AERE WORKSHOP

ON

MARINE POLLUTION AND ENVIRONMENTAL DAMAGE ASSESSMENT

FINAL REPORT

Cooperative Agreement CR-812056

September, 1986

V. Kerry Smith
Principal Investigator

DISCLAIMER

The purpose of the second phase of funding of Cooperative Agreement No. CR-812056 was to hold a workshop on Marine Pollution and Environmental Damage Assessment. The workshop was held in Narragansett, Rhode Island June 5-6, 1986. Professors James Opaluch and Thomas Grigalunas of the University of Rhode Island helped in the design and local arrangements for the workshop, contributing their time at these tasks as part of the cost sharing required by the Cooperative Agreement.

Attached are a list of participants, agenda for the workshop, and drafts of the papers delivered at the workshop. In one case (that of Michael Hanemann and Tony Fisher), the actual paper delivered by the author was substantially different from the text available here.

Discussion at the workshop was excellent. Each session chair led the discussion providing initial reactions to the papers in his session and James Opaluch provided an overall summary of the discussion and research issues that emerged.

The workshop did meet its goals of discussing conceptual and empirical dimensions of policy relevant research in this area. It attracted a good cross-section of economists in academia as well as the public and private sectors.

At present V. Kerry smith and James Opaluch are working with Professor Jon Sutinen, the editor of Marine Resource Economics, to arrange to have a special issue of the journal devoted to papers from the workshop after the reviewing and revision process have been completed.

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Workshop on Marine Pollution and Environmental Damage Assessment
Preliminary Agenda

Thursday, June 5, 1966

8:00 - 8:30 am	Sign-in Period
8:30 - 8:45 am	AERE Workshop Program, V.Kerry Smith, Vanderbilt University
8:45 - 9:00 am	Introduction to Workshop, Glen D. Anderson, U.S. EPA

9:00 -12:00 am SESSION I. Economic Valuation in a Policy Context

Session Chair: Glen D. Anderson, U.S. EPA

Compensation for Natural Resource Damages:
An Emerging Federal Framework
Roger C. Dower and Paul F. Scodari,
Environmental Law Institute

Measuring Damages to Coastal and Marine Natural Resources from Oil and Hazardous Substance Spills: Application of an Integrated Ocean Systems/Economic Model
Thomas A. Grigalunas and James J. Opaluch
University of Rhode Island

Economic and Environmental Conflicts in OCS Oil and Gas Leasing: An Analysis of National VS Regional Benefit8 and Costs
Philip E. Sorensen
Florida State University

Break
Open Discussion

1:30 - 4:30 Session II. Economic Methodologies and Ecological Constraints: Case Studies of Marine Pollution

Session Chair: Steven F. Edwards, Woods Hole Oceanographic Institute

Regulation of Marine Contamination Under Environmental Uncertainty: Shellfish Contamination in California
Erik Lichtenberg, Western Consortium of Health Professional8
David Zilberman, University of Calif., Berkeley

Mitigating Damages from Coastal Wetlands Development: Policy, Economics and Financing
Leonard A. Shabman and Sandra S. Batie,
Virginia Polytechnic Institute and State University

Measuring the Economic Damages Associated with Terrestrial Pollution of Marine Ecosystems
James R. Kahn, SUNY-Binghampton

Break
Open Discussion

Friday June 6, 1986

8:30 - 12:00 SESSION III. Conceptual Nees for Marine Pollution Policy

Session Chair: George Parsons, U.S. EPA

Economic Valuation of Wildlife:
Does Existance Value Exist?
Ronda K. Hageman, San Diego State University

Risk Sharing and Liability In the Control of Stochastic Externalities
Kathleen Segerson, University of Wisconsin-Madison

Paper Title to Be Announced
Michael Hanemann and Anthony C. Fisher
University of Calif., Berkeley

Break
Open Discussion Period

Workshop Wrap-Up
James J. Opaluch, University of Rhode Island

SESSION I. Economic Valuation in a Policy Context

COMPENSATION FOR NATURAL RESOURCE DAMAGES: AN EMERGING FEDERAL FRAMEWORK

by Roger C. Dower and Paul F. Scodari*

INTRODUCTION

Until quite recently, the most visible application of economic techniques for natural resources valuation was in the context of helping to guide policy decisions. For example, economic tools for measuring natural resource values have been used to determine the benefits of specific regulatory actions and to establish the impact of alternative development decisions. The passage of the Comprehensive Environmental Response, Compensation and Recovery Act in 1980 placed the spotlight on compensation for damages to natural resources as an alternative medium for the application of these tools. While there is a history under Federal and state statutory and common law of using economic analysis to value natural resource damages (especially from oil spills), CERCLA formalized this process by establishing a Federal regulatory and legal structure that will set the rules for how economic analysis will be factored into judicial proceedings involving oil and hazardous waste spills and releases.

The CERCLA compensation framework is just emerging and the regulations implementing the statute are being promulgated over the course of the next several months. The content and requirements of these regulations will have important implications for the allocation of social resources and perhaps for the field of natural resource economics. Further, the potential tensions between the theory of natural resource valuation and the practical constraints of an adversarial judicial System are bound to affect the ability of any compensation scheme to be equitable and cost-effective.

* The authors are Research Director and Staff Economist, respectively, at the Environmental Law Institute in Washington, D.C.

The purpose of this paper is to provide an overview of the CERCLA natural resource damage assessment and compensation framework and to highlight several broad economic and legal issues that may affect the ability of the framework to achieve its intended purpose. By briefly reviewing CERCLA and its natural resource damage provisions as a whole; outlining the current assessment process; and identifying certain potential concerns, we hope to help provide a better understanding of the compensation process and foster a broader evaluation of the emerging framework. We should note one important caveat. The current damage assessment regulations have only been proposed. Final regulations are due in the near future and undoubtedly these will modify the current provisions, perhaps making some of our observations obsolete. Further, even if the regulations remain unchanged (which seems unlikely), many of the provisions will be the subject of judicial review as cases are brought under the statute. Court decisions on various aspects of the regulations could change their meaning and interpretation.

THE LEGAL STRUCTURE

Statutory Framework

1. Overview of the Act

In response to public conern over releases of hazardous substances into the environment heightened by the discovery of contamination at Love Canal, Congress enacted the Comprehensive Environmental Response, Compensation and Liability Act [1/] (CERCLA) in 1980 to deal with the threats posed by abandoned hazardous wastes sites and hazardous substances releases in general. The Act provides Federal and state governments with broad authorities to respond to past as well as future releases (actual or threatened) of hazardous substances into the environment. CERCLA also provides a liability and compensation mechanism for recovery of governmental response costs from the parties responsible for hazardous substance releases. To assure that money would be available to complete the job of cleaning up abandoned hazardous waste sites, CERCLA established a $1.6 billion Hazardous Substance Response Fund financed primarily by excise taxes levied on crude oil and certain chemicals.

The basic liability and compensation provisions for response costs are set out in Section 107 of the Act. Liability is imposed on current and former owners and operators of polluting vessels or facilities, as well as those engaged in the generation, treatment, and disposal of hazardous substances[2/] for damages resulting from releases[3/] into the environment. The courts have interpreted these provisions as imposing strict, joint and several liability on these parties for hazardous substance releases.[4/] Essentially, this liability scheme can be used to force a "responsible" party to bear the full cost of cleaning up a hazardous waste release no matter how tenuous their connection to the release (or how many other parties contributed to the release) or how carefully they handled the offending wastes.

The $1.6 billion Hazardous Substance Response Fund[5/] was established to finance clean-ups in cases where the polluting parties are not known or are unwilling or unable to provide recompense. The types of claims permissable against the Fund include claims for payment of governmental response costs incurred under the Act's response authority provisions and other necessary response costs under the National Contingency Plan.[6/] Payment of claims by the Fund transfers to the Fund the right of the claimant to sue the polluting parties.

An important but often overlooked component of CERCLA is the Act's natural resource damage provisions.[7/] While the problem of cleaning up abandoned hazardous wastes sites has garnered considerable publicity, and a vast amount of litigation involving liability for response costs has occupied the courts, the potential significance of the natural resource damage provisions has generally escaped attention. However, these provisions have been called the Superfund "sleeper" and have the potential for greatly increasing the amount of damages polluting parties may be held liable for under CERCLA.

2. Natural Resource Damage Provisions

The CERCLA natural resource damage provisions authorize Federal and state governments to recover damages from polluting parties for the value of publicly owned natural resources injured by dicharges of oil or releases of hazardous substances. These provisions reflect Congressional recognition that hazardous substance contamination of the environment may impose social costs which would not be fully redressed by the clean-up of waste sites or private causes of action brought under state common law. The CERCLA legislative history suggests Congress' intent to allow for compensatory natural resource damages following existing common law doctrines. Together, the response cost and natural resource damage compensation provisions of CERCLA create a mechanism to force responsible parties to bear the full public costs and provide redress for their polluting activities.

Compensable natural resource damages are defined under Section 107 of CERCLA as damages for " . . . injury to, destruction of, or loss of natural resources, including the reasonable costs of assessing such injury, destruction, or loss resulting from such a release."[8/] The Act specifies that in the case of such natural resource injury " . . . liability shall be to the U.S. government and to any State for natural resources within the State or belonging to, managed by, controlled by, or appertaining to such State" and that "the president, or authorized representative of any State, shall act on behalf of the public as trustee of such natural resources, to recover for such damages,"[9/] Natural resources are defined very broadly to include land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources.[10/] The Act thus enables Federal agencies and state governments, who act as custodians for the public through protection and care of a wide range of publicly owned resources, to recover damages for injury to such resources caused by releases of oil or hazardous substances. CERCLA further specifies that "sums recoverable shall be available for use to restore, rehabilitate, or acquire the equivalent of such resources by the appropriate agencies of the Federal government or the state government, but the measure of such damages shall not be limited by the sums which can be used to restore or replace such resources". 11/

The Act contains certain restrictions on compensation for natural resource injury. Section 107(f) provides that there can be no recovery for natural resource damages where the release of hazardous substances or oil causing the injuries occurred wholly before December 11, 1980. One court has held that defendents can escape liability for natural resource damages only if all release ended before, and no damages were suffered after, December 11, 1980. 12/ The Act further limits the liabilities of responsible parties for natural resource damages to $50 million. 13/

Trustees are also authorized to make claims against the Hazardous Substance Reponse Fund for natural resource damages in cases involving resource injury caused by hazardous substances. 14/ These types of claims can be made only for the costs of restoring or replacing the injured resource and only if the trustee bringing the claim has developed a restoration plan. 15/ While the Fund is theoretically available for such claims, it is likely that response actions will subsume most of the Fund resources and that trustees will be forced to sue responsible parties directly.

To assist trustees in bringing natural resource damage actions, Section 301(c) of CERCLA requires the President to promulgate regulations for use in guiding the assessment of natural resource damages. These regulations are to include two different types of standardized procedures for assessing natural resource injury and placing a dollar amount this damage: Type A or simplified assessment techniques for smaller releases; and Type B protocols that will include more detailed and extensive assessment methodologies for more major releases. Type A procedures are defined by the Act as "standard procedures for simplified assessments requiring minimal field observation, including establishing measures of damages based on units of discharge or release units or units of affected area". Type B procedures are specified by the Act to include "alternative protocols for conducting assessments in individual cases to determine the type and extent of short- and long-term injury, destruction, or loss". The Act specified that these regulatons "shall identify the best available procedures to determine such damages, including both direct and indirect injury, destruction or loss and shall take into consideration factors including, but not limited to, replacement value, use value, and ability of the ecosystem or resource to recover". 16/ CERCLA also provides that damage assessments developed using these regulations will create a rebuttable presumption of accuracy. 17/

In summary, the CERCLA natural resource damage provisions create a powerful mechanism for the recovery of public damages resulting from natural resource injury caused by discharges of oil or releases of hazardous substances. By providing for damages from injury to a broad range of natural resources caused by many types of contaminants, and by providing a set of regulations to guide damage assessments bolstered by a rebuttable presumption of accuracy; the CERCLA natural resource damage provisions go beyond the scope of previous common law doctrines and statutes. 18/

Regulatory Famework

1. Implementation

The President, in Executive Order No. 12316, delegated to the U.S. Department of the Interior (DOI) responsibility for promulgating the Type A and Type B natural resource damage assessment regulations. This order also assigned to the U.S. Environmental Protection Agency (EPA) the task of promulgating procedures for trustees to follow for making claims against the Fund for natural resource restoration costs. However, the December 11, 1982 deadline imposed by the Act for promulgation of the assessment regulations and the claims procedures passed without either being published. In order to force the rulemaking process, the State of Montana filed suit against DOI and EPA for failure to perform their respective duties. This suit was subsequently voluntarily withdrawn, but was followed by two new suits, one brought by the State of New Jersey and the other by the New Mexico Department of Health and the Environment.

