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Judith Spiller and *Alison Rieser*

SCIENTIFIC FACT AND VALUE IN U.S. OCEAN DUMPING POLICY

A fundamental controversy exists among scientists about the ocean's abilities to neutralize and absorb wastes. Resolution of this controversy will determine the direction of future ocean disposal policy. While this dispute seems to revolve entirely around science, it has at its core a dispute over values--that is, to what use should society put the ocean. Failure to recognize that these values affect the science underlying policy will continue to impede policy in this area.

This essay examines how the merging of science and value by experts has influenced United States policy on ocean dumping. It begins by describing the relation between fact and value in science and public policy. It next reviews the development of U.S. ocean dumping policy over the past ten years. It then analyzes the roots of the confusion over fact and value in the science underlying ocean dumping policy by documenting how experts' values have played a dominant but unacknowledged role in shaping this policy. In conclusion, it proposes a mechanism that could clarify the role of values in scientific assessments.

SCIENTISTS' VALUES AND SCIENTIFIC FACT

Personal values often shape scientists' conclusions. This influence is particularly important in controversial areas of public policy. Many scientists, like other members of the public, hold personal views about uses of society's resources (Gilpin, 1962; Mazur, 1973). Valuing one use of the ocean over another is one among many examples.

Members of the public present their views and values in public hearings and through their government representatives. Scientists primarily express their values in their interpretation of science. Thus, scientists' values are not open to public scrutiny.

Value conflicts in science may be detected though. When scientists, arguing from the same scientific information, reach opposing conclusions, they are influenced by nonscientific factors (Culver & Gert, 1982; McGarity, 1979). The basis for these differing conclusions often lies in conflicting values rather than conflicting science.

Scientific concepts often reflect this mixture of fact and value. Ecosystem degradation and health, for example, are concepts central to the debate over ocean waste disposal. They appear to be matters of science, yet they are elusive terms in ecology. When closely examined, they reflect values about how the world is organized and how its resources should be used as much as they describe purely scientific phenomena. Thus, in assessing an ecosystem's condition, scientists inevitably weight their evaluations according to their personal values.

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Several reasons dictate that scientists acting as experts in policy areas publicly acknowledge their value-based biases. First, science plays an influential role in most areas of public policy (Schmandt, 1984). Further, scientists occupy a special role in our society, and their evaluations strongly influence public policy disputes (Sabatier, 1978). Finally, the unacknowledged interweaving of science and values contributes to the confusion over what is fact and what is preference, a problem that plagues many science-based policy disputes (Longino, 1983; Lowrance, 1976; Mc-Garity, 1979).

Acknowledging that values influence scientific evaluations is difficult because scientists seldom make these factors explicit (Lowrance, 1976). The contextual influence of social, economic, political and other normative forces on science has been documented by philosophers, historians, and sociologists of science (Gilbert & Mulkay, 1984; Kuhn, 1970; Longino, 1983; Mazur, 1973).

Few scientists, however, recognize the degree to which the world in which they live influences their choice of research area, method, and presentation of findings. Thus, many scientists believe the scientific method gives their research objectivity and that that objectivity extends to their judgments on public policy issues.

The expectations society places on science reinforce the view of science as a wholly objective activity (Nelkin, 1975). Legislators and regulators often prefer to cast questions of societal choice in scientific terms, moving discussions to what is perceived as neutral ground (Bazelon, 1979; Sabatier, 1978). Thus, many argue for techniques like risk assessment that separate scientific assessments from evaluations of social preference (National Academy of Science, 1983; Ruckelshaus, 1985). Entanglements of fact and value in science, though, place these techniques in doubt. The science adopted as the basis for decisionmaking for ocean dumping illustrates this problem.

SCIENCE AND THE MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

Concern in the United States over the effects of wastes intentionally transported to sea for disposal culminated in 1972 with passage of the Marine Protection, Research, and Sanctuaries Act (33 U.S.C. 1401-1445). Title I of this statute, known as the Ocean Dumping Act, disallows ocean dumping which would "unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities(.)" [Sec. 102(a) 33 U.S.C. 1412(a)]. Scientific assessments are central to making the judgment as to whether a proposed waste will "unreasonably degrade," and Congress provided the responsible agency, the U.S. Environmental Protection Agency (EPA), with nine statutory criteria to guide it in this judgment.

