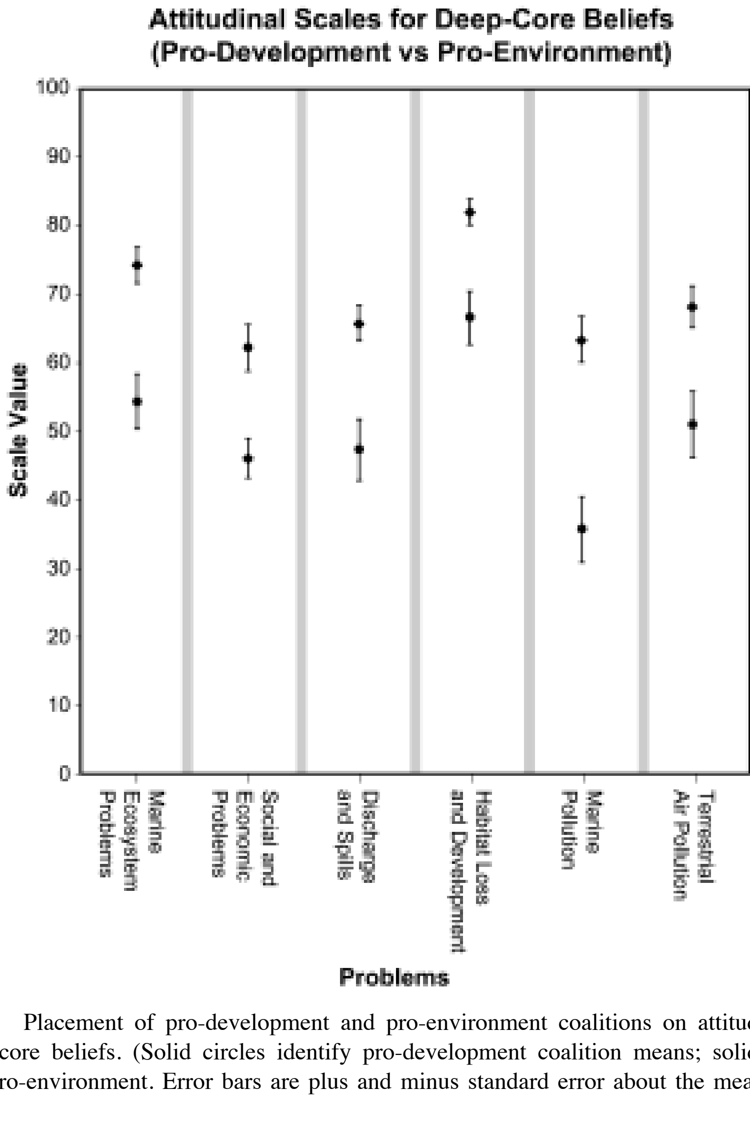

Figure 2. Placement of pro-development and pro-environment coalitions on attitudinal scales for deep core beliefs. (Solid circles identify pro-development coalition means; solid diamonds identify pro-environment. Error bars are plus and minus standard error about the mean [SEM].)

business environment. The pro-environment coalition consists of all tribal and environmental group representatives, academic scientists, and regulatory/resource agency representatives, while the pro-development coalition is made up of consultants, industry representatives, and representatives of regulated or potentially liable public agencies. As Figure 2 shows, this division yields statistically significant and distinct differences between group means for the coalitions on each scale, consistent with the expectations of ACF.

As might be anticipated since the representation of some individual groups is small in our survey (e.g., just four tribal representatives and six environmental consultants), the results for individual groups show less coherence than results for the broad coalitions. Tribal representatives' and consultants' scores show particularly high variances. Most group means do not differ significantly from the grand mean (Figure 3a–f). One result of interest, however, is the generally statistically significant difference in group means between agencies with primarily regulatory roles (Ecology and three federal agencies) and those that are either regulated or potentially liable parties under the sediment management standards (the state's DNR, public ports, municipalities, sewage treatment districts, the Navy, and the Army Corps of Engineers; Lind, 1994). This split in alignment among public agencies, defined by deep and policy core beliefs, is consistent with the findings of Sabatier and Zafonte (1994) in their study of bureaucratic bias in public officials associated with water management in the San Francisco Bay Delta.