The two suits were consolidated into one and heard in the District Court of New Jersey.[19/] As a result of a finding in favor of the plaintiffs on December 12, 1984, DOI entered into a consent order whereby the agency agreed to a specific timetable for the promulgation of the regulations. Under the consent order, DOI agreed to publish notices of proposed rulemakings for Type B regulations by December 20, 1985 and for Type A regulations by April 5, 1986. The consent order further specified that final Type B and A regulations would be published by April 22, 1986 and August 7, 1986, respectively. These deadlines have recently been extended slightly by the court. A notice of proposed rulemaking for Type B regulations was published in the Federal Register on the court imposed deadline.[20/] Proposed Type A regulations were published on May 6 of this year (51 Fed. Reg. 16636).

The proposed Type A regulations deal exclusively with damage assessments involving injury to coastal and marine environments. These assessment procedures make use of a computer model capable of mathematically calculating damages based on data concerning the types of discharges or releases of specific contaminants and the type of receiving coastal and marine resources. Because the model is only applicable to certain types of discharges and releases, and requires specific data on the resources affected, it can only applied to discharges into marine or coastal environments for which this type of data is available. At some future date, this system may be expanded or new systems developed to cover other types of resources and different types of discharges and releases. For now, however, damage assessments in cases involving injury to other types of resources are to guided by the Type B procedures.

The Type A regulations also provide trustees broad discretion in choosing between Type A and Type B procedures even in cases where the Type A procedures are applicable. Furthermore, potentially responsible polluting parties are given the option to request Type B assessments even when Type A procedures are applicable provided they are willing to advance the costs to the trustee for performing the Type B assessment.

The remainder of this paper focuses only on the proposed Type B damage assessment regulations.

2. Overview of the Type B Regulations

The Type B regulations set out the basic processes to be followed by Federal and state trustees for: 1) determining and documenting natural resource injury caused by releases of oil or hazardous substances, 2) quantifying the effects of this injury on the human uses of the services provided by these resources, and 3) determining natural resource damages. The regulations explain the procedural steps for trustees to follow and provide criteria for selecting methodologies to determine resource injury and damages. They do not, however, provide specific guidance for implementing the various methodologies. This information is provided by a set of accompanying Technical Information Documents which evaluate and provide more specific information on the various alternatives. Because trustees are authorized to recover the costs of performing the assessment fro m the responsible parties, the regulations mandate that the assessment process be performed at reasonable cost. "Costs are reasonable when 1) the injury, quantification, and damage determination phases have a well-defined relationship to one another and are coordinated and 2) the increment of extra benefits obtained by using a more costly injury, quantification, or damage determination methodology are greater than the cost of that methodology." 21/

Our focus here is on the major provisions of the proposed regulations which contain key economic decision points or provide guidance for the use of economic methodologies for damage assessment. These provisions include Subpart B — Preassessment Phase, Subpart C – Assessment Plan, and Subpart E – Type B assessments.

a. Subpart B - Preassessment Plan - Subpart B of the proposed rule sets out the procedural steps for initiating the damages assessment process and for preliminary analysis of potentially injured natural resources. The most interesting section of this Subpart from an economic perspective is Section 11.23 which outlines the preassessment screen. The pre-assessment screen provides the criteria for determining whether the identified discharge or release justifies a natural resource damage assessment, and includes the first key economic decision point in the process.

The pre-assessment screen is defined as a "desk top" review of the existing data capable of being performed within a few days. The screen requires that a decision to proceed with an assessment should be based on the following determinations by the trustee: 1) that the discharge or release is covered under the relevant sections of CERCLA or The Clean Water Act 2) that the discharge or release has likely injured natural resources under the jurisdiction of the trustee; 3) that the quantity and concentrations of the contaminants released is sufficient to potentially cause resource injury; 4) that the data required to perform an assessment can be obtained at a reasonable cost; and 5) that any planned or completed response actions will not completely remedy the injury to the natural resources. The pre-assessment screen thus requires a preliminary determination by the trustee of the nature and extent of possible resource injury, based on the early sampling of contaminants and the area potentially exposed, as well as a determination of the human uses of the resources potentially affected. This information is to be used by the trustee to determine whether an assessment could be performed at reasonable costs, and the likelihood that a damages action would be successful.

b. Subpart C - Assessment Plan - After an affirmative decision is made to proceed in the pre-assessment screen, but before initiating a damage assessment, the trustee must develop a detailed assessment plan in accordance with the procedures set forth by Subpart C of the proposed regulations. Section 11.31 requires that the assessment plan identify all of the scientific and economic methodologies to be used in assessing the resource injury and determining damages in sufficient detail to be able to make a determination of whether the proposed assessment approach is cost-effective. The regulations interpret the term "cost-effective" to mean " . . . that when two or more activities provide the same level of benefits, the least cost activity providing that level of benefits will be selected."22/

The Economic Methodology Determination section of the proposed rules (Section 11.35) allows the trustee to use restoration or replacement costs, or dimunition in use values as the basis for measuring natural resource damages and provides guidance to the trustee for the choice. This section specifies that "the authorized official shall select the lesser of 1) restoration or replacement costs or 2) dimunition of use values as the measure of damages." 23/ It further specifies that the costs and benefits of these alternative measures of damages be calculated based upon the readily available data and used to make this determination. The costs and benefits in this calculation are defined as "the expected present value, if possible, of anticipated restoration or replacement costs, expressed in constant dollars, and separated into capital, operating, and maintenance costs, including the timing of the costs"; and 2) "The expected present value, if possible, of anticipated use values gained through restoration or through replacement, expressed in constant dollars, specified for the same base year as the cost estimate, and separated into recurring and nonrecurring benefits, including the timing of the benefit."24/

The proposed regulation provide for an interesting exception to the above decision rule for "special resources". Special resources are defined as "natural resources that have been set aside and committed to a specific use by law before the discharge of oil or release of a hazardous substance was detected. The term includes resources that were set aside primarily to preserve wildlife habitat or other unique and sensitive environments. It does not include resources listed on administratively determined lists for "special protection", or resources protected by regulatory status" or multiple use resources.[25/] In the case of special resources, the trustees may seek damages based upon restoration or replacement costs as long restoration or replacement of the resource is feasible and the costs "will not be grossly disproportionate to the benefits gained".[26/]

The regulations further specify that the economic methodology determination should rely upon existing data and studies, and that no new data collection or modelling is needed to complete the determination. It also stipulates that if the existing data is insufficient to perform the economic methodology determination, it may be postponed until the completion of the formal injury determination phase in Subpart E.[27/]

c. Subpart E - Type Assessments - Subpart E of the proposed regulations deals with the actual implementation of Type B assessments, and lays out the steps to be followed by trustees for choosing among and implementing alternative methodologies for each of the three major phases in the damages assessment process - injury determination, service reduction quantification, and damages estimation. The following discussion deals. only with those parts of the Subpart dealing with the estimation of resource damages.

Guidance to trustees for estimating damages based upon restoration or replacement costs and certain restrictions on what these measures may include is discussed in Section 11.81. When restoration or replacement costs are to be used, they must be based on the least-cost alternative restoration or replacement scheme that returns the resource to its pre-injury baseline condition. Further, the restoration or replacement alternative used to calculate damages must be technically feasible to undertake. The measure of damages calculated using restoration or replacement costs may also include any dimunition in resource use value over the recovery period. 28/

Criteria for the selection and implementation of use value methodologies is provided by Sections 11.83 and 11.84 of Subpart E. Key interpretations and definitions are also found here. The term "use value" is defined as "the value to the public of recreational or other public uses of the resource, as measured by changes in consumer surplus, any fees or other payments collectable by the government for a private party's use of the natural resource, and any economic rent accruing to a private party because the government does not charge a fee or price for use of the resource." Additionally, the regulations provide that, "In instances where the Federal or State agency acting as trustee is the majority operator or controller of a for- or not-for-profit enterprise, and the injury to the natural resource results in a loss to such an enterprise, that portion of the lost income from this enterprise . . . may be included as a measure of damages". 29/ Only the dimunition in value of baseline "committed uses" of natural resource services over the period it takes for the injured resource to actually recover can be used to measure damages. In addition, these baseline "committed uses" must be reasonable probable; purely speculative uses of the injured resource are precluded from consideration. 30/ A committed use of natural resource services is defined as "a current use, or a planned use of a natural resource for which the Federal or State agency acting as a trustee or another party has made a documented legal, administrative, budgetary, or a financial committment before the discharge of oil or release of a hazardous substance is detected." 31/

Section 11.83 of the regulations identifies and briefly describes the specific methodologies which may be used by trustees to estimate damages for both market and nonmarket natural resource services, and stipulates the conditions under which they may be used to estimate certain resource damages. An evaluation of these methodologies which includes more specific information on their use is provided by an accompanying technical information document.[32]

In the case of a resource for which a welldefined market exists, the regulations stipulate that the trustee must make a determination as to whether the specific market is reasonably competitive before choosing a valuation methodology. If the market for such a resource is reasonably competitive, the trustee should first turn to the market price methodology for detemining damages, which is based on the dimunition in market price for the injured resource. If the trustee determines that the market price methodology is not appropriate for valuing a particular resource, the regulations provide that the "appraisal" methodology be employed to value the resource if sufficient information exists. This methodology simply uses the difference between the before injury and after injury appraisal values for resource in question. Trustees are instructed to turn to the "Uniform Appraisal Standards for Federal Land Acquisitions" for guidance in making such resource value appraisals.[33]

The proposed regulations also provide for the use of specific methodologies for measuring the use value of nonmarket natural resource services. For nonmarket resources, the regulations allow the trustee to use various methodologies to estimate use value measures of damages based on estimates of either willingness-to-pay or willingness-to-accept (WTA).[34] (Presumably, the regulations allow for WTA measures of damages because the property right for the resources covered under CERCLA are held by the public.) For injured resources which are used as inputs into the production of products associated with well-defined market prices, the factor income methodology may be employed to estimate the economic rent attributable to the resource as a measure of damages. Alternatively, for natural resources which provide consumer utility, the regulations specify the travel cost method, hedonic pricing, and the contingent valuation (CV) methods as acceptable approaches for measuring damages.[35] While the regulations allow the trustee complete discretion in their choice of the travel cost or hedonic pricing methods for measuring damages in the case of injury to nonmarket resources, certain restrictions are placed on the use of the CV approaches.

Section 11.83 (d)(5) explains that CV "can be used to survey consumptive, option, and existence value," but provides that "the use of this method to estimate option and existence values should be used only if the authorized official determines that no other valuation technique will be feasible." This stipulation can be interpreted as meaning that CV can only be used to measure resource values when no other valuation technique can be applied to estimate use values, and only under this condition can option and existence values (intrinsic values) be used as a basis for natural resource damages. This discussion is the only mention of intrinsic values in the regulations and suggests that DOI was unsure of how to handle these non-use values. Also, it suggests that DOI was uncomfortable with the CV methodology as a tool for measuring resource value.

Guidance is also provided on various smaller issues related to the implementation of the valuation methodologies. These issues include the handling of possible double counting problems; the treatment of uncertainty in damage determination; and discounting costs and benefits over time. The regulations specify that double counting of resource benefits should be avoided, but offer little guidance except to say that resource damages should be based on the residual resource injury after incorporating the effects, or anticipated effects, of response actions on resource services.[36/] With regard to the treatment of uncertainties in damage determination, the regulations state that when considerable uncertainties exist concerning the assumptions made when implementing valuation methodologies, trustees should consider alternative assumptions and document their effects on the calculation of costs and benefits.[37/] For discounting costs and benefits over time (including past and future), the regulations mandate the use of a 10% real rate of discount as specified by the Office of Management and Budget.[38/]

SOME PRELIMINARY OBSERVATIONS

The natural resource damage assessment process should establish a framework to accomplish two important purposes. In an aggregate sense, the regulations should compensate the public for injuries to their natural resources from oil or hazardous waste spills and releases. Specifically, the scheme should make the public whole, so that the public is as well-off after natural resource injury as they were before the injury. The law should also seek to redistribute a specific subset of the costs of certain types of industrial or commercial activities: those non-health related external economic costs that fall on the public as a result of "improper" disposal or handling of oil and hazardous wastes. 39/ In this sense compensation, in combination with the other provisions of the Act, intends to fully internalize the social costs associated with past and future waste disposal practices. CERCLA assumes that the disposer is always in the position of being able to reduce risks most cheaply and thus bears the full responsibility of insuring against, and compensating for public natural resources injury.

