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# Distributed costs of environmental contamination

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ABSTRACT

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Improper disposal of toxic contaminants costs society far more than just cleanup costs. Agency expenses, costs of research and litigation, and resource damages represent additional costs of pollution. These costs are generally borne by the public rather than by the polluter, and are therefore termed 'distributed'. Two cases of PCB contamination in aquatic systems were analyzed from a distributed-costs perspective: New Bedford Harbor, MA, and the Hudson River, NY. For the cases analyzed, the major distributed cost was the loss of past and future fishery revenues. For the cases analyzed, distributed costs made up from about 40% to 99% of total costs.

## INTRODUCTION

Toxic chemicals are products or by-products of many industrial processes. When disposed of improperly, the toxicant's presence is usually discovered either through routine monitoring or an onset of unusual morbidity or mortality. After the discovery, a number of events customarily follow (although not necessarily in the following order):
- the toxicant is identified or characterized;
- the spatial coverage and concentration of the toxicant is determined;
- the source of the toxicant is identified;
- the source is regulated or mitigated;

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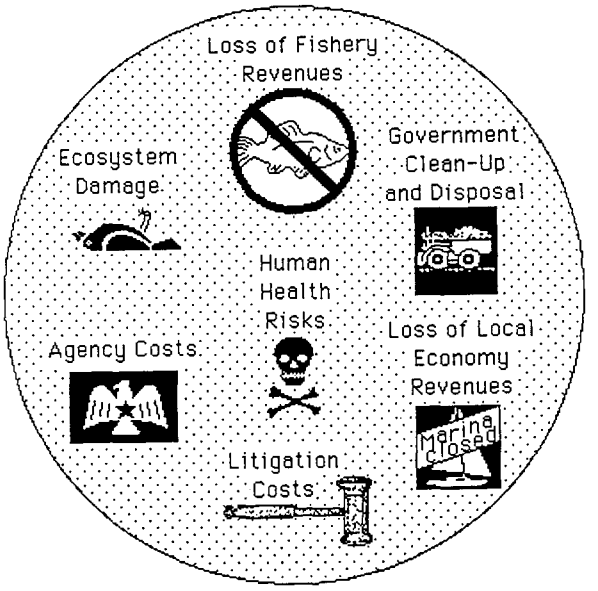


Fig. 1. Examples of the types of distributed costs that are often caused by pollution.

- penalties are imposed, if appropriate;
- in certain instances a cleanup is begun;
- revenues to ecosystem-based economies decline;
- research is conducted to predict the environmental fate and behavior of the toxicant;
- litigation against the originator of the pollutant proceeds in an attempt to recover damages.

There are numerous costs associated with each of these events (Fig. 1). Some are paid for by the originator of the pollution problem, but many are paid for by government agencies and ultimately by the taxpayer. Long-term damages to ecosystem-based economies (e.g. fishing and tourism) also represent costs in the sense of foregone revenues. What, then, are the total costs of pollution episodes? What portion of the total costs is used for cleanup and what portion is used for other expenses? How much of the total bill is paid by the polluter and how much is paid by the public at large? We sought to address these and related questions through the analyses described below.

Distributed costs are a subset of the total cost of pollution episodes. Those pollution-related costs borne by the public, rather than by the polluter, are distributed costs. These costs are incurred either through loss of potential revenues or through taxation. For instance, distributed costs include uncompensated loss of revenues resulting from damages to sport or

commercial fisheries, and loss of revenues from decreased tourism and property values. Increased tax burdens are incurred to cover additional water treatment costs, public agency regulation and litigation costs, as well as special study and monitoring costs.