An ACF Perspective on Ecology's Risk-Based Approach

Having demonstrated that a coherent coalition structure exists for the sediment management problem, we take up next the question of whether the response patterns described above extend into the realm of "secondary" beliefs where many of the important scientific and technical underpinnings of the sediment management system reside. Specifically, we ask whether survey respondents exhibit similar differences when queried about the importance of the "risk" factors that frame Ecology's approach to site ranking. Our mail survey included a brief description of the principal factors taken into account in Ecology's SEDRANK model, as a lead-in to a question in which a list of eight such items was presented. Survey respondents were asked to rate the relative importance of each of the following on a 100-point thermometer scale:

- human health effects associated with sediment contamination;
- ecological effects associated with sediment contamination;
- the specific exposure pathways by which contaminants affect receptors;
- a threshold on size, below which an area of contamination would not be considered to require remediation or other attention, regardless of toxicity levels;
- off-site impacts to areas of human use or important ecological resources, when the exposure pathways are indirect, such as through water column transmission;
- impacts on commercially important marine and estuarine resources;
- impacts on noncommercial marine and estuarine species;
- Presence or absence of source control.

Overall the "ecological effects" item scored highest in importance (mean score 88) and the "threshold on size" item scored lowest (mean score 28). Impacts on commercial and noncommercial species, presence or absence of source control and human health effects all scored about the same in importance, with mean scores in the upper 70s. A principal components factor analysis on all eight items produced three factors, explaining 68% of the total variance in the scores on these items. The first factor, termed *concern for species impacts and source control*, consists of impacts on noncommercial species (r = .84), impacts on commercial species (r = .74), and presence or absence of source control (r = .74). The second factor, termed *site size and ecological effects*, con-