In order for the CERCLA natural resource assessment process to achieve an efficient allocation of social resources, the system has to generate accurate estimates of the true economic value of injured natural resources and to do so while incurring the least costs possible. Given the nascent nature of state or Federal attempts to utilize the damage assessment scheme, it is difficult to forecast how closely it will hit the mark. Many elements of the assessment process will be modified and more fully defined by the court system as cases are heard and evaluated. However, there are several controversial elements, definitions and assumptions built into the damage assessment regulations that, assuming they are upheld by the courts, appear to undermine the equity and cost-effectiveness of the process. As currently written, the proposed regulations appear to suggest that natural resource injuries may be undervalued and the compensation process over-priced. These issues, as will be discussed below, are quite varied, but share one common characteristic. They all reflect, in part, tensions between the economic concepts of natural resource value (and their estimation) and the constraints imposed by the legal environment in which these economic concepts will be brought to bear,

Public Versus Private Damages

The proposed regulations provide for the assessment of damages to publicly owned resources, but explicitly exclude compensation for injury privately owned resources. The justification for this bifurcation of damage categories is the definition of resources covered by the Act which is interpreted by DOI to exclude damages that might be recoverable under private rights of action for injury to privately owned resources. Even in the absence of an actual natural resource damage case under these rules, this distinction between private and public resources has already generated tremendous confusion and controversy. Several key positions may help focus this debate if not provide ready resolutions. To help frame the following discussion, we refer to "private damages" as those private losses which result from injury to privately owned resources and define "public damages" as the aggregation of those private losses which result from injury to publicly owned resources.

- First, to an economist the distinction between public and private damages may seem somewhat arbitrary. If a hazardous waste release has altered the characteristic of a natural resource that serves as an input to the production of a recreational experience (utility function) or commercial product (production function), the economic damages are given by the willingness-to-pay (or sell) of recreationists or producers to avoid (accept) the additional cost of adjusting to the altered input. Whether the natural resource is privately or publicly owned is inconsequential at least on this level of analysis. However, accepting this distinction between public and private resources defined by the Act, economists would take the view that damages resulting from injury to publicly owned resources are represented by the aggregation of losses to all parties who use the resource.

In a strict legal setting, however, using the lost economic rents accruing to commercial harvestors of an injured animal species, for example, to place an economic value on that species, may suggest that private damages which are not permissable under the Act are at stake, regardless of the possible public trusteeship of the injured animals. The proposed regulations adopt, at least on the surface, the economic view of estimating public damages, which holds that private losses to individuals who use public resources represent the lost value of these resources. However, there appears to be an increasing tendency to interpret the rules to limit the use of private losses to individuals who use public resources to estimate for diminished public use values. To the extent that the rules change or that courts do not accept the economist's approach, it is possible that many uses of natural resource damage will go uncompensated under the rules.

- Second, is the issue of who is in the least-cost position for bringing successful natural resource damage claims. If the Act or the proposed rules limit the use by a public trustee of private losses as an approximation of public damage, private parties would be forced to bring individual suits under state common law to seek compensation. Given the subtlety of many of the injuries from hazardous waste spills and the expense and complexity of proper economic damage assessments, the conditions under which a private party could mount a successful case may be limited. A further complication results from damages to natural resources that do not obey property lines or political boundaries. It is not clear how injuries to private parties from contaminated air would be handled under a strict interpretation of private versus public resources. The risk of too narrowly defining public versus private damages is excessively large litigation and other transaction costs (such as duplicative assessments) to achieve fair compensation and possibly too few cases being brought. A more cost-effective solution might allow for consolidation of public and private damage claims when the trustee can take advantage of cost economies-of-scale.

- Finally, the economic notion of damages and their estimation does raise the issue of who gets the award. As the rules currently read, a public trustee claiming damages based on private losses has to use the award to restore, rehabilitate or acquire comparable natural resources. Private users would not receive compensation for losses incurred after the release but before the restoration even though such losses would be included in the assessment. From an economic point of view the resource allocation implications of such a distributional outcome are minimal. The legal questions are more interesting. For example, would a private party have standing to bring suit under state tort law against the state or the responsible party for damages incurred but for which they receive no compensation? The answer is unclear, but there may be some potential for double payments for the same injury to the extent that the private party is viewed by the courts as having a cause-of-action independent of the trustee's claim over the injured resource.

The debate over public versus private resources is not only a question of ownership. It involves distinctions between ownership, private versus public injuries, and private versus public losses. The net effect is uncertain pending resolution by the courts. In at least one case the court has ruled that private and public natural resources damages are best treated as one. However, the current bias would seem to be towards a more limited view suggesting higher transaction costs and fewer cases than may be warranted by the level of social costs involved.

The final assessment of this tension is an empirical one and has to await some practical experience with the process. It may be that the assessment process conducted by a public trustee will provide potential private parties with all the information and analysis they will need to bring compensation actions under state common law. On the other hand, the incentives for any one injured party to undertake the necessary studies to support a tort action on their behalf are sufficiently small to assume that few private actions will be brought in the absence of an organized group of plaintiffs or readily identifiable and easily valued damages (such as fish kills). Is it in society's best interest to encourage a large number of relatively small but still expensive legal actions?

Intrinsic Values

The statute and the proposed assessment regulations allow for economic use values to be used as the basis for a natural resource damage claim. While the regulatory definitions appear to include both consumptive and non-consumptive uses of natural resources, the inclusion of intrinsic values such as option and existence values is not so clear. On its face, CERCLA could be read to include such losses when it defines the basis of a damage claim to include "but not be limited to" costs of restoration, lost use values, etc. The regulations also explicitly mention option and existence values but only in the context of using contingent valuation studies and then only when other techniques for measuring use value are not feasible. Other portions of the regulations limit economic damages to only those damages that can be associated with "committed" not "speculative" uses of the resource, perhaps ruling out the consideration of option and existence values in all but a few situations. On the other hand, there is a more subtle treatment of intrinsic values within the regulations when the economic decision rule concerning the choice of restoration costs or diminished use values is dropped for "special resources." The implicit recognition here is that there are some resources that would be undervalued if only consumptive and non-consumptive use values formed the basis for total economic value. The definition of special resource, however, is so narrow as to sharply limit its potential.

The apparent confusion in the regulations and growing debate among various interested parties concerning intrinsic values is the result of differences in perspective and philosophy. Some of these are more easily identified and discussed than others. Two examples may be helpful.

o First, is the issue of whether such values are true economic values. The answer here is somewhat a matter of philosophy; an environmentalist would say yes, an industrial polluter might say no. Yet, the evidence would seem to support a positive response. It is difficult to explain the high level of social resources that are devoted to protecting wilderness areas and endangered species; the creation of national parks and marine sanctuaries; and the whole of our nation's environmental protection efforts if option and existence values were not some part of the value we accord those programs. Further, the growing body of economic literature on the subject of intrinsic values, while not strictly in accord, does provide considerable weight at least on a conceptual level, as well as some empirical evidence for these values. 40/

o Second, is the question as to whether intrinsic values fall within the traditional legal concepts of economic value as defined under common law theories of damage. The case law involving natural resource damage cases is not very helpful here. We know of no single case where option and existence values formed an explicit basis for the damage claim. While some states have included such values in estimating damages to natural resource, we are not aware of any that have been the subject of court scrutiny, most are settled out of court and thus do not provide much in the way of precedent. 41/ However, a legal parallel may exist in personal injury cases. Courts have long held that in such cases compensation may be made for both direct economic losses (such as lost income, medical expenses, etc.) as well as "non-pecuniary" damages including pain and suffering, loss of consortium, and mental anguish over the loss of a loved one. 42/

Although not a perfect fit, intrinsic values have many of the same characteristics as the non-pecuniary damages in personal injury cases. Most notably, they both represent kinds of effects that we perceive to be real, but have a very hard time putting into dollar terms. There is an important difference between speculative damages (those that require a stretch of one's imagination to believe) and damages that are uncertain as to their value. While courts may be comfortable with the notion of pain and suffering as a very real and believable effect of personal injury, they continue to grapple with how best to express those values in dollar terms. This uncertainty may not be the basis for excluding the consideration of "non-use" values, but may lead to widely varying outcomes for very similar cases.

- Finally, the uncertainty as to how best to value intrinsic damages leads to a third element of the controversy over their inclusion in natural resource damage assessments. While it may be theoretically possible to measure option and existence values through various economic methods, the technique with the most promise and that has been applied most often is contingent valuation. The question of whether one can accurately measure individuals' valuation of any commodity through preference revealing surveys continues to divide the economics community and is often dismissed out-of-hand by non-economists.

It is beyond the scope of this paper to venture into the contingent valuation debate except to note that there appears to be developing a consensus on the conditions that need to be met in order for a C.V. study to be credible, and an improved understanding of the limits and biases of the technique in its general application. 43/ Courts have extensive experience with judging the credibility of alternative approaches to measuring economic damages and a rather strong argument can be made that the option should continue to be. available to public trustees (and others) subject to review and consideration of the judicial system.

There are undoubtedly other factors that carry weight in the intrinsic value debate. Once one is willing to admit that such values do exist under certain circumstances and that they are permissible under the law, the tensions between economics and the law would appear to collapse into a series of questions that courts have to deal with all the time to some degree. This would argue for more explicit recognition of the potential for such values in the regulations and the flexibility for the trustee to attempt to estimate such damages if they feel a credible case can be made.

The current trend in the proposed regulations and, it appears, at DOI is to limit the consideration of such values rather to expand it. Without offsetting changes in other parts of the regulations (such as broadening the definition of special resources) to provide some mechanism for incorporating such values on an indirect basis, there is a real possibility that many types of natural resources will go undervalued.

<u>Real Versus Perceived Damages</u>

The proposed regulations set out a process in which an injury to a natural resource is quantified and an economic value attached. The rules require that an injury be "measurab1e" in order for it to be part of a damage assessment. At the same time, the rules provide for the application of economic valuation tools in the damage assessment phase that do not necessarily require estimation of measurable injury (a trustee is still required to demonstrate the relationship between the pollutant and the damage). Because economists, value damages on the basis of changes in consumer and producer behavior, actual physical injury is assumed to result if one can isolate individuals' responses to a set of new conditions and resource characteristics. For an economist perceived damages are real damages if they result in changes to consumer utility or producer production capabilities.

It is not clear whether the authors of the proposed regulations were aware of this potential for conflict. Yet, given the bias of the legal system towards the demonstration of physical harm before the award of damages, the potential is very real. This is particularly so given the chronic, sub-acute nature of many of the environmental injuries that are likely to occur from hazardous waste releases. A wetland area containing above background levels of a particular pollutant (but below a state or federal standard) has experienced an economic damage if certain birdwatchers make fewer trips to the wetland. This is so even if there is no physical injury or risk of injury to the biological system. The proposed rules appear to accept this proposition, but at the same time require a substantial demonstration of physical harm. Given what appear to be rather high burdens of proof concerning biological harm in the proposed regulations, it is not difficult to imagine a bias towards natural resource compensation only in those cases where clear evidence of physical effects is available.

CONCLUSION

The emerging compensation framework for natural resource damages attempts to integrate the economics and law of natural resource valuation into a single comprehensive package. The ability of the framework to achieve the dual goals of fair compensation at the lowest possible cost is a function of how carefully the perspectives and limits of economic valuation are coordinated with the constraints imposed by the legal structure in which these assessments will be judged. We have singled out three current issues concerning the application of natural resource economics to the CERCLA assessment process (as outlined in the recently proposed regulations) that appear to have the potential to skew the compensation formula towards under-compensation at relatively high costs. Others may well be equally important. For example, the reliance in the regulations on a 10 percent discount rate is a double edged sword, perhaps under valuing future losses but over-valuing past damages.

We do not have a crystal ball that offers a clear picture of how the assessment process will actually be implemented in practice. Many of the issues raised here as well as many technical elements of the DOI proposed regulations await resolution in the final rules or in the courts. Nevertheless, we have tried to provide some hints as to likely outcomes. The magnitude of the possible effects cannot be predicted, but a qualitative assessment can be constructed. Our sense is that the tendency will be towards awards that represent something less than the full economic value of natural resources and involve relatively high transaction costs. Current litigation costs of CERCLA response cost recovery actions have been estimated to be as high as 40 percent of actual clean-up costs (which EPA estimates to be around $7 million per site). The natural resource damage assessment process appears to risk raising these costs further.

The potential for the CERCLA assessment process to skew the costs and size of awards for natural resource damages places a high premium on incentives for the trustee to make decisions within the assessment framework that will lead to the most accurate estimates of value at the lowest costs possible. However, the basic decision rule imbedded in the proposed regulations is unlikely to provide much in the way of guidance to the trustees. The proposed rules require the trustee to seek a balance between the costs and benefits of the assessment, but benefits are defined in terms of the size of the award. Everything being equal, the larger the award for a given cost, the more justified is the assessment. A more appropriate decision rule for choosing methodologies would define benefits in terms of the value of additional or new more accurate estimates of damages and the reallocation of resources resulting from that award. Of course, it is possible that the current decision rule will foster large awards and thus offset some of the more negative impacts discussed above. Yet, the net result is hard to predict and may bias the outcome of the rules even more. While we acknowledge the tremendous difficulty in assigning dollar benefits to information, there would seem to be rather high payoffs from investigating alternative specifications for the current decision rule.

FOOTNOTES

1/ 42 U.S.C. §§9601-9657 (hereinafter cited as "CERCLA").