## DISTRIBUTED COSTS AND SOCIAL TRAPS

In a society of increasing technical skills and a heightened public awareness of environmental issues, why do pollution problems continue to plague us? Some scientists believe the answer is that pollution is an example of a social trap. Social traps are described (Platt, 1973; Cross and Guyer, 1980; Costanza, 1987) as behaviors encouraged by short-term incentives (bait) which lead to long-term problems for society. Social trap theory can be used to explain many types of short-sighted behavior that are destructive either to personal health or the environment. One such example is cigarette smoking, where the smoker opts for immediate pleasure at the known risk of developing cancer later. In an environmental context, the bait for polluters is the seemingly free waste disposal offered by the atmosphere or a large body of water. Analagous to the smoking example, however, the cost of pollution-damaged natural resources and contami-

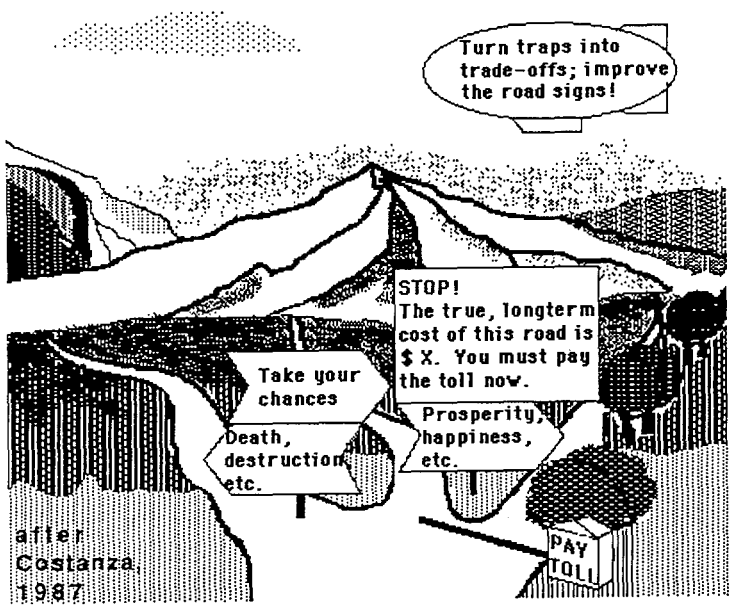


Fig. 2. Costanza's (1987) proposed approach to avoiding social traps: turn the trap into a tradeoff by imposing a toll based on the true social cost of the activity. Without the STOP sign, the road sign shows the way to short-term prosperity.

nant-associated health risks may be much greater in the long run than the cost of proper waste disposal.

Social traps cause problems to be passed to future generations by encouraging short-sighted behavior. To prevent this from occurring, the long-term costs and consequences of mis-managed toxic wastes must be understood in the present. Current U.S. approaches to avoiding social traps are education and regulation (Costanza, 1987). Education is not effective, since individuals generally take the short-term view. Regulation requires costly enforcement and monitoring. Costanza (1987) suggests that a more effective approach would be to turn the trap into a trade-off by imposing a toll (Fig. 2). Instead of warning people not to smoke or forbidding it, smokers would be required to pay taxes that are commensurate with the burden they will place on society if and when they develop pulmonary problems. Similarly, polluting industries would be charged a fee per unit of waste produced so that, in theory, potential cleanups can be provided for without distributing the cost among future generations of taxpayers. The appealing aspect of this approach is that it provides an incentive to change behavior – to produce less waste – because the waste producer is confronted with the possible long-term financial consequences of his actions. In addition, those consumers who utilize the industry's product will learn that there is an environmental cost of manufacturing that product, since any taxes will probably be passed on to them. In order to impose a toll, or in Costanza's terms, "... improve the road signs ...," estimates must be made of the distributed costs that result from environmental contamination. Toward that end, an attempt was made to tally the distributed (and total) costs of two significant industrial pollution episodes: PCB contamination of New Bedford Harbor, Massachusetts and the Hudson River, New York.

## NEW BEDFORD HARBOR, MA

New Bedford Harbor in southeastern Massachusetts is the largest revenue-producing fishing port on the eastern seaboard (Fig. 3). New Bedford ranked fifth among the nation's large ports in value of catch: $71 million in 1980 (Mayer et al., 1982). PCB contamination of the 1000-acre ($\approx$ 400 ha) harbor was first documented in 1976 by the U.S. Environmental Protection Agency (EPA) during a PCB survey of New England. Unusually high PCB levels have been documented in New Bedford Harbor air, waters, soil, aquatic organisms, and humans. Two capacitor manufacturing plants have been major contributors of PCBs to the harbor area by direct discharge, improper landfilling, and release to the New Bedford sewage treatment plant for at least 40 years (Weaver, 1984). Current owners of the manufac-