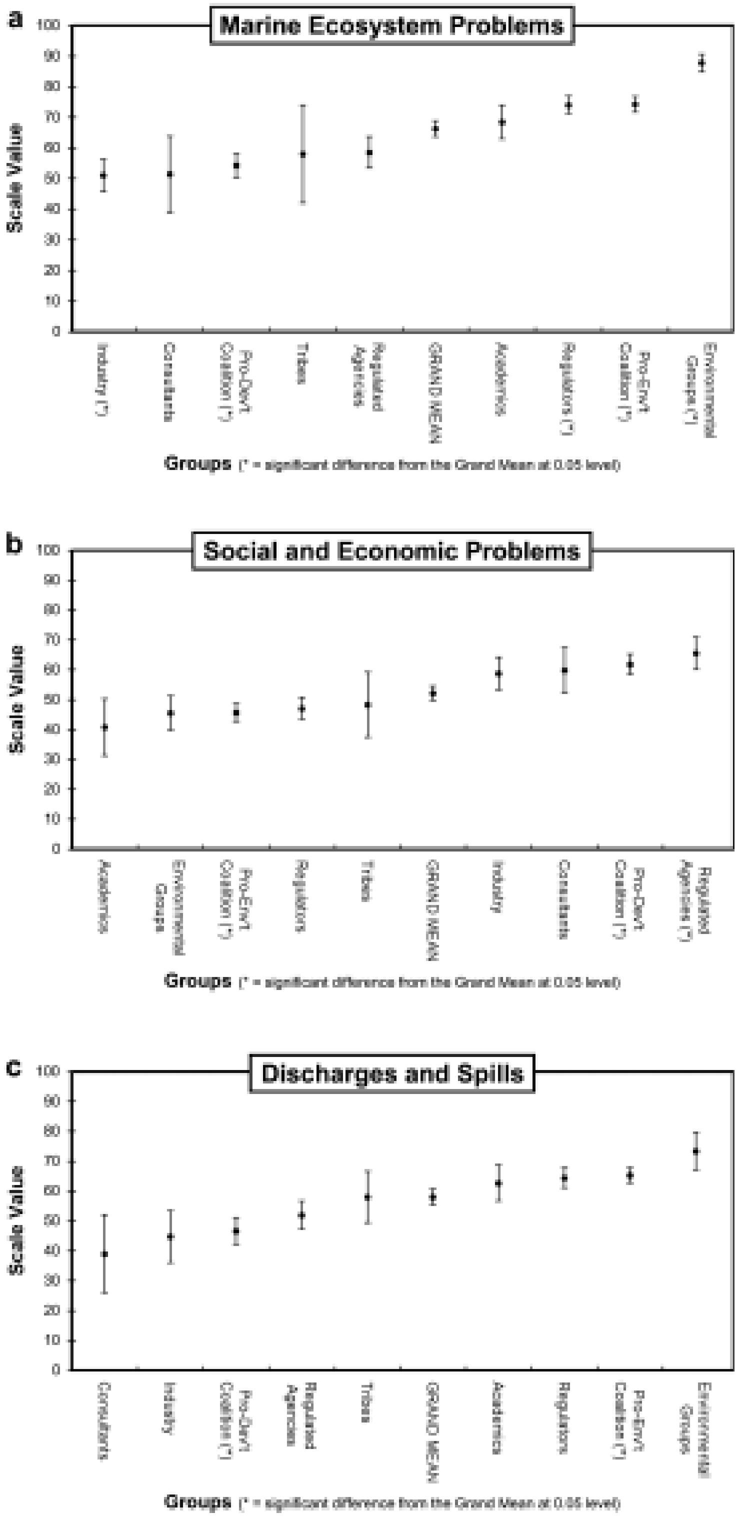

Figure 3a–c. Placement of individual groups on attitudinal scales for deep core beliefs. (An asterisk indicates that the mean for a group differs at the 0.05 significance level from the grand mean for that problem.)