A central criterion was Congress' requirement that potential changes in ecosystem diversity, stability, and productivity be evaluated. In choosing to incorporate these concepts in the Ocean Dumping Act, Congress was clearly influenced by scientific expertise. Yet the meaning of these apparently scientific concepts is heavily tinged with value. That value content has undermined these concepts' utility as the EPA has attempted to implement the Ocean Dumping Act over the past ten years. The Agency's struggle to specify scientific criteria that will withstand adjudication and yet protect the environment is reflected in influential reports (NACOA, 1981; NRC, 1984) on this problem.

Diversity, Stability, and Productivity

By adopting ideas about stability, diversity, and productivity, the Ocean Dumping Act incorporated thinking that was prominent in ecological science in the 1980s (for a review, see Woodwell & Smith, 1969). Diversity and stability were considered to exemplify healthy communities. Diversity, the measure of species number present in a given area, seemed to hold promise as providing a straightforward tool for measuring ecosystem change. Decreases in diversity would indicate something harmful happening in a community. Stability and productivity, thought to be positively correlated with diversity, were also considered indications of ecosystem health.

High diversity communities, it was theorized, were characterized by many species bound together by multiple interactions. The more species, the more interactions resulted. These interactions maintained species numbers through time and created a stable community. Further, they resulted in a more efficient transfer of energy throughout the entire system and, hence, higher productivity. Removal of a few species, though, would lower diversity, perturb species interactions, and in the long term, reduce stability, possibly leading to community collapse. Ecosystems like coral reefs and rain forests that exhibited high numbers of species, many biological interactions, and apparent temporal persistence seemed to provide evidence of these relationships.

Ideas about diversity and stability had also gained momentum with the discovery in the 1960s of a diverse fauna in the deep ocean, previously thought to be a barren environment (Sanders, 1969). Some ecologists argued that the constancy of this habitat over long time periods had provided the perfect environment for the evolution of diverse communities with numerous biotic interactions. These ideas also gained a following among many ecologists who sought to elevate their science by defining more theoretical underpinnings. Nature's vagaries have always limited ecologist's predictive abilities. A science structured around laws would strengthen those abilities. But theory in science proves transient as it gives way under repeated testing.

Through this testing process, fundamental problems emerged regarding the stability-diversity-productivity relationship. Agreement on the meaning of diversity measurements proved elusive (Hurlbert, 1971). Mathematical representations failed to be robust, and observational data did not confirm the relationship between diversity and stability (Goodman, 1975). Finally, research on pollutant effects demonstrated that community rebound depended on individual species, detoxification potentials, and the nature of the pollutant exposure rather than on the number of species present in the community (for reviews, see Brown et al., 1982; Bryan, 1980; Jenkins et al., 1982; Sanders et al., 1980).

At the same time that ecologists were documenting flaws in their thinking about diversity and stability, legislators were incorporating these concepts into law to protect the ocean (U.S. Senate, 1972). None of the lengthy congressional testimony on the Ocean Dumping Act suggests that these ideas had limited utility in protecting the ocean. Rather, they were presented without debate as properties in need of protection. Congress, by adopting them, believed it was supplying the EPA with properties that could be used to achieve that protection. The EPA, however, was left with scientific criteria for which no credible scientific tools existed to use in their implementation.

The persistence of ideas about diversity and stability stemmed as much from the values they embodied as from the scientific rigor they possessed.

Ecosystems with many species are inherently more appealing, at least superficially, than are more monospecific ones. The former possess the richness many would like to see persist through time and to which some ascribe a dense web of relationships that under natural conditions are seen as assuring their perpetuation. Advocates of this view saw these ecosystems as particularly vulnerable to human actions. Finally, the diversity-stability relationship presented a simple way of looking at the world and the effects of humans on it.