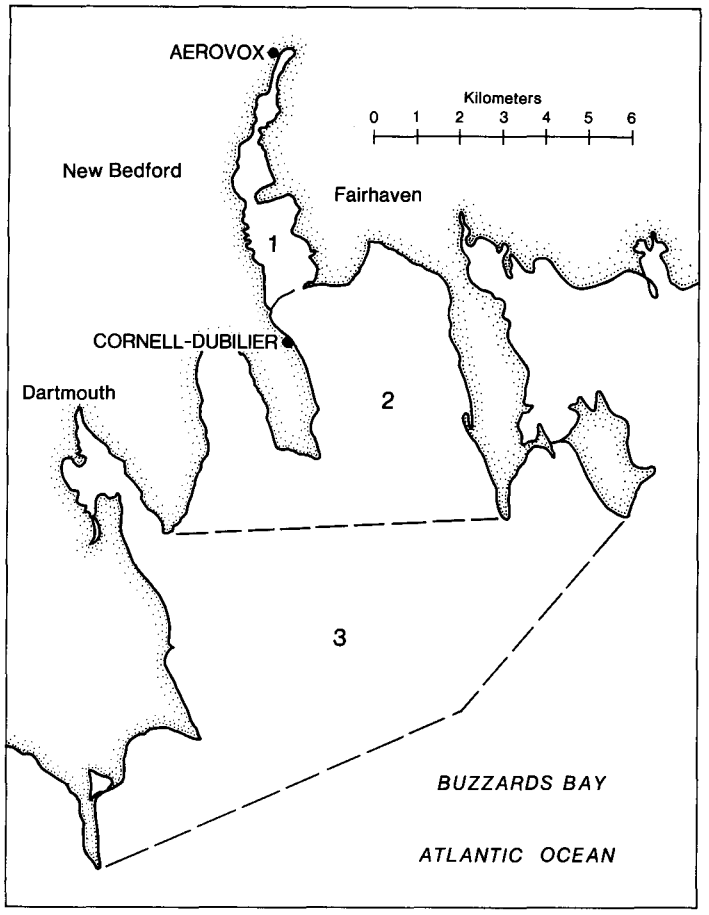


Fig. 3. New Bedford Harbor, Massachusetts area. Area 1, the inner harbor, is closed to all fishing activities. Area 2 is closed to the taking of lobsters, eels, flounder, scup, and tautog. Area 3 is closed to lobstering.

turing plants, Aerovox, Inc. and Cornell-Dubilier Electronics Corp., along with three previous owners, are charged in a federal pollution suit.

Area fisheries were closed in 1979, following consumption warnings that had been issued since 1977. New Bedford Harbor itself (Fig. 3, Area 1) was closed to the taking of all finfish, shellfish, and lobsters. The nearshore areas of Buzzards' Bay (Fig. 3, Area 2) were closed for lobster and bottom-feeding finfish. The outer portions of Buzzards' Bay (Fig. 3, Area 3) were closed only for lobstering. The closing of 18 square miles ($\approx 47$ $km^2$) of prized lobstering grounds had a profound emotional and economic impact on local communities.

TABLE 1

New Bedford Harbor, MA: Summary of costs (millions of 1985 dollars)

| Agency cost | Cost (year) | 1985 $ | |
|---|---|---|---|
| EPA pilot cleanup project | 5.00 (1989) | 5.30 | |
| EPA (90%), MA (10%) Phase I cleanup | 14.40 (1989) | 15.20 | |
| EPA Phase II cleanup | NA | NA | |
| EPA admin. & studies | 12–15 (1988) | 12.7–15.8 | |
| MA DEQE admin. | 0.09 (1988) | 0.10 | |
| Litigation (EPA, DOI, MA) | NA | NA | |
| NOAA Sea Grant research | 0.65 (1988) | 0.69 | |
| NOAA damage assessment preparation | 0.50 (1986) | 0.51 | |
| | Subtotal | $34.5–37.6 | |
| **Resource damages** | **Period covered** | **Present value, past and future losses (1985 $)** | |
| Lobster fishery | 1979–2085 | 2.1 | (McConnell and Morrison, 1986) |
| Beach use | 1979–2085 | 8.3–11.4 | (McConnell, 1986) |
| Sport fishing | 1979–2085 | 3.1 | (McConnell, 1986) |
| Amenity value | 1980–1985 | 26.2–39.0 | (Mendelsohn, 1986) |
| | Subtotal | $39.7–55.6 | |
| **Industry** | **Cost (year)** | **1985 $** | |
| Settlement with AVX, Inc | 66.0 | 57.3 | |
| | Subtotal | 57.3 | |
| GRAND TOTAL | | $131.5–150.5 | |