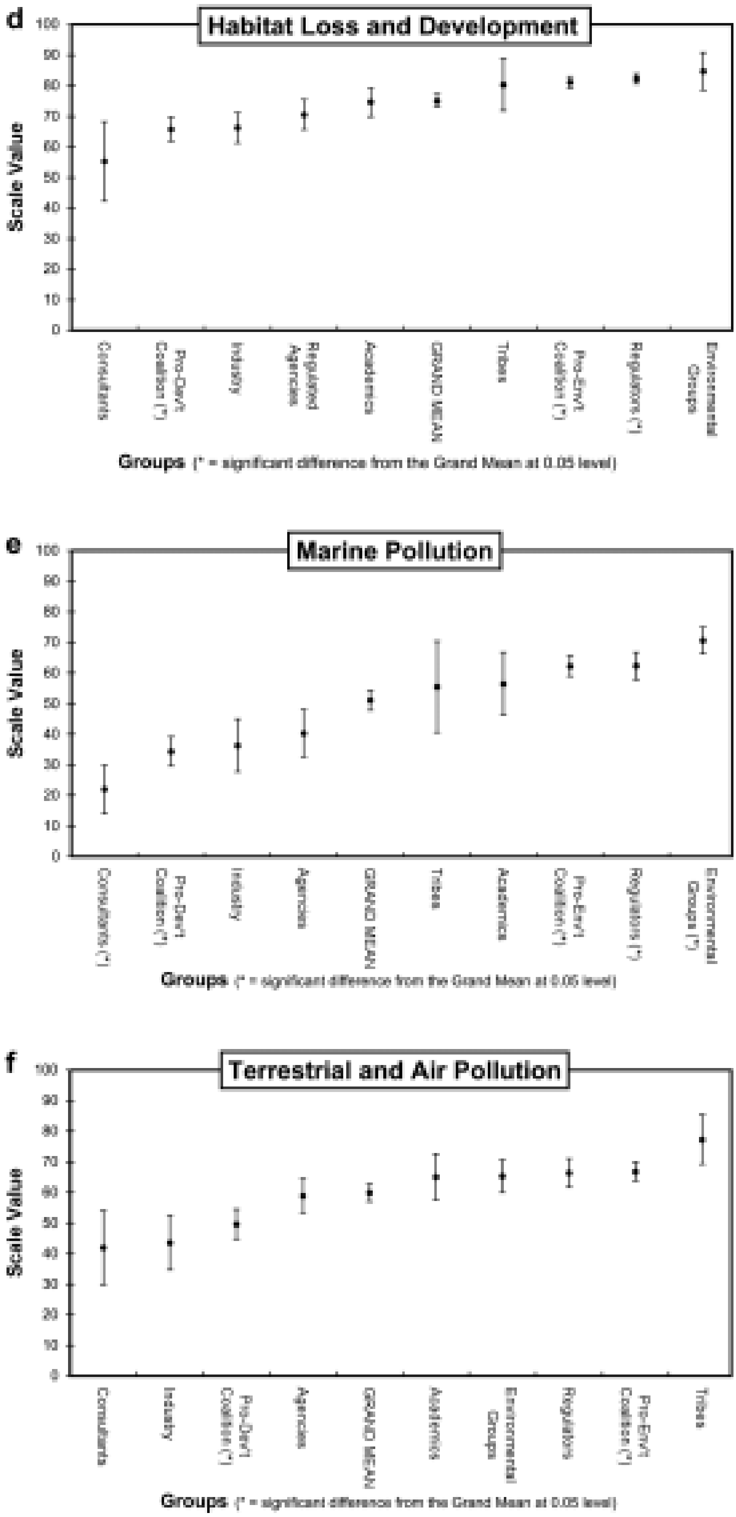

Figure 3d–f. (*Continued*) Placement of individual groups on attitudinal scales for deep core beliefs. (An asterisk indicates that the mean for a group differs at the 0.05 significance level from the grand mean for that problem.)

sists of threshold on site size (r = .89) and ecological impacts (r = .68). The third factor, termed *contaminant pathways and human health effects*, consists of human health effects (r = .74), exposure pathways (r = .74) and offsite impacts (r = .60). The third factor contributes just 12% to the total variance explained. The two-factor model is illustrated in Figure 4. All three factors enter the discussion below.[4]

SEDRANK was developed in a way that accords roughly equivalent treatment to human health and ecological effects, with the rationale that other models applicable to rating hazardous waste sites (e.g., EPA's Hazard Ranking System) place emphasis on human health effects to the detriment of the consideration they give to ecological effects. The overall higher ratings given to ecological effects in comparison to human health effects by respondents may signal acceptance by them of the contentions of Ecology officials and others that marine environmental effects are the more important to take into account when making decisions on contaminated sediments. (See the discussion at the end of this section, however.) Offsite impacts, rated next to lowest in importance among the eight factors, are treated qualitatively in SEDRANK. The high loading in the principal components analysis on the "threshold on site size" item (r = .89) appears to mirror the policy debate that occurred concerning the issue of a site-size exemption as the sediment management standards were being developed. The makeup of SEDRANK thus appears to reflect well the analytical debate that occurred as the same issues were considered in the policy arena where the sediment management standards were developed.