2/ CERCLA §101(14) defines "hazardous substance" primarily by referring to designations made under a variety of other environmental statutes. These hazardous substances include 696 substances (see 48 FR 23552) as well as any additional substances designated by EPA pursuant to §102 of CERCLA.

3/ CERCLA §101(22). "Release" is broadly defined but excludes exposures resulting from specified nuclear materials, workplace emissions, most engine exhausts, fertilizer applications and "federally permitted releases." (See §101(10))

4/ Reed, P.D., "CERCLA Litigation Update: The Emerging Law of Generator Liability," 14 ELR 10024 (1984).

5/ CERCLA §22

6/ CERCLA §111(a)(11)-(4).

7/ The CERCLA natural resource damage provisions are contained in three separate sections of the Act: §107, §111 and §301.

8/ CERCLA §

9/ CERCLA 107(f).

10/ CERCLA §101(16).

11/ CERCLA §107(f).

12/ 546 F. Supp. 1100, 12 ELR 20954 (D. Minn. 1982).

13/ CERCLA §107(c)(1)(C).

14/ CERCLA 111 (b).

15/ CERCLA §

16/ CERCLA §301(c)(2).

17/ CERCLA §

18/ The provisions of various Federal Laws relating to natural resource damage compensation are reviewed in: Yang, E., R. C. Dower, and M. Menefee, The Use of Economic Analysis in Valuing Natural Resource Damages, U.S.Department of Commerce, Washington, DC 1984.

19/ State of New Jersey et al. v. Ruckelshaus et al., Cir. No. 84-1668 (D.C.N.J.)

20/ 50 Fed. Reg. 52127 (Dec. 20, 1985) (hereinafter cited as "Regulations").

21/ Regulations §

43/ A current overview of contingent valuation methods is found in, Cummings, R.O., D.S. Brookshire and W. Schulze, “Valuing Public Goods: The Contingent Valuation Method, Totowa: Rowman & Allanheld, 1986.

22/ Regulations 11.14(j).

23/ Regulations 11.35(a)(2).

24/ Regulations 11.35(e)(3)(i) and (ii).

25/ Regulations 11.14(pp).

26/ Regulations §

27/ Regulations 11.35(e)(1) and (2).

28/ Regulations 11.8

29/ Regulations §11.83(b)(1) and (2).

30/ Regulations 11.84(b)(2).

31/ Regulations 11.14(h).

32/ Desvouges, William H., Type B Technical Information Document: Techniques to Measure Damages to Natural Resources, Draft Report Prepared for the CERCLA 301 Project, U.S. Department of Interior, September 1985.

33/ Regulations §11.83(c)(1) and (2).

34/ Regulations 11.83(d)(7).

35/ Regulations §11.83(d)(1)-(5).

36/ Regulations 11.84(c).

37/ Regulations 11.84(d).

38/ Regulations 11.84(e).

39/ For an economic analysis of compensation see, Viscusi, W. K., "Alternative Approaches to Valuing Health Impacts of Accidents: Liability Law and Prospective Valuations," Law and Contemporary Problems, Vol. 46 (1983), pp. 49-68.

40/ See, for example: Desvouges, W.H., V.K. Smith and M.P. McGivney, A comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvements, U.S. EPA; Wash., D.C., 1983; and Walsh, R. G., J. B. Loomis and R. S. Gillman, "Valuing Option, Existence and Bequest Demands for Wilderness," Land Economics, Vol. 60 (May, 1981).

41/ The historical treatment of natural resource damages in courts and a review of past cases can be found in Yang, E., R. C. Dower and M. Menafee, The Use of Economic Analysis in Valuing Natural Resource Damages, U.S. Department of Commerce: Wash., D.C., 1984.

42/ A general treatment of damage categories for tort actions is found in Prosser, W. C. and J. W. Wade, Torts 2nd - Restatement of the Law, American Law Institute: St. Paul, 1979.

Measuring Damages to Coastal and Marine Natural Resources from Oil and Hazardous Substance Spills: Application of An Integrated Ocean Systems/Economic Model

Thomas A. Grigalunas, James J. Opaluch*, Deborah French and Mark Reed**

Introduction

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), and the Clean Water Act (CWA) as amended, establish polluter liability for the costs of responding to and cleaning up spills of oil or hazardous substances covered by these Acts and for the costs of assessing damages to natural resources. In addition, the Federal government and the States, in their roles as trustees, can claim damages for injuries to natural resources. CERCLA requires the Federal government to promulgate two types of regulations for assessing damages to natural resources: type A regulations are to provide standard procedures for simplified assessments requiring minimal field observations, and type B regulations which specify alternative protocols for conducting assessments in individual, site-specific cases (Sec. 301(c)(2)). Hence, the Act recognizes that damage assessment studies can be quite costly; the simplified, type A assessment is intended to apply to cases for which an incident-specific, type B estimate of natural resource damages is judged not to be worth the cost.

In addition to its distributive implications (i.e., compensating governments as trustees for natural resources), the liability provisions of CERCLA can have important resource allocation effects. Liability for damages is akin to a Pigouvian tax on externalities, and recent research suggests that liability can provide incentives for controlling stochastic pollution events (e.g., Opaluch and Grigalunas, 1984). As recognized in

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the Clean Water Act, liability has the potential "... to create incentives to achieve a higher standard of care in all aspects of the management of hazardous substances ...". Liability is one of the few examples where federal environmental policy uses financial incentives, which economists typically argue are potentially more cost effective then traditional Command-and-Control regulations. However, assessing damages from an incident can be extremely costly and may bring to question the cost effectiveness of liability rules. For example, estimating the social costs from the AMOCO CADIZ oil spill cost approximately $6.6 million. Clearly, this magnitude of expenditures can be justified only in the relatively rare case of a catastrophic incident.

Further, much of the injury which occurs may not be readily observable, particularly for marine spills, where many dead organisms sink, disperse, or are rapidly eaten by scavengers. For example, approximately $1.4 million ($1986) was spent to evaluate the consequences of the 179 thousand barrel ARGO MERCHANT spill, but no injury was found. For most relatively modest marine incidents damages may not be observable; and hence it may not be desirable to base liability on observed damages.

To be effective, the assessment process must be relatively quick and inexpensive to administer, and must not be based only on damages which are readily observable. This paper discusses an alternative approach for measuring liability for damages from pollution incidents based on the concept of a damage function. A model which runs on the IBM PC (or compatible) is constructed which simulates the dispersion of a pollutant through the environment and the resultant injury to biological communities. The model then provides an economic measure of damages from this presumed injury without the need to carry out a damage assessment involving expensive field observations. This framework is currently being considered by the U.S. Department of Interior for use in measuring damages to coastal and marine environments for the relatively small incidents which would call for a type A natural resource damage assessment.

Following a brief description, the model is applied to measure the damages from hypothetical oil and hazardous substance spills in selected coastal and marine environments. Because the draft study described in this paper is in the review process, which may lead to refinements of the model and the data, the analysis and results presented must be regarded as preliminary.

Due to space constraints, the discussion in this paper will be extremely brief. The interested reader is refered to the draft technical report upon which this paper is based (Economic Analysis, Inc. and Applied Science Associates, 1986).

II. Overview of Methodology and Data

Clearly, the consequences of a given oil or hazardous substance spill could vary greatly, depending upon the amount and characteristics of the substance spilled, such as its physical and toxicological properties, and the characteristics of the environment in which the spill occurs, such as the location and season of the incident, the water depth, currents, temperature, and the specific natural resources in the affected area. The measurement of damages from a particular incident requires that linkages be established, in sequence, from an incident covered by CERCLA or the CWA, to its effect on ambient conditions, to biological and physical injuries and, ultimately, to the measure of damages which is quantified in monetary terms. An integrated, interdisciplinary model provides an operational framework for quantifying these linkages. As depicted in Figure 1, the model is comprised of three submodels: the physical fates, biological effects, and economic damages submodels.

The physical fates submodel has a chemical data base which contains information on several hundred chemicals obtained from established data bases. The physical and toxicological data contained in this data base includes such parameters as density, solubility, vapor pressure, degradation rates in sea water and in sediments, octanol/water partition coefficient (Kow), adsorbed/dissolved partition coefficient (Koc), and toxicological information for phytoplankton, zooplankton, ichthyoplankton, adult fish, and benthos.

Given the amount and the physical/chemical parameters of the substance spilled, the fates submodel simulates its spreading, mixing, and degradation in four layers of the environment: the surface, upper rater column, lower water column and bottom. In addition, the submodel accounts for the amount of pollutant lost to the atmosphere through evaporation, where appropriate. A mass balance calculation ensures that

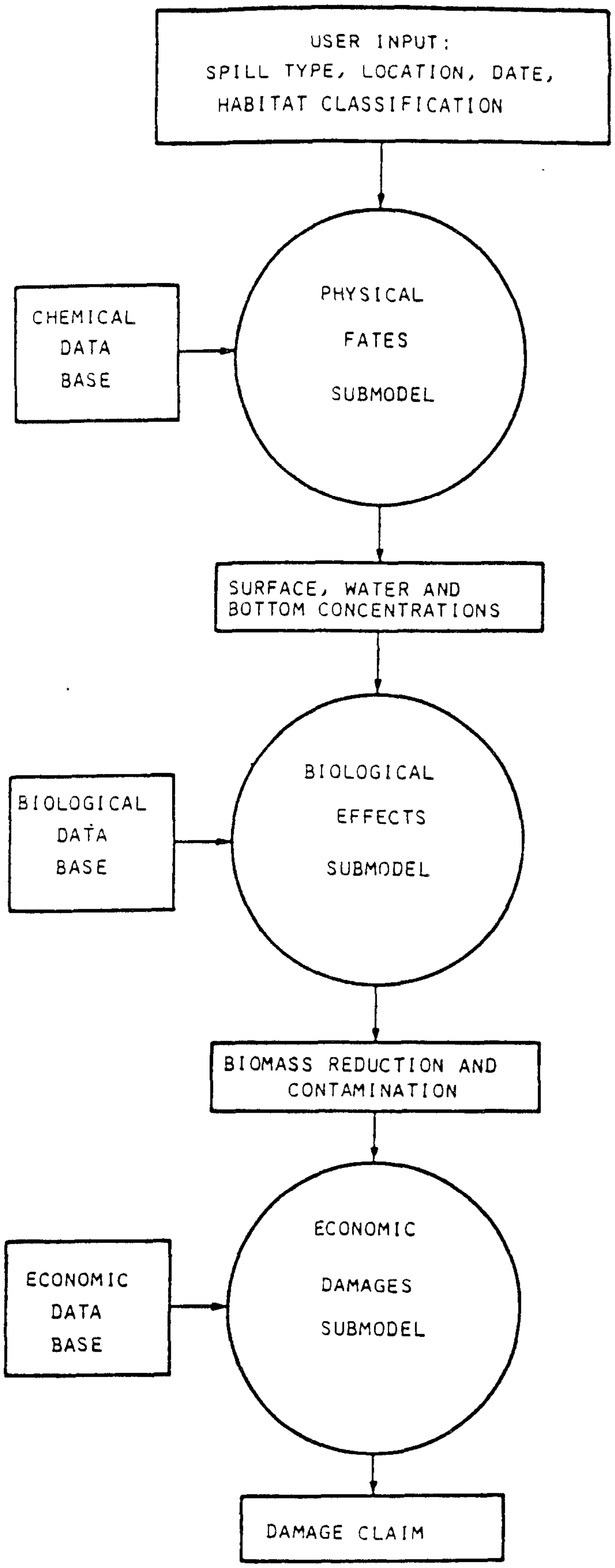


Figure I Overview of type A natural resources damage assessment model for coastal and marine environments.