In December 1983, the U.S. Department of Justice filed suit under Section 107 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA, or the 'Superfund' Act) on behalf of the National Oceanic and Atmospheric Administration (NOAA) as resource trustee for damages to New Bedford Harbor. This suit, *U.S. vs. AVX, Inc., et al.,* was joined by the EPA and the Commonwealth of Massachusetts. The suit seeks compensation for damage to the New Bedford area resources caused by PCBs, and for recovery of Superfund remediation costs from the five current and past owners of the facilities.

### *Cost summary*

Resource damages were calculated for both past (1979–1986) and future (1986–2086) losses (Table 1). A 100-year future was selected by economists preparing the damage assessment case based on the proven persistence of PCBs in the environment, and the expectation that cleanup would never be attempted. Lobster fishery damages were based primarily on increased costs and risks to the 49 fishermen who had to move to more distant lobstering grounds. Sport fishery losses were also based on increased travel cost. Amenity value was measured using a repeat sale property value methodology to evaluate the effect on nearby property owners of the polluted harbor.

Industry costs are still being determined by the courts. One of the five defendants, AVX Corporation, recently agreed to pay $66 million ($57.3 million in 1985 $) to the U.S. government. That amount could increase if the total cleanup of the harbor exceeds $130.5 million. An undisclosed settlement has been reached with two other defendants while a trial date of March 1991 has been set for the government's claims against the two remaining defendants.

Since New Bedford Harbor is a Superfund site, and cost recovery mechanisms under Superfund are rather inclusive, all of the costs detailed here will be assigned to the responsible parties, assuming that they are solvent. Money recovered from responsible parties will be used for cleanup, restoring injured natural resources, and reiumbursing agencies for funds already spent. Those who live in the harbor area and have suffered damages in the form of property value declines, disrupted employment or loss of recreational opportunities will bear the brunt of the distributed costs. Even if the federal suit is successful and the money recovered is used to restore the value of New Bedford Harbor, it would seem that the home-owners and fishermen who were directly affected by the contamination will never be fully compensated.

HUDSON RIVER, NEW YORK

The Hudson River is one of the most heavily PCB-contaminated waterways in the U.S. (U.S. EPA, 1981). From 1950 to 1976, General Electric Corporation (GE) released approximately 227 000 kg of PCBs to the river from its capacitor manufacturing plants in Fort Edward and Hudson Falls (U.S. EPA, 1981). When the dam at Fort Edward (Fig. 4) was removed due to structural problems in 1973, significant quantities of contaminated materials trapped behind it were released downstream. The New York State Department of Environmental Conservation (NYDEC) has identified 40 'hot spots' in the upper Hudson where PCBs are at dangerously high levels (above 50 ppm). The upper Hudson 'hot spots' are a significant