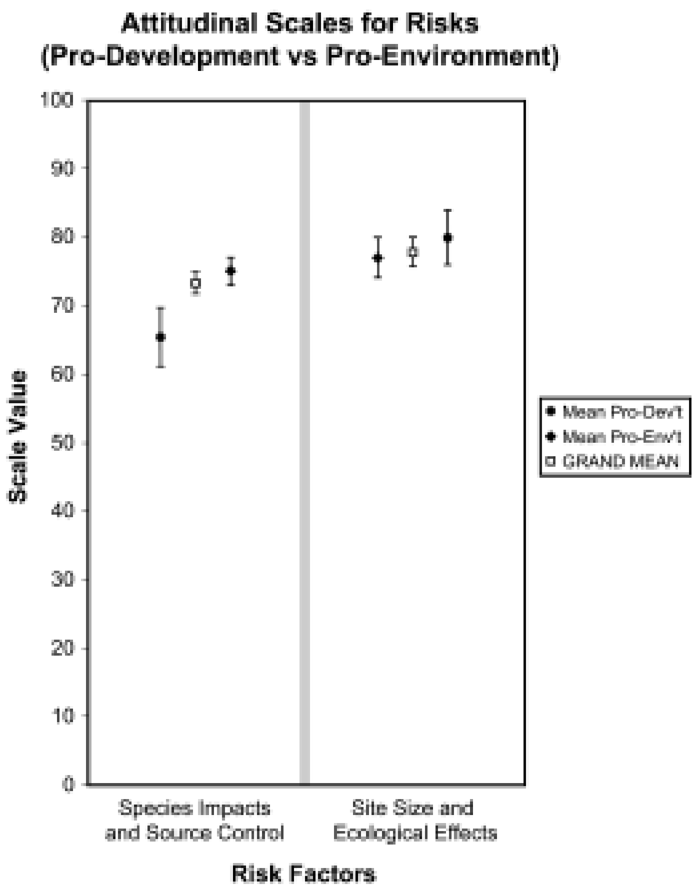

Figure 4. Placement of pro-development and pro-environment coalitions on scales for risk factors.

The differences that emerge in the ratings respondents assigned to these items reflect well the kinds of disputes that typify the development of risk assessments in other environmental management arenas where the risk assessment approach has been employed. The principal differences here concern how much weight to assign to species and ecological effects, the presence or absence of source control, and the presence of contamination "hot spots" when the risks of sediment contamination are weighed. Although such questions have traditionally been viewed as within the province of scientific and technical experts, decisions on them are nevertheless inherently subjective (NRC, 1983). Termed "inferential bridges" in the NRC's 1983 report, such questions are fundamental to the development of environmental risk assessments. In our survey the debate implied by the respondents' views breaks down along lines different from those which define the basic coalition structure. Clear differences in deep and policy core belief permitted us to distinguish the pro-development and pro-environment coalitions in the first place (Figure 2). The differences in placement of these same two coalitions on scales defined by these risk factors are smaller and are only statistically significant on the first risk factor (two-tailed t, $p = 0.05$), illustrated in Figure 4.

The site-screening model SEDRANK appears based on a general approach to risk assessment that is accepted by pro-development and pro-environment coalitions alike in the sediment management arena. Such differences as do exist across respondents regarding the emphasis to be placed on particular factors as sites are screened are typical of scientific and technical disputes concerning the use of risk assessment in environmental management and break down along lines different from those that define the overall coalition structure.

Although we did not conduct a direct test on this point, the acceptance of the use of SEDRANK by stakeholders in the sediment management arena is perhaps conditioned on the way in which broader social, economic, and other factors not incorporated into SEDRANK are given separate consideration as risk management decisions are made. Stated in the language of ACF, we infer that cross-coalition agreement on secondary aspects of the respective belief systems of pro-development and pro-environment coalitions is sufficient to entrust these secondary aspects to computation via a computer model, *provided* that issues in the policy core that are less agreed upon are kept in the realm where discretionary judgment can prevail on a case-by-case basis. In its emphasis on explicit separation of assessment and management and on seeking broad consensus as the approach to assessing and managing risks is developed, Ecology's program thus embodies key features of the consensus-oriented risk-based paradigm espoused by the NRC and the Commission on Risk Assessment and Management and outlined in the article's second section. This leads us to the final question we address: To what extent does acceptance of Ecology's approach to defining risks connote also consensus over the specific policies Ecology should pursue and the weight it should accord to risk relative to other considerations as sediment management decisions are made (i.e., what is the level of agreement at the policy core)?

We approached this question with a series of survey items concerning specific policy proposals and beliefs in connection with the quality and appropriate use of scientific and risk information in decisions. The degree of agreement or disagreement with 13 specific propositions was assessed on Lickert scales. A model based on two factors (not shown), selected on the basis of the factor scree plot, explains 47% of the total variance on these items.