Scientists' Pronouncements as Instrumentalities

The scientists consulted in drafting the Ocean Dumping Act were probably aware of the diversity-stability relationship's crumbling foundations and the difficulties the EPA would encounter in trying to translate these terms into regulation. If they were, then they were also apparently willing to perpetuate the belief that diversity and stability were ecosystem properties that revealed ecosystem health and should and could be protected.

This willingness to compromise scientific integrity in the pursuit of what might otherwise be a good goal is not unique to ocean dumping questions. Sagoff (1985) provides several examples of this propensity. Ecologists continue to argue in public policy forums that salt marshes provide the major source of nutrients for coastal ecosystems and the principal spawning grounds for important commercial fisheries; that tropical forests are a critical source of the earth's oxygen; that organochlorine pesticides are biomagnified through food webs; and that survival of endangered species affects survival of society. In each case, scientists argue for preferential treatment and protection. Yet, their research indicates that the evidence to support these positions is arguable at best.

Compromising one's arguments and using them as an instrumentality to achieve a goal perceived as good for other reasons is not unusual in argumentation. Its use by experts in areas of public welfare, however, creates special problems. Because scientists hold a position of unique trust in society, they are expected to act as objective evaluators, informing policy decisions and in some cases making policy judgments based on their scientific knowledge (Lowrance, 1976; Nelkin, 1975; Weinberg, 1972). But the Ocean Dumping Act's criteria suggest that scientists' values rather than scientific principle influenced the policy process. What then were these values and to what degree can they be expected to affect the current debate over U.S. ocean dumping policy?

Scientists' Values and World View

Analysis of the testimony and the legislative history of the Ocean Dumping Act and in related materials suggests that scientists approached the ocean disposal questions from one of two competing viewpoints. On the one hand, there were those who argued that the ocean is the ultimate repository for the minerals and nutrients that naturally wash off the earth's surface. They argued that with few exceptions the ocean has, through geologic time, absorbed all the wastes that humans now want to prohibit from the ocean. Those exceptions (e.g., anthropogenic compounds like polychlorinated biphenyls (PCBs)) should be strictly controlled, although in some cases ocean processes may also exist to detoxify them.

This view is of a hardy, robust ocean able to rebound within reason from most of the abuses we might impose on it. One scientist holding this view even suggested that the oceans need all the wastes we can feed them

(Isaacs, 1978). Further, proponents of this view also tend to be technological optimists, seeing human ingenuity as capable of monitoring the ocean's health (Goldberg, 1981; Smith, 1970).

The opposing view suggested that ocean communities were maintained by subtle relationships, the result of eons of evolution (Sanders, 1970). Overloading these communities with wastes, regardless of whether they were nutrients or anthropogenic compounds never before encountered, would change the communities' biotic relations. Without knowledge and understanding of that change, experts with this view argue that wastes should only be released into the ocean under the most restricted circumstances.

These views relate to a larger sense of how the world is organized. Scientists arguing for the vigorous exploitation of the ocean's waste processing capabilities suggest that a combination of human intelligence and ocean hardiness will redress any deviations from normal conditions. In fact, they argue that the ocean is highly variable and that variability contributes to its hardiness (Spencer, 1981). Those advocating the conservative course also see the ocean as variable but look at that property from a different perspective, arguing that it limits predictive capabilities (Woodwell, 1983). Further, the vastness and inaccessibility of the ocean make it difficult to monitor human effects on them (Sanders, 1970). Finally, the nature of the critical pollutants involved results in effects often not seen until many years after exposure (Rowe, 1982). This property results in changes only detectable after it is too late to correct them.

Crudely, these groups may be divided into the ocean users and the more conservative ocean preservationists. Two scientists who testified before the Senate when the original Ocean Dumping Act was being drafted represent these positions. One was Dr. David D. Smith, a geologist and engineer and the co-author of a study (Smith & Brown, 1970) that was the basis of the 1970 Congress on Environmental Quality's influential report (CEQ, 1970) on the status of the ocean. Holding the view of the ocean user, he argued that most wastes, if properly disposed of, were harmless to the ocean since they are the same as the rocks and organic matter carried into the ocean by erosion. He also raised the issue of the ocean as a more efficient assimilator of these wastes than the land. Finally, he pointed to coastal ecosystems which receive large contributions of wastes from many sources and argued that their apparent health was as an indication of the oceans' durability (Smith, 1970).