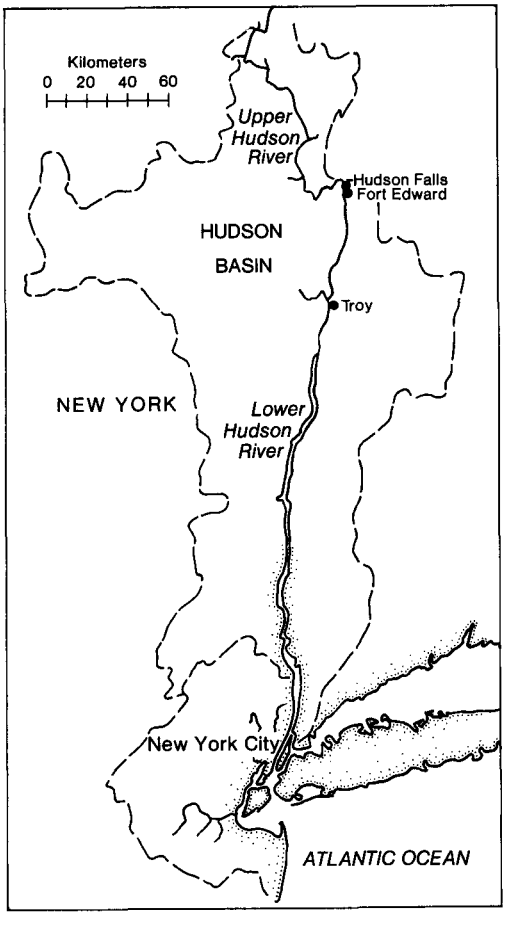


Fig. 4. Hudson River, New York drainage basin. PCB sources in Fort Edward and Hudson Falls have closed most fisheries for the entire river.

source of PCBs to the lower Hudson. Approximately 3200 kg of PCBs were washing over Troy Dam each year as of 1979. (Weaver, 1984). The final dredging plan was not complete until 1986 (U.S. EPA, 1987).

The Hudson River supported a huge commercial and sport fishery prior to 1976. An advisory was issued in February 1976, prohibiting fishing on the upper Hudson (Fort Edward to the Troy Dam). The commercial fishery for the entire river was closed except for a few species (Schupp, 1987). By 1986, the closures extended to striped bass in New York marine waters, thereby affecting millions of fishermen.

Because state permitting procedures were deemed partially responsible for the PCB problem, the New York State Department of Environmental Conservation (NYDEC) and General Electric shared the responsibility for mitigation. In 1976, the court ordered the two parties to establish a $7 million fund for research and further studies. GE was required to pay $4 million.

*Cost summary*

Using Schupp's (1987) annual fishery value estimates (Table 2), present values (in terms of 1987 $) of both past and future fishery losses were calculated with the same type of present value analysis used by New Bedford Harbor economists. A 3% interest rate was used in these calculations, as was the case for New Bedford. Past losses are based on different numbers of years depending on when each specific fishery was closed. Using standard economic techniques and data on usage of the Hudson by fishermen, past damage was estimated at $344.5 million.

Choice of time frame for the calculation of future losses is important. New Bedford economists chose a 100-year future, due to the persistence of PCBs and their belief that mitigation would not be forthcoming for a long time. The question of when PCB concentrations in Hudson River fish will decline to acceptable levels is a controversial one. According to a recent state study of PCBs in Hudson River striped bass, the PCB concentration will drop to 2 ppm no earlier than the year 2019 (Sloan et al., 1987). This estimate was based on the rate of decline observed between 1980 and 1986. Therefore, losses due to foregone future fishing opportunities were estimated (for a 31-year future, 1989–2019) to be $772 million.

In 1987 dollars, the state's investment in the problem is at least $24.5 million (not including the fine) and the federal government has contributed nearly $35 million (Table 2). These totals reflect cleanup, studies, and research costs only; they do not include expenses for administration, litigation, or other costs that were incurred, but were difficult to document. Adding the $65.3 million in documented costs incurred by federal and state

TABLE 2

Hudson River, NY: Summary of costs (millions of 1987 dollars)

| Agency costs | Cost (year) | 1987 $ | |
|---|---|---|---|
| NYDEC (fine) for research | 3.0 (1976) | 6.0 | |
| New York state cleanup | 6.7 (1980) | 9.2 | |
| New York state cleanup | 13.3 (1987) | 13.3 | |
| U.S. Treasury cleanup | 20.0 (1978) | 34.8 | |
| New York state fishermen assistance | 2.0 (1987) | 2.0 | |
| | Subtotal | $65.3 | |
| **Resource damages** | **Losses/year** | **Past losses (years)** | **Future losses (1989–2019)** |
| commercial fishery | 2.0 | 31.2 (1976–1988) | 40.0 |
| sport fishery, upper Hudson | 4.8 | 75.0 (1976–1988) | 96.0 |
| sport fishery, tidal | 19.8 | 201.2 (1980–1988) | 396.0 |
| marine Striped Bass | 12.0 | 37.1 (1986–1988) | 240.0 |
| | Subtotals | $344.5 | 772.0 |
| **Industry costs** | **Cost (year)** | **1987 $** | |
| GE fine | 4.0 (1976) | $ 8.0 | |
| | Subtotal | $ 8.0 | |
| GRAND TOTAL | | $1189.8 | |