The first factor, termed *use of risk assessment and risk information*, is associated with four items: that a threshold level of scientific evidence should be required before a site is declared a candidate for remediation ($r = -.77$), that a precautionary approach should be followed requiring remediation in some cases even though the actual level of risk cannot be measured (r = .75), that public perception tends to exaggerate the risks of contaminated sediments (r = –.69), and that cleanup to the "no adverse effects" level should be required whenever sites are identified as high priority (r = .62). The second factor, termed *scope of liability*, is also associated with four items: that liability should be limited when contamination is historic and present site owners do not bear direct responsibility (r = .79), that current site owners should not be held liable because the sources of historic contamination are often unclear (r = .71), that a fund should be established to assist private property owners to clean up sediment contamination (r = .70), and that the liability of DNR in particular should be limited with respect to contamination on public trust lands (r = .60). In essence, these results show that considerable disagreement exists across the two coalitions on important policy core items, namely the role consideration of risk should play in the broader policy context, and the prominence to be accorded to liability as a potential "hammer" driving regulatory aspects of the management regime.

The areas of disagreement identified reflect broader societal debates now taking place in the environmental policy arena, concerning risk vs. precaution (Bodansky, 1991) and the use to be made of strict liability as an incentive to promote cleanup and to curtail additional production of hazardous wastes (Hird, 1993). While advantages are seen in framing cleanup decisions in the metric of risk, there appears to be considerable disagreement still about the extent to which risk per se should drive decisions. Scientific and technical debate over how best to quantify and utilize risk information has not supplanted political and economic debate about the degree to which risk should drive decisions and liability should also be used as a policy tool.

Perhaps indicative of the power these unresolved questions have to rekindle debate over the reach of sediment management policy, Ecology abruptly suspended in late 1999 a new rule-making process it had embarked upon two years earlier to amend the 1991 sediment management standards. The original purpose was to include, among other things, more comprehensive consideration of human health risks in site evaluations. In suspending its rule making, the agency acknowledged that its earlier issuance of draft rule revisions for public review had raised a host of policy concerns on multiple sides of the contaminated sediment management standards debate (Fitzsimmons, 1999).

Summary and Conclusions

The rapidly increasing use of risk and hazard assessment in support of environmental management decisions where there is a high level of public involvement raises a number of questions about effects on decision process and the quality of decision outcomes. While risk assessment can promote efficiency by avoiding both under- and overprotection from risk (Ruckelshaus, 1983), it may also serve to highlight the value content of scientific judgments (Clark & Majone, 1985; Weinberg, 1977) or the differences between risk assessment as a technical enterprise and the cultural, social, and institutional dimensions of risk (Nelkin, 1988; Freudenberg, 1988; Jasanoff, 1993).

ACF is well suited to addressing these and other issues that attend the use of risk assessment in environmental policy making. These include the virtues and practical difficulties of separating the subjective scientific inferences that go into the development of risk assessments from the broader social values that are supposed to inform risk management decisions (NRC, 1983) and the extent to which early stakeholder involvement in the development of risk assessments succeeds in producing agreement about the most urgent risks to address (NRC, 1994a, 1994b; Commission on Risk Assessment and Risk Management, 1996). The latter looms particularly important when there is substantial disagreement among stakeholders over basic policy preferences and with respect to their fundamental normative orientations (Sabatier & Jenkins-Smith, 1993).

The development of management and cleanup standards for contaminated sediments in Washington State's Puget Sound proved to be a useful arena in which to examine these questions. The management regime that was developed through state rule making in 1991 came out of a more than decade-long history of concern for the presence of contaminated sediments in Puget Sound and involved many of the same actors who had initiated efforts to deal with the problem in the late 1970s. That well-developed and differentiated "deep core" beliefs exist for this problem is apparent in the survey results. Policy preferences also differ in ways that demonstrate a well-developed advocacy coalition structure. As with the federal Superfund program, concern for liability is a major motivation for the economic development coalition to stay involved as the management regime is further developed and implemented. Interestingly, representatives of public agencies with statutorily defined liability for contamination they generate or on lands they hold in trust also aligned with economic development interests in the survey we conducted.