Representing the other point of view was Dr. Howard L. Sanders, a marine biologist from the Woods Hole Oceanographic Institution and one of the first scientists to discover the abundance of marine organisms in the deep ocean. Sanders, in his testimony presented at a hearing on the ocean disposal of nerve gas, depicted marine ecosystems as fragile, interrelated entities whose complexity and diversity held the key to their existence (Sanders, 1970). The long time period involved in fine-tuning these communities meant that removing a few elements could result in a collapse difficult to overcome. He saw proposals to dump wastes in deep ocean waters as "simplistic solutions that reflected our ignorance(.)" (Sanders, 1970, p. 24).

Scientists' Values and Current U.S. Ocean Dumping Policy

The basis of these arguments is strikingly similar to those now being advanced by scientists in Congress' current reexamination of the Ocean Dumping Act. Some influential marine scientists now suggest that ocean disposal decisions be premised on the ocean's ability to absorb and neutralize specific wastes on its assimilative capacity. Its proponents argue that this approach, first applied at the Crystal Mountain symposium (Goldberg, 1979) sponsored by the National Oceanic and Atmospheric Administration, provides a theoretical method to calculate the amount of waste that an ecosystem can absorb without unacceptable biological effects.

As set forth by the organizer of the Crystal Mountain meeting, Dr. Edward Goldberg, a marine geochemist from Scripps Institute of Oceanography, the technique could be applied to ocean disposal by identifying checkpoints that would indicate ecosystem response to pollutants and provide an early warning before detrimental endpoints were reached (Goldberg, 1979). As an example, Crystal Mountain participants estimated the assimilative capacity of the New York Bight, until recently a major ocean dumping site, for PCBs. Goldberg, in his summary of the meeting, concluded that these calculations indicated that the Bight could absorb more PCBs than were accumulating at that time in the Bight. While not all symposium participants shared Goldberg's enthusiasm for this approach's potential, his view remains the one reflected in the congressional hearing record (for example, see U.S. House of Representatives, 1981, 1982, 1983) and plays a prominent role in the policy debate over ocean dumping.

Dr. Goldberg's conclusions reflect his view that the ocean is able to assimilate larger amounts of wastes than society is currently releasing into them. Two factors are at the heart of his conclusions. First, his thinking is obviously influenced by his impressive body of research on the geochemical behavior of metals and synthetic organic compounds in the marine environment. Second, he believes that humans are more vulnerable to groundwater contaminated by toxicants than they are to wastes in the ocean (Goldberg, 1981, 1983). Thus, Goldberg stresses his pro-ocean arguments with an anti-land disposal bias.

Unclear in his arguments is the influence his beliefs about the value of protecting groundwater resources have on his presentation of fact concerning the ocean's geochemical processing of wastes. Goldberg is not alone among marine scientists in advancing the land protection view. Congressional hearings on this topic contain the testimony (U.S. House of Representatives, 1981, 1982, 1983) of other prominent supporters of this view.

A recent meeting on land versus ocean waste disposal sponsored by the National Academy of Science's National Research Council (1984) and co-chaired by Goldberg presented the same line of argument. The National Advisory Committee on the Oceans and Atmosphere released a report (NACOA, 1981) supporting the assimilative capacity approach. Despite NACOA's recommendations, the scientific analysis accompanying that report suggests that determining assimilative capacities may not be as simple as its advocates suggest.