TABLE 3

Comparison of theoretical disposal costs and actual costs of pollution episodes (in millions of dollars)

| Site | Theoretical disposal cost | Actual industry cost | Estimated total cost |
|---|---|---|---|
| New Bedford | \$0.14 | \$57.3 (1985 \$) | \$131.5–150.5 |
| Hudson River | \$0.08 | \$8.0 (1987 \$) | \$1,189.8 |

agencies, and the \$1.1 billion estimate of past and future fishery losses, the estimated distributed cost for this case is \$1.2 billion. Since the industry's documented cost was \$8 million (1987 \$), the ratio of distributed costs to responsible party costs is 150 to 1.

## THE COST OF DEFERRING COSTS

There are considerable costs to society associated with short-term approaches to managing pollution (Table 3). By multiplying estimates of the PCB loads to New Bedford and the Hudson River by recent, unit cost estimates for incineration of PCB-contaminated soils (\$300/ton; Ebasco, 1987), estimates were made of what disposal costs might have been had adequate, initial waste disposal procedures been followed. These are crude estimates that are based on a number of assumptions: (1) that the 1987 incineration cost figures are appropriate for situations that occurred in the 1970's and earlier; (2) that there would have been no additional disposal costs beyond incineration; (3) that incineration was the cheapest means of permanent disposal at the time; and (4) that the estimates of amount of PCB-contaminated waste disposed are accurate.

In each case, the total long-term cost of improper disposal of contaminants greatly exceeded the estimated cost of adequate, up-front waste disposal. This is a classic illustration of the social trap of distributed costs. Referring back to Costanza's social trap/road sign analogy (Fig. 2), if the industries had been faced with the true social cost of their activities (i.e., a toll) from the start, the distributed costs documented might have been avoided. Thus, a system of effluent taxes would, theoretically, prevent pollution and the distributed costs associated with it, by turning the 'trap' into a 'trade-off'. However, since U.S. environmental policy has a regulatory focus, we generally find ourselves in cleanup and cost-recovery modes.

billion (US) = $10^9$.
short ton = 2000 lb ≈ 90.7 kg.

## REGULATORY TOOLS FOR RECOVERY OF DISTRIBUTED COSTS

Natural resource trustees in the U.S. now have a potentially powerful regulatory tool that is designed specifically for recovering distributed costs from polluters: the Natural Resources Damage Assessment regulations, 43 Code of Federal Regulations, Part 11. These regulations can be used by state or federal resource protection agencies in case of an oil or chemical spill to assess the compensation for damaged resources owed by the polluter. The regulations were called for by the Clean Water Act of 1977 and by CERCLA, the Superfund Act, in 1980. They were promulgated by the Department of the Interior (DOI) in two parts: Type A (simple spills) in 1987 and Type B (complex situations) in 1986. An overview of the regulations and the economic principles behind valuing damages to natural resources can be found in Desvousges and Skahen (1986).

Under CERCLA, resource trustees are required to sue polluters for damaged resources. Resource trustees are designated state and federal agencies whose purpose is resource protection. They do not have to use the DOI regulations, but if they do, they have a legal advantage called 'rebuttable presumption'. This legal term means that when trustees can demonstrate that they carried out the damage assessment according to the DOI regulations, the resulting dollar amount (compensation owed) is presumed by the court to be correct.

The damage assessment process is virtually untested. Its lack of use can be attributed to some very serious drawbacks in the regulations themselves (Atkeson and Dower, 1987). A 'Type B' damage assessment requires much field data and is very expensive to carry out. In 1986, when CERCLA was reauthorized in the Superfund Ammendments and Reauthorization Act (SARA), a last-minute provision was included that prevents Superfund money from being used for conducting damage assessments or providing damage claims. Very few assessments have been done, because agencies simply cannot afford them. As a result, the government has attempted to recover natural resource damages at less than ten of the more than 1000 Superfund sites (U.S. Congress, 1989).