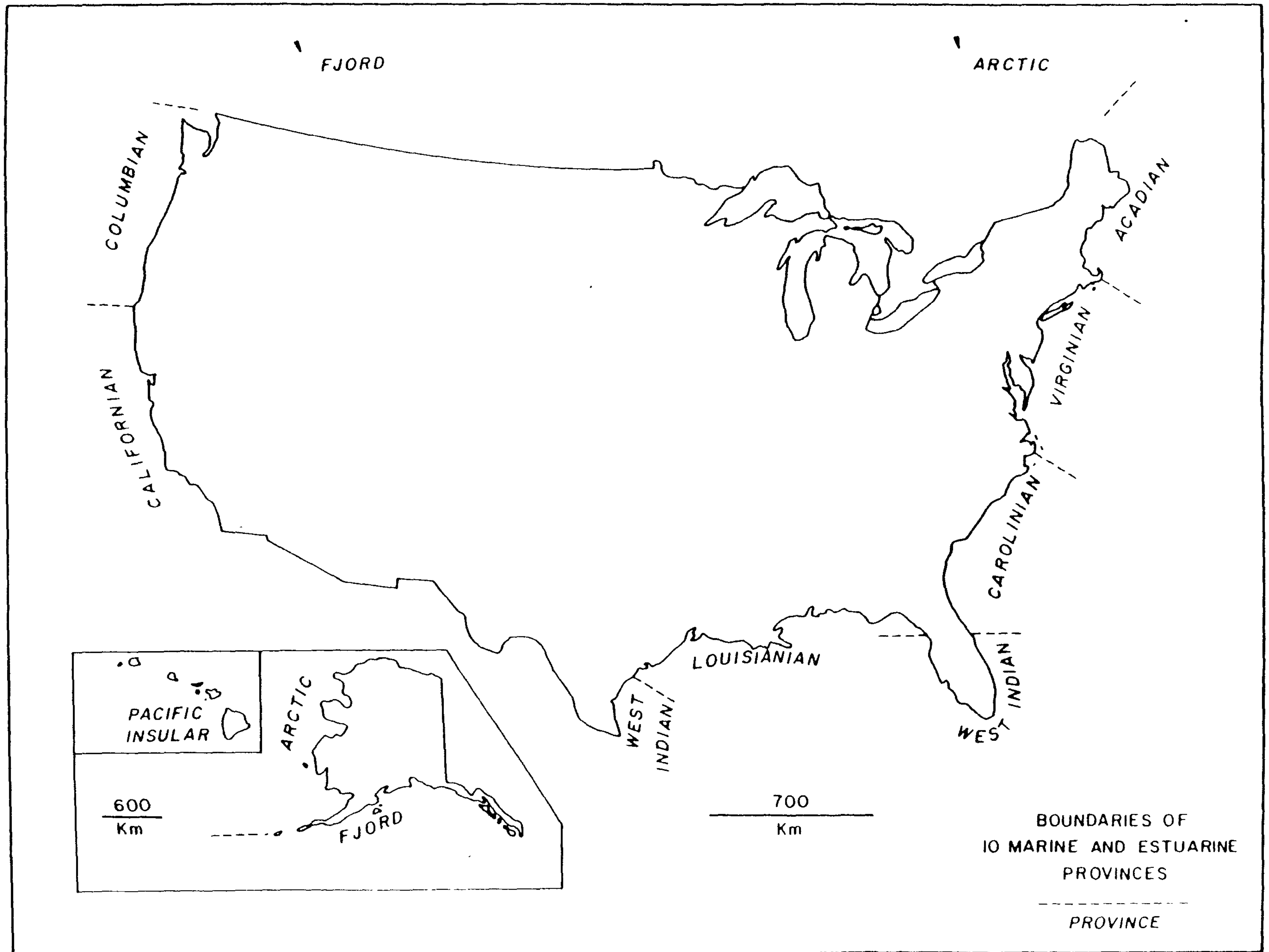
the sum of the mass of the pollutant in all environmental compartments at each point in time equals the mass spilled.

To simulate the fate of a spilled oil or hazardous substance, the physical fates submodel incorporates information on specific coastal and marine environmental parameters. These parameters include the mean and tidal currents, wind speed and direction, depth of the upper rater column, depth of the lower water column, as well as the air and water temperatures and distance to shorelines, or boundaries of concern, in each direction. In a particular application, these environmental parameters can be set by the user; otherwise the model employs default values for each parameter.

The output of the physical fates simulation is concentration of the pollutant, over time, in various cells for each of the four layers. This information is passed to the biological submodel, which calculates injury to various biota in the environment. To define biological resources in contact with the spill, the biological submodel employs a substantial data base on biological abundance of various categories of finfish, shellfish, marine mammals (fur seals), and birds. The data base specifies the abundance of species groups in each of 10 provinces/ecosystem types defined in Cowardin et al. (1979) for the marine environment of the U.S. and its territories (Figure 2). Abundance of the species groups vary by season, bottom type, marine vs estuarine, and tidal vs subtidal environments. In total, 91 different ecosystem categories are considered in the biological submodel.

The effect of a spill on marine organisms depends on the concentration of the substance in the physical environment where the organisms live. Above a threshold level, the impact increases with concentration, using the results of standard laboratory toxicity test data. The biological submodel calculates direct loss of adult and juveniles for waterfowl and shorebirds and fur seals and for nine fish and shellfish species categories and loss of larvae for each of these categories In addition, a simple trophic model is used to trace indirect losses through the food chain.

Biological injury quantified in the submodel includes (1) short-term injury (e.g., death) and (2) long-term injuries which occur over time (e.g., reduced recruitment). Three categories of short-term biological effects are considered. First, surface slicks (e.g., oil) may be



[illegible] Marine and Estuarine Provinces [illegible] Adapted from L.M. Cowardin et al., 1979. "Classification of Wetlands and Deepwater Habitats of the United States," FWS/OBS 79/31.

encountered by birds and fur seals. Second, the dissolved portion of a spill can kill various fish species. Finally, spilled material can sink to the bottom, killing bottom fish species.

Long-term losses due to the effects of acute toxicity on the productivity of the biomass also are taken into account. The dynamics of the biological system is traced using the Ricker model (Ricker, 1975) which simulates the dynamics of cohorts, or age classes, of organisms by calculating changes in biomass due to changes in numbers of individuals within a cohort through natural and fishing mortality, as well as the change in biomass due to growth of individuals within the cohort. The dynamics of the number and weight of indiviuals within a particular age class are described as:

$$N(t) = N(0) \exp[-(M+F)\, t]$$

$$W(t) = W(0) \exp[G\, t]$$

respectively, where N(t) is the number of individuals within an age class at time t, M is the natural mortality rate, F is the fishing mortality rate, W(t) is the weight of a representative individual in the age class at time t, and G is the natural growth rate. Thus, the biomass of a particular age class at time t is:

$$B(t) = N(t) * W(t) = N(0)*W(0)*\exp[(G-M-F)\, t]$$

and the total biomass of a fishery is:

$$X(t) = \sum_{i=t_0}^{T} B(i)$$

where $X(\cdot)$ represents the total biomass of all age classes in the fishery, t_0 is the age of recruitment to the fishery and T is the maximimum life span of the fish.

Using a simple bioeconomic model, lost catch from a spill can simulated over time as:

$$H^{NS}(t)-H^{S}(t)= q^{NS}E^{NS}X^{NS}(t)-q^{S}E^{S}X^{S}(t) = F^{NS}X^{NS}(t)-F^{S}X^{S}(t) \quad (1)$$

where H is total catch, superscript NS represents the case with no spill and S represents the case with the spill, q is the catchability coefficient and E represents the level of fishing effort applied. The resultant lost total discounted economic rent to commercial fisheries, for example, is:

$$\pi^{NS}-\pi^{S} = \int_{t_s}^{\infty} \left[(p^{NS} H^{NS}(t) - c^{NS}E^{NS} - (p^{S} H^{S}(t) - c^{S}E^{S})) \exp(-rt) \right] dt$$

where t_s represents the time of the spill, p is the ex-vessel price of the fish, c represents cost per unit effort, and r represents the discount rate. Thus, in general, all variables must be allowed to change as a result of the pollution incident. However, since the methodology is meant to be used for relatively small spills some simplifying assumptions are possible. First, small spills are unlikely to cause changes in market prices of fish, the catchability coefficient or in cost per unit effort. Hence, these are assumed to be constant with and without the spill. In addition, small spills are unlikely to have a substantial impact on the level of effort applied to the fishery as a whole. In addition, very little work has been done on the issue of effort response (e.g. Bockstael and Opaluch (1983)) and predictions of changes in effort would be difficult, at best, without an incident- specific study to consider alternatives available for the particular individuals impacted by the spill of concern. For these reasons, fishing effort is presumed to be unaffected, by the spills of concern. *

Using the methodology described above, long-term commercial and recreational fishery losses due to the effects of acute toxicity on the biomass are considered. The output of the biological submodel is a time series of lost catch for species groups for fin and shellfish, as well as losses in various groups of birds and fur seals. Should this be constant?

Indirect biological losses quantified in the submodel fall into two categories. First, larvae and juveniles may be killed, resulting in long term losses through eventual reduction in recruitment. Second, spills may kill lower food chain organisms which have no commercial or recreational value but which contribute to predator species which do have economic value. A food chain model specifically allows for an assessment of incident-specific damages via predator-prey relationships.

Once the short-term and long-term biological injuries have been quantified following a particular incident, damages can be measured. The measure of damages is defined as the present value of the lost in situ use value of the injured natural resources over the time period through resource recovery. The categories of coastal and marine natural resource damages considered, and the general relationship of the economic damages submodel to the other submodels are illustrated in Fig. 3.

Damages resulting from injury to lover trophic, non-commercial organisms are based on the ultimate loss in the in situ use value of predator species (commercial and recreational fisheries, waterfowl and shorebirds, and fur seals) which occurs when an incident affects the productivity of the food chain. The food chain or ecological model developed in the biological effects component of the ocean systems model is incident-specific and quantifies the biological injuries to predator species which arise over time as a result of the incident. Given the quantification of biological injuries, damages are measured using the concepts and data applicable to commercial and recreational fisheries, to waterfowl and shorebirds, and to fur seals, outlined below.

In order to measure lost in situ use value, fish resources injured by an incident must be allocated between commercial and recreational harvests foregone. Lost in situ value for commercial fisheries is the change in the total value of landings minus the change in the cost of harvesting the fish (i.e., lost economic rent). For recreational fisheries, lost in situ value is the loss in sportsfishing benefits due to the reduced catch rate from smaller stocks. net of the change in the cost of catching the fish (i.e., lost consumer surplus).

A standard bioeconomics model is used to derive the measure of damages to commercial and recreational fisheries. The short-term and long-term and direct and indirect injury to fish which would have been harvested in the absence of the incident is an output of the biological effects submodel. Injured species are allocated between commercial and recreational uses, given estimates of the relative weight of recreational and commercial landings, by species, for each province and of the total

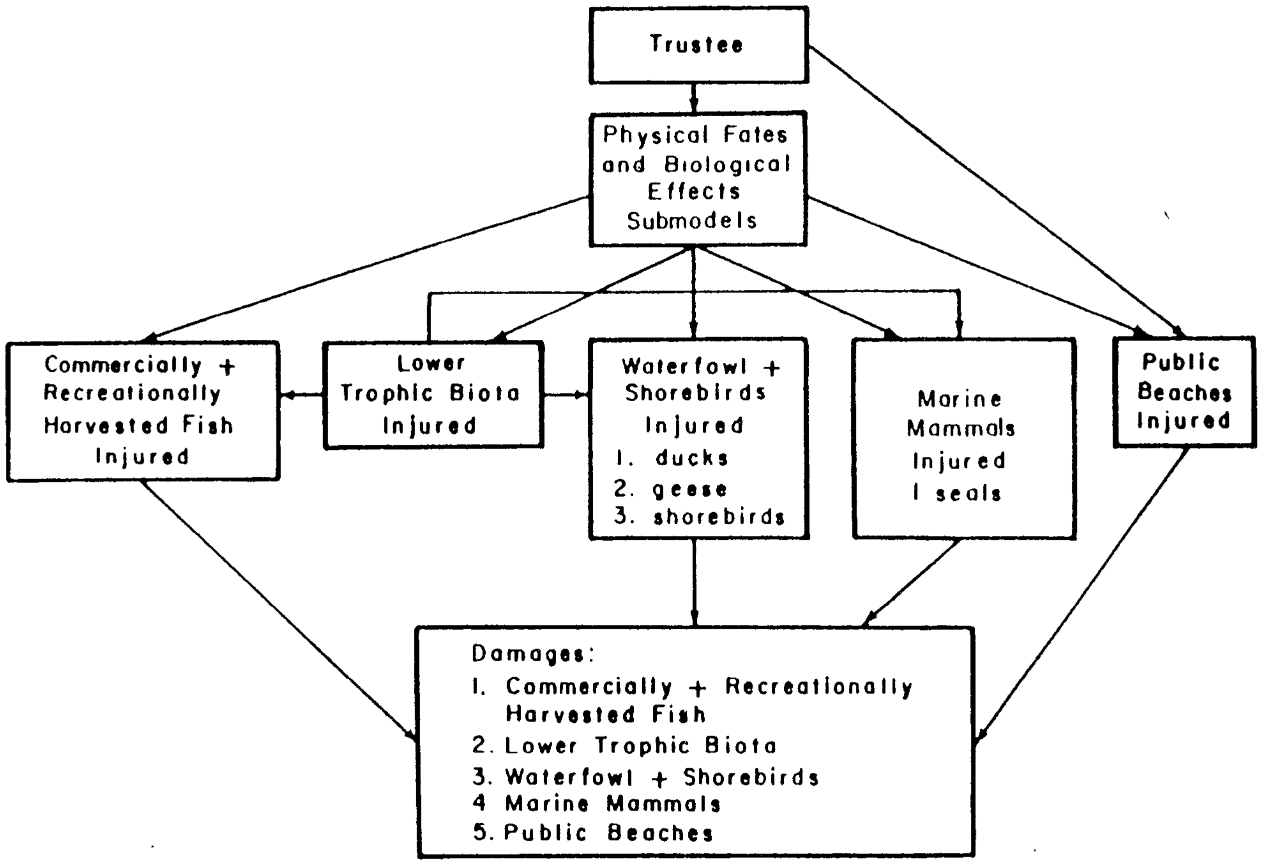


Figure III Simplified representation of the natural resource damage assessment process and damage categories considered in economics component for the coastal and marine environment for CERCLA Type A incidents.

fishing mortality rate for species groups. Total fishing mortality is broken into commercial and recreational fishing mortality as:

$$F_{TOT} = F_{COM} + F_{REC} = q_{COM}\ E_{COM} + q_{REC}\ E_{REC}$$

Since

$$H_{COM} = q_{COM}\ E_{COM}\ X = F_{COM}\ X$$

and

$$H_{REC} = q_{REC}\ E_{REC}\ X = F_{REC}\ X$$

Commercial and recreational fishing mortality rates can be calculated as:

$$F_{COM} = H_{COM}/(H_{COM} + H_{REC})\ F_{TOT}$$

$$F_{REC} = H_{REC}/(H_{REC} + H_{COM})\ F_{TOT}$$

Hence given estimates of total fishing mortality rates and commercial and recreational catch, lost stock can be allocated among lost recreational and commercial catch over time using Equation (1) above.