Predictably, advocacy of the assimilative capacity approach has catalyzed opposition. The countering scientists, though, are no more immune from mixing of fact with their values than are the proponents. This mixture can be seen in testimony by Dr. George Woodwell (1983), a leading ecologist responsible for much of the basic research that led to banning DDT. Woodwell, testifying before Congress on ocean pollution programs, argued strenuously against the assimilative capacity approach. He stated that existing techniques were inadequate to detect the small changes that with time radically alter ecosystems. Further, he found a fundamental flaw in the reasoning of those who maintain the ocean is a preferable disposal site because its links to humans are less direct than are those on land. Rather, that link would not be an issue, he testified, if efforts were directed against producing the wastes altogether. Finally, Woodwell concluded that our knowledge of marine ecosystems remains highly uncertain, and therefore, extreme caution should be practiced in decisions about ocean use.

The absence of debate among scientists over the adequacy of science to implement the assimilative capacity approach suggests the potent role that their values play in it. If the debate over assimilative capacity's efficacy revolved principally around science, then its focus would be on evaluating whether that science has the predictive capability "to identify and be able to quantify, the biological consequences of all those physical and chemical factors that disperse, detoxify or sequenter toxic effluents (.)" (Stebbins, 1981, p. 362). Scientists' testimony (Capuzzo, 1981; Goldberg, 1983; Spencer, 1981; Woodwell, 1983), technical reports (Goldberg, 1979; NACOA, 1981; NRC, 1984) and popular writing (Adler, 1981; Goldberg, 1981) devote little attention to this aspect, focusing instead on the suitability of land for disposal activities.

CONCLUSION: RECONCILING SCIENTISTS' BELIEFS IN POLICY

A new scientific concept to guide decisions concerning ocean disposal of wastes has emerged from recent debate in Congress over the Ocean Dumping Act's goals. Some scientists have offered it as a method that can both accommodate waste disposal and protect the ocean (Goldberg, 1981). At its core, though, this concept is as driven by scientists' values as were the ideas about diversity, stability and productivity. Unless the value content of the assimilative capacity is recognized, any policy based upon it will be as bitterly contested as has past ocean dumping policy.

Assimilative capacity, like the ideas about diversity-stability-productivity, is an appealing and simplistic approach to making decisions about waste disposal. Obviously, ecosystems assimilate and detoxify some things and not others. Understanding these processes of discrimination would solve many waste problems. Debate among ocean scientists and ecologists most usefully should focus on the science necessary to reach this goal. Thus, assimilative capacity could play its most effective role as a heuristic, guiding research rather than making policy. Yet the opponents of assimilative capacity's use as a regulatory tool have been ineffective in making that point. Their failure results in part because they continue to guide their arguments based on science filtered through their values.

Fundamental differences exist in the values underlying scientists' thinking about the ocean's capacity to assimilate various wastes. Nonetheless, in this instance as with others, scientists' participation is essential to sound policymaking. How, then, are legislators, regulators, and the public to reconcile experts' conflicting opinions and distinguish the factual from the value components?

Scientists, themselves, must first develop an awareness of the contextual influences on their scientific thinking. Much of scientific training selects against entertaining "nonobjective" influences in their work. Yet the essence of the scientific method, though, is identifying and refuting the multiple hypotheses that may account for a given phenomenon. That method seems to give scientific thinking the opportunity to bring these influences to bear, once their potential for influence is recognized.

But if scientists do make the nonscientific factors behind their reasoning clear, then legislators, regulators, and the public are still left with determining which science best supports or guides decisions to reach society's goals. Risk assessment has been advanced as one approach to achieving this end (NAS, 1983). Its proponents argue that by separating measurement of risk from management or the actual decisionmaking, social objectives may be distinguished from issues of scientific fact (Ruckelshaus, 1985). If, however, scientists' values remain hidden, they will flaw the assessment process. If they are made explicit, then these values and the scientific evidence both may be evaluated in the context of what effects an activity will have on society.

The interplay of scientific fact and value in policy raises a larger issue: What are the values society seeks to elevate? Legislation is a compromise of competing values (Jasanoff & Nelkin, 1981). The protectionist and the user aspects of the Ocean Dumping Act reflect that dynamic. Social objectives change with time and perhaps the Act has the flexibility to withstand those changes without inordinate harm to society or the environment. Careful explication of the factors behind expert reasoning can only improve the information that goes into legislation and so contribute to the determinations that ensure the welfare of society.

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