A month before the Valdez oil spill disaster, representatives from ten states and several environmental groups stated their objections to the DOI regulations in federal appeals court. The suit entitled *State of Ohio v. U.S. Department of Interior*, filed in 1986, charged Interior with failing to uphold the intent of CERCLA by limiting compensation for damaged resources to the lesser of market value or use value. In 1989, a panel of U.S. Court of Appeals judges ordered the Department of Interior to rewrite the damage assessment regulations. The ruling stated that costs must include more than

just "the monetary value of the animals killed." The decision stated (Lancaster, 1989):

> "The fatal flaw of Interior's approach ... is that it assumes that natural resources are ... goods, just like any other, and that the value to society generated by a particular resource can be accurately measured in every case ... Interior's response to its assigned task of promulgating regulations for assessing natural resource damages was, to put it charitably, relaxed."

In the rewritten version of the damage assessment regulations, polluters will be held accountable for more than just the market value of the damage they create.

Superfund and the damage assessment process do not protect against all distributed costs, even when implemented correctly. CERCLA specifies that the damage assessment mechanism is to be used for the recovery of losses to public resources. Financial losses suffered by private individuals, such as commercial fishermen or marina operators, must be recovered through personal legal actions. Recently, a New York appeals court ruled that commercial fishermen from the Hudson and Long Island may sue General Electric (GE) for lost earnings (Morgan, 1989). The fishermen are seeking at least $20 million in damages since the state ban on the sale of striped bass in 1985. GE had been attempting to block the suit on the grounds that it was preempted by the federal cleanup and damage assessment suit, which is still awaiting trial. Fishermen from the New Bedford Harbor area were unable to carry out a similar lawsuit due to preemption by two federal laws (Bondareff, 1987).

EPA will spend an estimated $120 billion cleaning up existing and yet-to-be-identified Superfund sites over the next 120 years, assuming EPA pays 80%, and responsible parties pay 20% (Dowd, 1988). Despite this, EPA's Science Advisory Board recently concluded that unknown billions of dollars in compensation from polluters for damaged resources remain untapped. For example, an $80 million claim from the responsible party might be realized at NOAA's top priority coastal hazardous waste site near Los Angeles (U.S. Congress, 1989). Regrettably, Superfund money cannot be made available for a $1–$2 million damage assessment at that site, so the public will bear the costs in the form of taxes and decreased resource and property values.

## CONCLUSIONS

Cost analyses of two very different pollution incidents resulted in a range of distributed cost estimates. In both cases, costs due to damaged fisheries exceeded cleanup and other documented agency costs. Costs due to foregone past and future fishing opportunities comprised 93% of total pollution-related costs for the Hudson River.

The costs attributable to resource damage are not insignificant. The federal natural resources damage assessment suit for New Bedford Harbor is claiming from $40 to $55 million (1985 $) in PCB damages to sport and commercial fisheries, beach use, and shore property values. PCBs in Hudson River fish have already cost sport and commercial fishermen an estimated $300 million (1987 $). By the time the PCB levels in fish flesh have returned to 2 ppm or below, the damage figure may exceed $1 billion. These fishery damage costs are in addition to cleanup costs, agency and litigation costs, which are also quite large. The cost of deferring costs by passing them on to future generations is substantial.

The EPA is beginning to shift its focus from a post-damage cost recovery approach to a prevention and waste reduction approach. A recent article in a Congressional research publication addressed the need for "market-type mechanisms along with traditional regulation" to control pollution and related costs (Moore, 1989). Meanwhile, current Congressional efforts to revamp the existing natural resources damage assessment system may improve our ability to minimize the distributed costs that result from short-term thinking.

Costanza (1987) used a road sign analogy to show why regulation was an ineffective mechanism for avoiding social traps. Costanza's proposed solution was to convert the trap to a tradeoff by imposing tolls: let the true costs be paid "up-front" by the traveler, rather than allowing them to be distributed through space and time. To improve the road signs properly, many distributed cost figures are needed. With a system of effluent taxes based on distributed cost data, a federal emphasis on waste reduction, and an improved damage assessment process, perhaps the real intent behind CERCLA, "the polluter pays" will be realized.

## ACKNOWLEDGEMENTS

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