Ex-vessel (price at the dock) fish prices, averaged over 1982-1984, are used to evaluate damages to commercially harvested fish. Province-specific price information for commercial fisheries and catch data for commercial and recreational fisheries are from National Marine Fisheries Service sources. Values for recreational sports fishing are adapted from the literature.

Injury to waterfowl and shorebirds results in losses of consumptive (hunting) and nonconsumptive (e.g., viewing, photographing) in situ use values. The quantification of biological injury to waterfowl and shorebirds is an output of the biological effects model. Damages resulting from consumptive use value losses are measured using available estimates of the marginal value of an additional waterfowl (duck or geese) harvest. Using the results of Brown and Hammack (1977) damages arising from non-consumptive use value losses for non-game species are measured by employing an estimate of the marginal change in visitor days associated with a change in bird population for a wildlife refuge. The resulting estimate of lost visitor days then are evaluated based on a unit day value published by the Water Resources Council (1979).

IV. Discussion of Selected Preliminary Results

This section describes applications of the model to a variety of environments and substances spilled. The esturarine spills presented in this section assume that all incidents take place at a location where the water depth is 30 feet; the pycnocline (separating the upper and lover rater columns) is assumed to be at 15 feet. The marine spills presented all assume water depth of approximately 120 feet with the pycnocline assumed to be 60 feet. Except where otherwise indicated, all spills are assumed to take place on mud bottoms during the summer season when the surface water and air temperature are assumed to be 25 and 24 degrees Centigrade, respectively. Again it is important to note that because the draft study described in this paper is under review, which may lead to refinements of the model and data, the results contained in this section must be regarded as preliminary.

The sample runs were chosen to provide a perspective on how the results change as the major characteristics of hypothetical incidents vary. Since oil is by far the most common substance spilled, the base case incident is the 100 metric ton (750 bb1) oil spill. Sensitivity analyses were run in which the quantity of oil spilled varied from 40 metric tons (300 bb1) to 1,000 metric tons (7,500 bb1) in both marine and estuarine environments to indicate how damages vary with the quantity spilled and in marine vs. estuarine environments. Additional cases were run to examine how damages vary with province in which the spill occurs and the season of the spill. For this purpose, the base case 100 metric ton estuarine spill was run in all ten provinces and in one province (the Virginian province) during each of the four seasons. Also, two cases of onshore (intertidal) spills were run to indicate damages from spills which come ashore.

Additionally, a series of runs is provided to examine releases of non-oil substances with different physical properties to indicate the sensitivity of damages with respect to the characteristics of the substances. The oil cases discussed above provide a perspective on floating substances. Hence, additional cases are run on a sinking substance and on a substance which mixes readily in the water column. Each of these cases is run for spills of 50 and 100 metric tons.

Table 1 contains the model output for the base case 100 metric ton oil spill. As can be seen, the largest categories of damages to finfish occur to demersal fish (e.g. flounder) at $58.7 thousand, piscevorous fish at (e.g. striped bass, bluefish) at $54.2 thousand and semi-demersal fish (e.g. cod) at $49.6 thousand. The damages to mollusks (e.g. oysters, clams, scallops) total $42.4 thousand and damages to decapods (e.g. crabs) total $24.4 thousand. Also, substantial damages occur to waterfowl ($2.5 thousand). Using a discount rate of 10 percent as required by Office and Management and Budget Circular No. A-94 (as revised), the present value of the total damages from this 100 metric ton spill are $241.6 thousand.

The results for the damages as a function of the quantity of oil spilled in July in the Virginian province are presented in Table 2 and in Figure 4. As can be seen, oil spill damages increase with quantity spilled, and do so at an increasing rate. However, damages become more closely linear as quantity spilled increases. A spill of 300 barrels of oil in an estuary leads to losses of $34 thousand. Increasing the quantity spilled to 1500 barrels leads to damages of nearly $850 thousand. Hence, for this 5-fold increase in amount spilled in an estuary, damages increase by a factor in excess of 25. Increasing quantity spilled to 7,500 barrels results in damages of nearly $8 million.

Thus, damages from oil spills exhibit rapid increase with the quantity spilled, such that the damage function is clearly nonlinear. This suggests that a fixed charge per barrel spilled would be inappropriate for oil spills, as both the average and the incremental damages per barrel increase as the quantity spilled increases, particularly for relatively small spills.

The second set of sensitivity analyses examines damages from the base 100 metric ton oil spill in each of the ten provinces. As can be seen in Table 3, the highest level of damages occurs in the Louisian province

Table 1

Lost In Situ Value of Commercial Plus Recreational Fin Fish in the Virginian Province from a 100.0000 Metric Ton Spill of Prudhoe Bay Crude Oil (HEAVY - 20% volatiles)

YEAR	Anadromous Fish	Planktivorous Fish	Piscevorous Fish	Top Carnivores	Demersal Fish	Semi-Demersal Fish
1986	18.33	866.32	3243.65	.00	739.78	9075.97
1987	17.77	795.38	2998.12	.00	679.37	8251.66
1988	14.41	1207.82	4156.92	.00	617.60	7501.51
1989	11.59	999.84	3697.79	.00	7748.87	6535.24
1990	9.23	851.73	3324.97	.00	7269.06	4379.76
1991	7.26	744.28	3022.83	.00	6868.05	3052.22
1992	5.62	664.55	2778.57	.00	6518.15	2212.83
1993	4.27	603.78	2581.67	.00	6203.07	1664.76
1994	3.15	556.09	2423.50	.00	5913.12	1293.41
1995	2.23	517.49	2297.00	.00	5642.50	1031.65
1996	1.48	485.28	2196.36	.00	5387.60	839.81
1997	.88	457.65	2116.83	.00	5146.16	694.05
1998	.39	433.35	2054.51	.00	.00	579.88
1999	.00	411.53	2006.22	.00	.00	488.24
2000	.00	.00	1969.33	.00	.00	413.27
2001	.00	.00	1941.74	.00	.00	351.10
2002	.00	.00	1921.67	.00	.00	299.03
2003	.00	.00	1907.72	.00	.00	255.10
2004	.00	.00	1898.70	.00	.00	217.88
2005	.00	.00	1893.69	.00	.00	186.23
2006	.00	.00	1891.87	.00	.00	159.26
2007	.00	.00	1892.67	.00	.00	136.25
2008	.00	.00	.00	.00	.00	.00
Total	96.61	9595.09	54216.33	.00	58733.33	49619.11

Total Discounted Commercial Plus Recreational Loss for All Species of Finfish (Rounded to the Nearest Dollar) ...$ 172260.

Table 1 (Continued)

Lost In Situ Value of Commercial Invertibrates in the Virginian Province from a 100.0000 Metric Ton Spill of Prudhoe Bay Crude Oil (HEAVY - 20% volatiles)

YEAR	Mollusks	Decapods	Squid
1986	2189.18	3841.46	1.03
1987	2023.80	3492.24	1.51
1988	1839.82	3174.76	.98
1989	1672.56	2886.15	.48
1990	3140.53	2623.77	.00
1991	2835.69	2385.24	.00
1992	2586.84	2168.40	.00
1993	2383.03	1389.84	.00
1994	2215.46	890.53	.00
1995	2077.04	570.63	.00
1996	1962.07	365.68	.00
1997	1865.97	234.37	.00
1998	1785.03	150.23	.00
1999	1716.30	96.32	.00
2000	1657.40	61.77	.00
2001	1606.41	39.63	.00
2002	1561.78	25.44	.00
2003	1522.29	16.34	.00
2004	1486.94	10.50	.00
2005	1454.95	6.76	.00
2006	1425.67	4.36	.00
2007	1398.59	2.82	.00
2008	.00	1.83	.00
2009	.00	1.19	.00
2010	.00	.78	.00
2011	.00	.51	.00
2012	.00	.00	.00
2013	.00	.23	.00
2014	.00	.15	.00
2015	.00	.11	.00
2016	.00	.00	.00
2017	.00	.05	.00
2018	.00	.04	.00
2019	.00	.00	.00
2020	.00	.02	.00
2021	.00	.02	.00
2022	.00	.01	.00
2023	.00	.00	.00
2024	.00	.01	.00
2025	.00	.01	.00
2026	.00	.00	.00
2027	.00	.01	.00
2028	.00	.00	.00
2029	.00	.00	.00
2030	.00	.00	.00
2031	.00	.00	.00
2032	.00	.00	.00
2033	.00	.00	.00
2034	.00	.00	.00
2035	.00	.00	.00
2036	.00	.00	.00
2037	.00	.00	.00
2038	.00	.00	.00
Totals	42407.35	24442.66	4.00

Total Discounted Loss for All Species of invertibrates
(Rounded to the Nearest Dollar) ...$ 66854.

Table 1 (Continued)

Lost Value of Birds and Marine Mammals in the Virginian Province from a 100.0000 Metric Ton Spill of Prudhoe Bay Crude Oil (HEAVY - 20% volatiles)

Year	Seals	Waterfowl
1986	.00	2477.77
1987	.00	.00
Totals	.00	2477.77

Total Discounted Loss for Seals and Birds
(Rounded to the Nearest Dollar) ...$ 2478.

Total Discounted Losses For All Categories	
Fishery Losses - $	239114.
Bird and Fur Seal Losses - $	2478.
Total for All Categories - $	241592.

Table 2 Damages From Oil Spills As A Function of Quantity Spilled

----Quantity----		Total Damages ($000)	Damages per Barrel	Incremental Damages per Barrel Increment
Metric Tons	Barrels			
40	300	$34	$113.80	$0.11
60	450	$84	$185.68	$0.33
100	750	$242	$322.12	$0.53
200	1500	$848	$565.01	$0.81
400	3000	$2,380	$793.31	$1.02
800	6000	$5,998	$999.71	$1.21
1000	7500	$7,990	$1,066.36	$1.33

Table 5 Total Damages to All Categories from a 75 Metric Ton Spill of Prudoe Bay Crude Oil (20% Volitiles) in an Estuarine, Intertidal Environment in the Virginian Province

	Sandy Shoreline	Rocky Shoreline
Fishery Losses -	$ 42.	$ 80035.
Bird and Fur Seal Losses -	$ 192.	$ 1754.
Damages to Public Beaches -	$ 40481.	$ 0.
Total for All Categories -	$ 40715.	$ 81789.

Table 6 Comparison of Properties and Damages from Spills of Various Substances in an Estuary in the Virginian Province.

Property	Prudo Bay Crude Oil	Pentaclorophenol	Sulfuric Acid
Density	0.89	1.98	1.84
Solubility	1.OOE+00	8.00E+01	1.00E+06
Degradation Rate	1.00E-03	7.70E-03	1.90E-03
Octonol/Water (Kow)	1.00E+01	3.10E+03	1.00E-03
Adsorbed/Dissolved (Koc)	1.00E+03	3.71E+02	1.00E-01
LC50 for Fish	1.00E+03	1.15E+02	7.50E+04
Damages			
@ 50 Metric Tons	$57,079	$57,355	$72
@100 Metric Tons	$241,592	$127,261	$174

and has a relatively low level of toxicity (LC50 of 7.5 ppm for fish). Due to a high solubility, sulfuric acid is rapidly diluted in the water column, and quickly becomes non-lethal to marine biota. Damages for the 50 metric ton discharge total $72 and for the 50 metric ton discharge damages total $174.