Ecology's approach to developing the standards utilized a model of open participation that produced sustained involvement by a wide range of interests, including most of our survey participants. The management regime was implemented in a way that made it highly dependent on technical assessment, and Ecology's approach was to develop technical assessment procedures for identifying and rating levels of contamination in parallel with development of the management standards that would utilize these procedures. The necessary technical assessment methods either were adapted from existing procedures, developed originally to address other Puget Sound sediment contamination problems, or developed to complement assessment procedures or data sets already in use.

Our survey shows that while the "decision logic" embodied in Ecology's site-ranking model SEDRANK is not totally agreed upon by respondents, at least with regard to the relative importance to attach to the risk factors SEDRANK considers, the pattern of disagreement is largely decoupled from the broader differences in beliefs and values that define the basic coalition structure and the policy positions each coalition brings into the policy arena. Ecology's attempt to separate the scientific and technical judgments that are used to screen contaminated sites from the social, economic, and political considerations that are ultimately to determine the application of cleanup requirements to specific sites appears to have been at least partially successful. The debate over one important facet of sediment management decision making, site screening, has shifted from the realm of unbounded dispute into a realm where collegial judgment in a forum dominated by scientific norms can prevail. Lee (1993) notes that such shifting in the framing of problem resolution strategies can prove instrumental to effective environmental problem solving. How much influence such decision outcomes will have in the broader scheme of things remains to be seen.

Risk assessment is a potentially powerful tool that can help reframe questions of risky choice in new ways. It can, as we have seen in the present study, lead to broad agreement on ways in which scientific beliefs and values will be brought to bear on environmental problems, in concert with agreement about the locus wherein the non-scientific social and economic aspects of the decision process will lie. Continued debates over application of the standards to specific sites within Puget Sound are highly likely, and they could ultimately result in a bogging down of the decision-making process that has thus far been avoided. The real stability of the consensus achieved to date over how risks should be defined is already being tested, as the suspension of the rule revision process in 1999 illustrates, and may not be as strong now as it was when our survey was conducted in 1994.

A possibly greater test of the resilience of these agreements and procedures may now be gathering steam, as the Puget Sound region considers policies for locating disposal sites for highly contaminated dredged materials, a question which has been deferred for many years. Issues of liability for contamination and the potential costs to the region's port-related economy of failing to permit disposal of highly contaminated sediments will likely have to be confronted more directly than in the past if a proposed system of MUDS sites (multi-user disposal sites) is to become a reality. Parenthetical to these results, ACF appears to offer a robust approach for examining the impact of technical assessment on policy disputes in arenas in which scientific and technical issues have the potential to gray into broader questions of human values and preferences.

Notes

1. An AET is the sediment concentration of a contaminant above which statistically significant biological effects would always be expected. AET values are empirically derived from paired field samples for sediment chemistry and a range of biological effects indicators, including amphipod mortality and depression in the abundances of several groups of benthic infauna. See Lind (1994) for details.

2. Here and elsewhere, the scales developed from survey responses generally utilized those items for which $r > 0.60$. Variables with lower factor loadings are reported in the text to provide more complete information on the range of variables associated with each factor. Where such variables are included in the scales, note is made in the text.

3. Individuals were assigned to either the pro-environment or the pro-development coalition on the basis of group membership. Individual scores were averaged across all items with $r > 0.60$ for each scale. Differences between means for the two groups on each scale were then tested via a two-tailed t (Zar, 1996). All differences are significant at the 0.01 level.

4. Examination of the factor scree plot suggests that the first two factors alone comprise a sufficient model for these responses (Norusis, 1994). The three-factor model is described in the text because it produces communalities > 0.50 for each of the eight independent variables. The two-factor model explains 56% of the total variance.

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