V. Summary and Concluding Comments

In summary, various properties of substances released have dramatic effects on the level of damages caused by the release, as well as the shape of the relationship between damages and the quantity of the substance released. Further, for a given substance, damages are sensitive to the location and the season of the discharge or release. This suggests that an approach which sets liability as a function of characteristics of the substances must consider how the substance behaves in the environment, and not simply descriptors such as the level of toxicity and the amount spilled. This was made clear by comparing the case of oil discharges, which rapidly spread, with that of sinking substances released, where the area impacted is more restricted. For the latter case, releases in the range of 50-100 metric tons resulted in relatively constant average damages per ton of PCP as the amount released increases. In contrast, average damages per barrel of oil discharged increase with increasing amounts spilled. An approach which assigns liability to spills without regard to considerations such as the location, season or transport of the pollutant can easily be in error concerning the relationship between damages and quantity released, or other characteristics of the pollution incident.

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Economic and Environmental Conflicts in OCS Oil and Gas Leasing
An Analysis of National vs. Regional Benefits and Costs

by

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INTRODUCTION

A now commonplace chapter in Principles of Economics textbooks points out that smoke from a factory which damages nearby crops or noise from airplanes which overfly residential areas in the process of landing constitute economic externalities--costs borne not by the firms causing the injuries nor by their customers but by third parties: costs not accounted for in the usual market process.

Looking more deeply into this issue, a further point might be made that an increasingly important category of external costs does not involve actual damages to third-parties but, instead, merely the risk of damages. Risk-bearing of this type lowers real income for affected individuals and communities just as surely as conventional damage: we know this to be true from many studies of consumer behavior.

But a particularly troublesome aspect of risk-bearing (and one seldom acknowledged in the literature) is the fact that the costs involved are often not determined by the actual risk or harm to the individual but merely by the perception of risk. The significance of this principle in relation to environmental policy is apparent. If the public comes to believe that the risks of a government program affecting the environment are high (whatever the true risks), the expected political outcome will be that implementation of the program will be made more difficult or stopped entirely. Indeed, one of the most effective methods of opposition to programs sponsored or regulated by the government, including nuclear power, has been to convince the public that the risks associated with the program are unacceptably high while at the same time ignoring the offsetting reduction of other (and often greater) risks which the program would provide.

This method of opposing government programs is particularly effective if it is supported by the political leaders within an affected region. As an example of this principle, consider the case of the recent efforts by the Department of Interior to accelerate the pace of leasing of lands on the Outer Continental Shelf for oil and gas development. Opponents of an expanded leasing program have managed to stifle the Interior Department's efforts by exploiting the well-known principle that whenever conflict exists between national and local benefits from a public program, most politicians will put local interests ahead of the national interests.

The degree to which public perceptions of risk may be altered by misinterpretation of scientific evidence is exemplified by a recent experience in California where U.S. Geological Survey researchers reported findings in 1982 suggesting that the Mammoth Lakes area had a high probability of experiencing a major earthquake. Although the report did not say this, the media misinterpreted the findings as predicting an earthquake in the the immediate future. This sent the local real estate market into a tailspin, reducing property values by about 40 percent over the next three years. While the actual risk of earthquakes was unaffected by the USGS report, the perception of risk was dramatically heightened. And once this perception took hold, it was almost impossible to dispel it, despite vigorous attempts by the USGS researchers to downplay the practical significance of their research after they recognized the impact it was having.

Similarly, in the first fourteen years of leasing federal lands offshore for oil and gas development (that is, prior to the Santa Barbara oil spill of January 1969), OCS lease sales inspired little comment and no serious protests. In the years since the Santa Barbara spill, however, the public response to proposed OCS lease sales has been almost uniformly negative. This misperception by the public of the true risk of oil spills has heightened in recent years, largely because of legal and political opposition mounted by state and local governments (typically with the enthusiastic support of the local media) in California, Massachusetts. Alaska, Florida, and other coastal states. As a result, the Interior Department's plan for greatly escalating the pace of OCS leasing has been effectively blocked and some 52 million acres of potentially productive OCS lands have been declared off limits for leasing by means of legislatively imposed moratoria.

One of the remarkable aspects of this situation is the fact that state and local objections to federal leasing have no reference point in party politics. Leasing opponents include both conservative Republicans like Governor George Deukmajian of California and Senator Paula Hawkins of Florida, and their more liberal political opponents, Mayor Tom Bradley of Los Angeles and Governor Bob Graham of Florida. Indeed, the public opposition to OCS leasing has become so nearly universal in some states that it seems no longer to require the support of scientific evidence but has taken on the character of a quasi-religious crusade.

The oil and gas resources of the Outer Continental Shell represent a major economic asset to the nation whose utilization can contribute to economic growth, national security, and the improvement of real income for all Americans. If the true benefits and costs of enhanced development of OCS oil and gas resources are not being correctly balanced in current deliberations over leasing policy, what needs to be done to change this situation so that the full benefits of these resources can be secured for the nation? This is the essential issue that this paper will attempt to deal with.

I. THE ECONOMIC BENEFITS TO SOCIETY OF OCS LEASING

Economics benefits flow to American society as a result of OCS oil and gas leasing in three major ways:

1. Economic Rent. For all OCS lands leased in total, the market value of expected oil and gas resources exceeds expected costs of production. The difference is referred to by economists as economic rent. Competition among bidders for OCS leases results in the transfer of this economic rent to the American people as owners of these resources. As indicated in Table 1, lessees of OCS lands had paid the federal government $59 billion in bonus, royalty, and other payments of OCS resources through December 31, 1982 (or 56 percent of the total cumulative production value of these resources). In 1982 dollars, the total amount of rent collected amounts to $90.4 billion. About half of the royalty payments included in this figure (or about 15 percent of the total) were derived from production of natural gas. But it is impractical to look for or produce natural gas from the OCS independently: thus OCS oil and gas may essentially be considered to be joint products. Thus in balancing the risk of environmental damage in relation to collection of economic rent, it is appropriate to include all economic rent collected from OCS oil and gas on the benefit side. Looked at this way, it can be seen that the federal government, through 1982, collected $15.00 in economic rent (1982 dollars) for each barrel of oil produced on the OCS.

2. Marginal Import Premium on Petroleum. It is often assumed in theoretical discussions that the elasticity of supply of petroleum imports into the U.S. is infinite. In truth, given the share of world imports accounted for by the U.S., any increase in U.S. demand for imported oil has some impact on the price paid,

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[1]Economic rent is maximized when competition in the market for leases induces winning bidders to pay all but the necessary costs of production, including a normal profit, over to the lessor (the federal government). Studies by Mead, et al., have shown that winning bidders for U.S. leases have earned no more than normal rates of return on their OCS lease investments, suggesting that the federal government has received full economic value for the leases issued. See Table 3-1. p. 53.

particularly in the short run. A study of this impact made by the Energy Vulnerability Modeling Project at Stanford University estimated that the "monopsony buying power wedge" for the U.S. was $7.70 per barrel in 1980 (8, p. 13). A more recent analysis suggests that the marginal import premium (or the excess of import costs per barrel above actual price) is about $6.00 per barrel under plausible assumptions about recent market conditions (12, p. F-34). The $6.00 per barrel figure would appear to be a conservative measure of the import premium associated with additional production of crude oil from the OCS since the premium is being attributed only to oil production when,in fact, both crude oil and natural gas produced from the OCS have the effect of offsetting petroleum imports.

3. Enhancement of National Security. Two aspects of the national security argument are considered below. The first is based strictly on considerations of national defense; the second considers the broader issue of economic security.

a. National Defense. Few would deny that petroleum supply is a critical requirement for a country in a time of war or national emergency. While the validity of the arguments supporting protection of the domestic oil industry on national defense grounds has often been questioned. Congress has at various times endorsed policies designed to promote the security of domestic petroleum supply using various legislative approaches such as tax subsidies for domestic oil producers, the Mandatory Oil Import Quota System, and the Strategic Petroleum Reserve.

b. Economic Security. An interruption in the supply of imported oil has the potential to severely disrupt the functioning of the U.S. economy, as the experience of the period following the Arab oil embargo of 1973 indicates. Estimates of the potential economic disruption premium in social cost of imported oil range up to $100 per barrel (2, p. 54), but these estimates are highly speculative and, in any case, include both real and pecuniary external costs. A more conservative approach is to assume that the benefits to U.S. economic security gained as a result of enhanced OCS oil and gas production are about the same, on a per barrel basis, as those which are obtained from the existing Strategic Petroleum Reserve. The full economic security benefits of the SPR are not known, but we may assume they are at least as great as the SPR's current opportunity cost, which is estimated to be between $3.25 and $4.00 per barrel (3, p. 235). We will accept the latter figure as as a low-range estimate of the national security benefits of enhanced OCS oil production.

The listing of benefits given above is probably conservative because it ignores possible benefits of enhanced productivity of U.S. labor and capital in OCS replacement and production and makes no allowance for the impact of OCS development on the U.S. balance of payments, both of which would likely result in higher real income for Americans. Furthermore, no account is taken of possible technological spillover benefits from OCS development which could be captured by U.S. exploration and drilling companies (benefiting the nation both directly and through enhancement of export income to U.S. oil service companies).[2]

In summary, the benefits of enhanced OCS oil production include collection of economic rent by the federal government, reduction in the price premium on imported oil, and national security benefits. Together, these benefit categories amount to about $25 per barrel on average, expressed in 1982 prices.

It must be emphasized that these benefits are in addition to the value of the oil in the marketplace. They represent a true social surplus or premium above resource cost. From the point of view of national economic policy, they are the benefits which should be contrasted with the estimated external social costs of OCS development in determining whether enhanced OCS development is economically justified.

II. THE EXTERNAL SOCIAL COSTS OF OCS OIL AND GAS DEVELOPMENT

No environmental policy issue, with the exception of nuclear power, has received deeper or more comprehensive study in the U.S. than that of offshore leasing and development. Through 1983, the Department of Interior alone had spent over $340 million on environmental and related studies of offshore development, and announced plans to continue such studies at the rate of about $30 million per year in succeeding years (13, pp. 48, 82, and 121-23). Additional studies of offshore oil and gas development and oil spill impacts have been carried out or funded by the Environmental Protection Agency, the U.S. Department of Commerce (NOAA), and other federal and state agencies. At this point, there is little likelihood that critical information relating to the environmental costs of offshore oil development--information of such gravity that it might significantly alter the scientific outlook on the issue--has yet to be discovered.

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[2]Paul Kobrin has shown that if OCS resource development is merely delayed rather than foregone, a significant social cost is incurred because delay in receipt of economic rent diminishes its present discounted value (see (4)). The Department of Interior has used this approach in estimating the cost of OCS moratoria. It should be noted that this analysis of the cost of delay is valid only if the proposed rate of production is optimal in a capital theory sense (i.e., each unit of production over time has the same expected present value).

Nevertheless, concerns continue to be raised about the environmental and other impacts of OCS development, usually in these categories of potential social cost:

1. Impairment of water quality resulting from disposal of drilling muds or cuttings, or of water produced from wells.

2. Impairment of air quality resulting from loading, unloading, or processing of oil and gas.

3. Oil spill impacts on commercial fishing.

4. Oil spill impacts on tourism and recreation.

5. Oil spill impacts on the natural environment.

6. Oil spill impacts on property values.

7. Uncompensated costs of oil spill cleanup.

8. Infrastructure costs to local governments.

These areas of concern will be addressed individually in the sections which follow.

1. Drilling Muds, Cuttings, Produced Water. The possible impact of drilling muds and cuttings on the marine environment has been of major concern to both industry and government, leading to research expenditures of about $15 million in recent years. These studies conclude that environmental impacts of drilling muds are localized, temporary, and minor (see (13). pp. 86-87; (5), p. 725; (1), pp. 119-21; and (9), pp. 100-03). Only low toxicity drilling muds (all approved by the EPA) are used offshore. Some turbidity is created by offshore drilling, but it is of little significance in comparison to the impact of of conventional dredging activities or clam harvesting. Studies both in U.S. waters and the North Sea show that drilling muds have only minor ecological consequences within a limited area around the platform. Similar conclusions are reported in studies of "produced water", which, under strict environmental stipulations, must be treated and separated before it can be reinjected or discharged from the platform.

2. Air Quality. Environmental stipulations attached to OCS leases require use of "best available control technologies on production, transportation and storage facilities to protect air quality. Both the EPA and state air pollution control agencies are involved in development of stipulations and in monitoring of compliance, and these agencies have full access to platforms purposes of inspection or testing see (13). pp. 84-85; and (p. 125).

3. Impacts on Commercial Fishing. Studies by the present author of the impact on commercial fisheries of three major oil spills (Santa Barbara, USA, 1969; Zoe Colocotroni, Puerto Rico, 1973; and Amoco Cadiz, France, 1978)--only one of which resulted from offshore drilling--concluded that in no case did the oil spill cause any major loss to open seas fisheries (see [6], [10], and [11]). Damage to shell fisheries in bays and estuaries was significant in the Amoco Cadiz case, but this damage was quite easily quantified and thus the damaged parties were more quickly and adequately compensated. Oil spills have their major impact on open seas fisheries by preempting access to the fishing grounds, but the studies noted above found that the catch lost during shut downs was more than fully recovered in later fishing efforts. The same conclusion was reached by European researchers studying impacts of oil spills on fisheries in the North Sea. Commenting on these studies, the Royal Commission on Environmental Pollution declared, "we agree with the findings...that the effect of oil pollution in general on adult fish populations is so slight as to be undetectable in fishery statistics" (9. p. 54).

4. Impacts on Recreation and Tourism. Potential impacts of oil spills on tourism are generally exaggerated by opponents of OCS leasing, who often suggest that oil operations offshore have the potential to "destroy" an invaluable onshore tourism industry. In fact, only limited damage to tourism from oil spills has been documented. Researchers in Britain discovered no impacts on tourism as a result of two major oil spills occurring near tourist destination sites on the coast of Cornwall (Torrey Canyon and Newquay). They concluded that "most people accept oil pollution as just another uncertainty relating to a seaside holiday," and that factors such as bad weather or other forms of coastal water pollution, particularly sewage, are "much more significant" than oil pollution in affecting tourism (see 9, p. 56). Losses to tourism were also insignificant in the Zoe Colocotroni, Argo Merchant, and Ixtoc spills. Only two oil spills appear to have affected tourism in any major way: Santa Barbara and Amoco Cadiz. In both cases, some shifting of tourists from affected to unaffected sites nearby was detected (meaning that social costs to the local economy were greater than to the state or national economies). Also in both cases, unusually bad weather was experienced at the time of the oil spill, making it difficult to identify the impact of the oil spill alone. As might be expected in view of the unique qualities of Santa Barbara and Brittany as destination sites, impacts on tourism were temporary.

5. Impact on the Natural Environment. This is the most controversial aspect of oil spill damage, and the one which clearly elevated the Santa Barbara spill above all others in public significance. A considerable body of research has documented the damage to marine organisms caused by oil spills, particularly in the cases of Torrey Canyon, West Falmouth, Santa Barbara, Zoe Colocotroni, and Amoco Cadiz. Later studies have

shown, however, that the natural environment in each area has either completely recovered or is in the process of recovering. No long-term damage to the ecosystem has been documented. It is beyond question that the environmental damage observed in Santa Barbara, particularly in respect to bird losses, was shocking to the public. But is was, nevertheless, temporary. How should the social cost of this type of loss be evaluated? At this point, economists have not developed a completely convincing and practical methodology.[3] Most economists accept the idea that monetary values should be attached to the amenity or psychological losses suffered by society when living organisms are killed or injured as a result of oil spills.[4] A conflict in values arises, however, when economists try to sell this idea to environmentalists who may insist that living organisms should be accorded unique or paramount value over all other categories of social cost. This conflict cannot be resolved by debate, but it is worth noting that society routinely accepts various risks to human life in all areas of human activity and has accepted, as well, the need for (and appropriateness of) economic approaches to evaluating actual or potential loss of life. Is it not reasonable to accept a similar approach, using economic criteria, in evaluating the worth of other living things?

6. Impacts on Property Values. Our study of the economic cost of the Santa Barbara oil spill concluded that property values of private homes in the beachfront area had declined temporarily as a result of the spill, with a consequent loss of economic rent to owners [6, p. 225]. A similar investigation of the question of potential loss of property values in the area of Brittany most impacted by the Amoco Cadiz oil spill, however, showed that no discernible losses had occurred [11, p 77]. This result is not surprising since few buyers of real estate in that area of Brittany are speculators and an oil spill, even in the light of recent history, is an exceptional and temporary event. Beachfront property owners in California are among the most vociferous opponents of OCS leasing, but the potential for damage to property values from offshore oil development cannot be taken too seriously in view of the risks routinely faced by such owners from earthquakes, mudslides, fires, and flooding. Realistically, the oil spill risk is of negligible significance.

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[3]A review of some of the methodologies used in evaluating environmental damage and their theoretical and practical difficulties is provided in [11], pp. 81-85.

[4]The response of the oil industry to the public outcry over environmental damage caused by the Santa Barbara oil spill has been dramatic. In the entire period since 1970, less than 800 barrels of oil have been spilled as a result of well blowouts on OCS leases (see [13], p. 3).

7. Uncompensated Costs of Cleanup. Fears that coastal residents or government agencies would be saddled with the costs of cleaning up oil spills left behind by unknown or insolvent parties led to a spate of legislation in the early 1970's, resulting in the establishment of oil spill compensation funds in several states and at the federal level. To this date, no losses from oil spills related to OCS development have been paid for out of these funds. This is an expected result, since spilled crude oil can be fingerprinted and OCS operators, even if they wanted to, could not steal away from the scene of a spill. The record of payments from the Florida Coastal Protection Fund over the most recent six-year period indicates that only $20,000 per year has been paid out for all cleanup and damage claims. Indeed, the Fund balance of about $40 million has been accumulating interest so rapidly in recent years that the Legislature has had the luxury of diverting part of it to handle inland and groundwater problems in Florida. The Offshore Oil Pollution Compensation Fund created by the OCS Lands Act amendments of 1978 has also been faced with only a small total value of claims, despite its capitalization level of $200 million. Some may not want to accept the fact, but phantom oil spillage is quite unusual and not very expensive to deal with. Significant oil spills are not easily covered up, and responsible parties are usually quick to act in payment of cleanup costs.

8. Infrastructure Costs. This category of damages is highly suspect since most local governments assiduously seek out new industries expecting to recover for any short-run costs through expansion of their tax base. If the proposed developments have particularly high start-up costs to local governments (as might be true for a major new OCS oil storage or transport facility the best way of dealing with this situation is through use of impact fees or special assessments. Reviewing several studies of the benefits and costs to local governments of OCS oil development, a recent analysis concludes that the most reasonable hypothesis is that such developments have no net fiscal impact [12, p. G-62]. This and other evidence suggests that the issue of local infrastructure costs should not be accorded any great weight in determining the future course of OCS development.

SUMMARY AND CONCLUSIONS

We may obtain some idea of the total expected social cost of oil spills from enhanced OCS development, expressed on a per barrel basis, from a recent comprehensive analysis of this issue carried out by the Department of the Interior. This analysis includes estimates of costs in the categories discussed above (and several more, in addition), drawing inferences from a number of well-known studies of the economic costs of oil spills in the marine environment. In its summary of expected costs, the authors take the conservative approach of accepting estimates of costs which are consistently biased upward, or in favor of the opponents of OCS leasing. Despite this bias, the analysis concludes that the total estimated social costs of enhanced OCS production (net of the benefits gained from reduced levels of oil spillage from tankers which would have had to bring offsetting barrels of imported oil into the U.S.), ranges from $6 million to $53 million per billion barrels of oil equivalent production (BBOE), the amount depending on the particular OCS area being considered [see Table 2].

The analysis above estimated that the social benefits of enhanced OCS oil production were about $25.00 per barrel in excess of the market value of the oil produced. In comparison to even the highest estimated social cost of OCS production ($53 million per BBOE), this means about the benefit/cost ratio for enhanced OCS oil production is about 500 to 1, or that each $500 in social benefits from enhanced OCS oil production can be expected to create only $1.00 in external social costs. More typically, the benefit/cost ratio will be over 1,000 to 1, as can be seen in Table 2.

In view of this preponderance of benefits over costs, it is unlikely that any reasonable analysis of OCS leasing could dispute the conclusion that enhance OCS development is in the interest of the nation. Why, then, does social policy toward this issue remain as it is, with the Department of Interior on the defensive and the opponents of OCS leasing continuing to win major political and legal battles?

The answer is suggested by the Interior Department's analysis of the regional distribution of the benefits and costs, which shows that for most affected coastal states, the potential net social costs of OCS development are larger than the benefits which would be paid from federal compensation funds in the case of OCS oil spills [see Table 2]. Even if the distribution of benefits to regions from reduced requirements for federal tax collections were taken account of within the affected regions, several would still end up as losers.[5]

What this means is that for some states the benefit/cost ratio for OCS leasing and development is (or certainly appears to be) less than one, despite the overwhelming preponderance of national benefits. From a public choice perspective, therefore, it is not surprising that politicians representing these states should oppose enhanced OCS leasing near their coastlines. They may or may not recognize the national benefits of OCS leasing, but they will probably believe that their constituents have more to lose than to gain from the proposed new leasing programs.

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[5]See [12], Table 10, p. 65.

Joined in interest with politicians from other affected coastal regions, and using the well-known technique of vote-trading to gain the support of members of Congress from inland states who may have no great concern for the issue one way or the other, opponents of OCS leasing can effectively shackle the federal effort at enhanced leasing. Given the support of local and state politicians, environmental activists who are also opposed to leasing may then use the public hearing process and a sympathetic media to provide a relentlessly negative commentary on the risks of OCS development, with little chance of contradiction except from the promoters of such development--the Department of Interior and the oil industry--who unfortunately have little credibility in the mind of the public.

To break this impasse, the federal government must accept responsibility for a legislative effort to change the distribution of property rights for OCS resources, eventually awarding a share of the bonus and royalty income derived from OCS leases to the states which will bear most of the external social costs associated with OCS development. A blueprint for this approach is suggested by the recently approved legislation awarding coastal states a 27 percent share (amounting to $1.4 billion) of income derived from leases issued within the first three miles of the OCS. The theory underlying this award (that previous state leasing activities had enhanced the value of nearby OCS lands) was clearly questionable, but a political compromise granting a share of OCS revenues to the coastal states was nevertheless reached. A much more convincing body of theory and evidence could be cited in support of the transfer of property rights which is proposed here. Thus, a proportionally greater federal commitment to implement the solution should be forthcoming.

Obviously the federal government will be very reluctant to give up any significant amount of OCS revenue. But the halfway measures currently in place, such as payments made out of OCS funds to <u>all</u> states for the Land and Water Conservation Fund ($800 million per year) and the Historic Preservation Fund ($150 million per year), do nothing to change the incentives of state and local politicians in coastal areas to continue to oppose OCS leasing, because these payments are made irrespective of the risks faced by the states receiving the funds.

One of the keys to bringing this solution about is to recognize that the transfer of property rights being proposed is not simply a "bribe" to recalcitrant states; it is a policy justified by the economic facts in the case. Most importantly, as long as the federal government refuses to share a portion of the OCS pie with the states which now bear a disproportionate part of the social costs of this enterprise, the pace and scope of OCS development will continue to be toppled with consequent loss of potential real income for all Americans.

Table 1

LEASING, PRODUCTION, AND REVENUE DATA RELATING TO OFFSHORE OIL AND GAS LEASES IN THE U.S.

OCS Acreage Offered for Lease 1954-82	175,647,953
OCS Acreage Leased. 1954-82	29,819,834
Total Wells Drilled on OCS Leases, 1954-82	20,956
Cumulative Production of Crude Oil and Condensate from OCS thru 1982 (000 of barrels)	6,027,440
Cumulative Production of Natural Gas from OCS thru 1982 (MCF)	58,182,510,479
Cumulative Production Value of OCS Oil and Gas thru 1982	$105,514,662,534
Bonus, Royalty, and Other Payments to the Federal Government from OCS Leases thru 1982	$58,987,881,911
Payments to the federal Government from OCS Leases in 1982 Dollars*	$90,351,187,734
Federal Government Share of Total OCS Production Value	56 percent
OCS Oil Production as Share of Total U.S. Oil Production thru 1982	6.82 percent
OCS Gas Production as Share of Total U.S. Gas Production thru 1982	11.59 percent

SOURCE: U.S. Department of the Interior, Minerals Management Service, Federal Offshore Statistics. December 1983.
*Conversion to 1982 dollars made using GNP deflator.

Table 2

ESTIMATED NET DISCOUNTED SOCIAL COSTS ASSOCIATED WITH TOTAL PRODUCTION OF ALL LEASABLE RESOURCES IN EACH OCS AREA
(High Range Estimate in Millions of 1987 Dollars)

Region	Total Costs	Net Costs per 880E
Central Gulf of Mexico	$40.52	$ 9
Western Gulf of Mexico	29.44	6
Navarin Basin	26.97	34
Southern California	20.10	16
Eastern Gulf of Mexico	6.48	14
Northern California	6.36	15
Central California	6.24	15
Beaufort Sea	6.24	21
Chukchi Sea	5.28	13
South Atlantic	4.61	6
Mid-Atlantic	1.51	8
North Atlantic	0.98	22
Washington-Oregon	0.54	10
Straits of Florida	*	53
Gulf of Alaska	*	14
Norton Basin	*	22
Cook Inlet	*	28
St. George Basin	*	18
North Aleutian Basin	*	18
Kodiak	*	15
Shumagin	*	9
Hope Basin	*	8

[1]Per billion barrels of oil equivalent production.
*Less than $500,000.

SOURCE: U.S. Department of Interior. Proposed Program: 5-Year Outer Continental Shelf Oil and Gas Leasing Program for January 1987 - December 1991. Detailed Decision Documents, February 1986, Tables 7 and 8, pp. 45, 47.

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